The Energy Policy Act of 2005: (H.R. 1640) A Policy Analysis

"To enact an energy research and development program to ensure reliable energy and job security"

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Executive Summary

The U.S. consumes more energy than any other country in the world. The Energy Policy Act of 2005, H.R. 1640, addresses the need of the U.S. to ensure energy reliability and reduce foreign energy dependence through two objectives: 1) enhancing domestic energy sources; and, 2) decreasing energy consumption, both of which are to be reached in an environmentally friendly manner. To fulfill the first objective, areas such as renewable energy, oil and gas, coal, and nuclear energy are considered. Additionally, H.R.1640 encourages alternative vehicles and fuels, and promotes efforts to decrease energy consumption. Our final report focuses on three important facets of the Energy Policy Act of 2005: the Clean Coal Power Initiative and Clean Coal Power Projects; renewable energy, ethanol and biofuels; and, finally, energy efficiency, through the Energy Star Program. These three issues exemplify the basic intent of H.R. 1640.

Incentives, rather than regulations, are the political tools embedded in the H.R 1640. The Clean Coal Power Initiative provides $1.08 billion over nine years for projects on coal-based gasification technologies; $125 million for Clean Power Projects to build power plants using integrated gasification combined cycle technology; and $2.5 billion for Clean Coal Power Generation Projects to fund coal-based electrical generation equipment and processes, such as gasification. Gasification technology will help reduce pollutants emitted by traditional coal-fired power plants. For example, 99% of emitted sulfur dioxide (SO_2) and 90% of emitted mercury (Hg) will be reduced.[a] One of the negative impacts of SO_2 emissions is acid rain; Hg is considered a neurotoxin when ingested by humans. Although gasification represents an affordable and desirable solution to coal plant emissions, questions are raised on whether contaminant fossil fuels, like coal, should capture the majority of the funding priorities within the legislation as opposed to that needed for spinning renewable energies. Energy security and economic interests play a large role in the continuous funding of the coal industry.

To introduce renewable energy through ethanol and biofuels, the Renewable Content of Motor Vehicle Fuel section of the Act aims, on a yearly basis, to increase the available volume and use of renewable fuel in the country. H.R. 1640 enlists three incentive-based mechanisms to achieve this goal, mostly for cellulosic and waste conversion to ethanol and biofuels. First, it establishes renewable fuel credits; second, it provides guarantees for private loans; and finally, it gives $750 million in grants to enhance renewable fuel production. Renewable fuels reduce nitrogen oxides (NO_x) and are claimed to be carbon neutral.[b] Mitigation of such pollutants will contribute to decrease smog produced by NO_x and carbon dioxide (CO_2), a greenhouse gas. The controversy with renewable fuels, and with ethanol specifically, is that the Environmental Protection Agency (EPA) believes that ethanol use reduces NO_x emissions, while the Department of Energy (DOE) asserts that NO_x emissions actually increase from ethanol combustion. In addition, the economic implications for the agricultural sector are of enormous proportions since crops can be used as primary inputs for ethanol production. Therefore, domestic political and economic interests play an active role in the design and implementation of policy.

[a] Mercury and Sulfur dioxide will be the focus of the coal analysis in this paper.
[b] With ethanol the amount of carbon dioxide (CO_2) will be stored by the plants grown to produce more ethanol

Finally, to address energy efficiency, H.R. 1640 augments the Energy Star labeling program, started since 1992, aiming at expanding market awareness and penetration of energy efficient products. Energy efficiency is considered the most effective way to reduce the amount of energy needed in the country, and thus, contribute to reduce pollutant emissions. The Energy Star Program is voluntary and uses three tools to promote energy efficiency: labeling, through the Energy Star Label; public awareness, through the HVAC Maintenance Consumer Education Program; and producer assistance, through the Energy Star for Small Business Program. Consumer preferences will mold producers towards more energy efficient technology for their products. If products use less energy, then coal power plants will not need to produce so much electricity, and thus, fewer emissions are expected.

As shown above, H.R. 1640 provides incentives for the improvement of existing fuel sources such as coal, for the creation of new fuels, such as ethanol and biofuels and for the reduction of energy use with energy efficiency under the expanded Energy Star program. The policy framework establishes environmentally friendly ways to achieve energy security. Clean technologies, renewable fuels and a decrease in overall energy use help to ease negative environmental and health effects caused by pollutant emissions such as SO_2, Hg, NO_x and CO_2. As with any policy, H.R.1640 is not without controversies. Evaluation of these controversies is essential to accomplish a complete analysis of the implications in the adoption of the policies enclosed in H.R. 1640.

Introduction

The Energy Policy Act of 2005, HR 1640, is the end point of energy concerns that surged in the United States more than 30 years ago. Although the U.S. energy supply was not gravely affected by the oil crisis of 1973, the national system in charge of ensuring that supply revealed some problems. Most problems were related to the lack of coordination between the different federal agencies dealing with particular energy sources. Therefore, it was more a management and decision-making procedure crisis.[1] After that there was a shift in focus towards the nation's energy policy.

Most of the concerns revolved around the effects another crisis would have on the U.S., primarily to economic growth. The aim was at reducing dependence on foreign energy by increasing the use of domestic energy sources such as coal. Some of the policy instruments used included taxes or tariffs on oil, but the shift to coal proved too costly.[2] Others also pointed out the environmental costs it would entail. At the time, hopes where on technological changes that would make domestic energy sources more cost-effective and less detrimental to the environment.[3]

This belief in technology as the answer to all problems has become a foundation of American policy making. The clearest example can be found in the use of technology as guarantor of U.S. international security during the Cold War. The United States depended on its technology to show superiority.[4] When the Cold War ended, more attention has been given to Middle East counties and their control over oil resources. Their sociopolitical instability represents a major threat to the Worlds energy supply. In the U.S., as with the Cold War, this problem is addressed as national security issue.[5] The technology to reduce the threat by improving U.S. domestic energy sources and reducing energy consumption exists, it is up to the American government to implement the policies needed.

Policies such as the Energy Policy Act of 2005 address both issues in a way that also protects the environment. The original demand of the 1970s to increase use of domestic resources and protect the environment at the same time has finally found its way into legislation. Unlike the policy tools suggested in the 30 years ago, HR 1640s guidelines step away from taxes and tariffs, and into incentives that promote the creation of new technology. Undoubtedly, policies such as this one will prove once more that technology enhances U.S. superiority, now in the 21st century.

A History of Energy Policies in the U.S.

Historically, the widely held belief in unlimited energy resources, led to a virtual absence of energy policies in the U.S. prior to the 1970's. Apart from a few energy policies resulting from World War II and the Manhattan project, the energy industry operated largely unregulated. It was not until the energy crisis in the 1970's that the U.S. adopted a more comprehensive national energy plan.[6] The need for a national energy policy became evident because of the growing imbalance between energy supply and energy demand in the U.S.[7] During the 1970's there were several attempts to formulate a national energy policy to encourage independence from foreign oil by promoting domestic energy supplies. Policymakers at the time also stressed energy conservation as a necessary part of the solution to an ever increasing energy demand.[8] The most comprehensive national energy policy was the Energy Policy and Conservation Act (EPCA), passed in 1975, with the primary goal of setting a permanent oil reserve.[9] Three years later, Congress passed the National Energy Policy Conservation Act (NEPCA), which further stressed the importance of conservation of energy for energy independence, as well as for environmental protection.[10]

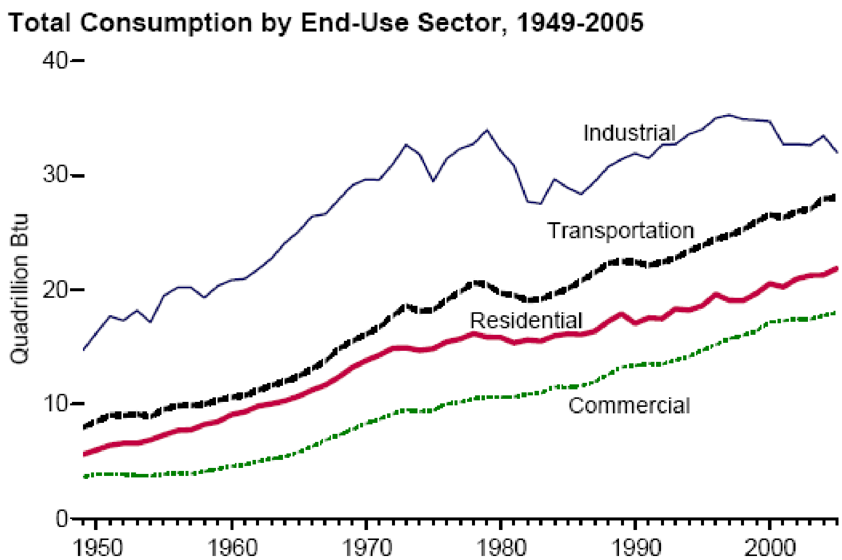

Figure 1: Total consumption of energy is on the rise, and has been steadily increasing in the Industrial, Residential, Commercial and Transportation sectors since 1949 [11]

As part of President Reagan's deregulation policies, many of the attempts to reduce energy demand and increase domestic energy production were reversed when the energy crises of the 1970's had subsided. Despite the long gasoline lines and high gasoline prices experienced by all consumers in the U.S., the 1970's energy crisis "seems, in retrospect, to have left no lasting public legacy." [12]

The Energy Policy Act of 1992 was a more recent attempt to reduce energy demand and promote competition and efficiency in the electricity industry.[13] Rather than conservation of energy, the Energy Policy Act of 1992 promoted energy efficiency in order to reduce energy demand. Among other things, the Energy Star Program was established to promote energy efficient products. In addition, the 1992 act promoted alternatively fueled vehicles to reduce the dependence on foreign oil and hence foster national security.

In general, the overall purpose of federal energy laws has been to “provide affordable energy by sustaining competitive markets, while protecting the economic, environmental, and security interests of the United States.” [14] The Energy Policy Act of 2005, H.R.1640, is no different. To further ensure energy independence, H.R.1640 incorporates economic incentives for domestic energy sources such as coal and ethanol, as well as energy conservation through labeling, and educational programs. These three policy tools will enhance energy security through domestic production growth and energy demand reduction, while also minimizing environmental impacts.

I. The Proposed Legislation of H.R. 1640

H.R. 1640 addresses issues concerning the production and consumption of energy from multiple sources. Topics addressed by the legislation include energy efficiency, renewable energy, oil and gas, clean coal technologies, nuclear energy, vehicles and fuels, ethanol, electricity, and energy tax incentives. Due to the breadth of the bill, this policy analysis is focused on three core themes. Within each theme, we have chosen a major constituent to help illustrate these themes and their significance. The themes and constituents are as follows:

- traditional energy: coal;
- renewable energy: ethanol and biofuels
- energy efficiency: consumer products

a. Traditional Energy: Coal

Title IV of H.R. 1640 covers all of the projects that allocate funds and resources toward the advancement of coal as an energy source. This title is further broken down into three subtitles. First, the Clean Coal Power Initiative (CCPI) provides for the allocation of $1.08 billion to be appropriated by the Secretary of the Department of Energy (DOE) over a 9 year period. This allocation will be utilized to fund projects furthering coal-based gasification technologies. Funded projects must demonstrate advances in efficiency, environmental performance, and be cost competitive. The projects include:

- *gasification combined cycle*: allows for the powering of two thermodynamic cycles
- *gasification fuel cells*: allows for a byproduct of gasification (hydrogen) to power a fuel cell
- *gasification co-production*: allows for the co-production of hydrogen and electricity based on the reduction and oxidation from the gasification process
- *hybrid gasification/combustion*: allows for the integration of the gasification process with fuel cell technology
- *capture and storage of carbon*: allows for the capture and storage of greenhouse gases like CO_2
- The CCPI also includes the award of grants to universities for the advancement of new clean coal technologies

The second subtitle addresses The Clean Power Projects (CPP), which provides for the allocation of a loan of $125 million to build coal plants using integrated gasification combined cycle (IGCC) technology. The loans are subject to specific terms regarding interest rates and upfront payments, which are to be determined by the Secretary. The CPP aims to provide power at competitive rates in deregulated energy generation markets that do not receive any subsidies.

Finally, the third subtitle, The Clean Air Coal Program (CACP), provides for the allocation of $500 million for the funding of pollution control equipment production. Funds will be utilized to further the advancement of traditional equipment, such as scrubbers,[c] as well as the development of advanced combustion technology. CACP aims

[c] Wet scrubbers remove air pollutants by inertial of diffusional impaction, reaction with a sorbent or reagent slurry, or absorption into a liquid solvent. Spray dry scrubbers are a widely used flue-gas desulfurization (FGD) technology. (http://www.frtr.gov/matrix2/section4/4-60.html)

to meet current and future obligations of coal-fired generation units regulated under the Clean Air Act.

Under the Clean Air Act of 1990, the EPA sets limits on the levels of a pollutant that are allowed in the air anywhere in the U.S. The equipment being promoted by Title IV of H.R.1640 facilitates the continued control and mitigation of air pollutants such as mercury, nitrogen oxide and sulfur dioxide emissions. CO_2 remains to be regulated.[15]

b. Renewable Energy: Ethanol and Biofuels

H.R.1640 incorporates renewable energy through The Renewable Content of Motor Vehicle Fuel (RCMVF), which amends the Clean Air Act to establish a renewable fuel program consisting of cellulosic biomass and waste-derived ethanol, and biodiesel. Whereas traditional extraction of ethanol is through the kernel of a crop like corn, cellulosic biomass and waste-derived ethanol allows for ethanol extraction from a great diversity of biomass including waste from urban, agricultural, and forestry sources. The RCMVF directs the Environmental Protection Agency (EPA) to implement a renewable fuel program that ensures that gasoline introduced into commerce in the contiguous U.S. contains set specific increases each year in the quantity of renewable fuel at the pump until 2013, when it establishes a formula for calculating renewable fuel levels. The act also establishes a credit program that provides credits for any person that refines, blends, or imports gasoline that contains a quantity of renewable fuel that is greater than the required volume. The credit program provides market-based incentives to exceed the yearly quantities defined in H.R. 1640. The credits can be sold to other industry players that fail to meet the cap, thereby creating a financial incentive to overshoot the predefined levels. These credits can be carried over to the following fiscal year only.

H.R. 1640 establishes two major programs to support biofuel production infrastructure. The first of these programs provides guarantees of loans by private institutions for the construction of facilities that process and convert municipal solid waste and cellulosic biomass into fuel ethanol and other commercial byproducts. The second program provides grants ($750 million allocated for 2005-2007) to merchant producers of cellulosic biomass ethanol and waste-derived ethanol in the U.S. to assist the producers in building eligible production facilities for the production of ethanol.

The proposed legislation includes provisions on analyses to be conducted by the Federal Trade Commission (FTC) and the EPA. The FTC will perform a market concentration analysis of the ethanol production industry to determine whether there is sufficient competition among industry participants to avoid price fixing and other anticompetitive behavior. Within five years of the enactment of the bill, the EPA will perform an analysis of the changes in emissions of air pollutants and air quality due to the use of motor vehicle fuel and fuel additives.

c. Energy Efficiency: Products

H.R. 1640 enhances energy efficiency in products in three ways: through The Energy Star Program, through the heating, ventilation, and air conditioning systems (HVAC) Maintenance Consumer Education Program, and the establishment of energy conservation standards for additional products.

The Energy Star Program amends the initial draft of this initiative from the 1992 Energy Policy and Conservation Act (EPCA). The Energy Star program was initiated as a voluntary labeling program designed to identify and promote energy efficient products in order to reduce greenhouse gas emissions. The program established energy efficiency labeling rules for appliances such as refrigerators, freezers, air conditioners, and dishwashers. The Energy Star Program also provides labeling rules for various types of light bulbs, such as fluorescent and incandescent. The revised version of this program, jointly run by the DOE and EPA, aims to identify and promote energy efficient products and buildings to reduce energy consumption and pollution. Promotion of these products will be achieved through voluntary labeling and communication about products and buildings that meet high energy-efficiency standards. The aim is to promote Energy Star technologies as “preferred technologies” in the market. The program is also designed to enhance public awareness of the Energy Star label.

The HVAC Maintenance Consumer Education Program is also a derivative of the EPCA and is a cooperative program consisting of EPA, industry trade associations, and energy efficiency organizations. This program aims to educate homeowners and small business owners about the energy savings resulting from properly maintained air conditioning, heating, and ventilating systems (HVAC) to ensure that they operate at their maximum efficiency levels. The bill does not mandate any particular action to meet these standards, as it is solely an educational program. A government-wide program will also be developed to build on the existing Energy Star for Small Business Program to assist small businesses to become more energy efficient, understand the cost savings obtainable through efficiencies, and identify financing options for energy efficiency upgrades.

The EPCA is further amended to include energy conservation standards for additional products, such as ceiling fans and unit heaters. Standards are also specified detailing requirements and testing procedures for these products. An assessment will be undertaken to determine the potential energy savings from technical improvements to some products, such as battery chargers. H.R. 1640 also includes a review of standby energy use in products that are major sources of standby mode energy consumption. Standby energy is defined as the electrical current drawn by many electronic devices, such as TVs, VCRs and microwaves, when they are sitting idle because some components will always require power regardless of whether the entire unit does. The review will determine whether to incorporate standby mode into such test procedures and energy conservation standards, taking into account, among other relevant factors, standby mode power consumption compared to overall product energy consumption. An Energy Labeling program is also initiated to consider the effectiveness of the current consumer products labeling program in assisting consumers in making purchasing decisions, and to consider changes to the rules to improve the effectiveness product labels.

II. Sources of Pollutants Addressed in HR 1640

This report focuses on four major environmental contaminants in the context of H.R. 1640: sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury (Hg), and carbon dioxide (CO_2), and provides a brief technical analysis of the environmental challenges each one poses. It examines the processes through which they enter the natural environment, both from fixed and mobile point sources, and then turns to their consequences for human health and the environment.

a. Stationary Sources: Coal-Fired Power Plants

Coal is a sedimentary organic rock that contains between 40-90 percent carbon by weight. Coal also naturally contains sulfur because the plant materials from which it formed included sulfur-containing compounds. A typical (500 megawatt) coal plant burns 1.4 million tons of coal each year. There are about 600 coal plants in the U.S. In an average year, a typical coal plant generates 3,700,000 tons of carbon dioxide (CO_2), 10,000 tons of sulfur dioxide (SO_2), 500 tons of small airborne particles, 10,200 tons of nitrogen oxides (NO_x), 720 tons of carbon monoxide (CO), 220 tons of hydrocarbons, volatile organic compounds (VOC), 170 pounds of mercury, 225 pounds of arsenic, and 114 pounds of lead.[16]

As mentioned above, CO_2, SO_2 and NO_x, are vented from the boiler along with fly ash and mercury. When coal is burned, the sulfur is oxidized to form sulfur oxides ($S + O_2 = SO_2$). Sulfur oxides can turn into sulfuric acid when they mix with water droplets in the air ($SO_2 + H_2O = H_2SO_4$). At the very high temperatures that exist in the coal power plant furnaces, normally unreactive nitrogen, which exists naturally in the atmosphere, readily combines with oxygen to form nitrogen oxide ($N_2 + O_2 = 2NO$). When released into the atmosphere, NO can combine rapidly with atmospheric oxygen to form nitrogen dioxide (NO_2).

Since mercury occurs naturally in the earth’s crust, coal is naturally contaminated with small amounts of mercury, as are all rocks, sediments, and water on earth. When coal is burned to generate electricity, mercury is released into the air through the smokestacks.[17] According to the EPA, electric utilities released 48 tons of mercury in 1999, the latest year for which data are available. During coal combustion, three different forms of mercury are released: oxidized (or ionic) mercury, which is water-soluble; elemental mercury, which is not very water-soluble; and particulate-bound mercury. Oxidized (ionic) mercury can be washed into local bodies of water by rainfall. Almost all of the elemental mercury and most of the oxidized mercury are carried away by wind and enter the global mercury cycle.[18] On the other hand, when released, particulate-bound mercury is a relatively stable chemical, and most of it is typically removed through the use of conventional particulate matter controls like electrostatic precipitators and baghouses.[19]

Carbon is the major component of coal and the principal source of heat, generating about 14,500 British thermal units (Btu) per pound, equivalent to approximately 4,250 Watt-hours. The typical carbon content for coal ranges from 60 to more than 80 percent. CO_2 forms during coal combustion when one atom of carbon (C) unites with two atoms of oxygen (O) from the air. If complete combustion were to occur, 1 pound of carbon combined with 2.667 pounds of oxygen would produce 3.667 pounds of carbon dioxide. [20]

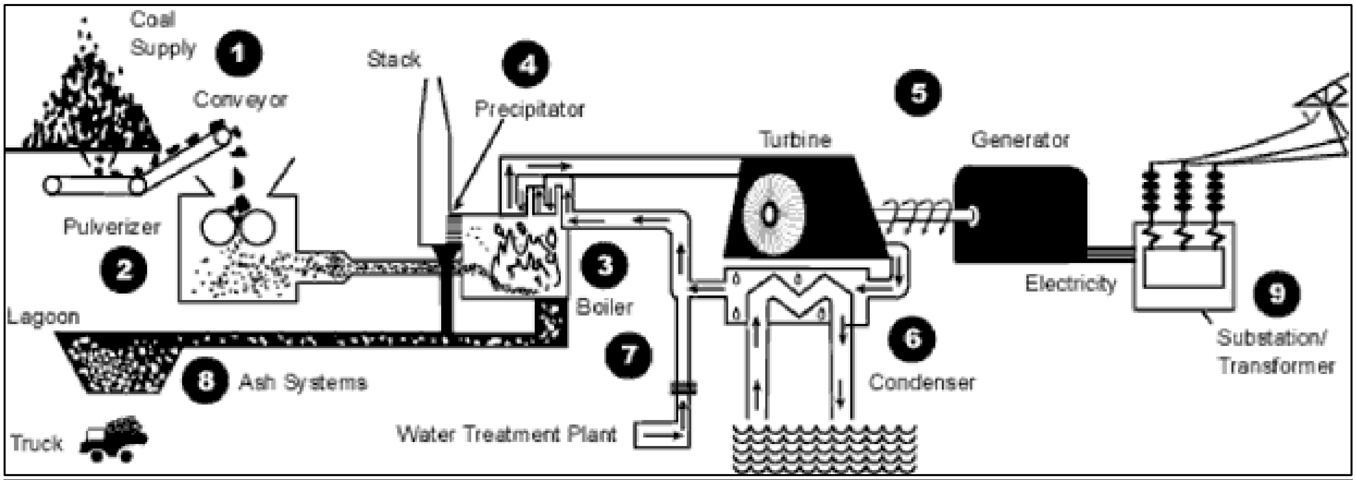

Figure 2 illustrates a typical coal-fired power plant. In step (1), coal is delivered from the mine into the coal hopper, where it is crushed to around 2 inches. It is later pulverized into a fine powder (2) and blown into a furnace where it burns (3). Water flows through tubes that run through the furnace and is heated to boiling while under pressure. This pressurized steam blasts through a turbine, which turns a generator to produce electricity. After the steam has passed through the turbine, it is condensed into water and cooled, and sent back into the furnace. Heat from the furnace then converts the water in the boiler tubes into high-pressure steam, which turns the turbine (5), causing a shaft to turn inside the generator, and finally, creating an electric current. [21]

b. Mobile Sources of Pollutants

An Internal Combustion Engine (ICE) and its components in an automobile are depicted in Figure 3. An ICE operates by burning fuel to create heat, which is converted into mechanical energy and finally, motive power.

Gasoline and diesel fuels are comprised of a mixture of hydrocarbons, compounds which contain hydrogen and carbon atoms. In perfect combustion, oxygen in the atmosphere would convert all of the hydrogen in the fuel to water and all the carbon in the fuel to carbon dioxide, while nitrogen would remain unaffected. However, in reality the combustion process is imperfect and results in the emission of various pollutants. In the presence of oxygen, nitrogen, and sufficient heat, hydrocarbons in the fuel react to produce energy, water vapor, carbon dioxide, nitrogen oxides, and carbon monoxide. The combustion of diesel fuel, which has a high sulfur content, results in the oxidation of sulfur dioxide, which is responsible for the sulfate particulate matter emissions that cause acid rain. [22]

Under the high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides, collectively known as NO_x. As the atmosphere is 78 percent nitrogen, so is the air drawn into the engine to supply oxygen for combustion. The high temperatures achieved in the engine cause some of the nitrogen to react with the oxygen in the cylinder during combustion. They then combine to form nitric oxide (NO), which is released into to the atmosphere. Once there, NO eagerly combines with another oxygen molecule to form nitrogen dioxide (NO_2), a principal contributor to smog and acid rain.[c]

On the other hand, carbon monoxide (CO) is also a product of incomplete combustion and occurs when partial oxidation of carbon takes place. Full oxidation of carbon in the fuel creates carbon dioxide.[23] CO_2 is expelled at the tailpipe into the atmosphere. As it is a chemically stable molecule and does not break down easily, it accumulates over long periods of time in the atmosphere[e], amplifying the greenhouse effect and causing global warming.[24]

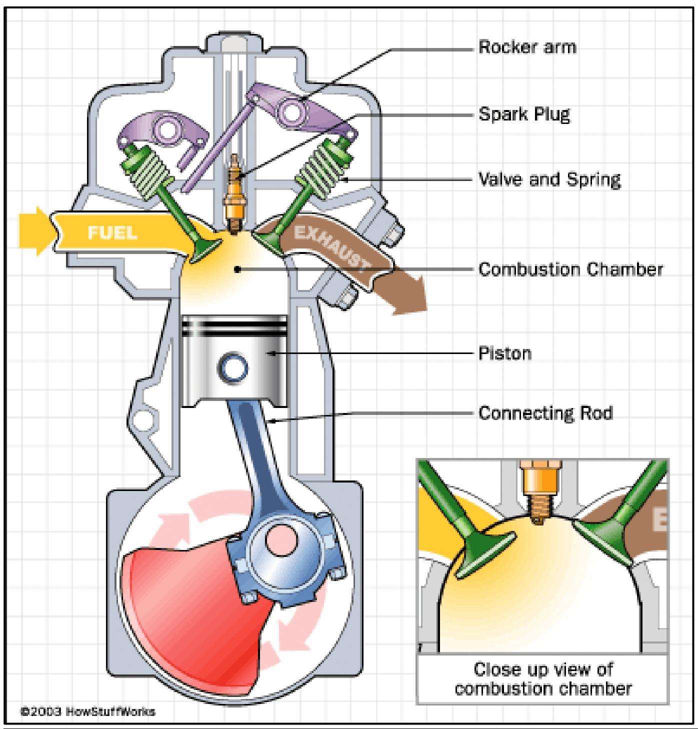

Figure 3: A schematic of an internal combustion engine. The piston starts at the top, the intake valve opens, and the piston moves down to let the engine take in a cylinder-full of air and fuel, compressing the mixture of fuel and air, while the spark plug ignites the fuel, which explodes, creating an exhaust comprised of various chemical compounds which exit out the tail pipe.[25]

[c] The chemical reaction for NOx is the following: N2 + O2 = 2NO, 2 NO + O2= 2 NO2

[e] CO_2 has an atmospheric lifetime of approximately 250-400 years

III. Effects of Pollutants Addressed in H.R. 1640 on Humans and the Environment

Energy in the U.S. is produced from a variety of sources, and each source creates a multitude of impacts on the environment. We have focused on four major environmental contaminants from coal-fired power plants and internal combustion engines in the context of H.R. 1640: sulfur dioxide (SO_2), nitrogen oxides (NO_x), mercury (Hg), and carbon dioxide (CO_2). All of these pollutants are produced from the burning of fossil fuels, and constitute the core of major environmental problems such as air pollution, climate change, and heavy-metal water contamination. Furthermore, they exert a range of effects on human health, and contribute to ecosystem degradation. This section will look at: a) the role of SO_2 in acid rain formation and its human health effects; b) how NO_x produces smog and what some of the health risks are; c) the interaction between aquatic biota and Hg and how it may be ingested by humans and its consequences; d) CO_2 emissions and their contribution to global warming; and e) the role of energy efficiency in reducing high energy demand, which in turn will reduce pollution linked with energy production.

a. Sulfur Dioxide (SO_2): acid rain formation and human health effects

The environmental impacts of sulfur dioxide (SO_2) are related to deposition of acid rain or sulfate particles. Reaction of SO_2 with other gases in the air produces sulfuric acid. When this acid precipitates with rain, snow, fog, or as dry particles, it causes the acidification of freshwater and soils, as well as damage to vegetation. Non-acid sulfate particles can also precipitate to the ground; this process causes nutrient loading and eutrophic effects.

Bodies of water with weak, or no, ability to neutralize acids are particularly susceptible to both wet and dry acid deposition. Some bodies of water have a higher buffering capacity than others; however, when they can no longer tolerate it, acids act to alter the pH of the water, affecting plant and aquatic life in the water. Certain species, for example, rainbow trout, snails and clams, are highly sensitive to minimal changes in pH. A drop in pH will affect their ability to reproduce, grow, and survive.[26]

In some acidified lakes and streams, entire fish populations have disappeared, leaving the bodies of water barren. For example, many lakes in the Adirondack Mountains of New York and many streams in the Appalachian mountain region have experienced losses of trout and other aquatic life due to acid rain.[26] Furthermore, acids act to release aluminum in aquatic environments which can be toxic to fish and other organisms. Aluminum and pH levels are inversely proportional so that as pH decreases (the water becomes more acidic), aluminum concentration increases. Chronic exposure to sub-lethal aluminum levels and reduced pH levels causes reproductive stress and depressed growth among fish populations and aquatic vegetation. In forests, acids rapidly deplete essential nutrients while simultaneously leaching toxic elements (such as aluminum) in soil. This results in loss of foliage, increased susceptibility to weather and disease, and depressed growth and reproduction.[27]

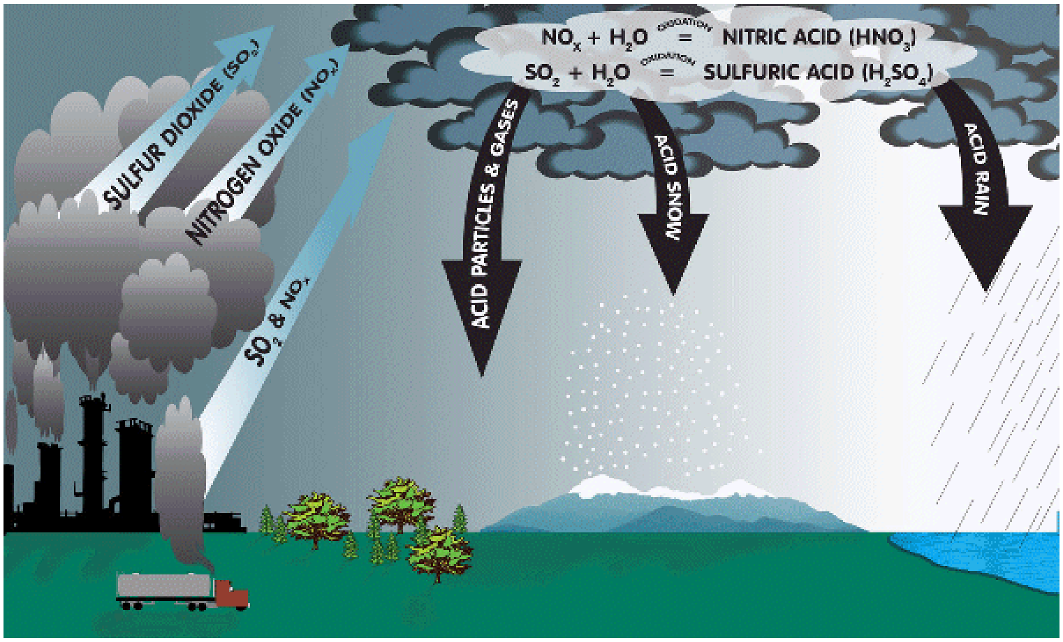

Figure 4: a diagram illustrating the process of acid rain as a result of SO_2 and NO_x emissions from coal-fired power plants and internal engine combustion in automobiles

Acid rain also damages trees by stunting their growth, removing essential nutrients from the soils, and limiting their ability to prevent disease. Forests affected by acid rain are easily seen, as the leaves and needles have turned brown and fall off, as opposed to healthy green trees.[28] Many historical buildings are affected by the sulfurous, sulfuric, and nitric acids in acid rain, which act to corrode buildings made of materials such as marble and limestone. They contain calcite, which is dissolved by the acids, leading to removal of material and carvings at the surface.[29]

Sulfur dioxide emissions can also affect human health, principally through inhalation. Direct inhalation of the gas causes respiratory illness in susceptible populations such as the very young, the elderly, and individuals with heart and lung disease, with chronic inhalation of SO_2 contributing to the development of these ailments in otherwise healthy populations. High levels of SO_2 in the air have been proven to cause and aggravate various types of lung disorders. These lung disorders, which affect some people's ability to breathe, have led to both increased disease rates and mortality in young children and the elderly. When reacting with particles and other gases in the air, SO_2 generates sulfate particles. Chronic inhalation of these particles can cause a build up of residue in the lung, which causes lingering respiratory dysfunction and illness.[30] Furthermore, short-term exposures to high levels of SO_2, such as 100 parts of sulfur dioxide per million parts of air (ppm) can have serious consequences and is considered dangerous to human health. In one study, previously healthy and non-smoking miners who breathed SO_2 released as a result of an explosion in an underground copper mine developed burning of the nose and throat, breathing difficulties, and severe airway obstructions.[30]

b. Nitrogen Oxides (NO_x): smog formation and human health effects

Nitrogen oxides have environmental and health impacts very similar to those of SO_2, particularly related to acid rain, nutrient deposition and particle inhalation. Ground-level ozone (O_3), also known as "smog" is common in urban areas with dense traffic congestion. NO_x are a key component in the formation of smog. When NO_x and Volatile Organic Compounds (VOCs), usually hydrocarbons, come into contact with heat and UV light, the molecules combine to form ozone in the lower layers of the atmosphere. Because of the importance of heat and sunlight in the chemical reaction, smog is most prevalent in the summer months, when there is the most sunlight and temperatures are the highest.[31]

Smog (ground-level ozone) has health effects when it enters the lungs through respiration and can cause up to a 20 percent decrease in lung function, exacerbating asthma, causing bronchitis and chronic lung inflammation. Smog is a large problem in urban environments where many automobiles are driven, and thus there are increased levels of NO_x and hydrocarbons in the air. This has resulted in increased childhood asthma rates in some cities such as Los Angeles. Researchers have found an increased risk of premature death associated with increased levels of ozone in the U.S. They estimated that over 3,700 deaths annually could be attributed to a 10-parts-per-billion increase in ozone levels.[32]

c. Mercury (Hg): effects on the environment and human health

Mercury emissions are problematic to the environment and to human health ultimately because of the process of bioaccumulation (see Figure 5). Mercury is released into the air as a result of coal combustion and is easily transported in the atmosphere. Mercury often precipitates with snow and rainfall and is deposited on land and water flowing into rivers and lakes. Trace amounts of mercury are soluble in bodies of water, and in the anoxic (oxygen-deprived) conditions at the bottoms of lakes and estuaries, microorganisms convert the mercury into methylmercury (MeHg), a more toxic form of mercury.[33]

Methylmercury is made by methane-producing bacteria, which "methylate" the mercury when they ingest it and bind a carbon atom to a mercury atom, altering mercury's properties so it can be readily accumulated in fish. Once methylmercury enters the environment, it accumulates in organisms over time through a process called bioaccumulation. Once released from microorganisms, methylmercury diffuses and binds to proteins in fish. These fish absorb the methylmercury in the water as it passes over their gills when they breathe, or when they feed on microorganisms that contain methylmercury. These fish are then consumed by larger and larger fish. As a result, the fish at the top of the aquatic food chain contain the highest concentrations of methylmercury. The process by which organisms higher on the food chain accumulate greater amounts of contaminants is referred to as biomagnification. Consequently, when human beings eat predator fish they also ingest the methylmercury. [34]

In the human body, mercury contaminates the brain and nervous system. The nervous system is very sensitive to all forms of mercury, but methylmercury and metallic mercury vapors are more damaging because of their effect on the neurological system. In adults, mercury poisoning can adversely affect fertility and blood pressure regulation, cause memory loss, tremors and vision loss, and permanently damage the brain, kidneys, and developing fetus.[35] Pregnant women and children are especially susceptible. Children poisoned by mercury may develop problems of their nervous and digestive systems, and kidney damage. Pregnant women may pass mercury's harmful effects to the fetus resulting in brain damage, mental retardation, a lack of coordination, blindness, seizures, and inability to speak.[36] It can also pass to a nursing infant through breast milk.[37]

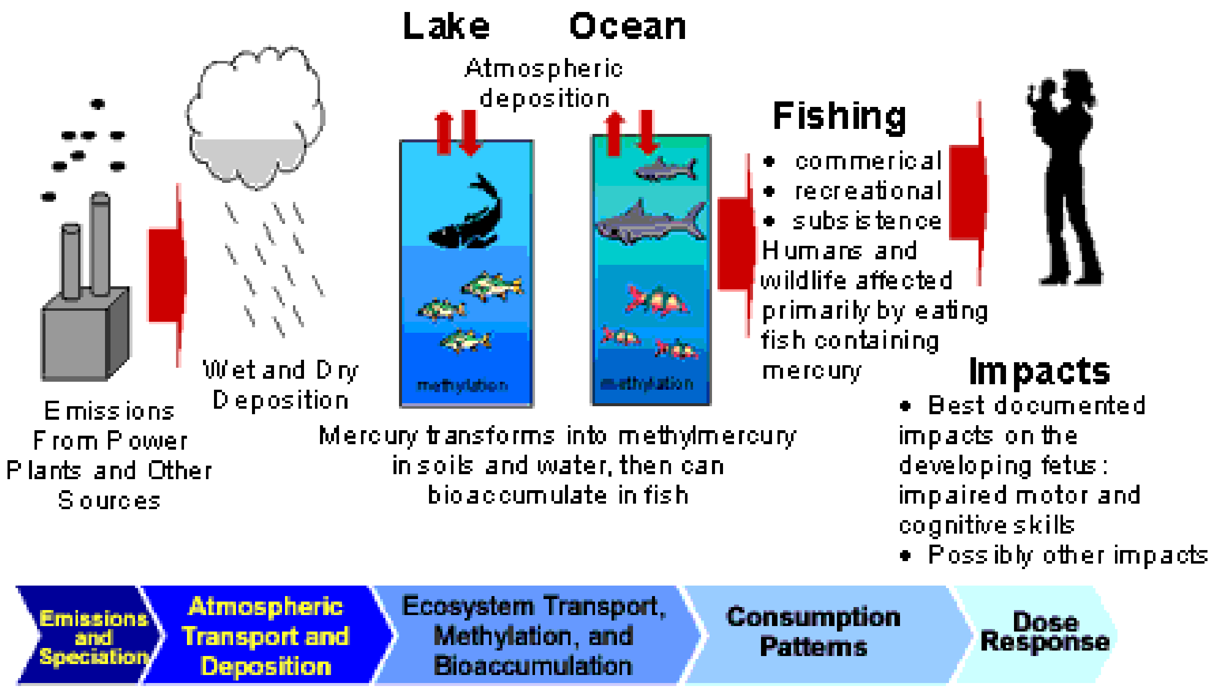

Figure 5: The cycle of mercury in the environment from power plant emissions, deposition in the environment, and bioaccumulation in humans from the consumption of fish. (Source: U.S. Environmental Protection Agency)

<u>d. Carbon dioxide (CO_2) emissions and Global Warming</u>

Release of carbon dioxide (CO_2) from the combustion of fossil fuels in both coal-fired power plants and gasoline combustion from mobile sources constitutes the largest anthropogenic contribution to global warming (see Figure 6). The principal environmental effect of increased CO_2 quantities in the atmosphere is an elevation in average global temperature. This rise in temperature is expected to trigger such impacts as sea level rise, increased incidence of extreme weather phenomena, regional climate pattern shifts, and the disruption of major ocean currents, which act to regulate climate and weather in many regions of the world. Environmental effects include increased ocean acidity, ice melting (at the poles and glaciers), forest fires, and other positive feedbacks to the climate change pattern conditions.[38] Health effects to humans are related to these environmental impacts. Elevated temperatures can cause more heat waves and heat-related illness in humans. Higher temperatures may also expand the habitat range for disease vectors, such as mosquitoes.[39]

Increasing levels of CO_2 in the atmosphere exact a toll on the Earth's climate through global warming. Incoming sunlight heats the Earth's surface throughout the day. At night, the surface cools, releasing this energy as infrared waves, which are absorbed by CO_2 molecules in the atmosphere, trapping the energy near the Earth's surface. CO_2 molecules persist in the atmosphere over time so that the process reinforces itself; it operates in a positive feedback mechanism. According to the UN Framework on Climate Change Convention, carbon dioxide is responsible for over 60 percent of the human-induced greenhouse effect, through the incineration of coal, oil, and natural gas at an exponential rate, releasing the carbon stored in the fuels into the atmosphere and altering the balanced carbon cycle by which carbon is exchanged between the atmosphere, oceans, and vegetation on land. Currently, atmospheric levels of carbon dioxide are rising by over 10 percent every 20 years." [40]

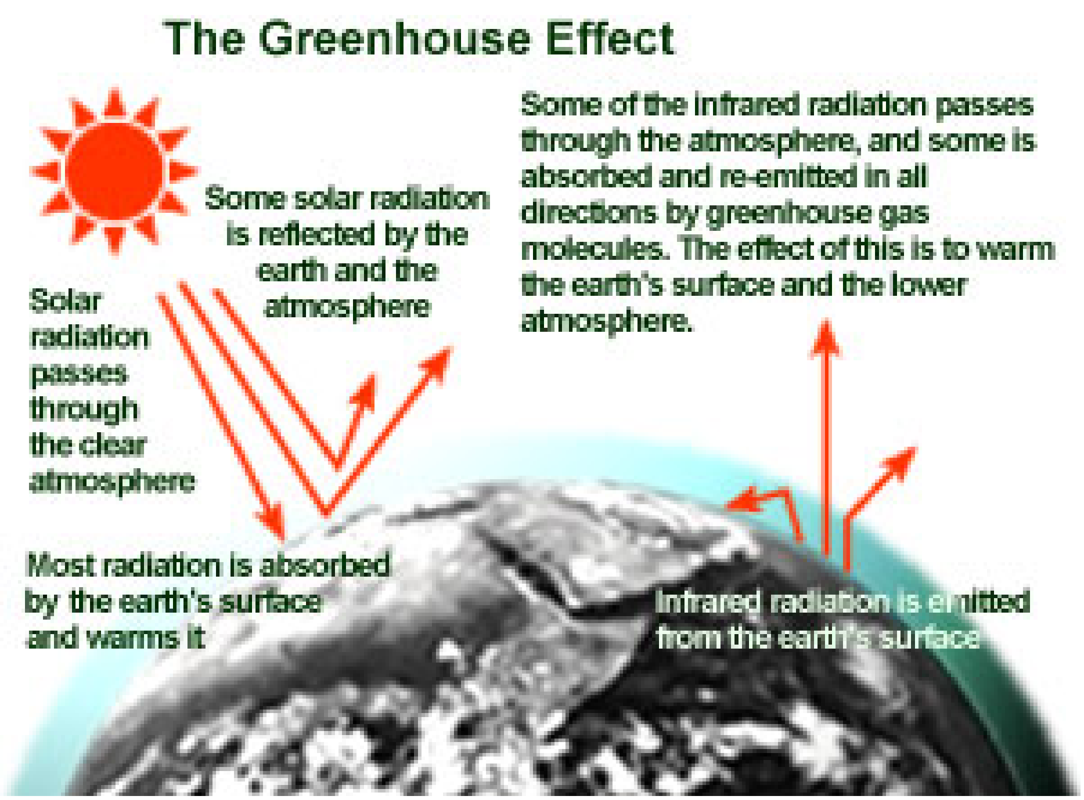

Figure 6: The greenhouse effect, and its contribution to global warming, in which carbon dioxide plays a major role.[41]

e. The Role of Energy Efficiency in Reducing High Energy Demand

American demand for energy is on the rise, with the highest demand falling on petroleum, natural gas, and coal.[42] Figure 6 illustrates that total primary energy consumption grows 1.1 percent each year, with fossil fuels accounting for 88 percent of this consumption, with coal and petroleum increasing by 53 percent and 34 percent, respectively.[43] Pollutants like SO_2, NO_x, Hg, and CO_2 all enter environmentally significant pathways through energy production. Thus any efficiency loss in consumption directly intensifies the environmental and health effects associated with production. Unless changes in demand or energy use are made, the environmental and health effects related to the use of these resources will be continuously exacerbated.

Figure 1: NO_x, SO_2, and CO_2 Emissions in the US, 1989-2004

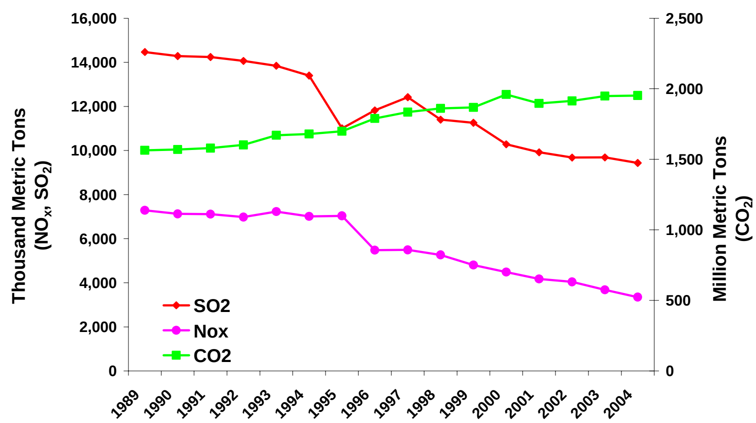

Figure 7: Emissions trends from 1989 to 2004 illustrate decreases in nitrogen oxides and sulfur dioxide and increases in carbon dioxide over time. [44]

Government intervention has greatly reduced the releases of NO_x and SO_2.[45] Carbon dioxide, however, has not been regulated on a federal level, and is ever-increasing (see figure 7). Additionally, though highly regulated, NO_x and SO_2 persist as important pollutants for public health and environmental degradation. Especially significant for these pollutants is that they are not restricted to the location in which they are formed; NO_x and SO_2 generated at Midwestern coal-fired plants precipitates on the eastern seaboard. The interstate and global nature of the effects of these pollutants calls for a decrease in their emissions, which can be achieved through greater energy efficiency.

Case Study: "Vampire" Power

Many electronic devices—TVs, VCRs, microwaves—draw some electrical current whether turned on or sitting idle because some components will always require power regardless of whether the entire unit does. Across millions of devices in millions of home and offices, power consumed in standby mode, otherwise known as vampire power, represents a large amount of energy resources consumed. According to the Lawrence-Berkeley National Laboratory, current estimates indicate that standby power use in the U.S. accounts for about 5 percent of residential electricity use, and residential consumers in the U.S. spend over $4 billion on standby power each year.[46] Some household devices are capable of sucking 20 to 25 watts in standby mode alone. (A typical light bulb is 75 watts). Technology exists to reduce power consumption in standby mode significantly, in some cases to as low as 1 watt.[47]

IV. Solutions in H.R. 1640 to the problems associated with the production of traditional energy

H.R. 1640 has been successful in tackling the problems resulting from the production of traditional energy, and subsequently looks to mitigate these problems through more efficient, environmentally and technologically sound initiatives.

a. Traditional Energy: Coal

i. The Clean Coal Power Initiative (CPPI)

Coal-fired power plants are linked to pollution by sulfur dioxide (SO_2) and mercury (Hg). CPPI proposes a number of alternatives that decrease the deposition of Hg and SO_2 into the atmosphere, and consequently lessen the environmental and human health risks that they currently pose. The Secretary of the DOE allocated $1.08 billion over 9 years to fund projects furthering coal-based gasification technologies, which include gasification combined cycle; gasification fuel cells; gasification co-production; hybrid gasification/combustion and the capture and storage of carbon dioxide.

Coal gasification breaks down the coal into its components, usually by subjecting it to high temperature and pressure, using steam and measured amounts of oxygen. This leads to the production of carbon dioxide and oxygen, as well as other gaseous compounds. Once these gases have been separated, they can be used individually to either lessen the effects of particulate matter emissions or to further the push toward implementing renewable energy sources. This deals with the problems concerning global warming as well as the physiological effects resulting from pollutants being released into the atmosphere.

ii. Clean Air Coal Program (CACP)

CACP aims to institute pollution control equipment to meet current and future obligations of coal-fired generation units regulated under the Clean Air Act. The program grants $500 million for the funding of pollution control equipment. These funds will be utilized to further the advancement of traditional equipment, like scrubbers, as well as the development of advanced combustion technology. Advanced combustion technology will allow the industry to meet pollution reduction milestones set out by the Secretary of the DOE. These are to reduce SO_2 emissions from coal burning power plants by 99% by 2020, as well as to demonstrate substantial reductions in Hg emissions.

The DOE has embarked on a project that embraces all of the initiatives proposed in the Act, with the hope of setting a template for the way that power plants will be built in the future. This project is called Futuregen. This is an initiative to build the world's first integrated sequestration and hydrogen production research power plant. The $1 billion project is intended to create the world's first zero-emissions fossil fuel plant. When operational, the prototype will be the cleanest fossil fuel fired power plant in the world. While Futuregen was not directly mandated from the legislation, it does represent the industries’ response to the proposals outlined in H.R. 1640.

b. Ethanol and Biofuels:

Ethanol and Biofuels are claimed to provide a solution to the environmental problems caused by nitrogen oxide (NO_x) and carbon dioxide (CO_2) gases emitted from fossil fuels combustion –such as gasoline- because they facilitate a carbon neutral output of CO_2, therefore negating these gases' effects on global warming. Ethanol is an alcohol fuel made from agricultural products including corn, sugar cane, cellulose, starches, sugars, or agricultural waste.

i. The Renewable Content of Motor Vehicle Fuel (RCMVF)

The RCMVF amends the Clean Air Act to establish a renewable fuel program consisting of cellulosic biomass, waste-derived ethanol, and biodiesel. This initiative directs the EPA to implement a program that ensures that gasoline introduced into commerce in the contiguous U.S. contains a set applicable volume of renewable fuel until 2013. The program mandates a 300 million gallon a year increase culminating in a level of 5 billion gallons of ethanol and biofuels at the pump by 2012.

A tax credit program is proposed whereby any person that refines, blends, or imports gasoline that contains a quantity of renewable fuel that is greater than the required volume of renewable fuel is eligible for a credit. The credit program provides market-based incentives to exceed the yearly limits defined in the bill. The credits can be sold to other industry players that failed to meet the cap, thereby creating a financial incentive to overshoot the predefined levels. These credits can be used, sold or carried over to the following fiscal year only. Credit based programs have shown to be very successful in engaging the private sector in new industry initiatives.

ii. Supporting the Development of Biofuel Production Infrastructure

Two major programs to support biofuel production infrastructure are proposed. The first provides loans that are backed by the government. This means that in the case of default, the U.S. government can step in and bail out the defaulting party. These loans are made available to private institutions for the construction of facilities, such as specialized extraction plants, which utilize new technology to facilitate the processing and conversion of municipal solid waste and cellulosic biomass into ethanol. The grant program allocates $750 million between 2005 and 2007 to merchant producers of cellulosic biomass ethanol and waste-derived ethanol to help build infrastructure for the production of ethanol.

Ethanol today is largely a blend component with gasoline, adding octane, and displacing compounds such as MTBE (methyl tertiary-butyl ether—a highly polluting gasoline additive). This helps refiners to meet specifications detailed in the Clean Air Act. Ethanol will soon saturate the blend market and refiners and producers are looking, in particular, for market opportunities with E85, a mixture of 85% ethanol and 15% gasoline.

There are currently 5 million Flex Fuel Vehicles (FFV) on the road, a number that represents less than 2% of the total U.S. motor vehicle fleet. FFVs run on a blend of ethanol and traditional gas, such as E85, whereas regular vehicles are not always compatible with variations of traditional gasoline. The main barrier to the adoption of ethanol as motor fuel in the U.S. is the low number of fueling stations existing in the

U.S., currently counted at 656. These fueling stations are found predominantly in the Midwest, where corn for the ethanol is grown. The industry hopes to penetrate different parts of the market throughout the country once they have achieved economies of scale.

c. Energy Efficiency

The U.S. consumes more electricity than any other country in the world. In 2004, the U.S. consumed over 3.7 trillion kWh (kilowatts per hour), exceeding the consumption of all European countries combined. This high consumption level amplifies the environmental effects of electricity production from all sources.

i. The Energy Star Program

The Energy Star Program aims to reduce U.S. energy consumption and associated greenhouse gas emissions through the voluntary labeling of energy-efficient products and the promotion of these products among individual consumers and businesses. The provisions contained in H.R. 1640 aim to promote Energy Star technologies, increase awareness and preserve the integrity of the Energy Star label, gather feedback from the industry, and provide lead time for manufacturers to make adjustments in the case of program changes. The bill also builds upon the Energy Star for Small Businesses Program by improving efforts to educate small business owners about energy efficient heating, ventilation and air conditioning (HVAC) units.

Since the program's inception, Energy Star has been expanded to include more than 40 product categories, with more than 1500 manufacturers participating in the labeling of over 35,000 product lines. Consumers have purchased more than 2 billion Energy Star products since 1992, of which 31% comprised computers and monitors, 23% consumer electronics, 22% lighting products, 18% office equipment, and 6% other products. Average households can save 30% on their electricity bills by using Energy Star products. The program has also been beneficial to manufacturers due to the popularity of many Energy Star products (60% of Americans are aware of the Energy Star label). In addition, the program has been successful in reducing greenhouse gases. Energy Star has been responsible for roughly one-third of all of EPA-led greenhouse gas reductions to date and is projected to have prevented 160 million metric tons of carbon equivalent emissions by 2014.

V. The Science behind the Proposed Solutions in H.R. 1640

H.R. 1640 promotes several solutions to problems related to American energy use. To combat the problems of coal burning power plant emissions, automobile emissions, and high energy demand, the legislation offers the solutions of integrated coal gasification combined cycle technology, developing cellulosic ethanol for use in motor vehicles, and expanding the Energy Star consumer product labeling program. Here we examine the technology and science behind these solutions.

a. Integrated Coal Gasification Combined Cycle Process

Integrated Gasification Combined Cycle (IGCC) combines coal gasification with a more efficient modern turbine system (combined cycle) for the purpose of energy generation. IGCC drastically reduces emissions of greenhouse gases (CO2, CH4), mercury (Hg), and acid rain-causing gases (NOx and SO2) that are produced during coal combustion (see figure 8) .[48]

i. Coal Gasification

Raw coal is placed in a gasifier under high temperature and pressure under controlled amounts of oxygen and water vapor. This causes solid coal to be converted into its constituent gases. Methane, the molecule burned in combustion, is converted to carbon monoxide (CO) and hydrogen (H2). This resulting syngas also includes any impurities found naturally in the coal source.[49]

ii. Combined Cycle

Syngas is used to drive a gas or combustion turbine. This turbine is propelled by the force resulting from gas combustion. This combustion is extremely hot, and the high heat release is used to generate steam. Steam is then used to run a secondary and more conventional steam turbine.[50]

This process contributes to alleviating pollution in two ways. First, the pollutants in the syngas are easily removed. Mercury is removed using an activated charcoal filter that exhibits removal efficiencies around 90%. Sulfur is removed as hydrogen sulfide (H_2S); this unoxidized sulfur form can serve as a marketable byproduct of coal consumption. Sulfur removal can exceed 99%. Second, IGCC plants exhibit energy conversion efficiencies of 20 to 35% higher than conventional coal burning power plants. As a result, less coal is needed to generate the same electrical energy, and pollutant removal is much more efficient (see Table 1).[51]

Pollutant	**Traditional Coal Plant**	**IGCC Plant**	**Reduction**
Sulfur Dioxide (SO_2) (lb/106 Btu)	**31.25**	**<0.15**	**99%**
Mercury (Hg) (lb/109 Btu)	**21.4**	**1.5**	**93%**

Table 1: a comparison of the emissions of pollutants sulfur dioxide and mercury from traditional and IGCC coal plants[52]

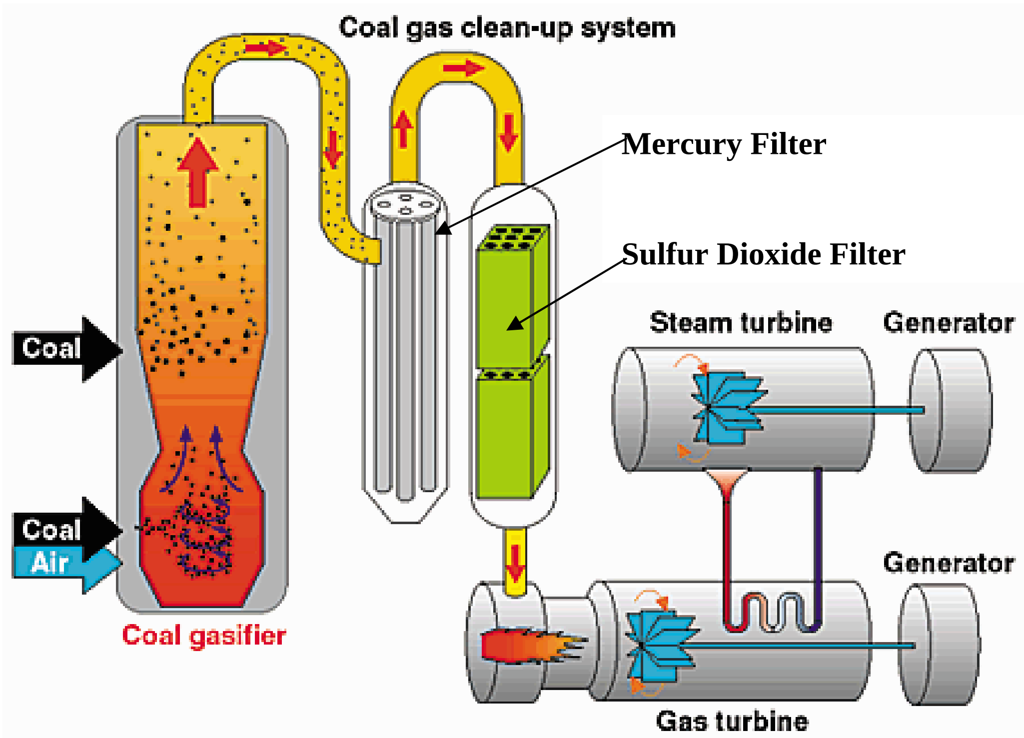

Figure 8: Integrated Coal Gasification Combined Cycle. In coal gasification, raw coal is placed in a gasifier converting solid coal into its constituent gases. This resulting gas, known as syngas also includes any impurities found naturally in the coal source, such as mercury and sulfur. Mercury is removed using an activated charcoal filter (shown in grey) and sulfur is converted to hydrogen sulfide (H_2S) using limestone (shown in green).

b. Production and Use of Cellulosic Ethanol

Cellulosic ethanol is an alternative to the more traditional crop-based ethanol that is currently being generated from corn and sugarcane. Any cellulosic material can be used as a feedstock, including agricultural residue (stalks, leaves), herbaceous energy crops (switchgrass), fast-growing hard woods, and municipal solid waste (paper, yard trimmings, and food scraps).[53]

i. Ethanol Production (see figure 9)

Cellulosic feed-stocks are mechanically broken up and converted into a slurry of cellulosic material. The cellulose and other long carbon-containing compounds in this slurry are broken up by acids or enzymes into smaller compounds, particularly glucose. Glucose is then fermented by yeast and converted into ethanol (identical to the process used to make wine). This produces an industrial beer, which is a soup that contains ethanol, water, and all portions of the cellulose-rich slurry that was not converted to glucose. Distillation and dehydration follow, whereby water and unused material from the feed-stocks are removed. The result is nearly 200-proof (100%) ethanol. This ethanol can then be burned in cars as a fuel or fuel additive.[54]

Ethanol has a relatively low energy density in comparison to gasoline; 1.42 gallons of ethanol need to be burned to generate the same amount of energy as 1 gallon of gasoline[55]. As a result, NO_x emissions increase[d]. NO_x is created independent of the fuel source, but as a result of combustion in the presence of N_2 and O_2. As a result, by requiring more combustion to produce energy, ethanol allows for increased NO_x generation. Ethanol is readily decomposed, reducing volatile organic compound (VOC) emissions. Lower VOC emissions decrease ozone formation. [56e]

Cellulosic ethanol has the potential to be a carbon-neutral fuel source[57]. When cellulosic ethanol is burned, CO_2 is released to the atmosphere, as in all other combustion processes. This CO_2 can be assimilated by plants into tissues. These plants can then be used as a cellulosic feedstock for ethanol generation. This ethanol is then burned for fuel. As a result, the same amount of carbon can be re-circulated by using plants both as a source and sink of CO_2.[58]

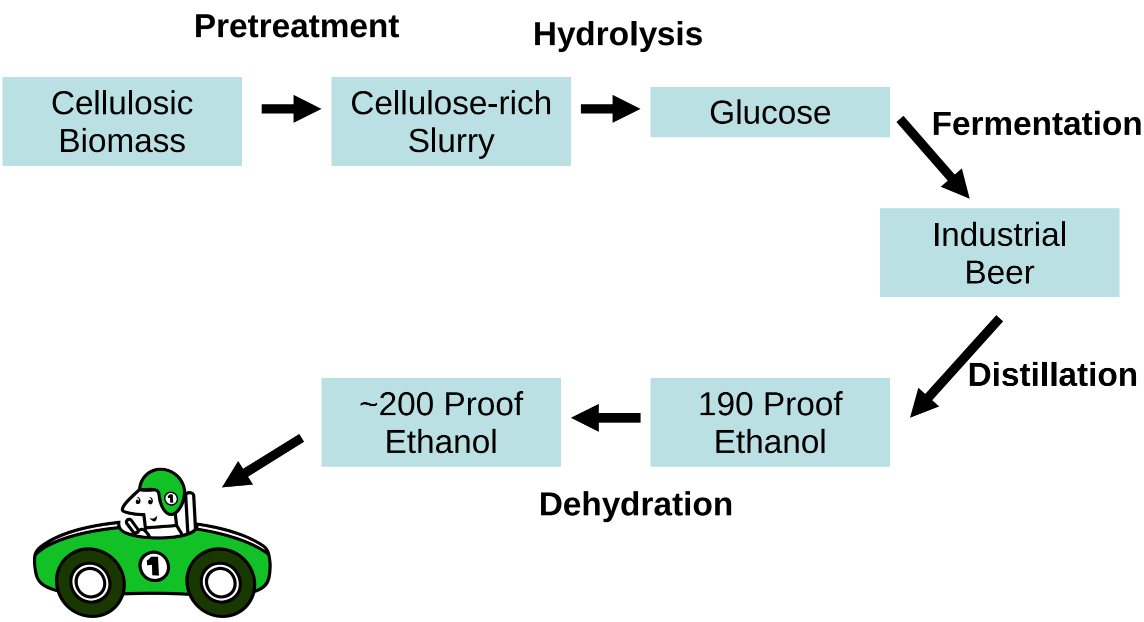

Figure 9: An illustration of the ethanol production process. Organic matter is pretreated by grinding it up and creating a mash or slurry. The slurry contains cellulose molecules. Enzymatic and acid hydrolysis generates simple sugars from the sophisticated cellulose molecule. Fermentation of glucose by yeast generates an "industrial beer," or a soup of ethanol, water, and solid matter. Distillation separates the alcohol, and dehydration removes excess water. The result is nearly pure ethanol (~200 Proof Ethanol), which can be used as a gasoline additive or an alternative fuel source.

c. Energy Star Consumer Product Labeling System

Energy Star is a jointly administered program by the Environmental Protection Agency (EPA) and Department of Energy (DOE). Product standards to qualify for Energy Star labeling are different for each product category, but are aimed at reducing air pollution (especially CO_2 emissions), delivering energy savings to consumers, and developing niche markets for consumer products. Labeling is a result of joint research conducted by government and industry to arrive at particular standards and efficiency-enhancing

[d] This is a contentious issue: the Department of Energy states that ethanol blends over 10% cause NOx emissions to increase. The Environmental Protection Agency, however, states that 85% ethanol blends reduce NOx emissions.

[e] VOC + NO + $h\nu \rightarrow O_3$. Removing VOCs reduces O_3 formation.

technologies.[59] Labeled products cost more to purchase, but this price premium is recouped through energy savings. As an example, compact fluorescent lamps (CFL) are labeled as an alternative to incandescent light bulbs. CFL cost a little over ten times more than the incandescent bulb (depending on the model), but last ten times longer and use 66% less energy. Thus, the price premium is recouped as a result of decreased energy demand and increased life span of the bulb.

Energy Star product labeling encourages decreased energy demand among consumers. By decreasing demand for energy, pollution released in electricity production is less severe.

Energy Efficiency Eligibility Criteria

- **Significant energy savings can be realized on a national basis**
- **Product performance can be maintained or enhanced with increased energy efficiency**
- **Purchasers will recover their investment in increased energy efficiency within a reasonable time period**
- **Energy efficiency can be achieved with several technology options, at least one of which is non-proprietary**
- **Product energy consumption and performance and can be measured and verified with testing**
- **Labeling would effectively differentiate products and be visible for purchasers**

Box 1: Energy Efficiency Eligibility Criteria for the Energy Star Label

VI. Controversies of the Solutions

The scientific solutions proposed in the legislation related to coal gasification and traditional automobile fuels are very promising in their technologies to reduce pollutants caused by conventional fuels. However, these solutions come with drawbacks, which in turn make opponents question whether these are the best steps forward for the U.S in terms of developing an environmentally sound energy infrastructure capable of meeting its energy demand goals.

<u>a. Controversies Associated with Coal</u>

i. Benefits

The Clean Coal Power Initiative is a large program within the legislation and meets the goal of energy independence. According to the National Coal Council, coal provides a domestic source of energy with an estimated supply of 250 years at current usage rates.[60] The U.S. contains 27% of the world's coal supplies, which is the largest of any single country.[61] (See figure 10). The Energy Information Administration's 2006 energy sources forecast report projects coal to be by far the largest source of electricity by 2015 and increasing the gap even more by 2030 (see figure 11). [62] From an environmental perspective, the new integrated gasification combined cycle (IGCC) plants greatly reduce pollutants such as sulfur dioxide and mercury created by coal plants. Studies by the Department of Energy (2003) show that this is a viable technology that can produce electricity at competitive rates compared to traditional coal plants. [63,64]

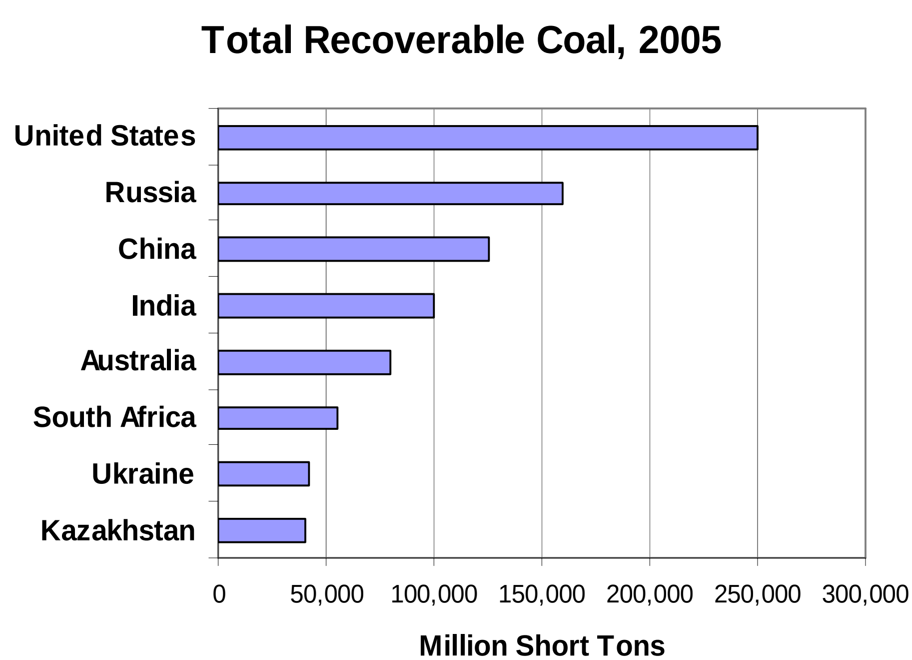

Figure 10: The U.S. contains 27% of the world's coal, the largest of any country in the world.[65]

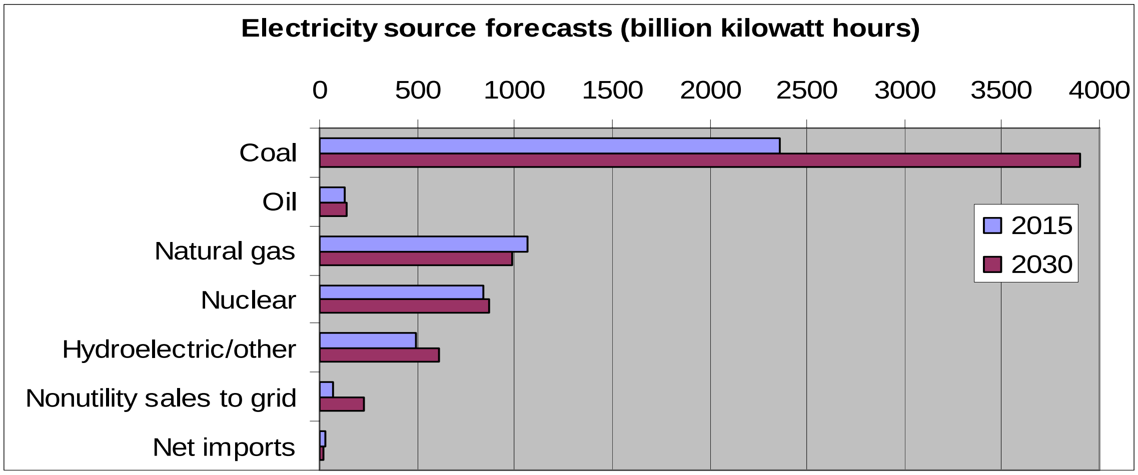

Figure 11: High economic growth scenario projected in the U.S. illustrates the amount of coal used for electricity in 2015 and 2030 compared to other energy sources in a business-as-usual scenario. [66]

ii. Mining

The benefits of gasification technology do not address the issues related to coal mining that impose significant environmental and health hazards. There are 1,379 coal mines throughout the United States,[67] composed of two types. Surface or mountaintop mines are used when the coal deposits are close enough to the surface to access them by removing the top layer of ground or a mountain top.[68] When the coal deposits are too deep underground for this method, the underground method is used, where deep tunnels are dug to access the coal.[69]

Both types of mines result in contamination of waterways with acidic and metallic residues. Through a process called acid mine drainage, sulfuric acid is formed during oxidation of iron sulfide minerals found adjacent to coal and exposed to air and water through mining operations.[70] This runoff causes a reduction of the pH levels of nearby streams which results in loss of ecosystem health, including complete loss of fish in some waterways. In addition to the aquatic problems, coal mining degrades terrestrial areas by removing the top vegetation layer.[71] Even if this layer is later replaced, the composition of the soil has been inverted such that the top layer is now underneath, prohibiting vegetation re-growth for a long time.[72]

iii.Funding Priorities

Funding priorities for electricity production is another controversy surrounding coal. The issue is whether the money committed to promoting coal production would be better invested into development of new renewable technologies, such as solar and wind power. H.R. 1640 provides $1.08 billion for coal gasification construction projects and $500 million for pollution control equipment for coal-fired power plants.

The legislative provisions to promote "renewable energy" sources include electric energy generated from solar, wind, biomass, landfill gas, ocean (tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation. However, this portion of the legislation contains only $10 million in annual appropriations to the Department of Energy (DOE) until 2010 to conduct research and issue reports assessing levels of renewable energy resources. The bill then extends the Production Tax Credits first established in the Energy PolicyAct of 1992 to the year 2015. These credits provide an inflation-adjusted tax credit of 1.5 cents per kilowatt-hour to producers using solar, wind, geothermal, or closed-loop (dedicated energy crops) biomass technologies to generate electricity. There is also a mandate for federal procurement of renewable energy, setting levels of electricity consumed by federal buildings that must come from renewable sources. The provisions for the use of photovoltaic energy in public buildings allow the Secretary of the DOE to establish a photovoltaic energy commercialization program for the procurement and installation of photovoltaic solar electric systems in public buildings. However it does not require this action of the DOE.

When compared to funding for coal technologies development, there is far less support in H.R. 1640 committed to solar and wind electricity generation programs. In fact there are no direct grant or loan programs. Much of the public funding for coal technologies is committed in this piece of legislation to coal-fired power plant technologies such as combined cycle generation and carbon sequestration, which have not been proven to address carbon dioxide emissions. To some, investment in coal technology is logical considering its low cost and the large resource found in the U.S. To others, solar and wind power generation are superior methods of generating electricity due to their low levels of emissions.

b. Controversies Associated with Ethanol and Biofuels

i. Benefits

The primary environmental benefit of ethanol is carbon neutrality, such that the amount of CO_2 released during the burning of ethanol is consumed by the plants when they are re-grown for making more ethanol. In addition, ethanol can be a domestic supply, replacing foreign imports of oil for gasoline, while revitalizing the U.S. farming industry.

ii. Environmental Effects

There are several major controversies surrounding the production of ethanol. First, the Department of Energy (DOE) and the Environmental Protection Agency (EPA) have differing opinions on ethanol's impact on NO_x emissions from automobiles. The DOE estimates that NO_x emissions increase with fuel blends that are 10% or more ethanol by content, whereas the EPA states that E85 (85% ethanol, 15% gasoline) fuel reduces NO_x emissions by 10%.[73,74] Second, experts dispute the efficiency of ethanol production from corn and biomass inputs.[75,76,77] The crux of the disagreement lies in divergent opinions of the total energy required for ethanol production and refinement.[78,79] Significant disagreement exists whether the production process consumes more fossil fuel energy than its output replaces, meaning ethanol may be a dubious policy choice when measured in terms of total energy efficiency.[80]

iii. Politics

There is also significant controversy over whether the push for ethanol reflects environmental concerns or economic motives. Although importing ethanol is cheaper than producing at home, there is a tariff of 54 cents per gallon to protect the nascent domestic industry. Some contend that this tariff, coupled with the federal tax credit of 51 cents per gallon refined (state tax breaks may increase the total value of the subsidy), is a hidden form of corporate welfare for large “agri-business” producers such as Archer Daniels Midland.[81] These interests form an impressive lobbying presence and give generously to political campaigns. They have contributed $3 million to both parties since 2000.[82] Further, this debate spills over into arguments over international trade as low cost producers such as Brazil push for access to the American market.[83] In May 2006, when President Bush considered decreasing the tariff on Brazilian ethanol to combat rising gasoline prices, several senators, led by Charles Grassley (R-IA, a prime corn-growing state) argued against the action.[84]

VII. Measuring the Energy Star Program's success

The ultimate goal of the Energy Star program is to lower the otherwise increasing energy demand by end-users and thus contribute to lowering the environmental pressure associated with the current energy sources. Energy efficiency is understood as the reduction of the overall electricity consumption by specific end-use devices without affecting the service provided. Attaining energy efficiency implies lowering the total energy inputs normally required to produce a given level of service, or enhancing the amount of service for a given quantity of energy inputs.[85] Tracking energy efficiency can become more complex given that efficiency gains pertain to each product and the amount of energy required in delivering a service.

Assessing energy efficiency in appliances is based on minimum efficiency standards set for manufacturers by the Department of Energy (DOE).[86] Such standards serve as a reference for setting the Energy Star product criteria, which in turn is used to test Energy Star qualifying products. The DOE also sets energy test procedures to measure energy consumption under a controlled environment to maintain consistency in the testing process. The result is an energy consumption value, such as kilowatt hours/year or Btu per hr. Appliances compliant with the Energy Star Program criteria can lower their energy usage up to 10-50% compared to the standard models.[87] The following are two examples out of the 8 appliance categories certified by the program, on how efficiency is measured:

Case Study 1: Washing machines [88]

The criteria for this product type defines efficiency levels based on an energy performance metric, the Energy Factor, measured in cubic feet/kilowatt hours/cycle. Since 2004, a new factor is being used to incorporate the energy inputs needed for the modified energy factor.

$$\text{Modified Energy Factor (MEF)} = \frac{C}{(M + E + D)}$$

C = clothes capacity
M = machine electricity use
E =water heating energy
D =energy for moisture removal

Criteria/Product Type	Previous Criteria Levels	Current Criteria Levels	Future Criteria Levels
ENERGY STAR top and front loading (with capacities of greater than 1.6 ft^3)	MEF > 1.26	MEF > 1.42	MEF > 1.72

Table 2 -Key product criteria for clothes washers [89]

Case Study 2: Air conditioners

The criteria for this product define efficiency based on the Energy Efficiency Ratio (EER), which measures the ratio of the cooling effect measured in BTU per hour, divided by the electrical energy input in measure watts.

<table>
<tr><th>Capacity (Btu/Hr)</th><th>Federal Standard EER, w/ louvered sides</th><th>ENERGY STAR EER, w/ louvered sides</th><th>Federal Standard EER, w/o louvered sides</th><th>ENERGY STAR EER, w/o louvered sides</th></tr>
<tr><td>< 6,000</td><td rowspan="2">> 9.7</td><td rowspan="2">> 10.7</td><td rowspan="2">> 9.0</td><td rowspan="2">>9.9</td></tr>
<tr><td>6,000 to 7,999</td></tr>
<tr><td>8,000 to 13,999</td><td>>9.8</td><td>>10.8</td><td rowspan="3">>8.5</td><td rowspan="3">>9.4</td></tr>
<tr><td>14,000 to 19,999</td><td>>9.7</td><td>>10.7</td></tr>
<tr><td>> 20,000</td><td>> 8.5</td><td>>9.4</td></tr>
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Table 3 -Key product criteria for room air conditioners [90]

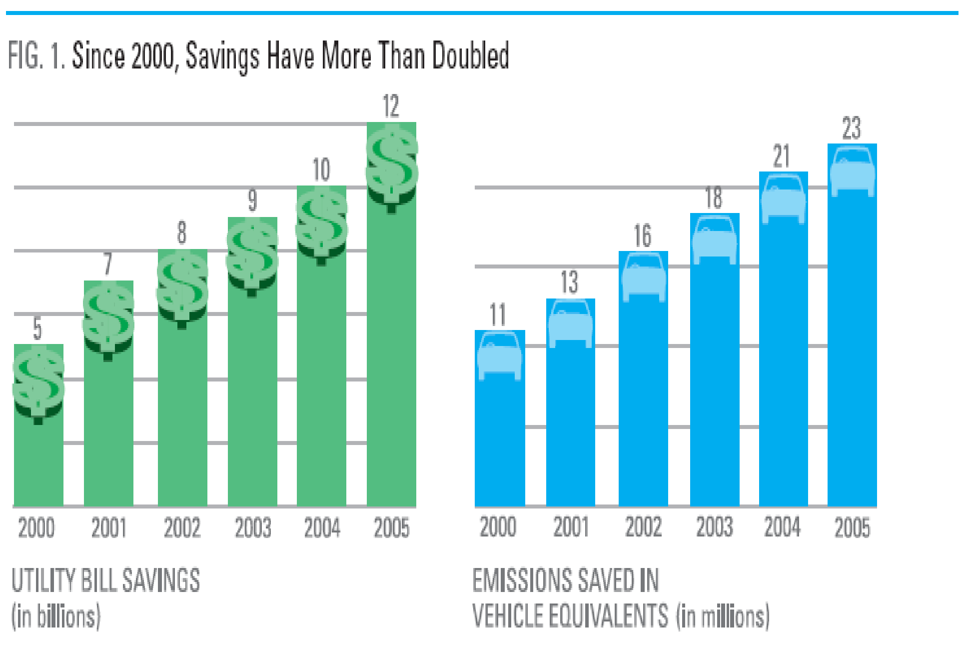

Figure 12: Since 2000, savings in utility bills have more than doubled to $12 billion and the emissions decreases have more than doubled (equivalent to taking 23 million cars off of the road) per year due to energy efficiency standards established by the voluntary Energy Star program

VIII. Conclusion

The Energy Policy Act of 2005 (H.R. 1640) is a meaningful effort to identify ways to ensure reliable energy supply, create job security, and decrease the U.S.' dependence on foreign sources of energy, while protecting human health and the environment. It institutes incentive-based policies to improve traditional energy such as coal, through cleaner technology (e.g. gasification); production of non-traditional renewable fuels like ethanol and biofuels; and, finally, it addresses energy demand reduction by enhancing energy efficient products through the expansion of the Energy Star program. As explained in Section II, coal-fired power plants and automobiles emit a broad range of pollutants; this policy analysis has focused on contaminants such as sulfur dioxide (SO_2), nitrous oxides (NO_x), carbon dioxide (CO_2), and mercury (Hg).

Pollutants such as SO_2 produce acid rain and can produce nose and throat burn when inhaled. NO_x deteriorate the environment through ozone formation which causes lung irritation in humans. A neurotoxin like Hg can be ingested when eating fish, which have acquired it as methylmercury in the process of bioaccumulation. Finally, CO_2 is the main contributor to global warming. One way to reduce all of the pollutants at once is through energy efficiency, i.e. by diminishing energy demand. Solutions to reduce certain pollutants individually require more specific considerations. For coal related pollution, for instance, the solution lies in the gasification process, whereas, for gasoline pollution, the solutions look for carbon neutral fuels, such as ethanol.

The scientific analysis behind H.R.1640's proposed solutions indicates that most of them prove to be adequate means of addressing the problem appropriately. The Integrated Gasification Combined Cycle (IGCC) is an innovative technology that can efficiently reduce pollutants while increasing the power generated; ethanol has the potential of becoming a truly carbon neutral fuel (in spite of the suspected NO_x increase); finally, the Energy Star Program sets the framework for the proper consumer and producer market mechanisms to come together and trigger the reduction on energy demand.

As any piece of legislation, H.R. 1640 is not without its critics. Some interesting controversies are found, not only within the issues that finally were included to enhance U.S. energy security, but also in the way the solutions are scientifically measured. Some critics say that H.R.1640 looks at particular solutions in industries purely as a response to economic or political incentives. As often happens with policies, when approved, certain sectors will benefit more than others. With H.R.1640, for example, the coal industry receives more money than the renewable industry in spite of the latter's proof of cleaner energy production. On the other hand, domestic corn producers gain the government's backup through high tariffs to yet another product they can produce: ethanol. But not all is entangled in economic and political intrigue. The Energy Star Program has proven that the standards and goals it sets are adequate, and the program's success to date sets very high standards for all voluntary measures.

The Energy Policy Act of 2005, H.R. 1640, balances energy security through traditional and non-traditional energy sources in an environmentally friendly manner, it also innovates policy by installing proper amendments to the Energy Star Program which has been a remarkable example of how voluntary, market-driven, efforts can lead to significant improvements in lowering environmental stress from energy consumption. With this in mind, H.R. 1640 has undoubtedly taken the lead in an effort to bring innovative energy policy making to the forefront of the 21st century.

IX. Questions and Answers about H.R. 1640

Q: *How does smog hurt humans?*

A: 'Smog' is the brown haze that is visible over congested cities like Los Angeles. The brown haze is actually NO_2. NO2 can affect human health, but not nearly as much as O3, which is a secondary pollutant produced by the reaction of NOx with molecular oxygen in the presence of UV radiation. O3 is a tissue irritant, which is why it contributes to respiratory distress. So NO2 => Smog, O3 => respiration problems.

Q: *How does acid rain affect humans?*

A: Acid rain is not a human health hazard. We are principally concerned with acid rain because of soil and freshwater acidification, destruction of vegetation, and damage to structures like historical landmarks. Older buildings that are predominantly made of limestone bear the greatest risk of degradation.

Q: *Does mercury cause effects in fish?*

A: Mercury is a neurotoxin and affects cognitive functions. In animals with high level of mercury, behavioral patterns can be disrupted. Fish ingest methyl mercury and this stays deposited in their fatty tissues. When these fish are eaten by fish higher up in the food chain, the mercury deposits are bioaccumulated, therefore increasing their carcinogenic effects.

Q: *Are any of the measures on energy efficiency binding?*

A: The energy efficiency provisions are voluntary; the goal is to improve the efficiency of consumer and industrial products through the extension of credits, promoting the purchase of energy efficient products, and to get industry feedback to improve the labeling system and specifications for other products not included in the 1992 Energy Policy and Conservation Act.

Q: *What is the difference between the energy efficiency language in this bill and the previous Energy Star Program?*

A: This bill amends the Energy Policy Conservation Act (EPCA) of 1992 to establish a new voluntary program to more strongly promote energy efficient products and improve communication about the products to the public. H.R. 1640 looks to add to the foundation already set by the EPCA of 1992, while directing efforts towards consumer awareness of the products as well as establishing education programs for small businesses.

Q: *How do the Ethanol Credits work?*

A: Credits will be supplied to refiners, blenders and importers that surpass the predefined levels specified for that given year in the legislation. There credits can be transferred, but can only be used within the year that they are granted. The credit program provides market-based incentives to exceed the yearly limits defined in the bill. The credits can be sold to other industry players that failed to meet the cap, thereby creating a financial incentive to overshoot the predefined levels. These credits can be used, sold or carried over to the following fiscal year only. Credit based programs have shown to be very successful in engaging the private sector in new industry initiatives.

Q: *What other pollutants are associated with coal, gas and diesel?*

A: There are over 180 hazardous pollutants. They main contributors are Sulfur Dioxide, Nitrogen Oxide, Suspended Particulate Matter (SPM), Lead, Carbon Monoxide, Respirable Particulate Matter (RPM) and Mercury

Q: *What are renewable fuels?*

A: Renewable fuels are a kind of fuel derivative that use naturally occurring materials found in everyday agricultural and waste products as a source of energy provision. The 2 most commonly available renewable fuels are Ethanol and Biodiesel.

Q: *Who guarantees the loans and grants programs for development of infrastructure in the renewable energy sector?*

A: The government of the United States of America guarantees these loans against default. By taking this position, they are de facto government backed securities. This implies that in the case of a default, the government will step in and ensure that the defaulting party makes good with their outstanding payments.

Q: *What are VOCs?*

A: VOCs (Volatile Organic Compounds) are organic compounds with high vapor pressure and low water solubility, such as hydrocarbons from the combustion of gasoline. They are difficult to eliminate in the environment and they are airborne.

Q: *Where are the majority of the Ethanol filling Stations found?*

A: The majority of the Ethanol filling stations are found predominantly in the Midwestern states, where the raw material input is harvested. Gasoline and Ethanol have to be mixed on-site, and productive and cost effective means of transporting Ethanol throughout the states via pipelines have not been sufficiently set up.

Q: *Is there a viable market for Carbon capture and storage yet?*

A: Anglo American and Shell Oil signed on to a deal that represents the private sectors entry into this arena. On June 1 2006, these 2 companies formed an alliance to develop clean coal projects, including carbon capture and storage, with the aim of becoming a leading player in the market. Both companies have shown intent to lobby for changes to regulations and subsidies to improve the viability of carbon capture and storage, as well as risk-sharing arrangements so that governments take on responsibility for any CO2 leaks once the gas has been stored underground.

Q: *Where does disagreement over ethanol come from?*

A: Disagreement comes from statements from two government agencies the Environmental Protection Agency (EPA) and the Department of Energy (DOE). EPA maintains that E85 offers potential NOx emissions of 10%. This estimate is based on "ethanol's inherently 'cleaner' chemical properties" and an engine that takes proper advantage of these properties. On the other hand, the DOE supports studies that demonstrate an increase in NOx emissions from 10% + ethanol blends, including E85, dependent upon engine conditions. These studies are available on the DOE website and were published in peer reviewed journals.

A potential source of dispute may be that NOx emissions are heavily dependent on the type of vehicle. So if EPA and DOE used different kinds of vehicles for examination, it is likely that their numbers must be different.

Q: *How is oil used to generate electricity?*

A: Most natural gas facilities are also able to burn oil. The choice of fuel is dependent upon market prices, which is why natural gas is usually used. Example: last summer, Keyspan Energy's facilities in New York burned mostly oil because the price of natural gas went up. In addition, gas is 3% less efficient in terms of energy generation than oil, so oil is an energetically preferable fuel source.

Q: *How does acid rain deteriorate buildings?*

A: Acid precipitation contains two active compounds: sulfuric acid and nitric acid. These acids corrode limestone and sandstone materials in buildings. They transform limestone/sandstone into gypsum, which is then washed away, exposing a surface for weathering.

Additionally, acid will dissolve exposed iron surfaces, literally washing it away and exposing fresh iron. This a big problem for bridges, trains, cars as they are exposed to environmental elements for their entire lifespan. Some examples are the Parthenon at Acropolis (Athens), Taj Mahal (Agra), St. Paul's Cathedral (London).

Q: *How does mercury-poisoning work?*

A: Mercury enters the environment through atmospheric deposition from the atmosphere. Aquatic bacteria convert mercury to methylmercury in bodies of water, a more noxious type of mercury. Fish absorb methylmercury from the water and ingestion of plankton. Because methylmercury is not broken down in digestive processes, it concentrates in tissues, in a process known as bioaccumulation. Concentrations increase in organisms at higher levels of the food chain ultimately reaching humans when they eat seafood. Overtime, bioaccumulation in humans can have toxic effects (chiefly neurological).

In the human body mercury contaminates the brain and nervous system. Pregnant women and children are especially susceptible. Prenatal and infant exposure to mercury can cause mental retardation, cerebral palsy, deafness and blindness. In adults, mercury poisoning can adversely affect fertility and blood pressure regulation and can cause memory loss, tremors and vision loss.

Q: *Is gasification really cost competitive with traditional coal?*

A: An important benefit of gasification is the capture of carbon dioxide (CO_2), which then could be used to enhance recovery of oil and coal-bed methane from underground fields. If the CO_2 produced by coal gasification and liquefaction were to be used to enhance oil-field recovery, the cumulative gain in GDP would exceed $4 trillion by 2025.

According to a study conducted by Penn State University, implementation of clean coal technologies would reduce energy prices by 33% by the year 2025.

Q: *How do the mercury and Sulfur dioxide filters work?*

A: Sulfur is removed from the syngas before combustion using acid gas removal technology, so sulfur is in its *unoxidized* state as hydrogen sulfide (H_2S). It is removed by an iron-catalyzed reaction, giving elemental sulfur (S^0).

Mercury is removed by an activated charcoal filter. This is essentially a giant Brita filter. The activated charcoal is impregnated (or mixed) with sulfur at a concentration of 10-15% by weight. The mercury reacts with the sulfur as the syngas passes through the filter and forms mercuric sulfide by reaction with the sulfur. Once the sulfur is exhausted, the spent adsorbent is disposed of as hazardous waste. Alternatively, the carbon can be incinerated and the mercury recovered (expensive). A 90-95% Hg removal has been reported with a filter life of 18 to 24 months at active coal IGCC plants in the U.S. (filter life independent of Hg content in coal, dependent on buildup of other contaminants like H2O or trace metals that interfere with Hg capture).

Q: *How are the numbers so different for energy return?*

A: The Department of Energy has estimated energy balance from corn-based ethanol at 1.34, or 134% energy return on energy applied in ethanol production. For cellulosic ethanol, the energy balance is estimated at 2.62. David Pimentel and Tad Patzek, two researchers in the field (Cornell and Berkeley, respectively) claim net energy losses of 29% for corn-based ethanol and 45-57% for cellulosic ethanol. Various different studies offer different figures for energy return, each based on the types and amounts energy inputs included in the ethanol production process, particularly in terms of energy required for crop harvest; the accuracy and relevance of various energy inputs are heavily disputed.

Pimentel and Patzek consider: labor, machinery, diesel, gasoline, nitrogen, phosphorus, potassium, lime, seeds, irrigation, herbicides, insecticides, electricity, transport, for corn grain, corn transport, water, stainless steel, steel, cement, steam, sewage effluent, etc. Exhaustive survey of every input needed for both crop growth and production process, doesn't acknowledge best practices and includes some factors (like energy required for manual labor) that are controversial.

Q: *What does H.R. stand for?*
A: It stands for House of Representatives. The Energy Policy Act, H.R., was introduced in the House of Representatives by Representative Joe Barton, a republican from Texas.

Q: *What is a BTU?*

A: British Thermal Units—amount of energy raise the temperature of one pound of water 1 degree Fahrenheit. Turns out the 63-64 thing isn't really necessary because there are a few different measures of exactly what a BTU is. Best just to say the first sentence and add that this is about 1054-1060 joules (SI unit of energy).

Q: *What are other pollutants from coal beside the ones we mentioned?*

A: When coal is burned, carbon dioxide, sulfur dioxide, nitrogen oxides, and mercury compounds are released. Coal pollutants other than nitrogen oxides and carbon dioxide/monoxide are determined by impurities in the coal itself. Sulfur is a coal impurity; there is less S in Midwestern (bituminous) coal than in Appalachian (anthracite) coal, so when the sulfur emission cap and trade program was instituted, coal plants largely just switched to low sulfur coal. Other coal impurities similarly differ according to location. Examples of coal impurities are Hg, aluminum, iron, and other trace metals, and even radioactive metals like uranium and thorium. (Coal is often "washed" before distribution, removing many of the impurities before its use in a coal plant).

Q: *Is IGCC a closed-loop system?*

A: It can be. We have a 20% tax credit for IGCC plants that use a closed-loop biomass system. IGCC can be used for zero CO_2 emissions using a carbon capture system. Most IGCC plants still have emissions, though they are approaching the very low emissions of natural gas.

Q: *What happened in 1985 with the number of ethanol plants?*

A: In 1985 there was an industry shakeout. Of the 163 commercial ethanol plants existing in 1985, only 74 (45 percent) were operating, producing 595 million gallons per year. The high failure rate was partially the result of poor business judgment and bad engineering. Many ethanol producers went out of business, despite the subsidies. One reason for producers going out of business was the very low price producers could receive for their ethanol (even with a subsidy of 60 cents per gallon), since the prices of crude oil and gasoline were so low. Despite the very low price of corn, which is the main driver of the cost of producing ethanol, nothing was enough to prevent the high rate of market change.

Q: *What are the capacity units for ethanol plants?*

A: It is measured in millions of gallons per year.

Q: *What is fermentation?*

A: A chemical reaction catalyzed in nature by yeast that converts a sugar into an alcohol. The sugar is cleaved and a hydroxide group is added. The conversion releases two molecules of CO_2 and two molecules of ethanol.

Q: *What is distillation?*

A: Distillation is a physical separation of a mixture that is dependent upon the volatility of the components. Heat is applied to the fermented mixture and the liquid solution evaporates. In the generation of both ethanol and alcoholic beverages, the vaporized component is ethanol (95%) and water (5%).

Q: *What are some examples of products included in Energy Star?*

A: For the category of products that we have covered in this policy analysis you find washers (for clothes), dishwashers, freezers, and air conditioners to give some examples. There are a total of 40 categories of eligible products, with more than 35,000 models certified so far.

Q: *What is a scrubber?*

A: A scrubber is an industrial pollution control device, usually installed on the exhaust flue gas stacks of large furnaces, but may also be used on any number of other air exhaust systems. Wet scrubbers remove air pollutants by inertial of diffusional impaction, reaction with a sorbent or reagent slurry, or absorption into a liquid solvent. Spray dry scrubbers are a widely used flue-gas desulfurization (FGD) technology.

Q: *What is production of ethanol compared to gasoline?*

A: Of all fuels produced, 3% is ethanol and oil constitutes around 26%

Q: *How many ethanol fuel stations in the U.S.?*

A: There are over 600 stations in the U.S., mostly concentrated in the Midwest.

Q: *What is cost of coal? How cheap is it?*

A: The price for coal in 2005 was 1.54$ per million BTU in 2005. For natural gas it is 7.54$ per million BTU. Even if coal and natural gas prices change substantially, coal is almost constantly 7 times cheaper than natural gas.

Q: *Why do university professors say we lose energy by consuming ethanol?*

A: Production consumes more energy than output provides – consumes the fossil fuel equivalent of one gallon of gasoline to produce one gallon of ethanol.

Most an accounting question – they say that government methods do not capture all energy inputs, for example, the energy spent in agricultural production of corn (e.g. application of fertilizers, the production of fertilizers, energy used in irrigation).

They also disagree on the net energy value of ethanol – disagree on how many BTUs a bushel of corn represents, since incorporated inputs represent energy consumed to produce ethanol.

Q. *How do the credits for refining, blending and importing work?*

A. The tax credit program is proposed whereby any person that refines, blends, or imports gasoline that contains a quantity of renewable fuel that is greater than the required volume of renewable fuel is eligible for a credit. The credit program provides market-based incentives to exceed the yearly limits defined in the act. The credits can be sold to other industry players that failed to meet the cap, thereby creating a financial incentive to overshoot the predefined levels. These credits can be used, sold or carried over to the following fiscal year only. Credit based programs have shown to be very successful in engaging the private sector in new industry initiatives.

Q: *Do we already use technologies such as cellulosic ethanol?*

A: Cellulosic Ethanol, while not cost-competitive today, already observed advances in technology lead us to believe that in the next few years, ethanol made from these crops will become cost-competitive, won't compete with food for cropland, and will have a sizeable positive energy balance.

In July, 2006, according to the Boston Globe, the production cost of cellulosic ethanol was approximately $2.25. At that price it is not competitive when distribution costs are added. However, the Department of Energy is optimistic and has requested a doubling of research funding.

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