Senate I

Energy Innovation

By Benjamin Leibowicz

Introduction

fossil fuels— *combustible organic materials derived from the remains of former life*

"The nation that leads on energy will be the nation that leads the world in the 21st century." If this statement made by President Barack Obama proves to be correct, then the future position of the United States in global affairs will be determined by our ability to first adapt and then respond to the continuously changing landscape of the international energy debate. America must get to work and establish itself at the forefront of an energy revolution—and it must do it now.

Using the speed of technological progress and the increased levels in standard of living as benchmarks, the 20th century stands alone as the most productive century in the history of mankind. Much of this progress, however, was built on the unsustainable practice of burning **fossil fuels**. The world supply of fossil fuels is dwindling so rapidly that the possibility of a world without fossil fuels is conceivable, if not inevitable, in our lifetimes. In order to prevent this scenario from happening while preserving our quality of life, the global community must undergo a revolution in energy. Only by converting an international energy system based on fossil fuels to one run by clean, efficient, renewable energy sources can we simultaneously ensure an energy-secure future and achieve the equally important goal of preserving the environment.

What makes energy innovation both promising and challenging is the sheer number of available alternatives to fossil fuels. Some, such as solar power, wind power, and hydroelectric power, have already proven successful on small scales. If further developed and implemented on a large scale, these alternative energy sources could ameliorate the current energy situation and ease our transition to a renewables-based economy. Other options include longer-term projects with higher reward potentials, such as tidal energy or—in the more distant future—nuclear fusion.

As senators, you must remain cognizant of the fact that the government has finite resources, and you must make informed, critical, and often difficult decisions among different alternatives. Of course, there are larger questions looming behind all of these more specific decisions. What balance between efficiency and environmental impact should decisions aim to achieve? How can we use energy innovation initiatives to jumpstart the struggling economy? Should the future energy landscape be based on large-scale, central power generation or should it rely on small-scale energy production? How can we convert a fossil fuel infrastructure to a renewables infrastructure without hurting the economy?

Until it is addressed with force and leadership, the issue of energy innovation will continue to raise doubts about the future of America. As senators, the ability to ensure a future of global energy security under American leadership rests in your hands.

inexhaustible— *incapable of being used up*

Explanation of the Problem

History of the Problem

Fossil Fuels

Fossil fuels are fuels formed over millions of years from the decomposing buried remains of plants and animals under intense heat and pressure. Fuels formed by this process, including the familiar petroleum, coal, and natural gas, contain high levels of carbon and hydrocarbons that release large amounts of energy when burned. Currently, fossil fuels provide more than 85% of the energy consumed in the United States. More specifically, they account for nearly two-thirds of domestic electricity consumption and virtually all domestic transportation fuel consumption. Worldwide, it is estimated that fossil fuels provide more than three-fourths of the energy consumed by mankind. Among fossil fuels, petroleum contributes the most to global energy consumption by a fairly substantial margin – roughly 43.4% of total consumption, compared to 15.6% for natural gas and 8.3% for coal.

Although fossil fuels were once thought to be **inexhaustible**, it is now painfully obvious that we are using fossil fuels at an unsustainable rate. Since fossil fuels take millions of years to form, our rate of usage is far beyond their natural rate of formation, leading to a dwindling global supply of fossil fuels. For years, experts have attempted to determine when global petroleum extraction and production would peak. Some say this peak may have already occurred or may occur in the next several years. According to oil and gas company Chevron-Texaco, petroleum production in 33 of the 48 largest petroleum-producing countries has already begun to decline. Forecasts of exactly when our fossil fuel supplies will run out are speculative at best, but most sources claim that petroleum reserves will be depleted some time between 2025 and 2070 and that natural gas reserves will be exhausted in about fifty years. The world coal supply is thought to be much larger and should last for quite a while, but this might change if economies begin to rely heavily on coal as other fossil fuels are depleted. As supplies of fossil fuels diminish, prices will inevitably rise while availability falls, potentially leading to competition and conflict as nations struggle desperately for access to scarcer and scarcer resources.

Environmental Impact

To yield usable energy, fossil fuels must be burned via the combustion process, which releases a broad array of particulates like sulfur, nitrogen, and carbon into the atmosphere. Many of these emissions are harmful to the environment. Sulfur and nitrogen combine with water vapor in the atmosphere to create acid rain. The existence of acid rain and its causes have been understood since the mid-19th century, but only in the 1960s and 1970s did it become a widespread phenomenon. Acid rain remains a significant problem in many industrialized regions of the world, and toxic rainwater pH readings of below 2.4 are observed quite regularly. Carbon dioxide, the infamous environmental villain largely responsible for global warming, is a greenhouse gas released during the burning of fossil fuels. The level of carbon dioxide in the atmosphere is currently 40% higher than the pre-**Industrial Revolution** level and is believed to be at its highest point in 650,000 years. Environmental hazards are also created by the extraction, transportation, and consumption of fossil fuels. Mining for coal and drilling for petroleum can dramatically change landscapes and bring unusually high concentrations of saltwater to the surface, endangering nearby ecosystems.

The environmental impact of fossil fuels and other energy sources is an issue challenging and comprehensive enough to be a topic unto itself, and thus will not be the focus of our debate. While considering solutions to the issue of energy innovation, however, it is important to keep environmental concerns in mind when debating the merits of proposed solutions.

Industrial Revolution—*beginning in Great Britain in the late 1700's and spreading to other nations throughout the 1800s, the period was characterized by great advances in technology*

hydroelectric—*power resulting from the motion of water*

fission—*the cleaving of a nucleus of an atom which results in a significant release of energy*

Pressure for Energy Innovation

Many of the energy innovation solutions gaining popularity today as potential cornerstones of the future energy landscape have been around for a very long time. Long before humans had any use for fossil fuels, the forces of wind and water were harnessed to facilitate tasks such as grinding grain into flour or powering a loom. With the advent of the Industrial Revolution, fossil fuels proved their convenience and became the energy source of choice for the modern economy.

In the first half of the 20th century, the only renewable energy source to be exploited to a significant extent was **hydroelectric** power, with large-scale projects completed in the United States including the Hoover Dam (1936) and the Grand Coulee Dam (1942). Initially constructed as Depression-era public works projects designed to provide jobs, these facilities continue to provide electricity today. Following World War II, wartime scientific research potential was at least partially diverted to energy innovation efforts. Nuclear **fission** reactors first provided electricity in the 1950s and continued to be constructed in abundance through the end of the 1970s. Before the 1970s, solar power had been used only for such limited applications as powering early satellites,

but the oil crises of that decade motivated a drastic increase in interest in further developing this form of renewable energy. Solar cell production spiked and continues to rise today. The experience of the 1970s also led to the development of the first modern wind power turbines in the early 1980s.

Heightened awareness of the environmental impact of fossil fuels and the dangers posed by global warming has increased pressure for energy innovation in the last decade. An option discovered only recently that has demonstrated great promise is **biofuel**, fuel comprised of biological material that is living or has been lifeless for only a short time. For the first time since the end of the 1970s, the United States plans to construct a new generation of nuclear reactors. In addition to proposed energy sources, the US has recently trended towards conserving energy and decreasing its consumption demand. This has resulted in the construction of "green" buildings that are designed to use energy more efficiently and hybrid vehicles that require less fuel to travel a given distance.

biofuel—*fuel coming from biomass*

cap-and-trade system—*a system where the government places a set limit on the amount of a pollutant that can be released nationwide, then gives away or auctions off portions of that allowance to polluters*

Recent Developments

New Energy for America Plan

Presented during President Obama's 2008 presidential campaign, New Energy for America is the overarching Obama-Biden energy innovation plan that outlines our energy strategy in broad terms. Its aims are to make the United States invest in renewable energy, reduce dependence on imported fossil fuels, and address global climate change. The plan calls for an investment of $150 billion over the next decade to stimulate private sector efforts to develop clean energy technology, in the process creating five million new jobs in that area. It also calls for an increase in the number of electric and hybrid cars on American roads and produced by American automobile manufacturers. New Energy for America sets goals for the share of total electricity consumption derived from renewable sources: 10% by 2012 and 25% by 2025. Further, also it proposes the implementation of a carbon **cap-and-trade system** to reduce greenhouse gas emissions by 80% before 2050. New Energy for America is an admirable plan for our immediate energy future, but its components must be legislated in order to be incorporated into meaningful United States energy policy.

Solar Energy Technologies Program

Launched at the heel of the 2009 conclusion of the Solar America Initiative, the Solar Energy Technologies Program is a Department of Energy initiative that aims to aid the development of cost-effective solar energy technologies. It funds research on photovoltaic cells and new concepts in solar technology such as concentrated solar power. The

program also includes a group charged with the task of determining how best to introduce and integrate solar energy production into existing power grids.

California Solar Initiative

California has taken a leading role in the quest for renewable energy by making a commitment to dramatically increase the use of solar energy in the state. The California Solar Initiative, a solar rebates program launched in 2007 by the California Public Utilities Commission, is authorized to provide $2.2 billion in cash and tax incentives to those who install **photovoltaic** systems on their buildings. When these incentives are considered, the program in some cases covers almost half the cost of purchasing and installing solar panels.

photovoltaic— *adjective describing processes that convert incident light into an electromotive force*

International Thermonuclear Experimental Reactor (ITER)

ITER is an international scientific collaboration organized to demonstrate the feasibility of nuclear fusion power in the not-so-distant future. The parties involved in the effort are the European Union, the United States, Russia, China, India, Korea, and Japan. The reactor will be constructed in France at a cost of $10 to 20 billion. Proponents of the collaboration hail nuclear fusion as the energy source capable of ultimately lifting the globe out of its energy crisis. Indeed, nuclear fusion is efficient, clean, and, in contrast to nuclear fission, does not produce radioactive waste. ITER, however, has found staunch critics in organizations like Greenpeace International who claim that nuclear fusion is not feasible in the near future and is a dangerous option to explore, as well as in scientists who doubt our collective readiness to take on such a challenge. United States involvement in ITER has been tenuous, with our unwillingness to provide our expected funding contribution to the project at least partially explaining why the European Union was chosen to host the reactor. In fiscal year 2008, the United States zeroed annual funding for the collaboration and currently plans to invest far less than the European Union and Japan.

Congressional Action

Energy Policy Act of 1992 (PL 102-486)

The Energy Policy Act of 1992 (EPACT) was a landmark piece of legislation in that created enforceable energy conservation and efficiency regulations and offered solid government support for alternative energy innovation. The act mandated that each state adopt energy efficiency codes for buildings that would have to be deemed acceptable by the Department of Energy. It also directed the Secretary of Energy to establish a national system of energy standards for household appliances and construction components such as windows. A Federal Energy Effi-

ciency Fund was established to provide grants to federal government agencies to help them meet the new standards. EPACT also offered corporate tax credits for the production of renewable energy such as hydroelectric and geothermal power. It attempted to modify the utility system in the United States by helping smaller competitors enter into the wholesale electricity market and compete with large utility companies. Lastly, Title III of the act required that urban public transportation networks acquire a certain number of alternative fuel vehicles capable of operating on non-petroleum fuels while Title IV gave state and local governments the authority to provide tax breaks and financial incentives to developers and users of clean-fuel vehicles.

biomass—*organic material like plant matter*

subsidies—*money given by the government to promote certain behaviors*

Energy Policy Act of 2005 (PL 109-58)

Conceived of as an updated version of the Energy Policy Act of 1992 that marks a more substantial break from fossil fuels and pledges stronger federal support for energy innovation, the Energy Policy Act of 2005 was signed into law by President Bush on August 8, 2005. The act authorizes loan guarantees for the development of innovative energy technologies that do not emit significant greenhouse gases, including modern nuclear reactor designs, clean coal technology, and renewable energy. Specifically, it provides $50 million per year for **biomass** energy initiatives while authorizing additional **subsidies** for the production of wind and other alternative energies and cost overrun support for the construction of up to six new advanced nuclear power plants. The act demands that the amount of biofuel (in almost all cases, ethanol) mixed with gasoline sold in the United States double between 2006 and 2012 and that Federal Fleet vehicles with the capacity of doing so to operate exclusively on alternative fuels. It is also the first piece of legislation to identify wave and tidal power as renewable energy sources. While it preserves the ban on oil and gas drilling in the Great Lakes, the Energy Policy Act of 2005 offers incentives for companies drilling in the Gulf of Mexico. To encourage more widespread energy conservation, the act provides tax breaks to those who make energy efficiency improvements to their homes.

American Recovery and Reinvestment Act of 2009 (PL 111-5)

Signed into law by President Obama on February 17, 2009, the American Recovery and Reinvestment Act of 2009 consists primarily of federal spending programs intended to provide a stimulus to the struggling American economy. Of the $787 billion in total domestic spending authorized by the act, about $61 billion is slated to be spent in the energy sector. The largest portion of this amount will be spent on upgrading the nation's existing electrical grid into a "smart" electrical grid, bringing our electrical infrastructure into the digital age by using advanced computer technology to efficiently distribute electricity from

source to consumer. In addition to providing continued financial support for the forms of renewable energies delineated in the Energy Policy Act of 2005, the recent act authorizes more than $6 billion for state and local governments to invest in energy efficiency, $5 billion for the **weatherizing** of modest-income homes, and $6 billion for nuclear waste cleanup. The list of smaller funding targets is very long and includes items like acquiring electric vehicles for federal vehicle fleets ($300 million), and increasing energy efficiency in low-income housing projects ($250 million).

weatherizing— *improving insulation efficiency*

Focus of the Debate

Conservative View

Traditionally, the conservative view on energy has been to trust that market forces alone will eventually solve the current energy problem. According to the basic principles of supply and demand, as fossil fuels become rarer, their prices will rise. Soaring prices will make alternative energy options comparatively cheaper and thus more attractive to consumers, encouraging the private sector to take advantage of this profit opportunity by investing in the development of alternative energy technology. Most conservatives therefore oppose large federal spending on energy innovation, preferring to rely on the private sector. This sentiment has grown stronger during the current economic downtown; conservatives have vehemently opposed recent deficit spending, claiming such policies are fiscally irresponsible.

Conservatives still see a lot of potential in fossil fuels, at least in the near future. They frequently point out that the United States has large untapped fossil fuel reserves and support increases in fossil fuel production even if it means overturning drilling restrictions and environmentally-conscious measures. Conservatives emphasize the large quantity of coal available domestically and believe that we should exploit it, making coal a central part of our energy fabric. The differences between the conservative and liberal views on energy are at least to some extent rooted in differences between their views on environmental issues. The conservatives' willingness to rely on fossil fuels in the near future and to let the market gradually guide our shift toward renewable energy is made palatable by the relatively low importance they assign to global climate change as a political issue, compared to liberals.

When conservatives have pushed for renewable energy, it has usually been for nuclear energy or biofuels. The Bush administration was a firm supporter of nuclear energy, initiating the Nuclear Power 2010 Program in 2002 in order to initiate the site selection and construction of a new generation of nuclear power plants as well as to develop and bring to market advanced nuclear plant technologies. The goals of the program were reaffirmed when President Bush signed the Energy

Policy Act of 2005. Conservative trust in nuclear energy stems from its proven efficiency track record, its feasibility for the near future, and its roots in the military apparatus. Biofuels have been another favorite alternative energy source of conservatives, largely due to conservative links to the agricultural sector.

stringent—*rigorous and strict*

Liberal View

In recent years liberals have devoted a great deal of energy to the issue of energy innovation and view it as a necessary and worthy target of government spending. They believe that the federal government is the correct engine for the energy revolution and that only with government financial support can the private sector be motivated enough to devise successful energy solutions. Contrary to conservatives, who oppose deficit spending as fiscally irresponsible policy, liberals feel that investing funds in energy innovation will not only aid our long-run quest for energy security but will also stimulate the economy in the short run by providing jobs. Liberals generally focus on environmental issues far more than Republicans, and are thus more likely to consider the environmental impact of fossil fuels and the various alternative energy options when debating policy. In order to avoid the economic and environmental problems that will result from their continued use, they are in general agreement that the sooner the United States gets over its addiction to fossil fuels, the better. Thus, even though they support clean coal technology as a sort of intermediary between traditional fossil fuels and renewable energy sources, they are more of the opinion that our nation should get off fossil fuels entirely.

Liberals also emphasize reducing oil consumption through the establishment of more **stringent** efficiency standards and the manufacturing of more fuel-efficient vehicles and strongly oppose temporarily increasing our oil supply by drilling in protected wildlife areas. They want to cut subsidies for oil and gas companies, using the savings to provide tax incentives for renewable energy production and development. They also support a wider range of renewable energy sources than conservatives and believe both in the power of small-scale operations like in-home solar panels and in the potential of the cleanest of alternatives: wind power, hydroelectric power, and solar power.

Presidential View

President Obama typifies the liberal view on energy and assigns the issue extremely high importance. A powerful advocate of the American Recovery and Reinvestment Act of 2009, he clearly supports well-targeted government spending as a good stimulus for the economy and has shown himself willing to invest significant financial resources in energy innovation. He believes in the power of subsidies and tax incentives to guide the private sector toward ends that benefit the public

good. Obama recognizes the seriousness of the environmental issues we are now facing and will not compromise his environmental goals when considering energy policy. Nuclear energy is a topic that tends to divide Democrats, but Obama has been a fairly strong supporter of nuclear energy initiatives.

think tank—*a group whose members research issues advocating for certain social, economic, political or military policies*

sensationalized—*synonym for exaggerated*

Interest Group Perspectives

Greenpeace

Greenpeace is an international organization dedicated to protecting and conserving the environment. As such, Greenpeace campaigns for an energy revolution to reduce greenhouse gas emissions and address global warming. It focuses on the cleanest of alternative energy sources including wind and solar power. An environmental group that fights to protect wildlife habitats, Greenpeace strongly opposes opening up new territory to oil drilling and other fossil fuel extraction activities. The organization lists the elimination of toxic wastes as one of its primary goals and therefore opposes nuclear energy, a stance that conflicts with the views of many Republicans and Democrats alike, including President Obama and former President Bush. Despite its involvement in the issue of energy innovation, Greenpeace is ultimately an environmental organization. Its support for renewable energy sources is rooted in their environmental merits, and environmental impact is the number one criterion for Greenpeace when evaluating an energy proposal.

The Heritage Foundation

The Heritage Foundation, a conservative **think tank**, believes that nonintervention by the government is the best option. It maintains that successful energy policy originates in the private sector. Furthermore, Heritage opposes subsidies and loan guarantees intended to "accelerate, deploy, and commercialize a number of energy sources including wind, solar, biofuels, and clean coal" believing that such subsidy expansion distorts the market and causes consumers to face higher future energy prices. Additionally, Heritage is against any government attempts that deal with global warming, such as the regulation of CO_2 emissions, believing that the issue has been **sensationalized**. The Heritage Foundation ultimately believes that government energy policy should have three aims: 1) to equalize supply and demand 2) to ensure that energy in the future is stable and reasonably priced and 3) to ensure accountable management of the US's energy resources.

Center for American Progress

A liberal think tank, the Center for American Progress (CAP) supports progressive government energy policy. CAP believes that the lack of innovation, reliance on imported and dirty fossil fuels like oil,

and failure to fully embrace the move towards clean energy policy put the US at an economic and competitive disadvantage. Consequently, CAP is a big supporter of the American Recovery and Reinvestment Act of 2009. While it acknowledges that the law will minimally increase short term electricity prices, CAP maintains that investing in clean energy will save money for consumers in the long term and will create many new jobs, as clean energy is more labor intensive than fossil fuel-based energy. The think tank also believes that inaction by the government will do little to curb the rising costs of global warming—costs pegged at $1.9 trillion per year by the year 2100. Therefore, CAP feels that it is necessary for the government to pursue energy innovation and domesticate energy supplies.

invisible hand—*coined by economist Adam Smith, the notion states that if people act in accordance with their private interests, they actually end up benefiting society as a whole*

Possible Solutions

Take the Conservative Stance: Trust the Invisible Hand

The simplest "solution" to the energy issue is to trust that the economic forces operating within the energy market will eventually drive the private sector to produce renewable energy. In pure economic terms, this solution appears plausible. As fossil fuels become rarer, they will also become more expensive. Consumers will demand cheaper energy, and producers encouraged by the profit motive will deliver by developing renewable energy technology. This Adam Smith "**invisible hand**" approach is based on empirical evidence that free markets do a fairly good job of producing beneficial outcomes for society. Recently, however, this stance in its purest and strongest form has received little support as more moderate conservatives have recognized the seriousness of the energy issue and have come to believe that the government must step in to address it. Those who advocate government intervention highlight the amount of time it will take to research and develop alternative energy sources; by acting now, the federal government can ensure a smooth and gradual economic transition away from fossil fuels, but if left to the private sector, research and development will start late and the transition could be brief and disruptive. Environmental concerns are also a reason to reject the most conservative approach. Letting the market determine its own course does not take into account the harmful environmental effects of all the fossil fuels that will be burned before the private sector begins to move away from fossil fuels.

The Demand Side: Energy Conservation

An option for mitigating the energy problem in the short term while easing our transition to a renewables economy in the long run is to reduce our demand for energy consumption. The United States is the largest consumer of energy in the world and ranks seventh in per-capita energy consumption, so room for improvement exists. Energy con-

sumption can be reduced through such strategies as subsidization of fuel -efficient vehicles, construction of more green buildings, and expanded public transportation systems. Fuel-efficient vehicles like hybrid cars run on less gasoline than standard vehicles and can be made more cost-competitive with standard vehicles through financial incentives and subsidies. Green buildings, also called sustainable buildings, are designed to make efficient use of resources such as water and heat and are sited, designed, and constructed with their environmental impact in mind. The United States has historically been lacking in public transportation systems compared to other developed countries, and expansion and modernization of these systems would reduce automobile usage and gasoline consumption. More cities should be encouraged to invest in subway, light rail, and rail systems.

Arctic National Wildlife Refuge (ANWR)— *located in the Alaska region, ANWR is a refuge for animals such as polar bears and caribou*

Strategic Usage of Remaining Fossil Fuels

As fossil fuels are depleted, some believe that we should exploit fossil fuels to their maximum potential in order to make the transition to a renewables economy more gradual, keep energy prices down in the short run, and buy time for the research and development of alternative energy sources. The Bush administration and other conservatives have periodically made calls for allowing oil drilling in currently protected areas such as the **Arctic National Wildlife Refuge (ANWR)** in Alaska and various offshore sites, but as of yet the bans remain in place. Opponents of desperation efforts to increase fossil fuel production feel that the short term benefits of these measures do not justify their potential long-term environmental impact. How we handle our remaining fossil fuel resources as their global supply is depleted will be of key importance for the transition period that is bound to accompany any energy revolution.

Coal

Coal is unique among the three major fossil fuels in that the world's current coal reserves do not appear to be nearing depletion. Since the United States has vast coal resources, many have proposed that coal be given a greater share of energy production as we phase out other fossil fuels while researching renewable energy sources. A little less than half of the electricity consumed in the United States is currently derived from coal, with this figure having room to rise significantly if desired. However, increasing the use of coal presents serious drawbacks. Burning coal releases both carbon dioxide and other greenhouse gases that contribute to global warming as well as pollutants such as ash. Mining coal is a very dangerous human activity and interferes with the environment, primarily by altering groundwater and water table levels. The dangerous emissions from coal energy production can be reduced by about 77% with the application of cutting-edge "clean coal"

technology, an umbrella term which can involve purifying coal before burning, treating released gases immediately after combustion to eliminate sulfur dioxide, and removing carbon dioxide from the emissions via carbon capture techniques. Unfortunately, cleaning coal is very expensive. Multiple agencies claim that for clean coal to have any substantial impact on global climate change, the total investment would have to be several tens of billions of dollars over the next ten years.

turbine—*a machine having a rotor that moves due to moving water, wind, etc.*

President Bush supported clean coal technologies and President Obama has included $3.4 billion of clean coal funding in the American Recovery and Reinvestment Act of 2009, largely in the form of carbon capture demonstration projects. Critics of clean coal claim that the very term "clean coal" is an oxymoron, because even the process of extracting coal from the Earth is itself environmentally dangerous. Others are simply turned off by the high cost. Nevertheless, clean coal represents a compromise between maximizing the potential of remaining fossil fuels while showing concern for the environment.

Solar Energy

The potential for solar energy production is virtually unlimited and has almost no discernible environmental impact. The primary obstacle of solar electricity production is the high cost of semiconductor materials like silicon which are necessary to make photovoltaic cells. Over time, solar panel technology has become cheaper and more efficient and with more research the hope is that this trend will continue. One of the newest advances in solar energy is concentrated solar energy, a concept in which a setup of lenses and mirrors is used to focus sunlight intensely on one or more photovoltaic cells to increase its output. The potential supply of solar power is huge; covering merely 4% of the world's deserts with solar panels would meet the world's electricity demand. A key challenge of solar power has been devising ways to store power for use during the night or at times of weaker sunlight and for transportation to less sunny areas. One way this is done is by storing solar energy as heat, which can later be used to turn water into steam and drive **turbines**. In many climates, solar hot water devices are used in addition to photovoltaic cells to provide all the hot water needed for individual buildings. These systems cycle the building's water supply through heating tanks on the roof that feature a transparent top and a dark, sunlight-absorbing bottom. Solar hot water has proven effective in all but the coldest climates, functioning at latitudes as high as northern Canada.

Historically, the United States has lagged behind other parts of the world in solar energy production. Japan and Europe have taken the lead in photovoltaic cell production while Israel and Spain derive a comparatively high portion of their energy consumption from solar energy, with both countries requiring solar hot water systems in new buildings

and Spain even requiring solar electricity generation in most new buildings. 2008, however, was a tremendous year for solar energy in the United States, with the nation's solar energy capacity growing by 17% year on year. Large-scale solar power plants are becoming commonplace, and the Solar Energy Generating Systems (SEGS) facility in California's Mojave Desert is currently the largest solar power plant in the world in terms of power generation. There is still great room for growth in solar energy production, however, especially at the level of the individual building. Finding cost-effective ways to take advantage of this abundant renewable resource will be a primary challenge in the decades to come.

aesthetics—*concerns dealing with appearance rather than functioning*

Wind Energy

Like solar, wind energy has no significant environmental impact and, compared to our ability to develop it, is an essentially unlimited resource. Support for wind power in the United States and the rest of the world has been consistently high, and wind power capacity is growing rapidly. In 2008, the United States led the world for the first time in installation of wind power capacity. Currently, we are second to Germany in total wind power generation. Wind power is being produced in several modes: at large wind farms, on small scales, and recently through offshore turbine facilities. Given the large size of the United States and the favorable conditions for wind energy generation particularly in the Great Plains but also in many other areas of the nation, the overall contribution of wind power could rise substantially in the coming years from its currently meager contribution of just over 1% of total electricity production. The primary obstacles standing in the way of wind power are cost and **aesthetics**. Wind turbines, although much cheaper and more efficient than they were two decades ago, are expensive and usually do not recover their installation cost until at least ten years of operation. The aesthetic effect of wind turbines is another consideration, as many people simply don't want turbines on or near their property. A major factor that has delayed construction of the Cape Wind offshore wind farm in Nantucket Sound, Massachusetts has been its proximity to valuable seaside real estate on Cape Cod. United States policy currently provides a small tax credit for each unit of wind energy produced, with some states offering further incentives such as property tax exemptions for wind power capacity installation. Other proposals to encourage wind power have included granting simple loans for wind turbine installation that can be paid back in time by the power the turbines produce.

Hydroelectric Power

Up until now, hydroelectric power has been by far the most successful renewable energy source, providing approximately 20% of the

world's electricity and accounting for roughly 88% of electricity produced from renewable sources. Some countries produce nearly all their electricity through hydroelectric power, such as Norway (98% of total electricity) and Brazil (86%). The United States, however, relies on hydroelectric power for only 6% of its electricity generation. While dams are expensive to build, they recover their cost rather quickly, often in less than a decade. The primary drawback of hydroelectric power is that the dams can have significant negative environmental consequences on surrounding aquatic **ecosystems**. Water flowing downstream from a dam is often warmer and lacking in sediment compared to pre-dam water, changing the characteristics of the river habitat and in some locations preventing natural freezing processes from occurring. Near the Atlantic and Pacific coasts, dams serve as an obstacle for salmon trying to reach spawning grounds upstream, even when fish ladders are used to mitigate the effect. A growing area of hydroelectric research deals with design strategies to limit the environmental impact of dams. Hydroelectric power definitely has potential to be a larger contributor in the United States but, as elsewhere in the world, eventually the number of sites suitable for dams will decrease, setting an upper bound on its potential.

ecosystem—*a group of organisms who live in the same area and depend on each other*

fermentation—*when a small organism breaks down a substance to create other substances such as alcohol*

Biofuels

Biofuels describes a diverse category of fuels derived from living or recently lifeless biological material. Usually the term refers to agrofuels, which are obtained from plants. There are essentially two strategies currently utilized to produce agrofuels. One is to convert plant matter high in sugar or starch, like sugar cane or corn, to ethanol via yeast **fermentation**. The other is to extract vegetable oil from plants like soybeans and turn it into biodiesel. Biofuels have been the subject of much recent debate. One issue critics often point to is the relatively low energy production capability of biofuels compared to the input energy needed to produce them. Depending on the particular crop, producing a biofuel might require more energy than the biofuel will ultimately be able to generate. A contentious debate is the "food vs. fuel" debate, in which opponents of biofuels point out that using edible crops for fuel removes the crops from the global food supply, and that increased demand for those crops raises their price. Next-generation biofuel research hopes to devise a way to turn the cellulose of crops—the non edible parts—into fuel and to efficiently obtain biofuels from offshore algae farms, a prospect that has many biofuel advocates particularly excited.

Tidal Power

A renewable energy source that has not been exploited to a significant extent but is receiving serious consideration for the future is

tidal power, which places turbine generators off coastlines and converts tidal movements into energy. The biggest reason for the relative lack of tidal power facilities at present is the high capital cost of installing a tidal power generator. The relatively long payback period also prevents investors from participating in the development of tidal power. Environmentally, tidal facilities may alter sandbanks, affect water salinity, and disrupt habitats directly during the construction phase. Nevertheless, tidal power is another virtually inexhaustible resource and is certainly a viable option for the future.

radiation—*energy given off during a nuclear reaction. Can be extremely harmful to any person exposed to it.*

Nuclear Energy

Until a few years ago, nuclear power seemed to have fallen out of favor in the United States, with the vast majority of our current nuclear power plants having been built in the 1970s and the last functioning nuclear facility in 1996. Now, with the energy crisis worsening and the number of efficient alternative energy sources proving limited, nuclear energy has re-entered the spotlight, as demonstrated by the passing of the Energy Policy Act of 2005, which authorized the construction of a new generation of nuclear reactors. Nuclear power produces 19% of the electricity in the United States, a significant contribution but lagging far behind figures like 78% in France. Nuclear energy has the potential to supply a large portion of our electricity needs should we want it to. Like some of the other energy alternatives, however, it has its share of drawbacks. Nuclear fission creates dangerous radioactive waste that must be deposited, at great expense, at remote waste facilities. Should a nuclear power plant malfunction, the impact could be devastating. The infamous Chernobyl disaster that occurred when a Soviet nuclear power plant melted down resulted in a massive radiation release over almost all of Europe, more than fifty deaths directly due to the accident and thousands more due to the effects of **radiation** exposure, the evacuation of hundreds of thousands of people, and the area in the vicinity of the plant becoming virtually uninhabitable. Not surprisingly, most people in the United States are not clamoring for a nuclear facility in their backyards.

Nuclear fusion power is seen as an investment for the future; but some scientists, including those involved in the aforementioned ITER project, believe that recent advances in plasma physics mean it could be a viable option sooner than we think. The advantage of fusion over fission is that it would produce more energy, not produce radioactive waste as a byproduct, and, according to projections, be less susceptible to catastrophic failure.

Questions a Bill Should Address

How serious is the United States' current energy situation? Should we continue to use fossil fuels until they are depleted, or do we

aim to diminish their use as quickly as possible? To what extent should environmental considerations dictate American energy policy? Should we prioritize investment in currently operating alternative energy sources, or should we invest in research and development of longer-term but potentially more effective options? Of the renewable energy sources now gaining in popularity, which should we emphasize? What balance between government initiatives and private sector development should we aim to achieve? How can the government properly encourage renewable energy?

Summary

The issue of energy innovation is one of the key issues for the United States and the world in the 21st century. A lasting solution to the problem of dwindling fossil fuels and their effects on the environment will have to come in the form of an energy revolution. As senators, it is your duty to legislate sound and feasible energy policy for the United States that will represent a major step in the right direction and a commitment to the issue at hand.

Guide to Further Research

Innovations in energy are certainly hot topics in today's world. Check out the below links to get a further grasp on the topic as it is quite complex. A comprehensive knowledge will only make your proposed bills stronger! Good luck!

http://www.nytimes.com/pages/science/earth/index.html

Look at major newspapers for the latest headlines concerning energy and the environment. The above link is to *The New York Times* environment page, which has links to the latest findings, the Dot Earth Blog, and so much more!

http://belfercenter.ksg.harvard.edu/publication/765/energy_innovation_imperative.html

The Belfer Center for Science and International Affairs at Harvard's Kennedy School of Government publishes many academic papers and reports. The above link is to one such journal article, entitled "The Energy Innovation Imperative: Addressing Oil Dependence, Climate Change, and Other 21st Century Energy Challenges" by John Holdren. Explore the website for more articles concerning energy!

http://www.npr.org/templates/story/story.php?storyId=103631430

The above link is to a ten-part series entitled "Could Energy Innovation Create A 'Green Bubble?'" by Jeff Brady from National Public Radio. Take a listen and peruse the website for more energy related news!

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