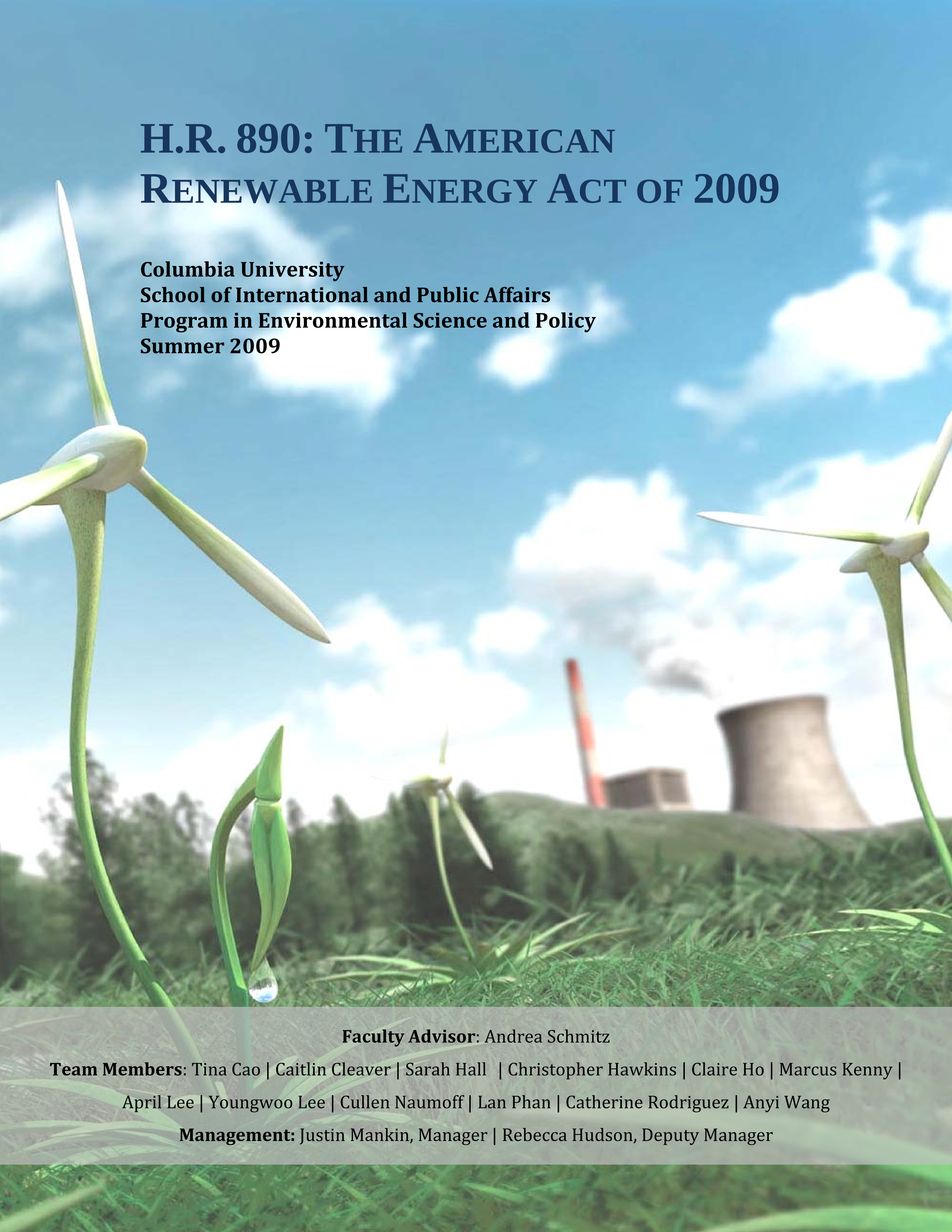

H.R. 890: The American Renewable Energy Act of 2009

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EXECUTIVE SUMMARY

The United States (U.S.) currently generates over four trillion kilowatt hours of electricity annually (U.S. Department of Energy [US DOE], 2007). It is the energy source that propels progress, affecting all aspects of modern life. From the incandescent light bulb to supercomputers modeling climate change and global economies, electricity is the fuel of technical innovation. But for all the progress that electricity makes possible, there is a problem with electricity in the United States and it unfolds in two parts: first, demand for electricity is increasing and secondly, current methods of electricity generation in the United States have negative impacts on the environment and public health. For electricity generation, a primary fuel source is required and the United States continues to rely on the combustion of coal to generate a staggering 48% of its electricity, more than double the next leading source, natural gas. Coal is cheap, abundant and with its long history as an energy source in the U.S., takes up the dominant share of electricity generation for the last 130 years. But with available technology and developments in research, how can less harmful methods of electricity generation sources be utilized? How can renewable energy sources play a more significant role in such a well-established and saturated market?

The American Renewable Energy Act (H.R. 890) is a policy proposal that utilizes regulation and a market mechanism to address the negative impacts of electricity generation in the United States. It proposes to reform the current electricity portfolio by incentivizing the growth of renewable sources of electricity by establishing a renewable portfolio standard. This standard mandates all utility providers generate 25% of their electricity from renewable sources by 2025. According to H.R. 890, utilities can meet this mandate by generating electricity from six eligible renewable sources: solar, geothermal, qualified hydroelectric, hydrokinetic, biomass, and wind. Of these, wind-generated electricity presents the most salient counterpoint to coal-generated electricity for four reasons. Wind is an abundant resource in the United States, is relatively cost-competitive with coal in cents per kilowatt hour, is the subject of research and development projects to maximize electricity generation, and produces zero emissions.

Using mechanisms akin to cap and trade, H.R. 890 gives a market value to a unit of renewable electricity generation, called a renewable energy credit. This credit can be traded among those utilities in the United States that can exceed the mandate set and those utilities that cannot. Renewable growth eventually becomes market driven. Utilities that are well-placed to generate renewable-sourced electricity can do so in a cost-competitive manner through sale of credits. No longer do they need to use coal or other traditional sources to ensure competiveness.

Coal exemplifies the problems of electricity generation. Wind is representative of the type of solution incentivized by H.R. 890. The bill is a crucial first step in laying the foundation for innovation and investment in renewable energy technologies by creating a market for it. Though only a first step, H.R. 890 provides the opportunity to restructure electricity generation in the United States, and with it, craft a model of development that is sustainable.

Introduction

Bill McKibben, in his book *Deep Economy* writes an allegory of two birds: More and Better. For most of history, he tells us, the two birds roosted on the very same branch. An individual on the ground could throw a single rock and hit both birds, attaining More and Better. But things have changed. Better has taken flight and settled on a branch several trees away. No longer can a single rock hit both birds, and now that individual is left with a choice: More or Better.

This allegory illustrates the dilemma of electricity for the twenty-first century: more no longer means better. America's electricity generation portfolio has become a luxury it can no longer afford. Though electricity continues to be cheap, the price Americans pay goes far beyond cents per kilowatt hour. Environmental and public health costs must be part of this calculus—and when they are considered, the costs of electricity quickly become untenable. Two simple facts inform this dilemma: first, the demand for electricity in the U.S. is increasing. Second, this is a problem because the current methods of electricity generation, which includes a heavy reliance on coal, negatively affect the environment and public health. The systemic mechanisms and interests that perpetuate this dilemma must be eroded, but the fiscal and technical costs of doing so have so far been prohibitive. Legislative and regulatory solutions have long been pursued, however market inertia persists, and with it, entrenched and damaging methods of electricity generation.

This essay examines the scientific genesis of a new regulatory proposal, the American Renewable Energy Act (H.R. 890). H.R. 890 is designed to rout the shortcomings of previous regulation. It seeks to use market mechanisms to change incentives, nudging the very decision-makers that perpetuate our electricity dilemma towards more sustainable and renewable methods of generation.

This essay advances in five parts. After providing a legislative background on H.R. 890, the second part scopes the environmental problem with the current American electricity portfolio, focusing on coal powered electricity generation as emblematic of the issue. The third section examines the solution H.R. 890 proposes, focusing on wind powered electricity generation as a heuristic tool for illustrating the technological and market context in which the Act seeks to operate. The third and fourth sections will consider controversies and indicators for success, respectively. Finally, the fifth part concludes with projections for the future.

An H.R. 890 Primer

The American Renewable Energy Act (H.R. 890), introduced in February 2009 by Representative Edward Markey of Massachusetts, attempts to incentivize the growth of renewable, clean technologies in electricity generation. In amending the Public Utility Regulatory Policies Act of 1978, H.R. 890 gives the Department of Energy authority to establish a federal renewable portfolio standard, which requires utility companies to supply a percentage of their total electricity generation from renewable sources. H.R.

890 utilizes market optimization principles known to create economic efficiency and as a consequence, indirectly offers the potential to achieve carbon emission reductions at minimal economic expense.

H.R 890 builds upon similar, existing state programs designed to increase renewable electricity generation. In 1983, Iowa adopted America's first renewable portfolio standard by committing to generate 105 megawatt-hours of renewable electricity. Iowa met its standard in 1999 and continues to increase renewable electricity generation today (Pew Center on Global Climate Change, 2009). During the 1990s several states adopted similar standards. Twenty-eight states and Washington, D.C. have either implemented or approved renewable portfolio standards.

In creating a national standard, the Department of Energy will make a concerted attempt, to the extent practicable, to utilize existing state or regional tracking systems and coordinate with state programs to minimize additional administrative costs to utility companies (U.S. Congress, 2009).

The Problem of Electricity

Current Demand

Electricity generation reflects its demand. Current annual electricity generation in the U.S. is roughly 4,200 billion kilowatt hours (BkWh). By 2030, U.S. electricity generation is projected to increase to 4,770 BkWh in low-growth estimates (15% increase from 2007 levels), and to 5,590 BkWh in high-growth estimates (34% increase from 2007 levels) (U.S. Dept. of Energy, Energy Information Association [US DOE EIA], 2009f). Figure 1 illustrates these projected scenarios. Increases in electricity demand can be attributed to several factors. Electricity in the U.S. is supplied by a regulated utilities market whose mission is to provide cheap, plentiful and reliable electricity with little concern for energy efficiency. Additionally, electricity consumption in the U.S. per capita is increasing, further driving electricity demand (U.S. Department of Commerce [DOC], 1996). For example, over the last decade in New York City, electricity demand rose by 22% while population only increased by approximately 10%. This rise in demand is likely due to the increasing number of air conditioners, computers, and other electronic devices in the Con Edison service territory (Con Edison, 2009a).

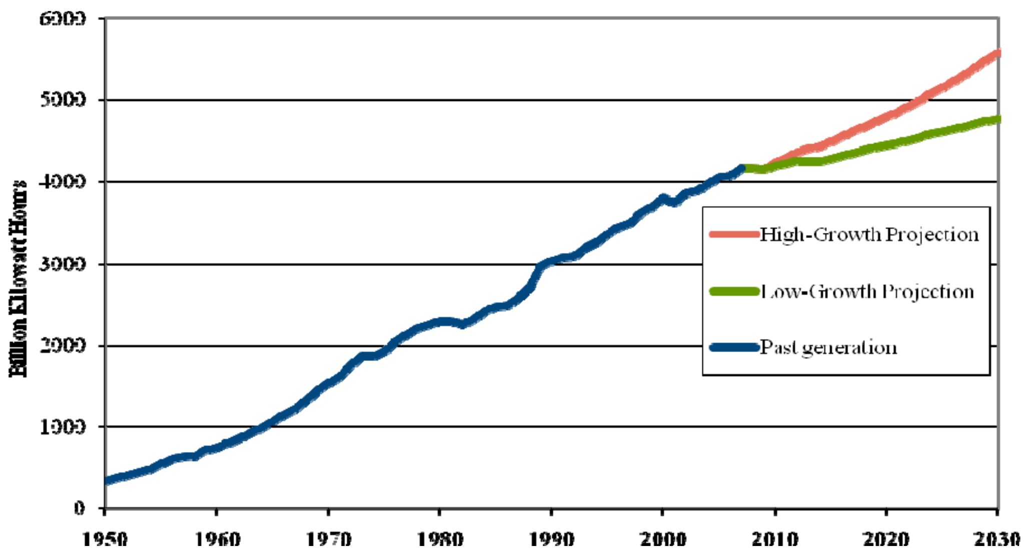


Figure 1. Total and projected electricity generation in the United States from 1950 to 2030 (EIA, Table 8., 2009)

Current Electricity Sources

The current portfolio of electricity generation in the United States includes five major sectors (Figure 2). Coal, natural gas, and nuclear power supply the bulk of electric power. However, coal-derived electricity is responsible for approximately 48% of total electricity generation in the U.S. This amounts to more than twice the electricity generated from any other energy source (US DOE EIA, 2009f). Notably, renewable energy sources only account for 3% of the current net electricity generation in the country.

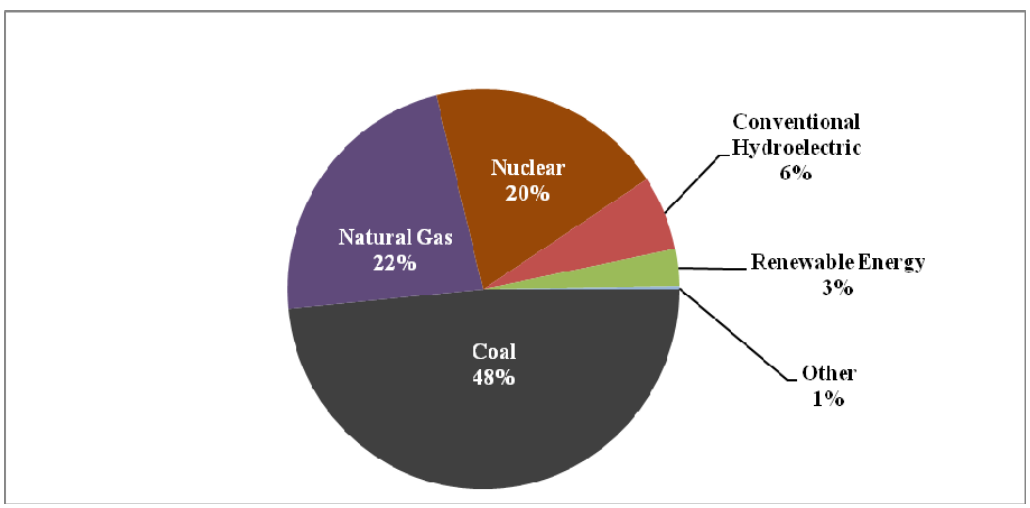
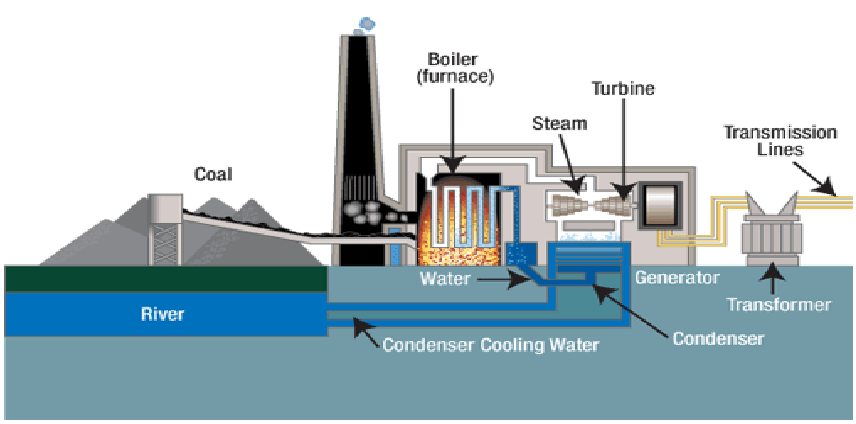


Figure 2. Total electricity generation by energy source from 2008 data (US DOE EIA, Table 1.1, 2009f)

Coal holds this market strength for several reasons, including its abundance and well-established infrastructure (McCollum, Ogden, Sperling & Yang, 2007). As a function of coal's high availability and the industry's deeply-rooted infrastructure, electricity generation from coal is significantly less expensive than electricity generation from both natural gas and nuclear energy sources, around 6.0 cents per kilowatt hour (kWh) (Deutch Forsberg, Kada, Kazimi, Moniz, & Pearsons, 2009). Natural gas typically costs 6.5 cents per kWh while nuclear energy sources costs 8.4 cents per kWh.[1] In contrast, renewable technology has a range of 5.0-38 cents per kWh. The large range is due to the high variability in the sources depending on local conditions for the energy source. Notably, wind is one of the cheapest renewable sources, ranging from 5.0-8.5 cents per kWh (U.S. Department of Energy [US DOE], 2008). The reasons for wind's price competitiveness and how it illustrates H.R. 890's proposed solution will be explored in later sections. First, as a means to illustrate the adverse effects of the current model of electricity generation in the U.S., we will examine the most dominant source for electricity generation: coal.

Electricity Generation from Coal

As the main combustion source driving mechanical energy in most of America's power plants, coal is pivotal to the process of generating electricity. The process from an engineering standpoint is simple and cost effective: a coal-powered plant generates electricity by burning coal, which heats water, generating steam; the steam then turns a turbine. A generator then converts the mechanical energy of the spinning turbine to electrical energy that is distributed to consumers at a mere 6.2 cents per kWh. Figure 3 below depicts the journey from combustion to mechanical energy and finally to electrical energy in a coal-fired power plant. While consumers enjoy inexpensive and easily produced electricity, there are many direct adverse effects of coal-produced electricity. These effects complicate the simple calculations of costs associated with the coal to electricity process.



[1] These estimates include building, operation, maintenance, and fuel costs over a 40-year timeframe in the U.S. (Deutch et al., 2009).

Figure 3. Schematic of a generic coal-fired power plant (TeachEngineering.org, 2008)

Environmental and Health Impacts of Coal

Mining

Coal mining significantly alters the landscape, destroying habitat. Habitat loss and destruction are major contributors to biodiversity loss. Since mountaintop removal coal mining began in 1970, more than 470 mountaintops have been destroyed, more than 1,200 miles of streams buried, and 1.5 million acres of hardwood forest are no longer in existence (Center for Biological Diversity, 2009). Other mining impacts include accumulating contaminated rock wastes and tailings and leaching of heavy metals into waterways decreasing pH, which negatively affects aquatic species (Driscoll, Han,Chen, Evers, Lambert, Holsen, Kamman, & Munson, 2007).

Mercury is released into water as a byproduct of mining and settles into watersheds. In this environment, anaerobic organisms transform mercury into a methylmercury (CH-$_3$Hg), the most toxic and mobile derivative of mercury (Tewalt, Bragg, & Sinkelman, 2001). Methylmercury bioaccumumulates in fish (Speight, 1994). As mercury bioaccumulates, it causes an increase in mercury concentrations at each level in the food chain, thereby affecting many organisms with mercury contamination. Human health is affected by consuming fish and other aquatic life that have ingested methylmercury. Consumption of contaminated aquatic life can lead to mercury poisoning. Mercury inhibits the nervous system and can lead to paralysis and ultimately death. Coal-fired power plants also release airborne emissions containing mercury which will be addressed in the next section.

Emissions

On an annual basis, the conversion of coal into electricity emits hundreds of millions of tons of deleterious chemicals into the atmosphere. The combustion of coal releases over 73 elements through stack emissions (Anderson, Beer, Buckwalter, Clark, McAuley, Sams, & Williams, 2000). According to the Energy Information Administration, the most prevalent compounds released, in descending order, are: carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) (US DOE EIA, 2009e). Figure 4 illustrates the percentage of total annual emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2) and mercury from electricity generation. In the U.S., coal combustion for electricity is the greatest contributor to emissions of all four substances. These emissions have been linked to many public health issues including cancer, respiratory diseases, kidney disease, and high blood pressure (U.S. Environmental Protection Agency [US EPA], 1986).

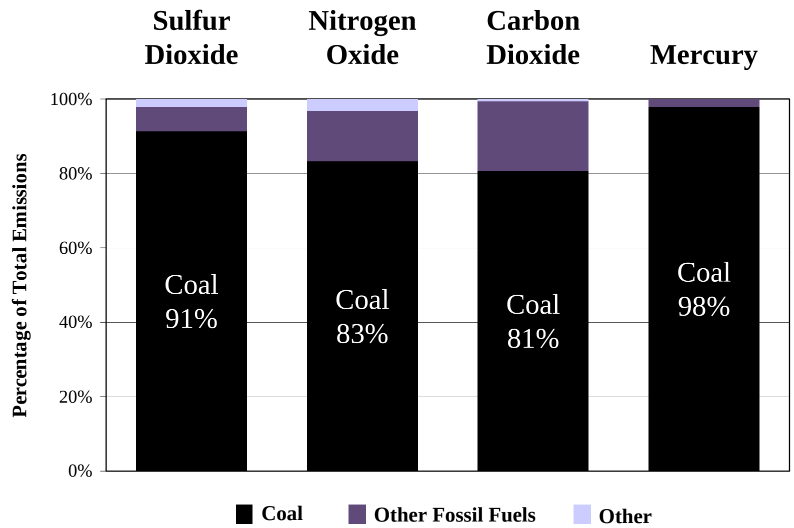


Figure 4: U.S. electricity generation emissions by energy (Data taken from US DOE EIA, 2007)

Sulfur Dioxide

Sulfur dioxide is a major component in acid rain formation. In the atmosphere, oxygen oxidizes sulfur dioxide (SO_2) forming sulfur trioxide (SO_3). As temperature decreases and water vapor condenses forming precipitation, sulfur trioxide readily reacts with the water vapor and forms sulfuric acid (H_2SO_4). Acid rain deposits sulfuric acid onto sediment and forest causing a variety of environmental impacts which include degradation of regional water quality and forest ecosystems as well as changes in soil composition (Likens & Davis, 2007).

In humans, sulfur dioxide poses a dangerous threat to the respiratory system. Sulfur dioxide reacts with other chemicals in the air to form tiny sulfate particles. When these are inhaled, the small size of the particles allows them to fit into the lungs' alveoli. Sulfate particles are associated with increased respiratory symptoms and disease, difficulty in breathing, and premature death (US EPA, 2009h).

Nitrogen Oxides

Nitrogen oxides released by coal combustion increase air pollution by creating smog. Nitrogen oxides include various nitrogen compounds, such as nitrogen dioxide (NO_2) and nitric oxide (NO). Upon entering the atmosphere, nitric oxide readily bonds with ozone (O_3) producing nitrogen dioxide (NO_2) or smog.

Nitrogen oxides released by coal combustion increase air pollution by creating smog. Nitrogen oxides include various nitrogen compounds, such as nitrogen dioxide (NO_2) and nitric oxide (NO). Nitric oxides are commonly emitted from coal driven power plants. Upon entering the atmosphere, nitric oxide readily bonds with ozone (O_3). This reaction produces nitrogen dioxide (NO_2), commonly known as smog. The chemical equation below describes this chemical reaction:

$$NO + O_3 \rightarrow NO_2 + O_2$$

Smog forms in the troposphere, directly affecting air quality. This presents a hazard particularly in urban areas where population densities are high. Smog causes problems in the sinus and respiratory systems. Small particulates cause eye, nose, and throat irritation. In the most severe cases, nitrogen oxides may cause impaired lung function and increased respiratory infections in young children (US EPA, 1986).

Carbon Dioxide

Carbon dioxide naturally occurs in the atmosphere. However, excessive amounts of carbon dioxide trap radiating surface energy causing an increase in the earth's surface temperature (US EPA, 2009d). In the U.S., coal-fired power plants release over 40% of the total carbon dioxide emissions (US EPA, 2009e). High levels of carbon dioxide and rising temperatures indirectly affect human health by increasing the regional distribution of infectious diseases like malaria and yellow fever (US EPA, 2009c).

Mercury as an Emission

Mercury is the most prevalent heavy metal emitted through stack emissions. Airborne emissions are "dry deposited" on land where a similar transformation to methylmercury occurs. As mentioned previously, methylmercury can bioaccumulate in the food chain and cause harm to the nervous system if contaminated animals are eaten.

The numerous environmental impacts of coal-fired electricity generation highlight the root of the problem that H.R. 890 seeks to address: electricity generation is harmful, and because of an increase in demand, this harm is going to increase. H.R. 890 attempts to mitigate the negative effects of coal-generated electricity by shifting the market towards the use of renewable technologies. The next section examines the solution H.R. 890 proposes — the creation of a renewable portfolio standard.

Renewable Portfolio Standard: The H.R. 890 Solution

Calendar Year	Required Annual Renewable Percentage
2012	6.0
2013	6.0
2014	8.5
2015	8.5
2016	11.0
2017	11.0
2018	14.0
2019	14.0
2020	17.5
2021	17.5
2022	21.0
2023	21.0
2024	23.0
2025	25.0

Table 1. Percentage of renewable energy required each year by H.R. 890 (U.S. Congress, 2009)

To reduce the environmental and health effects of burning coal and other fossil fuels to generate electricity explored in the previous section, the U.S. needs to increase the use of cleaner sources as a sustainable long-term replacement. Unfortunately, many of these sources are not currently price competitive with coal, so legislation has been proposed to instigate a shift in the electricity market. If adopted, H.R 890 would create a national renewable portfolio standard (RPS) commencing in 2012. The standard would require all utilities to generate a minimum percentage of their total electricity each year from renewable sources. As indicated in Table 1, the minimum percentage for renewable electricity starts at 6% in 2012 and steadily increases to its target of 25% by 2025. Utilities have three options to comply with the renewable energy minimum requirement[2].

These options include increasing renewable capacity, purchasing renewable energy credits (RECs) from another utility or paying a compliance fee. Increasing electricity generation from renewable sources will be discussed in the next section.

Option 1: Increasing Renewable Capacity

As defined by H.R. 890, there are six technologies that qualify as "renewable," namely wind, solar, geothermal, biomass or landfill gas, qualified hydropower, and marine and hydrokinetic renewable energy. Renewable sources of electricity are defined as energy sources that can be replenished in a short period of time. If it is a viable option, utilities can build new renewable energy plants and generate renewable electricity directly. While the potential and economic attractiveness for most of these technologies varies considerably across the country, all regions have access to biomass-based electricity generation (Sullivan, Logan, Bird, & Short, 2009).

Option 2: Renewable Energy Credits (RECs)

A renewable energy credit is an existing market instrument representing the rights to a quantity of renewable electricity generation. These credits act as a currency for H.R 890, allowing utilities to purchase the rights to renewable energy from renewable suppliers in lieu of producing the renewable energy internally. Given the geographic and environmental variability in the United States, some regions are more conducive to renewable power generation than others. Through the use of renewable energy credits,

[2] H.R. 890 defines utilities, or "retail electric suppliers" as any utility that sells at least 1,000,000 megawatt hours of electricity to consumers for use (as opposed to resale).

H.R. 890 aims to gain market efficiencies: though each utility may not actually produce its required quota of renewable electricity, the entire system will fulfill the quota through a market exchange of renewable energy credits.

Renewable electricity credits may be sold, exchanged, transferred, or submitted by retailers for compliance within three years of issuance. Any renewable electricity credits older than three years will be retired by program administrators. Thus, if a utility generates or purchases an excess of renewable energy credits one year, they can apply those credits to two subsequent years. This mechanism is designed to promote near-term renewable energy generation and provide utilities flexibility.

Option 3: Compliance Fee

Rather than submitting renewable electricity credits, retailers can meet a portion or all of the required percentage by paying either a portion or the entire requirement through alternative compliance payments. Rates of alternative compliance payments will equal 200% of the average market value of Federal renewable electricity credits for the previous compliance year or 5 cents, adjusted annually by the Federal government to account for price changes.

Enforcement

The Federal government will levy a fine on any utility that fails to fulfill its minimum renewable requirement through a combination of any of the above-mentioned options. Fines will be proportional to each utility's shortfall: for each required credit not submitted, the utility will owe twice the compliance payment amount calculated for that year. As with compliance fees, enforcement penalty payments will also contribute to the Renewable Electricity Deployment Fund. H.R. 890 stipulates that this fund will be distributed to utilities that complied through generating renewable energy or by trading renewable energy credits. The specific refund amount will be calculated based on the number of credits submitted by the utility as a proportion of the total number of credits submitted that year.

Utility providers, therefore, have three options before them, and each is worthy of further discussion. The next section will discuss examine the potential under option 1, where utilities seek to increase renewable capacity. Simply mandating more renewables creates numerous challenges—not all of the renewables H.R. 890 designates are created equal. For example, both the lack of market and mechanical efficiency associated with solar power make it a non-starter to implement on a large scale without significant technological advancements. Thus, electricity generation from renewables, much like the traditional electricity portfolio, is likely to come from a dominant source. For a variety of reasons explored below, analysts predict wind to be that source. The next section examines wind as the principal renewable responsible for fulfilling H.R. 890s mandate under option 1, increasing electricity generation from a renewable source. It will highlight the strengths and challenges wind would face in becoming a major source for electricity generation.

Wind as a Renewable Energy Source

Wind power is the fastest growing source of renewable energy in the U.S. From 2000-2007, wind energy installed capacity increased 6.5 times, accounting for 31% of all electricity generated from renewable sources (U.S. Department of Energy, Energy Efficiency and Renewable Energy [US DOE EERE], 2008b). Figure 5 demonstrates the increase in wind-generated electricity in the U.S.

Wind energy generated 32 BkWh in 2007 and is projected to increase to 208 BkWh by 2030 (US DOE EIA, 2009b). The two primary reasons for the high current growth of wind-generated electricity are its low cost and relative abundance. Similar to coal, wind energy is highly abundant in the U.S., with pockets of greatest availability in the Midwest and along the coastlines (US DOE EIA, 2009c).

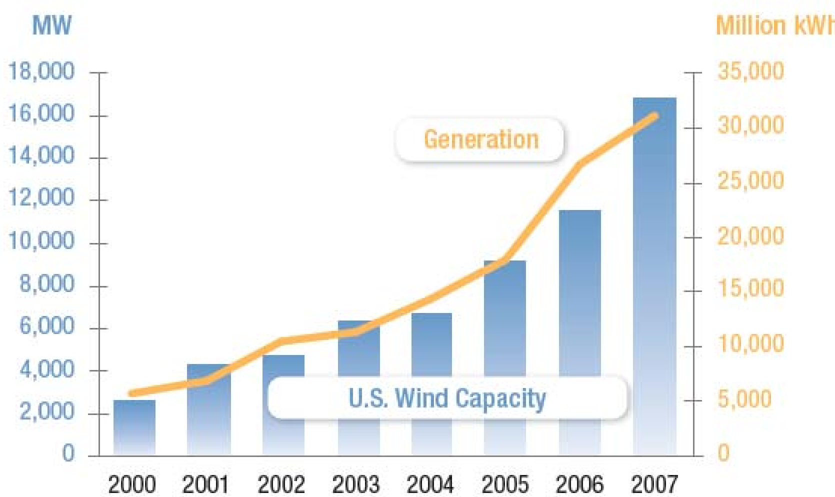


Figure 5. U.S. Wind capacity from 2000-2007 in megawatt (MW) and million kilowatt hours (US DOE EIA, 2009a)

The price range of wind-generated electricity is 5.0-8.5 cents per kWh. Though highly variable, wind's price is one of the cheapest renewables. The price variance encompasses a national range based on geostrategic advantages—wind generation in Texas is likely to be cheaper than in Vermont. Thus, in specific regions, where wind is plentiful, and the infrastructure is in place, wind can be very competitive with the 6.2 cents per kilowatt hour price of coal-generated electricity (see Figure 6) (US DOE, EERE, 2008a). Nationally, coal will have a competitive advantage do to its relative price stability. However, this scenario of coal's national advantage may not hold forever. There are emerging technologies with the potential to capture wind energy more efficiently. Given this information, it is likely that the use of wind energy as a principal source of renewable energy will be a major component of the 25% mandate, and could eventually do much to compete with coal across regions. Analysts form their projections on wind's growth potential based on several factors, the market, the supply, and the technology. With this projected contribution of wind to future electricity generation, the next sections outline an examination of wind's potential as one of the technology options utilities can use to meet H.R. 890's options as well as some of the issues associated with wind-generated electricity.

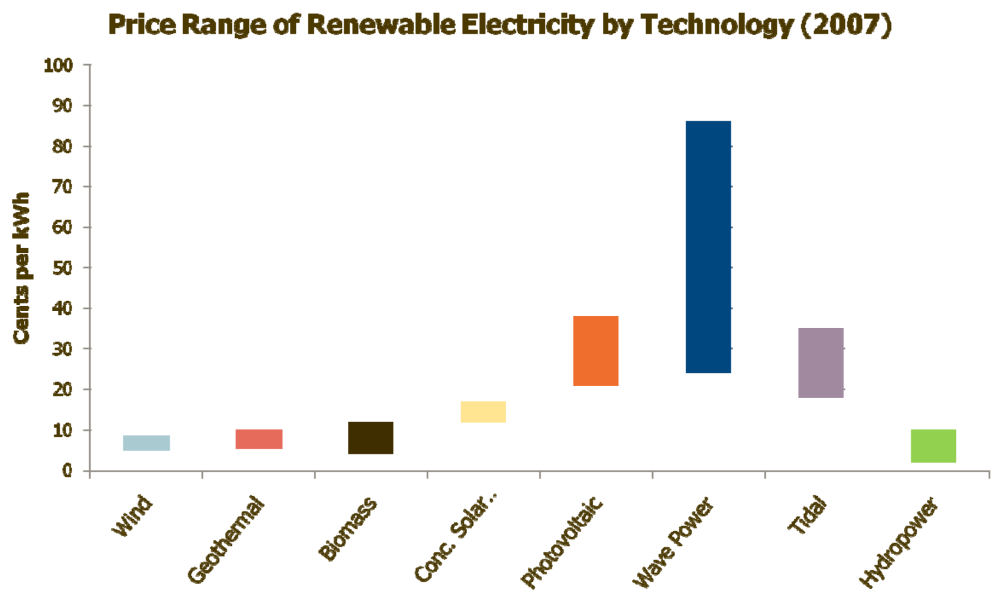


Figure 6. Price range of renewable electricity by technology in 2007 (US DOE EERE, 2008a)

Electricity Generation from Wind

Generally, modern wind turbines have rotor blades attached to a tower. The kinetic energy of the wind is captured by the blades and is transferred to a generator that converts it to mechanical energy to generate electricity. The electricity generated from the wind turbines is transmitted to the grid where transformers adjust the voltage (US DOE EIA, 2009c, 2009i).

Input Requirements for Wind-generated Electricity

Wind-generated electricity is dependent on the ability of wind turbines to effectively capture wind energy. The U.S. is abundant in wind energy, especially in the mid-Western regions and the coastlines as demonstrated by Figure 7 (US DOE EIA, 2009c).

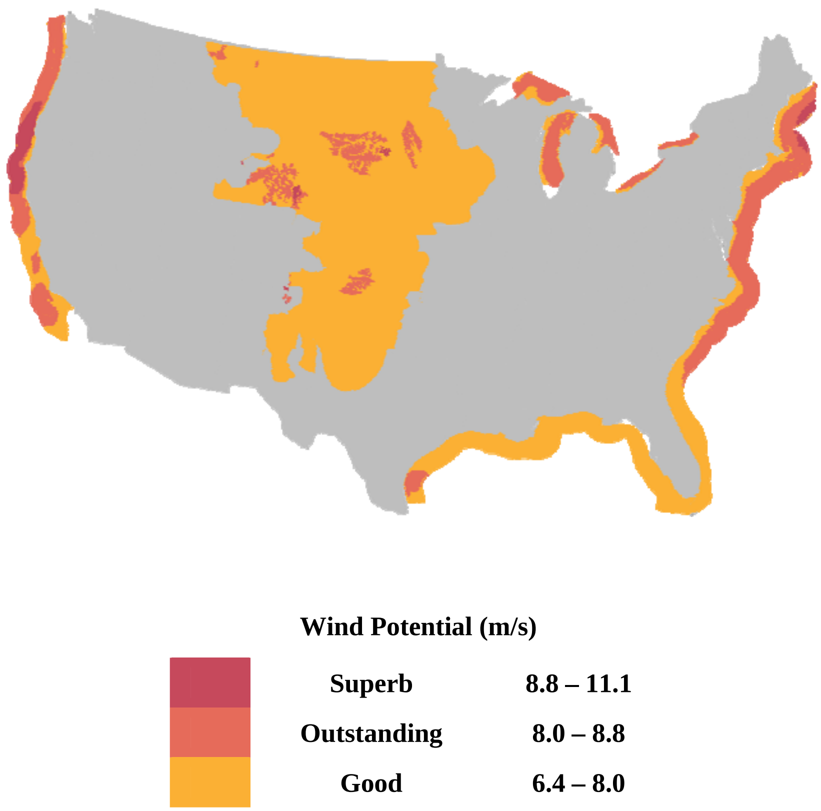


Figure 7. Wind energy resource potential of the United States (Adapted from: US DOE EIA, 2009c)

Wind energy resource potential also dramatically increases dependent on the height of the wind turbine tower. At higher heights, wind turbines are able to capture stronger winds that are not weakened due to surface drag (US DOE EIA, 2009c).

Utility sized wind turbines, more than 500kW, can start generating electricity around 5.36 meters per second, and reach a maximum power output at 12.52-13.41 meters per second (US DOE EIA, 2009c).

Wind Turbine Size and Efficiency

Larger blades on wind turbines do capture wind more effectively than smaller turbines simply because they are able to reach stronger winds at greater heights. Figure 8 shows the different turbine sizes and respective electricity generation capacity. Note that turbine size has steadily increased since 1998.

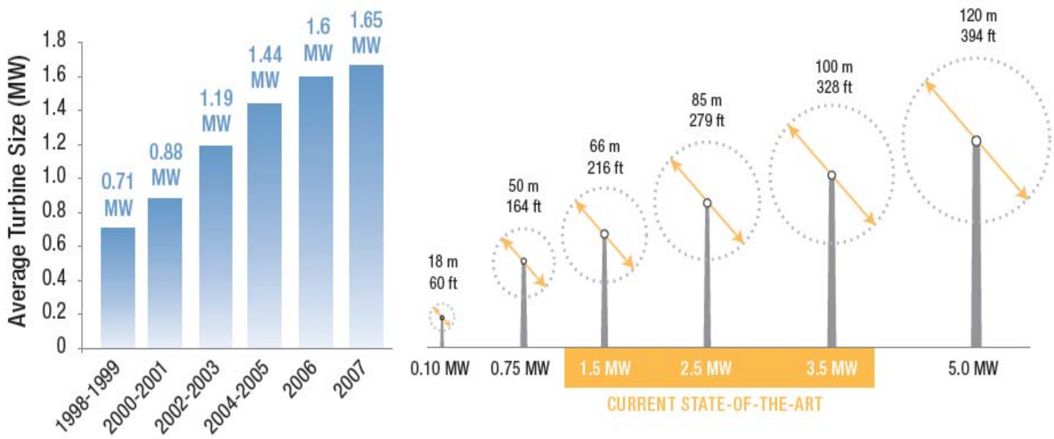


Figure 8. Turbine size and respective electricity generation capacity in megawatts (MW) (US DOE EIA, 2009a)

It is projected that the majority of utility blades will not exceed 100 meters due to logistical problems of transport. Wind turbines with blade diameters of 66-100 meters are the most effective electricity generators respective to input costs as well (US DOE EIA, 2009c).

Power Generation

Most wind farms utilize 66-100 meter wind turbines capable of generating 1.5-3.5 MW each (US DOE EIA, 2009c). Offshore wind turbines with a blade diameter of 120 meters are able to generate 5.0 megawatts (MW) that would be able to provide electricity for 1,400 homes. Table 2 describes wind turbine size and application for generation capacity.

Wind Turbine Markets		
Turbine Size	**Households Served**	**Applications**
Small (<10 kW)	<1	Residential, off-grid
Intermediate (10 kW - 500 kW)	1-140	Wind/diesel, industrial
Large (500 kW - 5 MW)	140-1,400	Utility grid
Very Large (>5 MW)	>1400	Offshore utility grid

Table 2. Wind turbine size and application (DOE Energy Efficiency and Renewable Energy Wind and Hydropower Technologies Program, 2007)

The U.S. currently has the capacity to generate 18,000 MW of power and is the international leader in wind installation capacity for the past three years (US DOE EIA, 2009c). But it remains that wind's true potential remains untapped. Both infrastructural improvements for transmission and technological advances can help the United States harness its wind potential.

For example, there are no active offshore wind farms in the U.S. (US DOE EIA, 2009c). Nine projects are in development, most notably the Long Island/New York City Offshore Wind Collaborative, a joint project with Con Edison and New York State and City agencies. The Long Island/ New York City Offshore Wind Collaborative is in the request for information (RFI) phase and will be the largest offshore wind farm in the country. The wind farm will be situated 13 miles off the Rockaway Peninsula in the Atlantic and set to generate 350 MW with the capacity to increase to 700 MW. Con Edison and the Long Island Power Authority are also conducting a grid transmission interconnection study. The Long Island/New York City Offshore Wind Collaborative is consistent with the "45 by 15" program in which New York will generate 45% of its electricity from renewable sources by 2015 as proposed by Governor David Patterson (Con Edison, 2009b).

Wind potential has not been realized in part due to the state of technology. New technology will allow wind energy to be captured in more places. Emerging wind power technology generally focuses on maximizing wind capture efficiency as well as utilizing existing structures to install wind turbines. New designs emphasize dual function by placing wind turbines directly on existing electricity pylons, feeding generated electricity directly into the grid (Alternative Energy, 2009).

Fenner Farm

An example of a small-scale industrial wind farm is Fenner Farm, located in upstate New York with 20 wind turbines, each with a generation capacity of 1.5 MW. The farm generates 83,000 megawatt hours (MWh) annually, the electricity generation equivalent of 3.5 million tons of coal. The wind turbines use 1% of the farm's 6.2 km^2, allowing the remainder of farmland be used for grazing and agricultural purposes (The Fenner Renewable Energy Center, Inc., 2009). Fenner Farm is one of 20 wind farms in New York (American Wind Energy Association [AWEA], 2009a).

Given wind's tremendous growth potential relative to other renewables, it is important to explore some of the issues that might stymie wind's growth projections, and how that relates to future evaluations of whether H.R. 890 was effective legislation.

Potential Problems with Wind

Wind Variability

Wind is not a constant; directional and speed changes will affect operational capacity of wind turbines. When wind direction changes, wind turbines utilize the blade pitch and yaw mechanisms to maximize wind capture. Blade pitch is the angle at which each blade faces the wind to maximize contact area. The yaw mechanism is the rotation of the entire wind turbine (rotor and blades) to turn into the wind when directional changes occur.

As a generating source, wind cannot be adjusted to create more or less energy, and the amount of energy generated is based on the fluctuations of air currents (US DOE EERE, 2008b). As a result, wind turbines across the country vary in their available output energy. The variability and subsequent unpredictability of wind energy could potentially create disruptions in the current electricity grid. Furthermore, wind energy is not predictable enough to reliably meet energy demands. Due to load variability from both the commercial and residential sectors, wind energy alone is not sufficient to ensure that energy demand is consistently met. Thus, the current U.S. electricity grid is not capable of coping with the combination of wind and load variability (US DOE EERE, 2008b).

However, wind power will not be the sole source of electricity generation in the future electricity portfolio. Thus, if there is an interruption in wind energy, other sources, like coal or natural gas, will supplement supply to meet demand. According to the American Wind Energy Association, "reliable electrical service can be maintained by system operators dispatching generators up and down in response to variation in load and wind generation" (AWEA, "Wind Power – Clean and Reliable"). Energy reserves, as a wind variability mitigation tool, will be maintained from energy supplied by coal and natural gas (Gul & Stenzel, 2005). Similar to their current role, reserves would be used as a buffer in the event of electricity loss. According to the U.S. Department of Energy, current systems have enough buffer capacity to handle 20-35% of electricity from wind (US DOE EERE, 2008b). Additionally, wind forecasting helps wind farms predict the amount of electricity that prevailing wind conditions can generate and more efficiently use other grid sources to make up for wind variability (US DOE EERE, 2008b).

Transmission[3]

Wind energy is readily available in localized sites across the U.S. Despite the potential 300,000 MW from wind projects that are ready to connect to the electricity grid, each project faces the same obstacle, transmission (AWEA, 2009a). In its recently released report, "20 Percent Wind Energy by 2030," the U.S. Department of Energy (DOE) identified transmission as the largest obstacle to realizing the economic and environmental benefits resulting from attaining 20 percent of electricity from wind (US DOE EERE, 2008).

In order to establish wind as a significant source of electricity generation, it is imperative to have a well-established transmission and distribution network. Currently, there are three main problems with the transmission and the distribution grid, including a lack of transmission lines, especially between high- and low-density populations, low-voltage

[3] Transmission is defined by the U.S. Department of Energy as: "An interconnected group of lines and associated equipment for the movement or transfer of electric energy between points of supply and points at which it is transformed for delivery to customers or is delivered to other electric systems."

lines already at maximum capacity, and little communication between the "balancing areas"[4] managed by electricity operating centers.

The current high-voltage transmission infrastructure is not established between low-population areas where wind is most likely to be generated, and areas of high population where energy demand is likely to be greatest. Currently, most transmission exists within the Midwest. As seen in Figure 9, transmission must expand to include an expansive high voltage network (765 kilovolts[5]), as illustrated by the blue lines, if wind is to displace fossil fuels as a source of electricity generation.

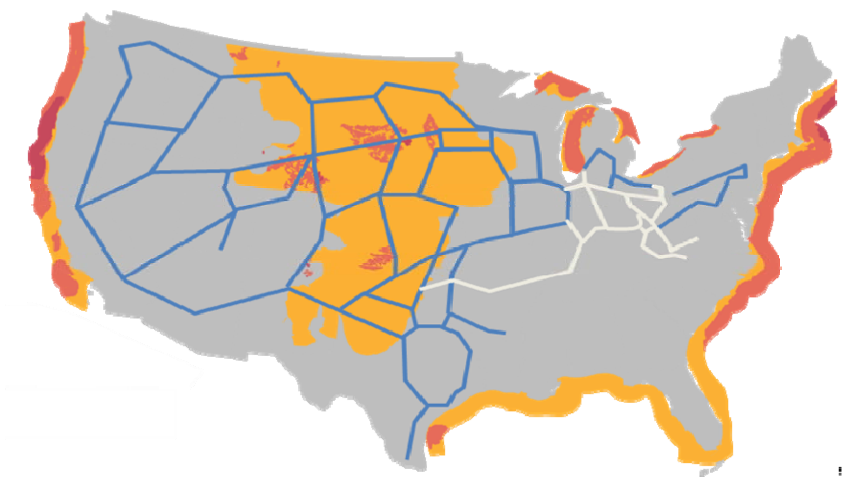


Figure 9. High Voltage Network: The map highlights areas of wind potential paired with existing transmission lines (gray lines) and proposed new transmission lines (blue lines) needed to harness the wind energy (US DOE EIA, 2009b)

Furthermore, the more extensive low-voltage transmission electrical line network that does exist in the U.S. is too overloaded to support the addition of another generating source to the network. Low-voltage lines (345 kilovolts) require large amounts of space and have a high rate of electricity loss as capacity is added, which does not bode well for wind joining the transmission network (AWEA, 2009a). As of January 2009, for example, California had over 13,000 MW in wind energy capacity waiting to be connected to the grid, but the projects are still waiting for answers in the strained transmission infrastructure (AWEA, 2009a).

Finally, the country's electricity grid is currently divided into autonomous operating areas, otherwise known as "balancing areas", and electricity within each of these areas must be continually adjusted by operators to ensure that supply and demand are in equilibrium. Currently, due to issues of transmission ownership and constrained transmission lines, it is possible to have a balancing area with excess generation adjacent to another balancing area with a generation shortfall, yet the energy between these

[4]The country's electricity grid is currently divided into autonomous operating areas, otherwise known as "balancing areas" (AWEA 2009a)

[5] A kilovolt is equal to 1,000 volts. A volt is a measure of electric potential or electromotive force.

neighboring areas cannot be shared (AWEA, 2009a). The fact that the output of both electricity generators would need to be altered highlights another issue with the current system of electricity transmission. Ideally, the balancing areas would be consolidated or their operation coordinated to enhance the reliability and reduce the cost of managing the electricity grid.

Ecological Issues with Wind

Wildlife

Harm to wildlife, namely birds and bats, has become a concern as the wind industry expands. Opponents to expansion of wind power cite scenarios which resulted in significant wildlife losses. The most commonly cited events took place in Altamont Pass, California, in the 1980s and West Virginia in 2003, and negatively impacted birds and bats, respectively (Sagrillo, 2003; AWEA, "Wind Energy and Wildlife"). Since this time, the wind industry has facilitated research studies and taken action to ensure that wildlife populations and habitat are protected on each wind farm site, and the National Academy of Sciences estimated in 2006 that wind energy is responsible for less than 0.003% (3 of every 100,000) of bird deaths caused by human activities (AWEA, 2009b). Steps taken by the wind industry and outside monitoring organizations have therefore led to public support from the National Audubon Society, the nation's oldest birding conservation organization. Bat studies have been more difficult to conduct, due to the mammal's nocturnal nature. However, preliminary data indicate that bat deaths that do occur as a result of wind turbines are not numerous enough to lead to the demise of a bat population (Sagrillo, 2003).

Land Use

Land use is the topic of another wind power debate. As acknowledged by the wind industry, installing wind turbines results in some vegetation loss, soil disruption, and potential erosion, but it does not cause irreversible loss of habitat as in the case of mining (National Academy of Sciences, 2007). Furthermore, wind farms are most often built in areas close to transmission lines where habitat has already been modified (AWEA 2009b). Finally, turbines do not significantly alter the function of the land where they are placed. In most cases, less than one percent of a typical wind farm is used for the turbines and associated infrastructure, thus allowing the remainder of the land area to be used for agriculture or other purposes (BWEA, 2009).

Having discussed many of the strengths and weaknesses of wind as the principal renewable to meet H.R. 890's mandate, it is clear that all utilities across the nation will not be well-placed to take advantage of wind power. H.R. 890 recognizes that not all utilities can generate renewable electricity, and as such, provides a second option under which they can meet the bill's mandate: a market for renewable energy credits. The next section describes the market mechanisms proposed in H.R. 890 and an examination of existing state renewable portfolio standards building the case for a national standard.

A National Market for Renewable Energy Credits

H.R. 890 does not require all utilities to generate more renewable electricity. Instead, utility providers can purchase renewable energy credits as described previously.

The market-based approach outlined in H.R 890 relies on renewable energy credits to serve as currency. Simply stated, a renewable energy credit is equivalent to the "renewable rights" of one kilowatt-hour of electricity that was generated from renewable sources, and is awarded by the Federal government. Credits offer potential for systemic optimization and efficiency; areas that are best suited to renewable electricity generation can exceed their minimum requirement and sell surplus credits to areas less amenable to renewable technologies. Thus, while each individual utility may not actually generate sufficient renewable energy, collectively utilities can meet the requirement.

H.R. 890 creates a national market for these credits and outlines two conditions for this credit instrument. First, renewable energy credits can be used for three successive years following their issuance. For example, a credit issued in 2012 can be submitted by a utility for compliance years 2012-2015, after which the credit will expire and be retired. Secondly, distributed generation facilities[6] will be awarded three renewable energy credits for each kilowatt-hour of electricity produced initially. As this option becomes more economically feasible, the government may lower this amount as is deemed appropriate.

To account for the possibility of a shortage of renewable energy credits and to provide utilities with greater flexibility, H.R. 890 offers utilities a third method for fulfilling the minimum renewable requirement. Utilities can pay the compliance fee, which contributes to a Renewable Electricity Deployment Fund. This compliance fee, calculated per credit, will vary annually and be the lesser of 200% of the prior year's average market value of a renewable energy credit, or 5.0 cents. This amount will be adjusted annually by the Federal government.

Existing State Renewable Portfolio Standards

Twenty-eight states and Washington, D.C. have either implemented or approved renewable portfolio standards (RPS). Collectively, these policies cover more than half of the total electricity generated in the U.S. Given the fact that similar policies are in place at the state level, what is the case for a national policy? Further examination of the weaknesses in state policies illustrates the need for a national market such as the one H.R. 890 proposes.

With a narrow policy focused on hydroelectric generation requirements, Iowa implemented the first renewable portfolio standard in 1983. Starting in the late 1990s, other states began to follow Iowa's lead. Figure 10 shows all states that have a RPS in place as well as those with a voluntary goal in place. Nearly half of all policies have been enacted in the last two years.

[6] Distributed generation facility is located close to the particular load it is expected to serve (see Glossary).

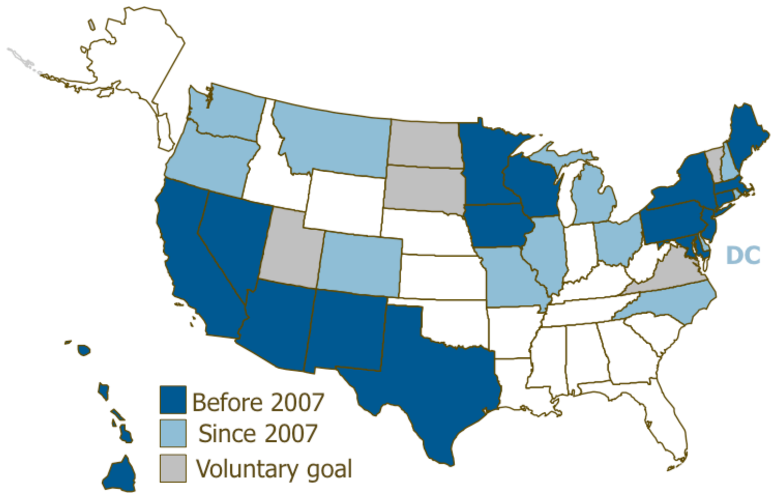


Figure 10. Map of United States with renewable portfolio standards in place (Wiser & Barbose, 2008; DSIRE, 2009)

Eleven of the sixteen states with operational performance data available from 2006 met more than ninety percent of their goal (Wiser & Barbose, 2008). Nine states met their goals in full. These results suggest that RPS goals are achievable and offer insights about challenges faced by some states. Arizona, for example, has a solar-focused policy that has failed to meet goals partly because of insufficient funding for solar capacity in the state. New York fulfilled just 52% of its goal in 2006, its first year for the policy. This failure was mainly due to a delay with the state's largest renewable facility and part due to renewable energy credit prices that exceeded budgeted prices (Wiser & Barbose, 2008).

Insights from state policies

A comparison of current state policies shows tremendous diversity in fundamental aspects of program design; states' programs differ from each other in definitions of renewable energy technology, the required renewable percentages, the compliance payment structure, and the constraints placed on the renewable energy credit market (Wiser & Barbose, 2008). Given this variety, it is difficult to compare state policies. Though economic impact varies between states, rate increases for end customers is typically less than one percent excluding the costs of transmission (Chen, Wiser, & Bolinger, 2007). Finally, the volume of policy approval in the last three years indicates that public support exists for RPS policies in many states.

Rationale for H.R. 890, a national policy

H.R. 890 offers two main advantages over state-level policies. First, a national policy will standardize the definition of eligible renewable technologies as well as allow improved evaluation and require participation by all utilities. Participation will increase in two different ways; first, the remaining 22 states without a state RPS will be required to adopt the Federal RPS requirement, and second, energy generators with existing renewable electricity generation facilities will be encouraged to increase capacity. The second advantage of H.R. 890 is the potential to maximize efficiency on a national scale. State experience indicates that regional restrictions on the renewable energy credit market can reduce efficiency (by raising credit prices) and impede results (Wiser & Barbose, 2008). By standardizing the renewable energy credit market across the country, renewable energy generators will not need to rely on within-state utilities to purchase the renewable energy credits they produce. Instead, the pool of potential credit buyers will expand to consist of all utilities in the country. This is expected to be particularly beneficial in the later years as the minimum renewable energy requirement increases towards 25%.

Renewable energy credits are likely to be landmark in the potential growth of renewables, long after H.R. 890 has expired on December 25, 2040. The next section examines analyst projections of how H.R. 890 may impact renewable growth over the next several decades.

Projected impact of H.R. 890

At the present time, roughly 3% of the electricity generated in the U.S. comes from renewable energy sources, excluding conventional hydroelectric power (US DOE EIA, 2009b). According to an analysis by the Energy Information Administration of the United States, electricity generation from renewable energy sources would only increase to 15% of the portfolio by 2025 without additional legislation (US DOE EIA, 2009b). Thus, the mandate set forth by H.R. 890 is expected to drive additional growth of renewable electricity (see Figure 11). Economically, H.R. 890 is projected to pose 0.01 cents per kilowatt-hour increase to end-users, which suggests a minimal economic burden (US DOE EIA, 2009b).

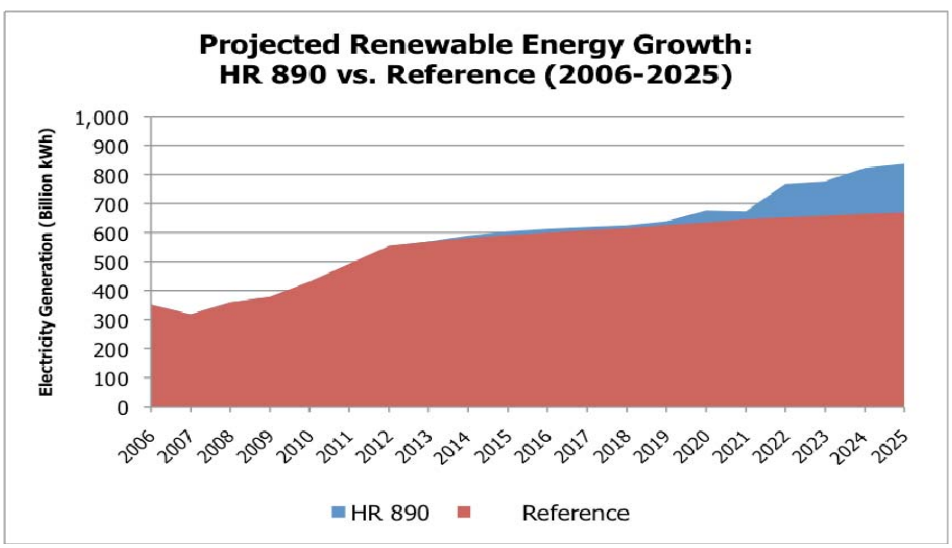


Figure 11. Comparison of growth projections for renewable electricity generation with H.R. 890 and without (reference case) (US DOE EIA, 2009b)

Current and Projected Renewable Energy Portfolio

Currently, 65% of electricity generation from renewable energy sources is derived from wind, 20% from biomass, 14% from geothermal energy and 1% from solar energy (US DOE EIA, 2009c) (see Figure 12). Future projections from the Energy Information Administration forecasts the contribution from wind power to be between 40-55% of renewable energy electricity generation, 5% from geothermal and the rest from biomass sources (US DOE EIA, 2009b).

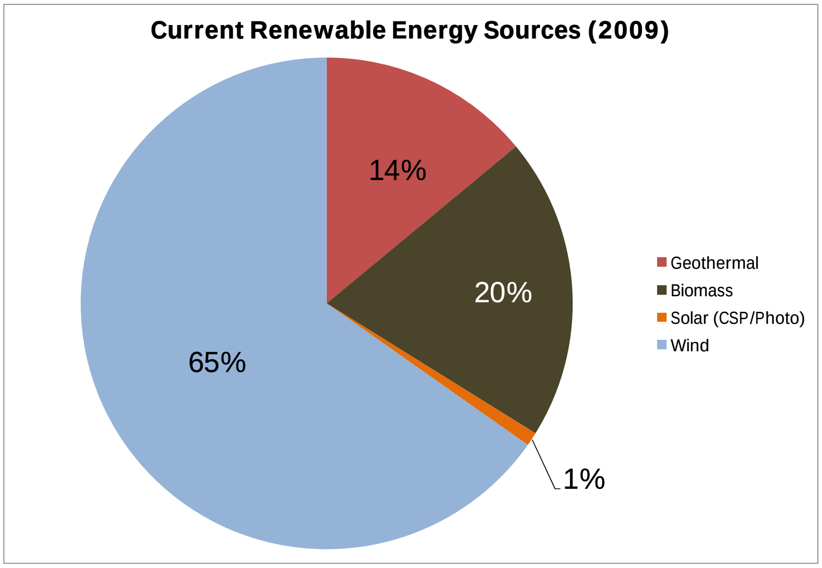


Figure 12. Percentage of different renewable energy sources currently generated (US DOE EIA, 2009c)

Projections of Coal Consumption and the Impact of Wind

Trends in Coal Consumption

The U.S. Energy Information Administration estimates that 259 gigawatts (GW)[7] of new generating capacity will be needed between 2007 and 2030 to meet electricity demand. This is a result of the projected increase in electricity demand and the retirement of 30 GW of existing generating capacity. Analysts predict that capacity additions will be generated primarily from natural gas (53%), renewables (22%), coal (18%), and nuclear energy (5%). Even with these projections, which assume that electricity generation from renewables will increase 100% from current levels, coal-fired plants would still account for 47% of total electricity generation. Thus, coal consumption would rise between 10% and 28% over 2007 levels in low- and high-growth scenarios respectively (US DOE EIA, 2009a).

The Impact of Wind Power on Reducing Carbon Emissions

As established in previous sections, coal mining significantly impacts the environment by releasing heavy metals into the environment. The combustion of coal to generate

[7] A gigawatt (GW) is equivalent to one billion watts or one thousand megawatts.

electricity produces stack emissions that include sulfur dioxide, nitrogen oxide, carbon dioxide, and mercury. Wind-generated electricity, on the other hand, does not require the combustion of a fuel source and has no direct air emissions. Wind turbines also require few natural resources, creating less land degradation in the process of wind capture (US DOE EIA, 2009b). With more wind generating electricity to meet demand, the reliance on coal could reduce, and along with it, harmful emissions. However, the relationship between H.R. 890's mandate and its effect on mitigating environmental harm is not so simple. H.R. 890's environmental effect will depend on how the electricity portfolio grows—renewables could replace electricity generation from coal, or they could replace generation from other traditional sources.

While a mandated increase in the production of electricity from renewable energy sources would decrease the proportion of other energy sources used, an increase in wind-powered electricity would not necessarily result in a decrease in coal-fired generation[8]. Some analysts speculate that the fuel source most likely to be displaced by wind power would likely be natural gas (Chen et al., 2007). Analysts forecast this because of gas' variable prices and the need for new supplies of natural gas. Figure 13 illustrates the variable price of natural gas and how it can spike suddenly. When natural gas prices are high, it becomes the most likely energy source to be replaced by wind energy. In contrast, coal's price is stable and predictable, and so renewable energy, such as from wind, would be less likely to take coal's market share.

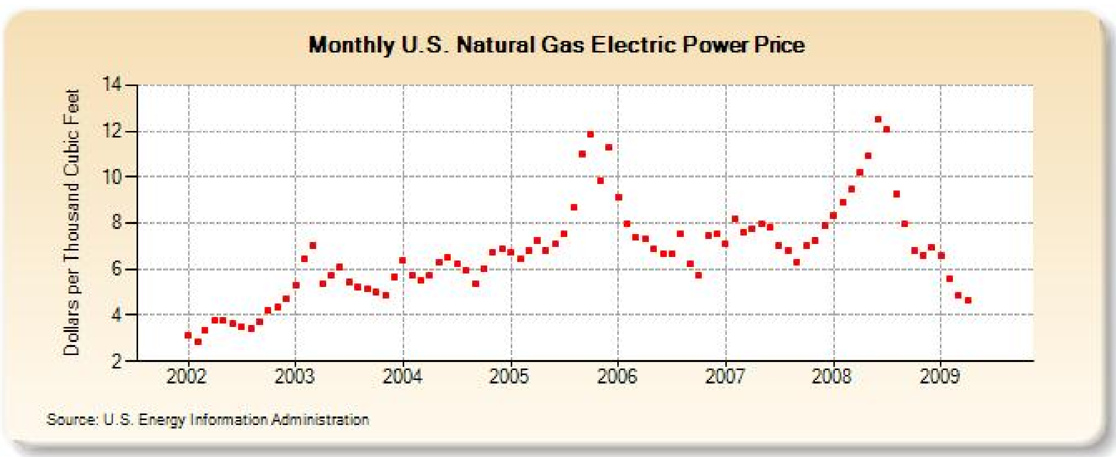


Figure 13. Variations in natural gas electric power price between 2002 and 2009 (US DOE EIA, 2009h)

The amount of carbon dioxide offset by wind powered electricity generation will depend upon which fuel source the wind power is displacing. If wind displaces natural gas-powered electricity, 117,000 pounds of carbon dioxide will be offset per billion BTUs of energy used. Alternatively, if it displaces coal-fired power the offset amount will be 208,000 pounds (US DOE EIA, 1999). Therefore, due to market inertia, H.R. 890 may not have as great an impact on carbon dioxide as the legislation intends. Rather than cannibalizing coal, the most detrimental source for electricity, renewable energy may

[8] Coal-fired electricity is both the most dominant and environmentally harmful method of electricity generation.

take market share away from less harmful sources of electricity generation, such as natural gas. Even if natural gas is displaced by wind, however, the result will be offsets in carbon dioxide, since wind power is carbon neutral.

Measures of Success

H.R. 890 represents a plan to reshape the U.S. electricity market. There are three different indicators to gauge the success of H.R. 890 in addressing the current problem with electricity generation.

The short-term success of H.R. 890 would be measured by utilities meeting or exceeding the interim targets proposed in the legislation with the ultimate goal to meet the mandate of 25% of electricity generation from renewable sources by 2025. This means that utilities will either increase their renewable electricity generation or buy renewable energy credits and will not use the compliance fee mechanism.

The long-term goal of program would be measured by the continued growth of the renewable energy market after 2025, in which the market share of renewable-sourced electricity would continue to grow without subsidies. In short, the long-term goal is the creation of an established and growing market for renewable energy without government intervention.

There are three general categories of indicators applicable to H.R. 890—renewable energy industry indicators, environmental indicators, and economic indicators. Indicators for each category will be explained below; each is designed to be general enough to be applied to the entire renewable electricity sector, or each of its technologies. To illustrate this, each indicator is applied to wind power, highlighting metrics and targets that would illustrate H.R. 890 is meeting its goals.

Renewable Industry Indicators

H.R. 890's success hinges on the growth of the renewable electricity generation industry relative to other primary sources, such as coal or natural gas. Therefore, examining the health of the renewable industry can provide insights into H.R. 890's role in generating growth.

In assessing the health of the renewable industry, there are numerous indicators, though each is insufficient to fully capture the state of play in the industry at any given moment in time. Example indicators include an increase in overall capacity of utilities generating electricity from renewable and an increase in the rate of kWh of renewable electricity produced will serve as indicators.

Under the conditions set by H.R. 890, utilities should have incentive to develop renewable electricity generation capacity. Many utilities will source electricity or renewable energy credits, rather than generate renewable electricity themselves. Though this is sufficient to meet the mandates set in H.R. 890, the sudden demand for renewables, could in the short term, increase the price per kWh dramatically. Therefore, an indicator for H.R. 890's success could be an increasing number of utility suppliers generating electricity from renewables themselves.

Renewable kWhs currently have a positive growth trajectory prompted by other legislation, investment, and incentives. This positive trend makes absolute measurements of kWh growth irrelevant in assessing H.R. 890's success. A more accurate means to assess the renewable industry's health, as well as H.R. 890's impact on that health would be to measure changes in the rate of increase of kWh generated from renewable sources. If rates are increasing, then the growth trend for renewable kWh's is no longer linear, but exponential and could be reflective of H.R. 890's market mechanisms. For example, from 2003 to 2007, renewable electricity generation growth occurred at a rate of approximately 3%, totaling over 100 billion kWh generated in 2007 (US DOE EERE, 2008a). An indicator of an increasing growth rate would be an increase in that percentage over time. Consideration of this indicator as reflective of H.R. 890, however, cannot take place in a vacuum. For example, renewable kWh generation declined from 2006 to 2007 from 385,669,799 to 351,300,592 kWh. This decline was not entirely indicative of a decline in industry health. Rather it was more reflective of reduced precipitation, and its effect on hydroelectric generation in the West. If hydroelectric generation were removed from the average, the rate of increase in renewables over 2006-2007 would have been an increase in 7%, not a decline of 9% (US DOE EERE, 2008a).

Increased generation capacity from renewable electricity measured in capacity of wind-generated electricity and with a target of increasing wind installations from 3 GW per year to 16 GW per year by 2018 can serve as a wind-based target for a renewable industry indicator._Wind capacity has been growing. It has grown from an estimated 3 GW added annually as of 2006 to 8.3 GW in 2008. (Bode, 2009; US DOE EERE, 2008b). Studies have determined that to achieve 20% wind energy installation rates need to increase from 3GW in 2006 to 16 GW a year by 2018 (US DOE EERE, 2008b). Figure 14, below, is a graphical representation of the required capacity additions per annum, to attain 20% by 2030.

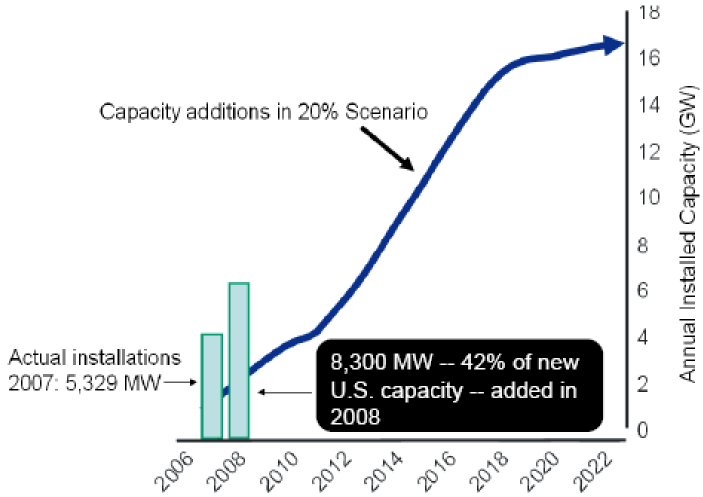


Figure 14. Achieving 20 % wind energy by 2030 (Bode, 2009)

This can only be achieved by improvement in turbine performance and using wind optimally. Through the combination of cost, technology, and improving operational efficiencies, studies have shown if the wind industry can obtain an annual installation rate of 16 GW/year by 2018 it could be capable of generating 20% of the U.S.'s electricity demand by 2030 (US DOE EERE, 2008b).

Environmental Indicators

H.R. 890 does not explicitly state an environmental goal; further, once implemented, the act will be interacting with numerous other programs aiming to reduce environmental impacts. As such, the legislation's effect on reducing environmental harm will be difficult to quantify. Nonetheless, the program seeks to grow renewable forms of electricity generation. As such, with an increase in the percentage of renewable electricity generated, there will be a reduction in the share of traditional (and more environmentally detrimental) sources of energy such as coal, thereby decreasing the overall environmental impact of electricity generation (US DOE EERE, 2008a). There are a variety of indicators that can measure the environmental impact of H.R 890. However, this section will focus on a single indicator, total greenhouse gas emissions reduced and total emissions from electricity generation reduced.

Traditional forms of electricity generation, most notably coal, account for much of the greenhouse gases emitted into the atmosphere. According to the U.S. Environmental Protection Agency, for every megawatt hour[9] of electricity generated from coal, some 2,249 lbs of carbon dioxide are emitted. In contrast, renewable forms of electricity generation do not prompt carbon fluxes to the atmosphere. Thus, successful implementation of H.R. 890 would therefore include reducing the amount of greenhouse gas emissions from the electricity sector. Using baseline data on current carbon dioxide emissions from electricity generation, as well as projections of the growth in renewable

[9] A megawatt hour equals one thousand kilowatt hours or 1 million watt hours.

forms of energy, a picture emerges of a successful scenario where H.R. 890 prevents carbon emissions. Figure 15, below, illustrates the potential impact of H.R. 890 on preventing carbon dioxide emissions.

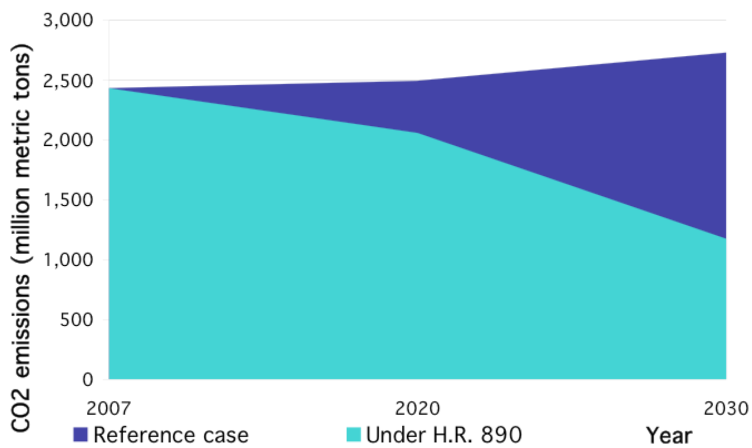


Figure 15. Carbon dioxide emissions under H.R. 890 with respect to a reference case of current trends (US DOE EIA, 2009b, 2009e)

The combustion of coal releases at least 73 elements through stack emissions (Anderson et al. 2000). According to the Energy Information Administration, the most prevalent compounds released, in descending order, are: sulfur dioxide, nitrogen oxides, and mercury (US DOE EIA, 2009e). Much like for greenhouse gases, a reduction in the percent of electricity generated from traditional sources due to growth in renewables would reduce the amounts of these emissions from power plants. Reducing these emissions is an added benefit of the legislation.

Another way to monitor the reduction in greenhouse gas emissions is to calculate the amount of greenhouse gas emissions avoided by using renewable energy, such as wind. Carbon emissions avoided are calculated per kWh using the current U.S. average utility fuel mix emissions rate. Currently, a "single 1.5 MW wind turbine displaces 2,700 metric tons of CO_2 per year, […] or the equivalent of planting 4 square kilometers of forest every year." (US DOE EERE, 2008b). Figure 16 shows the projected annual and cumulative carbon dioxide emissions avoided under a scenario of 20% of electricity generated from wind by 2030.

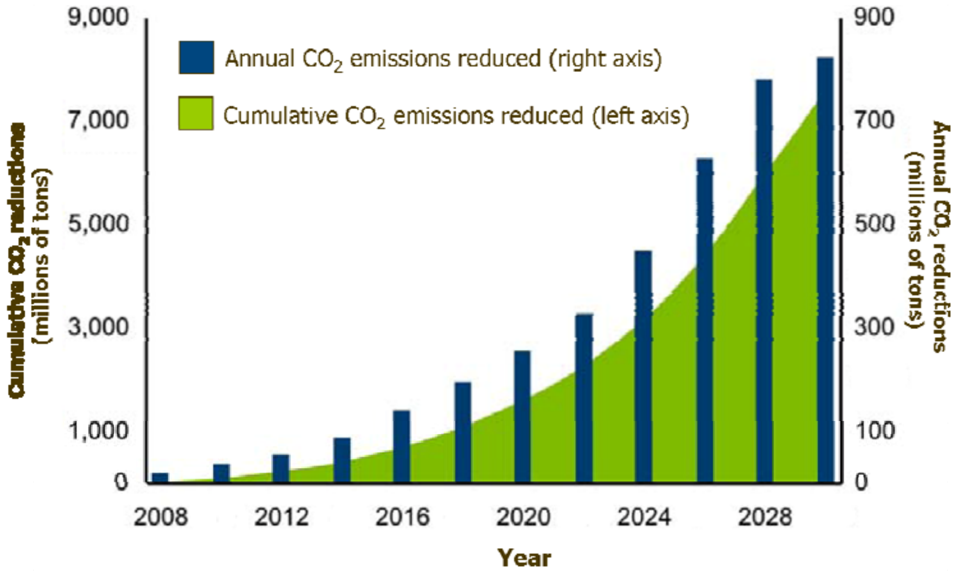


Figure 16. Potential reductions in carbon dioxide from wind (US DOE EIA, 2008b)

Economic Indicators

On the economic front, making renewable energy competitive with other, more traditional sources of electricity generation will display H.R. 890's success. There are numerous indicators that can point to the economic impacts of H.R. 890; however, there is no single indicator that will be able to assess the economic strength of the renewable market. Below are two possible indicators to determine the overall economics behind the electric industry. Possible indicators include reduction in the per unit price of kWh for renewable energy per source – either average across or within technologies, within generating utilities, or across regions. A second indicator is increased renewable energy market penetration – growth relative to any other non-renewable primary source.

Currently, per kWh cost of renewables is within the range of 5 cents to 38 cents, depending on the type of renewable. (US DOE EERE, 2008b) Success would be measured by decreasing the range of kilowatt hour cost amongst the renewable sources and possibly making this section more cost competitive with the largest primary source for electricity, coal, which currently costs 6.2 cents per kWh.

Currently the renewables market makes up 3% (US DOE EERE, 2008a) of the total electricity generation market. H.R. 890 proposes to increase the market of renewables to 25%. Success would be measured by increasing the overall market share of electricity generation. Reaching the 25% goal will be the result of improvements in generation capacity and reduction in cost per kWh hour. As renewable energy sources increase their percentage, they will demonstrate that they are reaching economies of scale.

A wind-based target could be the cost per kWh hour of wind power either equal to or cheaper than the cost per kWh of coal by 2025 with the reduction in the per unit price of kWh for renewable energy per source serving as the economic indicator. This indicator could be measured by price per kWh for wind-generated electricity.

Coal is currently 6.2 cents per kWh hour (Deutch et al., 2009), whereas wind ranges per kWh hour from 5.0 cents to 8.0 cents (US DOE EERE, 2008c). Success would be measured by reducing the range in kWh of wind generation and striving to either meet or be cheaper than the price per kWh hour of coal by 2025. This goal would drive innovation and stress economies of scale in order to make wind power competitive.

Focused, clear indicators, metrics, and targets, which all point to the short- and long-term goals of H.R. 890 will help policymakers evaluate the success or failure of the legislation.

Conclusion

The current electricity portfolio of the U.S. is heavily dependent on coal for electricity generation. Because coal is cheap, abundant, and has a vast infrastructure in the U.S. for its use, it is the dominant source of electricity generation. But the price Americans pay for cheap electricity goes beyond cents per kWh; it is expressed in a degraded environment and stack emissions that contribute to climate change, lead to acid rain and cause respiratory diseases. The fact that electricity generation in the United States has remained relatively unchanged for 130 years demonstrates a business as usual approach that ignores ever-increasing signs of the harmful environmental and public health impacts of coal-generated electricity. These impacts are also exacerbated by an increasing demand for electricity.

The American Renewable Energy Act (H.R. 890) addresses the impacts of electricity generation by growing the market for renewable sources of electricity with the establishment of a renewable energy standard. Of the eligible renewable sources, wind power, with its vast resource and technological potential in the United States, is projected to supply the most significant portion of renewable generated electricity. Without any stack emissions and minimal land use requirements, the tremendous potential of wind-generated electricity is only beginning to be realized. However, wind-generated electricity is not without its drawbacks. The stabilization of coal as a primary source of electricity generation requires the creation of a new transmission grid that may not be economically feasible. Wind power is also variable, subject to fluctuations in speed and direction. But coal-generated electricity is no longer tenable; the cheap price of electricity generated from coal does not reveal the costs in environment and public health impacts. But does H.R. 890 directly address increasing electricity demand and the negative impacts of coal-generated electricity?

The answer is no. H.R. 890 does not directly address the problem of electricity consumption and operates on the current model of natural resource use and development that is unsustainable. But it is a step in the right direction. H.R. 890 is a step towards long-term change and progress because it establishes the opportunity to assess market mechanisms and their ability to create fundamental changes in infrastructure and behavior. It lays the foundation for invention and innovation that has defined the United States.

And so, the story of electricity generation in the U.S. comes back to McKibben's tale of More and Better. With electricity demand rising and current methods of electricity generation negatively impacting an environment pushed to the limits of its carrying capacity, American must decide how progress will be defined: the same of More or the endurance of small sacrifices in the hopes of Better.

Glossary

All definitions are sourced directly from the Energy Information Administration (EIA) of the United States Department of Energy (DOE) or from the North American Electric Reliability Corporation (NERC). The respective glossaries can be accessed at: http://www.eia.doe.gov/ and at http://www.nerc.com/. If another source is used, it is noted in parenthetical citation.

Base Load: the minimum amount of electric power delivered or required over a given period at a constant rate (NERC).

BTU (British thermal unit): The quantity of heat required to raise the temperature of 1 pound of liquid water by 1 degree Fahrenheit at the temperature at which water has its greatest density (approximately 39 degrees Fahrenheit) (EIA).

Billion kilowatt hours (BkWh): see kilowatt hour, below. The equivalent of one billion kilowatt hours (EIA).

Carbon dioxide (CO_2): a colorless, odorless, non-poisonous gas that is a normal part of Earth's atmosphere, comprised of two oxygen double bonded to a central carbon atom. Carbon dioxide is considered a greenhouse gas as it traps heat (infrared energy) radiated by the Earth into the atmosphere and thereby contributes to the potential for global warming (EIA).

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

Distribution: the delivery of energy to retail customers (EIA).

Distributed generation: generation located close to the load the load it is intended to serve (EIA).

Distribution provider (electric): provides and operates the "wires" between the transmission system and the end-use customer. For those end-use customers who are served at transmission voltages, the Transmission Owner also serves as the Distribution Provider. Thus, the Distribution Provider is not defined by a specific voltage, but rather as performing the Distribution function at any voltage (NERC).

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

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

Electric utility: any entity that generates, transmits, or distributes electricity and recovers the cost of its generation, transmission or distribution assets and operations, either directly or indirectly, through cost-based rates set by a separate regulatory authority (e.g., State Public Service Commission), or is owned by a governmental unit or the consumers that the entity serves. Examples of these entities include: investor-owned entities, public power districts, public utility districts, municipalities, rural electric cooperatives, and State and Federal agencies. Electric utilities may have Federal Energy Regulatory Commission approval for interconnection agreements and wholesale trade tariffs covering either cost-of-service and/or market-based rates under the authority of the Federal Power Act (EIA).

Electricity: a form of energy characterized by the presence and motion of charged particles. The charge is generated by friction, induction, or chemical change (EIA).

Electricity distributor: see distribution, above. A company primarily engaged in the sale and delivery of natural and/or supplemental gas directly to consumers through a system of mains (EIA).

Electricity generator: a facility that produces only electricity, commonly expressed in kilowatt hours (kWh) or megawatt hours (MWh). Electric generators include electric utilities and independent power producers (EIA).

Electricity retailer: firm that sells the electricity product directly to the consumer (EIA).

Electricity transmission: power is generated at power plants and then moved to distribution substations by transmission lines. The nearly 160,000 miles of high voltage transmission lines is known as the grid. Transmission systems are unique because they transfer electricity at the speed of light as there is no long-term storage capability for electricity. There are three major transmission grids: 1) Eastern, 2) Western, and 3) Texas Interconnects (EIA).

Generation: the process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in kilowatt hours (DOE EIA).

Generator: a generator is a device that converts mechanical energy into electrical energy. The process is based on the relationship between magnetism and electricity. A typical generator at a power plant uses an electromagnet—a magnet produced by electricity—not a traditional magnet. The generator has a series of insulated coils of wire that form a stationary cylinder. This cylinder surrounds a rotary electromagnetic shaft. When the electromagnetic shaft rotates, it induces a small electric current in each section of the wire coil. Each section of the wire becomes a small, separate electric conductor. The small currents of individual sections are added together to form one large current. This current is the electric power that is transmitted from the power company to the consumer (EIA).

Gigawatt (GW): see watt, below. One billion watts or one thousand megawatts (EIA).

Greenhouse gas: those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride, that are transparent to solar (short-wave) radiation but opaque to long-wave (infrared) radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere. The net effect is a trapping of absorbed radiation and a tendency to warm the planet's surface (EIA).

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

Kinetic energy: the energy of motion. Energy available as a result of motion that varies directly in proportion to an object's mass and the square of its velocity (EIA).

Load: An end-use device or customer that receives power from the electric system (NERC).

Megawatt (MW): one million watts of electricity (EIA).

Natural gas: a gaseous mixture of hydrocarbon compounds, the primary one being **methane**. *Note*: The Energy Information Administration measures wet natural gas and its two sources of production, associated/dissolved natural gas and nonassociated natural gas, and dry natural gas, which is produced from wet natural gas (EIA)**.**

Nitrogen oxides (NO_x): compounds of nitrogen and oxygen produced by the burning of fossil fuels (EIA). In the atmosphere, nitrogen oxides can contribute to smog, can decrease visibility, and have bad consequences for health.

Renewable energy credit (REC): an intangible asset or property right, issued by an appropriate government authority (i.e. Federal or State government), that represents the nonpower environmental benefits of producing renewable electricity. A REC is created at the same time that the electricity is generated. It separates the environmental benefits of renewable electricity generation from the actual electricity generated by bundling those benefits into this item called a REC. This lets people buy RECs and be able to claim the rights of using clean energy. In H.R. 890, the Federal government will issue 1 REC for every 1 kWh renewable electricity generated (except in the special case of distributed generation). Important note, this may be different from other existing programs like state programs where the rules or equivalent amounts may be different, but this won't matter if the policy is passed because they will only be able to submit the government-issued RECs in this program (i.e. they can't submit state-issued RECs to fulfill H.R. 890's requirements). They've also been called renewable energy certificates, tradable renewable certificates (TRCs), and green tags, but the concept is all the same. (US EPA, 2009g).

Renewable: see renewable energy source, below.

Renewable energy source: an energy source that can be replaced within a short time frame and will not run out (EIA).

Renewable portfolio standard (RPS): a renewable portfolio standard is a policy that requires that utilities obtain a minimum amount of their retail electricity from qualified renewable sources. Policies are typically structured by setting a minimum percentage of total electricity but can also be structured by setting a minimal amount irrespective of total electricity. Each policy defines what sources qualify as renewable. Finally, these policies specify how utilities can obtain electricity from renewable sources and typically include an option to purchase renewable energy credits in lieu of purchasing actual electricity that was derived from renewable sources. (Wiser & Barbose, 2008).

Sulfur dioxide (SO_2): a toxic, irritating, colorless gas soluble in water, alcohol, and ether. Used as a chemical intermediate, in paper pulping and ore refining, and as a solvent; is also a by-product in fossil fuel combustion (EIA).

Transformer: transformers transfer electrical energy from one circuit to another. The transformer allows electricity to be efficiently transmitted over long distances. The electricity produced by a generator travels along cables to a transformer, which changes electricity from low voltage to high voltage. Electricity can be moved long distances more efficiently using high voltage. Transmission lines are used to carry the electricity to a substation. Substations have transformers that change the high voltage electricity into lower voltage electricity. From the substation, distribution lines carry the electricity to homes, offices and factories, which require low voltage electricity (EIA).

Transmission: an interconnected group of lines and associated equipment for the movement or transfer of electric energy between points of supply and points at which it is transformed for delivery to customers or is delivered to other electric systems (NERC).

Volt: the International System of Units (SI) measure of electric potential or electromotive force. A potential of one volt appears across a resistance of one ohm when a current of one ampere flows through that resistance. Reduced to SI base units, 1 V = 1 kg times m^2 times s^{-3} times A^{-1} (kilogram meter squared per second cubed per ampere) (EIA).

Wind turbine: Wind energy conversion device that produces electricity; typically three blades rotating about a horizontal axis and positioned up-wind of the supporting tower (EIA).

Watt (W): the unit of electrical power equal to one ampere under a pressure of one volt. A Watt is equal to 1/746 horsepower (EIA).

Wind energy: kinetic energy present in wind motion that can be converted to mechanical energy for driving pumps, mills, and electric power generators (EIA).

Wind farm: a group of wind turbines interconnected to a common utility system through a system of transformers, distribution lines, and (usually) one substation. Operation, control, and maintenance functions are often centralized through a network of computerized monitoring systems, supplemented by visual inspection. This is a term commonly used in the United States. In Europe, it is called a generating station (EIA).

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