H.R. 1945: Energy for our Future Act
"To improve energy efficiency in the United States"

Columbia University
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Executive Summary

Fossil fuel electricity production in the United States has, and will continue to have, detrimental effects on public health and the environment. Yet Americans increasingly have a voracious appetite for electrical power. In 2005 alone, 4,103,484 megawatt hours of electricity were consumed, and approximately sixty seven percent of that electricity was produced by way of fossil fuel combustion. Of the total fossil fuel consumption, coal represented seventy six percent (EIA, 2007). As Americans become more reliant on electronics the demand for electricity is expected to rise. Currently, only 8.8 percent of U.S. electricity production comes from renewable sources. Our heavy reliance on non-renewable forms of energy is becoming more and more problematic because resources are finite; once depleted they cannot be replaced. Furthermore, in addition to producing power, they create polluting emissions—Carbon Dioxide (CO_2), Sulfur Oxides (SOx), Nitrogen Oxides (NOx), and heavy metals—that are negatively impacting the environment and are harmful to human health. A shift towards renewable energy generation is crucial at this point in time, especially with the reality of climate change.

To address and mitigate these problems, the House of Representatives has proposed The Energy for Our Future Act - House Resolution 1945 (H.R. 1945). H.R. 1945 provides legislation to promote renewable energy production, such as solar power, and encourage energy efficiency.

The most prominent goal of HR 1945 is to reduce the overall amount of non-renewable fossil-fuel energy consumed by the U.S. population, and also shift remaining energy production towards clean, renewable sources, thus resolving environmental problems while promoting energy efficiency. There are a number of ways HR 1945 sets out to accomplish this, but the most significant is removing fossil fuel subsidies and establishing a renewable electricity generation requirement for utilities. This stipulation directs the Secretary of Energy to require that 20 percent of electricity produced be from renewable resources by the year 2020, establishes a Carbon Dioxide Exchange Market, and creates a system of subsidies for solar electricity generation. The key measure of success for the bill is to drive down per unit production costs to a point where renewable energy is cost competitive with non-renewable energy production by 2015.

Currently, less than 0.1 percent of energy used in the United States is provided by solar power. Industrial applications of solar energy have the potential to meet a higher percentage of our current energy need. According to the Energy Efficiency and Renewable Energy division of the Department of Energy: "The solar energy resource in a 100-mile-square area of Nevada could supply the United States with all its electricity (about 800 gigawatts) using modestly efficient (10 percent) commercial [photovoltaic] modules."

Thus, the controversy surrounding solar technologies stems from the question as to why a greater percentage of vastly accessible, free, clean, and renewable incoming solar radiation is not being captured and converted into energy applicable to meet all the domestic U.S. electricity needs. The answer to this question is multifaceted; however, an analysis of the science reveals that it is mainly a matter of technological feasibility on a large and reliable scale.

Therefore, it is probably more appropriate to suggest that the issues that surround the application of solar energy are less of a controversy and more of a continuum concerning the advancement of solar technology. It is fair to suggest that solar energy suffers from a public perception problem – or a lack of confidence in the technology - which has aided in stifling the adoption of solar energy on a larger scale.

Introduction: Trends in Electricity Use

Collectively, Americans have a voracious appetite for electrical power. In 2005 alone, 4,103,484 megawatt hours of electricity were consumed (EIA, 2007). As Americans become more reliant on electronics this need is expected to rise. The largest consumer of electrical power is, and will continue to be, the commercial sector, where demand is projected to grow by 63 percent from 2005 to 2030.

The second largest consumer of electric power is the residential sector, where demand is projected to grow by 39 percent from 2005 to 2030 (EIA, 2007). Population growth and increased disposable income is expected to spur demand for services and products that will, in turn, increase the demand for the energy to power the products and appliances used by residences and businesses, as well as heat and cool spaces. While the idea of energy efficiency is beginning, over the last five years, to gain more of a foothold in homes and businesses, there remains a lot to be desired: for instance, it is estimated that half of the energy used by consumer electronics is actually consumed while the products are turned "off". (EIA, 2007)

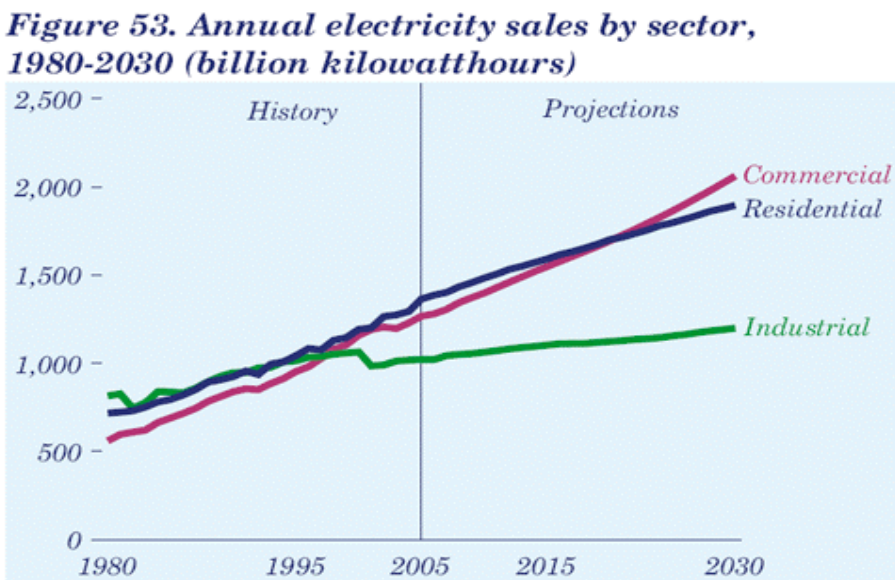


Figure 1: Commerical, Residental, and Industrial electricity sales from 1980-2030

Source: Energy Information Administration

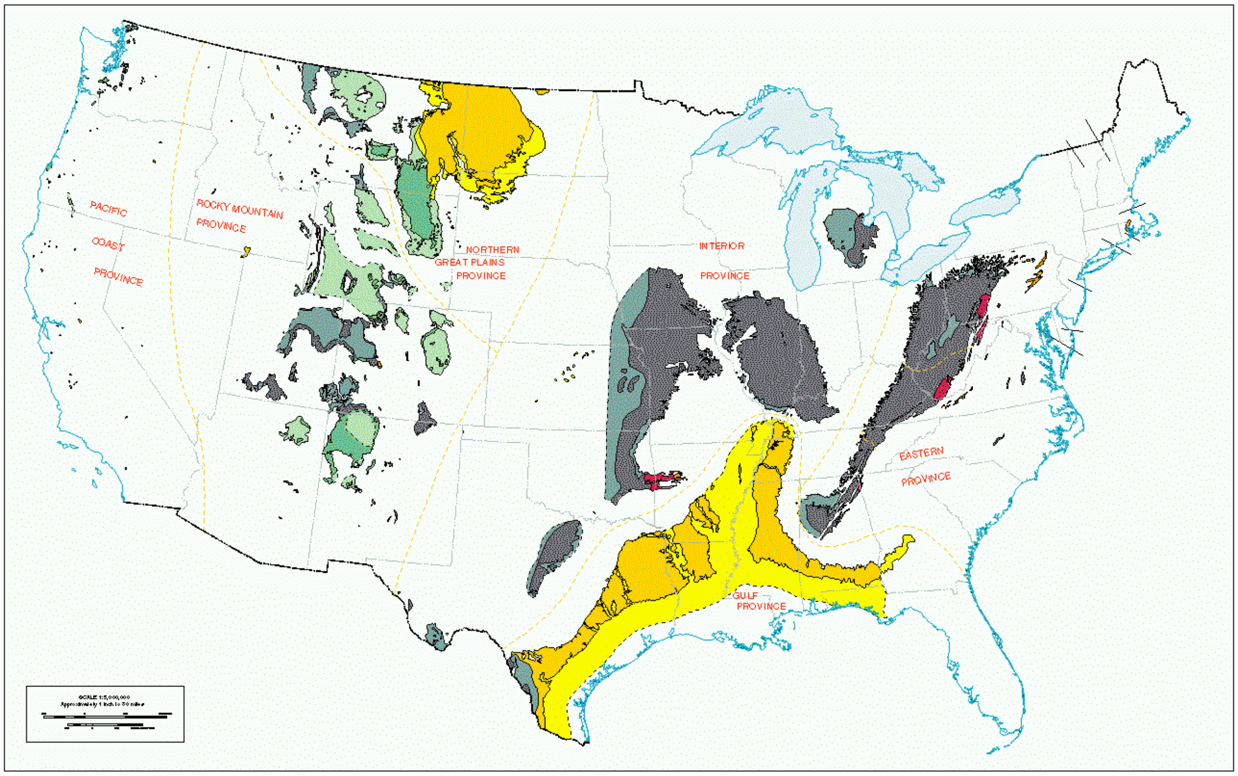


Figure 2: Remaining coal reserves in the United States
Source: USGS

Currently only 8.8 percent of U.S. electricity production comes from renewable sources, such as solar; the rest is produced from non-renewable sources, such as coal. These non-renewable forms of energy are problematic because resources are finite; once depleted they cannot be replaced. If production and consumption patterns remain the same as the year 2000, it is estimated that coal reserves in the US would last for approximately 255 more years. This, however, is a mischaracterization of how much coal the United States can actually rely on. There is an inverse relationship between coal use and projected availability. For instance, if we use more today than we calculated yesterday the reserve estimates would decrease unless either new reserves are found, better extraction techniques are discovered, or we stop using coal. Because we are accelerating our coal consumption every year, previous coal reserve estimations become inconsequential.

In addition to producing power, non-renewables such as coal create polluting emissions—Carbon Dioxide (CO_2), Sulfur Oxides (SOx), Nitrogen Oxides (NOx), and heavy metals—that negatively impact the environment and are harmful to human health. Also, combustion of fossil fuels, such as coal, constitutes one of the largest anthropogenic contributions to global warming. A shift towards renewable energy generation is crucial at this point in time, especially with the reality of climate change.

The Energy for Our Future Act, also known as H.R. 1945, aims to reduce environmental and health problems by helping to make the widespread use of renewable energy, in particular solar power, a reality. This report focuses on solar power because it shows the greatest potential for development of efficiency and widespread use. It was also allocated the largest amount of funds in the Act - a total sum of $800 million for research and development grants through to 2012.

Problems with Current Electricity Generation and Consumption in the United States

The Environmental Impacts of Coal Extraction and Combustion

Electricity consumption is a necessary and important aspect of life in the United States. However, many Americans do not stop and think about where the electricity that lights and powers their homes is coming from, or how it was generated. In fact, the United States consumes more electricity than any other country in the world – and this electricity is generated predominately by burning fossil fuels. In 2007, approximately 72 percent of all electricity will be produced from fossil fuel combustion, with almost 50 percent attributed to coal (EIA, 2007).

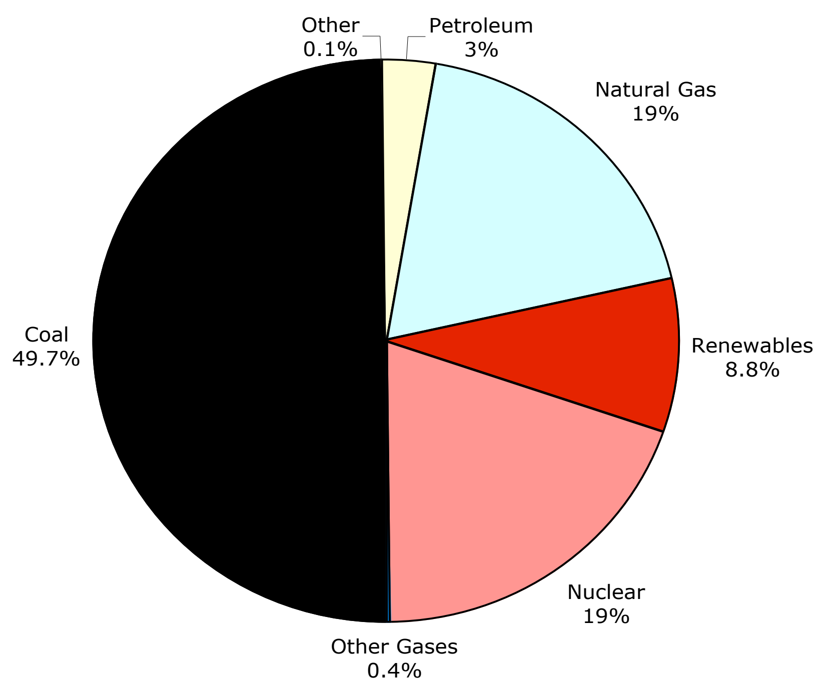


Figure 3: 2007 Electric Power Generation by Fuel Source
Source: Energy Information Administration

According to the Clean Air Task Force, a staggering nine hundred million tons of coal are burned each year by about 600 plants to generate electricity (Keating, 2001). In a typical year, the average coal plant in the US generates 3,700,000 tons of carbon dioxide (CO_2), 10,000 tons of sulfur oxides (SO_x), 10,200 tons of nitrogen oxides (NO_x), 720 tons of carbon monoxide (CO), 170 pounds of mercury, 225 pounds of arsenic, 114 pounds of lead, and 220 tons of hydrocarbons (Union of Concerned Scientists).

The environmental impacts and human health risk associated with the extraction and combustion of coal are substantial, and will continue to be substantial as long as electricity is being produced from these sources. Each step in the process of generating electricity from coal has health related and environmental ramifications, from increased rates of asthma and respiratory illness, to degradation of ecosystems, to global warming. To fully appreciate the extent to which the coal industry affects the environment and human health, this report offers a brief analysis of how coal is extracted from the environment, combusted to generate electricity, and releases by-products of that combustion into the environment.

Coal is extracted through two main methods: surface mining and underground mining. Whereas both of these methods pose devastating impacts to the environment, surface mining is highly visible, while contamination and pollution associated with underground mining operations is less obvious. A surface mine is created by stripping away the top layers of soil and rock in a given location to reach the coal beneath. A typical surface mining practice is mountaintop removal, which involves blasting the top of a mountain off, dumping the excess sediment into nearby valleys and stream beds, and mining for the resources below (PBS). While reclamation projects eventually replace the blasted mountaintop, restoring the site to its original state is nearly impossible due to loss of species and ecosystem damage (Keating, 2001).

Underground mining has undesirable effects as well. Environmental impacts include contaminated surface runoff from material removed from the mine, and contaminated groundwater. If a mine bisects the water table, the result can lead to groundwater acidification. Highly acidic water dissolves heavy metals from its surroundings and becomes toxic to aquatic life and harmful to humans.

The health impact to miners is also an issue. Coal dust and prolonged exposure to other toxins associated with the processing of coal can lead to severe respiratory problems such as asthma, bronchitis and black lung disease (Keating, 2001).

Combustion of coal poses another set of environmental and health risks. The burning of coal emits a myriad of chemical pollutants that are harmful to the environment and to humans, including sulfur oxides, nitrogen oxides, carbon oxides, heavy metals, volatile organic compounds and particulate matter (Keating, 2001). The environmental impacts of these pollutants include: acid rain, ground level ozone (smog), biomagnifications of toxins such as mercury, and the greenhouse effect. The areas that are most directly affected by these pollutants can be local, however many of these pollutants also travel downwind from the source.

In order to understand the environmental impacts of coal combustion, one must consider the life cycle of coal. As shown in figure 4, the original source for the energy contained in coal is energy (electromagnetic radiation) from sunlight. Plants convert sunlight energy and carbon dioxide (CO_2) into plant matter (carbohydrates) and oxygen. The energy from sunlight reacts with water (H_2O) and carbon dioxide (CO_2) to produce the plant matter, which is also known as carbohydrates or glucose ($C_6H_{12}O_6$) and oxygen (O_2). The energy from sunlight catalyzes the formation of the additional bonds that are formed in the chemical composition of carbohydrates (plant matter). Therefore, the energy or sunlight is stored in the chemical bonds of plant matter.

After these plants die, the natural forces of decay, time, temperature, and pressure at and below the earth's surface convert plant matter into a dense, energy rich material known as coal (The Quest 2007).

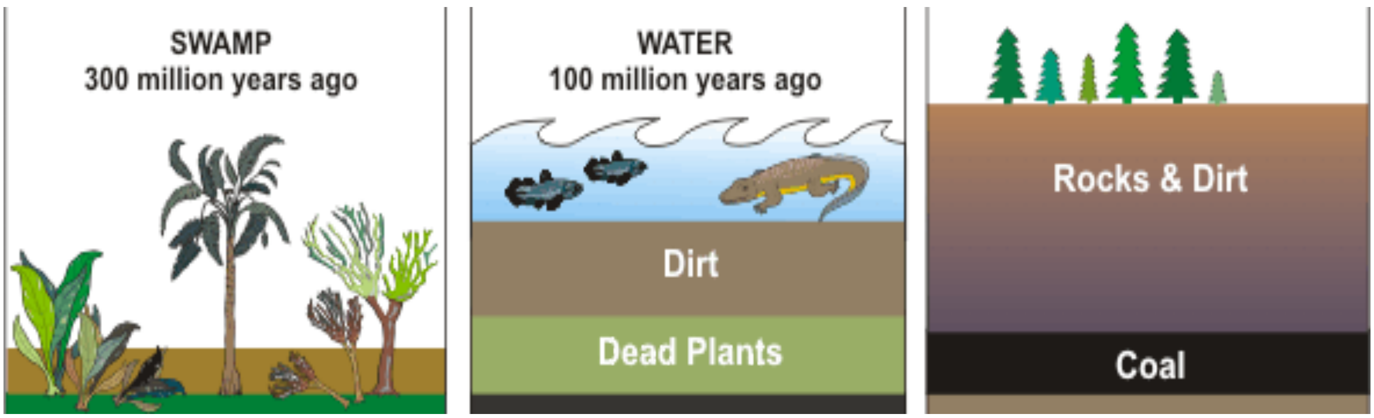


Figure 4: The Conversion of Plant Matter to Coal
Source: DOE

The potential energy stored in the chemical bonds of this dense, energy rich material is converted to electricity in coal-fired power plants. A schematic of a classic coal-fired power plant is displayed below in figure 5.

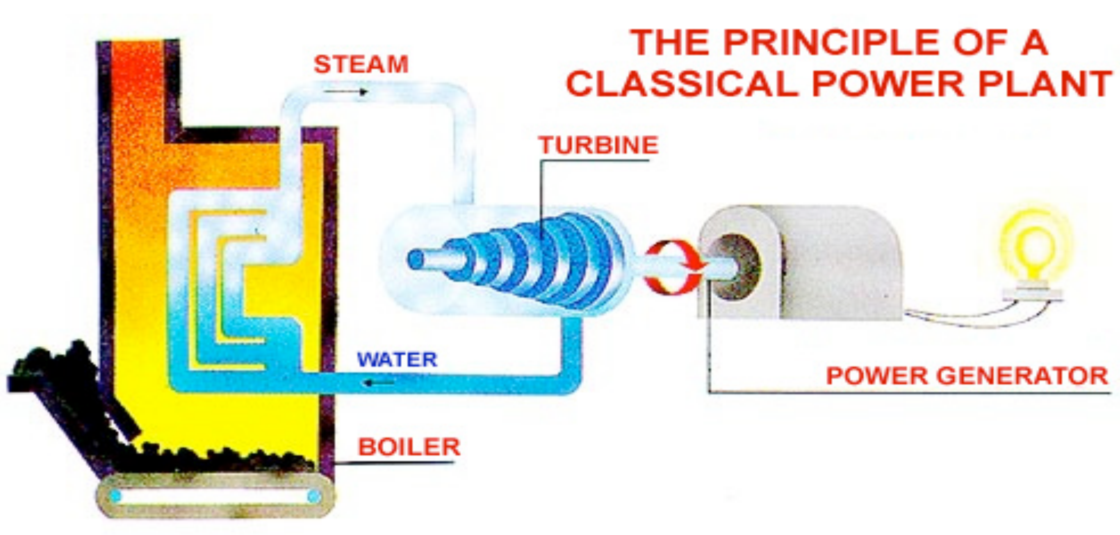
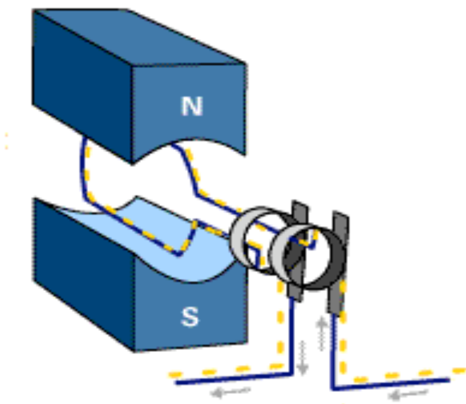


Figure 5: Schematic of a Classical Coal-Fired Power Plant
Source: Slovenské elektrárne



Coal is ignited and partially combusted in boilers, producing carbon dioxide (CO_2), water (H_2O), and energy in the form of heat. The heat warms water within pipes and creates steam, which has kinetic energy (energy of motion). The kinetic energy of steam confined in the volume of the pipes exhibits a force and pressure, which is channeled to act on the blade of turbines, causing them to rotate. A shaft connects the turbine on one end with a wire loop on the other end. The wire loop is contained within a magnetic field. This portion of the power plant is known as the electrical generator. The shaft that connects the turbine and the wire loop transfers rotation to wire loop, resulting in a flow of electrons through the wire (electricity).

Figure 6 : Schematic of an Electric Generator
Source: PBS: American Experience: Edison's Miracle of Light.

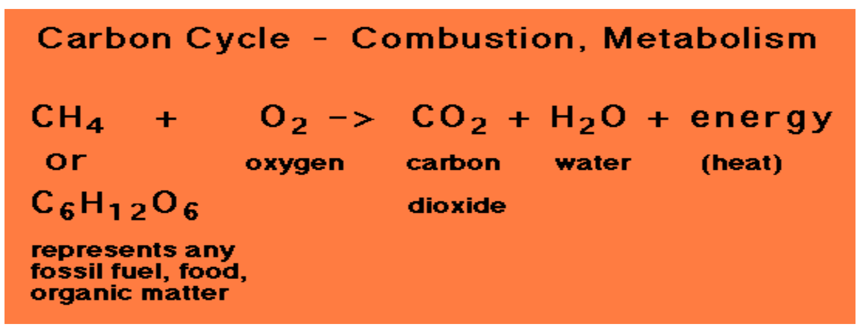


Figure 7 : Combustion Reaction of the Fossil Fuel Coal

Source: Virtual Chembook Elmhurst University

Coal Emission Environmental Effects

In the United States, approximately two-thirds of all sulfur oxides ($SO_{x)}$ and one-quarter of all nitrogen oxides ($NO_{x)}$ come from electric power generation through the burning of fossil fuels, like coal (EPA Acid Rain 2007). SO_x and NO_x emissions enter the atmosphere in gas or particle form. Once in the atmosphere, these emissions can either deposit directly into the environment through dry deposition or they can combine with water vapor in the atmosphere to form acidic rain ($SO_2 + H_2O = H_2SO_4$). Acid rain greatly alters the areas on which it falls by raising the acidity of fresh water bodies to the point where they can no longer sustain fish and plant life. Furthermore, acid rain contributes to the leaching of nutrients from soils and the defoliation of trees. Loss of trees and vegetation is particularly important because of their role in producing oxygen and filtering carbon dioxide from the atmosphere. An example of the effects of acid rain is the New Jersey Pine Barren Streams. The EPA declared that greater than 90 percent of the New Jersey Pine Barren Streams are acidic, which is the highest rate in the nation (EPA Acid Rain 2007). In the Pine Barren, as in other affected ecosystems, individual plants, animals, and other organisms are adversely affected by these pH changes. Although some species are more sensitive to pH changes than others, a cascading effect throughout the ecosystem can be triggered when just one or more species are adversely affected. Since ecosystem connections exist between fish, plants, and other organisms, acid rain poses serious risks for biodiversity.

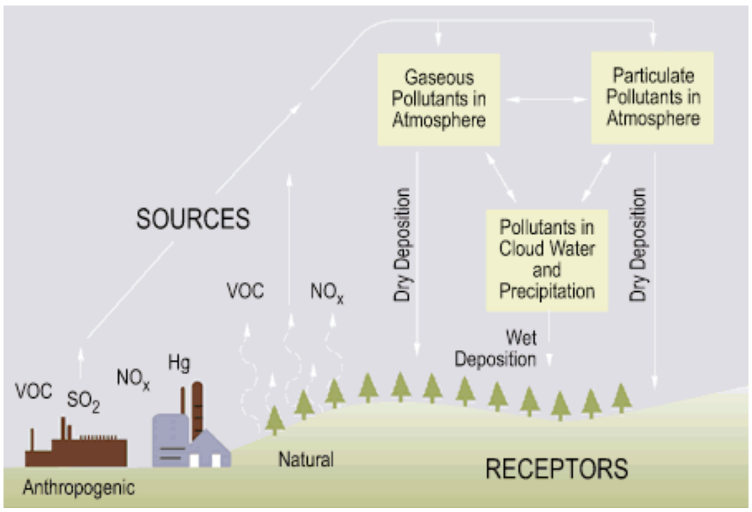


Figure 8 : The Effects of Coal Emissions in the Environment
Source: The Environmental Protection Agency

To limit the ecological effects, hazardous emissions can be trapped or "scrubbed" from the smoke stacks of coal power plants, reducing emissions of sulfur dioxide by 99 percent and mercury by 90 percent. However, the issue of what to do with the exhausted scrubbers still remains. If the coal waste cannot be properly disposed of, we are only creating a transfer of waste from one waste stream (air) to another (land/water) (Keating, 2001). Steps have been taken to reduce emissions from fossil fuel emitting power plants, but ensuring that those wastes are properly disposed of in effectively lined landfills is a key factor in determining the effectiveness of the air pollution reducers. If the pollutants can seep back into the environment after they have been removed from the air, nothing has been done to mitigate their harmful effects. Most importantly, scrubbers have no impact in reducing carbon dioxide emissions, one of the world's most potent and pervasive greenhouse gases (meaning that it is efficient in trapping heat from incoming solar rays and well as heat that is emitted from the earth's surface). In a recent decision on April 2, 2007, the Supreme Court ruled that carbon dioxide was, in fact, a pollutant, thus opening a door for the Environmental Protection Agency to begin regulating those emissions under the Clean Air Act (Hogue). A drastic increase in carbon dioxide levels in the earth's atmosphere over the last hundred years has caused a gradual elevation in average global temperatures. This rise is expected to trigger various impacts such as sea level rise, increased loss of biodiversity, decreased albedo due to the melting of the polar icecaps, heat waves, increased incidences of forest fires and extreme weather (such as hurricanes), and disrupted ocean currents.

Coal Emission Public Health Effects

The emissions from coal combustion that affect the environment also affect public health. SO_x and NO_x can cause respiratory illness and can lead to premature death; particulate matter can produce respiratory and/or cardiovascular disease; and trace elements (i.e. mercury) can cause mild to severe toxic effects (Keating, 2001).

The role of sulfur oxides in the formation of acid rain has been discussed above. Additionally, they have been proven to cause respiratory dysfunction and illness in susceptible populations, such as the elderly and children. Nitrogen oxides interact with volatile organic compounds in the air forming ground level ozone also known as smog ($N_2 + O_2 = 2NO$; $NO_2 + O_2 = O_3 + NO$). In addition to being visually unpleasant, surface ozone causes respiratory damage after prolonged exposure. Nitrogen oxides have also been linked to increases in susceptibility to respiratory problems. (Keating, 2001).

Approximately 2,000 to 3,000 tons of mercury are released into the atmosphere each year by human activities, such as fossil fuel combustion (EPA Mercury, 2007). Mercury is converted to methyl-mercury, a highly toxic form of mercury, by microorganisms in soil and water. This toxic form of mercury commonly bioaccumulates in fish species up the food chain. (EPA Mercury, 2007). Human ingestion of fish that contain methyl-mercury can produce a number of toxic effects and damages organs or systems including the kidneys, the nervous system, respiratory system, and reproductive system (FDA, 2007). Scientific research has found that methyl-mercury in blood can combine with cysteine, an amino acid, forming a compound that is structurally similar to another amino acid, methionine (Mercury, 2007). Methionine is an important component in protein synthesis - specifically the protein synthesis in nerve cells. Interference in protein synthesis can affect protein structure, which can cause a cascading effect that can range all the way from cell damage to organ and system damage (Mercury, 2007).

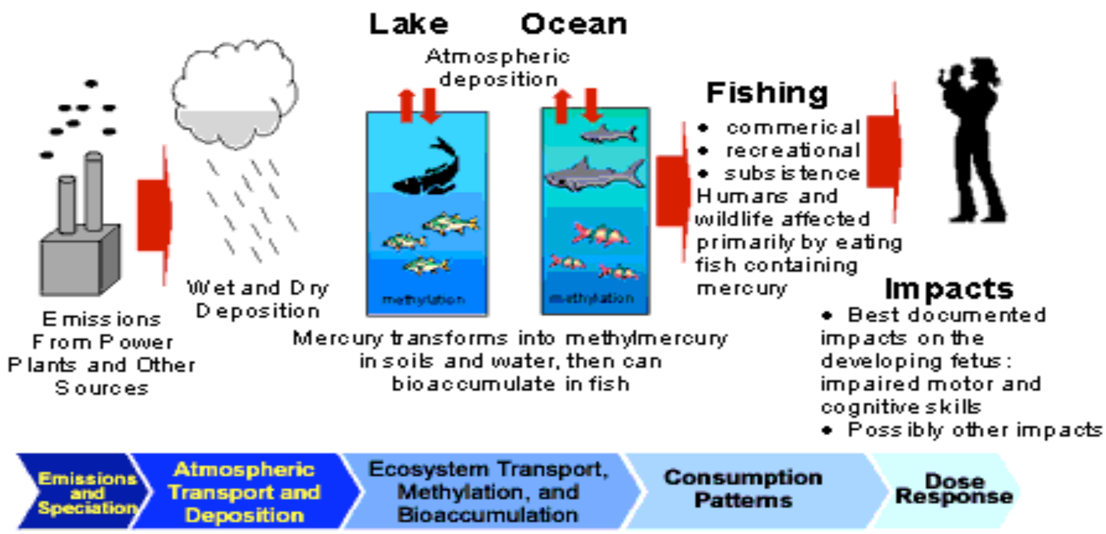


Figure 9 : The Pathway of Mercury from Coal Power Plants to Human
Source: Environmental Protection Agency

Another pollutant emitted from the combustion of coal is particulate matter. Particulate matter is dangerous because it can also cause damage to the lungs, and increase one's susceptibility to respiratory diseases such as pneumonia.

Reducing the amount of energy we use on a regular basis can help curtail the amount of energy needed from these sources. More importantly, a shift in generation from non-renewable fossil fuels to clean, renewable energy, such as solar, will not only supply us with the electricity we need but will help protect the environment from further degradation.

H.R. 1945: Proposed Solutions: Solar Power

The environment and public health of the United States continues to experience the negative affects of fossil fuel electricity production and consumption problems. To address and mitigate problems of this matter the House of Representatives has proposed The Energy for Our Future Act - House Resolution 1945 (H.R. 1945). H.R. 1945 provides legislation to promote renewable energy production and encourage energy efficiency.

Rep. Christopher Shays, a Republican from Connecticut, introduced H.R. 1945 on April 19th, 2007.[1] On May 8th 2007, the bill was referred to the subcommittee on Energy and the Environment within the House Science and Technology committee. The bill currently has 13 cosponsors, the majority of whom are Democrats.

[1] H.R. 1945 was originally introduced as H.R. 4384 during the 109th Congress (Dec, 16th 2005) but languished in committees and never came up for debate.

As stated in the text of the bill, the provisions in H.R. 1945 are aimed at reducing oil usage and emissions from cars, reducing electric energy usage in corporate or residential buildings, expanding renewable electricity production, shifting the price of fossil fuels production back to true market levels, and researching and developing (R&D) renewable energy technologies. Within H.R. 1945 there are more than $4.3 billion in direct appropriations allocated per year over the next five years. That figure does not include estimated loss of federal revenue for the many tax credits which the bill makes available to the public, or the increased revenue from the repeal of certain corporate tax-breaks. There would also be unspecified amounts of money (to be requested by the Secretaries of Transportation and Energy) for different programs, such as the National Tire Efficiency Program, a 5-year extension of tax credits to commercial renewable energy producers, new tax credits for private homes up to $6,000 each, and an R&D program for portable hydrogen fuel technologies.

This report focuses on investigating one of the most significant environmental problems addressed by the legislation, electricity production, and the proposed solutions with greatest potential for alleviation of those problems, specifically the shift from fossil fuel electricity production (in particular, coal) to renewables, (in particular, solar).

The most prominent goal of HR 1945 is to reduce the overall amount of non-renewable fossil-fuel energy consumed by the U.S. population, and also shift remaining energy production towards clean, renewable sources, thus resolving environmental problems while promoting energy efficiency. There are a number of ways HR 1945 sets out to accomplish this, but the most significant are removing fossil fuel subsidies and establishing a renewable electricity generation requirement.

Removing fossil fuel subsidies, or incentives, will have a dramatic and almost immediate impact. Fossil fuel subsidies work by lowering the production cost of coal electricity through means such as requiring assessments of federal lands to establish the location of coal deposits, directly paying a portion of research, development and/or production costs of new "clean" coal plants, paying for research into carbon sequestration, or providing tax credits to producers. By lowering the cost of production, the federal government is essentially stoking demand for this "dirty" energy. Figure 10 below shows how lowering the output price of a particular good shifts the demand curve - in this case, coal-produced electricity. The x axis is quantity and the y is price. The line with the negative slope is the demand curve and the one with the positive slope the supply curve. The parallel lines show the impact of a subsidy on the supply curve, increasing the demand by lowering the price at a given quantity. As the subsidy level increases, the demand for the good continues to increase. This maximizes the amount of consumption of that good.

The other component of H.R. 1945 that is fundamental to the promotion of solar energy is the renewable electricity generation requirement, which establishes a number of important regulations. It directs the Secretary of Energy to require that 20 percent of electricity produced be from renewable resources by the year 2020. The renewable energy requirement also establishes a Carbon Dioxide Exchange Market and a system of subsidies for solar electricity generation.

The Carbon Dioxide Exchange Market works by establishing limits on carbon dioxide output. Each electricity producer, as well as members of other industries, is provided a certain amount of Carbon Dioxide "Credits". Unused credits can be sold at market prices to producers that have exceeded their credits. This increases the profits of producers that cut their carbon dioxide emissions. Electricity produced by renewable means, such as solar, are awarded Green Tags for every 1,000 kWh of power they produce. These Green Tags can be sold on the Carbon Dioxide Exchange, increasing the profits for solar producers by acting as a indirect subsidy for the solar electricity generation industry, and, in turn, promoting its expansion.

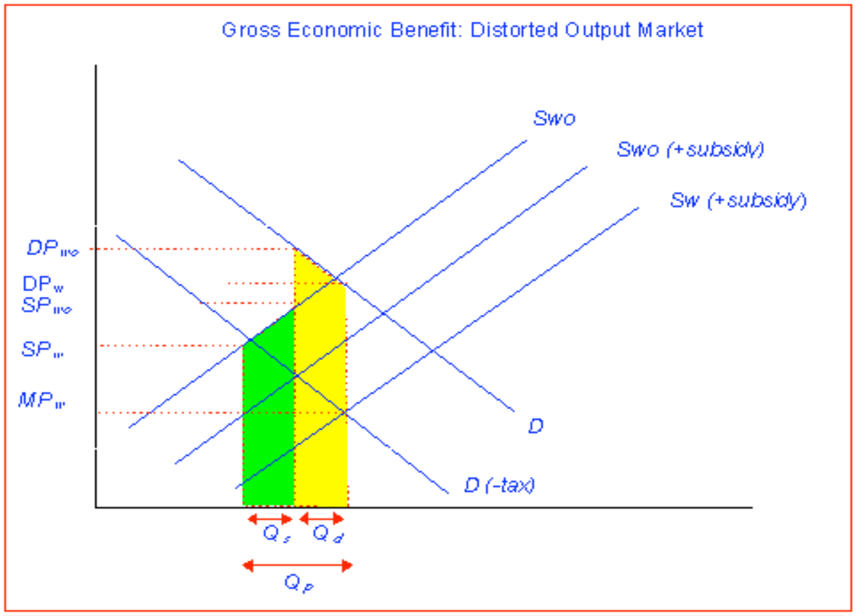


Figure 10: Gross Economic Benefit
Source:
http://www.adb.org/Documents/Guidelines/Eco_Analysis/graph5.gif

The renewable electricity generation requirement also establishes a number of subsidies for solar electricity production. The main subsidies are: extending tax credits for commercial solar energy producers from 2006 to 2012, extending tax credits for residential solar systems from 2007 to 2014, appropriating $650 million for commercial photovoltaic research and development and $800 million for States to demonstrate photovoltaic technologies. These subsidies effectively lower the consumer cost, while also lowering the production cost of solar produced electricity.

HR 1945, The Energy for Our Future Act effectively reduces our reliance on dirty coal power by eliminating fossil fuel subsidies and establishing a renewable generation requirement. The Energy for Our Future Act also promotes renewables, such as solar power, by lowering solar electricity consumer cost and increasing producer profits.

The Science and Controversies Associated with Solar Power

The research and development section of this bill will further facilitate technological advancements in solar energies. As solar technologies advance, the efficiency at which they operate will continue to improve. Efficiency refers to the percentage of energy from the sun that is converted to electricity with photovoltaic cells. Solar technologies are becoming more accessible to consumers and more applicable in industrial settings.[2] The initiative in H.R. 1945 is to make solar energy costs competitive with fossil fuels by 2015.

Photovoltaic (PV) Cells

In 1954, the first photovoltaic cells were introduced by scientists at Bell Laboratories. These cells operated at 4percent efficiency. Today, photovoltaic cells are performing at an average of 15 percent efficiency, but Boeing Laboratories has cells in the experimental phase that are performing at 36.9 percent efficiency. The energy payback time (i.e., the amount of time it takes for the photovoltaic cell to generate the amount of energy that was required to manufacture and produce it) for photovoltaics is, on average, 2.2 years. Given that cells can last up to thirty years, the average solar cell could produce 27.8 years worth of carbon neutral electricity (EERE "Photovoltaic Basics"; EERE "Solar History Timeline").

Precious or semiprecious metal are used to manufacture photovoltaic cells. Currently, most photovoltaic cells use silicon because it is relatively inexpensive and is a good semiconductor. Silicon is chemically altered usually by adding impurities, like other metals, to create a slightly negative electron field. Another layer of silicon is similarly altered to create a slightly positive field with spaces for electrons to flow. These two layers are placed together and covered with a layer of non reflective glass. As light from the sun penetrates the glass, the photons of light incite the negatively charged particles to move to the positive layer creating a current between the layers. The wire then channels the current out as electricity. A wire conducts the electrons from the system in the form of electricity.

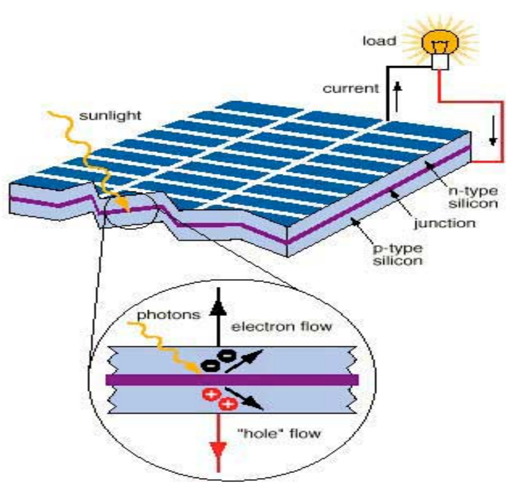


Figure 11: Inside a Photovoltaic Cell
Source: NREL

[2] Solar power usually refers to power produced by photovoltaic cells, but solar power also refers to solar thermal power and concentrated solar power.

Individual cells are electrically linked together to form modules, which are then connected to form panels, and then finally linked to form arrays. Arrays come in a variety of sizes for variability in application.

Emerging technologies, such as thin films, utilize more efficient metals like Cadmium-Telluride. These flexible sheets of photovoltaic cells have the potential to expand the applications of solar power(EERE "Thin Films").

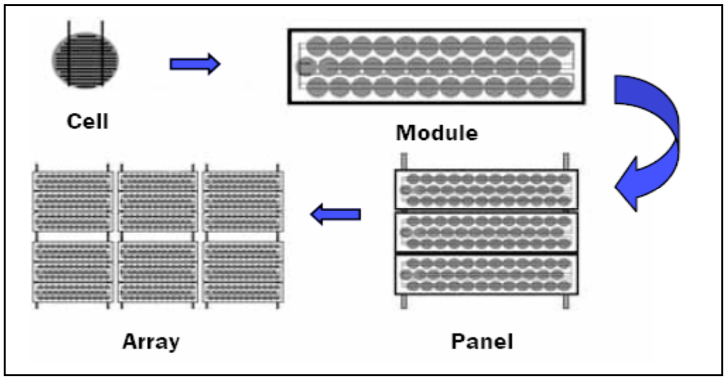


Figure 12: Production of Photovoltaic Arrays
Source: NREL

Solar Thermal Energy
Solar thermal energy is direct heating from the sun of a fluid, air or water. It is most commonly applied residentially. Active solar thermal systems involve the heating of a fluid from the sun and then *actively* pumping that fluid to a conventional heating system to be stored until use. Passive solar thermal systems do not contain a storage component and rely on convection to transport heat throughout the system—the heated fluid mixes with cooler air or water present in the system. Both types of thermal systems are coupled with traditional heating systems using natural gas or electricity. Integrating a solar thermal component with a traditional heating process can reduce the electrical consumption of a household by 80 percent (EERE "Solar Heating").

Concentrated Solar Power
Some Solar power plants use a thermal energy technology called Concentrated Solar Power (CSP), also known as parabolic troughs. CSP uses mirrors to concentrate the incoming solar radiation to heat a transfer fluid. The fluid is channeled out through conductive piping and then stored in a battery until use. A CSP plant exists in Nevada and powers about 10,000 homes. Realistically, CSP could provide up to 10 percent of our current energy needs, if utilized to its full potential (NREL).

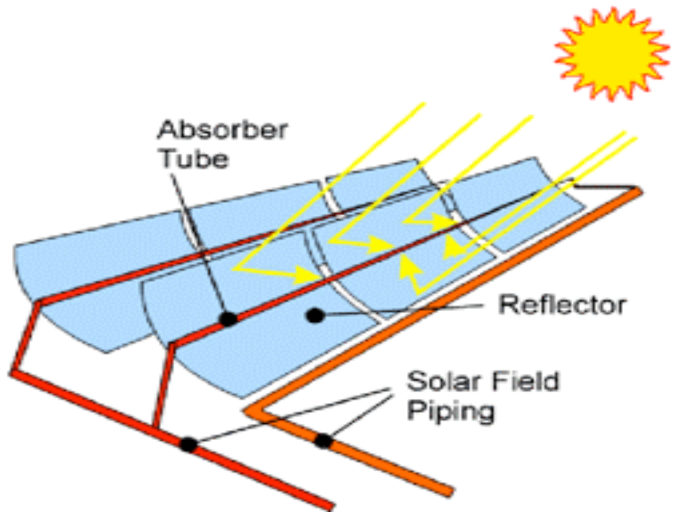


Figure 13: Concentrated Solar Power model Source: NREL

Scales of Use

One of the unique conveniences of solar energy is that it can be applied residentially, commercially and industrially. Photovoltaic cells can be applied to residential and commercial buildings by mounting them on roofs or choosing a convenient location on the ground. Newer forms of cells look like traditional roof shingles and can easily be incorporated to new homes during construction. The average cost of a residential photovoltaic system after rebates is $10,000, and can save the consumer over $400 a year in energy costs. Thermal solar systems are also available for residential and commercial buildings and typically appear similar to sky lights on the roofs of houses. (EERE "Solar Heating").

Currently, less than 0.1 percent of energy used in the United States is provided by solar power. Industrial applications of solar energy have the potential to meet a higher percentage of our current energy need. According to the Energy Efficiency and Renewable Energy division of the Department of Energy: "The solar energy resource in a 100-mile-square area of Nevada could supply the United States with all its electricity (about 800 gigawatts) using modestly efficient (10 percent) commercial PV modules." (EERE "Learning About Pv: The Myths of Solar Electricity") There are plans in place to build the world's largest photovoltaic plant in California. This solar farm will produce enough energy to power 21,000 homes and provide 80 megawatts of power.

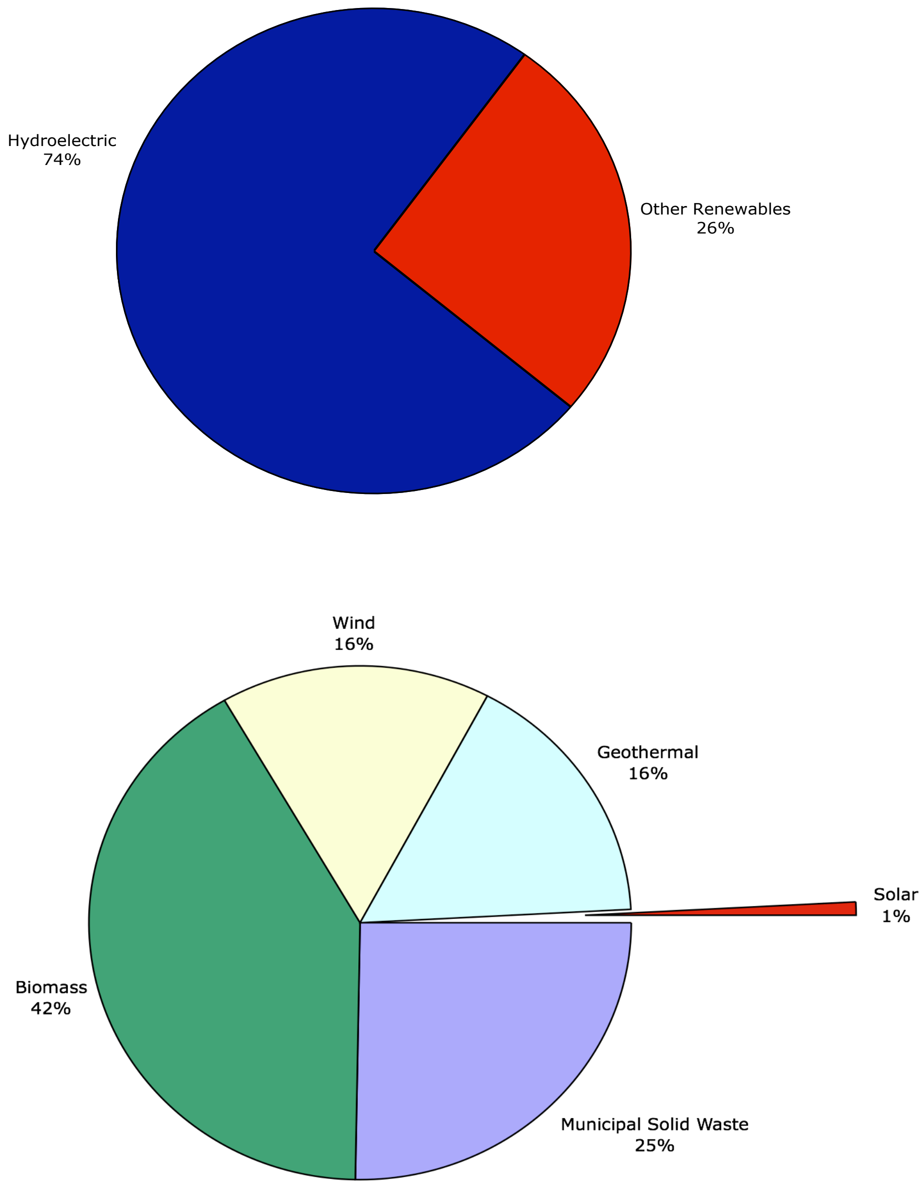


Figure 14: Percentages of Renewables in Electricity Consumption
Top: Ratio of all Renewables
Bottom: Breakdown of "other renewables" from top.
Soure: Energy Information Administration

Controversies behind Solar Power

In order to feasibly and cost-effectively achieve the goals of H.R. 1945, it is prudent to investigate the scientific controversies related to solar energy generation.

The amount of incoming solar radiation that is absorbed by the Earth is abundant: Every day the continental United States receives 500 times more incoming solar radiation than the total energy requirements of the entire nation (all sources – fossil fuels, electric, hydro, nuclear, and renewables: "Tidbits", NREL).

Currently, however, solar energy constitutes only 0.1 percent of the U.S. energy matrix. Thus, the controversy surrounding solar technologies stems from the question as to why a greater percentage of vastly accessible, free, clean, and renewable incoming solar radiation is not being captured and converted into energy applicable to meet all the domestic U.S. electricity needs – if not the needs of the entire planet. The answer to this question is multifaceted; however, an analysis of the science reveals that it is mainly a matter of technological feasibility on a large and reliable scale.

Therefore it is more apropos to suggest that the issues that surround the application of solar energy are less of a controversy and more of about the advancement of solar technology. In addition, it is fair to suggest that solar energy suffers from a public perception problem – or a lack of confidence in the technology - which has aided in stifling the adoption of solar energy on a larger scale.

The key issues concerning the current public perception surrounding the state of solar energy capture, conversion, and utilization are listed individually below:

Misperception #1: Solar is not sufficient to meet U.S. Energy Demands.
This is indeed true, but no single energy source can meet the entire energy demands of the U.S. Some forms of energy are better suited for certain applications than others; however, such reasoning does not dismiss the role that solar can play as a vital part of the domestic energy matrix. Because peak energy demands often occur during daytime hours, solar is optimally suited to supplement those periods and thus reduce potential strain on utility grids. According to the National Renewable Energy Lab (NREL), photo voltaics (PV) are expected to provide approximately 15percent (3.2 gigawatts) of "U.S. peak electricity generating capacity" required by 2030 (NREL).

Misperception #2: Solar is not practical for reliable deployment.
A common public misconception is that solar is not practical because it is not reliable due to issues concerning energy storage, inclement weather, and required land area for PV siting.

While it is true that during periods of darkness PV modules have no incoming solar radiation to convert to electricity, they can be connected to common lead-acid or lithium-ion batteries so that excess energy generated during daylight hours can be stored for use during periods of darkness. It is typical that residential customers are not home during daylight hours and thus it is common for PV systems to capture excess energy, which can then easily be stored for use when the residents return home in the evening. Care should be taken to properly dispose of the batteries when they have expired. For large-scale solar sites the energy would most likely be directly fed into the utility grid and thus energy storage would not be necessary.

Another concern is that snow and ice can limit, if not eliminate, incoming radiation to the PV module. This is a potential issue, since the PV cells must be clear and accessible in order to function. However, elements of their design usually eliminate this concern. Because the PV panels have a dark face and are usually mounted at a relatively steep incline, snow and ice have a tendency to melt and fall from PV units relatively readily. Other PV materials, such as thin-film PV – can be mounted on the vertical face of skyscrapers where it is nearly impossible for snow and ice to accumulate. For residential owners who still may find snow accumulation on their modules, they can be swept clean with a broom or some modules have heating units which ensure that snow or ice will not form on their surface.

Finally, at only an 10 percent energy conversion rate (average for most currently deployed PV units) enough electrical energy could be generated to meet the needs of the entire planet through six large-scale sites (placed around equatorial regions) averaging 151,670 km^2. For solely domestic purposes, the U.S would require 0.4 percent of a highly radiated land area, an equivalent of 100 km^2 (NREL). Such a relatively small land area would seem efficient (although not practical in terms of transmission, diversification, or security purposes) for use in domestic electricity generation in comparison to the infrastructure required to locate, mine, transport, and combust coal, as well upgrade plants and dispose of by-products.

Misperception #3: Solar is not efficient in comparison to other energy sources.
Currently, most PV modules in use achieve 7 to 17percent conversion efficiency. Traditional coal processes achieve 35percent conversion efficiency (PSU.edu) and newer integrated coal-gasification combined cycle units are expected to achieve 45 percent by 2010 (DOE). This is the challenge that solar technologies are up against – raising efficiency. It appears solar technologies have the potential to meet that challenge.

For perspective, by 1980 the PV peaked under 10 percent whereas current multi-junction concentrators can achieve of a conversion efficiency of ~36percent (NREL). As of summer 2007 two new technologies have achieved similar, if not higher conversion efficiencies. The Defense Advanced Research Projects Agency (DARPA) is shooting to develop Very High Efficiency Solar Cells (VHESC) with a minimal 50 percent conversion efficiency. The University of Delaware and DuPont, under funding from DARPA, have recently achieved a conversion efficiency of 42.8 percent. Boeing's Spectralab has achieved conversion efficiency rates of 36.9 percent by adapting the design of a solar cell that was previously used for satellites and space missions. These units both achieve efficiency ratings that are competitive with traditional sources of electricity; the key to implementation requires building the technology to scale and at cost – a process influenced by subsidies. (Eurekalert & Boeing)

Misperception #4: Solar is not cost effective in comparison to other energy sources.
It is difficult to determine with any reliable degree of accuracy whether it is cost effective in comparison to other energy sources without a detailed analysis of subsidies and externalities. Nonetheless, given current subsidies, solar is more expensive per/watt than fossil fuel electricity generation.

While most people compare energy costs in terms of a price per kilowatt hour, experts in the energy industry usually evaluate different energy technologies using a measure of the price per watt. Unfortunately, direct comparison between these two measurements is problematic. According to the U.S. Department of Energy, the average American home uses about 30 kilowatt hours per day, or 30 kilowatts per hour per day, or 720 kilowatts per day. The average price of a kilowatt hour is currently about $0.08, meaning that the average American household spends anywhere between $50-$100 per month on electricity. The price of electricity per watt, on the other hand, is a measure of the fixed installation costs associated with building an electric generating facility. If the costs of building a 500 megawatt coal plant were $1 per watt, then the entire facility would cost $500 million. Therefore, one can see that kilowatt hours and the investment costs per watt are not easily comparable. A lower installation cost per watt may lead to lower kilowatt hour costs for consumers, but this is not always the case.

Energy Source	**Price per Watt**
Fossil Fuels	$1/watt
Solar	$3 - $4/watt

(Source: Treehugger)

As of December 2003, the average per-watt lifetime price for a $16,000 -18,000, 2-kW, solar system installed in a city such as Denver would be $8 - $10/watt. In 2010, the NREL expects that that system price should drop to approximately $3 - $4/watt. Due to technological advancements in conversion efficiencies and improved manufacturing costs, solar's price-to-energy ratio is expected to be less than $1/watt in five years and $0.50/watt in ten years – a price-to-energy ratio which meets and even exceeds current grid generated prices (Treehugger).

PV suffers from a dilemma of economy of scale; however, it is expected that PV will be a $15 billion domestic (U.S.) industry by 2020 and its currently annualized growth rate will equal 15 to 20 percent - a figure comparable to the semiconductor and computer industries. Growth in PV is expected due to a projected rise in demand for the technology, as well as increased efficiencies in both the production of PV modules and their energy output capabilities.

Inputs

Currently silicon is a significant cost for the PV industry. Silicon is a necessary ingredient in most solar PV modules and has traditionally has been sourced from the scrap of the semiconductor industry; however, efficiencies in the semiconductor industry have resulted in less silicon that is available for the PV industry. As a result, current demand for silicon outstrips supply: worldwide silicon production averages about 40,000 tons/year, while the demand is about 75,000 tons/year. Prices reflect the supply imbalance as the silicon spot market has climbed approximately ten-fold in five years.

However, Reaction Sciences Inc. (RSI) has developed a new silicon manufacturing process which won the Massachusetts Institute of Technology's (MIT) energy business plan contest "Peoples Choice Award" and First Place for their invention, which produces solar-grade silicon at a fraction of current costs.

In conclusion, it can be seen that the controversies of solar are more aptly referred to as scientific continuums – a process towards improved solar technologies. Although solar already has a role to play in the domestic U.S. energy market, its potential appears even brighter. As solar technologies improve and the market develops competitive and efficient economies of scale, including a drop in price below $1/watt, there should be relatively little controversy surrounding the increased percentage of solar energy in the broader energy marketplace. The future of solar appears ready to receive greater political support in the form of subsidies and research funding/grants in order to help it achieve its full potential.

H.R. 1945: Key Program Elements and Measures of Success

This section discusses three mechanisms in the H.R. 1945 that promote a shift towards producing electricity using renewable sources, with particular focus on solar energy:

- Minimum renewable generation requirements for utilities
- Financial Mechanisms: Tax Incentives, Bonds and Credits
- Federal research and development (R&D) grants

Overarching Measures of Success

The overarching measures of success for the Energy For Our Future Act are to increase the market for renewable energy to 20 percent of total U.S. energy output by 2020 and drive down per unit production costs to a point where renewable energy is cost competitive with non-renewable energy production by 2015. The bill aims to achieve these goals through a mix of R&D investment, renewable portfolio requirements, and tax incentives. For instance, if the U.S. emitted about 1.53 billion tons of CO2 in 2000, and H.R. 1945 aims for a 20 percent use of renewable energy by 2020, then 20 percent of 1.53 billion tons would mean a reduction of 0.31 billion tons of CO2. (Nova: Who Will Take the Heat?) The current U.S. mix of energy generation results in 160 g of CO_2 per kW/h of conventional electricity, so an average 1 kW PV array in the U.S. produces about 1600 kW/h per year, and 48,000 kWh in 30 years. This means a reduction of about 7 metric tons (MT) of CO2 during its lifetime [(48,000*0.95)*160 g/kWh]. The "0.95" represents an estimation of future energy payback. (Photovoltaics and the Environment. Conference Brookhaven National Laboratory and the National Renewable Energy Laboratory)

Mechanisms for Increasing Size of Renewable Power Market

Currently, renewable energy produced represents 8.8 percent of the total energy mix in the United States. Solar energy production represents a mere 1 percent of renewable electricity generation and a miniscule 0.1 percent of total production.

To be considered successful, the bill would have to facilitate an increase in the size of the market for solar and other renewable energy options. In addition, provisions in the bill should cause the percentage of renewable electricity generation to increase in relation to the entire U.S. energy supply mix. Specific mechanisms, discussed in detail below, contain more specific and quantifiable goals.

Minimal Renewable Generation Requirements

Minimum Renewable Generation Requirements are designed to increase the overall market size of renewable electricity through supply-side pressure. The Energy For Our Future Act stipulates specific targets and timelines for producers to gradually supplement their current production with renewable energy technologies. Commercial measures of success include an increase of kilowatt-hour (kWh) produced through renewable sources. Each producer must increase the portion of their renewable energy production to meet the minimum requirement of 2 percent portfolio renewable energy by 2009. Producers must also increase their percentage of renewable energy production by 2 percent every two years. The goal is to achieve a minimum of 20 percent renewable energy production by 2020.

Financial Mechanisms:

A. Federal Tax Incentives

A multitude of federal tax incentives are in place to stimulate investment in solar power production in order to increase the overall market for solar and other renewable energy options. These incentives are in place to stimulate both renewable power supply and demand. Provisions exist for both individual residential consumers as well as for power producers. The Energy For Our Future Act extends the horizon for several existing incentives, enabling additional businesses and individuals to take advantage of the incentives. Incentives focus on mitigating initial investment costs of renewable energy technologies for producers, corporations and individuals. In addition, a financing scheme for providing a pool of capital for investment in renewable energy generation exists that rewards investors with credits for energy savings certifications.

B. Clean Renewable Energy Bonds

The Energy Policy Act of 2005 created Clean Renewable Energy Bonds by adding section 54 to the tax code (26 USC). Essentially, the owners of the bond receive federal tax credits instead of tax-free interest payments from the bond issuer. Available national allocation for these bonds is $1.2 billion. Under the 2005 Act, the original bond issuance period was limited to December 31, 2005 to December 31, 2007. The Energy For Our Future Act reopened the program beginning January 1, 2007 extending the period during which bonds must be issued an additional year, until December 31, 2008.

The act stipulates that 95 percent of capital raised through the sale of Clean Renewable Energy Bonds must be spent on one or more eligible projects within five years of the date of issue.

C. Renewable Electricity Production Credit

The Renewable Electricity Production Credit for solar and other renewable energy producers provides a 1.5 cent per kWh federal tax credit for electricity generated by qualified energy resources (inflation adjusted). The Energy For Our Future Act extends the expiration date of this tax credit from 2006 extended to 2012.

D. The Federal Solar Tax Credit
Aimed towards individual citizens, the Federal Solar Tax Credit is for individuals installing active/passive solar on residential homes. The Energy For Our Future Act extends the expiration date on this credit from the end of 2007 to the end of 2014. By providing a tax credit of 30percent of costs of purchase and installation up to $2,000, this incentive allows consumers to offset installation costs for active or passive solar array systems for the home. An increase in number of kilowatt hours of energy produced using solar or other renewable technologies is the technical measure of success for this incentive.

Together, the Minimal Renewable Generation Requirements and the financial mechanisms discussed above will stimulate the growth of the market for energy produced through renewable sources such as solar power.

Mechanisms For Increasing Cost-competitiveness of Renewable Energy Production

The Energy For Our Future Act aims to create conditions whereby renewable energy options become cost competitive with non-renewable power options by 2015. If the supply-side measures outlined above successfully increase market size it will be possible to achieve economies of scale. This condition should contribute to the decrease in per unit production costs associated with production of electricity through renewable sources, such as solar technologies. Research and Development will also help drive down production costs.

Research and Development Grants (R&D)
The Energy For Our Future Act repeals the mandate for federally funded R&D of Ultra Deepwater and unconventional gas and petroleum production, and research into carbon sequestration and greenhouse gas emissions reduction. These funds are reallocated towards R&D geared towards renewable energy generation. To be considered successful, expenditures in R&D should result in a lower per kWh cost of solar power production. According to the Department of Energy, the average cost for non-renewable energy is currently 8.8 cents per kWh (average over past 4 months). To compete, renewably produced electricity would have to be equal or less than this cost. The cost of solar electricity in the U.S. is currently about 22 cents per kWh.

R&D grants should spur technological innovation to a point where solar power generation technology is cost competitive with nonrenewable energy sources by 2015. The goal of this program is the full appropriation of $650 million through 2011, followed by a decline of cost per unit of energy produced using solar or other renewable energy technology. The technical measure of success is an increase in the number of new types of solar applications discovered, as well as an increase in efficiency.

'Solar Utilization Now Demonstration Act of 2007' or the 'SUN Act of 2007'
A subset of the R&D grants are the demonstration grants - Solar Utilization Now Demonstration Act of 2007' or the `SUN Act of 2007. These grants are to be disbursed to states for demonstration of available renewable energy producing technologies. Education and an increase in general awareness regarding the technologies is the desired outcome of this incentive. Ultimately this increased awareness should result in an increase in demand for solar power generation technologies.

The primary measures of success for the Energy For Our Future Act is the ability to increase the market for renewable energy, in particular solar, to 20 percent of total U.S. energy output by 2020 and drive down per unit production costs to a point where renewable energy is cost competitive with non-renewable energy production by 2015.

Conclusion

The Energy for Our Future Act, H.R. 1945 is one of the first meaningful efforts in this country to shift subsidies and resources away from non-renewable energy industries and towards developing alternative and renewable energy technologies, especially solar power. This is significant, because past bills have attempted to seek solutions through technologies like coal gasification and scrubbers, which are indeed an improvement on our current system, but, nonetheless, still focus on turning dirty, non-renewable sources into clean ones. The United States, being the largest consumer of energy as well as the largest contributer of greenhouse gases, should rightfully be at the forefront of developing safe, green, reliable renewable energy technologies. This report has shown that solar has made great progress in becoming cost competitive, practical, and effecient, but the progress has been slow due to lack of public investment and interest. Its strength lies in its flexibility in application; any home could have solar panels on its roof and generate its own energy.

Significant challenges will continue to exist in reducing energy consumption, increasing efficiency, and ensuring energy security. But H.R. 1945 is sure to be a positive first step through its balance of incentives and repeals of traditional energy subsides.

Glossary

Acid Rain – Source: EPA: "Acid rain is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. The precursors, or chemical forerunners, of acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) resulting from fossil fuel combustion. In the United States, roughly 2/3 of all SO_2 and 1/4 of all NO_x come from electric power generation that relies on burning fossil fuels, like coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild

solution of sulfuric acid and nitric acid. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles.
As this acidic water flows over and through the ground, it affects a variety of plants and animals. The strength of the effects depends on several factors, including how acidic the water is; the chemistry and buffering capacity of the soils involved; and the types of fish, trees, and other living things that rely on the water."

Active solar: As an energy source, energy from the sun collected and stored using mechanical pumps or fans to circulate heat-laden fluids or air between solar collectors and a building.

All-electric home: A residence in which electricity is used for the main source of energy for space heating, water heating, and cooking. Other fuels may be used for supplementary heating or other purposes.

Allocation: The act of distributing funds according to a plan. Federal funds are set aside for Clean Energy Bonds in the amount of $1.2 billion.

Amorphous silicon: An alloy of silica and hydrogen, with a disordered, noncrystalline internal atomic arrangement, that can be deposited in thin-film layers (a few micrometers in thickness) by a number of deposition methods to produce thin-film photovoltaic cells on glass, metal, or plastic substrates.

Ampere: The unit of measurement of electrical current produced in a circuit by 1 volt acting through a resistance of 1 Ohm.

Anthracite: The highest rank of coal; used primarily for residential and commercial space heating. It is a hard, brittle, and black lustrous coal, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter. The moisture content of fresh-mined anthracite generally is less than 15 percent. The heat content of anthracite ranges from 22 to 28 million Btu per ton on a moist, mineral-matter-free basis. The heat content of anthracite coal consumed in the United States averages 25 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter). *Note:* Since the 1980's, anthracite refuse or mine waste has been used for steam electric power generation. This fuel typically has a heat content of 15 million Btu per ton or less.

Appliance efficiency standards: The National Appliance Energy Conservation Act of 1987 established minimum efficiency standards for major home appliances, including furnaces, central and room air conditioners, refrigerators, freezers, water heaters, dishwashers, and heat pumps. Most of the standards took effect in 1990. The standards for clothes washers, dishwashers, and ranges took effect in 1988, because they required only minor changes in product design, such as eliminating pilot lights and requiring cold water rinse options. The standards for central air conditioners and furnaces took effect in 1992, because it took longer to redesign these products. Appliance efficiency standards for refrigerators took effect in 1993.

Appropriation: The act of a legislature authorizing money to be paid from the treasury for a specified use here, $650 million in R&D grants.

Average Annual Percent Change (Coal): The average annual percent change over a period of several years that is calculated by taking the ***n*^th^** root [where ***n*** is the number of years in the period of interest] of the result of the current year's value divided by the value of the first year of the period; this result then has 1 (one) subtracted from it and that result is then multiplied by 100.

$$(\sqrt[n]{V_n / V_0} - 1) x 100$$

Where: V_0 = the value for the base period.
V_n= the value for the n th period.
n = the number of periods.

Average daily production: The ratio of the total production at a mining operation to the total number of production days worked at the operation.

Average delivered price: The weighted average of all contract price commitments and market price settlements in a delivery year.

Average household energy expenditures: A ratio estimate defined as the total household energy expenditures divided by the total number of households.

Average mine price: The ratio of the total value of the coal produced at the mine to the total production tonnage.

Average production per miner per day: The product of the average production per miner per hour at a mining operation and the average length of a production shift at the operation.

Average production per miner per hour: The ratio of the total production at a mining operation to the total direct labor hours worked at the operation.

Average revenue per kilowatthour: The average revenue per kilowatthour of electricity sold by sector (residential, commercial, industrial, or other) and geographic area (State, Census division, and national) is calculated by dividing the total monthly revenue by the corresponding total monthly sales for each sector and geographic area.

Backup Generator: A generator that is used only for test purposes, or in the event of an emergency, such as a shortage of power needed to meet customer load requirements.

Backup power: Electric energy supplied by a utility to replace power and energy lost during an unscheduled equipment outage.

Base bill: A charge calculated by taking the rate from the appropriate electric rate schedule and applying it to the level of consumption.

Base load: The minimum amount of electric power delivered or required over a given period of time at a steady rate.

Base load capacity: The generating equipment normally operated to serve loads on an around-the-clock basis.

Base load plant: A plant, usually housing high-efficiency steam-electric units, which is normally operated to take all or part of the minimum load of a system, and which consequently produces electricity at an essentially constant rate and runs continuously. These units are operated to maximize system mechanical and thermal efficiency and minimize system operating costs.

Base rate: A fixed kilowatthour charge for electricity consumed that is independent of other charges and/or adjustments.

Bituminous coal: A dense coal, usually black, sometimes dark brown, often with well-defined bands of bright and dull material, used primarily as fuel in steam-electric power generation, with substantial quantities also used for heat and power applications in manufacturing and to make coke. Bituminous coal is the most abundant coal in active U.S. mining regions. Its moisture content usually is less than 20 percent. The heat content of bituminous coal ranges from 21 to 30 million Btu per ton on a moist, mineral-matter-free basis. The heat content of bituminous coal consumed in the United States averages 24 million Btu per ton, on the as-received basis (i.e., containing both inherent moisture and mineral matter).

Bioaccumulation – The movement of a substance up the food chain though transfer of residues of the substance in smaller organisms that are food for larger organisms in the chain. As the substance goes from one organism to the next the concentration of the substance get greater, this typically causes a great effect on the organisms at the top of the food chain.

Bond issuance: A bond is a financial instrument used to raise money for a particular undertaking or project. In return the issuer - a person, corporation, or government - guarantees to pay the lender a stated sum of money on or before a specified day. In the U.S. Federal Bonds also called Treasury Bonds are coordinated by the central bank. Federal bond issues tend to be the safest fixed income investments available because they are backed by the tax-generating powers of the government. Bond issuance refers to the offering of bonds to the market.

Capacity factor: The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period.

Capital pool: Capital is the wealth, whether in money or property, owned or employed in business by an individual, firm or corporation. Capital pool refers to a combination of capital to be employed towards a particular end.

Carbon cycle: All carbon sinks and exchanges of carbon from one sink to another by various chemical, physical, geological, and biological processes. Also see **Carbon sink** below.

Carbon dioxide (CO_2): A colorless, odorless, non-poisonous gas that is a normal part of Earth's atmosphere. Carbon dioxide is a product of fossil-fuel combustion as well as other processes. It is considered a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming. The global warming potential (GWP) of other greenhouse gases is measured in relation to that of carbon dioxide, which by international scientific convention is assigned a value of one (1). Also see **Global warming potential (GWP)** and **Greenhouse gases**.

Carbon dioxide equivalent: The amount of carbon dioxide by weight emitted into the atmosphere that would produce the same estimated radiative forcing as a given weight of another radiatively active gas. Carbon dioxide equivalents are computed by multiplying the weight of the gas being measured (for example, methane) by its estimated global warming potential (which is 21 for methane). "Carbon equivalent units" are defined as carbon dioxide equivalents multiplied by the carbon content of carbon dioxide (i.e., 12/44).

Carbon flux: See **Carbon budget** above.

Carbon intensity: The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. Also see **Emissions coefficient** and **Carbon output rate**.

Carbon output rate: The amount of carbon by weight per kilowatthour of electricity produced.

Cast silicon: Crystalline silicon obtained by pouring pure molten silicon into a vertical mold and adjusting the temperature gradient along the mold volume during cooling to obtain slow, vertically advancing crystallization of the silicon. The polycrystalline ingot thus formed is composed of large, relatively parallel, interlocking crystals. The cast ingots are sawed into wafers for further fabrication into photovoltaic cells. Cast silicon wafers and ribbon silicon sheets fabricated into cells are usually referred to as polycrystalline photovoltaic cells.

Cells: Refers to the un-encapsulated semi-conductor components of the module that convert the solar energy to electricity.

Cells to OEM (non-PV): Cells shipped to non-photovoltaic original equipment manufacturers such as boat manufacturers, car manufacturers, etc.

Climate change: A term used to refer to all forms of climatic inconsistency, but especially to significant change from one prevailing climatic condition to another. In some cases, "climate change" has been used synonymously with the term "global warming"; scientists, however, tend to use the term in a wider sense inclusive of natural changes in climate, including climatic cooling.

Coal consumption: The quantity of coal burned for the generation of electric power (in short tons), including fuel used for maintenance of standby service.

Coal delivered: Coal which has been delivered from the coal supplier to any site belonging to the electric power company.

Coal exports: Amount of U.S. coal shipped to foreign destinations, as reported in the U.S. Department of Commerce, Bureau of Census, "Monthly Report EM 545."

Coal Gasification – Source: http://www.emeryenergy.com/
"Unlike combustion processes, gasification is an oxygen-starved process that converts solid fuels (biomass, coal, etc.) into gaseous fuels (Hydrogen and Carbon Monoxide). Gasification is uniquely capable of producing not only heat and power, but also can be used with downstream catalysts to convert the syngas to liquid fuels and chemicals (diesel, ethanol, methanol); and, to hydrogen gas for fuel cell applications.
When using biomass feedstocks, which are considered 'carbon-neutral' (i.e. no net added carbon emissions), gasification technology can concurrently mitigate wastes (i.e. municipal, industrial and agricultural) while producing renewable energy. When using coal feedstocks, gasification technology can achieve greater efficiencies compared to combustions processes while removing trace contaminants from the gas prior to combustion of the syngas."
Contract Price: "The average price at which a contract trades, calculated at both the open and close of each trading day."
< http://www.investopedia.com/terms/s/settlementprice.asp >

Domestic Energy Portfolio: In the U.S. Energy is produced and supplied by several diverse means - through burning coal and other fossil fuels, hydro electric power plants, photovoltaic cells, and so on. In aggregate, the sum of these types of energy production represents the domestic energy portfolio.

Economy of scale: The principle that larger production facilities have lower unit costs than smaller facilities.

$$\text{Efficiency} = \frac{\text{Useful power output}}{\text{Total power input}}$$

Electric generation industry: Stationary and mobile generating units that are connected to the electric power grid and can generate electricity. The electric generation industry includes the "electric power sector" (utility generators and independent power producers) and industrial and commercial power generators, including combined-heat-and-power producers, but excludes units at single-family dwellings.

Electric generator: A facility that produces only electricity, commonly expressed in kilowatthours (kWh) or megawatthours (MWh). Electric generators include electric utilities and independent power producers.

Electric power: The rate at which electric energy is transferred. Electric power is measured by capacity and is commonly expressed in megawatts (MW).

Electric power grid: A system of synchronized power providers and consumers connected by transmission and distribution lines and operated by one or more control centers. In the continental United States, the electric power grid consists of three systems: the Eastern Interconnect, the Western Interconnect, and the Texas Interconnect. In Alaska and Hawaii, several systems encompass areas smaller than the State (e.g., the interconnect serving Anchorage, Fairbanks, and the Kenai Peninsula; individual islands).

Electric power plant: A station containing prime movers, electric generators, and auxiliary equipment for converting mechanical, chemical, and/or fission energy into electric energy.

Electric power sector: An energy-consuming sector that consists of electricity only and combined heat and power(CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public--i.e., North American Industry Classification System 22 plants. See also **Combined heat and power (CHP) plant** and **Electricity only plant**.

Electricity demand: The rate at which energy is delivered to loads and scheduling points by generation, transmission, and distribution facilities.

Electricity generation: The process of producing electric energy or the amount of electric energy produced by transforming other forms of energy, commonly expressed in kilowatthours (kWh) or megawatthours (MWh).

Electricity Supply Mix: In the U.S. Energy is produced and supplied by several diverse means - through burning coal and other fossil fuels, hydro electric power plants, photovoltaic cells, and so on. In aggregate, the sum of these types of energy production represents the domestic energy portfolio.

Emergency: The failure of an electric power system to generate or deliver electric power as normally intended, resulting in the cutoff or curtailment of service.

Emergency backup generation: The use of electric generators only during interruptions of normal power supply.

Emergency energy: Electric energy provided for a limited duration, intended only for use during emergency conditions.

Emissions: Anthropogenic releases of gases to the atmosphere. In the context of global climate change, they consist of radiatively important greenhouse gases (e.g., the release of carbon dioxide during fuel combustion).

Energy: The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatthours, while heat energy is usually measured in British thermal units (Btu).

Energy exchange: Any transaction in which quantities of energy are received or given up in return for similar energy products. See **exchange, electricity; exchange, petroleum;** and **exchange, natural gas** (see definitions further below).

Energy Payback (Lifecycle): Total lifetime useful electrical energy output of a PV cell vs. the total amount of useful energy contained within all the inputs of the manufacturing, installation and lifetime operating processes of the PV cell.

Energy source: Any substance or natural phenomenon that can be consumed or transformed to supply heat or power. Examples include petroleum, coal, natural gas, nuclear, biomass, electricity, wind, sunlight, geothermal, water movement, and hydrogen in fuel cells.

Energy supply: Energy made available for future disposition. Supply can be considered and measured from the point of view of the energy provider or the receiver.

Energy supplier: Fuel companies supplying electricity, natural gas, fuel oil, kerosene, or LPG (liquefied petroleum gas) to the household.

Feedstock: A raw material utilized in the industrial manufacture of a product.

Fuel: Any material substance that can be consumed to supply heat or power. Included are petroleum, coal, and natural gas (the fossil fuels), and other consumable materials, such as uranium, biomass, and hydrogen.

Fuel Conversion Efficiency : A measure of how effectively fuel is transformed into usable energy. Each type of fuel is deemed to have a specific energy-producing potential per unit of weight, but some or most of that potential is lost during production or refining. While 100% efficiency is always the goal, in practice the fuel conversion efficiency of a typical commercial steam turbine generator is only about 30 percent efficient. Household natural gas furnaces typically achieve only about 70% efficiency. Automobiles rarely boast better than 20% fuel conversion efficiency, and even a well-tuned bicycle rates

about 75%. <
http://www.energyvortex.com/energydictionary/fuel_conversion_efficiency.html >

Generating facility: An existing or planned location or site at which electricity is or will be produced.

Generating station: A station that consists of electric generators and auxiliary equipment for converting mechanical, chemical, or nuclear energy into electric energy.

Generating unit: Any combination of physically connected generators, reactors, boilers, combustion turbines, and other prime movers operated together to produce electric power.

Generation: The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in kilowatthours.

Generation company: An entity that owns or operates generating plants. The generation company may own the generation plants or interact with the short-term market on behalf of plant owners.

Generator capacity: The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, adjusted for ambient conditions.

Giga: One billion.

Gigawatt (GW): One billion watts or one thousand megawatts.

Gigawatt-electric (GWe): One billion watts of electric capacity.

Gigawatthour (GWh): One billion watthours.

Greenhouse effect: The result of water vapor, carbon dioxide, and other atmospheric gases trapping radiant (infrared) energy, thereby keeping the earth's surface warmer than it would otherwise be. Greenhouse gases within the lower levels of the atmosphere trap this radiation, which would otherwise escape into space, and subsequent re-radiation of some of this energy back to the Earth maintains higher surface temperatures than would occur if the gases were absent.

Greenhouse gas (GHG) are components of the atmosphere that contribute to the greenhouse effect. Some greenhouse gases occur naturally in the atmosphere, while others result from human activities such as burning of fossil fuels such as coal.[1] Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Green pricing: In the case of renewable electricity, green pricing represents a market solution to the various problems associated with regulatory valuation of the nonmarket benefits of renewables. Green pricing programs allow electricity customers to express their willingness to pay for renewable energy development through direct payments on their monthly utility bills.

Grid: The layout of an electrical distribution system. See electric power grid.

Grid-Parity: A term that refers to a price-point that is equivalent to the price-per-watt that energy utilities achieve via converting fossil fuels to electricity.

Gross generation: The total amount of electric energy produced by generating units and measured at the generating terminal in kilowatthours (kWh) or megawatthours (MWh).

Kilowatt (kW): One thousand watts.

Kilowatt-electric (kWe): One thousand watts of electric capacity.

Kilowatthour (kWh): A measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000 watts) of power expended for 1 hour. One kWh is equivalent to 3,412 Btu.

Lead acid battery: An electrochemical battery that uses lead and lead oxide for electrodes and su **Megawatt (MW):** One million watts of electricity.

Megawatt electric (MWe): One million watts of electric capacity.

Megawatthour (MWh): One thousand kilowatt-hours or 1 million watt-hours.

Net electricity consumption: Consumption of electricity computed as generation, plus imports, minus exports, minus transmission and distribution losses.

Net energy for load: Net generation of main generating units that are system-owned or system-operated, plus energy receipts minus energy deliveries.

Net energy for system: The sum of energy an electric utility needs to satisfy their service areas, including full and partial requirements consumers.

Net generation: The amount of gross generation less the electrical energy consumed at the generating station(s) for station service or auxiliaries. *Note*: Electricity required for pumping at pumped-storage plants is regarded as electricity for station service and is deducted from gross generation.

On peak: Periods of relatively high system demand. These periods often occur in daily, weekly, and seasonal patterns; these on-peak periods differ for each individual electric utility.

Passive solar heating: A solar heating system that uses no external mechanical power, such as pumps or blowers, to move the collected solar heat. lfuric acid for the electrolyte.

Nitrogen Oxide - Source: EPA. "**Nitrogen oxides,** or NOx, is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. The primary manmade sources of NOx are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels. NOx can also be formed naturally."

Nuclear Energy: A good website to look at is:
http://www.howstuffworks.com/nuclearpower1.htm

Photovoltaic cells are made with a precious or semiprecious metal. Currently, most photovoltaic cells use silicon because it is inexpensive and is a good semiconductor. Silicon is chemically altered usually by adding impurities, like other metals, to create a slightly negative electron field. Another layer of silicon is similarly altered to create a slightly positive field with spaces for electrons to flow. These two layers are placed together and covered with a layer of non reflective glass. As light from the sun penetrates the glass, the photons of light incite the negatively charged particles to move to the positive layer creating a current between the layers. The wire then channels the current out as electricity. A wire conducts the electrons from the system in the form of electricity.

Radiation: The transfer of heat through matter or space by means of electromagnetic waves.

Reliability (electric system): A measure of the ability of the system to continue operation while some lines or generators are out of service. Reliability deals with the performance of the system under stress.

Renewable Electricity Production Credit: The Renewable Electricity Production Credit (REPC) is a per kilowatt-hour tax credit for electricity generated by qualified renewable sources. Qualified producers receive a 1.5 cent federal tax credit per kWh of power produced.

Renewable energy resources: Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

Renewable Generation Requirement: Refers to a minimum proportion of a power producing utility's total energy portfolio that is generated through renewable sources. Renewable Generation Requirement is also referred to as Renewable Portfolio Standard.

Smog – Source: Environment Canada (http://www.atl.ec.gc.ca/weather/smog_faq.html). "Smog is a mixture of pollutants with ground-level ozone as the main component. Ground-level ozone is formed when nitrogen oxides and volatile organic compounds interact in the presence of sunlight. High up in the stratosphere, ozone protects the earth from harmful ultraviolet rays, but at ground level, it can be a harmful air pollutant.

About 95 per cent of nitrogen oxides that lead to the formation of smog, are produced when we burn fuels in our cars and trucks, or generate energy using combustion engines, combustion turbines, industrial boilers and power plants. Nitrogen oxides are related to other atmospheric problems such as climate changes and acid rain.
Volatile organic compounds are also necessary to produce smog. They come from the evaporation of liquid solvents and fuels such as gasoline or barbecue starter fluid, and from oil-based paint."

Solar cell: See Photovoltaic cell.

Solar constant: The average amount of solar radiation that reaches the earth's upper atmosphere on a surface perpendicular to the sun's rays; equal to 1353 Watts per square meter or 492 Btu per square foot.

Solar energy: The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Solar radiation: A general term for the visible and near visible (ultraviolet and near-infrared) electromagnetic radiation that is emitted by the sun. It has a spectral, or wavelength, distribution that corresponds to different energy levels; short wavelength radiation has a higher energy than long-wavelength radiation.

Solar spectrum: The total distribution of electromagnetic radiation emanating from the sun. The different regions of the solar spectrum are described by their wavelength range. The visible region extends from about 390 to 780 nanometers (a nanometer is one billionth of one meter). About 99 percent of solar radiation is contained in a wavelength region from 300 nm (ultraviolet) to 3,000 nm (near-infrared). The combined radiation in the wavelength region from 280 nm to 4,000 nm is called the broadband, or total, solar radiation.

Solar thermal collector: A device designed to receive solar radiation and convert it to thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with appropriate insulation. The heat collected by the solar collector may be used immediately or stored for later use. Solar collectors are used for space heating; domestic hot water heating; and heating swimming pools, hot tubs, or spas.

Solar thermal collector, high temperature: A collector that generally operates at temperatures above 180 degrees Fahrenheit.

Solar thermal collector, low-temperature: A collector that generally operates at temperatures below 110 degrees Fahrenheit. Typically, it has no glazing or insulation and is made of plastic or rubber, although some are made of metal.

Solar thermal collector, medium-temperature: A collector that generally operates at temperatures of 140 degrees F to 180 degrees Fahrenheit, but can also operate at temperatures as low as 110 degrees Fahrenheit. Typically, it has one or two glazings, a metal frame, a metal absorption panel with integral flow channels or attached tubing (liquid collector) or with integral ducting (air collector) and insulation on the sides and back of the panel.

Solar thermal collector, special: An evacuated tube collector or a concentrating (focusing) collector. Special collectors operate in the temperature range from just above ambient temperature (low concentration for pool heating) to several hundred degrees Fahrenheit (high concentration for air conditioning and specialized industrial processes).

Solar thermal panels: A system that actively concentrates thermal energy from the sun by means of solar collector panels. The panels typically consist of fat, sun-oriented boxes with transparent covers, containing water tubes of air baffles under a blackened heat absorbent panel. The energy is usually used for space heating, for water heating, and for heating swimming pools.

Solar thermal parabolic dishes: A solar thermal technology that uses a modular mirror system that approximates a parabola and incorporates two-axis tracking to focus the sunlight onto receivers located at the focal point of each dish. The mirror system typically is made from a number of mirror facets, either glass or polymer mirror, or can consist of a single stretched membrane using a polymer mirror. The concentrated sunlight may be used directly by a Stirling, Rankine, or Brayton cycle heat engine at the focal point of the receiver or to heat a working fluid that is piped to a central engine. The primary applications include remote electrification, water pumping, and grid-connected generation.

Spot Market: "A commodities or securities market in which goods are sold for cash and delivered immediately. Contracts bought and sold on these markets are immediately effective. A futures transaction for which commodities can be reasonably expected to be delivered in one month or less. Though these goods may be bought and sold at spot prices, the goods in question are traded on a forward physical market.
< http://www.investopedia.com/terms/s/spotmarket.asp >

Sulfur Oxide – Source: http://www.elmhurst.edu/~chm/vchembook/193sox.html. Coal may contain from 1-4 percent of the element, sulfur. When the coal is burned with oxygen in the air, the sulfur reacts to form **sulfur dioxide**.

Questions and Answers about the Problems, Proposed Solutions, and Policies

Where is H.R. 1945 currently in Congress?
It has been referred to 5 House Committees (Energy and Commerce, Ways and Means, Natural Resources, House Transportation and Infrastructure, and Science and Technology) three of which have referred them to subcommittees (Subcommittee on Highways and Transit, Subcommittee on Energy and Mineral Resources, and Subcommittee on Energy and Environment).

Who are the co-sponsors and what is their political affiliation? What do the dates below mean?
15 Co-sponsors besides Rep Chris Shays (R) of Connecticut, 3 Republicans and 12 Democrats, mostly from east-coast and west-coast states.
Rep Baldwin, Tammy (DEM) [WI-2] - 5/24/2007
Rep Berkley, Shelley (DEM) [NV-1] - 6/20/2007
Rep Brown-Waite, Ginny (REP) [FL-5] - 5/8/2007
Rep Cohen, Steve (DEM) [TN-9] - 6/20/2007
Rep Delahunt, William D. (DEM) [MA-10] - 4/20/2007
Rep Ehlers, Vernon J. (REP) [MI-3] - 5/1/2007
Rep Gilchrest, Wayne T. (REP) [MD-1] - 5/8/2007
Rep Grijalva, Raul M. (DEM) [AZ-7] - 5/7/2007
Rep Hinchey, Maurice D. (DEM) [NY-22] - 4/19/2007
Rep Inslee, Jay (DEM) [WA-1] - 5/7/2007
Rep Lee, Barbara (DEM) [CA-9] - 5/3/2007
Rep Lowey, Nita M. (DEM) [NY-18] - 5/17/2007
Rep Maloney, Carolyn B. (DEM) [NY-14] - 4/25/2007
Rep Moran, James P. (DEM) [VA-8] - 5/3/2007
Rep Stark, Fortney Pete (DEM) [CA-13] - 5/1/2007

How much money would be directly allocated by HR 1945?
Approximately $4.3 billion per year over the first 5 years after passage, with decreasing amount in succeeding years. There would also be unspecified amounts of money (to be requested by the Secretaries of Transportation and Energy) for different programs: National Tire Efficiency Program, 5-year extension of tax credits to commercial renewable energy producers, new tax credits for private homes up to $6,000 each, and an R&D program for portable hydrogen fuel technologies.

How many sections are there in the bill?
HR 1945 has 33 separate sections.

How many of the sections deal with solar energy? What are those sections and what do they do?
Six Sections (though two do so indirectly):
Section 9: Time extension for tax credits to commercial renewable energy producers
Section 10: Extension of tax credits to individuals installing solar on residential homes
Section 12: Minimum Renewable Generation Requirement for commercial electricity producers…20percent of generation portfolio by 2020 (indirect)
Section 13: Net-metering available to any customer (indirect)
Section 30: R&D program for the development of commercial solar-voltaic technologies ($650 million per year)
Section 33: demonstration grants to States to test advanced photovoltaic technologies ($800 million per year)

What issues do the rest of the sections deal with?
9 sections: Repealing tax credits/subsidies to oil/gas/nuclear producers (some very minor)
6 sections: Private/Commercial building energy efficiency
6 sections: Car/Truck fuel efficiency and technology
4 sections: R&D programs for other renewable energy technologies
1 section: Public Transportation
1 Section: Reducing electricity usage from commercial producers

How much coal does the U.S. consume?
In 2000 U.S. consumption of coal was approximately 1.07 billion short tons (2,000 lbs)

How limited are our supplies of oil and coal?
At the end of 2006 North America (yes…including Canada) had proven coal reserves of 254.4 billion short tons.
-Source: British Petroleum Statistical Review of World Energy

What percentage of the U.S. energy supply currently comes from solar?
According to the US Geological Survey, in 2000 only .07percent of US energy demand was fulfilled by solar power.

How much energy does the typical coal plant generate?
A conventional electricity power plant can range in size from 500-3000 Megawatts
-Source: Department of Energy

Clearly your focus is on the Health and Environmental affects of criteria pollutants such as SO_x *and* NO_x *– but What about global warming?*
The issue of global warming is certainly not being ignored, nor are we suggesting that it is of little consequence in relation to the burning of fossil fuels such as Coal for electricity generation. For the purposes of this workshop policy-analysis, we have simply chosen to narrow our focus to those pollutants and their effects.

Where do mining operations take place?

- Appalachian Region. Consists of Alabama, Georgia, Eastern Kentucky, Maryland, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia.
- Interior Region (with Gulf Coast). Consists of Arkansas, Illinois, Indiana, Iowa, Kansas, Louisiana, Michigan, Mississippi, Missouri, Oklahoma, Texas, and Western Kentucky.
- Western Region. Consists of Alaska, Arizona, Colorado, Montana, New Mexico, North Dakota, Utah, Washington, and Wyoming.

I've read that solar power is totally inefficient and cannot compare with the amount of electricity produced by fossil fuels. How can solar energy be a solution?
With the adequate research and development in renewables, e.g. if the same level of funding was given to renewables that are allocated to nonrenewable research (finding, cleaning, transporting, etc.), electric generation from sources like solar would become much more efficient and reliable. Avoid commentary

Are there different types of coal? What are they?
The Rarest and Cleanest Burning: Anthracite Coal – Limited Deposits mostly located in Pennsylvania and Rhode Island. The second, and most abundant type of coal is Bituminous. This kind of coal is slightly softer (i.e. has not been buried as long). A result of this is that it does not burn as clean.
Two lesser types of coal are sub-bituminous coal and peat. Both consist of buried and compressed plant matter but have spent much less time subjected to the heat and pressure of higher forms of coal. These are the dirtiest burning forms of coal.

What is Biomagnification?
"B*iomagnification* is the bioaccumulation of a substance up the food chain by transfer of residues of the substance in smaller organisms that are food for larger organisms in the chain. It generally refers to the sequence of processes that results in higher concentrations in organisms at higher levels in the food chain (at higher trophic levels). These processes result in an organism having higher concentrations of a substance than is present in the organism's food. Biomagnification can result in higher concentrations of the substance than would be expected if water were the only exposure mechanism. Accumulation of a substance only through contact with water is known as bioconcentration." – USGS

How much Carbon Dioxide is emitted from Coal Power Plants in the United States each Year?
According Energy Information Administration's *International Energy Annual 2004* report, in 2004, the United States emitted 5,912.21 Million Metric Tons of Carbon Dioxide. Just to put this into perspective, the total emissions from all of the countries of Central and South America was **1,041.45** Million Metric Tons of Carbon Dioxide. Therefore, the total carbon emission from all of the Central and South American Countries is only 17.6 percent of U.S. carbon emissions.

How much Mercury is emitted from Coal Power Plants in the US each year?
Source: EPA: "Coal-burning power plants are the largest human-caused source of mercury emissions to the air in the United States, accounting for over 40 percent of all domestic human-caused mercury emissions. EPA has estimated that about one quarter of U.S. emissions from coal-burning power plants are deposited within the contiguous U.S. and the remainder enters the global cycle."

Do you need full sunlight for photovoltaic cells to properly function?
As long as there is light, PV cells will function whether it is cloudy or not. They do not produce energy at night, but they will on a cloudy day. Battery storage is possible for electricity use at night. Commercial applications will especially benefit from PV because they typically only use electricity during sunlight hours.

Can PV cells work in areas with severe winters?
Yes: PV cells are black so ice melts off, they are also situated at steep angles and snow andd ice slides off more easily.

What's the likelihood that solar will actually replace coal?
Well, this bill appropriates more funding to solar for R & D than for any other renewable source, so we can speculate that this will increase. It's probably a ways off from actually replacing coal.

Will R & D go for education for installation?
As R & D funding is appropriated by State, it depends on what each State proposes for its use. Some projects may qualify under education.

Is solar economically feasible?
If big business begins to support it more, there are more governmental incentives, such as net metering, and it becomes more efficient, then yes, it will gain in popularity and use.

Is R & D appropriated through the Department of Energy (DOE)?
Yes, this is the agency that this bill falls under, however, it's appropriated to individual States for use.

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