DOE *Biomass Power* Program

U.S. Department of Energy
Office of Solar Thermal, Biomass Power,
and Hydrogen Technologies

Overview

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Biomass power is poised to make a major contribution to domestic and international electricity needs while providing substantial environmental benefits. In a world of rapidly changing requirements for power production, there is a need for long-range planning to help assure that new approaches and new technologies are available to keep pace with society's need for new power alternatives. Advanced biomass power options include competitive, highly efficient technologies that also offer important environmental advantages, particularly in reducing greenhouse gas emissions (carbon dioxide) and acid rain precursors. This strategic plan establishes a vision for biomass power development over the next 20 years (1996-2015), and sets a framework for the U.S. Department of Energy's (DOE's) Biomass Power Program to help achieve this vision and meet the challenges that lie ahead.

In 1991, DOE formed the National Biomass Power Program to help establish a sustainable option to contribute to the 600 gigawatts of new electric generating capacity projected to be needed globally over the next 10 years. The Biomass Power Program includes such activities as:

- Working with the biomass power industry to overcome problems in using some forms of biomass in existing boilers.
- Evaluating and developing advanced technologies such as gasification and pyrolysis.
- Developing clean-up technology for high-temperature biogas.
- Sponsoring cost-shared feasibility studies with industry.
- Supporting cost-shared, small, and large system demonstrations.

In a continuing effort to increase its effectiveness, the Biomass Power Program is working cooperatively with a number of other programs and federal agencies. For example, DOE is working with the United States Department of Agriculture (USDA) on the Biomass Power for Rural Development Initiative to help private industry demonstrate and deploy cost-competitive renewable biomass power systems that also stimulate rural economic development. An ongoing collaboration is the Advanced Turbine Systems (ATS) Program, a joint effort between industry and DOE's Offices of Fossil Energy (FE) and Energy Efficiency and Renewable Energy (EERE) to develop higher efficiency (gas-fired) turbines for industrial and utility applications using fuels derived from coal and biomass, as well as natural gas. The Biomass Power Program also works with other programs within EERE, including the Biofuels Feedstock Development Program for short-rotation woody crops and herbaceous energy crops.

The Biomass Power Program's continued success requires an awareness of the current situation and future challenges, and a clear vision of where it is going and how it is going to get there. The purpose of this strategic plan is to address the challenges ahead and set a course for overcoming them during the next 20 years. Future challenges include identifying and validating new technologies, responding to the need to create more jobs, cost-effectively attaining the environmental goals of federal, state, and local governments, and wisely spending limited public monies. Finally, continued success requires explicit strategic tools to implement the Biomass Power Program's goals and objectives, which are described in detail in this strategic plan.

Program Mission

The mission of the DOE Biomass Power Program is to expand domestic and global markets for renewable electricity from sustainable biomass resources by fostering partnerships with U.S. industry, agriculture, and forestry. In this effort, we will encourage the highest standards of stewardship of our air, water, and soil resources, with improved biological diversity, while providing strong economic and environmental benefits to society.

Vision

Where we want to be in 20 years

The integration of sustainable farms and forests with efficient biomass power production from dedicated feedstocks will be a major cost-competitive contributor to power supplies in both domestic and international markets. Collaborative partnerships between DOE and the private sector will facilitate the commercialization of a range of small- to large-scale systems, substantially revitalizing rural economies through the integrated development of biomass power and coproducts such as feed, fiber, or fuel.

Situation Analysis

Biomass is a Major Renewable Generation Source Today

Domestically, grid-connected biomass electric capacity is nearly seven gigawatts, which is 1% of all generating capacity and about 8% of non-utility generation capability. Much of this capacity is in combined heat and power (CHP) facilities in the industrial sector, mainly in the wood products industry using process residues. The next most viable sector for biomass power applications includes stand-alone capacity dedicated solely to electric power generation. These facilities are typically fueled with noncaptive residues

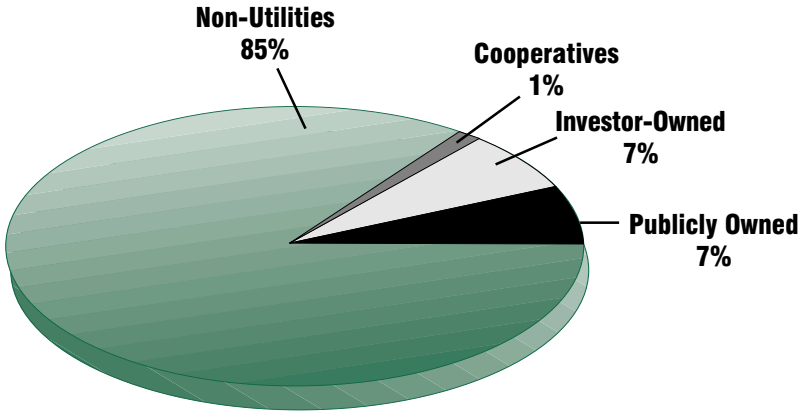
drawn from urban living, and smaller or seasonal sources that generate residues such as orchards, food processing, and building construction and demolition.

Stand-alone power producers often play an integral role in the management of residue and waste flows in a region, accepting clean materials that otherwise would be landfilled. As a consequence, the fuel cost to the generating plant is often only that of transporting these materials. This added dimension of waste and residue management is at the core of sustainability issues for society. Many people recognize that using dedicated biomass crops for electricity production offers a closed-loop carbon cycle. However, few recognize that the current use of biomass waste and residues for power production closes many other loops by capturing and using material and energy that might otherwise be lost or wasted.

The U.S. biomass power industry is located primarily in the Northeast, Southeast, and along the West Coast, representing an investment base of $15 billion and supporting about 66,000 jobs. For stand-alone facilities that produce only electricity, net power efficiency in the existing biomass power industry is in the 20% to 25% range, using steam-cycle technology with conventional furnace and fluidized-bed combustors. While this efficiency is lower than modern coal- and gas-fired units, recent projects have demonstrated the potential to improve the reliability and efficiency of existing biomass systems.

Currently, biomass residue sources account for 100% of the fuel used for biomass power production. About 90% of the residues are wood waste and the remainder are agricultural residues. Use of these resources, coupled with favorable power contracts, fueled the rapid development of the industry up until the mid-1980s. Expiration of these early contracts and competition for biomass resources have put significant pressure on the power industry to close or revitalize the

Bioenergy Capacity by Owner Company Type



less efficient operations. In California and the Northeast, stand-alone biomass power facilities have been vulnerable to competition for biomass fuel resources due to over-building of generating capacity. These facilities have also experienced downward pressure on their revenue as "avoided cost" rates paid for electricity have declined. This is causing a shakeout of the least profitable power producers.

Changes in the Power Generation and Delivery Market are Creating New Opportunities and Some Problems for All Generation Sources

Restructuring of the electric generating industry is putting considerable downward pressure on power prices, challenging both traditional electric utilities and independent power producers. In the U.S., utilities are devolving to multiple companies competing for pieces of the electric power business: generation, power brokering, transmission, distribution, and on-site energy services. These same trends are beginning to be felt in other countries where the first tests of privatization of power and competition for generation contracts have already begun.

The existing fossil fuel supply infrastructure provides a competitive challenge to biomass power development. The Energy Information Administration (EIA) projects a favorable fuel supply environment for coal and natural gas until 2010. At present, natural gas represents the majority of new capacity. Environmental constraints have changed the way power is produced, but many environmental benefits of renewable energy are still not valued or are undervalued in the market-place.

Biomass resources can be expanded through development of renewable energy crops and can bring added value in coproducts, local environmental preservation (soil and water conservation and wildlife biodiversity), and global climate change insurance benefits (biomass sequesters carbon while growing).

Major Factors That May Facilitate the Greater Use of Biomass Resources Include:

- Aging chemical recovery boilers in the pulp and paper industry may be repowered and/or reconfigured with biomass integrated gasification combined-cycle (IGCC) systems, where biomass can be uniquely used as fuel in combined heat and power applications.

- The cofiring and repowering of coal facilities in regions where biomass resources are abundant provides another route to capacity growth at lower cost per unit of capacity. Cofiring may pave the way for other advanced technologies into commercial markets.

- Biomass power/natural gas hybrid systems may offer a reduced risk in electricity bids by independent system operators.

- Developing a local bioenergy market and providing reliable electricity will stimulate rural economic development and help sustain biomass industry growth domestically and in developing countries. Furthermore, expanded use of biomass in developing countries will decrease the need for subsidies to the power and fuels sectors while also reducing their reliance on imported petroleum products.

- The EIA forecast for market penetration of biomass increases after the year 2010 due to projected upward pressure on natural gas prices. However, the price of coal is expected to remain steady or decline over this time frame.

The potential exists for biomass power to grow to an industry with 30,000 megawatts (MW) of capacity, employing 150,000 persons in mainly rural areas, and producing 150–200 billion kilowatt-hours (kWh) of electricity by the year 2020. This potential is not based solely on the sale of kWh as bulk power, but recognizes that there are drivers such as social, political, and environmental factors that, along with technology development, can expand biomass power. Among these drivers are issues such as stronger enforcement of landfill diversion rules to ensure that clean materials are either recycled or reused as fuel for energy production. Agricultural field residues represent another near-term opportunity to expand biomass fuel supplies, now that the practice of in-field burning is generally being banned as a residue management approach. Increases in the efficiency and reduction of the capital intensity

of commercial biomass power plants are also required to expand the role of biomass power. This efficiency gain has a multiplier effect back through the supply chain by requiring less feedstock per kWh of electricity produced. The increase in the productive use of biomass feedstocks will reduce the amount of land and other inputs needed per kWh for energy crop production, while also displacing large amounts of fossil fuels.

Foundations for the Future

DOE recognizes the critical role of industry-led partnerships and the need for multiagency collaboration if the full potential of biomass power is to be realized. DOE, in collaboration with USDA, has helped form partnerships among industry, agriculture, and forestry interests. These partnerships are building a strong foundation for enhanced deployment of integrated biomass power systems. DOE recently funded seven industry cost-shared feasibility studies, which include business plans to develop viable partnerships among electric power companies, equipment manufacturers, farmers, and universities, to produce electricity from biomass crops. DOE and USDA have entered into agreements with several private consortia to demonstrate utility-scale biomass energy projects. These pioneer facilities will set the stage for a stronger and more competitive biopower (biomass power) industry because they are driven by the power industry and the energy crop growers, with DOE and USDA providing technical assistance and sharing the risks.

DOE and USDA have also broken ground in test plots and system scale-up projects for crops and conversion systems. These efforts could double the efficiency of conversion to power, halve the cost per unit of output, create added value for farm products, and increase the biomass resource supply by a factor of ten. The projects will demonstrate the essential elements for repowering facilities with an IGCC system fired by biomass. The Program will provide visible evidence that high-yield energy crop species, together with efficient planting and harvesting methods, can provide the tonnage needed for processing biomass fuels at competitive costs.

There is substantial agricultural land which is marginal for conventional crop production that can be productively used to grow energy crops (because perennial herbaceous and woody energy crops can be selected which provide advantages such as erosion protection or drought tolerance). In addition, the development of processes that generate multiple products for food, fuel, chemicals, and fiber in an integrated system is pointing the way to more productive agriculture, generating greater revenues for the farmer. For example, the figure on the following page illustrates the approach that will be used in a joint project between DOE and the Minnesota Valley Alfalfa Producers to produce electricity from alfalfa stems and animal feed from alfalfa leaves.

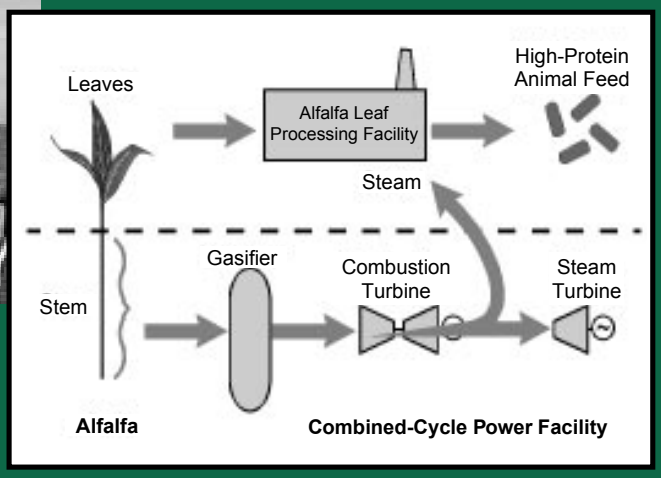
In addition to technology advancements, policy initiatives and environmental mediation efforts are helping to create conditions favorable to the development of biomass resources. The National Biofuels Roundtable, which included a variety of influential environmental organizations, has laid the groundwork for research and project development approaches that will lead to sustainable biopower systems. Current energy and agricultural policies directly and indirectly impact the attractiveness of biomass power. As an example, the 1992 U.S. Energy Policy Act introduced a 1.5¢/kWh tax credit for closed-loop biomass projects (those that use dedicated energy crops). Also, current USDA programs offer assistance to growers who are switching to crops that place less burden on the land and protect streams from chemical and sediment runoff.

There are also new forest management projects under way by the U.S. Forest Service designed to protect prime forest lands from severe fire destruction, which may increase supplies of biomass feedstocks/residues from low-grade forest materials. A number of

Processing Alfalfa to Feed and Power: Minnesota 75-MW Agri-Power Project

Predicted Net Power Output from Stem Gasification

Output:	75 MW
Heat Rate:	8,910 Btu/kWh
Efficiency:	38.3%



Alfalfa Processing and Production Estimates
(tons per year)

Alfalfa:	680,000
Stem to gasifier:	374,000
Leaf to animal feed:	306,000

environmental and development assistance policies will also help foster increased support for biomass power development. For example, most countries signed the Global Climate Change treaty and agreed to reduce air emissions, including CO_2, and many international lending institutions incorporate a substantial environmental component in qualifying their loans. Market-based environmental trading mechanisms included in the Clean Air Act Amendments encourage innovative transactions such as fuel switching or blending with biomass. Power marketers are investigating the salability of "green electrons," which gives consumers the opportunity to purchase their electricity from producers using renewable energy technologies.

All of these efforts provide the necessary foundation for future expansion of both the biomass power and biomass fuel supply industries. The strategic plan for the DOE Biomass Power Program builds on this foundation to achieve the mission, goals, and strategic objectives of the Program.

Overview of the Program Strategy

The basis of the strategy is to ensure that both the producers of biomass feedstocks and consumers of electricity obtain the benefits of biomass power, while meeting the goals of rural development, environmental protection, development of new technologies to open export opportunities, and diversification of the U.S. energy portfolio. Decreasing the cost of fuel supplies clearly helps the generator, while efficiency improvements and reductions in fixed and variable non-fuel costs at the generating plants enable the facilities to be competitive, while providing fair returns to biomass producers.

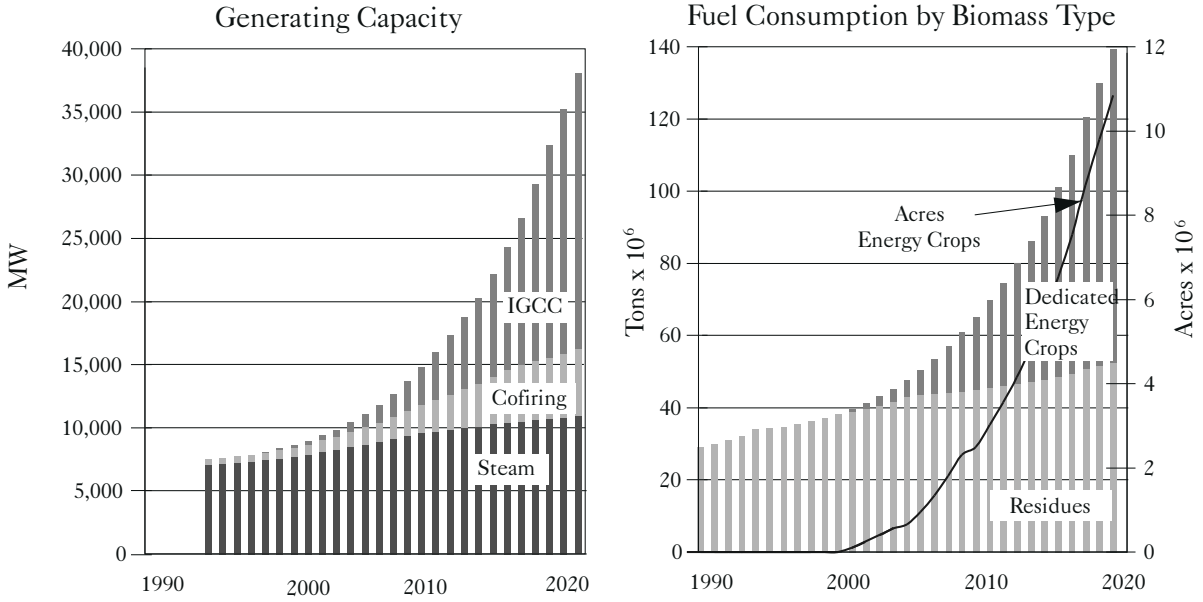
There are many pathways by which this may be achieved. However, the central goal is to have an economically and environmentally sustainable system based upon a sustainable fuel supply infrastructure that will facilitate investment in modern high-efficiency power production cycles. The first component of the strategy is to create the conditions for a significant and early market for biomass in cofiring

applications with coal in existing utility boilers. This strategy involves little risk in the power production component at a very low investment cost per installed kilowatt (kW). Cofiring gives offsets in carbon dioxide, sulfur, and nitrogen oxide emissions, while converting biomass at high efficiency (>35%) into electricity. Even by substituting only 5% of coal with biomass, a major coal-fired plant can provide a market for biomass at the 50–100-MW scale in a given region, requiring in excess of 500,000 tons of biomass per year. This will build a sustainable fuel supply infrastructure —one that can be used in the future as a base for expanded, and even more efficient, power generation options which are currently under development. This strategy minimizes the capital investments required, while aiding existing power producers in their carbon management strategies. Because future biomass fuel supplies will be derived from residues as well as energy crops, such a strategy will improve recycling and reduce landfill impacts, while enhancing rural economics with increased crop revenues.

Coal cofiring represents a huge market. However, the distribution of suitable generating facilities for cofiring is mainly in the eastern U.S. Due to location and transportation costs, large quantities of available and/or potential biomass resources in other parts of the U.S. will be without a market, offering significant opportunities for development of new dedicated biomass power facilities. The commercialization of energy crops will occur as current demonstrations prove the stabilizing effect of dedicated feedstocks on biomass fuel supply systems.

To reach the full growth potential that DOE projects for biomass power development (shown in the figures below), new and efficient technologies which are less scale dependent are needed, such as gasifiers, gas turbines, fuel cells, steam cycles, and others. Unlike the cofiring option, such technologies will have global market potential. These markets will lead to worldwide sales of U.S. technologies in developing economies that are undergoing electricity growth rates of greater than 10% per year. Early investments in the development of improved biomass conversion technology could pay off in the rural American economy and in targeted industrial sectors in developing countries, such as the tropical cane sugar processing industries. Technologies with scale independence down to 100 kW that maintain efficiency and low investment costs could open up enormous worldwide village electrification markets in regions such as India, China, and Latin America.

Projected Biopower Growth



Goals of the Biomass Power Program

The Biomass Power Program has identified seven strategic goals that are contained within four primary program areas. These identify the critical few, high-level accomplishments that will "make a difference" in fostering a viable integrated biomass power industry. These program areas and our associated goals are outlined below.

Technology Development

- Feedstocks Goal: Facilitate the commercialization and widespread production of environmentally acceptable energy crops and dual-use crops, and the use of biomass wastes and residues as feedstocks for biomass power facilities.
- Conversion Technology Goal: Facilitate the commercialization of advanced and high-efficiency biomass power conversion technologies integrated with dedicated feedstock supply systems.

Environmental Issues

- Environmental Goal: Improve the capability of biomass resources to provide goods and services, including electricity, by fostering the highest standards of environmental performance consistent with the social and economic goals of society.

Policy, Planning, and Producer-User Linkages

- Power Sector Acceptance Goal: Facilitate the establishment of biomass power as an economically credible and attractive option for the power sector industry, particularly in the context of the future deregulated utility environment.
- Fuel Supplier Acceptance and Risk Goal: Reduce fuel supplier risks associated with biomass supply and energy crop production.
- Financial Goal: Address financial and investment hurdles for domestic and international markets.

Education

- Educational Goal: Improve public understanding of the technical, economic, and environmental attributes of biomass power.

Technology Development

Goals: *Facilitate the commercialization and widespread production of environmentally acceptable biomass fuel supplies for power plants.*

Facilitate the commercialization of advanced and high-efficiency biomass power conversion technologies integrated with dedicated feedstock supply systems.

Strategic Issues

Technology development for biomass power can be grouped into two categories: feedstock development and conversion technologies. To achieve the goal of 17,000 MW of additional biomass power capacity over the next 20 years, an expanded, sustainable supply of biomass feedstocks is needed. The supply sector needs to make the transition from a residues-based approach to an integrated, dedicated feedstock supply system using energy crops, plus residues. The barriers to achieving this are: the uncertainty of decision-makers regarding the potential role of energy crops in competing with or complementing production of food or fiber crops; the need to demonstrate the environmental and economic sustainability of energy crops; and the need to reduce the average delivered cost of energy crops by means such as improved crop yields and improved harvesting equipment.

The barriers facing conversion technologies include: current limited cost-competitive niche applications for biomass-to-electricity technology; the absence of incentives to invest in higher-risk, longer-term projects; the lack of demonstrated advanced biomass IGCC technology; and the absence of power technologies suitable for export to foreign markets. In light of these barriers, the program has identified the following objectives for overcoming barriers to advance biomass conversion technology in the competitive marketplace.

Strategic Objectives

Feedstock Development

- Facilitate the transition from the use of residues to the integrated use of dedicated energy crops and residues.
- Demonstrate the technical and economic competitiveness and benefits of integrated energy crop systems.
- Facilitate the expansion of agriculture and its related infrastructure for large-scale energy crop production, achieving deployment of 5 1/2 million acres of energy crops within the next 20 years.

Conversion Technology

- Encourage biomass cofiring as a cost-effective, nearer-term opportunity.
- Cost-share the development of efficient pioneer technologies at small, industrial, and utility scales for domestic and international markets.
- Facilitate the deployment of an additional 17,000 MW of improved biomass fuel supply and conversion technologies within the next 20 years.

Environmental Issues

Goal: *Improve the capability of the ecosystem to provide goods and services, including biomass electricity, by following the highest standards of environmental performance consistent with the social and economic goals of society.*

Strategic Issues

The future success of biomass power development requires that feedstock supply and conversion systems meet high standards of environmental acceptability. Key issues that need to be addressed include uncertainty regarding the magnitude of biomass power's potential role in reducing greenhouse gas emissions, and questions regarding potential benefits and impacts on soil nutrients and habitat associated with use of agricultural and forestry residues for fuel. There are also insufficient data regarding the emissions of conventional and advanced biomass power conversion systems for decision makers to assess life-cycle benefits.

Strategic Objectives

- Invest in stewardship of our air, water, and soil resources to produce electricity, goods, and services by following the highest standards of environmental performance consistent with the social and economic goals of society.
- Establish criteria for environmentally acceptable integrated fuel supply and conversion systems used in biomass power applications, in cooperation with the Environmental Protection Agency and other environmental groups.
- Improve methodologies for assessing and reporting the environmental impacts of feedstock supply and conversion systems used in biomass power applications.
- Validate the ability of dedicated biomass feedstock and advanced conversion technology to meet high environmental standards for air, water, and soils.
- Support biomass power applications and approaches that maintain or enhance biodiversity and that are environmentally and economically sustainable.

Policy, Planning, and Producer-User Linkages

Goals: *Facilitate establishing biomass power infrastructure as an economically credible and attractive option.*

Reduce fuel supplier risks associated with biomass energy supply and energy crop production.

Address financial and investment hurdles for domestic and international markets.

Strategic Issues

A diverse array of constituency groups are involved in biomass power, including consumers, farmers/landowners, forest products industries, power producers, and others. The wide range of constituency groups creates unique challenges to the growth of the biomass power infrastructure. Key strategic issues that need to be addressed include: opportunities created by utility restructuring; continuing low fossil fuel costs for the near- to mid-term (2007); and existing energy and agricultural policies, which include inadequate valuation for biomass externality benefits such as carbon recycling and local job creation. International strategic issues include: lack of adequate knowledge about biomass resource availability and exploitation in emerging markets, lack of standard power purchase agreements, subsidization of power tariffs, and lack of power banking and wheeling arrangements. In addition, for a number of developing countries, there are issues associated with protection of intellectual property rights, unenforceable contracts, and repatriation of profits.

Issues associated with fuel supplier acceptance and risk must also be addressed, including: the volatility and inefficiency of current markets for wastes and residues; policies that currently favor conventional crops over energy crops; and lack of demonstrated large-scale competitive results for biomass energy crop production.

Significant financial and fiscal challenges that biomass power faces in domestic and international markets include: the financial community's unfamiliarity with biomass conversion and fuel supply issues, which creates difficulties in obtaining project financing (both debt and equity); and failed or inadequate tax incentives that have hindered biomass power development, such as the highly restrictive tax credit for "closed-loop" biomass supply systems.

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Strategic Objectives

- Cooperate with the private sector to foster market-driven approaches that address the externality benefits of biomass (such as distributed generation and green pricing).
- Provide inputs to legislative actions correcting failed incentives or policies that discourage integrated biomass power development.
- Continuously monitor the impacts of various trade policies and tariffs in relation to biomass power export opportunities for U.S. industry.
- Evaluate the competition among feedstocks for food, fuel, recyclable fiber, and land. Look at the synergy of multiple-use feedstocks for different markets and products in the demonstration of marketing arrangements that will support successful energy crop production.
- Support the creation of strategic alliances between power producers and agricultural constituencies, such as those involving local and national farm organizations, conservation districts, agricultural industries, equipment manufacturers, and others.
- Support efforts to reduce the financial barriers and transaction costs for entering international markets.
- Support financial packages with equity and loan provisions that help buy-down risks for U.S. demonstrations of domestic use and exportable technologies (combustion, gasification, fuel cell, and other advanced conversion technologies), as well as exploring other forms of risk buy-down for international projects.
- Support collaborative efforts between key government and private interests, including efforts with multilateral and bilateral banks and pursuit of joint off-shore implementation opportunities for biomass power.

Education

Goals: *Improve public understanding of the technical, economic, and environmental attributes of biomass power.*

Strategic Issues

The public is generally not familiar with biomass power technologies, and, to the extent that it is aware of biomass, there is often a tendency to focus on potential drawbacks rather than recognizing the significant benefits biomass power offers. This will have to be overcome if biomass is to make a larger contribution to domestic and international fuel supply situations.

Environmentalists want more information on issues such as the potential impact of biomass energy crops on biodiversity or the impacts of removing residues or low-grade trees from forests. How biomass is perceived by these various groups will have a tremendous impact on the future of biomass industry growth. For this reason, education of the various interest groups and the public is a primary goal.

Strategic Objectives

- Widely disseminate information on biomass power technologies and benefits to a broad range of customer audiences, including the general public, electric power providers, the agricultural and forestry communities, environmental planners, the media, elected officials, and land use planners.
- Develop data on energy crops appropriate to important geographic and climatic zones.
- Develop an effective media outreach program to include story development and placement in a number of print and other media (including the Internet), conferences, and roundtables. Databases will be developed for easy access to project information.
- Present the benefits of biomass power in reducing the threat of global warming; facilitating sustainable forestry and agricultural practices; creating jobs; and solving waste management problems.
- Seek stakeholder participation so that program managers have the opportunity to actively listen to and better understand constituent concerns.
- Foster partnerships among constituents and between constituents and DOE.
- Encourage cooperation from other energy and related programs at the federal, regional, state, and local levels.
- Work with USDA and other federal agencies to help educate legislative decision makers regarding the barriers caused by current legislation, and potential ways to modify legislation to overcome these problems.

To learn more about the Biomass Power Program:

Visit the Biopower Web site of the U.S. Department of Energy's Biomass Power Program:
www.eren.doe.gov/biopower

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Produced for the
U.S. Department of Energy

1000 Independence Ave., SW
Washington, DC 20585

by the
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
a DOE national laboratory

DOE/GO-10096-345
DE97000081
December 1996