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®

Assessing America's Renewable Energy Future

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Congress on Assessing America's Renewable Energy Future

Presented by

Renewable Natural Resources Foundation

at

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RENEWABLE RESOURCES JOURNAL

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A special thanks is extended to **Brenda S. Pierce,** of the U.S. Geological Survey, for arranging our use of USGS's state-of-the-art Dallas Peck Memorial Auditorium in Reston, Virginia.

Sarah Gerould served most capably as chair of the congress program committee. Sarah brought leadership and experience to the table. The congress program committee was a group success and every member made significant contributions. Committee members are listed on page three.

RNRF Program Director **Ellen Vaughan** performed admirably in working with our committee, delegates, and speakers. She managed meeting logistics, associated grants and contracts, and contributed to this report as an editor.

Finally, sincere appreciation goes to the first-class speakers and delegates who contributed their expertise, experience, and commitment to conservation, to advance public knowledge on the assessment of America's renewable energy future. A complete list of congress speakers and delegates appears in the appendices.

Robert D. Day
Executive Director

Executive Summary

America faces a convergence of multiple environmental and energy challenges. Coping with global climate change and striving for national energy independence are among the most difficult tasks. The scientific community is advising immediate reductions in greenhouse gas emissions. At the same time, anticipated increases in energy demand will require extensive construction of energy generation facilities and unprecedented progress in energy conservation and efficiency.

America's current options for significantly reducing emissions while increasing energy production include a handful of renewable energy technologies. America should embrace the most efficient and environmentally safe options for its future energy portfolio. Actions taken within the next few decades will have a critical impact on the environmental and economic future of the U.S. and the world.

Directors of the Renewable Natural Resources Foundation (RNRF) recognized the importance of this energy challenge and authorized a national "Congress on Assessing America's Renewable Energy Future."

The congress brought together a select group of professionals from RNRF member organizations and leaders from government, industry, academia, and nongovernmental organizations (see Appendix B). Delegates met December 8-9, 2009, at the Dallas Peck Memorial Auditorium in Reston, Va. (see Appendix C for a copy of the congress program). The congress assessed the virtues and shortcomings of each renewable energy type (wind, solar, hydroelectric, geothermal, and biomass) and discussed ways to strengthen America's renewable energy portfolio.

Congress delegates discussed current impediments to the growth of each renewable energy alternative and options for overcoming obstacles. Presentations and discussions concentrated on the following congress objectives:

- Discuss the state of renewable energy in the U.S. including current federal programs.
- Provide a general overview of each renewable energy alternatives' science and technology, environmental impacts, industry barriers, and science needs.
- Present an interactive forum to discuss solutions (including multi-party collaboration opportunities) for overcoming barriers.

Summary of Renewable Energy Presentations

The Federal Plan

The congress opened with an overview presentation of the environmental, economic, and political factors that are affecting renewable energy adoption in the U.S. Major factors include: growing energy demand, national security, economic development, job creation, climate change, and pollution. The presentation also provided an overview of different Obama Administration initiatives to help create a new renewable energy future. For an explanation of federal policies and agency involvement in renewable energy development see Appendix A.

Energy Distribution Overview

An overview presentation described the condition and capacity of the U.S.'s electrical grid system—focusing on the high voltage transmission system. Both the high-voltage transmission system and the distribution grid (the grid) affect the integration and use of each renewable energy technology. Also discussed were the technical, financial, and political actions that will be required to rehabilitate and upgrade the system to accommodate future energy needs.

The U.S. grid system is vast and impressive. Unfortunately, it also has multiple problems related to reliability, congestion, and geographical issues. Upgrades to the grid should include: additional high-voltage transmission lines to connect renewable energy sources to locations of high-energy demand; upgraded or new transmission lines which will alleviate congestion and improve system efficiency; and smart-grid technology on the distribution side which will improve grid reliability, promote conservation, help integrate variable renewable generation, and play an important role in successfully electrifying a portion of the transportation fleet.

Renewable Energy Panels

Panel presentations offered a diverse and comprehensive analysis of each renewable energy technology. Each panel consisted of a representative of the scientific community, federal government, and industry. The scientific community representative provided a general overview of each alternative's science, technology, and environmental issues. The federal representative provided an overview of federal agency missions, programs, and administrative and financial challenges related to each alternative. The industry representative discussed the most significant barriers (economic, technical, and political) that constrain each alternative from meeting its safest and most effective potential. Recommendations for overcoming the barriers also were presented. Each section of this report on renewable energy is a summary of key facts and concepts from the panel presentations and discussions.

There is no single renewable energy option that can quickly provide the U.S.'s energy needs. Rather, a combination of renewable energy alternatives will need to be deployed, integrated, and balanced on local, regional, and national scales. All congress speakers acknowledged that the transition to a clean-energy economy would occur over an extended period of time. The transition will be gradual because only 7% of current U.S. energy use is derived from renewable energy sources, the demand for energy is expected to increase significantly, and current technological issues are complex and difficult.

The distinct requirements for each renewable energy alternative provide significant opportunities for regional diversity. Some regions in the U.S. have a prime opportunity to capitalize on a specific technology (solar in the Southwest, wind in the Great Plains, geothermal in the West, etc.). Other regions will have to be more aggressive in their diversification of energy sources to meet demand. They also may need to enlarge their geographical energy area to deal with solar and wind intermittency issues.

Wind

Utility-scaled wind-energy generation is providing increased amounts of electricity across the nation. The U.S. is the world leader in wind-energy generation and is aggressively developing additional wind projects. Specific challenges to the wind industry are financing, managing the various special interest groups concerned about determining the locations of new wind farms, the distance between the location of wind resources and regions of high energy demand, and intermittency issues.

The U.S. Fish and Wildlife Service (FWS) is mitigating the concerns of special interest groups through the formation of the Wind Turbine Guidelines Advisory Committee. The committee uses a multi-disciplinary approach to assessing stakeholder concerns and works to develop guidelines to ensure that safe and practical sites are selected. It can serve as a model nationwide.

Solar

Solar energy technology has experienced tremendous improvements over recent decades. This progress has facilitated exponential growth in deployment. Solar energy is the most popular option for on-site energy generation. This characteristic helps insulate the solar technology owner from utility energy price variations, it eliminates utility line losses, and provides a stable long-term economic investment. Like wind, solar energy is challenged by financial, geographical, and intermittency issues.

Hydropower

Hydropower energy has been the dominant form of renewable electricity for over a century. The technology for traditional impoundment dams is well established and facilities have proven their effectiveness by providing clean and reliable energy over long periods of operation. There is tremendous potential for hydropower growth by upgrading existing hydroelectric dams, retrofitting non-hydroelectric dams to be energy producing facilities, and developing new hydrokinetic technologies. Significant hydropower energy challenges are managing concerns of special interest groups regarding environmental impacts of hydroelectric facilities, and acquiring construction and upgrade permits.

Geothermal

The geothermal industry has dozens of new projects in line for development. Construction of these new facilities will double geothermal capacity within the coming decade. Geothermal energy also is expanding beyond traditional geyser facilities to capitalize on a variety of potential new ways to extract heat energy from the earth. The industry faces financing issues, and research and technological needs, as it further develops enhanced geothermal systems and explores co-production with oil and gas.

Biomass

Biomass is the one renewable energy resource that is being utilized to produce transportation fuel, mainly from corn. The U.S.'s limited domestic oil reserves and tremendous consumption requirements are driving demand for a substitute for and supplement to fossil fuels. The biomass industry is researching the next generation of fuel-crops while working to make current biofuel production more sustainable and efficient.

The federal government has mandated the creation of the multi-disciplinary U.S. Department of Agriculture (USDA) Biomass Research and Development Board to help assess the environmental and social concerns related to biofuel production and to coordinate federal research and development activities.

Multi-Party Dialogues

Delegates acknowledged that managing the conflicting concerns of citizens is a significant challenge to renewable energy development. For example, when assessments are being made about the feasibility of developing a wind farm, a neighboring community may voice concerns about impacts on visual aesthetics, birds and bats, and recreation resources. The renewable energy industry must be sensitive to environmental and social concerns.

Delegates recommended engaging multi-disciplinary partnerships early in the renewable energy development process to help anticipate and accommodate these issues and concerns. The federal government could support this type of collaboration by mandating the creation of groups like the FWS Wind Turbine Guidelines Advisory Committee and USDA Biomass Research and Development Board. The congress panel on multi-disciplinary partnerships consisted of speakers from these multi-party efforts. The speakers explained their interdisciplinary partnerships and programs, the challenges that they face, remaining obstacles, and advice for implementing new multi-party dialogs.

Working Group Discussion

Following presentations and discussions, delegates participated in a working group discussion. The working group provided observations and suggestions on three general areas of inquiry.

1. Determining the scientific, technical, and environmental needs related to advancing the use of each renewable energy technology.
2. Developing multi-party partnerships to advance the use of each renewable energy technology.
3. Assessing national policies and programs (existing and proposed).

Delegate observations and suggestions for the first two working group discussion questions are incorporated into the body of this report. Comments concerning the third question follow.

Renewable Energy Challenges and Policy Options

Congress presenters discussed multiple factors that constrain use of renewable energy alternatives and highlighted some specific policy options that could help all renewables meet their full potential. Most of the renewable energy technologies are new and have significant upfront development costs. They also must compete with fossil fuels that benefit from numerous and substantial subsidies.

Congress presenters and delegates discussed the following policy options.

Tax Carbon

Delegates and presenters recognized that the price of fossil fuels does not include the costs of externalities. Thus, society absorbs the costs of negative impacts on human health and the environment. Placing a cost (tax) on carbon would more accurately reflect its cost to society while encouraging conservation and energy efficiency. Delegates discussed both carbon tax and cap-and-trade policies as possible options.

A carbon tax would tax the production, distribution, or use of fossil fuels (coal, natural gas, and oil) based on how much carbon (the main anthropocentric contributor to climate change) they emit during combustion. Many policy proposals phase the tax in so that industries and consumers have time to adjust. Revenue from the tax can be filtered back to consumers and/or conservation and energy efficiency programs.

A cap-and-trade system allocates greenhouse gas (GHG) emission permits to energy production companies—creating a cap on the amount of GHGs that can be emitted into the atmosphere. The number of permits is then lowered over time until the reduction goal is met. Under this system, the most efficient companies will be able to sell their permits to competitors. A cap-and-trade system can guarantee reductions, promote efficiency, and use free market principles to reach results at the lowest possible cost to the economy. A straightforward cap-and-trade policy will auction 100% of the pollution permits, not allow for carbon offset projects, and remain off limits to financial speculators.

Federal Renewable Portfolio Standard (RPS)

RPS requires that a certain percentage of electricity from utilities and other retail electric providers comes from renewable sources. Currently, 29 states have agreed to mandatory RPS and six have set state renewable goals. RPS is significant because it lessens the competition between renewable energy and fossil fuels and it provides investors with a stable market.

A benefit of a federal RPS is that it will allow for regional variation. For example, the Dakotas may choose to reach their renewable energy requirement by developing wind farms, New Mexico and Arizona may support solar installation, and Iowa and Illinois may choose to grow fuel-crops and produce biofuel.

Financing

A lack of consistent policies over the years has made renewable energy investment risky and thus intermittent. To help maintain steady growth, the federal government should consider financial incentives for the established production tax credits (PTC), investment tax credits (ITC), manufacturing incentives, and loan guarantees.

Timely Leasing and Permitting

Allocation of sufficient resources to leasing and permitting agencies to develop and assess accessible and efficient applications will expedite the development of renewable energy projects. Delegates noted concern with the difficulty in hydropower dam re-licensing.

Educate and Train Workforce

The U.S. has seen a distressing decline in the number of students majoring in math, science, and engineering. With a lack of expertise in these disciplines, the U.S. could fall behind other countries in the creation of future energy innovations. Greater investment in education, support for workforce development programs, and facilitating the use of international talent could improve this deficiency.

Appendices

Federal policies and agency involvement in renewable energy development are included in Appendix A.

Delegates to the congress are listed in Appendix B.

A copy of the congress program is included in Appendix C.

Factors Contributing to Renewable Energy Adoption in the U.S.

"So we have a choice to make. We can remain one of the world's leading importers of foreign oil, or we can make the investments that would allow us to become the world's leading exporter of renewable energy. We can let climate change continue to go unchecked, or we can help stop it. We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for lasting prosperity."

—President Obama, March, 2009

There are multiple factors that are contributing to the U.S.'s mounting support for the research, development, and deployment of renewable energy alternatives. Major factors include the need to:

- Meet the U.S.'s rising demand for energy by secure processes.
- Create new cleantech jobs and gain market share of new and emerging technologies.
- Protect the health of humans and the environment by pollution reduction and climate change mitigation.

Energy Demand

America requires a constant and secure flow of energy to fuel its economy and maintain a safe society for its citizens. This will require the procurement of raw materials for the production of electricity and fuel and the delivery of that energy to end users in an affordable and sustainable way.

America's current energy mix is comprised of 84% fossil fuels, 9% nuclear, and 7% renewable energy.[1] Based on current projections, the U.S. faces the need to increase its electrical power generating capacity by approximately 300,000 MWs or 30% over the next 20 years. To ensure the long-term, sustainable production of energy, the U.S.'s utilization of renewable energy alternatives should increase dramatically in the coming century.

National Security

The U.S. is the largest consumer and importer of oil in the world. (see graph on page 10) The U.S.'s longstanding inattention to energy issues is negatively impacting foreign policy and jeopardizing national security. Considering the amount of required petroleum to fuel the U.S. economy, it is unlikely that expanded drilling can single-handedly achieve energy independence. Better management of the U.S.'s current consumption and existing resources along with new technological advancements (more efficient cars, plug-in hybrid electric vehicles, biofuels, etc.) could play a significant role in mitigating U.S. dependence on oil.

Economic Development and Job Creation

The growth of world energy demand and international environmental legislation has made renewable energy a rapidly expanding multi-billion dollar industry. The industry has the potential to enhance the U.S.'s economy through job creation and development of the country's manufacturing sector.

Complications with America's Current Fossil Fuel Energy Economy

Climate Change

The vast majority of the U.S.'s energy requirements are supplied by fossil fuels which create unsustainable amounts of carbon dioxide (CO_2) pollution. Climate change effects are numerous and highly variable across the planet. Scientists predict increases in the frequency and severity of heat waves, droughts, floods, hurricanes, and storms. Among other consequences, changing climatic conditions will impact wildlife and their habitats, ecological interactions, agriculture, fresh water regimes, real property values, and marine coastal communities. The value of losses will total in the billions of dollars.

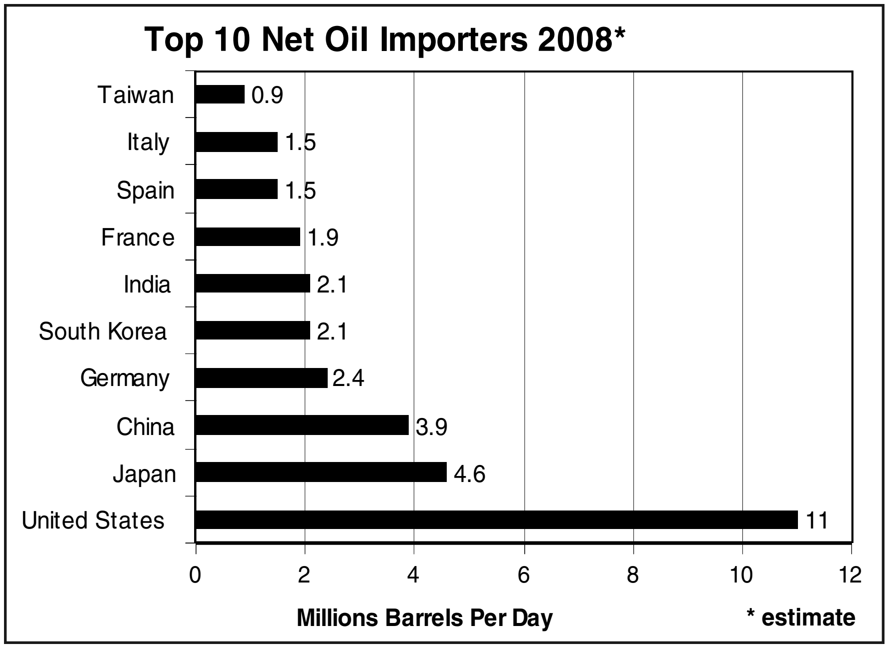
Pollution

Use of fossil fuels and the resulting CO_2 affect more than climate. Emissions from fossil fuels release other pollutants that adversely affect human health, degrade air and water quality, acidify the oceans, and degrade plant communities. The National Research Council highlights the severity of fossil fuel emissions by quantifying hidden costs of energy production and use. They estimate that in 2005 the U.S. spent $120 billion on primary health damages from air pollution associated with the use of fossil fuel. This figure does not include damages from climate change, harm to ecosystems, effects of some air pollutants such as mercury, and risks to national security.[2]

Extraction: Extraction of coal and oil each comes with its own catalog of complications. Through the practice of surface mining, coal is extracted after the layers of earth above it have been removed. This practice is used across the country and has resulted in strip-mined land in the West and the removal of mountains in the biologically diverse Appalachians. Surface mining has a severe impact on fish, wildlife, bird species, and neighboring and downstream communities.

Spills from the extraction and transportation of oil can have serious environmental and economic impacts. Oil spills diminish the living conditions of affected communities and can have a severe impact on regional fisheries. The 2010 BP oil spill off the Gulf Coast demonstrated that although drilling technology has made significant advances over the years, the extraction process is still susceptible to major failures.

Ocean Acidification: A less visible side effect of the use of fossil fuels is ocean acidification. The oceans absorb one-fourth of anthropocentric CO_2 emissions each year and this is changing the chemistry of the ocean. Ocean acidification affects the basic building blocks of the shells and skeletons of many marine organisms. Ocean acidification has potentially profound consequences for marine plants and animals.



Source: EIA Short-Term Energy Outlook (July 2009)

> *"Smart manufacturing and job creation plans have important roles as we recognize the need to look at home first, look at America first for developing our energy resources and therefore enhance our energy security"*
>
> – Thomas Darin
> U.S. Department of Energy

Electricity Generation and Transmission – The Grid

Every stakeholder concerned about the electricity sector—industry, consumers, states, federal government, NGOs, and generation companies—are looking at a challenging future. Achieving a significant long-term reduction in U.S. carbon emissions by 2050 will require replacing or greatly modifying most of the existing generation plants, building major new transmission facilities, and electrifying significant portions of the transportation sector. Throughout this daunting transition, the U.S. must keep the lights on and electricity prices reasonable.

Development of renewable energy and other low-carbon resources in the U.S. should not be discussed without first addressing the role of the electrical grid system (both high voltage transmission and distribution). The U.S.'s current system is in need of upgrading. In many instances, the grid is not physically located in the areas of abundant renewable energy resources. The system's degrading condition and limited capacity is influencing renewable energy developments in significant ways. To successfully prepare the U.S. energy network for the installation of vast amounts of new renewable energy, major investments in grid research and infrastructure will be required.

America's grid has a generating capacity of approximately 1.1 million MW,[3] 157,810 miles of high voltage transmission lines (230 kV and higher), and hundreds of thousands of miles of lower-voltage distribution lines (generally 69 kV and lower). Unfortunately, the increased frequency of grid failures has provided a stark demonstration of how strained the grid system has become and how unprepared America is for handling projected future demand. For example, there have been massive blackouts over the past 40 years due to grid failure—with some of the largest failures within the last decade. Blackouts and even rolling brownout events can have severe repercussions and affect millions of people and result in billions of dollars of economic loss.

Beyond struggling with demand issues, the current structure of the grid presents substantial challenges to integrating renewable energy in three primary areas: geography, congestion, and the ability of the current transmission and distribution grid to reliably integrate variable generation.

Geography: Existing power lines are not located where the best quality renewable energy resources are. This is especially true for wind and solar. America's vast onshore wind resources are located in remote regions like the Dakotas and interior Rocky Mountain West where there are very limited transmission lines. The same can be said for solar resources in the Southwest as well as some geothermal resources in the West. Where there are existing transmission lines, they are in many instances at or near transfer capacity limits, such that grid upgrades or new transmission lines are needed to allow the development of these resources.

Along with its limited connection to remote renewable energy resources, the existing grid system is not adequately interconnected across the nation. We currently operate with three major grid systems, the Western, Eastern, and Texas Interconnections. Tying together the nation's interconnections may help integrate additional generation sources including variable renewable generation.

The upgrades to the grid must incorporate extra high-voltage transmission lines from remote renewable energy generation sources to regions of high-energy demand and interconnect the nation's grids. This will make isolated renewable energy projects viable, improve peak load management, and increase power quality and reliability by improving grid stability. While planning for these major system upgrades, consideration should be given to a variety of future electricity scenarios including high penetrations of demand-side technologies such as energy efficiency, distributed solar (photovoltaics), and demand response and smart grid improvements.

Congestion: As electricity demand increases beyond the capacity of existing grid infrastructure, bottlenecks deny consumers access to lower-cost electricity supplies, and line losses increase. A 2009 Department of Energy (DOE) congestion study found that major areas of concern were the Los Angeles to San Diego region and the New York to Washington, D.C. region—two of the U.S.'s most populated and economically vital regions.[4] Congestion limits U.S. energy diversity which affects consumer choices. Upgrades to the grid will enhance distribution management and improve operational efficiency.

Reliability: The integration of different renewable energy technologies must be done in a manner that maintains system reliability. To maintain a reliable and secure electricity transmission grid, an intricate physical balance must be constantly maintained between the amount of power that is generated and the amount that is consumed. Reliability includes proper attention to reserve generation capacity, maintaining consistent frequency, and other issues.

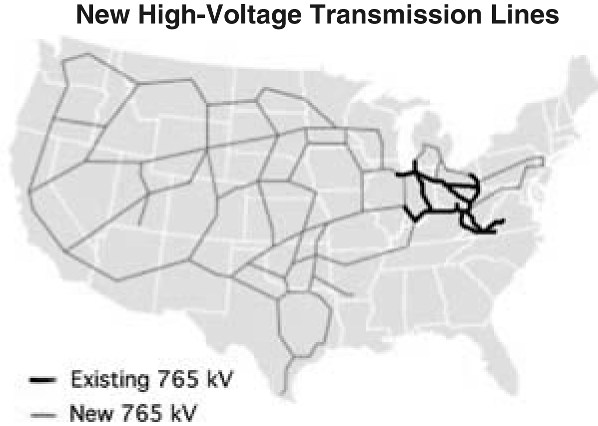
A current subject of emphasis at the distribution level is the smart grid. Utilities and consumers, as well as electric meters and appliances, cannot make the most efficient choices without communicating with each other. Without the proper technology relaying real-time information from the consumer to the utility and from the utility to the consumer—as well as to high-demand appliances like air conditioners and hot water heaters—electrical and financial resources are lost. A smart grid would be comprised of new, end-use technologies like intelligent appliances and smart meters. Automated meter reading will decrease emissions from transportation, reduce human errors, and save utilities money. These technologies will also enable utilities to address disruptions in service faster and educate the consumer about the specifics of their energy use, potentially allowing them to make cost-saving adjustments.

Several studies suggest that to successfully integrate the nation's best wind and solar resources the U.S. will need to construct tens of thousands of miles of new transmission and distribution lines.[5] This considerable endeavor will cost billions of dollars. Proponents of the new grid upgrade argue that it is a necessary upfront cost to creating a stable system. Improved reliability, efficiency, and access to energy sources will lower consumer cost and recoup system upgrades in the long run.

Federal Actions to Upgrade the Grid

Completion of new grid upgrades will require input and collaboration from multiple states, agencies, and organizations. Tom Darin, transmission planning and siting specialist, DOE Office of Electricity Delivery & Energy Reliability, explained how the agency is advancing new transmission development through the creation of interconnection-wide transmission plans.

New High-Voltage Transmission Lines



The construction of these new high-voltage lines will link new renewable energy resources efficiently and effectively into a nationwide clean energy grid. Source: American Electric Power

DOE is engaging in "an interconnection-wide planning effort to look at future scenarios, bring in diverse stakeholders, and really plan comprehensively and together for our energy future." Stakeholders will be engaged in interconnection-wide transmission analysis and planning early on. The process will be transparent, collaborative, and open with a focus on consensus.

Darin discussed the matter of new grid sites and the impacts it could have on lands and wildlife. He highlighted the importance of addressing these values at a high level in planning efforts. "The DOE gets it. We get that it's just not all renewable energy or all generation and transmission lines. There needs to be a balance struck between protecting other [natural] resources." He mentioned the need for states to have uniform mapping of crucial wildlife habitats and corridors, and that researchers need to collect better information on wildlife corridors and crucial habitats to improve location decisions for new sites. He also stressed the role that demand-side technologies such as energy efficiency and rooftop solar should have in transmission planning as they may reduce transmission needs and associated environmental impacts.

Darin highlighted key federal financial support for upgrades to the grid that were allocated with passage of the American Recovery and Reinvestment Act (ARRA). The act allocated billions for transmission technology loans; smart grid projects dealing with storage, meters, and distribution monitoring devices; and development of regional transmission plans. DOE's overarching goal is to support development of clean, renewable, and low-carbon energy generation.

Darin emphasized that there are many key requirements for successfully upgrading the grid. Specifically, any interconnection-wide plans must reliably "achieve and balance" the following five objectives:

- Consider all available technologies for electricity generation, energy storage, transmission, end-use efficiency, and demand side management.
- Satisfy all current state and federal clean-energy requirements for renewable energy, energy efficiency, and GHG reductions.
- Minimize long-term costs of producing and delivering electricity.
- Minimize overall long-term impacts on "electricity supply activities" on the environment.
- Provide for efficient grid development (e.g., over-sizing concept).

Renewable Energy Alternatives

The bulk of congress presentations detailed the specifics of each renewable energies' technology, policy, and industry.

Peak interest and development of hydroelectric facilities occurred in the first half of the 20th century but this early interest is the exception to most renewable energy development. The modern renewable energy industry began during the energy crunch of the 70's. Over the next 30 years fossil fuel energy prices continued their volatility but remained cheap and abundant enough to deter major investment in alternatives. Compounding concerns and external factors (such as those discussed earlier) have spurred exponential growth of renewable energy development and investment.

Figures 1 and 2 outline America's leadership in renewable capacity while showing the growing competitive threat from other nations.

Wind Panel

The three presenters on the wind energy panel were Neil E. Rondorf, vice president, Science Applications International Corporation; Ray Brady, manager, Energy Policy Team, Bureau of Land Management (BLM); and James P. Lyons, chief technology officer, Novus Energy Partners.

Rondorf gave an overview of wind energy's science and technology issues including wind resources and potential, energy transport options, off-shore wind geophysical issues, and environmental impacts.

Brady discussed the federal government's wind energy incentive programs as well as the BLM's current and planned involvement in wind energy development. BLM participates in wind-site authorization by assessing environmental impact statements, reviewing site applications, and participating in post-construction assessments.

Lyons provided an overview of the current state of the wind industry. He elaborated on wind forecasting, grid interconnection, and the different wind turbine technologies (on- and off-shore).

Wind

The U.S. first began to seriously develop wind technology after the 1970's oil shock. California lead the way with progressive state policies and a generating capacity of nearly 90% of world production by 1986. The U.S. is the world leader in wind energy generation and wind power is now the largest source of non-hydroelectric renewable electricity in the country. Wind provides approximately 2.3% of total U.S. electricity generation.

Technology

There is tremendous variety in the size and structure of wind turbine machinery, and new technological breakthroughs and innovations develop daily. Wind energy is usually generated from a small, solitary turbine or large, grouped turbines.

Small wind turbines are used around the world to power remote homes, telecommunications sites, and villages. Small blades can have a diameter of just a couple feet with the generation capacity of a few kWs.

Most wind energy generation comes from large (1.5 MWs or greater) three-

FIGURE 1:
Top 10 in Renewable Energy Capacity (GW)

United States	53.4
China	52.5
Germany	36.2
Spain	22.4
India	16.5
Japan	12.9
Rest of EU-27	12.3
Italy	9.8
France	9.4
Brazil	9.1

FIGURE 2:
Top 10 in Five-Year Growth in Installed Capacity

South Korea	249%
China	79%
Australia	40%
France	31%
India	31%
United Kingdom	30%
Turkey	30%
United Sates	24%
Canada	18%
Rest of EU-27	17%

Source: Who's Winning the Clean Energy Race. Copyright 2010 The Pew Charitable Trusts http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Global_warming/G-20%20Report.pdf

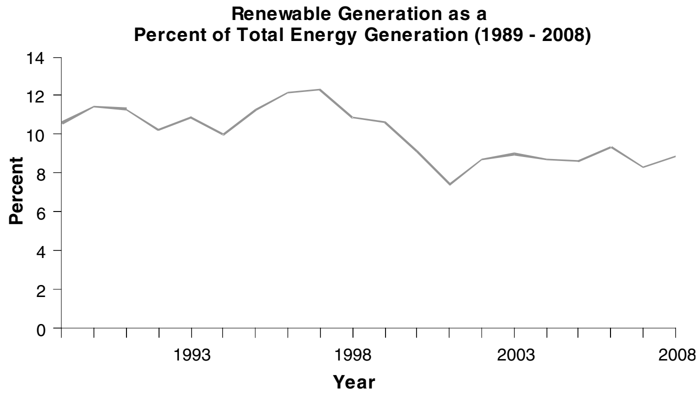
Energy Efficiency and Conservation

Energy efficiency is not a renewable energy resource but was discussed by congress delegates. Delegates unanimously agreed that implementing efficiency measures is one of the fastest and smartest ways to create jobs, save money, and improve the environment.

The current growth rate of renewable energy is not compensating for the faster growth rate of energy demand. Therefore, as a percentage of total electricity generated, renewable energy has failed to make significant advances (see graph). Combining aggressive efficiency programs with renewable energy development can increase renewable energy's share of energy production and lessen U.S. dependency on fossil fuels.

There are many ways energy efficiency can be supported. For example, by creating standards and codes for green building (from design to appliances), improving the transportation sector (automobile fuel efficiency, moving freight from trucks to rail, etc.), and supporting industry improvements (combined heat and power, technology upgrades, etc.). A federal policy that establishes a price on carbon emissions also will promote efficiency.

Energy conservation is another key approach to decreasing U.S. consumption of fossil fuels. There are many ways conservation can be supported by the federal government. For example, improving the quantity and quality of public transportation options (creation of bike lanes, high-speed rail, etc.), installation of smart meters to inform consumers of their energy use, increasing taxes on energy, supporting conservation in design (green buildings, green infrastructure, smart growth cities, etc.), providing incentives for energy efficiency equipment/appliances, and education campaigns.



Although renewable energy generation has increased significantly over the last 20 years, it has only experienced a minimal rise as a percentage of total electricity due to increases in total energy consumption and the relative decline in hydroelectric power.

blade wind turbines grouped together in wind farms. The average wind farm is typically comprised of 30 to 150 machines with a turbine rotor radius of approximately 110 feet mounted on 225 foot towers.

Wind speed is the most important factor to energy generation since power generated increases as a cubic function of wind speed. Therefore, a 10% increase in wind speed creates a 33% increase in generated energy.

Industry

Wind is one of the fastest growing renewable energy alternatives in the U.S. and the world. The U.S. industry has sustained an impressive annual growth rate of approximately 25% over the last ten years. The industry is currently valued at $50 billion. Ever improving technology, federal and state initiatives, economies of scale, maturing industry knowledge, and increased public support and demand continue to propel wind development and deployment.

Although offshore wind has multiple technology and infrastructure challenges, it is predicted to play an essential role in future wind development. Rondorf and Lyons highlighted the notable potential of offshore wind. "The Atlantic coast is an ideal resource because it is relatively shallow, close to major load centers, and fits our existing technology," explained Rondorf. Lyons added that, "Offshore wind will be the end game with GW-scale plants."

One of the main reasons for wind's explosive development is its financial promise. After incorporating federal and state incentives, wind power costs around five cents/kWh or less at good U.S. sites. This rate is competitive with all new generation technologies.

DOE has partnered with the American Wind Energy Association (AWEA) to complete a road map for achieving 20% wind energy by 2030.[6] This will require 300,000 MW of new wind to come online and a $60 billion investment in the transmission system. Lyons outlined some of the predicted benefits of this accomplishment, which include a 50% reduction in utility natural gas consumption; an 18% reduction in coal generation; 7,500 million metric tons of carbon equivalent reduction; 17% reduction in water use from waste generation and the creation of 150,000 direct jobs.

Environmental Impacts

Environmental concerns stop or delay 10% to 25% of proposed wind energy projects. Many of these concerns are the result of regions taking a Not in My Backyard (NIMBY) position.

A common concern of local communities is the visual and audio impacts of the wind turbines. Wind developers are researching ways to decrease these impacts by experimenting with different paints, operating the nightlights only when a plane has entered the region, and testing quieter components.

Wind turbines require a negligible amount of land once constructed. To achieve 20% wind by 2030 the technology will require 620 to 1,560 m^2 and could potentially coexist with land uses such as farming, ranching, and forestry.

The greatest concern for wind's impact on wildlife is its contribution to bird and bat mortality. Although many sites show nominal fatalities, more research is needed. Improved mapping of migratory bird flight paths will advance the ability of developers to make better siting decisions.

Rondorf observed that John Flicker, the president of the Audubon Society, supports wind, saying you can't even count the number of bird carcasses from the pollution from coal and gas burning furnaces, so letting those continue to be the main sources of U.S. energy is much worse for birds than turbines.

Further research is needed to determine the environmental effects of offshore wind. The construction of towers creates artificial reefs that can provide habitat for fish and other marine animals. These areas have the potential for providing new recreational fishing and diving opportunities resulting from a 20- to 50-times higher fish density. Research into whether this increase in fish density will have a negative effect on existing ecosystems should be pursued.

Intermittency

The issue of intermittent energy production, predominantly in reference to wind and solar resources, is often cited as a major shortcoming of these technologies. Variability issues must be addressed because the wind is not always blowing, the sky is not always cloud-free and electrical storage technologies are not yet prepared to handle a high quantity of energy.

Presenter Neil E. Rondorf, vice president, Science Applications International Corporation, believes the intermittency issue has not been properly evaluated. "Renewables are cast in a bad light with regard to variability… I can tell you the snowfall prediction of Vail, Colo. a quarter of an inch, everyday. Why? Because somebody cares. We should be able to take that skill and capability and convert it into predicting outputs of the renewable energy industry and then look at how to incorporate that variability into the grid. It's not impossible. We just haven't put enough investment into predicting renewable energy outputs," Rondorf explains.

He highlighted a study conducted in the Hampton Roads, Va. region that demonstrates how solar energy will come online during the day when wind resources are lower and vice-versa. An integrated renewable energy system will have to balance the resources available. Managing for resource intermittency will require a holistic approach in which we "…step back and take a look at these systems at a larger scale," he concludes.

Presenter James P. Lyons, chief technology officer, Novus Energy Partners, agrees that a large regional balance becomes a prerequisite for wind being a major energy provider. He explained that, "We can already get a good prediction." By utilizing state-of-the-art modeling, predictions can be made with a 10-15% mean absolute error for a day ahead and 5-10% error for six-hour ahead forecasts.

Federal actions to mitigate intermittence issues include funding for improved monitoring and establishing a federally run national data center to have a central resource hub for assessing wind farm data. Also, upgrading the U.S. grid system will mitigate energy spikes and lulls.

Specific Challenges for Wind

Energy Delivery

Location: Major wind resources in the U.S. are in mid-America and offshore. Developing land resources is significantly cheaper than offshore development. However, as discussed in *Electricity Generation and Transmission – The Grid*, these major land resource regions are far removed from major transmission lines. Connecting wind power to where it is needed, like mid-America wind to areas of energy demand and offshore wind to landlines, will require substantial investment to grid infrastructure. Policies for planning, funding, and permitting of wind power need to be streamlined.

Intermittency: Increasing the number of turbines on wind farms and increasing the area contributing wind energy will decrease production variability. Integrating different renewable energy alternatives within a given region also will help manage variability.

Technology and Research Needs

The greatest material challenge will be in acquiring the significant amounts of fiberglass needed for wind turbine production. Other material constraints include resins and permanent magnets. Increases in capital costs such as those associated with steel, transportation, and

Source: U.S. Department of Energy, National Renewable Energy Laboratory. January 3, 2008.

exchange rates have impacted project deployment costs.

Offshore wind research and development is needed to survey the ocean floor to determine if tower construction is viable. This process, along with the testing of new turbine technology, will be expensive.

Manufacturing

The 20% wind energy by 2030 goal will require approximately 100,000 new turbines. This substantial figure will require the industry to maintain a 20% growth rate, which will require significant new manufacturing capacity. The size of many wind turbine components makes long-distance transportation difficult and expensive. This makes producing them in the U.S. more competitive but overseas competition remains due to government manufacturing incentives in other industrialized countries and lax labor and environmental regulations in developing countries.

Solar Energy Panel

The three presenters on the solar energy panel were Ken Zweibel, director, George Washington Solar Institute, George Washington University; Scott Stephens, technology manager, Solar Energy Technologies Program, U.S. Department of Energy; and Kent Baake, owner, Continuum Energy Solutions.

Zweibel provided a science and technology overview of the various solar technologies. He outlined solar energy's existing and predicted future capacity, solar applications, market predictions, and specific issues each solar technology currently faces (intermittency, water, economics, etc.). He highlighted solar's strengths such as its low land requirements and its multi-generational value.

Stephens explained the Office of Energy Efficiency and Renewable Energy's (EERE) technology portfolio and the office's programs for promoting solar development. He outlined EERE's multiple analysis efforts that are monitoring progress, projecting growth, and exploring potential in the solar industry.

Baake discussed solar energy's extensive capacity potential at the global and domestic scale, new solar site analysis tools, and economic trends in the solar industry. He provided examples of government and utility company leadership in solar energy development and enumerated policy options for advancing the industry.

Solar

Solar energy was researched for decades before it was given serious consideration during the 1970's energy crisis. Cost constraints limited the number of photovoltaic purchases, while the less expensive solar hot water heaters were more widely embraced. The first solar energy plants were constructed in the 1980's and remain in operation today. Solar energy provides approximately 0.1% of total U.S. electricity generation.

Energy from the sun is the Earth's largest power resource. Every hour enough solar energy reaches the surface of the Earth to provide more than the total amount of energy that the world's population uses in a year. Considering that the sun does not shine everywhere all the time, the efficiency of all solar technologies is subject to the weather (degree of cloud cover), air pollution (particulates blocking the sun) and the seasons (the Earth's position relative to the sun). Taking these factors into account, the U.S. has tremendous solar resources.

Technology

The U.S. is rich in solar resources and is competitively developing and deploying the two major technologies that utilize solar energy: photovoltaic (PV) and solar thermal.

Photovoltaics: PVs or solar electric systems, convert sunlight into electricity. The basic PV device consists of multiple small semiconductor cells connected together to create a PV module. The more of these modules that are combined into PV arrays the greater the energy production.

PV modules are usually used as standalone energy generators on rooftops or ground-mounted fixtures. They provide energy to homes, businesses, and remote areas. As a result of PV installation's exponential growth rate, the U.S. is rapidly approaching 100,000 grid-tied PV systems.[7]

Solar energy, due to its distributed generation capability (ability to produce energy on-site), could be a particularly favorable technology in an oil-constrained world. Once plug-in hybrids and electric vehicles become more prominent, consumers who are producing their own electricity will have an economic buffer from unstable oil and electricity markets.

PV technology also has the unique feature of mobility, allowing the technology to provide energy to small portable devices like watches and to complex systems such as satellites.

Although the technology is used most often as point-source energy generation, thousands of panels can be scaled up to create larger power plants.

Without having any moving parts, PV panels require little maintenance and can last over 40 years. There are no specific technological restrictions that limit future improvements to expand the useful life of PV panels by decades.

Photovoltaic Industry: The global PV market has seen annual growth of 25% over the past ten years; within the past five years that growth has increased to over 35%.[8] These high percentages can be partially attributed to solar energy's small market size. Credit for growth also can be attributed to progressive policies and solar energy's decreasing payback period and subsequent increased consumer profit.

Photovoltaics are still considered one of the more expensive renewable energy technologies because of the high system and installation cost, and because the conversion efficiency of solar energy to electricity is still low. Although current prices are high, technological improvements to PV systems over the past 60 years have been impressive and inspire confident predictions for future developments. PV efficiency has increased dramatically over the same period and cost per watt of PV energy has dropped from hundreds of dollars to approximately \$3-\$7 per watt. Once PVs are paid for their operation is cheaper than any other source of electricity right now.

The belief that efficiency improvements and economies of scale will continue to reduce the cost of solar energy has contributed to the estimate that over the next decade, solar will reach a cost of \$2.5-\$3 per watt.

Solar Thermal: Solar thermal technology transfers the sun's heat to a useful application. There are two main solar thermal technologies, concentrated solar power (CSP) and solar hot water heaters.

Concentrated Solar Power: CSP technologies convert solar energy into electricity but use a process different than photovoltaics. CSP uses reflective material to concentrate the sun's heat toward a receptor. Heat is used to power a steam turbine or drive a generator. This technology requires much more machinery than a PV array and therefore is not ideal for distributed generation energy production. Instead, the energy is generated in one central location and is distributed through transmission lines—much like a wind farm.

Concentrated Solar Power Industry: CSP plants can generate hundreds of MWs and are ideal for high solar resource regions such as those found in southwest America. Although CSP is a relatively new technology, the success of its first generation plants has sparked extensive interest in the technology's research, development, and deployment.

Solar Hot Water: Solar hot water heating is the most efficient solar technology. Instead of converting solar energy into electricity it transfers solar heat to useful heat, such as to a residential hot water heater or swimming pool. Solar hot water saves energy by displacing electricity that would otherwise be needed to heat water. Most solar hot water heaters are dispersed like PV systems on residential and commercial rooftops.

Solar Industry

Solar energy is one of the fastest growing energy markets today. Countries around the world are researching, manufacturing, selling, and installing solar technologies. Countries producing and deploying solar power are enjoying the financial profits from exporting their products along with benefiting from solar energy's environmental advantages. Today's current world leaders are Germany, Spain, Japan, China, and the U.S.

Solar energy's share of the market should continue to increase if state and federal incentive policies continue, and technology and economies of scale improve. Assigning a cost to carbon emissions would accelerate the adoption of solar technologies.

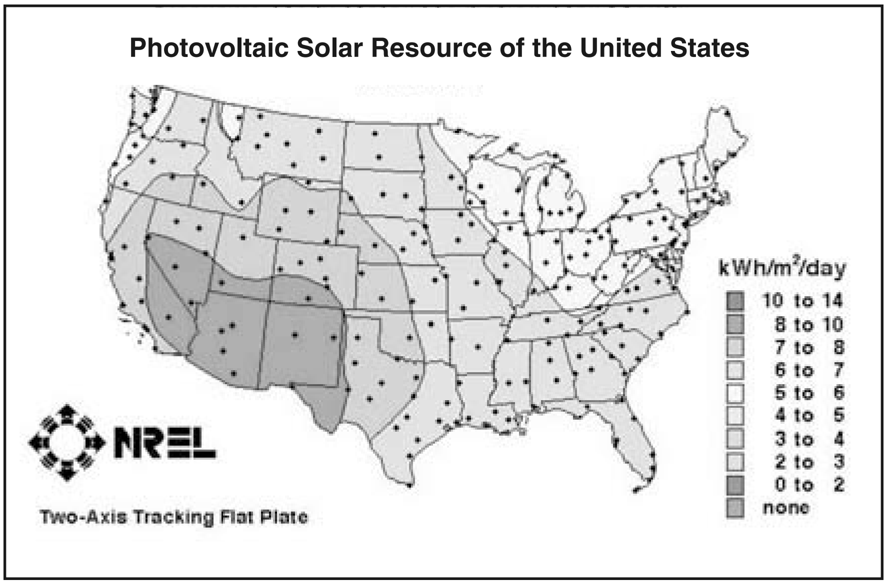
Environmental Impacts

Solar power has a very minimal impact on the environment. PVs create little to no visual obstruction, they emit no air, water, or ground pollution, and they do not require any water or additional energy source to operate. The amount of energy that it takes to manufacture PV machinery will be recouped within the first few years of use. Current PV systems generally last around 30 years and their energy payback is considerable. Solar hot water devices have an even faster return.

Concerns have been raised about heavy metals and toxic chemicals used in the manufacturing of PV cells. The industry is working to develop more environmentally friendly materials, and disposal/recycling methods.

CSP projects have a larger environmental impact than small PV installations. Like any development, there are site disturbances during the construction, installation, and demolition phases. Large CSP projects require hundreds of acres of land and thorough environmental impact statements. The federal government is taking these environmental concerns into consideration when determining which projects to support.

Overall, solar energy has minimal land-use requirements. Zweibel reported that, “All energy production will require use of land but in comparison to other energy-producing technologies, solar takes a fraction of the space.” Solar energy would only require 0.5% of U.S. land to provide 100% of its electricity needs—30 times less land than hydroelectric.



Annual average solar resource date are shown for a tilt-latitude collector. The data for Hawaii and the 48 contiguous states are a 10km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005. The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003). Author: Billy Roberts, October 20, 2008. This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

Specific Solar Challenges

Although laboratories have been researching and producing solar cells for decades, the industry is in its infancy compared to other technologies. Large-scale manufacturing plants are a relatively new development. Therefore, scaling up production and distribution is the major requirement needed to reduce high up-front costs. Other specific solar challenges are energy distribution, intermittence, and technology issues.

Connecting PVs to the grid such that there can be a free flow of energy is also very important. When individual systems are capable of having their energy flow to the grid (when it is not required on site) the additional power helps meet local demand.

Instituting a national policy that requires utilities to purchase excess kWs of solar energy from suppliers at market price would help make solar cost competitive. This practice of getting paid for excess energy produced is termed, “net metering.” Some states take the policy a step further and provide, “feed-in tariffs.” Under this structure the utilities are obligated to purchase the excess renewable energy at a higher than retail rate—providing an extra incentive for producing renewable energy and shortening the payback period. For example, Germany has one of the highest feed-in-tariffs in the world. Their policies have created tremendous demand for PVs and have made Germany a world leader in solar technology, installed capacity, and solar industry jobs.

CSP projects have geography issues similar to wind power. Regions with abundant solar resources and few adverse environmental impacts (desert regions) are not located near dense population centers. Therefore, upgrades to the U.S. electric grid are a central requirement for solar plant growth. Grid upgrades will also ease the intermittency complications of solar by providing utilities and customers with more information and by interconnecting electricity distribution over larger regions.

A significant technology issue with CSP is its current method of system cooling. CSP plants can use more water then natural gas, coal, or nuclear plants, and they often need this water in dry, desert regions. Plants can be air-cooled but that requires more energy, space, and money. Federal funding for research and development of CSP will help resolve outstanding technological issues.

Hydropower Panel

The three presenters on the hydropower panel were Brennan T. Smith, program manager, Wind and Water Power Technologies, EERE Program, Oak Ridge National Laboratory; Kamau Sadiki, national hydropower business line manager, Headquarters, U.S. Army Corps of Engineers (USACE); and Linda Church Ciocci, executive director, National Hydropower Association (NHA).

Smith provided a breakdown of hydropower facility ownership, the technically feasible capacity of U.S. hydropower, hydropower science and technology—including management options for sustainable operation.

Sadiki summarized federal hydropower capability and elaborated on USACE’s hydropower program. He explained the challenges and opportunities USACE faces as it strives to provide power services at the lowest sustainable cost through sound project management principles.

Ciocci provided an overview of NHA's mission and goals, the current state of the hydropower industry, and its future potential. She also offered solutions to the significant challenges hydropower faces in the areas of policy, research and development, environmental impacts, market barriers, and attitudinal and institutional perceptions.

Hydropower

Humans have been harnessing the power of water for millenniums. Like old windmills, watermills have historically conducted basic services like textile production, wheat grinding, and woodcutting. The first hydroelectric power was produced over a hundred years ago. The industry has grown to become the largest renewable energy electricity provider in the U.S. Hydropower provides approximately 7% of total U.S. electricity generation.

Dams provide other services besides electricity. They can be used to farm fish, control floods, supply water to communities and farms, and provide recreational services like fishing, swimming, and boating.

Technology

There are three major types of hydropower facilities: impoundment, diversion, and pumped storage. All three technologies channel water through a turbine, which powers a generator, which produces electricity. Each facility is uniquely constructed for its site and varies in capacity from being able to power small villages to millions of homes.

Impoundments are the most typical hydroelectric facility. Impoundments dam up a river, creating a reservoir, which provides the height differential and pressure to force released water through the turbines installed in the dam. Dam reservoirs can play a significant role in lowering renewable energy intermittency issues because they can store extra potential energy (water) when the wind is blowing or the sun is shining and later generate energy on less windy or cloudier days.

Diversion hydropower reroutes a portion of a river through a hydroelectric plant and returns the water downstream. Diversion does not require damming the river and therefore avoids some environmental impacts but it rarely produces as much electricity.

> *"One of the best opportunities we have to increase our supply of clean energy is by bringing our hydropower systems into the 21st century. With this investment, we can create jobs, help our environment, and give more renewable power to our economy without building a single new dam."*
>
> —Steven Chu
> Secretary of Energy
> Announcing modernization awards under the American Recovery and Reinvestment Act

A pumped storage facility utilizes the low cost of off-peak electricity to pump water to a higher storage reservoir. When the demand and cost of electricity rise again, the stored water is released. Pumped storage increases grid efficiency by smoothing out demand peaks. However, unlike other hydroelectric technologies it requires an outside source of energy and therefore is not a stand-alone renewable energy technology.

Industry

Smith stated that technically feasible hydroelectric resources are larger than previously considered. He estimates potential U.S. capacity to be between 326-334 GWs. Smith added that the new estimates have yet to be screened for costs or environmental issues, and that improved technologies can overcome some of those challenges.

Ciocci offered her case for development, "only 3% of the dams in the U.S. are hydropowered. That gives us tremendous opportunity to maximize the existing infrastructure which we know is not going to be removed… so it makes sense to capitalize on their societal benefit."

All regions of the country have potential for hydropower growth, especially the West. Most of the new hydroelectric power will not come from undeveloped sites. Most prime hydroelectric sites are already built so developers will capitalize on the abundant opportunities to turn existing non-hydroelectric dams into energy producing facilities. New hydropower also will come from small development, additional generation and efficiency upgrades at existing plants, pumped storage, and new hydrokinetic projects (tidal, wave, and ocean).

Interest in hydroelectric development is at a ten-year high with thousands of MWs of proposed projects being attributed to renewable tax credits, state renewable portfolio standards, and the cost of oil.

Environmental Impacts

Hydropower's primary environmental disturbance comes from its impact on surrounding ecosystems. The creation and operation of a dam have significant consequences for flora and fauna both up and downstream. When a dam is built, the resulting reservoir can submerge hundreds of acres of land. This ecosys-

Hydroelectric Capacity and Potential

Existing hydroelectric plants and potential high head/low power energy sites. Exclusion area represents areas excluded from hydropower development due to Federal statutes and policies. Source: Water Energy Resources of the United States with Emphasis on Low Head/Low Power Resources, U.S. Department of Energy. 2004

tem alteration changes the habitats and mobility of wildlife.

Conservation groups and the hydropower industry have yet to come to an agreement on how to reduce hydropower's footprint, how to site small hydroelectric plants, and what new mitigation technologies are acceptable.

Specific Challenges to Hydropower

Hydropower challenges vary significantly depending on the technology (pump storage, small or large hydroelectric, hydrokinetics).

Pumped storage construction costs are high and the technology is not yet recognized in many government programs.

Permitting agencies often have process duplications and resource constraints. Ensuring that these agencies have sufficient resources to streamline permitting and meet permitting requests will facilitate hydropower development.

Most hydrokinetic technology is in its infancy and therefore has the challenge of attaining start-up investment for its research and development.

Geothermal Panel

The three presenters on the geothermal energy panel were Roy Mink, water and geothermal energy consultant, board member of U.S. Geothermal and Nevada Power; Brenda S. Pierce, program coordinator, Energy Resources Program, U.S. Geological Survey (USGS); Karl Gawell, executive director, Geothermal Energy Association.

Mink provided an overview of geothermal's current and potential domestic capacity, including probable undiscovered resources. He described the different technologies for electricity generation and heat transfer, and enumerated geothermal energy development needs.

Pierce highlighted the geological and technical requirements for developing enhanced geothermal, and explained the need to research its contribution to seismic activity. She also summarized federal geothermal programs at the DOE, BLM, and USGS, and described the information needs and technical

New Hydropower Technologies

Some of the newest, most innovative, renewable energy technologies are emerging from the hydropower industry. Scientists and engineers are creating new technologies that utilize the predictable power of waves, tides, and ocean currents to create energy. Substantial private investment is flowing into these modern devices, and although they are in their infancy, many projects are demonstrating impressive potential.

There are a variety of these hydrokinetic technologies being researched today. Waves, which are formed from winds and oceanic geology, are abundant both close to shorelines and farther offshore. New hydrokinetic ocean technology extracts energy from the waves up and down motion.

Energy also is extracted from ocean tides. Gravitational attraction (mainly from the moon) creates rises and ebbs in the world's oceans. Placing devices that act like underwater wind turbines in ocean channels can collect energy from these rhythmic tidal streams.

Other hydrokinetic options include capitalizing on the flow from ocean currents and free-flowing rivers and streams. Environmental impacts from these technologies have yet to be fully documented. Technological progress and setbacks in the coming years will impact what machinery will advance in this emerging industry.

challenges for geothermal resource studies.

Gawell presented a market analysis of geothemal's projected growth and industry priorities. He also gave an overview of the provisions in ARRA that are of particular interest to geothermal.

Geothermal

Using the Earth for its heating and cooling resources is not a new activity. For thousands of years, people have been enjoying the warmth from hot springs and subterranean refrigeration properties for food storage. But only within the past century have people used different geothermal technologies to create electricity or provide heating and cooling to communities. The Earth's consistent temperature can be utilized 24 hours a day, 365 days a year.

Much of the technology used for geothermal deployment has already been developed by the oil and gas industries. In the U.S., the geothermal industry has used those innovations to develop the world's leading geothermal market. Geothermal energy provides approximately 0.3% of total U.S. electricity generation.

Technology

Geothermal technologies are categorized by being either direct use, conventional, or unconventional.

Direct Use: The direct use of geothermal energy comes in the form of heat pumps. This technology circulates fluid between the earth and the surface and is used for heating or cooling air, water, or building materials. This application is used in the housing and commercial sectors. Some larger facilities pipe hot water from one or more geothermal wells through a heat exchanger plant into a community water-infrastructure system. The hot water circulating through this large system is then used to heat buildings. Direct use also is being utilized in new applications such as bio-fuels production, timber/lumber drying, mineral recovery, greenhouses, aquaculture, and agriculture. There are currently more than one million geothermal heat pump installations, providing hundreds of thermal MWs of heating and cooling.

Conventional: Conventional geothermal electricity plants route steam through a turbine to generate electricity. These plants can produce substantial amounts of power (Reno, Nev. is entirely powered by geothermal) and use three different types of technology: dry steam, flash, or binary.

Dry steam is the simplest technology and has been successfully producing power for more than 100 years. Dry steam directly moves steam from the earth into turbines.

A flash system sprays liquid into a low-pressured tank which is heated by a hot geothermal well, this causes the liquid to "flash" into steam and drive turbines.

The binary system uses a second closed-loop liquid system to conduct heat away from the geothermal well, the low boiling point liquid in the new loop quickly vaporizes and enters the turbines.

Unconventional: There also are a few forms of unconventional geothermal energy that hold tremendous potential. Two of those technologies are enhanced geothermal systems (EGS) and co-production with oil and gas.

To create EGS, wells are drilled miles down, and engineering techniques are used to fracture the subterranean rock, enhancing the permeability of water into the area, allowing it to heat up, and be extracted to the surface. Many geothermal advocates put a large portion of the industry's future success in the emerging field of EGS. There already are operational plants in France, Germany, and Australia that are demonstrating EGS's potential. Deep earth is ubiquitously hot and potential capacity for EGS is in the hundreds of GWs.

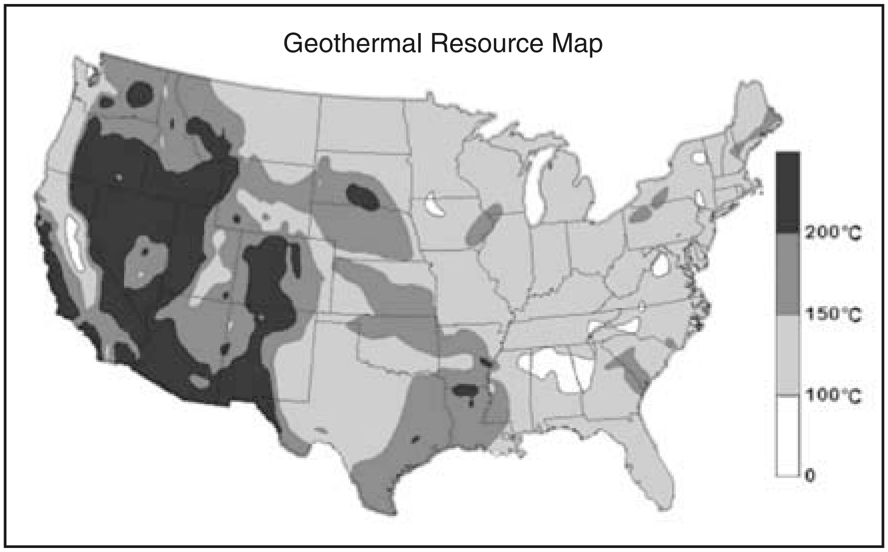
Mink, explained that, "If EGS were to meet its potential we could replace half of our electricity needs, but there are still a lot of unknowns." Preliminary international projects have highlighted some of the lingering concerns with EGS technology. There have been earthquakes directly linked to the EGS process which have sparked considerable apprehension from local residents. Also, EGS technology requires substantial, deep-earth permeability over a large area and not all of the technology's variables have been fully researched. Specific questions remain as to how much rock stress can occur at specific depths, which rock types can be utilized, what are appropriate temperatures, what are the water availability issues, and what is the appropriate fluid chemistry.

Another unconventional application of geothermal energy is its co-production with oil and gas. Billions of barrels of hot water are brought to the surface during oil and gas extraction. This existing resource is being utilized at some sites and assessed for potential utilization at others.

Industry

Pierce observed that geothermal is a highly underutilized resource. USGS has a mean estimate of 9,000 MW of identified conventional geothermal and an estimate of another 30,000 MW of still undiscovered conventional geothermal. The industry is quickly moving to capitalize on these resources—over 140 new projects are under development in 14 states. These projects are expected to put thousands of geothermal MWs online, which positions the industry to more than double its existing capacity over the next five years.

The price of geothermal energy depends on the technology. At resource rich geysers, power can be sold for as little as \$0.03 per kWh[9], proving that the cost of operation is financially competitive with other sources of energy. The high, upfront cost of plant construction is much more of a factor in project development than long-term maintenance.



Source: Geothermal Resource Map. U.S. Department of Energy

Environmental impacts

Geothermal plants produce either no emissions or trace amounts depending on the technology.

Some plants do require hundreds of gallons of water per minute. Plants in the U.S. reinject the water once it goes through the power plant. This allows the water to be reheated by the hot rock and maintain reservoir flow and pressure.

Seismicity from EGS projects, as discussed above, could create significant environmental and societal impacts. Further research will help to define this threat.

Specific Challenges for Geothermal

Geothermal will require the development of the U.S. grid but as declared by Gawell, "[most] geothermal resources follow the transmission lines!" This fortunate coincidence eases the interconnection challenge but grid development will still be required in some regions.

Rising drilling costs and competition with the oil and gas industry for similar talent and capital reduce attractiveness of geothermal investment.

Geothermal has many information needs and technical challenges such as:

- Continent-scale maps of regional geologic variations.
- Improved understanding of permeability creation.
- Identification of active faults and evaluation of potential for seismicity.
- Understanding of water requirements and regional water attainment options.
- Detailed information on fluid characteristics at oil wells.

Biomass Panel

The three presenters on the biomass energy panel were Thomas Richard, professor, Agricultural and Biological Engineering, and director, Biomass Energy Center, Pennsylvania State University; William Hagy, special assistant and director, Alternative Energy Policy, U.S. Department of Agriculture (USDA) Rural Development; and William Holmberg, chairman, Biomass Coordinating Council, American Council on Renewable Energy.

Richard explained the science behind converting biomass into useful bioproducts and biofuel. He detailed the latest research on the net energy and emission output from biofuel production, and discussed the science and planning requirements for global sustainable fuel-crop production.

Hagy gave an overview of the federal programs, groups, and laws which impact biofuel production in the U.S. Specific programs that are advancing the Obama Administration's biofuels production objectives include the formation of the Biofuels Interagency Working Group and multiple Farm Bill assistance programs.

Holmberg highlighted biomass's multiple applications, such as "The Six F's": food, feed, fiber, fuels, fertilizers, and feedstocks for chemicals. He discussed biomass's potential to address several of the U.S.'s greatest challenges such as decreasing its dependence on oil, creating jobs (specifically in the fields of agriculture, engineering, and the sciences), and mitigating climate change.

Biomass

There are multiple ways to use biomass (organic material derived from plants and animals) for the creation of energy. Worldwide, biomass accounts for 80% of renewable energy, much of which is used for heating and cooking. Biomass's applications are being expanded beyond their traditional uses to include conversion to other forms such as biogas and biofuels.

Electricity generated from biomass has been growing steadily in recent years and now contributes approximately 1.1% of the U.S.'s electrical needs. There are many resources for producing renewable electricity but biomass is the only one capable of providing a substitute for America's other primary energy resource—petroleum. For that reason, RNRF's congress focused its biomass discussions predominantly on biofuels.

There are a wide variety of biofuels, such as starch and cellulosic ethanol, biobutanol, green gasoline, jet fuel, and biodiesel. Each biofuel market is at its unique stage of development. The U.S.'s most important biofuel—ethanol—accounts for the vast majority of total biofuel usage. Ethanol refiners have more than 170 plants, and have the capacity to produce more than ten billion gallons annually.[10] The U.S.'s current portfolio of biofuels provides about 4% of U.S. energy use.

Technology

Ethanol and biodiesel (the most popular biofuels) can be used independently as transportation fuel but are more often blended with petroleum (ethanol with gasoline and biodiesel with diesel).

Ethanol: Ethanol is typically made from the sugar found in grains. In the U.S., starch ethanol is primarily distilled from corn. There have been environmental and social concerns stemming from the use of food to produce fuel. In response, researchers are working to develop other second-generation biofuels which use cellulosic alternatives such as switchgrass, small poplar trees, wood waste, agricultural residue, and algae.

Cellulosic ethanol provides a much higher energy return on energy invested than traditional ethanol. Realizing the environmental and economic promise of using this type of biomass will require the breakdown of sturdy, plant cell wall material—no easy task. Ethanol is typically blended with gasoline—"gasohol" and can be safely added to typical car engines up to an 85% blend (E85).

Biodiesel: Biodiesel is made from vegetable oil or animal fat. It is mainly derived from soybeans but some users acquire it from restaurants that recycle oils and fats that would have otherwise gone to waste. Biodiesel can be blended with diesel or directly used in a diesel engine. One hundred percent biodiesel (B100) is sensitive to temperature and may require special treatment in cold weather. It is the fastest growing alternative fuel in the U.S.

Industry

Continued growth in biofuel production appears likely because of substantial levels of federal support and a nationally-mandated renewable fuel standard (RFS). The RFS requires the production of 36 billion gallons of biofuel a year by 2022.

Government subsidized ethanol or biodiesel is currently more expensive than government subsidized petroleum-based fuels. Thus, government funding is essential for continued market growth of biofuels. Hagy elaborated on the USDA's multiple programs to assist farmers, rural residents, and the nation to respond to energy-related issues and opportunities.[11]

The most economical way to produce biofuels is in an integrated biorefinery, where the biomass can be used to produce fuels, high-value bioproducts, and power. The legislated capacity pledge of the RFS has given investors confidence to commit to project development like integrated biorefineries. The RFS has been the leading driver of the industry's rapid progress. Excitement over new biofuel breakthroughs has investors predicting that growth in the second-generation biofuels industry will continue to increase in the future.

It is nearly impossible to estimate the potential capacity for biofuel production in the U.S. because capacity is dependent on which resources and technologies are used. For example, new breakthroughs in biofuel from algae might only require a minimal amount of land to produce high fuel outputs. If biofuels continue to be produced from existing feedstocks, millions of acres of farmland would be required to meet domestic gasoline needs. This fact highlights the regional sensitivity of biofuel feedstock. The most suitable and sustainable biofuel feedstocks vary regionally all around the world. Some examples are corn and switchgrass in the U.S., sugarcane in Brazil, and yam and sweet potato in China. There is no single biofuel feedstock without economic, environmental, and social issues because of regional agricultural and societal differences.

In America, the diverse agricultural, research, and manufacturing components of the biofuel industry employ hundreds of thousands of workers.

Environmental Impacts

Biomass is used for multiple human needs from car parts to pharmaceuticals. Regardless of biomass's application, the agricultural practices used when it is grown will be one of the main determinants of its environmental impact. Two additional environmental considerations are the impacts of its production and combustion.

Agriculture: Production of fuel crops requires managed plantations, the operation of which may require fossil fuel inputs for heavy machinery, fertilizers, and pesticides. Production of fuel crops also requires significant amounts of water. The agricultural development needed to reach biofuel goals should be done sustainably to lessen environmental impacts such as soil erosion, soil degradation, and excessive water runoff.

If there is a land-use change from forest to monoculture crops this could lead to diversity loss, invasive species issues, and adverse impacts on forest-dependent communities.

Richard summarized the situation, "Sustainable forests and agricultural systems are a prerequisite for sustainable biomass energy systems."

Production and Combustion: The energy required for producing biofuels varies depending on the technology being used and the fuel being created. The efficiency of existing energy-intensive processes can be improved by integrating production of fuels, bioproducts, and power.

Both ethanol and biodiesel are biodegradable and emit less toxins, particulates, and total GHGs than their fossil fuel counterparts.

Ethanol can increase engine performance while substituting for lead or other chemical additives. Biodiesel can replace dangerous sulfur in diesel while making engines run smoother. Biodiesel emits slightly more nitrogen oxides then diesel.

Biomass and Climate Change: Land-use change is responsible for 18% of the U.S.'s GHG emissions and agricultural processes are responsible for 13%. Therefore, biofuel production will have some impact on the carbon cycle. For example, if forestland is converted into a fuel-crop field, the area will change from a carbon sequestering forest to a carbon neutral plantation.

There have been multiple studies that examine biofuel's ability to lower emissions. This issue has drawn attention to the numerous considerations required for a reasonable calculation of biofuel's carbon footprint. Some positive components or "carbon sinks" are the growing of biofuels and the lowered emissions from combustion while some negative components or "carbon sources" are the farming of biomass and the production of biofuels. Richard highlighted a 2006 article in *Science* magazine, which evaluated multiple studies pertaining to the issue and found that ethanol nets less GHGs while providing more energy than gasoline.[12]

Specific Challenges for Biofuel

Environmental and economic impacts of biofuels are both positive and negative. Holmberg believes misperceptions can be overcome if we, "Educate, Educate, Educate!" He proposes engaging educational institutions from pre-school to the Ph.D. level with math and science as the foundation.

Education about biofuel's benefits must expand beyond the classroom and be understood everywhere from the public's perception to the political realm. Providing research funding for sustainable fuel crop agriculture along with the creation of a performance-based certifying system will improve biofuel technology and its image.

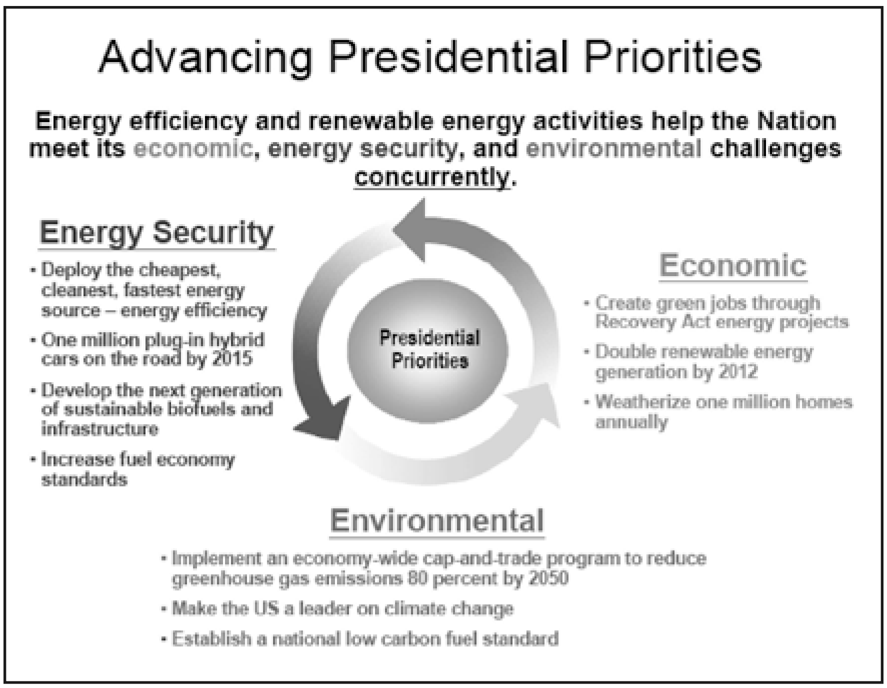
Technological advances are required to attain the highest energy returned on energy invested. This is especially true for second-generation biofuels.

Hagy explained one of the major challenges that his office confronts is that, "every week we hear from people expressing the challenges that they're having in advancing their technology from the research and development phase to the pilot and demonstration phase… to get it to the point where if it's successful it could be viable at the commercial scale, this is called the valley of death."

Endnotes

1. U.S. Primary Energy Consumption by Source and Sector, 2008. U.S. Energy Information Administration. June, 2009 http://www.eia.doe.gov/emeu/aer/pecss_diagram.html
2. Hidden Health and Environmental Costs of Energy Production and Consumption In U.S. National Academies Press. 2009 http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12794
3. Existing Capacity by Energy Source, Electric Power Annual with data for 2008. U.S. Energy Information Association. 2010 http://www.eia.doe.gov/cneaf/electricity/epa/epat1p2.html
4. National Electric Transmission Congestion Study. U.S. Department of Energy. December, 2009
5. Western Wind and Solar Integration Study. Prepared for The National Renewable Energy Laboratory. Prepared by GE Energy. May 2010. Eastern Wind Integration and Transmission Study. Prepared for The National Renewable Energy Laboratory. Prepared by EnerNex Corporation. January, 2010
6. 20% Wind Energy by 2030: Increasing Wind Energy's Contribution to the U.S. Electricity Supply. U.S. Department of Energy. http://www.20percentwind.org/20percent_wind_energy_report_revOct08.pdf
7. Renewable and Alternative Fuel. U.S. Energy Information Administration. http://www.eia.doe.gov/fuelrenewable.html
8. See note 6.
9. Geothermal Technology Program. Department of Energy. http://www1.eere.energy.gov/geothermal
10. Biomass Program. U.S. Department of Energy. http://www1.eere.energy.gov/biomass/
11. The Energy Matrix is a Navigational Aide to USDA's energy related programs: http://energymatrix.usda.gov/
12. A. E. Farrell et al., *Science* 311, 506–508. 2006

Appendix A: Federal Policies and Agency Involvement



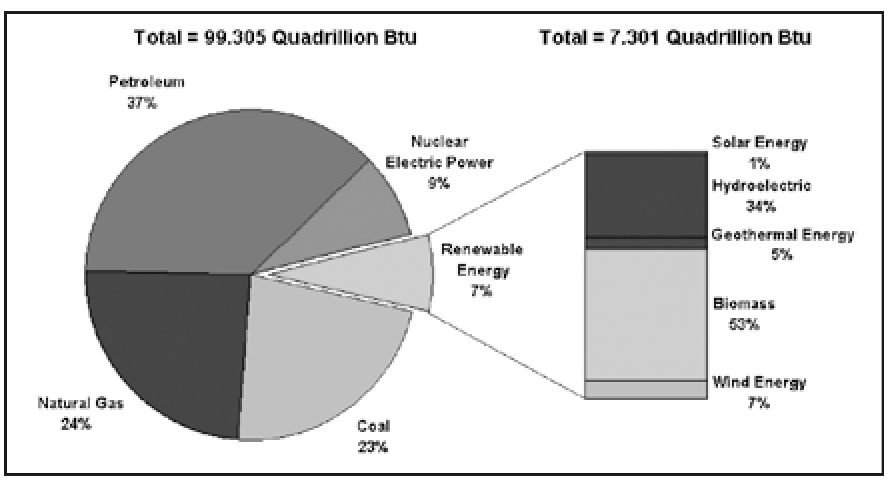
Source: DOE, Office of Renewable Energy and Energy Efficiency

Current Energy Portfolio

Tom Darin, transmission planning and siting specialist, DOE Office of Electricity Delivery & Energy Reliability, provided an overview of the current state of renewable energy in the U.S. and the administration's plan for developing new renewable energy. The President has an overarching goal of acquiring 10% of electricity from renewable energy by 2012 and 25% by 2025. The American Recovery and Reinvestment Act (ARRA) of 2009 provides the financial means to achieve the administration's goals.

American Recovery and Reinvestment Act

ARRA allocated the greatest funding for renewable energy in America's history. Major programs include tax incentives for producing renewable energy, investing in renewable energy technology, and manufacturing renewable energy components. ARRA authorized billions of dollars to direct spending on renewable energy, energy efficiency, grid development, and green job training programs along with mandating multiple research studies. It allocated billions to the creation of bond and loan programs to assist in the financing of renewable energy. The act encourages greening the transportation sector by supporting alternative fuel pumps at gas stations, plug-in electric vehicles, and an increase in fuel economy standards.[1]

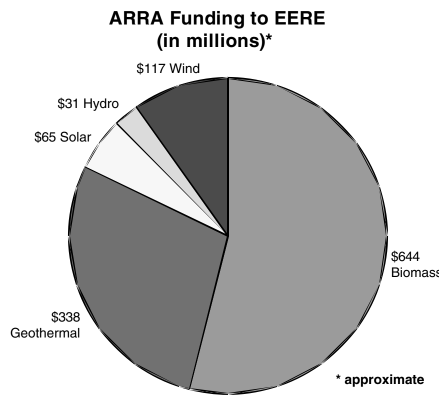


America's primary energy use by source, quadrillion BTU and percent, 2008. Source: Renewable Energy Consumption in the Nation's Energy Supply. Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

The American Recovery and Reinvestment Act of 2009 Energy- and Transportation-Related Spending *(Amounts are in the Thousands)*	
Area of Investment	**Total Investment**
Energy efficiency and conservation	$16,470,000
Improving the grid	$11,000,000
Energy research	$7,900,000
Clean energy generation	$6,000,000
Jobs training	$500,000
Vehicle spending	$2,600,000
Transportation Spending	$18,400,000
Climate science research	$570,000
Tax credits for renewable energy and energy efficiency	$19,668,000
Tax credits for alternative fuel pumps	$54,000
Investment credits in energy generation and energy efficiency technologies	$1,600,000
Total	$84,762,000

The federal stimulus bill enacted in February 2009 includes an array of provisions to spur clean energy generation and energy efficiency businesses, jobs, and investments. A total of $84.8 billion has been set aside for energy- and transportation-related spending. Source: Pew Center on Global Climate Change, Key Provisions: American Recovery and Reinvestment Act, March 2009 (updated April 16, 2009), http://www.pewglobalwarming.org/cleanenergyeconomy/Clean_Energy_Economy_Report.pdf

Graph 1



Source: Department of Energy, Energy Efficiency and Renewable Energy. http://www1.eere.energy.gov/recovery

Federal Agencies' Role in Renewable Energy

The following summaries of federal agency involvement in renewable energy development where compiled from Darin's presentation and the presentations from each renewable energy federal agency panelist. Wind energy was presented by the U.S. Bureau of Land Management, solar energy was presented by the U.S. Department of Energy, hydroelectric energy was presented by the U.S. Army Corps of Engineers, geothermal energy was presented by the U.S. Geological Survey, and biomass was presented by the U.S. Department of Agriculture. Each presenter discussed his/her agency's work and the role that other federal agencies have in developing each respective renewable energy alternative.

Department of Energy (DOE)

Department of Energy presenter Scott Stephens, technology manager, Solar Energy Technologies Program, explained that DOE's renewable energy mission is to develop cost competitive clean energy technologies and practices and facilitate their commercialization and deployment in the marketplace to strengthen America's energy security, environmental quality, and economic vitality.

DOE was by far the largest federal agency recipient of funding for renewable energy development. ARRA allotted $36.7 billion to DOE. $16.8 billion of that went to DOE's Office of Energy Efficiency and Renewable Energy (EERE). At EERE, over $1 billion was given directly to EERE's renewable energy research, development, and outreach programs related to geothermal, solar, biomass, wind, and hydroelectric technologies. (Graph 1)

The DOE works closely with its principal research laboratory the National Renewable Energy Laboratory (NREL). NREL's mission is to develop renewable energy and energy efficiency technologies and practices, advance related science and engineering, and transfer knowledge and innovations to address the nation's energy and environmental goals.

Department of the Interior (DOI)

DOI manages 500 million acres of land, or about one-fifth of the land in the U.S. The Bureau of Land Management, Bureau of Ocean Energy Management, Regulation and Enforcement (formerly, Minerals Management Service), Fish & Wildlife Service, U.S. Geological Survey, and Bureau of Reclamation play a major role in renewable energy development.

Fish & Wildlife Service (FWS)

FWS will be developing comprehensive national guidelines for siting and constructing wind energy facilities. The purposes of the guidelines will be to help protect wildlife resources, create a more effective site selection and design process, and to assist in avoiding post-construction environmental issues.

In 2007, the secretary of the interior created the Wind Turbine Guidelines Advisory Committee. The scope and objective of the committee are to provide advice and recommendations to the secretary on developing effective measures to avoid or minimize impacts to wildlife and their habitats related to land-based wind energy facilities.[2]

Congress presenter Cheryl R. Amrani, fish and wildlife biologist, Division of Fisheries and Habitat Conservation, explained the committee's multi-party efforts to develop wind with utmost environmental sensitivity. The committee emphasizes the importance of balancing federal, state, tribal, NGO, and industry perspectives to reach a consensus.

The committee recommends early and effective coordination and use of the best available science and management practices. Following these principles garners the greatest conservation benefits while maintaining cost effectiveness.

Amrani explained some major accomplishments of the Wind Turbine Guidelines Advisory Committee:

- Trust has been built and strengthened among diverse stakeholders through collaborative processes.
- Environmentally responsible wind energy development has been promoted.
- A model has been developed for other renewable and traditional energy industries to coordinate and collaborate with FWS to voluntarily protect trust resources.

Bureau of Land Management (BLM)

BLM has received $41 million from ARRA for renewable energy studies and projects. BLM presenter Ray Brady, manager, Energy Policy Team, explained the BLM's process of reviewing and approving permits and licenses for companies to explore, develop, and produce both renewable and non-renewable energy on federal lands. The bureau also ensures that proposed projects meet all applicable environmental laws and regulations. It works with local communities, states, industry, and other federal agencies in this approval process. Once projects are approved, BLM is responsible for ensuring that developers and operators comply with use authorization requirements and regulations and that they pay the appropriate rental fee. BLM has established renewable energy coordination offices to help administer over 260 million acres of land under its management.

Bureau of Ocean Energy Management, Regulation and Enforcement (BOE) (formerly, Minerals Management Service)

BOE manages the outer continental shelf for offshore wind development. It grants exploratory leases, establishes frameworks for development, and supports hydrokinetic research.

Geological Survey (USGS)

USGS maintains a national assessment of geothermal potential. Brenda S. Pierce, program coordinator, Energy Resources Program, explained how the USGS helps DOE and other agencies evaluate resources, economics, technology, and land use for potential site development.

U.S. Department of Agriculture (USDA)

USDA has multiple departments and programs that research and support the development of renewable energy. The Farm Bill provides the major financial support for energy and biofuel initiatives.

Congress presenter William Hagy, special assistant and director, Alternative Energy Policy, USDA Rural Development, discussed the Biomass Research and Development Board, a multi-party consortium working to coordinate federal research and development activities relating to bio-based fuels, power, and products. The board is chaired by the secretaries of energy and agriculture and the administrator of the Environmental Protection Agency. The board is working to

- Create a biofuel market development program to boost next-generation biofuels, increase use of flex-fuel vehicles, and assist retail market development
- Coordinate infrastructure policies
- Create new policy options to promote sustainability

In 2008, the board released the National Biofuels Action Plan.[3] It identifies key research challenges and defines clear interagency actions critical to developing the science and technology needed to make advanced biofuels cost competitive. Another goal of the plan is to grow the nation's biofuels' industries in a sustainable manner.

U.S. Army Corps of Engineers (USACE) and Bureau of Reclamation (BOR)

USACE is the largest producer of hydropower in the U.S.—followed by BOR. USACE presenter Kamau Sadiki, national hydropower business line manager, Headquarters, explained how the two agencies coordinate their hydropower efforts with DOE and other federal, regional and state agencies, and private companies. They are in the process of upgrading many of their facilities to increase output, efficiency, and reliability.

Endnotes

1 H.R. 1—111th Congress: American Recovery and Reinvestment Act of 2009. February 13, 2009

2 Wind Turbine Guidelines Advisory Committee Recommendations to the Secretary. March 2010. http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html

3 National Biofuels Action Plan. Biomass Research and Development Board. October, 2008. www1.eere.energy.gov/biomass/pdfs/nbap.pdf

Appendix B: List of Delegates

Cheryl Amrani
Fish and Wildlife Biologist,
Division of Fisheries and
Habitat Conservation
U.S. Fish and Wildlife Service
Arlington, VA

Robert Anderson
Public Lands Foundation
Centreville, VA

Kent Bakke
Owner
Continuum Energy Solutions
Alexandria, VA

Ray Brady
Manager,
Energy Policy Team
Bureau of Land Management
Washington, DC

Nicole Carter
Specialist in
Natural Resources Policy
Congressional Research Service
Washington, DC

Tom Chase
Director,
Coasts, Oceans and Ports
Institute
American Society of
Civil Engineers
Reston, VA

Linda Church Ciocci
Executive Director
National Hydropower
Association
Washington, DC

Blaine Collison
Director,
Green Power Partnership
U.S. Environmental Protection
Agency
Washington, DC

James Critchfield
Environmental Protection
Specialist
U.S. Environmental Protection
Agency
Washington, DC

Thomas Darin
Transmission Planning
& Siting Specialist
U.S. Department of Energy,
Office of Electricity Delivery
& Energy Reliability
Washington, DC

Robert Day
Executive Director
Renewable Natural Resources
Foundation
Bethesda, MD

Tom Decker
Vice President
CH2M HILL
Chantilly, VA

John Durrant
Managing Director,
Engineering Programs
American Society of
Civil Engineers
Reston, VA

Richard Engberg
Technical Director
American Water Resources
Association
Middleburg, VA

Karl Gawell
Executive Director
Geothermal Energy Association
Washington, DC

Sarah Gerould
Senior Program Officer,
Biological Resources Discipline
U.S. Geological Survey
Reston, VA

Jessica Goad
Policy Fellow,
Energy and Climate Change
The Wilderness Society
Washington, DC

William Hagy
Special Assistant and Director
of Alternative Energy Policy
U.S. Department of Agriculture,
Rural Development
Washington, DC

Paul Higgins
Senior Policy Fellow
American
Meteorological Society
Washington, DC

William Holmberg
Chairman, Biomass
Coordinating Council
American Council on
Renewable Energy
Washington, DC

Walter Kelly
Falls Church, VA

Allen Kolker
Research Geologist,
Eastern Energy Resources
Science Center
U.S. Geological Survey
Reston, VA

Jamie Link
Research Staff
Science and Technology
Policy Institute
Washington, DC

James Lyons
Chief Technology Officer
Novus Energy Partners
Alexandria, VA

Lew McCreery
Woody Biomass Coordinator
U.S. Forest Service,
Northeastern Area,
Wood Education
and Resource Center
Morgantown, WV

Wayne McFarland
Principal
Stearns & Wheler GHD
Cazenovia, NY

Roy Mink
Board Member,
U.S. Geothermal
and Nevada Power Consultant,
Water and Geothermal
Worley, Idaho

Larry Nielsen
Professor,
College of Natural Resources
North Carolina State University
Cary, NC

Randall Packer
Professor of Biology and
Associate Dean
George Washington
Solar Institute
George Washington University
Washington, DC

Monica Pearce
Project Coordinator
RARE
Washington, DC

Brenda Pierce
Program Coordinator,
Energy Resources Program
U.S. Geological Survey
Reston, VA

Kenneth Plum
Delegate
Virginia House of Delegates
36th District
Reston, VA

Thomas Richard
Professor,
Agricultural and
Biological Engineering
Director,
Biomass Energy Center
Pennsylvania State University
University Park, PA

Neil Rondorf
Vice President,
Maritime Science Applications
International Corp
Virginia Beach, VA

Howard Rosen
RNRF Vice-Chairman
Volunteer
U.S. Forest Service
Silver Spring, MD

Don Ryan
Vice President for Policy
Second Nature, Inc.
Washington, DC

Kamau Sadiki
National Hydropower Business
Line Manager
U.S. Army Corps of Engineers
Washington, DC

Michael Sanio
Director,
International Alliances
American Society of
Civil Engineers
Reston, VA

Brennan Smith
Program Manager,
Wind and Water Power
Technologies, EERE Program
Oak Ridge National Laboratory
Oak Ridge, TN

Barry Starke
RNRF Chairman
Former President, American
Society of Landscape Architects
Earth Design Associates, Inc.
Casanova, VA

Scott Stephens
Technology Manager,
Solar Energy Technologies
Program
U.S. Department of Energy
Washington, DC

Alan Thornhill
Executive Director
Society for Conservation
Biology
Washington, DC

Ellen Vaughan
Program Director
Renewable Natural Resources
Foundation
Bethesda, MD

Ken Zweibel
Director,
George Washington
Solar Institute
George Washington University
Washington, DC

Appendix C: Congress Program

Congress on Assessing America's Renewable Energy Future

Tuesday, December 8, 2009

8:30–8:40 am
Welcome and Opening Remarks

Barry Starke
RNRF Chairman
Former President, American Society of Landscape Architects
Principal, Earth Design Associates

USGS Welcome

Sarah Gerould
Senior Program Officer - Science Policy, Planning and Review, U.S. Geological Survey and Chair, RNRF Congress Program Committee

8:40-8:50 am
Conference Context & Goals

Robert Day
RNRF Executive Director

8:50–9:30 am
The Federal Plan: Creating America's Renewable Energy Portfolio & Energy Distribution Overview

Thomas Darin
Office of Electricity Delivery & Energy Reliability,
U.S. Department of Energy

9:30-10:00 am
Discussion and Questions

10:20-11:20 am
Wind Energy Panel

Neil Rondorf
Vice President, Science Applications International Corporation

Ray Brady
Manager, Energy Policy Team,
Bureau of Land Management

James Lyons
Chief Technology Officer,
Novus Energy Partners

11:20-11:45 am
Discussion and Questions

12:55–1:55 pm
Solar Energy Panel

Ken Zweibel
Director, GW Solar Institute,
George Washington University

Scott Stephens
Technology Manager,
Solar Energy Technologies Program,
U.S. Department of Energy

Kent Bakke
Owner, Continuum Energy Solutions

1:55–2:20 pm
Discussion and Questions

2:20-3:20 pm
Hydroelectric Energy Panel

Brennan Smith
Program Manager, Wind and Water Power Technologies, EERE Program,
Oak Ridge National Laboratory

Kamau Sadiki
National Hydropower Business Line Manager, Headquarters, U.S. Army Corps of Engineers

Linda Church Ciocci
Executive Director, National Hydropower Association

3:20-3:45 pm
Discussion and Questions

4:00-5:00 pm
Geothermal Energy Panel

Roy Mink
Board Member, U.S. Geothermal and Nevada Power; consultant, water and geothermal energy

Brenda Pierce
Program Coordinator,
Energy Resources Program,
U.S. Geological Survey

Karl Gawell
Executive Director,
Geothermal Energy Association

5:00-5:25 pm
Discussion and Questions

Wednesday, December 9, 2009

9:05–10:05 am
Biomass Energy Panel

Thomas Richard
Professor, Agricultural
and Biological Engineering,
Director, Biomass Energy Center,
Pennsylvania State University

William Hagy
Special Assistant and Director of
Alternative Energy Policy,
USDA Rural Development

William Holmberg
Chairman,
Biomass Coordinating Council,
American Council on
Renewable Energy

10:05-10:30 am
Discussion and Questions

10:45-11:45 am
Case Studies: Multi-party Dialogs
Wind Turbine Guidelines
Advisory Committee

Cheryl R. Amrani
Fish and Wildlife Biologist,
Division of Fisheries
and Habitat Conservation
The Biomass Research and
Development Board

Bill Hagy
Deputy Administrator,
Business Programs,
USDA Rural Development

11:45-12:15 pm
Discussion and Questions

1:30-3:00 pm
Working Group Discussion

4:00-4:10 pm
Concluding Remarks

Robert Day
RNRF Executive Director

About RNRF

Purposes

The Renewable Natural Resources Foundation (RNRF) was incorporated in Washington, D.C., in 1972, as a nonprofit, public, tax-exempt, operating foundation. It was established to:

- Advance sciences and public education in renewable natural resources;
- Promote the application of sound scientific practices in managing and conserving renewable natural resources;
- Foster coordination and cooperation among professional, scientific and educational organizations having leadership responsibilities for renewable natural resources; and
- Develop a Renewable Natural Resources Center.

The foundation represents a unique, united endeavor by outdoor scientists to cooperate in assessing our renewable resources requirements and formulating public policy alternatives.

Membership

RNRF's members are professional, scientific, and educational organizations interested in sustaining the world's renewable natural resources. The foundation is governed by a board of directors comprised of a representative from each member organization. The directors also may elect "public interest members" of the board. Board members are listed on the back cover of the journal. Individuals may become Associates for an annual contribution of $50 or more.

Programs

RNRF conducts national meetings, congressional forums, public-policy round tables and briefings, and international outreach activities. It also conducts an annual awards program to recognize outstanding personal, project, and journalistic achievements. More information about RNRF's programs is available at www.rnrf.org.

Renewable Resources Journal, first published in 1982, promotes communication among RNRF's represented disciplines. The journal is provided to the governing bodies of RNRF member organizations, members of the U.S. Congress and committee staffs with jurisdiction over natural resources, federal agencies, and universities. Tables of contents of all volumes of the journal are available at RNRF's web site.

Center Development

The Renewable Natural Resources Center is being developed as an office and environmental center for RNRF's members and other nonprofit organizations. The Center is located on a 35-acre site in Bethesda, Maryland, where lawns and forested buffers provide an exceptional work environment.

The master site plan for the Center contemplates additional construction—including a 16,500 square foot conference and common-services facility. Organizations may either lease or purchase their offices. The Center currently has approximately 52,500 square feet of office space.

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