World Renewable Energy Congress VIII

BOOK OF ABSTRACTS

Denver, Colorado USA
August 29-September 3, 2004

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NOTICE

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DEVELOPMENT AND APPLICATION OF RENEWABLE ENERGY PLANTS IN ANGOLA

By Mateus Neto

1, INTRODUCTION:

The sprouting process of the renewable renergy plants in Angola and its insertion in the market

2, DEVELOPMENT

The development of the renewable renergy plants that is necessarily pass for the creation and materialization of politics that they aim at to stimulate the use of these technologies in the systems of energy supply the communities. The development factor is a state task a time that in Angola the production and the supply of energy are tasks of the government. Possessing the government politics of massification use of renewable renergy plants difficult if it has become the use of these technologies in the centers of national energy supplying.

3, REALITY IN ANGOLA

The reality in Angola, consists in practises of sporadical importation of these technologies. Some sectors exist where if it was installed some renewable renergy plants, particularly the Photovoltaica, but these programs had been in its majority realyt through donations of organizations not governmental foreigners and others acquired by the Angolan state. The lack of consistent politics the use of renewable renergy plants makes with that the singular people if move away from the initiatives of development these technologies, a time that do not find reciprocity on the part of the agencies the state that they control this area.

4, PERSPECTIVES IN ANGOLA

The new perspective consists of fomenting the use of the energies renewed, through specific programs bred for the effect. The initiative is of the Ministry Science and Technology through its National Direction of Technological Development. We have registed already some advances, weighs the results even so still dont satisfy our expectations. The program consists of the promotion of the study and research of renewable renergy plants in the university centers. Today in Angola they dont exist in the university resumes the study of renewable renergy plants it disciplines, from there the initiative of Ministry Science and Technology in fomenting the study of these technologies in the university centers country.

5, CONCLUSIONS

We wait to conclude our communication with the reached results and projects materialized in the scope of the program of development of the renewable renergy plants in Angola.

Mateus Manuel Neto, National Director Development Technology, at Ministry Sciense and Technology Angola.

COMBUSTION CHARACTERISTICS OF CPO AND ITS EFFECTIVENESS AS AN ALTERNATIVE TO DIESEL FUEL

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ABSTRACT: For countries, which produce oil crops, vegetable oil is a potential source of alternative fuel. Over the years there have been many attempts to use various types of vegetable oil directly in diesel engines. These include palm oil, soybean oil, sunflower oil, safflower oil, coconut oil, rapeseed oil, jatropha oil etc. Crude Palm Oil (CPO) is one of the promising renewable bio-fuels. Many researchers have reported of successful short-term trials with this particular vegetable oil. However, long-term tests revealed degraded engine performance and problems such as deposit build up in the combustion chamber, injector coking, piston ring sticking and lubrication oil dilution.

In the present research, a Yanmar L60AE single cylinder direct injection diesel engine was coupled to an electric dynamometer to provide load. The engine was run at a constant speed of 3600 r/min. Pressure transducer was used to measure the in-cylinder pressure while other instruments were available to determine fuel flow rate, ambient temperature and exhaust temperature. The engine was started with diesel fuel only and switched to CPO after the engine was warmed up.

Despite the higher viscosity at 60°C, the ignition delay was found to be shorter for CPO than that of diesel, thus producing less intensive premix combustion. This was probably due to chemical reactions of CPO during the injection period. Breaking of the double bond carbon chain produce lighter volatile compound, leading to shorter ignition delay. Combustion analysis revealed that combustion of CPO reached a higher peak pressure at earlier crank angle and lower premix combustion than diesel. It was found that with CPO brake thermal efficiency was comparable to that of diesel, however, specific fuel consumption was higher, due to lower calorific value of CPO. In term of emission, relative to diesel engine CPO produces higher CO but comparable NO emission.

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Use of biogas technology for sanitation improvement in the slum areas

by: M.A.Gofran

Abstract:

The world is gradually becoming urbanized. World Habitat Conference-11 held in Istanbul in 1996 identified urbanization as the biggest challenge for 21st century. With the urbanization the cities experience an increasing need of basic services including housing, which the city authorities often fail to cope with. As a result slums are developed, cities become urban agglomeration and unfit for human habitation.

In the slum areas most people use hanging latrine for fecal disposal and open space for waste disposal. Thus they are polluting city environment, causing health hazard and are becoming threat to city life. Biogas technology may be the best solution for the environmental improvement of the slum areas. Both night soil and solid waste are the raw materials for a biogas plant.

In Nobodoy Housing, Dhaka, there is a slum with 147 people in 28 families. There were 4 hanging latrines without any septic tank or sewerage connection. Night soil from the latrines was passing through the surface drain, spreading bad smell and health hazard. They had been using open space for waste disposal. A NGO named BSCE took initiative to improve the environmental condition of the slum. Two options were known to them, a) connecting the latrines to nearest sewerage line, which would cost US$ 1000.00, b) constructing a septic tank, which would cost US$ 1200.00. Instead of going for those options, BSCE constructed a biogas plant there by spending only US$ 400.00. They connected the latrines to the plant and pushing the domestic waste into the digester. The plant is giving 6m^3 of gas a day and fertilizer for farming. Since the biogas plant is giving gas, fertilizer and improving environment, it is called 3 in 1.

PLANT BIOMASS FOR RENEWABLE PRODUCTION OF FUELS AND OF INDUSTRIAL ORGANIC PRIME SOURCES

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ABSTRACT:

We have developed, taken to pilot-plant scale and patented technologically efficient and economically viable *continuous* processes for the *dilute acid* hydrolysis of the cellulose of plant biomass (ligno-cellulose) to glucose for fermentation to ethanol; of the hemicellulose to pentoses and associated processes for the conversion of pentoses via furfural to tetrahydrofurfuryl nitrate (THFN) – a safe cheap additive which allows azeotrope ethanol to substitute Diesel fuel. Azeotrope ethanol is widely used in Brazil to substitute gasoline; while anhydrous ethanol is added to conventional gasoline.

The lignin via lignin coke is converted by reaction with steam to Synthesis Gas for C-1 chemistry, including methanol. The conversion of this to aromatics to C-10 is well-known; as is the Fischer-Tropsch processes to produce fuels which can be cracked, reformed etc: “Fischer-Tropsch petrochemistry”. The aromatics include benzene, toluene and the xylenes; while the conversion of ethanol to ethylene, propylene and the butylenes is also well-known. Thus, globally, the seven prime souces of industrial organic chemistry currently produced from petroleum and natural gas, can be renewably substituted.

As a bonus we have shown that auto-hydrolysis of plant biomass produces an excellent feed for ruminants.

It should be recalled that the very growth of plant biomass *consumes* carbon dioxide, thus leading to climate protection.

A High Hydrate Alcohol as a Special Fuel

Bristot, A[X]., Ocácia, G.C[XX]., Gomes, A.[XX]

As it is well known any liquid binary mixture can be separated through a process called fractionalized destillation. The energy supplied in order to perform this separation is obtained by heating the mixture in the case of water and alcohol at a temperature arround 80 ºC.

In the case of sugar cane alcohol the appropriated fuel is sugar cane bagasse. This fuel is a low heating value fuel, approximately 2000 kcal/kg and in large destillaries has two uses: as a source of heat in the alcohol destillation process and as fuel for cogenerating electricity.

It turns out (Ladish,1989) if the mixture of water and alcohol is maintained at aproportion of 85% alcohol and 15% water in volume (85 GL, Gay Lussac degree), the energy input is 10 times less than the alcohol combustion energy. On the other hand if the binary mixture of water and alcohol reaches the azeotropic point (96% alcohol in volume) the above mentioned energies become equals. In this case the only energetic gain is in the form of the fuel quality, the imput energy is abtained from a solid fuel (sugar cane bagasse) and the energy of the alcohol is that from a liquid fuel. Also the necessary equipment for the destillation of the 85% alcohol is much simpler than that one emploid in the conventional hydrate (96% alcool) alcohol obtention.

For instance the destillation tower is just an one stage tower having arround 5 meter high.

This simplified alcohol destillary can be constructed in a cooperative way in order to supply a local fuel for farmers. This fuel can be used in small tractors and for thermoelectric purposes.

The main characteristis of this fuel are being studied such as: corrosion behavior and the increase in consumption whern compared with the conventional hydrate alcohol.

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KINETIC STUDIES OF THE ELEPHANT GRASS COMBUSTION OF CHARCOAL FINES BY THERMOGRAVIMETRIC ANALYSIS-TGA USING LOW HEATING RATES

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ABSTRACT

Dynamic Thermogravimetric Analysis (non-isothermical technique) were conduced in several samples of charcoal fines obtained by fast pyrolysis of elephant grass in fluidized bed reactor.

The study of the thermodynamic behavior of the decomposition of the material was examined in the following conditions: 980^{o}C as final temperature, 10^{o}C.min^{-1} as a constant heating rate, particle size from 36 to 98 μm in an oxidizing environment.

The elephant grass charcoal fines were produced in the following conditions: superficial gas velocity and inert stationary bed height from 0.09 to 0.156 m.s^{-1} and 164 to 250 mm respectively. For each experimental condition to produce the charcoal fines in the fluidized bed reactor, a empirical model was used to estimate the average bed temperature (TML=654,42+63P_{aec}-43,67HL_c-72,25[HL_c]^2), with R^2=99%, where P_{aec} is the value relationship air actually supplied to air theoretical supplied (%) and HL_c is the value the inert fixed (with no fluidizing) bed height (mm).

The kinetic parameters involved in the decomposition reactions were obtained for each temperature range where the maximum decomposition occurs (maximum decomposition range), and in the picks (maximum decomposition temperature).

The TGA experimental data were compared to empirical volatilization model and ultimate analysis. It was found that the mass loss of biomass during the devolatilization is significant, and that several types of charcoal fines have different thermal characteristics under oxidizing atmosphere. It was also observed that the beginning of the exothermic reactions varying in the range temperature from 100^{o}C to 230^{o}C.

Keywords: Kinetic Parameters, Thermogravimetric Analysis, Charcoal Fines, Empirical Model

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Gasification of biomass for power supply in tropical humid areas: case study of Cameroon.

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Abstract

Cameroon is situated in the forest zone and Electricity is one of its main forms of energy consumption; averagely, in rural areas, less than 10 % of households have access to electricity. The are many problems in energy supply : production, transportation, management and distribution of electricity.
Our objective through this paper is to show that it is possible to use waste wood products from wood of forestry industries (biomass) to produce electricity and mechanized power in isolated villages of the zone. In that light, it seen indispensable for us to define the socio-economic contexts capable of favouring the implantation of technical solutions of valorisation of biomass in the working context.
To achieve these objectives, a total of fifteen villages of the forestry- zone of the Centre Province of Cameroon with favourable conditions to the development of biomass energy project were selected following an exclusive and stratified procedure which consisted first of defining set of scientific criteria enabling one to choose objectively the sites suitable to eventually assure the reward of the action. After inventorying the energy need of the villages of the zone under study, a gasification trial has been made from an available Indian gas producer (AEW gas producer) in a pilot site in Yaounde. Through this trial, thermodynamic parameter such as temperature of the system has been studied. Those tests for gasification of charcoal were made in order to master the technical functioning of the gas producer.

Key words: *biomass, rural electrification, methodology, gas generator, charcoal, gasification*.

Recovery of fish biomass by a low–energy ensiling operation

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Abstract

Fish silage was produced by the addition of formic acid to minced tilapia fish (*Oreochromis niloticus*) waste biomass. The process lasted for 30 days, and the chemical composition and total amino acid of the silage were determined and compared with those of fishmeal, which is the commercial product generally employed as the main source of protein in feed formulations. The aim was to evaluate the potential incorporation of formic acid fish silage into the diets of cultivated fish as the main source of protein.

Results showed that formic acid silage has good storage properties. The formic acid silage was able to provide similar values of protein (approximately 53% on a dry matter basis), lipids (approximately 14% on a dry matter basis), and energy content (approximately 483 Kcal per 100 g of dry silage) to those provided to by the fishmeal employed in this study. In addition, the use of formic acid silage did not produce significant changes in the amino acid profile of the diets, and it is able to supply the amino acids requirements of cultivated fish.

Based on the good nutrient content and amino acid composition of the diets prepared, it can be concluded that formic acid fish silage could be successfully utilized as an alternative protein source for fishmeal in feed production. In this way, it is possible to utilize processing wastes for producing valuable animal protein and, furthermore, avoid the pollution problems associated with the discard of fish processing wastes into the environment.

Conventional forestry systems for sustainable production of bioenergy

J. Richardson, R. Björheden, C.T. Smith

Forest ecosystems constitute the world's largest accessible source of biomass, which may be available from forest operations in conventional forestry systems, and thus may be one of the most important suppliers of fuel to the bioenergy industry. An important way to realize this potential is the integration of biomass production and forest fuel harvesting into conventional forestry practices. This was the focus of IEA Bioenergy Task 31 'Conventional Forestry Systems for Sustainable Production of Bioenergy'. Silvicultural and forest management systems offering opportunities for biomass recovery for energy were identified, including different stand treatments, mixed stand management and expanded utilization. Forest operations systems were developed to enable cost-efficient and environmentally acceptable recovery of biomass for energy and conventional forest products. The sustainability of production systems was assessed, based on forest ecosystem research with a focus on nutrient cycling and wood ash recycling, carbon sequestration, stand productivity, and soil and water conservation. Several current situations present specific challenges and opportunities for biomass recovery for energy. In densely-populated regions, energy needs are often greater than elsewhere, but public opinion may dictate that forest conservation for recreation and environmental purposes takes higher priority than harvesting of forest fuels. A related situation exists in the 'urban-wildland interface' where long-term exclusion of fire from forests in which it was a normal feature of the ecosystem has resulted in dangerously high forest fuel build-ups and potential for disastrous wildfires. Bioenergy use can help make the management of such fuel loadings economic and effective. A third issue is the contribution of forest-derived bioenergy to greenhouse gas balances, currently one of the key drivers for increased use of biomass energy.

EXPERIMENTAL STUDY OF FLASH PYROLYSIS OF LIGNIN OBTAINED FROM PAPER INDUSTRY

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Abstract: The residues produced in papermaking industry are the components of biomass except cellulose and hemicellulose. It mainly consists of lignin, metallic salt and other additives. The treatment or reutilization of lignin residues appears to be very difficult. Combustion or pyrolysis seems a good method to solve this problem. Here, series of experiments on lignin pyrolysis was done on our heat radiation reactor to investigate the pyrolysis behavior and understand products distribution. The experimental result showed that temperature had an obvious effect on the production of char and tar. A maximum production of 27wt% for tar was obtained at 550°, which was very far lower that obtained in biomass pyrolysis. GC-FTIR analysis showed that the yield of formic acid and acetic acid in the tar decreased with temperature increase. Compared with cellulose pyrolysis, lignin pyrolysis contributes more gas and char production while less tar production.

Keywords:
lignin, pyrolysis, tar, formic acid, acetic acid

THE EXPERIMENTAL RESEARCH OF ALKALI TRANSFORMATION DURING RICE STRAW PYROLYSIS

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Abstract: Herbaceous fuel, such as rice straw, is usually high in alkali relative to other biomass fuel. To better understand the mechanisms behind the serious alkali problems appear in application of herbaceous biomass thermochemical utilization, the alkali transformation during rice straw pyrolysis is studied experimentally. The solid pyrolytic residues were sampled during the pyrolysis by quenching the reaction at different temperature stages. The chemical fractionation of samples and succedent alkali identification of cut fractions in both liquid and solid phases revealed plenty of information about pyrolytic alkali transformation. The initial presence and the change of every group of alkali material with different bound states with the increasing temperature were studied quantitatively. The results show that more than 90% of alkali in rice straw is water-soluble, and contribute mainly to the release of relative materials. Two stages of release were characterized during heating, which is consonant with the results from literature. The form and quantity of Alkali in residual solid was also discussed, with is extremely important to the potential slag of the ash.

Keywords:
biomass, rice straw, alkali, potassium, pyrolysis, transformation

Fluidized Bed Gasification of Biomass for Small Scale CHP unit

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This contribution deals with gasification of biomass in an atmospheric fluidized bed gasifier and possibility of utilizing of produced gas in small scale CHP unit equipped with a stroke engine or a stirling engine.
Department of Thermal and Nuclear Power Plants at the Brno University of Technology is equipped with an experimental gasification unit „BIOFLUID 100“. The unit is used for the gasification of biomass and solid wastes in an atmospheric fluidized bed. Generated gas can be used as a fuel for boilers or combined heat and power production in a small scale cogeneration plant. This solution gives an opportunity to substitute natural gas by LHV gas from gasification equipment. Direct utilizing of LHV gas in internal combustion engines is unacceptable due to high level of tars in the produced gas. This issue has to be coupe for a long life of engines and minimal maintenance guarantee. Decreasing of tars concentration is so critical task that we must struggle to reach lower concentration of tars at all levels of the process.
First reduction of tars concentration we tested by operating of gasification process in conditions with minimal production of the tars. In next step, we realized decreasing of tars level by filtration and cleaning of the produced gas. Cleaning offers very intensive decreasing of tar concentration but requires intensive cooling of the produced gas and chemical substances that are not convenient for an environment friendly technology. With this knowledge, we tested high temperature reforming of tars that can overcome any disadvantages of low temperature cleaning methods. Parallel research deals with utilizing of the LHV gas in a stirling engine with external combustion.

CORRELATED BEHAVIOR OF RELAXED SAWDUST AND RICE STRAW BRIQUETTES

Part I: The Role of Dwell Time and Moisture Content

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The ultimate availability and economics of fossil fuels utilization, and its contribution to CO_2 emission, have increased the interest in utilization of other energy resources such as biomass. Biomass is an attractive energy resource with zero net CO_2 emission when grown and utilized in a closed loop system. However, some biomass resource such as residues from forest and agriculture, may not be feasible to use in conventional industrial combustion systems. This is due to associated low bulk density which is unfavorable for direct use in conventional handling, storage and combustion systems utilizing fuel wood or coal. Densification of loose biomass waste to form briquettes is an attractive option to circumvent the situation. Its advantages among others lie in improving combustion characteristics. Results from this study, on densification and relaxation of rice straw and saw dust briquettes, demonstrates the influence that dwell time and storage relative humidity, (RH) have on relaxation behavior and relaxed density of the briquettes. The relaxation behavior of the products depended on absorbed moisture. The contribution of the volume of moisture gained is negligible compared to the total expansion of the particle. The weakening of bonds between the particles due to swelling and the change in properties of material due to increase in moisture content has a lager effect on the increase of expansion. Storage in high RH increases the time taken for the particle to reach the final relaxed state.

Part II: The Role of Pressure, Die Size and Material

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The ultimate availability and economics of fossil fuels utilization, and its contribution to CO_2 emission, have increased the interest in utilization of other energy resources such as biomass. Biomass is an attractive energy resource with zero net CO_2 emission when grown and utilized in a closed loop system. However, some biomass resource such as residues from forest and agriculture, may not be feasible to use in conventional industrial combustion systems. This is due to associated low bulk density which is unfavorable for direct use in conventional handling, storage and combustion systems utilizing fuel wood or coal. Densification of loose biomass waste to form briquettes is an attractive option to circumvent the situation. Its advantages among others lie in improving combustion characteristics. Results from this study, on densification and relaxation of rice straw and saw dust briquettes, demonstrates the influence that die pressure, die size and material have on relaxation behavior and relaxed density of the briquettes. The exponential pressure-density (relaxed) relationship: $P = Ae^{(B\rho)}$, seems to best represent the uniaxial compression process for the densification of rice straw and sawdust briquettes. The values for coefficients 'A' and 'B' depend on die size, material type, and storage RH.

Integrated Biomass Utilisation System

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Modern waste- and biomass-fired power plants have low electrical efficiency compared to power plants using fossil fuels, mainly because of the increased corrosion risk caused by alkali chlorides. Pre-treatment in the form of leaching of the organic fuels can reduce this problem. The leachate from the extraction process has a high content of organic compounds which can be used for ethanol production. The ethanol will, among other things, be suitable for utilisation in the transportation sector in a cost effective and environmentally sound way. Elsam is project coordinator in a large EU-project with the aim of demonstrating this new technology in a bench-scale plant and a pilot plant with a capacity of 1 t/h. The project also comprises a detailed design and a feasibility study of a full-scale plant with a total capacity of 450,000 t/y of biomass. The total project budget is approx. 13.6m Euro of which the European Commission funds 6.5m Euro. The project participants are: EHN (Spain), TMO Biotec (UK), Sicco, RVAU, Risø and Elsam - the last four from Denmark.

A REVOLUTION IN ANAEROBIC DIGESTION

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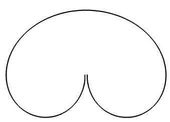
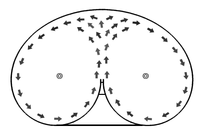
Purpose of the work:
Historically the biodegradation of organic wastes, effluents and wastewaters using the process of anaerobic digestion has taken place in a single cylindrical tank. A tank of this shape is difficult to mix efficiently as there are dead spots in the corners. Also, partially treated material is present in the final product when the full retention time is not achieved due to short circuiting.

If the ends of a sheet of material are rotated towards themselves the material takes up a shape where it is in a state of minimum energy and forms a tank without any corners:


Bubbling biogas from along the central cusp of this low energy tank shape creates two opposing circulation patterns within the tank and results in very efficient mixing of the contents. Adding liquid organic material at the centre of one circulation pattern and removing it from the opposite end of the other circulation pattern gives a continuous plug flow through the tank, resulting in the organic material being fully digested:

Using a series of such tanks for anaerobic digestion results in the complete treatment of organic materials to produce pathogen free fertilisers and the maximum yield of biogas. These low energy tanks are economical to construct and initial results far exceed anything previously achieved using cylindrical tanks.

Approach:
A worldwide study of almost every anaerobic digestion system was carried out by the author who then put together a team of twenty people to design and build a plant as described in this paper.

Scientific innovation and relevance:
Never before has a tank been designed which has the properties, or this able to produce these results. There are now patents on this technology in over 160 countries worldwide and the company intends to use this technology to alleviate energy and food poverty worldwide.

Results:
Recent tests (June 2003) on a commercial sized plant based on a series of these tanks as described shows that a highly polluting organic waste is converted to sterile but nutrient rich fertiliser with a BOD (biological oxygen demand) of 1.25 milligrammes/litre. Should this treated material stray into water courses while being uses as a fertiliser, it would cause no pollution.

Conclusions:
Dwindling natural resources, a shortage of food, water and energy, and environmental pollution are some of today's global problems which need to be solved. Using this technology provides a method of producing renewable energy and fertilisers out of the organic wastes arising from the preparation and consumption of food throughout the world, so that these resources are balanced in a sustainable eco-cycle.

The design of the low energy tanks described is such that they can be manufactured locally and mixed and heated using solar energy. As no external power is required for the actual process, all the methane gas is available as a renewable and clean energy source. The clean organic fertilisers produced give superior crops and require less water than artificial fertilisers, forming the basis of sustainable farming.

TRAFFIC FUEL POTENTIAL OF WASTE BASED BIOGAS IN INDUSTRIAL COUNTRIES – THE CASE OF FINLAND

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Biogasification is the only means to produce energy from biodegradable waste without losing its recycling value. Fertilizing value of the waste is not only retained but even upgraded in the digestate. In addition, biogas process does not compromise food use of biomass. Biogas traffic use results in very low emissions of SO_2, NOx, particles and noise. Waste based biogas has the lowest greenhouse gas emissions of all traffic biofuel chains, including all ethanol and biodiesel chains. Thus, if there is a meaningful potential for waste based biogas production, it is a good reason to give biogas a high priority in traffic, waste and climate policies.

Waste statistics in EU or other OECD countries do not yet give enough information for calculating the biogas production potential. Thus, more detailed Finnish statistics and studies were used to obtain a technical potential for one country as an example. The results show that maximum of one third of total car traffic in Finland could be powered by waste based biogas. A lot of additional potential are found by utilizing energy crops and by improving anaerobic digestion technology. Based on existing statistics some indicative potential figures are given to other industrial countries. Suggestions for waste statistics collection improvements are given, to be able to provide more detailed potential estimates in the future, as well as corresponding updates in waste and traffic policy.

Keywords: biogas, traffic fuels, greenhouse gases, biodegradable waste, methane

DECENTRALISED BIOMASS SYSTEMS FOR THERMAL AND ELECTRICAL POWER

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ABSTRACT

Purpose of work:
Biomass is still the main energy source worldwide for the major part of the global population and in many countries an important economic factor. In Asian countries alone the woodfuel sector amounts to some 29 billion US$ per annum. This amount is substantial within the regional economy e.g. when compared to overall export earnings. About 10% of the rural population, or 200 million people, find their main cash income in the woodfuel business, and local employment in the wood energy sector is at least 20 times larger than that in the oil sector (per unit of energy).
Since the 90ies biomass is also gaining growing importance as energy source and economic factor in industrialised countries: Estimations for Europe show that within the coming 20-25 years up to 20% of energy might be based on biomass.

Approach, Innovation and Relevance:
The technical processing of biomass as renewable source of energy is done by fermentation (i.e. biogas) or raffination (i.e. biodiesel) or now in the focus of interest the use of wood for decentralised district heating systems and for thermal gasification for co-generation of electrical and thermal power.
Since a number of years automised decentralised district heating systems based on local agricultural and forestry products had been installed in villages in Germany, Scandinavia, Austria and Switzerland. Biomass Heating Centers are already standardised in technology and have their own logistics. Parallel intensive research was carried out on thermal gasification to produce heat and electrical energy. While the process of thermal gasification is not new for biomass systems a technical and environmental “re-invention” was required. Problems related to the quality of the produced burnable gas which served as fuel for combustion engines were the main obstacles.
In northern part of Germany in 1990 a project on thermal wood gasification started with a low power (80 kW_{th}) experimental twin-fire gasifier. In several follow-up projects the power output over the years was increased and the process of environmental standards improved.

Some results:
Latest projects in 2003 show co-generation sets with 700 kW thermal and 550 kW elektrical power output. The remarkable success of this technology is now the high quality and tar-free gas which opens new dimensions for wood-based combustion engines.

Conclusion:
Energy from biomass is an upcoming option for decentralised energy systems in industrialised countries. This is a new dimension for local resources to partially substitute fossile fuels, for local energy demand and supply system and for micro circles of economy.

Chemical-looping combustion for clean energy production from methane and an oxygen carrier reaction

Abstract :

Increasing amounts of CO2 released to the atmosphere can promote the natural greenhouse effect, and so affect the global climate. The use of chemical-looping combustion could be an option for reducing emissions of this greenhouse effect gas in atmosphere by using fossil fuels, as energy source, by separating and disposing CO2 from flue gas. In this process, metal oxide is used to transfer oxygen to fuel for its combustion and thus, the flue gas issued from the combustion is composed exclusively of CO2 and H2O, which could be separated without any energy lost, by condensation of water. The metal obtained from the combustion is regenerated in a second reactor using air, and recycled.

In chemical-looping combustion, it is important that the metal oxide, which is used as an oxygen carrier, has a sufficient reduction and oxidation rate and should be enough strength to limit particle breakage; it is also an advantage if the metal oxide is cheap and environmentally sound. In this study, a number of different metals and their corresponding oxides were tested and their feasibility was investigated. The kinetics study of oxidation and reduction of respectively the metals, using atmospheric air and metals oxide, using methane was realised in a fixed bed reactor. The performance of each reagent was evaluated and their reactivity was compared. The parameters obtained are closely related and could be used to design a chemical-looping combustion system based on two interconnected reactors.

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Evaluation of the energetic consumption based on wood, charcoal and fossil energy in the north of Tunisia

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Abstract

The rural Tunisian families are particularly dependant on the forest biomass, in order to satisfy them energy requirements.
A few researches are conducted and the energetic investigations are also limited. This work is based on inquiry on 500 hold rural families in the north of Tunisia.

This investigation showed that the wood consumption is varied from 3 to 6 tons / family/year. The principal use is for cooking bread and heating.
In other hand, the charcoal is used for heating and for tea preparation with 100 to 490 Kg/family/year.
For food cooking, the family requires 150 to 560 Kg of gas per year.
The petroleum is generally used for heating with 45 to 260 l / family/year.
All this results are discussed depending on the uses as related to the family size and specific regions.

Calorific capacity and gas emanation resulting from combustion of ten forest tree species leafs

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Abstract

Biomass is considered as useful component for the energetic needs and also for the animal nutrition.
Leafs are used as compost substrate and also as energetic resources. They are the principal cause of fire extension.
In this paper we present results of energetic characterization of ten leafs forest tree species. The results showed that depending on the species:

- The moisture of all leafs varied between 27 to 61%
- The calorific capacity obtained was from 18572 to 22534 Kj / Kg.
- The inflammation temperature fluctuated from 128 to 420 °C
- The internal combustion temperature varied from 460 to 744 °C
- The ash percentage resulted from the combustion, has a value sited between 35 to 10 %

The maximum gas emanation during the combustion was 0.5 to 1.5 % for the CO and 11.5 to 16% for the CO_2.

Calorific capacity and gas emanation resulting of 13 fruit tree species leafs

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Abstract

Leafs and branches from fruit trees cutting are used for animal nutrition component and also as energy resources.
This paper is interested on the second one by studying the energetic characteristic of 13 leafs fruit tree species combustion and the resulting gas emanation.
The results showed that depending on the species:

- The moisture of all leafs varied between 8 and 17 %.
- The calorific capacity obtained was from 12830 to 20298/Kg.
- The inflammation temperature fluctuated from 72 to 236 °C.
- The internal combustion temperature varied from 530 to 738 °C.
- The ash percentage resulted from the combustion has a value sited between 5.6 to 14 %.

The major gas emanations measured particularly the CO (0.5 – 1.5 %) and the CO_2 (11-15.5 %) recognized as harmful for the environment ecosystems.

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Biomass-to-Liquid Fuels – Energy for the Future

The development of motor vehicles continues to be determined by increasingly stringent emissions standards including fuel consumption and CO_2 emissions. In addition, the dominance of crude oil as the primary energy source for mobility gives rise to considerable future risks. So, there is a strong need for new fuels and diversified energy sources including renewables.

Synthetic, liquid fuels play a major role in this, as they enable the use of a multitude of diverse primary energies for generating high quality fuels. In an first step GTL-fuels will come in the market, providing an high-quality, environmentally-friendly diesel fuel. In comparison with conventional diesel, GTL-Diesel revealed significant lower particle emissions and NO_x emissions in various vehicles. In a second step, biomass may also be used to manufacture fuels. Synthesis gas out of biomass, combined with Fischer-Tropsch synthesis, leads to CO_2-neutral BTL-fuels ("SunFuels") with properties similar to GTL-fuels. On a well-to-wheels basis, this dramatically reduces CO_2 emissions from vehicle operation whilst consumption remains the same.

In a third step, thanks to its high flexibility, the GTL/BTL process can be used to manufacture tailor-made fuels which optimally satisfy the high demands of modern engine generations and of novel combustion schemes such as Homogenous Combustion Engines as well.

In the long-term, it is assumed that the current hydrogen storage and infrastructure problems will be solved. Synthetic, liquid fuels meanwhile offer an ideal transition from hydrocarbon to hydrogen management. However, this is not anticipated within the next 20 years.

Techno-economic evaluation of biomass conversion routes for power generation, in particular via gasification and fermentation – results from a feasibility study in Northeast Europe

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Abstract

Focusing efforts on the most purposeful conversion routes should significantly increase the probability of achieving policy set energy supply targets using biomass. Some main aspects dealt with are: 1) assessment of the technical feasibility of various conversion technologies; 2) techno-economic evaluation of logistically and technically different manufacturing routes for biomass energy carriers; 3) assessment of favourable biomass-mixes considering regional, agricultural, technological, economic and environmental conditions; 4) analysis of potential technical, socio-economic and ecological impacts, benefits and risks at different levels; 5) identification of pre-conditions (technological, economical, socio-political, ecological) and recommendations for the successful implementation.

A geographic information system and optimisation model was applied for the process design and to identify optimal biomass-mixes for specific conversion routes and conditions. The susceptibility of the results to changing conditions was analysed within a sensitivity analysis. Results were used in a detailed techno-economic scenario analysis.

Short-term preferences are based on the present economic advantages of "omnivore" conversion routes, fed with low cost biomass inputs. Nevertheless, the results also indicate that cost-competitiveness of biomass production specifically for energy generation via fermentation and gasification is achievable at a medium-term in Northeast Europe.

Integration of Renewable Resources into Heat and Power Supply Systems

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CHP units that link heat and electricity systems will be important elements for a sustainable energy future in which renewable resources need to be integrated. The necessary conversion should, therefore, not be planned separately, but ought to follow an integrated concept that includes the proper sizing of the energy converters and of the storage devices to adapt the supply to the demand, as well as an optimal control strategy for the energy management. Since some of the renewable resources and, of course, the demand are time dependent a certain amount of controllable power is indispensable. Consequently, the energy management will try to lower the energy costs by maximizing the harvest of uncontrollable renewables, such as radiation and wind, while downsizing the technical devices.

Here, a planning tool is presented that combines economic models with a simulation of the heat and electricity systems, thereby employing mathematical models of both, the technical energy conversion (fossil and renewable) and the storage devices. In order to meet the technical requirements (as described above) at the best economics, the user can compare the outcome parameters by varying the input for sizing, controlling, etc.; this procedure, thus, allows a certain sensitivity analysis.

The range of application for the new software tool includes:

the (simulated) integration of renewables into existing energy systems; the planning of integrated heat and electricity systems, both local and regional; the optimization of the portfolio of electric power companies, energy contracting, etc.

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Crops - a big potential for biogas production

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Anaerobic digestion of especially cultivated crops – so called biogas crops is definitely both a contribution of fulfilling the demand for renewable energy and a new income alternative for farmers.
Lab-scale experiments were conducted to determine the suitability and yield capacity of various plant material from barley (*Hordeum vulgare*), rye (*Secale cereale*), triticale (*X Triticosecale*) and maize (*Zea mays*) as co-ferments by wet fermentation under mesophilic conditions. Results demonstrated remarkable differences between species and varieties with respect to biogas yield. For cereals investigated, the biogas yields vary after a 28-day period in the range of 0.491-0.987 $m^3 \cdot kg^{-1}$ organic dry matter (ODM). There is also considerable influence on biogas yield from harvest stage of the crops. Results show the milk stage as a probably optimum cutting stage for cereals. Further emphasis was placed on the use of silage as a conservation method for harvested biomass. In our study, all ensiled whole crop cereals resulted in higher biogas yields than did fresh matter, whereby methane recovery where almost constant. Also, the biogas yields of whole crop maize silages investigated vary considerably with variation in varieties and stages at which harvested. Measurements vary after a 28-day period in the range of 0.865-1.129 $m^3 \cdot kg^{-1}$ ODM (variety 1), 0.730-0.919 $m^3 \cdot kg^{-1}$ ODM (variety 2), and 0.770-0.865 $m^3 \cdot kg^{-1}$ ODM (variety 3), respectively. There are several suitable crops for biogas production which also have considerable ecological benefit. Under the conditions in Germany – guaranteed prices for electricity produced and fed to the grid – the production of biogas from biogas crops and its subsequent conversion to power and heat is a feasible pathway for farmers to secure their income.

Production of Diesel fuels from *Mesua ferrea* L. seed oil

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Mesua ferrea L. tree grows mostly in the mountains of the eastern Himalayas, eastern Bengal, eastern and western Peninsulas of India. It seeds contain an oil which is non-edible. The oil consists of glycerides of oleic (52.3 %), linoleic (22 %), palmitic (15.9 %) and stearic (9.5 %) acids. Atpresent, *M. ferrea* seeds are are not utilised for any purpose. So, we converted the *M. ferrea* seed oil to diesel fuel by two different processes.

In one process, we esterified the oil to biodiesel (methyl esters) and evaluated its properties as diesel fuel. Biodiesel thus produced have density at 15^0 C: 0.9225; kinematic viscosity at 40^0 C: 38.62 cst.; cetane number: 55; pour point: 0^0 C ; ash content: 0.001 % wt. and carbon residue: 0.45 % wt.

In the second process, we pyrolysed the *M. ferrea* seed oil in presence of 1 % wt. of solid sodium carbonate upto a temperature of 500^0 C when a black petroleum-like crude oil was produced. Distillate fraction of the crude oil boiling between 140^0 and 370^0 C (about 55 % by wt. of the crude oil) was tested as diesel fuel. This fraction showed density at 15^0 C: 0.8362; kinematic viscosity at 37.78^0 C: 1.82 cst; cetane number: 54; pour point: -3^0 C and C/H ratio: 5.58. This fraction can easily be used as the substitute of petroleum diesel fuel. Moreover, in this process, besides obtaining diesel fuel, the distillate fraction boiling between 37^0 C and 139^0 C, which is 16 % by wt. of crude oil, can be used as gasoline.

From the experimental results, it can be concluded that the methyl esters of *M. ferrea* seed oil can not be used directly as the substitute of petroleum diesel. However, it was found that upto 10 % by volume of its blend with petroleum diesel can easily be used in diesel engines.

Properties and use of Methyl ester of Jatropha Curcas Oil in Compression Ignition Engine

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ABSTRACT

The depletion of world petroleum reserves and increased environmental concerns has stimulated recent interest in alternative sources for petroleum-based fuels. In this context, Biodiesel produced by the trans-esterification of vegetable oil is considered as a potential candidate for a diesel substitute due to the similarity it has with diesel fuel. In the present investigation, methyl ester of Jatropha curcas oil, which has been considered as a potential alternative fuel, was prepared by trans-esterification method to make it suitable for use in C.I. engine and the performance of the engine was evaluated using the developed Biodiesel. The effects of reaction variables such as type of catalyst, temperature and ratio of oil to catalyst on transesterification reaction were investigated. A reduction in viscosity of 60-65% with an ester yield of 90-94% was achieved. The various properties of the esterified oils were determined and compared to diesel fuel. The performance of the engine using jatropha oil and its methyl ester was evaluated in a single cylinder C.I. engine and compared with the performance obtained with diesel fuel. Significant improvement in engine performance was observed with the biodiesel compared to original vegetable oil. Acceptable thermal efficiencies, specific fuel consumptions, exhaust gas temperature and smoke density were observed with the methyl ester of jatropha oil. It has also been established that biodiesel developed from jatropha oil can be substitute for diesel in C.I. engine without any operational difficulty.

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The Role of Biofuels in Rural Energization - An Indian Perspective

By Somnath Bhattacharjee

Abstract

The role of biofuels in meeting the future energy needs of India is gaining lot of prominence. In July 2002, The Planning Commission constituted a Committee on Development of Biofuels in order to accelerate the developmental pace in this emerging field of renewable fuels. The Committee recently submitted its report to the planning Commission, giving recommendations on various aspects of biofuel use like; commercialization, prospects, quality standards, development of large scale projects, marketing strategies, research & development etc. The emphasis so far, however, is on utilizing biofuels for vehicular applications, as a fuel extender in internal combustion engines. Keeping in mind the high demand for petroleum products in the transport sector and a steeply escalating fuel import bill to bridge the demand supply gap, the focus on environment friendly alternate transport fuel based on renewable energy sources seems quite justified. However, it is strongly felt that while encouraging the use of biofuels for the transport sector, one should not loose sight of its possible use in other potential applications. One such application area, which holds enormous promise, is in use of biofuels to energize the rural India.

India has embarked on a major rural electrification programme that aims to electrify more than 80000 villages that are still unelectrified. Out of these 80000 villages, more than18000 are classified as `remote', where the extension of the grid is considered unviable, either because of difficult terrain, or the high cost of grid extension. It may be noted that a remote village in this context is defined as the one which has less than 60 households, and which is located at or more than 7 kms from the grid. In hilly and forest areas, any village located beyond 3 kms is considered 'remote'. In view of the resource constraint, the focus is on providing lighting to this target group on a priority basis. But in the longer run, the electrification programme has to go much beyond just meeting the lighting needs of the rural community. One of the major challenges in mainstreaming renewables, and in renewable based rural electrification is to link the availability of energy with productive work. This is extremely important for long-term sustainability of such initiatives.

The Ministry of Non Conventional Energy Sources is responsible for the electrification of these remote villages through use of renewable energy based distributed generation by the year 2012. The various options being considered are wind, mini/micro hydel, solar photovoltaic, and biomass gasifier. Along with these options, the option of biofuel powered diesel-generating sets (either in 100% biofuel mode, or in blends with high speed diesel) also merits attention for electrification of such villages. The biofuel route holds the promise of not just improving the quality of life of people living in such remote villages by providing access to clean energy, but also stimulate regional development by generating rural employment as also opportunities in small and micro enterprises in the areas of cultivation of oil bearing species, and in downstream processing of oil seeds, which could be complimentary to the National agenda of promoting such fuels for vehicular application. Since biofuels can be used in compression ignition engines with little or no modifications, it is a relatively simpler form of distributed generation to be managed by the local community, and do not require additional servicing/repair infrastructure, which has been one of the major bottlenecks in mainstreaming renewables.

This paper presents an overview of the possibility of using Tree Borne Oilseeds (TBOs) to electrify rural villages. The power situation in India and the rural electrification plan of the government is reviewed, and the advantages and barriers of the use of biofuels vis-à-vis more popular renewable energy sources/technologies are analyzed with a view to weigh the applicability of TBO based fuels for village energization.

THERMAL GASIFICATION OF SAW DUST IN A FLUIDIZED BED GASIFIER

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ABSTRACT

Thermal gasification of saw dust, obtained during the sawing process of timber and trees in the forests and near-forest areas, is considered to be a very attractive proposition to meet the energy needs of rural people inhabiting these areas. This paper reports the work on thermal gasification of saw dust in a fluidized bed gasifier. Thermal gasification was carried out in a 100 mm i.d. and 1650 mm high fluidization column. Saw dust particles in the size range of -2.032 + 0.420 mm were used with silica sand of the size in the range of -500 + 350 µm. The gasifier was operated at several air (fluidizing) velocities (v_f=0.53-0.73 m s^{-1}) and equivalence ratios (ER=0.2-0.4). The best composition (in volume % dry basis) of the gas was obtained at the fluidization velocity of 0.53 m s^{-1} and ER of 0.2: H_2=4.3%, CH_4=2.7%, CO=19.9%, C_2H_m=0.7%, O_2=1.2%, N_2= 58% and CO_2= 13.2 %. The high heating value (HHV) of the gas was in the range of 3.24 to 4.14 MJ Nm^{-3}.The carbon conversion efficiency for saw dust gasification using air as the gasifying medium varied between 57.21 and 66.93% while the maximum tar content of the gas was found to be 3.6606 g Nm^{-3}. A maximum thermal efficiency of 73.2% was obtained at ER=0.25 and a v_f= 0.53 m s^{-1}.

RENEWABLE ENERGY POTENTIAL FROM THE INDIAN SUGAR SECTOR

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ABSTRACT

The paper gives an overview of the Indian sugar industry, the present status of the sector, its cogeneration potential, constraints faced and catalysts required for rapid penetration of surplus power generation from sugar cogen plants. The paper discusses relevant basic engineering issues for grid connected bagasse based cogeneration projects with case studies for implemented and under implementation projects. The operations, typical ratios and sensitivity analysis of implemented projects is demonstrated. The incremental cogeneration potential due to energy efficiency programmes in the sugar mill is presented. Comparison of this de-centralised renewable power source with centralised power generation in India is presented. Opportunities for investing in the Indian sugar cogeneration sector is summarised.

Water Pumping Using Community Biogas Plants: An Economic Analysis

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Abstract

An economic analysis of biogas based systems for water pumping has been presented. The primary objective is to identify conditions in which biogas based water pumping systems are economically beneficial (though the same may not be financially viable) so that suitable policy support could be provided. Both the costs and the benefits of a biogas based water pumping system as applicable to the society have been estimated. The fuel saving accrued to the user(s) has been valued at economic cost(s) of the respective fuel(s) to the society by using shadow prices for commercial fuels substituted by the biogas based water pumping system. The reduction in the amount of CO_2 released in the atmosphere due to the use of the biogas based water pumping system has also been taken into account in the estimation of the economic benefits. The unit cost of water has been estimated. The values of economic figures of merit such as the payback period, benefit to cost ratio, net present value and internal rate of return have also been estimated. The economics of biogas based water pumping systems is found to be more attractive in case of diesel substitution as compared to the case of substitution of grid electricity. The economic indices for the system are found to be substantially higher than their financial counterparts.

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AN OVERVIEW OF STUDIES ON FLUIDIZATION BEHAVIOR OF BIOMASS MATERIALS

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Powdery biomass residues (bulk density < 200kgm^{-3}) like agricultural, agroindustrial and forestry wastes are generally considered as unsuitable feedstock for moving bed gasifiers while a Fluidized bed gasifier can accept such fine granulometry and high ash content biomass as feedstock. For their proper thermochemical processing, *a priori* understanding of the fluidization characteristics. Several investigators have studied the fluidization of biomass alone as well as a binary mixture mixed with inert solids like sand, alumina etc. In a majority of studies biomass materials like rice husk, sawdust,coal dust,wood chips have been adopted with sand,bauxite.alumina etc. The phenomenon of fluidization, mixing and segregation were visually observed. The biomass materials, alone as a bed charge was found not fluidising. The minimum fluidization velocity for a binary mixture was determined experimentally from the plots of superficial gas velocity and bed pressure drop. Some authors developed mathematical correlations for biomass-inert solid binary mixtures, which did not compare well with the experimental results. Some workers have found that the mathematical expressions available in the literature for the binary mixtures of geometrically regular solids for the prediction of minimum fluidization velocity did not hold good for the binary mixture of biomass-inert solid.A few workers have given the definition and values of some terms like minimum velocity of complete fluidization, minimum velocity of total fluidization etc.
The present paper gives an overview of such studies highlighting the significant results.

POWER GENERATION FROM MSW IN INDIA

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The presence of combustible materials, in the urban municipal solid waste, determins the quantum of energy contents, present in the available quantity of garbage. Based on the indigenously proven pelletisation technology, at the pilot scale of 2/tons per hour for producing RDF (Refuse Drive Fuel Pellets), two commercial level plants for producing 210/Ton per Day capacity output of RDF, have been set up in Hyderabad, as well as, in Vijyawada and Guntur, Andhra Pradesh, India.

RDF pellets, so produced, have found to be coal-substitute, with better advantages over coal, in respect of ash contents, emission parameters, easy availability for coal--user industries. The pelletisation has better plant economics, besides providing employment opportunities to the scavengers

As a follow-up of the success of the commercial RDF Plants, two electric power generation plants, with 6 MW capacity, have been set up there. These power generation plants, by using MSW/RDF pellets as coal substitute are in operation for the past six months. Special boilers have been designed, traveling grate/fluidized bed type to ascertain the use of Indian MSW – which is heterogenous, unsegregated, have lots of dust and high moisture contents.

With these efforts a technological solution has been found for generating power from MSW, which is suitable for replication purposes at other cities in India and abroad.

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Potential of Bottled Biogas as Source of Power for Rural Industries Development in India

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Abstract
Employment generation and poverty alleviation are the two main issues related with rural development. These issues can be tackled by rural industrialization using local resources and appropriate technologies. However, sufficient number of industries can not be set up in rural areas so far due to scarcity of energy supply i.e. electricity, diesel etc. Biogas, a renewable fuel may be able to fill the gap in energy availability in the rural areas. Biogas can supply energy near to biogas plant which makes it hindrance in its wide spread application and therefore mobility of biogas is must, which is achieved by bottling of biogas. Here a model is conceptualized to bottle the biogas in cylinders and then use it to power the rural industries. It is found that use of bottled biogas can save diesel of the worth US $ 231per day and also generate employment for 20 persons.

A Study of Anaerobatic Digester of Iran's Environmental Pollutants to Build the First Bio-gas Power Plant in the Country

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Abstract

Bio-gas is produced from Anaerobic digestion of waste organic material in the absence of oxygen. This flammable gas contains 60% to 70% methane, and 30% to 40% carbon dioxide and would be a suitable replacement for fossile fuels. Taking Bio-gas into consideration, it would not only provide part of the energy requirements of the society. But it would also be an effective help in resolving the surmountable problem of ever increasing varieties of garbage, sewage, sludge of different food and agricultural industries, and the sludge of sewage treatment plants.

In this article, for establishing the first Bio-gas power plant in Iran in the city of Saveh, the anaerobic process of a mixed feed consisting of four main groups of urban environmental pollutants, namely municipal solid waste, sludge of sewage treatment plant of Saveh industrial zone, slaughter house waste water, and sludge of leaching pit relative to their actual volume of each pollutant is being studied. Thus a variety of statistics in different seasons of the year in the different parts of city were studied in order to determine the quality and quantity of the pollutants and taking these parameters into consideration, a mixed feed was prepared. The anaerobic process of this mixed feed was continuously studied by determining the exact PH, T, TS, VS, COD, BOD and VFA parameters and the alkalinity in the semi-industrial 10000 liters reactors. The result show that by utilization of anaerobic digestion process, a daily reduction of 55.87% of TS and 66.7% of COD could be observed.

This indicates the possibility of a daily production of 1,927 cubic meters of Bio-gas in the first anaerobic plant in Iran.

In addition to the results of practical study of separating function and related statistical analysis, the detailed results of the cloning anaerobic feed for the urban pollutants, by taking their actual (quality and quantity) weight into consideration will be discussed.

The above results could prove very effective in making decision concerning Bio-gas power plant in Iran.

Keywords: Bio-gas anaerobic digestion, municipal solid waste (MSW), sludge of sewage treatment plants, slaughter house waste water, sludge of leaching pit, Bio-gas power plant.

A waste to energy power plant for Kingston, Jamaica.

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The management and disposal of municipal solid waste (MSW) is a growing problem. It has been reported that between 1975 and 1990, production of MSW in industrialized countries increased by more that 40%. The production of increasing amounts of MSW will have serious implications for human health, for the visual environment, and for pollution of both land and water. However, management of MSW can be very expensive; estimates for developing countries suggest that the cost of collection and disposal may be as high as 0.5-2.0% of national GDP. At the local level, 20 –50% of municipal budgets may be devoted to MSW management. Governments over the years have continually tried/seek to reduce the financial burden.

The waste to energy gives at least one opportunity to realize some financial returns from waste. Jamaica being a small country and its city Kingston, already in need of land space for infrastructure development cant afford to continue with the policy of landfill. This paper will look at the opportunities available for utilizing our waste for producing and supplying energy to the grid from waste. With the policy of cogeneration now a reality, and the planned development of the Bay as a large transhipment port, the available waste will increase significantly and should provide fuel for the proposed power plant.

The proposed plant would be environmentally friendly, as a scrubber will be used on the exhaust stack to reduce the emission gasses. The plant will also produce fertilizer using the waste from the fuel. The economic and social benefits of this project for Jamaica are worth investigating. Considering that Jamaica is an oil-importing nation with very limited land space to encourage landfills for waste disposal.

An environmentally friendly power plant

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The generation of electricity using fossil fuel power plants was intended to improve the living conditions of people. Electricity is necessary for communication, transportation, medicine, and industry just to name a few. Fossil fuel, Coal, Oil, etc. has served us well in the generation process, however, studies over time has shown that these plants emits CO_2, and other harmful gasses. The build up of CO_2 in the atmosphere has lead to the green house effect and the concept of global warming, which is now of great concern to the world at large. Much of the energy in the short-wavelength visible light from the sun, that is absorbed by the earth's surface is in turn radiated by the earth as long-wavelength infrared light that is absorbed by CO_2 and H_2O in the atmosphere.

If we are to reduce the amount of CO_2 in the atmosphere, there are at least two options.

1. Reduce the amount emitted from the various sources, chief of which is the fossil fuel power plants.
2. Develop technology so as to reduce the amount of CO_2 emitted to the atmosphere by power plants and other sources.

Although energy conservation has been put forward as a short-term solution, to the emission problem, that is all it can offer. If societies are to develop and as we understand it, development is extricable linked to countries fuel consumption, then invariably there will be an increase in CO_2 production, and ultimately an increase in the green house effect.

This paper will speak to producing electrical energy from hydrogen in a modified thermal power plant. The exhaust from this plant will have no CO_2, and in fact will produce water as a by-product. Hydrogen is the most abundant element in the world, however it is not available as a free element.

There are lots of technologies available to extract hydrogen from its various compounds, however this paper will look at using the sun's energy to split water molecules into hydrogen and oxygen. A relatively new technology uses solar concentrators to heat water up to very high temperatures. These solar concentrators are able to increase the power of the sun as much as 5,000 times as reported by some research.

For Jamaica to survive the next 20- 30 years we must find alternative to oil base electricity generation, which is now 91%. The possibility of producing hydrogen using solar technology, gives us the hope to produce our own fuel which can be used in conventional thermal power plants.

Strategy for sustainable energy system with biomass resources

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Since biomass resources are carbon neutral, it is proposed that they will be one of the alternatives for conventional fossil fuels to mitigate global warming. Biomass resources are scattered widely, and linked with the industry of the area. Therefore, for establishing sustainable society, the wide use of biomass sources is indispensable. This study aims at the evaluation of an integrated renewable energy system which provides demanded energy to local community, with combination of several renewable energy sources including biomass technologies and resources.

In this study, the system provides electricity generated from wind power, photovoltaics (PV), direct-fired biomass power plants, biomass gasifier-based power plants, and biogas generation. The study analyzes the system characterization from both single-year perspective and long-term perspective, on the assumption that the energy system is introduced to local town. Single-year analysis examines the operation of system with consideration for the fluctuation of hourly electricity demand and the availability such as wind power and PV output. Long-term analysis studies the penetration of each technology over years. We find that about half the electricity supplied to the community comes from wind power, and biomass power plants serve as a base load. The result also shows that the penetration of biomass energy will hardly change in the future. This is because the amount of biomass resources in the area is not enough to supply more energy. In order to increase the energy supply derived from biomass, it is necessary to improve the energy conversion efficiency of biomass power plants and reestablish biomass-based communities in Japan.

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Economics and policy options for introducing woody biomass energy in Japan

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Woody biomass is gaining the interest as a renewable energy in Japan. However, its potential is uncertain. The purpose of this research is to evaluate the potential of woody biomass in Japan considering economic competency and policy options. CHP with woody biomass requires relatively large amount of resource. Therefore, it is only feasible under certain conditions. The conversion technologies that are analyzed in this research are pellet stove and chip boiler. Since they have small capacities, large amount of local resource is not required. The target of the analysis is the space heating demands in residential and commercial sectors in Japan. An energy-economic model is designed for the analysis. The consideration of carbon tax and subsidy is included in the model. The impacts of these policy options on dissemination of woody biomass and CO_2 emission are evaluated.

The result of the analysis shows that woody biomass can have the strong competence provided carbon tax of 30,000Yen/tC. Carbon tax could also lead to the significant reduction in CO_2 emission, which is driven by two factors. One is that the total heat consumption decreases due to the increase of heat price. The other is that heat source shifts from fossil fuels such as kerosene and city gas to woody biomass.

As a consequence, carbon tax of 30,000Yen/tC would be preferred for the purpose of dissemination of woody biomass and CO_2 reduction.

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Catalytic Fluidised Bed Steam Gasification of Biomass using Common Building Waste Clay Materials

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ABSTRACT

Fundamental biomass gasification experiments were carried out to develop an appropriate gasification process by utilizing common building waste materials such as bricks and roof tiles. Catalyst deterioration by alkali accumulation is avoided by returning the bed material to the soil together with biomass ash after several times regeneration A laboratory scale fluidized bed reactor of 43mm i.d. and 80mm in static bed height was used for catalytic steam gasification of wood chips in an 85% steam/ N_2 balance atmosphere. Gasification results were compared against previous data on commercially available activated clay, silica sand and raw bentonite. Tar and water-soluble species decreased by applying clay-derived waste building catalysts. In the case of commercial activated clay an increase of hydrogen yield and a significant reduction of tar were observed in comparison to silica sand and raw bentonite. The waste clay-derived catalyst products show a potential for economic use in the gasification of biomass.

Introduction of Biomass Energy into a Society through Pulverized Wood Charcoal Chain

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ABSTRACT

Compared with other form of biomass energy, charcoal has some unique features including: 1) high heating value, 2) stability in transportation and storage, 3) easy crushing property, 4) much less potential of POPs and DXNs emissions. Before the 60s Japanese house heating and hot bath water supply were much dependent on charcoal and firewood and the major manmade forests were sort of energy station producing firewood and charcoal. To establish a social infrastructure for charcoal utilization that fits to the modern lifestyle we have been developing a modern charcoal combustor, a powdered charcoal heater and a business model for charcoal market creation. The charcoal heater is a co-annular fluidized bed of portable size and the gas turbine combustor is a fixed bed type. The test results from both facilities are presented. The social network model is discussed based on the inquiry to the public and on the discussion among business consultants, charcoal manufacturers and municipalities.

Wood Gasification by a Three Column Circulating Fluidized Bed System

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To establish an efficient biomass gasification process a new concept of a circulating fluidized bed system with three reactors i.e., a low temperature steam gasifier for wood chips and a partial combustion steam gasifier (for carbon deposited on bed material and char) and a regenerator has been proposed. In this process, economic porous catalysts having a capacity to capture tar-like components are applied for bed material.

To obtain fundamental data for conceptual design tar absorption capacity and a catalytic effect of bed material was experimentally determined by using a laboratory scale batch reactor (i.d.=43mm,static bed height≈80mm). Reaction rates of wood chips, accumulated tar in bed material and char were quantified by using a laboratory scale fluidized bed system.

Preliminary data from the bench scale three column CFB (raiser i.d.=20mm, height=1.5m) are also presented.

Design and economic analysis of optimal waste management system

Michiro Urabe, Takemi Sato, Toshihiko Nakata*

Abstract

Many countries have experienced environmental impacts, such as land use, air and water pollution, resulting from improper management of municipal solid waste (MSW). Since the generated MSW represents a loss of both raw materials and energy resources, it is necessary to improve MSW management system. The purpose of this study is to propose the integrated MSW management system. The system has achieved the intended aim of both reducing the amount of landfill and increasing waste recycling and recovery rate.

The MSW management model, which consists of both alternative and conventional facilities for MSW disposal, has been designed. In order to achieve the economic operation of the MSW management system, the total costs of MSW management such as collection, intermediate treatment, and final disposal, are minimized. As a result of the analysis, the optimal system configuration of the integrated MSW management system has been derived. The system is effective to dispose of MSW in an environmentally safe manner with an economical operation. Moreover, by-products in the process of waste disposal, such as electricity and heat, could be supplied to local area as alternative fossil fuels. In conclusion, the installation of the alternative facilities into MSW management system with optimal system configuration has contributed greatly to (1) reduce amount of landfill, (2) increase recycling rate, and (3) the efficient use of waste energy.

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Coconut Oil as an Alternative Fuel for Diesel Engines

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Coconut is grown in large quantities in the coastal areas of Papua New Guinea including other Pacific Islands. Over the last 50 years, the prices of coconut oil had decreased steadily due to competition from other vegetable oils. The value of locally produced coconut oil may be enhanced if alternative uses are discovered. One of the most suitable uses of coconut oil is as an alternative fuel for diesel engines. Though coconut oil has much higher viscosity, it has higher cetane value than petroleum diesel, which makes it a suitable fuel for diesel engines. This paper reports the results of an investigation into the possibility of using coconut oil as a substitute fuel for petroleum diesel. Coconut oil somewhat performed much better than petroleum diesel in a single cylinder diesel engine. Moreover, the effects of reducing viscosity and injection timing on the engine performance when using coconut oil were determined using the Taguchi method.

Keywords: *Coconut oil, alternative fuels, Taguchi method*

Biomass Potential in Offsetting Energy Needs in Lebanon

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Abstract:

Lebanon has been suffering from a chronic deficiency in electricity supply. In addition, due to its high population density and relatively small area, Lebanon also suffers from the lack of appropriate solid waste disposal methods. This work aims at quantifying the potential of biomass in general, and municipal solid waste in specific, in the partial fulfillment of Lebanon's electricity needs. The results obtained indicate potential generation of up to 52% of Lebanon's electricity needs from the combustion of MSW. A practical 29% coverage can be obtained by the proper manipulation of the waste from Lebanon's two largest cities. A biogas generation approach for farm and municipal waste treatment could generate up to 3.2% of Lebanon's electric needs. Biodiesel generation from waste cooking oil and fat can offset 0.8% of Lebanon's fuel imports. This paper indicates that despite the lack of widespread forests, other biomass sources can still be tapped. A similar approach may be considered in most neighboring countries. With these numbers at hand, the use of available biomass resources is perceived as a necessity. Significant financial, social and environmental benefits are gained by this approach.

Development of NO_x Emissions Model of Palm Oil Methyl Ester (POME) Fueled Turbocharged-Diesel Engine Using Response Surface Methodology

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Abstract

NO_x emissions from diesel engines are influenced by several engine parameters such as speed, engine load and engine operation time. This paper deals with such factors above in order to predict the emissions from diesel engine fueled by Palm Oil Methyl Ester (POME). In order to do so, 20% POME blended fuels, 100% POME and 100% conventional diesel fuel were used as fuel on 4cylinder turbocharged-diesel engine to investigate the combined effect of engine speed, engine load and operation time on NO_x emissions. Response Surface Methodology (RSM) was used to develop a mathematical predicting model with correlation of NO_x emission as a function of engine speed, load, and time operation. The Analysis of Variance (ANOVA) was used for checking of the adequacy of the model. Finally, engine load and speed are shows the significant effects on NO_x formation of diesel engine while running with POME.

RHEOLOGICAL STUDY OF FOOD GRADE VEGETABLE OILS AS POTENTIAL ENERGY TRANSPORT MEDIA

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ABSTRACT

Todays consumption of mineral-based oil has brought to concern over the availability of high quality mineral-based crude oils in the future. Therefore, many researchers are now searching for substitute including the replacement of the mineral oil with vegetable oil. This is also due to the concern of protecting the environment from pollution, which has encouraged the research and the use of environmentally friendly product. Vegetable oils are potential energy transport media in hydraulic and lubricating systems. To be successfully in applying this, an understanding of the vegetable oil properties is necessary in order to overcome the possible failures or obstacles that might occur in real operating conditions. The use of vegetable oil as hydraulic fluid would help to minimize hazardous pollution caused by accidental spillage, lower disposal costs of the used fluid, and helps the user industry to comply abide with environmental safety regulations. Rheological property is one of the most important parameters and for this reason this parameter is being investigated. The present work evaluates the temperature and shear rate effects of food grade vegetable oils that include superolein, coconut, canola, corn and sunflower oils. A rotational viscometer was used to determine the flow behavior of the oils at different temperatures and discrete shear rates that are ranged 40 – 100 ^{o}C and 3 – 100 rpm, respectively. Various empirical models such as Cross, Carreau, Herschel-Bulkley and Arrhenius-type-relationship are used to evaluate the experimental data. A modified form of Power Law model is also proposed specially to monitor Newtonian and non-Newtonian behavior of the oil. The influence of shear rate and temperature on the variation of viscosity is clearly observed but temperature has more significant influence. Interpretations of rheological models indicate that these food grade vegetable oils belong to pseudo-plastic category. The estimation of zero-shear rate viscosity value by Cross and Carreau models is found unreliable and therefore an alternative method is proposed. The superolein and sunflower oils are highly stable, in terms of shear rate and temperature, respectively. The overall results suggest the potential substitution of food grade vegetable oils as an energy transport media.

MALAYSIAN MUNICIPAL SOLID WASTE MANAGEMENT WITH ENERGY RECOVERY

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ABSTRACT

The average amount of municipal solid waste (MSW) generated in Malaysia is around 0.5 to 0.8 kg/person/day but in the cities the figures have escalated to 1.7 kg/person/day. This paper highlights the MSW characteristics for the city of Kuala Lumpur. Currently, the waste management approach being employed is by landfill, but due to rapid development and a lack of space for new landfills, the big cities in Malaysia are switching to incineration. Beside this, a simple evaluation was carried out to establish the best returns in terms of energy recovered based on the MSW input using various technologies. From the characterization exercise the results showed that food, paper and plastic made up almost 80% of the waste by weight. The average moisture content was 55%, making incineration with energy recovery a formidable effort. The energy recovery exercise showed that based on an average calorific value of 1500 kCal/kg, an incineration plant would be able to recover 436 kW / ton MSW input. As for other treatment technologies such as conversion of MSW to refuse derived fuel, composting in an anaerobic digester and other waste to energy options, the results were very encouraging but did not yield energy as high as direct incineration. However, based on the net energy recovered per ton MSW input the usage of anaerobic digestion combined with fuel cell for methane conversion to electricity, although not equal in terms of energy returned but is environmentally friendly and accommodative for the type of waste currently being generated in Malaysia.

*(**Keyword**:- Municipal Solid Waste, Renewable Energy, Refuse Derived Fuel, Anaerobic Digestion, Fuel Cell)*

Reason for the success of biogas program in Nepal

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The acceleration of biogas dissemination in Nepal will face a number of challenges in the future. These include the need to further stimulate market demand for biogas plants, strengthen Nepalese biogas institutions, bolster the private sector biogas firms, maintain high plant quality standards and reduce the relative input of the financial subsidy given to farmers. Without the great support, it is certain that the standards, quality and dissemination rates for biogas plants in Nepal would not have risen. Now Nepal's biogas program is success by the following reason;
*Well-proven / reliable biogas plant design
*Quality control mechanism (Monitoring & Evaluation)
*Good organizational networking between stakeholders
*Technical capacities have been properly examined.
*There has been a significant improvement in community environment due to the attachment and use of toilet
*Reduced the rate of deforestation and environmental deterioration by providing biogas as a substitute for fuel wood to meet the energy demand of the rural population.
*Increased the agricultural production by optimal use of digested dung as organic fertilizer.
*Improved the health and sanitation of the rural people
*Supported in reducing the workload especially for women.
*Continuous and proper channeling of subsidy.
*Generation of employment in rural areas.
*R&D activities carried out in this technology.
Renewable energy protects the environment and contributes to the mitigation of climate change. It is sustainable in the long run, as it can be continued indefinitely into the future. Poor countries usually face a chronic shortage of energy. Thus these countries should encourage the adoption of renewable energy to meet their growing energy needs.
Biomass is clean energy, so, developing countries can take benefit from this energy by help of Kyoto protocol. They can do Carbon trading and make sustainability of their technology. Presently it is necessary to built strong biogas network between experts, country region and to the world.

Waste Wood to Heat: beyond technology to quality of life in Christchurch, New Zealand

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Christchurch has a forty year history of choking wintertime smog from wood and coal burning for domestic heating. A new methodology for strategic analysis of complex energy and environment systems (SACEES) was employed to provide a long term renewable energy solution to a very old and very complex problem. Historical review and characterization of the problem was the first step, including economic, psychological, and cultural factors, as well as technical and environmental factors. A performance-objective design of an optimal form of the energy architecture was generated for the year 2008. In order to achieve health standards and fully renewable energy supply, waste wood pellet fire appliances would need to be installed in one half of residences to replace existing solid fuel burners and to heat homes which are presently not heated. An integrated policy, resource, and business strategy for maximizing quality of life over the shortest timeframe was developed, including banning of visible emissions, security of the pellet industry, and subscription-type purchasing arrangements for heating.

The SACEEP methodology provided a new and viable solution to a very old and untenable problem. The fundamental premise of the approach is to research the social and economic history of the problem, pick a target date for resolution of the problem, define the optimal performance characteristics, and then design an *energy architecture* within the social, economic, cultural, and environmental context. This study illustrates how, once a relevant solution is designed and described to all parties, the means to achieving the solution becomes apparent and achievable.

SOYABEAN OIL AS A FUEL FOR COMPRESSION IGNITION ENGINE

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Abstract

The state of environment has driven researchers into a quest for greener alternative energy sources. Combustion of fossil fuels has been identified as a major contributor in raising the carbon dioxide (CO_2) content of the atmosphere, a consequence of global warming. This has resulted in world summit aimed at addressing the issues leading to the improvement of the state of environment. Internal combustion engines are the major source of urban pollution and efforts are being made to address the issue by identifying potential alternative greener energy substitute for the present high pollutant fossil fuels. Bio-derived fuels such as alcohol and vegetable oils, appear more attractive due to their environmental friendly nature. In recent years, there have been reports on flood water and land slides disasters resulting from increase in ambient temperature. This is again the effect of greenhouse gases. The present study investigates the performance of diesel engine running on neat soyabean oil. The test results showed reduced power output and high fuel consumption when running on soya oil compared to baseline diesel fuel. There was a significant improvement in brake thermal efficiency recorded with soya oil operation. The brake specific fuel consumption was comparable to the test results obtained with diesel fuel.

Keywords: Brake specific fuel consumption, brake thermal efficiency, mechanical efficiency, exhaust temperatures, ignition delay, volumetric efficiency and fuel consumption.

Energy Analysis of Technological Systems of Combined Heat and Power Plants Integrated with Biomass Gasification

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In the paper there will be presented the complex energy analysis of technological systems of gas combined heat and power (CHP) plants integrated with biomass gasification. The basis of energy analysis performed is the elaborated mathematical model of main elements of the technological systems of these CHP plants, such as: gas generator, gas cooler, block of gas turbine (compressor, combustion chamber, and gas turbine), and heat exchanger. The mathematical model of biomass gasification includes the system of equations, which describe chemical, physical and energy phenomena occurring in gas generator. This model was elaborated to allow one to perform multivariant simulation investigations of energy aspects of this process with changeable parameters such as: temperature, pressure of the process, kind, temperature and excess number (ratio) of gasifying medium. The solution of mathematical models of gasification process allows one to determine the composition of produced gas. The equations of model of gas turbine block describe the energy processes in compressor, combustion chamber and gas turbine. In equations which describe energy processes in gas generator and gas turbine block the physical enthalpies of produced gas, gasifying medium and oxidizer (air) are determined with the help of statistical physics. In the paper will be presented the results of the computer simulation of gasification of various kinds of biomass with the help of various kinds of gasifying medium and the results of simulation of energy efficiency (energy utilization factor), efficiency of electric energy generation and cogeneration factor for various technological systems of gas CHP plants integrated with biomass gasification.

From Coal to Biomass – Development of the Dispersed Power Industry in Poland

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Purpose of the work: Poland has significant power resources, chiefly hard and brown coal (59 000 Mt) but simultaneously is an agricultural country (19 million hectares of arable land), with almost 30% of her territory (9 million hectares) being covered with forests. This constitutes huge potential resources of bioenergy. For many decades, however, the basic source of the energy generated in Poland has been hard and brown coal (62% of TPES – Total Primary Energy Supply). During the recent several years, the implementation of a consistent and well-considered EcoFund's strategy resulted in rapid development of the generation of energy from biomass. A key issue for the making of investments in renewable energy sources (RES) is the setting up of an economic system in the conditions of a competitive market through the making use of financial instruments related to the Kyoto Protocol. For the 11 years of operation, EcoFund provided financial support for almost 100 projects undertaken in the dispersed power industry sector and dedicated to the use of renewable energy sources.

Approach: At the beginning, problems were encountered as regards the unit project costs per 1 MW of the power capacity involved, which were more than twice as high as those of traditional boiler plants fired with gas or coal; the unavailability in Poland of manufacturers of the appropriate equipment and contractors capable to successfully carry out projects of this kind; and the absence of any biomass distribution system. As the first step, large-scale information campaigns were run among gminas (local administrative units) and companies that generated energy for local purposes. Numerous conferences and educational events were aimed at changing the project profitability calculation method, where not only the investment outlay but also the system operation costs and external costs should be taken into account. With such a project profitability calculation approach, the use of biomass for energy generation purposes proves to be cheaper by 50% than the generation of energy from traditional fossil fuels, because the costs of the obtaining of renewable fuels are incomparably lower than those of natural gas and coal. Moreover, the utilization of ample local resources of straw (which otherwise would be uselessly burnt away in fields) or wood wastes generated in forests or in the wood-processing industry entails the creation of new jobs in the gminas involved. EcoFund has found this, apart from energy savings, to be one of the most effective greenhouse gas abatement methods and, at the initial stage of the introduction of biomass into the energy market, has applied a system to provide financial support for projects dedicated to the use of bioenergy.

Scientific innovation and relevance: During the first years, the development of the utilization of bioenergy was based on the import of know-how and equipment. The dynamic growth in investment projects dedicated to the use of biomass in the energy generation sector resulted in the development of domestic research work and production. At present, there are numerous innovatory engineering solutions of this kind in the Polish market.

Results: In the years 1999 ÷ 2003, about 1 000 heat-only generating plants as well as a few heat and power generating plants fired with biomass were built in Poland. The largest municipal heat generating plant is a facility of 24 MW_t thermal power rating. Now, projects to build heat and power generating plants of 50 MW_t and 12 MW_e thermal and electric power capacity, respectively, as well as a fluidized-bed boiler of 460 MW_t power rating where biomass may constitute up to 10% of the fuel used, are being prepared. "The share of renewable energy in the primary energy output is rapidly increasing in Poland, to 4.7% at present, chiefly thanks to the use of biomass" (*Environmental Performance Reviews OECD – Poland 2003*). Now, bioenergy successfully competes in the energy market, because the unit energy generation cost in Poland is 5 ÷ 6 EUR/GJ for biomass and 10 ÷ 15 EUR/GJ for fossil fuels.

Conclusions: In the conditions of economic transformations and free energy market, the stable introduction of bioenergy requires that large-scale information campaign addressed in particular to local communities should be launched as well as the economic and technical education of the managers who administer gminas and energy generating companies should be developed in the initial period. As the next step, financial instruments to support demonstration projects should be established and then the projects should be promoted, with the environmental and economic effects being presented in practice.

Biomass for Energy in a Country in Economic Transition, Polish Experience: Barriers vs. Support

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Abstract:

The *National Development Strategy of Renewable Energy Sources* adopted by Polish Parliament in 2001 sets ambitious goals to increase the RES share from the present ca. 2.5% to 7.5% in 2010 and 14% in 2020. In achieving these targets biomass will play a dominant role: according to estimates it will constitute up to ca 85% in the RES mix. It is of primary importance to identify and overcome the existing barriers and enhance the mechanisms supporting the development of the bio-energy sector. The paper addresses both issues based on concrete examples. Given the structure of Polish agriculture, there exists a huge potential of biomass for energy production. The dynamic development of dedicated energy plantations (mainly *salix viminalis*) observed recently is, however, far from optimal. A system that would encompass different aspects of biomass for energy production: (agricultural, technological, financial, social) is needed. In this connection a pioneering initiative of four Krakow universities to coordinate research to optimize the use of the locally available biomass resources is presented. The goal is providing support to decision-making at the local or regional level. On the demand side, an uneven competition is emerging in Poland between power plants increasingly co-firing biomass with coal to lower their environmental fees, with the local users who need it for space heating. To achieve maximum environmental benefits, legal and financial instruments are needed. In this connection, an innovative project, aimed at overcoming the cost barrier by low budget, large scale, installation of biomass boilers in individual houses in rural communes is described.

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Small Scale Ethanol Production for Farms and Villages

By
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President
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In 1984 the TVA Biomass Program at Muscle Shoals, AL. published their research results on the construction and operation of Farm Scale Ethanol production plants. I used these research results to build a 396,000 gallon per year Farms Scale ethanol production plant which we demonstrated at an official exhibition site at the 2002 World Summit on Sustainable Development in Johannesburg, South Africa. The ethanol demonstration plant was sponsored by USAID and the South African government.

We proved that small scale Village or farm production is a cost effective way for manufacturing fuel ethanol not only for Third World sustainable development but also is more cost effective for American farmers than building large ethanol plants. With recent energy incentive programs in America we present the case for why the American farmer should be producing ethanol on his farm and how development agencies can use this technology to create sustainable development for rural farm communities in the developing nations.

Anaerobic biodigestion treatment for the disposal of vegetable market garbage

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Abstract

The 'Semi-Dry Batch Anaerobic Biodigestion System', developed by the NERDC of Sri Lanka, has been successfully applied at domestic and semi-industrial levels for the production of biogas and biofertilizer for the last few years. Mostly paddy straw, and vegetable market garbage and land and aquatic weeds have been the feedstocks.

Based on the results achieved from these biodigesters, a US$ 330, 000 industrial project was recently launched by the NERDC for Vegetable Market Garbage Treatment. The project is financed by the Ministry of Economic Reform, Science and Technology. At the site in Muthurajawela, about 12 miles North of the capital Colombo, already constructed are 16 anaerobic digesters each of 50 tonne biomass capacity, their individual floating gas-holders, two mobile gantry cranes, a grabber, bakery units, biofertilizer processing and packing units, a power generator, an incinerator for undigestibles, and buildings for administration, sales etc.

On commissioning, the plant is to receive domestic and vegetable market garbage and agrowastes from a few small towns in north Colombo and the suburbs. The biogas will be used to fuel small the bakeries and confectioneries, to incinerate undigestibles, and to generate electricity in dual-fuel mode. It is in plan to operate this system of digesters and the other units by the NERDC for a period of one year, and then to transfer the plant to a selected party to run the system profitably, and in a trouble-free and an environmentally friendly manner.

Optimization of the Yeast and Nutrients Dosage in the Fermentation step in fuel Ethanol production from Spruce

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Research on the production of liquid fuels such as fuel ethanol from renewable resources is a prioritized subject in many countries worldwide. Fuel ethanol can be produced from various lignocellulosic and/or starch containing materials such as wheat, corn or spruce. The material used in this study is spruce, which is available in large quantity and to a low price in Sweden.

The main object of this ongoing study has been to reduce the production cost of fuel ethanol and to optimize the fermentation step in the Simultaneous Saccharification and Fermentation (SSF) of steam-pretreated spruce. Some of the most important factors to reduce the cost are: efficient utilisation of the raw material and optimization of yeast and enzyme dosage. Other important factors are selection and dosage of nutrients and pH-adjusting substances. The production rate and yield of ethanol are highly dependent of the factors mentioned above.

Yeast and nutrients dosage has been studied and results from this ongoing study will be presented. The work has been performed at the Process Development Unit (PDU) situated in Lund, Sweden

Performance Improvement of a Power Generation System by The Recovered Waste-Heat

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Abstract

With a high back-work ratio and a high exhausting temperature, the simple cycle gas turbine generation system is usually inherited a low generation efficiency especially when the ambient weather is hot. Among many technologies to improve the efficiency of simple cycle gas turbine, inlet-air cooling(IAC) and steam reinjection(STIG) are considered the best ways to modify an existing simple cycle unit without the major destruction to its original integrity. In this study, an existing power generation unit GE MS7001B was considered to implement both the IAC and STIG features. The energy used to activate the IAC and the STIG functions are recovered from the system's exhaust heat.

To evaluate the individual effect after system modifications, a computer code for the simulation of the power generation system was developed and validated in this study, and ABSIM code developed by Oak Ridge Lab. was adopted to simulate the absorption refrigeration system. Based on the calculated improvement, results indicate that the system with steam reinjection feature has the highest generation efficiency and thus the most potential profit on investment, while the system with both inlet-air cooling and steam reinjection features can generate the highest power output and release the least exergy via the flue gases.

PROTEIN ENRICHMENT AND CELLULASE PRODUCTION OF PANGOLAGRASS WITH SOLID STATE FERMENTATION

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ABSTRACT

The yield of pangolagrass, *Digitaria decumbens* Stent, is between 44.79 and 80.21 ton ha^{-1}, and the cultivation area ranged from 4,817 to 6,166 ha during 1990 to 2001 in Taiwan. The annual production was 2.41–3.86×10^5 ton. It contained 1.67% crude fat, 6.17% crude protein, 7.89% lignin, 14.73% soluble carbohydrate, 29.79% hemicellulose, 31.86% cellulose and 7.47% ash in dry weight base. To improve the quality of pangolagrass for animal feeding, cellulolytic microbes were isolated from various sources and cultivated with solid state fermentation. The optimal conditions for protein enrichment and cellulase production were initial moisture 65-70%, initial pH 6.0-8.0, supplementation with ammonium sulfate and minerals, and cultivated at 35^{o}C. The protein content in non-sterilized substrate enriched from 6.48% to 8.46, 8.52, 9.68, 9.52, 11.99 and 12.25% with the inoculation of *Mucor hiemalis* 2216, *Aspergillus niger,* isolate SC99, *Streptomyces thermonitrificans* NTU-88, isolate SC2, and *Myceliophthora lutea* CL3 for 29 days incubation, respectively; while the protein contents in sterilized substrate were 8.26, 9.82, 9.68, 11.20, 16.85 and 18.89%, respectively. The *in vitro* digestion improved from 4.11-4.38% to 7.53-17.82%. Each gram of dry substrate yielded 1.02-3.76 U Avicelase, 1.50-4.98 U CMCase and 1.50-5.18 U β-glucosidase. *M. lutea* CL3 was the best strain in the improvement of the quality of pangolagrass for animal feeding with solid state fermentation.

MICROBIAL CONVERSION OF FOOD WASTES FOR BIOFERTILIZER PRODUCTION

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ABSTRACT

To investigate the feasibility of microbial conversion of food wastes for biofertilizer preparation, food wastes were mixed with bulk materials to adjust moisture content and C/N ratio, and converted in mechanical bioreactor with the inoculation of thermophilic and lipolytic microbes. Microbial inoculation enhanced the degradation of cellulose and fat, increased the total nitrogen and germination rate of alfalfa, reduced crude fat and total organic carbon, shorten the period of maturity, and improved the quality of biofertilizer. The food wastes composting without inoculation for 28 days, the products had pH 6.98, total organic carbon 36.21%, total nitrogen 2.01%, crude fat 4.88%, ash 24.94%, C/N ratio 18.02 and germination rate of alfalfa 98%; while the food wastes with inoculation of thermophilic and lipolytic *Brevibacillus borstelensis* SH168, the products had pH 6.83, total organic carbon 37.09%, total nitrogen 2.10%, crude fat 1.34%, ash 29.21%, C/N ratio 17.65 and germination rate of alfalfa 97.50%. In addition, each gram of final product had higher population of thermophilic microbes than mesophilic microbes with the inoculation of *B. borstelensis* SH168. From the mention results, it showed that microbial conversion of food wastes to biofertilizer is a feasible and potential technology to maintain the nature resources and to reduce the impact of food wastes on environmental quality.

ENVIRONMENTAL AND HEALTH IMPACTS ASSESSMENT OF LIQUID-BIOFUEL PROJECT IN TANZANIA

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Abstract
Because of stronger dependency on biomass for energy in Tanzania, there is a need for improved technologies for biomass-to-energy conversion. This paper analyzes the environmental and health impacts of a project aimed at conversion of wood and wood waste to liquid-biofuel using fluidized bed pyrolysis, as a first step for project implementation. The assessment covers all steps from feedstock collection, preparation and feeding, the pyrolysis facility itself, storage, transportation and the end-use of the biofuel. This project is very important for the economic growth of Tanzania as it will reduce national dependency on petroleum fuels and will change the standards of lining in the rural areas of Tanzania.

Life cycle assessment (LCA) was also conducted for the biofuel including process synthesis, LCA parameters, and product parameters. Assessed using LCA were geographic, temporal, technical and environmental scenarios. The analysis shows that this fuel has little negative impacts to human health and the environment during its life cycle. The impacts of the project on air quality, land use sustainability and on forestry and agriculture were also analyzed from which control strategies were recommended to offset negative impacts. The study shows also that the biofuel have excellent performance in different combustion facilities, with emission levels well below the legal limits compared to petroleum fuels.

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Physical And Structural Changes of Large Biomass Particles During Combustion

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Abstract

Control of combustion systems needs the knowledge on how the changes in properties and structure of the particle during combustion affect the performance and control of the system. In this experimental study, a large number of burning particles were examined after retrieved from the furnace and quenched at different stages of devolatilization. The cylindrical particles of wood and briquettes measuring 38mm x 38mm were suspended in a single-particle tube furnace at temperature range of 1073K and approach air velocity of 2 m/s. After quenching, physical observations, structural changes, and dimensional measurements were taken for each sample at the char, pyrolysis, and unburned zones.

Wood showed slight shrinkage, whereas, briquettes showed up to 50% more expansion during combustion. The sectioned samples of both wood and briquette particles exhibited fine separation of outer char layer, pyrolysis reaction zone, and inner unburned zone. Pyrolysis zone for both types of particles was also observed to increase in thickness towards the center of the particle. This suggests that they burn through the same mechanism during devolatilization. Anisotropism in wood permeability affect most of the volatile gases to flow out of the particle in the direction parallel to the grains. This creates cooling effect and slow pyrolysis speed along the grain, whereas, in briquettes it was noted to be the same in both directions. Wood and briquettes exhibited different crack patterns. Cracks in wood particles were noted accelerate the progress of pyrolysis.

ANAEROBIC–GRANULAR BACTERIAL TREATMENT SYSTEM FOR COCONUT WASTEWATER VIA HIGH RATE BIOGAS DIGESTER TECHNOLOGY

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ABSTRACT

Desiccated coconut manufacturing factories emit a high-strength, low-degradable wastewater having a low pH value. This study was conducted in Sri Lanka, to investigate the applicability of a three-stage anaerobic filter (Up flow anaerobic floating filter – UAFF) system for coconut wastewater. In this study, a series of laboratory-scale experiments were conducted to recover the biogas as much as possible and to treat the wastewater based on the UAFF process under tropical conditions.

The experimental set-up was made with three anaerobic filter reactors coupled to a sedimentation tank and a biogas holder. A bacteria growing medium in, coconut coir fibres, which facilitate granular bacteria formation, was installed inside the anaerobic digesters. Bacterial seeding was made from cow dung rich wastewater to activate the microbs. It achieved more than 90% of the removal rate for Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and turbidity was achieved with an average organic loading rate of 1.21 kg COD/m^3 day, for coconut wastewater as an influent to the system during the laboratory scale experiment. Average biogas yield during this experiment was 2.5 litres (at atmospheric pressure and temperature)/ litre of coconut wastewater/day with an average methane percentage of 65%.

Since that average biogas production from the wastewater of a D. C. mill would be 75m^3/ day. This is a considerable amount of energy while the system improves the quality of output wastewater to control the damage to the environment, which is significant specially at coconut growing areas.

Environmental Evaluation of Energy Production from Agricultural Products in a Life Cycle Perspective

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The potential resource for bioenergy is large, especially in agricultural countries such as Thailand, where high biomass yields are available. The major challenge of using dedicated energy crops, especially in Thailand, is the competition of land use for food. The other important concern is the loss of biodiversity. Therefore, use of agricultural residues as bioenergy resource represents an appropriate option to be considered. However, its environmental impacts should first be analyzed and evaluated.
In the case of Thailand, several sugar and rice mills are already producing energy from bagasse and rice husks for their own use as well as selling the excess power to the national grid with the support of national policy. This study reviews the current situation of energy production from agricultural residues in Thailand, the actual energy potential of available residues and the environmental profiles of the existing power plants. Major environmental emissions of energy production from agricultural residues and their causes are identified using Life Cycle Analysis technique. Recommendations for reduction of potential environmental impacts are also suggested.

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Implementation of biomass CHP in Fructose industry: the economics and environmental perspective

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Abstract

The processing of agricultural produces in Thai's industry results in a large production of residues. These residues are considered as wastes and are disposed off through various methods such as open burning and dumping. Some portion of biomass is combusted in boiler to generate steam. However, the mentioned activities are considered as inefficient biomass conversion processes. In order to achieve the optimum usage of biomass for energy in industry, the combined heat and power (CHP) system, which is a promising biomass energy technology, should be employed. The specific industry, considered for the replacement of existing fuel oil-based steam boiler with mixed biomass CHP system, is the food industry that produces fructose syrup. The biomass residues from the process are tapioca residue and activated carbon. However, the amounts of these residues are not sufficient to generate steam and electricity through CHP system to fulfill the daily requirement. Hence, the additional paddy husk supply is purchased from the nearby rice mill. The designed CHP system is able to generated 1 MW of electricity and 17 tonne per hour of steam for process heat. The present value of CHP system is about 4.5 million US$ with the pay back period of approximately 4.5 years. The benefits of CHP system are not only the economic in term of short pay back period but also the environmental benefit. The estimated environmental emissions emit from the CHP system are lower than those from the existing oil-fired boiler. Moreover, the CHP system also has the significant potential to mitigate CO_2 emission.

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Application of AHP for prioritizing barriers on the implementation of improved biomass stoves in Thailand

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Abstract

The population of Thailand is largely rural based as in many Asian and other developing countries. A large portion of rural household still depends on fuelwood and charcoal as a source of energy for cooking. The high average daily consumption of energy for cooking arises from the widespread use of inefficient cooking methods, the most common of which is the traditional biomass cooking stoves. Inefficient use of fuelwood is considered one of the important causes of deforestation. Use of efficient cooking stove is one of the measures that can reduce fuelwood and charcoal demand and help in lowering the deforestation and conservation of energy. However, the implementation of efficient stoves still represents a small fraction due to some problems often known as barriers. The identification and analysis of certain barriers which could hinder the implementation of improved biomass cooking stoves are carried out in this study. The general barriers of the improved cooking stoves are firstly identified and then the ranking of barriers corresponding to stipulate criteria are carried out. The prioritization process of the barriers is a multi-criteria decision making problem that involves subjective value judgments and are suitable application of the analytic hierarchy process (AHP). To prioritize the barriers, 60 persons from 4 groups of stake-holders including policy personal, researchers, manufacturers, and users are interviewed. The results show that the first three ranks of barriers are: 1) the lack of micro-credit financing, 2) the high initial cost and 3) lack of local expertise or know-how or skills. Apart from the barrier prioritization process, the measures to overcome the key barriers to improved and increase the utilization of efficient stoves are also proposed. The most essential measure that expected to be able to overcome the first two barriers is the distribution of efficient stoves with equal prices to traditional stoves while the training program for local pottery considered as solution for the last key barrier.

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FLASH PYROLYSIS OF LINSEED IN A TUBULAR TRANSPORT REACTOR: yields and structural analysis of bio-oil

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ABSTRACT

Flash pyrolysis experiments of linseed (*Linum usitatissimum L.)* were performed in a tubular transport reactor at atmospheric pressure under nitrogen atmosphere. The effects of pyrolysis temperature and particle size on the yields of products were investigated with the sweep gas flow rate of $100 cm^3 min^{-1}$. The temperature of pyrolysis and particle size were varied in the ranges 400-700^{0}C and $0.6 < Dp < 1.25$, $1.25 < Dp < 1.8$, $Dp > 1.8$mm, respectively. The maximum oil yield of 68.8% was obtained at a pyrolysis temperature of 550^{0}C, and the particle size of $Dp > 1.8$mm. The char and liquid product were analyzed to determine their elemental composition and calorific value. In particular, the chemical composition of the oil was investigated using chromatographic and spectroscopic techniques (^{1}H NMR, IR, column chromatography and GC). The chemical characterization has shown that the oil obtained from linseed can be used as a renewable fuel and chemical feedstock.

Keywords: Biomass; Linseed; Flash pyrolysis; Characterization

PRODUCTION OF BIO-OIL FROM PISTACHIO NUT SHELL VIA FAST PYROLYSIS

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ABSTRACT

Advances in petroleum cracking technology, particularly the cracking of heavy residues, indicate that similar approaches could be applied to the pyrolysis of biomass materials in order to maximise the production of low molecular weight volatile intermediates. Such approaches are known as “fast pyrolysis”. The development of advanced fast pyrolysis processes for liquids production has gained much attention in the last decade, because they offer a convenient way to convert low value woody residues into liquid fuels and value-added products.

In this study, the role of the important pyrolysis parameters, peak temperature, and heating rate, in defining the pyrolysis yields were investigated. Experiments were carried out in the temperature range from 400 to 700^{o}C, with a constant heating rate of 300^{o}Cmin^{-1}. In the second part of the experiments, pyrolysis experiments were performed at optimum pyrolysis temperature at different heating rates such as 5, 100, 500, and 700^{o}Cmin^{-1}. The effects of pyrolysis temperatures and heating rates on pyrolysis yields and compositions were determined. Compositions of gas and liquid products were given. The various characteristics of liquid product obtained under these conditions were identified. Thus, the aliphatic and low-molecular-weight aromatic sub fractions of the bio-oils were then analysed by GC and further structural analysis of bio-oils and aromatic and polar sub fractions were conducted to IR spectra. The H/C ratios and the structure analysis of the fractions obtained from the biocrudes show that the fractions are quite similar to currently utilised transport fuels.

A TWO STAGE FIXED BED REACTOR FOR UPGRADING OF VOLATILES FROM THE FAST PYROLYSIS OF OLIVE RESIDUES

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There are a lot of works aimed at developing processes to produce liquid fuels from varies sources of biomass has demonstrated that an oil product can be produced from biomass in significant yields. Pyrolysis oils are complex mixtures of organic compounds that exhibit a wide spectrum of chemical functionality, and general some water. Their direct use as fuels may present some difficulties due to their high viscosity, poor heating value, corrosiveness and instability. The upgrading of pyrolytic oils, a necessary process before they can be used as a regular fuel, essentially involves removal of oxygen. Currently, two methods have been proposed. The first method is a typical catalytic hydrotreating with hydrogen and carbon monoxide under high pressure and/or in the presence of hydrogen donor solvents. As a thermal treatment in the absence of catalysts does not seem to produce a significant upgrading, alternatively, upgrading may be achieved using cracking catalysts (zeolites, silica-alumina and molecular sieves).

This study involved the fast pyrolsis of the olive residues and immediate catalytic cracking of the pyrolytic oils in the second stage of the reactor. The effects of catalyst temperature and concentration of catalyst on product yields and compositions were determined. Detailed analyzes of gas and liquid tar were performed by using GC, GC/MS, column chromatography, and elemental analyzer. The results were compared with previous studies.

SLOW PYROLYSIS OF RICE-STRAW IN A FIXED-BED TUBULAR REACTOR: YIELDS AND CHARACTERISATION OF CHAR AND BIO-OIL

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ABSTRACT

In rice-producing countries, large amounts of rice straw and rice husks generated as waste material which are difficult and costly to manage and no ready to use. Most of these countries depend on fossil fuels for their energy supply, and rice straw can be used to supplement as an energy sources by thermochemical conversion processes. Pyrolysis is one of the fundamental thermochemical methods to obtain bio-fuels easily. The crude pyrolysis oil is currently attracting the most interest because of its high energy density compared to raw biomass, easy transportability, ease of use and utilisation. Slow pyrolysis is also an ancient art of production char and activated carbon.

In this study, the slow pyrolysis of rice-straw was performed in a fixed-bed tubular reactor under nitrogen atmosphere at a heating rate of 5^oCmin^{-1}, and different pyrolysis temperatures either 350,400,450,500,550 and 600^oC.The maximum liquid yield was attained at pyrolysis temperature of 550^oC at a constant heating rate of 5^oCmin^{-1} with a sweeping gas velocity of $100cm^3min^{-1}$. The elemental analysis and calorific values of the bio-fuel were determined, and then the chemical composition of the oil was investigated using by chromatographic and spectroscopic methods such as column chromatography, FTIR, and GC. For all pyrolysis temperatures, the solid product (char) was characterised using by proximate, elemental and FTIR analysis methods.

Effect of pyrolysis atmosphere on pyrolysis product of rapeseed

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The use of renewable energy sources is becoming increasingly necessary if we are to achieve the changes required to address the impacts of global warming. Biomass can be converted into useful forms of energy using a number of different processes.

Pyrolysis processes of biomass yield different quantities of gas, liquid and charcoal in accordance with the operating conditions. When solid (charcoal) is the main product, the pyrolysis is carried out at a slow heating rate. When heating of biomass to final temperature (between 450 and 600°C) is very fast, high yields of liquids are obtained (the condensation reactions of the intermediate products that lead to the formation of charcoal are minimized). However, the primary oils produces in high yield by fast (fluidized bed) pyrolysis generally have extremely high oxygen contents and contain a number of simple sugar derivatives, such as levoglucosan. The high oxygen content, and the water present, make these oils hyrophilic to extent that, without emulsifying agents, they do not blend readily with conventional petroleum products. For possible future use as replacements for hydrocarbon chemical feedstocks and fuels, liquids will require considerable upgrading. To produce bio-oils with lower oxygen contents, pyrolysis under high hydrogen pressure (hydropyrolysis) can be used.

In this study, fixed-bed experiments were conducted on rapeseed with the aim of producing bio-oils with high yields and low oxygen contents that can be readily utilized as hydrocarbon feedstocks. Rapeseed (*Brassica napus*) which is a oil crop and has been grown in the northern and southern Turkey, was selected for this study. Rape plant, with some advantages over sunflower, is expected to become one of the major oil seed crops upon full implementation of Southeastern Anatolia Project (GAP) in the southeast of Turkey.

The fixed bed pyrolysis experiments was performed to establish the effect of pyrolysis atmosphere and heating rate on the pyrolysis product distribution. The experiments were conducted using three different pyrolysis atmosphere, namely the self, nitrogen and hydrogen pyrolysis atmosphere. The effect of heating rate of either 8, 100 or 300°Cmin^{-1} and the pyrolysis temperature of 550^{o}C have been used in this experiments.

The maximum bio-oil yield of 84% was obtained in hydrogen atmosphere at hydrogen pressure of 15MPa, hydrogen flow rate of 10 dm^{3}min^{-1}, hydropyrolysis temperature of 550°C, and heating rate of 300 °Cmin^{-1}.

In addition, the pyrolysis oil obtained at the condition of the maximum liquid product yield was investigated, using chromatographic and spectroscopic techniques, to determine its possibility of being a potential source of renewable fuel and chemical feedstock.

The effect of heating rate and pyrolysis temperature on the pyrolysis of safflower seed

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The abundance of agricultural products, waste and high recoverable yield of liquid product from biomass pyrolysis present an attractive process alternative. Pyrolysis products, gas, liquid and char, the relative proportions of which depend very much on the pyrolysis method and process conditions. Biomass pyrolysis seems to be the most promising thermochemical conversion technology for production of liquid oil. Pyrolytic oil has a strategic value because, as a liquid with high calorific value, ease at handling, storage, transportation and utilization similar to that of oil. It could be upgraded to obtain light hydrocarbons for transport fuel. Furthermore, compared to most coal and petroleum derived fuels, biomass oils contain low level of aromatics and sulfur.

With its 25 million hectares arable land Turkey has a vast agricultural potential. Total cereals production of Turkey (29 million tones) ranks third in Europe. Indeed there are a number of biomass sources being considered as potential sources of fuels and chemicals feedstock both natural resources and agricultural products. Sunflower, cotton, canola, safflower, castor, corn, rape are the major potential crops for vegetable oil production and biomass sources as well.

In this study, the influence of heating rate and final pyrolysis temperature on the product yields were studied. The fixed bed slow and fast pyrolysis experiments performed in a fixed-bed and well-swept fixed-bed tubular reactor. Particularly, pyrolysis experiments have been conducted with heating rate of 5, 40, 80, 100, 300, 800 °Cmin^{-1} and the final temperature of either 400, 450, 500, 550, 600, 650 or 700°C to determine the effect of pyrolysis temperature and heating rate on the pyrolysis yield.

The maximum oil yield of 54% was obtained at pyrolysis temperature of 600°C, sweeping gas flow rate of 100 cm^3min^{-1} and heating rate of 300°Cmin^{-1}.

In addition, the pyrolysis oil was investigated using some chromatographic and spectroscopic techniques. Proximate and elemental analyses were carried out on the sample of rapeseed. The elemental composition and calorific values of the oil was determined. The ^{1}H NMR and FT/IR spectra of the oil were obtained. Chemical class composition of the oil was determined by liquid column chromatographic fractionation. Elemental and IR spectrum and GC analyses were carried out for each fraction. The pyrolysis oil was fractionated by distillation according to ASTM D 86 to compare the distillation results of the pyrolysis product distillates with those of conventional transport fuels.

The Emerging Integrated Biorefinery: The New Model for Commercial Success & Oil Displacement

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ABSTRACT

Integrated biorefineries are currently being designed and built, differing in fundamental ways from previous smaller scale biomass conversion facilities that produced fuels or power or value-added products. This paper will examine the different approaches to designing biore-fineries worldwide, with particular emphasis on North America and Europe. It will survey current and planned biorefinery efforts, examining examines how the biorefinery's multiple product streams and higher value products enhance the financing and construction of large-scale plants, while the ready availability of low-cost feedstocks will help displace significant portions of current petroleum usage for transportation fuels and chemical intermediates.

The emerging integrated biorefinery is built on the con-cept of cheap sugars from cellulosic biomass. Recent breakthroughs in plant culture, biotechnology and engi-neering contribute to those cheaper sugars. Virtually all of the needed conversion steps have been proven at the bench-scale and are now being scaled up to pilot-scale, continuous, integrated operations. The results of detailed process modeling show that biorefineries can produce product streams that are competitive with products from existing petrochemical complexes and petroleum refineries. Modeling also indicates the areas of needed R&D focus for reducing capital and operating costs.

KEY WORDS: biorefinery, cellulosic biomass, biomass conversion, commercialization, fuels, chemicals

GENERATION OF BIOGAS FROM OLIVE MILL WASTE

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ABSTRACT

Special attention has been paid to the treatment of Olive Mill Solid Wastes and Olive Mill Waste-Waters due to the great pollution problem they create. Effluent treatment plant for water recycling, methane production and solid waste fertilizer production were not adequately used and installed by the community in Jordan.
Two pilot digesters have been investigated. The first digester was a horizontal flow, rectangular cross section with a length, width and height of 1.0, 0.5, 0.7 meters respectively, similar to the Indian type digester. The second digester was an Up Flow Anaerobic Sludge Blanket. This type is a bottom feed, vertical flow and circular cross section (European type) with a diameter and height of 0.35 and 1.1m respectively. Both digesters are to be used for both research and community demonstration.
Attempts were made to increase the anaerobic digestibility of Olive Mill Wastes and hence to increase digester gas yields by means of mechanical, thermal and chemical pre-treatment procedure (due to high acidity of 5 PH).A day-by-day PH monitoring, treatment (to keep its level close to 7) and gas collection show that both digesters experience very close results in terms of PH and biogas.
The rectangular cross sectional horizontal flow digester appears to be more practical for community use than the circular vertical flow digester in terms of construction, operation, maintenance and the easiness of solid waste flow.

BIODIESEL: A renewable alternative to improve the energy matrix in Uruguay

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The country has an energy matrix, that in 1996 was 60% oil, 25% hydro, 11% wood and 3% biomass, 1% gaz, few solar and eolian It has a limited renewable part.. Vehicule Gasoil consumption is more than the percentage obtained from regular petroleum so there is a net import of it. Sowing oleaginous in summer, as a second crop, is an option to produce biodiesel .To improve the sustainability of energy matrix, it is required as crop and land surface to substitute 20% of gasoil with national biodiesel for B20 fuel, about 300.000 hectares of sunflower or equivalent farming , mainly summer second crop. There are advantages associated (less foreing currency needed, more agriculture, more energy security) for the country and for less emissions to the atmosphere

.The biodiesel is viable economically (costs somewhat between 0,3 and 0.63 cents a liter) , if the changes in balance between petroleum, taxes and oil crop price for food is convenient and if the production is through associations or cooperative, individual local production). In many years of the economic cycle the balance is positive. More research on non-food crops are badly needed. Other uses (solvent for agrochemicals, paintings, lubricants are better prized. There is no land limitation for these purposes and quantities

It is possible to improve renewable energy and other uses. as . biodegradable, not toxic, non pollutant, especially in protected areas . There is also positive fiscal effects, in the employment and reactivación of the agricultural production and industry. There are important impacts from exchange policy, taxes and tariffs policy.

ENERGY FROM WEEDS

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Energy is one of the most important commodities in modern life. Even though the world's demand for energy is increasing the supplies of sources of this important entity are diminishing. There exists no single substance or commodity that can replace hydrocarbon fuel. Thus, it is necessary to find many smaller sources of energy. One of these potential sources is the energy stored in the rhizomes of many weed plants such as cattails. Cattails grow throughout the world. There are many different species. Some varieties are quite salt tolerant while others sources require little or no salt water. A test has been performed in the southeastern part of Florida that indicates that the rhizomes of certain species of cattails can produce sufficient starch to produce about 100 gallons of ethanol per acre of plants. This is nearly double the ethanol production of corn. Correct growth and harvesting could eliminate seeding costs and environmental damage. Many farms with submerged or semi-submerged land could have a cash crop. In many areas government cars are specified to use ethanol. But there is no ethanol available. However, there may be many acres of cattails or submerged land that can support a cattail crop. This paper explains the development effort that has been performed and presents the potential of a cattail to ethanol program

Southeast Alaska BioEnergy Project: Wood Residue Biomass to Ethanol

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Sealaska Corporation generates wood residues from operations, and wants to manage their residues by converting the biomass material to a useful product in an environmentally friendly manner. Merrick & Company previously evaluated the feasibility of a project to convert the residues to ethanol in a new installation at an existing industrial facility near Ketchikan, Alaska.

The Southeast Alaska BioEnergy Project has recently completed evaluating gasification technologies that allow conversion to ethanol. The carbonaceous portion of the residue feed (cellulose, hemicellulose, lignin, etc.) is gasified into a synthesis gas (syngas) of carbon monoxide and hydrogen. This syngas is then converted to alcohol by a fermentative process. Alcohol yields are now expected to be sufficient to justify the residue conversion project. Even with reduced feed quantities, the ethanol product is expected to match the gasoline blending market requirements in Alaska.

The current status and initial results of pilot testing of the major technologies will be addressed. First, both the gasification and the fermentation technologies will be separately tested using sea-water wet residues from Alaska. Then, a combination test will be run with a small-scale fermentative unit running on a slipstream from the gasification pilot plant. These results will be incorporated into a suitable project design and cost estimate. The project will manage regional wood residues while producing a useful, economic, fuel ethanol product.

Barriers to Bio-energy Refinery Technology Commercialization

By: Marc D. Rappaport, S.E.D.Inc

Abstract: One part of the success of renewable energy has been the biomass energy cogeneration facilities that have been built over the last twenty years since the passage of the PURPA Act of 1978. While a number of these plants built in California have shut down, it has not been because of the failure of technology. Improper policy planning and oversight of energy companies have been the biggest contributors to project failure and problems. The Enron scandal has cast a pall on energy investments and how they will fare; and gas fired generation has moved to the front of the line as the new clean source for power generation, for a fossil fuel.

Wind energy is being developed as never before, with the help of a generation tax credit, improved technical reliability and lower installed costs. Wind farms with 100 MW installed capacity or more are not uncommon. Where are the new biomass plants? EIA data shows that over the last twenty years biomass has been a significant part of the percentage of renewable power. What will the future be? Looking at the potential resources for feedstocks and the benefits to the environment from the continued applications of new bio-energy technologies, there are enormous benefits to be gained for communities, rural and urban, environmental and economic. Benefits in both electrical energy and green fuels are available from these resources, while benefiting the very environment that produces the biomass resources.

This paper will address a number of the issues that cause these failures and hurdles to implementation of new technologies that can provide substantial benefits in electrical energy and green fuels for countries throughout the world. Doing so in a clean and responsible manner that can combine the best benefits of distributed generation, base load reliable utility power and green fuels for substitution of MTBE as an oxygenate and E85 fuel. These benefits can be available while reducing heavy fuel loading and mitigating catastrophic fire potential, enhancing watershed environments, extending landfill life, and helping animal habitat. The potential is much larger than most people realize. This paper will provide some insight into these benefits as well.

Sustainable Agricultural Crop Residue Removal Methodology and Application for Single and Multi-Year Corn and Wheat-Based Rotations

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Purpose of Work: Current U.S. primary energy consumption is about 102 exajoules (EJ) (97 Quads) and is expected to increase to more than 137 EJ (130 Quads) by 2020. Transportation fuels produced from petroleum are projected to account for nearly one-third of U.S. energy consumption by 2020, and use of fossil fuels for transportation is a significant contributor of greenhouse gasses. An extremely critical component associated with developing renewable energy resources to meet impending energy shortages from conventional sources involves accurately assessing the renewable energy resource base and in particular, evaluating the sustainability of utilizing select biomass resources such as corn stover and wheat straw.

Approach: A detailed methodology was developed to assess quantities (dt/ha/yr) of removable agricultural crop residue from select single and multi-crop (two-year) corn and wheat-based rotations on all land-capability class (LCC) I-VIII soil types in all counties of 37 states, without exceeding the tolerable soil-loss limit due to rainfall and wind erosion. This methodology incorporated localized climatic factors, physical parameters and topologies of all individual LCC soil types, and localized tillage practices (conventional, reduced/mulch, and no-till field management practices).

Scientific Innovation and Relevance: The methodology developed and applied in this paper serves as a guideline on how the sustainable removal of agricultural crop residues from multi-year rotations should be approached and implemented given climatic conditions, field topographies, and agronomic practices. This methodology is also directly applicable to cropping rotations involving other grain and oilseed-based crops (barley, oats, sunflowers, canola, etc.).

Results: Application of this methodology indicates significant quantities of corn stover and wheat straw can potentially be removed from cropland without exceeding tolerable soil-loss limits, but removal rates are directly influenced by tillage practice, climatic conditions, and land capability class.

Conclusions: The analysis applied in this paper indicate potential removable quantities range from nearly 5.5 million dry metric tons/yr for a continuous corn rotation using conventional till in Kansas, to more than 97 million dry metric tons/yr for a corn-wheat rotation using no-till field management practices in Illinois.

Preliminary Assessment of Quality and Stability of Biodiesel in the USA

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Biodiesel, the fatty acid methyl esters of vegetable oils, animal fats, and waste cooking oil, is being used increasingly as a diesel blending-component in the USA, EU and throughout the world. The primary feedstocks in the USA at this time are soy and waste cooking oil. Engine and vehicle manufacturers have expressed great concern about the quality of this renewable fuel and the potential for poor quality fuels to cause excessive wear or premature failure of certain engine components. Potential quality issues include the presence of glycerine and glycerides, inorganic salts from the biodiesel production process, free fatty acids, and deposits formed from fuel oxidation. In this study we examine biodiesel fuels collected from across the USA using the ASTM D6751 biodiesel specification test methods as well as well as oxidation stability tests.

Computer Optimization of Supercritical Hydroconversion of Biomass

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Computer optimization of a supercritical hydroconversion process tested at lab scale is described. The process uses supercritical water above 221 bar (3205 psia) and 374 C (705 F) in once-through steam generator tubes to produce clean synthetic natural gas (SNG) from biomass without oxygen or air. The patented process converts high-pressure biomass-water slurry that is externally heated. Particle residue and carbon dioxide are separated for beneficial use. Cleaned condensate can be recycled to slurry preparation for zero liquid effluents.

Process flowsheets were prepared for computer modeling of commercial applications, using glucose (CHOH) as an analog for partially oxygenated biomass. Modeling of the most promising alternative for biomass predicted a thermal efficiency to fuel gas above 72% for glucose. Incorporating a gas turbine or solid oxide fuel cell in the flowsheet increases thermal efficiency to 49% to electricity. Thermochemical equilibrium modeling can predict the composition of fuel gas and efficiencies for a wide variety of biomass feedstocks without oxygen or air. Integrated SHC systems offer several potential benefits over low-pressure steam pyrolysis:

- Low temperature and high pressure promote the formation of methane, decreasing the heat required to make the gas and increasing its calorific value.
- Hydrogen can be separated as a valuable byproduct by membranes currently under development, producing synthetic natural gas (SNG).

Animal Waste Management - Converting Broiler Litter into Energy

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Abstract
Over the past 50 years, broiler production in the U.S. has increased steadily, reaching approximately 8.6 billion broilers in 2002. North Georgia has been the top poultry producer for the past 10 years, accounting for an estimated 1.3 billion broilers in the same year. This continuous rise in broiler production has created concerns about traditional litter disposal methods because of decreasing availability of land and potential environmental impacts. Earth Resources, Inc., GTI, and the University of Georgia are developing a cost-effective, environmentally sound gasification technology to convert poultry litter into useful electric power, heat, fuel (such as hydrogen), and fertilizer. Advantages of such a small-scale system include generation of distributed energy for local use, elimination of waste in an environmentally benign manner, and production of a pathogen-free, bacteria-free fertilizer that is high in nutrients.

In this paper, an overview of the technology will be provided and a preliminary resource assessment will be made. Results from analytical and gasification reactivity tests in a high-pressure thermobalance reactor, on two selected poultry litter samples, will be presented. Suitability of these feedstocks for gasification in a fixed-bed updraft flow gasifier as well as a pressurized fluidized-bed gasifier will be discussed.

Bagasse-Fueled Cogeneration Can Be A Sweet WIN^4

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Bagasse-fueled cogeneration can be a sweet **WIN^4** providing increased profits for the sugar mill, higher prices for the cane grower, a privately funded distributed generation source for the local electric distribution company, and a reduction in CO_2 emissions for the environment. Sugar cane mills are designed as bagasse-fueled cogeneration systems without selling excess electricity and therefore with the requirement of incinerating the bagasse, a waste material. By-products of this disposal of bagasse are steam and electricity to meet the process energy requirements of a reasonably operated mill. There is no incentive for energy conservation of electricity and steam, no incentive to utilize the full available energy potential of the bagasse, and no financial reward for the investment in equipment to maximize use of a resource that is the most efficient in converting solar energy to biomass material.

With the ability to sell excess electricity from a bagasse-fueled cogeneration system the incentive becomes real to optimize energy efficiency and to maximize the effectiveness of an underutilized biomass resource. Process unit electric energy consumption can be reduced from a nominal 16 kWh per metric ton cane to 12 kWh per ton cane and steam use can be reduced from 650 kg_s per ton cane to 400 kg_s per tonne cane. Installation of higher pressure boilers and condensing-extraction steam turbines to replace old boilers and backpressure steam turbines will result in reduced steam rates for turbines from 18 kg_s/kWh for old backpressure turbines to 5 - 7 kg_s/kWh for condensing –extraction turbines. As a result, a nominal mill crushing one million tons cane per year has the potential to export 23 MW of electric power for approximately 4,200 hours per year – 75 million kWh annually.

Barriers to increased efficiency in biomass conversion are primarily regulatory and to a lesser extent financial. For example, in Brazil a normative value for biomass produced electricity has been established that distribution companies could roll into the rate base but they won't. In the Philippines the national grid has been deregulated but the cooperatives have not. As a result, the full potential bagasse cogeneration is not realized, missing what could be a sweet **WIN^4**.

Emerging Biorefining Technology for the Pulp and Paper Industry

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Purpose: The PureVision reactive fractionation technology separates lignin and hemicellulose from cellulose in lignocellulosic biomass resulting in a relatively pure fiber that can be converted to pulp and paper products. The wash liquor streams contain lignin and hemicellulose that are recovered and can be further refined and converted to commercial products. This paper will present an alternative non-acid approach to conventional pulping using a novel biomass-processing technology to recover agricultural residues.

Approach: The PureVision process emphasizes cellulose purity as a key feature of treating biomass materials, resulting in corn stover and wheat straw fiber having >97% of the lignin and >99% of the hemi-cellulose removed. In the process of producing pure cellulose fiber, the PureVision technology separates the hemicellulose sugars and lignin components of the biomass in a single, continuous reactor. The wash liquor stream contains 5 and 6-carbon sugars and lignin from the wash liquor stream that can be converted into valuable product streams. During 2002 and 2003, PureVision carried out biomass fractionation chemistry at bench scale (15 grams) in a washed bed reactor. A process development unit (PDU) is now operational to fully execute continuous, counterflow processing at up to 10 kg/hour (dry weight).

Innovation & Relevance: The reactive fractionation technology has the potential to expand the use of agricultural residues and other types of biomass for producing a wide range of pulp, paper and non-paper products. No acid reagents are used in PureVision fractionation process to remove lignin and hemicellulose from the cellulose fraction and the resulting fibers could become a highly sought-after pulp and papermaking products including market pulps, substitute pulps and dissolving pulps. In non-paper applications, the very high purity of the pulp from the PureVision process could make it suitable as a precursor for the spinning of cellulosic based fibers and films, as agents in paints and adhesives, and as reinforcements in molding compounds and composites. The Kraft process has been employed for approximately 150 years without significant improvements being made to the basic technology. The new PureVision technology, if successfully applied, has the potential of becoming an alternative to the Kraft and other chemical processes for making fibers and paper products from agricultural residues and other types of lignocellulosic biomass.

Results: In July 2003, PureVision initiated a fiber assessment program using wheat straw. Fiber samples were prepared on a bench-scale washed bed apparatus. Standard TAPPI tests were performed. The pulp chemical composition of the fractionated fiber indicates low lignin content. The PureVision wheat straw samples were determined to be somewhat stronger than conventionally produced wheat straw hand sheets. Tear strength is more than double, tensile strength is 10-15% higher and the burst strength for the Pure-Vision pulp samples is 25-30% higher. Of particular note are the better strength properties “across the board” for the PureVision pulps compared to hardwood Kraft market pulp from Aspen wood chips. The fiber testing data demonstrates the new processing regime is a good candidate to supplement conventional pulp processing, as the fiber quality remains intact and similar to conventionally pulped fiber.

Conclusions: The reactive fractionation process offers an alternative method of processing biomass fibers for pulp and paper applications. The fractionation technology produces pure cellulose which potentially offers an alternative to traditional (Kraft) pulping with broad applications for the pulp and paper industry worldwide. The new process can substantially expand the supply of fiber while providing added-value products to farmers. The PureVision process will substantially reduce or eliminate caustic effluent discharges characteristic of conventional Kraft and chemical pulping by employing a closed loop system.. In addition to producing a cellulose fraction, hemicellulose and lignin fractions can also be separated and used in numerous commercial applications.

An Emerging Biorefining Platform Technology

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Purpose: To demonstrate and commercialize a new and more economical technology for the fractionation of biomass, the production of a purified cellulose stream followed by enzymatic conversion of its cellulose component to sugar, and the economic separation and utilization of other biomass components. Once demonstrated at pilot scale, this process can become the core technology of a biorefinery designed to produce fuel, power, and other chemical products. This paper will report on scale-up activities and results conducted during the first half of 2004 utilizing a continuous process development unit.

Approach: The PureVision process emphasizes cellulose purity as a key feature of treating biomass materials, resulting in corn stover and wheat straw fiber having >97% of the lignin and >99% of the hemicellulose removed. In the process of producing pure cellulose fiber, the PureVision technology separates the hemicellulose sugars and lignin components of the biomass in a wash liquor stream utilizing a single, continuous reactor. The wash liquor stream contains 5 and 6-carbon sugars and lignin that can be converted into valuable product streams. During 2002 and 2003, PureVision carried out biomass fractionation chemistry at bench scale (15 grams) in a washed bed reactor. A process development unit (PDU) to fully execute continuous, counterflow processing at up to 10 kg/hour (dry weight) is now operational.

Innovation & Relevance: Low-cost cellulosic biomass is uniquely suited to the production of commodity fuels, chemicals and fiber. However, a primary deterrent for economic utilization of lignocellulose as a source of sugars in a biorefinery has been the high cost of enzymes used to produce the sugars from cellulose, the most abundant constituent of biomass. Over the past several years, development efforts have been directed both at economically producing a reactive cellulose stream and at producing cellulase enzymes at a lower cost. The novel PureVision technology combines both of these approaches, first to produce purified cellulose that will undergo enzyme hydrolysis requiring a minimum of enzymes, and secondly, to have others develop a specific lower-cost enzyme system to enhance the hydrolysis and the overall economics of the biorefinery process.

Results. Recovery in pure solid form of 85% of the cellulose contained in corn stover feed has been obtained with 95% being hydrolyzed into glucose in 5 days by an enzyme loading of 8 FPU/gm cellulose. Our results show that the combination of elevated temperatures and counterflow washing reduces reagent consumption and makes possible short pretreatment reaction times (a few minutes). The process produces pure cellulose that potentially offers an alternative to traditional Kraft pulping for pulp and paper applications. In addition the resulting reactive cellulose reduces enzyme consumption in hydrolysis while enhancing sugar yields, with significant cost savings. Enzymatic hydrolysis of pure cellulose leads to toxin-free sugars that need no further processing before fermentation. No acid reagents are used in PureVision fractionation process and the problem of gypsum disposal is avoided and less costly materials can be used in reactor fabrication.

Conclusions: Our research indicates that the PureVision process has extended biomass pretreatment into a physiochemical regime not heretofore explored. Results are already comparable with the best of other pretreatment technologies and are only expected to improve because of features inherent in a multi-step counterflow process. The purity of the resulting cellulose stream, the decrease in enzyme costs, the reduction of toxins in other product streams, and the avoidance of acid reagents should significantly reduce the costs for pretreating lignocellulose materials, hydrolysis and other downstream processing as well as waste disposal costs and the cost of fabrication materials. The process also offers an alternative method of processing biomass fibers for pulp and paper applications.

EFFECTS OF BIOMASS BLENDING ON COMBUSTION ASH

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ABSTRACT:
In the United States there is currently little incentive for larger utilities to cofire biomass with coal, however, smaller industrial boilers have ample opportunities. Mechanisms of ash deposit formation specific to biomass cofiring in industrial-scale systems were studied. Low-ash, high-calcium wood residue and high-organically bound-potassium sunflower hulls, were cofired as 40 wt% biomass blends with a low-sulfur, low-ash, and high-calcium coal in a pilot-scale combustor. Analysis of the 60–40 coal–sunflower hull blend fouling deposits showed a potassium–calcium–aluminosilicate bonding matrix essentially "gluing" the deposit together. Potassium in the sunflower hulls reacted with the abundant calcium–aluminosilicates derived from the coal, leading to lower-melting-point, lower-viscosity phases, resulting in increased strength development in the ash deposits. Wood residue blend deposits showed calcium–iron–aluminosilicate bonding matrix with iron crystallization, which may have decreased deposit strength relative to that of the sunflower hulls. Fly ash particle sizes decreased with the biomass blends, probably due to the fine size of the fuel minerals in the biomass and the preponderance of organically associated inorganics. Fouling or slagging deposits observed for the biomass blends would not significantly reduce the capability of a boiler to produce steam; however, the generation of smaller fly ash particulate from the hulls may be a concern for existing control devices.

Keywords: Biomass/coal, fouling, sunflower

Modeling Economic and Environmental Tradeoffs in the Production of Switchgrass in the Fort Cobb Basin

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Biomass energy crops have environmental benefits in addition to serving as energy sources. Soil and Water Assessment Tool (SWAT) was used to determine sediment and nutrient loading. General Algebraic Modeling System (GAMS) was used to make land use decision to maximize net returns while meeting an allowable sediment and nutrient loading levels to the streams. Switchgrass, conventional and minimum tillage wheat, peanuts, sorghum, and Conservation Reserve Program (CRP) lands are used. Two approaches are used: a uniform reduction where loading reduction is shared equally among all subbasins and a non-uniform reduction approach where the amount abated by each subbasin varies. For the same loading level, the total income from the non-uniform reduction approach is 5% more than the total income from the uniform reduction approach. Another model was used to determine the minimum incentives required to induce a voluntary shift in land use to switchgrass or CRP to achieve a target sediment yield. The payment required per ton of sediment or nutrient reduced as a result of replacement of croplands by CRP is three times higher than for replacement by switchgrass. With incentives lower than required for CRP, it is possible to have landowners produce switchgrass for energy purposes while realizing more water quality benefits.

The Potential Use of Remote Sensing to Improve Biomass Energy Management

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Biomass is one of the most promising ways to supply sustainable and renewable sources of energy. In that domain agriculture plays a double role as energy user, as well as energy provider in the form of bioenergy. Thereby a precise and extended knowledge of agricultural biomass (availability, production, quality, location) is necessary to improve and refine the processes developed by the three components of bioenergy: biopower, biofuels, and biobased products. Significant amelioration to biomass accounting can be made with the efficient use of remote sensing. Remote sensing can provide parameters for such variables as, above ground biomass, land cover characterization, disturbance patterns, air and surface temperature, disturbed forest areas, required to drive models that can help improve the different processes involved in bioenergy. In addition remote sensing addresses the issues of transparent and verifiable biomass estimation, or other information, at the local, regional, and/or national scales. Remote sensing also enables the acquisition of reliable non-destructive field-base measurements without intensive and costly labor. Remote sensing based knowledge and tools developed for decades by the agricultural and forestry community can make a strong contribution to existing and/or future bioenergy initiatives.

PHOTOBIOLOGICAL PRODUCTION OF H_2 IN THE USA

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The goal of this inter-laboratory, integrated research effort is to develop a cost-effective process for H_2 production that is renewable (water is the substrate and sunlight is the source of energy) and environmentally acceptable (free of pollutants, toxic by-products, or greenhouse gases). Green microalgae are being employed in this process and serve as the biocatalyst in the conversion of sunlight energy to H_2. The advantages of these oxygenic, photosynthetic micro-organisms are their fast growth (biomass doubling in 8 hours) and potential solar energy conversion efficiency to H_2 of up to 10%. Mass cultivation of algae for H_2 production, in addition to the above-mentioned environmental advantages, can also sequester CO_2 into biomass and other valuable bio-products. Current R&D efforts on this area include (a) overcoming the O_2 sensitivity of the algal hydrogenase enzyme, (b) improving the efficiency of the electron-transport process from H_2O to the hydrogenase enzyme, and (c) optimizing light utilization and solar conversion efficiency of the algae. Current progress includes (a) investigation of factors that regulate the expression of the hydrogenase enzyme, (b) application of preliminary molecular engineering approaches to overcome the O_2-sensitivity of the algal hydrogenase, (c) application of metabolic regulation to separate O_2 evolution from H_2 photoproduction, (d) design of a membrane-spanning protein-channel to dissipate excess proton gradient and thereby enhance rates of H_2-photoproduction, and (e) genetic limitation of the chlorophyll antenna size of the photosystems in microalgae to permit greater light penetration and enhanced solar conversion efficiency by the cells in mass culture.

This work was sponsored by the USDOE Hydrogen, Fuel Cells and Infrastructure Program and by the Daimler Chrysler Corporation (UCB).

Application of Biomass Gasification in the Primary Metals Industry

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Production of primary metals is an essential component of the world manufacturing economy. The processes involved are characterized by low quality ores, environmental disruption and metals contamination at the mine, and the potential for soil pollution adjacent to the metal smelters.

There is a wide variety of plants adapted to high metals concentrations in the soil. These "hyperaccumulators" absorb the metals through the root system and sequester themin the plant tissue. The tissue concentrations are one to two orders of magnitude higher than the soil concentration.

Harvesting of the plants and recovery of the metals in a mineral ash results in a gradual lowering of the metals concentration in the root-zone soil. Depending upon the goal, the process is "phytoremediation" or "phytomining."

This paper uses data from both bench and pilot scale biomass gasification systems to evaluate the economics using hyperaccumulators as crops to be converted into primary metal ores. The metals of interest include copper, zinc, chromium, cobalt and nickel. The costs of producing the ores are compared with costs of recovery and refining of natural ores and with the costs for remediation of metals contaminated soils.

Small Modular Biopower for a Community Productive Use Platform

Art Lilley[a], Robb Walt[a], Jerome Weingart[b]

An advanced small modular biopower (SMB) system known as *BioMax** has been developed by Community Power Corporation (CPC) for markets worldwide. This *Community Productive Use Platform* (CPUP), converts available biomass into mechanical, electrical, and thermal power that can power many productive use applications, especially in off-grid areas. The heart of the CPUP is CPC's Gas Production Module (GPM), which converts coconut shells and other dry woody biomass to a producer gas. This producer gas is then supplied to prime movers such as internal combustion engines, Stirling engines, micro-turbines, or fuel cells. The current version uses an internal combustion engine, since this technology is readily available, cost effective, and proven in off-grid applications. The platform can allocate shaft power as needed to mechanical and electrical loads including motors and compressors. The peak electrical output is 15 kWe from conversion of 23 kg of coconut shells per hour. Also, 20 kW of thermal energy is available in the form of clean, hot air for drying crops and fish. A 5 kWe version has been developed for commercial combined heat and power (CHP) applications in a growing North American and European market. In a joint venture with the Philippine NGO *Sustainable Rural Enterprise (SRE),* the BioMax is powering electrical loads including a 10 hp decorticator that separates coconut husks into fiber and dust. The fiber is woven into soil erosion control nets, plant liners, and doormats, while the dust is processed into a highly valued plant growth medium. This successful *integration of renewable energy technology with economically productive uses* in the rural Philippines is providing income to many women at SRE's facility at a small coconut development cooperative.

(a) Community Power Corporation (Littleton, CO), (b) Jerome Weingart and Associates, (Arlington VA)

* The BioMax was designed and built with support from NREL and Shell Solar B. V.

Bioenergy Conversion for Sustainable Rural Enterprise in the Philippines

Perla Manapol[a], Jerome Weingart[b], Art Lilley[c], and Robb Walt[c]

In much of the rural Philippines there is an abundance of coconuts. Yet in many of these areas there are (a) high unemployment, especially among women, (b) lack of post-harvest technology due to lack of energy/electricity, (c) decline of the coconut industry due to depressed prices of traditional coconut by-products such as copra and oil, (d) lack of means to add value to coconut crude oil and waste coconut by-products, especially husks, (e) waste coconut husks are left to rot, or are burned, thus releasing hazardous particulates, (f) declining membership in local cooperatives due to lack of capital build-up, and (g) infrastructure projects often require importation of expensive, foreign currency-priced synthetic materials for soil stabilization. A two-year old Philippines NGO Sustainable Rural Enterprise (SRE) in collaboration with Community Power Corporation (US) has established a *unique integration of renewable energy technology and sustainable growing rural enterprise*. CPC's Small Modular Biopower system, running from coconut shells, is powering this enterprise that employs 200 families, and 90% of employees are women. Earnings from production of coconut coir soil stabilization mats and other high value products have doubled rural household incomes, and orders are growing faster than SRE can fill them. Previously unemployed rural women are earning regular income and have become the principal wage earners in many rural families. Many of the women are now *bonafide* (with voting privileges) members of the cooperative. Rural women do not have a voice in most cooperatives because they have no voting rights. Empowering women workers is one of SRE's most significant achievements! Also benefiting directly are small coconut farmers and their cooperatives, starting with the Ibajay Coconut Farmers Development Cooperative.

(a) Sustainable Rural Enterprise, Aklan, Philippines. (b, c) Community Power Corporation, Littleton, CO. (d) Jerome Weingart and Associates, Arlington, VA.

Biofuels + Precise Combustion Control = A Practical, Safe, Clean Platform for Immediate Transportation Needs

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ABSTRACT

With increasingly strict emission and fuel economy regulations for internal combustion engines, the need for more flexible and precise control of the combustion process becomes more important. This flexibility is necessary to run dramatic new combustion cycles that will reduce the requirements for emissions after-treatment, and will improve fuel efficiency and engine performance. To meet these objectives, the air and fuel management functions of an engine will require flexibility and controllability to a degree not currently available with fixed mechanical systems. This paper introduces new technology that can provide tomorrow's engines with that flexibility and control.

Part 1: Fuel Systems – The next generation injection system must provide the advantages of previous fuel systems as well as add new functionality. A new injector must utilize the High Pressure capability of Mechanical Unit Injectors; the Variable Timing and Duration, Performance, and Small Packaging of High-Pressure Common-Rail Injectors; the additional advantages of Safety and High Pressure of Intensified Injectors; and now add Active Rate Shaping.

Part 2: HVA (Hydraulic Valve Actuation) – There are many different system architectures that can be used to control the air in an Internal Combustion Engine. Different applications require different degrees of flexibility. These systems vary from very simple open loop systems with limited functionality to more sophisticated two-stage systems that offer maximum flexibility and performance benefits.

Part 3: Combustion Cell – A packaging concept is presented to demonstrate the advantages of optimizing the engine design to allow for both fuel and air control within a modular package.

**Revitalizing the Sugar Industry:
An Economic Analysis of Biomass Energy in Guyana**

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Abstract
Guyana is at a crossroads. Since its colonial foundations, sugar has been and continues to be the country's single largest employer and backbone of the Guyanese economy. However, newly established World Trade Organization restrictions on preferential trade agreements threaten to destroy the prime market of many sugar-producing Caribbean countries, including Guyana. The country's heavy reliance on sugar revenues has left it with two choices: Guyana must either substantially reduce production costs to meet low global market prices, or find alternative uses for its sugarcane resources. In order to address this dilemma, this paper addresses the potential for biomass energy to reduce sugar production costs through the use of high efficiency cogeneration systems that generate electricity for onsite use as well as sale to the national grid. The results of this study can potentially be extended to other sugar-producing developing countries, particularly in the Caribbean region.

Integrated Pilot/Prototype Design for Supercritical Hydroconversion Biomass

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Design of an integrated pilot/prototype system for supercritical hydroconversion of biomass tested at lab scale is described. The process uses supercritical water above 221 bar (3205 psia) and 374 C (705 F) in once-through steam generator tubes to produce clean synthetic natural gas (SNG) from biomass without oxygen or air. The patented process converts high-pressure biomass-water slurry with external heat. Particle residue and carbon dioxide are separated for beneficial use. Cleaned condensate can be recycled to slurry preparation for zero liquid effluents.

The process was optimized using computer modeling that produced the commercial process design, including mass & energy balances. The commercial process design was used to develop the flowsheet and material and energy balance for an integrated pilot/prototype designed for 625 kg/hr of slurry feed. The pilot/prototype process design was used to prepare preliminary cost estimates by the Energy and Environmental Research Center of the University of North Dakota. The preliminary cost estimates provide the basis for life cycle cost analyses, sensitivity analyses, and proposals for detailed design, assembly and testing of the integrated pilot/prototype with the capability to produce 350 kW of electric power from biomass when combined with a 300 kW fuel cell.

UTILIZATION AND DEVELOPMENT OF BIOMASS OPERATED INTEGATED SYSTEMS OF GASIFIERS, GAS CLEANING, GAS COMPRESSION AND GAS TURBINES WITHIN EU PROJECT TARGET (ENK-2000-00313)

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ABSTRACT

Biomass is considered the renewable energy source with the highest potential to contribute to the energy needs of modern society for both developed and developing countries.

The innovation in practically all demonstration projects relies not only on the technical aspects of the various processes but also on the integration of the technologies in existing or newly developed systems that offer better prospects for economic development.

In the EU project TARGeT (ENK-2000-00313) coordinated by Technical University Delft six partners (SIEMENS, ALSTOM, HOST, IVD, KTH and TUD) have combined their efforts on utilizing and developing technologies for the operation of integrated systems of gasifiers, gas cleaning, gas compression and gas turbines.

Within the current paper the operating experiences are described of an integrated system of Fixed Bed Gasifier, cold fuel gas cleaning (HOST), fuel gas compression (ALSTOM) and small-scale gas turbine (TUD) for power production. Also, the work performed on pressurized gasification, high temperature gas cleaning with ceramic channel flow filters and fuel gas combustion at (TUD) and catalytic gas cleaning using Iron based catalylists (KTH) are described.

Two tar measurement techniques were enhanced (IVD, KTH) in order to perform on-line and off-line tar measurements. With these techniques tar related problems could be examined since condensation is one of the major problems during the use of biomass derived fuel gas for gas turbines. Apart from operational problems also the emission aspects of LCV gas combustors are studied. The combustors provided by SIEMENS showed low emission for the required settings.

Finally, the conclusions and recommendations with respect to systems operation and implementation of gas cleaning are presented in a summary of the technology and implementation plan.

Biogas Systems: Small Is Beautiful

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A 200kW$_e$ digestion plant was analysed at farm-scale; the feedstock consists of pig slurry and the organic fraction of municipal solid waste (OFMSW). These plants tend to have cheaper capital costs than Centralised Anaerobic Digestion (CAD) facilities due to lower specification and the involvement of the farmer in the construction process, reducing the labour element of cost. A more primitive engine is utilised for combined heat and power (CHP) production, resulting in lower cost and lower electrical efficiency. Farm-scale plants tend to operate at mesophilic temperature ranges (35^{o}C), as the digestate is land applied on the farmer's land; this reduces the risk of cross infection of livestock. In the analysis it was found that electricity could be provided to 472 houses and heat to 86 houses. It was found that the gate fee for electricity production was €27/t OFMSW.

The analysis was compared with a 1MW$_e$ plant (CAD-scale). At this scale CHP systems produce electricity at a higher conversion rate than at farm-scale (35% ηe versus 25%ηe). A disadvantage of the CAD-scale system is the requirement to transport all biomass; a transport fleet is part of the CAD-scale system. CAD-scale plants also tend to operate at thermophilic temperature ranges (55^{o}C) as the digestate is exported off-site; this leads to higher parasitic thermal demand. In the model it was found that electricity could be provided to 2501 houses and heat to 240 houses. It was found that the gate fee associated with electricity production was €83/t OFMSW.

The net greenhouse-gas production is negative for both systems when the do-nothing scenario involves landfill of OFMSW without combustion of landfill gas. CAD-scale systems have an advantage in terms of greenhouse-gas savings per unit of biomass.

Supercritical Hydroconversion of Biomass

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Lab-scale testing of a new supercritical hydroconversion process is described that uses supercritical water above 221 bar (3205 psia) and 374 C (705 F) in once-through steam generator tubes to produce clean synthetic natural gas (SNG) from biomass without oxygen or air. The patented process converts high-pressure biomass-water slurry that is externally heated. Particle residue and carbon dioxide are separated for beneficial use. Cleaned condensate can be recycled to slurry preparation for zero liquid effluents.

The California Energy Commission sponsored the project to demonstrate conversion of compost to fuel gas. In-vessel composting of as-received municipal packer-truck refuse and biosolids was used to produce compost. The following conclusions resulted from this project:

- Conditions promote the formation of methane, decreasing the heat required to make the gas and increasing its calorific value.
- CO_2 can be removed automatically in the condensate.
- Pumpable biomass slurry mixtures containing 40 wt% solids are feasible.
- The lab-scale reactor tube converted 98% of the carbon in the slurry to gases at 650 C in less than one minute without tar formation.
- Condensate can be recycled to avoid liquid effluents.
- No noticeable erosion, corrosion or deposition was observed in the test equipment.

CANTEEN WASTE MANAGEMENT THROUGH BIOGAS PLANT AT ASIA'S LARGEST BAUXITE MINES. A CASE STUDY AT PANCHPATMALI BAUXITE MINES, NATIONAL ALLUMINIUM COMPANY LIMITED (NALCO), INDIA.

A. Roul, India

ABSTRACT

In tackling the problem of Solid wastes, the world is divided in to two kinds of people: the back-end thinkers who devise expensive technologies to capture pollution after it is created and the front end thinkers who advocate processes that prevent pollution from happening in the first place. Progressive environmental thinkers maintain that the solution to the environmental and health threat posed by Solid wastes lies not in its recycling but in its reduction and if possible elimination.

The substrate for Biogas generation mostly Dung. Other organic matter available as waste also generate Biogas once it is anerobically treated. The canteen waste, which contains mostly vegetables, Rice, Meat, Fish etc., can also generate Biogas if anerobically treated. The gas generation would be from the base, during digestion of Dung and canteen waste digestion and finally the canteen waste alone.

Panchpatmali Bauxite Mines, National Alluminium Company Limited (NALCO) is a highly mechanized opencast Bauxite Mines and also the largest Bauxite Mines of Asia. The existing canteen at Panchpatmali Bauxite Mines, NALCO, Damanjodi where breakfast, launch and dinner for 300 to 400 people is served every day the Canteen waste per day collected is around 40 Kgs. As the Canteen waste is a nuisance and disposal is also problematic, recycling is required.

A 03 (Three) CUM Biogas plant has been installed at Panchpatmali Bauxite Mines of NALCO. The gas pipes (about 100mtr.) has been connected to the gas stove, which is located in the Kitchen room of Mines Nursery. The gas is used for cooking purpose, making tea/ coffee etc.

From the 40 Kgs of canteen waste per day, 03 cum Biogas is generated which serves the purpose of Coffee/Tea preparation to a great extent in the Mine's canteen. An estimated quantity of 8 tonnes of rich organic manure is yielded per year, which is utilized in the Mines Nursery and also for the purpose of Pisciculture and Mushroom cultivation in mass scale in Mines. The plant is charged initially with cow-dung only. Once the gas is generated canteen waste is mashed and crushed and fed in to the chamber @ 40Kgs per day. This status of waste and during mixture is maintained for a specified period. There after it is slowly reduced to canteen waste only.

The best way to avoid the waste problem is to avoid generation of waste. But still with taking all sorts of care wastes are generated so alternative action should be taken care to recycle it or dispose it. In the process of canteen waste management by Biogas plant, generates not only use full renewable energy (Cooking gas) but also the residue helps in increasing the fertility of the soil/ground and also solve the problem of huge solid waste generated in Mines.

Biofuels in Brazil: a benchmark for sustainable development

José Goldemberg, Oswaldo Lucon, Suani Teixeira Coelho

Abstract

Biofuels are one of the most promising alternatives to increase substantially the share of renewable energy sources in the global matrix, which today is 4.4% including hydroelectric plants. As a means of promoting sustainable development in tune with the Millenium Development Goals, biofuels produced in developing countries could be traded to developed nations. All parts would reap the benefits of mitigating greenhouse gas emissions. Developing countries would have more local jobs, plus economic revenues. Developed nations would have reduced air pollution in urban areas, plus the diversification and security of energy supply. Technology is available and production costs are dropping. It was proven by the Brazilian Alcohol Program, which provided maturity to ethanol, a biofuel that competes with fossil fuels without subsidies in that country. This paper will describe the learning curve effect, the achieved benefits with this Program and a future vision with the flexible fuel vehicles. It will also present the current stage of the Brazilian Biodiesel Program, promoting another important fuel derived from renewable sources. Finally, will be made recommendations for the international deployment of biofuels, towards the achievement of a large international market of renewable energy certificates.

Demonstration and Commercialization of Zero-Emission Power Plants

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ABSTRACT

Clean Energy Systems (CES), of Sacramento CA, has developed and demonstrated a technology that allows construction and operation of efficient, zero-emission power plants. The enabling oxy-fueled gas generator and reheater technologies have been successfully demonstrated under programs, co-funded by the California Energy Commission (CEC) and the Department of Energy (DOE) National Energy Technology Laboratory (NETL). In 2002, the CEC awarded CES $2 million to build and operate a 500 kW_e natural gas fired zero-emission demonstration power plant based on CES technology. That program was restructured in 2003 to change the demonstration site to CES' recently acquired "Kimberlina" power plant and to increase the scale of the demonstrations from 500 kW_e to 5 MW_e. The CEC has added $2 million of supplemental funding to help support the added scope. This new site and facility provide broadly expanded test and demonstration opportunities and will shorten the time to commercialization of CES technology. Plant-level 5 MW_e demonstrations of the CES technology will be conducted in 2004 using natural gas as fuel. The facility will be developed in stages in 2005 to accommodate additional types of demonstrations that can include operation on gasified biomass or the gas products from the anaerobic digestion of plant or animal wastes. These demonstrations set the stage for first-generation zero-emissions power plant (ZEPP) projects as early as 2005. Three such projects in the 40-70 MW_e range are described. CES' ZEPP technology, combined with modern gasification and bio-digestion technology, will make possible zero-emission biomass power plants of modest size (up to 50 MW_e) within 5 years.

Distributed Heat and Power Biomass Systems

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Abstract

Biomass has two important characteristics that impact energy conversion technologies: (1) it has low energy density and high moisture content, and (2) it is a distributed resource of low mass density; expensive to transport over distances. Large centralized power generating systems can take advantage of economies of scale and are the preferred choice. However the bulk of the available biomass can only be utilized if decentralized biopower energy systems (less than 5 MWe) are implemented. Small distributed systems would preclude the need for biomass transportation and could match the distributed power demand in remote areas. Because of their small size, distributed biopower systems face significant restrictions on capital cost which has an impact on efficiency. Relying on efficiencies developed for large-scale systems will lead to invalid power and carbon displacement estimates for distributed biomass use. It is important to analyze and compare practical distributed power systems that account for plant scaling issues as these impact biomass government policies, the economics of distributed power systems, and the life cycle analysis for carbon displacement. This paper will compare four distributed biopower technologies designed to produce 2 MWe using forest wood residues with a higher heating value of 20.5 MJ/BDkgfuel and moisture content of 50%. Modeling assumptions, design decisions, heat losses, and component efficiency assumptions made during the analysis are discussed.

Performance characteristics and thermophysical properties for solid oxide fuel cells

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Abstract
The Energy and Environmental Research Center at the Univesity of North Dakota is working on the development of a biomass power system using a solid oxide fuel cell (SOFC). The successful integration of this new technology requires the knowledge of performance characteristics in the SOFC unit. This work presents the results of a polarization-model applied to an anode supported cell. Although similar models have been developed previously, this work focusses on the implementation of such models using simple computational tools. The activation, concentration, and ohmic losses are considered the limiting factors in our model. A qualitative analysis of these losses is presented using di_erent approaches. The thermophysical properties required in the model were calculated using the method of rational approximations. The method of rational approximations gives better results than conventional curve fitting techniques. Finally, the results obtained from this model will be used as guidelines for improvements in the design of the gasifier-SOFC system and for determining e_cient operating conditions.

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Beehive Briquette – A Reliable Alternative Fuel

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Abstract: Biomass has been the prime source of fuel from time immemorial. About 85 percent of all energy consumed in Nepal at present is supplied by biomass. With the present crisis of fuel wood shortages, the rural population is depending more and more to the burning of loose agro-residues and cow dung for domestic cooking and other purposes. This is a highly polluting practice associated with health hazards. To solve the problem of fuel wood and associated deforestation, these agro-residues should be upgraded to convenient and smokeless fuels. In the present study a simple technology is developed for the production of beehive briquettes by the carbonization of the agro-forestry residues and mixing of the char with binders followed by briquetting. It provides smokeless domestic fuel easily ignitable with sustained uniform combustion. The test results and the tentative financial analysis are presented.

Keywords: Biomass, beehive briquette, agro-residues, briquetting , carbonization, char

Sustainable Biomass Energy Conversion into Charcoal and Its Utilization as Household Energy in Cambodia

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A link between Community Forest and the Community Forest Users group was established to conduct Community Forest Management to get forest concessions and maximize yield. Forest concessions were turned into high quality charcoal using improved technologies and side-by-side collected wood vinegar as a by-product. Charcoal production from a simple 200 liters drum is gaining popularity as a household women's business and is becoming a daily regular income. Char briquettes were also produced from the sugarcane residue were used as a usable fuel to replace charcoal for urban cooking.

The charcoal produced from the Community Forest and char briquettes were compared with the local charcoal in the New Lao bucket Stove (NLBS) and found the charcoal produced from the Community Forest demonstrated better and also the char briquettes could compete with the local charcoal for short time cooking as daily practiced by the Cambodians. NLBS are commercialized through the existing marketing channel. To create sustainable commercialization, CFSP focused on training to quality control and encouraging Stove Producers' Association to safeguard the stove products from unhealthy competition and the warranty system as developed by some stove producers. The pay back period of these stoves are within 2 months. In the year 2003, 36,000 NLBS could saved 5,321 tons of charcoal, which is equivalent 35,478 tons of wood means 8.5 hectares of forest was not being cut and 31,107 tons of CO2 were not emitted to the environment. In terms of cash, it could save US $ 656,598.

Key words: charcoal; community forest; char briquette; calorific value; energy efficiency; commercialization

RULE BASED POWERHOUSE CONTROLS INCREASE BIOMASS FUEL USAGE AND SAVE PULP MILL $500K IN PURCHASED ENERGY IN THE FIRST MONTH

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Abstract

This case study describes the successful application of ruled based regulatory and supervisory controls to a biomass powerhouse operation at a large pulp mill in British Columbia. The project reduces pulp production costs by $10/ton by offsetting natural gas consumption with biomass hog fuel while increasing electric power generation and steam system stability. The project payback was less than three months through substantial reductions in mill operating costs obtained by actively managing boiler and turbine generator operation in coordination with mill operations. The first full month of operation indicated purchased fuel savings and reduced electric power imports in excess of $500K. A new predictive pressure control algorithm stabilizes steam header pressures permitting header pressure control on biomass fuel only. Biomass consumption increased 12% to offset expensive fossil fuel usage while reducing waste biomass to undesirable disposal alternatives. Powerhouse natural gas consumption decreased 48% and net electrical imports reduced 30%.

The project consisted of regulatory control to improve boiler operation and a supervisory rule based fuzzy logic control system to optimize overall powerhouse and facilitate efficiency while improving operator and management decision making tools residing in a personal computer.

Demonstrating the Use of Alaska Fish Oil as a Feedstock for the Commercial Production of Biodiesel

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The Alaska seafood processing industry produces approximately 8 million gallons of fish oil annually. Typically, 2.8 million gallons are sold into commodity markets with the balance consumed on-site as boiler fuel. Some success has been recently achieved in the use of fish oil as a supplemental fuel for large stationary reciprocating engines but the widespread applicability of this practice may be inherently limited. Alaska has potential uses for biodiesel, particularly in fueling smaller stationary engines in remote and ecologically pristine areas where the impacts of engine exhaust and risk of fuel spills are of high concern. There are, however, no commercially viable biodiesel sources in the state attributable largely to a lack of conventional agricultural-based feedstock oils. The Alaska Biodiesel Project intends to demonstrate that biodiesel may be efficiently produced from Alaska fish oil feedstock. Accordingly, the project had procured approximately 5,000 gallons of fish oil from an Alaska seafood processor and arranged for its processing by a commercial biodiesel firm. Operational testing of the resulting product in select engines will be performed by the Alaska Energy Technology Development Laboratory at the University of Alaska in Fairbanks in the summer of 2004. Impacts of the fuel's use on exhaust emissions and durability/maintenance impacts as well as fuel handling attributes will be evaluated.

Waste to Energy
The Vertical Market of Renewable Biogas

By Rocky Hofstetter

Abstract

This presentation will include the following: A definition of anaerobic digestion, and the vertical markets that fall under this category of biogas. These would include agriculture, consisting of dairy, hog, poultry and feedlots. Also waste water treatment plants, and food processing facilities. Other vertical markets include Landfill gas, oil field, and coal bed methane(geothermal).

The presentation will then go into the drivers associated with anaerobic digestion and waste to energy projects. This would include a more in-depth analysis of manure based projects (agriculture waste to energy). Government programs and trends (RPS), and

Market potential of the vertical markets will be analyzed. State market potential breakdown will be discussed specifically for Agricultural applications.

Economics and explanation of project dynamics (case study) will be discussed for wastewater treatment plants, dairy applications and landfill sites.

A strategic analysis on the biogas market will be discussed as well.

Finally, Sterling Engines and there place in the biogas market will be discussed, including the reason for their resurgence and the benefits of using sterling engines compared to reciprocating engine technology.

Utilizing Forest Biomass for Energy in the Western United States: Lessons Learned

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Abstract

Over the past 5 years, McNeil Technologies staff have performed numerous feasibility studies for utilizing biomass from forest thinning projects for energy production. The purpose of this paper is to identify common themes and lessons learned from conducting these studies throughout the western United States of America (USA). Specific topics to be addressed include, lack of data and data reliability, impacts of biomass costs on the economic feasibility, fuel supply risk, challenges associated with developing small scale plants (< 5 MW), impacts of current wholesale electric and natural gas prices on economic feasibility, and common concerns of environmental groups and their impact on implementation of thinning and biomass production. Typically, large biomass plants must be built to take advantage of economies of scale in terms of lower per unit capital and operating costs and improved conversion efficiencies. However, large plants have significant fuel supply requirements, thereby making it difficult to obtain sufficient long-term fuel supplies at a reasonable cost from forest thinning operations. Development of small-scale community based biomass systems offers less risk in terms of fuel supply, but the per unit economics and efficiency of small systems present barriers. The lack of long term planning data by federal, state and local land management agencies hinders the development of long term fuel supply assessments, which in turn increases the fuel supply risk of biomass plants and reduces investor confidence.

Biodiesel: The Driving Forces Behind Commercial Growth in the US

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Abstract

Biodiesel has been called the fastest growing alternative fuel in the nation. Enthusiasm for the fuel seems to be contagious thanks to its ease of use, thorough testing and a host of benefits. The nonprofit National Biodiesel Board (NBB) is widely hailed as the voice of the biodiesel industry. This presentation will give a snapshot of the US biodiesel industry as it stands today, including who uses it, which markets hold the biggest potential for growth, and how the distribution process is likely to change. Highlights from the latest research addressing technical barriers will be covered as well as state and federal regulatory issues impacting the industry's success.

Biofuel for rural sustainable development in drought prone Africa: A collaborative development model

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Abstract

Biofuel technologies offer the potential for reducing the depletion of fossil fuels and the emissions of carbon dioxide and other greenhouse gases. Renewable energy is shifting from the fringe to the mainstream of sustainable development. In Africa, this is primarily due to an abundance of renewable energy sources and characteristics specific to remote rural communities that make fossil fuel based energy systems extremely expensive. It has been argued that jatropha oil, a renewable energy source, currently being promoted in some African countries can be a suitable substitute for diesel. This paper examines the physico-chemical properties of Jatropha oil that makes it a cleaner and locally available diesel fuel substitute. It assesses the potential impacts of the biofuel on the rural economy and presents a development model for a sustained biofuel enterprise aimed at rural economic empowerment in drought prone rural African communities.

*Keywords:*Jatropha; biofuel; development; rural African communities; diesel

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Renewable hydrogen production combined to allow synergies of CO2, SOx and NOx capture from fossil fuel combustion and large scale carbon utilization

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Purpose: The development of hydrogen as a renewable energy source with a large and value added sequestering fertilizer co-product.

Approach: A technical and economic overview will be presented covering recent research of a renewable energy production with a carbon/charcoal utilization process.

Scientific Innovation and Relevance: In this system, predominately rural based agriculture energy crops and forestry residue are used to produce hydrogen and charcoal, which together can be processed into a novel catalytic agent for the formation of sequestered carbon compounds from fossil fuel (or biomass) combustion containing high percentages of available nitrogen for farming applications. This allows renewable energy to provide both sustainable energy and fertilizer production.

Results: While a portion of the hydrogen is consumed, three times as much is produced for utilization or sale. The low efficiency requirements of renewable hydrogen conversion to ammonia and the economical production of charcoal based fertilizer support this path for rural economies. Evidence of charcoal effects as a soil amendment and agent for increasing crop productivity will be presented.

Conclusions: Production and processes appear economically and environmentally attractive for ingredients in fertilizer manufacture and evidence shows contribution to long-term soil fertility increases. The process offers mutually beneficial roles for fossil fuel, agriculture and forestry to allow a simple and reasonable migration to sustainability.

Global Biomass Potential for Power and Heat Generation

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Abstract

Fuels derived from biomass are not only potentially renewable, but are also sufficiently similar in origin to be the fossil fuels to provide direct substitution. They can be converted into a wide variety of energy carriers as of recent through conversion technologies, and thus have the potential to be significant new sources of energy into the 21st century.
Energy balance of biomass production The CO2 mitigation potential of energy crops and the energy balance are considerably large.

- Annual primary biomass production: 220 billions DM, 4,500 EJ = 10 times of world primary energy consumption.
  Biomass used for food: 800 millions DM = 0.4% of primary biomass production.
- Annual food production corresponds to 140% of the needs of world population.
- Biomass currently supplies 14% of the worldwide energy consumption. The level varies from 90% in countries such Nepal, 45% in India, 28% in China and Brazil with conversion efficiency of less than 10%. The potential of improving this efficiency through novel technologies is very high.
- Large areas of surplus of agricultural in USA, EU, East Europe and former soviet countries and could become significant biomass producing areas (> 200 millions ha).
- Micro algae have the potential to achieve a greater level of photosynthetic effiency than most other forms of plant life. If laboratory production can be effectively scaled up to commercial quantities levels of up to 80 mt/ha/yr may be obtained.
- The efficiency of photosynthetic is less than 1%. An increase in this efficiency (through plant breeding and genetic engineering) would have spectacular effects in biomass productivity: successful transformation of C4-mechanism (from maize) to C3-crops (rice). New achievement in accelerating cell division opens opportunities to speed up the growing seasons, resulting in several harvests per year and an overall increase in biomass.
- Developments in power and heat generation as well as car technologies are leading to significant reduction in biomass fuel consumption.

This contribution will discuss all these aspects in details.

Renewable Energy Scenario in Bangladesh: Estimation, Expectation and Future Trend

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Abstract

Renewable energy scenario of Bangladesh is estimated on the basis of solar insolation, biomass, wind, hydropower and tidal sources. The patterns of the total sunshine hours (ten years) have been obtained and expected value of solar radiation is presented by statistical analysis. It has been observed that strong solar insolation is achieved in the month of March, April and May, and 1 sq. meter area has the potentials of generating 5 to 6 KW electricity per hour. Biomass and hydropower are in active use that supplies about 70% and 0.15% respectively of the total amount of energy demand. Per capita energy consumption is 240 KgOE that is 115 KW/h (2002). But the energy demand is growing at a rate of 10% to 13% per annum. The power generated from PV and other sources are solar PV (800KW), wind turbine (20KW), wind pump (6), micro hydro (10KW) and biogas plants (10,000). The demand supply situation in 2005 is 4597 (D), 24,000 GWH (S) and in 2010 6779 (D), 35,000 GWH (S). Energy supply by traditional fuels like cow-dung, jute stick, firewood, twigs and leaves is about 10760 MkgOE in 1999. Energy reserve in Bangladesh from resources like coal, crude oil, natural gas are 70 million, 5.5 million, 10.44 TCF (17 gas fields) respectively. Potential and other alternative energy sources are wind power, hydroelectric power, tidal wave, nuclear power, etc. As expected solar power remains fairly uniform in this region, it is suggested that with suitable tracking system and storage facilities SPV system would be a strong reliable and environment pollution-free source of energy in Bangladesh.

PROMOTION OF RENEWABLE ENERGY SOURCES IN ROMANIA: CURRENT STATUS AND BUSINESS OPPORTUNITIES

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The present paper intends to emphasize relevant business opportunities related to the capitalization of renewable energy resources on the national energy market. The total technical potential of renewable energy resources is over than 11 millions toe, that represents about 30% from the total primary energy supply reported in 2001 (the most important contributors being the solar energy, wind power and biomass). The main goal of national policy in the field is to increase the weight of renewable energy sources up to 11% from the total primary energy supply in 2010 and up to 11,2% in 2015. Romania is a country of about 238.391 km^2, situated in the South – East region of Europe. The relief configuration comprises all three major forms, from Carpathians heights to lowlands, Danube Delta and Black Sea coast. The population is of about 22 millions inhabitants. Aiming the increase the security of primary resources and the mitigation of economic activities' impact on environment, the Romanian Government decided to develop a sound policy for the development and capitalization of renewable energy resources. Consequently, the Government Decision no.443/2003 related to the promotion of electricity generation based on renewable energy sources, the Government Decision no.1535/2003, regarding the **S**trategy of **R**enewable **E**nergy **S**ource**S** (STRESS) and its corresponding **PRO**gram for **R**enewable **E**nergy **S**ources (PRORES) have been recently issued. Based on the commitment of the Romanian Government to launch credible programs for the renewable energy sources use at national scale, an Action Plan defining actions, measures, responsibilities, financial needs, financial sources and deadlines has been settled. Details on current political, legal and institutional framework, on regulatory issues and tariffs, existing financial and fiscal incentives should be provided. Conclusions on already executed pilot projects should be envisaged, too.

Renewable Energies: present situation and future development

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It is commonly believed today that Renewable Energies Technologies (RET) are mature and for certain applications, under certain conditions are competitive with conventional electricity generation plants. RET cover a large number of applications and are costly-effective, particularly in remote area where grid connection is costly ,or when they are utilized to meet specific needs like water desalination with solar energy or hybrid systems. The best example of technological improvement of RET is the large use of wind energy to produce electricity for the grid. The installed wind capacity in European countries exceeds 15500 MW and in some cases the achieved penetration is over 6%.

Two main features characterize the situation of RET. On the one hand, we can note a great progress of available technology in the market, strongly concentrated in the north of Mediterranean Basin, versus an important natural potential of solar radiation and windy sites in the south of the same region. On the other hand, installed capacities, especially in developing countries are still limited in comparison with the high potential demonstrated by several national and regional studies relating to rural electrification with photovoltaic systems, solar water heating and pumping, water desalination and of course wind energy.

It is obvious that this contradictory situation of RET opposing technological maturity to limited share in the national electricity production, which is less than 0.1% in many cases, is due to many barriers. Maybe, the most important is financial backing shortage. This main barrier constitutes a serious handicap to Renewable Energies (RE) development and competitiveness with conventional technologies such as combined cycle using cheap natural gas.

In this paper, the emphasis will be put on three main issues (1) description of present situation of RE in Tunisia and the experience of the Tunisian Society of Electricity and Gas (STEG) in this domain, (2) the point of view of Tunisian operators with respect to RE market development and (3) an attempt to analyse the financial barrier and to propose possible mechanisms to make easier the promotion of RE, considering the specific case of wind energy.

Collaborative Efforts with Institutes in the Former Soviet Union on Renewable Energy Technologies

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The Initiatives for Proliferation Prevention program (IPP) funded through the US DOE is a cooperative program designed to provide meaningful, sustainable, non-weapons related work for former Soviet Union (FSU) scientists and engineers, working on weapons of mass destruction. The IPP program provides seed funds for the identification and maturation of technology and facilitates interactions between U.S. industry and NIS institutes for developing industrial partnerships, joint ventures, and other mutually beneficial arrangements. To date, the IPP Program has engaged over 14,600 FSU weapons workers in 180 FSU institutes. The collaborative nature of this effort, as well as its wide reach into the FSU scientific community, makes IPP unique among non-proliferation initiatives. In the last three years, as projects have matured there has been an increased rate of commercial outcomes in the FSU and US, creating sustainable jobs. Under the IPP program, NREL has been collaborating with two-dozen institutes in Russia, Ukraine, and Armenia. Special emphasis has been placed on projects connected with renewable energy technologies. These include: wind, and biomass resource assessment; hydrogen from photosynthetic processes; the development of PEM hydrogen fuel cells; low-cost silane production for silicon solar cells; triple junction concentrator cells; new encapsulants for solar cells, and UV-solar concentrators for the accelerated testing of materials. In the presentation, the rationale for the IPP program will be discussed and highlights given of the various collaborative efforts. In addition, there will be several poster sessions exhibiting the scope of these projects and their successful outcomes.

Developing a Renewable Energy Strategy for Victoria, Australia

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With energy demand rising at over 2% per annum, renewable energy has an increasingly important role to play in Victoria's transition to a sustainable energy future.

The Victorian Government has set a target that by 2010, 10% of Victoria's electricity consumption will be from renewable sources. Currently, the majority of electricity is generated from brown coal.

While Victoria has an abundance of renewable energy resources including wind, hydro, geothermal, and biomass, there is a range of constraints limiting the development of this potential.

The Victorian Renewable Energy Strategy identifies measures to address these constraints and to facilitate achievement of the renewable energy targets by 2010. The Strategy also looks at innovative measures to realise Victoria's renewable energy development potential in the long-term.

PROBLEMS AND PROSPECTIVES OF SOLAR ENERGY APPLICATION IN UZBEKISTAN

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In this report there is given a review information about problems and prospective of using solar energy in Uzbekistan. There are shown the main directions of development of solar power engineering in Uzbekistan. The data about demonstrational installations working on solar energy and which are perspective for Uzbekistan are brought.

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Comparison of Energy Storage Systems Applicables to Sustainable Use of Energy

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This work is a comparative study of the different energy storage systems, which are already in use or are still in development.
The implementation of energy storage system has many advantages: enable the integration of renewable energy to the grid, enable the energy supply to remote locations, enable a better utilization of the generation and transmission capability, and improve the grid stability. Because of this, the implementation of energy storage system play a fundamental role in the sustainable use of energy.
This work deals with different energy storage systems: batteries, regenerative fuel cells, CAES, pumped hydro, flywheels, supercapacitors and SMES. The evaluated issues are: range of application, advatanges, disadvantages and enviromental impact. This comparative study facilitates the choice of the best energy storage system for each application.
The different energy storage technologies cover a wide range of applications: from hundreds of kW-h (flywheels, supercapacitors) to a few GW-h (SMES). Batteries are most popular, cheap and adaptable, but require replacement and have dangerous materials. This can be replacemnet by supercapacitors and regenerative fuel cells, which are more expensive and require more sofisticated technology but have less enviromental impact. Pumped hydro and CAES are used in large scale applications, with low enviromental impact. SMES are a large scale storage system too, but it still in development and require complex technology. The stand-by losses of flywheels difficult its implementation to storage energy from renewable sources.

RELIABILITY AND PERFORMANCE OF POWER DISTRIBUTION NETWORK – A CASE STUDY IN THE CITY OF DHAKA, BANGLADESH

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Abstract

In the modern world, the importance of uninterrupted supply of electricity cannot be overemphasized. Per capita consumption of electricity is universally adopted as a yardstick of the living standard of a nation. There are three principal components in a typical electric power supply system. These are (a) the generating plant (b) the transmission system and (c) the distribution network. All these components must function properly to ensure the quality of electricity supplied.

The paper reports the performance characteristics of the distribution network in the context of reliability. The distribution network plays a vital role in the total power system. This links the consumers and sells electricity produced by the generating plants. A number of factors influence the smooth functioning of the network system. Network structure, method of operation, fluctuation of voltage and frequency, nature of protection system, maintenance management, organizational structure etc. may be identified as the major factors.

In this paper attempt has been made to investigate the reliability of electricity supply of distribution network under Kawran Bazar sub-station in particular and Dhaka city in general. Appropriate reliability indices have been calculated using the data and information collected from the consumers and departments. The distribution network under study having about 17 (seventeen) vulnerable elements is effectively a series system without having any parallel facility. Failure of one or more of the elements in the system results in disruption of electricity supply of the selected part. Data and information gathered from relevant sources have been utilized to evaluate the expected failure rate of the elements. These results have been used to determine the overall reliability of the system.

The average outage duration has been estimated to be about 38 hours in a year. Surveyed. This parameter for a developed country like France is only 0.82 hours. Failure rates for individual elements of the system have been evaluated and the rates for switch gear, overhead line, underground cable, and transformer are unusually very high compared to any developed nation. Though this study is confined within a part of Dhaka, Capital City of Bangladesh, the paper describes the critical factors, which are responsible for reliability of distributed electricity in a developing country

European Laboratories for Distributed Energy Resources —Technology and International Co-operation

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The current change of the electricity supply structure towards decentralised power generation requires a change of current safety, control and communication technology. New technical approaches concerning the functions of distributed energy resources (DER) have to be tested, quality of products has to be guaranteed and operational requirements have to be harmonised. DER laboratories are essential to cover these tasks.

In this paper selected European DER laboratories will be technically described. One of these laboratories is the DeMoTec Test and Certification Centre operated by ISET and Kassel University. The laboratory environment enables tests concerning the grid integration focussing on grid control, local generator control, power and communication interfaces. A primary role of the hardware environment is to ensure the performance and safety of distributed generation technologies and to support the development of standards.

Pre-standardisation activities are necessary on the system level as well as on the component level and especially concern interfaces and control features of the units. Today's pre-standardisation activities for new DER technologies take place independently and are not yet internationally co-ordinated. On the European level ISET chairs the European cluster of research projects in the field of DER and co-ordinates the area for laboratory activities that will be described. The chance of close international co-operation between DER laboratories at an early stage is to get a common understanding of the standardisation requirements for an efficient future power supply's systems technology.

A neural network model to forecast urban electricity consumption from weather data

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Abstract

The short-term load forecasting (STLF), with lead times ranging from a few hours to several days ahead, helps grid operators to make a cost effective scheduling of resources, purchase of energy, maintenance and security analysis studies. The use of reliable load forecasting models is necessary for a rational use of electricity, taking into account that it is not storable. Climatic conditions certainly have a remarkable influence on electric energy demand, and their incidence became quite overwhelming also for supply of energy, when it is obtained by renewable energy sources such as wind power and hydroelectric power.

This paper investigates the correlation of weather variability with the electricity demand of a suburban area, focusing attention on load forecasting with a prediction time of 24 hours. A preventive classification of the historical load data is carried out by means of a hierarchical clustering algorithm. The actual forecast is obtained using a two layered feedforward neural network, trained with the back-propagation with momentum and variable learning rate algorithm. The neural network is trained using weather data along with historical load data related to a part of the electric grid of the town of Palermo (Italy).

A Theoretical Evaluation of A Cogeneration System's Total Energy Efficiency Considering Fluctuation in Heat and Power Demands

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ABSTRACT

The total efficiency of a CHP system is commonly estimated using average heat and power demands. It is known that the estimated total efficiency greatly differs when using hourly average demand as opposed to using annual average demand data. The aim is to determine the numerical values of the demand effect when examining the total efficiency of a CHP system; and to explain analytically why the influence arises. In the study, the degree of fluctuation in demand affects total efficiency of a CHP system; such process is termed the error in estimating total efficiency. The error is simulated by a mathematical model. The error is modeled as the ratio of the estimated total efficiency to the real total efficiency. The model indicates that the error is affected by: (1) the heat to power ratios of the site and of the CHP system itself; (2) the efficiencies of CHP-power generation and of the auxiliary boiler; and (3) the demand fluctuation of the site. Total efficiency is always overestimated and not underestimated, compared with actual total efficiency. The error achieves its maximum value when the heat to power ratio at site and of the CHP system match. The error is nearly constant, when a heat to power ratio at the site is higher than the heat to power ratio of the CHP system itself. The proposed study serves to improve theoretically the evaluation of total energy efficiency of a CHP system. A Fuel-cell-based CHP system is investigated as a numerical example.

Distributed PV Solutions for Power Outages: Case Study of 8/14 Northeast Power Blackout

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Tom Hoff, Clean Power Research
John G. Williams, New York State Legislature
Christy Herig, Segue Consulting
Steve Letendre, Green Mountain College
Robert Margolis, NREL

The massive power outage that affected the northeastern US on 8/14/04 was initiated by a failure to take immediate corrective action when power lines tripped off after touching trees. It is generally accepted that, had regional demand been lower, the initial triggering events may not have cascaded into a massive regional blackout.

In this paper we evaluate the role that distributed PV could have played to mitigate this outage by enhancing the reliability of power delivery. Specifically we

- Review the ongoing investigation on the power outage -- notably as it concerns the determination of its triggers and aggravating factors -- with the objective of (1) extracting the enhancing roles played by high loading throughout the concerned portions of the grid, and (2) estimating the amount of demand reduction and reactive power support that could have mitigated the cascading effects.
- Present the regional and localized capacity that would have been available from a dispersed PV resource prior, and during the outage event. In particular, we focus on the load pockets of New York City and Long Island where millions stayed out of power for more than 24 hours.

IEEE Std 1547 Series of Standards: Interconnection Issues

Thomas S. Basso and Richard DeBlasio, National Renewable Energy Laboratory

Abstract-- The IEEE Std 1547^{TM} – 2003 *Standard For Interconnecting Distributed Resources With Electric Power Systems* is the first in the 1547 series of planned interconnection standards. There were major issues and a wealth of constructive dialogue and documentation that arose during 1547 development, as well a perceived increased vitality in updating complementary IEEE standards and developing additional standards for accommodating modern electrical and electronics systems and improved grid communications and operations for today's electric power systems. Power engineers and other stakeholders looking to the future are poised to incorporate 1547 into their knowledge base to help transform our nation's aging distribution systems while helping to alleviate some of the burden on the existing transmission systems.

The Role of Storage Devices in Distributed Electricity Networks and Renewable Energy Systems

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Distributed energy (DE) has become almost a catch-all phrase for anything that is (1) smaller than a "central" generating station and high-voltage transmission line; (2) non-utility, at least the regulated variety; and/or (3) operates at voltages characteristic of the electric distribution portion of the transmission and distribution grid.

Among other things, DE represents an ideological shift from a highly regulated, socialized approach to electricity supply to a consumer-oriented approach that stresses individual responsibility. Analogies can be made to health care and other services: A minimum level of service and quality will be guaranteed, if you will, by the regulated model to all consumers (see figure 1). Beyond this, individual consumers will be responsible for identifying what their reliability, security, and price needs are, and then paying for them. The identified services may still be provided by a utility or utility-like entity, and multiple DE systems could be networked and operated and managed as a micro- or mini-grid, but the consumer will ultimately be more and more responsible for his or her "electricity destiny."

However you define it, DE will only succeed if it can meet the following demands, compared to the traditional approach of coupling large remote central stations and long transmission lines:

- Lower or at least equivalent price of delivered electricity to the consumer
- Equivalent or higher reliability and energy infrastructure security features
- Better overall environmental footprint, an evaluation that is very subjective and difficult to quantify
- Systems and hardware that are appliance-like, in that they operate largely unattended (central air conditioning units, refrigerators), or can be serviced in ways that make them unobtrusive to the consumer.

These demands are more easily met if energy storage devices are integrated into the DE network. Storage devices play a role that can described as in-between traditional uninterruptible power systems (UPS) and distributed generation (DG) devices—prime movers such as microturbine/generators and engine/generators, and fuel cells, and Stirling engines. Devices include advanced batteries, including flow batteries; large scale versions of traditional batteries; and flywheels.

Above all else, storage must be considered an *asset optimization* tool. These devices help bridge the gaps between generating electricity, moving electricity, and using electricity.

"Renewable Energy, a topic for motivation in Education"

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Three aspects of the present way of education are considered in this work:

- To clarify the concept of Renewable Energy.
- To present an alternative way to light educational technology.
- To impulse the demand of Renewable Energy applications.

Renewable Energy is commonly confused with its energy sources and/or applications. That is why some people say: "Renewable Energies", in plural, when the energy is only one. This mistake occurs particularly in Latin languages.

The term Renewable energy is singular because is only one energy which is transformed depending on the way, fluid action or device. Also the first source of renewable energy over the world is the Sun.

Related to the second aspect is the extended application of computational software for education. On the other hand Renewable Energy Applications not only can be explained by software but also by handcraft practical models and prototypes. Particularly is developing countries, there is a common sense of advantages and disadvantages among the renewable energy sources but the people is not very fond of how to make the application and how it costs.

This work presents:

- The concept over Renewable Energy, and its difference with Renewable Energy resources and applications
- The harmony between cybernetical and practical education through renewable energy applications and sources in the teaching-learning process.
- How renewable energy topics in education impulse the demand of its applications.

Efforts on Building Human Capacity Through Curriculum Development and Renewable Energy in Nepal

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Abstract

This paper presents a portfolio of various academic and policy works intended to build human capacity in Nepal, particularly related to environment and energy, and were initiated by U.S. organizations and U.S. interest groups. The U.S. Department of Energy and the National Renewable Energy Laboratory began the work to assist Nepal with energy policy and curriculum development in 1998. A plan was devised to support His Majesty's Government of Nepal in establishment of self-sufficient centers for the coordination and promotion of renewable energy business development and deployment in Nepal. This effort introduced renewable energy curriculum and engineering evaluation of micro-hydro in Nepal. After the conclusion of this task, another initiative was brought together that included University of Colorado, Boulder, NREL, and Nepalese experts to establish a Masters degree in renewable energy engineering in Nepal. The work was well received by the Nepalese government that it later completed a 'Zero Energy House' and an Energy Park in Nepal. The drive to promote higher education and sustainability in Nepal resulted another initiative that brought together NREL, Colorado School of Mines, and Red Rocks Community College in partnership with a Nepalese national university, Tribhuvan University. The goal was to establish an environmental engineering curriculum at all the Diploma engineering schools across Nepal and also to help reduce the high failure rates of Diploma students in mathematics and science. The curriculum has been developed at CSM and shared with the administration and faculty of Tribhuvan University. Additionally, discussions about reducing the failure rate of engineering students at Tribhuvan University have taken place and suggestions for remediation offered at seminars in Nepal.

To meet the energy and environmental challenge faced by the Kingdom of Nepal, Tribhuvan University now has established a Center for Pollution Studies in addition to the Center for Energy Studies. One of the primary goals of the Center for Pollution Studies is to launch a pollution testing laboratory of national standing. This will bring much needed research and development work on energy and environment to the university and the country. In order to accelerate this process, Tribhuvan University has just signed a memorandum of understanding with Colorado School of Mines. Soon, given adequate funding, these two universities will work together with U.S. and Nepalese governments and interest groups to bring the pollution lab and environmental research to Nepal.

Solar Energy Educational Demonstration System for Schools "Mini Solar Laboratory"

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The UK's Department for Environment Food and Rural Affairs (DEFRA) has supported the purchase of a "Mini Solar Laboratory" for a secondary school in Warsaw (Gimnazjum nr 4) via its Environmental Assistance Fund. The project was of one year duration, commencing February 2003, and its aim was to establish a demonstration instrumented solar water heating system as a teaching resource.

Scientific and technological management was provided by Dr. Chwieduk of the Polish Academy of Sciences, solar panels were sourced by Riomay Ltd (UK), installation and instrumentation by HEWALEX (Poland) and educational materials by Dr. Chwieduk (Poland) and Dr. Critoph (UK).

The tight time schedule necessitated close liaison between the local authorities, the school and the suppliers. Progress was facilitated in March 2003 by the decision of the Mayor of the Ursynów District to become a patron of the project and assist with planning approval etc. All parties agreed the basic system concept and instrumentation needs and by June the plans were fully formulated. Two types of solar collectors were installed, a typical flat plate solar collector produced in Poland and vacuum solar collectors (Nippon Electric 'Suntubes' sourced by Riomay). Both solar collector systems have been linked to one storage system, one DHW system and a space heating system. The instrumentation had to be 'student-friendly' and so a PC based monitoring and graphic visualisation was needed. After reviewing solar monitoring systems, equipement, tools and software available on the British and Polish market it was decided that Polish products would be used, thereby making the system easier to install and maintain (in its country of origin). It is also most important that the software was in Polish, which helped dissemination of the operating results.

In June, PAS, Riomay, Warwick and the school decided to equip the solar lab with 10 educational PV sets and not to install the PV on the roof (as per the original plan). The decision was made partly because of the complicated and expensive monitoring and visualization system needed for PV but also because it enabled a much more direct 'hands-on' experience for the pupils.

In July the shipment of the solar equipment: the Suntube DP6-2800 solar collector and 10 PV educational kits took place. Installation of the water heating system was completed in August and the monitoring system in December. The visualisation system allows monitoring and analysis of the solar system not only by the school pupils it is provided for but also by anyone interested, via a telephone link to the modem of the school PC.

The education materials were prepared in a form of special solar brochures, leaflets, Power Point presentation and posters.

The full paper will give schematic diagrams and photographs of the system and describe how it is planned to introduce the school pupils to the technology of solar water heating.

Development of a Renewable Energy Engineering Instructional Laboratory

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This paper presents the development of the renewable energy (RE) instructional laboratory at Northern Arizona University. The Sustainable Energy Solutions Group had many goals when designing this laboratory. The primary goal was to increase awareness of renewable energy and related concepts within the minds of engineers. Another core goal was to create a catalyst for collaborative RE design projects involving students and the business community. By creating opportunities for hands-on experience and applications for theory, the teaching laboratory is being incorporated into standard curricula in fluid dynamics, thermodynamics, solid mechanics, and engineering design. It also provides working examples of power generation, conversion, and energy storage systems for an upper-level course focusing on renewable technologies. The facility has matured into a flexible off-grid and grid-tied system housed within a small building and fenced yard. The current data collection capability consists of 40 channels where students can monitor system performance parameters such as available energy (wind or insolation), power production, and conversion efficiencies throughout the system. Additional channels are periodically reconfigured for student projects. Specific examples of laboratory activities are presented including exercises used in the RE Technology course and strategies for increased visibility and community involvement.

FROM CARHARTS TO BENCHMARKS: ENERGY EDUCATION AT YAMPAH MOUNTAIN HIGH SCHOOL

PRESENTER: SUSY ELLISON
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Shelter, that most basic of animal needs, receives an interesting twist in the human world; it often becomes a means of ignoring and shutting out natural systems instead of conforming to the requirements of those systems. Buildings are designed with no apparent regard for natural resource consumption, both during construction and throughout the life of the building. Sites are chosen that are distinctly 'out of sync' with natural processes. Materials are selected that show no awareness of their origin, abundance, or appropriateness. Human shelter at the beginning of this millennium seems to be synonymous with arrogance; we build as if we have a right to use resources both in the building process and throughout the life of the building, without any care towards long term sustainability of natural systems. Schools are usually built to satisfy financial constraints. Funding is rarely available to cover the 'up-front' costs of designing and building facilities that incorporate energy efficiency and resource conservation as guiding principles.

As part of a curriculum focusing on energy-efficient building, students at Yampah Mountain High School designed and built a 500 square-foot classroom building. The building's electricity is provided by a grid-tied PV system. While the final, tangible result of this project was a building; the project's primary focus was energy education and helping students to develop a personal connection between their actions and the natural environment. The construction process was a vehicle for developing this connection, while the completed building provides its own curricular lessons. Today's students will be making decisions in the future about resource extraction, use, and value. One of the primary goals of education must be the creation of environmentally literate citizens who make those decisions fully understanding the potential environmental impacts that they may have. This project helped students develop those environmentally based critical thinking skills that are so important to the future sustainability of our planet's ecosystems. Since completion of the strawbale classroom, curriculum offerings at Yampah Mountain High School continue to focus on resource and energy use.

My presentation will include background information on the project, images taken during the construction of our building, and information about incorporation of energy-related topics into Yampah's science and social studies curriculum.

Micro-enterprise of Rural Women for Modern Energy Services in Bangladesh

by

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Energy for lighting by solar photovoltaic (PV) made available in the remote areas has dramatically changed the lives of many people in the off-grid areas of Bangladesh. It is being found that proactive development planning can contribute to use of alternative energy sources both as income generating opportunity and improvement of overall quality of life. A micro-enterprise of trained women in the remote locations have made significant contribution to this endeavor under the project "Opportunity for Women in Renewable Energy Technology Utilization in Bangladesh". This paper presents an example of women's involvement in providing energy service to the local area in remote locations in Bangladesh and their replication in other areas of the country. In their communities women are providing energy services, in addition to manufacture, sales and maintenance of components of solar home systems, battery charging stations, and other energy applications. The project promoters were able to organize women to utilize their skills for income generation in an unfamiliar field and thereby enhancing the status of women for the whole community and improving their livelihood. This project holds the promise of being replicated in other developing countries with similar needs and resources.

Benefits and Constraints Perceived by Women in Use of Solar Cooker for Domestic Cooking

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ABSTRACT

Increased uncertainty regarding future cost and availability of fuel energy has led to an intensified research for viable commercial renewable sources of energy. Solar cooker assumes a special significance in context of cooking fuel requirements of India as the country receives 250-300 days of sunshine per year. For the present study, a sample of 100 women users of solar cookers was selected randomly from the list of owners of solar cookers which was prepared using the snow-ball technique. Findings revealed that the majority of respondents were in the age group of 32-50 years (82%), were housewives (58%), having education up to graduation level (42%), and possessed the solar cooker for more than one year (74%). Nutritional aspects (preserving nutritive value and natural food flavors), environmental aspects (keeping environment and utensils clean), and economical aspects (saving fuel and money) were perceived as most beneficial, in the given order. Personal benefits like saving of time, convenience, and enjoyment of solar cooker ranked quite low in the ranking of perceived benefits. Situational constraints like no cooking after evening, seasonal use of the cooker, and no cooking at a short notice were perceived as most severe constraints. These were followed by technical constraints (limited cooking possibilities and the device not being durable) and personal constraints (shifting of device and requiring early planning of meals). Respondents also reported lack of knowledge regarding the contact person/place for repair of solar cooker as a problem. On the whole, respondents were only partially satisfied as far as availability of solar cooker in the market, its construction and use were concerned. The paper also highlights the modifications as desired by the respondents in the design of the solar cooker.

Gender Perspective on Fuel Energy Resource Management Problems in Rural Households of India

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ABSTRACT

Gathering of minimum of fuels for cooking and other domestic purposes is an important task for rural women in India. A vast majority of women walk long distances to collect it and carry it as a head load, thereby, making it a physically strenuous and time consuming activity. The problem of fuel wood energy resource management becomes more acute with the depleting forest resources. A direct impact of fuel wood scarcity is observed in food preparation patterns. As a coping measure, women now cook fewer meals a day and have shifted away from foods that require longer cooking times; thereby spending less time on cooking. This is leading to under-nutrition among children who are unable to consume large quantities at a time. Non-availability of fuel wood has also forced women to substitute it for poor quality biomass that produces noxious smoke from cooking fires, resulting in enhanced indoor air pollution. Increased exposure to this smoke has increased health risks for women and children. Thus, the problem of fuel wood (un)availability is as much an issue of quality as of quantity. Increased time and energy allocated to fuel wood collection can be responsible for constant strain on their health, besides the loss of man-days as agriculture labor which results in diminished agricultural productivity and overall money income. Further, to meet their requirements, women are substituting cow dung and agricultural residues (which fertilize the lands) for fuel wood in domestic cooking. Diversion of dung and biomass to cooking fuel, in marginal farming areas can lead to reduced agricultural productivity by lowering the water absorbing capacity of the soil. These issues, discussed in detail in the paper, have strong implications for the policy makers and program implementers in promoting the use of renewable energy resources at household level in rural areas.

Harnessing Renewable Sources of Energy As An Important Tool For Entrepreneurial Venture and also to Reduce The Drudgery that Many Rural Poor Women are Facing in India

By: Anil K. Singh, Ashoka Fellow Chief Executive, NEED, Lucknow, India

1- Elevator Pitch : Did you know that India's extremely with 2700-3000 hours of sun rays each year that becomes most potential natural & environment friendly assets to eradicate the mounting poverty among large section of marginalized women of the society? This will enhance the quality of life through out the community in the villages by empowering women to raise their standard living through sustaining this Micro-Sun Bakery Programme as self-sustaining micro–enterprise. This enterprise will utilize the ultimate renewable resources, sunshine, to cost effectively provide a needed food stable while combating the destructive forces of deforestation & the working to decrease desertification. Besides, these households of villages are without electricity and absence of this technology will remain so far for the indefinite future. The solar power technology that NEED empowers to implement will be used for Micro-Enterprises devoted to producing ranges of bakeries in match with the current & future demand of market-forces. Women entrepreneurs will accordingly be trained in basic business management skills & specific solar bakery management techniques so that they can develop a customized marketing & distribution plan for her region. Touch of quality with non-polluting energy in match with growing daily demand of the market forces shall certainly open-up an innovative eco-friendly avenues with lots of human cum commercial values that together will boost up significantly the living standard of deprived women. Additionally, the majority of India's population, particularly women and girl-child, are quite often in state of living with terrible drudgery. For an instance, Planting, Maintenance, Watering, Harvesting, Crafts Work, Occupational other Agriculture related activities etc. can very well be reduced from the existing state of drudgery by way of introducing the appropriate technology based on harnessing renewable sources of energy.

2. Value : The demands of massive population growth inefficient conversion of woods to charcoal, have outstripped the forest's ability to regenerate. Science strongly supports fact that deforestation is changing weather patterns, soil erosion & depleting plant & animal live. Currently much of the baking in our region is done in ovens that are fueled by charcoal. The use of an oven powered by the energy of sun will allow for enormous volumes of baked goods to be prepared without further damaging to already fragile environment. In the cities, the gas is use to power ovens & utilizing the free energy of the sun will help to decrease the need to import cooking gas and will contribute in a positive way to our country's balance of trade. NEED's project will combine training & business development to provide solution to the growing problems to deforestation and global warning through economic empowerment. Northern Region is the most populated zone of India, particularly the state of Uttar Pradesh because of which India becomes the 6 largest populated nation of the world. Of the total population, women constitute 46.9% as per census in 1991 resulting in a sex ratio of 879 females per 1000 male. NEED in networking with 200 grass-root NGOs from this northern region of country with grass-root endeavors in about 120 villages in a few districts of the states are also growing in terms of increasing the no. of population both in women & grass-root NGOs. Therefore, these villages of the area are almost 2/3 population are untouched by electricity & hence, the growing demand of bakeries and necessities of eco cum environment friendly products, this project is certainly having a very potential & growing market. NEED's project is meant first to enhance the capacity of its primary stakeholders. The mission behind the endeavors primarily rests on the idea of creating a very powerful demonstrative model at local level but with macro-reach prosperity. Based upon NEED's past experiences, a successful project should lead to large scale replication in the entire region of country within 4-5 years, to be followed & cooperated by govt., bank, cooperative, Panchyati Raj Institutions (PRIs) even corporate sector as well.

HOUSEHOLD POLLUTION: ESTIMATION AND MANAGEMENT

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Abstract

Biomass fuels contribute to a major fraction of domestic energy requirements in India. Direct combustion of different biofuels pollutes the indoor environment. In the present work an experimental investigation was undertaken to study the emission of various air pollutants from the combustion of fuelwood, dung cakes, charcoal and biogas in their respective cooking appliances approved by government of India. The air pollutants studied were carbon monoxide, suspended particulate matter (SPM) and Benzo(a)pyrene.

The performance of improved mud stove-Sugam-II (for the combustion of fuelwood and dung cakes), charcoal stove and biogas stove was studied. The characteristics of four biofuels and the specifications of all the three stoves are presented in the paper. The concentrations of all the pollutants at three positions (breathing level in squatting posture, breathing level in standing posture) in room A and breathing level in standing posture in room B for one hour combustion of all the biofuels were studied at an interval of 10 minutes. A comparison of the concentration of SPM observed in the present study with the air quality standard values shows that the combustion of all the fuels except biogas releases much higher SPM in the indoor environment than the prescribed limit. The concentration of benzo(a)pyrene is found more in dung cake and agro-waste at all the three monitoring positions. Hence the direct combustion of wood and agro-waste should not be encouraged for domestic use.

A new approach to posing problems and finding solutions; Drawing on the experience of women

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The energy consumed, and the pollution generated by a civilization are a direct consequence of the cumulative day-to-day actions of individuals. Individual decisions are made within the context of social values, culture, and regulations, economic possibilities, and technological capabilities. Decisions and actions are made through individual analysis of how to achieve a desired quality of life. The cumulative impact of individual actions also includes environmental degradation, pollution, and depletion of resources. Individuals receive feedback information about these consequences in a way that does not relate to personal decisions. Individual personal decisions and actions are the driver for the whole system, and these decisions are based on what we perceive, according to our own analysis, will perform according to our objectives.

The only way to achieve a sustainable society is to have a sustainable energy and environment architecture, where the system works within natural constraints to provide services, regardless of individual choices. The critical and necessary first step for achieving a sustainable society is to discover what a sustainable society *is*.

Today's planners ask, "What new technology and prices are required to substitute renewable energy for fossil energy to sustain growth?" This question has no answer. We asked "What do people need for a high quality of life and what resources are available for sustainable human use?" The answer is a *new system* where sustainability is achieved by design, not as an option.

Renewable Energies, Rural Woman and Sustainable Development in Rural Area in Senegal (West Africa).

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Summary

The third Millennium starts with major challenges whose one of the most important remains the access of a significant part of the world population, in particular Rural Women, to a sustainable development, with all that supposes as regards satisfaction of requirements in goods and additional material services for the ones and of primary education needs for the others. The realization of this ambition will require the installation of energy services adapted for all, in particular the resort to renewable energies.

From their activities (cooking, search for wood of heating, search and pumping out of water, productive activities realization) and her position in the rural society (on the fringe of the society, exclusion from decisional authorities, mother, wife, etc), the Rural Woman is in the heart of the Rural Energy System.

Thus, Senegal, in its strategy of the development and the exploitation of renewable energies, tries as far as possible, to involve the Rural Woman for launch the sustainable development of its rural world.

It's why, today, learning the lessons from successes and the failures known at the time of the setting in of rural energy projects and/or programs, our country understood the need to position some actions in the field of renewable energies in favour (towards) of the Rural Woman while involving her in the realization.

In most of the time, the results were reached, thus confirming the need that the Rural Woman has to be involved in the management of the renewable energies projects for a rural sustainable development.

Key words: access, challenges, sustainable development, renewable energies, rural woman, energy services, rural energy system.

The Importance of Incorporating Women into Renewable Energy Projects

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The purpose of this paper is to demonstrate the importance of incorporating women into renewable energy projects to ensure their sustainability.

Renewable energy technologies can greatly improve life for women in rural communities of developing countries. However, 90% of the time technical training opportunities are only targeted toward men. Cultural barriers and historical methods of international development continue to keep women out of the loop even when it is well known that women play a central role in household energy use. By introducing clean, cost-effective renewable energy technologies to women, gains can be made toward improvements in quality of life and the general welfare of families and communities. Case studies will be discussed that show not only how women benefit from renewable energy technologies, but also the importance of including women in the planning and implementation of renewable projects.

In order for renewable energy projects to be successful, and improve the quality of life for the entire community, a new framework for development must be created that includes the active participation of women in the planning, design, implementation and evaluation phases of development projects.

Energy, Poverty, Gender

By Dr. Aparna Basu,
President-All India Women's Conference

Energy is one of most basic inputs into sustaining people's livelihoods. It provides cooked food, boiled water and warmth. Use of energy is closely linked with issues of poverty and gender.

It is the poor who use biomass fuels – wood, cow-dung and crop residues. In India, nearly 86% of rural households and 24% of urban household rely on biomass as their primary cooking fuel. Of the approximately 1.3 billion people living in poverty in the world, nearly 70% are women. Women's activities whether they live in female headed households or otherwise, centre round the kitchen. Burning biomass in traditional stoves, which emit smoke containing particulate material and gaseous pollutants, affects lungs, eyes, etc. According to WHO this is a serious health hazard.

The poor would obviously prefer using clean fuels like electricity and LPG but are not able to do so because of the high cost involved. It is a vicious circle. They use biomass fuels because these are cheap or cost free. But collecting fuel is time consuming and allows women no time for income generating activities. It is not easy to start income generating activities, this requires skills, access to capital, transport, raw material and marketing.

The formation of Self-Help Groups is a possible solution. However, the Deepam Scheme introduced in the state of Andhra Pradesh which gave free LPG cylinder connection to 3 million women below poverty line who were members of SHGs was not as successful as expected. Biomas still remained the main cooking fuel, as the poor could not afford the relatively high cost of LPG refills.

The All India Women's Conference has formed 4000 SHGs. The experiment of giving loans for LPG cylinder is being tried but the results are still being reviewed. AIWC has been working for the installation of smokeless chulhas, biogas plants, solar cooker, lanterns and home light systems. These have been fairly successful. In many cases women have been provided with regular income, their health has improved and they have gained self-confidence and respect in the family.

Poverty leads people to opt for poor quality fuel. This particularly affects women. In the final analysis the answer is economic growth which will generate employment and income and help women to break the energy poverty barrier.

Strategies for Gender and Energy Advocacy at Upcoming Meetings of the UN Commission on Sustainable Development (CSD)
Gail Karlsson, USA

The CSD meetings in 2006 and 2007 will focus on energy for sustainable development, and preparations for them will present opportunities for promoting the integration of women's concerns into national and international energy programs as a way of helping to fulfil countries' commitments to sustainable development and gender equity. One of the greatest challenges for gender and energy advocates is explaining to policy decision-makers the linkages between these topics. The connections are clearest in certain developing countries. Access to affordable energy is particularly important to women who live in areas where there is no electrical grid and only limited availability of modern fuels for cooking, heating and income-producing activities. Although poverty, not gender discrimination, may be the underlying problem, nevertheless, in many areas the traditional roles prescribed for women make the lack of energy more burdensome for them than for men. Gender equity is an important reason for attention to women's needs, but the effectiveness of poverty alleviation and environmental programs is also relevant. In places where women's responsibilities include collecting and burning traditional biomass fuels, women and girls would likely benefit the most from access to improved energy services that lead to better health, education and economic opportunities, but these benefits can also lead to improved living standards and environmental conditions for whole families and communities.

Canadian Gender and Energy Network: Initiatives and Challenges

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The Canadian Gender and Energy Network was initiated in 1998 by a small group of people interested in strengthening women's role in domestic and global energy issues. The first initiatives of the group involved building a Canadian network, applying for funding, and considering opportunities for education and research. After the initial activities a number of challenges were met in attempts to sustain the goals and objectives of the network. However, individual members of the Canadian Gender and Energy Network have continued to network, conduct research and consult on issues related to gender and energy. Currently, the original group is preparing to move forward with the next phase in the development of the network. There is a distinct need for a Canadian Gender and Energy Network since Canada, a nation built on cheap power to fuel national growth, continues to consume energy at an alarming rate and export energy development projects. Despite the ratification of the Kyoto Protocol in the fall of 2002 by the Canadian Government little has been done to provide education, incentives, and choices toward more sustainable energy use. Considering both Canadian and international contexts, this paper provides a brief history of the formation of the network, and discusses the goals, objectives, initiatives and plans of the network. This paper also emphasizes the number of challenges of forming a gender and energy network in a large, northern, energy consuming country.

A Poverty Reduction Strategy for the Power Sector in Uttar Pradesh, India

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Major restructuring of the power sector in India is intended to attract private investment, increase the supply of electricity and achieve financial viability of the State-owned utilities. A cycle of poor supply, low bill collection, high level of thefts and therefore inadequate funds for system maintenance and rehabilitation, is especially pernicious in India's northern State of Uttar Pradesh. 80% of the population of 166 million live in 97,000 villages, 60% of which have been electrified. 30% of the population is living below poverty line and few of them are using electricity, due to a combination of lack of availability, affordability and poor supply. A Poverty Reduction Strategy was developed as part of the Canadian-funded Energy Infrastructure Services Project to recommend measures to ensure that the poor will have a share in the benefits promised from power sector reform. This paper will give an overview and critique of the Poverty Reduction Strategy proposals in the context of the huge challenges facing UP's energy sector and economy.

Energy and Women's Empowerment

By Govind Kelkar
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Paper Abstract:

This paper draws attention to the complex inter-relationship of energy and socio-economic position of women in rural Asia. That the sustained under-investment in labor saving devices that saves women's labor time, which also save fuel, is a function of the relatively low opportunity cost of women's labor time compared to that of men, and the systematic male bias in favor of their own leisure time in preference to that of women. In looking at the energy impact on the empowerment of women it is necessary that energy policy and practice be directed towards addressing its male bias and increasing women's adequate participation in energy institutions. These, in turn, demand a gender-responsive energy culture increasing women's income earning opportunities outside the home and reducing their drudgery (related to housework) through low cost, energy intensive projects. It is important to look into the linkages of energy and empowerment of women in the area of the opportunity cost (that is alternative income earned) of women's labor time saved by the energy projects.

Based on several case studies in Asia, the paper concludes that substantive gender equality is essential to the economic and social prosperity of a country. By denying itself energy and intellect of half of the population, a discriminatory society stifles its own economic and social growth and condemns itself to continued underdevelopment, as noted in reports from Indonesia and other countries in Asia and Africa. Social and institutional inclusion of women is pivotal to the context of empowerment and crucial for a sustainable development of energy.

Household Energy for Rural Women in Nepal: Reality and Potential

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Socio-cultural, economic and legal factors have caused gender imbalance in the rural household energy sector of Nepal. The patriarchal culture of Nepal has had a humongous impact in the way labour and resources have been divided and assigned to women. Evidently, most households' decision-making power and control of energy resources has always been and still is in the hands of the men of the house. The major workload, however, is borne by the women, with subsequent impacts on their health as well as their children's. The beneficial impacts of improved renewable energy technologies and projects can not be accomplished without the involvement of women in all stages of planning, designing, implementation, maintenance and monitoring. With constant local, national and international efforts, this situation is slowly being alleviated. This paper gives an overview of the past and present situation in this regard, incorporating real community women's views and experiences gathered during the authors' work with them in rural parts of Nepal. A review of related studies has also been done.

Gender Mainstreaming in Energy Conservation and Renewable Energy in the South

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Abstract

Women are continuously marginalized in economic activity in the South and thus their role in socioeconomic development is mitigated. Energy sector is recognized with a very low proportion of women in all its fields and at all levels. It is necessary to redress this state of affairs in the South and to take a collective initiative at international level to explore new ways and means to enhance the women's participation in energy conservation and use of new and renewable energy resources. This paper, while highlighting various current figures regarding the status of women in renewable energy in the South, discusses gender mainstreaming in renewable energy and recommends measures to encourage women involvement in energy at various levels. It proposes strengthening their traditional role in the rural and remote areas, their increased involvement in energy production as well as in planning, decision-making, and policy.

Gender and Energy at the Eighth World Renewable Energy Congress

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An international network on gender and energy, called ENERGIA,[1] is based at a Secretariat in The Netherlands. It was founded eight years ago by three women researchers[2] interested in improving the lives of women in the south (e.g., the developing world) through analysis and publication, empowerment, networking, policy development, education, and communications.

ENERGIA has supported the formation of networks on gender and energy in Africa and Asia, but, to date, no network exists in the north. Its directors have long noted the need for such a network. Programs in the north have tended to focus on the problems of women in the south, such as the United Nations Development Programme (UNDP), the World Bank, and Winrock, International. Often enough, the development programs do not adequately take into account the key part that energy could play in ameliorating the subsistence burden carried by women in the developing world. Energy is generally considered a field in which men dominate professionally. The needs and concerns of women, as well as their metabolic energy contributions to the world's economies, are routinely ignored in many energy policy discussions and, often enough, in development efforts as well.

From 1990-1994, I was on assignment in Washington, DC, and in January 1994 I went to an invited Workshop on Women and Global Energy Policy in Dakar, Senegal, Africa, where I met Elizabeth Cecelski. The workshop opened my eyes to the problem faced by women in the developing world. More than 2 billion people have no electricity. Women's lives (and particularly the lives of rural women and girls) are dominated by poverty, and by hard manual labor gathering fuelwood, hauling water, and cooking over polluting cookstoves. What role could energy policy play in improving the plight of women in "the south?" Subsequently, I became involved in working with ENERGIA, serving on their advisory board for a time.

The first gender and energy workshop at a World Renewable Energy Congress, organized by NREL's Barbara Farhar and Carol Tombari, was held in June 1996 in Denver, Colorado. Since then, gender and energy sessions have been held at the World Renewable Energy Congresses in Florence (1998), Brighton (2000), and Cologne (2002). Still, 2004 was the first year in which Gender and Energy was called out on the Congress Program as a separate technical topic in its own right, on the same level with, for example, wind, photovoltaics, and solar thermal.

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[1]Http://www.energia.org.
[2]Elizabeth Cecelski, Joy Clancy, and Margaret Skutsche.

SOLAR PHOTOVOLTAIC SYSTEMS—INDIAN EXPERIENCES

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Abstract :
The paper has examined the solar photovoltaic systems and the efficacy in the Indian environment. The system can be utilized for a variety of equipments and applications. In the present changing scenario of the Indian power sector there are greater opportunities for the solar photovoltaic system to become a solution for the raging power problems within the country. The paper also profiles some of the successful experiments within India, which have transformed the lives of the consumers and suppliers, providing a roadmap for the future.

GENDER AND HEALTH THREATS RELATED TO ENERGY: ISSUES OF WOMEN'S RIGHTS TO ENERGY RESOURCES AND SERVICES

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ABSTRACT

Health being the physical and psychological wellbeing extends beyond the curative intervention and health services and includes a vast array of aspects of human lives, livelihood and rights of humans to lead a healthy life. How does energy with all multiple potentials to improve quality of life, economies and the environments has detrimental to some, and become a threat to women's health is a question in hand.

This paper in analyzing the health threats related to energy examines with field evidences the inherent limitations of the energy system. In the process of energy development the promoting of clean energy and better energy services for the better off, resulted in neglecting the energy needs of the poor as their self-responsibility. Lack of economic capacity to accessing and using clean sources has deepened the poverty while strengthening the energy-poverty nexus. The manner in which per capita energy use acts as a proxy indicator to development, lack of clean energy acts as a proxy to poverty and health issues trapped in a vicious circle. The findings of research are presented focusing on the health aspects of using biomass, kerosene and human energy to sustain and maintain the energy system. The biomass fuel system within which women's health issues are seriously trapped seems central to impoverishing women across developing regions. The two billion people of the world relying on biomass fuel, also rely heavily on women's energy invested on procuring, portaging and combustion. The same category of energy providers suffers from lack of proper lighting to perform their activities at their households, and lack of services to achieve capacity and power. The energy development dominated by science, technology and business rather than as a service and a means and instrument to dismantling the interconnected root causes in gender-health-energy nexus has failed to promote a holistic approach to energy development.

The major health outcomes such as respiratory illness, repetitive strain injuries, skin problems, physical injuries, sufferings, fatigue and trauma are related with women's functional occupations in energy system, the workplace conditions, lack of resource security and personal safety, poverty, undernourishment and poor living conditions. Women's rights to function as equal citizens reported to be essential to deal with the root causes of unjust and thereby to promote health for all through energy services. This paper presents a simplified model to broaden our understating of the gender-health-energy nexus with special emphasis on health threats related to energy. It also suggests indicators to be used in introducing solutions systematically.

GEOTHERMAL ENERGY DEVELOPMENT IN ETHIOPIA FOR ELECTRICAL POWER GENERATION: PROSPECTS AND STATUS

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Extended Abstract: The presentation first briefly appraises prospects for geothermal energy development in Ethiopia for electric power generation in the Rift Valley Region of east Africa. From extensive studies undertaken at four fields, the total proven resources have been estimated to be 700 MW. The status of geothermal development is next discussed in relation to drawbacks and experiences with a failed 5.5 - 7.2 MW pilot geothermal power plant using combined dry and binary methods of conversion.. The plant started to deliver 4.1 MWe, in June 1998, but power output kept on decreasing to 0.82 MW, after which the plant was closed in December 2000. Causes of failure of operation are yet to be investigated. The repair of the pilot plant and its upgrading to 30 MW are also recommended. Still, based on the proven potential of 700 MW geothermal resources, a generating capacity of 60-120 MW is seen to be feasible for development within a decade. This corresponds to a "3% - 5%" geothermal target out of a total generating capacity of 2000 MW - 2400MW of largely hydro power-based load forecast. Viability of the proposal will depend on availabilities of technical and financial supports. Two benefits to be gained from realizing the geothermal target will be: (1) least -cost connection to the national grid, with opportunities for export of electric energy to neighboring countries, and (2) strengthening of a hydro-geothermal generation mix, with protection against recurring droughts and low water levels in dams.

1. Prospects of Geothermal Energy Development in Ethiopia

Explorations of Geothermal Resources

ENVIRONMENTAL IMPACT OF GEOTHERMAL ENERGY DEVELOPMENT

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ABSTRACT

Geothermal power is often billed as a clean form of energy. The reference to cleanliness is true compared to other sources of energy such as petroleum, nuclear, coal and hydrothermal. This scenario changes drastically when geothermal power plant is examined by itself. Geothermal energy generation involves the direct production and utilization of hot underground fluids. Accompanying this production of hot water and steam are chemical and physical pollutants. Amongst the most noticeable physical effects of withdrawing steam from the earth are noise, earth tremors, and land subsidence. In most geothermal energy developments, attention is often focused on the chemical contaminants at the expense of these lesser but sometimes very significant effects. The effluent is directed on three media, namely, air, land, and water. This paper discusses the impact of geothermal fluids on the three media, and for each case the environmental impacts that need to be mitigated are presented. Technologies for handling the environmental aspects of geothermal power production exist, and environmental issues can now be dealt with satisfactorily. The article concludes that during environmental impact assessment (EIA) of geothermal power plants, the impacts associated with geothermal development should be balanced against geothermal energy's advantages over conventional energy sources.

Hybrid Geothermal-Solar Generation

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Abstract

With the years, the depletion of the reservoir in the western part of the Cerro Prieto geothermal field has decreased the amount of separated water that goes to the flash station for Unit 5 with the consequent derating of the power plant.

Taking advantage of the high solar radiation in the Mexicali zone and the coincidence of the maximum energy demand, exactly at the hours of maximum solar radiation, an arrangement is proposed to increase the enthalpy of the hot water using solar concentrators increasing the steam to Unit 5

Ten troughs of parabolic mirrors of 5 by 1000 meters are analyzed obtaining an increase on the geothermal steam production of 52 tons per hour at noon in summer equivalent to 6.5 MW electrical power, without modifying the existing arrangement. Integrating all the electrical energy generated with the solar concentrators during one average year, one can obtain up to 21 610 000 additional kWh.

The array is very simple. The mirrors are located in between of the water pipes and in the empty flat terrain of the western part of the field. The concentrated energy of the solar radiation is collected in the focus of the cylindrical parabola where thermal oil is heated in the traditional way. The hot oil flows inside a 2” pipe that runs all along the interior of the water pipes. The proposed array is shown to be the simplest and least expensive way to increase the generation in Cerro Prieto, exactly at the hours of maximum demand.

An innovative, renewable energy system for space heating and cooling – using ubiquitous shallow geothermal resources

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Low-temperature geothermal energy from the shallow ground is an abundant, renewable energy source. Beijing Ever Source Science & Technology Development Co., Ltd has invented and developed the “Single Well System of Supplying and Returning Water” technology to utilize this energy source to provide heating & cooling as well as domestic hot water for buildings. The new system uses the heat content of shallow groundwater which is constantly replenished from above (meteoric water) and from below (geothermal heat flux). Since this technique emerged in 2001 it has attracted the attention of users and government agencies in China.
For the Single Well System a borehole of about 80m depth with a diameter of 0.5 m is drilled. Groundwater with 12 - 15°C is pumped from the well at a rate of 100 m^3/h via heat exchangers to heat pumps which absorb the heat from the groundwater and raise the temperature of the circulating water to 50 °C to supply fan coilers for space heating whereas the released water temperature is lowered down to 10 °C. This water is injected into the same well where heat exchange with the surrounding ground takes place through a special metal mesh at the borehole wall where the water reaches the original 15°C. The thermal capacity of a single well is around 0.6 MWth. In summer, “free cooling” (i.e. without heat pump) is provided by the groundwater. Presently over 100 such systems are in successful and reliable operation in the Beijing area, with a total area of $2x10^6$ m^2. The system is now ready for world-wide implementation.

EFFECT OF NON-CONDENSABLE GASES ON GEOTHERMAL POWER PLANT PERFORMANCE

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ABSTRACT

Non-condensable gases (NCGs) (CO_2, H_2S, CH_4, N_2, He, H_2, etc.) are natural components of geothermal fluids, and they are a source of considerable capital and operating costs for power plants. The NCG content of geothermal steam varies considerably over the world from almost zero to as much as 25% by weight of steam. Energy consumption to remove NCGs increases with increasing NCG content.

The influence of NCG and turbine inlet temperature is analysed for the main power generation components such as turbine and compressor. The avalible work potential at turbine inlet, turbine work output, net work output and exergetic efficiency of the turbine is evaluated for a temperature range of 140-200°C and a NCG content of 0-25%.

At low temperatures (<160°C), the effect of NCG content changes is more significant than higher temperatures. The deterioration in all parameters becomes insensitive with increasing turbine inlet temperatures. At low temperatures and high NCG content, the net work output becomes too low and requires an economical analysis whether the resource should be developed or not.

Opportunities for Hydrogen Assisted Renewable Power (HARP) in British Columbia, Canada

by
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BC Hydro is a provincially owned electric utility located in British Columbia Canada, primarily generating with hydroelectric facilities. However, there are some non-integrated areas and other remote communities relying on independent sources of electrical and other energy.

Hydrogen assisted renewable power (HARP) is one of the fundamental concepts of the hydrogen economy that promises to make renewable energy more practical and mainstream through the use of hydrogen based electricity generation systems.

Initially, BC Hydro will investigate the benefits of HARP as an environmentally friendly replacement for diesel in the supply of electricity to off-grid communities. However, as the hydrogen and fuel cell technologies reach commercial viability, there could be larger and longer term benefits to BC Hydro.

To meet the overall objectives, BC Hydro has selected a suitable location for a small scale pilot project, which will:

- Generate hydrogen from excess water at a small hydro project
- Store hydrogen until the load demands its use
- Offset diesel usage by generating electricity from stored hydrogen (Fuel cell technology or H2 ICE)
- Provide power-conditioning capabilities.

The paper will describe the components of the proposed HARP system as well as its costs, benefits and opportunities for future applications.

Fueling Our Future: Four Steps To A New Reliable, Cleaner, Decentralized Energy Supply Based On Hydrogen And Fuel Cells

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Abstract: As we examine various market strategies, this presentation demonstrates the possible driving factors and necessary elements needed to move Hydrogen and Fuel Cells (H2/FC) to commercialisation. Rather than focusing on the technology itself, the presentation looks at the "bigger picture" comparing how certain trends have impacted the progress of new technologies developments in the past and how these models can be applied to our present day situation. In this process, the consumer has played and will continue to play the key and leading role. Due to such strong influence, the consumer will ultimately fuel the future of H2/FC commercialisation by a desire for new and not yet discovered products & services. Future products & services powered by Hydrogen and Fuel Cells. One possible step towards realising the H2/FC Economy could be the use of Personal Power Cars equipped with a Fuel Cell which not only drive on Hydrogen, but also supply (while standing) electricity /heat to residential and commercial buildings. The incentive for car owners driving and using these vehicles is twofold: either save or earn money while their cars are parked and plugged into buildings via a smart docking station. Cars parked at home in the garage will supply electricity to the homes and additionally, replace the function of the existing boiler, thus saving money. Car owners can earn money by selling the electricity generated, but not used at home at that time, to the utilities and feed it into the existing electricity grid. The inter-dependability between supply and consumer-driven demand (or better demand and supply) are explained. Motivators are explored as they will eventually be the driving force behind consumers looking to new energy supply services to ensure and protect them against future incidents. The steps necessary to achieve a new reliable, cleaner and decentralized Energy Supply which will be based on Hydrogen and Fuel Cells are examined.

Prospect of Proton Exchange Membrane Fuel Cell (PEMFC) for transport

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Abstract

The emissions due to the combustion of fossil fuels in vehicles cause the air pollution problem to a great extent. A potential solution is to substitute the detrimental combustion engines with environmentally friendly proton exchange membrane fuel cells (PEMFC). Such fuel cells have many advantages, including high efficiency, high power density, light weight, low operating temperature and rapid startup. This review paper presents the scientific fundamentals of PEMFC and its development. The effects of important design and operating parameters on the fuel cell performance are discussed. Moreover, comparisons with other types of fuel cells and hydrogen internal combustion engine (ICE) are provided. The above evaluation shows the promise of using PEMFC to replace existing fossil fuel ICE in transportation for our future hydrogen economy and sustainable development.

TITLE - Vehicles as a new power-generation source. Hydrogen a possible bridge between mobility and distributed generation (CHP)

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ABSTRACT - If vehicle power-generation system (fuel cell based) become more sophisticated, the role of the vehicles within the power grid may change. Vehicles could become a new power-generation source, supplying electricity to home and to the grid (in a new different tipe of distributed power generation). Moreover most vehicles sit idle about 90% of the time.
Based on forecast data it's possible to define the dimension of this new kind of power generation source (i.e. vheicle power-generation system) and compare it with the actual power grid installed generation capacity. The results are surprising. This new kind of power generation source appear as a multiple of the actual power grid installed generation capacity.
The paper include this kind of USA forecast data (for year 2025) and develop some consideration in term of energy policies usefull for energy operators and policy makers.

LONG-TERM ENERGY SYSTEMS ANALYSIS OF JAPAN BASED ON BACKCASTING APPROACH

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In Japan, fuel cell and hydrogen R&D program has been strongly promoted, but they do not have precise roadmap toward hydrogen economy like US and EU, yet. And there is no enough energy systems analysis of hydrogen economy in Japan toward 2100. Based on the background mentioned above, the author proposes an analytical study on the hydrogen economy in Japan, especially focusing on transition process to it. This analysis is expected to show a robust and flexible energy system against uncertainty of future energy technologies and to give useful information for describing a vision of hydrogen energy in Japan. In this paper, the author proposes a framework of the study and shows the results of investigation and consideration for the analysis. In the analysis, the author uses energy system model of Japan which covers from 1988 to 2102 by using MARKAL. The analysis also based on the idea of Backcasting approach and assumes a goal that the hydrogen economy which does not depend on fossil fuel will be realized in Japan in 2100. By assuming the goal and optimizing the energy system during 115 years at once, the optimal transition processes to the hydrogen economy are given. In this analysis, affects of energy technologies which have large uncertainty in available time, cost and available amount, such as nuclear fusion, space solar power system, methane hydrate, international natural gas pipeline and high temperature gas-cooled reactor on the future energy system and transition process to it are especially focused on. Their goals of commercialization are, therefore, investigated. However, the hydrogen economy in 2100 in Japan, which should be described in the model as the goal of energy system, is still under investigation.

Prospectives for the provision of hydrogen in a European context—a selection of plausible hydrogen routes and policy recommendations.

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Abstract

The paper will describe a European Commission initiative aimed at establishing a European hydrogen economy. Results from two expert assessments studies addressing technology areas and ways conducive to introducing the hydrogen society as well effective measures of hydrogen policies (framework conditions, implementation, impacts etc.) will be presented.

The studies address the establishment and further development of hydrogen supply from scratch, i.e. identifies plausible pathways from hydrogen source to end use including strategies and measures which can sustain the developments towards more extensive hydrogen applications. Additional criteria connected to technology characteristics, e.g. attitudes, economy, expertise, regulations, environment, etc. are also used in the path identification and assessment.

Important issues are; scoring of present and emerging hydrogen technologies against pre-defined assessment criteria, how to deal with barriers and obstacles in European societies and how to create a political courage to pursue a hydrogen society within a time aspect of 10-30 years. The paper will mention how the assessment studies will be further translated into an action plan for the European Commission.

Use of Solar Energy for the production of Hydrogen from Municipal Waste Water

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In the present scenario, crisis of fossil fuel and environment pollution caused by fossil fuel is of great concern. In search of alternative energy sources hydrogen is emerging as clean, renewable energy source. The only drawback of the hydrogen as a fuel is its high cost. Hydrogen can be produced simply by cleavage of water, and on burning with the oxygen it forms water again with the release of energy/electricity, which does not cause any pollution. The water splitting is endothermic process thus energy requirement is high which is responsible for higher production cost. This paper primarily aims at exploring the viability of production of hydrogen from electrolysis of municipal waste water by using solar energy. Lab scale experiments were performed using municipal waste water, which is available in abundance everywhere and has got better electric conductivity than potable water. The electricity required for electrolysis of waste water was supplied by inexhaustible solar energy through photovoltaic cell. The effect of variables such as voltage supplied, distance between the electrode, effect of various electrolytes have been studied to achieve the best operating condition for the production of hydrogen from municipal waste water. Hydrogen formed in this process can not only produce pollution free renewable energy but also minimize the disposal problem of municipal waste water.

Carbon-Metal Composites: Hydrogen Spillover to Enhance Hydrogen Storage

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Hydrogen storage in carbon materials can be increased by hydrogen spillover from a supported catalyst, suggesting that metals and carbon composites are a promising storage material. Secondary spillover studies allow the effect of the carbon surface properties to be isolated in order to study the relation between carbon properties and spillover. The pressure dependence of hydrogen spillover, the effect of carbon type, metal-carbon interface, relative content, and steady-state modeling will be discussed.

PLASMA CATALYTIC REFORMING OF BIOFUELS

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Bio-mass, as a renewable resource can potentially be converted into economically attractive fuels for transportation uses. Several processes considered for the reformation of biomass include fast pyrolysis[1], catalytic steam reforming[2], catalytic pyrolysis[3] and supercritical water reforming. However, these technologies are not suitable for onboard applications Plasma-based onboard generation of hydrogen is being developed at MIT for reformation of a wide range of fuels into synthesis gas (hydrogen and carbon monoxide).

Reforming tests of vegetable oils and ethanol have been carried out in a plasmatron reformer. Corn, canola, and soybean oils and ethanol have been reformed at different oxygen to carbon ratios and at power levels of 200 to 700 watts. Both homogeneous plasma reforming (non-catalytic) and catalytic plasma reformer have been evaluated. Hydrogen yields of close to 80% have been achieved during catalytic reformation of corn and soybean oils and ethanol. Canola oil catalytic reformation yielded 60% of hydrogen. Other major compounds of the reformat gas are carbon monoxide and light hyd[4]rocarbons such as CH_4 and C_2H_4.

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Market Potential for Initial Residential Penetration of Fuel Cells

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A body of evidence exists that illustrates new technologies are purchased largely by "innovators" and then "early adopters" for whom some characteristics of the technology offer special appeal. In the case of residential fuel cells, there is reason to expect that innovators and early adopters will consist of high-income homeowners.

The reasons for this are that high-income homeowners typically have: 1) substantial equity in their homes, 2) sensitivity to improvements that will increase property value and status within their socioeconomic group, 3) substantial disposable income, 4) a higher-than-average level of education and awareness of the advantages of new technologies, and 5) an interest in and ability to invest in environmentally friendly technologies. Members of this segment are the primary purchasers of homes in high-end developments and private communities. These homes may be large, detached, and placed on over-size lots—characteristics that are highly conducive to the installation of fuel-cell systems that provide both power and heat.

This paper examines: 1) a basic model for the diffusion of fuel-cell technology into the residential sector; 2) the potential for residential diffusion of fuel-cell technology, including market size; 3) current efforts to incorporate power reliability and quality, and also "eco-features" into homes; 4) other factors that would encourage or hinder adoption of fuel-cell systems within this demographic.

THIN PALLADIUM-COPPER COMPOSITE MEMBRANES FOR HYDROGEN SEPARATION

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An electroless plating technique was utilized to deposit subsequent layers of Palladium and Copper over zirconia and α-alumina-based microfilters. The composite membranes thus made were annealed and tested at high temperature (350-700°C) using both pure gases and mixtures. This plating procedure has been refined to reach metal film thicknesses below 1 micron, therefore decreasing the amount of expensive material required.

The alloy composition of the metal film was found to have a strong influence on the hydrogen permeance for these membranes, in concordance with relevant data from the literature. A $Pd_{60}Cu_{40}$ composite membrane was prepared and it exhibited a permeance of 0.32 cm^3 (STP)/$cm^2 \cdot s \cdot cm\ Hg^{1/2}$ at 350°C, the highest among all the membranes studied.

Some of these membranes were exposed to high pressures, the presence of contaminants and temperature cycling to determine the effect those variables had in H_2 permeation rate, selectivity and recovery. For instance, a membrane was tested at varying pressures as high as 450 psi and at temperatures from ambient to 450°C during 1 month and was found to maintain its initial H_2 to N_2 selectivity. Also H_2 recoveries in excess of 90% were observed for another membrane at 100 psi and similar temperature.

Advancing Production Technologies for Renewable Hydrogen – 2004 Status

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Affordable and reliable renewable hydrogen production technologies are a key to realizing the full benefits of a future hydrogen economy—sustainability, increased energy security, reduced air pollution and greenhouse gas emissions. Over the last 25 years, researchers have developed a number of promising technologies to produce hydrogen from renewable resources. Current research and development efforts are focused on water electrolysis powered by electricity from wind, photovoltaics, and hydropower resources; the thermal and biological conversion of biomass and wastes; and direct water splitting using photobiological, photoelectrochemical, and high temperature solar thermal systems. These advanced technologies are varied and complex, and each comes with its own set of challenges—performance, cost, reliability, safety, and durability—that must be addressed before they are ready for commercialization. Building on past successes, great strides are being made in refining and characterizing the hydrogen production technologies that will lead to a sustainable hydrogen future. The state of the art—including an overview of the technology itself, challenges, and current status—is presented for all of the renewable hydrogen production technologies under investigation at the U.S. Department of Energy's National Renewable Energy Laboratory.

A Strongly Quantized Electron-Transport Constraint on Practical Photolytic Biohydrogen Production

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Abstract

Kinetic modeling of the hydrogen-producing metabolic pathways in biological hydrogen producers can cost-effectively help to characterize systemic (e.g., mass/energy conservation or quantization) constraints on organism re-engineering. Among the more promising candidates for re-engineering are photolytic biohydrogen producers (PBPs) such as the microalga *Chlamydomonas reinhardtii*. *In vitro* kinetic studies suggest that the activity of the hydrogenases in several PBPs could be increased to as much as four times their nominal *in vivo* rate. It is much less clear, however, whether the *in vitro* activity maximum could be realized *in vivo*. Here I exploit the scale-independent form of *bioh2gen*, a highly parameterized S-system photosynthesis-based PBP (PSB-PBP) kinetics simulator, to show that the hydrogen production rate of PSB-PBPs cannot be increased by more than ~10% without drastic modification of their light-gathering/conversion efficiency.

Keywords: biohydrogen, S-system, metabolic modeling

Hydrogen storage for mobile- and stationary applications: The catalytic benzene-cyclohexane cycle

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ABSTRACT
Hydrogen storage is a crucial element in the anticipated hydrogen-based energy infrastructure of the future. However, various technologies are still competing for the most-economically- and technically- feasible way to store and transport hydrogen.

This review paper presents a study of the utilization of the catalytic benzene-cyclohexane cycle as a process for storing and transporting hydrogen. It is compared to technologies such as metal hydrides, liquid hydrogen and high-pressure gaseous hydrogen storage. Crucial elements to be considered include: hydrogen purity required as feed to the storage system, reversibility of the storage-liberation process, ease of regeneration, low energy consumption, possibility of thermal integration, safety, robustness and ease of maintenance, capital cost and operating expenditure, and maturity of the technology.

Experimental results are extracted from the literature and combined with a techno-economic feasibility study of the process. The thermodynamics and kinetics of the process is elucidated and comparisons are drawn with competing hydrogen-storage technologies.

The National Hydrogen Storage Project

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A critical enabling technology for the development of fuel cell-powered vehicles is the capability to have sufficient on-board hydrogen storage to allow for a driving range of 300 miles or more under the weight, volume, and cost constraints presented by the vehicle. However, current vehicular hydrogen storage systems cannot meet this requirement. In order to address this critical issue, the U.S. Department of Energy plans to launch the National Hydrogen Storage Project. This Project involves the establishment of National Laboratory-lead Centers of Excellence for research on hydrogen storage in metal hydride, chemical hydrogen, and carbon-based materials. These Centers will partner and coordinate with university and industry research activities. Research will also be conducted on new materials and processes for hydrogen storage via independent projects. The motivations, goals, and elements of the National Hydrogen Storage Project will be described.

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EXPERIMENTAL EVALUATION OF A FUEL CELL MODEL

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This paper presents a dynamic electrochemical model for representation, simulation and evaluation of performance of small size generation systems emphasizing particularly PEM fuel cell stacks. The results of the model are used to predict the output voltage, efficiency and power of FC's as a function of the actual load current and of the constructive and operational parameters of the cells. Partial and total load insertion and rejection tests were accomplished to evaluate the dynamic response of the studied models. The results guarantee a better analytical performance of these models with respect to former ones with a consequent reduction in time and costs of projects using fuel cells as the primary source of energy. This electrochemical model was tested for the SR-12 Modular PEM Generator, a stack rated at 500 W, manufactured by Avista Laboratories, for the Ballard Mark V fuel cell and for the BCS 500 W stack.

Keywords: *fuel cells, automation, control, modeling and simulation*

International Energy Agency Hydrogen Implementing Agreement (HIA) 25 years of Renewable Energy R&D

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The International Energy Agency (IEA) Hydrogen Implementing Agreement (HIA), a unique leader in collaborative hydrogen Research, Development and Demonstration (R, D&D) on a global basis, proposes to share highlights of its 25 year history of technical accomplishments in renewable energy hydrogen production, along with its plans for future international R, D&D for renewable hydrogen.

Over the last quarter century, the HIA has facilitated and managed a comprehensive range of R, D&D and analysis programs among its member countries through the creation and implementation of eighteen tasks. Tasks featuring renewable resources include: Photoproduction of Hydrogen, Photoelectrolytic Hydrogen Production, Photobiological Hydrogen Production, Integrated Systems Evaluation and a Comprehensive Study on the Status and Challenges to Hydrogen Production from Biomass.

The HIA operates on a task-shared basis and self-determines all activities using a "bottom-up" approach that assures member interest and commitment. Member countries now include Canada, the European Commission, Japan, Italy, Iceland, Lithuania, the Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom and the United States. Denmark and Singapore are in the process of becoming members. Australia, Finland, France and Korea have been invited to join. Another six nations are engaged in membership discussions. The HIA is a true international collaboration. Our strategy is to facilitate, coordinate and maintain innovative research, development and demonstration activities through international cooperation and information exchange. You are invited to learn about the renewable energy innovations that emerged from the HIA tasks and the significance of these contributions to the advancement of renewable energy.

Advances In Fiber Optic Hydrogen Sensor Technology

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Abstract

The implementation of an energy economy based on hydrogen as a fuel source requires safe, low cost, lightweight, reliable sensors wherever hydrogen is used, stored, or transported. The optoelectronics team at NREL has chosen to work on a fiber-optic sensor configuration that represents the best chance of meeting all of these goals. The NREL fiber-optic sensor consists of a chemochromic (color change produced as a result of a chemical reaction) thin-film coating at the end of an optical fiber that senses the presence of hydrogen in air. When the coating reacts with hydrogen, its optical properties are changed and can be used to detect concentrations of hydrogen in air in excess of 200 ppm.. This fiber-optic hydrogen detector offers inherent safety by removing all electrical power from the test site, and reduces signal-processing problems by minimizing electromagnetic interference. The NREL sensor shares a common link with many other hydrogen sensor concepts by using palladium (Pd) or one of its alloys as a surface catalyst. All sensor configurations utilizing Pd have the potential for degradation in their performance over time as a result of contamination from airborne impurities in the environments in which they will be used. The current focus at NREL is on the stability issues related to ambient exposure of Pd to hydrogen. A coating has been developed for protection of the Pd catalyst that can prolong the working life of the Pd from days or weeks to over one year. The protective coating may have further possible applications such as use in fuel cell membrane assemblies, hydrogen separation membranes and industrial catalysts.

Novel Membrane Gasifier for Hydrogen Production from Biomass – Thermodynamic Analysis

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Gas Technology Institute is developing a novel concept of membrane gasifier for high efficiency, clean and low cost production of hydrogen from biomass. The concept incorporates a hydrogen-selective membrane within a gasification reactor for direct extraction of hydrogen from biomass synthesis gases. This concept has the potential of significantly increasing the thermal efficiency of producing hydrogen and simplifying the processing steps by eliminating the downstream reformer, shift reactor, separation and purification operations for the conventional gasification technologies.

In this paper, thermodynamic analysis was performed to examine the performances of the membrane gasifier for hydrogen production from biomass. Different process schemes with and without the use of the membrane were simulated using HYSYS process simulator. The membrane gasifier section was modeled as a gasification reactor and a hydrogen membrane unit with part of its non-permeate stream recycled to the gasifier. The results show that the hydrogen production efficiency using the membrane gasifier concept can be increased by about 40% versus the conventional gasification process. The assumptions and limitations used in this preliminary analysis will be discussed in reference to the future research areas. Potential candidate membranes that are suitable for the high temperature and harsh gasification environments will also be discussed.

Hydrogen Production and Prices by Region to 2050

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A scenario of hydrogen (H2) demand to 2050 from fuel cell vehicles (FCVs) and H2 production by USA Census region to meet that demand was developed at the request of the USA Department of Energy. Regional price estimates for H2 were then developed for this scenario. Besides providing a set of regional price estimates that accounted for a wide variety of production pathways on a consistent basis, the development of the scenario and price estimates helped identify the many analytical issues that will confront more sophisticated approaches to estimating H2 prices regionally.

This paper provides a summary of the scenario and price estimates. Regional and national price estimates to 2050 are presented for H2 produced centrally (from natural gas, coal, renewables, advanced nuclear reactors, and electrolysis) or distributed H2 production (at service stations from natural gas or by electrolysis). Equally important, the paper highlights the key issues considered in the development of the scenario and price estimates.

Proton Exchange Membrane Fuels Cells or Internal Combustion Engines for Transportation?

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Implementation of electrochemical power plant technology is expected by many to revolutionize automotive transportation. However, in the short and long term, the viability of a particular powerplant choice depends on a multitude of factors including performance potential, emissions and total environmental impact, fueling requirements, durability and capital cost. In the long term fuels cells may dominate this application, but at least in the short term, proton exchange membrane fuel cells (PEMFC) may not offer an immediate substantial benefit over spark and compression ignition internal combustion (IC) engines. This is for a number of reasons in addition to expenses associated with the design and implementation of a new technology. Contrary to popular misconception, fuel cells are restricted by the second law of thermodynamics to the same degree as IC engines are restricted by the Carnot limitation. While the direct chemical to electrical conversion in a fuel cell avoids the requirement of an electrical generator, fuel cells require an electrically powered air compressor that consumes substantial work input. A framework for total environmental impact, from resource extraction to power generation, is presented and it is shown that it is most strongly affected by fuel choice, as well as by the implementation of hybrid vehicle technology utilizing regenerative breaking and near-design-speed operation of the power plant. Thus, the differential benefits from powerplant choice can be overshadowed by the advantages obtained from hybrid electric vehicle technology and alternative fuels. IC engines are advantageous because they are fuel flexible, while the PEMFC is relatively fuel inflexible. Environmentally friendly operation of the PEMFC results, partly due to low temperature operation, but mostly due to the requirement of clean fuels such as hydrogen or methanol.

High Storage Density of Hydrogen in Silicate Nanotubes. Control of Reactivity and Selectivity of Hydrogen Release from Ammonia Borane.

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We are using a combination of experimental and computational approaches to enhance the potential of NH_xBH_x (x=1-4) as chemical hydrogen storage materials. The optimum thermal decomposition reaction NH_4BH_4 = BN + $4H_2$, occurs by a four step process and provides a theoretical yield of >24 wt% hydrogen. However, even if only two of the four steps are utilized in a storage cycle, H_2 storage capacities of >12% could be obtained. In this current work we focus our studies on experimental efforts to enhance the properties of aminoborane [NH_3BH_3] as a potential on-board storage material. In the bulk material aminoborane (AB) loses hydrogen in the solid phase at temperatures below 100 ˚C at relatively slow rate, the activation barrier for hydrogen loss from the solid phase is ca. 35 kcal/mol. On the other hand, AB undergoes rapid dehydropolymerization reaction to yield polyaminoborane [$(NH_2BH_2)_n$] + H_2 upon melting at 115 ˚C. In a subsequent step the $(NH_2BH_2)_n$ decomposes to [$(NHBH)_2$] + H_2 at 170 ˚C. In the second step an undesirable side reaction, formation of a volatile product, cyclic borazine $(NHBH)_3$ competes with linear polymer formation in the bulk material. In this paper we present the results of our efforts using the mesoporous silicate template (SBA-15, pore diameter 7.5 nm, wall thickness 4.2 nm) to control the chemistry of dehydropolymerization. Thermolysis of AB coated within the pores of the SBA-15 template shows two profound effects different than observed in the bulk thermal reaction: (i) hydrogen is released from AB at significantly lower temperatures (below the melt, i.e., at temperatures < 100 ˚C) and (ii) no borazine is formed.

IMPACTS ASSESSMENT AND TRADE-OFFS OF FUEL CELL BASED APUS: A MULTI-OBJECTIVE ANALYSIS

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ABSTRACT

Since the late 1980s, there has been a strong push to develop fuel cells for use in light-duty and heavy-duty vehicle applications. A major drive for this development is the need for clean, efficient cars, trucks, and buses that can operate on conventional fuels (gasoline, diesel), as well as renewable and alternative fuels (hydrogen, methanol, ethanol, natural gas, and other hydro-carbons). The importance of fuel cells in automotive industries is in the sheer market size ($200 billion annually). However the benefits of fuel cell technology in terms of health and environmental impacts as compared to the cost of manufacturing has not been systematically identified and quantified. In this work we are presenting an integrated framework that can systematically identify and quantify trade-offs between cost effectiveness, and environmental & health impacts of fuel cell power systems. The integrated framework has six main components: *system level modeling, environmental impact assessment, cost modeling, health impact assessment, life cycle analysis and multi-objective optimization*.

This paper work takes full advantage of the integrated framework offers by performing a multi-objective optimization of the fuel cell system. Efficiency, cost, environmental impact and human health impact are optimized simultaneously. The solution of a multi-objective optimization problem is not a single solution but a complete non-dominated or Pareto set, which includes the alternatives representing potential compromise solutions among the objectives. This makes a range of choice available to decision makers and provides them with the trade-off information among the multiple objectives effectively. This paper presents the optimal trade-off design solutions or the Pareto set for a case study of introducing SOFC fuel cells as APUs in heavy-duty trucks and luxury vehicles (RVs and Limos) on US roads. A comparative analysis with current IC engines based vehicles is also presented.

ON THE HYDROGEN ON-BOARD STORAGE IN GRAPHITE NANOFIBERS FOR FUEL CELL VEHICLES

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A new simplified method is used of evaluation of hydrogen diffusion characteristics from the known data on temperature programmed desorption spectra (TPD peaks).

Thermodynamic and diffusion characteristics of two hydrogen desorption processes (TPD peaks # 2 and # 3) are obtained: (i) from the Atsumi H., et al. data (1988-2003) on isotropic graphite charged at 3-60 kPa and elevated temperatures, (ii) from the Orimo S., et al. data (1999-2003) on mechanically prepared nanocrystalline graphite charged at 1 MPa (under ball milling), and (iii) from the Bashkin I.O., Ossipyan Yu.A., et al. data (2003) on nanofibers charged at 9 GPa. Revealing of the chemisorption nature of the hydrogen sorption processes (TPD peaks of # 2 and # 3 types) is done by the use of the 'ab initio' molecular orbital study results (Yang F.H., Yang R.T. (2002)).

Thermodynamic and diffusion characteristics of three hydrogen desorption processes ('peak' # 1 (extremely anomalous), and two TPD peaks of # 2 and # 3 types) are obtained from the Rodriguez-Baker et al. unique (non-reproduced) data (1997-1999) on nanofibers charged at ~10 MPa; 'peak' # 1 could satisfy with the U.S. DOE requirements on the hydrogen on-board storage.

A possibility is considered of revealing of the true Rodriguez-Baker et al. regimes of hydrogenation and/or synthesis of graphite nanofibers, and the use of the anomalous 'peak' # 1 for the DOE problem solution.

Fuel Infrastructure Pathways for Fuel Cell Vehicles: A Scenario Analysis

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The potential for transition to a fuel cell-based transportation system is subject to an array of uncertainties, including cost and performance of technologies; prices of utilized and competing fuels; consumer willingness to adopt new vehicle and refueling technologies; and policy decisions. A broad range of infrastructure technologies and fueling pathways are possible, with the potential for very different economic and environmental implications. This paper presents a technology scenario analysis using the bottom-up, energy-economy-environment model MARKAL. This modeling approach allows rapid assessment of the consequences of varying assumptions on potential technology pathways. Sensitivity analysis allows the identification of key assumptions that lead to scenario branch points, and Modeling to Generate Alternatives (MGA) techniques are used to identify a number of very different scenarios. The paper describes the methodology used to model the hydrogen fuel cell infrastructure and the scenario, sensitivity analysis, and MGA results.

Modeling of a Passenger Car Equipped with a Fuel Cell Auxiliary Power Unit (APU)

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This paper addresses the performance and auxiliary power requirements of a passenger car equipped with a fuel cell Auxiliary Power Unit (APU). As an APU, fuel cells provide electric power to the vehicle accessories while the internal combustion engine (ICE) propels the wheels. The advantage of this arrangement is that fuel cells operate independently of the main ICE. The modeling tool ADVISOR (Advanced Vehicle Simulator), developed by National Renewable Energy Laboratory (NREL), is used to simulate and compare APU and the conventional alternator based ICE vehicles. Four different standardized drive cycles are analyzed and respective overall efficiencies and fuel economy are compared. Parametric studies are conducted to quantify the effects of APU performance parameters including startup-time, transient response, startup energy requirement, turndown ratio, fuel cell efficiency, and the APU mass. An additional parametric study is conducted to characterize the relationship between required battery size and APU startup time. The most important overall finding is that the relative advantage of an APU/ICE hybrid vehicle is very sensitive to fuel cell energy conversion efficiency. Also, the APU/ICE vehicle is not useful unless an ICE stop-start strategy is incorporated. Assuming a baseline fuel cell efficiency of 35% yields only slightly better mileage for the APU/ICE hybrid for urban driving cycles. If the efficiency of the fuel cell is increased to 40% or more, the APU/ICE hybrid offers considerable benefits over the conventional ICE vehicle over a wide variety of drive cycles.

Hydrogen's Value – An Aggravating Computation

By David Haberman, IF, LLC, and
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A major challenge for enterprises that intend to play in the hydrogen economy is finding consistent and generally accepted methods for valuation, whether it be used in support of government policy development or in a conventional business sense. Valuation is important to government policy because such policy must demonstrate the merits of taxpayer support for hydrogen. Valuation is used by the business community to quantify the potential risks and return on investment in the area. While various commercial products exist in certain elements of the hydrogen energy chain substantial pre-commercialization investment is still necessary to ensure the success of the hydrogen vision. As additional financial support is championed for this investment it is necessary to examine the status of valuation methods and highlight the rationale for certain approaches. This paper will compare and contrast quantifications that have been used recently in order to provide the logic for applying each approach. Each has its merits, but no single approach is viewed as valid.

Hydrogen energy will face growing scrutiny as more investment capital is pursued and the policy impacts of change become more evident. A multi-dimensional approach to economic modeling of hydrogen is required. Two major non-profit institutions: the Gas Technology Institute (GTI) a hydrogen energy expert and RAND, economic analysis experts are teaming up to address this complex topic.

Economic Feasibility of Producing Hydrogen Using Excess Electricity From Wind Turbines on the Big Island of Hawaii

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ABSTRACT

Like many islands, Hawaii is subject to a unique set of energy issues in terms of supply and reliability. The State is the most oil-dependent State in the nation, relying on oil not only for transportation applications but also to generate much of its electricity. Additionally, Hawaii's individual islands do not have interconnected grid, forcing each to be self-sustaining. While renewable resources are plentiful on the islands, to date there has been no economic method of using these resources to alleviate Hawaii's energy problems. Hydrogen, produced using renewable resources like wind, may provide a solution to the State's dependence on oil for electricity and transportation applications. The Big Island of Hawaii, in particular, provides an excellent opportunity to test the potential to produce hydrogen using renewables for use in stationary and transportation applications. The island has plentiful wind resources and also has a small, isolated, congested transmission grid that is strained during early morning and evening peak hours. This study analyzed the economic feasibility, given commercially available technology, of producing hydrogen using excess electricity from wind turbines and assessed the economic potential to use this hydrogen as a transportation fuel and a fuel for stationary power, on the Big Island of Hawaii.

Hydropower Pluralism in Nepal: Enhancing Social and Environmental Justice

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Abstract

Hydropower contributes to 90 percent of total energy generation in Nepal. However, after decades of hydropower generation, only 18 percent of the Nepali population is connected to electricity, a miniscule 2 per cent in rural areas. At the same time, there has been a pluralistic approach to hydropower generation where the technology ranges from the pico to medium sized plants. Out of the total hydropower production of 563.8MW, almost 90 percent comes from medium size plants, while micro and small hydro contributes 4 and 5 percent respectively. In this paper, I argue that technological pluralism through formal institutions (policies, law, acts, regulations and rules) and more inclusive management will be the engine for achieving social and environmental justice, especially in rural areas, who are particularly affected when large projects intervene.

The approach is essentially empirical based on institutional policy analysis. Information is derived from secondary sources, fieldwork and personal professional experiences. Albeit slowly, Nepal's hydropower sector is starting to balance rhetoric and reality. Different scales of hydropower technology have had its own tangent of development, but the overall picture is getting clearer. While knowledge and experiences are crucial to this development, adequate formal institutions need to be designed and implemented through transparent and participatory processes to sustain plurality and inclusiveness in management aimed to achieve equitable standards.

ENERGY EFFICIENCY REALIZED FROM EMPLOYMENT OF FUZZY LOGIC FOR CONTROLLING A DYNAMIC ENERGY SYSTEM

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Abstract

For proportional-integral-derivative (PID) and proportional-sum-derivative (PSD) controllers, the gain coefficients can be varied by making use of fuzzy-logic based rules and according to the energy system dynamics. The objective of this study is to examine the effects of setback and setup operational strategies on the performance of fuzzy-PID (FPID) and fuzzy-PSD (FPSD) controllers for a heating and cooling energy system during a transient operation period. To achieve the objective, a dynamic energy system model, described by a set of differential equations, is simulated and the gain coefficients of FPID and FPSD controllers are determined, for each time step of the operation period, by utilizing a set of pre-determined fuzzy-logic rules. The performance comparison for the FPID and FPSD control algorithms is made based on cost functions related to energy utility and offset from setpoint. The results show that the employment of fuzzy reasoning lowers heating and cooling energy demand as well as energy consumption when the setup operational strategy is applied.

Key words: Energy efficiency, Dynamics, Control, Fuzzy-PID, Fuzzy-PSD

Passive Solar Design of Constructions: An Analytical Method to Find Optimal Wall Thickness for Highly Insulated Environments

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ABSTRACT

Passive solar design is a field of architecture ruled by the application of classical premises involving the utilized concepts and materials, seldom reviewed as a consequence of quantitative or functional evaluations carried out after the construction is ended.

The aforementioned has centered the scope of this subject on the technological evolution of active systems and insulating materials rather than on the generation of analytical means applicable to buildings' thermal design on passive-system traditional-materials basis.

An algorithm oriented to that purpose is introduced in this work founded on the error maximization of the Interior Temperature / Temperature of Sky Transfer Function, which is defined by means of an electrical network model that captures representative aspects of the analyzed process. Heat transfer from the soil and by convection have been excluded in the present development phase of the model. The aforementioned Transfer Function is attained by linearizing the solar radiation transfer for the selected exterior temperature mean value.

An evaluation of the proposed methodology is included in the form of a parametric study for a base case with traditional materials where, for a constant ceiling height and thickness, wall thickness is optimized in terms of the construction dimensions.

Thermal Comfort in a Passive Solar Building

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ABSTRACT

The Subiaco Sustainable Demonstration Home (SSDH) is a collaborative effort between a local council and the building industry to create a house that uses fewer resources than normally built homes during its construction, use, and eventual demolition. The home will be used to educate the public on the benefits of integrating environmental design and construction techniques in the building of residential houses, which can also be applied in industrial or commercial situations. The house has been designed using Passive Solar principles, so should remain thermally comfortable inside for most of the year, without the need of active heating or cooling systems. Monitoring the thermal performance of the building is integral to the project to prove that there are benefits, both in living conditions and energy minimisation, to applying passive solar principles at the design stage. The house has a grid-interactive photovoltaic array, and if operated properly, should be a net energy exporter to the main grid. Monitoring will include the measurement of air temperature and relative humidity in the building to prove that the interior remains within established thermal comfort levels. Preliminary results are being collected, with more comprehensive data available mid-2004. Computer modelling of the building indicates that it will have low energy use compared to other comparably designed houses. SEDO (Sustainable Energy Development Office) rated 50 different house designs using the NatHERS energy modelling software and the SSDH performed the best in 11 of 28 different climate zones (SEDO, 2004), indicating the design could be replicated in other parts of the country. The SSDH is not a perfect passive solar design, but should still be able to remain thermally comfortable throughout the year without the need for mechanical cooling or heating.

SEDO, (2004), http://sedonewsbyemail.vividesign.com.au /DisplayNews.asp?id=76, [Accessed 13/1/2004]

ENERGY CODE FOR NEW RESIDENSTIAL BUILDINGS IN EGYPT

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ABSTRACT

Energy loads in new residential buildings were increased due to improper use of building materials and non-adequate building design. The increase in the overall energy demands has reached to about 64.3 Billion kWh with an annual increase of 5.7%. The potential for energy conservation for residential buildings is large in Egypt. This paper is mainly focused on improving the energy efficiency for the building envelope requirements of New Residential Buildings in Egypt. The residential energy code that has been developed recently and it specifies minimum building requirements to improve both thermal and visual comfort in non-conditioned buildings as well as minimum energy efficiency requirements in conditioned buildings. This Code gives minimum performance standards for building windows and openings, natural ventilation and thermal comfort, ventilating and air conditioning equipment, natural and artificial lighting and electric power. This study take in consider the building envelope, orientation, window opening size as a ratio of wall area, and the glazing type for Cairo and Alexandria. It was determined that for most Residential Buildings in Egypt with SHGC values above 0.61, increases the total Electrical Consumption by 25 %. Simulation results show that the range of wall U-value are between 1.0 and 1.33 $W/m^2.^oC$ while the roof U-value is the same as previously published in the Egyptian Insulation Standards in 1998. Roof and wall insulation provides significant energy savings, 40% for the roofs and 12% for walls. An Energy saving of 20% should be achieved when this code is enforcement by law.

From the Past to the Future of Bioclimatic Architecture in Cuba

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ABSTRACT

The model recommended in Bioclimatic Design Manuals for warm humid climates as Cubans one, correspond with the architecture developed by the aborigines before the Spanish colonization. However, this model is representative of a rural architecture, that continued been developed, but is being transformed and even substituted today by new models associated to false concepts of development, modernity, quality and comfort. The first urban settlements developed in the Island followed the Mediterranean Model imported by the Spanish colonizers, which are hence, contradictory with recommendations given for Cuban conditions in all the classic manuals about these issues. Nevertheless, it has been a common practice during the last decades to idealise the Colonial Architecture as the true, authentic and even, bioclimatic. How certain could be all this thought?
What could be considered Bioclimatic Architecture in Cuba, particularly taking into account the urban context? Which is the actual Cuban bioclimatic architecture?
The paper intends to give answers for these and other questions, based on an analysis of the climatic behaviour of Cuban architecture and urbanism along the History. The study about the past and the present is taken as a basis for the reflections about the future and the importance of the present generation legacy to the future ones, enriching tradition with contemporary and local with global.

SOLAR CHIMNEYS FOR VENTILATION AND PASSIVE COOLING

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The increasing impact of ventilation and air-conditioning to the total energy consumption of buildings has drawn attention to natural ventilation and passive cooling. A solar chimney represents an option to employ solar energy in this area.

Two full-scale solar chimneys have been built and tested at the Department of Thermodynamics and Environmental Engineering at the Brno University of Technology. The main goal of the experiments was to investigate performance of solar chimneys under the climatic conditions of the Czech Republic. Two different constructions of a solar chimney have been tested; a light weight construction and a construction with thermal mass. The thermal mass enables utilization of a solar chimney for ventilation or passive cooling at night. The chimneys have been located on the roof of one of the department's laboratories.

The investigations on the test chimneys revealed a significant impact of wind to the chimney performance in the tested configuration. The experiences acquired during the experiments were employed in design of solar chimneys for a demonstration house, fitted with a hybrid ventilation system, which was built in the university campus.

The experiments carried out in the demonstration house will enable investigation of the solar chimney performance under more realistic conditions - in regard to the building and the ventilation system.

Energy Efficiency Optimization in Air Conditioned Buildings through Summer Elusive Climate:
Case Study of Public Zones

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ABSTRACT
Human thermal comfort is affected by many variables, such as, Health, Age, Activity, Clothing, Sex, Food and acclimatization for any particular person. While there appears to be no rigid rules or fast formulae as to the best indoor climatic conditions for comfort for all human beings.

Rules that will apply to all conditions for all people cannot be generally given; this is why all previous investigations and referenced case studies had leads evaluate the best approximate conditions under which a majority of zone or space occupants will feel comfortable.

The present paper is a part of long-term field case-study investigations to establish compatible tropical comfort chart suitable and appropriately applicable to citizen at different Egyptian governorates. Such investigations were based on the same concepts and methodologies used and applied to establish the well known ASHRAE comfort chart.

Research dealt with only men over 45-years old with same metabolic rates at summer season who are dressed with clothing that ranges from 0.5Clo to 0.65Clo, Weighted from 70-to-90 kg and subjected to air treated conditions for long periods (over two hours) such as Theaters, Lecture halls, Hospital waiting areas, Conference halls, and Public office buildings. The questionnaire vote level was based on a minimum of 10 persons covering all Egyptian governorates.

Most of people after being subjected to treated air become acclimated to the indoor conditions in their original environment they are moved into another Pre-adjusted chamber such as Theater waiting lobby, Lecture hall salons, patient or laboratory room, conference dining halls or office. All of them had immediately expressed their vote and reactions to the new indoor climatic conditions, warm, cool, fair and same.
Great mass of data were collected and sorted out to apply the related Operative Temperatures (O.T.) on the psychrometric chart.

One of the main conclusions clearly outlined from the present analyses is that the obtained O.T. scale was different from that of the ASHRAE .At optimum O.T. the maximum acceptance of comfort did not exceed 78% according to the type of applications. Analyses of obtained results may aid to explain the causes and reasons of many up normal human characteristics due to the human stress modes. This would strongly recommend the inclusion of human stress modes to the human comfort variables.

Spherion – A Low Energy and High Comfort Office Building

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The “Spherion” is an outstanding office building in Duesseldorf, which fulfills the three main goals of the client and user Deloitte & Touche: Low energy costs, high comfort, and low investment costs. Extremely low values for heating (35 kWh/m²a), cooling (17 kWh/m²a) and lighting (8 kWh/m²a) had to be realised, which are far below building regulations and conventions. The overall annual energy costs of 6 Euro/m²a are far below those of conventional office buildings (about 18 Euro/m²a). The room comfort was defined by a performance specification for room temperature (winter / summer), natural ventilation (mechanical ventilation only for core and conference areas), daylighting for all office areas (including central areas with a window distance up to 7 m), and artificial lighting, automatically controlled in dependance of daylight and user presence. The investment costs for the building with a floor area of 27,000 m² are in the normal range of about 1,600 EURO /m².

This result was mainly achieved by an intelligent integration of advanced architecture, building components and services as well as an interdisciplinary planning approach (architecture Deilmann + Koch, energy and light GLB, services ZWP). The compact building shape with a central atrium was optimized as to site utilisation, heat losses, solar control, daylighting and natural ventilation.

Solar optical properties and daylight potential of electrochromic windows

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Daylight is a very pleasant, natural and energy-efficient light source for buildings and offices. The potential of utilization of daylight however depends on some demands for comfort in interiors. Thermal overheating and glare or too low illuminance due to stationary anti-glare shields are typical problems. Electrochromic windows seem to be an alternative with good potential in the future. Parameters like the visible light and solar transmittance, the reflectance, the switching time for bleaching and coloring were investigated. There were achieved good results by a new electrochromic system which consists of complementary electrochromic layers of Prussian Blue and tungsten oxide. It is possible to switch the visible light transmittance from up to 0.08 at the colored to 0.75 at the bleached state with very low electric energies. These measurement results were used for the data input in the light simulation software Adeline/Radiance. The practical use was investigated by help of the simulation results and in comparison by means of a test room. Falsecolored luminance pictures were used for the evaluation of glare on the windows or on the walls besides. The illuminance at workplace level in the room was measured for all seasons. These data are a qualified tool for the estimation of the daylight potential of electrochromic windows. The investigation has shown that electrochromic glazings make additional protection against the sun nearly unnecessary. There is a good lighting of offices during the whole sunshine period especially in combination with an automatic adjustment of the coloration level for the windows and daylight re-directing elements.

PV Solar stacks for "added value"

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In lower latitudes, such as Hong Kong (HK) at 22degrees N, the high solar path makes PV façades harder to justify due to their reduced output so secondary advantages are being researched to increase their cost effectiveness. A previous paper reported CFD Pro-Star software analysis investigating the updraft in a PV-faced solar stack of specified parameters. The results indicated a stable velocity of 4.0m/s over its 120m height in steady state sub-tropical conditions and though insufficient for a micro-turbine justified further research for enhanced ventilation potential. High-rise development for all building sectors is common in HK, with 120m height buildings being standard. Residential towers now rise over 200m and some commercial buildings exceed 300m tall. Using spreadsheet analysis, this paper reviews the local seasonal weather conditions and "solar chimney" characteristics to identify expected performance in order to define the determinants for further CFD study. The analysis identified that for a 300m stack, in no-sun conditions, the internal velocity exceeds 7.4m/s all-year and is suitable for a micro-turbine. At 600W/ms, maximum solar radiation intensity (vertical façade), the stack has an internal air velocity over 10.3m/s all year. Thus in very tall buildings although a conventional externally sited turbine(s) might be technically feasible, a range of small-scale stack integrated micro-turbines would be more practical and cost effective. The analysis further indicated that 0.6m deep, 120m height stacks provided useful velocity and volume in the "dry season" when natural ventilation is most useful. Taller stacks show marked improvement of velocity and air volume, especially in maximum solar intensity conditions, to warrant its study under dynamic conditions. This is now underway.

Optimum thermal insulation for building
Walls, in hot arid region

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ABSTRACT

Hot arid regions are characterized by high temperature, and high solar radiation.
The outdoor temperature fluctuates considerably during any one day and over the year.
Corresponding the indoor temperature changes due to such fluctuations.
In hot climates such as Iraq (lat. 29-37N) case study which is rich with solar energy with an arrange isolation of 7.5 kWh/m².day
The cooling is dominate this paper studies, the thermal performance of a residential building materials, and optimum walls roofs insulation thickness, to the external temperature fluctuation “temperature waves”.
Three types of thermal insulation used residential house (polystyrene, polyurethane and mineral wool) it is found that there optimum thickness are (10, 6 and 4) cm respectively.

Introduction: -

Hot arid regions are characterized by high temperature, and high solar radiation. The outdoor temperature fluctuates considerably during any one day and over the year. Correspondingly the indoor temperature change due to such fluctuations. Also the indoor temperature is effected by the details of the thermal properties of building materials, insulation thickens, building geometry and geographic orientation.
The clement in Iraq (case study) is very hot in summer, which is rich with solar energy with average insulation of (5 to 7) kWh/m²day.
As result a considerable amount of energy is consumed in summer time, (the cooling is dominant)
Due to there large masses, high specific heats, and low thermal conductivity, walls, roof, insulation layers, on the roof and walls, as delay elements, to the external temperature fluctuation “temperature weaves “ the amount of delay can be varied and the amount of heat intake
Changed. By controlling the wall, roofs, thickness, and insulates layer in roofs and walls.
There for the main factors which reduce the effect of external temperature fluctuates, walls, roofs materials insulation thickness.
To determine the roofs and walls insulation thickness is necessary ti minimizing the expenses of roofs and walls (system)
The present work is to give the designer a tool to select the exact insulation thickness to obtain the lowest total cost insulation and energy.

EFFECT OF GLASS THICKNESS ON THE THERMAL PERFORMANCE OF EVACUATED GLAZING

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Abstract

Flat evacuated glazing consists of two plane glass panes separated by a narrow internal evacuated space. Separation of the space is maintained by an array of support pillars typically 0.32mm in diameter and 0.12mm high arranged on a regular square grid with an inter-pillar separation of up to 40mm. A detailed three-dimensional finite volume model has been employed to determine the variation of thermal performance of an evacuated glazing as a function of glass pane thickness.

In general, for a standard glazing system, the thicker the glass sheets are, the smaller the U-value of the system will be, i.e. the thermal performance of the glazing will be better. For evacuated glazing with dimensions of less than about 1m by 1m, the opposite effect was observed if the pillar size and pillar separation were designed according to the four restrictions detailed by Collins and Simko, 1998. Increasing the glass sheet thickness leads to a decrease in the heat transfer through a single pillar, this is due to the thermal resistance of the glass sheet above the two pillar ends increasing. However increasing the glass sheet thickness leads to an increase in the heat transfer per unit length of the edge due to edge conduction. The rate of this increase is larger than the rate of decrease of heat transfer through the pillar array. This leads to an increase in the total heat transfer and thus U-value through the whole glazing system.

When the glazing dimension equals to or is greater than 1m by 1m, the ratio of the heat transfer through the edge seal to the heat transfer through the overall glazing reduces. The rate of increase in the heat transfer per unit length of edge is less than the rate of decrease in heat transfer through the glass central area with increasing glass pane thickness. If the evacuated glazing size equals to or is greater than 1m by 1m, the thicker the glass pane, the better the thermal performance of the evacuated glazing will be.

An optimal glass thickness exists for evacuated glazing systems of a given size. For the simulation undertaken it was found that if the glazing dimension is less than 1m by 1m, the thinner the glass thickness, the better the thermal performance will be. If the glazing size equals to or is greater than 1m by 1m, the thicker the glass sheets, the better the thermal performance will be. Increasing the frame insulation height or decreasing the edge seal width decreases the magnitude of the variation of heat transfer coefficient resulting from changing thickness of glass panes. This is due to the heat flow resulting from edge seal conduction decreasing.

Thermal Analysis of an Electrochromic Vacuum Glazing

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Abstract

The thermal performance of an electrochromic vacuum glazing was simulated using a three-dimensional finite volume model. The simulated 0.5m by 0.5m electrochromic evacuated glazing consisted of three glass panes with a 0.12mm wide evacuated space between two 4mm thick panes supported by 0.32mm diameter pillars spaced on a 25mm grid contiguously sealed by a 6mm wide metal edge seal. The third glass pane on which the electrochromic layer was deposited was sealed to the evacuated glass unit. The simulation results indicate that with increasing energy absorption of the electrochromic layer, the temperatures of the indoor and outdoor glass panes increased for the electrochromic layer when facing both the indoor and outdoor environments. The rate of increase in the temperature of the indoor glass pane was greater than that of the outdoor glass pane when the electrochromic layer was facing the indoor environment. The rate of increase in the temperature of the outdoor glass pane was greater than that of the indoor glass pane when the electrochromic layer faced the outdoor environment. With increasing insolation level incident on the outdoor glass pane, the temperatures of both the indoor and outdoor glass panes increased for the electrochromic layer facing both the indoor and outdoor environments. The rate of increase in the temperature of the indoor glass pane was greater than that of the outdoor glass pane when the electrochromic layer was facing the indoor environment. Using this installation method, the temperature of the indoor glass pane was higher than 100ºC when the insolation level was higher than 600Wm^{-2}, which will damage the glazing system and make the indoor environment unbearable. The rate of increase in the temperature of the outdoor glass pane was greater than that of the indoor glass pane when the electrochromic layer faced the outdoor environment. Using this installation method, the temperature of the indoor glass pane was 30ºC when the insolation level was 600Wm^{-2}. Setting the glass pane with the electrochromic layer facing the outdoor environment is the only suitable way to install electrochromic vacuum glazing. A deeper rebate depth of the window frame can increase the temperature difference between the indoor and outdoor glass panes, i.e. reduce the heat transfer coefficient, however the rate of reduction in the heat transfer coefficient of the glazing system decreases with increasing window frame rebate.

Tri-generation in the tertiary sector: Market potential in some European countries, Technical solutions and Demonstration project

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In order to reduce primary energy use, CO_2 and CFC emissions it is essential to develop trigeneration systems for cooling in the building sector. They will contribute to the achievement of the Kyoto targets and to the development of more sustainable energy systems and services. Trigeneration will increase the diversity of energy supply and reduce the environmental impact of cooling, heating and power generation. An increase in the overall energy efficiency of tri-generation systems of 15-20% can be realised by utilisation of the waste heat of a CHP system for the production of cold by means of solid sorption cooling technology. In addition peak electricity demands of cooling purposes can be reduced.

In 'SOCOOL', a project funded by the EU Framework V Programme, we are developing a small solid sorption system with high power density, by applying new working pairs and innovative system designs with high rates of heat and mass transfer. The new cooling machine developed within the project is to be low in cost (cheap to manufacture), and to have a high efficiency, and to operate with a high reliability. A prototype trigeneration system is to be built and tested at CRF's Eco-building in Turin. One sub-system is driven by the exhaust heat recovered from the CHP system and another is driven by the cooling jacket water. The principles and expected performance of both are described briefly.

A part of activity is addressed to the selection and development of adsorbent/adsorbate pairs most suitable for the realisation of the two sorption cooling subsystems. This activity has a difficult goal for the subsystem that is driven by the cooling jacket water of the CHP device. To this aim, a sorbent material has to be selected/developed, it must show good performance using a driving heat source as low as 75-80 °C.

For system analysis purposes a mathematical model is set up containing all the trigenerator subsystems as well as a model of the user system. This model will be used to simulate and evaluate the operational strategy of the trigenerator and will support in the definition of the technical specifications of the system.

In addition, an estimate of the potential demand for tri-generation in the tertiary sector within EU countries has to be made. Data on energy use patterns in the building sector of several countries is needed. Initially we have collected and analyzed both the general energy situation and the primary and end use energy structure data in Poland, Italy and The Netherlands. Analysis of the present state and development of CHP in the countries considered has been carried out. Following that, energy needs in the types of buildings that are appropriate for trigeneration in different countries has been analysed. To complete this task a technical description of the actual buildings (or set of buildings) and statistical data have been used.

The preliminary evaluation of the current and future demand for tri-generation has been performed. It is expected that the initial penetration rate (to 2010) will be different in the countries of consideration, in high latitude countries it will be rather low and based on new rather than retrofit applications. However, after 2010 when tri-generation technology becomes better known in considered countries the utilization of this technology is expected to appear a relatively good investment in offices and especially in the hotel and retail sectors.

Earth-Sheltered Housing in Hot-Arid Climates

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Abstract
The authors report on the development of a flowchart guideline to assess the suitability of earth-sheltered buildings for hot–arid climates. There is at present no established method for assessing the suitability of earth-sheltering for a specific location.

The demand for energy for cooling buildings in hot-arid climates causes problems not only in terms of global warming, but also in the demands on the local electricity infrastructure. Earth-sheltering can help reduce heat gains from the environment and result in lower cooling loads. By placing the walls of the building beneath ground level, solar gains are reduced and the walls are in contact with earth at a lower temperature than at the surface.

In developing the guideline, the advantages and disadvantages of earth-sheltering are discussed. A suitable method for estimating sub-ground temperatures is introduced, followed by a method for simulating heat transfer in the sub-ground areas. Use of this in Kuwait has demonstrated reductions in heat transfer greater than 40%.

The flowchart is arranged as a series of logical steps which include assessment of public acceptability, simulations of underground heat transfer, whole building energy consumption, direct sun penetration, daylighting and costs.

"COOLFAN" – ENERGY CONSERVING PERSONAL COOLING SYSTEM

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ABSTRACT

Malaysia is located in the tropics and thus experiences a hot, humid climate. Majority of the housing stock is terraced housing as well as multi storey condominiums. Each of the 3 or 4 bedrooms as well as the living and dining rooms are typically air-conditioned by using the commercially available split-systems. This involves a fan-coil unit in each of the air-conditioned space coupled to an appropriate outdoor condenser unit, usually located in the balcony or hung on the outer façade of the building. This disfigures the appearance of the exterior of the buildings. This paper investigates an innovative way of delivering cool air, using an energy efficient "COOLFAN" (a sort of a personal air-conditioning system) which successfully adopts the principles of partial air-conditioning. thus making the total system very energy efficient. This would lead to enormous savings in energy consumption, thus contributing to energy conservation in the building. This paper would describe the concepts, design and development of the above.

An Evaluation of Natural Ventilation Regimes in Refurbished Historic Buildings using Wind Tunnel Modelling and CFD

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Abstract

Wind Tunnel Modelling and Computational Fluid Dynamics (CFD) were used to simulate natural ventilation through refurbished historic buildings in an urban context. CFD is used to simulate the transient thermal performance of rectangular building sections, through transitional indoor/outdoor spaces. Results are compared with site monitoring and independent wind tunnel modelling.

Findings showed that the typical courtyard building performs differently from what was expected. In peak summer with nominal air movement hot air dips into the open courtyard, overriding any egress from internal gains, thus raising the indoor temperatures when windows were left open. This also depleted the precious '*coolth*' stored within the thick heavy mass of the building. In Malta's mild winter conditions, solar and internal gains were sufficient to retain temperatures within acceptable comfort conditions, thus diminishing heating loads. Across spring/autumn months, with wide-ranging temperatures, natural cross ventilation proved sufficient to keep the building within stable conditions, thus reducing annual energy bills.

An Evaluation of the Potential and Limitations of Critical Thermal Mass for Passive Cooling in Heavyweight Buildings in a Mediterranean Climate.

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Abstract

This study evaluates the effects of thermal mass on passive cooling in Malta. In consideration of globigerina limestone as the indigenous easily available material and its constituents, this paper looks closely at the thermal capacity of a composite wall structure. It was established that there is a critical thickness for a given composition of a typical traditional building in Malta in an urban context, typical of Mediterranean countries.

In order to assess the thermal performance of the local composite wall structure physical monitoring was carried out using multiple thermistors probes at different depths in order to establish the temperature profile through the wall over a given time frame. Concurrently air and surface temperatures were also monitored separately. The output was compared to a prediction model, HTB2, Heat Transfer through Buildings. The computer model was used to simulate both boundary and inner core transient conditions across a variable wall thickness.

Results concluded that although outdoor conditions play an important role in influencing indoor conditions, there is a critical thickness for the wall's thermal inertia to be effective. This is the critical depth beyond which any additional mass practically has no effect on moderating outdoor-indoor conditions, except for an increase in rising damp, depending on the construction methodology of the day. This critical mass is considered important when determining dimensions for new wall construction or scooping out existing walls in a refurbishment job. This reduces the embodied energy of the building in construction, and in turn its energy demand in use.

Monitoring of Energy Efficiency Upgrades of Public Housing in Southern New Zealand

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Abstract

The monitoring of an energy efficiency retrofit programme of state houses in southern New Zealand regions has being undertaken since December 2002. Monitoring equipment consisting of temperature, energy dataloggers and hot water run-of time counters have been deployed among the three groups of the 111 monitored houses during a three stage installation. Historical and sociological information concerning the occupants and the household energy use was obtained by the initial formal site survey. From the collected data in the first year the preliminary findings suggest low internal temperatures occur during the winter months. The minimum internal living room temperature recorded during a period in which a household room was occupied was just over 3.0 ^{o}C. Similar findings were obtained during a parallel exercise monitoring student accommodation in Dunedin. With the further collection of the logged data and other information over the whole monitoring period, more information concerning the efficacy of this energy efficiency upgrade programme will be revealed.

A Cost-Benefit Analysis of an Insulation Retrofit to New Zealand State Housing

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Abstract

In this study, we analysed the expected thermal performance effects of an insulation upgrade to a typical Housing NZ low income state house. The particular house chosen is one of 3600 on the South Island of New Zealand that are undergoing insulation retrofits in a national program to reduce energy use and CO_2 emissions while improving the health conditions in state-owned housing. The house was simulated using both steady state and dynamic modelling tools, and the results were validated against the monitored performance of the actual house. The planned upgrades were simulated over a variety of heating schedules to provide a broad view of how the retrofit will change the range of comfort vs. energy consumption choices of the tenant.

LOW ENERGY ARCHITECTURE – DESIGN AND PERFORMANCE IN PRACTICE: TE MANAWA O AKORANGA, AUCKLAND, NEW ZEALAND.

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This building won the 2002 Energy-Wise Commercial Buildings Award, the judge noting it was 'an excellent example of the result that can be achieved through the application of fundamental energy design principles at the early architectural concept stage, with appropriate follow-up during design development.' The aim here is to describe the design process, the outcome, and the performance of the Reception and Administration Building at the Akoranga Campus of the Auckland University of Technology.

The approach taken included interviewing the architect and the building services engineer to discover the processes involved and their (retrospective) thoughts on the design; conducting a PROBE-style questionnaire survey of the building occupants to gauge their response to the building; carrying out an energy audit and checking that aspect of its operation with the facility managers; and finally, monitoring temperature and humidity in the building over a range of climatic conditions.

The paper comments on each of these aspects and presents an overview discussion of the building's performance which, to judge from their responses, fulfilled most of the expectations of the users.

Testing the Thermal Properties of Earth Building Materials

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The inherent variability of earth building materials means there is a lack of reliable information on their thermal properties compared to that for more uniform, mass-produced building fabrics. However, such information is required to assess the thermal performance of a building design. Furthermore, many existing methods for testing thermal properties are unsuitable for earth building materials, as their inhomogeneous nature requires relatively large sample sizes.

The aim of this project was to develop and adapt suitable methods for determining the thermal properties of earth building materials and in the process determine the properties of a type of cement stabilised pressed earth. A dynamic, in-situ method of obtaining thermal diffusivity was developed and implemented using a purpose-built instrumented test wall section. Standard laboratory methods were used to obtain other material properties, and the thermal conductivity of the target material at in-use conditions calculated from the combined results.

The average thermal properties of the target material at equilibrium moisture content were found and were very similar to that for standard ‘sand and gravel’ concrete. The methods developed were successful at obtaining results for the target material within an acceptable error bound, given the significant degree of compositional variation between samples.

THE NATURAL VENTILATION POTENTIAL OF OFFICE BUILDINGS IN THE UNITED STATES

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ABSTRACT
Natural ventilation has the potential to reduce energy use in buildings by providing thermal comfort without the need for mechanical air conditioning. Moreover, the adoption of manually opening windows and narrow floor widths to achieve such objectives results in even greater returns than the above energy saving due to increased productivity, reduced staff turnover and reduced absenteeism. Despite this, many natural ventilation strategies do not eventuate and one reason has been the lack of tools suitable for the early stages of design where these decisions must be taken.

This paper uses recently developed nat-vent tools to compare the different levels of potential thermal comfort achieved by high rise buildings for the following cities: Miami and New Orleans (hot humid climate); San Diego and Phoenix (hot arid climate): Cleveland and Boston (temperate climate): and Denver and Chicago (cool climate). In addition large metropolitan areas such as Los Angeles, San Francisco and New York have been also included for a fuller comparison.

The results in this paper suggest that natural ventilation has definite possibilities for high rise buildings in warmer climates and potential for buildings in more temperate climates. Potential thermal comfort levels are lower in temperate climates but would still present opportunities for building developers and designers. The results would also suggest that design criteria used for buildings in the warmer climates do not necessarily apply in temperate climates and designers need to be cautious.

Energy consumption indicators for Technical University of Catalonia (UPC) buildings

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Abstract

The aim of this paper is to show an experience in the definition of indicators to measure the influence of the buildings use in the energy consumption, against the other factors that influence it.

This paper summarizes the study carried out by the authors by assignment of the Environmental Plan of Technical University off Catalonia (UPC) on the possibility of assessing the associated consumption to the different uses (educational, research, management, library, etc.) typified and quantified for the university spaces. The interest of the study for the UPC is to explore the possibility of determining possible energy efficiency policies based on actions on the user, that did not suppose discrimination in function of the different infrastructure that are used or the different types of activity that are carried out.

To do so it, was necessary to separate the different factors that influence in the energy consumption and, above all, to measure simultaneously the consumption and the use in each monitored buildings.

Particularly, the work consisted in collecting information of the energy consumption and the intensity of use in the annual academic cycle in 6 buildings of the Technical University. The buildings were selected in accordance with the characteristics of architecture, use and location. They were splitted into two groups, one with 3 buildings with common characteristics of architecture and location, but with different uses, and the other with similar uses but with differences in architectural characteristics and location.

The results of the study permit to carry out some discussion on which are the adequate indicators, to measure the energy consumption in relation to the use of the buildings, but also to establish the relation between the use of the buildings and their energy consumption.

THE NEW BUILDING FOR THE ENVIRONMENTAL SERVICES OF GENEVA STATE A GLOBAL SUSTAINABLE APPROACH

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ABSTRACT

The new building for Environmental Services of the State of Geneva (Switzerland) is an office building with analysis laboratories, where sustainable development purposes have been looked at in a global way, from the very beginning of the design process (architectural competition), to the final detailed drawings. This paper aims to present the work carried during the conception. It will show that, thanks to a real synergy between the building owners, the designers and the experts, it has been possible to achieve very ambitious targets in terms of sustainability.
After a short description of the thought process, this paper will particularly focus on the strategies that were carried out on the following topics:

- Comfort
  - Daylighting: the target for average annual daylight sufficiency of the office spaces is 60-65% of the opening hours.
  - Seasonal shading: the south facade is fitted out with a light external gallery that supports vegetation. Thanks to deciduous plants, this facade is naturally shaded during summer and keeps sunny in winter.
  - Natural ventilation: The use of automated windows leads to take benefit of night ventilation and provides free-cooling to the building.
- Energy
  - Minergie® standard: the combination of heat loss reduction through a high quality envelope, heat recovery on extract air and optimal use of solar gains leads to a very low heating energy consumption (86 MJ/m2.a) that fulfils the requirements of the Minergie® Swiss Label.
  - Heat production: a medium size wood heater fitted with particule filter provides heat to this building and an adjacent one, combined with a gas condensing boiler for peak periods.
  - Photovoltaic: The atrium roof is coated with semi-transparent PV cells (40 % of glass surface).
- Materials selection
  This paper will present the "Hermione" multcriteria analysis method that was used to evaluate different scenarii of material selection with a "sustainable" point of view.
  We'll show with a concrete example (partitions' choice), how it has been possible to make a global analysis including all the architectural, ecological and socio-economical aspects.

KEYWORDS: Global approach, sustainability, comfort, efficiency.

DIAL-AM INTEGRATED TOOL: FROM WINDOWS DESIGN TO BETTER INDOOR PERFORMANCE

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ABSTRACT

DIAL-Am is an extension of the European project DIAL-Europe, funded by the European Commission within the framework of the FP5 Program: Energy, Environment and Sustainable Development. It includes specific adaptations to the climatic conditions of North America.

The aim of this intuitive tool is to give relevant information regarding the use of daylight, at the very first stage of the design process. By integrating natural an artificial lighting purposes as well as their implications on summer overheating, this tool leads to promote the design quality as well as the reduction of energy consumption.

DIAL focuses on the following specific targets

- Daylight factor calculation (CIE overcast sky),
  Based on a split-flux method, the calculation is very fast and is particularily adapted to comparisons and parametric studies.

- Estimation of the annual daylight sufficiency
  The implementation of climatic data (50 cities in the USA and 150 in Europe) allows the user to estimate the percentage of time during which the indoor illuminance requirements will be satisfied by natural lighting.

- Estimation of artificial lighting system
  This module calculates the illuminance values on the room surfaces due to artificial lighting. The annual electricity consumption is then estimated in relation to the annual daylight sufficiency and the switching control.

- Prediction of summer overheating,
  This module indicates the implications of the user's design on the summer thermal comfort, by estimating on a yearly base, the number of days during which the indoor temperature will exceed a given overheating set point.

- Optimization process
  A qualitative and quantitative evaluation of the room performance is made using specific fuzzy logic rules. This leads to point out the possible weak points of the design and to guide the user toward an "optimal" design.

- Comparison with presimulated case-studies.
  This module allows the user to compare its design with similar case-studies. More than 200 real or simulated examples are proposed.

KEYWORDS: Daylighting design, early design stage, intuitivity.

Potential Assessment of an Energy-saving Ventilation Design: Combination of Turbine Ventilators and Bathroom Ventilation

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ABSTRACT

This study set out to investigate the potential of installing a common turbine ventilator on to a bathroom ventilation system which serves fourteen bathrooms in the 1st dormitory block of Leader University in Taiwan, and evaluate the overall ventilation performance of this new combination. Field detection of airflow in the ventilation ducts was carried out. The results showed that the combination of the turbine ventilator and bathroom ventilation were successful in achieving sufficient air change rate in bathrooms, and this ventilation design alternative is now proposed as a method of improving the indoor air environment in bathrooms. Natural force (wind power) is used to activate the turbine ventilators and this saves the energy that would otherwise be consumed electric fans. The data gathered about the effects of the turbine ventilator on ventilation rate can serve as a reference for future ventilation design.

Keywords: ventilation, turbine ventilator, bathroom, indoor air

DOUBLE SKIN FACADE'S EFFECTS ON HEAT LOSS IN OFFICE BUILDINGS IN ISTANBUL

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ABSTRACT:
Double skin façade has great effect on building energy demand. In this research, a single skin and a double skin office building's heat loss were compared to show the double skin's effect on building energy demand. Double skin façade in office building has not been applied in İstanbul and that is why this research aims to show the basic effects of double skin façade, if it would be applied. A new method is used in double skin façade's heat loss calculation The method is formed of a modified step, which is the modification of the method developed by B. Todorovic, and an additional step for the time dependent heat transfer calculations. In the first step, inter-space temperature calculated. In the second step, inter-space temperature, which is calculated in the previous step, are assumed as outdoor temperature and heat transfer through inner skin's components calculated in unsteady condition. Temperature estimation method here is adapted to the heat loss of step-by-step hourly calculation. The new method developed in the research is applied on an office building in İstanbul assuming that it would be renovated with double skin façade. Calculations have been made for the average climatic conditions of January, which is representing winter period in İstanbul. According to results of this application study single skin office building's heat loss is %40 is higher than that of double skin office building.

Key Words: Low Energy Building, Double Façades

Title: Gifford Studios – A Case Study in Commercial Green Construction

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Synopsis:
The new building on the New Forest campus of multi-disciplinary engineering consultants Gifford has been developed as an exemplar of the practice's strategy for delivering sustainable buildings known as 'Commercial Green'. Acting as funder, owner, occupier and designer of the building has given the company a unique perspective on the challenges to be faced in bringing a sustainable design to reality.

The project provides a new reception, two open plan design studios and a staff café, equating to a new building of approximately 1700 square metres.

This paper will examine the broad range of issues that a sustainable design must address, balancing not only environmental responsibility but social value and economic feasibility. The key features of the design will be highlighted and the results of dynamic thermal modelling presented.

Fundamental to the design strategy was the selection of the building fabric and the disposition of fenestration which allows the passive performance of the building to attenuate the internal environment naturally thereby enabling a light touch to be applied to the servicing and resulting in a low energy solution.

This is a unique building that not only addresses the sustainability agenda but is high in architectural design quality and is intended to provide lessons from which the wider construction community can learn.

CERAMICS COOLERS FOR BUILDING PASSIVE COOLING

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Abstract

Porous ceramic evaporators are being studied as suitable alternatives for cooling buildings. First generation ceramic panels were tested within an environmental chamber under controlled dry bulb temperature, relative humidity, supply water pressure, and layout within a test duct. Results showed higher porosity ceramic and higher water pressure delivered greatest cooling. High dry bulb temperatures coupled with low humidity also gave greater cooling. Dry bulb temperature drops of 6-8 Kelvin have been achieved parallel with a 30% rise in relative humidity. Mean cooling performance has been related to [e_s-e], ambient to saturated vapour pressure difference; a potent parameter in evaporation. Direct evaporative cooling using porous ceramic has demonstrated significant potential for building cooling.

The thermal dual-probe: its application to the *in situ* measurement of building envelope moisture content

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Abstract

Buildings must be designed and built to achieve low energy consumption and predictable service life. In order to achieve these goals the effects of combined heat, air and moisture (HAM) transfer must be understood. A suitable moisture measurement technique is thus required. Recent work has shown that the thermal dual-probe technique appears to be applicable to *in situ* moisture measurements in typical building fabrics. Such an approach offers significant benefits over existing methods. This paper deals with the *optimisation* of the design of such a probe. Firstly, the use of a one-dimensional heat and moisture transfer model to investigate the impact of the instrument on any moisture movement within a sample is described. Secondly, the results of simulations using proven two and three-dimensional finite element (FE) models are detailed. Finally, some comparisons with measured data from built probes are provided. This work has successfully demonstrated that, depending upon the building fabric material, optimal probe lengths and spacings range from approximately 20-50mm and 10-20mm respectively.

Reflectance distributions and atrium daylight levels: a comparison between physical scale model and Radiance simulated study

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Abstract
The aim of this research was to carry out a comparative analysis between scale model measurements and computer simulated daylight factor (DF) values for a square, four-sided, top-lit atrium. In a previous study, parametric changes were made to the distribution of diffuse surfaces reflectances in the well of a physical scale model that was placed inside an artificial sky. The artificial sky replicated the luminance distribution of a CIE overcast sky. The effects of these changes on the daylight levels at the centre, edge and corner of the floor of the atrium model were investigated. To achieve the variability in reflection distribution the atrium surfaces were painted in white (0.85% wall reflectance) and black (0.02% wall reflectance) alternating horizontal bands. For each of the experiments the widths of these bands were altered but the overall split between white and black bands was always maintained at 50% white and 50% black. Experiments were also conducted for atriums with all wall surfaces painted black (0.02% wall reflectance) and all wall surfaces painted white (0.85% wall reflectance). It was concluded from the study that atrium surfaces with wide bands of different reflectance values did affect the daylight levels at the base of the atrium. However, if these bands were narrow then the daylight levels were not significantly altered by different reflectance distributions. In this study, these experiments were repeated using Ecotect and Desktop Radiance. The study showed that Radiance always underestimated the daylight factor values in comparison with those obtained from physical scale model measurements.

The Development of Optimised Holographic Optical Elements (HOEs) for Solar Control: An Approach to Research and Development

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Systems that control illumination and solar gain into buildings have applications in new and existing buildings. Holographic optical elements (HOE) are designed to control the thermal gain and daylighting within a building and are glass laminated films, which refract light at specific angles or wavelengths incident on a building. Their use contributes to a decrease of energy demand and an increase of comfort. HOE's have a specific range of applications:

- *Solar control* via reflection of solar gain from a window. Added benefit is reduction in glare compared to reflective films. The window remains transparent enabling the occupier to still use the window for daylighting.
- *Light guidance* of direct light into a building structure by use of holograms to target the light in a specific direction.
- *Spectrum Dispersion* of the visible wavelengths into the constituent colours to produce aesthetically pleasing optical patterns.
- *Light concentration*, HOE's can act as light concentrators, focusing beam light onto a target surface.

This paper reports on the research and development approach undertaken by six EU partners to develop, evaluate and test HOE elements for the installation in buildings. The research programme was encompassed by chemical processes, structural and environmental testing and simulation of HOE systems. The paper discusses the initial results of prototypes testing and highlights the pathways undertaken within the programme.

EU Wide Field Results of Holographic Optical Elements used for Solar Control in Buildings

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Holographic optical elements can be considered as light transformers that can be used in smart glazings to provide comfort to the end user coupled with reduction in energy use. The comfort is manifested in two forms through improved natural daylighting and reduced solar gain (thermal load) on a building. HOE's can also be thought off as systems that aim to reduce energy utilisation through a reduction in artificial light and air conditioning loads in buildings.

To ascertain their potential in the above described functions; field trails of three types of HOE's have been undertaking in the UK, Germany and Greece. The systems used are a combination of HOE laminated heat strengthened glass and metal absorber. The holograms diffract the direct sunlight onto a metal absorber, which is positioned perpendicular to the hologram surface. The benefits of the grating holograms are the high diffraction efficiency of over 90%. The diffraction efficiency characterises the performance of the diffraction of the holograms. The absorber is matt black, absorbing incident sunlight and the arising heat convicted to the environment. For the test fields in Dortmund and Southampton a one-axis light directing system was used. Each lamella contains two different white-light holograms and directing light to either side of the absorber. The holograms are laminated serially between two glass panes. Hereby a maximum area efficiency of 100% is guaranteed. A similar system is used at Southampton University but has an additional functionality that tests the photovoltaic conversion efficiency of strategically positioned solar cells operating under HOE magnified light. For the light shaft in Athens a light directing system with fixed white-light holograms exposed by a two-axis tracking (manual tracking system) heliostat was tested.

The above installations have produced valuable first hand experience of HOE technology and operation in three different EU zones. A comparison of the field tests data and computer simulations are presented. These studies highlighted the beneficial applications of the technology in terms of solar gain and glare control in buildings. The paper also discusses HOE function and applications for a broad range of climates and latitudes.

An Adaptive Hybrid Energy-Source Home Water Heating Unit

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This work is driven by a desire for energy conservation and the use of clean energy where possible. The objective of this study is to develop a hybrid, highly efficient domestic water heating unit that maximizes the energy share of the renewables. Conventional water heaters simply turn the heat on and off when the water temperature crosses a given set point. The on/off control is simple, but inefficient. It does not take into account the amount of water and the frequency with which it is used, leading to high standby losses. The standby loss is the energy used to keep the tank at a set temperature when water is not being used. The high inefficiency results in high energy needs, making it particularly difficult to rely on the varying output of renewable sources. An improved controller will increase the efficiency of the conventional water heater and maximize the share of renewable sources in heating. To efficiently control the heating, the standby losses should be reduced. In other words only the water that is needed should be heated. For that, parameters such as duration, amount, time of day, and frequency must be determined. Since the use of water, climatic conditions, and rate of flow are dynamic, intelligent control methods are used to address the problem. The hybrid system includes two interconnected water tanks, one heated by conventional methods, the other heated by energy from the renewable sources. The controller employs artificial intelligence methods to create and update a demand profile, thus minimizing the total energy required and maximizing the share of renewable sources in supplying the needed energy.

Photovoltaic and Solar Thermal Modeling with the EnergyPlus Calculation Engine

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This paper summarizes models for active solar components recently incorporated into the EnergyPlus building energy analysis program. EnergyPlus has been developed by the US Department of Energy to provide a whole-building modeling tool that is comprehensive, geometric, and suitable for annual energy analysis. Three different models for photovoltaics (PV) have been implemented including: a simple user-defined PV efficiency model for design, a four-parameter equivalent one-diode model, and the parameter estimation model developed by Sandia National Laboratory. A traditional flat-plate solar thermal collector for water heating has also been implemented.

The EnergyPlus framework offers advantages when implementing and using models for active solar components because supporting models are already in the program. EnergyPlus already included models that account for shading, partial transmission, and reflections from other surfaces as it performs detailed calculations of beam, sky, and ground radiation for surfaces. In many installations, adjacent surfaces, buildings, trees, etc may shade solar panels at times. For building integrated PV, the solar electric panels can be coupled to detailed surface heat transfer models, based on the Heat Balance Method, to predict module temperatures. Solar thermal collectors can be connected to a variety of existing EnergyPlus HVAC components to simulate domestic hot water or low temperature heating systems.

ENERGYPLUS: NEW, CAPABLE, AND LINKED

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A new building energy simulation program, EnergyPlus, builds on the capabilities and features of BLAST and DOE-2 and includes many simulation features such as variable time steps, configurable modular systems integrated with a heat balance-based zone simulation and input and output data structures tailored to facilitate third party module and interface development—features that have not been available together in a mainstream building energy simulation program.

Other simulation capabilities include three thermal comfort models, extensive daylighting and advanced fenestration capabilities, multizone airflow modeling, more robust HVAC equipment models, more flexible system modeling, and active (photovoltaic and solar thermal) and passive solar simulation, and calculation of environmental impacts from energy sources. Currently, more than ten private sector companies have stated their intentions to create user interfaces for EnergyPlus.

Since EnergyPlus was first released in April 2001, more than 22,000 copies have been downloaded by users in more than 90 countries. The paper provides an overview of the capabilities and strengths of EnergyPlus.

Improving Sustainability of Buildings Through a Performance-Based Design Approach

Michael Deru and Paul Torcellini

National Renewable Energy Laboratory

Abstract

The design of most buildings is typically driven by the need to meet a set of minimum criteria. These criteria include budget constraints, certain functionality requirements, safety regulations, and energy codes. The results from this process are buildings that are functionally proficient but not the most energy efficient nor sustainable buildings. Performance goals established in the early stages of the design process can strongly influence the outcome. Setting convincing goals that the whole design team believes in will focus the design process to meet these goals. These goals should be carefully crafted in order to produce the desired product. For example, setting energy performance goals will focus the design process on minimizing the energy consumption but may not consider issues about electrical demand, water consumption, or materials selection. Another example is setting sustainability goals centered on material issues will focus the design process around material selection and not on energy or other issues. This paper describes how to establish performance goals and describe how they influence the design process. Several examples of real buildings are analyzed to show effects of setting performance goals.

BigHorn Home Improvement Center: Proof that a Retail Building Can be a Low Energy Building

Michael Deru, Paul Torcellini, and Ron Judkoff

National Renewable Energy Laboratory

Abstract

Energy efficiency and retail buildings typically do not go together. Retail businesses are usually more concerned about proper lighting and comfort to create an optimal environment that encourages customers to purchase merchandise. The BigHorn Home Improvement Center, located in the high mountain community of Silverthorne Colorado, is an exception to this trend. From the initial stages, the design of this store focused on minimizing the energy consumption through a whole building design approach. The final building includes extensive use of daylighting, good envelope design, simplified HVAC system, an energy management system, and onsite energy generation. The result is a comfortable, well-lit environment.

The building has been extensively monitored for three years, and the results show excellent performance. The building uses 54% less source energy and has 53% lower energy costs than a similar building built to standard energy codes. Most of this savings has come from the lighting systems, which use 80% less energy than standard construction. Equally import to lowering total energy use, is controlling the peak electrical demand, which has been reduced by 60%.

Simulating the Multi-Variables Effect on Double Skin Facades

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Double-Skin facades have increasingly been used in newly constructed buildings partly due to an increased interest in suitability practices. Their behavior is highly dependent on variety of different variables including their geometry, the properties of the materials used, their orientation and location, etc. Coupled with the need to insure enough natural convection during the summer time, these façades are typically used as environmental buffers or solar collectors in the winter times. Their implantation depends, among other things, on factors such as cost, appearance, and maintenance.

This paper describes a study that investigates the muti-variables that affect the thermal and the air movement operation of double skin facades using Computational Fluid Dynamics (CFD). To conduct the study, a computational system was developed to derive dynamically the boundary conditions for the variations of the study and investigate its transient effect. A thermal chamber was used to calibrate the initial CFD model developed. The model was then used to investigate various glass materials combined with variations of solar collector areas for four different orientations using various height conditions. Temperature and velocity profiles were examined to provide conclusions regarding the influence of these variables on summer and winter energy benefit of the double skin façades. The method used is discussed in detailed and a case study is presented for a two-story double skin facade in New York to illustrate the effectiveness of the conclusions presented in the paper.

Trombe Walls in Low-energy Buildings: Practical Experiences

Paul Torcellini and Shanti Pless

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Abstract

Trombe walls can be an important technology to consider when designing low-energy commercial buildings. They can capture and store direct solar energy and significantly reduce a building's heating load. Trombe walls have been integrated into the envelope of a recently completed Visitor Center at Zion National Park and a site entrance building at the NREL's Wind site. These commercial buildings were designed to minimize energy use, with trombe walls an integral part of this design. This paper will explain design and construction consideration issues when considering trombe walls, based on our application and evaluation experiences of these commercial buildings. Trombe walls provide a balance between solar gains and direct glare, allowing for passive gains without the typical glare associated with direct solar radiation. Design issues to consider include cooling loads imposed on the building due to the Trombe wall during the swing and summer months. Even when direct gains are shaded by overhangs, diffuse gains and low insulation values of trombe walls can provide additional cooling loads. Overheating can be an issue during swing seasons. Additionally, the performance of Trombe walls is sensitive to construction techniques. The paper discusses performance information of these applications and application successes. During periods of favorable solar conditions, Trombe walls can significanlty reduce heating loads.

Zion National Park Visitor Center: Performance of a Low-energy Building in a Hot, Dry Climate

Paul Torcellini, Shanti Pless, Nicholas Long, and Ron Judkoff

National Renewable Energy Laboratory, Golden, CO

Abstract

The Zion Visitor Center is a 1073 m2 facility located in southwestern Utah. The Center was designed with features that minimize energy use by designing to the context of the hot, dry climate. Features of the building include natural ventilation, natural draft cooltowers, Trombe walls, daylighting, good thermal envelope, radiant heating, and a photovoltaic array.

The energy performance of the Visitor Center was monitored, evaluated, and documented from April 2000 through October 2003. Monitoring not only provided energy performance, but several lessons learned on improving future buildings using low-energy architecture techniques.

Energy performance for the monitored period was 85 MWh/year—a reduction of 65% compared to a typical building that would have been built in this location. This was done for no additional cost of construction.

Many lessons learned including issues related to the Trombe wall, daylighting, and PV system, as well as improvements that could be made to the controls system are discussed.

Oberlin College Lewis Center for Environmental Studies: A low-energy academic building

Shanti Pless and Paul Torcellini

National Renewable Energy Laboratory

Abstract

The Adam Joseph Lewis Center for Environmental Studies is a 13,600-ft^2 (1263 m^2) academic building designed with the long-term vision of operating as a net energy exporter. The building, located in Oberlin, Ohio, was designed to consume significantly less energy than a typical building. Features to achieve the energy savings include daylighting, photovoltaic system, enhanced thermal envelope, ground-source heat pumps, dimming lighting system, and natural ventilation.

The annual energy performance of the Lewis Center was monitored, evaluated, and documented from March 2001 through March 2003. Lessons can be learned in the future design of low-energy buildings through understanding and documenting the building successes and flaws. The annual site energy use intensity is 324 MJ/m^2 (28.5 kBtu/ft^2), which is 47% less than a similar building built to standard energy codes. On-site PV production meets 57% of the buildings energy requirements, resulting in a net site energy use intensity of 140 MJ/m^2 (12.3 kBtu/ft^2). Daylighting meets a majority of the lighting load, reducing lighting use by 74%.

ACTIVE SOLAR ENERGY ARCHITECTONIC STRUCTURES

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Building integrated (BI) active solar energy schematic structure studies selected from a developing outline include: *Building size augmentation and CPC reflector troughs* (with movable reflector end wall options) symmetric for equatorial zone and asymmetric for higher latitudes, supported on earthen vaults, ferrocement channels, and concrete double Ts; *Interior concentrators* (stationary and tracking) in walk-in double envelopes with flat and ridged exterior glazing, for windy snow sites with heat pipe evacuated tubes and CPC reflectors, and 1-axis tracking parabolic troughs; and *PV pergolas - PVOLTs* (PV Overhead Linkage Trackers). Dimension ranges of active collectors and architectural schematic building structure-envelopes are correlated, e.g. a vault span for equatorial sites of 15m/49.2ft can have a CPC inlet of 17m/55.7ft. Design development is reported for a PV pergola (4 row wood PVOLT-16 PV modules) 1 horizontal axis tracking, with comparisons for solar radiation to 2-axis tracking az-el masts with 18 PV modules, for peak site power density and land use with same 0.92m^2 PV modules, e.g. given a 30.47m/100ft square site in Madison, WI: Nine 2-axis tracking PV arrays have 1237 kWhrs/June day, and eleven PVOLT PV pergolas have 1311 kWhrs/June day plus area for a building. Aims are to present architectural structure and site potentials with integral active collectors, and provide schematic dimension ranges for architectural, engineering and solar cities studies.

Thermal comfort perception and evaluation in urban space.

G. Scudo, A. Rogora, V. Dessì

ABSTRACT

The attractiveness of urban space are influenced also by the microclimate and its perception by people, which is a mix of psychological and physiological process. The paper describes the comfort analysis based on simulation tools, microclimatic measurements and people response to interview.
In this context The UE is financing the RUROS project (Rediscovering the Urban Realm and Open Spaces) with the aim to develop comfort models for different climatic conditions trough Europe. The used approach is to have a platform in which is possible to combine physiological environment (trough measurements, simulation, morphological analysis) and psychological ones trough people behavior observation and interviews.
The results confirm a low discrepancy between quantitative evaluation and sensation vote.
The discrepancies between the comfort evaluation based on the measurements (and/or simulation) and the sensation perceived by the people is the study area to focus on.
To reduce this gap means give answers to the people needs from the quantitative point of view (reduction of the thermal stress) as well as the qualitative one (attractiveness, expectation).

TECHNICAL AND ECONOMICAL EFFICIENCY OF THERMAL MASS IN TEMPERATE CLIMATE: THE CASE OF CENTRAL WESTERN OF ARGENTINA.

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Abstract

The role of mass in the storage of energy in buildings has long been a subject of interest in bioclimatic and sustainable buildings. The thermal inertia of building mass is used to produce heat up relatively slowly. For its there are often energy available from solar and internal gains during the daytime that is greater than the daytime heating requirements. This energy may be stored in the buidling structure and furnishings, and released at night to offset the buiding heat loss. In a similar manner, building mass may allow the structure to remain cool during daytime in summer and reduce air condictioning requirements. In this paper it is showed economical and technical efficiency of thermal mass and it conclude that, technical efficiency depend on thermal characteristic of building, but it is possible to obtain between 69.3% and 95.8% of savings in cooling requirements if building have thermal mass surface between envelope surface and envelope and internal partitions surface.

STATEMENTS OF ART DISCOURSE FOR A SUSTAINABLE ARCHITECTURE

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Abstract

In the field of architectural works consider as art objets, an aesthetic theory does not have the same pretensions of proof that science´s theories. It neither predict and does not give operative rules to obtain explanation of the existent . The Architecture situated between the technics and the arts, it constitute a judges system of validity, norms constantly renew, that distinguish the meaning and its originality. This is between dynamic and dialectic relation of project process and the designer, by means the suitable activity that is set up the investigation of the object, as knowledge object itself. It is important to reach effective statements or critic objects that show dispersions due to new and inexpected situations, that are developed throught the intercomunicational process.

RECENT EXAMPLES OF LOW ENERGY AND SUSTAINABLE BUILDINGS IN ITALY

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Abstract
In Italy about one third of the global energy consumption is somehow related to buildings. The building process, the maintenance of buildings as well as their control (HVAC and lighting) requires a huge amount of energy.
The first phase of energy efficient architecture in Italy regards some experience and examples designed soon after the 1973 (Kippur war). In the period 1973-1983 the ENEA (National Center for Alternative Energy) reported 151 bioclimatic buildings (that probably represents a high percentage of the energy efficient buildings built in that period).
During the 80' and 90' only few significant interventions are reported but in the last few years many bioclimatic buildings have been built.
Nowadays both private and public investors are getting more and more interest in energy efficient buildings, mainly because of the recent regulations on energy consumption but also because of the market request.
Most of these buildings have been built in northern Italy while in the south only few examples are available. The territorial distribution is strongly related to the climatic conditions (the colder the climate, the more efficient the intervention) but also to the local regulations and to the personal income of people. Efficient architecture still requires extra costs that can be difficult to sustain.
It can be noticed that nowadays public buildings and offices represent a large amount of the total energy efficient buildings.
Recent buildings take into consideration energy consumption (heating, cooling, lighting and ventilation) as well as the indoor quality because of the deep relationship between these factors.
In the paper 3 examples of recent energy efficient buildings are presented: Hospital for mental disease at Darfo, a private office at Legnano (Milan) and a museum at Naples.

SIMPLIFIED GRAPHIC TOOL TO EVALUATE THERMAL CONDITIONS IN AN URBAN CONTEXT

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Abstract

Materials of built environment (i.e. building materials for pavements and facades, shading devices, vegetation and water) have an important role in modifying microclimate and comfort conditions in urban space. Surface temperature depends on energy balance which is given by solar and thermal radiation budget (short wave and wave radiation), plus convective and conductive flows. In town context usually convective flows at pedestrian level are low, so the influence of materials is mainly due to radiant exchanges. While the general effect on microclimate of building material in specific urban context and configurations have been largely inquired by microclimatologist (summer and winter heat island effect, albedo distribution, radiant fluxes in canyons… see Akabari et al., Oke, Santamouris), the specific effect of single materials have been only recently inquired. Along with traditional materials, a large number of microclimate mitigating technologies are available:

- Shading devices (typology single layer or grey double layer)
- Vegetation, selective films (i.e. black and white film)
- Surface treatments:
  - Selective coatings and similar (i.e. White asphalt)
  - Vegetation: trees and green skin
- Water running in vertical/ tilted surfaces, spread or mecronized

The proposed graphic tool intends to help the planner to understand the effect of his projectual decisions on the radiant field in an open space with reference to: climate, physical properties of the parterre (albedo, weight, etc.) and of the vertical surfaces around.

The focus of the research was to investigate the modification of the radiant field changing the physical properties of the elements (main variable) in a given configuration and climate and how the radiant conditions changes through the day and around the space. Proposed variations are referred to:

- latitude (Kobenhaven, Milan, Athens)
- orientation vertical element (S-N, E-W,)
- albedo parterre (0.2, 0.8)
- materials parterre (concrete)
- coupled vertical elements (cross)
- seasons (summer, winter, middle)

The simulations have been performed using the software *Solene*; the horizontal plane is 50 x 100 m and the vertical element is of 18m and it is as large as the model. To isolate the edge effect the results are referred to the central orthogonal section. The use of vertical sections to describe the changing due to an obstruction has been successfully used in wind patterns; our idea is to define a sort of *radiant* pattern (or radiant budget) for a given configuration. The horizontal axis define Distance/Height (D/H), while in the vertical axis the radian budget is calculated. In the earlier phase we tried to find out a correlation using the surface temperature of the parterre, then we also calculated PMV but we finally decided to go back to the evaluation of the global radiation (radiation-energy budget). Together with the vertical sections an horizontal representation of the radiant conditions will be prepared in order to give information on the side effect with reference both to edge and corners.

For every latitude and geometrical obstructions a series of 5 schemes will be prepared. The schemes should represent the simplified radiant budget for one period of the day (night, morning, noon, afternoon and evening). During these period the radiant conditions are changing, of course, but we think that the variation can be conveniently controlled by our physiolological and/or psychological adaptations mechanisms.

GROUND COOLING IN ITALY: PROJECT AND EVALUATION OF BURIED PIPES IN NORTHERN ITALY

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Abstract

The use of the Ground as a thermal sinker has been largely used in the past in Italy and other mediterranean countries.

One of the best known historical example is the Villa Trento at Longare a small town 10 km far from Vicenza, a Palladian villa built in the XVI century in which the ground cooling system uses an existing cave (Covolo) to get air at constant temperature through the whole year.

More recently other examples of ground cooling systems have been built up using both natural caves or buried pipes.

In the paper two recent examples are presented.

The first example is a public building (Hospital for mental desease) in north Italy at Darfo (about 45°N Latitude and 220 m above sea level) in which an existing cave has been connected to the new building using a 35 m pipe.

The building has been finished in 2001, the buried pipe system cool the incoming air without any extra, active, cooling equipment. The system has been working for 3 years and no overheating has been registered even if the building is equipped with a direct passive solar system and a greenhouse.

The second example is a private factory and shop (wood) at Milan in which the cooling system has been recently projected and is currently under construction.

View of the building at Darfo

Modelling of Windcatchers for Natural Ventilation

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Abstract:

Interest in employing new natural ventilation technologies for the provision of a comfortable internal environment has been growing in northern Europe for the past number of years. These new technologies have the potential of reducing energy consumption and the release of destructive emissions into the environment. The windcatcher system is one of these novel technologies which has been installed in many buildings in the UK. A windcatcher is a device, installed on a roof, which utilises both stack and dynamic wind pressures to deliver ventilation air to a building.

Wind tunnel, explicit, implicit and CFD modelling techniques were used to assess the potential of windctacher systems. Wind tunnel and smoke visualisation tests were conducted on full-scale model of a square section windcatcher. Pressure coefficients distribution, internal air speed and volumetric air flow were measured for various wind speeds and directions. The C_p's were correlated with CFD results and then used in the explicit and implicit models to further validate the air flow measurements due to windcatcher

It is concluded that windcatchers will contribute towards the ventilation of spaces. The flow rate through the windcatcher increases with the increase in wind speed and is dependent on wind direction. The results obtained using explicit, AIDA and CFX code correlate relatively well with the experimental results at lower wind speeds and with wind incident at angles of 0-15°.

MICRO GENERATION OPPORTUNITIES IN THE UK RESIDENTIAL SECTOR

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ABSTRACT

To limit future growth in atmospheric carbon dioxide levels, the UK Government recently endorsed a recommendation by the Royal Commission on Environmental Pollution (RCEP) to reduce carbon emissions by 60% below 1998 levels by 2050. Achieving this substantial change will require numerous changes both on the supply side and demand side. In this context, reducing the overall carbon impact of the built environment, which accounts for about half of direct energy use, is particularly important. The UK Residential Sector consists of 24.3M households and this is predicted to rise to 28M households by 2050. It is responsible for ≈27% of total carbon emissions in the UK and as such, it has a significant role to play in meeting the 60% target.

This paper reviews the technological steps that would be necessary to achieve the 60% target in the UK Residential Sector. Four key areas were considered in this assessment: Architectural and Refurbishment Technical Potential in Housing; Technical Potential in Energy Efficiency of Appliances; Energy and Load Management Systems; Micro Generation.

This paper has a special focus on the potential for deployment of renewable and energy efficient micro generation technology at the household scale. The “micro generation” technologies considered include solar PV roofs, solar thermal collectors, micro cogeneration (or CHP) and micro wind systems. The status of current technology and market readiness was evaluated. Technological trends were then evaluated and the impact of these on future uptake of technology estimated. Using national building stock models, a ‘backcasting’ (inverse modelling) approach was taken to establish the market potential. In addition, the impact of micro generation of electricity on the UK national grid was estimated. Taken together the carbon savings associated with implementing micro generation technologies were predicted in the context of achieving the RCEP target.

It was found that the deployment of micro generation to their market potential would result in a reduction of approximately 8.5% in UK carbon emissions. However, removal of market barriers and behavioural and societal change will be required to accompany the step changes in technology indicated if this market potential and hence carbon savings is to be realised.

Knowledge Based Expert System Computer Aided Climate Responsive Integrated Approach to Climate Responsive Architectural Design

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ABSTRACT: Architectural design is indeed a complex process. Can this process be translated into design decision making system through a knowledge based expert system and achieve ecologically responsive architecture? is the quest of this paper. The computer aided system presented offers a system that supports such architectural design decision making.

DESIGN MATRIX AND THE EXPERT SYSTEM

Design and more so architectural design is intrinsically a decision making process. Computer aided knowledge based expert system based on a 'Design matrix' presented in this paper enables design decision making to achieve ecologically responsive architecture.

Climate Responsive Architecture 1.0 An integrated approach to design: is a design software that helps in achieving above design decisions based on quantitative analysis of thermal, daylight and ventilation performance of buildings.

The Prediction of the Energy Conservation Potential of Building Walls Augmented with Phase Change Materials

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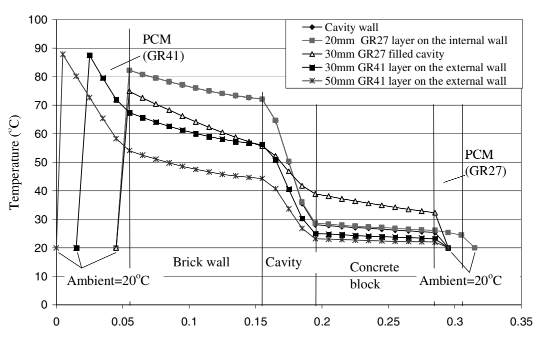
Abstract
Phase change materials absorb a large amount of energy as latent heat at a constant phase transition temperature and thus can be used for passive solar heat storage. Encapsulated high thermal mass phase change materials incorporated into buildings may be suitable for directly absorb incident solar energy and subsequently improve human comfort by decreasing the frequency and magnitude of internal air temperature swings, maintaining the temperature closer to the desired set point temperature for an extended period of time. A previously validated transient two-dimensional finite-volume heat transfer model has been used to predict the thermal performance of building integrated phase change material wall systems using different materials and under different applied conditions. This paper is based on thermal performance analysis and evaluation of PCM augmented masonry wall configurations with respect to thermal comfort and energy conservation.



Temperature profiles through the PCM augmented walls after 1760mins of exposure to insolation of 700Wm^{-2} at an ambient temperature of 20°C.

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Air Movement for Low Energy Summer Comfort

Richard Aynsley

ABSTRACT

There are two prevailing concepts for determining Human Thermal Comfort – Constancy and Adaptation. Their applications are discussed in conjunction with the current driving forces for passive building design and natural ventilation for thermal comfort in warm climates. These are the sustainability of commercial building operation in the face of global warming and the rapid increases in fossil fuel costs for cooling. Another trend in recent decades, in Australia and the United States, has been the significant number of senior citizens who migrate to warmer climate regions of their countries. The WBGT index is used to illustrate the consequences of exceeding comfort zones.

Sophisticated contemporary tools for quantifying the cooling sensation, provided by air movement over the skin, as well as simpler rules of thumb, are outlined. A recent study, which indicated the influence of gust frequency of airflow on the cooling sensation, suggests that current models do not account for this effect.

Airflow through and around buildings is examined with respect to heat transfers by surface conductance and air movement for summer comfort. The fundamentals of natural ventilation, and contemporary tools and techniques used for analysis and quantification, are summarized. There are methods to deal with the uncertainties associated with wind speed. Natural ventilation can be used to supplement ceiling fans or air conditioning. At a larger scale, mitigation of summer urban heat islands, by enhancing breeze penetration in urban environments, is a means to reduce outdoor heat stress.

LOW ENERGY ARCHITECTURE: SAVING ENERGY BY VEGETATION IN PLANNING

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ABSTRACT

This paper is concerned generally with the investigation of passive design strategies, and mainly with the thermal comfort provided by the cooling effects of plants through evapo-transpiration (Indirect evaporative cooling- one of the passive strategies the study is concerned with). Using passive design strategies in urban design and planning is considered as an elevated and gallant goal for architects, planners and those who are mindful with the saving of energy.
Laboratory experiments using smoke tunnel test facility were carried out on different building grouping models including spaces as vegetation areas and the stream lines of smoke around the grouping model were photographed and analyzed. Computer modeling, through the ANSYS 5.4/Flotran computer program, was used to predict the velocity contours for different building grouping. From the experimental and computational results, an empirical formula (including the building and vegetation area depth) in one dimension was derived out and could be useful in the design process for some urban structure in climatic environmental characteristics similar to the scope of this study.

THE USEFULNESS OF USELESS SPACES
A contribution to the evaluation of environmental comfort in the architecture of intermediate spaces.

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There are spaces in architecture that cannot be considered interior or exterior and whose existence cannot be attributed to a precise or specific function. If we were to represent interior and exterior environments as a positive-negative image, we would have to envisage grey areas, which appear as a blurring of the line that separates black and white, and which we refer to as intermediate spaces.

In the present paper, these spaces are analysed, preferably from an **environmental point of view**, which is only a partial view of the reality of architecture. Furthermore, although the chosen viewpoint is the **physical environment** and the **level of comfort**, we also consider the architectural context. The aim is to identify the mechanisms whereby intermediate spaces positively affect the perception of the environmental comfort of architecture.

The study of environmental comfort clearly shows that the environmental conditions should not be considered in isolation from the reality of architecture, because the comfort levels that are acceptable to users are higher than those that are recommended. The more specific the uses for which a space is designed, the more limited the users' choices become, which in turn restricts their levels of comfort.

It is not that the "regulatory" capacity of intermediate spaces modifies the environmental conditions in such a way that these always stay within the established limits, but that the users' choices (symbols) simultaneously modify and broaden these limits.

Architecture is not simply built-up space (MATTER), nor is it just the indoor environment (ENERGY) or the formalisation of symbols (INFORMATION); it is all these aspects in conjunction. In architecture, these three conditions must be fulfilled in order to reach the necessary levels of comfort.

Prototype testing of the wave energy converter Wave Dragon

by

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Abstract:

The Wave Dragon is an offshore wave energy converter of the overtopping type. It consists of two wave reflectors focusing the incoming waves towards a ramp, a reservoir for collecting the overtopping water and a number of hydro turbines for converting the pressure head into power.

In the period from 1998 to 2001 extensive wave tank testing on a scale model was carried at Aalborg University. Then, a 57 x 27 m wide and 237t heavy (incl. ballast) prototype of the Wave Dragon, placed in Nissum Bredning, Denmark, was grid connected in May 2003 as the world's first offshore wave energy converter.

The prototype is fully equipped with hydro turbines and automatic control systems, and is instrumented in order to monitor power production, wave climate, forces in mooring lines, stresses in the structure and movements of the Wave Dragon. During the last months, extensive testing has started.

In the coming 1½ years an extensive measuring program will establish the background for optimal design of the structure and regulation of the power take off system. Planning for deployment of a 7 MW power production unit in the Atlantic within the next 2-3 years is in progress.

The paper will in detail describe the prototype device, ongoing tests, preliminary test results, gained experiences and expectations for the future.

Simulation of electricity supply of an Atlantic island by offshore wind turbines and wave energy converters associated with a medium scale local energy storage

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Marine renewables like offshore wind turbines and wave energy devices will come to the market in a near future in Europe. For such intermittent sources the coupling with a local energy storage is often necessary in order to regulate the energy output flow. This is not a common practise when ones deals with large scale plants of dozens of MW which are most often connected to the general network acting then as a storage of infinite capacity.
In this study we have evaluated by numerical simulations the benefit of coupling a medium scale electric storage to offshore wind turbines and wave energy converters, to supply the electricity of a 5000 h island of the French Atlantic littoral, which has average annual electrical power demand of 4.2 MW.
The simulations were performed by using both real resource data (wind and waves) over a whole year (1999) and also the recorded data of the electricity demand of the island community, all considered on a one hour time step basis. We systematically varied the installed power at sea (mixing wind and wave energy at various levels) and the storage capacity. Then we can now predict the resulting flux of electricity between the island and the mainland, and we are able to size the storage depending on the energy management strategy chosen by the community.

[Title] Tentative Study on Applicability of Wave Power Conversion Turbines to Tidal Power

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[Abstract]

The applicable turbine systems for utilizing low head tidal power, which has been abandoned due to poor cost effectiveness for conventional systems, were investigated. Developed turbines for wave power conversion are focused in the present study, as a reciprocating flow turbine is utilized for wave and tidal power conversion systems though there is different fluid density and different time period of reciprocating flow. Three types of wave power conversion turbine systems, one of which is Wells turbine and the other are impulse turbines with guide vanes, are picked up in the present paper. Turbine characteristics in steady flow are, at first, compared with that of Darrieus type turbine, which has been proposed as appropriate one for low head tidal power. Then turbine operating behaviors are numerically simulated under various sizes of pond and turbine system and various levels of sea and pond. Finally the reciprocating flow characteristics of considering turbine systems are evaluated. As the results, the impulse turbine with self-pitch-controlled guide vanes indicates the most economical advantage in utilization of tidal power as generating the largest head difference between the sea and pond surface levels.

A European Platform for the Integration and Sharing of European Research and Technical Development Activities in Ocean Energy Systems

K. Nielsen, C.M. Johnstone, T. Lewis, A. Sarmento and G. Lemonis

Energy from the Oceans has the potential to make major contributions towards renewable energy targets being adopted by various European Governments over the medium to longer term time scales e.g. 10 – 15 years. To transform this from a possibility into a reality, numerous support frameworks for research and demonstration programmes are being put into place in the various European member states. To facilitate the success of projects achieving their goals, the European Commission is funding a Coordinated Action in Ocean Energy (CA-OE) via its RTD, Framework Programme VI. The purpose of which is to put into place a platform to stimulate the sharing of knowledge and resource information between all relevant parties working in the development and commercialisation of Ocean energy systems. This should avoid duplication and replication of development activities and the realisation of synergistic development between the various international parties. The successful adoption of these activities should nurture and prove robustness of the various technologies under development, leading to earlier market penetration.

This paper will report on the development of platforms to facilitate the international sharing of knowledge/ information; mechanisms being developed to engage the various national research programmes being undertaken in member states; and activities developed to engage and be fully inclusive of industry partners. The paper will conclude by reporting the success of activities undertaken to date, the impacts being made on the Ocean energy research and industry clusters and the extent this programme of work being undertaken can stimulate earlier market entry of these technologies.

FLOATING WAVE ENERGY CONVERTER AND ELECTROLYTIC HYDROGEN PRODUCER INTEGRATED SYSTEM

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Abstract

A comparison of the artificial world energy productivity with the value of natural energy fluxes shows the capacities of both power suppliers become already comparable. Harmful waste in parallel with other environment changes is dangerous because of the pollution, greenhouse & Earth overheating effects leading to biosphere degradation.

Quite apparently, the problem of benign power production could be solved most properly through the development of environmentally compatible power-industrial technique based on the use of regional renewable resources. The system made up of a sea wave energy converter, an electrolyzer, energy storage and an energy consumer presents an ecologically safe power-industrial complex built into environment. In such a system energy and sea water are recycled to the environment after power production-consumption circulation introducing no additional heat or other pollution. One of the promising devices for wave energy conversion is an offshore Float Wave Electric Power Station (FWEPS) which is been developed. The second technique considered is hydrogen production by means of sea water electrolysis followed by usage this ecologically safe fuel in different branches of economy. Real performances of the systems' components allow to treat such a system realizable.

Shape Optimization of a Wave Energy Extracting Device.

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For island states, the capture and conversion of wave energy would prove useful in the development of sustainable alternative energy sources. Previous research has shown that the power extracted from a mono-harmonic wave by an ocean wave energy conversion system (OWECS) is maximized when the natural frequency of the system coincides with the frequency of the incident waves.

In this work we optimize the shape of an axisymmetric heaving OWECS in order to maximize the efficiency of energy extraction over the most frequent range of wave frequencies, using a search algorithm. The efficiency of a given system is determined from the numerical integration of its dynamic equations of motion.

An optimization function related to the efficiency of the OWECS and wave frequency is defined. A population of candidate shapes is generated, the optimization function is evaluated for each element of the population and the quality of the solutions is evaluated and ranked. Based on the ranking, a new population is generated and the process repeated until the convergence criteria (or maximum number of iterations) are obtained. The results showed that the theoretical efficiency of the OWECS can be maintained at above 40% energy extraction, for incident waves having dominant periods between 3 s and 8 s.

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"Wet Renewables - A Development Routemap for the UK"

In recent times there has been increase in interest shown towards the technologies that encompass *Wet Renewables*, namely wave and tidal power. This partly due to the relative technological maturity of the onshore and offshore wind industry as well as other key driving forces, ie, with respect long term security of supply issues, Kyoto agreement obligations and the maturity of the offshore industry.
This paper describes how the UK can meet the challenge of developing a viable industry that can support the predicted demand for wave and tidal technologies. Specifically it describes the co-ordination of two major projects now in their development stages within the UK, namely The New and Renewable Energy Centre and The European Marine Energy Centre. Both of these represent a considerable step forward with respect to the establishment of a credible UK developmental route map for Wet Renewables within Europe.

The full paper will describe both the technical and economic routes to market with respect to specifically wave and tidal. This is being achieved through a combination of innovative techno-economic investment strategies in combination with the development of world class testing facilities.

The final proposed paper will fully introduce the concept of "The Knowledge Economy", a regional development program that has created NaREC, and more importantly how NaREC intends to become a financially self-sufficient organisation using public sector targets within the next five years.

Would a stimulus to energy efficiency improve environmental quality? Theory and evidence from an energy-environment-economy CGE model of Scotland

By Nick Hanley (University of Glasgow), Peter McGregor, Kim Swales and Karen Turner (all University of Strathclyde)
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Resource productivity is increasingly seen as an important aspect of sustainability by governments world-wide (e.g. UK Cabinet Office, 2001). Making more with less seems, intuitively, to be sensible in terms of reducing the burden on the environment whilst allowing for economic development. What is more, some authors have suggested that rather large reductions in resource use can be achieved without reducing economic well-being - the so-called "Factor 4" and "Factor 10" concepts (Weizsacker et al, 1997; EEA, 1999). Resource productivity may be defined in many ways: for example, as output per unit of materials input, or as output per unit of energy input. However, despite some reservations (eg Pearce, 2001), it seems generally accepted that improving resource productivity is "good for the environment".

In this paper, we take one measure of resource productivity, namely output per unit of energy input, and simulate what would happen in a regional economy if a rather moderate improvement in this measure were exogenously imposed as part of a regional "sustainability" policy. We find that this resource productivity improvement actually *increases* regional air pollution: energy efficiency improvements result in a fall in effective electricity prices, which result in a significant stimulus to electricity output and to pollution. The implications for policy depend on whether a regional, national or global perspective is relevant, and on the particular environmental goals of policy.

The UK SuperGen Marine Energy Research Programme

C. Bronsdon, Scottish Energy Environment Foundation;
R. Wallace, University of Edinburgh, et. al.

Abstract
There are formal targets of 10.4% (by 2010) and 15.4% (by 2020) for the supply of electricity generated from renewable sources in the UK, and higher aspirational targets for the same periods within Scotland (17.5% and 40% respectively). The UK Government Engineering and Physical Science Research Council (EPSRC) has funded a multi-technology Sustainable Power Generation and Supply research programme (SuperGen).

One of nine competitively-formed consortia, The Marine Energy Research Consortium was formally launched in September 2003 and has brought together 5 academic partners and more than 25 industrial partners supported for four years to the extent of €3.3 million. Their aim is to increase knowledge and understanding of the extraction of energy from the sea such that risks and uncertainties are reduced for future stakeholders in the development and deployment of marine energy technology.

The programme will establish methodologies for progression of new concepts and devices to assist marine energy to occupy its true position in a future UK and worldwide energy portfolio. This includes meeting fundamental challenges in: resource quantification and interaction; device design, evaluation and testing; energy conversion, control and transmission; and macro socio-economic appraisal of this growing UK industry sector.

This paper will: report on the project scope, describe its research focus and timescales; identify and describe the topic-specific research to be undertaken. Additionally it will identify the role of industrial partners and how they may benefit from the research outcomes. The paper will conclude by highlighting the experiences and benefits of the consortium approach and will summarise early progress.

Potential Base Load Power Supply from Strategically Located Tidal Power Stations

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Recent policy developments within the electricity supply industry have favoured the development of renewable technologies. The most accessible and economically viable renewable source, wind, is stochastic in nature, and extended use will result in higher levels of vulnerability within the electrical supply network. This, in turn, will increase the levels of control and reserve plant required to prevent supply disruption. This undesirable situation could be avoided if a more predictable renewable source could be accessed. Tidal currents are a potentially large resource for Scotland, for which the energy yield as a function of time may be predicted in advance. Further, by the combination of tidal power stations at several locations, a continuous base load power supply should be achievable. An adequate base load supply is crucial to maintaining electrical network integrity.

The work undertaken and reported here has identified a number of complementary sites for tidal current power stations, in the Malin and Hebrides shipping areas off the west coast of Scotland. It has assessed the potential energy yield and resulting performance from their integration into a single transmission system. Specifically, the paper will report on: the development of the sequential tidal flow appraisal method; analysis of the resulting dynamic bulk load flows occurring in the power take off and transmission system; identification of best and worst cases in terms of supply matching to established patterns of electricity demand; and resulting seasonal and annual capacity and utilisation factors at specific sites, and for the transmission system as a whole.

The results from the above case study will be used to explore the contribution tidal currents could make towards the attainment of the Scottish target of 40% electricity from renewable sources by 2020.

The European Marine Energy Test Centre

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Waves and tidal streams from the Atlantic Ocean give Scotland some of the most concentrated marine energy resources in Europe. Scotland's heritage in marine energy conversion research began in the 1970s. At the time of writing the Edinburgh company Ocean Power Delivery has just put the prototype 750kW Pelamis ™ device to sea. Once operational it will be the largest far-shore wave device delivering electricity to the network. Scotland's scientists, engineers, research and manufacturing base are at the forefront of the resurgence of interest in this low-carbon energy. For this nascent industry to reliably establish marine energy technology there must be acceptance of design, manufacturing and test standards that become practised within a regulated commercial environment. Predicted performance and survivability has to become more assured and central to this is the availability of facilities to perform model and full-scale testing of devices and sub-components. The sea-fetch leading to the northern tip of Scotland and the local land topography produce wave and tidal currents around the Orkney Islands that create a unique combination of natural resources.

This paper describes the establishment, facilities and purpose of the world-leading European Marine Energy Centre (EMEC) on Orkney. It is the first purpose built, multi-berth, network-connected and instrumented wave energy test facility that can accommodate up to four separate full-scale devices each rated up to 2.4MW. Tidal current test facilities will soon be added. Device developers are already endorsing the need for this facility by committing in advance to test programmes. EMEC, through strategic collaboration with the UK's research base, provides a necessary foundation for the creation of the UK and European marine energy industry.

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Evaluation of tidal stream energy resources at key UK sites

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Interest in tidal stream power generation has intensified in recent years, with three prototype generators operating in Europe.

Exploitable tidal stream energy resources in the UK were estimated by the Tidal Stream Energy Review (ETSU 1993) using data from published charts. A European-wide study (JOULE-II project results, European Commission 1996) estimated the European resource at 12500 MW, with UK sites contributing 8900 MW to this total. Less pessimistic assumptions were made compared with the previous report (allowing sites in water of depth less than 20 m for example) but the method of calculation was similar, using annual excedent velocity curves derived from tidal stream atlases rather than charts.

A promising site for tidal stream energy exploitation in the UK is off Portland Bill, Dorset; the site combines high tidal stream velocities around the headland with a location close to a 400 kV substation and closer to the load centre of London than other proposed sites. Current work has two main aims: (1) to produce a hydrodynamic model of the tidal stream around Portland Bill, including the effect of a hypothetical turbine 'farm' as a momentum sink and (2) to incorporate the results of the model with other data on environmental and technical constraints into a GIS database. The paper will report on the methodology and results of the project and will discuss its applicability to other potential sites, as part of generating a broader picture of economically exploitable renewable energy in the UK.

Basic Operational Parameters of a Horizontal Axis Marine Current Turbine

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A 0.4m diameter horizontal axis Marine Current Turbine (MCT) was tested in a circulating water channel. The model was designed to facilitate variable speed operation with full pitching blades to simulate off design point operational conditions. The power output was measured over a range of flow speeds from $1.2ms^{-1}$ to $2.8\ ms^{-1}$. Rotor torque and thrust were calculated using axial momentum theory.

Experimental results were compared with the output of a commercial BEM computer package named Bladed supplied by Garrad Hassan & Partners Ltd. Due to the prevalence of high blade angles of attack three separate aerofoil post stall equations were used to give varying levels of predicted power for the model.

Results from the water channel tests indicate that at high blade angles of attack the power generated was in excess of the most optimistic predicted values. At blade angles approaching pre-stall values measured power was in close agreement with predicted values. Cavitation was observed although appeared to have little effect upon power production although drivetrain vibration was noticeable.

This work will facilitate full-scale operational limits to be quantified for MCTs thus optimising performance of this new technology.

Wave energy resource assessment and routes to shore using a Geographical Information System (GIS)

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Marine energy is set to catalyse a new manufacturing industry as countries around the world turn to wave and tidal power as a means of providing reduced carbon, sustainable energy. A wide range of wave energy converters are in development, with a number now reaching full-scale prototype stage, and are likely to be commercially available within the next decade. The main challenges facing wave energy developers include reliability, survivability and economic viability. As wave energy is an unproven technology, it is necessary to be able to quantify the marine resource and assess the risks in its development in order to encourage investment and confidence in the industry.

This paper details a Geographical Information System (GIS) that encapsulates a wide range of extensive data that describes the marine environment. It demonstrates how this data can be analysed to determine the magnitude of the recoverable and deliverable wave energy resource. Spatial analysis techniques are used to identify areas of suitable resource and to establish routes to shore for submarine cables taking account of bathymetric, environmental and seabed data. This provides the route for transmitting electricity from an offshore wave energy converter to the onshore electricity network.

The GIS provides the ability to optimise the location of wave energy converters and routes to and through the shoreline, taking account of bathymetric and land-based restrictions. This will enable developers to prioritise development in areas that are physically and financially accessible.

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DEVELOPMENTS IN THE DESIGN OF THE PS FROG MK 5 WAVE ENERGY CONVERTER

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This paper describes one of the innovative wave energy converters under development by the Lancaster University Renewable Energy Group. An offshore point-absorber wave energy converter, PS Frog Mk 5 consists of a large buoyant paddle with an integral ballasted ‘handle’ hanging below it. The waves act on the blade of the paddle and the ballast beneath provides the necessary reaction. When the WEC is pitching, power is extracted by partially resisting the sliding of a power-take-off mass which moves in guides above sea level. Totally enclosed in a steel hull, with no external moving parts, PS Frog Mk. 5 is at least as robust as a ship and able to survive storms. Such a device could be very economic in terms of power output per unit of capital cost.

New experimental results and computer studies have led to promising improvements to the hull shape. The WEC is relatively small due to the use of special means to maintain a high dynamic magnifier in irregular seas. A robust feedback control system has been developed to ensure stability and maintain efficient power take-off. Some of these developments are described and illustrated with the results of computer simulations that show power outputs and device motion over a range of conditions. It is shown that useful advances have been made, with the power capture bordering on 1 MW in an increasing proportion of sea states.

HYDRODYNAMICS OF MARINE CURRENT TURBINES

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Abstract

Various global studies have shown that marine currents have large potential as a predictable sustainable resource for commercial scale generation of electrical power. For successful exploitation of this resource, understanding of the hydrodynamics of the marine current turbine is of primary importance. Although a lot can be learned from, the technology transfer of wind turbines and ship propellers, there has been scarcely any research for this application. The current research has judged the performance of 2D section shapes, suitable for turbine blades, experimentally in a cavitation tunnel and with numerical simulations. Based upon this and other 2D data a methodology is presented for the hydrodynamic design of marine current turbines. A model of a typical 3D rotor will be compared with future towing tank and 3D cavitation tunnel experiments.

Marine Energy Extraction: Tidal Resource Analysis

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This paper outlines some of the issues which need to be considered when analysing the extraction potential of a tidal current resource. Site selection is not a simple case of identifying an energetic site with an appropriately large peak tidal current. The characteristics of the current throughout the lunar tidal cycle must be considered. Furthermore, implicit in such an analysis is the assumption that the local tidal flow conditions will not be significantly altered by the energy extraction process itself. For high extraction rates, the general validity of this assumption is questionable. The influence of energy extraction upon the underlying hydraulic nature of the tidal environment must be considered. Analysis based upon open channel flow theory demonstrates that energy extraction in a simple channel driven by static head differences can have a significant upstream and downstream effect. This suggests that the environmental impact of energy extraction is not necessarily restricted to the immediate area around the extraction site. It also suggests that there is potential for the process of energy extraction to either diminish or even enhance the available resource at a particular site. Further research is required and is ongoing in this area. In the case examined, the limits to exploitation are shown to be inexact. However, a useful approximate guideline for resource analysis would be that 10% of the raw energy flux produced by the tide can be extracted without causing undue modification to the flow characteristics.

Extreme Wave Heights in the North Atlantic from Altimeter Data

By Werenfrid Wimmer and Peter Challenor

Abstract:

Extreme waves are an important and interesting feature of the ocean. We estimate return values of significant wave height data measured by by satellite altimeters over the North Atlantic. The data were gridded into 2° latitude by 2° longitude grid squares and in each of these grid squares the median along the satellite track was taken. The gridded data were then used to estimate the return values by fitting a Generalised Pareto Distribution to all values above a threshold. The threshold is allowed to vary spatially. This method is objective, more statistically robust, and is thus theoretically preferable to fitting a distribution to all the data. The novel method gave results that were up to 37% smaller than the return values estimated by fitting an Fisher-Tippet 1 distribution to all the data.

SELECTIVE BUILDINGS FOR VARYING TYPES OF OCCUPANCY IN A RANGE OF CLIMATES.

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ABSTRACT

The thermal capacity of buildings and the ability for flexible heat exchange with the environment should be part of current design practice so that carbon fuels need not be used for heating or cooling in temperate climates. The behaviour of thermal capacity over long time frames needs to be explained to designers. The idea of 'comfortable' temperature should be replaced by 'tolerable' temperature in the minds of society.

This paper builds on the ideas presented at the WREC 5 (ref.1)

RENEWABLE ENERGY DOMINANCE AFTER 2030 – AND A VISION OF HOW TO GET THERE

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In a carbon-constrained world of the future, renewable energy systems with low or zero net greenhouse gas emissions will have an increasingly important role to play to help meet the rapidly increasing global energy demand over the next five decades. Renewable energy sources are widely distributed so they have the potential to provide electric power, heating, cooling and vehicle transport fuels for the millions of people currently with limited or no access to them. Progress towards including the full externality costs relating to the use of fossil fuels in comparative economic analyses of energy supply systems will determine how significant the contribution of renewable energy to the global energy supply mix will become, as will the rate at which the costs of renewable energy conversion devices can be reduced by mass production and greater project experience.

There are three energy supply paradigm shifts occurring:
a) the move towards a hydrogen economy linked with the development of fuel cells for both stationary and vehicle applications supported by the automobile industry;
b) the biological and physical sequestration of carbon largely driven by the forest and coal industries; and
c) the growing trend towards distributed energy and security of supply including small scale heat and power generation, with growing interests developing by the electricity industry.

There are close linkages between all three and renewable energy has a contribution to make to each. To achieve a significant share of the global consumer energy mix however will remain a challenge for the renewable energy industry.

Handling Available Resources Responsibly: Case Study of a Renewable Energy Project with a Remote and Poor Mountain Village in the Nepal Himalayas

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Abstract

Almost all of the 2 billion people with no access to electricity live in developing countries, and four out of five live in rural areas. Nepal is a clear example of that relationship. Families in the remote areas use precious trees for cooking, room heating and light. These activities, especially the indoor cooking on open fireplaces, have a direct chronic impact on the health and extremely low life expectancy of the women and children along with devastating deforestation. In a remote and poverty stricken mountain village in the northwestern district of Humla Nepal, Kathmandu University and the ISIS Foundation are trying new ways to utilize the locally available renewable energy resources in a more affordable, sustainable and appropriate way. The rich solar energy resource is tapped to generate electricity for an elementary lighting system. A self-tracking solar PV system in the center of the village powers three 1-Watt WLED (white light emitting diode) lights per household through underground wiring. Additionally, in each household an efficient, smokeless, metal stove for cooking and heating is installed. It consumes only half the usual amount of firewood, enabling a smoke free, and save environment in the home. A pit latrine per house, and a common village drinking water system are also an intrinsically part of the holistic community development project. Project planning, installation, training for operation and maintenance, are all implemented in close partnership with the community and are part of the excitement. Renewable energy resources are a foundation for holistic community development of our poor and marginalized 2 billion neighbors. This paper describes the process, implementation and partial evaluation of the project.

TECHNICO-ECONOMICAL ASPECTS OF THE DESIGN OF SOLAR ENERGY CONVERSION SYSTEMS IN ALGERIA

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Abstract

Today, photovoltaïc (PV) modules are much cheaper than ten years ago, but they still remain expensive. For example, the peak-watt per square meter supplied by purchased PV modules costs about US $ 6 in Algeria (for the local money, i.e., the Algerian Dinar, DA 100 # US $ 1). However, in this country, the consumption rate has significantly increased in the invoice of electricity produced by the mains. In some applications such as the electrification of desert regions and remote locations, the PV solar energy conversion systems could therefore challenge the electric mains. This paper deals with the economical computations needed for sizing PV solar energy conversion systems. For this purpose, we have studied the case of a small stand-alone photovoltaïc system equipped with batteries and intended to satisfy the household requirements in the region of Algiers. The hybridising of the PV system to the electric mains has also been investigated and examples of PV installations in remote sites of the southern Algeria are given. These sites are Djelfa, Tiaret, Ain BelBel (Adrar), Matrimouane (Adrar) and Assekrem (Tamanrasset). The scenarios analysed depend on the choice of the operating point of the PV systems according as they are sized, undersized or oversized. The cost price of daily electric energy produced by each PV system, has been calculated by considering the purchase price of its constituent elements, the performance of PV modules, the statistical properties of solar radiation, the fixed expenses and the amortisation of investments. For a PV solar energy conversion system, the initial investments are obviously too high whereas the working expenses are weak. In addition, the lifetime of the PV modules can last till twenty years whereas the batteries must be changed every five years. In spite of the importance of the investments, the cost of energy produced by each PV system can be reduced if extending their time of amortisation. We get that the PV systems under study become competitive when taking the time of amortisation to be ten years or more.

Screen Printed Multicrystalline Silicon Solar Cells with Selective Emitters

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ABSTRACT

We present the results of a study aiming at the formation of selective emitter silicon solar cells. A technological work on the realization and development of selective emitter in multicrystalline silicon solar cells, based on the use of screen printing for junction formation, antireflective coating and metallization, is carried out. In particular our attention has been focused on those processes that seem to be scalable to industry.

Different methods of realizing selective emitter silicon solar cells were approached according to three main ways:

1-Homogeneous diffusion of an heavily doped emitter followed by a chemical etch.

2-Homogeneous diffusion of a shallow and moderately doped junction then deposition and annealing of phosphorous doped pastes.

3-Doping source deposition by screen printing followed by an anneal in a belt furnace.

A comparison between these methods is presented, all with their specific advantages and disadvantages.

The advantages of such structure were demonstrated with spectral response measurements showing an increase in the UV-VIS range of the solar spectrum.

As a result, the selective emitter cell shows a much higher J_{sc} and V_{oc} than the conventional emitter cell.

Identification and Modeling of the Optimal Sizing Coefficient of Stand-alone Photovoltaic Systems Using the RBF Networks

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Abstract

The objective of this work is to investigate the Radial Basis Function Neural Networks (RBFN) to identifying and modeling the optimal sizing couples of stand-alone photovoltaic (PV) system using a minimum of input data, These optimal couples allow to the users of stand-alone PV systems to determine the number of solar panel modules and storage batteries necessary to satisfy a given consumption. The advantage of this model is to estimate of the sizing PV system for any site in Algeria particularly in isolated sites, where the global solar radiation data is not always available. A RBFN has been trained by using 200 known sizing couples data corresponding to 200 locations. In this way, the RBFN model was trained to accept and even handle a number of unusual cases. Known sizing couples were subsequently used to investigate the accuracy of prediction, the unknown validation sizing couples set produced very set accurate predictions with the correlation coefficient between the actual and the RBFN model identified data of 98% was obtained. This result indicates that the proposed method can be successfully used for estimating of optimal sizing couples of PV systems for any locations in Algeria, but the methodology can be generalized using different locations in the world.

Variation of solar cells grid finger spacing for its application in the concentrator PV system

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Abstract

Normal silicon solar cell can generate higher power under concentrated sunlight if their series resistance is small enough and actively cooled. We have concentrated our work based on the effect of series resistance of the normal single crystal silicon solar cell due to its finger spacing and the shading by the lines. Simple screen-printing with silver paste and firing was utilized for the grid finger space modification. Single crystal silicon solar cell of size 11 cm x 11 cm was resized into four pieces of 5.48 cm x 5.48 cm size solar cell. The grid fingers spacing of the resized solar cell were modified with different finger spacing such as 2mm, 1.5mm, 1.2mm, 1mm and .75mm by keeping all other cell parameters same. Amongst them the finger spacing of 1.2 mm showed the best performance particularly in higher power generation. To evaluate the performance of this cell in a concentrator system, a continuous mirror parabolic concentrator with V shape absorber suitable for mounting of 5.48 cm x 5.48 cm size solar cell were designed and developed using a computerized ray tracing technique. The performance of V shape absorber mounted with resized 1.2 mm and 2mm (used in flat panel) grid finger spacing solar cell string were studied in the constructed concentrator system for the comparison of electrical power generation. The profile geometry was optimized for maximum power generation along with periodic tracking. The systems electrical and thermal power outputs efficiencies and its suitability as a small-scale power generator for the households of remote rural areas were evaluated.

RELIABILITY AND COMPATIBILITY IN PV SYSTEMS: DEVELOPMENT OF TEST PROCEDURES

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The sustainability development of photovoltaic systems demands equipment quality control. Presently, in Brazil, there are many initiatives being developed. The procedure development for monitoring, reliability tests and compatibility evaluations of equipments is vital to systems sustainability. To fund these initiatives and the sustainability of the systems of the *Luz Solar (Sun Light)* Program from Companhia Energética de Minas Gerais - CEMIG, monitoring systems procedures and tests are being developed for photovoltaic generators, charge controllers, batteries, inverters, electronic ballasts and fluorescent lamps, covering minimum requirements and in compliance with national and international standards. The test and monitoring facilities, and the irradiation and lighting station were implanted at the Smart Energy Research Center of the Group of Studies in Energy – PUC Minas, partnership with CEMIG. The initial acquired results are helping the sustainability of the systems installed by CEMIG, funding the government initiatives and promoting an improvement of equipment quality in the local industry.

DETERMINISTIC AND STOCHASTIC METHODS FOR SIZING STAND-ALONE PHOTOVOLTAIC SYSTEMS

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The aim of this paper is to compare methods for sizing photovoltaic systems to attend areas isolated from the power grid. The methods studied were the deterministic and the stochastic. Both, the load demand and the solar radiation were analyzed probabilistically since they present some random characteristics. The Markov chains and the Beta distribution function were considered for the stochastic sizing approach. They were verified several advantages and disadvantages of both methods. The method to be chosen to sizing an stand-alone photovoltaic system would be the one that be able to perform the calculations with the available data and tools. After appraise both methods it was concluded that the stochastic method, for sizing stand-alone photovoltaic system, although more complex represents better the reality.

MODEL AND SIMULATION OF PHOTOVOLTAIC MODULES

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A photovoltaic module is bound to have several variations in solar insolation, ambient temperature or load, which alters its optimum point of operation. Thus, one must analyze its behavior regarding such variations, so as to optimize its functioning. This paper aims at modeling a photovoltaic module taking into account features that are provided by the manufacturer and to simulate it, using for that purpose curves digitalization softwares and simulation (Matlab tool Simulink), reviewing its behavior with regard to the solar insolation variation and temperature, comparing the obtained curves with those provided by the manufacturer. In this modeling, the "one diode model" for the single photovoltaic cell was used, later it was extended to modules. The results obtained with the simulations were satisfactory. The maximum error between the simulated and observed values, supplied by the manufacturers, was 0.96%. The obtained voltage curves versus current and power matched those provided by the manufacturers.

Sustainable Solar Energy Development Strategies in Brazil

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Abstract

In Brazil, the power generation is predominantly hydroelectric, corresponding approximately to 91,4% of the installed capacity. The energy crisis in Brazilian electric sector, in 2001, call the attention for the need of a new approach for the sector, launching of a decentralized generation approach aiming to add to the existing plants through small and medium power capacity. So the exploitation of a natural, clean and renewable resource – the solar energy – associated with other type of renewable energy, can contribute to the self-sustainability of the Brazilian electrical system, in an active and passive ways, for the decades ahead.

Such approach matches the solar energy characteristic profile. The whole brazilian area is very promising for solar exploitation in many application, such as PV generation for rural electrification, hybrid system with mini-grid in isolated areas, in grid connected systems in urban area and also in solar thermal generation.

Also the solar energy is a very competitive instrument of energy efficiency. It has been largely used for solar heating water in several initiatives throughout the country, in smart windows and bioclimatic architecture.

The investments of the Brazilian electric sector and the signaling of incentive energy efficiency policies for alternatives energy sources make the future of solar energy in Brazil very promising, prevailing over the absence of a specific legislation for this source of energy.

Modelling daylight on inclined surfaces for Florianópolis, Brazil

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Abstract

The scientific literature does not bring many models of the solar radiation luminous efficacy on vertical planes. Only a few models are effectively available. Robledo and Soler have developed luminous efficacy models for both the diffuse and the global solar radiation on inclined surfaces, for various sky conditions, presented in four different papers. In one of them, the authors reported two clear sky luminous efficacy models for vertical surfaces of different orientations that use the solar altitude as the only input independent variable – one of the models being a simplification of the other. These models have been used to estimate the global luminous efficacy of a vertical surface in Florianópolis, Brazil. The result of this evaluation has served, on one hand, to reaffirm the validity of the models for a distinct place from where they have been developed and, on the other hand, to verify the local character of the coefficients that appear in those models. This evaluation has taken into account not only the accuracy of the models but also their performance when explaining the physical behaviour of the global luminous efficacy. The results obtained here have been compared with those obtained when making the same evaluation for Madrid, Spain.

VARIATIONS AND METHODS FOR DETERMINATION OF THE SOLAR CELL JUNCTION IDEALITY FACTOR.

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The origin of solar cell junction ideality factor (n), its physical meaning and its relation with the solar cell's model and performance are described in this paper. Then an analysis of the dependence on operation conditions and other parameters is made. It is shown that: (i) n increases on the I-V curve (4th quadrant) from point (o,-I_{ph}) to point (V_{oc},o); (ii) n decreases with increasing solar cell's temperature (T); (iii) n increases with the light intensity (E); (iv) low values of the reverse saturation current (I_o) yield low values of n; (v) n decreases with increasing R_s, the cell's series resistance; and (vi) n increases with increasing solar cell's shunt resistance (R_{sh}) for R_s < 1 W.

Furthermore, up to 18 methods for the determination of n are reviewed. For 15 of them, experimental tests are carried out on a conventional c-Si solar cell. Results of those tests and from other workers indicate that: (i) only a few number of papers consider more than one diode in solar cell's models for estimating n; (ii) only 2 darkness conditions' methods and 2 dynamic ones have been quoted; (iii) the different illumination levels' model and the I-V curve's slope models are less efficient than others; (iv) heterojunctions present higher n values than homojunctions; (v) the n average value of 1.4±0.1 has been obtained for the sample of this study from the 9 most accurate tested models, in the light intensity and temperature ranges of (345-400) W/m^2 and (295-321) K respectively.

KEYWORDS: Solar cell junction ideality factor; effect of operation on diode solar cell's model; darkness conditions and dynamic methods; different illumination levels' method; I-V curve slope's methods.

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Case study of Building Integrated Photovoltaic (BIPV) Installation

By Tim Yusishen and Reuben Janzen-Martin

The new Red River College Princess Street campus in downtown Winnipeg has a solar energy system that is the largest of its kind in Canada. The south facade of the Princess block includes a photovoltaic (PV) array integrated in the glazed curtain wall that forms the building envelope. The 133-module array is capable of producing 12.6 kW of electrical power as well as providing light, shelter and shade for the building's occupants.

An innovative technique was developed to electrically connect the modules on the outside of the building envelope to reduce heat loss and the chance of water entering the frame at connection points. The effectiveness of this method will be evaluated over the life of the project.

The array is completely monitored with several sensors installed and wired to a central data collection unit. The results are logged together with the electrical output of the system. Measured values include: voltage and power output of the array, cell temperature, ambient air temperature, wind speed and solar radiation.

Studies are in progress to compare the effectiveness of the array in winter and summer. Other data that will prove to be useful to the solar photovoltaic industry are the actual cell temperatures in a glass-laminated module compared to ambient temperature. The effectiveness of the PV module as a window to provide light and shade will also be considered from a more qualitative approach.

Systems of this kind represent a major step to reducing greenhouse gases and slow global warming, which will help to meet the requirements of the Kyoto protocol. As an energy efficient strategy, the project is highly visible and becomes an enduring symbol of environmental responsibility. Photovoltaic integration in the Red River college project provides an opportunity for education and the advancement of green technology.

STUDY OF CdTe SOLAR CELL MODULE AND CONSTRACTION OF 0.3MW DEMO PRODUCTION LINE

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ABSTRACT:

CdTe solar cell is considered as one kind of the most promising cheap effective thin film solar cells. A project about the large area modules of CdTe solar cell and has been carried out for three years in China. A main target of the project is to establish a demo production line of 0.3MW/year. Its main task is to demonstrate the advantages of CdTe solar cells, module stability, process flexibility and ability of manufacturing key equipment. In this work the technologies of CdTe solar cell module are studied. The technologies include the deposition and laser scribe of large area films of II-VI group semiconductors, structural design of module and manufacture of key equipment for producing CdTe solar cell modules. The module cost of the demo production line is analyzed, considering the module area of 30×40 cm^2, conversion efficiency of 8%. The feasibility of pilot-scale and commercial-scale production is discussed.

THE ELECTRICAL, OPTICAL PROPERTIES OF CdTe THIN FILMS DEPOSITED IN Ar/O_2 BY CSS FOR CdS/CdTe SOLAR CELLS

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ABSTRACT:
A technology of closed-space sublimation (CSS) in $Ar+O_2$ atmosphere has been studied. Specially, a method of depositing CdTe thin films on smooth glass substrata has been developed, and the structural characteristics of CdTe films, that are deposited on both kinds of substrata: glass and CdS film, have been compared. The effects of O_2 fractional pressure on the structural properties and preferred-orientation have been investigated, which show that there are the same structures of CdTe thin films on both kinds of substrata if these films are deposited in an appropriate CSS process. Then, the optical and electrical properties of CdTe films on glass substrata are researched. The experimental results do not show the obvious effects of O_2 fractional pressure on the properties, exactly, the optical gaps do not depend on O_2 fractional pressure. However, after post-treatment the large changes in dark conductivity and its activation energy are observed.

These results have been used to prepared CdS/CdTe/ZnTe/ZnTe:Cu solar cells. 13.38% of efficiency and 70.3% of fill factor have been demonstrated for a 0.5 cm^2 CdTe cell without an anti-reflection layer.

Structural, optical and electrical properties of the CdSTe thin films by co-evaporation for solar cells

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Abstract:
It is difficult to control the composition and thickness of CdS_xTe_{1-x} formed by interdiffusion. So the overall effect of the CdSTe ternary phase on solar cells efficiency is not be appreciated. However, some experimental results and theoretical analysis indicate that performance of solar cells can be significantly enhanced by introducing a CdS_xTe_{1-x} with optimum x. Therefore, CdS_xTe_{1-x} thin films ($0<x<1$) have been prepared by co-evaporation of CdTe and CdS, and their properties have been studied. CdSTe are cubic for $x<0.38$ and hexagonal for $x>0.38$. There are two values of activation energy in the curve of $\ln\sigma - T$, which indicates different dominant conduction mechanisms in different temperature ranges. And the predominant direct optical transitions have been observed from the optical transmission measurement. Meanwhile, the properties of CdSTe annealed have been investigated. Based on this work, we have introduced the CdSTe in the CdS/CdTe heterojunction, which shows the performance of the heterojunction has been improved.

INTEGRATION OF ROOF PV CLADDING INTO A SOLAR HOUSE FOR NATURAL VENTILATION AND POWER GENERATION

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With the onset of new policy to encourage use of solar energy in reducing energy consumption in buildings, more and more efforts have been made to develop commercial solar buildings in various regions of China. PV cladding on the roofs or the walls that can effect power generation for room lighting and driving home appliances have been one of components. By absorption within the body of the cell or its substrate, most of the energy of the solar radiation, which is not converted into electricity, appears as heat. The temperature of solar panels is usually in excess of 65℃ in sunny days. The result of elevated temperature is lower energy conversion efficiency from solar radiation to electricity, as well as a raised cooling load in some climates. In this paper, a novel naturally ventilated photovoltaic and thermal solar energy module, which is configured by integrating a panel of solar cells with an insulated air duct, has been studied. The module can induce some amount of natural ventilation rate by using the thermal effect of the solar cells. Extensive test and theoretical analysis have been performed. It is found that the efficiency of solar energy conversion can be improved by 10% when comparing the novel module and the solar cells alone. Some other factors, such as the dimensional sizes, solar irradiance, etc., that have influence on the practical effect of the module are also analyzed.

Photovoltaic Module Performance and Durability Tests

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Solar cell is a large area semiconductor diode exploiting the incidence of the light perpendicularly to the p-n junction and converting the energy of the light into electric energy. An interesting item for the application of the PV sources is the exploitation of transparent panels – glass layered structure – fulfilling the safety standards of the glass for windows.

Both, photovoltaic cells themselves as a more or less complicated semiconductor structure and constructional materials of the module undergo the degradation resulting in the electrical, optical and mechanical properties and the module performance deterioration. The possible damageable parts are solar cells, interconnections, substrate and top transparent cover and encapsulant. Field-mounted modules have been subject of the ageing test but simpler laboratory tests are more frequent and also performed in this work.

Simple small experimental modules have been prepared exploiting crystalline silicon solar cells. In order to estimate the degradation processes and to evaluate the deterioration, tested samples were stored at elevated temperature and humidity – the most usual environmental degradation influences.

The measurements of the cell/module parameters in the dark and under standard simulated illumination (AM1.5 spectrum, 100 mW/cm^2, room temperature) were performed and insulating resistance and dielectric behaviour investigated in order to estimate the environmental impact on the module.

A low cost solar cell based on dye sensitized nc-rutile TiO_2 films

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Abstract

This work shows a simple technology for fabricating TiO_2 solar cell with using cheaply available materials. It depends completely on rutile shape of TiO_2 only, which is simply fabricated for preparation of nano-crystalline (nc)-TiO_2 dye sensitized solar cell (DSC).

Nc-rutile TiO_2 is produced by hydrolysis of $TiCl_4$ and it is separated by simple manual way. Heat treatment conditions of films in air by varying several conditions (annealing temperature, annealing time and density of the film) are studied in this paper. Sensitization of films by using several dyes (black berries, N_3 and Rhodamine 6G) is used to form a photo- electrode. In addition, a soft pencil lead is used to apply a carbon film on a conductive glass to form the counter-electrode. On the other hand, NaI/I_2 is used as a mediator electrode to create recycling for the electron transfer in the nc-DSC. In addition, variation of the electrolyte media by using several solvents (acetonitrile and propylene carbonate) is also considered.

The particle size of nc-rutile TiO_2 is directly proportional with annealing temperature and inversely proportional with annealing time. Photocurrent and photo-voltage of nc-DSC depends on several parameters such as density of TiO_2 film, type of dye and the solvent used with the electrolyte. At AM0 with optimum conditions, the cell can produce photocurrent of $5\mu A/cm^2$ and photo voltage of 0.8V.

Keywords: dye-sensitized solar cell, photovoltaic, titanium dioxide

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Successful PV SHS project in Developing Countries? Barriers and way foreword

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It is well known among key stakeholders in the PV business that the implementation of a PV project in developing countries is highly tricky and its success is dependant on many factors that are usually difficult to handle. The objective of this paper is to address financial and organisational aspects – barriers and measures – to PV programme implementation drawn from two specific ongoing projects : 1600 and 3000 Solar Home Systems are (being) installed in Burkina-Faso and Mauritania, with the support from the French Development Agency (AFD).

The financial set-up for both projects (terms of repayment, financial equilibrium) is closely related to the preliminary surveys in rural households on their needs and actual substitutable energy bill ; their capability and willingness to pay for an electrical service were carefully assessed. Difficulties in identifying reliable financial "intermediary" are presented and financial tools for large PV dissemination among the poorest are discussed.

The set-up of a sustainable organisational scheme is another barrier to overcome, and not the least. The final choices of the most appropriate "type of service" (fee-for-service, credit, "hire-purchase",) were closely linked to the capability of the local private sector to operate infrastructures and to manage the after-sales services. The paper deals with the capacity reinforcement to stimulate "entrepreneurial initiatives" and professional practices.

Another important key issue during the implementation phase of these two projects was the quality control at different levels of the distribution chain. Testing of crucial components in European laboratories was necessary to dispel doubts about compliance with specs in despite of rigorous procedures for commissioning. Intensive efforts were also necessary to convince local service providers to work professionally by the "rule book".

The paper ends with some interesting feedbacks from monitoring of relevant indicators and from preliminary evaluation of the global impacts on social, economic and environmental development.

Classification of Off Grid Renewable Energy Systems with Similar Operating Conditions Based on Battery Use Profiles

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ABSTRACT

The purpose of the work described within this paper will be the classification of use profiles for off grid, electrically remote power systems incorporating battery storage. The operating conditions of components in renewable energy systems (RES), and in particular batteries, vary significantly depending on their use, available resource, other specific control and environmental considerations. As a result, similar power systems can operate very differently given their operating environment, thus impacting the use and life of the different system components that make up off grid power systems. Through analysing the operating performance of over 150 data sets representing operating power systems, categories of use of RES are defined in that RES in the same category are subjected to similar operating conditions and a similar combination of stress factors acting on the battery. Through the categorisation of the system use, recommendations can be made based on analytical modelling to the types or specific properties of components that should be used in the power system being designed for a specific application.

The ability to specify equipment that is more optimally suited for a specific type or profile of use, will allow better performance and life for system components, thus increasing performance and decreasing the life cycle cost of energy produced from the system.

This work is part of the European Union (ENK6-CT-2001-80576), United States and Australian funded Benchmarking research project which incorporates the combined experience of 12 internationally recognised research and development laboratories worldwide. The Benchamrking program focuses on the analysis and interpretation of data and experience in the operation of remote power systems incorporating renewable technologies. Through this program the partner institutions hope to provide useful tools to improve the design capabilities of organizations, private and public, in remote power systems. This work also hopes to engage the manufacturers of components widely used in remote area power systems, to specify these components in terms that are relevant to the hybrid systems industry.

DESIGN ASPECTS AND APPLICATION OF HYBRID PV/T SOLAR SYSTEMS

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ABSTRACT

In this paper a review of the design aspects and considerations for the hybrid Photovoltaic/Thermal (PV/T) systems is presented. In particular the systems investigated are analyzed with respect to their performance improvements, practical applications, constructional and operational requirements and environmental impact. The design concepts and the experience gained from testing PV/T prototypes with air and water heat extraction at our Universities is also included. The temperature of PV modules increases by the absorbed solar radiation that is not converted into electricity causing a decrease in their efficiency. This undesirable effect can be partially avoided by heat extraction with a fluid circulation. In hybrid PV/T solar systems the reduction of PV module temperature can be combined with a useful fluid heating. Therefore, hybrid PV/T systems can simultaneously provide electrical and thermal energy, thus achieving a higher energy conversion rate of the absorbed solar radiation. These systems consist of PV modules coupled to heat extraction devices, in which air or water of lower temperature than that of PV modules is heated whilst at the same time the PV module temperature is reduced. In PV/T system applications the production of electricity is the main priority, therefore it is necessary to operate the PV modules at low temperature in order to keep PV cell electrical efficiency at a sufficient level. This requirement limits the effective operation range of the PV/T thermal unit for low temperatures applications such as space heating and natural ventilation of buildings, and air or water preheating. In PV/T systems the thermal unit for air or water heat extraction, the fan or pump and the external ducts or pipes for fluid circulation constitute the complete system.

A SOLAR PV WINNOWER CUM DRYER

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Abstract

In connection with agriculture it is felt that after harvest farmers depend mainly on winds for purpose of winnowing. If there is a lull in the natural wind, the farmers face problem to contemplate the winnowing. Under such circumstances, sometimes the material gets wet due to unexpected rains leading to unnecessary wastage of the material and thus causing loss to the farmers. A solar PV winnower has been designed and fabricated to provide a convenient device for winnowing grains, spices and other agricultural produce in the absence of natural wind, which is commonly used for this purpose. Initial studies indicated the utility of the system for winnowing the grains.

On connecting the motor to PV-battery system, the dc fan start blowing sufficient air which can be felt at the exit. The material, to be winnowed is loaded on the top tray. Once the blower starts running in full speed, the slit is opened so that the produce falls down in a form of thin stream. The blast of air created by the fan flows through the entire width of the falling material which blows away light material like straw and dust while the grain falls down and thus winnowing can be accomplished.

The developed device was tested for winnowing of pearl millet, cluster bean and green gram. The blowing air could enable to accomplish the winnowing of pearl millet successfully with a capacity of 35-50 kg/h. In order to use the device throughout the year, a dryer has been developed which uses the PV run fan for air circulation. Further, a lighting system has also been incorporated and thus the same device can be used for winnowing or drying or lighting. The design details and performance are reported in the paper.

A NEW METHOD FOR RATING SOLAR WATER PUMPING SYSTEMS

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Abstract

Selecting the most appropriate pump is the most important design and performance factor in solar water pumping. The selection of the right pump in photovoltaic (PV) water pumping applications is influenced and controlled by many parameters including head-flow rate profile of the well, solar radiation pattern, demand profile, design criteria and nominal operational points. Analyses of field results for several systems have revealed considerable variation in system performance due to variation in pump characteristics. In this paper, a new method for rating solar water pumping systems based on actual field data is presented. A case study of a system installed in the field is considered and field data collected over a three-year period has been utilized in the study. Different options for pump selection are discussed. Several system head-flow rate profile scenarios have been considered. Subsystem efficiency curves are obtained for each corresponding profile. Yearly average subsystem efficiency (YAS) is calculated for each profile based on frequency distribution of solar insolation over the year. A newly introduced parameter, named Yearly subsystem yield (YSY), is calculated for each scenario by dividing YAS by the maximum subsystem efficiency of the inverter-motor-pump set. The method is extended to include the PV generator and thus concluding a new parameter for the Yearly total system yield (YTSY). A generalized method is proposed for YSY and YTSY based on component types, weather data and components characteristics. Threshold losses at low insolation are discussed. The phenomenon whereby the increase on pump performance is either retarded or even reduced despite increasing insolation, and the unutilized amount of solar energy due to the fact that the pump has reached its maximum capacity limit is discussed.

Keywords: Solar water pumping, subsystem efficiency, yearly subsystem yield, yearly total system yield

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EUROPEAN RESEARCH IN PHOTOVOLTAICS

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In the last five years, the production of photovoltaic cells has increased steadily by an average of more than 30% and ha reached more than 740 MWp/year at the end of 2003. This development is driven by market introduction programmes in many countries of the world. A further continuation of this growth will only be possible, if reliable political framing conditions are put in place to ensure a return on investment for the PV industry. Besides this political issue a continuous improvement of the solar cell and system technology is required. This leads to the search for new developments with respect to material use and consumption, device design, reliability and production technologies as well as new concepts to increase the overall efficiency.

Roadmaps are an important tool for future planning of technological developments. Within a European project PVNET developed a roadmap for PV R&D based on a broad consensus among the different technologies, among industry and research institutions, across the whole range from materials to systems. To do so, expert meetings, workshops and symposia were organised to stimulate communication and discussion within the European PV community. The preparation of the roadmap is an interactive and ongoing process. It points out major research areas for the short and long term, including cross fertilisation with other R&D fields. It will cover marketing, product and standardisation aspects, environmental issues as well as the issue of human resources for PV.

This presentation will present the findings of the roadmap as well as give an overview about the research activities for photovoltaics in Europe.

Evaluation of Solar Energy Potential and PV Module Performance in the Gobi Desert of Mongolia

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This paper presents the evaluation results of solar energy potential and photovoltaic module performance from real measured data in the Gobi Desert of Mongolia

For the purpose to estimate solar energy potentials and durability of PV systems in the Gobi desert area, a data acquisition system, which includes 75W, 80W modules and two precision pyranometers, thermometer and anemometer, has been installed at the Sainshand city in October, 2002. This system has been measuring 23 parameters including solar irradiation and meteorological parameters in every 10 minutes.

It has been observed that the high output gain due to the operating condition in an extreme low ambient temperature and the module performance ratio indicated very high value 0.9 or more in the winter. The monthly amount variation of in-plane irradiation and module output shows relatively small range in a year, by reason of low ambient temperature and the precipitation that concentrated on the summer time.

COMPARATIVE STUDY ON POTENTIAL OF VERY LARGE-SCALE PV SYSTEMS (VLS-PV) IN THE GOBI AND SAHARA DESERT

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Purpose of the work: Purpose of this study is to evaluate the Very Large-Scale Photovoltaic systems, and investigate feasibility and characteristics of poly-Si and a-Si module systems if these systems are installed in high and low temperature deserts.
Approach: 100MW VLS-PV systems with poly-Si and a-Si module were designed and evaluated in detail from cradle to grave by using life cycle assessment method under real material data.
Scientific innovation and relevance: This study focused on advantage of amorphous silicon modules. And this study shows its potential for high temperature desert area.
Results: VLS-PV system using poly crystalline silicon module is effective in cold arid land area such as Gobi desert. Amorphous silicone module is comparative in high temperature area such as Sahara desert. Generation cost in Gobi desert is 13 to 15 UScent/kWh with 3 USD/W module price, and 11 to 12 UScent/kWh in Sahara desert.
Conclusion: In spite of its high required materials, generation cost is lower than poly-Si module system at 3 or 4 USD/W module price. Amorphous silicone solar cells are not high efficiency. However, its character is effective and cost reducing in high temperature area.

ENERGY FROM THE DESERT

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Purpose of the work: is to examine and evaluate the capability of very large-scale photovoltaic power generation (VLS-PV) systems up to the order of giga-watts, by identifying their socio-economical benefits to neighboring regions, as well as to the global environment.
Approach: The key factors for the feasibility of such systems were identified. Then, Six desert first and then selected three were compared. Finally, three scenario studies have been performed to ensure sustainability.
Scientific innovation and relevance: When considering world energy fundamentals in 21st century, this option should become one of essential solution for the people.
Results: Electricity costs of between 0.09 and 0.11 \$/kWh are shown, depending mainly on annual irradiation level (module price 2 \$/W, interest rate 3 %, salvage value rate 10 %, depreciation period 30 years). The life-cycle CO_2 emission is around 13 g-C/kWh, due mainly to manufacturing of the modules and arrays. I/O analysis shows that 25,000–30,000 man-years of local jobs are created per 1 km^2 of VLS-PV installed. To assure sustainable local economic growth, the first local PV module production facility supplies 5 MW for the construction of the local VLS-PV annually In subsequent years, plural or larger production facilities are brought into operation and replaced every 10 years, so that after approximately 40 years a 1.5 GW VLS-PV plant is in operation stably, assuming 30 year module life.
Conclusions: In this way, local employment and economy will grow sustainably while VLS-PV produces energy from the desert.

The EMTP Simulation of the Large-scale Grid-connected Photovoltaic/Wind Power Generating System

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The fluctuating nature of renewable energy such as photovoltaic and wind power generation enlarges the load fluctuation. It has been required to estimate the power quality including harmonic distortion and electrical transitions before the construction of renewable energy power station.
We have studied the system performance of local hybrid power system planned in Kumamoto. The grid connection system is composed of 1 MW photovoltaic (PV) system, 17.5 MW wind power generator system and a synchronous generator (56.1MW). The overall output operation characteristics was simulated using the measured data of 10 kW PV system and 1750 kW wind turbine. The Electro-Magnetic Transients Program (EMTP) was applied to estimate the system operation under various conditions. The typical simulation shows that, when the output power of PV suddenly decreases 5% from the rating during 2s, the stable operation of the power system is obtained due to the supplement from the synchronous generator.

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Improving the Performance of a PV Module Using Inexpensive Sunlight Concentrators

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In this research, aiming to improve the performance of a PV module, we concentrate the sunlight to a PV module using an inexpensive reflector. The sunlight was concentrated on a commercially-available PV module by using low-priced materials, such as aluminum-metallized tape. Figure 1 shows the schematic design of the well-shaped sunlight concentrator. The ratio of the maximum generated power (Concentrating/Non concentrating) is improved up to 2.35. The sunlight concentration is effective during four hours even without tracking the sun. This concentrator is useful when the size of a PV module is not so large and the module is used only when sun shines, such as an electrical charging system for an outdoor-use, this system can be used to obtain high power output in short period of time. Also, this concentrator has good portability by a car because it can be folded in a small space. By using this well-shaped concentrator, which can be constructed using inexpensive materials, the cost of the power generation can be largely reduced.

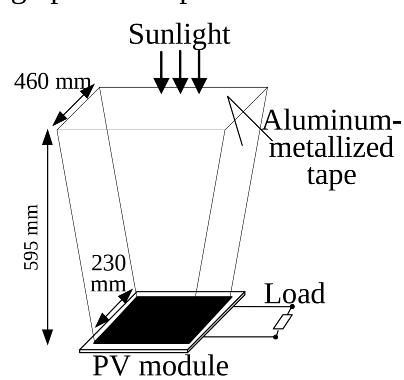

Fig. 1. Schematic design of a well-shaped solar concentrator.

A COMPUTATIONAL FLUID DYNAMICS ANALYSIS OF SOLAR CHIMNEYS INTEGRATED WITH PHOTOVOLTAICS

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ABSTRACT

A solar chimney is a device to use solar energy for the increment of ventilation of buildings. The chimney increases airflow rates by the stack effect. In the study, solar chimneys integrated with photovoltaics are investigated under the climate of Tokyo, Japan. The aims of the study are to investigate the optimum configuration of the system and to predict the performance of the system. In the climate of Tokyo, the system needs to operate in three different modes: the thermal insulation mode, the natural ventilation mode, and the passive heating mode, because the humidity in the summer is too high to achieve passive cooling by natural ventilation. Parametric analyses of the three operation modes are performed using a numerical model. The effects of the chimney configuration such as height, width and aperture size, as well as wall materials are considered. Solar radiation, wind, and photovoltaic cell efficiency are also investigated. From the parametric analyses, the optimum configuration to maximise the airflow rate is found. Electricity output from photovoltaics is estimated from annual solar radiation data. The system performance is compared with its counterpart under the climate of the UK, where the system can significantly reduce a cooling load.

Obtaining of heterostructures with quantum dots by liquid phase epitaxy for solar cells

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The purposes of this work were to investigate an influence of quantum dots (QD) sizes and their location on the efficiency of solar cells (SC), and to study a possibility of QD arrangement control over the surface during the process of their formation.

This article represents the model of QD formation by a method of pulse cooling of saturated solution - melt. This model takes into account the interaction of atoms of growing heterolayers, atoms of substrate material and solvent atoms (Rehbinder effect), lattice constants mismatch of contacting materials and relaxation processes in growing heterolayer. X-ray analysis, STM-image and photoluminescence spectra have shown the presence of InAs quantum dots in the obtained structures.

It was determined that the QD maximal size is smaller than distance between mismatch dislocations and not exceed 8 nm for InAs QD on GaAs substrate and 10 nm for InSb QD in GaSb matrix. The QD form an intermediate band in the band gap of a matrix and therefore through an intermediate band the two-photon absorption is realized. It allows utilizing the significant part of the IR-range of a solar spectrum.

The increase of efficiency is 10.5 % for a system of InAs QD in GaAs matrix at QD diameter of 6 nm and 7 % for a system of InSb QD in GaSb matrix at QD diameter of 10 nm.

Developed Numerical Modeling Code (DNMC) for Simulation of Solar Cells

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Abstract

In the present work, a numerical modeling code written in FORTRAN language has been developed for the purpose of Solar Cells Simulation. The code employs a linearized iterative algorithm proposed for solving the discretized semiconductor equations. It uses the Gummel block iteration method to decouple the nonlinear Poisson and electron-hole continuity equations. By means of sample computations and starting from a global convergent nonlinear approach according to Korman and Mayergoyz different versions were tested in order to minimize computer time. The tests have come up with the linearized iterative algorithm that uses Seidman modification for the linearization of the continuity equations as well as perturbation approximation for two succeeding Gummel iteration steps for the linearization of Poisson equation. The resulting linear systems of equations were solved by applying the *conjugate gradient method.* For the purpose of checking, comparison was made with De Mari's work for the case of p-n junction diode and with two simulation softwares SimWindows and PC1D for the case of a conventional solar cell. The comparison was quite satisfactory.

Stand Alone Solar Energy System Design in the Sahara Desert

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Abstract

Roads; especially in remote isolated areas in Sahara Desert lacks necessary service stations This makes people plan in advance for their trip, and carry with them all their needs; food, drinking water, fuel etc. The main reason for that is might be due to the absence or the high cost of the power source.

Present paper suggests solution for this problem, by designing a rest area station, which depends in its power supply completely on renewable energy sources.

The actual sizing methods of the PV array which charges the battery during daylight hours to supply power to the loads as needed, the charge regulator which terminate battery charging when the battery reaches its full charge, the load center which contain meters to monitor system operation and fuses to protect wiring in the event of malfunction or short circuit in the system are discussed.

Comparison on coast effectiveness and reliability bases shows its acceptability with a similar station that utilizes conventional power source.

OFF-GRID PV-DIESEL HYBRID SYSTEM FOR A HILL TOP TOURIST RESORT

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ABSTRACT

The benefits of photovoltaic hybrid system are numerous. These include (a) improved reliability, (b) improved energy services, (c) reduced emissions and pollution, (d) provide continuous power supply, (e) increased operational life, and (f) reduced cost, and more efficient use of power. Off-grid power generation is meant to supply remote or rural area, where grid connection is almost impossible in terms of cost and geography, such as island, aborigine's villages, and areas where nature preservation is concern. Harnessing an abundance renewable energy sources using versatile hybrid power systems can offer the best, least-cost alternative solution for extending modern energy services to remote and isolated communities.

The paper presents the performance of a 16 kW Photovoltaic Diesel Hybrid System operating on a hill top cable car facilities in the Island of Langkawi, Malaysia. The operational concept of solar hybrid system is that solar will be the first choice of supplying load and excess energy produced will be stored in battery. Genset will be a secondary source of energy. The system is controlled by a microprocessor-based controller to manage the energy supplied and load demand. The solar hybrid system consists of one or two diesel generator with electronic control system, lead-acid battery system, solar PV, inverter module and system controller with remote monitoring capability.

Keywords: Off-grid power supply, Renewable Energy, Solar Hybrid System.

Computer-Aided Design of a Stand-Alone Photovolatic System for Rural Electrification

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Abstract

Stand-alone photovoltaic systems have become widely used as a reliable and alternative energy source to meet the electrical energy requirement of rural settlements. A stand-alone photovoltaic system capable of generating electrical energy for application in rural electrification in remote location in Baro, Nigeria has been designed. The electrical energy consumption was adjusted to meet the load requirement of the system. A computer program in MATLAB code was developed to demonstrate the principles and techniques of the design parameters. The computer-aided design employed the ampere-hour method of sizing a photovoltaic system. The use of computer-Aided Design has improved the speed and accuracy of the design.

Modelling of a Photovoltaic Powered Rural Household Electrical Load

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Abstract

Stand-alone photovoltaic systems have become widely used as a reliable and alternative energy source to meet the electrical energy requirement of residential buildings in remote locations Modelling of rural electrical load for a household based on photovoltaic systems is presented. The study proposes an electrical generation system to power AC and DC loads for application in four-bedroom apartment in remote location in Bauchi, Nigeria. The electrical energy consumption was adjusted to meet the load requirement of the system. The analysis employed the ampere-hour method of sizing a stand-alone system to obtain the sizes of array and other balance-of-system components. The analysis of the modelling is discussed through simulation studies. The analysis proved that the electrical generation system for rural household could be attractive as a stand-alone photovoltaic systems renewable energy source.

A Life-Cycle-Cost Comparison of a Photovoltaic System and a Gasoline Generator Set for the Cathodic Protection of Remote Pipelines

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Abstract

The greater portion of pipelines (oil, gas and water) in Nigeria is in remote locations where grid electricity supply is unavailable. For impressed direct current to be used in the protection of such pipelines, a photovoltaic system or a generator set is required. In this work, the financial evaluation of providing a 165W photovoltaic system in a remote location was carried out and a comparison made with that of a 175W gasoline generator set. A 30year life-cycle-cost of the two systems was obtained using the present worth technique. The results show the photovoltaic system to be about 13 times more cost-effective than the gasoline generator set.

THREE YEARS of MONITORING of 1-kW GRID CONNECTED PV SYSTEM

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The paper describes the performance of the grid-connected 1-kW PV system installed on a grammar school in Poland after three years of operation. The project demonstrates and disseminates the concept of PV energy in Poland, as well as assesses the potential of thin-film a-Si photovoltaic modules in Polish climate. The PV system is installed in Warsaw, it faces south and is tilted at 30°. The system consists of twenty Millennia MST-50 MV modules and inverter Sunny Boy GCI 1200. The performance of the system is continuously monitored.

The monitoring system consists of: Sunny Boy Control Plus, DAS built into inverter for electrical parameters measurement and a set of meteorological sensors. The monitoring system and the data analysis meet guidelines of standard IEC 61724

Energy production in the first year was about 740 kWh and it was slightly higher than expected with respect to the simulation done before installation. In the second year the energy production was about 680 kWh. It is estimated that in 2003 the system will produce about 700 kWh of energy. In good irradiance conditions, the measured efficiency of the PV modules is about 5%, efficiency of the inverter is about 92% and efficiency of entire PV system exceeds 4 %. The Performance Ratio is in the range from 0.5 to 0.8. During the whole period of system working Final Yield is 63 %, Capture Loses are 31% and System Loses are 6% of Reference Yield – which is equal to solar energy that is available for PV array. There are no problems in compatibility of the PV system with Polish electrical grid.

STATUS OF PHOTOVOLTAICS IN CENTRAL AND EASTERN EUROPE

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The history of PV in the Newly Associated States is not long yet but some countries can already be proud of their achievements in this field. The photovoltaic activities are slowly emerging and markets are already being created in the CEEC. These countries are active in nearly all most important fields of PV RTD, from different materials for photovoltaic cells to inverters and other components of grid connected PV systems. One can point out a well developed research infrastructure for investigating the basic materials used in photovoltaics: all forms of silicon (crystalline, polycrystalline, and amorphous), chalcopyrite based materials for the thin-film cells, and the organic PV materials. The quantity and quality of achievements have reached a considerable level despite of rather limited (financial and other) resources and of the lack of the legislative support for the PV development.

These are quite considerable numbers of people involved in PV (about 265 scientists and 430 people of total staff) and it shows that there exists a big intellectual potential in the region. Most of the research concentrates on the basic research of the materials, which are used for solar cells and other semiconductor devices.

The research infrastructure and the qualified researchers existing in CEEC could become the basis for a further development of PV RTD and for a wider use of the photovoltaic solar energy. However, all CEEC state that the co-operation with the EC and USA should be considerably intensified in order to fully take advantage of their potential and capability. Further success stories are needed in order to convince decision makers to create favourable legal environment, to attract more potential investors and convince will-be customers to invest their funds in the PV installations.

Study of the Temperature Effect on the Performance of PV Modules with Methylmetacrylate Cell Encapsulation

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Purpose of the work
Energy losses due to the PV module heating even in typical conditions (without concentration) achieve 15…20%. At radiation concentration the losses increase proportionally. Moreover, increased operating temperature reduces the PV module lifetime significantly. The purpose of the present work is to study the temperature effect on PV modules of different encapsulation constructions.

Approach
The present work analyzes different constructions of PV modules encapsulated by the methylmetacrylate composition: glass, plastic face material, glass, plastic, aluminum sheet back material. Solar cell operating temperatures are measured at different wind speed and ambient temperature. One dimensional thermal model was used for calculation of the considered constructions.

Scientific innovation and relevance
Encapsulation with the help of methylmetacrylate composition allowed to use heat-conducting doughs in the construction with aluminum sheet back material that allowed to decrease solar cell operating temperature.

Results
We succeeded in obtaining NOCT at the level of 34ºC, that is close to the values received for free unencapsulated cells, for the construction of plastic face sheet, solar cell, thermal-conductive dough, back aluminum sheet. When increasing the wind speed up to 4m/s at the irradiance of 800 W/m^2 the operating cell temperature of 26…28ºC for the analyzed construction was received. So, PV module heating losses are reduced to 5…7%.

Conclusions
PV modules of the designed construction can be successfully used in systems with 2X and more radiation concentration.

Equipment and Technology for Solar-Grade Silicon Production

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Purpose of the work
In our recent reports we described and demonstrated the new technology for solar-grade silicon production. Comparison of the new technology and the widely used Siemens-process shows the advantages of the new technology in cost, low specific energy consumption of production, principal technological opportunities of high efficiency, low finance expenses for industrial equipment creation. The present work describes the process of the equipment creation and technology for the low cost silicon production.

Approach
The technology consists of 3 stages: silicon oxide carbothermic reduction, purification of liquid silicon at current flow in a transverse magnetic field and crystallization. The equipments is described in detail. Raw components (quartz and carbon) are prepared at the previous stages (ore mining and processing enterprises, chemical enterprises) to reduce the impurity content up to no more than 0.01%. Refining of silicon for removal of microparticles of carbon, silicon carbide, quartz and metal impurities by electrotransport in magnetic field is suitable before the further crystallization.

Scientific innovation and relevance
Equipment and technology for solar-grade silicon production use new methods at each stage. It is necessary to exclude the penetration of impurities in each equipment unit, so that the concentration of such impurities should not exceed the ones in initial components. That is why at the first stage of solar-grade silicon production it is already possible to get the material in 100 - 1000 times purer than usually obtained metallurgical-grade silicon. The process of silicon refining by electrotransport in a magnetic field is in volume of liquid silicon that is **in contrast to** crystallization where refining process is on the liquid-solid interface.

Results
The new technology makes it possible to reduce significantly the future price for solar-grade silicon (minority carriers' lifetime is 20-30 microseconds, p-type conductivity with the resistance of 35 ohm·cm) up to USD5.0-8.0 per kg.

Conclusions
The proposed technology and equipment allows to solve the problem of low cost for solar-grade silicon.

MONITORING AND CONTROL OF PV FARM USING WAP AND JAVA ENABLED MOBILE PHONE

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Abstract

It is often necessary to obtain remote monitoring and control of data and processes of PV panels arranged in the farm. There have been few different ways to do it, all relying on specially designed hardware and software installation. By using GSM infrastructure it is possible to achieve very flexible, distributed and very reliable method for monitoring and controlling of PV panels without using special installation.

The mobile phone had served in the beginning only for voice and SMS communication, but recently features of mobile phones have enabled its use for more sufficient tasks, such as communication with various devices using Internet. In case of Java enabled mobile phone it is possible to create very powerful application which can serve even for control processes.

Having had standard interface for gathering/sending data from PV panels one can, by using WAP server and gateway, approach Internet and send/receive data to/from mobile phone which is placed at remote location which is covered by GSM signal. This method provides two way communications with PV panels enabling monitoring of the data as well as controlling (sun tracking) of the PV panels. In the case when Java is presented on mobile telephone it is possible to process and analyze data graphically, and to create rich GUI.

The systems have been tested and they have shown good features.

Efficiency of Selected Photovoltaic Modules and Annual Yield at a Sunny Site in Jordan

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Abstract

A new method is proposed for the calculation of the annual yield of photovoltaic (PV) modules at selected sites, using site-specific meteorological data. The method is based on efficiency models taking into account that efficiency depends on cell temperature, solar irradiance and relative air mass. Annual yields are indispensable in calculating the cost of electricity generation, thus allowing the type of module best suited at a specific site to be selected. This paper deals specifically with a monocrystalline silicon module from BP Solar (BP 585F), a polycrystalline silicon module from Kyocera (LA361K51S), an amorphous triple-junction silicon module from Uni-Solar (US-30) and a copper-indium-diselenide (CIS) module from the former Siemens Solar (ST40). Yield calculations were performed for a sunny site in Jordan. The annual yields (per unit module area) for these modules with southern orientation and an inclination angle of 30° was found to be: (BP 585F) 291, (LA361K51S) 242, (US-30) 150 and (ST40) 225 kWh/m^2, and 2319, 2352, 2466 and 2237 kWh/kW$_{STC}$ respectively. For sun-tracked modules, the annual yield was: 396, 328, 200 and 310 kWh/m^2, and 3158, 3190, 3286 and 3082 kWh/kW$_{STC}$, respectively.

A maximum-power generation design of solar photovoltaic system

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A photovoltaic system requires a maximum-power-point tracking (MPPT) to control the photovoltaic arrays to operate at the highest efficiency. The present study proposes a design, called "near Maximum Power-Point Operation" (nMPPO) that could keep the performance of MPPT but eliminate the hardware of the MPPT. The concept of nMPPO is to match the battery voltage V_{set} with the MPP (Maximum-power point) of the PV module based on a statistical analysis using meteorological data. The analytical results show that nMPPO is feasible and the optimal V_{set} falls in the range 13.2~15.0V for MSX60 PV module. The long-term performance simulation of nMPPO shows that the total efficiency of nMPPO (defined with respect to the power generation of ideal MPPT) is higher than 94% if the voltage setting V_{set} is properly designed. A field test using a 1 kWp system was carried out in the present study to verify the design of nMPPO. The experimental results show that the long-term efficiency of nMPPO is higher than 93% and very close to that of MPPT (Figure 1).

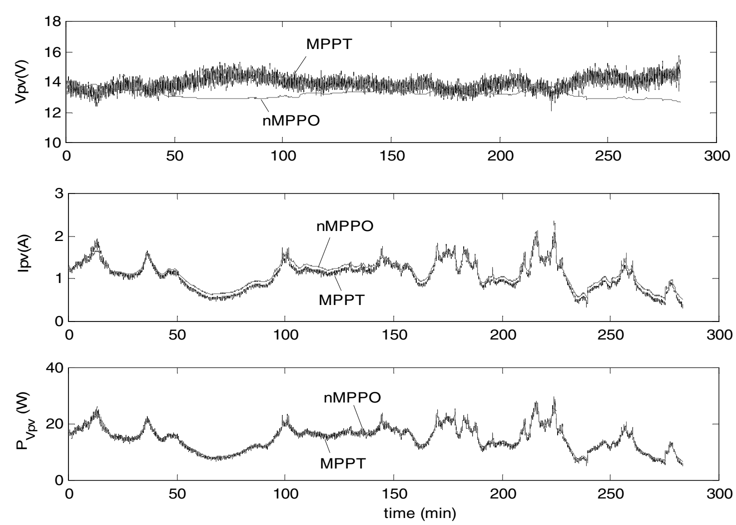

Figure 1 Field test results of nMPPO.

PERSPECTIVES OF USE A SOLAR ENERGY AND PV SOLAR ENERGY IN UZBEKISTAN

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Purpose of the work: Use of a solar energy and photovoltaic (PV) solar energy in an agriculture, transport and medicine. Improvement prophylactic and clinical medical services.

Agriculture. The purpose of research is the introduction in life of a more effective method of development of droughty grounds in remote areas of Uzbekistan and improvement of an ecological condition of region. It is based on application of a method drop irrigation the roots of plants with use of deep pumps for lifting of water from wells and filtration of salty water. Thus the electro supply of pumps is carried out by PV solar energy or hybrid sun-wind installations, and biomass for production of the biogas.

Transport. One of the basic sources of pollution of an atmosphere is transport with the engine of internal combustion. The annual emission in an atmosphere poisonous of gases for Tashkent makes 18 tons. With the purpose of decrease of emissions in an atmosphere poisonous of gases the authors offer proceed to use ecologically pure electro cars and automobiles with a hybrid drive on the basis of PV solar energy are considered.

Medicine. The cooperation heliotechnical specialists and medical workers had allowed the authors to develop model of mobile medical laboratory. The mobile laboratory will be equipped with PV solar energy for electro supply devices for physiotherapy and heliotherapy.

A Simulation Model for Predicting the Transient Performance of a Hybrid PV/T Forced Circulation Solar Water Heating System

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Abstract

A transient simulation model for a hybrid PV/T forced circulation solar water heating system is presented along with algorithms for making quantitative predictions regarding the performance of the system. The model consists of a set of mathematical equations governing the main components in the system; namely, transparent cover, solar cell, absorber plate, operating fluid, storage tank and controller. The model is developed based on the analysis of the balance of energy which includes photoelectric conversion, thermal conduction, convection and radiation. It predicts the dynamic variations of several system performance parameters such as electrical power output, amount of heat gained, and various types of efficiencies of the PV/T system. In this research, the developed model has been used to investigate the effects of various physical and operational parameters on the system performance, i.e. water mass flow rate, size of water storage tank and overall thermal conductivity of adhesive used for binding solar cells to the absorber plate. These results are useful for designing the most effective PV/T system to meet the load requirement at any operating site location.

Maximum Power Point Tracking Control of PV System Based on Scanning Method Under Non-uniform Insolation Conditions

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The photovoltaic (hereafter PV) system attracts attention as a clean and inexhaustible energy supply. However, the output density of PV system is low, and the output depends on the insolation conditions. Therefore, Maximum Power Point Tracking (hereafter MPPT) control is necessary to generate the output power at maximum. If insolation distribution is uniform over the PV array, only one maximum power point exists on the voltage-power characteristic curve (hereafter V-P curve) of the array, and it is easy to operate the PV system at the maximum power point. On the other hand, if insolation distribution is not uniform over the array, plural local maximum power points are likely to appear on the V-P curve, and the operating point may converge at a local maximum power point which is not the real one. Many methods have been proposed to overcome this problem. However some of them are too complicated, and others lack reliability of the control. In this paper, a novel method of MPPT control is proposed, which is based on a concept of scanning over a certain range of the V-P curve, monitoring momentary values of voltage and power of the array. According to comprehensive survey of effects of insolation distribution patterns, the real maximum power point lies somewhere between 40% and 90% of the open-circuit voltage, and it is satisfactory to scan over this voltage range of the array for tracking the real maximum power point even under non-uniform insolation. This concept enables easy MPPT control with high reliability even with plural local maximum power points on the V-P curve, avoiding unstable operation in the vicinity of short-circuit condition of the array. Simulation studies were performed using simulation- software PSIM for a PV system consisting of two arrays, rated at 50 kW for each, under different insolation distribution from each other. Simulation results show that the PV system could complete the MPPT process within 0.3 seconds even when the insolation pattern greatly changed. As above-mentioned, the feasibility of this MPPT concept was confirmed.

PV Village Power Systems in Developing Countries: A Discussion of Sustainability Issues

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Abstract
Sustainable development will need to be the driving force and the dominant criteria of development projects. This has been recognised more and more by the various international aid agencies and governments. As a result of this more research is needed that will allow tools to be developed to gauge sustainability as part of the project appraisal. The main reason attributed to this was that sustainability has not been properly defined in the project goals as funding was only provided for finite period of time. Photovoltaic (PV) systems provide an appropriate technical solution to supply power to people living in remote rural areas, where access to electricity services by grid connection is impossible or cannot be realised in the near future. Over the past 10 years, the international aid agencies have been supporting a wide variety of PV rural electrification projects in these countries. However, as a result of political interests, electrification programmes seldom last as long as they should, due to the lack of attention paid to their sustainability.

This work presents an evaluation of the sustainability of PV rural electrification projects in developing countries. It examines and analyses an existing project by through a methodology having sustainability at the core. The paper also adopts the methodology and specific indicators of gauging the sustainability into the evaluation of PV rural electrification programmes.

MULTIPLE STRING INVERTERS FOR PV SYSTEMS < 5kWp: WHEN IS THIS JUSTIFIED?

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A 24 string, 7.2 kWp vertical façade at Southampton University has been used as a test bed to study the effects of mismatch resulting from shading and module variation during manufacture. A range of schemes may be applied to reduce the effect, which, at its most extreme would be the use of a single inverter for each of the 24 strings of the array. This paper presents an analysis of the array operating under schemes of 2, 6 and 12 inverters.

It is shown that the increase in energy output of the multiple inverter systems cannot justify the large disparity in capital cost ($/Wp) compared to a single central inverter. An analysis is presented of the level of mismatch within the system that would have to be present to allow the multiple inverter solution to be selected on economic grounds. Such levels of mismatch are unlikely to be found in the majority of correctly selected PV installation sites.

Three years under a PV roof in Southern England

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Despite the lack of Government support at the time, the author decided in the millennium year 2000 to install a PV system on his house in Farnborough (latitude 51^{o}N). Having been involved professionally in many public PV projects over the years, he wanted to gain first-hand experience of living under a PV roof, monitor its performance and hopefully set an example for others to follow.

The system consists of a 2.04kWp array of high efficiency monocrystalline silicon PV modules on the south-facing roof, two high efficiency string inverters, dc circuit breakers, switchgear, meter and cabling. The inverters embody maximum power point trackers and are equipped with a display enabling key electrical parameters to be continuously monitored. The system is connected to the house distribution board in parallel with the mains supply. Surplus solar power is fed into the grid under a net metering agreement.

The results of three years' monitoring since January 2001 are presented. The system has worked faultlessly without cleaning or maintenance and has produced annual outputs averaging 861kWh/kWp. Increasing yields, combined with measures to reduce the domestic load, have resulted in the solar contribution rising from 47% in 2001 to 77% in 2003.

It is clear from this experience that building-integrated PV is technically capable of making a significant contribution to power supplies, even in the UK. It can do this silently, unobtrusively and without requiring extra land. The technology is mature and ready for take-off. The cost (in this case about £6/Wp) will come down as R&D continues and the market grows. But, even at present levels, it is only a small percentage of current house prices in the UK.

MODELLED AND MEASURED PERFORMANCE OF INVERTERS AT VARIOUS OPERATING INPUT VOLTAGES: IMPACTS ON OPTIMUM ENERGY YIELD

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ABSTRACT
Grid connected inverters require the input dc voltage to remain within a specific range to function correctly. Exceeding the open circuit or maximum power point voltage limit usually causes irreparable damage to an inverter. Undervoltage, created by shading or temperature effects, although not a problem for the inverter in terms of lifetime, will cause an inverter to stop generating. For many PV systems the installer is able to select more than one possible suitable working input voltage range on an inverter. This raises an important question for the installer: which voltage range will maximise the power output of the PV system? This paper considers 18 small string inverters (SMA700) installed on nine identical, domestic PV systems. Each inverter has a single string input of nine mono-crystalline PV laminates (BP585). The voltage of this string is such that the inverter can be safely configured on either its medium (100-200V) or high voltage range (125-250V). Each house has two inverters, with one set to the medium and the other to the high voltage range. Analysis of database and actual irradiance data is used to predict the electrical yield of the PV systems using various techniques. This paper compares this modelled work with real performance data to characterise the true relationship between prediction and reality.

Power Loss Analysis of an Experimentally Characterised Asymmetric Compound Parabolic Photovoltaic Concentrator for Building Integration

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Abstract

Asymmetric compound parabolic concentrator was designed to allow direct and diffuse insolation to be concentrated for building integrated photovoltaic applications. The maximum concentration ratio that could be achieved for this modular non-tracking system design while collecting the total direct solar radiation is 2.0, this allowed 70% of the diffuse radiation to be collected. Using a high-speed (i.e. 2500 readings per seconds) data acquisition system linked to a PC, measurements were taken at 10 sec intervals over an average 10 hour period for 30 days. The experiments were conducted at the University of Ulster, Newtownabbey, NI, UK (5°37′ W and 54°36′ N). Measurements were taken for short circuit current, open circuit voltage, instantaneous current and voltage and the solar radiation for both the concentrator and a similar non-concentrating system. I-V curves for each set of data measurements were determined and the maximum power generation, fill factor and efficiency of the system were calculated for each individual I-V curve. The results showed that the ACPPVC increased the short circuit current by a factor of 1.56 and the maximum power by a factor of 1.62 compared to a similar non-concentrating PV panel. The maximum power ratio of 1.62 was less than the desired value of 2.0 due to the optical losses that occurred due to the positioning of the solar cell and the ohmic losses due to the connecting wire. The comparative performance analysis of long and short tabbed solar strings shows that an average 5 to 6% electric power loss occurred due to the ohmic loss in the interconnections between each individual solar cell for the asymmetric compound parabolic photovoltaic concentrator (ACPPVC) system. The use of an asymmetric compound parabolic concentrator for low concentration photovoltaic applications enables a cost reduction if the material cost is comparable to or less than the cost of the displaced PV.

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Modeling Current-Voltage Curves Using Bilinear Interpolation

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ABSTRACT

The current-voltage (*I-V*) curve of a photovoltaic (PV) module or array for desired conditions of irradiance and PV module temperature is modeled by bilinearly interpolating the *I-V* curve from four reference *I-V* curves. The four reference *I-V* curves are measured at irradiance and PV module temperature levels above and below the desired conditions. Short-circuit current (*Isc*) and open-circuit voltage (Voc) correction factors are determined from the four reference I-V curves, with the *Voc* correction factors for temperature and irradiance determined by solving a system of nonlinear equations. The interpolation is performed first with respect to *Voc* to account for PV module temperature, and second with respect to *Isc* to account for irradiance. Applicable to all PV technologies, the method can accurately model an *I-V* curve for desired conditions of irradiance and PV module temperature. Modeled and measured *I-V* curves are compared for PV modules and arrays located at the National Renewable Energy Laboratory. Using only four *I-V* curves to characterize performance, the method requires less PV-specific data than other methods.

Computer Simulation of Solar Array Shading and Power Estimates

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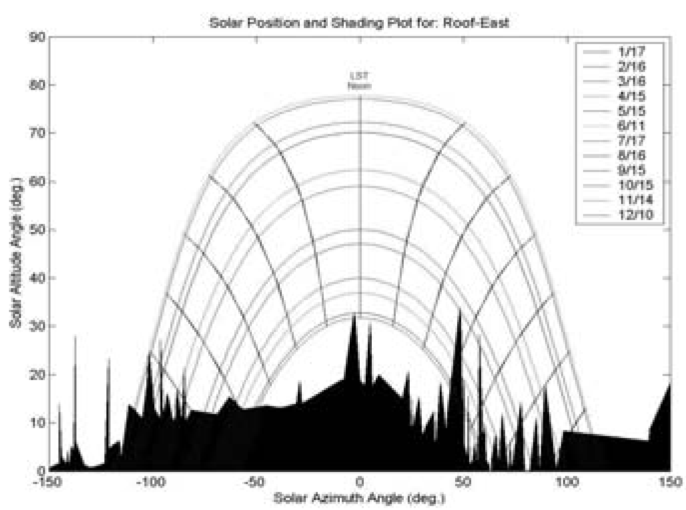
Four factors affects the ability to predict the energy capture of a solar array: shading, incidence angle, sky model, and panel efficiency. A new computer program was developed to determine shading maps and energy capture estimates for a given location of interest. The program predicts energy capture at any location in the northern hemisphere and analyzes the shading effects on any array placement within a surveyed site. The figure below illustrates computer generated monthly solar paths overlaid by the local horizon. Experimental data collected at the Northern Arizona University's Renewable Energy Instructional Laboratory is then used to verify the methodology.



Private-Sector Commercial Customers and Market Drivers to Early Solar Adoptions

Stephen Grover, ECONorthwest
Robert Margolis, NREL

Recent improvements in solar technologies combined with generous financial incentives offered in some states have made solar energy an increasingly attractive option for commercial customers. To date, however, solar adoptions for truly private commercial customers have remained low. While much research has been done on identifying both drivers and barriers to renewable energy adoptions, little has focused specifically on determining the relative importance of each factor in relation to the others. This study was conducted to determine the motivations of commercial solar early adopters and to develop a predictive tool that identifies those states with the greatest market potential using the market factors that are considered most important by commercial solar early adopters.

For this project, 48 commercial customers were interviewed to determine the most important factors driving the decision to install solar equipment. The data are used in a statistical model to estimate the relative importance of each factor. The model results are then combined with state-specific data to develop an interactive tool that estimates the market potential for solar commercial adoptions by state based on state characteristics, policies, and financial incentives. Key drivers include concern for the environment, return on investment, and a desire to demonstrate the technology. This research will be valuable for anyone designing renewable energy programs or policies.

Photovoltaic Applications in Energy Security

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Photovoltaic technologies are generally recognized as enabling technologies, providing electric power for a variety of applications, such as lighting, communications, water pumping and purification, etc. Less well recognized is the increasing role that photovoltaic technologies play in operating and protecting existing energy production and distribution assets, such as oil and gas wells, pipelines, railroads and transmission towers.

In many countries, the energy infrastructure is widely distributed in a physical sense, but very centralized and complex in its operation. Such infrastructures often operate near or at capacity. Most are physically unprotected and their operating status is not monitored. The effect of disruptions caused by natural disasters, human error, poor maintenance or even terrorism can be serious, resulting in large financial losses, environmental damage or even loss of lives. The large power blackout in the northeastern United States in August 2003 was a textbook example of how a single electrical fault can affect an entire region. The blackout affected 50 million people, caused an estimated $US6 billion in economic losses and brought productive activity to a standstill.

A specific example from the State of Alaska points out the potential seriousness of even a minor act of vandalism. The trans-Alaska pipeline winds for 1,300 km, mostly unprotected. It supplies more than one million barrels (3,785,000 liters) each day; nearly a fifth of U.S. domestically produced crude oil. In October 2001, a single individual shot at the pipeline with a high-powered rifle, puncturing it several times. Driven by a line pressure of about 362 kPa, crude oil sprayed more than 22 m. Before the flow of oil could be stopped, more than 6,800 barrels (1,080,996 liters) had soaked the landscape, causing the destruction of about 1 ha of spruce forest. North slope oil production was halted for two days, $US 8 million was lost to the State of Alaska in royalties and taxes, and $US18 million has been spent by the pipeline consortium for environmental cleanup.

Because of their ability to operate independently of a grid, PV systems are rapidly being adopted for a wide variety of operation and protection applications. The paper will present specific case studies, showing how photovoltaic systems are being used to aid in the extraction of fossil fuels, as well as their applications in energy infrastructure protection by detecting and preventing hazardous events, mitigating their effects if they do occur, and participating in restoration of service.

PARQUET FRESNEL LENS INCREASES EFFECTIVENESS OF SOLAR CONCENTRATION BY DELIVERING UNIFORM ILLUMINATION WITH BALANCED SPECTRAL DISTRIBUTION

R.A. MORGAL

HelioTrax, a San Diego based company, has developed a novel parquet Fresnel lens to achieve optimal efficiency for solar concentration onto a photovoltaic cell. Multi-junction photovoltaic cells operate most efficiently when incident light is uniformly distributed across the surface of the cell and when there is a balanced distribution of the spectral components of light. The parquet Fresnel lens design increases the cell's operational efficiency by addressing the mismatch between conventional concentrating lenses and cell illumination requirements. This paper presents the results of a computer simulation study predicting optical performance of the parquet Fresnel lens.

A PMMA parquet Fresnel lens was modeled in AutoCAD and a series of computer simulations were conducted using Light Tools 4.0 to predict optical performance. All optical parameters were modeled across a 300-1800nm spectrum, including the solar radiation distribution, lens absorption, Fresnel lens surface losses and dispersion. A simple low-profile secondary reflector was used to attain uniform cell illumination with balanced spectral distribution.

Simulation results graphically show cell illumination uniformity where 95% of the irradiance received at the cell's surface is between 23.6W/cm^2 and 23.9W/cm^2. The spectral components of the cell's incident light are similarly distributed and are individually discussed. Optical performance of the lens/reflector is presented with a tracking error of 1/10 of a degree in both one and two axes. The optical system's sensitivity to sun shape variation is also be presented. In conclusion, simulation results indicate that a parquet Fresnel lens can deliver uniform and spectrally balanced concentrated sunlight to the surface of a multi-junction cell with the aid of a simple secondary reflector.

Recent Progress and Future Potential for Concentrating Photovoltaic Power Systems

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The cost of PV systems may be reduced by using inexpensive mirrors or lenses to focus the light onto smaller solar cells if systems are produced in very high volume. As the PV industry has gained momentum through sales of solar cells in consumer products, there has been little interest in large systems that require tracking. However, in the past few years, the PV industry has begun to sell larger size systems and some customers are interested in using tracked systems that increase the power production in the late afternoon when air conditioning loads are often high. Thus, the market is reaching the point at which it may be feasible to be able to achieve the production volumes needed to reduce the costs of concentrator systems. Two companies are currently installing concentrating PV systems with sizes of hundreds of kilowatts. Amonix, Inc. of Torrance, California, and Arizona Public Service, of Phoenix, Arizona, are working together and have installed over 400 kW of systems in Arizona. The Amonix technology uses Fresnel lenses focused on silicon concentrator cells. In Australia, Solar Systems, of Hawthorn, Victoria, has installed more than 200 kW in a cost-effective application for their reflective dish systems. Their reflective dish focuses the light on a dense array, populated by silicon concentrator cells manufactured by SunPower, of Sunnyvale, California. While the PV marketplace has been changing, the technology available for use in concentrator systems has also evolved. Most notably, multijunction concentrator cells have now demonstrated an efficiency of 36.9%. The High-Efficiency Photovoltaics Project at the National Renewable Energy Laboratory is supporting work to increase this cell efficiency to 40% and the associated module efficiency to 33%. These higher efficiencies help to reduce the cost per watt of the PV concentrator systems while potentially providing the customer with a higher power density.

Solar Cogeneration (PV + Solar Thermal) with Unique Trough Concentrator

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Abstract

A new solar collector / concentrator based on a unique optical path has been developed which is particularly suited for energy harvesting by photovoltaic (PV) cells and hot water thermal extraction. The synergistic design features are discussed, including receiver light incidence angles, cost effective mounting & sun tracking, light intensity uniformity, avoiding shadows on PV cells, mechanical stiffness and minimizing wind loading which allows mounting the concentrating modules on roof tops. Roof mounting of solar cogen systems are particularly beneficial because the harvested heat must be used near its collection point and many commercial sites have little unused ground space. Concentrating sunlight to 15-20 suns reduces the PV cell area per unit output and makes the system substantially more cost effective than conventional PV on an electricity alone basis. The extra value of the harvested heat can provide another factor of two increase in annual energy value to cost ratio depending on the site's ability to utilize the heat. These features combine to offer a solar energy product that is directly cost competitive with grid electricity and natural gas - even while the product is in low volume production. This paper describes the many design interactions required for a cost effective solar cogeneration system. Specific application evaluations include the effects of direct sunlight flux by region, building thermal and cooling needs (by type and climate), use of adsorption chillers, and regional energy costs and indicate broad applicability of the product. On-going field-testing is briefly discussed, as well as a favorable cost / value comparison to NREL's long-term PV and Concentrating Solar Power cost goals.

Photovoltaics: Disaster and Energy Security Applications

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ABSTRACT

Purpose

In the past, natural disasters, such as hurricanes, floods, tornados, and earthquakes were our major concern. Now, terrorist events are becoming more common and more destructive. Whether, natural or man made, a disaster can happen at any time, often with little or no advance warning. A disaster, can leave many people without adequate medical services, potable water, electrical service and communications for long periods of time. They can be as destructive as Hurricane Mitch leaving several hundred-thousand people homeless or as minor as an afternoon thunderstorm knocking down local power lines to your home. Not only can lives be destroyed, but communities, businesses, and the environment. In our modern society, we have become dependent on electricity as electronic devices are an integral part of our lives.

This report discusses the needs for electrical power and the priority for those needs during disasters and terrorist attacks.

There is a need to understand and apply disaster resistant and fault tolerant architectural concepts in our buildings and communities to reduce losses and improve quality of life. The Photovoltaic industry needs to provide effective systems for response, recovery and mitigation in a disaster and disaster organizations need to properly use viable photovoltaic systems as a reliable source of energy.

Approach

Since Hurricane Hugo, photovoltaics (PV) have been used in many disasters in various ways. As a renewable energy source, PV is environmentally benign, inexhaustible source of electrical energy. Solar powered equipment require no fuel and are less expensive to operate than gas or diesel generators. Photovoltaic (PV) modules are modular allowing various outputs.

Wrec_pf-373-03-abs

What are the appropriate applications for photovoltaics in response to disasters and energy security issues? What criteria do disaster organizations need to know to effectively apply PV? What types of system are available and is there adequate support for deployment.? Previous uses will be evaluated and acceptable performance criteria determined to produce guidelines for use by disaster organizations. Benefits and disadvantages will be evaluated to determine the role of PV in disasters and use for energy security.

Scientific innovation and relevance

There are many PV systems available and many applications needing power. The trick is to apply the right system to the right application to satisfy a need in a disaster. Understanding users needs is important to successful applications of PV by the industry.

Results

A matrix of previous examples will present the advantages and disadvantages of these applications. Examples include vaccine refrigerators, microscopes, lighting, radios, fans, communication devices, traffic devices and other general electrical needs. The longer the period the power is out, the greater the benefit PV is as a sustainable energy source.

There are inappropriate applications that need understanding and education by disaster relief organizations.

Conclusions

Photovoltaics is a viable source of electrical power for certain disasters relief and energy security applications. This has been proven by the many successful examples used over the years. Increased educational and public awareness activities is needed for compete acceptance

Evolution of thin-film photovoltaics

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Abstract:

A brief history of the evolution of thin film PV technologies from the early Cu_2S/CdS solar cells to present day amorphous Si and polycrystalline thin film PV technologies that are on the verge of commercialization to the emerging future generation PV technologies will be discussed. The critical issue associated with future development and large scale manufacturing of these technologies will be identified and contrasted with the recent expansion of crystalline silicon manufacturing capacity.

PV. Stability Analysis of PV-arrays in the Foothill Territory of Uzbekistan

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Results of analysis of real exploitation data on operation of hybrid solar-wind system (HSWS) in conditions of continental climate of foothill zone are given. Level of influence of local meteorological conditions to main technical characteristics of solar batteries (PV-arrays), is analyzed. High energy efficiency of combined transformation of solar and wind radiation energies into electric one is shown.

Keywords: hybrid system, stability, real data.

Demonstration Hybrid Solar-Wind System of 5 kW capacity was developed, constructed and in August 2000 put into experimental operation under grant of European commission. Hybrid system consists of:

- Solar batteries with 6 kW peak capacity;
- Wind turbine – 3 kW;
- Storage battery of 1525 Ah;
- Inventor – 4.5 kVA;
- Measuring-controlling system.

System is allocated in foothill zone not far from Tashkent city on the height of 1148 m above the sea level and made for electricity supply to TV-transmitter. Monthly mean data on solar radiation are given for preliminary calculation of parameters of PV-arrays (Ec).

Taking into account the direction of this section work, in report the real exploitation data on production of electric energy by PV-arrays (Er) real data for 2001-2003 are analyzed.

Analysis of constructed characteristics Ec, Er=f (T) shows that during all 3 years of HSWS operation:

a. Value of Er=f (T) in November–March differs from Et=f (T) not essentially;

b. In April-October Er= f (T) gradually decreases reaching the minimum in summer period;

c. Also gradual decrease of Er=f (T) year by year is observed.

Consequently, temperature increasing reaching in June-August 60^0 on the PV-arrays' surface causes essential lowering the transformation coefficient. The third fact can be explained by changing of meteofactors and probably acceleration of worsening the quality of PV-arrays.

To estimate the level of influence on PV-arrays' productivity the indicator $Ke = \frac{Er}{Ec}$ is used. Analysis of curves Ke = f (T) shows that transformation coefficient of PV-arrays significantly decreases in summer period.

Stated facts show the necessity of development the researches in direction of detalization of influence of both temperature and atmosphere conditions (cloudiness, rain etc.) on decreasing the PV-arrays productivity. Therefore, creation of the variants of PV-modules resistant to temperature changes should be important direction of investigations and developments. Solution of this problem will allow more effective using of PV-systems in all countries with hot climate and long duration of sunny days during a year (Arabic peninsula, Central Asia, Sahara).

Energy Production curves by PV-arrays (Es), Wind Turbine (Ew) and HSWS (E_H) are analyzed and the high efficiency of combined use of Solar and Wind energies by HSWS is shown.

ANALYSIS OF THE CURRENT-VOLTAGE CHARACTERISTICS OF THIN FILM CdS-CdTe SOLAR CELLS FABRICATED BY CMBD

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Analysis of the temperature dependence of the current-voltage characteristics of glass-ITO-n-CdS-p-CdTe-graphite solar cells has been carried out in this report. CdTe films were fabricated by low cost novel chemical molecular beam deposition (CMBD) in the atmosphere pressure Ar flow from separate Cd and Te sources.

Value of the series resistance determined from the direct current- voltage characteristics is $R_S= 1.2 \times 10^5$ Ohm. It is rather high for thin film solar cells. Changing of the forward current with temperature is caused by the temperature dependence of the diffusion potential V_D. The slope of the forward current- voltage characteristics does not depend on temperature. It is shown that the predominant mechanism of the forward current is the multistep tunneling and recombination. The reverse current mechanism is the thermal excitement of carriers in the space charge region at $kT/e < V < 1.0$ V and the tunneling of carriers at $1 < V< 10$ V.

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Sizing of Solar Photovoltaic Powered Cathodic Protection System - Comparison Between an Analytical and a Numerical Method

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Abstract

Sizing a PV system is to determine according to the request such as the irradiation and the profile of load, the set of elements of the photovoltaic chain, as known as, the size of the generator and the capacity of storage.

However the used methodology and the precision with which is taken in account the different components of the chain, one remains confronted to two types of evaluations as known as : the demand or the profile of load and the solar field to which one comes up against a crucial lack of representative data. In a general, the methods of sizing can be classified in two groups : analyticals methods and numericals methods [1-2].

In order to assure the total cathodic protection of a structure during a time t of exploitation (t in year). We did a sizing of the cathodic protection station in the first to estimate the current of the protection (the impressed current), the voltage of this station and its power to define the daily consumption. Then we considered the results obtained and the meteorological data as parameter of entry of the program sizing of the photovoltaic installation applied to the cathodic protection system.

We considered in our work the sizing of solar photovoltaic powered cathodic protection system by two methods of the simplest ones among the two groups. And a comparison of the results obtained by these methods has been done with the help of the criteria of selection witch take in account the optimal sizing.

SOLAR PHOTOVOLTAIC SYSTEMS—INDIAN EXPERIENCES

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Abstract:
The paper has examined the solar photovoltaic systems and the efficacy in the Indian environment. The system can be utilized for a variety of equipments and applications. In the present changing scenario of the Indian power sector there are greater opportunities for the solar photovoltaic system to become a solution for the raging power problems within the country. The paper also profiles some of the successful experiments within India, which have transformed the lives of the consumers and suppliers, providing a roadmap for the future.

PHOTOVOLTAIC ELECTRICITY TO SUSTAIN DEVELOPMENT IN REMOTE AREAS

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ABSTRACT
The effort devoted to sustaining our energy future should consider immediate change in the composition of the energy resource portfolio, the ways of providing energy services (transmission, distribution, and transportation of energy), and the regulation of policies. This emphasizes the need for a reliable, un-depletable, inexpensive, and fast deployment and clean energy sources. In other words, modern energy systems should be designed and constructed to become distributed, more efficient and diversified. Most important of all, they should be less dependent on the extension of a vulnerable transmission grid, or pipeline. The purpose of this paper is to present the results of a feasibility study that was carried out to establish and accelerate the utilization of PV technology as a reliable, economically viable, and environmentally benign source of electrical energy for sustainable development in the South of Egypt. The objective is to use PV electric power for pumping under ground water enough to irrigate 10,000 acres of land in Toshka region. The proposed 100 PV systems of a total peak power of 4.5 MW are adequate for supplying electricity for land reclamation of the 10,000 acre in the project site. The project will contribute to electrification of the isolated farms in the project site and will increase agricultural production. Additional benefits of this project include fuel saving, reduction of CO_2 gas emission, utilization of unused land, and abatement of desertification. In addition, the implementation of the proposed PV systems is considered reasonable and realistic from technical, environmental, economical, and financial viewpoints, while presenting almost no risk in the course of its implementation.

Short Circuit Currents Improvements of In -doped Silicon (n) Structure

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Extended Abstract

In order to improve and extend the sub-band gab response in n-type layer of silicon Indium should be added. In fact indium acts as an electrical dopant responsible of changing the surface layer of n-type wafer to a p-type as well as the optical dopant (IPV effect). In this research theoretical and practical calculations of short circuit currents of Indium silicon (n) structure have been calculated. Theoretically modified Shockely-Read Holl model is used to calculate the recombination rate via an impurity level.H was concluded that either the current generation decreases when the recombination rate is positive or to increase the current generation when the recombination rate is negative. The current generation equation was solved numerically using matlab program. The maximum values of generated current was 5.25 mA at $0.5x10^{17}$ cm^{-3} indium concentration few samples of indium doped silicon (n) structure were prepared using vacuum Thermal evaporation. A thin layer of indium was deposited on the top of an n-type single crystal silicon wafer. In order to form a pn junction the indium must be diffused into the silicon wafer for depth between 0.2-0.4 llm by annealing. Practically it was found from I-V characteristics that this structure has a knee voltage at 0.8 V with very small value of reverse saturation current and 1.6 ideality factor. The maximum photogenerated current of the prepared sample was about 2.3 mA at $0.396x10^{17}cm^{-3}$ of indium concentration. Theoretical & Practical results agree that the maximum photogenerated current occurs at zero cell output voltage.

PIC Based Multilevel Inverter for PV Applications

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Multilevel inverters are suitable for connecting photovoltaic energy sources to AC loads as photovoltaic systems can easily form separated DC sources.
In this paper, a neutral point clamped (NPC) PWM voltage source inverter is studied. In this work, the symmetrical multilevel inverter delivers a three level output waveform by connecting two photovoltaic power sources.
The algorithm used to generate the PWM pulses is described The PWM pulses are obtained by comparing two sinusoidal references with a saw tooth carrier. This strategy reduces the low order harmonic contents.
The used algorithm is simulated and some simulation results are presented The harmonics gather by families centred on multiple frequencies of mf.
The control of the inverter is implemented on a low cost PIC microcontroller , the PIC16F877. The main program is presented and finally some experimental results are given.
The experimental results are similar to the simulation ones.
The proposed system is useful for both standalone and grid connected photovoltaic applications with PWM control of low cost microcontroller based inverters.

Direct and Indirect Benefits of Grid Connected Photovoltaics in Low Energy Social Housing

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The direct benefits of a photovoltaic system to a homeowner or tenant are easy to predict in terms of a reduction in electricity bills. There is an additional indirect benefit of the PV system in that it can change people's attitude towards energy usage and conservation. This paper reports on a study of the direct and indirect benefits of PV applied to nine low energy Eco-homes in Hampshire, UK. The three bedroom houses incorporate a range of energy features including photovoltaics, solar thermal, passive solar design, high insulation construction, energy efficient appliances and grey water recycling. In addition to detailed monitoring of the PV system in each house the environmental parameters and the electricity import and export is also recorded. The diverse range of tenant type (age, social background, family size) has resulted in a broad spectrum of energy requirements despite the relatively small size of the development. The selection of green electricity tariffs by some tenants; which credit the tenant for every unit of electricity generated; were seen to raise energy awareness, resulting in a further reduction in electricity demand. In the case of some of the high energy consumption tenants, the PV system raised energy awareness to such a level that energy savings in excess of that generated by the PV system itself could be realised. In these cases, the financial and energy payback times for the PV systems are, in reality, half the traditionally calculated figure.

STRATEGIES FOR BUILDING-INTEGRATED PHOTOVOLTAIC (BIPV) DEVELOPMENT IN MALAYSIA

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ABSTRACT

Several long-term strategies must be adopted for Malaysia to reduce the cost of building-integrated photovoltaics (BIPV), namely: (a) establishment of BIPV information services, awareness, and capacity-building programs, (b) development of BIPV market enhancement and infrastructure, (c) improvement of policy and financial frameworks supportive for BIPV market sustainability, and (d) establishment of competitive local BIPV manufacturing industries and R&D. The outcome of these strategies will strengthen the industry, consumers, and policy and decision makers. These activities will ensure the increase of BIPV installed capacity by 300% in 2010—and thus, the long-term cost reduction of the technology via the increase in demand, economies of scale, and competitive local manufacturing.

Keywords: BIPV potential, energy yield estimates, strategies for BIPV development

A PV PUMPING STATION FOR DRINKING WATER IN A REMOTE RESIDENTIAL COMPLEX

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ABSTRACT
A photovoltaic application project was designed to pump drinking water from an appropriate well to a residential complex located in a remote area near the Iraqi-Syrian boarder.
The system comprises, solar modules array, voltage controller, inverter and a submersible A ground storage tank of 130 m^3 is also used to store the pumped water that distributed to the complex. The work includes an evolution performance of one year operation of the whole system.

The Contribution of Photovoltaics to Meeting the Millennium Development Goals - the role of the International Energy Agency Photovoltaic Power Systems Programme

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ABSTRACT

With the agreement by the International Community to support the United Nations' Millennium Development Goals (MDGs) [1], the provision of overseas development aid is increasingly targeted at the alleviation of poverty. However, neither access to modern energy services in general, nor provision of electricity, are recognised as specific goals in themselves. It is nevertheless important to realise that providing electricity plays a central role in poverty alleviation, through its impacts on education, health and local enterprise, as well as access to modern telecommunications and information technology resources.

This paper presents the work of the International Energy Agency's (IEA) Implementing Agreement on Photovoltaic Power Systems (PVPS), in relation to developing countries and the MDGs. The IEA PVPS has several 'Tasks' (research projects) each of which focuses on various aspects of PV and its applications [2]. Task 9 has the objective of increasing the overall rate of sustainable deployment of PV systems in developing countries. The Task is unique amongst the activities of the IEA in that it is the only Task that works exclusively on PV applications in countries that are not members of the IEA – i.e., the developing world. The first 5-year phase was completed in May 2004, and an ambitious second phase has now commenced.

FINANCIAL BENEFITS OF UTILISING UNINTERRUPTIBLE POWER SUPPLY FOR POWER CONVERSION OF BUILDING INTEGRATED PHOTOVOLTAIC PROJECTS

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To demonstrate the financial and technical benefits of utilizing Uninterruptible Power Supplies (UPS) for power conversion of Building Integrated Photovoltaics (BIPV) in commercial building projects. Australia's first and largest BIPV project utilizes a UPS power conversion strategy. The William Buck Centre a 21 storey high rise in Brisbane central business district features a 60kW photovoltaic roof and shading devices on level 4, 19 and 21. Construction cost data was collected during 2001 and 2002. Operational performance data of the building has been collected over the past 18 months. The wide spread utilization of solar in buildings is projected to have the potential to generate over 1,000 MW in Australia. However, the use of BIPV is currently not cost effective. Current power costs for BIPV project are in the range 75 to 95 cents. This compares to 10 to 20 cents/kWh for grid supplied electricity. Clearly, the 1,000 MW solar potential will not be exploited until the economics improves. The William Buck building is one of the first buildings in the world to utilize a commercial UPS product for power conversion and distribution. The project has demonstrated that electricity production costs from BIPV project can be reduced by up to 75% with power costs to be equal to or within 20% of the cost of grid connected solar power. The key aspects of the cost reductions relate to the technical design that supports the proposed innovative commercial arrangements.

Quenching of Semiconductor Quantum Dot Photoluminescence by a Conductive Polymer

Donald Selmarten*, Marcus Jones, Garry Rumbles, Pinrong Yu, Jovan Nedeljkovic, Olga Micic, Sean Shaheen

Finding the means for efficient, low cost conversion of solar energy to electricity continues to be of interest to both the scientific community and industry alike. An exciting area of interest relative to this goal involves using inexpensive organic molecules (polymers) to build thin film photovoltaic structures. To improve organic conversion devises, researchers are merging old and new technologies and testing organic-inorganic hybrid devices.

An interesting flavor of 'hybrind' device is the mesoporus, dye-sensitized Titanium Dioxide Solar Cell (DSSC). Gratzel and Regan first made this interesting cell known to the worldThe sensitizing agent absorbs the solar light, generating an excited state electron. That electron would quickly be transferred to the conduction band of the TiO_2. Leaving the hole behind on the dye molecule to oxidize the electrolyte. Charge transport competes with the TiO_2conducton band to electrolyte charge transfer. The hole on the dye molecule is transferred to the electrolyte redox couple, where is can make its way through solution to the platinized counter electrode.

With a cheap cell that is non-toxic and showing efficiencies of close to 9%, one must ask why this cell is not in mass production. This cell employs an organic liquid electrolyte solution. Over long periods of time, the volatile components of the electrolyte evaporate and the cell is left non-functional. An obvious solution to this situation is to employ a non-volatile, solid-state hole-conducting phase in this cell. A specific flavor of solid state hole conductor that we find particularly interesting is hole conductive polymers.

These relatively new materials are attractive for PV efforts for several reasons. First, they solve the problem of dye regeneration without the evaporation issue rearing it's head. Second, because they are procesable they hold the promise of low cost production. Scientifically, these new materials are truly fascinating. They open up the door to a new investigation of the relationship between structure, form and function.

We are specifically interested in a special case of the sensitized solar cell where the sensitizer is a quantum confined semiconductor nanocrystal. A second major difference is that the sensitizing dot will be regenerated by a solid state, conducting, organic layer. The performance of such a device will be dependent on effectiveness of two major charge transfer events. The electron transfer from the conduction band of the dot to the TiO_2, and the hole transfer from the valence band of the dot to the conductive organic.

We show the photoluminescence of InP quantum dots is quenched by the addition of solvated Poly 3 hexylthiophene (P3HT). Time resolved PL results indicate that said quenching is static in nature. This suggests that in solution the quantum dot and the polymer exhibit a strong intermolecular interaction. It is likely that as the species diffuse around, they randomly encounter one another. Once the polymer has encountered the quantum, they irreversibly combine. The results presented here represent the proof of concept that the proposed quantum dot sensitized solid state solar cell may in fact be functional.

Solar Powered TPRs for Toll Highways

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Abstract:

During 2002-2003 solar powered TPRs (Traffic Probe Readers) for toll collection were installed on the Cross Israel Highway. This is the first automatic solar toll collection system that has been installed in the world for automatic man-free billing. The automatic solar toll collection system saves the manual manpower of existing toll collection systems. This paper describes the thorough tests that were conducted during the first two years of the system operation in Israel during the harsh winter months, and proves that this solar TPR system continues to demonstrate excellent reliability since installation.

DEVELOPMENT OF NON-IMAGING FRESNEL LENSES FOR 300X SOLAR CONCENTRATION

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ABSTRACT

The objective of this study is to develop various non-imaging Fresnel lenses of optical concentration ratios of 300X for a solar concentration photovoltaic system with a triple-junction cell. The non-imaging Fresnel lens has an advantage of concentrating solar incidence within a certain acceptance half angle onto the absorber: the optical system is robust against errors of tracking or alignment. The authors designed various lenses with the styles of flat, shallow dome and deep dome and examined their performances by ray tracing. Although the ideal lens consisting of undercut prisms gives the highest optical efficiency, it is difficult to manufacture it by injection molding. Finally it was found that the deep dome lens where center part has no undercut prism yields almost the same high optical efficiency and that there is a possible manufacturing process. Daido Metal company actually produced the lens, which was installed in a solar concentration photovoltaic module for power generation. Modules of this type in 2003 set the world record for photovoltaic module efficiency at 28%.

A DATA ACQUISITION SYSTEM WITH PHOTODIODE SENSORS SUITABLE FOR SOLAR ENERGY MEASUREMENTS

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Abstract

In general, solar radiation flux is measured with a pyranometer. Based on the thermoelectric conversion, this instrument is accurate, but expensive and fragile. It must then be handled with care and often calibrated. Another way to get solar radiation measurements is to use a silicon photodiode. For that, its current-voltage characteristic is calibrated in terms of solar radiation flux. The obtained sensor is robust but corrections have to be made since the I-V characteristic depends also on temperature. In this paper, a solar radiation data acquisition system constructed in our Laboratory is presented. It mainly consists of photodiodes BPX42 of RTC used as solar radiation sensors, a calibrated resistance used as temperature sensor, conditioning amplifiers, a temperature correction circuit, a multiplexer, an analogical – numeric converter, counting circuits and an interface which connects the system to a personal computer. All these circuits are supplied from either small batteries or the electrical mains. The solar measurements collected with this system, are the global, direct and diffuse components of solar radiation for different inclinations of the sensors. Thanks to specific software, the obtained data are corrected and then, archived in the computer every minute. Then, they can be gathered every hour, day, month and year. Preliminary tests show that the solar measurements are obtained with a reasonably good accuracy since the errors of measurement do not exceed 10 %. The solar radiation data acquisition system so described has the advantage of being easily transportable from a site to another. Therefore, it can be used in any place where solar energy conversion system has to be installed in spite of the shortage of solar radiation measurements.

A Three Dimensional Modeling Algorithm to Realize the Significance of Rainfall and Temperature on Global Radiation

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Prof. (Dr.) Shahida Rafique[2]

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Abstract

A single 3-dimensional model has been developed using multiple samples of global radiation, rainfall and temperature data. The magnitude vs. frequency plot provides a visual information of the three variables. The primary data have been sampled at a regular interval of time and a sequence of sampled values obtained. The data values are assumed to be real as they represent the values of time series. FFT algorithm has been used for processing the samples. Data is processed and sub-divided into regions until they have insignificant amount of variation. The sub-regional data are further processed through a function of two-dimensional Fourier transform and a new value for each sample is created. Multiple samples of a region have been combined to plot in a 3-dimesional space. To create a complete 3-D volume from the samples, interpolation is performed. It has been observed that the amount of received radiation varies non-linearly with rainfall and temperature at different location. The variation is found to be consistent with time, which agrees with the calculated values, by statistical analysis. Mathematical approach has been found to be better for accelerating calculations and to determine the inter-relationship between radiation, rainfall and temperature, as it deals with non-zero initial conditions nor step inputs. It has been observed that Fourier frequency components provide a more faithful representation of the data. The individual components are sinusoidal and are not distorted. They constitute a good test for data and can be computed rapidly.

An Approach to Find Out the Relationship between Solar Radiation, Rainfall and Temperature by Statistical Analysis: Bangladesh Region

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Abstract

Relational characteristics of some natural phenomenon like solar radiation, rainfall and temperature have been realized by statistical analysis. The degrees of relationship existing between them have been computed to find out the strength of the dependency. For statistical analysis, solar radiation is considered as dependent variable on rainfall and temperature variation. Regression analysis has been done for estimating the dependent variable solar radiation from the independent variables rainfall and temperature. Due to the fact that radiation varies partially because of rainfall and partially because of temperature variation, the partial regression coefficients have also been computed. A regression plane has represented these, in a 3-D rectangular co-ordinate system. Least square regression planes fitting a set of data, points in a 3-D scattered diagram have been obtained. From these the coefficient of linear multiple correlation is calculated. It has been found that the correlation coefficient between rainfall and solar radiation is about 0.000737 and that between radiation and temperature is about 0.00281 (annually). Coefficient of multiple correlation is found to be 0.00289. Standard error of estimate has also been computed. From this analysis, it is concluded that a non-linear relationship may exist between solar radiation, rainfall and temperature in this Ganges delta region. All the calculations were done with the data recorded in the visible radiation from 9 a.m. to 6 p.m. and the average daily solar insolation (ADSI) has been estimated from the information of the ADSI hours for Bangladesh which about 6KW/h.

The role of maximum daily clearness index for the cumulative frequency distributions models of daily clearness index in tropical climates

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The modelling and understanding of the cumulative distribution function of daily solar radiation are very important in solar engineering, among other reasons, because: a) in locals where only the daily solar, monthly mean radiation is known, the modelling of the accumulated function of probability permits the generation of statistically significant numeric values for use in solar system simulations and b) the utizability (method used in solar engineering for forecasting the long term behavior of solar systems) requires the information from the frequency distribution of daily solar radiation, be it measured or modelled. The non universal character of the diverses models of the cumulative distribution function of daily solar radiation has already demonstrated in works that cover diverse regions of the world. In tropical countries the Saunier model is the most appropriate. As much in the Bendt and Holland models as in the Saunier, the choice of the maximum value for the daily clearness index is made with some arbitrariness and requires a more detailed study. Then, this paper proposes to analyse the daily clearness index of a large number of brazilian localities to obtain correlation data for the maximum daily clearness index to be used with Saunier and Hollands cumulative frequency distribution models and improve them.

Luminous efficacy of solar radiation for the North-East of Brazil

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Natural lighting is recognized as an important strategy for the design of buildings that use energy in an efficient and rational manner. Natural illumination in hot tropical climates is very attractive, because artificial lighting, besides reducing the use of artificial, also reduces the air conditioning load, because after all, all artificial light is dispersed in heat form into the ambient. However, for the evaluation or elaboration of projects that use natural light data for external illumination are necessary. Unfortunately, in Brazil and particularly in the North-East of Brazil, these observations are still rarer than daily global solar radiation data. In this context, two stations were installed, at the beginning of 2003, on the Island of Fernando de Noronha, and another in Recife, Pernambuco, for carrying out simultaneous measuruments of daily solar radiation and daily illumination and thus for determing the luminous efficacy factors. Another two stations are being installed in Pesqueira –PE and Xingó-SE, completing a group of stations that are found between latitudes 8 and 10° S and longitudes 34 to 38° W. It has to be emphasized that these stations are representative of the typical climatologty of the region's: Islands, maritime continental, "Agreste" and semi-arid. The observed data were analysed and empiricals models of luminous efficacy of solar radiation under varied atmospheric conditions have been obtained and presented.

Uncertainty Analysis for Broadband Solar Radiometric Instrumentation Calibrations and Measurements: An Update

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ABSTRACT

With the advent of emphasis on solar renewable energy technologies in the 1970's, and the concern about the Earth's radiation balance related to the possibility of climate change in the 1990's, the measurement of broadband solar radiation has grown in importance. In parallel, standardized methods of uncertainty analysis and reporting have been developed. Here, we present a comparison of historical and recent studies of the uncertainty in solar radiometric instrumentation calibrations and measurements over the past 15 years. Both the historical and present updated analysis are based on the principles of the presently accepted international standardized uncertainty analysis method. Despite the fact that new and sometimes overlooked sources of uncertainty have been recently identified, over period from 1988 to 2004, the actual total uncertainty in broadband solar radiometric instrumentation remains relatively constant at 3% to 5% for pyranometers, and 2% to 3% for pyrheliometers. However, improvements in characterizing correction functions for these radiometers may lead to reduce total uncertainty. We show that using the standardized uncertainty analysis has helped identify new sources of uncertainty. The robust nature of the uncertainty analysis technique has produced consistent results, even though the relative mix of identified uncertainty sources has changed. We analyze the theoretical standardized uncertainty sensitivity coefficients for the instrumentation calibration "measurement equation" and highlight the single parameter (so-called "thermal offset voltages", which contributes substantially to the observed "cosine response") that influences calibration uncertainty the most.

Renewable Energy Data Sets from NASA Satellites and Research

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NASA's Earth Science Enterprise (ESE) Application program supports the development of datasets and methodology for use in government and industry from satellite measurement analysis and atmospheric modeling. The Prediction of Worldwide Energy Resource (POWER) project aims to provide such information for use in Energy sector applications. Under POWER work continues to improve the Surface Meteorological and Solar Energy (SSE) dataset that provides internet-based access to parameters designed for the renewable energy system design needs. The work is accomplished through government and industry partnerships including the US Department of Energy National Renewable Energy Laboratory (NREL) and the Natural Resources Canada (NRCan) of the Canadian government. NASA has delivered data to the Solar Wind Energy Regional Assessment (SWERA) project supported by NREL and NRCan. Here, the current status and accuracy of the SSE dataset are reviewed. SSE Release 4 is being upgraded with higher resolution satellite cloud and surface information. Refinements to solar (tilted surface fluxes) and wind (new higher levels) parameters are described and assessed. Direct links to other design tools are being developed (i.e., NREL's HOMER). Lastly, the vision of POWER towards the development of future long-term datasets including near-term (within 1 week) and forecasted (short, medium, long and climate) products will be presented.

The Eolic Resource In The Electricity Production With Renewable Resources In Rural Areas

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Purpose of the work:
The objective is to determine the technical viability of the use of the eolic resource to offer the electric power service (6700 kWh/año), for 160 inhabitants of Pastos Chicos community (Jujuy-Argentina), having electric power for night reading, communication, computers, refrigerators, microenterprice; with a system of generation hybrid eolic diesel solar.

Approach:
The eolic potential it is determined taking mensurations of wind with a NGR 9200 anemometric station to 10 meter high during one year. With the obtained wind dates, for every month of mensuration is made schedule summary containing the wind frequency distribution, Wind rose, and other data.
They are also obtained historical data of solar radiation of the area (minimum daily irradiation: 21 [MJ/m2].
The hybrid system configuration of electric power generation is calculated with obtained data and then is optimizing with the H.O.M.E.R. Pro., Hybrid Optimization Model for Electric Renewables.

Results:
The final configuration for 17 kWh/day and a mean annual windspeed of 5 m/sec is 1.2 kW of solar array, 3 kW wind turbine, battery bank of 60 Kwh and Genset to 4 kW.

Conclusions:
The eolic resource in Andean Mountain is profitable for electricity generation using hybrid systems, with annual half speed of 5 m/seg, and annual mean power density of 192 W/m^2 to 10 meters high.

Training of Solar Technicians in Developing Countries: Lessons Learned

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The World Bank estimates that there are 2 billion people in 400 million houses, which do not have access to grid electricity. During the last 25 years there have been many government or donor funded "demonstration" systems installed to show how solar power can meet the needs of the people in rural areas who are not connected to the grid.

Are these systems being maintained? Who is installing these systems? How are these technicians who install and maintained going to be trained?

Training within developed countries is very structured with schools, technical colleges and Universities and this is often similar in many developing countries. With the exception of a few countries renewable energy training for technicians is not "mainstream" in many developed countries, with most training being provided by industry or private training institutions. If its not mainstream in developed countries how should training of technicians be undertaken developing countries and service this large need for renewable energy.

In recent years GSES have been involved in technician training in Sri Lanka and Ghana and in April 2003 in refugee camps in West Sahara. This included conducting a "Train the Trainers" course in Sri Lanka in February 2000, this did not at first achieved it's aims. After further training of one Industry trainer, this has led to over 400 technicians being trained.

GSES undertook a training course in Ghana in 2003 and is now looking at how to build capacity within that country.

This paper looks at the lessons learned by GSES in developing technician training courses within Sri Lanka and Ghana. It will include summaries of other trainers experiences in China, India and Thailand and provides suggestions on how technician training can be implemented within a developing country.

PROSPECT OF RENEWABLE ENERGY-POWERED MEMBRANE TECHNOLOGIES FOR WATER PURIFICATION IN BANGLADESH

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Renewable energy can potentially play a crucial role in powering water purifiers in Bangladesh where arsenic exists in the shallow tube wells of 92% of the districts and where 90% of the rural people do not have access to electricity. The chemical treatment process being widely used in the country to obtain arsenic free water has a great number of techno-economic limitations such as cost, import dependency and availability of chemicals, operation and maintenance of technologies, replacement costs of filters, slow discharge and microbial contaminations. The present paper examines the application of physical process using appropriate renewable energy powered membrane technologies in the socio-techno-economic and environmental aspects to overcome most of these limitations to purify both bacteria-contaminated surface water and arsenic-contaminated ground water in a non-electrified Bangladesh village. Dissemination rate of this capital intensive water purification technology would be faster if it can be a means of water business run by the rural community. Finally, a market model of this technology is developed that allows rural poor to generate additional income from potable water business and also to meet their own safe water need.

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Present Status and Future Opportunities of Co-generation and Decentralized Energy Options in Bangladesh

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Abstract

Energy is a critical input for economic development and the development experience all over the world is associated with a massive increase in energy requirement. During the last 32 years since independence, there has been an expansion in the total energy use in the country with a shift from non-commercial to commercial sources. The use of commercial energy has increased substantially over this period. Nevertheless, per capita energy use in Bangladesh remains very low and growth in future requires a large increase in commercial energy. This calls for optimization of capacity to expand domestic production of commercial energy and the ability to do so will be a crucial constraint upon future growth. Even with the best efforts in this area Bangladesh may remain energy deficient and import of energy in the form of crude oil and petroleum products will continue.

A large potential of non-conventional sources exists in the country. These include bio-mass bio-gas, solar PV, solar thermal, wind power, co-generation and on site power and heat production and its utilization. These sources, besides being low carbon-dioxide emitters, also are generally distributed in the country thus having no needs for transmission and distribution. In view of the issues linked to climate change, these distributed energy sources seem to be a better alternative for sustainable development of the country for which energy is the most important input. These decentralized sources can play a significant role in the development of the country and in addressing Climate Change issues as well.

This paper presents the status of energy co-generation and decentralized energy options and opportunities in Bangladesh.

RENEWABLE ENERGY FOR SUSTAINABLE DEVELOPMENT: BANGLADESH PERSPECTIVES

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Abstract
It is now well accepted that energy is a very important ingredient for all aspects of development of a country.

Overuse of fossil fuels like gas, oil and coal has made the development and ecosystem unsustainable and threating the very reserve of these resources.

This paper will discuss this important subject matter, as sustainable development in both urban and rural environment using renewable energy sources in Bangladesh. In Bangladesh 80% of people leave in rural areas, where mainly biomass meets their energy needs, whereas oil, gas and electricity meet mostly the energy need of urban settlement.

The issue of meeting some of the energy needs by renewable energy, use of appropriate Renewable Energy Technologies (RET), compatible to sustainable development initiatives and proper institutional framework in relation to Bangladesh will also be discussed.

Solid State Lighting for Developing Countries
A cost effective solution, facilitator of gender equity and encourager of peace.

Light Up The World Foundation, University of Calgary
Calgary, Alberta, Canada. December 5th, 2003.

Abstract: Approximately 2 billion people, one third of humanity, lack electricity. The vast majority live in rural areas in developing countries, and may never be connected to the power grid. In most of the cases people rely on fuel-based lighting, which is inefficient, harmful, expensive, and offers poor levels of illumination. The lack of light makes it difficult to perform evening activities and sets a barrier to human development.

This paper presents the current work which "Light Up The World Foundation" (LUTW) is doing in order to address this problem. Created in 1997 by Dr. Dave Irvine-Halliday, this humanitarian organization has pioneered the use of White Light Emitting Diodes (WLEDs) and renewable energy as an alternative home lighting solution. The information presented is intended to be a useful technical reference for people around the world to build their own very low power and grid-independent home lighting systems.

Results from comprehensive field experience are presented taking three aspects into account; the economic, social and environmental. Economic benefits obtained by the communities and local micro enterprises are shown. Literacy, education and improvement in the quality of life are discussed. Reduction of carbon emissions and forest depletion are also estimated. The probability that the implementation of this initiative, in the long term, leads to gender equity and encourages peace, is also contemplated.

IPSYS – A simulation tool for performance assessment and controller development of integrated power system distributed renewable energy generated and storage

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An essential part of rural development is the supply electrical energy. Particularly, electrical energy is used for household appliances, telecom, clean water as well as many other services to the local community. This requires up to standards power quality and reliability. There is a push for exploitation of local renewable energy resources such as wind and a battery system will often be an option for further reduction of fossil fuel consumption. Such types of systems can be quite complex and there is a need during the feasibility study, design and evaluation phases of projects to be able to assess the performance of such systems.

A key factor in this assessment is the ability to model the power system accurately. This includes accurate modelling of the actual control of the system, voltages and frequency as well as losses. A new simulation tool, IPSYS, has been developed for that purpose. The core of the tool is a multi busbar load flow calculation for explicit modelling of voltage and frequency combined with the possibility of explicit modelling of other services e.g. water production and supply. This is combined with very flexible controller modelling that makes it possible to include the detailed behaviour of e.g. a battery energy storage in the system overall controls.

The IPSYS simulation tool will be presented illustrating its potential for modelling systems with wind, storage and diesel gensets in different grid layouts and with different controllers.

LOCAL SUSTAINABLE ENERGY – POTENTIAL AND BARRIERS FOR RENEWABLE ENERGY PRODUCTION IN FINNISH FARMS

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Renewable energy production in farms contributes to sustainable development in various ways. First, it is a means to replace fossil fuels, second, it is a step towards a more distributed energy system, and third, it contributes to sustaining the viability of rural areas by increasing energy self-sufficiency and offering energy income. In this study, the aim is to find out the potential to increase the utilization of renewable energy from farmers' perspective, and to identify the main barriers currently inhibiting the use and production of renewable energy in Finnish farms.

A survey questionnaire was sent to the farmers in two towns, Saarijärvi and Viitasaari, in central Finland. Questions were asked regarding their energy use patterns, possible energy sources, as well as opinions and interests towards renewable energy. Half of the 380 sent questionnaires were returned. Based on literature, six types of barriers were identified. They were economic, organizational/infrastructural and administrative barriers, lack of local energy and human resources and lack of information. This was used as the reference to which the results were mirrored.

Farms utilized wood fuels considerably: 93% of farmers used wood for space heating in some amount. Utilization of other renewable energy resources was rare. However, the farmers showed considerable interest towards various renewable energy production and were proven to have both human and energy resources. The most significant identified barriers were lack of financial support, especially in the form of investment subsidies, and lack of adequate information.

Economics of Energy Systems: A New Approach to Improve Planning Quality

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A sustainable energy system is based on renewable resources whose time dependancy can mostly be characterized as stochastic, actually quite similar to the energy demand. In order to plan such systems, the supply ought to be adapted to the demand by properly sizing the energy converters as well as the storage devices. Moreover, the control strategy for the energy management should be optimized with the aim to minimize costs. Consequently, a certain amount of controllable power within the system is indispensable. To lower the energy costs, the energy management would try to maximize the harvest of non-controllable renewables, such as radiation and wind, while downsizing the technical devices. Although, at the start of the planning process, most input variables show large uncertainty intervals (as, e.g. energy outputs of PV-generators or wind energy converters, investment costs, loan rates, etc.) that translate into corresponding uncertainties for the outcome parameters, these are totally neglected in the usual deterministic calculations.
In the newly developed method, the economics of arbitrarily configurated energy systems can be simulated while taking the input uncertainties into account. The outcome parameters along with their uncertainty intervals are determined by using the Monte-Carlo-Method with, typically, 50.000 realizations. From these results, the probabilities for the occurence of desirable circumstances (in terms of pay-back time, specific energy costs, etc.) are calculated. Obviously, the quantification of such uncertainties as well as probabilities improves the bais for any decision making.

(Funded by contract no. 1707499 with the German BMBF)

Household Electrification Strategy
Electricity for All

By Inderjit S. Anand and Lt. Gen S.K. Jain

India has been able to extend its Electrical infrastructure far and wide to enable the citizens to have access to electricity for Domestic, Commercial, agricultural, Industrial and other uses. All the Towns are claimed to be Electrified and more than 84% of 587,258 census (1991) inhabited Villages have access to electricity. The household with source of lighting as per 2001 census has indicated the following figures.

Source of Household Lighting as per 2001 census

Category	Total number of households	Electricity	%age	Kerosene	Solar Energy	Other oil	Any other	No lighting
Total	191,963,935	107,209,054	56	83,127,739	522,561	184,424	305,308	614,849
Rural	138,271,559	60,180,685	44	76,896,701	394,425	146,165	227,210	426,373
Urban	53,692,376	47,028,369	88	6,231,038	128,136	38,259	78,098	188,476

The Rural Households have 44% access and the country has to develop strategy for providing Electricity to balance 56% .The Kerosene is the biggest source for Household lighting with 56% share. The role of Solar Lighting and other sources is almost negligible. The country needs to replace Kerosene lighting with conventional or renewable grid quality Electricity to meet the need of home lighting.

The Government of India has launched a drive under" Rural Electricity Supply Technologies" Mission, to boost the development plans of various states to enable them to have appropriate Technologies, financial and management mechanism to electrify all the balance about 100,000 villages besides Hamlets and Scheduled caste Clusters by year 2007 and all households by year 2012 as per declaration of Indian Prime Minister.

The prospects of Grid Extension wherever possible, mini grid where feasible, remote area lighting through Pico/Mini/Micro/Small Hydro, Biomass gasifiers and Solar Photovoltaic systems being deployed on immediate basis are very bright as a number of systems are already in use under pilot projects promoted by Ministry of Non-conventional Energy Sources and State Nodal agencies. The agencies have lessons learned to develop a strategy for each area/region to adopt appropriate technology and management models with funding mechanism

The strategy/ies will be based on basic data of each village, location of each dwelling and load point, digital map of village with electricity distribution network planned and designed to have minimum losses, within limit voltage regulation and theft proof network. The management at local level backed by the manufacturers and utility with specified roles for Metering, billing, collection and attending to faults and providing basic services would be the main anchor for the success of the programme.

Low cost solar energy bed for control of pulse beetle *Callosobruchus maculatus* (F.) for safe storage of green gram, *Vigna radiata* (L.) Wilczek: Renewable Energy for rural and urban households needs

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A low cost solar bed developed was tested for utilization of solar energy for control of pulse beetle, *C. maculatus* which infests stored green gram pulse, *Vigna radiata* (L.*)* Wilczek. Infested green gram is rendered unfit for human consumption. 12 green gram samples, each weighing 1 Kg. were prepared for 4 treatments, each treatment replicated thrice including control. Solar bed was prepared by placing a black polyethylene sheet on wheat husk mattress on bare ground. First exposure of all 10 % infested samples except control was given on solar bed for 5, 10 and 15 minutes on three solar beds before storage followed by second and third exposure after 60 and 120 days of storage, respectively. Results indicated that subsequent control in 10% green gram infestation level due to pulse beetle after exposure on solar bed for 5 minutes (from 10% to 15 %, 20.32% and 21.85%), 10minutes (from10% to 12.7%, 16.1% and 18.3%) and 15 minutes (from 10% to 11.06%, 11.4% and 10.9%) were better than control i.e. 25.3%, 54.5% and 72.0% at 60, 120 and 180 days after storage, respectively. At 60 days of storage for 15 minutes exposure, increase from 10% to 11.06% though at par with 12.7% in green gram infestation level for 10 minutes exposure but it differed significantly from rest of treatments. At 180 days, 15 minutes' three exposures proved better as increase in 10% infestation level was much less i.e. 10.9% as compared to 21.85 and 18.3% in 5 and 10 minutes exposures, respectively. Therefore, cost effective renewable solar energy bed for rural and urban households needs may be effectively used as alternative method of chemical control for safe storage of pulse green gram at small scale level for prosperity.

RENEWABLE ENERGY DEVELOPMENT IN INDONESIA

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ABSTRACT

Renewable energy development is part of the over all endeavor to achieve sustainable national development target and therefore, Indonesia should continue to conduct monitoring and evaluation on how renewable energy technology could fit into the Long Range National Development strategy and goals. As our fossil fuel is rapidly depleting, renewable energy resources may gradually substitute some of the role of fossil fuel wherever possible and become important part of optimum energy mix in the regional as well as national energy supply. Indonesia possesses about 236000 MWe of renewable energy potential which can be tapped from geothermal, biomass, small hydro, solar, wind and ocean energy sources. Our past experiences in introducing renewable energy technology to the country could become valuable lessen learned to improve our future strategy in R/D, as well as in adoption the technology into practical applications. R/D results can be applied either in the form of Pilot project, technology dissemination and commercialization to provide sustainable supply of primary energy in the country to support the ever growing economic growth. Stronger government commitment shown in recent years may provide conducive environments for investors and active players of renewable energy technology to take part in the form of concrete actions to realize the benefit of renewable energy sources as means for sustainable development of this country. While waiting for the government to ratify the Kyoto Protocol several CDM project developers of renewable energy technology are already preparing the necessary documents to actively participate in the project scheme.

Key words: renewable energy potential, CDM, energy mix, regional development, fossil fuel substitution, CO2 emission.

A Report on Renewable Energy Application to Rural Electrification on Self-help Basis in Myanmar

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A master plan study, sponsored by Japan International Cooperation Agency (JICA), was executed from Jan. 2001 to Sept. 2003 to support and accelerate rural electrification (RE) by renewable energy in Myanmar. The level of RE in Myanmar has remained as low as 17.7% while urban residents have been suffering from severe load shedding. A responsible authority and villagers in Myanmar have steadily implemented many small RE schemes. Noticeable among these was RE by villagers themselves on self-help basis with supports from local experts of micro-hydro and biomass gasification system.

Two unique and encouraging features of RE in Myanmar are: i) high willingness and efforts of villagers and engineers for RE and ii) local technologies in micro-hydro and biomass gasification power applicable to electrify villages at an affordable cost level.

In this report, we will introduce three features of RE on self-help basis in Myanmar. The first is RE schemes with local technology using abundant potential. The second is RE with micro hydro by community participation for funding, construction works, and operation to minimize the cash investment. The third is a small scale RE by original biomass gasification power. These local technologies and villagers' participation have facilitated a low cost RE and could be examples for RE in other developing countries. It is followed by recommendations for financial and institutional supports such as RE fund and an assurance system of construction completion to encourage villagers in decision making.

Key Words: Rural Electrification (RE), *Village Scheme,* micro hydro, biomass gasification, self-help bases

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The economic effects of renewable energy system in a rural area

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The main objective of this paper is to assess the economic effects of renewable energy system in a rural area. The renewable energy system consists of photovoltaic, wind, biomass and geothermal heat pump, and the optimal capacities of renewable energy facilities are designed based on local climate condition. We assumed that the saved personal expenditure for purchasing grid electricity in the rural area will be transferred to the additional consumption. The effects are analyzed with input-output techniques, and as a consequence, both positive and negative effects by the economic sector on the rural economy are derived.

Because of the changes in expenditures, total economic and employment effects increase by 43.2 % and 121.3 %, respectively, which are mainly derived by the additional consumption. Main positive economic effects appear at “construction and installation” and “real estate” sectors. On the contrast, outstanding negative economic effect appear at “gas and electric power” sector. Since employment coefficients are different by sectors, the tendency of employment effect is different from that of economic effect. Main positive employment effects appear at “construction and installation” and “personal services” sectors. Negative employment effects appear at “gas and electric power” and “trade”. Since the self-sufficiency rate of “gas and electric” sector is 54.5 %, large negative economic effect affect peripheral area. The value and coverage of the effects is now under calculation.

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Development of Triple Hybrid Renewable Energy Generation System

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Abstract: In these years, because of its low impact to environment, various renewable energy generation systems have researched. However, the spread of these systems has been prevented because the input power of renewable energy is instable. In order to stabilize the input power, the research group of A.I.T. is planning a development of the triple hybrid renewable energy generation system, consisting of a wind, solar and biomass generation system.
The authors made a trial calculation of its energy production to establish the best conditions for the system. As a result, it is clear that a system consisting of 40kW of wind, 20kW of solar and 20kW of biomass generation is appropriate.
Based on the result, the system is being constructed and expected to be completed by April, 2004. The authors are also planning to report the experimental data.

A Study on Multi Hybrid Generation System in Bolivia

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Purpose of the work:
This paper is intended as an investigation of the most feasible configuration of hybrid generation system by renewables in Chachacomani village, Bolivia.

Approach:
Detailed study on wind, solar and hydro energy potentials are carried out in the village. Energy balance calculations for different configuration of hybrid generation systems are conducted.

Scientific innovation and relevance:
Accurate energy potential of wind, solar and micro-hydro are observed at 4220 meters above sea level where Chachacomani is located.

Results:
The result of monitoring shows, there are complementary relations among three energy sources. Estimated power output from Micro-hydro generation system is the most stable in indigenous renewables.

Conclusion:
These results lead to the conclusion that Wind, PV and Micro-Hydro hybrid generation system is feasible at Chachacomani village.

Removal of Barriers to the Use of Renewable Energy Sources for Rural Electrification in Chile

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Rural economic development is a national priority in many developing countries. However, rural areas frequently lack the electricity supply that is needed for numerous economic activities. At the same time, the remoteness and isolation of rural communities make them unlikely to be reached by the grid. Therefore, off-grid generation systems are required.

The traditional solution to this problem has been the use of internal combustion engines, but renewable energy systems (RES) have recently emerged as a clean and easy-to-maintain alternative. This paper is aimed at identifying the barriers to the use of RES for rural electrification in Chile and making some policy recommendations to remove them. To achieve these goals, three different studies have been carried out: (i) a comparison of the Chilean program for rural electrification with other rural electrification programs in Latin America; (ii) a series of interviews with different agents involved in the rural electrification process; and (iii) the analysis of several RES projects in different regions of Chile.

Some barriers identified are the lack of knowledge about RES, the absence of a certification system for renewable energy equipment, the lack of arrangements for the long-term operation and maintenance of RES, and the lack of financial instruments for renewable energy microentrepreneurs. Some recommendations are to implement training programs for technicians on RES, to create a guarantee fund to support credit lines for renewables, to promote the certification of renewable energy equipment, and to develop a method for the definition of operation and maintenance responsibilities.

Development of a web based smart design tool to assist in the development of remote area power systems using renewable technology

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For many years renewable based power systems have been designed, built and installed based on expert opinion and the use of power system modeling tools such as the NREL developed tools of Hybrid2 and HOMER. However, even based on the information that these tools provide, little information is available about which type of specific components, such as batteries, should be used to maximize system life cycle cost, based on the environmental conditions at the site and the components operational experience. As an easy example, it is commonly recognized that standard car batteries should not be used in deep discharge applications. What might not be so commonly known is the impact that cold temperatures may have on a battery, and specifically on the performance of a specific type of battery.

Until this time designers of power systems have had to rely on their own experience to select the most appropriate component technology for their application. Through the work of the EU Benchmarking group, this process will change with the development of a Smart Design Assistant that will, based on the output of real data from a power system or the results of simulation models, provide guidance to the system developer on what specific component characteristics they should be looking for. This iterative approach will allow system designers to develop and then install the most appropriate system components for a specific power system design, thus increasing the operational life and performance of each component.

This paper introduces the concept behind the Smart Design Assistant and looks at the initial phase of its development into a publicly available web based tool to assist in the implementation of remote area power systems.

This work is part of the European Union (ENK6-CT-2001-80576), United States and Australian funded Benchmarking research project which incorporates the combined experience of 12 internationally recognised research and development laboratories worldwide. The Benchmarking program focuses on the analysis and interpretation of data and experience in the operation of remote power systems incorporating renewable technologies. Through this program the partner institutions hope to provide useful tools to improve the design capabilities of organizations, private and public, in remote power systems. This work also hopes to engage the manufacturers of components widely used in remote area power systems, to specify these components in terms that are relevant to the hybrid systems industry.

Potential of Renewable Energy Utilization for Irrigation Water Pumping in India

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Abstract: An attempt to estimate the potential of (i) SPV pumps, (ii) windmill pumps (iii) producer gas based dual fuel engine pumps, and (iv) biogas based dual fuel engine pumps for irrigation water pumping in India has been made. Using key input factors such as solar radiation intensity, wind speed, availability of bovine dung and agri-residue and their alternative uses, availability of surface water for irrigation, ground water table, affordability and propensity of the users to invest in renewable energy devices etc. the potential of above-mentioned renewable energy technologies has been estimated. Affordability of farmer has been estimated from disposable income of farmer, the annual amount to be paid by farmer for repayment of a loan taken for purchasing a renewable energy device and the cost incurred in repair and maintenance of the system. Possible effects of financial and fiscal incentives provided by the government for promotion of renewable energy technologies on the potential number of users have also been analysed. Among the four renewable energy technologies considered in this study for irrigation water pumping in India, potential of SPV pumps is found to be the maximum followed by that of windmill pumps.

Renewable energy and rural electrification in PNG

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Abstract

Rural electrification and sustainable energy has had very little impact in Papua New Guinea (PNG) over the last few decades. The bulk of its population (85%) lives in isolated and dispersed villages in the rural areas that are still yet to be connected to an electricity supply.

This paper looks at the national Government's and other stakeholders efforts towards rural electrification in the past few decades up to the present time. The paper looks specifically at the effort to introduce renewable energy sources like micro hydro systems and solar PV.

Case studies of three micro hydro systems were conducted to identify and expose the barriers that have tended to deny the rural population access to affordable electricity supply. In addition the associated problems in the commercialization and provision of infrastructure to support renewable energy systems are examined.

ON SOLAR POWERED BATTERY CHARGING OPTION

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ABSTRACT

A recent survey on the economic viability or otherwise of solar powered battery charging was carried out in the Lagos metropolis of Nigeria. A total of one hundred battery chargers using power from the national grid were sampled using questionnaires and personal discussion. Some of the information sought included: educational background, nature of ownership, source of power cost and source of distilled water, income generated, problems with job etc.

The result of the survey showed that about 90% had one form of formal education or the other, 77% depend solely on national grid for power while 23% on national grid and generators.

Also the operators spend 10% of their income on purchase of distilled water. Almost all the respondents welcomed the idea of having an alternative power supply since the national grid is erratic and unreliable hence loss of revenue.

The economic analysis showed that the difference between solar powered charger and conventional charger in terms of initial investment is about 35%.Also solar powered have a shorter payback period than the conventional one.

This paper will therefore address the survey findings, analysis and the setting up of a solar powered battery charging centre that will be all embracing (that incorporates solar still for distilled water production etc).

Solar Community Water Heating System: A Novel Concept at 12,000 Feet Elevation

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ABSTRACT

A site specific solar energy heated system suitable to meet heated water requirements of residents of the area was designed and installed after collecting basic solar energy availability data at an altitude of 12,000 feet. The purpose of this study was to provide alternate source of energy in areas that are consuming wood/ kerosene oil to heat water for bathing and washing. This effort also helped in reducing pollution and extensive forest degradation and helped to demonstrate the efficacy of solar energy to the local residents. Even if the water was heated the accommodation was so cold that most of the people would shy away from taking shower. Therefore an innovative solar shower room was also designed along with the water heating system.

The design worked wonderfully at the first instance and temperature of water rose to almost boiling temperature i.e. 94°C. The solar shower was designed for two persons at a time that could have hot running water to take shower in heated accommodation. The system has been operational since 2 years and every day 40 – 60 persons utilize the facility to take shower and even wash their clothes. The performance of the system was so perfect that it was immediately replicated by the residents of close by village. It was found that Solar energy can be effectively used to heat designed quantity of water at such an elevation for most of the time in the year. The system stopped only during the period in which the inlet froze due to extreme weather conditions. This was the only system of its kind reportedly operational at this altitude.

Revolving Fund for the Promotion of Micro Hydroelectric Power Plants in Isolated Rural Areas in Peru

Teodoro Sanchez-Campos

ABSTRACT

This paper contains an overview of the technical, financial and social issues, both before and after implementation, and the impact so far, of a credit scheme for dissemination of renewable energies "The Micro Hydroelectric Power Plant Promotion Fund", which was initiated by agreement between the Inter-American Development Bank (IDB) and the Peruvian branch of the international NGO, ITDG. It is an example of a successful model for financing rural electrification through local government, the private sector and communities, while providing technical assistance with planning, implementation, training and organization for sustainable management. The program started in 1994 and has provided loan finance for the implementation of 26 rural electrification schemes all of them installed in remote rural areas providing access to small villages and rural entrepreneurs, benefiting directly to more than 25,000 rural inhabitants with access to electricity. The total amount lent is about US$ 1 Million and the leveraged money about US$ 4 Million. The model has developed over time and has demonstrated that loan finance to communities and the private sector can leverage local capital and government funds for locally owned and sustainable decentralised rural electrification. This is a replicable model for decentralised electrification based on renewable energy.

Integrated Social Forestry: A Partnership Tool Between PNOC-EDC and Host Communities for Rural Development

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The formidable challenge of reconciling the conflicting interests of forest dwellers and the development of geothermal energy resources has led the state-owned Philippine National Oil Company – Energy Development Corporation (PNOC-EDC) to adopt the integrated social forestry (ISF) scheme. The scheme, which was piloted in 1989 in four upland communities, aims to improve the socioeconomic conditions of people living within and dependent upon PNOC-EDC-managed geothermal reservation lands for their livelihood. The scheme taps upland dwellers as forest management partners and encourages them to work collectively to improve their economic welfare on a self-reliant basis.

Forest dwellers are organized into farmers associations, hired to reforest denuded watershed areas for livelihood to build up their capital, taught to mobilize their resources, and linked up with relevant institutions for support. These efforts are paralleled by regular training programs on social development, financial management, and technical skills development. With self-reliant livelihoods, geothermal watershed areas were preserved as forest associations no longer encroach forest areas but instead assist the company in maintaining 90,000 hectares of residual forests and in planting 8,270 hectares more of agroforests as of 2003.

From four pilot ISF projects, the company has replicated the program in seventy-nine farmers associations in five watershed areas, benefiting more than 20,000 households. The program has brought significant changes in its farmer beneficiaries as mirrored in their enhanced economic status and positive attitude towards themselves, the community and the environment. PNOC-EDC's ISF experience proves that geothermal development projects can be an impetus in bringing about rural revitalization.

Technology for Sustainable Rural Development

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Purpose: Energy is needed for many activities essential to human development. "On-grid" communities have access to modern, low cost technology for lighting, refrigeration, cooking etc. "Off-grid" communities use alternatives which are often inferior, more expensive and "dirty." This paper documents the appropriate solutions we have developed to satisfy the needs of "off-grid" rural communities.

Approach: The most urgent energy needs in remote rural regions are for Cooking, Refrigeration, Water Provision and Lighting. We have developed high quality, yet low cost, sustainable, alternate off-grid solutions which are being implemented and tested in several selected target areas.

Scientific Innovation and Relevance: The lack of grid electricity in the remote regions seriously limits access to modern technology, thus hindering development in these regions. Remote rural communities are forced to rely heavily on unsustainable non-grid based technology, which is often expensive, inappropriate and "unfriendly" both to the user and the environment. This new range of products uses the latest modern technological advances in order to create user friendly "off-grid" *equivalents* to the standard range of "on-grid." products so the "off grid" user is *effectively* "on-grid."

Results: We have developed a range of products to ensure that rural communities are not disadvantaged, in cost or quality of product, by living "off-grid."

Conclusions: We believe that the introduction of this new range of products will go a long way towards closing the Urban / Rural Development Gap.

The Complementary Operations and Diverse Applications of Hybrid System (Small-scale Wind Power and PV) Used in Land Aquafarms in Taiwan

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ABSTRACT

Renewable energy has its own application potential and limitations, according to the in-situ natural resource. If an appropriate renewable energy source was selected and operated complementarily, the overall performance and potential supply time is anticipated to be higher than those operated individually. For example, electricity generation by solar and wind power are limited by the local sunshine and wind quality. In coastal areas, they could operate complementarily to create an effective electricity supply quality and obtain the most from our natural resources.

This study established a hybrid system, consisting of 0.5kw PV, 1.4kw small-scale wind power, batteries, and AC/DC DC/AC inverters. A 1kw simple desalinator was selected to be powered by this complementary system. Nodal electrics data and system performance were measured. HOMER, developed at the National Renewable Energy Laboratory, USA, was used to illustrate and evaluate the technical aspects in planning the diverse applications (desalination, lighting, pumping, and heating) in a conventional land aquafarm in Taiwan.

Keywords: renewable energy, solar, wind, aquafarm, HOMER

RURAL HOUSEHOLD ENERGY SUPPLY PROBLEMS IN DEVELOPING COUNTRIES; THE CASE OF SHINYANGA REGION IN CENTRAL TANZANIA

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Developing countries contain 80 percent of the world's population but consume only 30 percent of global commercial energy. As energy is important for improving living standards and for poverty alleviation, rural access to energy is therefore a pre-requisite.

This paper presents findings of a household energy study, which was carried out in sub Saharan Africa. The study involved three selected districts of rural Shinyanga region in Central Tanzania. Shinyanga region is characterized by a semi arid type of climate, which is worsened by human activities. The study aimed at assessing the current technologies used by the people in solving the existing problems of household energy supply. Specific objectives of the study were to establish the types, availability and cost of household energy; to establish the dominant household stoves in use; to understand the adoption rate of improved stoves; and to quantity household energy used per household per day.

A questionnaire was designed and administered in the study area. Further data collection was achieved through individual interviews, meetings, intensive discussions and observations. Semi structured interviews were conducted with key informants from different government departments, NGOs and Companies. Findings of the study showed typical rural household energy supply problems in the developing world and the associated drudgery and the vulnerable group. Furthermore, recommendations for improving rural access to energy have been given out.

The Potential Use of Solar Detoxification for Wastewater Treatment in Tropical Countries

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Abstract: Contaminated water is responsible for the death of millions of children in developing countries each year. Indiscriminate dumping of un-treated and under-treated industrial and domestic wastewater continues pollute potable water and destroy the environment. Current wastewater management techniques concentrate on waste conversion rather than waste destruction. Technology involving the photo-catalytic process using solar energy destroys hazardous waste. This paper presents the results of tests conducted on a reaction bed prototype using TiO_2 as a catalyst with simulated wastewater containing dichloroacetic acid (DCA). Water samples with 1 mmol/l, 2 mmol/l, 3 mmol/l, 4 mmol/l and 5 mmol/l concentration of DCA were used. Results show complete dissociation of DCA to produce chlorides within 1 hour of exposure and the photonic efficiency of the reaction varied linearly with the initial concentration of DCA.

Keywords: wastewater, photo-catalyst, titanium dioxide

An Economic Evaluation of Small-scale Wind-diesel Hybrid Systems in Kachchh, India

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Numerous renewable and small-scale distributed generation (DG) technologies have now progressed to the stage where their technical feasibility has been proven and full-scale projects have been successfully implemented worldwide. This paper surveys the available DG technologies and using the HOMER model from NREL evaluates their economic performance in rural India with particular emphasis on comparing the costs of hybrid DG systems with conventional grid connections for remote rural village-level applications. Modelling inputs are based on demand, fuel availability, costs and local operating conditions found in the Kachchh District of Gujarat, India. Results demonstrate that hybrid power systems can economically provide electricity in rural areas if local energy resources are adequate (e.g. wind, solar, biomass). Additional environmental and economic benefits of hybrid DG are also quantified for the case study area and reveal a 40% reduction in diesel fuel use compared to diesel genset only systems.

Renewable Energy Systems for Rural Health Clinics in Algeria: Homer Application

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The solar potential of Algeria ranks among the highest in the world. The annual sunshine duration reaches 2000hrs all over the territory and 3900hrs in the Sahara. The received energy is 1.7kWh/m^2/year in the north, 1.9kWh/m^2/year in high plains and 2.650kWh/m^2/year in the Sahara. The wind is characterized by a moderated speed (2 to 6 m/s) ideal for water pumping especially in high plains.

The southern Algerian population is concentrated in small villages where electricity is supplied by isolated networks that are fed by diesel plants. These plants are very expensive due to maintenance costs and fuel supply transported by trucks on desert roads exceeding 1000 km.

The study concerns the optimization and the cost analysis of RE hybrid systems for electricity production using HOMER. These systems have to supply rural health clinics situated in coastal, high plains and desert regions of Algeria, represented by Algiers, Ghardaia and Djanet.

Regarding the cost of fuel in different regions of Algeria, optimized RE systems found for Algiers and Ghardaia are composed of PV, Wind generators. Battery systems, while for Djanet it is a PV, Battery system.

The implementation of RE hybrid systems to supply Rural Health Clinics will contribute to reduce both electricity production cost and CO_2 emissions while improving health care and quality of life in isolated regions.

Financial Feasibility and Commercial Viability of Rural Sector Renewable Energy Service Companies in Fiji

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The viability and sustainability of Renewable Energy Service Companies (RESCOs) for Pacific island nations will be discussed. Practical experience was acquired in Fiji implementing fee-for-service solar home systems (SHSs) in remote villages as well as a hybrid PV/Wind power system for a provincial center.

In Fiji, presently, the only practical way of providing renewable energy based rural electrification for remote locations is with SHSs. Several issues must be resolved before RESCOs are commercially viable. By commercial viability it is meant that a service is provided for a fee that covers all life-cycle costs associated with providing that service and that the fee is collectable.

To estimate costs associated with SHSs operations one must have reliable information about replacement intervals for consumables (e.g., lights and batteries) and associated costs as well as the labor requirements for maintenance. Actual field experience operating 250 SHSs in Fiji is used to establish labor requirements and costs.

Financing of SHSs in Fiji appears feasible at least under two scenarios: (1) concessionary loan from the Government of Japan with tariff covering all costs; and (2) Fiji Government 90% capital subsidy with balance through commercial loan and recurring cost covered by tariff. The second scenario unfortunately only allows for about 300 installations per year while there are about 12,000 potential users identified through a recent socioeconomic survey.

Wind/PV/Diesel Hybrid Village Power Systems in Hawaii and Fiji: Long-Term Operational Records

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Since 1996 PICHTR has designed, installed and operated two wind/PV/diesel hybrid power systems. The 360-kWh/day Hawaii system was installed by June 1996. The 720-kWh/day Fiji system was installed by December 1997. Maintenance, repair and replacement records will be presented along with resulting estimates of the cost-of-electricity production, spare parts and labor requirements for these hybrid systems.

At first, incremental increases in simplicity, redundancy, capacity and operational history increased the reliability of the Fiji hybrid power system over the Hawaii system. Both are connected to existing mini-grids that were served by fossil-fueled generation. Both grids have seen an increase in power quality.

The Hawaii system renewable energy contribution, estimated at about 80%, meets design. In 1998, with PICHTR trained national engineers operating the Fiji system, renewable energy accounted for about 60% of production (e.g., the design value). Unfortunately, there was major political turmoil in Fiji resulting in budget and personnel reductions such that by 2001 the renewable contribution was down to 15%.

Siting of wind turbine generators (WTGs) in the mountainous terrain found in Pacific Islands presents a challenge. The eight units selected for Fiji provide plenty of redundancy but they were difficult to fit into the site. Three or at most four larger turbines would have been better but are not presently commercially available.

Performance Analysis of a PV – Wind – Diesel Hybrid System of a Countryside Community in the Amazon Region

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This work presents a performance analysis of a hybrid system for electricity generation installed in a small community in the Amazon Region, State of Pará, Brazil. The generation system is composed of a 3.2 kW_P PV array, a 10 kW wind turbine and a 20 kVA diesel generator, the latter acting as a backup system. Since the system started its operation, in early september, all the variables of interest have been monitored by a remote system and are real-time collected by a computer installed in the community. These variables are transferred by a mobile phone system to the internet, to be remotely collected by the researchers. Another innovation of the system is the application of a prepaid tariffing mechanism which, besides aiding the system's management, provides also important variables for the analysis here proposed, like load comsumption and demand. The main variables collected are the voltage and current provided by the generation and demand sides. These data are treated together with the data provided by the meteorological station to give a complete performance analysis including wind and solar profiles, system autonomy and a future preview of the system needs. The latter is the main conclusion of the present study, once it showed that the generation system will not be able to supply the expected increase in the load during the periods of low windspeeds and medium solar radiation levels (from december to may). This study led to the development of a second phase of the project that foresees increases in the generation system to supply the referred needs.

Designing High Reliability Power Systems For PEMEX Using HOMER

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This paper details use of the HOMER hybrid design program applied to a power generation system for PEMEX's offshore oil platforms. High reliability power systems for offshore platforms are critical to achieve optimal performance of all control, communication, and safety systems.

Renewable only and solar/fossil fuel hybrid power systems, have been used by PEMEX for the past 18 years. Designing high reliability hybrid systems depends on realistically assessing weather conditions, critical power demand, loads, schedules, and resources as part of the engineering analysis.

CICSA was the engineering firm PEMEX designated to perform an analysis of possible power systems architectures required for 5 platforms. Power demand ranges between 2 kW to 5 kW. Technologies such as solar, wind, diesel, natural gas, and battery bank storage were considered for the *Ku-Maloob-Zaap* region oil platforms complex.

To adequately perform this task, experience with power systems design and financial analysis is necessary. HOMER is a powerful tool that was used for this complex analysis. After over 20 hours; more than 250 possible systems configurations were analyzed in the study. Thus, PEMEX was able to make a logical decision based on the engineering and economic analysis.

At present, engineering for the PEMEX project has been completed that meets the high reliability power system design requirements while providing an acceptable net present cost. Specifications, drawings, and layouts were submitted during late 2003 and bid documents were issued in May 2004. The installed power systems on the platforms will be ready for service in early 2005. Two 30 kW micro turbines and a 6 kWp PV system with battery storage was the optimal design chosen by PEMEX for this application.

Application of HOMER software for village electrification project: A case study for village Jarha

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Distributed generation has been identified as one of the alternatives for augmenting the supply and reliability of energy services such as electricity supply in off-grid areas. In India, one of the most significant applications of DG is for electrification of remote rural households. It is estimated that around 18-20000 villages exist where grid based electrification is not possible. TERI has carried out detail survey of few villages for electrification projects. Variety of resources mainly diesel generator set, solar energy, forest biomass, agricultural residue, wind etc. are available in villages. Proper assessment of long term viability of power plant to meet the growing needs of the users is important. HOMER simulation software is useful for predicting the performance and financial viability of the project.

In this paper, a case study is presented for village Jarha, in Singrauli district of Uttar Pradesh in India. The village has more than nine hamlets and spread in 6 km^2 area. All the hamlets in the village are un-electrified and people are using kerosene for lighting purposes. The village has 59 households with the population of 415. The need analysis was carried out by detailed survey to identify the requirement of lighting, scope for income generation activity using electricity generated by proposed power plant. To make the plant viable paying capacity of the villagers and local resource availability was also assessed.

Five resource options are available for electrification - extension of conventional grid, forest residue, purchased woody biomass, diesel and solar energy. HOMER was used to analyse the requirement and electricity generation cost over lifetime (15 years) of the project. Innovative application for battery charging and for running small-scale industry are two major features of the proposed power plant.
The analysis proved that solar photovoltaic power plant is best option for the electrification.

The methodology followed for plant design and results of HOMER simulation are discussed and compared with actual field situation. This case study is typical of thousands of villages in India and results of this exercise show the utility of HOMER for similar applications.

Using HOMER and Simulink for Long-Term Performance Analysis of a Hybrid Electric Power System in a Remote Alaskan Village

Abstract--This paper discusses the Life Cycle Cost (LCC) and air emissions analysis of a photovoltaic (PV) with diesel battery system for the remote community of Lime Village, Alaska. An integral part of the optimization process is remote monitoring and ultimately control of the system. This project involves the installation of various types of sensors on electric power systems in remote villages in order to collect data for analysis of system performance. A long-term performance tool was developed in MATLAB™ Simulink for the design, simulation, and optimization calculations. Simulations were performed using an annual load profile for Lime Village. The simulation results were utilized to calculate the LCC of the system and the resulting air emissions. The economic part of the model calculates the LCC of the system, while the environmental part of the model calculates the levels of CO_2, NO_x, and the SO_2 emissions. The LCC and air emissions results of our Simulink model were comparable to those predicted by HOMER.

San Juanico Hybrid Power System Technical and Institutional Assessment

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San Juanico is a fishing village with approximately 120 homes and more than 400 people in the Municipality of Comondu, Baja California Sur. San Juanico's first autonomous diesel generator began operating in 1980. The system supplied unreliable power, usually 3 hours a day, from 1980 until 1999 when a hybrid power system was installed. Before the hybrid system was installed, NREL researchers conducted a pre-24 hour electrification field study to characterize San Juanico's electrical usage and institutional and social framework. The introduction of the wind-diesel-photovoltaic (PV) hybrid power system in April 1999 brought 24-hour power to the village. One year after the system was installed, researchers performed a "post-electrification" study to document changes to San Juanico's institutional and social framework that resulted from 24-hour electrification.

In June 1999, NREL researchers installed a monitoring system to record system performance data for the hybrid power system, including parameters such as the village load; power to and from the batteries; power to and from the inverter, wind turbine, and PV; and meteorological data.

Because the technical aspects and the institutional issues regarding the hybrid power system and the village's electricity use have been monitored since the system was installed, researchers have more information on the San Juanico hybrid power system than any other type of renewable energy village power system. In December of 2003, NREL researchers conducted a technical assessment of the system and revisited the social/institutional issues as detailed in the original assessment. This paper contains some of their findings, including a review of the hybrid power system, a description of the previous and current operational issues, updated institutional issues, and payment information. It also contains an assessment of the successes and shortcomings of the system and the ramifications these may have for other village power systems of this type.

Public-Private Partnership for Village Energy

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Over the past three years, a team of Lao experts has been training small companies to become village energy service specialists, to work in areas not due for electricity grid connection. The companies offer a choice of electricity supply technology, so that there is a solution for each village. Most villages have chosen solar home systems, but as the companies begin to work in the remoter cloudy and hilly areas, more villagers are choosing village-scale hydro systems.

The challenge has been to develop a framework within which an increasing number of companies can operate consistently over many years into the future. An ambitious goal for Laos is to connect 75% of rural families to the grid by 2020, and to help at least another 15% to receive off-grid electricity by this time. This would mean companies delivering over 10,000 connections per year over the next fifteen years, and providing ongoing service support to large numbers of operational systems.

A key challenge has been to make sure the stand-alone electricity installations operate reliably for many years. The solution has been to develop a “rent-to-buy” or hire-purchase mechanism. In the case of villagers choosing solar home systems, they buy the equipment by monthly payments over a period of several years. The solar panel then becomes an important economic asset to poor families, since it retains high re-sale value. They choose a Village Electricity Manager to provide technical support over this period and beyond. In the case of hydro and engine-generators, this “VEM” hire-purchases the equipment personally, using it to run a small business selling electricity. In both cases, prospective ownership has proved in practice to be an excellent motivation to take care of the equipment.

The Village Electricity Manager and the Electricity Service Company, both receive a portion of each monthly hire-purchase payment. In this way, a technical and management structure is permanently in place to support the long-term needs of operational customers. Both the Company and the VEM have a strong incentive to maintain the equipment in good working order, as they lose income if villagers with-hold payments for any reason.

This article outlines progress with the program so far, focusing on “best practices” – that is, choices we have made through careful testing of options, to ensure reliable service for Lao villagers and a self-sustaining framework for implementing companies. We have tried to move from project-cycle vulnerability, to a solid national program providing real opportunity for the private sector and for the majority of Lao villagers.

Although the focus of the program so far has been on electricity supply, the regulatory framework and financing approach has been designed to work for a wide range of renewable energy options for rural communities. The energy service companies (Escos) are able to diversify into technologies such as biogas-based cooking, biomass or solar thermal powered generators, using the same financing and administration structure. This financing method is suitable for energy installations orientated toward production and processing as well as for domestic needs, and the program is starting to prioritize productive applications.

ENERGY SUPPLY SECURITY with SUSTAINABILITY: THE 'NEW' RENEWABLE ENERGY PARADIGM

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ABSTRACT

There are 38 countries currently exporting conventional oil in significant quantity, but this number will fall dramatically within the next four decades. There will be heavy import dependency on fewer than six conventional oil producers, mostly in the Middle East, all of them with rising domestic needs for that oil. For natural gas the picture is similar, although with heavier import dependency on some CIS Republics. Price hikes are inevitable and, where import dependency and political risks are high, could occur suddenly and be provoked by supply disruption or its threat. Recourse to natural gas liquids, gas hydrates, tar sands and oil shales pose their own problems – not least high energy input/output ratios and adverse environmental impacts. There are considerable cost implications for all the foregoing, as there are for coal use. Yet relevant policy initiatives by key importers suggest limited sensitivity to the key conventional oil exporters in and adjoining the Middle East.

With supply insecurity increasingly unsustainable for fossil fuels, the need to bring on 'new' renewable energy capacity is ever more pressing when combined with global climate change, adverse local and regional environmental impacts, habitat and species losses, and human health damage resulting from fossil fuel use. Yet the diffusion of 'new' renewable energy is proceeding slowly, few national and regional targets are realistic, and many schemes show insufficient sensitivity to their surroundings and make exaggerated claims for their benefits.
The time is ripe to review the rationale for accelerating the use of 'new' renewable energy, highlighting those forms expected to make a major contribution in the longer term.

APPLICATION OF RENEWABLE ENERGY SOURCE IN THE GREEK ISLANDS OF SOUTH AEGEAN SEA

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Abstract

The use of renewable energy sources is a fundamental factor for a responsible energy policy in the future. Taking into account the sustainable character of the majority of renewable energy technologies, they are able to preserve resources and to provide security, diversity of energy supply and services, virtually without environmental impact. The present paper deals with the description of several applications of renewable energy sources in the area of the South Aegean Sea islands. The potential of the most important forms of renewable energy such as solar and wind energy, biomass, photovoltaics and geothermal energy, is investigated and analysed for the majority of the South Aegean Sea islands, while alternative scenarios are assessed and discussed.

The present paper aims mainly at investigating and assessing in depth the potential for energy conservation by exploiting the main renewable energy sources, such as solar, wind, biomass, photovoltaics and geothermal, in the area of South Aegean Sea islands. This area is strongly characterised by an increase of energy demands during last years mainly as a consequence of both increased tourism and economic growth.

Industry and Government Collaboration: Developing the Australian Renewable Energy Industry

Peter Rae, Chairman Renewable and Sustainable Energy ROUNDTABLE

Current patterns of energy supply are unsustainable, in terms of both increasing greenhouse gas emissions and finite fossil fuel resources. Electricity generation from the combustion of fossil fuels is a major contributor of GHG emissions and, at the current rate, it is predicted that these emissions will have increased globally by approximately 70% by 2030. Sustainable electricity generation requires an energy source that is renewable.

Australia has enormous renewable energy resources, particularly solar, wind, hydro and biomass, yet only 10% of Australia's electricity is derived from renewable resources because of a number of barriers, such as distorted energy costs.

These barriers have, however, begun to be addressed through government policies, which are designed to both reduce the ongoing level of GHG emissions by 2020 and to foster a viable domestic and international renewable and sustainable energy market.

Australia's pre-eminent policy initiative is the Mandatory Renewable Energy Target legislation, which has recently undergone its initial review. MRET has been a pivotal driver behind a number of new projects, but up to date has allowed for only modest industry growth.

This paper describes these issues and outlines the role of a peak renewable and sustainable energy industry association in creating unity within a diverse industry in order to facilitate effective and open dialogue with government in roundtable discussions. The paper also examines how the association has successfully advanced the energy policy agenda in Australia.

Successful instruments to increase the share of RES in the Energy System – Austria as example

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Abstract

In Austria Renewable Energy Resources (RES) cover about 25 % of the Total Primary Energy Supply (TPES). This high share of RES is the result of a variety of actions undertaken by private organizations and public authorities over the last two decades.

The paper describes in a brief first part the development of the different Renewable Energy Sources such as biomass for heat, for electricity, for liquid fuels, biogas, hydro power, wind, solar heating and PV over the past 20 years.

In the second part the paper evaluates the different instruments, being used, in their effect on the deployment of RES and draws some general conclusions on the basis of the gained experience. By doing so the paper will present drawbacks and successful examples, that could be of use also for other regions.

Finally the main obstacles, that hamper a more rapid development of RES are analysed, followed by a brief outlook on the next steps, that are at present under discussion in order to further promote a sustainable energy system.

Strategies for the Development of Sustainable Solar Photovoltaic Industries in Barbados

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Abstract

Purpose of Work: To recommend measures to be used to promote the development of sustainable renewable energy industries in Caribbean states.
Approach: The Porter's Five Force Model, and innovation theory were analyzed in the context of their application to the development of existing renewable energy projects in Barbados
Innovation/ Relevance: The analysis of market theories which are applied to established competitive industries, will lead to greater insight when attempting to develop renewable energy industries which are economically sustainable. In the Caribbean traditionally economic mechanisms for sustainability have not been included in renewable projects developed.
Results/ Conclusions : In facilitating renewable energy innovation it is important that attention is paid to both technology and process. Establishing competitive markets will require incentives for innovator, suppliers and buyer if the system is to be sustainable.

Success in the market will depend on whether the technology can be successfully "differentiated" from others. Emphasis must be placed on the benefits beyond economics, so that the customers consider these as cutting edge technologies and not cost or quality cutting.

Potential reduction of GHG emissions through landfill gases CDM projects in Brazil

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Methane is one of the main and most aggressive greenhouse gases (GHG). One important emission source of methane is solid waste, which is responsible for almost 10% of the world anthropogenic emissions of GHG. Kyoto Protocol prescribed the Clean Development Mechanisms (CDM) as a major instrument in developing means of reducing GHG emissions and promoting sustainable development. The purpose of the CDM is to assist developed countries in achieving compliance with their quantified emission reduction commitments. In the other hand, it also assists developing countries in achieving sustainable development goals. Despite the lack of reliable information of solid wastes in developing countries, it seems that landfill emissions control plays a central role among potential CDM projects. In such context, Brazil emerges as one of the major CDM projects receptor. Indeed, there are three waste-management-related CDM projects ongoing in the country: the Novagerar project (Rio de Janeiro), the Onyx project (São Paulo), and the Vega project (Salvador). The objective of this paper is to critically analyze whether the methodologies proposed by those projects comply with the main objectives prescribed by UN, i.e., the stabilization of GHG emissions and the achievement of sustainable development. The use of methane as fuel for electricity production is also considered and its impact on the reduction of GHG emissions is analyzed.

Key words: CDM, GHG emissions, landfill gas

CDM projects on sugarcane cogeneration in Brazil

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Greenhouse effect, and its relation with Climate Change, has emerged as one of the major global challenges to be faced by humankind. Aware of this problem and to complement the UNFCCC treaty, Kyoto Protocol was established. One of its purposes is to create mechanisms to allow emission reductions without compromising the economic welfare of countries listed in the Annex I. One of the fundamental instruments regarding this purpose is the Clean Development Mechanism (CDM) that allows developing countries to receive investments from Annex I countries and to implement projects that promote renewable energy. In order to be qualified as a CDM activity, a project must fulfill three prescribed eligibility criterions, being the most controversial the additionality criterion. The starting point of additionality criterion is the definition of the baseline, which represents the GHG emissions reference scenario in each specific situation. Cogeneration from sugarcane residues is one of the main possibilities for Brazil to participate as a CDM project host. In fact, this activity is a reality in Brazil, but the existing potential can be better developed as far as foster mechanisms are available. The objective of this paper is to discuss additionality criterions in the perspective of two CDM cogeneration projects so far proposed in Brazil.

Key words: CDM, GHG emissions, sugarcane cogeneration

Powering the Big Apple: Policy and System Factors Affecting the Deployment and Use of Renewable Power in New York City

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New York City is a city in love with electricity. The bright lights of Times Square, a large subway system, 200,000 businesses and 7.5 million residents all require massive amounts of power. On hot summer days, peak electricity demand in New York City can approach 11,000 MW. Yet of this amount, only 2-3 MW of electricity are currently derived from “new” renewable power systems, including solar panels, anaerobic digester and fuel cell systems, and small wind turbines. This amount is expected to grow in the next few years, but only marginally. Why is this true? Several reasons are involved: 1) Like most consumers, New Yorkers don’t like to spend a lot of money for electricity, so the higher cost of power from renewable sources discourages real estate developers and business and residential consumers from deploying renewable power schemes on their property; 2) The City of New York prefers voluntary action on renewables deployment to mandates; 3) Interconnection requirements imposed by the local load-serving utility to protect the continued reliability of the local grid force renewables project developers to shrink the size of their system or adopt other technical fixes that can adversely affect the long-term financial benefits of a renewables system installation; and 4) State and City officials, along with community and environmental advocates, have done a good job promoting the use of natural gas in new power plants and the re-powering of older “dirty” power plants, reducing the air quality impacts of local electricity production. Their success may have reduced pressures that would otherwise be felt to promote the use of non-polluting renewables technologies to help meet New York’s growing power needs.

Renewable Energy Policy and Impacts in Ethiopia

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Extended Abstract: The presentation begins with summarized features of the energy sector in Ethiopia in relative terms. Although faced with dwindling biomass fuels, untapped renewable energy resources comprise hydropower, geothermal energy, solar and wind energies. Dependence on biomass fuels is indicated to be 94% of energy types/uses. Impacts of the national renewable energy policy on modern/traditional energy services and the disseminations of renewable energy technologies (RETs) are also found to be relatively insignificant. The country therefore finds itself in an "energy-poverty" situation. Barriers and gaps in the renewable energy policy are identified and reviewed. The insignificant impacts of the renewable energy policy have been caused by the following gaps and barriers:

- Gaps in awareness about Renewables exist extensively.
- Barriers in technology transfer are yet to be fully addressed.
- Committed rural energy initiatives and budgetary allocations for research and development are lacking.
- Private sector involvements, except in the supply and distribution of traditional biomass fuels, are not present.

Options are next considered for lessening the gaps and barriers, these being: a. needs for upgrading priority limitations on Renewables; b. promotions of private sector involvements; private initiatives for promoting impacts of modern energy services in rural settlements for productive activities; c. overcoming technical barriers to initiatives for introducing renewable energy technologies (RETs); and d. strengthening of ineffective institutional framework for disseminations of RETs. Each option is aimed at addressing the incomplete components of the renewable energy policy.

Statutory power prices for wind energy in Germany – impact on the market penetration

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The presentation shows how the implementation of power prices for wind energy granted by federal law works in Germany and how the wind energy sector has grown in the past due to this pricing system.

The approach is both legal and economical. The experiences of the first years with the new statutes are to be outlined – where did power prices go, what impact did this have on the growth of wind energy? Comparisons to other countries, both EU and internationally, are made. After the first years the statutes are under review: which corrections are deemed necessary? Flexible measurements to control the impact of granted prices on the power market are to be discussed.

The results and experiences can be transformed into other energy regulation systems if there is a need or the political will for explicit support of wind energy.

Bio-energy Policy Option for Ghana
(highlighting strategies and implementation plans)

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Abstract

Biomass constitutes more than 75 % of the total household energy consumption in Ghana. The traditional use has not been sustainable since bio-energy has been ignored in the mainstream of energy policy analysis, planning, development and modernization; leading to socio-economic and environmental problems. Some research has been directed at wood-fuel, charcoal and biogas production, but there has been limited policy direction for conversion into high value energy. The primary strategy of the policy is to encourage the rapid uptake of modern technologies of improved biomass use, conversion of bio-wastes and biomass crops into biofuels. The ultimate goal is to disseminate technologies to raise the standard of living without adverse effects on health. The biological conversion of agro-industrial effluents, manures and sewage sludge by anaerobic fermentation will combine biogas extraction for cooking, heating and lighting with improved fertilizer value and better hygiene. By thermal conversion through gasification and pyrolysis, gaseous fuels and bio-oils will be produced to generate electricity. Biomass crops with high yield and high-energy ratio, such as jetropha, will be converted into bio-diesel. The key challenges are to intensify research and technology transfer by ensuring accessibility, availability and affordability through institutional support. The policy will address the problems of production, utilization, scarcity, collection and marketing associated with upgrading biomass into modern forms of fuel. For sustainability, all sources of biomass suitable for conversion into efficient biofuels will be identified and quantified to address competition between energy, food, medicine and building materials. Outreach programmes and technical assistance on setting up community bio-energy development projects will be provided. With dwindling fuel wood supply and associated deforestation, bio-energy will be the environmentally friendly and cost-effective option for renewable energy supply to rural communities where traditional biomass provides the main energy source.

Renewable Energy Dissemination in India: An Assessment Using Technology Diffusion Models

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Abstract

Considerable efforts have been made towards large-scale dissemination of renewable energy technologies in India during the last two decades. However, the current trend of diffusion of renewable energy technologies in India is rather distorted due to a variety of financial and fiscal incentives provided by the central and state governments. The diffusion and adoption of these technologies in future will depend on further development and cost reduction of these technologies through innovation and learning experience. A priori knowledge of the likely diffusion and dissemination of renewable energy technologies and its time variation is quite relevant for macro level policy interventions and planning. In this study an attempt has been made to estimate (i) the prospects for diffusion of renewable energy technologies using several technology diffusion models (such as the Logistic growth curve, Bass diffusion model, Gompertz growth curve etc.), (ii) the expected reduction in the cost of renewable energy technologies due to learning curve effect, and (iii) the possible contribution of renewable energy technologies in the energy supply mix. The results indicate that the dissemination of renewable energy technologies in India is not likely to reach its maximum estimated potential even in next fifty years.

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ASSESSMENT AND EVALUATION OF RENEWABLE ENERGY TECHNOLOGIES IN INDIA

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ABSTRACT

India has a very large potential for harnessing renewable energy sources. However, there is a large gap between the estimated potential and the cumulative achievements made so far. A variety of reasons are attributed to the current low levels of dissemination of renewable energy technologies in India as against their respective estimated potentials. Several of these attributes could, one way or the other, be related to the current status of development of the technology, its appropriateness and also the dissemination strategies adopted for their diffusion. It is in this context that an attempt has been made to obtain the feedback on the current status of renewable energy technologies in India through structured questionnaire based survey. This paper presents the main findings of the study.

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EVALUATING ALTERNATIVE TECHNOLOGIES IN MEETING ENERGY POLICY GOALS IN JAPAN: FINANCING BIOMASS AND WASTE TO ENERGY PLANTS

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Purpose of the work: Biomass and waste are considered to be an important fuels and renewable energy resources to construct a sustainable society in Japan. However, there are concerns about economic competitiveness and compliance of environmental regulations. There is few engineering and economic analysis for the emerging "green energy" industry in the literature.
Approach: This paper deals with the evaluations for public policy and private enterprise that require a resource supply analysis that including both costs and impacts to the environmental pollutions. We use engineering cost estimates and econometric modeling taking into account local variation in cost-determining factors such as biomass & waste contents, competition from alternative supplier, geographic density in the region and compliance of environmental regulations. In addition, we incorporate the dynamic aspects of technologies, i.e., innovation, learning-by-doing, and diffusion of new technologies in our simulations.
Scientific innovation and relevance: Using our estimates, we develop an optimal technological choice model and apply to prefecture-level data in Japan.
Results& Conclusions: Our results show that waste and biomass are more important energy source than previous estimates.

DYNAMIC ANALYSIS OF JAPANESE FORESTRY FOR RENEWABLE ENERGY POLICIES

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Purpose of the work: Forestry has been proposed as a mean to reduce net greenhouse gas emissions, by either reducing sources or enhancing sinks. Under the Kyoto Protocol, Japan plans to use forest absorption, or sinks to achieve 3.9 percentage points of the 6% cut in greenhouse gases from the 1990 level. The Japan's forestry productions, however, have reduced 60% in the last ten years.

Approach: This paper studies the forestry for renewable energy policies, and quantifies the link between alternative renewable policies and the productivity of forestry in Japan.

In forestry production, a stylized fact known as a rotation effect considering dynamic aspect since it takes several decades to have forest production. This paper develops a dynamic data envelopment analysis (DEA) model of forest production that accounts for the rotation effect

Scientific innovation and relevance: Dynamic DEA is developed in forestry sector. The model is applied to data from a comprehensive perpetual or regional database in Japan to investigate the role of capital plays in observed productivity growth.

Results & Conclusions: Our empirical investigation shows that alternative forest management and renewable energy policies improve the efficiency of forest use as an energy source.

Environmental Taxes and Agriculture in the European Union and the Netherlands

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Abstract: This paper analyzes the introduction of environmental taxes in the EU and Netherlands and their effects on agriculture, with a special focus on the background of the introduction of *environmental tax systems*, their design concepts and effects on agriculture, the effects of fertilizer taxes in promoting sustainable agriculture, policy packages between environmental tax and environmental agreements, effects on globalization and global competitiveness, and conversion to renewable energy based on biomass resources.

The *glasshouse horticulture industry in the Netherlands* sets an exceptional exemplar of “direct effects” with respect to increased energy efficiency, strengthened cost competitiveness, and suppression of CO_2 emissions through the transition of high energy-consuming agricultural facilities into energy-efficient facilities. These results were made possible by a combination of environmental taxation and voluntary environmental agreements (covenants). These measures also succeeded in producing a “dynamic effect” of internalizing environmental externalities into the market through technological innovations, enabling a successful switch to renewable energy sources; fully a quarter of the glasshouse horticulture industry has adopted cogeneration facilities, while 40% has adopted green electricity. The Dutch environmental policy is thought-provoking model for agricultural environmental policies in Japan.

CHALLENGES & OPPORTUNITIES OF AUTOMOBILE POLLUTION CONTROL IN DEVELOPING COUNTRIES

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ABSTRACT

Automobile pollution is a subject of growing public awareness and concern. It poses one of the biggest challenges for fast growing economies in the developing countries. The problem is fast growing and has assumed an alarming dimensions in almost all the major cities and towns in developing countries. Paper is designed to present an overview of road transport and sources of vehicular emissions and mechanism of various sources of vehicular emission in each of the major category of vehicles in some case study developing countries. A strategy for emission control using promising approaches to promote energy efficiency and renewable energy and plan of action for these countries is given to indicate that how increasing opportunities are becoming available as a result of breakthrough in technologies like: 1. Electric vehicles powered by batteries, fuel cell or hybrid power sources and 2. Clean fuels vehicles running on compressed natural gas (CNG), methanol, ethanol, propane, or hydrogen and 3.higher quality fuels like reformulated gasoline, limited volatility gasoline, limited sulfur diesel fuels, and oxygenated fuels.

Some key priorities are given to indicate that how developing countries can incorporate clean energy in to sustainable development in general and automobile industry in particular in the coming years. A new approach is suggested to show that how completely redesigning automobiles is feasible by reconfiguring key design elements using advances in electronics, software, materials, manufacturing and other techniques. This could save at least 70 to 80 per cent of fuel it currently uses, while making it safer, sportier and more comfortable. Finally the paper shows that what is needed is a Hyper car wherein materials would flow in closed loops, with toxicity carefully confined and longevity designed in. These Hyper cars would be weighing 2 to 3 times less than a conventional car. This would make cars not only ultra low drag so that it can slip through air and roll along the road several times more easily but also making its propulsion system hybrid electric.

Comprehensive Policies for Reaching Poor Households with Renewable Energy Services

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The issue 'access to modern energy services for poor people (AESPP)' has won global support conceptually. Agenda 21, Millennium Development Goals (MDGs) World Summit on Sustainable Development (WSSD), Country Assistance Programs (CSPs) of bilateral aid agencies (like DFID) and Poverty Reduction Strategy Papers (PRSPs) all accept the need to reach out around two billion people with modern energy services. Improved access to energy services has been considered as an underlying component linked to the achievement of the targets set by MDGs for reduction in poverty, improvement in health and education and protection of the environment. But the current progress towards improved access is far less satisfactory due to lack of serious exercise on the appropriate approaches and mechanisms specifically suitable to countries having different socio-cultural background, institutional development and market behaviour.

There have been some innovations under different projects and initiatives to enhance the access of poor people to renewable energy services. These isolated attempts, which are sometimes called best practices, represent just cases not a comprehensive package and therefore are not receiving recognition at wider level.

In the above context, this paper will attempt to present a comprehensive policy package that could make the renewable energy affordable and accessible to poor households. The sources of this package are the best cases so far demonstrated in different countries and contexts. Some common measures adopted in many places to enhance the access are soft loan for the purchase of equipments, easy instalments, subsidy, revolving funds, loan on group guarantee, material support etc. These measures have shown varied degrees of effectiveness because of the differences in socio-cultural and institutional set up. In Nepal too renewable energy programmes lunched by UN agencies, by governments and by multi lateral agencies have tested myriad of approaches to reach to the poor people. This paper reflects these approaches too.

There is an immediate need to adopt a set of policy measures followed by programmes that reduces cost of the equipments and delivery of services on the one hand and increases the income and affordability of the poor people to buy the renewable energy services at market rate. The two prone strategies consists of making market pro-poor through intervening it in the chain of supply and through strengthening the effective demand of poor consumer households. In an endeavour to create effective demand emphasis has been given to the end-use promotion of renewable energy services or tying up the renewable services with other income generating packages.

Policy Diagnosis: Case Study of RETs Development in Nepal

Abstract

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It is universally accepted that energy is the key to economic development of any country. Less than 7% of Nepal's rural populations have access to electricity, and centralised distribution is not expected to reach many areas of the mountainous country for the next 30 years. Renewable energy is the only source for lighting the rural households, besides finding a wider application such as heating, cooking, drying, power generation, and so forth. The Nepalese Government has been promoting the use of Renewable Energy Technologies to ensure the supply of a minimum amount of energy to meet the basic needs of the rural people; reduce drudgery for women and children; facilitate economic growth and to create opportunities for income generation through adequate supply of energy, including rural electrification; ensure minimum adverse environmental impact and ensure least dependency on external sources of energy through efficient and sustainable use of local energy resources for which adequate end-uses need to be developed to make harnessing of renewable energy financially viable.

This paper will highlight the impact of RETs Policy on the development of this sector. The presentation will focus on the various agendas of the policy that have influenced the development and growth of RETs, the impact upon project areas as well gender-segregated issues. The paper will be based on case studies of selected RETs over the years.

Performance-Objective Design for a Renewable Energy Transportation Circuit of Christchurch, New Zealand

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One of the most highly utilized public transportation routes in Christchurch is the *Orbiter*, a high frequency bus route that follows a circuit of the city through major shopping centers, high schools, recreation centers and industrial zones. Orbiters travel continuously in both directions, with ten-minute frequency. Eighteen buses with 30 passenger capacity circuit the 40km every 60min.

Christchurch is at 43^{o}S latitude, on the Eastern coastal plain of the South Island of New Zealand, with a 600m elevation hill range immediately to the south. The local rivers have highly seasonal flows and wide, braided beds, not suitable for hydroelectric development. The wind resource has not been well studied, but is in the range of class 4-5 on the hills. The solar resource is prone to overcast days, particularly in the winter. Local plantation lumber industry produces tons of waste wood per year, which is a locally used fuel source. All of the estimated biodiesel resources for the South Island would equal the current diesel consumption of the Orbiter.

An electric passenger light rail system has been designed to replace the Orbiter route. Electric energy is supplied through a dedicated network (not grid connected) from the modeled renewable generating plants to the rail line. Many combinations of renewable energy and storage technologies were modeled to provide the transportation energy. A real-time reservation and schedule system has been proposed to facilitate optimal operation efficiency of the model system which is fundamentally different than the current service.

RENEWABLE ENERGY: PANACEA FOR BENIGN ENVIROMENT AND SUSTAINABLE DEVELOPMENT IN AFRICA

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ABSTRACT
The combination of man's quest for a better quality of life and the need to accommodate population growth has led to tremendous increase in the demand for energy.
One obvious consequence of this is the triggering of irreversible damage to the ecosystem especially in Africa, where attempts to satisfy basic needs of a rapidly growing population have generally placed more emphasis on unsustainable rather than sustainable development. In addition, energy has greatly influenced development through scientific advances and inventions but at the expense of our scarcest resource- the environment. Some of the negative impacts include air and water pollution, ecological and health problems, poverty and so on.

The rising global concern about environmental degradation and global warming due to the almost total dependence on conventional energy resources has brought with it the need for the development and diffusion of alternative energy resources, such as Renewable Energy Technology (RETs), especially in African countries.

From the standpoint of sustainable development therefore, what is required is a re-orientation of the current approach to energy usage, taking into account the way and manner it is presently used, its potential for enhancing the human development index, and ways and means to increase access to its services for the poor.
However, we cannot change the environmental impact of energy use without addressing the characteristics of the technologies that produce, convert, distribute, and end use of energy. In pursuit of the above, education and training have a vital role to play in end users, not only the need to use energy more efficiently, but also embrace alternatives like the RETs that are more benign to the environment.

This will in turn promote sustainable environment and development. Most African countries contend that poverty was the ultimate environmental problem and therefore had no choice but to give socio-economic development priority over environmental sustainability.

This paper highlights the positive impacts on the environment that the development and adoption of RETs in national energy mix and energy education will have, taking into account the available energy option in the continent. It will also discuss strategies for tackling environmental and poverty for a sustainable future

Pakistan's Alternative/ Renewable Energy Policy

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Purpose of work: Promotion of Alternative/ Renewable Energy in Pakistan
Approach: To Develop Policy and Facilitate Development of Alternative/ Renewable Energy Technology after consulting similar policies adopted by countries in different parts of the world. Effort has been made to utilize relevant areas that are particularly suitable in Pakistani environments. Pakistan Council for Science and Technology, under the Ministry of Science and Technology sponsored the initial work in the year 2002. Considering the fact that conventional sources of energy are finite and heavy burden on national exchequer, it was further refined and presented to the Prime Minister of Pakistan in the Month of April 2003 by the author, and was accepted by the Prime Minister for adoption.
Scientific Innovation and Relevance: There was no national policy for promoting Alternative/ Renewable Energy in Pakistan. During this effort, Pakistan's Alternative/ Renewable Energy Policy has been formulated and partially implemented. An office in the form of Alternative Energy Development Board has been established directly under the Prime Minister and housed in the Prime Minister's Secretariat. The Board has representation from all relevant Ministries and Private groups. The policy has been presented at several forum and currently it is being evaluated at the highest level before final implementation at the national level. The main area that has been approved is that 10% of all electrical energy produced in the country will be shifted to Alternative/Renewable energy resources by the year 2015. This gives a target of around 1700 MW of production through Alternative technologies on the lower side and 2700 MW on the higher side. Solar geysers, solar cookers, accommodation heating systems, remote area electrification are other associated areas. Energy education, conservation, green house gas abatement are all linked in the policy so as to bring comprehensive national policy.
Results: Announcement of Policy has already resulted in tremendous activity in the country. More than 500 million dollars investment has been offered to the Alternative Energy Development Board through private commercial investments. The interested groups belong to different countries including Germany, Spain, Denmark, Sweden, Norway, USA, Iran, UAE, Russia and China. Most of the investment is coming from overseas and local entrepreneur are aggressively pursuing manufacturing some of the easily adoptable components locally. A consortium of large manufacturers and consumers has been formed and agreements of transfer of technology are in various stages of approval. Solar energy is being pursued for remote area electrification as well as water heating, cooking, water pumping etc where as wind energy is being pursued for grid-connected electricity at suitable wind speed regimes.
Conclusion: Alternative/ Renewable energy technology has already come to the level internationally where any government initiative seems to bring large investment in this sector. It can be clearly concluded that it is the government commitment that is lacking in developing world that needs to be further complimented by international aid agencies to ensure that at least 20% of all technology support is in the area of Alternative/Renewable Energy Technology. In fact this should be one of the conclusions and recommendations of the Congress, to be made at the end of the Congress to all aid giving countries for including as a policy measure in their international development programs.

PROSPECTS OF RENEWABLE ENERGY TECHNOLOGIES IN PAKISTAN

Pakistan, despite the enormous potential of its energy resources, remains energy deficient and has to rely heavily on imports to satisfy hardly its needs. Moreover a very large part of the rural areas does not have the electrification facilities because they are either too remote and/or too expensive to connect to the national grid. Pakistan obtains its energy requirements from a variety of traditional and commercial sources. Share of various primary energy sources in energy supply mix remained during last few years as oil: 43.5%, gas: 41.5%, LPG: 0.3%, coal: 4.5%, hydro-electricity: 9.2%, and nuclear electricity: 1.1%. The electric power generation included 71.9% thermal, 25.2% hydel and 2.9% nuclear. While it is difficult for Pakistan to reach self-sufficiency in hydrocarbons, the good option is the exploitation and utilization of the huge coal reserves of Thar and the other renewable sources.

Pakistan has a wide spectrum of high potential renewable energy sources, conventional and non-conventional as well, which have not been adequately explored, exploited and developed. Therefore, development of renewable energy sources can play an important role in meeting the energy challenge. Micro-hydels, biogas, wind, solar, utilization of low-head canal levels, sea wave & tide and geothermal energies could be utilized. Technologically, all these renewable energy sources are viable and consequently suit efforts for poverty alleviation and cleaner environment in Pakistan.

The paper will discuss the potential of renewable energy technologies in Pakistan, the government's policy framework in this regard and the potential for the future.

Renewable Energy and Sustainable Development in Palestine

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In spite of ten years of hard and intensive national and international work all indicators show that the situation in Palestine stills in need to pay more attention in order to be able to overcome the huge socio-economic problems. Construction of a modern state and civilized society requires special attention to be directed to the Palestinian economy, efficient programs and appropriate planning must be proposed to achieve sustainable development and reformation. Many factors are considered in this case. Demand on Energy, availability of water and environmental protection are three essential issues, which should be deeply dealt in the Palestinian territories. Identification and assessment of the current situation the work done in the Palestinian territories are very important in order to have a clear look for the future.

Energy is mentioned as the backbone of the every-day activities and it consider as essential element of the socio-economic development constituents. That forced one of the Palestinian specialists, experts and decision-maker to cooperate to set the policy and the long, medium and short plans in order to cope the energy crisis that swell up rapidly.

Considering the energy is one of the more important arbors for economic growth and social prosperity, the relation between the energy and development in Palestine reflects the unique hard situation, in which the Palestinians live. That will affect directly the Palestinian targets to reach a strategic action plan for implementing a sustainable and an independent Palestinian energy sector.

This study summarizes the present status of the energy sector in Palestine, concerning to consumption, amount of energy availability in Palestine and the obstacles facing development of this sector. Also, it shows the expected energy demand level throughout the upcoming ten years and the potential of renewable energy resources and its utilization in order to overwhelm the rapidly deficit in energy resources availability. The national and political motivations behind the development and establishment of small renewable energy projects are pointed.

On the other hand, this study includes presentation of short, medium and long-term proposed plans aim to develop the Palestinian human resources, prospects of enhancing the use of renewable energy, and the strategic programs to ensure a sustainable energy development in Palestine. It is worthy to mention that this paper emphasizes on the importance of the regional cooperation in the field of sustainable energy development. Thus, it will lead to improve the serious economical conditions in the Arab world, which will affect the welfare and style life of the Palestinian society.

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Current Status and Prospects for Use of Renewable Energy Sources in Russia

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Purpose
The purpose of the present work is to analyze the current status and prospects for use of renewable energy sources (photovoltaic, wind energy, geothermal energy, small hydroenergetics) in Russia.
Approach
The paper analyses the situation for electric and thermal energy generation using renewable energy sources taking into account the specialists' estimation, data base of the market study. The prospects for different technologies of renewable energy sources and the market requirements in the bounds of the Energy Strategy approved by the government of the Russian Federation are evaluated.
Scientific innovation and relevance
The methodology having been used allows to determine the potential of photovoltaic and wind power systems.
Results
1. The energy potential of renewable energy in Russia is defined.
2. The current status and prospects for renewable energy sources development in Russia is estimated.
3. New ways for expansion of renewable energy sources application are considered.
Conclusions
1. The energy potential of renewable energy sources in Russia is able to provide more than 20% of the total demand in electric-power industry and heat-power engineering.
2. Russia has practically all the types of renewable energy sources.

OPTIMAL TOTAL ENERGY SYSTEM WITH THE IMPLICATIONS OF RENEWABLE ENERGY DEPLOYMENT IN JAPAN

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Abstract

Aimed to reduce environmental impacts and to achieve future energy sustainability, various renewable energy conversions are dominant players in the 21st century. The penetration of renewable energy, however, calls for the optimal combination between the fossil and renewable resources, entitled as the optimal total energy system. Although a number of models for resource allocations and GHG mitigation policies have been developed, the optimal solutions are usually determined under perfect information of all parameters that are impossible in reality. Such scenario analyses leave us in a difficulty for decision making on the energy planning since only an optimal action may not be preferred. In this paper, a bottom-up optimization model with a stochastic programming paradigm is applied to clarify such circumstances, by merging two or more scenarios in a single model, and by recommending an optimal action with the presence of uncertainties. Japan's energy supply-demand is then presented as a case study. By this way, decision making on an optimal total energy system is made clear and evaluation criteria to minimize total system cost is, thus, more realistic than traditional scenario analysis.

Keywords: Total energy system; Renewable energy; Stochastic; Uncertainty; Decision making;

Impacts of carbon and energy taxes on biomass power generation expansion planning

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Abstract

At present, the main concern of public world wide is on longer the rapid depletion of the finite reserve of fossil fuels but rather the adverse environmental consequences of their combustion. Electricity generation is a major consumer of fossil energy as it converts primary energy into forms suitable for end-use consumers. At present, about one fourth of primary energy supply in Thailand is used for electricity generation. This energy supply mainly comes from fossil fuel and it produces significant amount of CO_2 emissions. An essential mechanism to reduce the impact of the power generation on the greenhouse gas emissions is the substitution of less or non-carbon intensive sources of generation for conventional generation. In Thailand, biomass for power is considered as a significant non-carbon based generation with high supply potential. However, the major barrier that could hinder the implementation of such non-carbon based generation is the high generation cost. One effective measure for overcoming such barrier is the implications of carbon and energy taxes. In the study, a least-cost generation planning model will be used to find out the optimal plan and to evaluate its impacts on the generation and fuel-mixes with changes in relative cost of different power generation options due to carbon and energy taxes. Both carbon and energy taxes show potential to reduce both energy supply and environmental emissions. However, carbon taxes are applicable for the biomass power generation whereas energy taxes are for advanced technologies with high generation cost.

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Potential of Biomass Fuels in the Independent and the Small Power Producers for Electricity Generation

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Abstract

Since Thailand's economic crisis in 1997, energy consumption has been continually increasing. To overcome this problem, government policies concerning energy conservation must be implemented in all economic sectors of the country. Over the decades, the power sector has been the largest primary energy consumer because it must not only consume the energy by itself, but also produce the secondary energy (electricity) for the other sectors (i.e. the industrial and the residential sectors, etc). Moreover, Thailand's government policies to construct the new power generation plants in the domestic areas and the collaborated utilization of energy (i.e. natural gas) with neighboring countries seems to be strongly resisted by the local populations for a variety of reasons. This paper describes an overview of the energy situation in Thailand, especially the power generation situation and the policies of power generation concerned with the independent and the small power producers (referred to as IPPs and SPPs respectively), which use biomass as the fuel to produce the electricity. In addition, in this paper, some aspects of biomass used for power generation are also discussed.

Keywords: energy, power generation, independent and small power producers.

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Strategies to Mitigate Air Pollution and Reduce Energy Consumption in the Transport Sector of Thailand

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Abstract

In Thailand, in 2001, the transport sector had the highest proportion of 37.6% of the final energy consumption and most of the energy demand in this sector was petroleum products. In recent years, the volume of road transport especially in Bangkok Metropolitan has rapidly increased. This situation results in crucial traffic congestion in the main cities and also increasing energy consumption and air pollution. The major purpose of this article is to formulate technical and policy alternatives considering two objectives: energy conservation and air pollution abatement, in the transport sector of Thailand. The energy demand and air pollution emission in the transport sector are estimated by using the Long-range Energy Alternative Planning (LEAP) model. The baseline scenario and alternative scenarios, regarding fuel switching and transport demand management options, are developed. Results from the LEAP model reveal that the improvement of fuel economy in passenger cars has high potential in the abatement of both energy demand and air pollutions followed by the improvement of public transportation system.

Keywords: crucial traffic congestion, energy conservation, air pollution abatement, fuel switching, public transportation system

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A SUSTAINABLE RENEWABLE ENERGY POLICY FOR A SMALL ISLAND PETROLEUM-BASED ECONOMY

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ABSTRACT

Trinidad and Tobago, as a petroleum-based economy is undertaking a review of its current national energy policy document that will help to clearly define the relevant issues and challenges that are confronting its energy sector. The changing market force along with the country's macro and socio-economic developmental thrusts are the major drivers that determine the increasing share of natural gas in our primary energy mix; and the marginal but noticeably growing share being allotted to renewable energy (RE). A sustainable renewable energy policy that develops the country's renewable energy resources and optimises energy efficiency and utilization will form part of the national energy policy document.

This paper investigates how the Ministry's RE policy will incorporate renewable energy projects in the schools of Trinidad and Tobago and involve the credit unions in micro-level financing of RE projects. Rural electrification by means of suitable renewable sources of energy will also be studied and promoted with the necessary supply-side governmental incentives.

Keywords: *Trinidad and Tobago Energy Policy, Renewable Energy Policy and Rural electrification*

Policy and Standard for Energy Efficient Building Design in China

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China's building sector currently accounts for 23% of China's total energy use and is projected to one-third by 2010. Energy efficiency policy is very important for sustainable building design. The aim of the paper is to illustrate the policy issue and its role in China's building energy conservation. Information of energy consumption in buildings has been collected and analysed. China's national energy policies, building energy policies and building design standards have been introduced in the paper.

In conclusion, the Chinese government is paying more attention to energy conservation and made a general energy conservation policy. However the energy standards and codes for building design have not, as yet, been completely finalised. There still exist barriers for the implementation of existing standards. Renewable energy is encouraged by national policy however the techniques are desired by building designers. The incentive policy of energy and renewable energy application is expected in China. There will be a great demand of renewable products for buildings in Chinese market. International collaboration in Chinese built environment for building professionals and policy makers to exchange information, knowledge and advanced technologies is important for setting up and implementation of building regulation related to Chinese situation.

Keywords: energy efficiency, building policy, standard, China

Renewable Energy: Market & Regulatory Forces at Work

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Purpose: Navigant Consulting completed a major renewable energy study in 2003, the "Changing Face of Renewable Energy," which provides an understanding of the outlook for renewable energy technologies and markets to 2013.

Approach: The study examined many different aspects of the renewable energy industry, including drivers and barriers to the development and commercialization of renewable energy. Key technologies examined include onshore and offshore wind, photovoltaics, concentrating solar power, hydro, biomass, geothermal, and wave, plus others, in addition to storage and inverter technologies.

Relevance: Many renewable energy technologies are approaching competitiveness with conventional power. Market conditions for renewable energy technologies are as varied as the technologies themselves, as seen in costs, performance, incentives, competition, and outlook for wind, photovoltaics, biomass, low-impact hydro, geothermal, and solar thermal electric.

Selected Results: The use of renewable energy technologies will more than double over the next ten years in North America. Continued technology improvements will help drive that growth. Renewable energy attributes will add value, but appropriate subsidies and support will still be important.

Conclusions: Renewable energy technologies will play a critical role in diversifying the supply of electric energy by 2013. Many common drivers and barriers will continue to shape the renewable energy market.

United States voluntary policies to reduce GHGs

By David Kassebaum

The federal government and roughly 40 of the 50 States in the United States sponsor programs designed to reduce greenhouse gas (GHG) emissions. Various private sector organizations likewise have GHG reduction programs. These voluntary programs vary widely in scope and strength of compliance incentives. With the uncertain future of the Kyoto Protocol GHG regime, these voluntary reduction programs are becoming important methods through which GHG emissions reductions are achieved. Some programs consist of little more than generalized registries, others represent industry actors attempting to cooperatively reduce their emissions, while still others are currently voluntary projects that may soon become mandatory. This paper will examine how the voluntary programs are structured and their success to date in achieving GHG emissions reductions.

The federal government has established, through the Department of Energy, a registry of companies reporting GHG reductions, the 1605(b) registry program. Recent revisions of the guidelines, issued months late, will be described.

Several states have enacted programs directed at GHG reductions. This paper will review those programs, including those limiting CO_2 emissions, those requiring emissions reporting, and those identifying CO_2 sequestration opportunities.

The Northeastern states and the Western states have agreed on work on plans on GHG reductions, probably based on the same guidelines, which would create a common product. This paper will highlight the goals of these proposed plans and the sectors that may be effected.

Finally, private parties have begun working on several initiatives to reduce GHG emissions. Among those to be described in this paper will be the Chicago Climate Exchange, the CERES Electric Power/Investor Dialogue, and the greater disclosure of carbon risks in company financial statements.

Renewable Energy in Massachusetts: Current and Emerging Regulatory Realities

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The Massachusetts Electric Utility Restructuring Act of 1997 (MEURA) included a provision for creating a Renewable Portfolio Standard (RPS) designed to gradually increase the state's reliance on renewable energy as a percentage of its overall power use. Starting in December 2003, 1% of the electricity provided by retail electric suppliers is required to be generated from qualifying renewable sources with this amount increasing by half a percent each successive year to achieve a modest target of 4% by 2009.

Since enactment of the RPS there have been other regulations and several regulatory initiatives in the energy and environmental fields that may impact (positively and negatively) the development and use of renewable energy and technologies in Massachusetts. This paper will review the renewable energy-related features of the MEURA as well as current and emerging state and regional regulations and initiatives concerning air quality, greenhouse gas emissions, and ocean management. Finally I will examine the potential impact of these regulatory developments on the supply and demand of renewable energy, with a specific focus on wind energy.

Guidelines to Improve the Impact of Renewable Energy in the Marketplace – A Practitioner's Perspective

By Federico S. Fische

The renewable energy (RE) sector is positioned to understand that the "one size fits all" approach, used by traditional energy suppliers, is not the right answer to energy demand. Nevertheless, from the perspective of infrastructure modernization, both at micro and macro levels, commercialization of RE differentiates itself very little from traditional energy suppliers.

Demand location, profile and needs makes the selection of a technology and its design-to-implementation model site related. Yet, RE policies and programs sponsored by governments, international aid and financial organizations are mostly focused on general supply side rather than demand driven solutions.

There is room to improve the way the RE sector addresses the marketplace. Policies and programs should focus on the marketplace as a whole, rather than on the state of the art and/or the resources available for a particular application. Lending and funding instruments should asses cost/benefit and risks from the perspective of project financing, rather than the creditworthiness of the project owner(s) and the experience of the technology elsewhere. Technology should be developed in response to the market needs; technology driven products designed and developed with inadequate attention to the needs of the demand would fail in the marketplace.

The paper concludes that RE market share should thrive in an environment that values access to clean energy, engages all stakeholders and uses the adequate technology to produce the right solutions that, with the right funding, will secure access to energy, reduce poverty and advance sustainable development.

ENERGY & ENVIRONMENTAL INSECURITY: A NEW GLOBAL LEGAL RESPONSE

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Energy shortages and energy inaccessibility pose threats to the national security both of developed and developing nations. Today's global energy consumption is 12 TW and is estimated to rise to 30-40 TW by 2040. Much of this projected 300 hundredfold increase in energy demand will arise from developing countries who presently rely upon the combustion of hydrocarbons such as coal to meet their energy demands. It is incontrovertible that the sustainable development of the developing world will depend, in significant part, on the use and availability of energy, especially electricity. In light of its accessibility and plenitude, and absent other economic alternatives, many developing countries are presently relying upon, and will continue to depend upon coal, to generate electrical energy. The environmental consequences of so doing are formidable and fearsome. The extent and manner in which energy demand can be met, within the framework of sustainable development through other sources of primary energy, poses the greatest global environmental challenge of the 21st century.

Much of the international environmental law response to climate change and energy security is embodied in two conventions: the 1992 United Nations Framework Convention on Climate Change (UNFCCC), and the 1997 Kyoto Protocol of the UNFCCC . The decision of Russia not to ratify it has effectively led to the demise of Kyoto, and accentuates the pressing need for a new Protocol addressing energy. The UNFCCC has established three important interlocking international obligations: (i) stabilization of GHGs, (ii) common but differentiated responsibility (CBDR), and (iii) the right to sustainable development. In principle, these three legal obligations require developed countries, independent of their own energy predicament, to strive for a more diversified energy portfolio, and place a duty on them to promote sustainable development in the developing world. A commitment to SD requires the developed world to undertake fundamental research and development (R&D) on new technologies for producing better forms of primary energy and transfer such technologies to developing countries.

Unfortunately, the UNFCCC creates obligations of principle, as distinct from obligations of effect. These obligations cannot be enforced in the present undeveloped international legal system. It is, therefore, necessary to translate the UNFCCC obligations into concrete commitments, or obligations of effect, through a new Energy Protocol. The new Protocol should, first, set up a global infrastructure for researching and developing new technologies such as terrestrial solar and wind , tidal , geothermal, and biomass; solar power satellites; de-carbonization and sequestration of carbon dioxide from fossil fuels; nuclear fission; nuclear fusion; fission-fusion hybrid hydrogen production, storage and transport; superconducting electric grids conservation and energy efficiency. Second, it should commit to huge public and private investments in promising technologies for harnessing new primary sources of energy. Third, such new technologies should be treated as a common pool resource to which developing countries have full and free access. The Protocol should aim to delineate the modalities of achieving these objectives.

Conceding Too Much? Conflicts between the Government and Developers in Promoting the China "Wind Concession" Project Model

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Abstract

The Chinese government has recently adopted a new wind project development model referred to as a wind concession. Two pilot wind concession projects are underway in Guangdong and Jiangsu provinces. Once the model becomes national policy, all wind projects over 100 megawatts (MW) will be subject to a government-administered competitive bidding process among potential project developers. The government anticipates the wind concessions will result in lower wind power costs by forcing companies to compete to develop prime wind farm sites. This model was adopted in response to years of relatively high wind electricity tariffs in China, despite declining technology costs in the global wind turbine market. However, many wind developers in China are discontented with the new concession model. Although some recognize the benefit to relatively low-risk and high-profile projects, others are wary of the concession model due in part to a currently inflexible 100 megawatt project size and a mandated competitive bidding process that likely results in a lower profit margin than a privately-negotiated tariff. In addition, wind resource data measurements in China are scarce, and sites being selected by the government for project development may lack sufficient wind resource data to encourage rational investment. Consequently, many developers are already looking for ways to benefit from the model but not necessarily participate in it. For example, developers looking to develop large wind projects are looking to build in smaller—often less economical—increments over several years so as to avoid being subject to a competitive bidding process. This is an example of how the concession model, hoping to encourage large scale wind development and lower wind power costs, may in fact have quite the opposite effect. This paper examines the current wind concession policy model, including the two pilot projects under development, and plans to scale up the model across China. It then offers recommendations for how the concession model could be modified so that it is able to achieve the goals as initially proposed by the Chinese government.

Renewable Energy Modeling and the Policy-Making Process

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Energy modeling on the future role of renewable energy in the electricity sector influences perceptions and policy decisions among renewable energy and electricity businesses, governmental energy and environmental policy-makers and planners, technology research and development institutions, investors, consumers, and others. Energy models, including NEMS, IPM, AMIGA, MARKAL, Mini-CAM, HAIKU, and Energy 2020, are used to assess this role, by exploring the dependence of electricity market penetration of different technologies on factors ranging from natural gas price to policy incentives to environmental constraints. Issues with model structure, algorithms, and data arise when modeling renewable power, because of differences between renewable energy and fossil fuels or nuclear power. For example, renewable energy resources are widely disbursed (wind, solar, biomass), whereas exploitable fossil fuels are concentrated; renewable resources are not easily transported (especially wind, solar, geothermal, hydro, and ocean); some renewables vary in their availability on an hourly, daily, or seasonal basis; and renewables bring different market inter-relationships, with links between generation and liquid ethanol fuel, food, fisheries, rafting, and building materials. These differences are significant for the modeling of transmission, intermittence, ancillary services, and market interactions. This paper is one output from the U.S. Environmental Protection Agency/Department of Energy/National Renewable Energy Laboratory/Energy Information Administration's renewable energy modeling series, and explores the issues for modeling renewable energy and propose approaches for dealing with several of the major issues.

Status of Green Power Markets in the United States

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Voluntary consumer decisions to purchase electricity supplied from renewable energy sources represent a powerful market support mechanism for renewable energy development. Beginning in the early 1990s, a small number of U.S. utilities began offering "green power" options to their customers. Since then, these products have become more prevalent both from utilities and in states that have introduced competition into their retail electricity markets. Today, nearly 50% of all U.S. consumers have an option to purchase some type of green power product from a retail electricity provider.

Currently, more than 500 investor-owned utilities, rural electric cooperatives, and other publicly owned utilities in 33 states offer green power programs. These programs allow customers to purchase some portion of their power supply as renewable energy or to contribute funds for the utility to invest in renewable energy development. In addition, in about a dozen competitive (or restructured) retail electricity markets, electricity customers can purchase electricity generated from renewable sources by switching to an alternative electricity supplier that offers green power. Finally, any consumer can purchase green power through renewable energy certificates (RECs), which represent the unique or "green" attributes of electricity generated from renewable energy-based projects.

This paper provides an overview of green power marketing activity in the United States. It describes green power product offerings, consumer response, and recent industry trends.

The Value of Renewable Energy as a Hedge Against Fuel Price Risk

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A substantial fraction of the incremental supply needs of the electricity sector are projected to come from natural gas-fired generation. The risks inherent in this strategy have recently become obvious, as gas prices appear to have reached a new plateau and have become increasingly volatile. These events highlight the value of renewable energy (RE) as a hedge against price volatility. Results presented in this paper demonstrate that RE provides two distinct risk mitigation benefits relative to high and volatile gas prices. First, in contrast to gas-fired generation, long-term contracts for RE are typically offered on a fixed-price basis. To obtain a similar hedge with gas-fired generation (using gas forwards) over the last four years, one would have had to pay a substantial premium relative to the most commonly used gas price forecasts in the USA. We conclude that one should not blindly rely on gas price forecasts when comparing fixed-price renewable with variable-price gas-fired generation. Second, a number of studies show that aggressive RE penetration may put downward pressure on natural gas prices by easing natural gas supply pressures. Based on an evaluation of numerous studies that have looked at this effect, it is not unreasonable to expect that any increase in consumer electricity costs that are caused by RE will be substantially offset by a reduction in delivered gas prices. While additional research will be necessary to further quantify these values, it is increasingly clear that RE may offer a potent hedge against price volatility.

BARRIERS TO THE DEPLOYMENT OF RENEWABLES AROUND THE WORLD

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ABSTRACT

With a need to dynamically address the world's energy issues by renewable energy technologies, barriers to the deployment of renewables must be understood and addressed. Dynamic growth to be expected in renewable energy sectors resulting from energy dislocations, environmental issues, and security hasn't happened. New creative business partnership models are needed to overcome these dislocations.

An examination of the stages of growth of the solar electric industry shows that the next five years is possibly the period in which substantial growth could occur. Possible high growth outcomes resulting from the profitable growth of solar businesses could result in attractive investments. Additionally, economic benefit would accrue with increased job opportunities and wages for the benefit and prosperity for the people in many nations. The factors relating to enterprise success as technology, customer base, marketing, management are now available as the industry grows globally. The status of these compelling factors for growth will be discussed.

New business models are needed which focus on market sectors rather than product technologies as the principal mantra of present business approaches. The new business models should include those companies which are in the forefront of the markets to be penetrated.

This paper will discuss the types of new partnership models which should be developed. Organizational structures and financing aspects will be included in the presentation.

Modeling Renewable Energy Systems and Policies – Challenges and Approaches

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Most models of capacity expansion in the electric sector at the regional or national level were developed to accommodate the attributes of the technologies that are the current major contributors to that market – fossil-fired generators and nuclear. Renewable electric technologies (RETs) possess several critical attributes that are generally not easily captured by these models. In particular, the cost and performance of RETs can be highly site specific; the conversion system must usually be located at the resource site, as the resource itself cannot be transported; and the resource may vary on a seasonal, daily or hourly basis, etc. To capture these attributes for wind turbines, NREL has developed the **W**ind **D**eployment **S**ystem (**W**in**DS**) model. **W**in**DS** is a capacity expansion model for the U.S. electric sector with over 350 regions that allow the simulation of site-specific economics and energy transport issues for wind. Also, **W**in**DS** includes a detailed probabilistic treatment of the intermittent nature of the wind resource and its value within the electric grid. This model is now being used to assess the impacts of various possible federal policies and programs, including extension of the federal production tax credit, carbon taxes and caps, offshore wind permitting, and accelerated R&D efforts on wind. This paper will briefly summarize the **W**in**DS** model structure and assumptions and present some of the major findings to date.

The Economics of a Transition to Greater Use of Renewables in the United States

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Renewable power systems are generally considered to be a more expensive option for generating electricity than conventional power technologies. While many people would like to realize the environmental and resource access benefits of renewables, this economic difference is delaying the start of a major transition to their greater use. This paper presents a simple analysis of the economics of initiating such a transition. The transition that is analyzed is based on adopting increasing levels of renewables as power generation plants are replaced or added. The timeframe for the analysis is now to 2025. The analysis uses EIA data for net power additions or replacements and for costs for conventional power systems. It uses cost and performance data from DOE and EPRI for renewable power systems. The results will indicate that the costs of a transition to high levels of renewables adoptions – over 50% of capacity additions and replacements by 2025 – will result in only a relatively minor change in the overall economics of the electricity sector in the U.S. Moreover, while the total annual electricity bill will increase slightly in the middle of the period, it will decrease by the end of the period.

This presentation also will provide results of some other analyses of the economic impacts of transitioning to significantly greater use of renewables.

GRID-CONNECTED PV CAPACITY FROM STATE RENEWABLE PORTFOLIO STANDARDS IN THE USA BY 2025

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ABSTRACT

Over the past decade, a number of states recognizing have embraced policies and programs that support the development of grid-connected photovoltaics (gc-PV). The most widespread and promising policies for gc-PV are net-metering, financial incentives, and renewable portfolio standards (RPS). These state-based policies are driving the installed capacity growth of gc-PV in the USA. RPSs hold the greatest potential for increasing the installed capacity of gc-PV in the USA over the next two decades. The analysis performed in this paper shows that gc-PV being installed to satisfy state RPSs at minimal, moderate, and aggressive levels produce significant amounts of gc-PV capacity in the USA by 2025. The aggressive scenario projects 21.4 GW of gc-PV capacity by 2025 as a result of the thirty-two current legislated and introduced state RPS policies. A regional analysis shows that the greatest amount of gc-PV from state RPS policies is likely to occur in the East North Central, Mid Atlantic, and Pacific regions of the USA.

Renewable Policies: A Proposed Taxonomy

John Millhone

The paper proposes a taxonomy for comparing national, state, and/or regional renewable energy policies. The initial, underlying requirement is an assessment of the area's unique mix of renewable energy resources. Building on this understanding, the policy components include: 1) Establishing a goal or goals, a metric for measuring progress toward the goal(s), a roadmap for achieving the goal, and regular evaluations, policy reviews and modifications; 2) Conducting RD&D to introduce advanced technologies, to lower costs, and/or to develop products that meet the area's market conditions; 3) Establishing mandatory requirements, including product performance standards and class-average measures such as renewable energy portfolio standards; and 4) Initiating market transformation measures to overcome barriers, including financing, information, and publicity barriers, e.g. campaigns that increase public awareness of the economic, environmental and security benefits of renewable energy. These strategies would be tailored to the differences between developed and developing countries. The taxonomy would need to be transparent, objectivity, and supported by the renewable energy community. The goal would be to produce a yardstick that could be used by policymakers to assist them in designing and implementing comprehensive and effective programs.

PROSPECTS FOR RENEWABLES IN THE NEW MEMBER STATES

By Anca-Diana Barbu, Martine Uyterlinde and Hage De Vries

The paper aims to provide a brief overview of risk factors likely to affect future investments in renewable energy sources in the New Member States. The analysis is based on the ADMIRE_REBUS model, previously developed to investigate prospects for renewable energy sources (RES) in current EU Member States.
Preliminary model runs for the New Member States show that these countries have the potential to become sellers of green electricity. However, the future development of RES systems is likely to be closely linked with the pace of further reforms in the energy sector, financial sector and other related sectors of the economy (e.g. agriculture, environment, etc).
Reforms in the energy sector are expected to alter significantly the electricity pricing, the consumer behaviour or even the future structure of the energy system.
Political and policy reforms aiming at strengthening the ability of local actors to conduct energy planning activities, to transpose national RES targets into local ones and actively participate in project preparation, development and monitoring seem to be crucial in attracting the much needed foreign investment.
Finally, the macroeconomic conditions and the ability of CEE governments to maintain a stable economic and politic environment will have a say in the cost of financing RES projects in the region.
All the above mentioned factors as the analysis suggests, may affect quite significantly the lead times, transaction costs and the project revenue of future RES projects in the New Member States.

Could Large Hydro Sink Renewable Energy Expansion? Twelve Reasons to Exclude Large Hydro from Renewables Initiatives

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• Purpose of the work

This paper will outline the factors that have encouraged the expansion of large hydro in recent years; and how this situation will negatively impact the potential for expansion of new renewables and sustainable development. Realizing the potential of new renewable energy technologies is vital if we are to achieve the UN's Millennium Development Goals of halving extreme poverty and hunger by 2015 and reversing environmental degradation. The urgent need to address these challenges has led to various international initiatives to promote the use of renewable energies. These initiatives could be counterproductive if, as the dam industry is advocating, they are turned into instruments to promote large-scale hydropower projects. Large hydropower dams are increasingly being incorporated into sustainable development projects alongside wind, solar and geothermal energy generating technologies. The wording "renewable energy technologies, hydro included" appears in the Plan of Implementation that came out of the World Summit on Sustainable Development (WSSD) in Johannesburg. The International Hydropower Association, World Bank, and other promoters of large hydro are now using the WSSD wording to lobby for large hydro to benefit from renewables initiatives. However, large hydro does not support sustainable development in the developing world, nor help meet the UN's Millennium Development Goals because it does not reduce the environmental impact of energy production and consumption, or does not enhance energy security. Large hydro also threatens to capture the bulk of special funds aimed at promoting renewables, hindering the spread of clean and sustainable technologies. Therefore in this paper, we will argue that it is thus imperative that large hydro be excluded from any initiatives to promote renewable energy technologies, such as the Johannesburg Renewable Energy Coalition or the Kyoto Protocol's carbon trading schemes.

• Conclusions

Realizing the potential of "new renewables" is vital if we are to achieve the UN's Millennium Development Goals of halving extreme poverty and hunger by 2015 and reversing environmental degradation.

Electric Cooperative Success with Renewable Energy

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In the United States of America a national network of 930 cooperative businesses has been established and operating for more than sixty years to bring electric service to rural locals. These not-for-profit utilities spread across 47 states, serving 70% of the countries landmass are seeking alternative technologies for providing energy to their 36 million consumer-owners. This group of privately owned businesses is working to expand their production and delivery of renewable power, giving the cooperative consumer-owners more choices in energy sources. Even with various financial constraints electric cooperatives have expanded their non-hydroelectric renewable generation capacity to more than 100,000 kilowatts. Even more renewable resources will start delivering power or will be in construction during 2004. Electric cooperatives are focusing on developing renewable energy from sources such as wind, solar and biomass resources.

Beyond the generation actually owned by electric cooperatives purchases are made from other renewable energy sources. Electric cooperatives across the country recognize the value of renewable resources in their power supply portfolios. In 2003, electric cooperatives purchased more than 275 megawatts (MW) of energy from renewable sources operated by various developers.

There are many obstacles to increasing renewable energy sources that must be addressed with practical solutions that will provide reliable and affordable power generation in the USA. As electric cooperatives strive to develop new technologies, their current goal for generation of "green power" is to remain reliable and affordable while meeting the needs of their consumer-owners.

The Solar Thermal Programme in India

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The solar thermal programme in India began in the mid-seventies with some R&D projects relating to materials and devices. A whole range of devices such as flat plate collectors, water heating systems, solar cookers, dryers and stills were developed and brought to commercial production. The deployment of these systems was supported through Government subsidies till 1994. Since then, the Ministry of Non-Conventional Energy Sources has been implementing soft loan programmes to help the propagation of solar thermal systems. The Ministry also supports research activities and demonstration projects for the introduction of newer technologies. These efforts have led to the installation of over 750, 000 sq.m of collector area for water heating as well as the two largest solar steam cooking systems in the world. Several interesting projects relating to solar drying have also been completed.

National standards have been notified for solar thermal collectors and box-type solar cookers. The Ministry has set up test facilities at 7 locations to assist industry in obtaining certification according to these standards. Over 60 companies have so far received certification. The Ministry is also implementing a programme to support the construction of buildings with solar passive features.

The Government of India has taken up a project for the establishment of a 140 MW integrated cycle solar thermal power plant in the state of Rajasthan with assistance from the Global Environment Facility and KfW of Germany. The plant will be based on parabolic trough collectors and is projected for completion in 2007. The details of this project and other activities pertaining to the solar thermal programme are provided in the paper.

Redefining Fiduciary Responsibilities: The Convergence of Public Policy and Fiduciary Responsibilities in Support of Renewable Energy Technologies

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We analyze and report on increasing convergence of public stewardship and fiduciary responsibilities with particular emphasis on clean energy technology support. Recent studies indicate increasing interest in quantification of social and environmental benefits of renewable energy and energy efficiency technologies, including job growth, tax revenue, and health impacts. U.S. State policy makers and fiduciaries have begun to redefine public policies and investment policies for state pension endowments in response to these analyses. The report will highlight a number of examples and provide a summary of quantification approaches and public policies that have been implemented to date.

Financing Options for Clean Development Mechanism Projects

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ABSTRACT

Clean Development Mechanism (CDM) is defined in the Kyoto Protocol, which seeks to encourage joint efforts between developed and developing countries to reduce greenhouse gas emissions through project-based activities. I assess the likely role of the financial institutions in the financing of CDM projects.

The study has been conducted through a combination of semi-structured interviews and structured questionnaire-based survey. The findings indicate that private sector financial institutions prefer to finance large-scale CDM projects through the project finance route. Private sector financial institutions, by adopting a project finance route in funding CDM projects, exhibit risk-averse behaviour. This aspect alludes to the fact that small-scale CDM projects need to be financed by exploring internal financing mechanisms (of corporations), for which project sponsors alone bear the risks and benefits of their investments in CDM projects. CDM is still not a widely articulated commercial concept among the financial institutions. The crucial issue of the effect of carbon prices on CDM project financial indicators does not appear to affect the lending decision of the financial institutions. However, CDM 'facilitators' such as consulting organizations and research institutions show promise in the propagation of the CDM.

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THE STATUS OF RENEWABLE ENERGY CERTIFICATES IN THE USA

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Renewable energy certificates (TRCs) first entered the US Energy market in 2000 with the formation of the Bonneville Environmental Foundation's (BEF) Green Tag program, and in California's competitive wholesale electricity market with "Green Tickets" issued and sold through the Automated Power Exchange (APX). In May 2000, the U.S. Environmental Protection Agency became the first institutional purchaser of TRCs when it entered into an agreement with the Bonneville Environmental Foundation (BEF) to purchase power from new wind resources to supply a portion of the agency's Northwest power needs. Since that early purchase of 2,100 MWhs of renewable tags in 2000, the U.S. TRC market has come a long way. In 2003, the voluntary TRC market sold more than 1.8 million MWh of certificates. The largest purchasers of renewable certificates are commercial, industrial, and institutional customers who in 2003 comprised 95 percent of the Green-e certified TRC retail sales.

How is this market expanding so rapidly? What are the tools that are supporting these impressive growth numbers? And what are the new markets and products that make the sale of renewable energy certificates one of the most exciting renewable energy markets in the U.S. today? This paper provides a survey of the history of TRC growth in the U.S., a description of the renewable certificate tracking systems that have been developed and are under development as well as a look into new markets and innovative products that are helping to fuel TRC growth.

An Experiment on Solar Eight-Effect Desalination

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Abstract

An Experimental Solar Eight-Effect Desalination system is introduced in this paper. An yield of 100kg/h, and performance ratio of 6.4, is achieved under a heat supply of 35.52MJ/h. The salinity of sea water is 35000ppm, while the designed salinity of fresh water is less than 450ppm.

The working hot water is supplied by all-glass evacuated tubular collectors. The heat-collecting efficiency reaches around 35% at a working hot water temperature around 90°C. The total area of the solar heat collector is 69.4m^2 Under an irradiance of 800W/m^2, heat supplied to the distiller by a heat collector of 35 m^2 is about 38.55MJ/h.. The redundant heat is store in a water tank for use after sunset. In the experiment, when the sea water temperature is 20°C and the sea water flow is 420 kg/h, the distilled water yield are 85.1 kg/h, 90.0 kg/h and 95.6 kg/h at working water temperature of 78°C, 81°C, and 83°C at the first-effect, respectively. When the sea water temperature is 19°C and the sea water flow 560 kg/h, the distilled water yield becomes 95.5 kg/h, 99.6 kg/h and 104 kg/h at working water temperature of 76°C, 77°C, and 78°C at first-effect respectively. The purity of distilled water is better than 130ppm。

Modular Solar Thermal Desalination System with Flat Plate Collector

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This contribution presents the experimental results of a solar desalination system to produce potable water for drinking purposes from either sea or salty ground water. This system consists of two components: a flat plate solar collector, and a desalination tower with multiple heat recovery stages.
The flat plate solar collector can be used in either direct or indirect heating mode. In the first case, the water that runs through the collector absorber is the condensate produced in the desalination tower. It is circulating to the first evaporator stage by natural convection. Here it transfers its energy to the first seawater stage atop of it. Condensate which is produced in this and the following stages by heat recovery drips down to the first evaporator. The collected condensate goes over an overflow down to a clean water tank.
In the indirect heating, solar radiation is absorbed in the collector and transferred to a thermal oil flux, which transport this heat to a mass of salty water in the desalination tower. The heat transfer takes place in a heat-exchanger at the lowest level, or the first stage in the desalination tower. Two units were built and tested, one for each heating mode. The desalination tower has six stages and a water flushing system to avoid the concentration of salt. The results show the good system thermal performance, and that improvements can be made to reach even higher potable water production rates. The water laboratory test results (polluted sea water and salty well water) show that the desalination process eliminates all Coli form group bacteria. Thus, with the addition of appropriate minerals, the water can be used as drinking water.

DESIGN STUDY OF A WALL MOUNTED SOLAR STILL

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ABSTRACT

Proposed wall mounted solar still is a three basin solar still with parabolic reflector and mirror. The solar still is so designed to receive maximum insolation for the same effective area of solar still.

The still is made south facing to receive maximum solar radiation with the inclination for the glass to be latitude minus 15 degrees which works out to be approximately 15^o. Inclination of all the basins is made at 5^o so that water can be collected at one side under the effect of gravitation and surface tension. Height, width and length of the still at ground are fixed at 1.5m, 1.2m and 0.8m respectively. Once these design parameters of solar still are known area and height of basin is decided using sun path diagram and using shadow coefficient. Knowing the azimuth and altitude of the sun at each time the horizontal shadow angle and vertical shadow angle can be calculated which would be used in determining the depth and width of the basin. This can be used to calculate the shadow of the basins used in solar still which in turn determines the shadow coefficient. The dimensions of the basins can be optimized for the minimum value of shadow coefficient.

In the proposed design top, south and east facing surfaces of the solar still are made transparent unlike conventional solar still in which only top surface is made transparent. As an advantage now same area of a solar still can gather high amount of solar energy as a result better augmentation energy ratio is achieved.

Design and Sizing of Solar Powered Desalination and Pumping Unit for Brackish Water in Jordan

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Many small rural communities in Jordan, the Middle East and Northern Africa (MENA) lack access to electricity and potable water. It is also true that many of these communities can access underground brackish water resources, much of it with salinity levels in the range of 3,000 to 8,000 ppm. By taking advantage of the high insolation in these areas, photovoltaic systems can be used as power supply source for pumping and desalination of brackish water, thus improving the health and sanitation conditions of the target groups. In the framework of a regional cooperation between USA, Israel, Jordan, and the Palestinian Authority, Jordan has received two desalination units. The first unit is a US-military RO-desalination unit (ROWPU), producing 16 gpm of fresh water and operated with diesel generator. The second unit designed for brackish water also produces 16 gpm fresh water, and is accompanied by a complete PV system. This paper describes the water situation in Jordan, the potential of solar radiation in the area, site selection criteria, and the designing and sizing of a photovoltaic power supply system for the second RO-desalination unit. Also the paper contains measurement and evaluation data concerning the water quality, energy consumption and efficiency of the (ROWPU), which has been installed and operated in the village of Qatar in Jordan.

Economic Viability of Renewable Energy Driven Desalination Systems in Remote Communities

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Abstract
Desalination can be advantageous in terms of economic costs and environmental impact, compared to the transportation of water in remote communities such as in islands regions. The large energy requirements of desalination systems, that are traditionally supplied by conventional energy sources (fossil fuels and electricity), consist a major drawback. The use of Renewable Energy Sources (wind and solar) as an optional power source for desalination systems have been extensively discussed in the literature as an innovative approach to desalinate water economically and in an environmentally friendly manner. In the present paper the economic barriers for the implementation of such systems in remote communities is discussed. A techno economic model is utilised in order to examine the economic viability of RES-desalination coupling schemes and to identify the major economic drawbacks. The model is taking into account the available RES potential and the requested water demand and optimises the RES-desalination coupling configuration for maximum economic efficiency. The model was developed in the context of REDDES project.

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Feasibility Study of a Pressure Retarded Osmosis Plant for Electricity Production in Tunisia

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ABSTRACT

Tunisian Energy sources are being depleted due to the scarcity of gas and petrol while energy needs are growing rapidly. Therefore alternative sources of energy must be developed in order to ensure future supplies. Besides the potential for solar energy, Tunisia has a 1200 km coast along the Mediterranean Sea where of the population is located and tourism is important to the economy.

Energy can be obtained from the mixing of salt and fresh waters. The quantity of energy available from salt and fresh water mixing is estimated to be over half of the earth's hydropower and it is believed that this is one of the few renewable resources that can be realized within the near future. Using a selective membrane, the fresh water will flow through to the other side of the membrane where sea water is present. The pressure created is released by water flowing through a turbine. Energy production is proportional to the difference in concentration between fresh and seawater.

Due to the high salinity of the Mediterranean sea (36 to 40 g/l of salt), the coast could constitute an ideal location to investigate salinity powered plants.

A feasibility study was performed for a 1 MW electricity generating power plant. Optimization of the power depends upon several different parameters including membrane characteristics and area. It was determined that a membrane surface larger than 1000 m^2 would be required.

This paper will present the full results of the feasibility study of the plant.

ZERO DISCHARGE WASTE BRINE MANAGEMENT FOR SOLAR DESALINATION PLANTS

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Desalination of brackish water at inland locations must consider environmentally appropriate and cost effective brine concentrate management and/or disposal. The Zero Discharge Waste Brine Management for Desalination Plants concept consists of a systems approach for desalination/brine management via a Salinity Gradient Solar Pond (SGSP) coupled with a Brine Concentration and Recovery System (BCRS). The BCRS was tested over broad range of operational conditions (salinity, ambient temperature, relative humidity and brine temperature) with the thermal energy derived from a SGSP operated by the University of Texas at El Paso. The relationship between system performance and operating conditions was analyzed to determine the economic and technical viability of the BCRS technology. Mathematical and computer models have been developed to describe the physical behavior of the BCRS and to predict its performance. The results concern the evaporation rate, freshwater production rate and the energy consumption rate. It is found, for example that the evaporation flow rate can reach 605 LPH and the freshwater production rate is of 70 LPH for an average conditions set of 28.7 °C ambient temperature, 9.3 kg/s mass flow rate of hot air, 9.4 kg/s mass flow rate of cold air, 5.2 kg/s mass flow rate of freshwater, a specific electrical power of 0.183 kWh/kg and 9.4 KWh/kg of thermal power provided by the solar pond.

Evaluation of Ballast Water Separator Performance For Solid Particulate Removal

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ABSTRACT

During the last decade an increase attention had been given the Ballast Water problem world wide. In this research, the different aspects of this problem are been briefly addressed and reviewed with special attached to the ballast water separator. Locally designed separator was under investigation to evaluate its performance in the removal of solid particulates at various operating conditions such as changing the position of the internal tube head and varying the inlet mass flow rate. Three particle sizes were used to test the separator performance and determine the best operating condition which gives the highest efficiency.

Keywords: Ballast Water Systems, Evaluation Performance, Solid Particulate Removal, coastal pollution

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Assessment and Control of Risk within Renewable Energy Systems

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Key Words: Hard and Soft Systems, Complexity, Hazard, Risk, Evidence, Systems Approach

Problems related to renewable energy systems are very complex. They comprise the traditional hard components, e.g. physical, technical, etc. and soft components as well, e.g. environmental, social, political, etc. In fact, the first ones are embedded in the latter.

Systems risk assessment is the result of the joint effect of the reliability of each part and depends on the interactions and dependences among them.

Sophisticated and successful techniques are used to predict and control hard characteristics while soft ones, due to their nature, are very difficult to assess.

A realistic assessment and control of risk should take both into account. A model based on a systems approach and Fuzzy Logic is proposed here, where each process is a part and a whole in itself.

The state of the processes is defined through a set of attributes and evaluated using the available evidence. Different types of hazard can therefore be identified and risk can be eliminated or reduced.

Prediction of emissions in turbojet engines exhausts: Relationship between emission of nitric oxide index (EI_{NOx}) and the operational parameters: fuel flow rate, output power, efficiency, compression ratio, flame temperature and inlet temperature.

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Abstract

The prediction of emissions in turbojet engines exhausts remains a field of great importance, considering the more and more coercive environmental requirements in relation with the pollution of air due to the combustion in turbojet engines. The emissions of nitric oxides (NOx) are submitted to limits fixed by the legislator in a lot of countries, because of their toxic character beyond some concentrations in the air and their effects on climate change. However, the analytic methods of determination of the quantities of the emissions are not perfectly finalized, because of a lack of complete understanding of the phenomena governing the formation of the NOx. The mechanism is a combination of chemical, thermo and fluid dynamical phenomena. It is presented in this work a semi empiric correlation permitting to predict the nitric oxide emission index EI_{NOx} in turbojet engines exhausts, once the main turbojet engine combustor operational parameters are known. The relationship between EI_{NOx} and the most important parameters in NOx production in turbojet engines can allow NOx pollution reduction. The relationship between EI_{NOx} and the following parameters (fuel flow rate, output power, pressure ratio, efficiency, flame temperature and inlet temperature) has been studied on 227 ICAO data [1] measured on turbojets engines from manufacturers such as **Pratt and Whitney, General Electric, CFM International, Roll Royce**. The 556 data used in flame and inlet temperature relationship with NOx emission index have been taken from G.F. Pearce et al [3] work on five turbojet engines. From this work one can observed that the relationship between EI_{NOx} and flame temperature has the highest index of correlation, the relationship between EI_{NOx} and the combustor inlet temperature is nearly the same. Since the combustor inlet temperature is easier to measure, EI_{NOx} value can be known from it. Predicting NOx emission from combustor inlet temperature can avoid exhausts gas measurement and analyses, so doing time and money can be save.

SOLAR ART PERFORMANCES AND PUBLIC AWARENESS

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This proposed presentation describes solar art performances shown by Huth Solar Performance from january 2000 until november 2003 all over Germany. Solar art performances show solar energy in action, creating new experiences and interaction possibilities for all visitors.

The solar art performances will be presented with the help of telling pictures and two short sequences of TV news coverage on those performances (5 min). There will be a focus on how the solar art performances help creating a new public awareness of fascinating possibilities of solar energies role in the future. Some of the future projects of Huth Solar Performance are discussed.

Here follow 3 examples of solar art performances:

1. Sonnenwende Turning Heads
This performance consists of 100 polystyrol heads of natural size that are professionally produced. Each head is driven by an electric motor connected to a single solar cell (Si-crystalline 100x100mm). Spread on an outdoor square, those heads keep turning the whole day with 5-10 seconds for one turn. This creates an impressive overall view. Many thousands of visitors took advantage of the opportunity to touch a solar cell: They were putting shadows on it and watching the turning head to be stopped only with carefully excluding any daylight from the cell. This experience is most surprising to the visitors. Sonnenwende Turning Heads has been shown in Bremen, Hannover, Osnabrück, Munich, Potsdam and in front of Brandenburg Gate in Berlin. (Sonnenwende is the german expresion for solstice.)

2. Solar Power Demonstration / Solar Tug-Of-War
This performance consists of 11 solar modules (Si-crystalline, 100 Watt each) and a rope-winding electric motor directly connected to them. Each module was placed in a stative allowing a manual position change along two axis. Up to 15 visitors fight together against the power of sunlight tugging the rope. This performance was shown from 21.4.–7.10.2001 at the big gardening exhibtion in Potsdam and was visited by more than 80.000 people.
The interesting thing to be observed was that visitors of all ages were eager to try out their power against the sunlight. Many visitors were inspired to imagine 11 or more solar modules on the roof of their houses.

2.3 Solar Sound/Solar Gong
An excellent chinese gong was placed into a wooden stative. The hammer moved up slowly, driven by an electric motor connected to a single solar cell (Si-crystalline, 100x100mm). At a certain height, the hammer falls back and the sound is heard widely.
This rather dramatic effect caused by a single cell often served as introduction for interaction with visitors. The solar gong was shown in Berlin, Magdeburg, Hannover and Potsdam.

Besides those solar art performances, there are the solar-shadow-game, the solar umbrella and another solar sound installation.

FUEL CELLS - past, present and future

by **Paul R.Brenner,** M.Sc.E.E., WREC Member, IEEE SM
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Starting with a new view on ancient issues, the article presents some aspects concerning the basic mechanisms in fuel cells, some types of fuel cells and their implementations as backup sources in diverse utilities: spaceships, military utilities, small electricity and heat power stations, remote consumers, working coupled with gas-turbines for electricity production, in primarily grid-supplied consumers (as backup for daily peaks covering), vehicles, computers, telecommunications, etc.
The "Regenesys" Project, even interrupted, and other planned fuel cells projects are also mentioned in the article.

THE ENERGY OF THE PYRAMIDS

by Paul R.Brenner

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This article was written with the aim to present some historical links concerning presumptive renewable energies' use in the far past of our civilization. Beginning with mythical and religious representations and symbols, artistically fashioned in sacred sites and manuscripts, continuing with scientifical works of the antiquity and culminating with modern theories, experiments and interpretations of ancient secrets, the present work is not only a simple enumeration of facts and ideas.

It aspire to be a source of questions, many of them having perhaps their material answers buried under 1400m of Antarctic ice, in the sandy bottom of the South China Sea or anywhere else. Who were these marvelous people which build the pyramids using quite (or perhaps really) magical technologies? ***And, after all, which were their (renewable) energy resources ? AND, LAST BUT NOT LEAST, HOW COULD A PYRAMID BECOME ITSELF A SOURCE OF RENEWABLE ENERGY ???????????***

Solar assisted "intelligent" houses - a modern implementation of automation and computers in householding electrical installations

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Continuing the idea of the necessity to reduce the energy consumption, presented in other WREN Congresses, the author refers now to a computerized house, which can be managed by automatic systems, using a PC, a laptop or a telephone. Diverse functions, like lights switching, garage gate opening or closing, window-shades operation, room heating, air conditioning, burglar alarms, etc. can be easily controlled using computers. The article shows a general schema of such a house, with its power and lighting circuits, which are controlled by diverse switches, operated by signals produced by adequate transducers. Despite the commodity offered by this automatization, automatic devices must be regarded as not 100% perfect and therefore manually disconnection of heating or cooking devices, etc., is however recommended before leaving the house.

Pressure into Power: Energy Recovery and Power Generation Through Pressure Regulation & Gas Expansion.

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Pressure into Power (PiP): the purpose is to recover energy and generate electricity from natural gas pressure reduction: e.g. at metering & regulation stations and gas distribution city gates. The approximate average daily consumption of natural gas in the US is greater than 60 billion SCF, nearly all of which at some point passes through compressors - in order to raise it to a high pressure and push the gas down the pipelines. When the natural gas gets close to its end destination (e.g. city, process plant or refinery) approximately 75% of this high pressure 60 BSCF per day gas will need to be reduced by more than half, to meet local requirements. All current pressure reduction is achieved using isenthalpic ball valves systems or regulators. Since neither ball valves nor regulators have any mechanism to drive rotational movement and a generator, vast amounts of potential energy is currently not being recovered when pressure reduction occurs.

By using a modified reciprocating piston steam engine to expand natural gas instead of steam, natural gas pressure reduction can be achieved whilst simultaneously generating electricity - by driving a generator with the nearly isentropic expansion engine. Using this approach, it is estimated that currently more than 1000 MW of electrical capacity awaits recovery within the US alone.

Further more, the temperature of natural gas drops whenever its pressure is reduced, but the natural gas industry needs to keep its gas temperatures above 32F to prevent damage to their pipeline systems. Therefore as a necessary part of operations, a certain amount of the on site natural gas is burnt for purposes of preheating. An alternative perspective is that, in practical terms, all preheating energy is lost with ball valve systems as compared with expansion engine systems where it is converted into electricity, with efficiencies >75% (as measured MW of electricity generated divided by MW of gas consumed). Whereas the best natural gas power station in the world is only 60% efficient.

Since pressure into power relies upon gas distribution it automatically is distributed generation and will generate power close to locations of large power consumption.

Automatic Sun Path Tracking System

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Abstract

Recently, solar energy has become an important issue, simply because of decrease and limited nonrenewable energy sources, such as oil, and natural gas and also due to environmental pollution that may occur from these energy sources Photovoltaic cells are widely used as means of generation of electric energy.

This work aims to develop active sun tracking system based on a microcontroller. The system consists of two main parts; hardware and software, the hardware is that of mechanical and electronic parts, where the mechanical section has a horizontal and a vertical axle, the software operates in the Microsoft Windows environment, a simple graphic display indicating the sun position is also incorporated

Two mathematical equations were used to compute the solar altitude angle (α) and the horizon angle (Azimuth γ), and hence to drive the electronic circuit to change the position of the solar cell by changing the polarity of two motors, whereas the usage of the fixed solar cells does not accomplish the desired object, that means fixed solar cells does not grant a suitable output during a day and season, where the sun position differs at the morning to the noon and at sunrise to the setting of the sun. The solar cell was controlled vertically and horizontally at period equal to one hour, and so the stored data that donate the sun position was computed each hour from sunrise to sunset. The amount of the stored data is different from a day to another; this variation is produced by the difference of day length during the year, whereas the computed data at the summer is more than of that at winter time. The microcontroller vouches for processing that data and issues the commands to actuators to change the solar cell's position.

The tracking system can automatically track the sun to accuracy better than 2^o and maximizes the sun's available energy by capturing as much as 35% more sun light than fixed solar electric system.

TOWARDS SUSTAINABLE STATE ENERGY POLICIES
The Promise of Combined Heat and Power and Distributed Energy Systems

John Mathews, University of Massachusetts, June 2004

The author recommends that States embark on sustainable energy programs that promote the innovation and deployment throughout their economies of combined heat and power (CHP) technologies and distributed energy (DE) systems. Using a systematic approach to analyze the markets for low carbon energy (LCE), the paper recommends that States further liberalize their regulatory regimes, create economic market incentives, improve market structures and institutions, and plan for a new horizon in a post-deregulated energy market. The author believes that State governments should design public policies to mitigate the impacts of fossil fuel energy on public health, ecological systems and the environment, and on the stability of the global climate.

LCE technologies satisfy many requirements in the industrial, commercial, institutional, and energy sectors of State economies for reliable, environmentally compatible, and low cost energy. Governments must be assured that low carbon energy technologies are chosen by industry as it replaces older, retired facilities. To make a significant contribution towards this goal, the author recommends policies that promote the use of new CHP technologies and DE systems. These technologies hold the promise of producing less greenhouse gas emissions per unit of energy consumed than other fossil-fueled energy sources.

The economic and technical merits of LCE technologies are well known in the European Union and the United States, but sectoral growth has declined over the last several years. The author compared market failures in the energy sectors of the US and EU to analyze the integrated systems of policy dimensions influencing the supply and demand for low carbon energy. Market barriers hinder development of CHP and DE technologies, but alternative policy designs can overcome these barriers in each of four strategic market systems comprising the low carbon energy sector – the political, technology demand and supply, and market learning systems.

By reducing market barriers, the author finds that governments can create new pathways that encourage superior energy technologies to emerge. The author recommends policy designs that reduce the demand for fossil fuel combustion by encouraging the use of more efficient, low carbon energy technologies. This approach to futurism directs the market towards technological and systemic innovation, thus enabling the energy sector to better address the significant problems of irreplaceable natural resource depletion and global climate change that future generations in the next century and beyond must overcome.

The author recommends that States pursue sustainable energy policies that formally adopt low carbon energy technologies and programs within the larger context of renewable energy, sustainable economic development, ecological and environmental protection, and global climate change. Coal and oil reserves are being depleted faster than economical energy alternatives are being developed and commercialized. Therefore, proposed policies encourage an accelerated pace of innovation and market deployment for low carbon energy technologies to reduce the consumption rate of fossil fuels. This allows the market time to explore alternative energy resources. Also, by expanding markets for CHP and DE, States will significantly improve human health, reduce the effects of carbon fuel combustion on ecological systems and the global environment, and preserve the welfare of their societies, now and for generations to come.

John Mathews is a registered Professional Engineer and writes on low carbon energy policy, planning, and economics. He received his Masters in energy policy and administration from the Center for Public Policy and Administration at the University of Massachusetts, Amherst, and a Bachelors of Science degree from Worcester Polytechnic Institute. He is currently managing a $97 CHP project for the University of Massachusetts.

FOLLOW THE YELLOW BRICK ROAD: A MODEL FOR ENERGY AND COMMUNITY RESTORATION

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ABSTRACT

This paper describes the energy plan for implementation, interconnection, and integration of a community renewable energy system built upon the utilization of efficiency, sophisticated controls, solar and biomass gasification CHP, in connection with a "new urbanism" restoration of historic buildings at a place called The Village at Grand Traverse Commons (GT Commons). This plan and project will be a model for "whole community" energy redevelopment of abandoned buildings. The GT Commons is a historic restoration project returning nearly 1 million ft^2/93,000 m^2 of residential, commercial and community space and parks (200+ acres/84+ hectares) back to life. Yellow bricks, manufactured locally, over 120 years ago, will pave the new paths leading through and from the GT Commons. At the heart of the restoration is Building 52, the old power plant which once pumped heat and electricity to 4,000 occupants of the former Traverse City State Hospital. A planned 6 mWe wood gasification CHP plant will be one new energy "heart" and "brain" interconnected to the commons, a micro-utility and municipal utility with sophisticate controls. The goal of this plan will be "metered results," when 100% net R-E generation is accounted for by biomass, wind, solar, efficiency, energy storage, and sophisticated monitoring and control systems. The plan will be "breaking out of the box" with unique <u>local</u> public and utility policy, and new interconnection, financing and operational frameworks with the establishment of a micro-utility at the Commons. With this plan we can say like Dorothy, "there's the Emerald City, we're almost there!"

THERMAL PERFORMANCE OF SOLAR THERMOCHEMICAL RECEIVER

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ABSTRACT.

The objective of this work is to obtain the temperature and concentration profiles from a solar fluidized bed reactor used like solar energy receiver in a thermochemical storage system. The complex phenomena that have to be in these reactors make difficult their design and sizing for solar applications. One of the present phenomena is the change of the empty fraction in the one which we concentrate our attention. This work proposes an alternative in the modeling of these systems, it considering the local fluctuations of the empty fraction or porosity in the bed. Is proposed a probabilistic distribution with uniform probability for all nodes in the mesh, where are associated local porosity values. The empty fraction plays an important role due to the fact that the breakthrough of the solar radiation in these opaque body systems depends directly of the empty space distribution in the path on the incident radiation that affects its thermal and kinetic performance. Is accomplished a sensibility study. It is modeling a solar fluidized bed reactor that involves a chemistry reaction reversible of thermal dissociation of the Zinc sulfate ($ZnSO4$), proposed as thermochemical storage agent of solar energy. From results can be observed the condition not isothermal in the reactor it gives as result a scattered concentration and temperature profiles. The empty fraction is a parameter that influences strongly on these profiles and increases sensibly the reaction time.

THERMAL PERFORMANCE OF A COMPOSED ABSORBER TUBE

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ABSTRACT

The utilization of the solar energy currently implies high costs of generation in thermosolars plants, that includes aspects like efficiency decrease in primary engines, transforming of solar energy to mechanic or electric energy, especially in the generation power, as in small power plants. One of proposals to reduce costs in the power generation by means of PTC, it is the direct generation of steam in the concentrator pipe. This proposal implies simultaneously the study of combination of materials that could sustain the thermal and pressure efforts during the phase change of the work fluid (water). In this work is presented the analysis of a concentrator pipe compound two materials copper and steel, walls, formed by commercial copper pipes type k. It is model was solved numerically. The thermal efforts that are generating, causative of the deformation of tubes in systems of concentration were modeling. The System presents the higher temperature gradient of 10 °C, with a liquid level of 50% is less favorable than with a liquid level of 100%.

THE LIGHTPYRAMID PROJECT

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Starting with a documented presentation of existent low-energy buildings and structures, which culminates with the renowned Arch of SANYO, the authors launch their own idea—the Lightpyramid project—a scale copy of the ancient greatest pyramid ever built on the American Continent, entirely covered with solar PV modules.
The idea of a pyramidal PV-structure as a symbol for solar energy use came from *Anga Sterrenberg*, a well-known modern Austrian sculptor, exhibiting in many collective and single exhibitions in Austria, Germany, Italy, United Kingdom, Hungary, Israel and USA. The article explains the artistic, historical and technical reasons to select a pyramid-body for the shape of the construction. Abandoning the original triangular model, we select the larger step-pyramid structure, which can provide 15 MVA of electrical energy and which may include some scientifical or educational facilities in the field of the photovoltaics, or a recreational space. At the real dimensions of its historical model - the Teotihuacan Pyramid of the Sun - our Lightpyramid can become - perhaps - the greatest PV structure in the world.

Solar studies of safranine, methylene blue & Azur-B with reductant and their photogalvanic effect

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ABSTRACT

PURPOSE OF WORK – The high energy consumption has traditionally been associated with high quality of life. There is a very good correlation between the quantum of energy used by any nation and its development. The scientists have to be leaned in finding out energy sources, which prove to be non-polluting, inexhaustible and can fulfill the energy demands of the world, solar energy is not only a non polluting, inexhaustible and harmless but clean, law cost and hazardless with no disposable problem.

APPROACH – The present work is studied by observing photopotential and photocurrent of mixture in photogalvanic cell, which contain photosensitizers, reductants in alkaline medium on the basis of photopotential and photocurrent, further parameters are also studied.

SCIENTIFIC INNOVATION AND RELEVANCE – The nature has been utilizing only 0.025% of solar energy in form of photosynthesis and is sufficient to feed the whole world. Hence one can easily appreciate the solar input on the earth, which is sufficient to accommodate all energy needs of the world. The photo electrochemical effect is basis for this purpose, which may be defined as change in electrode potential (in open circuit) or the current flowing (in closed circuit) in an electrode/electrolyte system on generating electroactive species.

RESULT – Photogalvanic effect was studied in photogalvanic cell containing EDTA as reductant and safranine, Azur-B and methylene blue as photosensitizer. The photopotential and photocurrent generated were 860.0 mv and 255.0 μA, respectively. The observed conversion efficiency were 1.20% and the maximum power of cell was 218.0 μW. The storage capacity of the cell was 62.0 min. in dark. The effect of different parameters, on electrical output of the cell were observed and a mechanism has also been proposed for the generation of photocurrent in photogalvanic cells.

CONCLUSION – Azur-B produces much greater photovoltage as compared to the other dyes.

Integration of Renewable Energy sources, active and passive Solar and Geothermal Heat Pump in Dwellings.

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ABSTRACT

Considering the future evolution of energy prices under the pressure of rarefaction of fossil sources, the incorporation of “external costs” and the pollution burden of fossil fuel burning, any conscious builder has to reconsider the type of building design as well as the heating/cooling system choice.
The paper concerns a demonstration of a practical bioclimatic architectural design combined with a geothermal heat pump system in order to achieve money savings together with environmental benefits in dwellings.

KEY WORDS. Solar skin, Sun space, Thermal diode solar collector, Seasonal storage, Geothermal heat pump, Bioclimatic architecture.

Evaluation of Innovative Active Solar Building Features.

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ABSTRACT

In order to fulfil its role, the ETC has recently constructed an innovative office, laboratory and exhibition complex (Waalitj complex). The construction of the complex aimed at several objectives; among them are: to demonstrate a cost-effective, functional facility based on ecologically sustainable design principles; and also, for each of the buildings, to be a simple model for residential and small commercial developments in urban, rural and remote environments. The complex incorporates passive solar strategies, energy efficient construction materials, and a number of advanced technologies. Several of the characteristics integrated in the new buildings were new and largely unproven in Western Australia. Therefore, a number of studies on the use of waste materials for construction, thermal performance of the heating and cooling systems, and performance of the PV system have been undertaken. Success has been found in the incorporation of low-embodied-energy waste materials for its construction, the incorporation of some passive solar design principles, and the generation of PV electricity. However, weaknesses have also been pinpointed. These include poor thermal performance of the office building (at times when active features are not working); excessive thermal mass in walls; insufficient shading; large heat losses through windows; as well as some faults in the monitoring systems. These studies identified required improvements in the insulation, shading, ventilation, cooling and heating mechanisms, monitoring systems, and metering capacity. This paper will provide lessons learnt and recommendations on how to successfully integrate the active components in future buildings.

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THERMAL PERFORMANCE OF A ROOF INTEGRATED SOLAR HEATING SYSTEM WITH PCM THERMAL STORAGE

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Abstract

Thermal performance of a roof integrated solar air heating system (RISHS) incorporating phase change material (PCM) thermal storage is analysed. The first prototype of the system has been installed in a home in Adelaide, Australia. The system consists of a single glazed solar collector unit integrated into the steel roof of the house and a PCM thermal storage unit (TSU). Various factors that affect the system performance are investigated. They are: solar radiation intensity, air flow rate, inlet and ambient air temperatures, the PCM material and melting temperature, and heating load characteristics. The mathematical models of the RISHS and the TSU which were developed for this analysis are incorporated into TRNSYS simulation package to analyse the whole system. This paper presents the results of the system analyses and comparison with the experimental results. Various system control strategies are also examined.

EFFECTS OF WINDOW SIZE AND LOCATION AND WIND DIRECTION ON THERMAL COMFORT WITH SINGLE-SIDED NATURAL VENTILATION

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ABSTRACT

An energy-efficient building is a major target in building research and design worldwide. Obviously, any portion of energy saved in this respect can be directed to consumer where energy may be badly needed. Building energy consumption can be reduced through manipulation of various systems such as mechanical air conditioning (a major building energy consumer), lighting, equipment, etc. In regions where energy is limited or scarce, one would have to resort to some natural ventilation system to achieve acceptable thermal comfort for occupants. The form of the building and wind direction determine its natural ventilation performance. This includes building's shape, number, location, size and form of openings (windows) , the ventilator's shape, etc.

In this paper, results of an investigation of natural ventilation criteria as affected by various factors such as window size WWR (window-to-wall ratio), window location and building orientation (wind direction) are considered. Wind tunnel measurements and finite-element-based computation were adopted to gain an understanding of such effects. A wind tunnel test facility was constructed at the Housing & Building Research Center (HBRC) and utilized to test several idealized building models. On the other hand, a CFD software package (ANSYS FLOTRAN) was applied to the problem. These techniques gave clear pictures of the situation inside the ventilated space with various opening sizes and locations and for several wind directions. With the flow structure inside the ventilated space, it is a simple task to evaluate a thermal comfort index ($\overline{PMV}$) for a given thermal load (internal heating, solar radiation, etc.). Results indicate significant effects of WWR, window location and building orientation on such index. Therefore, it is concluded that building designers should not overlook such factors if the buildings is to be naturally ventilated.

Performance Simulation of Roof Surface Evaporative Cooling System for India Using "TRNSYS"

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Roof surface evaporative cooling (RSEC) is one of the most effective techniques for reducing cooling load in hot and dry climates, which are usually encountered in tropical and sub-tropical countries. The adaptability of the technique depends on the local climatic conditions and also the availability of water at the site. Though the technique is quite well known and has also been applied in many of the buildings, yet an indication of its effectiveness under different climatic conditions has been a matter of speculation only. The available simulation tools could be quite useful in predicting thermal performance of buildings employing the roof surface evaporative cooling technique and also in estimation of the quantity of water that may be necessary to operate such a system. TRNSYS is one such computer code, which is widely used by the professionals all over world, but is not equipped to simulate roof surface evaporative cooling directly.

This paper presents a strategy to adapt "TRNSYS" for simulation of transient performance of a building having (RSEC) system. The numerical calculations have been made for representative cities in different climatic zones of India. Thermal performance has been evaluated in terms of reduction in cooling load and the inside temperature of the building.

Modeling of Solar Chimney for Ventilation

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Abstract

Solar chimney concept has been investigated for enhancing natural ventilation in buildings. An experimental setup has been prepared for conducting a parametric study of this concept. In the configuration, a chamber of 1mX1mX1m has been fabricated. The south facing wall is covered with ordinary 4mm thick glass fixed at some gap from the wall thus making an air channel. The wall is having blackened aluminum sheet on its exposed side and has been heavily insulated on its backside that faces the chamber interiors. This absorber wall has been provided with an opening at the bottom for entry of air into the air channel. The channel is open from top for air exit into the ambient. The north side of chamber has window opening for suction of atmospheric air into the chamber. The chamber has also been insulated from top, bottom and from all other sides for minimizing heat transaction with its surroundings.

Steady-state heat transfer equations have been written for the inner and outer surface of glass cover, absorber wall and air flow channel for determining the conditions that result into buoyancy driven ventilation. Simultaneous equations have been solved by the method of matrix-inversion. The values of temperature of glass, absorber and airflow channel as obtained from this solution have further been used to find the buoyancy effect causing suction of air from the window. For validation of these results, an experimental chamber having same dimensional details has been constructed. K-type thermocouples have been used to measure temperature at glass, absorber and flow channel. Besides, condition of ambient air and room air has also been recorded. Thermo-anemometer has been used to find airflow rate in the channel.

Close agreement has been obtained between the simulated and experimental results for four different parametric combinations by varying depth of air-gap and size of inlet opening in air-channel. Detailed experimentation for complete parametric study of system is ongoing. Results have been presented and discussed in this paper.

Daylighting using light rods

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ABSTRACT

A novel daylighting system is investigated in which a set of 'light rods' is used to transport light from the exterior of a building into unlit or windowless rooms within the building. With a 50mm diameter, these rods are sufficiently small to be fitted into most existing buildings without structural modification. During testing, using calibrated integrators, rods were found to have a transmittance equal to that of a light pipe that had aspect ratio 6 times smaller. Losses due to angled entry of light were investigated and it was found that transmission was effective across the whole 180° sky dome. Rods would collect both direct and diffuse light throughout the year, with high collection efficiency and could be used for desk-level task lighting. Benefit would include the reduction of pollution and expense associated with the use of electric lights and greater occupant well being. The system was tested in both Singapore and England.

An APPROACH for ENERGY CONSCIOUS RENOVATION of RESIDENTIAL BUILDINGS in TURKEY by INDIRECT SOLAR GAIN SYSTEM

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As is well known, solar energy is the primary source of the renewable energy sources and Turkey has a great potential of solar energy. Unfortunately, it can not be get enough benefit from this clean energy source in buildings; however, it is known that %36 of the total energy is consumed for heating the buildings in Turkey. Energy conservation standard in buildings neglect the real amount of solar energy potential and there is no any regulation to encourage the solar energy utilization in buildings. When we consider the amount of heating energy consumption, it can easily be seen that energy conscious renovation of the existing buildings became an important problem. Therefore, solar energy utilization should be considered for the renovation of existing buildings as well as for the design and construction of new buildings.

In this study, an approach was proposed for the renovation of existing building by the application of Trombe wall principle (indirect solar gain system) to the opaque component of building envelope. The comparison of thermal performances of existing wall and the proposed Trombe wall application has been made under unsteady state heat transfer conditions. The proposed approach has theoretically been carried out for the selected residential building in Istanbul and the heating energy conservation has been determined for the renovated wall. The results of the application study are given in this paper.

Keywords: Solar Energy, Energy Efficient Renovation, Trombe wall

HEATING ENERGY ECONOMY IN THE BUILDING SCALE

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ABSTRACT

In the building scale, the main design parameters affecting the consumption of heating energy are the building orientation, building form and the optical and thermophysical properties of the building envelope. In Turkey the building sector is the most important consumer of primary energy. The energy crisis which Turkey has been experiencing over the last few years has emphasised the importance of an efficient and more productive use of solar energy. The Turkish regulation on heating energy economy does not consider regional solar radiation data for Turkey, and the solar radiation data used do not reflect the actual situation. It is obvious that the incorrect consideration of solar radiation may result in unnecessarily higher heating load. In order to prevent erroneous results with respect to energy saving in the design of building it is obvious that besides the design parameters, regional meteorological and solar radiation data must be properly considered in the calculation with their true values. This is of particular importance for a developing country like Turkey which needs to use its resources diligently. The aim of this study, which is based on scientific research projects carried out on this subject at the Istanbul Technical University, was to develop a method which would provide an instrument to determine building which ensure minimal heating energy consumption by basing on the meteorological and solar radiation data. The application of the proposed method for Istanbul region and the results are presented in the paper.

Financial Payback on Residential California Solar Electric Systems After the State Rebates Are Gone.

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This is an update and follow-on to *Financial Payback on California Solar Electric Systems* (June 2003, Black, Solar 2003 Proceedings), presented at Solar 2003, Austin, TX, intended to confront the probable issue that the California residential solar industry will need to face the end of the generous California Energy Commission (CEC) Emerging Renewables Buydown Program (Rebate) funding.

The CEC provides a rebate on solar electric systems. The pool of rebate money was expected to last thru 2007, but is running out faster than expected, and is expected to be gone some time in the first of 2nd quarter of 2004.

The Rebate reduces the final cost of a system to the consumer by 30% to 50%. This Rebate and a number of other factors have also helped make solar electricity financially viable in California, as discussed in *Financial Payback on California Solar Electric Systems*:

- California's high electricity rates
- California's tiered rate system
- Time of Use (TOU) electricity metering
- Net Metering on an Annual Basis
- 7.5% State Income Tax Credit

The end of the Rebate Program will not mean the end of financially viable residential solar. Without any Rebate, California Investor-Owned-Utility residential customers with $150/month or larger electric bills could receive a greater than 11% return on investment, get 100% back on the system at resale (as estimated using a technique from the Appraisal Journal), or be cash positive when taking a 7% 30 year loan to purchase the system with $0 out of pocket cost.

Why is a Solar Electric Home Worth More?

By Andy Black

Solar Electric systems increase the value of homes because the operating cost of the home is reduced and the home is protected against electric rate inflation. There are four quantifiable financial tests that evaluate solar as an investment. Finally, there are numerous intangible benefits that will be valued to varying degrees by some buyers.

Reducing the operating cost by cutting the electric bill allows the owner to spend their money on a larger mortgage without increasing their monthly costs.

The Appraisal Institute reported a similar conclusion in October 1998 in the *Appraisal Journal*, found at http://www.natresnet.org/herseems/appraisal.htm. Nevin states that after-tax mortgage costs have averaged about 5% historically. At 5% a $20 mortgage costs $1 per year. This translates a 20-to-1 multiplier. That is, for every $1 that is available to spend on the 5% (after-tax) mortgage, the mortgage can be $20 larger.

There are several tempering factors to be considered; there has been very little turnover in the small but growing stock of solar homes, so there is very little "comparables" data to show that solar homes do sell for more. Also, it is unlikely that a future homebuyer would pay substantially more than the current going rate for a comparable new system. As systems age towards end-of-life, they will command a lower value. However, as time goes by, electric rate inflation will increase the annual value of the savings, thereby increasing the value of the system.

Pre-Solar Bill	kWh per Month	System AC Size	Final Net Cost w/ 7.5% State Tax Credit	Appraisal Equity Increase
$75	580	2.5 kW	$14.5K	$15K
$175	1050	5.0 kW	$26K	$39K
$300	1560	7.5 kW	$37.5K	$66K

Table 1. Appraisal Increases due to California PV Systems

BIPV in the infrastructure: the Stillwell Avenue Terminal Station

Fazla Hassan, Mike Kyriacou, New York City Transit
Gregory Kiss, Tony Daniels, Kiss + Cathcart, Architects

Purpose:
The focus of this paper is the implementation of an advanced Building Integrated Photovoltaic (BIPV) System at the BMT Stillwell Avenue Terminal Station, which is the largest Rapid Transit Terminal in the world.

Approach:
The paper describes the approach utilized during the planning and design stages of the project to formulate strategies for an informed decision-making process and building consensus within New York City Transit. Discussion will also include a description of the "design challenges", construction of the largest BIPV thin film (aSi) structure in the world, designed and built to uniquely rigorous performance criteria.

Innovation:
The innovations in this project are on several levels, from policy to procedure, PV technology, installation details and development of public policy guided by sustainable principles.

Results:
Given the complex nature of a large organization such as NYC Transit and the unprecedented technical and permitting issues, one important result is the successful planning process . Another outcome of this project is its effect on planning criteria for future NYCT projects. Finally, we will review the testing, installation, and operating performance of the project.

Conclusions:
• By careful planning and internal education, some of the most severe policy and operational criteria in the country can be met;
• A groundbreaking project significantly affects future policy
• There is extra value in locating an environmental project in an important civic setting;
• Urban civic infrastructure can be a source of large-scale PV generation.

The Hathaway "Solar Patriot" Home: Performance Testing and Simulation Results

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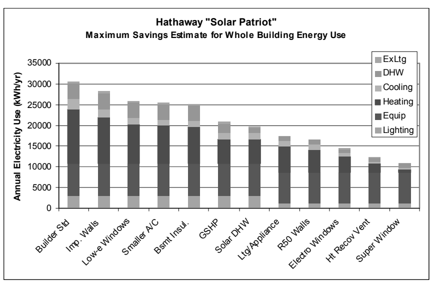

The purpose of this work is to understand the performance of a high performance home to aid in determining the best approach to designing zero energy homes.

The "Solar Patriot House" drew the attention of legislators and the press to solar homes when it was erected on the National Mall in 2001. The Hathaway family moved into the home once it was moved to its permanent location in Purcellville, VA. In September 2001 we instrumented the home to measure its energy performance. Since then we have created and verified a DOE2 model of the home and used the model to explore possible improvements to the energy performance.

Features of the home include modular 2x6 construction, passive solar tempering, solar water heating, a 6 kW PV system, and a ground-coupled heat pump. The home uses about have the whole-house energy that a similar home built using regional standard practices would use. In 2002 the PV system supplied about 70% of all the energy consumed.

This work is innovative in the approach of combining detailed measurements with hourly energy simulation, using the measurements to drive the simulation for difficult to simulate components, and used of the model to investigate the effect of implementing technology improvements. This study drives home the point that as we shrink space conditioning and water heating needs, the plug loads becomes a large portion of the overall energy use. It also emphasizes the large role efficiency must play in economical zero energy home designs.

Evaluation of the First Figure of Merit of a Box Type Solar Cooker by Simulation

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Abstract

One of the measures used to characterize the thermal performance of a box type solar cooker is its first figure of merit (F_1) which is defined as the ratio of optical efficiency to the overall heat loss coefficient of the cooker; it is determined from a no load test on the cooker under stagnation conditions. The value of F_1 is directly related to the maximum achievable cooker tray temperature for given values of ambient temperature and incident solar radiation intensity. In an attempt to study the role of location and season of testing, as well as the prevailing values of ambient temperature and intensity of solar radiation on the numerical value of F_1, a simulation model has been developed which uses an iterative technique to calculate the cooker tray temperature and the top heat loss coefficient of the cooker. Standard relationships available in the literature have been used to determine the optical efficiency and the side and bottom heat loss coefficients of the cooker. A comparison of the simulation results with the experimental values obtained on eight cookers tested in Delhi in different seasons will be presented in the paper. The first figure of merit, F_1, is found to be reasonably stable against moderate variations in test conditions.

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ENERGETICS OF BOX TYPE SOLAR COOKER UTILISATION IN INDIA

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ABSTRACT

An attempt to study and evaluate the energetic feasibility of box type solar cooker utilization in India has been made in this paper. Using the process analysis method the primary energy embodied in three different variants of the box type solar cooker commonly used in India has been estimated. A framework for estimation of the annual useful energy output delivered by a box type solar cooker has been developed. It makes use of the two figures of merit (F_1 and F_2) that characterize the thermal performance of the box type solar cooker. Box type solar cookers have been found to be viable in terms of the measure of energetic feasibility such as the Energy Yield Ratio, Net Energy Yield have and Energy Payback Period.

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DECENTRALIZED IMPROVED CHARCOAL PRODUCTION FROM BIOMASS FOR RURAL ENERGY APPLICATION

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Abstract:

A majority of population all over the developing world depends on biomass/fuel wood for a number of rural industries and for domestic energy. Its bulky nature, high moisture and tar content prohibits direct application in electricity generation and lift irrigation through pumps. More over direct biomass combustion releases a number of toxic pollutants affecting the health of women folk. In the present study, the biomass is classified into five categories for charcoal production. In the present study two types of kilns such as mud beehive and portable metal kilns of various sizes were designed and developed suited for different type of fuels. The paper deals with the kiln design, fuel wood grading, kiln operation and firing in the firing chamber. The relationship between kiln temperature vs smoke temperature and colour of smoke was optimized. In both the kilns, the kiln and smoke temperature generally raises along with the process of carbonization. Energy, material and economic balance for both types of kilns revealed that charcoal production in transportable metal kiln and subsequent use of charcoal in improved charcoal stove are more beneficial than burning the wood directly in open chullah and improved chullah. Operation time, quality of charcoal obtained, effect of moisture content on charcoal yield, the economic analysis and the production cost per ton of charcoal were studied.

SEMI LOG PLOT FOR THE SECOND FIGURE OF MERIT OF BOX TYPE SOLAR COOKERS

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ABSTRACT

Studies[1] on thermal performance of the box solar cooker have resulted in the Indian Standards on solar cookers.(IS: 13429:1992 & 2000)

Two figures of merit were proposed [1] to quantify thermal performance of box solar cookers and to characterize the cookers. The second Figure of Merit, F_2, takes care of the product ($F'\eta_o C_R$): i.e., a high value of F_2 indicates that the cooker has a high value of the product of heat exchange efficiency factor (F'), optical efficiency(η_o), and the heat capacity ratio (C_R). F_2 is obtained from the water heating test (Ref.1) using the experimental data on water temperature(T_w) and the climatic variables: insolation (I) and ambient temperature (T_a). It takes into account the climatic variables through a dimensional group consisting of [$(T_w-T_a)/I$]. It was shown that F_2 can be obtained by using an equation involving natural logarithm of a function with this dimensional group.

The present study shows that F_2 may be found by analyzing the experimental observations with the appropriate function on a semi-log plot. Linear regression of the experimental data on the semi-log plot is found to be excellent. The values of F_2 obtained from the slope of linear regression are close to the values obtained by the equation.

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A PERFORMANCE STUDY OF TWO SOLAR COOKERS EXPERIMENTED IN ABIDJAN (IVORY COAST)

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ABSTRACT

In the present work, we report the performances of two hot box type solar cookers built in materials easily found locally. The cookers have a double frame made of plywood. The insulation, which is made of polystyrene lies between the two frames. The northern and southern sides have a fixed tilt angle. As for the eastern and western sides, they are also inclined with a tilt angle i. The absorber is realised by stainless steel.. It is painted in black and lies on a plaster slab. A triple glass cover tops the absorber and is inclined with a tilt angle g. The cookers are fitted with four external reflectors realised by aluminium sheets. Two of them are set to the northern and southern sides and keep a fixed tilt angle. The other two reflectors are set to the eastern and western sides. They are set to three allowable tilt angles, depending on the height of the sun. The two cookers are designated by Cooker 1 and Cooker 2. They differ by the values of the design parameters which are i, g, and ep, where ep denotes the polystyrene thickness. Two sets of experiments were made with the cookers .The first experiments were made without any water boiling. The maximum global efficiency was η_1 = 52.2 % for cooker 1 and η_2 = 53.2 % for cooker 2. Then experiments of boiling water were made using two saucepans. The efficiencies obtained were η_1 = 56.72 % for cooker 1 and η_2 = 55. 81 % for cooker 2 .The overall heat losses were also determined and found to be U_{L1} = 6.81 W/m².°C for Cooker 1 and U_{L2} = 4.87 W/m².°C for Cooker 2 .

SECOND LAW ANALYSIS IN A SOLAR COOKER TYPE BOX WITH MULTI-STEP INNER REFLECTOR

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In the search of obtaining teams that allow to make more efficient the use of the solar energy for the heating of liquids, the calls solar cookers have been developed. The solar box cooker with multi-step inner reflector it is a strong representative of these cookers types. The solar box cooker is integrated by a covert that was made with double glass, this is use with two purposes, reduce the loss heat convection with outer and to generated the greenhouse effect with inner of cooker. In the inner of cooker there are a mirror arrangement in inclined position (inner reflectors) placed in angles that allows to reflex the solar rays in direction to one cook recipient. The temperatures reached by these teams can be of the order of 90 ºC, enough temperature for the heating of foods. However, the costs of construction of this stove type can be high and such a situation can end up being an important inconvenience if it is considered that these teams should be directed to sectors of the society with low resources.

In this work an analysis of second law is presented applied to a solar box cooker with multi-step inner reflector and by means of the concept of efficiency, the real yield of this cooker type settles down. The result of the analysis shown that the yield of the solar stove under conditions of transitory operation is smaller to 5% and this result added at the construction cost, allows obtaining a real evaluation of the same one. The obtained results can be useful to establish the operation conditions but high and this way to establish their use better. Another important use that can be given to this work this directed toward the design and improvement of this solar cooker type, since the reported efficiencies give elements and reasons for their study. The method used in the analysis is that of numeric simulation, the obtained data of the operation of the solar stove are obtained by means of a program non commercial called ESCRIM that allows analyze the operation of a solar box cooker of this type.

Promoting Improved Metallic Stoves for Reducing the Consumption of Charcoal and for Energy Efficiency

Purpose of work: to make extension of energy efficient stoves as alternative to traditional ones in the community for protecting environment (from deforestation caused by man's action of collecting firewood or charcoal).

Approach: - surveying to help people admit that there is problem of energy in the community / households when they use traditional stoves;
- sensitising people find alternative solutions of renewable energy to their burden (budget and time) of charcoal consumption as well as displaying to show the improved stoves efficiency.

Scientific innovation: The improved stoves are reducing cooking time thanks to mud put inside which traps, saves longer and reorients heat (calorific energy) under the pot. There is neither pollution (smoke) nor dust spread out. Kept clean after each cooking, the stove can last up to 30 months.

Results: In our country where 80 % of people are cooking with either charcoal or firewood, our project achieves the following results:
- twenty young people (needy children) trained in manufacturing improved stoves (appropriate technology or handy craft);
- more than 6,000 people (men and women) are aware of the existing stoves which uses 50 % less charcoal than the traditional ones;
- reduction of 10% / year of deforestation/desertification;
- capacity of women to be involved on community level, in ecological, gender sensitive projects /programs.

Conclusion: The extension of these improved stoves for the sake of renewable energy and other appropriate technologies is increasingly needed for the sake of future generations and sustainable development all over the planet.

TECHNOLOGY TRANSFER BY SOLAR OVEN WORKSHOP

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Abstract

The poverty-environment relation take different shape in general terms, in rural areas exist the over explotation of marginal resources and the consecuent reduction of the productivity. The process have cyclical characteristics, peoples that less resources have, go away to live in marginal areas of cities and this increase the population, marginal resources are overexploted and productivity are reduced, this process increase the poverty and pressure over environment and so on. The role of solar energy is strategic in order to create sustainable methods to live. The workshop is composed by theoretical and practical aspect in order to transfer a complete set of knowledge about solar cooking. In the workshop we have worked with two types of oven, Ñacuñan2 and Solar drum oven. In this work it is presented thermal characteristics of solar ovens mentioned and the program of workshop as a excellent mean to solar cooking transfer to peoples of whatever may be they conditions.

INVESTIGATIONS OF CERAMIC $ZnFe_2O_4$ PHOTOELECTRODES

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The aim of present work is to develop the technology of manufacturing of ceramic semiconductor photoelectrodes made of solid solution in the system ZnO (E_g~3.2 eV) - Fe_2O_3 (E_g~2.2 eV) and investigate a possibility of their application for photoelectrochemical conversion of solar energy in hydrogen. An attempt to the combination the best characteristics of each material is made: the good absorption of solar energy (~30%) by rather narrow band gap photoelectrodes made of iron oxide Fe_2O_3 and the rather large quantum yield of the photoelectrodes made of ZnO having wider band gap and higher mobility of charge carriers.

The measurements of electroconductivity and capacitance, current-voltage, spectral characteristics of semiconductor photoelectrodes made of solid solution $ZnFe_2O_4$ are carried out. The electrical conductivity of the obtained samples is stipulated by the presence of two types of donor centers. The region of spectral photosensitivity for this photoelectrodes covers lengths of waves from 270 nm up to 650 nm. The photosensitivity maximum corresponds to a wavelength 400 nm. The anodic photocurrent onset potential of manufactured photoelectrodes corresponds to a potential -0.2V vs. SCE. The influence of doping with titanium and zirconium on photoelectrochemical behaviour of $ZnFe_2O_4$ photoelectrodes is investigated.

AlB_2 – a new selective coating

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Abstract

The aluminum boride (AlB_2) selective coating has been developed on aluminum substrate at low temperature (100-110)^oC by chemical conversion method. The crystal structure of AlB_2 selective coating has been identified by X-ray diffraction (XRD) method. In the XRD pattern, fundamental peaks of both the AlB_2 and pure Al were identified. To confirm our results, chemical analysis method was used. In the chemical process, Al was found to be 51.0 %, B = 37.5 %, O = 6.5 %, Cu as impurity = 2.0 % and other impurities = 3.0 %, which confirmed the presence of Al and B in the sample.

The thermal and optical properties of this coating like emittance, reflectance and absorptance were studied and the best values were recorded as 0.05, 0.0011 and 0.9989 respectively. The selectivity factor was found 19.94. SEM study was also carried out.

Experiments on the Thermal Characteristics of Thermal-Insulation Bricks Incorporating Phase Change Material (PCM)

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Abstract

The geographic location of Taiwan is somewhere near Tropic of Cancer. Therefore, the roof of most buildings located in Taiwan can be exposed to a direct sun-ray during the summer season. In fact, the yearly cooling load that received from the roof is estimated to be 2.78 times that gained from south-side wall (the 2nd highest in terms of solar heat-gain). Phase Change Material (PCM) is known as a very effective way to shift the peak load and enhance solar energy utilization. Potential assessments of thermal-insulation bricks incorporating PCM (paraffin) were carried out

The result shows that thermal-insulation bricks incorporating PCM have a better daytime thermal insulation effect than ordinary hollow bricks. When the highest outdoor temperature is 35.5°C, the highest bottom side temperature of thermal-insulation bricks incorporating PCM is 31.7°C, which is 4.9°C lower than that of hollow bricks. During the nighttime, if thermal-insulation bricks incorporating PCM are used in the building construction, it functions better in heat preservation to prevent fierce temperature dropping.

Keywords: Phase Change material (PCM), roof, thermal insulation, brick

COBALT-COPPER OXIDE COMPOUND FOR SELECTIVE SOLAR ABSORBERS

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Abstract

There are several works on the preparation of selective films by using the spray pyrolisis method, being notorious the works on cobalt oxide and nickel oxide thin films. The literature lacks of studies on the preparation and optical characterization of mixed selective oxide films, like Co-Cu oxide, for instance. The spray pyrolisis, being a simple and inexpensive technique, allows preparation of multicomponent metallic oxide films,. In the present investigation, Co-Cu oxide films were deposited onto stainless steel substrates. Preliminary results on the fundamental optical properties measured by spectral ellipsometry, and the solar optical properties measured by UV-Vis and NIR spectrophotometer are reported. A microstructural model of this selective surface is proposed. We found that the optical properties for solar to thermal energy conversion are attractive. Also, the basic structure properties were obtained from XRD measurementes and a morphology study by AFM was carried out.

INVESTIGATION OF OXIDE SYSTEMS HIGH-TEMPERATURE PROPERTIES WITH THE USE OF SOLAR FURNACES

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Concentrated solar radiation is one of the renewable energy forms. It can be realized with the use of solar furnaces which are especially efficient for the synthesis of oxide compounds and investigation of their high-temperature properties. In the Institute for Problems of Materials Science of National Academy of Sciences of Ukraine (IPMS NASU) the complex of necessary equipment and original instruments are created for carrying out the investigations of phase transformations in oxides systems within wide temperature range (up to 3000 ^{o}C) and studying oxide materials properties including the equipment using concentrated solar radiation. They are intended for carrying out:

- thermal (TA) and derivative (DTA) analysis in air;
- ultra-fast quenching from liquid state with the velocity 10^4- 10^5 K/s;
- oxide phases synthesis and oxide materials melting excluding the pollution under the conditions of equilibrium partial pressure of oxygen.

The investigation of oxide systems was carried out in the solar furnaces of 1,5-2,0 kW power of direct tracking the Sun and with the use of heliostats. The diameter of mirror paraboloid – 2000 mm, focal distance – 840 mm. The pyrometric system supplied by narrow - band filters in visible (0,65 mkm) and near infrared (1,39 mkm) regions was used as a temperature sensor. Also the optical pyrometers INFRATHERM Converter IGA 100 and IS 100 (IMPAC Electronic GmbH, Germany) were used. The temperature of phase transformations and monochromatic radiating capacity of oxides was determined by the two following methods: by the radiation of melted rotary cavity and by melted sample surface.

Special consideration was given to the investigation of phase transformations in refractory oxide systems with melting temperatures of the components being above 2000 ^{o}C. The mentioned systems are not studied sufficiently till now on account of considerable experimental difficulties when the investigations are carried out by traditional methods with the use of vacuum arc furnaces or plasma installations for oxides heating. Using such equipment does not permit to avoid the pollution produced by materials of container or heater and to preserve rigorously stoichiometric composition of oxide phases. As a result of carried out investigations the phase transformations have been studied and state diagrams have been plotted within wide range of temperature and concentrations of some two- and three-component systems. They were formed by refractory oxides of elements of II - IV periodic table groups including such systems in which one or two components change the stoichiometry easily when the experiments are carried out by traditional methods in reducing, neutral mediums or vacuum (TiO_2, Eu_2O_3 and others). The majority of the investigated ternary systems included oxides of zirconium or hafnium as one of the components: $Zr(Hf)O_2$ - MgO - Y_2O_3; $Zr(Hf)O_2$ - CaO - Y_2O_3; ZrO_2 - Al_2O_3 - r.e.e. oxides; $Zr(Hf)O_2$ - Y_2O_3 - r.e.e. oxides; $Zr(Hf)O_2$ - TiO_2 - Al_2O_3; ZrO_2 - HfO_2 - TiO_2, ZrO_2 - HfO_2 - $Al(Sc,Y)_2O_3$ and others. The investigation of the mentioned systems clears the way for wider practical use of the materials based on them in power-engineering, metallurgy, medicine and other fields, for creation of highly producible materials of various purposes (power conductors, refractories, implants, heaters) including refractory lining and high temperature construction materials of concentrated radiation receivers in solar power and conversion installations.

Comparative Studies of Decolorization/Degradation of Azo Dye Using Solar and Artificial UV Radiation with Different Types of Photocatalysts

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ABSTRACT

The present work investigates the decolorization and degradation rate of carcinogenic component of industrial effluent, an azo dye (Crystal Violet), in aqueous solution on laboratory scale batch type reactor using solar and artificial UV radiation. The rates are calculated with different types of titanium dioxide photocatalyst (Degussa P 25, Qualigens and Hombikat UV 100). The optimization of the parameters such as catalyst loading, dye concentration, and radiation intensity (solar and artificial UV) on the rate of decolorization and degradation of the azo dye have been investigated. Under the experimental conditions the optimum rate of degradation has been found for a catalyst loading between 0.2-0.3 gm/litre for mean radiation intensity of 6.5 X 10^{-4} W/cm^2. The degradation rate has been found to be high even for very low dye concentration. The influence of sensitization by transition metal on the degradation rate has also been studied.

Key Words: Solar and Artificial Radiation, Titanium dioxide, Azo dye, Decolorization, Degradation.

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METHOD TO DETERMINE THE THERMAL EFFICIENCY OF AN AIR SOLAR COLLECTOR USING A NON-STEADY MODEL

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A non-steady model for the thermal efficiency of a simple air solar collector is developed. In the model, the thermal storage produced in the absorber mass is considered. An approximate analytical solution of this model is obtained, and the results are compared with experimental data corresponding to a collector of 18 m^2 and an absorber of 2 cm thick.

An expression of the collector thermal efficiency depending of three variables is obtained. One of these variables is a time function and takes into account the phase difference produced between the incident radiation and the output temperature. The other variable considers the inlet airflow temperature and the last one, the absorber initial temperature. Each of these has a specific coefficient associated that, joined to the optical efficiency, characterizes the collector thermal behavior.

The coefficient associated with the absorber temperature depends on the collector time constant and goes to zero according to the time advance. When this time constant is tripled, a shorter operational expression for the thermal efficiency is obtained. It can be used to characterize the air collector thermal behavior under open sky conditions of a sunny day. The proposed method results are compared with the ones obtained using the conventional model developed by Hottel and Whillier.

SOLAR TRACKING SYSTEM WITH STATIONARY CONCENTRATOR

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***Abstract*--There is presented a new Solar tracking system on the base of a spherical-parabolic stationary mirror concentrator with the heat exchanger motion on the internal concentric focal zone trajectory.

As it is known, tracking systems allow to receive from the Sun 20-30 % more energy during the day, than immovable ones. However, tracking systems, in their turn, need the electric power for rotation. And the more is the mass of the rotated mirror, the more is the power consumed. Heat exchanger movement solution consumes considerably less electric energy, than in case of rotation of the mirror itself.

It is possible to realize this Sun racking scheme only by using a concentrator of a spherical profile in the horizontal plane, as it has a circular symmetry. A hot focal spot moves in compliance with the Sun movement within the angle sector of 120°, without any change of its characteristics. Due to this it is sufficient to rotate the heat exchanger only around one axis.

Then during the Sun (spot) movement, in the angle sector of 120° -160° , there takes place smooth decrease of energy concentration in the focal spot.

For the purpose of increasing the concentration of the energy received the parabolic profile of mirror surface is used in the vertical plane. In designing spherical-parabolic (tore) mirror it is important to combine the sphere quasi-focus with the parabola focus. The concentrator overall dimensions are 4000 mm in horizontal and 2000 mm in vertical. The diameter of local concentrating subaperture of the mirror is 2000 mm.

In the Project there must be developed an adequate type of small-scale thermal exchangers for thermal (air/water) or electric power application and a solar sensor with high accuracy of Sun disc tracking.

OPTIMUM THICKNESS AND HEAT STORAGE CAPACITY OF THERMAL STORAGE WALL USING DIFFERENT STORAGE MATERIALS

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ABSTRACT:

To investigate the effectiveness of the thermal storage wall in winter, a thermal model and simulation program were developed. The outside wall surface temperature, the amount of heat stored, and the optimum wall thickness were calculated for different sensible and latent heat storage materials such as heavy concrete, light concrete, brick, rock, Glauber's salt, and paraffin wax.

A one-dimentional, unsteady state case was considered in this analysis. The inside face of the wall was perfectly insulated during day time to prevent heat transfer from the storage wall to the inside space while outer surface was painted black for maximum heat absorption.

The study shows that using one sheet of glass on the outside wall increases the wall surface temperature by about 50°C. It also shows that Glauber's salt was the best storage media. It has a high heat content and less wall optimum thickness, with a daily storage capacity of 32816 KJ/m^3 and 16cm optimum thickness. These values were 22949 KJ/m^3 and 50cm for heavy concrete, 7643 KJ/m^3 and 13cm for light concrete, 16561 KJ/m^3 and 33 cm for brick, 6377 KJ/m^3 and 13 cm for rock, and 14464 KJ/m^3 and 13 cm for paraffin wax. At wall thickness of 13 cm the heat storage capacity for Glauber's salt, paraffin wax, heavy concrete, brick, and rock was found to be 29890 KJ/m^3, 14464 KJ/m^3, 13670 KJ/m^3, 7643 KJ/m^3, and 6329 KJ/m^3 respectively. It was also observed that Glauber's salt, paraffin wax and heavy concrete have the ability of maintaining high heat storage in severe weather conditions.

SOLAR-THERMAL PROCESSING OF OIL-TAR

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The purpose of the work was clarifying the efficiency of using Solar-thermal energy in the refining of oil-tar and investigating mechanism and kinetics of the transformation processes.

The experiments were carried out in the Solar thermo-chemical laboratory installation and the oil-tar used in the experiment had an elementary composition (mass%): carbon - 84.7, hydrogen - 10.5, oxygen - 0.5, nitrogen - 0.6, sulphur - 2.0. The kinetic regularities of pyrolysis and gasification processes of the oil-tar in the Solar furnace at the temperature range ΔT=773-1073K were studied.

It was established that kinetics and mechanism of solar-thermal transformations of hydrocarbon raw-materials are very similar to traditional thermochemical processes. In the case of gasification of oil-tar with water vapor the processes of gas formation proceeds in 2 stages: thermal and thermochemical decomposition of oil–tar up to coke and thermal gasification of coke with water vapor.

In the favorable conditions up to 60 mass% of oil-tar in pyrolysis and up to 78 mass% - in gasification is converted to gaseous products and coke. The specific energy-consumption for gas production is 2.3-2.5 kWh/m^3, energy effectivity of the process is 58-60%. The accumulation degree of solar energy as a fuel gas reaches to 30%.

Economic optimization of stationary nonevacuated CPC solar concentrator with fully illuminated wedge receivers

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Stationary concentrated colletors, type CPC, of low concentration, with fully illuminated, inverted V, wedge type absorvers are viable alternatives for supplying thermic energy in industrial processes at a temperature range of up to 100 °C.
Knowledge of the optical and geometric properties of these concentrated cavities is essential as much for the development as for the optimization of solar radiation collector modules. The properties of the interest are: the lenght of the reflectorm the cavity height, both normalized by the area of aperture and the mean number of the reflections. In this work, the geometric characteristics were obtained by the deduction of analytical formulas wich permitted the generation of the reflector cavity curve, the calculation of the reflector area and the mean number of reflections. Using this information, the annual collection of energy through diverse configurations of the concentrator (at diverse nominal and truncated angles of acceptance) for some cities that are representative of the climatic point of the view, in Brazil, were calculated. Finally, considering a realistic scenario of cost, the optimum configurations of the concentrator, its concentration and sensibility to variations relative to component costs, climate, orientation and the operational temperature of the collector, were calculated.

Life Cycle Assessment of Solar Chimneys

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The main goal of the study is a comprehensive evaluation of the impacts caused by mass and energy flows of solar chimney systems using the method of life cycle assessment. The conventional LCA-method has been improved by an additional sectoral analysis (input-output analysis), namely the Hybrid Approach.

The impact assessment is usually done by aggregating mass flows which have similar impacts with non-site specific and non-time specific weighting factors in order to estimate the impacts on human health and the environment material and energy flows. The LCA of solar chimneys was conduced by using of the Hybrid Approach for three different power classes, what were calculated by means of a non-linear technical-economical optimization procedure.

The ecological analysis results in approximately 110 (5 MW) and 50 gCO_2-equivalent/kWh (100 MW). Between approximately 570 (5 MW) and 240 mgSO_2-equivalent kWh (of 100 MW) SO_2-equivalent is emitted. The consumption of not removable energetic and mineral resources as well as specific CO_2 and specific SO_2-emissions decrease with larger plants.

A comparison with conventional and renewable energy resources was carried out. In conclusion, a study for ecological evaluation of solar chimney has been developed. The Hybrid-Approach offers the possibility to complete the generally used Process Chain Analysis by adding a model based on economic Input-Output-Tables and corresponding data on sector specific elementary flows. The results show that large solar chimneys can help the relieving of the environment and the saving natural resources due its relative low CO_2 and SO_2-emissions.

COMBINED WORK OF VACUUM SOLAR COLLECTORS AND WARM WATER STORAGE

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ABSTRACT

There is a huge amount of articles and books in the world, which describe mathematically the work of vacuum solar collectors and storages. Some of them are basic books, which contain fundamentals of the thermo techniques and the solar energetics or of the heat pipes. Other authors present detailed models of solar collectors and of storage.

The current article has the purpose to present the joint work of vacuum solar collectors and warm water storage. The experiment structure and the measurement place plan of a system of vacuum solar collector - warm water storage are displayed. The simulation of the installation is done with the help of differential equations, which describe the solar collectors and the storage. The temperatures in the collector cycle (at the collector and storage entrance and exit) and the temperatures in the storage are calculated. The created computer program helps in the temperatures calculation of the overall collector installation on the one hand and the temperatures in the collector cycle and in the storage on the other. A comparison is made between the calculated and the experimental data.

The work done shows a very good coincidence of the measured and the calculated temperatures at the exit of the overall collector installation, as well as of the model and the experimental storage temperatures.

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EXPERIMENTAL INVESTIGATION ON AIR HEATING AND NATURAL VENTILATION OF A ROOF SOLAR COLLECTOR

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Abstract

Roof solar collectors are important components for solar energy utilization in green house. In this paper, experimental studies were carried out regarding to a roof solar collector (RSC), for which the length of air channel is 1500 mm, the width is 500 mm, and a variable air channel gap ranges from 100 mm to 500 mm. In the experiment, the uniform heat flux along the air channel is effected by three electric heating plates, which plays a role as solar radiation. It is found that the temperature distribution of air and the natural airflow rate are highly dependent on heat input, inclination angle, channel gap, etc. Experimental results indicate that the optimum inclination angle for the RSC is 45º, under which a maximum natural ventilation rate could be created. Also found is that there exists an appropriate channel length, about 1m in this study, beyond which the obtained heat and the natural ventilation rate can not be increased drastically. Higher the volume of airflow rate through the RSC, lower the temperature difference between inlet and outlet, consequently, it should be balanced between the air temperature rise and a suitable mechanical airflow rate in order to obtain maximum heat.

Keywords: Roof solar collector; heating; Natural ventilation

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Industrial process optimization using solar energy, condensate recovery and Stirling engine

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Abstract

In order to improve steam pressing process efficiency, hybrid system, which includes condensate heat recovery combined with solar energy for feed boiler water preheating as well as electrical energy production through low temperature Stirling engine, was analyzed.
In the steam pressing process 8% fuel will be saved when 60% process condensate is returned to the boiler plant.
If the whole waste condensate is used for driven low thermal difference Stirling engine, suggested by Toda, electrical energy in amount of $41*10^3$ kWh_e per year or 13% could be saved.
In the analyzed process only 60% of waste heat condensate i.e. 192 kg/h can be reused. This condensate is dividing on 76,8 kg/h (40%) for boiler feed water preheating resulting with 3% natural gas savings. The rest of condensate i.e. 115,2 kg/h (60%) is used for Stirling engine causing electrical energy decrease for 4,6%.
Applying solar energy for feed water preheating together with waste condensate, 74,6% natural gas will be saved with average flat plate collector area of 2557m^2 for selected location (Croatia, Zagreb $\varphi = 45^0 49^{'}$).
Such hybrid system is claimed to be not only energy efficient but economical and environmentally responsible.

ENVIRONMENTAL IMPACT OF DOMESTIC SOLAR WATER AND SPACE HEATING SYSTEMS

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ABSTRACT

All nations of the world depend on fossil fuels for their energy needs. However the obligation to reduce CO_2 and other gaseous emissions, in order to be in conformity with the Kyoto agreement is the reason why countries turn to non-polluting renewable energy sources. In this paper initially the pollution caused by the burning of fossil fuels is presented followed by a study of the environmental protection offered by two most widely used renewable energy systems, i.e., solar water heating and solar space heating. The results presented in this paper show that by using solar energy considerable amounts of greenhouse polluting gasses are saved. For the case of domestic hater heating system with electricity back-up the saving, compared to a conventional system, is more than 93% and with diesel back-up is about 80%. In the case of space heating and hot water system the saving is about 40%. It should be noted however that in the latter much greater quantities of pollutant gasses are saved. Additionally, all systems investigated give positive and very promising financial indices. It can therefore be concluded that solar energy systems offer significant protection of the environment and should be employed whenever possible in order to achieve a sustainable future.

PERFORMANCE OF A SOLAR WATER AND SPACE HEATING SYSTEM EMPLOYING COLLECTORS WITH COLORED ABSORBER

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ABSTRACT

To avoid the monotony of the black colored flat plate solar collectors we can use absorbers of blue, red-brown, green or other color. Because of the lower collector absorptance these collectors have lower thermal efficiency than that of the usual black type collectors, they are however of more interest to architects for applications on traditional or modern buildings. In this paper a solar hot water and space heating application with colored-absorber collectors of high (usual type) and low (selective) emissivity is presented and analyzed with respect to their performance. The house considered is 150 m^2 insulated construction with a UA value of 1200 kJ/hr°C, kept at 21°C. The solar system consists of solar collectors with total aperture area of 50 m^2 and a 3000 lt storage tank. The solar system provides part of the heating load and satisfies also the hot water needs of a 4-persons family. The system is simulated with TRNSYS on an annual basis at three different locations, Nicosia, Cyprus; Athens, Greece and Madison, Wisconsin. The first two locations represent locations with hot summer and mild winters, whereas the latter represents a location with mild summer and severe winter and was considered for comparison purposes. The results show that the energy output depends on the absorber darkness. For a medium value of the coefficient of absorptance, the colored collectors give satisfactory results with respect to the drop of the amount of collected energy, compared to collectors with black absorbers. This implies the use of slightly larger collector aperture area to have the same energy output as that of typical black colored collectors, which is acceptable comparing the aesthetic improvement of the solar system.

Theoretical and Experimental Investigation of Solar Heating Systems at specified output Conditions of Hot Water

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The proposed solar collector can be used in solar water heating systems by which hot water at pre-specified hot water temperature can be obtained. This can be achieved by the use of a thermostat by which hot water is not allowed to be discharged through a solenoid valve from the collector at lower temperature. The performance of the tested collector under the proposed intermittent flow conditions overcome that of the conventional thermosyphone flow collector. This is due to continuous increase of the absorber plate temperature as in the case of the thermosyphone system. As a result of this phenomena, thermal losses from the collector are limited and most of the absorbed solar energy is transferred to water and the overall efficiency of the system is increased. The piping system of hot water in the proposed system is shorter than that in the conventional thermosyphone system. No disturbance in the temperature of hot water, in the storage tank. The proposed system has less construction requirements than that required for the thermosyphone system .The obtained experimental results coincide with the obtained theoretical data obtained from the devised computer program.

Comparison of Solar Domestic Hot Water Systems in Solar Settlements - Decentralized or Centralized Systems?

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Within the project „50 Solar Settlements in North-Rhine-Westfalia" the state of North-Rhine-Westfalia, Germany supports the realization of solar settlements and investigations about the performance. A „Solar Settlement" is characterized not only by the active use of solar energy but also by an innovative energy concept and a holistic planning. Within the frame of the solar settlement Gelsenkirchen the question was answered if in comparison to standard solar systems for each of the houses, centralized systems for the combined supply of several houses in the range of 20 –60 m² can be an appropriate alternative. In the settlement both systems are realized side by side. This was an opportunity to compare both possibilities under same conditions, to investigate advantages and disadvantages and to create a guideline.

The results show that

- there is a high potential for optimization of both of the installed system-types,
- optimized operation considered the decentralized system has a better solar fraction but is much more sensible for a deviation in consumers behaviour,
- under economical aspects the mini-central system is better,
- in between the different simulated and calculated mini-central systems is not much difference,
- mini-central systems require more effort in planning in the beginning but less effort during operation.

The realization of solar domestic hot water systems as mini-central systems in the range of 20 – 60 m² size is more advantageous then several decentralized systems. But there are so many different influence parameters that it is not possible to give general recommendations. For each settlement an individual planning has to be carried out.

Solar Systems for Space, Water Heating and Cooking at High Altitude Regions with High Solar Radiation

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A simple system has been developed for solar space heating as well as for solar hot water heating for regions with high solar radiation and low ambient temperatures such as at high altitude regions. The main considerations for the developed technology were the system's robustness, low cost and easy maintenance and of course the performance. The developed system uses air as heat transfer medium since air can't freeze and improves the thermal capacity to reach the working point earlier in the morning. The main component of the system is therefore a solar air heating collector and a heat storage system based on pebble bed concept. When the collected energy is in excess, the solar heated air flows through an air-water heat exchanger, connected to a hot water storage tank. The system has been installed on the Altiplano (Argentina) at an altitude of 3700 m in a project sponsored by the German Government (BMZ). The design and sizing of the system was done through a simulation program developed in a modular form in the MATLAB/SIMULINK environment using local climatic data.

In the project, a couple of solar community cookers with a tracked concentrator have also been installed. The peak power of the installed collectors is 3 kW, which is enough to provide the cooking needs of 30-50 persons. A one month study was carried out in the village of Misa Rumi, it was shown that concentrating solar cookers are able to cover 70-80% of the cooking needs. This is due to the good solar insolation and the high acceptance of the inhabitants regarding solar cookers. Along with this demonstration program, a market strategy was also developed, by establishing a small scale industry for manufacturing of the developed systems with local skills and materials. Contacts are being undertaken to the local solar institutes and universities for necessary R&D support.

PARAMETRIC OPTIMIZATION ON THE SILICA GEL-CALCIUM CHLORIDE COMPOSITE DESICCANT ROTARY WHEEL

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Abstract

Desiccant rotary wheel, namely rotary dehumidifier is a competitive drying facility, which depends upon the vapor adsorption capacity of hygroscopic material to remove moisture from air, and can be applied to drying and air conditioning industries. The chosen adsorbent used in desiccant rotary wheel should have both high hygroscopic capacity and saturated adsorption rate. New composite materials based on silica gel-calcium chloride have become an attractive alternative to the existing silica gel or calcium chloride desiccants. Due to its physical structure the composite adsorbent takes an intermediate position between solid adsorbent and pure hygroscopic salt and can be organized in a way to demonstrate the best features of both systems.

This paper reports the performance comparison of the newly developed composite desiccant with that of the conventionality used non-impregnated silica gel. The results of both studying the composite adsorbent properties and analyzing their application for dehumidification system demonstrate clearly that these composite materials are highly competitive with the traditional working material, like chlorides, silica gels, zeolites, carbons. Thus, the composite adsorbent materials should be considered as good candidates for various thermal applications driven by low temperature heat sources. Further, the results obtained in this parametric study provide a new theoretical basis for the optimal design of composite desiccant wheel.

Thermal Performance of Paraboloid Concentrator Cooker: Comparative Evaluation of two Test Methods

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Abstract

Several designs of paraboloid concentrator solar cookers are available for domestic/community cooking in developing countries. Government of India is supporting dissemination of this technology through various policy measures. Performance evaluation of the product as manufactured by the industry assumes significance with a view to provide an equitable comparison of various models. There are two methods available in the literature for thermal performance evaluation of such cookers. One of these methods [1] recommends determination of $F'\eta_o$ and $F'U_L$ based on heating and cooling tests; while the second method [2] uses a heating test to determine the cooking power and the overall heat loss coefficient of the cooker. This paper will present results of a study aimed at to evaluate these two test methods based on detailed experimental investigations for the thermal performance evaluation of a paraboloid concentrator solar cooker. The role of different operational variables on the performance characterizing parameters suggested in both the methods will also be studied.

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Parametric Investigation on Thermal Performance of Box-type Solar Cookers Using Existing Models

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ABSTRACT

In the present work thermal performance evaluation of box-type cookers is done using the two popular models based on a series of experiments. The results are presented to underline the effect of temperature difference, number of pots, amount of load and radiative properties of pot surface on cooker's performance. An expression form is evolved to represent the standard cooking power, which takes into account number of pots also. A relation for sensible heating time of the load in the cooker is proposed in terms of the expression form evolved.

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Optimization of Solar Air Heater with V-shaped Staggered Discrete Rib Roughness

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Abstract

It is well known that the use of artificial roughness on the underside of the absorber plate of a solar air heater can substantially enhance its thermal performance. In this work, details of thermohydraulic analysis and consequent optimization results are presented for a solar air heater in which artificial roughness in the form of V-shaped staggered discrete ribs has been used. Design plots have been prepared to depict the values of individual roughness parameters that yield the maximum thermohydraulic efficiency for a given set of design conditions. Design methodology has been proposed to arrive at an optimum set of values of roughness parameters for a given set of design conditions.

Modeling and Performance Evaluation of Solar Water Heating Systems

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Abstract

This paper deals with the Modelling and performance evaluation of solar water heating systems of the hostel of our Institute. Two solar thermosiphonic water heating systems (1500 litres per day each) consisting of 10 and 11 numbers of liquid flat plate collectors respectively have been considered for the thermal analysis, operational behaviour and life properties of different components. The performance of these systems has been investigated separately. The simulation models involve first order differential equation based on heat balance for various components such as flat plate collector, storage tank etc. The daily variation of water temperature in the storage tank has been evaluated for various hot water consumption patterns such as- mode 1: hot water withdrawal once in a day; mode 2: hot water withdrawal twice in a day and mode 3: hot water withdrawal continuously through out the day. The simulated storage water temperature has been validated by actual solar water heating systems. The experimental water temperature is in good agreement with the simulated values. The experiments were conducted during winter season (November and January month) and temperature differences were obtained around 40^{o}C to 50^{o}C. The overall efficiency of both systems was around 20% to 25% and mode 1 involving hot water withdrawal once in a day was found to be more efficient than other two modes of water withdrawals. Due to the presence of one extra collector in system 2, a storage temperature of 2 to 3^{o}C more was obtained compared to system 1. The data collection and processing were carried out by computer integrated data acquisition system.

OPTIMISATION OF SOLAR-ASSISTED DESICCANT COOLING AND CONTROL SYSTEM

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Abstract

In Europe, there is a great potential for energy savings in the residential and tertiary building sector. Apart from the standard energy conservation techniques, the innovative technologies based on renewable energy, including solar energy, has a very important role for achieving a significant reduction in energy consumption. Among the various solar energy applications, the solar assisted desiccant cooling systems have the ability to provide efficient control on humidity and temperature while reducing the electrical energy requirement for air conditioning of a building.

This paper presents a detailed simulation model for performance prediction of a solar assisted desiccant cooling system with optimized control strategies for building air conditioning application. The typical algorithms based on simple psycrometric correlations, developed earlier by the present authors have been used for calculating relative humidity and temperature of regeneration systems.

The simulation code is written in FORTRAN for its integration with TRNSYS. The utility of the developed model has been shown by carrying out performance calculations for a solar assisted desiccant cooling system used in hotels corresponding to three typical climates of Italy viz. Milan, Rome and Palermo. The study shows that a solar assisted desiccant plants with optimized control system is found to be quite attractive and contribute an appreciably high energy savings for warm and humid climates.

ADVANCED SOLAR PULSE TURBINE SYSTEM FOR ELECTRICITY GENERATION

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A highly-advanced and unique solar pulse thermal electric system was proposed. The new turbine is invented and designed based on “the Concept of Superposition (COS)”. The future generation systems using renewable energies like solar, wind, biomass, ocean, and other potential energies should be small enough to provide energy at the demand locations. The COS turbine utilizes numerous ultimate thin disks (50 – 1000 disks) of the same diameter with blade elements on its surface. This unique turbine is very cost effective.

The present paper reports experimental results of the proposed system under constant heating condition that simulates the actual solar radiation input. Water and organic fluid are used for working fluid in the proposed closed cycle system. In order to improve turbine efficiency, pulsating supersonic flow is produced by a pulsating system, which is exerted at the throat of turbine nozzle. Further, total thermal efficiency of the proposed Rankine cycle system can be improved by introduction of reheating and regeneration. The electricity generation efficiency of the proposed system using organic working fluid is estimated to be over 10 – 20 percent, which is about two times better than that of conventional photovoltaic (PV) cell (about 6～8 percent) under a summer time operation. The total efficiency of the present system including space heating / hot water supplying exceeds 60 percent.

INTEGRATED SOLAR THERMAL DEVICES FOR MULTIPLE APPLICATIONS

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Abstract

Integrated solar thermal devices have been designed and developed for various domestic applications after considering practical aspects. For example, it has been observed that solar water heaters are useful only during winter months. There are problems in the commercially available solar cookers with single reflector due to continual attention to follow the device towards sun. Further, solar cookers do not find use in monsoon and other intermittent days. The utility of solar dryer is limited to that period only when fruit or vegetables are available. Moreover, different devices are required for these different applications.

Considering these factors attempts have been made to integrate the devices. A solar cooker cum dryer and a solar cooker cum still were developed earlier. In addition, a solar water heater cum dryer has been designed and developed which can be used to heat water and also to dehydrate fruit and vegetables. In this device the dehydration process continues even during night through the heated water.

The conclusions derived from the extensive trials of these devices were used to develop a new three in one integrated device i.e. solar water heater cum cooker cum dryer. This device can be used for heating water or cooking food or dehydrating fruit and vegetables and thus find year round application. Techno-economic evaluation of these devices has been carried out and it indicated that the integrated multipurpose devices are more useful and economically viable.

THE APPLICATION OF PARABOLIC TROUGHS TECHNOLOGY UNDER JORDANIAN CLIMATE

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Abstract - Parabolic trough solar thermal power plants are a proven technology in the utility scale since mid of the eighties. Between 1984 and 1991 nine power plants with an overall capacity of 354 MW have been installed in the Mojave Desert in California. Since these power plants can be equipped with a thermal storage or a fossil back-up they offer a fully dispatchable electricity generation capacity. This technology will be a very interesting near term option for countries with high solar irradiation levels and small resources of fossil fuels like Jordan.
This paper discusses the numerical simulation of parabolic trough solar thermal power plants under Jordanian climate for Ma'an site. An analysis of the daily power output, direct normal irradiation and the efficiency for the Ma'an site has been carried out. The results show that Ma'an site is preferable.

Development of Solar Cooling/Air-Conditioning System Using Hot Water from Solar Collectors

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ABSTRACT

In East Asia such as Korea and Japan, solar collectors have commonly been used for the heating purpose in the cold weather. On the other hand, the operation of solar collectors is often being suspended in the hot weather during summer. When solar collectors are not in operation, a strong solar radiation poured on them may cause the surface irritated, which may result in a shortened lifetime of solar collectors. It would thus be meaningful to investigate how to utilize solar collectors for the cooling or air-conditioning purpose in the hot weather. The lifetime of solar collectors may not only be expanded, but an excessive electricity consumption may also be compromised by replacing electricity-intensive mechanical air-conditioners. The main purpose of this paper is to develop a solar absorption air-conditioning system using hot water from solar collectors.
A liquid desiccant of lithium chloride (LiCl) is adopted in this system, and hot water obtained from the solar collector is used for recuperating a dilute liquid desiccant. An experimental apparatus is set up in a climate-controlled chamber. Experimental results indicate that the dilute LiCl solution could be regenerated by hot water from the solar collector. It may also be observed that the regeneration rate heavily depends on the temperature of liquid desiccant. Operating characteristics of the proposed system are further analyzed and discussed based on the experimental results.

SOLAR ENERGY UTILIZATION IN COMBINATION WITH TRADITIONAL ENERGY RESOURCES

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The paper describes the greatest on the scale of three Baltic States Demonstration Project concerning implementation of solar thermal collectors. The objectives of the Project were to define the optimum solutions for introducing the solar energy technology into typical for Latvia district heating systems in residential area.

The paper also elucidates previous investigations and practical work in the field of solar collectors, considering the corresponding costs of installation, operation and maintenance under Latvian conditions. In the process of Project realisation the climate and solar radiation data for Latvia were revised, which is reflected in the paper. The results have testified that the radiation level is sufficient for using solar collectors under Latvian climatic conditions. A highly important point in the technological solutions of Project was co-ordination of operating conditions of solar collectors with those of heat and hot water supply systems.

As is shown in the paper, Project envisages integration of solar collectors into heating systems for different groups of consumers – schools, kindergartens, boiler houses and possibilities to use solar energy in combination with traditional energy resources.

The paper also presents evaluation of the environmental, legislative, technical and economical aspects of solar energy applications.

The results of the Project are applicable not only in Latvia but also in Lithuania and Estonia, which possess similar climatic conditions and technical parameters of heating systems.

Thermal Analysis of a Compound Parabolic Concentrator Designed to Evaporate Ammonia

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The useful heat and instantaneous thermal efficiency of a compound parabolic concentrator was determined. This concentrator was designed as a vapor generator in a solar ammonia-water absorption refrigerator.

Based on the main advantages of direct steam generation in solar trough concentrators, the present study applied the same principle in order to evaporate ammonia using a CPC. To our knowledge, there is not another study about direct ammonia vapor generation in a solar concentrator. In addition, the low operation temperatures (around 120°C) required to evaporate ammonia could increase the collector performance and reduce the solar collector cost.

The CPC was constructed and characterized as ammonia vapor generator using water as working fluid. This was done because thermal behavior does not depend of the fluid kind and the complications for using ammonia-water mixture are avoided.

The CPC prototype was 2m length, 0.66m wide and 0.84m high, its solar concentration was 3.5x with an aperture angle of 15°. The construction materials were: high polished aluminum for the reflector, commercial black paint as selective surface, carbon steel for the receiver tube, and commercial glass for the cover. As results, the useful heat obtained was in the order of 500W, and the instantaneous collection efficiency was around 0.4.

NUMERICAL STUDY OF THE BEHAVIOR OF AN ARRANGEMENT OF COVER GLASSES USED IN HEATING WATER

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In the present work are shown numerical values that result of a mathematical model obtained of the energy balances that are made over an arrangement of cover glasses that contains water in their bottom part. The numerical values obtained are temperature distribution in six different cases considered. In each case, is studied the effect that is produced in the temperature distribution when the area and thickness defined in this work Volumetric Product (VP) are modified, this is, are studied six different glass types used to six different arrangements. The arrangement of cover glasses considered is formed for five of them placed in horizontal position one on another. In their bottom part is placed water to heat. In the upper part of the arrangement solar radiation impacts and the lateral parts are isolated. The mathematical model obtained is formed by a six differential equations system and the Runge-Kutta fourth order method is used to solve it. The numerical solution is obtained with a computational program developed in C++ and for the solution solar radiation and environment temperature data were used. The data used are for México City. The numerical results show when the VP is the greatest, the water temperature vales are the least. The VP values considered are 1.92, 0.72, 0.16, 0.028, 0.005 and 0.00075 $\cdot 10^{-2}$ m^3 and the water values obtained are 69.8, 74.7, 81.9, 84.6, 86.6 and 88.7 ºC respectively. Also is shown the temperature distribution in each glass of the arrangement and their numerical behavior is analyzed.

With these results and analysis is possible to conclude that use of an arrangement of cover glasses can be an alternative in the water heating and their use can be useful in improvement of solar box cookers.

Finally, the numerical model presented in this work can be extended for use in the studies of effect of several cover glasses used solar equipments.

ECONOMIC OPTIMIZATION AND DIMENSIONING OF HYBRID SOLAR INSTALLATION

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Abstract:
In this research work, we are interested in evaluating the economic profitability of a hybrid drier installation while leading a comparative study between two total costs:
- The first one is relative to hybrid installation (solar-fossil) where air collectors and stock, which are considered as a solar size, were modelled.
- The second one, used as a reference, is relative to the fossil dryer installation. It must satisfy the same energy demand than the first one.

For this, we must establish the general equation of assessment of values relative to the drying operation; the energy value is not necessarily currency, but it could be done by any unspecified scale of reference. We retained that of thermodynamic origin.
The object of these methods, when it acts only on one optimisation constraint, is to minimize the function-objective, organized by the total cost of the project, expressed in certain domains of value (currency, energy). This total cost being given by the balanced sum of the investments and exploitation costs, considering a certain mode of calculation of depreciation over a supposed lifespan.
In this paper, we use a function Z, depending on two costs of two dryer installations process, to evaluate the optimal dimensions of a hybrid installation dryer destined to agricultural products.

Key Words: Dryer installation, fossil installation, global cost, economic optimisation, dimensions.

CFD Simulation of Fluid Flow and Heat Transfer in a Flat Plate Solar Collector

By

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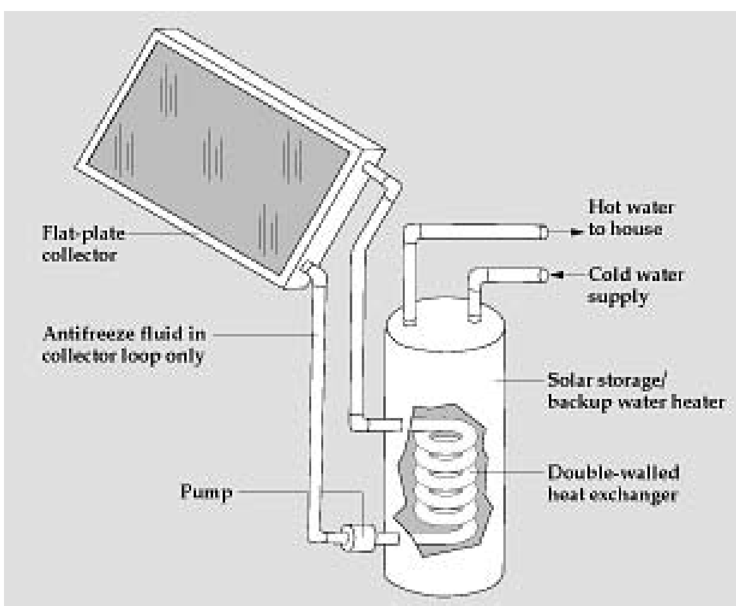
Abstract

This paper is concerned with modeling and simulation of fluid flow and heat transfer in a simple flat plate solar collector using the CFD package CFDRC ACE. Starting with a simple geometric configuration of one tube in a rectangular cavity, the aim is the CFD modeling of the mixed modes of convective and radiative heat transfer between the tube surface and the glass cover of the collector as well as the convective heat transfer in the circulating water inside the tube. Experiments are conducted using a flat plate collector apparatus and verification and calibration of the model are addressed. Comparison of the CFD simulation is conducted with both classical methods of analysis and experimental results.



A CONSTRUCTION OF SUN-TRACKING SOLAR ENERGY CONVERTER

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ABSTRACT

In an earlier paper it was shown that, if a solar energy converter (solar thermal collector or photovoltaic panel) is placed on a carrier in such a way that its active surface tracks the sun, i.e. is placed at all times normal to sunrays, in theory it can receive twice as much energy during a sunny day than a classical stationary converter placed on a fixed carrier inclined southwards at the optimum angle. It was also shown that using additional reflecting surfaces placed around the coverter at an optimal angle this amount of energy can be up to eight times larger.

Three factors limit the competitive capacity of coverters placed on suntracking carriers as oposed to the classical coverters. Those are: a) higer cost of its production, b) poorer mechanical stability at high winds and c) diffuse skylight energy adding up to the energy of direct sunlight. This contribution considers possible constructions which can eliminate the first two of those factors, i.e. which can be materialized at costs which fall within the cost margins of a classical convertor of close to twice (or to eight times) as large a surface area and be stable enough as to stand high wind blows.

A type of converter carrier is presented of a very simple construction, developed to a stage of prototype, the sun-tracking being achieved by automatic regulation of the surface orientation governed by a computer programme. Also a “light-tracking” principle is introduced, mounting some sensors onto the collector, which by means of a servo-system choose the position om maximum light.

The problem of the negative effect of the diffuse skylight on the coefficient of enhancement of energy gain of sun-tracking converter compared to the stationary one, will be discussed at another instance.

A SOLAR HEAT-PUMP SYSTEM FOR AIR-CONDITIONING, WATER HEATING AND DRYING

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Abstract – In this study, the performance of a three-in-one solar system is investigated. A proto-type of this system has been fabricated and installed on the roof top of a four storey building located at the Department of Mechanical Engineering, National University of Singapore. The performance evaluation and optimization have been carried out through simulations as well as a series of experiments conducted under the meteorological conditions of Singapore. The three applications of this system are: air-conditioning, water heating and drying, which can be served simultaneously or independently. The system can be scaled to suit for residential and commercial applications. The presence of evaporator-collector makes the system to work round the clock even in the absence of sunlight. Parallel arrangement of the evaporator and evaporator-collector is made to improve the system performance. A large fraction of the energy requirements is met by a combination of collected energy from sun and the energy recovered from a vapour compression heat-pump system, which also serves as an air-conditioner, including space heating or cooling. Refrigerant R134a is used due to the better thermodynamic and environmental performance. Preliminary simulation results are encouraging and show a system coefficient of performance (COP) of 6.0 and a solar fraction of 0.8. Results also suggest that a payback period of the system shall be as low as 5 years against the total life span of about 20 years. The above results suggest a potential implementation of the system for a commercial set-up and would give a new dimension in the process of replacement of conventional energy with renewable energy sources.

Keywords: vapour compression heat-pump, coefficient of performance, drying, solar fraction and payback period

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WATER HEATING IN THE RESIDENTIAL SECTOR - USE ALTERNATIVE SOLAR COLLECTORS A CONTRIBUTION FOR REDUCTION OF THE CONSUMPTION OF ELECTRIC ENERGY

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The solar collectors of low cost represent an alternative way to get hot water. As a result, the dependence from the traditional water heating system (electric shower) is minimized. Through technological solutions of low cost, this work approaches the possible substitution of the electric shower for the solar alternative water heating system. The alternative technological solutions of low cost provide comfort to consumers and help the country to reduce electric energy consumption in the tip schedule. Such fact constitutes one of the biggest concerns of the electric sector concessionaires. Based on the fact that the biggest percentage of the Brazilian population is constituted by low-income consumers and the initial cost for the acquisition of conventional solar collectors becomes impracticable for many families, the purpose of this work is to study the solar collector constructed by home building. The work focuses in consumption and costs estimations of electric energy comparing the electric shower vis-à-vis the alternative solar heating system in a period of one year. As a result, there was verified that the use of alternative solar heating system promotes lesser demand of electricity at the lowest cost.

Performance of Single Axis Tracking Solar Parabolic Trough In Riyadh Saudi Arabia

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Abstract

There are wide ranges of medium temperature thermal applications in which solar can be a prime source of energy. In spit of the high solar radiation in the kingdom of Saudi Arabia, relatively low cost of energy and high cost of solar energy conversion systems are obstacles toward a wide spread use of solar energy; hence there is a balance between cost and efficiency. In this paper an experimental results of a simple and locally constructed single axis tracking solar trough efficiency and quantitative measure of heat losses are presented, aimed to developed a low cost solar thermal conversion system for medium temperature applications.

MODELING OF SOLAR COOLING SYSTEMS – A Systems Approach

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The energy consumption for air conditioning of buildings can be decreased by avoiding direct solar radiation entering buildings either by using shading devices or overhang and wing walls or better insulation of walls, roof and floor. The energy consumption can also be minimized by more energy efficient technologies for air conditioning.
In this paper a systems approach is chosen. An analytical study is performed on solar energy utilization for space cooling of a building, using a solar assisted single-effect absorption refrigeration system. The model is built in the dynamic simulation tool TRNSYS which in turns calls EES, Engineering Equation Solver for analysis of the absorbtion chiller. The main components of the system are solar collectors, hot water storage tank, auxiliary heater, absorption chiller but also the different components of the building.
Three types of solar collectors: single-glazed, double-glazed and evacuated tube collectors are used in this study. The effect of collector area and hot water storage tank volume on the solar energy extraction is studied and discussed. The performance of the absorption machine is also studied by varying hot water entering temperature.
The effect of shading devices, sizes of insulation thickness, overhang and wing wall on cooling load of the building is calculated and discussed. The effect of collector area and storage tank volume in conjunction with all means of cooling load reduction on overall system performance is calculated and discussed.
A life cycle economic analysis of the system is performed since the total cost is one factor, which influences the performance of the system. The analysis is based on the cost of improvement, operating and maintenance costs. The result is compared in terms system performance, efficiency and cost.

Study of air-source heat pump water heater with solar preheating

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An air-source heat pump water heater (ASHP) with solar preheating was developed in the present study. The ASHP integrates all components of the heat pump in a single unit that can be completely fabricated in factory. No field assembly is required except the connection of water pipe line and electric connector. ASHP absorbs heat simultaneously from solar radiation and ambient air. Better thermal performance than conventional air-source heat pump thus can be achieved. A prototype was designed and fabricated (Figure 1). The long-term outdoor test results (Figure 2) show that ASHP consumes 20% less energy than conventional air-source heat pump water heater.

Figure 1 ASHP.

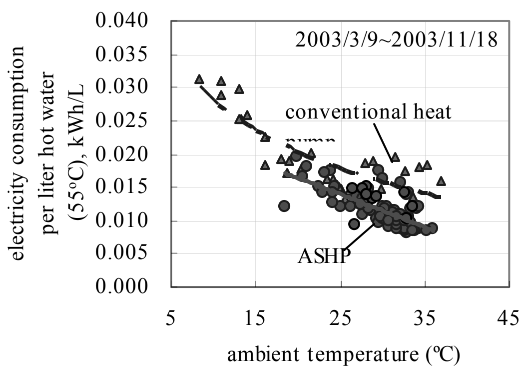

Figure 2 Field test results of ASHP.

MODELING OF MULTI-PASS SOLAR AIR HEATERS WITH EXTERNAL REFLUXES

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ABSTRACT

The solar air heaters, in which energy transfer is from a distant source of radiant energy to air, may be used for space heating, drying and paint spraying operations. Without optical concentration, the flux of incident radiation is approximately up to 1100 W/m^2, and flat-plate solar collectors are designed for applications requiring energy delivery at moderate temperature. The solar air heater occupies an important place among solar heating systems because of minimal use of materials, and the direct use of air as the working substance reduces the number of required system components. The influence on the collector efficiency in multi-pass solar air heaters with external refluxes has been investigated theoretically under countercurrent-flow operations. The absorbing plate and insulation sheet are inserted horizontally and vertically, respectively, to divide a flat-plate channel into four subchannels for conducting a multi-pass operation. The theoretical predictions show that the recycle effect can enhance the collector performance compared with that of the single-pass device without recycle under the same airflow rate and working dimension. It is our purpose in the present studies to investigate theoretically, the effect of the design and operating parameters on collector efficiency for such solar air heaters. The effects of subchannel thickness ratio on both the heat-transfer efficiency improvement and hydraulic dissipated power increment have been also discussed.

KEYWORDS

Solar air heaters; Flat-plate type; Multi-pass operations; External refluxes; Collector efficiency.

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Solar Air Conditioning System for a Single Family House in Teheran

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Abstract

In this paper, the solar air conditioning system for a single family house located in Teheran, a city with a latitude of 35, 68° N and about 1191 m above sea level. For the house with overall floor area of 402 m^2, the heating, cooling and hot water supply loads have been evaluated based on the possible weather conditions in Teheran. Solar insolation and many other meteorological factors have been analysed and the psychrometric chart for the moist-air thermodynamic properties has also been developed for Teheran.

Basic and systematic analysis and discussions with respect to the solar heating and cooling systems have lead to the design of solar air conditioning system as well as their essential components including solar collectors, absorption chiller, heat storage system, heat exchanger, air handling unit, fan coil units and plumbing systems.

Although the solar insolation would be rather prospective in Teheran, not only in summer but also in winter, it was still necessary to provide auxiliary gas fired boiler and conventional electric heater.

The detailed technical discussions on the selection of the best equipments have been considered primarily, but some economical aspects to the solar air conditioning system in Teheran have also been carefully discussed. The present paper may conclude that the solar energy application for air conditioning is promising. However, one of the most essential key factors for the solar house in Teheran is the fiscal problems as well as the selection of the best suitable equipments.

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MODELLING OF HEAT TRANSFER IN A SEMI-TRANSPARENT OPTICALLY THICK POROUS MEDIUM IN A SPHERICAL ENCLOSURE

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The current study examines the steady state heat transfer by simultaneous radiation, conduction and convection in an optically thick semitransparent porous medium in a spherical enclosure. We introduce explicitly the radiative heat flux expression in the conservative energy equation using ROSSELAND approximation to take account to radiation in the heat transfer rate

The considered medium here consists on a pile of homogeneous semi-transparent spherical particles contained between two concentric spheres: the inner sphere has a radius R_1 and is at a constant temperature T_1 and the outer sphere is insulated and has a radius R_2. A schematic diagram of the physical system is shown in figure 1.

For the mathematical analysis, the following basic assumptions are made: (a) steady state; (b) the fluid flow and heat transfer are one dimensional; (c) all the thermo physical properties are constant; (d) the solid is absorbent, participating, scattering and it behaves as a optically dense gray body for radiation; (e) the temperature gradients in the solid particles are negligibles; (f) the fluid phase is incompressible and the mass flow rate at every cross-section of the medium is constant.

The governing equations for the problem considered here, are non-linear differential equations depending on the dimensionless coordinate, conduction-radiation parameter and scattering single albedo. The numerical technique used here namely BVPFD solves a (parameterised) system of differential equations with boundary conditions at two points, using a variable order, variable step size finite difference method with deferred corrections. It is taken from the IMSL MATH/LIBRARY.

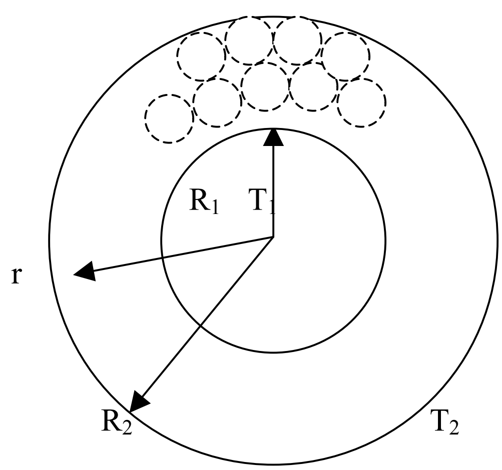

Fig. 1. Concentric spheres separated by an optically thick semi-transparent porous medium.

Modeling Convective and Intermittent Drying of agricultural products

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Abstract : The purpose of this work is to quantify the energetic interest of convective and intermittent drying process of natural products. This drying mode has been achieved within a climatic blower. This laboratory device permitted us to achieve several tests for different conditions of drying for apples, carrots and peppers. For the convective and intermittent case, the sudden change of operative conditions has been achieved of a way that permitted the continuous acquisition of the mass loss and the temperature profiles. These studies show the considerable advantages of the intermittent drying of agricultural products and confirm the preservation of these qualities and the reduction of the global drying time.

The numerical resolution is based on a physical description that takes the heat transfers within the product and between the fluid and the product layer. The equations are solved by an implicit method of finite differences. The numerical simulation profiles in the intermittent case give us more information on what happens really to the product during periods of stop. Intermittent drying process presents an energetic gain. A major gain of time and energy is gotten by an increase of the airflow temperature and a reduction of the air velocity. Our model can be adapted to other products.

Comparing a Way to Calculate the Heat Loss Coefficient of Solar Flat Plate Collectors.

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ABSTRACT

The need for a simple solution to derive the heat loss coefficient is unquestioned as this reduces time to compute the performance of investigated system, especially in the atmosphere when practicality is highly needed.

This paper describes a simulation in calculate the heat loss coefficients which were applied by three different authors in solar thermal collector.

The assumptions used, the boundaries and the method to apply it are described briefly within the law of conservation of energy.

The analysis of the result shows that the latest equation applied for solar box cooker, which is considered as a thick solar flat plate collector, is found simplest. The long field test has proved its simplicity and people can understand it easily in practice.
This way of calculation the heat loss coefficient to get the performance of investigated solar box cooker can be a tool for the scientist to transfer this knowledge to a wider level of education in the context to popularize the application of renewable energy.

ADSORPTION PAIRS FOR USE IN SOLAR COOLING – THE NEED FOR LOW DRIVING TEMPERATURES V. THE NEED FOR HIGH-PRESSURE SYSTEMS

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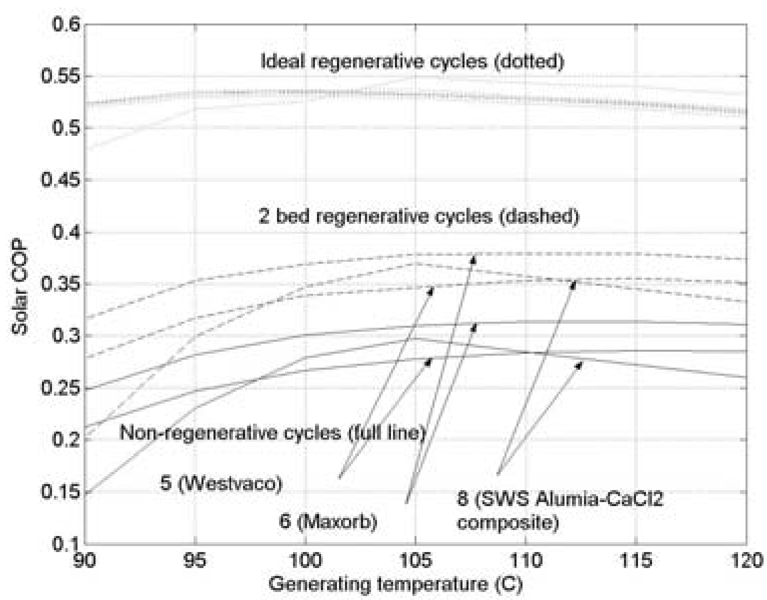
ABSTRACT
Conventionally, water has been regarded as the refrigerant of choice for solar air conditioning systems, partly because the low heat input temperatures required. The case is put for ammonia refrigerant, which with the correct adsorbent, exhibits similar driving temperatures but results in much more compact equipment. The temperature at which desorption starts is independent of the refrigerant used.
2-bed systems using highly activated carbon powders or SWS material can achieve a COP of 0.5 or solar COP of 0.3 at a heat input level of 105°C. This is about 20% less than silica-gel water, but other SWS materials are expected to be better and the equipment is much more compact and lower cost.



Case study of a swimming pool

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Abstract

The open swimming pool season in Uruguay, extends from December to March, but even in this short period, some days are too chilly for use and the first hours in the morning are generally too cold to plunge. The use of conventional heaters is getting increasingly prohibitive. For this reason a national project is proposed to solar heat open swimming pools so the season can be widened from November to April and the whole day use can be assured. Also it is thought of the best way to make a round year use of swimming pools. Necessarily we have to go to an enclosed swimming pool, because of a rather cold winter.
Despite local singularities, the country is quite homogenous from a climatic point of view and the results obtained in any site can well be extended to all others.
The reference swimming pool site we chose, is located in Carmelo, over the Uruguay River (34º S, 58º 16' W). The pool size is 25 m x 12.5 m, a volume of 633 m^3 and with an average attendance of 200 persons per day. An Excell macro programming model of the thermal behaviour of open and enclosed swimming pools is run in six different scenarios of increasing complexity. To secure a swimming season for the whole year, the use of a tent, a battery of collectors and auxiliary heat, to cope winter, is advice. The tent can be removed or vented from November to March and must be tightly closed the rest of the year. An area of collectors equal to half the pool area is enough to avoid excessive overheat and to assure the use of the pool in the morning in summer. The calculated yearly solar participation in energy consumption is 52%.

Solar-thermal Fluid-wall Transport Reactor for Hydrogen Production

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A graphite fluid-wall transport reactor heated with concentrated sunlight has been developed over the past four years for the solar-thermal production of hydrogen. Initial investigations focused on the rapid decarbonization of methane, while current investigations are focusing on thermochemical water splitting cycles. The fluid-wall is provided by an inert or compatible gas that prevents contact of reactants and products of reaction with graphite. The reactor provides for a low thermal mass that is compatible with intermittent sunlight and the graphite construction allows rapid heating/cooling rates and ultra-high temperatures. The decarbonization of methane has been demonstrated at over 90% for residence times on the order of 10 milliseconds at a reactor wall temperature near 2200 K. The carbon black resulting from the dissociation of methane is nanosized, amorphous, and ash-free. Recent preliminary experimental results have shown that zinc oxide can be dissociated at near 50% conversion using a transport tube reactor at a reactor wall temperature near 2200 K. The resulting zinc is submicron in size. The zinc oxide dissociation is the first step of a two-step thermochemical cycle to split water.

OPTIMIZATION OF THE INSULATION THICKNESS OF SOLAR REFRIGERATION INSTALLATION CASE OF THE BECHAR SITE FOR THE CONSERVATION OF DATES

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Abstract:

The agro-alimentary field took a great step as regards production, i.e. one produces more than consumes some from where the need for preserving the products in excess. Therefore resorts it to the cold stores is the solution palliative with this problem. A cold room must be designed according to a compromise between preserving the cold and the electric consumption of power.
A technique of optimization for the estimate thickness of the economic insulation of a cold room supplied with solar energy is presented in this work. The climatic conditions of the Saharan site (Béchar) and the physical characteristics of insulator are snuff in consideration. A data-processing program is elaborate in MATLAB.

Key words: Insulator, solar Refrigeration, Optimization, the Sahara, Dates, MATLAB

Solar water heating system with remote storage tank

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Abstract- The energy problem becomes more and more seriously in China. Especially in 2003 winter many huge cities experienced "lack of electricity" which makes the government begins to pay attention to the renewable energy. In recent years, millions of solar water heating systems appeared on the top of the houses, most of them are close-coupled, new style of solar water heating systems are needed to meet the market.

This paper describes design of the solar water heating system with remote storage tank.

The system includes four parts: collectors, storage tank, controller and solar circuit. We have two series of collector to fit the system: SLU and SLR. Both of them have good thermal performance characteristic, identified by Fraunhofer-ISE. The storage tank is vertical with a built in heat exchanger spiral at the bottom of the tank used to transfer heat from the solar collector fluid to the domestic water. The auxiliary energy supply from the electric heating element heats up the tank from the top or the medium. The multifunction controller is flexible that it can be adjusted according to different hot-water consumption amounts and different consumption patterns. The controller also controls the operation of the whole system. The solar circuit filling with anti-frozen fluid is equipped with expansion tank, safety valve, pump, etc. All factors are taken into account in the design to make the whole system safe even in the worst condition.

THEORETICAL ANALYSIS OF THE NATURAL CONVECTION FLAT PLATE COLLECTOR OIL HEATER

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ABSTRACT

This paper describes the mathematical analysis of the thermodynamics of the coconut oil heater incorporated into the *Natural Convection Flat Plate Collector Solar Cooker*. The cooker is powered by a double glazed flat plate collector covered with Maxorb® foil. Reflectors installed along the longer sides of the collector serve to increase the aperture area and solar energy collecting capacity. The heat transfer medium through the collector as well as the heat storage medium is coconut oil (derived from the fruit of *Cocos nucifera*). The cooking chamber is situated at the highest part of the thermosyphon loop.

Heat transfer equations describing the heat and mass transfer along the collector of the solar cooker were formulated. The energy balance profiles along the top plate, the bottom plate and the fluid within the collector were investigated by considering mass flow and heat transfer along the centre line of the collector in the direction of fluid flow. Solutions to the energy balance equations at steady state were found using *Fourth Order Runge-Kutta Algorithm*. After linearization of the equations, eigenvalues and eigenvectors were obtained using the software *S-Plus*. The general solution of the set of inhomogeneous equations was obtained using the MAPLE software. It is possible thus to obtain solutions for any set of parameters. The unknown constants were calculated using empirical initial conditions. The model yielded an analytical solution with quantitative values comparing favourably with experimental results.

SOLAR ASSISTED DEHUMIDIFICATION OF *CENTELLA ASIATICA*

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ABSTRACT

Centella asiatica (Linn) is an ethnomedical plant used in different continents by diverse ancient cultures and tribal groups. Different uses are claimed for the plant, the more common being its use as a wound-healing agent, constituent of braintonics for the mentally retarded. These properties have been ascribed to the active principles: asiatic acid, asiaticoside, madecassic acid and madecassoside. *Centella asiatica* could be used as anti-infection, anti-cancer, anti-dysenteric and anti-toxin agent, and as a medicine for relieving fever, easing of urine flow and lowering of blood pressure in alternative medicine. This paper present the comparison of *Centella asiatica* drying quality (water activity, color, and constituent) using solar assisted dehumidification drying system with an environmental chamber, and sun drying on the ground.

Keywords: *Centella asiatica*, drying quality, dehumidified air

NUMERICAL HEAT TRANSFER STUDY IN A SEMI-TRANSPARENT CYLINDRICAL POROUS MEDIUM

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Abstract

Keywords Porous medium; semi-transparent; radiative; conductive; convective; cylindrical geometry; transient.

Heat transfer process in porous media arise in many applications using high temperature systems such as radiative converter, industrial furnaces and in process for crystal growth by solidification in an outer space environment.

To take into account radiation, researchers introduce it in the solid thermal conductivity expression: the thermal apparent conductivity (Olalde et *al*. 1980, Genevieve et *al.,* 1980). The radiative transfer equation was solved, explicitly, in an infinite anisotropic scattering steady state porous medium using the Discrete Ordinates Method combined with an asymptotic analysis (Cherif and Sifaoui, 1995) and a transient rectangular semi-transparent porous medium (Ben Kheder et *al*., 2002). The current study examines the heat transfer by simultaneous radiation, conduction and convection in a scattering, absorbing, emitting porous medium in a cylindrical enclosure. We introduce explicitly the radiative heat flux expression in the balance sheet energy equation. We extend the discrete ordinates method (DOM) to study heat transfer in the medium, we evaluate the derivative term appearing in the radiative transfer equation with recourse to a classical difference schema (Modest, 1993)

The considered medium consists on a pile of homogeneous spheres contained between to isothermal cylinders: the inner cylinder has a radius R_1 and is at a temperature T_1 subject simultaneously to a radial fluid flow and a diffusely incident radiation. The outer cylinder has a radius R_2 and is at a temperature T_2.

For the mathematical analysis, the following basic assumptions are made: steady state regime,the fluid flow and heat transfer are one dimensional, all the thermo-physical proprieties are constant, the fluid phase is incompressible and the masse flow rate at every cross-section of the medium is constant. The (DOM) discrete ordinates method is adapted to model the term of divergence of the radiative heat flux in the energy equation. The numerical technique used here namely BVPFD solves a system of differential equations with boundary conditions at two points, using a variable order, variable step size finite difference method with deferred corrections. It is taken from the commercial software IMSL MATH/LIBRARY.

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The Choice of Solar Energy in the Field of Electrical Generation - Photovoltaic or Solar Thermal - For Arabic Region

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Abstract
Many countries utilize solar energy to generate electrical power directly by means of photovoltaic cell (PV). In the same time, many of them considered the concentrating solar thermal technique as a source of heat to operate the power generation units. These are the two types of solar power generation. This paper will answer the question, which is the appropriate one for our climate condition?
The paper will give the answer during a comparison between the two technologies, providing a short description of how and where they are working, areas of operation and cost – considerations, availing from the other international experiences.

INNOVATION IN SOLAR CROP DRYING TECHNOLOGIES

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ABSTRACT

Innovation in solar drying technologies can take place in two forms; introduction of new invention or to have new idea or method in the drying process. The drying technology development can proceed in two directions, either simple, low power, short life, and comparatively low efficiency-drying system or high efficiency, high power, long life expensive solar drying system. The Solar Energy Research Group at our university has developed five solar assisted drying systems namely (a) PV assisted solar dryer (b) Solar dryer with V-groove solar collector, (c) Solar dryer with double-pass solar collector with integrated storage system, (d) Photovoltaic thermal (PVT) collector system and (e) Solar assisted dehumidification system for medicinal herbs. The drying systems designed are to cater for wide range applications of agricultural produce.

Keywords: PV solar dryer, Double-pass solar collector, V-groove solar collector, solar dehumidification system, photovoltaic thermal solar collector.

The Emerging "Green Heat" Market in the United States.

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Whether driven by subsidy, environmental considerations, economics or lack of alternatives, the solar thermal or "green heat" industry overseas is much larger than the US industry. Europe is a major market. Turkey has a large industry. China is the largest market of all with an annual turnover of $1 billion. In comparison, annual turnover of US collector manufactures is $33 million.

Europe has built a significant industry in spite of the fact that most subsidies are directed at technologies, such as photovoltaics, aimed at generating electricity. Likewise, Portfolio Standards in the US favor solar electric generation, even though solar heat technologies can be more cost-effective at displacing electricity or in displacing natural gas that can be used more productively for the clean and efficient generation of electricity in combined cycle gas turbines.

The US has many advantages that favor the spread of solar heat technologies. There is a large potential market and especially in the southwest the solar resource is excellent. Areas of high insolation favor the use of concentrators, such as parabolic troughs, that for large-scale applications are more efficient and less costly than flat plate or evacuated tube collectors.

The US green heat market has been constrained by competition with low-cost natural gas and by lack of economic incentives. However, recent increases in the price of natural gas, the possibility of federal incentives for residential solar systems and activities at the state level could provide the impetus for the growth of the market. Increased deployment will reduce the cost of solar thermal installations. The potential US green heat market is staggering if green heat can compete economically with natural gas. The question arises as to whether US industry will have a stake in this emerging industry or whether it will come to be dominated by large overseas producers already well positioned in established markets.

Is Parabolic Trough Solar Power Plant Technology Ready for its Next Growth Surge?

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Kearney & Associates
Vashon, WA

Henry Price
NREL
Golden, CO

Parabolic trough solar technology is the lowest cost large-scale solar power technology available today, primarily because of the development and experience associated with the nine large commercial-scale solar power plants that are operating in the California Mojave Desert, totaling 354MWe capacity. This paper reviews the current state-of-the-art of parabolic trough solar power technology and describes the R&D efforts that are in progress to enhance this technology. The paper also shows how the economics of future parabolic trough solar power plants are expected to improve.

The operating performance of the existing SEGS plants has shown that parabolic trough solar power plant technology is robust and an excellent performer in the commercial power industry. Since the last commercial parabolic trough plant was built in 1990, substantial technological progress has been realized. Together, these factors mean that the next generation parabolic trough plants are fully expected to be even more competitive, with enhanced features such as improved collectors and economical thermal storage. In addition, worldwide R&D efforts are likely to continue to drive costs down and improve the performance and capabilities of this renewable energy option. Parabolic trough solar power technology appears to be capable of competing directly with conventional fossil-fuel power plants in mainstream markets in the relatively near-term. Given that parabolic trough technology utilizes standard industrial manufacturing processes, materials, and power cycle equipment, the technology is poised for rapid deployment.

Parabolic Trough Solar Technology For Utility Power Markets In The Southwestern United States

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NREL
Golden, CO

If solar energy is ever to be a significant contributor to the world's primary energy supply, then large-scale solar energy systems must be developed. The southwestern United States represents one of the best regions in the world for the development of large-scale solar electric power systems. This desert climate has excellent solar resource, abundant land availability, and a growing population with increased demands for electric power. Solar electric power systems are a good match for this region because peak electric generation coincides with cooling loads that drive the peak demand for electricity. Studies have shown that there is sufficient land availability for solar energy to provide a significant portion of the total electric needs for the southwest and potentially even a sizable contribution to the energy needs of the entire United States. For this vision to be realized, large-scale centralized solar electric systems need to be deployed to replace the region's dependence on conventional fossil fueled electric generation systems. This paper looks at what the cost of power would be from conventional fossil power technology and compares this to what the cost of power might be from new parabolic trough power plants. A number of approaches are shown that bring the cost of solar electricity to parity with that of electricity generated from natural gas power plants.

An Analysis of Siting Opportunities for Concentrating Solar Power Plants in the Southwestern United States

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Abstract

In 2002, Congress asked the U.S. Department of Energy to "develop and scope out an initiative to fulfil the goal of having 1000 megawatts (MW) of new parabolic trough, power tower, and dish engine solar capacity supplying the southwestern United States [[1]]." The major purpose of a large solar installation initiative would be to accelerate the transition of concentrating solar power (CSP) generation technologies to a point where they could establish sustainable markets. A recommendation was made at the North American Energy Summit in April 2004 that the Western Governors' Association (WGA) form a task force to coordinate the development of 1000 MW of new CSP capacity. A formal declaration of the WGA-led effort was presented and accepted at the WGA annual meeting held in Santa Fe, New Mexico, in June 2004.

In this paper, we present a review of the solar resource for Arizona, California, Nevada, and New Mexico. These four states have the greatest number of "premium" solar sites in the country and each has a renewable portfolio standard (RPS), or in Arizona's case an environmental portfolio standard. In addition, we present information on the generation potential of the solar resources in these states, and present regions within each state that may be ideally suited for developing large-scale CSP plants because of their proximity to load and access to unconstrained transmission.

STUDIES ON HYBRID PV/T SOLAR COLLECTOR

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ABSTRACT: One of the most ingenious methods of solar energy conversion systems is the photovoltaic thermal solar collector system, which converts solar radiation directly to both thermal and electrical energies. In its simplest form a photovoltaic thermal collector consists of photovoltaic cells affixed to the absorber surface of a flat-plate collector. The main goal of this project to predict the outlet temperature using Mat lab soft ware after done simulation for energy balance equation of Hybrid PV/T solar collector with CPC by applying the three matrices,[A],[B],[C], and run this three matrices into Mat lab program. The results show that when increase global solar radiation the outlet temperature increase, and when decrease the mass flow rate the outlet temperature increase. And also comparisons are made between the performance of the two types of combined photovoltaic thermal collectors, single-pass and double-pass. Also the results show that the new design, the double-pass photovoltaic thermal collector, has superior performance. Important parameters for both types of collector are identified, and their effects on the performances of the two types of collectors are presented in detail.

ENERGY, COMPLEXITY AND CITY

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Abstract

Thermodynamics is a science with a very wide application field. Its principles are well established (see, for instance, Zemansky & Dittman, 1981), and the energy resources and energy consumption at human scale follow these principles.

In the consideration of energy resources and its use by the mankind it should be pointed that work (mechanical work) is very important. This can be noted in the history of mankind, and now, in the cities, this is emphatised: in public works, building industry, obtention of food and supplies, transportation... From the observation of natural (darwinian) selection, what has produced the prevalescence of some species has been the mobility (which needs mechanical work) and the adaptability and ability to obtain resources, aspects linked to mobility and to the availability of mechanical work.

Thermal machines are used to obtain work from heat transfer. These are subjects of thermodynamics. The detailed consideration of thermal machines shows that, in simple cases, an external work source is needed to obtain cyclic (sustainable) working (for instance, from time to time it is necessary to compress the gas inside the cylinder of a motor), or it is needed a "forcing" device, as indicated in (Shukuya, 1996).

It has to be also noted that an increase in the complexity of the system (for instance, the use of various cylinders appropriately linked) allows the independence from the external work supply. This suggests a general law of increase of complexity in some systems, facing the second thermodynamics law of "tendence to universal uniformity": Increase in complexity of a system will proceed if this allows to obtain further resources, enough to sustain the procedure running in the system. Following this analogy, urban tissues will continue to increase its complexity and extension if enough resources can be obtained.

The project GÖTEBORG 2050: Working with visions of a sustainable society

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In the project GÖTEBORG 2050 visions of a future sustainable city and region of Göteborg, Sweden, have been developed. The visions are to be compatible with a global and equitable sustainable development.

Using a methodology called backcasting, the visions are being used for local strategic planning in order to accelerate sustainable development. The project is active in a number of planning processes for sustainable urban design in the City of Göteborg and the Göteborg Region, including energy planning, regional planning for sustainable transportation futures, urban planning and planning for waste management.

In the report "Solar City Göteborg 2050" a long-term sustainable regional energy scenario has been presented as input to the development of a new energy plan for the City of Göteborg. In the scenario the per capita energy use is less than 25 000 kWh and all energy supply is renewable. This means that energy use per capita is reduced by 50% while keeping the energy services of today. This can be accomplished using a combination of smart and efficient energy technologies, a change in life-styles and energy efficient urban planning. The renewable energy supply scenario includes the use of biomass, waste, wind, hydro, marine currents as well as solar heating and electricity.

In the reports "Transportation Göteborg 2050", "Urban Structure Göteborg 2050" and "Eco-cycling Göteborg 2050" other aspects of sustainable urban design are covered and the interactions with the energy sector are explored.

More information can be found at **www.goteborg2050.nu** .

Innovative On-site Integrated Energy System Tested

Jeanette B. Berry, Oak Ridge National Laboratory
Ed Mardiat, Burns & McDonnell
Rod Schwass, Burns & McDonnell
Cliff Braddock, Austin Energy
Ed Clark, Austin Energy

Abstract

A prototype power plant could revolutionize on-site generation for businesses. The Department of Energy and Oak Ridge National Laboratory teamed with Austin Energy, a municipal utility, to develop this plant, called an integrated energy system. Burns & McDonnell developed, installed and is testing one of the largest systems in the nation to use a new technology approach: use the waste heat exhaust from a natural gas–fueled generator as the only fuel source for a chiller that provides air conditioning. Recycling waste heat to power another generator or to help run a chiller is not new. What is new is for a chiller of this size to be fueled by waste heat alone—without any supplemental fuel. The project's chiller, called an absorption chiller, is capable of delivering 2,500 tons of chilled water. By design, the full waste heat output of the natural gas-powered 4.5-MW Solar turbine closely matches the chiller capacity. Operation, which began in June 2004, should verify fuel efficiency of 70% to 80% against 55% efficiency for the best central power plant technology available today. Testing and verification of the skid-mounted design should lead to adoption of this system in commercial and institutional settings.

ARCHITECTURE FOR A SUSTAINABLE FUTURE

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ABSTRACT:

Sustainability and Architecture are synonymous terms. While sustainability; physically and economically is to a large extent manifest in the habitat built form, it is the scientific temper that will lend a design methodology and process, in order to render Architecture sustainable. To achieve this; A 'Energy, Resource Flow – Ecological Foot Print' model is suggested which can help optimize input-output parameters and their relationship. Possible formulation of these parameters leading to a Sustainability Indicator is also suggested. This leads to a process of design and various actual projects in response to critical issues. Thus suggesting **A New Language of Architecture**.

Some Contemporary Solutions:

PEDA Building Complex: Designed in the composite climatic context of Chandigarh. The Project is a fine example of Sustainable Architecture integrating renewable energy systems as elements of design.

National Institute of Renewable Energy: Designed in the composite climate context of Punjab. A complete Institute based on principles of ecological Architecture.

CITIES GOING SOLAR: THE SAN FRANCISCO STORY

David Hochschild, Director of Policy, The Vote Solar Initiative

In recent years, local governments have assumed a leadership role in bringing solar energy into the mainstream. San Francisco has adopted one of the most ambitious solar programs in the nation. In November 2001, San Francisco voters approved a $100 million revenue bond to pay for solar panels on public buildings. Come learn about the large scale solar projects the city is implementing and explore other successful approaches to designing, financing and implementing large-scale solar energy programs in cities around the country.

WAsP Analysis for Wind Energy Assessment over Kutubdia Island

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Abstract

Though the best method to determine the wind energy potential of any location is to measure the wind on site for several years, it takes a lot of time with huge investment. Wind Atlas Analysis and Application Program (WAsP) is a powerful software package that can be used to predict the wind climate for any location with the help of data of another station several kilometers away under the same climatic condition. In this work WAsP has been used for wind energy assessment of a coastal location Kutubdia island, Bangladesh where the Bangladesh Meteorological Department (BMD) wind monitoring mast (91.85^0 E, 21.82^0 N) is located at the top of the roof of a two-stored building. A comparative study has been done between the measured monthly values of BCAS stations (91.84^0 E, 21.86^0 N) at 25m height and the predicted wind climate at the same location using the data of BMD stations. Then a wind energy assessment at 50m height has been done for Kutubdia by generating the wind atlas using 10 years (1991 – 2000) data of BMD. As wind has strongly seasonal effect in Bangladesh, monthly wind atlas has also been developed. It has been found that monthly averaged wind speed varies from 2.5 to 7.5 m/s.

MODELING PARALLEL SEIG FOR WIND FARM SIMULATION

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Abstract— Self-excited induction generators (SEIG) offer many advantages as variable speed generators in renewable energy systems. Small hydro and wind generating systems have constraints on the size of individual machines and several induction generators must be paralleled in order to fully access the potential of the site. SEIGs connected in parallel may lose excitation momentarily due to large transient currents caused by differences in individual instantaneous voltages and frequency. This phenomenon cannot be easily simulated using the conventional models due such a fast transient nature. This paper presents an innovative and automatic numerical solution for steady-state and transient analysis of any number of SEIGs operating in parallel. Experimental results confirm the accuracy of the proposed model opening new possibilities to incorporate advanced control to monitor and optimize a parallel installation of SEIGs. The proposed SEIG model is applied to a two-turbine case, which can be extended to simulate a wind generating system.

Keywords: *State space methods, Induction generators, Transient analysis, Parallel machines*

DEVELOPMENT OF RENEWABLE ENERGIES IN CUBA FOCUSING ON WIND ENERGY

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ABSTRACT

In the present work a brief summary of the main activities developed in Cuba in the field of renewable energies with special emphasis in wind energy is presented. An overview of current status of wind energy in Cuba is given. Details of recent decisions related to wind energy are presented through the national government policies and the national wind energy program for 2003 to 2010. Derived from this, the strategies for technical development and implementation are discussed.

During the 1990's several studies of the wind resources in Cuba have been carried out in order to obtain a better understanding of the wind resources in specific areas of the country. These studies are based on wind measurements from 150 meteorological stations spread all over the country and local measurements using data logger, and as expected the studies conclude that the best wind resources are to be found along the northern coast. The main conclusion is that there are sites in Cuba with mean annual wind speed comparable to sites utilized for wind power projects in other parts of the world. The total installed capacity of wind turbines in Cuba is 0.45 MW. Another two projects are in negotiation. The scope is to develop for the first time in Cuba two commercial projects of electric generation by means of wind energy, deploying wind farms in 2 regions where Cuban Electric Union foresee future deficits of electricity, taking into account that as a consequence of the State orientation in favor of the environment conservation it becomes of high importance to introduce generation capacities based on environmentally friendly technologies, either connected to the NES grids or to isolated systems in weak ecosystem areas.

Recently, the Front for Renewable Energy (FRE) was created, focusing on renewable energy development. The objectives for the FRE is to advise the government on the policy related to the use of renewable energy resources and to propose the most technical, economical and feasible projects. Within the FRE diverse institutions, entities, universities and research centers linked with this strategy activity are represented. At the beginning of the last year the FRE officially established the Program for Wind Energy Development which will be present in this paper. This program declares that the Cuban Government has considered wind power as an important part of energy sector and mapped out a development plan for wind power up to year 2010. The Program is divided into two parts: Generation using wind parks connected to the grid and Hybrid systems PV-wind-diesel for the electrification of objectives in remote areas no connected to the grid.

11kW stand alone wind turbine based on proven wind turbine

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The paper will present the rationale behind the design of a stand-alone version of a existing 11kW wind turbine that has been installed at 100 sites mainly in Denmark. The wind turbine has been developed as a part of the Danish household wind turbine programme that included certification, and a measurement programme. The positive operational experience with the turbine has motivated the development of a stand-alone version.

The stand-alone version uses the standard version of the wind turbine combined with a back-to-back converter arrangement in order to decouple the wind turbine from the grid and enable control of frequency and voltage independently on both the grid side and the generator side.

The prototype has been installed at Risø. The paper will present results from test runs of the system both operating stand-alone supplying a single load and in parallel operation with a diesel genset.

Randomly Wind Energy Calculation Formulation at Inshas, Egypt

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Abstract:

It is well known that the wind energy potential is proportional to both air density and the third power of the wind speed averaged over a suitable time period. The wind speed and air density have random variables depending on both time and location. The main objective of this paper is to derive the most general wind energy potential formulation putting into consideration the time variable in both wind speed and air density. The correction factor is derived explicitly in terms of the cross-correlation and the coefficients of variation. The application is performed for wind speed measurements from the Radiation Protection Department, Nuclear Research Center at Inshas, Egypt.

NONLINEAR DYNAMIC FEEDBACK CONTROL OF A VARIABLE SPEED WIND TURBINE

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The purpose of this work is to develop a nonlinear feedback control law in order to optimize the wind power capture in the partial load operation (below rated power). The wind turbine considered in this study is a variable speed one. Nonlinear model of the wind turbine is first constructed including three parts: the rotor aerodynamics, the gearbox dynamics and the asynchronous generator electrical equations.

As wind speed undergoes significant variations, linear control methods do not lead to acceptable performance. Nonlinear Dynamic Feedback Control of the wind turbine is then designed based on the constructed model, the objective is to maximize power extraction from the wind by adjusting the rotor rotational speed to wind speed variations. In fact, the aerodynamic power is proportional to the aerodynamic power coefficient that reaches its unique maximum for a fixed ratio between the rotor speed and the wind speed. The control action is the excitation winding voltage of the asynchronous generator related to the rotor through the gearbox, this action has to make such that the aerodynamic power stands at the maximum in spite of the wind speed variations.

Simulation results show good performance of the proposed control law for different reference rotor speed profiles that correspond to proportional wind speed profiles.

Design and running tests with MoWEC in stand alone use

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ABSTRACT

Wind energy is one of the most important sources of renewable energy. But disadvantages include the minimal energy concentration and the irregular availability of wind power. For this reason, multivalent energy systems with preferential use of renewable energy should be also built for future applications.

As an enhancement to the permanently installed wind power facilities, the concept of a patented M**o**bile **W**ind **E**nergy **C**onverter **MoWEC** has been effectively in the home institute since 2002 for further testing and developing under practical field conditions. The MoWEC is planned as an easy to handle wind energy device with one or more rotors to convert preferable electrical energy for entire rural areas. The MoWEC can work in **stand alone** and/or with grid connection. The rated power ranges at the moment from 5 to 30 kW.

The approaches lead to **MoWEC 1** with two rotors and a yaw drive which turns on a chassis. In 2004 we worked to develop a **MoWEC 2** with a diesel engine (photos in Fig. 3-6). The diesel engine can be used at times with insufficient wind velocities. This second MoWEC 2 system, which will be field tested in 2004, is designed on the same principle but now features a yaw drive frame with road wheels which are also suitable for road transportation.

Utgrunden Offshore Wind Farm Research Project

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The offshore wind farms have become economically viable alternatives for large-scale renewable energy production. However, many technical issues remain to be solved in order to allow a further reduction of the cost of energy. For the Utgrunden offshore wind farm a research study has been launched to gain further understanding in several technical challenges. The research project is divided in five different work packages.

Work package one deals with the design verification, performance and loads. One main objective is to verify the measured loads with simultaneous measurements of the wind, waves and currents with the simulated loads for this soft-soft monopole support structure. Another objective is to map the power losses due to operation in wakes. The power losses can be mitigated through the so-called active wake control by a controlled yawing the upstream wind turbine. The increased loading due to forced yaw operation needs to be taken into account; furthermore, the extra energy yield will be quantified in order to assess the efficacy of the active wake control.

The main subject of work package two is the electrical performance and the grid connection. The goal is to study the impact of the offshore wind park on the grid. The ability of the control system to influence the power quality and the response of the offshore wind park to a grid disturbance will be investigated as well.

To have a better understanding of the offshore meteorological conditions different models are being used to model the offshore wind climate, a WAsP model and the MIUU- model in work package 3. This shall shed more light on the uncertainty concerning the calculation of offshore wind potential. The thermally driven flow due to the temperature difference over land and over water will have impact on the wind potential; this is another study item in this work package.

Operation and maintenance is still loaded with considerable uncertainties because of the lack of extensive experience on operating and maintaining large offshore wind parks. For this reason in work package 4 different databases concerning the service activities, wind power production, access report etc. will be used to determine the impact on energy output, availability etc.

In work package 5 the installation techniques will be assessed in order to draw recommendations for faster installation in future projects.

The work reported here forms part of a Swedish Energy Authority funded research project for the Utgrunden offshore wind park and is being undertaken by GE Wind, Chalmers University of Technology, FOI, and Uppsala University.

Feasibility of wind-powered water pumping for rural agriculture production in Ghana.

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Abstract

Wind energy potential in Ghana indicates that an average wind speed of 4.5 m/s is attainable at a height of 9 m above the ground, which is sufficient to operate wind-powered displacement pumps to extract water from boreholes for irrigation, livestock and household needs to enhance agricultural production. The wind power was employed directly through mechanical coupling of a multi-bladed 5 m diameter rotor (on a tower on concrete foundations) with lift pump and rods. The design is simple and robust with very low materials and manufacturing costs, and excels in water output per unit cost and reliability. Prototype wind-powered water pumps with direct drive (no gearing) horizontal axis rotors and reciprocating pumps were built and installed at two small farming communities isolated from the national electricity grid lines. The systems were manufactured locally and installed to pump water from average head of ~ 40 m using small diameter rotors directly coupled to single acting piston pumps without any back gearing. The transmission assembly consisted of a welded frame to which components such as drive shaft bearings and other moving parts were bolted. The bump stop frame was also bolted onto the transmission-welded frame. Apart from the low operational and main-tenance costs, the wind-powered pumps cost less than other water pumping systems on the market, and have capacity to pump water to tanks at a distance of over 1 km and heights of 50 m for either pressurized drip irrigation or water distribution systems. The field results from the two installed pilot wind-powered pumping syst-ems at Kweiman and Tolon, operating at a pumping head of about 30 - 40 m, indicate that water output of about 25,000 litres per day could be obtained from each pump. A cost benefit analysis of the operation indicates that for irrigation and other water requirements in the rural areas, wind power has comparative advantage over other conventional energy options.

PERFORMANCE STUDIES ON A DIFFUSER AUGMENTED, HUBLESS WIND ENERGY TURBINE

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Performance studies have been conducted on a new concept namely, a hub-less Diffuser Augmented Wind Turbine (DAWT). The concept consists of circumferentially mounted blade rotors coupled with a diffuser ring. It gains advantage in terms of better torque absorption as shown in numerical studies. The ring diffuser also helps in flow augmentation. Two methods have been considered for the basic prime mover. In the first case, as an induction generator, the ring houses the rotor windings of an induction machine. In the second case, as a DC brushless alternator, it houses permanent magnets. The ring and blades configuration is mounted for concentricity, on a central hub with strut supports. The stator winding surrounding the rotor is independently supported on a tower.

Conceptually this set up extracts more aerodynamic power leading to better overall efficiency. As an induction machine, power generation starts when rotational speed exceeds the synchronous speed. As a DC brushless generator, it is powered initially to work as a motor, to overcome starting friction and then will be switched to run as a generator. The set up is ideal for moored floating system with self yawing property for optimal wind direction. CFD modeling of the flow in the presence of the flow augmenting rotor (diffuser) shows improved power absorption. Simulation studies on the combined pneumatic-electrical model have shown improved power generation efficiencies.

Wind Energy Potential and its sustainable exploitation in Sicily – A GIS based methodology

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Abstract

A Geographical Information System (GIS) supported methodology has been defined and adopted in order to assess the real technical and economical potential of wind energy production in Sicily contest. This methodology is based on a data base referred to a (GIS) collecting data about wind speed and frequencies, transport facilities, urban cartography, regional territorial planning, terrain digital model, lithology, climatic types, civil and industry census. By means of that GIS it was possible to select potential areas for wind farm installation.

The study has been conduced in the framework of Regional Energy Master Plan (REMP) for Sicily in order to assess the potential exploitation of RET and to develop and support policies voted to the reduction of environmental impact of the Regional energy system.

Because of favourable wind availability and of recent energy market rules, allowing for green certificates trading, a very impressive venture has been addressed to wind energy, with about 100 wind farms projects proposals. This have generated a big debate concerning the rules to be defined for a "sustainable" exploitation of land. In this framework such methodology represents a decision support tool either for technicians either for administrative/politicians actors in order to define shared criteria and guidelines for the correct implementation of Wind Energy in Sicily.

The common task could be to develop a Wind Energy Master Plan, where potential areas, installation typologies, land-use densities are defined according to different constraints and interests.

Flow Analysis of Straight Wing Vertical Axis Type Wind Turbine

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Abstract

Researches about the aerodynamics of wind turbine with straight wing vertical axis (SW-VAWT) are very limited, in spite of a number of advantages such as low dependence on wind direction variation and easy constructible straight blades. For these reasons, we are researching the lift type SW-VAWT for many years. The elucidation of the behavior of the flow inside and neighborhood of the wind turbine during the rotation is very important because of the performance improvement of the vertical axis wind turbine. This research examined to the aerofoil characters by using the numerical simulation technique and the precision of the prediction technique was confirmed as this result. Furthermore, we estimated flow behavior during the wind turbine rotation by using this numerical simulation technique, and evaluated the flow around the wind turbine. This paper presents outline and results of these calculations and evaluations.

Lightning Protection of FRP Blades for Wind Power Generators

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Abstract:

In Japan, lightning damage of FRP blades for wind power generators is increasing according to the increase of wind power generators installation in the recent years. In Kochi, Japan, six 600-750 kW grade generators were installed and met several lightning damages. The damage of FRP blades is hard to be quickly recovered, because the majority of the generators are from mainly Europe.

After surveying literatures or asking the related organizations such as NREL or Toray USA, the experiments were planned to perform lightning damages to FRP specimens. The experiments were conducted mainly in TMT&D Laboratory in Kawasaki. The laboratory is one of the biggest ones for high voltage and high current experiments.

The specimens prepared are GFRP (45degree prepreg), GFRP(special prepreg), GFRP(special prepreg and cupper mesh sheet inside), and CFRP plates. The plate size is 450mm width x 2.5 m length x 4mm thickness. The condition of non-aluminum coating and aluminum coating was considered. Aluminum coating was considered from the information about aircraft application.

The result was that all FRP plates aluminum coated survived even under the impulse current conditions. However, other plates without aluminum coating suffered from more or less damages.

Therefore, it resulted that one possible candidate for lightning protection for FRP blades is aluminum coating. However, more experimental researches such as exact reproduction, perfect protection methods, and other issues like cost and weight for coating are needed.

Evaluation of wind power generation patterns in (CEGCO) Jordan

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Member of the Jordanian Engineers association
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(listed in the second call for abstracts)

Purpose of the work:
This paper focuses on the two existing wind power parks at CEGCO and the only ones in Jordan (Hofa and Ibrahymia). It provide an analysis of their performance in terms of annual power generation (load factor) in comparison with Jordan's power demand pattern and prevailing wind power potential relation and defines the mathematical function that predicts power generation verses time.

Approach:
Based on collected data from wind park operation records, wind measurement stations and CEGCO power generation records, data were analyzed, sorted, tabulated and compared with relevant sets for a series of five consecutive years.

A series of curves were generated which mainly defined the annual patterns for wind speed, wind power generated, Jordan's actual power consumption for each of the five years. Using the averaged data and a set of regressions, a function was derived that best fits wind power generation for each site and which can be further used to predict power generation for that specific site. Furthermore the paper evaluates economical and environmental performances of both wind parks where it concludes the conditions that need to be set to attract such renewable (wind energy) projects in Jordan.

Conclusion:
The work concluded that the wind power generation in both wind parks has a defined pattern that can be mathematically represented which can be used for future load for casting. It also shows that the maximum power demand period of Jordan coincides with the maximum wind power potential period, which is a major advantage for wind power generation. Although Jordan's wind power generation installed capacity is very modest and represents only ~0.1% of CEGCO's 1535 MW installed capacity, future power generation development and expansion plans call for investment in renewable wind power generation and in relatively large scale by adding 100~120 MW of wind power.

DESIGN, MANUFACTURE, TRANSPORTATION, AND FOUNDATION CONSTRUCTION OF WIND TURBINE TOWERS

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ABSTRACT

The more conventional types of wind turbine towers are lattice, concrete, and guyed. But modern wind turbine towers are mostly cylindrical shells fabricated of welded steel. The towers range from 25 – 80 meters high. The height of the tower is a trade-off between the benefits of catching more wind at some height above the ground versus the increased bending moment at the base. Thus tall towers generally increase the wind turbine's energy production, but whether a taller tower is worth the extra cost depends both on the roughness class and the cost of electricity. The main problems for high towers are the manufacturing techniques, which put an upper limit on the concrete tower. Towers are a fairly heavy part of the wind turbine; therefore, transportation costs are an important element in project design. The foundations and installation costs of offshore wind turbine towers are significantly higher than onshore turbines. This is mainly due to economic challenges associated with sea-bed development. The paper presents an overview of the principles of design, manufacturing, transportation, and foundation construction of wind turbine towers. Continued research in lightweight composite materials will provide the most efficient and cost effective options for both onshore and offshore wind turbine towers. A further spin-off benefit will be reduced transportation costs.

Development of a 800 kW RFPM Synchronous Generator for KBP-750D

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Pohang Wind Energy Research Center (PoWER-C) is developing a 800 kW Radial Flux Permanent Magnet (RFPM) Synchronous Generator for KBP-750D wind turbine development. It features direct drive and permanent magnet excitation for higher energy yield and higher efficiency. The stator inner radius is 3.32m with 42 pole pairs which gives 17.5Hz at the rated 25rpm. The utilization of strong rare earth magnet resulted in a high efficiency of 95.6% at rated speed when the internal power factor of the generator is controlled actively with generator side inverter. In this report, the design, manufacturing, test results of the efforts are described.

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A conceptual design of a direct driven wind energy converter of 750kW

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As a part of national efforts to establish an own design capability to construct a 750 kW wind energy converter system in Korea, a prototype of a direct driven wind energy converter is developed currently. This presentation will report on the conceptual design and some design details on blade performance, drive train and radial flux permanent magnet multi-pole generator with inverter as well as the controller.

Figure: Artistic view of the direct driven WEC of 750kW

Sri Lankan case study on Public / Private participation in the promotion of wind energy

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Micro wind power systems are one of the most appropriate and comparatively economical renewable energy sources to meet the off-grid energy needs of Sri Lanka. To penetrate the target markets and intended beneficiaries of Sri Lanka, it requires sound demonstrations to prove its technical, financial and or economic viability. This paper, presents a case study of a successful wind powered rural electrification project and the establishment of a revolving fund with public / private participation.

ENERGY STORING WIND DAMS

Allan McCreadie, BE Director, Green Zephyr Co Ltd, NZ

Concept Explanation:

Integration of high density wind turbine massive cellular array with direct driven water pumps for storage in aquaduct over. For hydro generation on demand / price, irrigation or water supply. Can recirculate on existing or new hydro dams.

Reasons:

Turbine density; Responsible responsive generation; Capital security; Simple refined low technology; Can maximise local involvement, materials, labour, and maintenance; Minimise number of generators to synchronise; Wind energy initiative that doesn't alienate 75% World population; Collect all accessable energy without "regulating" (dumping) to trough level output.

History:

Fixed orientation cellular arrays of wind turbines axial and cross-axis flow types.

Our Enabling Technology R&D:

Ducted bidirectional flex-set sailwing turbines; Inlet area based results; Area ratio- choked flow Interaction; yawed flow / reversed flow results; Pump matching for hard-coupled direct drive from turbine. (Work in progress)

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Grid connection of large wind farms – a technology assessment

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Development of large wind farms may just as any other large power plants require reinforcement of the power transmission system. The grid reinforcement may be economic, i.e. paid back by reducing losses, but often it is suggested as a necessity to ensure system stability. The system stability is commonly assessed considering the implications of various grid faults and combinations of system load and generation. This paper demonstrates that in such analyses the assumptions made for describing the wind farm technology can dramatically influence the analysis results.

Models of various wind farm technologies are applied to the same regional power system grid model, and for each case of wind farm technology the same set of analyses are prepared. This highlights the pros and cons of the various wind farm technologies with regards to grid impact. Both fixed and variable speed wind turbines are considered, but also control schemes that may be combined with wind farms are assessed.

Variable speed wind turbines offer improved active power control compared to fixed speed wind turbines. Dynamic reactive control is a built-in capability of most variable speed wind turbines, whereas wind farms with fixed speed wind turbines may be equipped with static var compensation to achieve similar control capabilities. In the event of a grid fault, e.g. a nearby temporary short-circuit, the response of the wind farm depends on various factors as rating of power electronics and operation of protection system. Study results indicate that it may be relevant to consider preparation of standardized test routines to document grid fault response of wind turbines.

Wind Mapping of Pakistan and Wind Turbines Manufacturing Program in Pakistan

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ABSTRACT. There was no wind speeds data available at standard 30 meters height desirable to assess true wind energy potential. There was therefore an urgent need to develop contour maps of Pakistan showing effective wind regimes in the country so as to catch up with other countries in this field. Wind speeds data was being collected all over the country at different heights from 2 meters to 10 meters. This data was initially simulated to standard height of 30 meters, while simultaneously a major project was initiated under the Ministry of Science and Technology through Pakistan Meteorological Department to collect data at suitable locations highlighted by the study especially near the seacoast at a height of 10 meters and 30 meters. It was ensured that data is collected in such a way that inland depth of wind belt/ high wind zone is also ascertained.

There is an acute shortage of energy resources in the country and despite of apparent good wind speeds the technology of wind turbines was not being pursued. All international agencies required accurate wind data to even initiate feasibility studies. Wind maps were prepared for 12 months based on monthly average wind speeds and the data was published. This data became the base on which further evaluation of true potential was made and 40 sites were selected to install masts to collect wind speeds for one year. Wind energy data is now being collected at 40 different locations in Pakistan at 10 and 30 meters height above ground. Some interesting features and a significant potential of utilizing wind energy is now available in the country.

APPLICATION OF ARTIFICIAL NEURAL NETWORKS FOR PREDICTION OF WIND ENERGY

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To take into account, the non linear nature of wind speed time series, we fitted a variety of Artificial Neural Network models for prediction of hourly wind speed (which a few hours in advance is required to ensure efficient utilization of wind energy systems) at Quetta, Pakistan, and the results were compared. We used one year data (8760 values). Approximately 5000 values were used for training. Approximately 7000 values were used for testing to find the best neural network models and 1000 values for validation set. Preprocessing of the data gave satisfactory results with Back Propagation Neural Networks.

LOW-WIND-SPEED SMALL-SCALE WIND TURBINES FOR RURAL ELECTRIFICATION IN SRI LANKA

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ABSTRACT

The design wind speeds of most of the existing small-scale wind turbines are in the range of 6 to 15 m/s with cut-in wind speed of 3 m/s. In Sri Lanka where the wind velocities are relatively low, the performance of such a wind turbine is not satisfactory. This is due to low initial torque, which leads to difficulties in starting, as well as poor running efficiencies. This makes wind turbines less attractive for areas with low wind speeds.

The main objectives of this study were to improve the performance of the rotor of a horizontal axis wind turbine at low wind speeds. This study intends to analyse the aerodynamics of wind rotors theoretically and thereby introduces appropriate changes to the geometrical parameters of the blades. Especially, the possibility of increasing the solidity of the rotor, without adversely affecting its aerodynamic efficiency was analysed. The blade elementary theory and the momentum theory were used to analyse the aerodynamic performance of rotors and these results were validated by model testing at a wind tunnel.

Solidity of the rotor was increased to improve the starting torque. The other important fact was that, in designing a wind turbine, the wind rotor and the generator should be properly matched for its optimum operation. The main finding of this study was that a suitable wind rotor to extract more energy from low wind potential should have a higher diameter and a higher solidity.

THE POTENTIAL OF WIND ENERGY IN ELECTRIC GENERATION TO ALLEVIATE THE DESTRUCTION OF FORESTS IN DEVELOPING HYDRO-PLANTS: A Case Study From Tanzania.

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Abstract

Dam construction for electricity generation destroys a huge amount of indigenous forest in the initial stages of the construction and thereafter. In Tanzania, where most of the electricity is generated from hydro plants, reservoirs are usually built to increase the head of the water level because most of the rivers have low declination. The vegetation around the dams that survived during development of the hydro-electric schemes are further destroyed when harnessing firewood required to dry the harvested fish that are normally planted in such dams. Introduction of an alternative method, such as wind, in generating electricity, can reduce to a large extent, this massive destruction of the native vegetation. This papers reports on the potential of wind energy in Tanzania and the possibility of using it in electricity generation so as to alleviate the destruction of forests that takes place in construction of hydro-plants. Wind speed data collected from Makambako (Iringa region) for the period from May 2002 to August 2003 shows that the average monthly wind speed is 7.27 m/s. Wind speed of this magnitude is sufficient to generate electricity. If a substantial amount of electricity required in Tanzania is generated from wind, the current enthusiastic of developing hydroelectric schemes can be reduced to a large extent. Arresting the construction of such dams will also rescue the destruction of natural vegetation associated with hydroelectric schemes. It is estimated that if the current patterns usage of water in Tanzania continue, there will be no sufficient water to meet industrial, domestic and ecological demand in thirty years' time. Since the water resources need to be considered for this generation as well as for the future generations, it is important to explore an alternative method for generating electricity rather than greatly depend on the water resource.

Simulation of wind over Tokyo bay area for construction of wind turbines

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Chuichi Arakawa, The University of Tokyo
Makoto Iida, The University of Tokyo

On March 19th 2003, two 850kW wind turbines started operating at Tokyo bay area. The authors have researched wind around the bay and found that annual mean wind velocity there exceeds 6m/s. This data of annual mean wind velocity was important in this project.

The purpose of this research is to assess whether another wind turbine can be constructed in Tokyo bay area. Furthermore the authors propose new method to design urban wind farms to match the landscape and cultural aspects of each site.

To estimate wind flow over Tokyo bay area, CFD simulation was executed. Pseudo-compressibility method and Spalart-Allmaras turbulence model was selected for compatibility with simulation of flow around wind turbine. The authors have measured wind at two points near the wind turbine site for two years and acquired data for another site in Tokyo bay. The acquired data is used to compare with CFD results. From the result of simulation, fine sites for wind turbines in terms of wind velocity was found.

The mixed reality technology was used for assessment of landscape view before the construction of wind turbines. After consulting the result from CFD, places with better wind condition were selected and several types of wind turbines were chosen. Wind turbines were created in 3D virtual reality and mixed with actual view of Tokyo bay area. This method enabled easier and faster understanding of influence that wind turbine might give to surroundings.

A PROPOSED TEMPLATE FOR THE INTEGRATION OF WIND ENERGY CONVERSION SYSTEMS (WECS) INTO SMALL POWER GRIDS.

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Wind power generation has emerged as the fastest growing alternative energy source with an average installation growth rate of 35% over the last five years. Although much research has been performed on wind energy, there is minimal information regarding a standard procedure for Wind Energy Conversion Systems (WECS) integration into small power grids. The authors attempt to address this gap by providing a standard template. The template illustrates a scientific method for determining WECS feasibility and value. This includes a wind resource assessment and the selection of an appropriate WECS, after which the economic, reliability and electrical effects of the WECS on the grid are investigated. The method identifies the main issues involved in WECS integration and evaluates their impact on the grid connected WECS. The John Dial site in Tobago is used as a case study to demonstrate the application of this general methodology. The results indicate that John Dial has tremendous potential for wind power generation. A Vestas V-80 2MW WECS at a hub height of 50m can produce energy at approximately 0.03 USD/kWh and an investor can expect an internal rate of return between 10 to 12%. In addition, the amount of conventional generation that the WECS will displace is approximately 40% of its rated capacity.

The Wind Energy in Tunisia : Reality and prospects

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Abstract

This article aims at the identification of the necessary technical-economic data to a possible strategy of integration of the wind energy in the national park of production of electric energy of the Tunisian Society of Electricity and Gas (STEG).

An approximation of the potential wind in Tunisia is estimated about 1000 MW, with a producible energy of 3000 kWh by installed kW.

In this paper the interest will be focused on the profitability of the wind option in an approach of cost/profit analysis. Here the study of the profitability of the wind is based on the simulation of a first scenario including no subsidy and in normal conditions of financing and a second scenario taking into consideration the possible international subsidies and a flexible financing.

The results of profitability of the two scenarios permitted to involve rates of internal profitability (RIP) of 10.7%, 11% and 11.6% respectively for sizes of power stations of 40, 60 and 80 MW for the first scenario and the RIP of 12.2%, 12.6% and 13.2% for the second scenario.

The cost of the wind energy kWh produced by respectively 60 and 80 MW without subsidy is estimated respectively to 0.045 and 0.044 $ /kWh. It is nearly equal to the cost marginal of fuel that is of 0.044 $ /kWh for a price of the barrel 30$. On the other hand the cost of the kWh subsidized, it varies from 0.042 $ to 0.040 $. It corresponds to the marginal cost of fuel for a price of the barrel being located between 27 $ and 28 $.

Tunisia enjoys a potential wind relatively important especially to the North and to the Northern East. The part of the wind in the production of electricity is estimated for Tunisia of 4% in 2010, equivalent to 250 MW and of 6% in 2015, equivalent to 500 MW.

Integrated Test Facilities to support the Development of Renewable Technology

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The New and Renewable Energy Centre has been developed from ONE NorthEast's Strategy for Success initiative. The program was launched recently by the UK's Prime Minister Tony Blair. The primary aim of the centre is to create a national Centre, recognised world-wide, in new and renewable energy technologies based upon a strong partnership between academic and industrial research centres in offshore engineering, power generation and renewable energy.

The centre acts as a virtual and real hub for the renewables industry in the UK. Virtual in that it forms part of the UK renewables network of academic institutions and industrialists. Real by providing a cost effective step between model testing on a small scale within industrial and academic organisation.

As well as providing facilities on a commercial level the centre acts as a catalyst for increased work within the new and renewable energy sector, providing focused facilities that are not financially viable to setup on university campuses and thus provide academics and industry access to world class research facilities. NaREC is presently constructed a flexible integrated power lab that will be used to integrate energy generation, distribution, storage, distribution, and utilisation elements. The lab is able integrate into a deep sea wave dock, thus allowing full systems test to be carried out, this represents an internationally unique facility. This will be combined with a 70m wind turbine blade test facility as well as a High Power Network that incorporates multi-megawatt renewable generation technology, a test lab and the local distribution and transmission system. NaREC is presently considering a offshore wind test station (10 to 20 turbines).

The final paper will explain how these will operate together with NaREC's commercial model.

PERFORMANCE OF DFIG WIND GENERATOR UNDER TRANSMISSION FAULT CONDITIONS

Bing Xie, Brendan Fox and Damian Flynn

There has been a dramatic increase in wind power generation world-wide in the past decade. Much of this development is concentrated in relatively small countries such as Denmark and Ireland. These concentrations of wind farms leave the host systems vulnerable to large-scale wind generation loss under fault conditions.

The concern here is not so much with distribution system faults. These will often lead to wind farm disconnection in the vicinity of the fault. Such a limited loss of generation does not pose a major threat to the system. Of more concern are transmission system faults, which cause short-term voltage dips throughout the system. Such dips could cause wind farm trips over a wide area, with severe consequences for the entire power system. It is important therefore that wind farms should withstand these conditions and support the system. For this reason, grid codes have been developed in many countries to avoid this possibility. They call for a 'fault ride-through' capability from wind farms.

The present paper proposes a fault-ride through scheme suitable for wind generators based on doubly-fed induction generators (DFIG). This is currently the dominant wind power technology. The new scheme will be described. Then the performance of the proposed scheme will be tested for a variety of transmission faults. These will be located at various points of a generic transmission system. They will range from the most common – single-line-to-ground – to the most severe – three-lines-to-ground. It will be shown that the new DFIG fault ride-through scheme can limit wind farm trips. This will ensure that large future wind power penetrations can be accepted without loss of supply reliability.

AN INTERNATIONAL DESIGN STANDARD FOR OFFSHORE WIND TURBINES

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Although certification rules and design recommendations for offshore wind turbines have been published in Germany and Denmark, there is a clear need for an international standard for offshore wind turbines. This need has been recognised within the International Electrotechnical Commission (IEC) and a Working Group (TC88 WG-3) has been established to develop such a standard. The declared objective of this Working Group is "to develop an international standard for the engineering and technical requirements which should be considered during design in order to ensure the safety of systems and components of offshore wind turbines, inclusive of their support structures". The standard will be documented in IEC 61400-3 and will cover only those issues relevant to offshore wind turbines, fully consistent with but not duplicating the requirements of the equivalent onshore standard IEC 61400-1.

The work underway within WG3 has brought together expert knowledge from the wind power and offshore engineering industries in order to formulate a state of the art guideline specification of the design requirements for offshore wind turbines.

This paper will report on the progress made by WG3 with the development of the offshore design standard. Key issues and problem areas will be discussed, and the basic framework of the standard will be described.

Analysis of Autonomous Renewable Energy Systems with Grid Control Interchanged between Diesel and Inverter

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In renewable energy systems, several energy sources can be combined to supply the main load. In remote areas, where an interconnected grid is not available, a diesel generator or an inverter can be used to control the frequency and the voltage. Such autonomous systems may involve wind turbines, photovoltaic panels (connected to the local grid through an inverter), and diesel generators. In other systems, an inverter can be used to store or retrieve energy in a battery bank or a flywheel energy storage. In other applications, a power converter with energy storage (i.e., a battery system) is included in the system with or without a diesel generator. In such autonomous systems, the master function of frequency and voltage control can be interchanged between the diesel generator and the inverter. For such applications, a proper control system must be designed. The system must maintain power quality, as measured by electrical performance. To ensure stability, power quality, and reliability, each new system should be simulated before it is implemented in the field. The simulation is intended to confirm the desired system performance or to reveal necessary design modifications, or both. In this paper, we describe the mechanism that serves to implement control system that switches the master function between the diesel generator and the inverter. Next, we describe the inverter module, emphasizing the description of control systems involved in the switching of the grid control. To illustrate the usefulness of simulation-based analysis, we present a case study using the simulation package RPM-SIM developed at the National Renewable Energy Laboratory.

Lifting Surface and Reynolds Averaged Navier-Stokes Power Predictions for NREL's Phase VI Experiment

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Accurate modeling of the 3D aerodynamics is essential to predict rotor performance and loading. Two performance prediction codes, Reynolds-Averaged Navier-Stokes code (OVERFLOW-D) and NREL's Lifting Surface Prescribed Wake code (LSWT) were utilized to predict the aerodynamic performance of a two-bladed, constant speed, horizontal axis wind turbine. An iterative approach was taken to obtain accurate three-dimensional (3D) airfoil data tables for LSWT. The two-dimensional (2D) airfoil data tables were modified to account for the 3D effects until the normal and tangential force predictions from LSWT converged with the Phase VI experimental data collected at the NASA Ames Research Center 80- by 120-Foot Wind Tunnel. Comparisons between the experimental data and the computed aerodynamic loads show the OVERFLOW-D code can predict the power and spanwise loading of a wind turbine rotor relatively well. OVERFLOW-D provides flow field and blade loading information that aids in further understanding of the 3D aerodynamics. The results of this study identify the 3D blade element performance characteristics that are necessary to accurately predict rotor power.

Influences of offshore environmental conditions on wind shear profile parameters in Nantucket Sound

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Simultaneous wind resource and oceanographic data are available from an offshore monitoring tower in Nantucket Sound, off the coast of Massachusetts. These data provide an excellent opportunity to investigate the influence of various environmental variables on typical wind resource assessment techniques. This paper presents a review of wind shear profile extrapolation models and an MCP estimation method. Simultaneous wind, wave, and temperature data are used to determine the effects of environmental variables on model parameters and the results are then compared with those from the Vindeby wind farm in Denmark (Barthelmie, 1999). The environmental variables of wave height, wave period, tide, atmospheric stability, air-sea temperature difference, and wind-wave direction difference are considered in this study.

Estimates of shear model parameters and zero-height are determined for both logarithmic and exponential models for different stability, wave height, and period conditions. An MCP method is used to determine whether atmospheric stability affects the correlation or confidence interval when comparing these data with a long-term data set. A proxy for stability is also calculated using the air-sea temperature difference and the MCP analysis is repeated.

Analysis of Wind Velocity Data in Kansas Using A Two Parameter Weibull Probability Distribution Function

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Purpose of Work: Likely exhaustion of petroleum resources within the next five decades has necessitated utilization of non-conventional and renewable sources of energy like wind energy. A critical component in being able to economically develop wind energy involves accurately assessing the wind resource and in particular, the potential capacity value of wind energy.

Approach: *Kansas Tall Tower Wind Resource Assessment* is a US Department of Energy research project aimed at providing detailed information regarding wind resource characteristics at five counties in western Kansas at heights of 50 meters (m), 80 m and 110 m. Continuous readings of wind resource data (speed and direction) was taken using conventional anemometers and wind vanes installed in pairs at each height on each tower. Data readings were stored in a data logger at each site and sent electronically to a central location at Kansas State University for analysis.

Scientific Innovation and Relevance: Rigorous examination of the data found that two parameter Weibull probability distribution functions suit wind velocity distributions best. A number of methods have been devised to calculate parameters c (scale parameter) and k (shape parameter) of the Weibull distribution.

Results: This paper deals with comparison of two acceptable methods for calculating the parameters of Weibull distribution and determining how well each method fits wind resource data collected in western Kansas over a period of six months (May 1- October 31, 2003) the two methods considered for analysis are the *Cumulative Probability Method* (C.P.M) and *Maximum Likelihood Method* (M.L.M).

Conclusions: It is found that the Cumulative Probability Method gives a better fit to actual probability distribution at 50 m. while the Maximum Likelihood Method gives a better fit at 80 m. and 110 m (Figures 1 and 2).

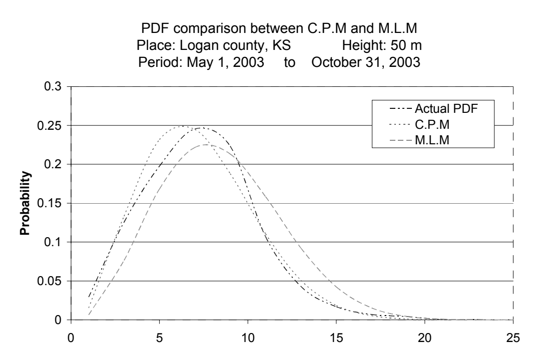

Fig 1: P.D.F Comparison (Height 50 m.)

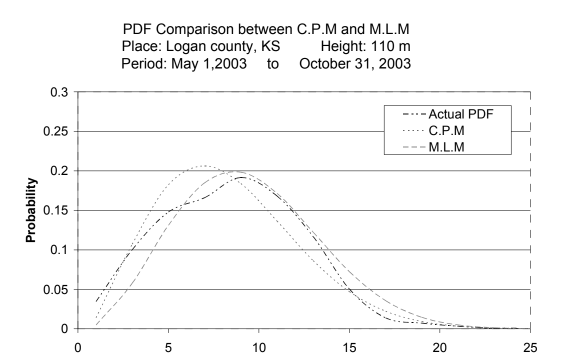

Fig 2: P.D.F Comparison (Height 110 m.)

A NEW TECHNIQUE FOR SHORT-TERM WIND ENERGY FORECASTING: A RAPID UPDATE CYCLE WITH A PHYSICS-BASED ATMOSPHERIC MODEL

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Short-term wind energy forecasts have traditionally been produced by a statistical model that utilizes a time series of recent generation and meteorological data from a wind plant and perhaps some data from a few offsite met towers or a regional physics-based atmospheric model. It is difficult to expand this purely statistical approach to incorporate the large and growing volume of remotely sensed data that is becoming available to specify the current atmospheric conditions within the local-area surrounding the wind plant. The difficulty is attributable to the need of statistical models to sort through the enormous quantity of data to find subtle and complex relationships during the training process.

TrueWind Solutions has developed an alternate approach that utilizes a very high-resolution physics-based atmospheric model operating in a rapid update cycle mode. In this approach the model assimilates all of the different types of data available in the local-area environment of a wind plant to produce a three-dimensional representation of the current atmospheric state. This is the starting point for a short-term three-dimensional forecast simulation of the atmosphere. The advantage is that the physical relationships in the physics-based model allow the large volume of input data to efficiently interact in a physically consistent manner to produce forecasts of meteorological variables at a wind plant site. The presentation provides an overview of the formulation of the method, an example of the results and a comparison of its performance with that of traditional, purely statistical techniques.

Optimization of Utility-Scale Wind-Hydrogen-Battery Systems

Lee Jay Fingersh, NREL

Traditional utility-scale wind-energy systems are not dispatchable – that is, the utility cannot control the power output on an instantaneous basis. In order to add dispatchability to a wind farm, energy storage is required. This energy storage can come in many forms. This study investigates two options, batteries and hydrogen.

Batteries can be integrated into a wind farm in many ways. However, since batteries are inherently DC devices and power grids are AC, some type of conversion technology is required. Many wind turbines are variable-speed and thus contain power conversion equipment in order to interface the turbine to the grid. This conversion equipment can be utilized to both integrate the battery with the grid and to control the battery.

It has been proposed that a hydrogen system can be used for the same purpose. Wind power would be utilized to electrolyze water to create hydrogen, the hydrogen would be stored and then either a combustion device or a fuel cell would be utilized the convert the hydrogen back into electricity. Such a system is also feasible but suffers from much lower round-trip efficiency than a battery.

Hydrogen can also be used as a fuel at remote locations and in vehicles. It is therefore possible for a wind farm to produce hydrogen not for on-grid energy storage but for sale as a fuel.

This paper will demonstrate that a hybrid system involving wind, batteries and hydrogen production for fuel use is an optimal combination. The hydrogen system is too inefficient for on-grid energy storage. A wind-hydrogen fuel only system is too expensive. A wind-battery system is attractive but adding hydrogen production for fuel use makes both systems, the grid system and the fuel system, more cost effective.

Validation of Updated State Wind Resource Maps for the United States

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Updated wind resource maps have recently been developed for many states and areas of the United States. The new "high-resolution" maps show the spatial variability of the resource at much greater detail (horizontal resolution of 1-km and finer) than the maps in the 1987 "Wind Energy Resource Atlas of the United States". The validation and accuracy of these new maps has been an issue of concern.

The United States Department of Energy's National Renewable Energy Laboratory (NREL) is coordinating comprehensive validations of the preliminary wind maps to ensure the final maps have the highest possible accuracy. The validation of the updated state maps in several regions of the United States including the Northwest, Southwest and Mid-Atlantic areas has been a major focus of the validation effort. A private company, TrueWind Solutions (TWS), based in Albany, New York was responsible for producing the preliminary maps using their proprietary MesoMap® system, and using the validation results to produce the final wind maps. TWS uses a version of a numerical meso-scale weather prediction model as the basis for calculating the wind resource and important wind flow characteristics. The meso-scale methodology is a recently developed one, and comprehensive validation of these maps augments the confidence users have of the information presented on the maps.

The validation efforts are a cooperative activity among NREL, TWS, and expert meteorological consultants of the United States wind energy community. Considerable proprietary wind data collected for wind energy assessment studies have been used in the validations, in addition to numerous wind data collected by weather service, agricultural, transportation, environmental, and other agencies. NREL has established procedures and tools to simplify and standardize the validation process. The validation efforts underway or completed to date indicate that this comprehensive effort results in the final wind maps having better accuracy than would be otherwise possible.

This paper will cover the details and results of the United States mapping and validation process, and discuss, from NREL's point of view, the experiences and lessons learned through this process.

Advanced Control Design and Field Testing for Wind Turbines at the National Renewable Energy Laboratory

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Utility-scale wind turbines require active control systems to operate at variable rotational speeds. As wind turbines become larger and more flexible, advanced control algorithms become necessary to meet multiple objectives such as speed regulation, blade load mitigation, and mode stabilization all the while maximizing energy capture. The National Renewable Energy Laboratory (NREL) has developed control design and testing capabilities to meet these growing challenges. Several algorithms that seek to maximize power production in below rated wind speeds have been evaluated both through simulation and field-testing. The importance of precise, prior knowledge of the tip speed ratio at which maximum power coefficient is attained has been documented, and an adaptive control algorithm that negates this need for such precise, prior knowledge has been developed. Linear, state-space models that incorporate sufficient detail of wind turbine dynamics have been designed to mitigate blade loads, reduce tower motion, minimize blade pitch actuator demand, and maintain speed regulation. Because coherent turbulence can be generated in atmospheric boundary layers where large wind turbine will operate, the vortex/wind turbine interaction has been quantified and a blade load mitigation control scheme implemented in simulation. All of these activities serve to improve the viability of multi-megawatt wind turbine deployment and increase wind turbine reliability.

Utility Scale Wind Turbines on a Grid Connected Island

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Vinalhaven and North Haven are the two main islands making up Fox Islands, located 12 miles from the coast of Maine in North Eastern United States. The nearly 1600 year round residents receive their electricity from the mainland via undersea cables. Due to the high cable cost, transmission charges to customers are nearly twice the cost of electricity itself. This paper analyzes the technical and economic feasibility of installing utility scale wind turbines on Vinalhaven. Annual hourly load and wind speed data is available for the island. Three locations are analyzed in detail as potential sites for wind turbine installations. The logistic problems of transporting and installing wind turbines on the island required innovative solutions. These include locally available amphibious vessels, which can land turbine components at suitable shallow spots on the island, self-erecting towers, which allow use of a smaller crane for installation and a special turbine foundation suitable for the local ground conditions. For economic analysis, the market for Massachusetts Renewable Energy Credits has been considered. It can be concluded from the study that the installation of sub-megawatt wind turbines on the island is logistically possible and will lead to a reduction in the cost of electricity to the customers. With 14 year round inhabited islands in Maine, this project could serve as a model for wind energy development in the State.

A Worksheet for Computing the Cost (US$/MWh; ε/MWh) of Electricity Produced at a Model 1 MW Grid Connected Colorado USA Wind Turbine

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This paper presents a worksheet to compute the levelized cost of electricity (US$/MWh) generated at a model 1MW grid connected Colorado sited wind turbine. The worksheet converts US$ monetary values into ε. This paper briefly reviews the technical and economic basis for measuring the cost of wind electricity. The technical analysis involves predicting the physical life and electric production of the model wind turbine. The economic analysis involves using a financial annuity to cost account for the capital recovery (depreciation) of the initial capacity cost and for the financial expense (interest) of using the financial capital during the predicted physical life of the turbine. The paper discusses the worksheet's computational algorithm, benchmark inputs [foreign exchange rate-US$1.22/ε, capacity-1MW, capacity cost-US$1,000,000/MW, turbine efficiency, physical life-25 yr, wind resource, levelized cost method, interest rate-10%, fixed (5% of capacity cost) and variable (US$7.50/MWh) operating and maintenance costs], and computed outputs [yearly electric output-3,066MWh/yr and Total Levelized Cost-US$59.74/MWh (ε48.97/MWh)]. Based on the computed Total Levelized Cost and an assumed 20% mark-up at retail on the current cost of Colorado's regular household grid electricity, wind electricity is cost competitive. Readers entering different input variable values might reach a different conclusion.

Modeling of Aeroacoustic Noise from Wind Turbines

By Pat Moriarty
National Renewable Energy Laboratory

As wind turbines continue to proliferate globally and are placed close to population centers with restrictive noise ordinances, the amount of acoustic noise that a turbine radiates is becoming a crucial design driver for manufacturers. To provide manufacturers with better tools for designing future turbine configurations, researchers at the National Renewable Energy Laboratory (NREL) have developed a semi-empirical noise prediction code based on the works of Brooks, Pope, and Marcolini, Amiet and Guidati. This code models six different potential noise sources that are superimposed to estimate the total noise spectrum emitted from a wind turbine rotor. Each of these noise sources has a different physical method of noise generation that can be broken into two different categories: airfoil self-noise and turbulent inflow noise.

To examine the validity of this prediction code, predicted sound pressure level spectra were compared to measurements of two-dimensional airfoils in wind tunnel tests. The ability of the prediction code to accurately predict the noise depended on the dominant noise source for the configuration. For airfoils with tripped boundary layers, which are dominated by turbulent boundary layer trailing edge noise, agreement between predicted and measured spectra was within 5 dB for most test conditions. For airfoils with untripped boundary layers of the agreement was not as good. The agreement between measurement and prediction was excellent for a NACA 0012 airfoil, but for other airfoils with more camber and thickness, the prediction overestimated the measured values by up to 30 dB. This discrepancy is primarily due to improper modeling of boundary layer transition of different airfoil shapes, and its effect on laminar vortex shedding at the trailing edge. For airfoils tested with a highly turbulent inflow, the agreement between prediction and measurement was excellent. The effects of Mach number and airfoil shape were accurately predicted by the code and were within 2 dB of the measured values for most conditions. The largest differences between measurement and prediction occurred at higher frequencies for thicker airfoils.

Poland 250MW Slupsk Shoals Offshore Wind Feasibility Study

S. Brennan

The Project - AWS Scientific, Inc. (AWS) is working together with Morskie Elektrownie Wiatrowe, Ltd. (MEW), the project development sponsor, with funding from the U.S. Trade and Development Agency (USTDA), on a proposed sustainable offshore wind farm adjacent to Poland's coastline in the Baltic Sea. MEW, a private Polish company, plans to construct up to 100 wind turbines, with an installed capacity of up to 250 megawatts, on the accessible Slupsk Shoal, approximately 30 km offshore. International cooperation is at the core of this renewable energy project.

Phase I Feasibility Study tasks involve: (1) resource assessment and site selection and (2) infrastructure assessment and preliminary economic assessment. As part of the resource assessment a new wind map will be produced using TrueWind Solutions MesoMap ® system.

The corresponding paper prepared for the World Renewable Energy Congress VIII will detail the results of these activities. The paper will also demonstrate the advantages of using a Geographic Information System to assist in selecting a suitable location for an offshore wind farm.

Policy Framework
Poland is scheduled for succession into the European Union on May 1, 2004. This project will help Poland reach its renewable energy goals of 7.5% by 2010, as adopted by the Polish Council of Ministries on December 5, 2000. The Polish Government has also currently proposed the Renewable Energy Act, which will help facilitate a secure market for Certificates of Origin.

Permitting Small-Scale Wind Projects; experiences in siting and permitting distributed generation projects

by Thom Wallace and Heather Rhoads-Weaver

Distributed generation technologies are an important part of the solution to transmission grid congestion . This paper suggests guidelines for land use officials to follow when developing standards for siting and permitting of small wind distributed generation systems. Drawing on lessons learned from small wind permitting experiences throughout the U.S., the paper will, as appropriate, apply general principles of renewable DG system siting.

This paper reviews how California's groundbreaking state law (Assembly Bill 1207) establishing permitting standards for small wind energy systems applies at local levels, describing key findings of a handbook recently released by the American Wind Energy Association and the California Energy Commission.

Expanding on findings from the handbook, the paper explores the steps Counties have taken (and could take) to streamline the permitting process, using existing installations as examples and showing how the handbook will help turbine owners and planning officials integrate small-scale wind energy projects into communities across the nation. The paper helps fill a long-standing need for information about how local agencies can make sure prospective turbine owners are treated fairly in obtaining permits for their machines, based on lessons learned in a state that has made significant efforts to promote small-scale wind development.

The paper provides a concise summary of up-to-date information to address the most common issues raised in response to small wind turbine installations, including visual impacts, acoustics, concern for wildlife, and property values, with documented facts that refute the myths and web links to crucial reference publications.

Evaluating the Most Promising Sites for Wind Energy Development in Arizona USA

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During the summer of 2003, the state of Arizona took delivery of a set of high-resolution wind energy maps. The maps were purchased by Northern Arizona University on behalf of the Arizona Wind Working Group, through funding provided by the National Renewable Energy Laboratory and the three largest Arizona utilities. The maps have been instrumental in elucidating the wind energy resource within the state. The *raw* wind energy potential in Arizona is 35,430 MW of class 3 or higher, 5,980 MW of class 4 or higher, and 2,040 MW of class 5 or higher winds. After applying various exclusions to this raw resource, such as excluding windy lands in urban areas, national parks, etc., the *developable* wind energy potential is 23,290 MW of class 3 or higher, 2,630 MW of class 4 or higher, and 775 MW of class 5 or higher winds. Having identified the potential wind resource, the geographical information system data supplied with the wind maps was used to aid in systematically identifying the most promising sites for wind energy development. Considerations such as proximity to transmission lines and roads, land use, the wind resource, etc., were used in the evaluation. Following that, the cost of energy was estimated at a few geographically diverse sites, including class 3, 4, and 5 wind resource areas. This paper documents the findings of the wind mapping process, describes the method and results of evaluating the most promising sites for wind development, and presents the cost of energy results.

AN H-ADAPTIVE FINITE ELEMENT MODEL FOR WIND ENERGY ASSESSMENT

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ABSTRACT

A three dimensional h-adaptive mass consistent finite element model is used for wind energy assessment studies. An initial wind field is first constructed using results obtained from the widely used MM5 model. The algorithm adapts the original mesh using rules established for local mesh refinement and unrefinement based on topology and power density gradients. A preliminary simulation for an area in the north-west region of Nevada has been conducted. Several optimal sites that have good potential wind power densities have been selected for further study.

Key words: wind energy; finite element; h-adaptation

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Fully Coupled Dynamic Analysis of a Floating Wind Turbine System

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This article presents an analysis of the technical feasibility of a floating wind turbine concept for operation in an offshore environment exposed to stochastic wind and wave loads in water depths of 200 meters. A 1.5 MW wind turbine system is mounted on a Tension-Leg Spar Buoy connected to the seafloor with pre-tensioned tethers. This support promises to be both stable and economically feasible. A fully coupled dynamic analysis of the wind-turbine/floater system was carried out by interfacing wind turbine aerodynamic loading and structural analysis programs with a floater hydrodynamic loading and response module in nonlinear random waves. The damping properties of the system were evaluated and simulations were carried out in normal operating wind and wave conditions as well as in extreme wind and wave events. The structural loads on the system components were evaluated for several test cases in order to determine the concept feasibility in realistic wind and wave environments.

The floating wind turbine system was found to be strongly damped in both the yaw and pitch modes of motion (wind the turbine moving into/away from the wind). Extreme-event and fatigue loads on most of the system components were found to be less or marginally higher than the same turbine with its base fixed. The floating system stiffness in pitch and roll was found to be a key design attribute for the reduction of the loads on some wind turbine components, leading to specific recommendations on the design of the system tethers.

Dynamic Stall and Rotational Augmentation in Wind Turbine Aerodynamics Experiments

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Horizontal axis wind turbines (HAWTs) routinely experience amplified and time varying aerodynamic loads that adversely impact structures, mechanical components, and power production. In the future, lighter and more flexible wind turbines will be designed to reduce the overall cost of energy. Thus, the accuracy and reliability of aerodynamics models will assume even greater importance than at present. To facilitate aerodynamics model improvements, HAWT aerodynamics must be accurately characterized and thoroughly understood.

In response to this requirement for accurate, reliable turbine aerodynamics measurements, the NREL Unsteady Aerodynamics Experiment (UAE) HAWT was tested in the NASA Ames 80 ft x 120 ft wind tunnel during 1999 - 2000. During this test, detailed blade surface pressure data and local inflow information were acquired at multiple blade span locations. In addition, strain gage data documenting mechanical stresses were acquired for the blades, drive train, and hub. These data have been found to contain unique information regarding two crucial turbine aerodynamics events, rotational augmentation and dynamic stall.

In this effort, turbine blade surface pressure distributions and local inflow data acquired by the NREL UAE during the NASA Ames wind tunnel experiment will be examined to isolate rotational augmentation and dynamic stall. Detailed analyses will be carried out to identify systematic modifications to these phenomena in response to changes in turbine operating state. Finally, some implications for turbine operation and predictive modeling will be summarized.

VAR Support from Distributed Wind Energy Resources

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Abstract

As the size and quantity of wind farms and other distributed generation facilities increase, especially in relation to local grids, the importance of a reactive power compensator or VAR support from these facilities becomes more significant. Poorly done, it can result in cycling or inadequate VAR support, and the local grid could experience excessive voltage regulation and, ultimately, instability. Improved wind turbine and distributed generation power control technologies are creating VAR support capabilities that can be used to enhance the voltage regulation and stability of local grids. Locating VAR support near the point of consumption, reducing step size, and making the control active all improve the performance of the grid. This paper presents and discusses alternatives for improving the integration of VAR support from distributed generation facilities such as wind farms. We also examine the relative effectiveness of distributed VAR support on the local grid and how it can be integrated with the VAR support of the grid operator.

Our Wind Co-op: Exploring Joint Green Tag Financing and Marketing Models for Energy Independence
by Jennifer Grove

A collaborative of non-profits have launched a unique cooperative investing in small-scale wind projects on farms, ranches, public and private facilities across the rural Northwest, increasing self-sufficiency and securing long-term fixed price energy sources.

This paper highlights new strategies for distributed generation projects in expanding markets for Green Tags, utilizing the cooperative business model, and leveraging capital funds, including federal and local sources.

This paper documents the progress of Our Wind Co-op in financing capital costs with up front Green Tags investments and multiple funding sources, and helping low-income agencies secure ownership shares and new funding sources for rate discounts through community-based wind development. The cooperative structure has removed financial barriers and generates revenue streams for farmers, ranchers, residential homeowners, and businesses who may be discouraged by the front-end costs of solar and wind generation.

The environmental attributes of this energy are aggregated, marketed and sold as value-added Green Tags providing an ongoing revenue stream to help repay initial loans and ongoing operations and maintenance costs.

This paper summarizes the initial lessons learned and describes recommended strategies for using cooperative models for financing and marketing the green attributes of energy produced by community-based wind projects, where possible to benefit low-income households with supply-side solutions.

OFFSHORE WIND DEVELOPMENTS IN THE UNITED STATES: INSTITUTIONAL ISSUES, ENVIRONMENTAL REGULATIONS, AND JURISDICTIONS

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In November 2001, the USA Army Corps of Engineers (USACE) received an application from a private developer for an offshore wind park off of Cape Cod. This is the first proposed project for offshore wind power in the United States. Last year another project was proposed off of Jones Beach New York by the Long Island Power Authority, a municipal utility. These two projects, along with several other proposed developments off the East Coast, have triggered discussions and analyses relating to existing jurisdictional authority and regulatory compliance, as well as scientific uncertainties regarding the potential impacts to the marine environment. The presenter will provide both the current events of these projects and an overview of the current federal and state regulatory framework for permitting offshore structures, including a table identifying the major agencies participating in the permit approvals. The discussion of the framework will present proposed timeframes, procedures, key regulatory instruments, and state and public involvement requirements. The presenter will conclude with a summary of the challenges for the nascent offshore wind industry in the USA and lessons learned from Europe.

OFFSHORE WIND ENERGY POTENTIAL FOR THE UNITED STATES

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ABSTRACT

Until recently, the offshore wind energy potential in the United States was ignored because the vast onshore wind resource of the United States has the potential to fulfill the electrical energy needs for the entire country. However, the challenge of transmitting the energy to the large load centers has limited short-term grid penetration. To take advantage of much broader wind resources closer to load centers, the U.S. Department of Energy (DOE) is conducting the Low Wind Speed Technology Project, which targets development of cost-effective wind turbines for Class 4 sites that can produce electricity onshore for 3¢/kWh and offshore for 5¢/kWh by the end of 2012. Resource assessments show that the best wind energy potential for many areas, including much of Eastern United States, is offshore. Offshore wind turbines can generate power much closer to higher value coastal load centers. Reduced transmission constraints, more energetic and steady winds, coupled with recent European success, have made offshore wind energy look more attractive for the U.S. However, U.S. waters are generally deeper than the European coast, which will require new technology. This paper presents an overview of US coastal resources, explores promising deepwater wind technology, and predicts long-term cost-of–energy (COE) trends. COE estimates are based on generic 5-MW wind turbines in a hypothetical 500 MW wind farm. Technology improvements and volume production is expected to lower costs to meet the DOE target range of $0.05/kWh for large-scale deployment of offshore wind turbines by 2012. Offshore wind systems can diversify the future U.S. electric energy supply, and provide a new push for wind energy that is complimentary to existing onshore development.

Wind Farm Power System Model Development

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ABSTRACT

In some areas, wind power has reached a level where it begins to impact grid operation and the stability of local utilities. Utility system operators and engineers now want a better understanding of the impacts of large wind farms on grid stability before they are interconnected to the grid. They need wind farm electrical models that will help them analyze potential grid stability problems. Without the necessary tools and knowledge of large wind power plant behavior, utilities are reluctant to integrate more wind power into the grid.

The operating characteristics of a single wind turbine are well known and models to simulate and predict dynamic characteristics under various wind and grid conditions are available. However, models that can simulate and predict the behavior of large wind power plants with hundreds of wind turbines and their impact on the power system operations have yet to be developed. In this paper, the model development for a large wind farm will be presented. Grid stability during electrical transients depends on generators providing voltage stability. Wind farm dynamic behavior and contribution to stability during transmission system faults will be examined.

Index Terms-- wind turbine, wind farm, wind energy, aggregation, power system, variable speed generation, renewable energy

THE OPTIMUM SIZE OF A WIND TURBINE

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(Private Consultants)

ABSTRACT

Twenty years ago, many large wind turbines were being built as prototypes for experimental designs in the 1MW to 4MW range. On the other hand, most of the machines being sold commercially at that time were much smaller, in the 50kW to 250kW range. There was a considerable amount of argument about the optimum size of a wind turbine. Swift-Hook concluded that the optimum size of a commercial machine would depend upon the size of the market.

His argument went as follows: to commercialise any new design, development work is needed, including a number of prototype machines, so the total development cost will be as much as, say, 10 wind turbines. This cost cannot exceed a modest fraction of the production cost, say 10%, or the development will not be viable. So the market must exceed 100 wind turbines before significant new developments become viable and the optimum size of a wind turbine will turn out to be around 1% of its market.

A corollary of this argument is that the sizes of commercial machines would be predicted to grow in line with the amount of wind power installed. As this paper will show, that has been the case for nearly the last two decades. Machines sizes have doubled every three years or so, just as the installed capacity of wind power has.

This observation seems to confirm Swift-Hook's original assertion that the optimum size of a production machine is determined by the size of its market. There is every indication that machine sizes will continue to grow as the market grows and as more wind turbines are installed around the world.

THE MAXIMUM SIZE OF A WIND TURBINE

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(Private Consultants)

ABSTRACT

Typical sizes of wind turbines have been growing rapidly for nearly two decades and several companies are building production prototypes with rotors as large as 100m to 120m in diameter, to generate 3MW to 5MW each. It is not surprising that new technical problems have emerged and that delays have been reported and these have sometimes been taken as signs that we are approaching physical limits on size with present technology.

The familiar square-cube scaling law limits the practical sizes of many objects, from huge buildings to tiny insects. The tensile strength of any material is a force per unit area, so the breaking force of any component increases according to its cross-sectional area, which scales as a square. On the other hand, the weight increases according to the volume, which scales as a cube. So as any device is scaled up to be bigger and bigger, it eventually grows so large that it can no longer support its own weight. This will obviously apply to the scaling of a wind turbine design when each rotor blade become so large that its own weight produces a greater bending moment than it can support.

This paper considers where such gravitational-stress limits lie with conventional and advanced materials. A conventional steel-bladed rotor has a limit around 100m diameter. Although this is the size of many existing machines, no-one today is putting steel blades onto such large wind turbines. With gfrp (glass-fibre-reinforced plastic), the limit would be around 200m (16MW) and for wood-epoxy, which is in wide-spread use, 500m (100MW). Present-day designs and materials are evidently nowhere near their maximum feasible sizes.

With more advanced materials, even larger designs are possible. Carbon-fibre materials could go to 800m diameter or more than 250MW from a single rotor. These results do not necessarily indicate that rotor sizes will grow indefinitely but they do show that such growth will not be limited by gravity stresses in the blades of conventional rotor designs for a long time to come.

Experiences of Indian Certification System

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Carsten Skamris, RISOE

In the global scenario Indian Wind Energy Sector is on the growth path with an aim to achieve an installed capacity of 5000 MW by 2012. The Government of India envisaging the necessity of quality aspects has been issuing guidelines keeping the interests of the end users in view. However, still the cyclone as that in Gujarat proved the necessity beyond doubt and the inadequacy of the assessments in those days. With the advent of Centre for Wind Energy Technology (CWET), a technical focal point for the wind power development in the country, a major thrust has been given.

To cater to the needs of the Indian industry an innovative certification system, Type Approval-Provisional Scheme (TAPS-2000), has been introduced and implemented for about three years.

The system facilitates certification of products already certified abroad with additional assessments for Indian requirements. The certification systems of Denmark, The Netherlands, Germanischer Lloyds and IEC are recognised for the purpose. New turbines are assessed in a normal method as specified by IEC:

Safety is the principal premise as in other systems. The special Indian requirements are in terms of external conditions including wind conditions, electrical network conditions, and other environmental conditions. Towers, conventionally tubular for either European or American Turbines, have been converted to lattice towers. Assessment of the turbine designs, originally designed for western conditions though adapted for Indian needs, revealed and brought out the necessity for introducing special load cases.

This paper describes the implementation experiences and the learning brought out as additional load cases.

WIND ENERGY AND ITS ECONOMY IN SOUTH OF MOROCCO

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ABSTRACT

This study is about wind characteristics and the feasibility assessment of using wind farms to generate electrical power in the south of Morocco. Long term hourly wind speed recorded data over (10 years) in two windy coastal sites (Laayoune and Dakhla) have been used. The annual average wind speed for the considered sites are 5.7 m/s and 7.6 m/s respectively at a height of 10 m above ground level. Statistical data on wind speed and related Weibull Hybrid distribution parameters is also available in this study.

The cost generation of the kWh of electricity produced by wind power is evaluated for three sizes of wind turbines to take into account various dimensions based on the parameters given by Beurskens and Hjuler Jensen [4]. For example, output is calculated at hub height of 40 m typically 500 kW wind turbines. The generating cost is estimated to 5.2 Eurocents/kWh for Laayoune and 2.9Eurocents/kWh for Dakhla. It is a result comparable to the one obtained by Khalaji and Taléghanis : the final cost of a kWh energy produced with a velocity of 6 m/s is twice the final cost of electricity produced with 8 m/s [9]. This study shows that the south of Morocco, particularly the Atlantic zone, is suitable for electrical power production by installing wind farms

The Potential for Bulk Energy Storage in the USA,
Current Development & Future Prospects

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Stored Energy can provide electricity during periods of high demand, as currently demonstrated with bulk storage systems such as Pumped Hydro, which accounts for only 2.5% of the current installed base load in the USA. Sites for future development have become less available, and environmental siting issues, as well as high costs has stopped further prospects Base load plants are being detrimentally cycled at higher frequencies with no available added storage, and the situation is further exacerbated with the latest growing demand for renewable energy such as Wind Energy. At the end of 2003 +/- 6500MW will be installed, and the AWEA (American Wind Energy Association) project up to 30GW by the Year 2020. Wind Energy and Storage, will be essential to realize the full potential of this renewable energy source.
This paper will look at the potential beyond PHS, with such bulk storage systems such as CAES (Compressed Air Energy Storage) Flow-Batteries and One MW Flywheel systems that can provide system stability/support at the grid, substation and distributed level. Smaller storage devices at the end use level such as batteries and capacitors etc. will not be covered.
Current developments in the bulk Energy Storage will be reviewed as well as some storage project developments incorporating Wind Energy, and the impact on base loaded coal plants and natural gas fired GT Combined Cycle Plants. The large potential and economic benefits for Energy Storage in the US will be examined in a 1000 GW system consisting of 50 year and older fossil facilities to the Modern highly efficient, low emissions gas fired GT/CC power plants. Geological suitable identified sites for bulk energy storage using salt domes, hard rock or aquifer can be readily exploited for 20/30GW capability by 2020 or sooner, a fact not fully recognized by the Power Entities.

The Emergence of International Standards for the Financing of Renewable Energy Projects

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Purpose: The global financial markets are focused on renewable energy as an attractive investment. These sources of financing – including international banks, investment banks and funds – are applying a set of standards for investment in renewable energy projects. These standards will be relatively uniform wherever the project is located. This paper will examine these standards and their applicability to renewable energy projects.

Approach: The paper will focus on several key areas in which there are emerging standards required by international financing sources, including technology (including warranties, credit and installation terms), resource assessment, construction, operation, revenue (including power sales and other off take agreement terms) and legal/regulatory risks.

Relevance: The ability to attract long term financing for renewable energy technologies will support next generation innovation.

Conclusion: Renewable energy project financing sources will impose relatively standard requirements. Mastering the application of such terms will insure success in raising long term, large scale financing.

Generation and Economic Evaluation of Hybrid Wind/PV Systems in The State of Qatar

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Abstract - The aim of this study is to investigate the application of wind, photovoltaic (PV), and hybrid wind/PV power generating systems for utilization as stand–alone energy generating systems in Qatar. A simple numerical model has been developed for sizing the different energy generating systems. Generation and storage units, for each system, are properly sized to meet the annual load of a typical residential load. An economical analysis is undertaken to compare the generation cost of the renewable energy systems to that generated from conventional power plants. Hourly mean wind speed and solar radiation data for the period (1976-2000) recorded at the meteorological Department at Doha airport are analyzed.

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* Assistant Professor

Making wind power dispatchable with compressed air energy storage

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Wind electricity, despite falling costs, rapidly growing market share, and low life cycle CO_2 emissions, must address its inherent intermittency if it is to become a significant power source in the 21st century. Energy storage offers one solution. We describe an on-shore wind farm/compressed air energy storage (CAES) model with long-distance electric transmission, and find that wind power can be transformed into a fully dispatchable (> 95% capacity factor) baseload power source at a premium of only ~0.5 US¢ per kWh. While the size of the premium depends on cost and performance assumptions, the general result of small incremental cost for a large increase in capacity factor is robust.

However, among on-shore wind resources in the US, most are located far from demand centers, and the additional cost of long-distance transmission makes it difficult for wind/CAES to compete in most current electricity markets. But several factors may make wind/CAES more attractive in the near term, including renewal of the production tax credit (PTC), installation of a carbon tax on fuels, willingness of consumers and/or government to pay more for green energy, exploitation of premium wind sites, and future cost reductions of wind turbines and/or CAES technology. We argue that the current political climate, particularly in Europe, will increasingly demand low-carbon energy technologies and will drive down the cost of wind/CAES to assure it a prominent place in future energy markets.

The model calculates synthetic hourly wind speeds and transforms them into hourly power output from the wind/CAES system. System configuration is optimized for the lowest cost of energy (COE) as a function of CAES expander capacity. Some parameters explored in this study include wind speed shape, scale and temporal persistence, wind turbine rating, wind farm generation capacity, CAES compressor, expander and storage capacities, transmission line distance and transmission voltage. Currently, constant demand (baseload operation) is assumed, but variable demand can easily be simulated with the model, and will be the topic of a future investigation.

Addendum

RECENT ADVANCES IN SOLAR PHOTOVOLTAIC TECHNOLOGY IN JAPAN AND ITS ROAD MAP TOWARD 2030

by

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Abstract

The current state of the art in the solar photovoltaic (PV) technology in Japan is reviewed. Firstly, a new government program aim for the development of self-sustaining PV industry by the year of 2010 is introduced. As the action planning, some new R&D programs for the advanced solar cell technology and development of module mass production technologies are demonstrated. Secondary, recent R&D efforts for the solar cell efficiency improvement are over-viewed together with their device physics, new junction structure and new material innovations such as nc-Si and double hetero-junction solar cells etc. Then, the results of recent achievements on the efficiency improvements are summarized. Thirdly, another new strategy aim for the cost reduction of the solar cell module with mass productions of the solar cell modules; an accelerated promotion of PV system utilizations, government subsidy for the private house, namely as "PV House Plan", for the public facilities as "PV Field Test Experiments" are also introduced. As the results, a remarkable increase of the annual productions of the module has been seen in recent few years, and statistics of the annual productions for three kinds of silicon basis modules are also reported. In the final part of paper, the technological roadmap of the PV up to 2010 and long-term prospect to2030 are investigated and discussed. Then, possible new roles to contribute to the global environmental issues by the PV system utilization are proposed.

GENERAL CHARACTERISATION OF THE SOLAR RADIATION BEHAVIOUR IN MOZAMBIQUE

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Just as with the other Southern African Development Community (SADC) countries, Mozambique faces severe and interrelated problems of energy and environment linked with the massive consumption of fuel wood biomass. The conventional power grid caters for less than 7% of the energy needs for the country's 17 million inhabitants, and about 83% of the energy consumed in the country comes from biomass. Areas around the major urban centres and along the main development corridors are the most affected by energy shortages. This hinders the country's economic and social development as it is generally acknowledged that no development can be sustainable without linking it to energy planning and environmental management.

Renewable energy resources can play an important role in the process of development of the country. From the vast renewable energy resources available in the country, solar energy represents one of those with the highest potential. Thus the evaluation of the potential of solar energy systems in small-scale applications suitable for villages is a strategically good starting point for promotion of a sustainable rural development. One of the major impediments in carrying out such studies is the fact that the exact behaviour of solar energy resources throughout the country has not been well studied yet.

In this paper a general characterisation of the global, diffuse and direct solar radiation fields in Mozambique is presented. The study is based on experimental data measured by the National Institute of Meteorology (INAM) in the period 1970-2000. Data from 11 stations recording global solar radiation, from 6 stations measuring diffuse solar radiation, as well as data from 80 sunshine hours stations have been used for this work. For this purpose the country has been divided into four main climate zones. The northern and coastal regions, representing 60% of the total surface of the country, have a tropical rain savanna climate. The inland parts of the central and southern sedimentary terrains, with a share of 28%, have a dry savanna climate. A small area around the border crossing of the Limpopo River, representing 2% of the country's surface, has a dry desert climate, whereas the upland areas, with a share of 10%, have a humid temperate climate.

Results of the present work reveal that the country has substantial solar energy resources for a variety of solar energy technologies. Areas with the dry savanna and dry desert climates, representing in total around 30% of the country's surface are particularly appropriate for concentrating solar energy technologies.

Designing of coatings for solar absorbers: an overview

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In the field of solar energy, the research and application of photothermal energy conversion is strongly influenced by the development of new materials. One of the most popular spectrally selective surfaces due to its low price is obtained by applying a layer of pigmented paint on a high-reflective surface. The coating has to posses high solar absorptance and in the same time low emittance in the thermal infrared region. For this purpose, the optical properties of the coating must be optimized in order to minimize the expense of the final coating. To design final coating all constituents have to be defined separately. Prepared paints were carefully studied to define all parameter in order to understand the influence of production process (the way how paint is applied on substrate) as well as the influence of paint thickness, the surface roughness, the flocculation of pigment particles, optimal thickness, and critical pigment-to-volume concentration ratio (PVC). The prepared paints were tested and good thermal stability was proved, what enable their use for absorber surface in solar collectors up to at least 14 years. The paints were applied on different substrates (Al, Cu and stainless steel) with two different application techniques. At paint layer thickness between 2-3 μm solar absorptance was about 0.9 with corresponding thermal emittance 0.2. We prepared paints at different PVC (PVC=16,18,20,24,28), and obtained results show the existence of the optimal PVC, where the solar absorptance is the highest (PVC=18). It means that with adding more pigment to get higher PVC the absorption abilities were actually lower. We will also present that the paint prepared from higher PVC does not necessarily show the best covering efficiency in the UV-VIS spectral region. Finally, all data obtained by modeling are very useful to reduce the price of the final product.

MESOSCALE-MICROSCALE MODELING FOR WIND RESOURCE ASSESSMENT

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Increases in computer speed and the rapid growth of the wind energy industry in the past decade have led to the development of an important new technique for mapping wind resources: mesoscale-microscale modeling. One of the first such methods, MesoMap, was developed by TrueWind Solutions, and has been used in the past five years to create wind maps of about half of the United States as well as other parts of the world. A companion method called SiteWind is used for micrositing.

As with all modeling techniques, validation is crucial. Through TrueWind's internal efforts and a public/private partnership with the National Renewable Energy Laboratory (NREL), the accuracy of MesoMap has been assessed by comparing estimates with data from nearly 1000 surface stations. The typical root-mean-square MesoMap error, after accounting for uncertainty in the data, has been found to be 0.3-0.5 m/s, or 5-7% of the mean speed at 50 m. Independently, TrueWind has verified SiteWind, for which, assuming reliable measurements from a mast within the area are available, the rms error is typically 3-5% over project scales in complex terrain.

While mesoscale-microscale modeling techniques provide a quantum leap in wind mapping and micrositing capability, improvements are continually being sought. This paper reviews the status of TrueWind's mesoscale-microscale modeling and discusses sources of error and priorities for improvement.