JISEA Joint Institute for Strategic Energy Analysis

Guiding the transformation of the global energy economy

2012 ANNUAL REPORT

CONTENTS

Cover photo from Native Energy, Inc., NREL/PIX 17592
Above photo from Iberdrola Renewables, NREL/PIX 16110
Right page photo by David Hicks, NREL/PIX 18556

“ Sustainable solutions meet the needs of the present without compromising the ability of future generations to meet their own needs.”

~1987 Brundtland Commission*

*The Brundtland Commission, formally the World Commission on Environment and Development (WCED), known by the name of its Chair Gro Harlem Brundtland, was convened by the United Nations in 1983. The commission was created to address growing concern "about the accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development." In establishing the commission, the UN General Assembly recognized that environmental problems were global in nature and determined that it was in the common interest of all nations to establish policies for sustainable development.

“Our partnership with the Joint Institute has been instrumental with not only refining our investment thesis, but also with improving our investment process.”

~Bruce M. Kahn Ph.D.
Director and Senior Investment Analyst, Climate Change Investment Research Group
Deutsche Bank, Deutsche Asset Management

Photo by Warren Gretz, NREL/PIX 06942

MESSAGE FROM THE EXECUTIVE COMMITTEE CHAIR

It is my pleasure to welcome you to this inaugural annual report for the Joint Institute for Strategic Energy Analysis! This has been an amazing year for JISEA, and this volume only hints at the transdisciplinary work that is being done to provide pragmatic, real-world insights to inform and guide the myriad of decisions that will lead to change in the global energy economy.

In 2010, the Alliance for Sustainable Energy[1] was motivated to launch the JISEA in order to amplify the impact of the National Renewable Energy Laboratory with its mission in energy efficiency and renewable energy. Alliance understood that to realize a sustainable energy future, a much deeper understanding must be developed of the synergies among all energy pathways and the interactions among energy systems, earth systems, and social and economic systems. JISEA was established to leverage the deep knowledge and capabilities across six founding institutions and global affiliates to pursue the vision of providing comprehensive insights to guide a global energy transformation.

The engagements to date have proven that our unique approach of combining deep technology knowledge with strategic analysis provides invaluable input to dialogues that are taking place worldwide. These discussions bring a comprehensive perspective to the nexus of energy, economics, development, environment, and society.

Through our initial analyses and key stakeholder engagements, JISEA has seen a significant growth in support and commitment from its virtual network of researchers. This foundation enables the institute to expand its analysis and encompass the breadth of sustainability issues locally and globally.

On behalf of the partners, I am pleased to invite you to "turn the page" and read some of the highlights of our year and our work. We are proud to acknowledge a successful year for JISEA and also reinforce our commitment to its continued success.

Bobi Garrett

Bobi Garrett
Executive Committee Chair
Senior Vice President, Alliance/NREL

[1] Manager and operator of the National Renewable Energy Laboratory under contract to the U.S. Department of Energy.

Left page photo from Invenergy LLC, NREL/PIX 16042

Photo by Dennis Schroeder, NREL/PIX 20130

MESSAGE FROM THE EXECUTIVE DIRECTOR

With its roots in both academic and national laboratory research environments, the JISEA leverages the combined expertise of member institutions to fill global information gaps and enable decision making regarding energy futures. In our first full year of operation, we made great progress toward our vision by building a substantial portfolio of research and scoping studies, as well as a global network of talent to help us fulfill our mission.

This annual report celebrates accomplishments from the past year. We highlight the U.S. Natural Gas Study (in progress), our Nuclear and Renewable Energy Synergies workshop and published report, and profiles for research both underway and completed. We are extremely pleased with our portfolio of work to date and the results and insights from our multi-institutional, cross-functional, global teams. This portfolio is delivering on the strategic intent to establish a leading source for strategic energy analysis that could not be performed by individual institutions alone. This year, we established a solid base and processes to realize that vision. Study teams were drawn from the founding institutions as well as a virtual network of national and global affiliates.

JISEA created its Innovative Research Analysis Award Program (IRAAP) as a way to catalyze research and promote teamwork among its member institutions on a smaller scale. As member researchers have seen their IRAAP proposals go from concept to completion, they have witnessed the advantages of pursuing a "joint" effort. IRAAP projects have ranged from research that examines the energy-water nexus to studies that explore a nuclear and renewable solution for decarbonizing the electric sector. We recently selected four new research projects for our 2012 awards, from a pool of applications that has tripled in size since the first year. In total, we've awarded over $700,000 in funding to 14 innovative research projects.

On a larger scale, JISEA kicked off its first major study in April 2011 with a scoping workshop on natural gas and the U.S. electric power sector. This project focuses on impacts of the natural gas revolution on the U.S. economy, beginning with an in-depth evaluation of the electric sector. The study addresses key areas related to supply such as greenhouse gas emissions, water use, and legal, and regulatory issues, and will evaluate possible pathways of the U.S. power sector, including competitive and synergistic interactions of natural gas with renewables and other energy sources. The final report will be released later in 2012. In the year ahead, we look forward to continued engagement of stakeholders and our global network of thought leaders from the financial, legal, industrial, and academic sectors. We look forward to advancing our mission to provide seminal analyses to help guide the transformation of the global energy economy.

Douglas J. Arent, Ph.D., MBA
Executive Director, Joint Institute for Strategic Energy Analysis
U.S. National Renewable Energy Laboratory

OUR MISSION

JISEA seeks to guide the transformation of the global energy economy through comprehensive, transdisciplinary research focused on the nexus of energy, finance, and society.

To enable a cost-effective transition to sustainable energy at significant speed and scale while minimizing unintended impacts, we offer practical answers to complex questions:

- What will work, what won't, and why?
- What's worth investing in and why?
- How can we avoid unintended economic and social consequences of energy development?

JISEA provides decision-making support to industry, finance, and government. By delivering groundbreaking strategic insights and explaining their real-world implications, JISEA contributes insights to the strategic dialogues that are taking place worldwide, both globally and locally and in developed and developing countries.

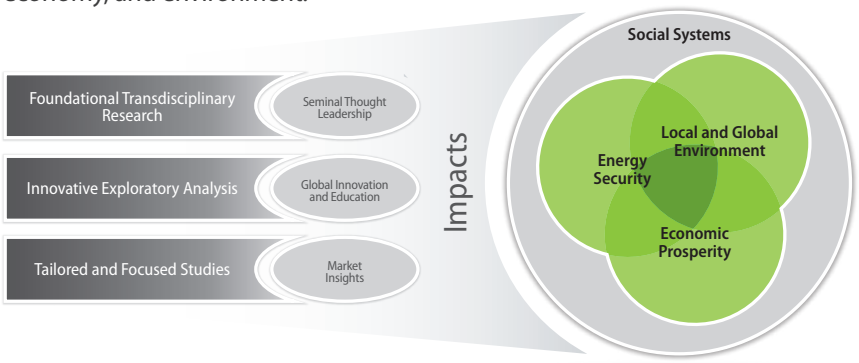
Progressive, visionary leadership leverages deep technical expertise and strategic excellence of JISEA's member institutions to fill gaps in understanding and illuminate new possibilities for the global energy system.

We strive to provide analysis that

- Guides, influences, and informs global energy investment and policy decisions
- Integrates social, behavioral, economic, and strategic insights
- Remains unbiased and unattached to a specific agenda.

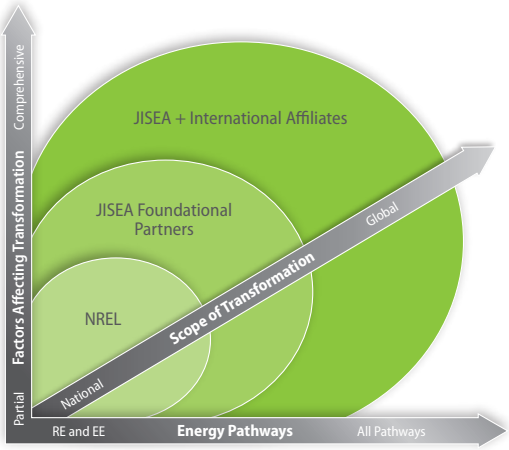
Focused Mission.

Applying unique analytical capabilities, we focus on the intersections of energy, economy, and environment.



Expansive View.

JISEA works with international affiliates to develop a comprehensive understanding of the factors driving transformation of the global energy economy. We examine renewable energy and energy efficiency as well as other energy sources and the potential synergies between them.



OUR WORK – GUIDING THE TRANSFORMATION OF THE GLOBAL ENERGY ECONOMY

This year, JISEA advanced its mission through work in two core program areas:

Conducting seminal analysis

By adapting a "best in class" philosophy and creating virtual project teams that are beyond the reach of any single institution, JISEA combines the strengths and capabilities of its founding institutions and global network of affiliates to comprehensively address the full spectrum of issues required to transform the global energy system:

- Physical systems (earth systems and engineered infrastructure)
- Economic and market systems
- Legal and institutional systems.

Funding innovative, collaborative research and analysis

Through the Innovative Research Analysis Award Program (IRAAP), JISEA seeks to fund energy analysis projects that focus on gaining critical, timely, and deep understanding of global market dynamics, technologies, and systems, and interfaces across industries, economies, and markets.

The pages that follow elaborate on analysis projects underway and under development and the funded IRAAP projects.

Conducting Seminal Analysis

The Role of Natural Gas in Transforming the U.S. Energy Sector

In April of 2011, JISEA launched a comprehensive, sector-by-sector study of the impacts of the natural gas revolution on the U.S. economy, beginning with the electric sector.

Photo by Dennis Schroeder, NREL/PIX 17612

Background

Reportedly abundant and affordable natural gas is beginning to fundamentally reshape the U.S. energy landscape. Rapid changes in knowledge of shale gas resources, extraction technology advancement, and the climate impacts of a natural gas revolution are raising new questions related to energy security, economic revitalization, and environmental protection.

A Game Changer?

Electric Sector Analysis

This initial study phase will explore the competitive and synergistic interactions of natural gas, renewable energy, carbon capture and sequestration (CCS), and nuclear power generation technologies between now and 2050. The study will:

- Provide insights on the impacts of different transition pathways
- Inform investment, research and development, and deployment strategies given a dynamic policy, regulatory, and financial environment.

Expected Outcomes

Our study will address these questions regarding natural gas supply:

- What are impacts and risks of shale gas development and can they be addressed in a cost-effective manner?
- What are the lifecycle greenhouse gas emissions of shale gas? What are mitigation options? What are the costs of mitigation?
- What is the overall price risk given demand from other sectors and global markets?
- What are the implications for other power generation technologies and systems between now and 2050?
- When do low cost gas and renewables complement each other, and when do they compete?

The study will also guide development of the U.S. electric power sector by:

- Identifying transitional pathways to enable decarbonization of the U.S. power sector
- Providing insight regarding likely impacts of new Environmental Protection Agency regulations on air quality, water intake structures, and coal residue disposal.

Learn More

JISEA assembled a selection of exemplary readings to inform discussion about natural gas and energy. Find it at *JISEA.org/event_scoping_workshop_0411_bibliography.cfm*

Initiating a Conversation

This discussion has identified several broad categories of synergies between nuclear and renewable energy that could foster solutions to energy challenges and warrant additional investigation:

- Energy for transportation*
- Hybrid energy systems *
- Business model development*
- Balancing capacity on the grid
- Islandable micro-grids and small modular reactors
- Energy for industrial applications
- Permitting, licensing, and financing
- Policy and institutional opportunities.

*Identified as categories with greatest potential for impact.

Top photo from iStock/17403062

Bottom photo from iStock/16702791

Right page photo from iStock/13656290

Nuclear and Renewable Hybrid Systems - Potential Synergies

Background: Why Nuclear and Renewables?

Two of the major challenges the U.S. energy sector faces are greenhouse gas emissions and oil that is both predominately imported and potentially reaching a peak. Historically, interest in development of renewable and nuclear energy has been strong because both have potential for overcoming the first of the challenges—decarbonizing the energy sector. The second challenge, reducing imported oil and decarbonization of transportation, has been outside most of the discussions for uses of nuclear energy, but can be addressed through electrification of transportation as well as alternative fuels. Though renewable and nuclear energy sources are typically analyzed independently as low carbon energy sources, potential synergies, largely unexplored, may exist and amplify the potential for each of these energy sources. Integrating nuclear energy and renewable energy systems may lead to additional and better options for meeting energy needs and energy policy goals.

Making Connections, Expanding Options

JISEA's Analysis

Seeing a gap in understanding, JISEA initiated exploration of synergies between nuclear and renewable energy. Beginning with a gathering of 40 thought leaders from industry, government, and academia, JISEA launched an ongoing effort to identify and prioritize topics for research in this area. The discussion is a natural fit for JISEA, an organization founded to move global energy systems toward a sustainable future through transdisciplinary development of objective and credible data, tools, and analysis.

JISEA published a report of proceedings of its exploratory discussion. The paper summarizes the workshop and its findings and may be used to guide future funding opportunities. We've also funded exploratory analysis examining some potential synergies.

A follow up workshop is scheduled for April 2012.

Learn More

Nuclear and Renewable Energy Synergies Workshop: Report of Proceedings
by Mark Ruth, Mark Antkowiak, and Scott Gossett
JISEA.org/pdfs/52256.pdf

JISEA thanks representatives from the following organizations who participated in the kick-off discussion for this study: AREVA Federal Services, CH2M HILL, Duke Energy, High Bridge Associates, Idaho National Laboratory, Lifeboat Energy, Massachusetts Institute of Technology, NREL, Oak Ridge National Laboratory, Sandia National Laboratory, TerraPower, U.S. Nuclear Regulatory Commission, U.S. Department of Energy, and White Sands Missile Range.

JISEA stays engaged in the global energy dialogue by continually planting seeds for future studies and collaborating to bring the studies to fruition.

Photo by Dennis Schroeder, NREL/PIX 18070

Integrating High Penetration Variable Renewable Electricity

Representative of its global focus, JISEA is undertaking an examination of high penetration of renewable energy in electric systems for the Clean Energy Ministerial (CEM), a global forum dedicated to accelerating the transition to clean energy technologies. JISEA is leading the analysis with support of a broad coalition of international partners bringing their expertise to this virtual team.

Global Lessons Learned

Goals

The analyst team, drawn from NREL, SKM, New Resource Partners, and Spain's Ministry of Industry, Energy, and Tourism, is examining lessons learned from Australia, Denmark, Germany, Ireland, Spain, and the United States. Case studies on each country synthesize lessons on effective policies, regulations, planning, and practices for achieving and managing significant renewable energy penetration into large-scale electricity grid systems.

With this study, JISEA seeks to:

- Highlight multiple approaches for achieving technical and institutional capabilities to accommodate renewable energy through case studies situated in diverse geographical, market, and institutional contexts
- Present to Energy Ministers and Industry leaders at the CEM-3 meeting key actions that energy ministers and other stakeholders can pursue now to ensure that electricity markets and systems can effectively co-evolve with increasing penetrations of renewable energy.

Initial Findings

Analysis of the country experiences indicates that governments can best enable high renewable energy penetration through four leadership areas:

- Commission a comprehensive assessment of the technical, institutional, human capital, and market status and factors influencing renewable energy integration
- Develop visionary goals and plans at national and regional levels
- Lead the public engagement to communicate goals and needed actions to attain them
- Engage in international collaboration to share best practices and strengthen common technical resources.

Funding Innovative Research

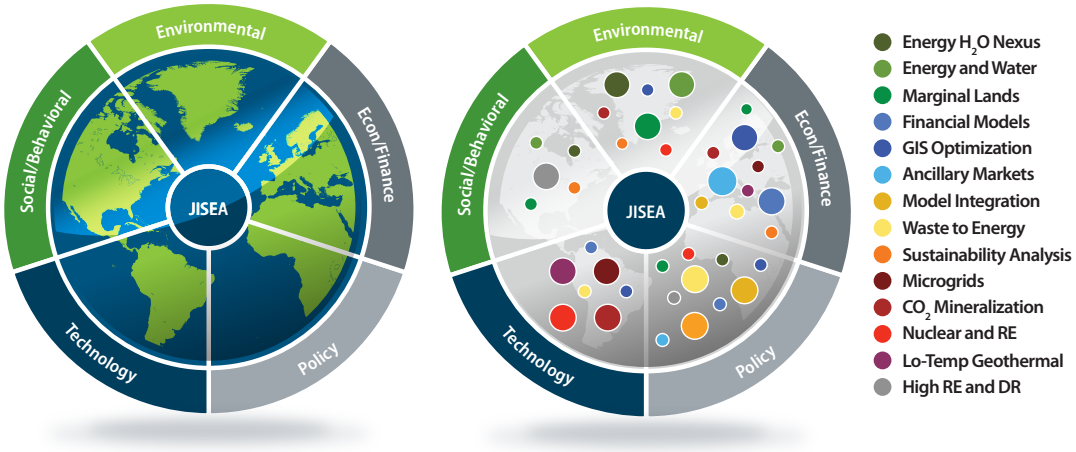
JISEA's Innovative Research Analysis Award Program (IRAAP) provides research awards for innovative analytical energy research. JISEA makes awards to selected collaborative teams of faculty members and researchers from its founding partner institutions:

- Colorado School of Mines
- Colorado State University
- Massachusetts Institute of Technology
- National Renewable Energy Laboratory
- Stanford University
- University of Colorado at Boulder.

To date, JISEA has provided $700,000 in funding to 14 research teams.

Through the IRAAP, JISEA seeks to fund energy analysis projects that focus on gaining critical, timely, and deep understanding of global market dynamics, technologies, and systems, and interfaces across industries, economies, and markets.

A brief description of all the IRAAP projects in progress follows.



We seek to fund a balanced portfolio of research. As shown in the images above, IRAAP projects' major emphases (large dots) and minor emphases (small dots) touch on environmental, economic and financial, policy, technological, and social and behavioral aspects of energy systems.

Innovative.

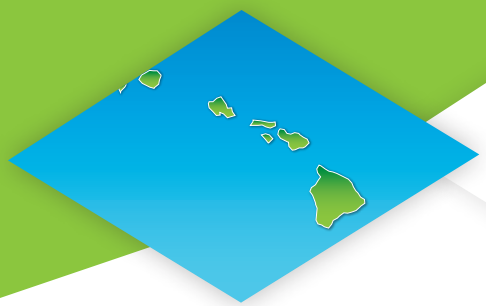
IRAAP projects focus on analytical research that works toward a more sustainable global energy economy.

Learn more: *http://www.jisea.org/research_award_program.cfm*

What We Fund

Collaborative, multidisciplinary research which:

- Encompasses an integrated systems perspective
- Considers the implications of findings in economic, social and environmental terms
- Applies at local, domestic, and international scales
- Leads to significant global impacts on energy sector transformation.



IRAAP in Focus:
Power System Balancing with High Renewable Penetration: the Potential of Demand Response in Hawai'i

Collaborators: Massachusetts Institute of Technology, National Renewable Energy Laboratory

Table 1. Improvement with demand response

Performance Metric (2030)	Unit	No DR	With DR
Operational cost	$/MWh, mean	104	92
Wind energy potential	% of demand	25	26
Reliability reserve deficit	days/year	31	0
Demand response calls	days/year	1	8

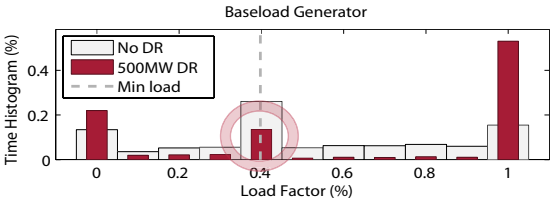


Figure 1. Improvement in thermal efficiency

The Challenge

The State of Hawai'i has adopted an aggressive renewable portfolio standard of 40% renewable energy by 2030. Hawai'i has targeted a renewable energy mix that will (according to traditional methodology) rely on additional expensive spinning reserve or energy storage to balance the electrical grid.

The Research

This study investigated Demand Response (DR) as an alternate lower-cost solution to balancing intermittent supplies. In a DR scenario, the grid operator ensures system stability by managing select consumers' loads.

A stochastic unit commitment model simulated the relative production of wind, thermal, and demand response resources and predicted the frequency, duration, and scope of curtailment events necessary to maintain grid balance. Similar utility direct load control programs were benchmarked to investigate best practices for program design. Results were evaluated by system operating cost, wind energy contribution, reliability reserve, and customer impact (Table 1).

Findings

Demand Response provided a lower-cost solution to balancing intermittent supplies, which may enable Hawai'i to achieve its goals for reduced energy dependence. DR enhances system operation by enabling thermal generators to operate more efficiently. In all scenarios, baseload and peaking generators spent less time at inefficient minimum load levels (circled in Figure 1) because fast-acting DR provided reserve capacity.

IRAAP Projects 2010–2012

Integration of Low-Temperature Geothermal Resources with Other Power Generation Technologies to Improve System Performance and Resource Utilization

The low-temperature (<150°C) geothermal resource base for the U.S. is estimated to be >500 GW, but is under-utilized largely due to the current limitations on geothermal power plant technology. One potential way to better utilize the large low-temperature resource would be to use the warm fluid to augment energy inputs into other types of power plants (e.g., waste-to-energy and biomass). This project will conduct a techno-economic analysis that compares augmented versus non-augmented power plants. Expected results include: 1) identification of promising novel applications for low-temperature geothermal resources, and 2) insight into the impact that low-temperature geothermal could have on other energy resources.

Collaborators: Colorado State University, National Renewable Energy Laboratory

A Study of Emerging Ancillary Service Markets in Non-Restructured Regions of the Western Power Grid

Rising penetrations of renewable energy generation in the Western United States pose new requirements for ancillary services, which are the services required, in addition to energy service, in order to maintain the system reliability. In non-restructured Western power markets, little is known about the quantity of ancillary services that will be required to ensure grid stability and system reliability as utilities strive to meet rising state renewable portfolio standards (RPS). Also uncertain is the cost at which those ancillary services will be procured, both from within vertically-integrated footprint utilities and from third-party power producers selling ancillary services on the wholesale market. This project will attempt to provide more accurate information to market participants and regulators about the present and future size and composition of ancillary service markets in the non-restructured regions of the West. Research activities will focus primarily on the impacts of variable and uncertain generation (e.g., wind and solar generation) on technical grid requirements for ancillary services, as well as on detailed studies and economic analysis of several balancing authority areas to define existing and potential ancillary service market participants (e.g., investor-owned utilities, generation and transmission cooperatives, federal power marketing agencies, and third-party generation owners). Results will attempt to predict future costs and supply-side pathways for ancillary service provision, given the outputs of NREL's demand-oriented research activities. This information would provide market participants and state and federal regulators with a more transparent view of future ancillary service markets, and allow for more efficient system planning in both the private and public sectors of the electricity market.

Collaborators: University of Colorado at Boulder, National Renewable Energy Laboratory
In-kind Collaborator: RASEI

Multi-metric Sustainability Analysis

The National Renewable Energy Laboratory and the Colorado School of Mines are partnering on the development of a multi-metric sustainability framework and analysis. The objective is to compare the sustainability of conventional and renewable technologies using a suite of study-relevant indicators, including metrics in social, economic and environmental categories. Comparisons can be made between different or similar technologies, in different ecosystems, and for different end goals. The approach will capture quantitative analysis results where available

Photo from Iberdrola Renewables, NREL/PIX 16703

and represent the value of non-monetized benefits of alternative technologies. With funding from JISEA, we would seek to establish a core set of metrics for evaluation, conduct a literature search on state-of-the-science analytical approaches and qualitative findings for each metric, and identify areas where new tools and approaches are needed.

Collaborators: Colorado School of Mines, National Renewable Energy Laboratory

Marginal Lands Availability in the United States

The project intends to define and identify the marginal lands in the United States, as well as assess their renewable energy potential, including biomass, wind, solar, geothermal and hydro. The researchers will integrate and analyze various environmental data (e.g. soil, topography, climate, land use/cover) and apply geospatial techniques using state-of-the-art geographic information systems (GIS). The results will be presented in a tabular and geospatial format (maps). This study will be the first to provide detailed information on marginal lands in the United States. It aims to provide policy makers and industry developers with a better understanding of the marginal lands availability in the country and thus guide their future strategic decisions.

Collaborators: Stanford University, National Renewable Energy Laboratory

Integration of a Computable General Equilibrium Model with an Electricity Sector Optimization Model to Assess the Economic Impacts of U.S. Climate Policy

This project developed the capability to perform a comprehensive analysis of U.S. climate policy by combining the strengths of both an economy-wide, "top-down" computable general equilibrium model (the Massachusetts Institute of Technology's U.S. Regional Energy Policy model or USREP) and a technology-rich "bottom-up" electric-sector-only model (NREL's Regional Energy Deployment System model or ReEDS). This resulted in an innovative analysis tool to examine economy-wide impacts of climate and energy policy. The integrated model framework is applied to analyze the efficiency and distributional implications of a Clean Energy Standard policy in the U.S. electric power sector.

Collaborators: Massachusetts Institute of Technology, National Renewable Energy Laboratory

A Combined Nuclear and Renewable Solution to Decarbonizing the Electric Sector

This project investigated the potential compatibility of a high renewable energy grid with load-following nuclear power plants. Using a systems approach, it described combinations of wind, solar, and nuclear that can provide a large fraction of a system's electricity, along with the characteristics of high-temperature nuclear power plants needed to support these scenarios.

Collaborators: Colorado School of Mines, National Renewable Energy Laboratory
In-kind Collaborator: University of Wisconsin at Madison

Financial Models for Electric Utility Market Transformation

Distributed Generation (DG) technologies can be beneficial in that they allow the society to achieve widespread diffusion of energy choice, appropriate energy systems, and clean energy technologies. Under traditional business models, coupled electric utilities increase profits by selling more electricity. Because they decrease net central station electricity generation, DG projects typically decrease profits for utilities along the value chain between the customer and the central station generator. New business models are required that can recognize and

monetize the potential benefits of DG resources. This study identifies the business model that utility customers are using to justify DG development and installation. Then, this work quantifies the deleterious effect of DG on traditional utility business models. Finally, alternative business models are introduced and evaluated to understand the potential for novel valuations of the performance of DG resources. Through the development and implementation of novel business models to support DG, the electric utility industry has a unique opportunity to lead the transformation to a clean energy economy resulting in more jobs, a healthier society, increased energy security, improved energy price stability, and less expensive electricity in the long term.

Collaborators: Colorado State University, National Renewable Energy Laboratory
In-kind Collaborator: Rocky Mountain Institute

Verifiable Decision-making Algorithms for Reconfiguration of Electric Microgrids

Researchers worked to discover new algorithms for reconfiguration of electric power microgrids subject to specific objectives such as maximized economic benefits and minimized losses. They used detailed modeling and simulation along with formal verification techniques for validation of these algorithms, addressing issues such as reliability and cyber-security. The research has yielded new topologies and operations aspects of electric power microgrids that will accelerate the penetration of renewables in the grid.

Collaborators: Colorado State University, University of Colorado at Boulder

Impact of Alkalinity Sources on the Life Cycle Energy Efficiency of CO_2 Mineralization Technologies

Carbon dioxide (CO_2) mineralization has been proposed as a method to reduce greenhouse gas emissions from fossil fuel combustion in a scalable manner. Mineralization produces a safe, stable form of CO_2, which could be an advantage over conventional carbon capture and storage, where safety and regulatory matters are a concern. A promising mineralization technology is highly dependent on efficient and inexpensive alkalinity generation or extraction. Researchers assessed the usefulness of several potential alkalinity sources. The information is directly usable in life cycle assessments of mineralization-based CO_2 capture systems.

Collaborators: Massachusetts Institute of Technology, Stanford University

Waste Not, Want Not: Analyzing the Economic and Environmental Viability of Waste To Energy (WTE) Technology for Site-specific Optimization of Renewable Energy Options

Waste-to-energy (WTE) technology burns municipal waste in an environmentally safe incinerator to generate electricity, provide district heat, and reduce the need for landfill disposal. While this technology has gained acceptance in Europe, it has yet to be commonly recognized as an option in the United States. This study investigated the environmental, policy, economic, and technical factors that have contributed to the success of the technology abroad, and considered how they are likely to impact the adoption of the technology in the United States. WTE has been incorporated into NREL's Renewable Energy Optimization (REO) tool, which allows it to be considered alongside other renewable energy options and serve to introduce the technology to a broad audience, which will help advance the technology in the United States.

Collaborators: National Renewable Energy Laboratory, University of Colorado at Boulder

Photo from iStock/15274873

Energy - Water Nexus in a Drying West: A Case Study Analysis and Methodology

Researchers analyzed the intersection of energy generation and transmission planning, water demands, climate change, and agricultural water use to determine the water impacts of different energy and climate change scenarios. A case study analysis of the South Platte River Basin in Northeastern Colorado was used to evaluate energy generation risk and resiliency in the face of changing and uncertain water availability in the West. The results will provide a template for both utilities and key policymakers in developing long-term energy and transmission planning strategies that meet not only energy but also water demands while protecting valuable natural resources.

Collaborators: Colorado State University, National Renewable Energy Laboratory, University of Colorado at Boulder

A GIS-based Mapping and Optimization Tool to Aid Siting, Design and Assessment of Utility Scale Energy Development

Siting large-scale solar projects is complex and solar developers must take into consideration many environmental, social, and economic factors when evaluating a potential site, in addition to the quality of the solar resource. This research developed a proof-of-concept web-based GIS tool that evaluates multiple user-defined criteria in an optimization algorithm to inform discussions and decisions regarding the locations of large-scale solar projects. This tool could be expanded to optimize siting decisions for other mineral and energy developments, and could also be utilized to better understand the cumulative effects of multiple developments on a region. Energy resource and infrastructure information from all energy sectors was consolidated to provide a unique mechanism to comprehensively evaluate a proposed energy project or select a site for a new energy project while considering varying degrees of preference for economic considerations and environmental effects.

Collaborators: National Renewable Energy Laboratory, Stanford University

Toward an Improved Methodology for Comparing Water-related Environmental Impacts of Electricity Generation: A Preliminary Analysis of Concentrating Solar Power Data

Water is a critical commodity, and its use is an important factor to consider when evaluating large industrial systems such as power plants. Current water analyses ignore important attributes of water (e.g., salinity, flow rate, temperature) that can vary spatially, temporally, and across electricity-generating technologies, and they do not take into account broader environmental and/or socio-economic impacts. This research analyzed the inputs, internal uses, and outputs of water in concentrating solar power (CSP) facilities in an effort to develop more comprehensive and accurate metrics for water use by electricity generating technologies. Further research is necessary to fully consolidate these attributes and broader impacts to allow for fair and accurate comparisons across competing technologies. Results would assist utility regulators, water resource managers, electricity resource planners, and others to understand the water quality and quantity impact of electricity-generating technology choices.

Collaborators: National Renewable Energy Laboratory, Stanford University, University of Colorado at Boulder

THE YEAR AHEAD: PROJECTS IN DEVELOPMENT

Enhancing Capacity for Low Emission Development Strategies

Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) is a U.S. government program to support developing countries' efforts to pursue long-term, transformative development and accelerate sustainable, climate-resilient economic growth while slowing the growth of greenhouse gas emissions. The program is an integral part of U.S. government efforts to build capacities in partner countries, provide targeted technical assistance, and build a shared global knowledge base on low emission development.

Under the EC-LEDS framework, JISEA is spearheading an initiative to mobilize private capital and investment.

Substantial investment by both the public and private sectors in low carbon infrastructure will be necessary to help countries achieve their economic development objectives while combating climate change. JISEA is providing thought leadership to address key issues that will enable greater capital mobilization. In addition to assisting countries in a pilot program to develop LEDS policies and programs that will be effective at mobilizing high levels of private sector investment, JISEA will identify effective approaches for potential expansion of this investment mobilization program and communicate lessons learned through case study analysis, workshops, and peer-to-peer learning activities.

JISEA Fellowships & Visiting Scholar Program

In 2012, JISEA will launch a new capacity-building program that helps deepen and broaden expertise in energy and sustainability analysis. JISEA will host visiting fellows, scholars and professionals from sponsor organizations, JISEA affiliates, and leading international organizations in short-term research positions at JISEA member institutions. The program is intended to enhance skills of participants for analyzing, designing and implementing transformative energy strategies.

Natural Gas & U.S. Transport

A deeper investigation of natural gas and the transportation sector will expand on the JISEA seminal study of the U.S. electric sector. The study is envisaged as a comparative assessment of mobility—train, bus, plane, passenger vehicles—powered by natural gas versus other fuels. JISEA will examine the broad array of technical, economic, and social issues related to use of natural gas for mobility.

U.S. Electricity Market Design

Power markets around the world are evolving to include greater amounts of variable generation, dispatchable power, and real time demand response. Market mechanisms will be needed to ensure variable generation and dispatchable technologies are built at the appropriate levels, demand response is properly rewarded, and that storage is given credit for the full range of services it provides. JISEA researchers will analyze how electricity markets can better offer a variety of pricing and revenue responses to generators. The study will build on grid integration studies and identify new business models for electricity generators.

“Our work with the Joint Institute for Strategic Energy Analysis is a testament to the possibilities made achievable when the private and public sector unify efforts and collaborate toward a common purpose. The Joint Institute for Strategic Energy Analysis, with their wealth of knowledge and first-class capabilities, is a vital resource for companies seeking leadership in the energy and climate change arena, one of the most significant drivers of innovation and business opportunity of our time.”

~ Seth Roberts
Director Energy & Climate Change Policy
The Dow Chemical Company

OUR GLOBAL TEAM

JISEA—rooted in both academic and national laboratory research environments—is operated by the Alliance for Sustainable Energy, LLC, on behalf of the U.S. Department of Energy's National Renewable Energy Laboratory, the University of Colorado-Boulder, the Colorado School of Mines, the Colorado State University, the Massachusetts Institute of Technology, and Stanford University. We also assemble teams from a virtual network of global affiliates and partners.

JISEA includes representation from each of our founding partners, is led by an executive director and program committee, and is governed by an executive committee representing the Alliance for Sustainable Energy's board of directors.

Our program committee provides guidance on program direction to the executive director and reviews and approves JISEA's research agenda, priorities, and annual research program plan. Current program committee members are profiled on the following pages. For more information on the committee members, visit *JISEA.org/leadership.cfm*.

The executive committee provides oversight and advice to the executive director in our leadership, management, guidance, and oversight on behalf of the Alliance board. The executive committee also provides guidance and governance over our strategic intent, annually evaluates our performance relative to our strategic intent, and makes recommendations for improvement.

Also, a small, dedicated staff helps lead and execute the mission of the partners.

JISEA thanks and acknowledges our program committee:
Gian Porro (NREL)
Ron Sega (CSU)
Douglas Arent (JISEA)
William Boyd (CU)
John Reilly (MIT)
John Weyant (Stanford)
Dag Nummedal (CSM)

Founding Institutions

Program Committee

STANFORD UNIVERSITY

John Weyant — *Professor of Management Science and Engineering, Stanford University*

Weyant came to Stanford in 1977, primarily to help develop the Energy Modeling Forum. Prof. Weyant was formerly a Senior Research Associate in the Department of Operations Research, a member of the Stanford International Energy Project and a Fellow in the U.S.-Northeast Asia Forum on International Policy. He is currently an adviser to the U.S. Department of Energy, Pacific Gas & Electric Company, and the U.S. Environmental Protection Agency.

Weyant's current research is focused on global climate change, energy security, corporate strategy analysis, and Japanese energy policy. He is on the editorial boards of The Energy Journal, and Petroleum Management. His national society memberships include the American Economics Association, Association for Public Policy Analysis and Management, Econometric Society, International Association of Energy Economists, Mathematical Programming Society, ORSA, and TIMS.

Massachusetts Institute of Technology

John Reilly — *Co-Director, Joint Program on the Science and Policy of Global Change, and Senior Lecturer, MIT Sloan School of Management, Massachusetts Institute of Technology*

John Reilly is a Co-Director of the MIT Joint Program on the Science and Policy of Global Change and an energy, environmental, and agricultural economist. His research is focused on understanding the role of human activities as a contributor to global environmental change and the effects of environmental change on society and the economy. A key element of his work is the integration of economic models of the global economy as it represents human activity with models of biophysical systems including the ocean, atmosphere, and terrestrial vegetation. By improving understanding the complex interactions of human society with our planet, the Reilly's research aims to aid in the design of policies that can effectively limit the contribution of human activity to environmental change, to facilitate adaptation to unavoidable change, and to understand the consequences of the deployment of large scale energy systems that will be needed to meet growing energy needs.

William Boyd — *Associate Professor, University of Colorado Law School*

William Boyd joined the University of Colorado Law School faculty in 2008. Professor Boyd teaches energy law & regulation, climate change law & policy, and environmental law. His current research focuses on legal and institutional design issues associated with emerging GHG compliance markets; integration of forests and land use into climate policy; carbon accounting and verification

systems for biofuels; regulatory challenges associated with implementation of smart grid technologies; electricity policy; technology transfer in the energy and climate fields; risk assessment; and the role of science and technology in law. Since arriving at the University of Colorado, Professor Boyd has played an active role in establishing the new Renewable and Sustainable Energy Institute (RASEI)—a joint institute between the National Renewable Energy Laboratory (NREL) and the University of Colorado, Boulder—serving on the campus-wide steering committee that recommended the creation of RASEI and as an inaugural fellow on the RASEI Council of Fellows.

Dag Nummedal — *Director, Colorado Energy Research Institute, Colorado School of Mines*

Dag Nummedal has been the director of the Colorado Energy Research Institute at the Colorado School of Mines, Golden, CO, since its opening on July 1, 2004. Prior to joining CSM, Nummedal was Professor of Geology and Geophysics at Louisiana State University (1978–1996) and the University of Wyoming (2000–2004), and served as manager of E&P geosciences at the Unocal Corporation, Houston, TX (1996–2000). Nummedal's research over the past 30 years has covered coastal and shallow marine sediment dynamics, planetary geology, sequence stratigraphy, lacustrine sedimentation, tectonics and stratigraphy, energy systems analysis, carbon sequestration, and sustainable energy technologies. Nummedal served as president of SEPM (Society for Sedimentary Geology) in 2001–02, and was AAPG distinguished speaker for Europe in 2002.

Ron Sega - *Woodward Professor of Systems Engineering, Colorado State University; and Vice President for Energy, Environment and Applied Research, Colorado State University Research Foundation*

Ronald M. Sega is Vice President and Enterprise Executive for Energy and the Environment at both Colorado State University (CSU) and The Ohio State University (OSU). He is also the Woodward Professor of Systems Engineering, Director of Graduate Studies in Systems Engineering, and serves as chair of the Sustainability, Energy, and Environment Advisory Committee at CSU and the President's and Provost's Council on Sustainability at OSU. He most recently was the under secretary of the Air Force from 2005–2007 where he led the Air Force team that won the Presidential Award for Leadership in Federal Energy Management for 2006. From 2001–2005, he served as Director of Defense Research and Engineering, the chief technology officer for the Department of Defense. He retired from the Air Force Reserve in 2005 as a major general in the position of reserve assistant to the chairman of the Joint Chiefs of Staff after 31 years in the Air Force. A former astronaut, Sega flew aboard space shuttles Discovery (1994) and Atlantis (1996).

Gian Porro — *Laboratory Program Manager for Strategic Energy Analysis, National Renewable Energy Laboratory*

Gian Porro is a laboratory program manager for energy analysis at the National Renewable Energy Laboratory (NREL) in Golden, Colorado. He is responsible for delivery of cross-cutting analysis projects—including market, carbon, and impact analyses—to the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE). He has worked in analysis at NREL since 2005, focusing primarily on estimating the benefits of EERE's R&D and deployment activities, carbon emission impact assessment, and technical risk and deployment analysis for geothermal technologies. He spent the early part of his career in the upstream segment of the oil and gas industry, primarily developing and implementing technical computing applications for geoscientists and engineers. He has earned master's degrees in economics (Colorado School of Mines) and geophysics (Stanford University).

Photo by Dennis Schroeder, NREL/PIX 18828

"At Hogan Lovells we are pleased to have the opportunity to work with and support the general research work of the Joint Institute for Strategic Energy Analysis to come to a better understanding of the global energy needs and supplies that we can expect for the future."

~ C. Kyle Simpson
Senior Advisor
Hogan Lovells US LLP

JISEA Core Staff

Doug Arent - *Executive Director*

Photo by Dennis Schroeder, NREL/PIX 20130

Douglas J. Arent, Ph.D., MBA specializes in strategic planning and financial analysis competencies; clean energy technologies and energy and water issues; and international and governmental policies.

Arent currently serves on the National Academy Oversight Committee for the U.S. Global Change Research Program. He is also a Senior Visiting Fellow at the Center for Strategic and International Studies and a member of the Keystone Energy Board. In 2008, Arent was appointed to the National Academy of Sciences Panel on Limiting the Magnitude of Future Climate Change.

Arent is a coordinating lead author for the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report, and was a lead author for the Special Report on Renewable Energy, and a member of the U.S. Government Review Panel for the IPCC Reports on Climate Change. Arent was a member of the National Petroleum Council Hard Truths and Prudent Development of North American Natural Gas and Oil Resources research teams. Arent was on the Executive Council of the U.S. Association of Energy Economists. He also served on the Chancellor's Committee on Energy, Environment, and Sustainability Carbon Neutrality Group at the University of Colorado. Arent was the chair of the Quantitative Work Group in support of the Clean and Diversified Energy Advisory Council of the Western Governors' Association.

Prior to his current position, Arent was director of the Strategic Energy Analysis Center at NREL from 2006–2010. Arent has a Ph.D. from Princeton University, an MBA from Regis University, and a bachelor of science from Harvey Mudd College in California.

Patricia Statwick - *Program Administrator*

Photo by Dennis Schroeder, NREL/PIX 20109

Patricia Statwick is JISEA's program administrator and works with Executive Director Douglas J. Arent to develop and implement JISEA programs.

Prior to joining JISEA, Statwick was associate director of an entrepreneurship development program at Northwestern University that was focused on launching Homeland Security technology start-ups. She managed a seed grant program to assist start-up technology companies to reach the next level of development, and provided access to training and resources to improve the entrepreneur's chances for success. In support of these activities, Statwick has worked to build partnerships and relationships with private and public sector organizations that support entrepreneurial activity.

Statwick's experience extends to technology transfer and commercialization activities for NASA; business development for a start-up satellite imagery analysis company; and small business consulting.

Statwick has an MBA from Northwestern University and a bachelor of arts from the University of Notre Dame.

Research Affiliates

JISEA works with leading analysis centers across the globe to augment the capabilities of its founding partner institutions with specialized and complementary skills and knowledge needed for particular studies.

Institutions interested in becoming a JISEA research affiliate should contact JISEA's program administrator at *patricia.statwick@jisea.org*.

Profile: Research Affiliate – International Institute for Applied Systems Analysis (IIASA)

IIASA investigates the critical issues of global environmental, economic, technological, and social change in the 21st century. IIASA researchers—200 mathematicians, social scientists, natural scientists, economists, and engineers—develop assessment and decision-support methodologies, global databases, and analytical tools to study issues. IIASA works within three core research themes: energy and climate change; food and water; poverty and equity.

Learn more at *iiasa.ac.at/docs/IIASA_Info.html*.

Photo by Patrick Corkery, NREL/PIX 16560

Our Sponsors

JISEA appreciates and welcomes the support of all of our generous sponsors, including those who choose to remain anonymous.

JISEA offers unique analytic capabilities and an effective organization promising value, quality, and comprehensiveness.

To learn more about JISEA sponsorship opportunities, visit our website at *JISEA.org/sponsorship.cfm*.

The Value of Sponsorship

"As a UK public-private partnership focused on low-carbon technology development and demonstration, it has proved extremely valuable to have JISEA as a sounding board to assist the development of our energy system modeling environment and to provide strategic input to some of our core technology programs."

Andrew Haslett

Director - Strategy Development, Energy Technologies Institute

JISEA Joint Institute for Strategic Energy Analysis

Joint Institute for Strategic Energy Analysis
1617 Cole Blvd., MS 301
Golden, CO 80401-3305
www.jisea.org
303.384.3767

To receive announcements about JISEA activities, sign up for our e-mail newsletter at JISEA.org/news_subscribe.cfm.

The Joint Institute for Strategic Energy Analysis is operated by the Alliance for Sustainable Energy, LLC, on behalf of the U.S. Department of Energy's National Renewable Energy Laboratory, the University of Colorado-Boulder, the Colorado School of Mines, the Colorado State University, the Massachusetts Institute of Technology, and Stanford University.

NREL/MP-6A50-53256 • Revised March 2012