National Center for Policy Analysis

Alternative Energy Overview

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Introduction

The American people are very concerned with energy — its availability, reliability, cost and environmental impact. The United States is the largest participant in the global energy system — the largest consumer, the second largest producer of coal and natural gas, and the largest importer and third largest producer of oil.[1]

Alternative energy is a complex topic that requires discussion of the overall economy, the environment, and U.S. foreign relations. It is also a timely issue with world energy demand increasing about 60 percent in the last quarter-century and is expected to grow another 50 percent in the next 30 years alone. Energy derived from fossil fuels have played a significant role in supporting economic activity and development in the past, and will likely continue to do so in combination with alternative energy. Fortunately, we are not running out of energy, but this issue will require us to examine how to increase energy efficiency and draw on sources that are sufficient, reliable, affordable and safe.[2]

Defining Alternative Energy

Alternative energy has a number of definitions. The Encarta Dictionary defines alternative energy as "any form of energy obtained from the sun, wind, waves or another renewable source in contrast to energy generated from fossil fuels." While this definition equates alternative energy with renewable energy, other definitions are broader. Russell Hasan, President of the Alternative News Company, says this of alternative energy:

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[1] "Hard Truths: A Comprehensive View to 2030 of Global Oil and Natural Gas," National Petroleum Council, July 2007.

[2] Ibid.

> "We must differentiate between alternative energy and renewable energy. Alternative energy refers to any form of energy which is an alternative to the traditional fossil fuels of oil, coal and natural gas. Renewable energy are the forms of alternative energy that are renewed by the natural process of the Earth."[3]

Using this definition, some non-renewable sources like nuclear power and hydrogen fuel cells can be considered along with other renewable energy sources. In addition, other definitions consider "energy conservation and enabling techniques" components of alternative energy.[4] Using this definition, incentives for meeting energy efficiency requirements or subsidizing green appliances would also be included.

Alternative Energy Sources

Alternative energy sources include: renewable sources (solar, biomass, hydropower, wind, geothermal, ocean, and solar powered satellites), hydrogen fuel cells and nuclear energy. Below is a brief discussion of each energy source.

Solar. Solar power is energy generated by the sun's radiation. Historically, solar energy has been used for heating human-made structures and growing crops. Only recently have humans been able to more effectively harness this energy by collecting and storing it.[5] There are four main ways to harness solar energy:[6]

Solar Architecture. Intentionally designing buildings so that they gather the sun's heat in the winter and repel it in the summer can lead to huge savings in electricity. Another option that coincides with heating involves placing windows where they will

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[3] Russell Hassan, "Introduction to Alternative Energy," Alternative Energy News, 2007.

[4] The Free Dictionary [http://www.thefreedictionary.com/alternative+energy].

[5] Union of Concerned Scientists (UCS), "How Solar Energy Works," 2007.

[6] Ibid.

capture the most light, thus reducing lighting costs. Experts call these types of architecture passive solar designs because no electronic or mechanical parts are necessary to utilize the energy.

Solar Heat Collectors. Another form of solar energy requires making large boxes that are painted black on the inside and covered in glass. Water pipes running through these ‘solar collectors’ can absorb the sun’s heat and function as water heaters, or the solar energy can be used to provide cool air to air conditioners. Desiccant evaporators use solar heat to pull moisture from the air, making it cooler, and then A/C units separate the hot moist air and vent it outside.

Solar Thermal Concentrating Systems. Other forms of solar technology use solar energy to heat water and create steam that powers electricity-generating turbines. One type called parabolic troughs uses curved shaped mirrors to concentrate energy on tubes carrying liquid parallel to the device. Once hot this liquid produces steam. Parabolic dishes, capable of much higher temperatures, concentrate solar energy on one central point to produce steam. Central receivers are a third type. They use mirrors to concentrate energy on a single ‘power tower’ that houses water for steam and large generators.

Solar Photovoltaic (PV) Panels. Solar panels are what most people think of when they hear the term solar power. Also called solar cells, solar panels were essentially discovered in 1839, when a French scientist named Edmund Becquerel learned that certain materials would give off an electrical charge when hit with solar radiation. By the late 1800s, primitive solar cells made out of selenium were being used as an industrial energy source but on a very small scale.

In the 1950s, the cost of solar panels dropped. At that time, Bell Labs made a technological breakthrough by redesigning solar panels to use silicone, making it possible to collect up to 4 percent of the energy from sunlight and turn it into electricity.

Solar panels are designed to turn electromagnetic charges into electricity. Thin panels usually consist of two layers of semi-conducting material, most often silicone crystals, compressed together and separated in the middle by a layer of material impermeable to electric charges. The top layer of silicone is usually bonded with phosphorous to form a negative charge, and the bottom layer with boron to form a positive charge. When sunlight hits this top layer it dislodges electrons that naturally want to flow toward the positive side, but are prevented from doing so by the middle layer, called the P-N junction. Instead, the electrons are forced to travel through a wire connecting the two charged layers, a process that generates electricity for other uses. There are three types of solar panels:

- Single-Crystal cells are molded into cylinders and cut into wafers. They are the most expensive type of solar panel but can turn 25 percent of the sun's energy into electricity.
- Polycrystalline cells come in squares made of molten silicone. They are less expensive but achieve only 15 percent energy efficiency.
- The last type, Amorphous silicone cells, can be spray painted onto glass and metal surfaces and used for things such as shingles. Although very versatile and less expensive, this type only attains efficiency rates of 5 percent.

Currently, solar panel power represents 0.039 percent of global energy consumption and 0.9 percent of U.S. energy consumption.[7] As a substitute for fossil fuels, solar power theoretically has a much greater potential to generate energy. It has been estimated that 20 days of sunshine is the equivalent of all the Earth's reserves of coal, oil and natural gas.

Proponents note several benefits of solar energy. First, it is free and inexhaustible because the sun's radiation is self-perpetuating. A process of fusion reactions on the sun's surface constantly replenishes its supply and its rays incessantly bombard the planets of our solar system, including Earth. Unused solar-generated electricity can be pumped back into the grid and net metered. Also, solar powered electricity does not emit any greenhouse gas pollutants.

Improvements in solar technology are being made regularly.[8] Only a year ago a project co-sponsored by the U.S. Department of Energy and run by Boeing Spectrolab set a new world record by creating solar panels that have a 40.7 percent conversion efficiency. With further development, this technology could be used in the next 10 to 20 years to reduce the price of solar generated electricity to 8 to 10 cents per kilowatt hour (kWh).[9]

Solar energy, however, has many limitations. Compared to other energy sources, the price of solar power still remains relatively uncompetitive. Prices for electricity are

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[7] "Renewables in Global Energy Supply: An IEA Factsheet," International Energy Association, January 2007.

[8] Thomas Tanton, "Expensive New Solar Project Announced in California," Heartland Institute, *Environment News*, October 2007.

[9] U.S. Department of Energy, "New World Record Achieved in Solar Cell Technology," Press release, Dec. 2006.

usually discussed in terms of the amount of money it takes produce a certain amount of energy, commonly measured as cents per kilowatt-hour (kWh). As it stands now solar thermal electricity costs from 12 to 13 cents per kWh, and solar PV cells cost from 25 to160 cents per kWh. Compare this with other forms of renewable energy: biomass can cost from 1 to 25 cents per kWh, wind from 4 to 8 cents per kWh, hydro electricity from 2 to 12 cents per kWh, geothermal from 0.5 to10 cents per kWh, and tidal energy from 8 to 40 cents per kWh. Contrastingly, coal fired power can be as little as 3.5 cents per kWh and nuclear power can reach 2 cents per kWh or less. (See Table I.)

Table I: Cost of Energy Sources Per Kilowatt Hour

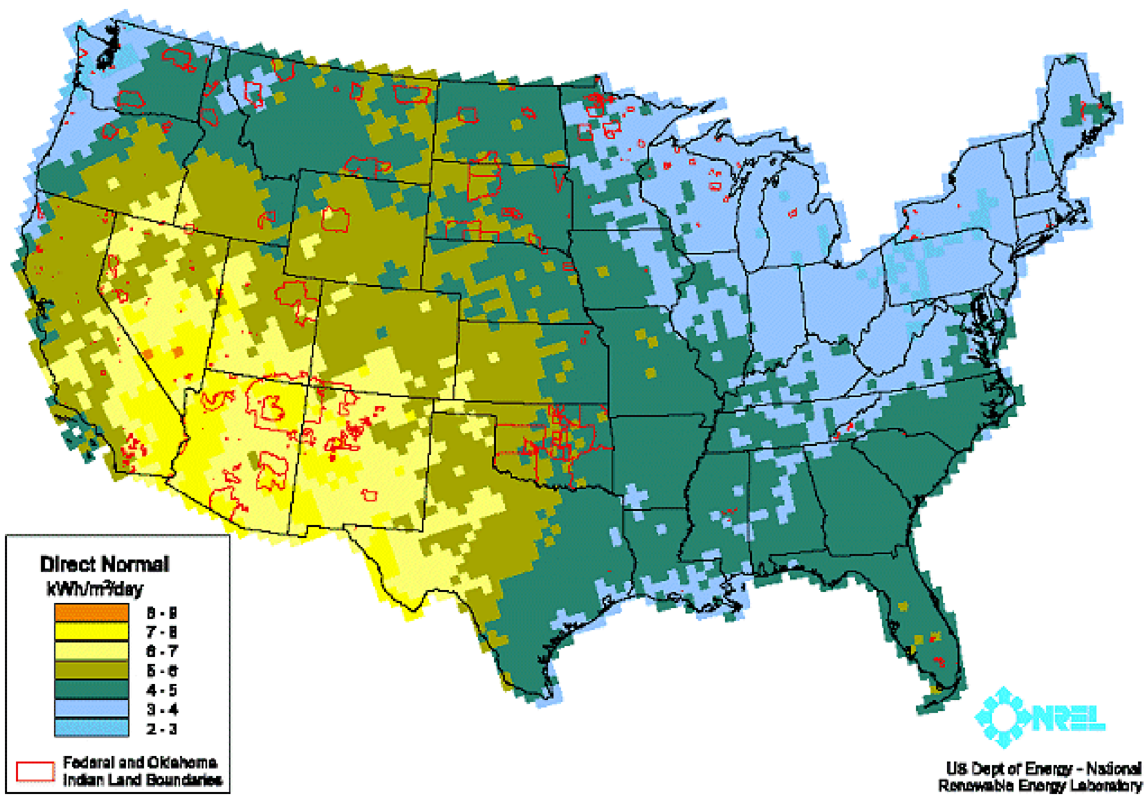
Energy Source	Cost (in cents per kilowatt hour)
Solar Thermal	12 - 13 ¢/kWh
Solar Panels	25 -160 ¢/kWh
Biomass	1 - 25 ¢/kWh
Wind	4 - 8 ¢/kWh
Hydroelectric	2 - 12 ¢/kWh
Geothermal	0.5 - 10 ¢/kWh
Tidal	8 - 40 ¢/kWh

Source: United Nations Development Program,
World Energy Assessment: 2004

In addition, different regions of the United States have different levels of solar energy potential. Northern areas like New England and Oregon have between 3 to 4 kilowatt hour per square meter (kWh/met2) of solar energy potential per day. The hottest place in the United States, the Mojave Desert, could be expected to collect about 7 to 8 kWh/met2 per day. Places like Seattle in December, however, only collect about 0.7

kWh/met2 per day.[10] By nature of their climate, some states would simply be unable to depend too heavily on solar power.[11] (See Figure I.)

Figure I: Solar Energy Potential across the United States



NOTE: Average daily solar energy received in specific geographical locations measured in kilowatt hours per square meter. Orange and yellowish regions contain more solar energy than more bluish areas. The higher the solar energy received, the greater the potential for using solar power concentrators and panels. In regions receiving an average of 2 – 3 kilowatt hours of solar energy per day, such as light blue areas in northeastern Oregon and New England, solar power technology would not be economically cost-effective or technologically viable.

[10] Energy Information Administration, "Concentrated Solar Power Potential Resource Potential," 2003.

[11] Mark Clayton, "As TVs Grow so do Electric Bills," *Christian Science Monitor*, 2007.

Biomass. Biomass is energy taken from biological material such as farming wastes, grasses, trees, bark, sawdust and even garbage. Biomass energy comes from the sun. During photosynthesis, plants capture the sun's energy by converting carbon dioxide into carbohydrates. When these carbohydrates are burned, they are converted back into carbon dioxide and water, releasing the energy they contain. The most common form of biomass is wood; for thousands of years people have burned wood for heating and cooking. In addition to burning, biomass can be converted into energy in several ways:

- **Co-firing.** Co-firing is the combustion of two different materials at the same time. Biomass can be combined with fossil-fuel technologies by processing biomass particles with coal to be used for electricity. According to the IPCC, biomass can substitute for up to 20 percent of the coal used in a boiler.[12]
- **Thermochemical.** When biomass is heated but not burned, it is broken down into gases, liquids, and solids that can be refined into useful fuels such as methane and alcohol. Biomass gasifiers capture methane released from the plants and burn it in a gas turbine to produce electricity.[13]
- **Biochemical.** Fermentation, the process used to make wine, changes biomass liquids into alcohol, a combustible fuel. This process is used to turn corn into ethanol, a fuel that can power some vehicles.[14]

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[12] Intergovernmental Panel on Climate Change, *The Physical Science Basics*, 2007.

[13] "Clean Energy: Biomass," Union of Concerned Scientists, December 2007.

[14] Ibid.

- **Chemical.** Biomass oils like soybean and canola oil can be chemically converted into a liquid fuel similar to diesel fuel and into gasoline additives. Cooking oil, for example, has been used as a source to make "biodiesel" for trucks.[15]

In the United States, biomass supplies about 1.2 percent of our nation's total electricity sales and about two percent of the liquid fuel used in cars and trucks.[16] Globally, biomass is estimated to provide over 10 percent of global primary energy. Two-thirds of biomass energy is consumed in developing countries, most often by burning wood for household use.[17]

Reliance on biomass energy is expected to grow. The Department of Energy estimates that the United States could produce four percent of its transportation fuels from biomass by 2010, and as much as 20 percent by 2030. For electricity, the U.S. Department of Energy estimates that energy crops and crop residues alone could supply as much as 14 percent of our electrical power needs.[18]

Sidebar: Ethanol

Ethanol is an alcohol fuel made from the sugars found in grains, such as corn, corghum and wheat, as well as potato skins, rice, sugar cane, sugar beets and yard clippings.[19] Most of the ethanol used in the United States today is distilled from corn.

[15] Ibid.

[16] Ibid.

[17] Intergovernmental Panel on Climate Change, *The Physical Science Basics*, 2007.

[18] "Clean Energy: Biomass," Union of Concerned Scientists, December 2007.

[19] Max Borders and H. Sterling Burnett, "The Environmental Costs of Ethanol," National Center for Policy Analysis, Brief Analysis No. 591, August 2, 2007.

About 99 percent of the ethanol produced in the United States is used to make E10 or gasohol, a mixture of 10 percent ethanol and 90 percent gasoline. Currently, ethanol fuel accounts for two percent of fuel used in vehicles in the United States. There is growing bipartisan political support for increased use of ethanol. An energy bill recently passed by the U.S. Senate would increase mandated ethanol use in blended fuels from 8 billion gallons to 36 billion gallons. Some assert that ethanol is a viable alternative to fossil fuels, but opponents note several problems.

Problem: Ethanol Drives Up Fuel Prices. Ethanol made from corn is currently more expensive than gasoline on a gallon-for-gallon basis. Federal laws requiring the inclusion of more ethanol in blended fuels will drive up the price of gasoline.[20]

Problem: Ethanol Reduces Fuel Economy. Ethanol produces 35 percent less energy per gallon than gasoline; thus the fuel economy of vehicles burning ethanol is lower. For instance, Consumer Reports tested a Chevrolet Tahoe running on E85 — a blend of 85 percent ethanol and 15 percent gasoline. Fuel economy fell from 21 miles per gallon (m.p.g.) to 15 m.p.g. on the highway and from 9 to 7 m.p.g. in the city. As a result, when E85 was $2.91 a gallon in August 2006, for example, it would have taken $3.99 of E85 to equal one gallon of gasoline.

In addition, poorer fuel economy means vehicles will use more gallons of fuel, which could negate any air quality gains due to fuel economy improvements.

Problem: Ethanol Corrodes Pipelines, Storage Tanks and Engines. Ethanol absorbs water and cannot be shipped through existing pipelines used to transport unblended gasoline. The water can separate, causing pipelines and fuel lines to freeze

[20] "Clean Energy: Biomass," Union of Concerned Scientists, December 2007.

and, perhaps, burst during cold weather. Under the right conditions, the water can damage car engines. Furthermore, ethanol corrodes soft metals, and contaminants from corrosion can damage vehicle fuel systems.

Thus, in order to use more than 5 percent to 10 percent ethanol blended with gasoline will require building a new generation of vehicles to use it, in addition to new storage tanks and pipelines. As a result, expanding the use of ethanol means using more natural resources, not less.

Problem: Ethanol Production Diverts Land from Other Uses. American farmers can meet the congressionally created demand for more ethanol by taking steps to increase production, such as: 1) devoting more cropland to corn and less to other crops, 2) diverting more of the corn crop from human and animal food supplies to fuel production, 3) increasing corn yields by using more chemical fertilizers and pesticides, and 4) converting fallow fields, forests, wetlands and wild lands to agriculture. The third and fourth options have environmental consequences. For example, ethanol boosters are already pushing to allow corn production on millions of acres farmers have been paid to set aside for environmental protection under the Conservation Reserve Program.

The first and second options are already having human consequences:

- The increased use of ethanol in the United States has caused the price of corn to double, raising livestock and wildlife feed prices.
- Corn prices have also risen beyond U.S. borders — for instance, in Mexico, where a dramatic increase in the price of corn tortillas led to riots in early 2007.

- Prices for meat and vegetables have also increased and, in June 2007, the United Nation's food envoy Jean Ziegler, warned that the diversion of crops from food to biofuels could result in hundreds of thousands of deaths from hunger worldwide.

Furthermore, land uses will have to change dramatically to meet future increases in the ethanol mandate. For instance:

- If every acre of corn were used to produce ethanol, it would supply the equivalent of only 12 percent to of current gasoline use, according to researchers at the University of Minnesota.
- Displacing just 5 percent of the U.S. demand for gasoline and diesel with ethanol would require more than 21 percent of U.S. cropland, according to the International Energy Agency.
- If all the cars in America were fueled with 100 percent ethanol from corn, it would require 97 percent of the 1.9 billion acres of land in the United States to grow the feedstock, according to Cornell University scientist David Pimentel.

Senators apparently recognize the impact ethanol demand has had on food prices and the limits of corn-based production because the Senate bill requires that a majority of ethanol eventually come from switchgrass. Switchgrass could yield much more fuel per acre than corn, but the technology to convert switchgrass to ethanol at affordable prices does not yet exist. However, even 300 million acres of switchgrass — using all of the land currently devoted to crop production in the United States — couldn't supply current gasoline and diesel demand, according to researchers at the Polytechnic University of

New York. Furthermore, the demand for gasoline and diesel is expected to double by 2025.

Problem: Ethanol Production Endangers South American Rainforests. For years, Brazil has subsidized the production of ethanol from sugar cane, which is why ethanol has appeared to be a renewables success story. In the past, farmers have turned to clear-cutting the Amazon jungle for soybean production. Currently most sugar cane is grown in the South Central region of Brazil — away from Amazonia. But the rainforest could be in greater peril is Congress clears the way for ethanol imports under a new agreement between the Bush Administration and the Brazilian government.

Soon, Brazil could be facing deforestation similar to that occurring in the tropical forests of Southeast Asia where jungles are being cleared for palm oil plantations to fill Europe's increasing demand for biodiesel.

Problem: Ethanol Pollutes the Air. Ethanol reduces overall emissions of CO_2, though the amount is debated. The crops grown for ethanol remove CO_2 from the atmosphere, and ethanol blended gasoline reduced CO_2 emissions by 18 percent to 29 percent. However, some of those gains are lost because ethanol production is more energy intensive than refining gasoline, leading to higher CO_2 emissions from burning fossil fuels in the ethanol distilling process.

In order to meet congressional mandates for ethanol in fuels, the Environmental Protection Agency has relaxed clean air regulations on ethanol production facilities, allowing 250 tons of emissions per year before regulations are triggered, whereas other industrial facilities violate clean air rules if their emissions top 100 tons per year.

While ethanol reduces some air pollutants, it increases others. Ethanol is blended with gasoline in some cities to reduce carbon monoxide (CO) emissions to meet clear air requirements. However, ethanol increases emissions of volatile organic compounds (VOCs) and nitrogen oxides (NOX), which are components of smog. As a result, some cities that achieved compliance for CO levels could violate the EOA's VOC and ozone standards if ethanol use were mandated nationwide. Under current mandated use:

- Ethanol is increasing ozone-forming emissions on hot days by 72 percent in Southern California, 48 percent in Sacramento and 55 percent in San Jose, according to the California Air Resources Board, jeopardizing the state's ability to comply with federal air quality standards.
- Ethanol will increase ozone-forming NOX emissions in Wisconsin by twice as much as the emissions reduction achieved through vehicle inspection and maintenance programs, says the state's Department of Natural Resources.

E85, used in some areas, reduces levels of carcinogenic benzene and butadiene, but increases two other carcinogens — formaldehyde and acetaldehyde. E85 also produces peroxyacetyl nitrate, which damages plants.

End of Sidebar

According to proponents, biomass is a viable alternative to traditional energy sources because it reduces air pollution and creates more efficient uses for waste. Opponents of biomass, however, argue that instead of being a clean energy source, burning biomass pollutes the environment and is harmful to human health. Biomass smoke contains a large and diverse number of chemicals, many of which have been associated with adverse health impacts. The main gaseous components in smoke which are potential health hazards are carbon monoxide and aldehydes. Two preliminary reports suggest that wood smoke exposure may lead to increased susceptibility to lung infections. These observations lend support to epidemiological associations between wood smoke exposure and respiratory illnesses in young children.[21]

Opponents also cite the impacts of biomass on biodiversity. Transforming natural ecosystems into energy plantations with a very small number of crops, as few as one, can drastically reduce the biodiversity of a region. Such "monocultures" lack the balance achieved by a diverse ecosystem and are susceptive to widespread damage by pests or disease.[22]

Finally, biomass fuels are costlier than fossil fuels. Biomass energy has a lower density compared to fossil fuels. In other words, a significantly large volume of biomass fuel is required to generate the same amount of energy a smaller volume of fossil fuel can produce. The low energy density means that the costs of fuel collection and transportation can quickly outweigh the value of the fuel.[23]

Hydropower. Hydropower is generated by moving water. Water has been used for centuries to power water wheels. The evolution of the modern hydropower turbine began in the 18th century when French engineer, Bernard Forest de Belidor, discussed different types of turbines in his seminal paper *Architecture Hydraulique*. Water turbine development continued throughout the 19th century. Soon hydropower was being used to

[21] Michael Brauer, "Health Impacts of Biomass Air Pollution," University of British Columbia, June 1998.

[22] Stuart Baird, "Biomass Energy," Local Governments for Stability, 1991.

[23] "Beginner's Guide to Biomass: A Biofuel Overview," *Alternative Energy Solutions News*, July 2007.

transport barge traffic up and down steep hills, provide electricity and power street lamps. Today hydropower is most commonly used for electric power generation.[24]

There are three types of hydropower facilities: impoundment, diversion and pumped storage.[25]

- **Impoundment.** Impoundments are hydroelectric power plants that store water behind dams and then divert it through a channel to a water turbine. To generate electricity from the kinetic energy in moving water, the water has to be moving with enough speed and volume to turn a generator. Approximately one gallon of water per second falling one hundred feet can generate one kWh of electrical power.[26] As a result, the most common type of hydroelectric power plant are impoundments or reservoirs that use dams on rivers to increase the force of moving water by creating a height differential.
- **Diversion.** Hydroelectric generation can also work without dams, in a process known as diversion. Portions of water from fast-flowing rivers, often at or near waterfalls, can be diverted through a canal to a turbine set in the river or off to the side. While this approach is inexpensive and easy to implement, it does not produce much power. It is often used for localized distributed generation.

[24] "History of Hydropower," Energy Efficiency and Renewable Energy, U.S. Department of Energy, September 2005.

[25] "Technologies," Energy Efficiency and Renewable Energy, U.S. Department of Energy, September 2005.

[26] "Clean Energy: Hydroelectric Energy," Union of Concerned Scientists, June 2007.

- **Pumped Storage.** In a pumped storage plant, water is pumped from a lower reservoir to a higher reservoir during off-peak times, using electricity generated from other types of energy sources. It is then released back into the lower reservoir through turbines when energy is needed.

Currently, hydropower provides one-fifth of the world's electricity, second only to fossil fuels. In the United States, hydropower has grown steadily, from 56 gigawatts (GW) in 1970 to more than 95 GW today. As a percentage of the U.S. electricity supply mix, however, it has fallen from 14 percent 20 years ago to 10 percent today.[27]

In some parts of the country, hydropower is utilized to a much larger extent than others. For example, the Pacific Northwest generates more than two-thirds of its electricity from 55 hydroelectric dams.[28] The Grand Coulee dam on the Columbia River is one of the largest dams in the world and has a capacity of nearly 6,500 MW.[29]

Proponents of hydropower claim that it is a clean and renewable source that is generally available as needed. Unlike intermittent sources such as wind and solar power, engineers can control the flow of water through the turbines to produce electricity on demand.

Opponents, however, note numerous environmental problems caused by hydropower, as well as its high cost. Dams that replace a river habitat with a lake habitat produce environmental tradeoffs because they replace one ecosystem with another.

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[27] "Facts About Hydropower," Wisconsin Valley Improvement Company, September 2004.

[28] M.A. Bernstein, A. Mejia, C.G. Pernin, F. Reuter, H. Shih and W. Steger, "Generating Power in the Pacific Northwest: Implications of Alternative Technologies," RAND.

[29] "Clean Energy: Hydroelectric Energy," Union of Concerned Scientists, June 2007.

Dams block the migration of species like salmon from the ocean to their upstream spawning grounds. Many fish that swim through turbines are killed. The number of salmon making the journey upstream has fallen 90 percent since the construction of four dams on the lower Snake River. Dams also harm fish by forcing air bubbles into the water when it flows over spillways. This air can be absorbed into fish tissue, ultimately killing the fish. Furthermore, by slowing down rivers, the water can become stratified, with warm water on top and cold water on the bottom. Since the cold water is not exposed to the surface, it loses its oxygen and become uninhabitable to fish.[30]

Wildlife habitats destroyed by reservoirs can be especially valuable. In South America, 80 percent of the hydroelectric potential is located in rain forests, one of the most rich and diverse ecosystem on Earth. The Rosana dam in Brazil destroyed one of the few remaining habitats of the black-lion tamarin.[31]

Many are also concerned about greenhouse gas emissions from hydropower systems. Researchers have found that while some reservoirs absorb CO_2 at their surface, most emit small amounts as water converts carbon in the natural carbon cycle. High emissions of CH_4 have been recorded at shallow plateau-type tropical reservoirs where the natural carbon cycle is most productive. These findings call into question the claim that hydropower is truly a clean energy source.[32]

Another problem frequently cited by opponents is the prohibitive cost of building hydroelectric plants. They require an enormous capital outlay (up to $4,778 per kWh)

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[30] Ibid.

[31] Ibid.

[32] Duncan Graham-Rowe, “Hydroelectric Power’s Dirty Secret Revealed,” *New Scientist*, February 2005.

and a relatively long time to build — which means that it will usually take a longer time to see a profit from a hydropower plant than from other types of power plants.[33]

Wind. Wind energy is tapped from the natural movement of the air. Throughout history, windmills have captured wind energy. The earliest windmill was used to power an organ in the 1st century A.D. In the United States, wind energy was pivotal in the development of rural America. The "water-pumping windmill" was a major factor in allowing the farming and ranching of vast areas of North America, which lacked accessible water. Windmills also contributed to the expansion of rail transport systems throughout the United States and the world by pumping water from wells to supply the needs of the steam locomotives.[34]

Today, wind energy is most often captured by wind turbines. Modern electric wind turbines come in different styles and sizes, depending on their use. The amount of power wind turbines can produce has dramatically increased in the last 25 years. In the early 1980s, average wind turbines produced less than 50 kW. In 2006, the largest commercially available turbine produced 5 MW of energy and had a rotor diameter of over 120 meters. These large wind turbines are most often used by utilities to provide power to a grid. Small turbines are used to provide power off the grid, ranging from very small to charge up batteries on a sailboat to much larger to power dairy farms or remote villages.[35]

Wind power currently provides less than one percent of U.S. energy, but proponents of wind energy assert that wind has the potential to contribute much more to

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[33] "Hydropower Today," Hydropower Research Foundation.

[34] "Clean Energy: How Wind Energy Works," Union of Concerned Scientists, May 2007.

[35] Ibid.

the U.S. energy supply.[36] Some argue that wind energy has neglible fuel costs and relatively low maintenance costs.   According to a British Wind Energy Association Report, cost per unit of energy produced was estimated in 2006 to be comparable to the cost of new generating capacity in the United States for coal and natural gas: wind cost was estimated at $55.80 per megawatt (MWh), coal at $53.10 per MWh and natural gas at $52.50.[37]

Opponents of wind power, however, argue that relying on wind energy is problematic for several reasons. First, wind is intermittent. While in theory wind systems can produce electricity 24 hours every day, even in the windiest places, the wind does not blow all the time. Due to the inconsistent nature of wind power, energy plants that rely on wind need redundant or additional power supplies — usually generation systems that use fossil fuel.[38]

In addition, wind farms are very expensive to build and maintain. Constructing a wind farm can cost over a million dollars. Operating costs can reach $50,000 a year.[39] Wind power, like almost every other source of renewable energy is more expensive than non-renewable energy sources.

From an environmentalist's point of view, perhaps the worst problem caused by wind power is the number of birds that wind turbines kill each year. The most viable locations for wind farms are also critical flyways for many migratory bird species and

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[36] "U.S. Wind Power Grows by 45 percent in 2007," *Environment News Service*, July 31, 2007.

[37] "Wind and the UK's 10 Percent Target," British Wind Energy Association, October 2005.

[38] "Clean Energy: How Wind Energy Works," Union of Concerned Scientists, May 2007.

[39] L. Fingersh, M. Hand, and A. Laxson, "Wind Turbine Design Cost and Scaling Model," National Renewable Energy Laboratory, December 2006.

prime habitats for several endangered raptor species. Most of these birds are protected by treaties or laws. However, every year thousands of birds in the United States are killed when they fly into the turning blades of wind turbines. They are the Cuisinarts of the air. For example, 4,720 birds, including 1,300 endangered birds such as golden eagles, red-tailed hawks and burrowing owls,[40] are killed each year at just one wind farm in Altamont Pass, California.[41]

Wind farms can also contribute to health problems in humans. The low frequency noise of wind turbines can cause headaches, migraines, dizziness, palpitations, sleep disturbances, stress, anxiety and depression.[42]

Geothermal. Geothermal comes from the Greek words "geo" meaning earth and "therme" meaning heat. Geothermal energy is derived from heat stored in molten rock called magma miles below the earth's surface. For thousands of years people have used steam and hot springs for bathing and cooking food. Today it is still common to capture geothermal energy by tapping into naturally occuring hydrothermal convection systems where cooler water seeps into Earth's crust, is heated up and then rises to the surface. With advanced technology, rather than waiting for hot water to come to the earth's surface we can drill wells deep below the surface of the earth to tap into geothermal reservoirs.[43]

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[40] James Taylor, "Environmental Group Sues Wind Farm to Stop Bird Deaths," *Environment News*, Heartland Institute, March 2004.

[41] Leonard, Anderson, "Big California Wind Farm to Stop Bird Deaths," *Environment News*, Heartland Institute, March 2004.

[42] James Taylor, "Environmental Group Sues Wind Farm to Stop Bird Deaths," *Environment News*, Heartland Institute, March 2004.

[43] "Clean Energy: How Geothermal Energy Works," Union of Concerned Scientists, December 2006.

There four geothermal power plant designs, all of which pull hot water and steam from the ground, use it and then return it as warm water to prolong the life of the heat source.[44]

- **Dry Steam.** In the simplest design, the steam goes directly through the turbine, then into a condenser where the steam is converted into water.
- **Flash Steam.** Very hot water is depressurized or "flashed" into steam which can then be used to drive a turbine.
- **Binary System.** In the third approach, called a binary system, the hot water is passed through a heat exchanger, where it heats a second liquid that boils at a lower temperature than water. This liquid is more easily converted into steam to run the turbine.
- **Hot Dry Rock.** Another approach to capturing heat in dry areas is known as "hot dry rock." The rocks are first broken up by pumping high-pressure water through them. Water is then pumped from the surface down through the broken hot rocks. After the water heats up, it is brought back to the surface through a second well and used to drive turbines for electricity or to provide heat. This type of geothermal system can be used anywhere, not just in tectonically active regions. However, it requires deeper drilling than the other forms of geothermal energy harvesting.

In 2005, geothermal energy constituted about 4 percent of renewable energy use in the United States, making up less than 1 percent of total U.S. energy use.[45] Due to

[44] Ibid.

[45] Alyssa Kagel, Diana Bates and Karl Gawell, "A Guide to Geothermal Energy and the Environment," Geothermal Energy Association, April 2007.

declining costs and increased state and federal support, geothermal development is likely to increase. In addition, as hot dry rock technologies improve and become competitive, even more of the largely untapped geothermal resource could be developed. The U.S. Geological Survey estimates the geothermal resource base in the United States to be between 95,000 and 150,000 MW, of which about 22,000 MW have been identified as suitable for electric power generation. In addition to electric power generation, which is focused primarily in the western United States, there is a bright future for the direct use of geothermal resources as a heating source for homes and businesses everywhere.[46]

Proponents of geothermal energy argue that it can play a significant role in moving the United States toward a cleaner energy system. From an environmental perspective, some argue that geothermal energy is sustainable because the hot water used in the geothermal process can be re-injected into the ground to produce more steam. In addition, geothermal energy is one of the few renewable energy technologies that, like fossil fuels, can supply continuous, base load power. Geothermal power plants are unaffected by changing weather conditions.

From an economic view, geothermal energy is extremely price competitive in many areas. Some geothermal facilities have realized at least 50 percent reductions in the price of electricity since 1980. New facilities can produce electricity for between 4.5 and 7.3 cents per kilowatt-hour, making it competitive with new conventional fossil fuel-fired plants.[47]

Critics, on the other hand, have highlighted several problems with geothermal energy. One concern with open systems like the Geysers is that they emit some air

[46] "Clean Energy: How Geothermal Energy Works," Union of Concerned Scientists, December 2006.
[47] Ibid.

pollutants.[48] Hydrogen sulfide, a toxic gas with a highly recognizable rotten egg odor, along with trace amounts of arsenic and minerals are released in the steam. These gases are harmful to humans and can cause symptoms ranging from headaches, eye irritation, nervous and circulatory system irregulation, asthma attacks and pulmonary edemas.[49]

In addition, some argue that, contrary to claims made by proponents, geothermal energy is not a sustainable source. Land may subside as the result of extraction or extraction rates may exceed natural replinishment. Although geothermal sites are capable of providing heat for many decades, eventually specific locations will cool down.[50]

Ocean. Important components of ocean energy include tidal power and ocean thermal energy conversion. Tidal power, sometimes called tidal energy, is the movement of water caused by tidal currents or the rise and fall in sea levels due to the tides. The height of the tide produced at a given location is the result of the changing positions of the moon and sun relative to the Earth coupled with the effects of Earth's rotation and the local shape of the sea floor. The tidal energy generator uses this phenomenon to produce energy.

Tidal stream generators are a relatively new technology that draws energy from currents in much the same way as wind turbines. The higher density of water means that a single generator can provide significant power. The selection of location is important for the tidal turbine. Tidal stream systems need to be located in areas with fast currents where natural flows are concentrated between obstructions, for example at the entrances

[48] "Common Airborne Pollutants," BRANZ, February 2008.

[49] "Benefits and Barriers to Renewable Energy," Energy Education Program, 2005.

[50] "Clean Energy: How Geothermal Energy Works," Union of Concerned Scientists, December 2006.

to bays and rivers, around rocky points, headlands or between islands or other land masses.

Although not yet widely used, proponents of tidal power assert that it has potential for future electricity generation and is less intermittent than other energy renwable energy sources like wind or solar power. Critics, however, note several downsides that make its application difficult. For instance, tidal barrage power schemes have a high capital cost. For example, the construction of a barrage between Wales and England would cost approximately $29.5 billion. As a result, a tidal power scheme may not produce returns for many years, and investors may be reluctant to participate in such projects.

Another form of renewable ocean energy is found in ocean thermal energy conversion (OTEC). This method uses the temperature differences that exist between deep and shallow waters to run a heat engine. Temperature difference contains a vast amount of thermal energy which can potentially be harnessed for human use. The total energy available is one or two orders of magnitude higher than other ocean energy options such as tidal power, but the small size of the temperature difference makes energy extraction comparatively difficult and expensive, due to low thermal efficiency. Some energy experts believe that if it could become cost-competitive with conventional power technologies, OTEC could produce an immense amount of electrical power.

Solar Power Satellites (SPS). Space-based solar power refers to the concept of developing satellites for transmitting solar energy from space to antennas on Earth. Large solar panels connected to these satellites would collect the energy, convert it to microwave rays, and beam it to the Earth for use in electricity grids.

The idea for SPS was first examined in 1968, but no practical solution existed for getting the energy down to earth and converting it into a useable form of power. This all changed in 1973 when Peter Glaser designed a system for transmitting solar power from an antenna on a satellite to antennas on Earth using microwave rays. Several broader studies followed.

In coordination with Glaser, NASA performed its first study in 1974, concluding that the technology would have extremely high costs but warranted further investigation. Building off this assessment, the U.S. Department of Energy and NASA conducted the most comprehensive analysis to date on every aspect of SPS between 1978 and 1981. No further consideration was given however, until 1997 when NASA published the study "Fresh Look," evaluating the feasibility of SPS in light of newer technologies. At that time policymakers chose to delay action.[51] Recently, the National Security Space Office of the Department of Defense embarked on a study discussing the feasibility of SPS in providing energy security both militarily and commercially.[52]

SPS provide a more promising alternative to ground-based solar power, at least in theory. Initially, SPS looks more attractive because placing solar panels in space would provide un-impeded access to solar radiation. The typical limitations of regular solar power on Earth — intermittent weather, periods of darkness and varying levels of radiation in certain geographical areas — would conceivably disappear under SPS systems.

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[51] John C. Mankins, "A Fresh Look at Space Solar Power," NASA, 1996.

[52] National Security Space Office (NSSO), "Space-Based Solar Power," U.S. Department of Defense, 2007.

Compared to other forms of energy, SPS has one of the lowest levels of life-cycle carbon dioxide (CO_2) emissions. Measures of life-cycle CO_2 emissions take into account the emissions released while manufacturing the plant as well as emissions released while the plant generates energy. In the case of an SPS system, the measurement of life-cycles CO_2 emissions accounts for emissions from the fuel used to launch the satellite into space and emissions from solar panel production. SPS emissions are estimated at 11 g CO_2 per kWh. This is 1/60 of the output of coal-fired power stations and 1/30 of the CO_2 output of LNG-fired power stations.[53]

Another benefit of SPS is that it can be used in conjunction with ground-based solar power. Both can feasibly be integrated by placing SPS antennas in the same compound or structure as ground solar and by using SPS to supplement ground solar when there are interruptions in supply.

Critics, however, note that solar powered satellites face two major obstacles: cost and technology. Launching an SPS into space would prove very costly. In addition, nothing as large as an SPS system has even been constructed in space. The only structure that approaches the size of an SPS system is the International Space Station**.** SPS systems would be much larger.[54]

Hydrogen Fuel Cells. Hydrogen is a versatile energy carrier that can be used to power nearly every energy need. The fuel cell is an energy conversion device that can efficiently capture and use the power of hydrogen. A fuel cell is an electrochemical

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[53] Keeichiro Asakura et al, "CO2 Emission from Solar Power Satellite through its Life Cycle," Keio Economic Observatory, Keio University, Japan, 2000.

[54] Taylor Dinerman, "Space Solar Power: Opposition and Obstacles," The Space Review, June 4, 2007.

device that produces electricity from a combined chemical reaction and electrical charge transport that occurs within the fuel cell. This is very similar to the way a battery produces electricity. However, unlike a battery, a fuel cell only produces electricity while fuel is supplied to it. The reaction is at relatively low temperatures, and no combustion takes place in the fuel cell. When hydrogen is supplied, a chemical reaction, between hydrogen and air produces electricity, pure water and some heat. The electrical power available is proportional to the rate of fuel flowing into the fuel cell, limited by the physical size of the fuel cell itself.[55]

The markets for fuel cells are virtually unlimited. Since a fuel cell is a device that produces electricity directly from hydrogen fuel, it can power anything that requires electricity, rotary power or heat. A unique characteristic of all fuel cells is that they can be made small enough to power a cellular phone or large enough to power a town, without significantly changing the design. Fuel cells are very useful as power sources in remote locations, such as spacecraft, remote weather stations, large parks, rural locations, and in certain military applications. A fuel cell system running on hydrogen can be compact, lightweight and has no major moving parts.

Fuel cells directly convert the chemical energy in hydrogen to electricity, with pure water and potentially useful heat as the only byproducts. A fuel cell running on pure hydrogen is a zero-emission power source. Some stationary fuel cells use natural gas or hydrocarbons as a hydrogen feedstock, but even those produce far less emissions than conventional power plants. Fuel cell power plants are so low in emissions that some areas of the United States have exempted them from air permit requirements. Based on

[55] Karin Nice and Jonathan Stickland, "How Hydrogen Fuel Cells Work," 2005.

measured data, a fuel cell power plant may create less than one ounce of pollution per 1,000 kilowatt-hours of electricity produced - compared to the 25 pounds of pollutants for conventional combustion generating systems.

When hydrogen is produced through electrolysis, the energy comes from electricity produced in the United States. Though the fuel cell itself will only emit heat and water as waste, pollution is often caused when generating the electricity required to produce the hydrogen that the fuel cell uses as its power source (for example, when coal, oil, or natural gas-generated electricity is used). This will be the case unless the hydrogen is produced using electricity generated by hydroelectric, geothermal, solar, wind or other clean power sources. Ultimately, hydrogen is only as clean as the energy sources used to produce it.

Hydrogen-powered fuel cells also can have two to three times the efficiency of traditional combustion technologies. The gasoline engine in a conventional car is less than 20 percent efficient in converting the chemical energy in gasoline into power that moves the vehicle. Hydrogen fuel cell vehicles, which use electric motors, are 40-60 percent efficient.

Because fuel cells have no moving parts, and do not involve combustion, in ideal conditions they can achieve up to 99.99 percent reliability. This equates to less than one minute of down time in a six year period. The level of development and international interest to date assure that fuel cells will play a significant role in nations' economies.

Reducing cost and improving durability are the two most significant challenges to fuel cell commercialization. Fuel cell systems must be cost-competitive with, and perform as well or better than, traditional power technologies over the life of the system.

Ongoing research is focused on identifying and developing new materials that will reduce the cost and extend the life of fuel cell stack components including membranes, catalysts, bipolar plates, and membrane-electrode assemblies. Low cost, high volume manufacturing processes will also help to make fuel cell systems cost competitive with traditional technologies.

Nuclear Energy. There are currently two ways to produce nuclear energy: fission and fusion reactions. Fission reactions, the most commonly used method, occur when an atomic nucleus is split into smaller nuclei, usually through the bombardment of neutrons. In splitting the nucleus, the reaction also releases free neutrons and other particles, which create large amounts of energy. These particles then collide with other large atomic nuclei, creating a self-sustaining chain reaction. In a nuclear reactor, this process is harnessed and controlled, providing a steady stream of energy. This is usually accomplished through fuel rods, which consist of enriched uranium or plutonium.

Alternatively, nuclear fusion involves the joining of two atomic nuclei to form a heavier, single nucleus. This is accomplished by bringing two nuclei together so that strong nuclear forces between the nuclei will cause them to combine together. When the nuclei combine, energy is released. Currently, nuclear fusion reactors are still in the experimental stage. In both cases, the released energy takes the form of heat, which is used to boil water, creating steam to turn turbines that can be used for electricity.[56]

Although many nations sought to reduce their dependence on nuclear power following the Chernobyl catastrophe, volatile fossil fuel prices have renewed the demand for nuclear energy. As of 2005, nuclear power constituted nearly 20 percent of U.S.

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[56] "Nuclear Power 2010," U.S. Department of Energy," 2007.

electricity use and about 15 percent of the world's electricity. The International Atomic Energy Agency (IAEA) reports that there are 439 nuclear reactors in operation in 31 countries. Most of the major countries in the world rely, at least partly, on nuclear power. France, for example, generates over 75 percent of its electricity from nuclear power. The United States, the United Kingdom, China, India, Japan, and Russia all operate nuclear facilities. Nuclear energy is of particular interest to the developing nations of China and India in order to support their rapidly expanding economies.

Extensive research has been done for future development of nuclear energy. In particular, steps have been taken to increase the safety of newly built reactors, including improved emergency procedures. Additionally, researchers are developing new uses for the excess heat generated by nuclear reactors, focusing on desalinization and hydrogen generation. Russia has recently announced its intent to construct floating nuclear generators that can produce power for a city of 200,000. In early 2008, the United Kingdom declared its intent to start building a new generation of nuclear power plants in order to meet the country's growing energy need. In the United States, no new nuclear reactors have been constructed since 1996, but the country has recently approved new sites for future nuclear power development.

Nuclear energy proponents claim that nuclear power is a sustainable energy source and is less environmentally harmful than other traditional fossil fuels. For example, it is estimated that in 1982, coal-based energy production generated 155 times the amount of radioactivity that the Three Mile Island incident produced. Although nuclear energy does generate gas emissions and waste products, supporters argue that it does so in far less quantities than most other forms of energy production. In addition, advocates assert that the storage of spent nuclear fuel rods has become much safer in recent years with improved technology and that the chance of significant catastrophes is much lower as well. Consequently, proponents promote continued research and development of nuclear energy in order to improve safety and maximize the benefits gained from nuclear energy.[57]

Despite these positives, nuclear energy still faces considerable opposition from critics. Primary concerns include the storage of spent fuel rods, reactor malfunctions that could lead to meltdowns and terrorist attacks on nuclear reactors. No one can guarantee that radioactive material from the fuel rods will not leak into surrounding areas, harming the world's water supply. In addition, there is a chance that severe catastrophes on par with the Chernobyl incident in 1986 and the Three Mile Island accident in 1979 could occur. (Follow the links for overviews of Chernobyl and Three Mile Island.) Meltdowns not only destroy the reactor, but also expose the public to dangerous amounts of radiation. It also renders the surrounding area uninhabitable for thousands of years due to radiation. Another issue considered by governments, especially in recent years, is the possibility of terrorist attacks on a nation's nuclear power plants. These concerns continue to make nuclear energy a contentious issue.

The Case for Alternative Energy

Many scholars claim that there are numerous benefits to increasing our use of alternative energy. These include slowing climate change, enhancing energy independence, sustainability and strengthening energy reliability. . .

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[57] "Nuclear Energy: A Key Tool in Reducing Greenhouse Gas Emissions," October 2007, Nuclear Energy Institute.

Climate Change

Proponents argue that using alternative energy will slow or halt climate change by offsetting fossil fuel use. The reality, causes and effects of climate change are widely debated. .

Climate Models. The Intergovernmental Panel on Climate Change (IPCC) asserts that the Earth's surface temperature has increased 0.7 °C over the last 100 years.[58] The IPCC predicts that this warming trend will continue. In 2007, the IPCC issued its *Fourth Assessment Report*. The report included predictions of significant increases in average world temperatures by 2100.[59]

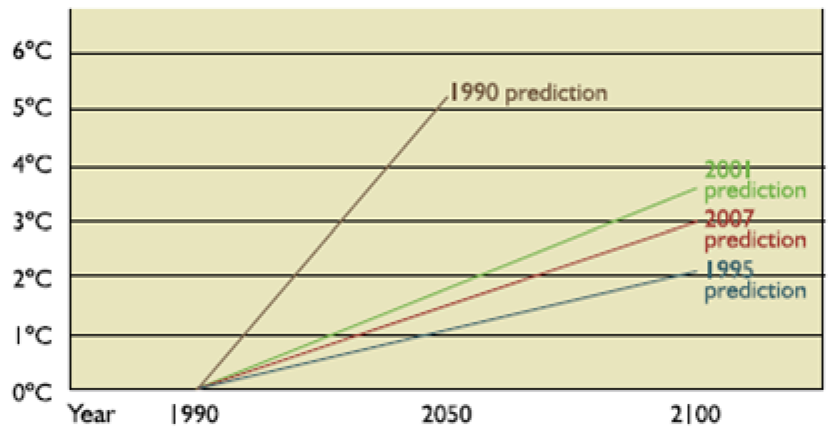
Scientists use models to predict future warming. Climate models are very complex and include numerous components and processes. The graph below shows how the mid-range estimates of those models have changed over time.[60]

Figure II: Predicted Temperature Increases of Computer Climate Models

[58] H. Le Treut, R. Somerville, U. Cubasch, Y. Dine, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather, *Climate Change 2007: The Physical Science Basis*, Intergovernmental Panel on Climate Change,(Cabridge University Press: Cambridge, United Kingdom and New York, USA) 2007.

[59] Ibid.

[60] "Global Warming Primer," National Center for Policy Analysis, 2007.



Some argue that there are several reasons we should not rely on models to predict future temperature increases.[61]

Problems with Computer Models. There is no evidence that model predictions are accurate. For example, according to the models, the Earth should be warmer than actual measurements show it to be. Furthermore:

- The General Circulation Models that are used failed to predict recent global average temperatures as accurately as fitting a simple curve to the historical data and extending it into the future.
- The models forecast greater warming in higher altitudes in the tropics, whereas the data show the greatest warming has occurred at lower altitudes and at the poles.
- Furthermore, individual models have produced widely different forecasts from the same initial conditions, and minor changes in assumptions can produce forecasts of global cooling.

[61] Kesten Green and J. Scott Armstrong, "Global Warming: Experts' Opinions Versus Scientific Forecasts," National Center for Policy Analysis, Policy Report No. 308, January 2008.

Skepticism Among Scientists. International surveys of climate scientists from 27 countries in 1996 and 2003 found growing skepticism over the accuracy of climate models. Of more than 1,060 respondents, only 35 percent agreed with the statement, "Climate models can accurately predict future climates," whereas 47 percent disagreed.

Violations of Forecasting Principles. Forty internationally-known experts on forecasting methods and 123 expert reviewers codified evidence from research on forecasting into 140 principles. The empirically-validated principles are available in the Principles of Forecasting handbook and at forecastingprinciples.com. These principles were designed to be applicable to making forecasts about diverse physical, social and economic phenomena, from weather to consumer sales, from the spread of nonnative species to investment strategy, and from decision in war to egg-hatching rates. They were applied to predicting the 2004 U.S. presidential election outcomes and provided the most accurate forecast of the two-party vote split of any published forecast, and did so well ahead of election day.

The authors of this study used these forecasting principles to audit the IPCC report. They found that:

- Out of 140 forecasting principles, 127 principles are relevant to the procedures used to arrive at the climate projections in the IPCC report.
- Of these 127, the methods described in the report violated 60 principles.
- An additional 12 forecasting principles appear to be violated, and there is insufficient information in the report to assess the use of 38.

As a result of these violations of forecasting principles, the forecasts in the IPCC report are invalid. Specifically:

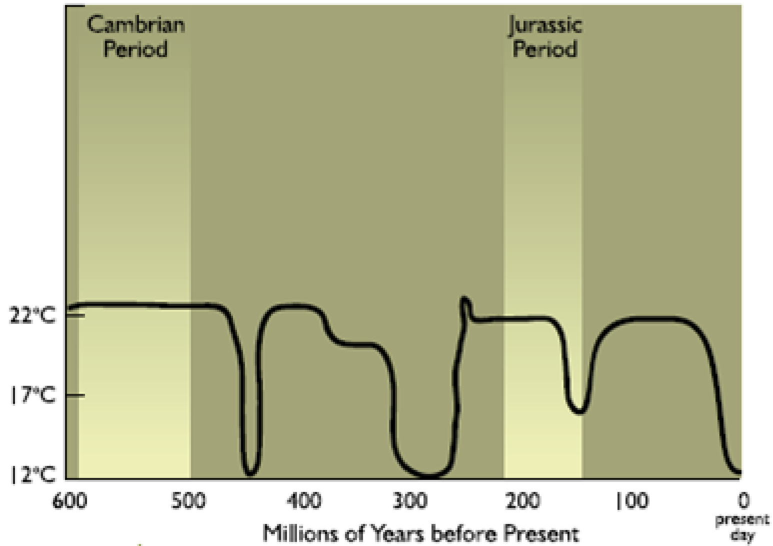
- The Data Are Unreliable. Temperature data is highly variable over time and space. Local proxy data of uncertain accuracy (such as ice cores and tree tings) must be used to infer past global temperatures. Even over the period during which thermometer data have been available, readings are not evenly spread across the globe and are often subject to local warming from increasing urbanization. As a consequence, the trend over time can be rising, falling or stable depending on the data sample chosen.
- The Forecasting Models Are Unreliable. Complex forecasting methods are only accurate when there is little uncertainty about the data and the situation (in this case: how the climate system works), and causal variables can be forecast accurately. These conditions do not apply to climate forecasting. For example, a simple model that projected the effects of Pacific Ocean currents (El Nino-Southern Oscillation) by extrapolating past data into the future made more accurate three-month forecasts than 11 complex models. Every model performed poorly when forecasting further ahead.
- The Forecasters Themselves Are Unreliable. Political considerations influence all stages of the IPCC process. For example, chapter by chapter drafts of the "Fourth Assessment Report Summary for Policymakers" were released months in advance of the full report, and the final version of the report was expressly written to reflect the language negotiated by political appointees to the IPCC. The conclusion of the audit is that there is no scientific forecast supporting the widespread belief in dangerous

human-caused "global warming." In fact, it has yet to be demonstrated that long-term forecasting of climate is possible.

1,500 Year Warming-Cooling Cycles. Moreover, even if it is true that the earth is experiencing a warming period, this may not be cause for concern. In fact, warming seems to be part of a natural 1,500-year cycle (plus or minus 500 years) of moderate temperature swings. (See Figure III below.) The current warming cycle is not unusual: Evidence from around the world shows that the Earth has experienced numerous climate cycles throughout its history. These cycles include glacial periods (more commonly known as Ice Ages) and interglacial periods, as well as smaller fluctuations. During the past 20 years, scientists have been accumulating strong physical evidence that the Earth consistently goes through a climate cycle marked by alternating warmer and cooler periods over 1,500 years.

It has long been accepted that the Earth has experienced climate cycles, most notably the 90,000 year Ice Age cycles. But in the past 20 years or so, modern science has discovered evidence that within those broad Ice Age cycles, the Earth also experiences 1,500 year warming-cooling cycles. The Earth has been in the Modern Warming portion of the current cycle since about 1850, following a Little Ice Age from about 1300 to 1850. It appears likely that warming will continue for some time into the future, perhaps 200 years or more, regardless of human activity.

Figure III: Average Global Temperature over the Past 600 Million Years



Evidence of the global nature of the 1,500-year climate cycles includes very long-term proxies for temperature change — ice cores, seabed and lake sediments, and fossils of pollen grains and tiny sea creatures. There are also shorter-term proxies — cave stalagmites, tree rings from trees both living and buried, boreholes and a wide variety of other temperature proxies. Scientists got the first unequivocal evidence of a continuing moderate natural climate cycle in the 1980s, when Willi Dansgaard of Denmark and Hans Oeschger of Switzerland first saw two mile-long ice cores from Greenland representing 250,000 years of Earth's frozen, layered climate history. From their initial examination, Dansgaard and Oeschger estimated the smaller temperature cycles at 2,550 years. Subsequent research shortened the estimated length of the cycles to 1,500 years (plus or minus 500 years). Other substantiating findings followed:

- An ice core from the Antarctic's Vostok Glacier — at the other end of the world from Greenland — showed the same 1,500-year cycle through its 400,000-year length.

- The ice-core findings correlated with known glacier advances and retreats in northern Europe.
- Independent data in a seabed sediment core from the Atlantic Ocean west of Ireland, reported in 1997, showed nine of the 1,500-year cycles in the last 12,000 years.

To dismiss the evidence of the 1,500-year climate cycle, it is necessary to dismiss not only the known human histories from the past 2,000 years but also an enormous range and variety of physical evidence found by a huge body of serious researchers.

Sidebar: Ice Cores

In the 1980s scientists got the first unequivocal evidence of a continuing, moderate natural climate cycle. The 1,500-year climate cycle emerged almost full-blown from Greenland in 1983.[62]

Denmark's Willi Dansgaard and Switzerland's Hans Oeschger were among the first people in the world to see two mile-long ice cores that brought up 250,000 years of the Earth's frozen, layered climate history. Over the previous dozen years, the two researchers had pioneered ways to pry information from the ice cores. They had learned, among other things that the ratio of oxygen-18 isotopes to oxygen-16 isotopes in ice could reveal the air temperature at the time when the snowflakes that made the ice fell to earth.

Dansgaard and Oeschger expected to see the big 90,000-year Ice Ages in the cores, and they did. But they were startled to find, superimposed on the big Ice Age

[62] Fred Singer and Dennis Avery, "The Physical Evidence of Earth's Unstoppable 1,500-Year Climate Cycle," National Center for Policy Analysis, Study No. 279, September 30, 2005.

swings, a smaller, moderate and more persistent temperature cycle. They estimated the average cycle length at 2,550 years. They dismissed volcanoes as a causal factor because there's no such cycle in volcanic activity. The timing of the cycles seemed to match closely with the known history of recent glacier advances and retreats in northern Europe.

The report that Dansgaard and Oeschger wrote in 1984, "North Atlantic Climatic Oscillations Revealed by Deep Greenland Ice Cores," was, in retrospect, almost eerie in its accuracy, its completeness and its logical linking of the climate cycles to the sun. The only major correction imposed by subsequent research is that the cycles were more frequent than they thought. The average length of the cycles has now been shortened by almost half — from their original estimate of 2,550 years to 1,500 years (plus or minus 500 years).

Dansgaard and Oeschger were correct when they told us that the climate shifts were moderate, rising and falling over a range of about 4° C in northern Greenland, with very little temperature change at the equator — and only half a degree when averaged over the northern hemisphere.

The cycles were confirmed by 1) their appearance in two different ice cores drilled more than 1,000 miles apart; 2) their correlation with known glacier advances and retreats in northern Europe; and 3) independent data in a seabed sediment core from the Atlantic Ocean west of Ireland.

They noted that the cycle shifts were abrupt, sometimes gaining half of their eventual temperature change in a decade or so. That suggested an external forcing, perhaps amplified and transmitted globally by the ocean currents and winds. (In the mid-19th century, the Upper Fremont Glacier in Wyoming went from Little Ice Age to

Modern Warming in about 10 years. That implies a climate driver from outside our planet, almost certainly involving the sun.)

However, Dansgaard and Oeschger noted, “Since the solar radiation is the only important input of energy to the climatic system, it is most obvious to seek an explanation in solar processes. Unfortunately we know much less about the solar radiation output than about the emission of solar particulate matter in the past.”

The two scientists did know, however, that both carbon-14 and beryllium-10 isotopes vary inversely with the strength of the solar activator. The isotopes of both elements in their Greenland ice cores showed historic temperature lows during what solar scientists term the Maunder sunspot minimum (1645–1715) — the absolute coldest point of the Little Ice Age and a period when sunspots virtually disappeared.

Today, we can measure variations in the sun’s irradiance from satellites out beyond the obscuring atmosphere of our own planet. The solar constant isn’t — constant, that is. We also know that when the sun is less active, its solar wind weakens and provides less shielding for the Earth from the cosmic rays that bounce around space. With a weaker sun, more of the cosmic rays hit the Earth, creating more charged particles in the atmosphere, which then become low, wet clouds reflecting more heat back into space. A less active sun thus means a cooler Earth.

The importance of the 1,500-year cycles found in the Greenland ice cores increased dramatically four years later when they were also found at the other end of the world — in an ice core from the Antarctic’s Vostok Glacier. The Vostok ice core went back 400,000 years, and showed the 1,500-year cycle through its whole length.

The scientific world had known about the sunspot connection to Earth's climate for some 400 years. British astronomer William Herschel claimed in 1801 that he could forecast wheat prices by sunspot numbers, because wheat crops were often poor when sunspots (and thus solar activity) were low. Not only did the Maunder minimum (1645-1715) coincide with the coldest period of the Little Ice Age, the Sporer minimum (1450–1543) aligned with the second-coldest phase of that period.

In 1991, Eigel Friis-Christensen and Knud Lassen noted that the correlation between solar activity and Earth temperatures is even stronger if we use the length of the solar cycle to represent the sun's variations instead of the number of sunspots. (The solar cycles average about 11 years in length, but actually vary between eight and 14 years.) Their paper in Science concluded that the solar connection explained 75 to 85 percent of recent climate variation.

End of Sidebar

Role of Greenhouse Gases. The IPCC contends that increased greenhouse gases, from human activity, are the cause of recent warming.[63] Since the 1800s, scientists have known that greenhouse gases warm the Earth's surface. In a process called the greenhouse effect, the sun radiates energy at very short wavelengths, predominately in the visible or near-visible part of the spectrum. Roughly one-third of the solar energy that reaches the top of Earth's atmosphere is reflected directly back to space. The remaining two-thirds are absorbed by the surface and, to a lesser extent, by the atmosphere. To balance the absorbed incoming energy, the Earth must, on average,

[63] H. Le Treut, R. Sommerville, U. Cubasch, Y. Ding, C. Mauritaen, A. Mokssit, T. Peterson and M. Prather, *Climate Change 2007: The Physical Science Basis*, (Cambridge University Press: Cambridge, United Kingdom and New York, USA), 2007.

radiate the same amount of energy back to space. Because the Earth is much colder than the sun, it radiates at a much longer wavelengths. Much of this thermal radiation emitted by the land and ocean is absorbed by the atmosphere, inclined clouds, and reradiated back to Earth. This is called the greenhouse effect, like the glass walls in a greenhouse reduce airflow and increase the temperature of the air inside. Similarly, the Earth's greenhouse effect warms the surface of the planet. Without the natural greenhouse effect, the average temperature at Earth's surface would be below the freezing point of water. In this way, the Earth's natural greenhouse effect makes life as we know if possible.[64]

According to the IPCC, human activities, primarily the burning of fossil fuels and clearing of forests, have greatly intensified the natural greenhouse effect, causing global warming. Human activities result in emissions of four principal greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the halocarbon (a group of gases containing fluorine, chlorine and bromine). These gases accumulate in the atmosphere causing concentrations to increase with time.[65]

- Carbon dioxide in the atmosphere has increased from fossil fuel use in transportation, building heating and cooling and the manufacture of cement and other goods. Deforestation also releases CO_2 and reduces its uptake by plants. In addition, carbon dioxide is released in natural processes such as the decay of plant matter. According to the IPCC, CO_2 in the atmosphere has increased by 35 percent in the industrial era.
- Methane emissions are a result of human activities related to agriculture, natural gas distribution and landfills. Methane is also released from

[64] Ibid.

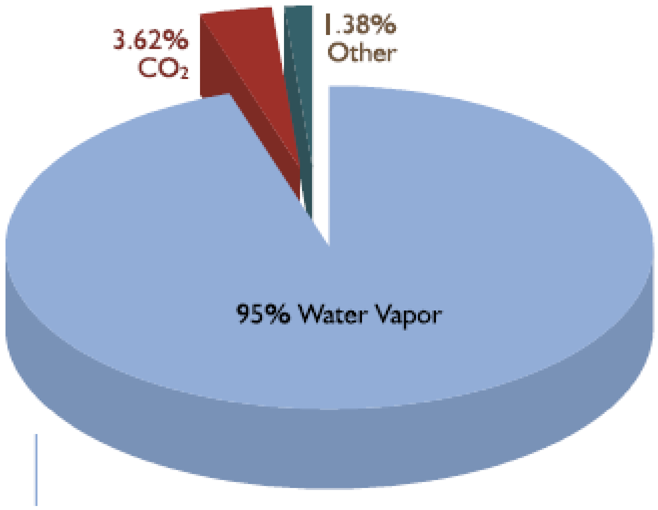
[65] Ibid.

natural processes that occur, for example, in wetlands. Methane concentrations are not currently increasing in the atmosphere; in fact, growth rates decreased over the last two decades.

- Nitrous oxide is also emitted by human activities such as fertilizer use and fossil fuel burning. Natural processes in soils and the oceans also release nitrous oxide.
- Human activity can also increase halocarbon gas concentrations in the atmosphere. Principal halocarbons include the chlorofluorocarbons, which were used extensively as refrigeration agents and in other industrial processes before their presence in the atmosphere were found to cause stratospheric ozone depletion. The abundance of chlorofluorocarbon gases is decreasing as a result of international regulations designed to protect the ozone layer.

Water vapor is the most abundant and important greenhouse gas in the atmosphere (see Figure IV). However, human activities have only a small direct influence on the amount of atmospheric water vapor.

Figure IV: Greenhouse Gases in the Atmosphere



Those who worry that too much CO_2 is being sent into the atmosphere by human use of carbon-based fuels may be surprised to learn that CO_2 levels in the atmosphere have varied radically as life on earth has evolved (see Figure V). For example, when dinosaurs walked the earth, there was from five to ten times as much CO_2 in the atmosphere as there is today, and the average temperature was from 5° C to 10° C warmer.[66]

[66] Kent Jeffreys, "Why Worry About Global Warming," National Center for Policy Analysis, Policy Report No. 96, February 1991.

Figure V: Changes in CO_2 Levels over the Past 600 Million Years

CO_2 has a well-known fertilizing effect on plants, including most of the major food crops. Increasing atmospheric CO_2 not only increases plant growth rates but also reduces a plant's water requirements. Coupled with the fact that a warmer atmosphere would hold more moisture (and therefore increase average precipitation), more CO_2 and a warmer planet could produce an agricultural Garden of Eden.[67] For example:

- Sherwood Idso who, in addition to his own research, has reviewed over 1,000 scientific papers on CO_2 argues that the "green revolution" that has tripled crop yields since the 1950s is partly due to the 0.4° C degree warming that has occurred since the extreme cold dip of the late 1950s and early 1960s. Those conditions must have been extremely life-enhancing, since they permitted the huge creatures to find plenty of food and survive — a task that is difficult for our largest land animal, the elephant, today.

[67] Ellsaesser, "The Benefits of Increased CO_2 Have Been Ignored and the Warming Exaggerated."

- The Darwinian ancestors of the earth's plants evolved at a time when there was so much abundant, plant-life-enhancing CO_2 that some scientists fear today's plants are suffering from CO_2 deprivation.

Effects of Global Warming. The IPCC contends that the increase in greenhouse gases affects the Earth in many ways including an increase in number and strength of hurricanes, decreased agricultural yields, spread of famine, and spread of tropical diseases.[68]

Hurricanes. Current models suggest that the intensity and duration of hurricanes should increase by 5 percent for every 1° C rise in sea-level temperature. In the last three decades, temperatures have risen 0.5 percent, so a 2.5 percent increase in hurricane intensity and duration is expected. However, a 2005 study conducted by Kerry Emanuel, a professor of atmospheric science at MIT in Cambridge, found a 50 percent increase over the last three decades.[69]

Critics assert that the argument that hurricanes increases are a result of global warming is flawed. Hurricanes have nothing to do with global warming.[70]

- William Gray of the Department of Atmospheric Science, Colorado State University, has discovered a strong correlation between severe Atlantic hurricanes reaching the United States and an approximate 20-year cycle of

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[68] H. Le Treut, R. Sommerville, U. Cubasch, Y. Ding, C. Mauritaen, A. Mokssit, T. Peterson and M. Prather, *Climate Change 2007: The Physical Science Basis*, (Cambridge University Press: Cambridge, United Kingdom and New York, USA), 2007.

[69] John Roach, "Is Global Warming Making Hurricanes Worse?" National Geographic News, August 4, 2005.

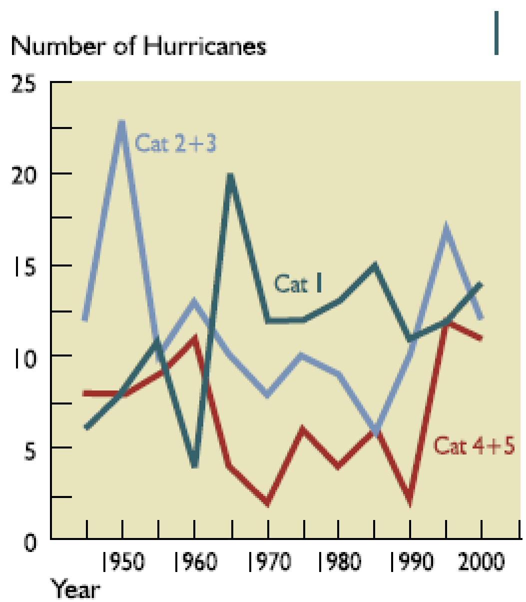
[70] H. Le Treut, R. Sommerville, U. Cubasch, Y. Ding, C. Mauritaen, A. Mokssit, T. Peterson and M. Prather, *Climate Change 2007: The Physical Science Basis*, (Cambridge University Press: Cambridge, United Kingdom and New York, USA), 2007.

wet and dry periods going back for hundreds of years in the western Sahel region of Africa.

- To the degree that temperature makes any difference, the historical record indicates that a warmer climate results in weaker hurricanes while cooler temperature produce more powerful storms.

Moreover, neither the number nor the strength of hurricanes has increased outside the natural range of variability in recent years (see Figure VI).

Figure VI: Number and Strength of Hurricanes Since 1950



NOTE: Category 1 is the lowest wind velocity and category 5 is the highest.

Crop Failure. The fear of crop failure and mass starvation is similarly fading. Those predictions were based on the assumption that daytime temperature would soar, greatly increasing water evaporation and drying out of the soil. But the climate data suggests that if average temperatures are going up, it is mostly due to an increase in nighttime low temperatures. This has the effect of lengthening the growing season by reducing the likelihood of frost and does not increase the likelihood of drought. Far from causing crop failure, as discussed earlier, warmer temperatures stimulate record agricultural harvests.[71]

Adapting to Climate Change.[72] With respect to some other problems that might be caused by climate change, such an increase in the number of people who are infected with malaria, it is best to combat these problems directly instead of trying to halt climate change. In a series of studies, Indur Goklany of the U.S. Department of Interior's Office of Policy Analysis examined the relative benefits and costs of mitigating carbon emissions versus adapting to climate change. He concludes that in some cases mitigation has small benefits, but that adaptation can produce the same or greater benefits at a fraction of the cost. Among the mitigation scenarios Goklany compared to adaptation:

- Meeting the carbon dioxide emissions reductions required by the Kyoto Protocol — an average for developed economies of 5 percent below 1990 levels by 2012 — carries an estimated total cost of more than $165 billion annually (in 2003 dollars).
- While Kyoto will not halt the increase in the level of atmospheric CO_2, more aggressive proposals to stabilize it at 550 parts per million — which is higher than today — would cost trillions of dollars.
- By contrast, a multipronged effort of focused adaptation — to solve the problems of climate change is expected to exacerbate — would cost approximately $10 billion annually.

[71] Ibid.

[72] Sterling Burnett, "Climate Change: Consensus Forming Around Adaptation," National Center for Policy Analysis, Brief Analysis No. 527, September 2005.

Sidebar: Reducing Malaria[73]

Up to 8.8 billion people worldwide are expected to be at risk from malaria in 2085. Global warming is projected to contribute about 3 percent (up to 323 million people) of the total, as warming increases the range of malaria-carrying mosquitoes.

- Meeting the Kyoto Protocol's emission reduction targets would reduce the population at risk from malaria by only 0.2 percent.
- Stabilizing CO_2 emissions at 550 ppm would reduce the at-risk population a mere 0.4 percent.
- By contrast, an additional $1.5 billion annual investment in malaria prevention and treatment today would cut the current annual number of deaths due to malaria in half — from more than 1 million to less than 500,000.

Sidebar: Reducing Hunger.[74]

Even with population growth, the number of people worldwide at risk of hunger should fall from about 521 million people today to 300 million in 2085, due to continuing increases in agricultural productivity. However, global warming could change weather patterns, modestly reducing the growth of agricultural productivity enough to expose an additional 69 to 91 million people to food shortages.

- Meeting the Kyoto Protocol's emission reduction targets would reduce the population facing hunger by approximately 1.5 to 2 percent.

[73] Ibid.

[74] Ibid.

- Stabilizing $C0_2$ emissions at 550 ppm would reduce potential hunger by approximately 9.7 percent.
- Investing an additional $5 billion annually to solve agricultural problems in developing countries today would cut the population at risk of hunger by 50 percent — beginning today, not 2085.

End Side Bar

Energy Independence

Another benefit cited by proponents of alternative energy is increasing energy independence. At its most basic level, energy independence is the idea that a nation can be completely self-sufficient in generating its own energy. Achieving this goal would protect the United States from price volatility and disruptions in the oil supply, while simultaneously preventing any oil funds from financing terrorist operations in oil-rich countries that harbor these groups.

Ideally, energy independence means being totally dependent only on domestic sources of energy; realistically, it usually means being less than fully independent of all foreign sources. For instance, U.S. Senator Benjamin L. Cardin (D-Md.) proposed the Energy Independence Act in May of 2007, which set a goal of reaching independence by 2017 (10 years out), but defined energy independence “as getting 90% of our energy needs from domestic sources.”[75]

Energy independence in the United States is essentially freedom from imported oil. In 1973 oil imports amounted to 35 percent of the U.S. oil supply, but by 2006

[75] Benjamin L. Cardin, “Cardin Introduces Bill to Achieve Energy Independence,” U.S. Senate, press release, May 2007.

approximately 60 percent of the oil Americans consumed came from overseas, with 40 percent produced domestically. Besides being America's main energy import, oil also constitutes the largest share of our energy consumption, making up about 40 percent in 2005.[76]

Future projections of oil supply and demand also look bleak. Worldwide demand for oil is projected to increase by 50 percent over the next two decades, and U.S. consumption of oil is projected to rise by 40 percent by 2025.

Sidebar: Brazil's Ethanol Industry

Brazil first committed to becoming less energy dependent when large oil price shocks in the 1970s greatly inflated the cost of energy worldwide. At the time, Brazil was importing 80 percent of its oil. The decision to move away from an oil economy was initiated by General Ernesto Geisel, then-president of Brazil, who in 1975 mandated that gasoline be mixed with 10 percent sugar-based ethanol. During the next five years the requirement was raised to 25 percent ethanol, and throughout the 1980s Brazilian gasoline stations began offering a blend of 94–95 percent ethanol. Then things changed. Sales of ethanol tapered off in the late 1980s and throughout the 1990s as oil prices remained consistently low. However, the ethanol industry once again took off early in the 21st century as oil prices exploded.[77]

[76] Energy Information Administration, "US Energy Consumption by Energy Source," Department of Energy, July 2007.

[77] Jaclyn Fichera and Jeff Kueter, "Considering Brazil's Energy Independence," Marshall Institute, Policy Outlook, Sept. 2006, pages 1-2.

Mid-year 2007, The U.S. Energy Information Administration estimated that Brazil would become a net oil exporter by year-end.[78] Energy experts believe it has achieved this milestone because of two policies: an integration of ethanol into the fuel supply, and more significantly an exploitation of its oil resources. Even though Brazil produces 34 percent of the world's ethanol supply, compared to the United States' 35 percent, this only amounts to 13.6 percent of Brazil's total transportation fuel consumption. The other 86 percent is still met through oil production. Concurrent with Brazil's rising investment in ethanol, oil production has grown 9 percent a year since 1980.[79]

End Sidebar

Increasing Domestic Oil Production. As the example of Brazil shows, energy independence does not need to be achieved through alternative energy alone. Instead, building new oil refineries in the United States and increasing domestic production will lower prices.[80] By reducing domestic refining capacity, the U.S. government has decreased our energy independence. No new oil refineries have been built in the United States for almost 30 years, and many refineries have closed. Building new oil refineries or expanding existing ones is among the most affordable, effective and reliable ways to increase supplies of gasoline and diesel fuels, to lower prices and increase energy independence.

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[78]Energy Information Administration, "Country Analysis Brief: Brazil," Department of Energy, Sept. 2007.

[79]Fichera and Kueter, "Considering Brazil's Energy Independence," pages 3-4.

[80] D. Sean Shurtleff and Sterling Burnett, "Increasing America's Domestic Fuel Supply by Building New Oil Refineries," National Center for Policy Analysis, Brief Analysis No. 603, November 2007.

Unfortunately, environmental regulations, requirements for so-called boutique fuels and mandates for ethanol have raised the cost of building new refineries. Increasingly, it is cheaper to import refined petroleum products instead of producing fuel here. The energy bills currently being considered by Congress are likely to discourage new refinery construction rather than encourage it. These policies will not lower prices at the pump or increase energy security.

Total refining capacity fell as small refineries closed, but the capacity of the remaining refineries has grown due to expansions and improvements in efficiency. For example, due to efficiency improvement refineries that operated at 78 percent of their maximum capacity in the 1980s, on the average, have produced more than 90 percent of their potential output since 1993. However, higher utilization rates increase the seasonal volatility of gasoline prices. Refineries cannot pick up the slack caused by shortages which arise when capacity is taken off-line because of maintenance or natural disaster. Thus, outages cause supply to fall and prices to rise. In the summer or 2007, for example, the loss of output from two refineries led to a gasoline price increase of 24 cents in the Midwest.

Unfortunately, because of emissions controls, mandates for gasoline blends and alternative fuel requirements have forced many refineries to close and have made building new oil refineries extremely difficult, the older inefficient plants were not replaced with new, more efficient plants, and the increased capacity and efficiency gains at existing plants have not kept pace with growing demand. As a result, over the past few decades the United States has increased imports of gasoline refined in other countries. The Federal Trade Commission notes that from 1992 to 2004, the U.S. annual average of weekly gasoline imports more than coupled from 4.7 percent to 9.7 percent o gasoline used.

Sidebar: Clean Air Regulations[81]

Clean Air Act amendments in 1990 and 1997 required refineries to limit emissions of air pollutants and to make cleaner reformulated fuel. This forced refiners to install expensive pollution-control technology when they modified existing plants. These air quality gains carried a high price tag:

- Throughout the 1990s, nearly 25 percent of the capital investment in refineries was to comply with environmental regulations.
- Between 1992 and 2001, the oil industry spent more than $100 billion to bring oil refineries into compliance with environmental regulations.

This led to the closure of additional refineries. For instance, Premcor, an oil producer and refiner, was compelled to close down two of its Illinois refineries because it could not afford the upgrades necessary to meet specifications for new refined products. Modifications in one refinery alone would have cost $70 million.

Clean air regulations have also discouraged the construction of new facilities. For example, construction of a new refinery in Arizona has been delayed for almost 10 years. When developers initially planned to begin construction in 1997, it would have been the first new refinery built in 20 years. But concerns regarding its impact on air quality and the purposed site of the plant have delayed construction even after the plant has received

[81] Ibid.

the required air permits. Now, even under the best circumstance, construction will not start until 2008 and the plan will not be operational until 2011.

End Sidebar

How Much Is Enough? An academic debate rages on as to whether energy independence or energy security is better. Some experts in favor of expanding domestic production of fossil fuels find the notion of energy independence quixotic. One such person is Steven F. Hayward, F. K. Weyerhaeuser Fellow at the American Enterprise Institute.[82] He describes energy independence as a form of "energy protectionism or isolationism," and declares it a "counter productive goal" because cheaper sources of energy exist outside U.S. borders. As an alternative, he pushes energy security--freedom from unstable sources of energy. He believes "[a] sensible policy goal would be not independence, but diversification: a portfolio of energy technologies and global supplies that minimizes the economic and political risk of disruptions from any particular region or energy source."

Sustainability

Because oil is a nonrenewable resource, and every gallon of petroleum burned today is unavailable for use by future generations, some argue that the United States should begin to look for a more sustainable form of energy.

However, over the past 150 years, geologists and other scientists often have predicted that our oil reserves would run dry within a few years.[83] When oil prices rise

[82] Steven F. Hayward, "Q&A: Energy Independence," American Conservative Union, May 17, 2007.

[83] David Deming, "Are We Running Out of Oil?" National Center for Policy Analysis, Policy Backgrounder No. 159, January 2003.

for an extended period, the news media fill with dire warnings that a crisis is upon us. Environmentalists argue that governments must develop new energy technologies that do not rely on fossil fuels. But the facts contradict these harbingers of doom:

- World oil production continued to increase through the end of the 20th century.
- Estimates of the world's total endowment of oil have increased faster than oil has been taken from the ground.

How is this possible? We have not run out of oil because new technologies increase the amount of recoverable oil and market prices — which signal scarcity — encourage new exploration and development. Rather than ending the Oil Age has barely begun.

Nonexperts, including some in the media, persistently predict oil shortage because they misunderstand petroleum terminology. Oil geologists speak of both reserves and resources.

- Reserves are the portion of identified resources that can be economically extracted and exploited using current technology.
- Resources include all fuels, both identified and unknown, and constitute the world's endowment of fossil fuels.

Oil reserves are analogous to food stocks in a pantry. If a household divides its pantry stores by the daily food consumption rate, the same conclusion is always reached: the family will starve to death in a few weeks. Famine never occurs because the family periodically restocks the pantry.

Similarly, if oil reserves are divided by current production rates, exhaustion appears imminent. However, petroleum reserves are continually increased by ongoing exploration and development of resources. For 80 years, oil reserves in the United States have been equal to a 10- to 14- year supply at current rates of development. If they had not been continually replenished, we would have run out of oil by 1930.

Scaremongers are fond of reminding us that the total amount of oil in the Earth is finite and cannot be replaced during the span of human life. This is true; yet estimates of the world's total oil endowment have grown faster than humanity can pump petroleum out of the ground.

The Growing Endowment of Oil. Estimates of the total amount of oil resources in the world grew throughout the 20th century.

- In May 1920, the U.S. Geological Survey announced that the world's total endowment of oil amounted to 60 billion barrels.
- In 1950, geologists estimated the world's total oil endowment at around 600 billion barrels.
- From 1970 through 1990, their estimates increased to between 1,500 to 2,000 billion barrels.
- In 1994, the U.S. Geological Survey raised the estimate to 2,400 billion barrels, and their most recent estimate (2000) was of 3,000-billion-barrel endowment.

By the year 2000, a total of 900 billion barrels of oil had been produced. Total world oil production in 2000 was 25 billion barrels. If world oil consumption continues to increase at an average rate of 1.4 percent a year and no further resources are discovered, the world's oil supply will not be exhausted until the year 2056.

Role of Technology. With every passing year it becomes possible to exploit oil resources that could not have been recovered with old technologies. The first American oil well drilled in 1859 by Colonel Edwin Drake in Titusville, Pa. — which was actually drilled by a local blacksmith known as Uncle Billy Smith — reached total depth of 69 feet.

- Today's drilling technology allows the completion of wells up to 30,000 feet deep.
- The vast petroleum resources of the world's submerged continental margins are accessible from offshore platforms that allow drilling in water depths to 9,000 feet.
- The amount of oil recoverable from a single well has greatly increased because new technologies allow the boring of multiple horizontal shafts from a single vertical shaft.
- Four-dimensional seismic imaging enables engineers and geologists to see a subsurface petroleum reservoir drain over months to years, allowing them to increase the efficiency of its recovery.

New techniques and new technology have increased the efficiency of oil exploration. The success rate for exploratory petroleum wells has increased 50 percent over the past decade, according to energy economist Michael C. Lynch.

In the long run, an economy that utilizes petroleum as a primary energy source is not sustainable, because the amount of oil in the Earth's crust is finite. However, sustainability is a misleading concept, a chimera. No technology since the birth of civilization has been sustainable. All have been replaced as people devised better and more efficient technologies. The history of energy use is largely one of substitution. In the 19th century, the world's primary energy source was wood. Around 1890, wood was replaced by coal. Coal remained the world's largest source of energy until the 1960s when it was replaced by oil. We have only just entered the petroleum age.

How long will it last? No one can predict the future, but the world contains enough petroleum resources to last at least until the year 2100. This is so far in the future that it would be ludicrous for us to try to anticipate what energy sources our descendants will utilize.

Energy Reliability

Overreliance on large centralized power plants connected to high voltage transmission lines that bring power to consumers over long distances can make us vulnerable to blackouts and brownouts. Recently, distributed generation using alternative energy has been discussed as one of several ways to solve the problem of blackouts and brownouts.

Distributed generation is a decentralized energy policy that uses small-scale power generation located close to where the energy is used. Through net metering, individuals that own small energy production facilities like wind turbines or solar panels can sell power to electric companies and it can be placed on the a larger grid.

Since these sources of power do not rely on fossil fuels, they continue to generate power safely when the electrical grid encounters a problem such as a short circuit. Although it is unlikely that these renewable resources would completely eliminate blackouts in the entire electrical grid, they could diminish the widespread effect of a power failure. According to Thomas Starrs, vice president and chief operating officer of the Bonneville Environmental Foundation, distributed energy is likely to result in an electricity system that is more efficient, reliable and resilient.[84]

Because continuous, uninterrupted power is essential to the information economy, many affirmative teams may claim this as an advantage to distributed generation.[85] The economic implications of loss of power (even in very short time intervals) are staggering:[86]

- A power outage lasting one hour costs a cellular communications company $41,000. The same outage would cost a credit card company $2,580,000, and a brokerage operations firm $6,480,000.
- Some high-tech companies, like Sun Microsystems, would bear a cost of up to $1,000,000 per minute
- Hewlett-Packard reports that a 20-minute outage would cost $30 million.

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[84] Thomas Starrs, "National Electricity Policy: Barriers to Competitive Generation," July 2001.

[85] U.S. Department of Energy – The National Renewable Energy Laboratory, "The Value of Electricity When It's Not Available." May 2003.

[86] Ibid.

Critics argue that the intermittent nature of renewable energy sources such as wind and solar make it difficult to use them as backups in case of a blackout. The Department of Energy's Energy Information Administration best describes the problem:

> "projections of large increases in renewable energy should be viewed with caution. The availability of renewable energy resources to support major growth is often uncertain, particularly in cases of biomass, geothermal, and wind resources, and the costs and performance of new technologies also are uncertain. Consumer tastes, environmental accommodation, and market acceptance may be problematic, and the ability of different suppliers and regions to integrate large proportions of renewable, especially intermittent sources like solar and wind, into overall supply is not known."

In addition, net metering may be a bad deal for utilities. By definition, true net metering calls for the utility to purchase power at the retail rate. Utilities do more than just generate and sell electricity to customers. They also are responsible for transmission (delivering the electricity) and reliability (making sure that the lights work when you flip the switch.) This means that they the retail rate is not a fair price for net metered energy.

Alternative Energy Incentives

A large number of government incentives already exist to promote alternative energy. . . . Positive incentives for alternative energy generally fall into one of two categories: conservation or production.

Conservation: Energy Efficiency. Lawmakers have enacted a wide variety of tax credits, regulatory policies, and research and development programs to reduce energy usage through energy efficiency. In the area of tax incentives, government usually provides subsidies for upgrading homes and businesses with more energy efficient lighting and insulation materials. Congress renewed or created most of these incentives in The Energy Policy Act of 2005 (EPAct 2005). For example, home improvement credits of up to $500 set to expire December 31, 2008, are available to consumers who install more "energy-efficient windows, insulation, doors, roofs, and heating and cooling equipment."[87]

Research and development subsidies can spur production of energy-saving technologies. One good example is demand-side electricity technology. Using devices like smart meters (which allow two-way communication between electric utilities and consumers) and programs like appliance cycling (placing switches on appliances to turn them on and off during possible power outages), electricity grid operators can curb electricity consumption during times of peak usage or consumers can reduce demand in response to price signals. Technology like this requires that national and state regulators allow electric utilities to install demand-side technologies and recover their investment by passing on costs to customers, something most states currently forbid. However, in the EPAct 2005 Congress mandated that states investigate how to restructure electricity rates to allow for cost-recovery from investing in demand-side technology, and has lately established subsidies in EISA 2007 for further research and development.[88]

Another way the U.S. government encourages energy efficiency is through stricter regulatory policies. Essentially, the government mandates that private businesses

[87] Energy policy Act of 2005: What the Energy Bill Means to You," US Department of Energy.

[88] Sissine, "Energy Independence and Security Act of 2007," page 20.

make more efficient products or derive a certain amount of their energy from alternative energy sources:[89]

- The Energy Independence and Security Act of 2007 (EISA 2007), an expansion of the EPAct 2005, increases the Corporate Average Fuel Economy (CAFE) standard to require carmakers to reach a fleet wide average fuel efficiency rating of 35 miles per gallon.
- Also among the provisions in EISA 2007 were efficiency standards for appliances (clothes washers, dishwashers, etc.) and lighting (incandescent light bulbs, fluorescent lamps, etc.).

While research subsidies can encourage the development of energy-saving technologies, regulations often impede such efforts. Environmental regulations that cap or tax the output of pollutants raise the cost of production. Many industries will have to process waste generated by production rather than discard it, thereby creating additional costs. This means higher prices for consumers and lower wage income for workers.

Furthermore, businesses may simply find that it would be more cost effective to leave an area with caps on emissions and relocate to one that does not have such limits. In this case, entire industries could move, creating a significant loss of jobs and investment in a formerly prosperous area. In politics, these new locations are referred to as “safe-havens” because they allow industries to operate with less government regulations.

[89] Fred Sissine, “Energy Independence and Security Act of 2007: A Summary of Major Provisions,” Congressional Research Service, December 21, 2007, page 1.

A recent example is the state of California. In 2006, the state approved a deal that would limit greenhouse gas emissions by industries in the state. However, business leaders were vehemently opposed to such restrictions, citing many of the arguments mentioned above. For instance, Tupper Hill, a spokesperson for the Western States Petroleum Association trade group, said that the only way for companies to meet such emissions regulations would be to cut production by 17 percent. This would cause a large rise in prices for consumers as a result of lowered supply. In addition, Allan Zaremberg, CEO of the California Chamber of Commerce, stated that these limits would place the affordability of California's energy supply at risk. Industrial groups also emphasized that these caps would lead to higher energy costs, lost jobs, and cause corporations to leave the region to escape the government mandated regulations. Although these regulations do not take effect until 2011, the tensions in California mirror those that are expressed in other states looking to pass environmental regulations.

Production: Energy Generation. Just as incentives exist for cutting energy usage and demand, they also exist for increasing production in alternative energy to replace fossil fuels. First of all, the U.S. government gives tax credits to consumers to buy cars that run off of alternative energy and to install devices that generate renewable electricity. For instance, through 2010 the EPAct 2005 is offering a tax credit of up to $3,400 to individuals who purchase a car powered by electricity, hydrogen and biofuels. Government subsidies also encourage the production of alternative biofuels like ethanol, biodiesel, and methanol. Under current law, ethanol producers receive a subsidy of 50 cents per gallon.[90]

[90] "Energy Policy Act of 2005."

Besides providing financial incentives for alternative energy, the U.S. government has also developed regulatory policies that mandate production. The Renewable Fuel Standard (RFS) in EISA 2007 requires that fuel suppliers produce 9 billion gallons of renewable fuel in 2008 and 21 billion gallons by 2022.[91] One provision of EISA 2007 that was dropped from the bill in final negotiations was the Renewable Energy Portfolio Standard (RPS). It would have required that 15 percent of electricity come from renewable sources.

Subsidies for research and development also supplement investment in the production of alternative energy. The Bush administration currently has implemented at least six broad-scale initiatives to foster research and development of this sort.[92] This is in addition to the $14.6 billion spent on renewable energy research and development between 1973 and 2003.[93] One thing to note is that certain tax credits for renewable energy, called Renewable Energy Production and Investment Credits are set to expire at the end of 2008 unless extended.

Sidebar: Carbon Taxes and Cap-and-Trade Schemes

Carbon Taxes and Cap-and-Trade Schemes are both examples of negative incentives for alternative energy. Several types of government incentives exist to encourage firms to develop and produce alternative energy. Those that are positive give subsidies to businesses and individuals to directly produce and purchase alternative

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[91] Ibid.

[92] About the Office of ERRE: Initiatives," US Department of Energy, Energy Efficiency and Renewable Energy.

[93] Fred Sissine, "Renewable Energy: Tax Credit, Budget, and Electricity Production Issues," Congressional Research Service, December 21, 2007, page 1.

energy technology. On the other hand, those that are negative seek to discourage the use of fossil fuel based energy, indirectly encouraging the use of alternative energy.

A carbon tax is a variable fee that increases with the level of carbon usage and is levied on suppliers or users of fossil fuels; the more carbon content in the fuel source, the more one pays. For instance, energy consumers using natural gas, which is less carbon intensive, would expect to pay fewer taxes than those using coal, which has a much higher concentration of carbon. Carbon taxes seek to limit the amount of carbon dioxide (CO2) emitted and encourage development of energy-efficient and alternative energy technologies by imputing extra costs on fossil fuels. Companies have an incentive to develop better, carbon-free technologies if the cost of doing so is lower than the cost of the carbon tax.

Cap-and-trade laws set a maximum limit to carbon emissions and give energy producers allowances or credits to emit a specified amount of CO_2 per year. Energy companies that emit less CO_2 than their allotted amount, by conserving or installing energy efficient devices or using alternative energy, can sell unneeded allowances to energy producers who expect to go over their allotment. In this way a market for trading carbon allowances is established, and incentives to cut back on carbon usage and invest in lower-carbon or non-carbon energy are created.

The precedent for this market-based system has already been set by the U.S. cap-and-trade program for sulfur dioxide (SO_2). Sulfur dioxide is produced when coal containing sulfur is burned for energy. Studies have shown that SO_2 is detrimental to human health and contributes to acid rain. For this reason, Congress passed an amendment to the Clean Air Act in 1990 to create a cap-and-trade system, placing limits on SO_2 emissions coming from utilities and setting goals to reduce overall levels from 17.5 million tons in 1980 to 8.95 million tons by 2010. So far the program has lowered SO2 emissions to about 10.5 million tons as of 2007.[94]

Building on the success of the U.S. SO_2 program, the European Union (E.U.) has attempted to implement a cap-and-trade program for CO_2. However the E.U. program has largely failed due to the complex nature of regulating CO_2 emissions. For one, only about 33 percent of CO_2 emissions come from electricity generation compared to 66 percent for SO_2. This means that even if the E.U. program works, it will only impact one-third of CO_2 emissions. In addition, the program let individual countries determine the amount of CO_2 emissions that would be allowed under the cap and every country except the United Kingdom allocated 15 percent more allowances than their utilities were already emitting. Due to this blunder, utilities essentially faced no restrictions on the amount of CO_2 they could release because there were more than enough allowances to go around.[95]

It may seem counterintuitive to some, but carbon taxes may offer the most transparent, efficient, and effective means for regulating CO_2. They are transparent because society would know exactly how much energy producers are being charged to emit CO_2, and thus how much energy prices could be expected to rise. Besides this, most

[94] Ronald Bailey, "Carbon Taxes Versus Carbon Markets," Reason Foundation, May 24, 2007. Available at http://www.reason.com/news/show/120381.html. See also Larry Parker, "Global Climate Change: Market-Based Strategies to Reduce Greenhouse Gases," Congressional Research Service, CRS Issue Brief IB97057, November 18, 2004. Available at http://www.usembassy.it/pdf/other/IB97057.pdf.

[95] Bailey, "Carbon Taxes."

economists agree that carbon taxes would theoretically be the most efficient free-market plan.[96]

Critiquing Alternative Energy. By subsidizing alternative energy or taxing fossil fuel based energy, many affirmative plans will allow the government to pick winners and losers among energy sources. Economists, such as Robert Bradley, president of the Institute for Energy Research, argue that this approach is not only ineffective and inefficient, but harmful to the economy. Instead, Bradley argues that the market, not the government, should pick the desired energy sources.[98]

The 30-plus-year history of federal attempts to encourage alternative energy sources includes numerous failures and few, if any, successes.[97] Alternatives have been subsidized for decades — ethanol, for example, since 1978. Originally, it was promised that alternatives would become viable within a few years on their own and not require subsidies. But his has never happened. Instead, Congress just passed a huge expansion of the ethanol mandate, essentially forcing Americans to use more of it even as it continues to be heavily subsidized. Wind and solar are doing no better.

Even after decades of special tax breaks, alternative energy still constitute only a small fraction of the U.S. energy supply. For example, wind and solar energy account for less than three percent of U.S. electricity because of their high costs and unreliability.

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[96] A majority of economists interviewed during a Wall Street Journal survey expressed the belief that a carbon tax would be the "most economically sound way to encourage alternatives." Taken from Phil Izzo, "Is it Time for a New Tax on Energy," *Wall Street Journal*, February 9, 2007. Available at http://online.wsj.com/public/article/SB117086898234001121.html. Also see "Global Climate Change: Market-Based Strategies to Reduce Greenhouse Gases," page 8.

[97] Ben Lieberman, "The 2008 House Energy Tax Bill: Repeating Past Mistakes," The Heritage Foundation, Web Memo No. 1816, February 14, 2008.

Further, the overall percentage of electricity attributable to renewable sources is not expected to increase by 2030, according to the Energy Information Administration.[98]

. Changes in consumer demand and technology can make what is uneconomic today economic in the future.[99] The chance that market verdicts may change with such resources as wind and solar in central-station electric generation cannot be a rationale for government to pick "winners" and "losers" before the market does. The evolutionary market process is theoretically and empirically the best way to allocate scarce resources amid uncertainty — a conclusion buttressed not only by theory by the history of market and government forces in energy markets.

Government planners and the eco-energy planning intelligentsia cannot know if a transformation to preferred renewables will occur or what its specific parameters might be if it were to occur. The results of a complex evolving market discovery process cannot be known ahead of time.

In fact, government subsidies often stifle innovation. Government subsidies and handouts distort the economy by creating an incentive structure that hinders innovation. Under a free market system, economic agents will use resources in the most efficient manner possible. As a result, these agents will also be looking to innovate and improve upon current production processes in order to cut costs or boost production. This chain of events often leads to new inventions in technology that use resources more efficiently than before. However, if the federal government provides an incentive that negates the need for innovation, producers will operate inefficiently. In this case, producers do not

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[98] Ibid.

[99] Robert L. Bradley, "Why Renewable Energy Is Not Green and Not Cheap," National Center for Policy Analysis, 1996.

have an incentive to innovate because essentially, the government pays for their inefficiency.