The Effect of Government Subsidies and Tax Credits on the Economic Viability of Wind Energy Development in the United States

By

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Abstract

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The development of renewable wind energy in the United States is a capital intensive and costly venture, and is heavily dependent on economic subsidies and tax credits offered by the federal government. This study tests the effects these subsidies have on the costs of potential wind development when compared to development costs of traditional fossil-fuel based, natural gas electrical generation sources.

In the study, models were constructed to determine the present value of cost for both the wind and natural gas generation sources under different conditions. Initial tests were done for the unsubsidized costs of a 500 megawatt installed wind project compared with a 500 megawatt combined cycle gas turbine, as these tests served as the baseline for the application of variables later in the study. These variables included applying a Production Tax Credit and Investment Tax Credit to wind costs, as well applying a hypothetical carbon tax and fluctuating natural gas prices on the costs of the combined cycle gas turbine project.

In conclusion, it was determined from the data produced in the models that the continued policy renewals of the aforementioned economic subsidies are necessary in order for the future economic viability of wind development in the United States. Barring the implementation of a policy such as the carbon tax presented in the study, the lack of these subsidies are too risky for guaranteed returns on large-scale investment in wind energy.

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List of Exhibits

List of Acronyms

MW	Megawatt
CCGT	Combined Cycle Gas Turbine
KW	Kilowatt
kWh	Kilowatt-Hour
mWh	Megawatt-Hour
ARRA	American Recovery and Reinvestment Act of 2009
PURPA	Public Utilities Regulation
PTC	Production Tax Credit
ITC	Investment Tax Credit
DOE	United States Department of Energy
USDA	United States Department of Agriculture
CREB	Clean Renewable Energy Bond
EESA	Emergency Economic Stabilization Act of 2008
EERE	Department of Energy Office of Energy Efficiency and Renewable Energy
MTC	Manufacture Tax Credit
CO2	Carbon Dioxide
R+D	Research and Development
O+M	Operations and Maintenance

Introduction

Purpose of the Study

The realm of energy in the world is quite an immense and almost endless spectrum of thought. Most energy is some derivative of solar energy; the hydrocarbons that are pumped out of the ground as crude oil have their origins in plant matter, which depended on the sun. The water trapped and released to create hydroelectric power relies on the sun, as solar energy controls weather patterns that result in fluctuations in the water cycle; these same weather patters are what create wind that is captured to generate electricity. However, the reality of the matter is that mankind relies on energy for everything, and the energy currently relied out is not only running out, but is having a severely negative impact on the environment.

In the United States, the future of energy is very much in question. As war continues to rage in the Middle East and the price of crude oil continues to rise, the realization of the necessity for fossil-fuel alternatives to meet energy demand is becoming more evident by the day. However, dependence on fossil-fuels has left society in a predicament that makes fossil-fuel itself and fossil-fuel technology the most dependable, efficient, and cost-effective method of creating energy, especially in regards to the generation of electrical energy. Therefore, how does the United States facilitate a major paradigm shift to clean, renewable, and yet affordable energy?

Many questions exist regarding renewable energy developments, especially those centered on and around wind energy development. However, the obvious issue – money, especially subsidized federal funds – appears to be the key in the widespread development of wind energy in the United States. Immense costs, relatively new technology, and the ease of using existing technologies continue to deter the overhauling of the America’s fossil-fuel based energy economy for a much environmentally friendlier renewable energy future. For this to occur, these issues need to be addressed and thoroughly analyzed and answered in order for a real shift to begin towards a more energy-independent future in the United States.

Different types and levels of subsidization for the development of wind energy generation are, and have been, essential for legitimate, sustained periods of development in the United States. Large subsidies available in places as France and Germany have resulted in large amounts of wind development in those countries; in the United States, the high levels of development when federal subsidies, tax credits, and other incentives are in place, followed by the lulls of development that follow when these policies expire, prove nothing except the necessity of maintained periods of economic incentives in this country as well. Therefore, the purpose of this study is to examine the policies, subsidies, and possible scenarios that would have a positive effect on wind development in the United States. Based on patterns seen in the existing environment, the investment in and sustained development of renewable wind energy and its competition with fossil-fuel based electric generation is dependent on the continuation and expansion of policies that provide economic subsidization and incentives for wind energy installation and the electricity it provides to United States energy demands.

Outline of the Study

In Chapter 2, we first briefly survey the history and development of wind energy technology across multiple centuries, culminating in technology currently employed in our world today. Next, we examine the basic technology of wind energy generation, and potential upgrades in technology that could revolutionize the efficiency and subsequent development of wind energy. Finally, and most importantly, we examine comparable foreign policy examples and the evolution of United States renewable energy-based legislation, legislation that has developed into the many tax credits and subsides that have a substantial role in wind and other renewable energy development.

In Chapter 3, we provide analytical framework for evaluating the impact of subsidy on the viability of the development of wind and other renewable energy sources in comparison to existing fossil-fuel based generation. First, we examine a basic cost-benefit analysis for investment in both wind and conventional fossil-fuel generation. We then discuss the issue of subsidies versus taxes, and differences these two policies could potentially have on investment. Next we discuss some potential issues of social resistance and the actual value humans put on renewable energy, especially if it may interfere at all with their daily lives. Finally, we will discuss the intermittency issue, and problems associated with the installation of renewable energy and problems that arise due to the many variables that play into actual electrical generation from these sources. These are all fundamental issues that must be addressed in order to ensure the best, and most dependent, return on energy investments in the future.

In Chapter 4, we examine different scenarios involving multiple variables, such as the ITC, PTC, and potential carbon taxes that will affect wind energy development in the United States. First, we will look at the empirical framework for our tests, and the data that will serve as a baseline for the test models. Next, we will use this data to make a central comparison between wind and CCGT electrical generation, and the present value of cost for each generation source without any externalities. Then we will analyze the effects of applying current and potential subsidies, taxes, and variable fuel prices on the cost comparison of the two central generation sources, and how these policies do and could, if implemented, affect the present cost of value for both projects.

Background and Historical Context of the Technology, Subsidization, and Development of Wind Energy

In this chapter, we first briefly survey the history and development of wind energy technology across multiple centuries, culminating in technology currently employed in our world today. Next, we examine the basic technology of wind energy generation, and potential upgrades in technology that could revolutionize the efficiency and subsequent development of wind energy. Finally, and most importantly, we examine comparable foreign policy examples and the evolution of United States renewable energy-based legislation, legislation that has developed into the many tax credits and subsidies that have a substantial role in wind and other renewable energy development.

A Brief History of Wind Energy

Wind energy, unlike most renewable sources, has been around for thousands of years. Since as early as 5,000 B.C., the Egyptians were using wind to power boats, and as far back as 200 B.C. the Chinese were harnessing the wind with simple windmills for pumping water. Windmills eventually spread to Europe, where they were refined, and eventually began producing electricity – mainly what we know them for today, as modern day wind turbines are being increasingly looked at as the future of renewable energy systems [http://www1.eere.energy.gov/windandhydro/wind_history.html]. In the United States, the early 1940’s saw the largest wind turbine of its kind begin operation on a Vermont hilltop, providing electricity to utilities for a short period during World War II. However, the short-lived success of this particular project – the turbine effectively crashed down the mountain – served as foreshadowing to some of the many capital-intensive issues wind energy would face in the future to make it a viable and dependable source of electrical generation.

Background of Turbine Technology[1]

The "modern day" movement towards wind and other renewable generation was greatly influenced and spurred by the energy crisis of the 1970's. Since the 1900's, the technology of wind turbines was fairly stagnant in terms of new technological developments. The energy crisis was a major catalyst in the growth of R+D that eventually led to many of the developments and technological advances in today's wind turbines. The ability of turbine systems to self-adapt to ever-changing weather and wind conditions through advanced technologies and computer systems have helped to revolutionize and efficiently capture the wind as a source of electrical energy. However, it is important that developments continue to occur with turbine technology, as new developments will directly aid in the increased cost-effectiveness and feasibility of future wind development.

Like most sophisticated technological machines, wind turbines have a fairly wide array of moving parts and computerized applications that allow them to produce energy. Exhibits 2.1 and 2.2 look at turbine structure as a whole and some of the more intricate components of the internal workings of current wind turbine technology. Essentially, wind turbines work in complete reverse of that of an electrical fan; instead of using electricity to create air as a fan does, turbines are powered by the energy of the wind flowing across and spinning the blades, which in turn drive a shaft, which is attached to a generator that creates electricity.

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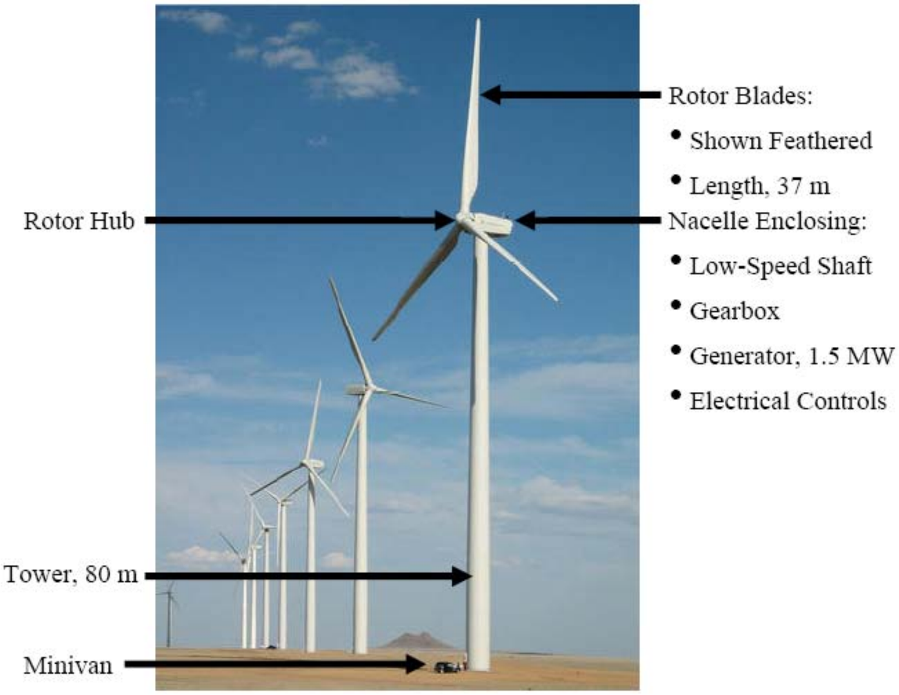
[1] Unless otherwise noted, all of the material for this section has been taken from *20% Wind Energy by 2030; Increasing Wind Energy's Contribution to U.S. Electricity Supply*.

Exhibit 2.1

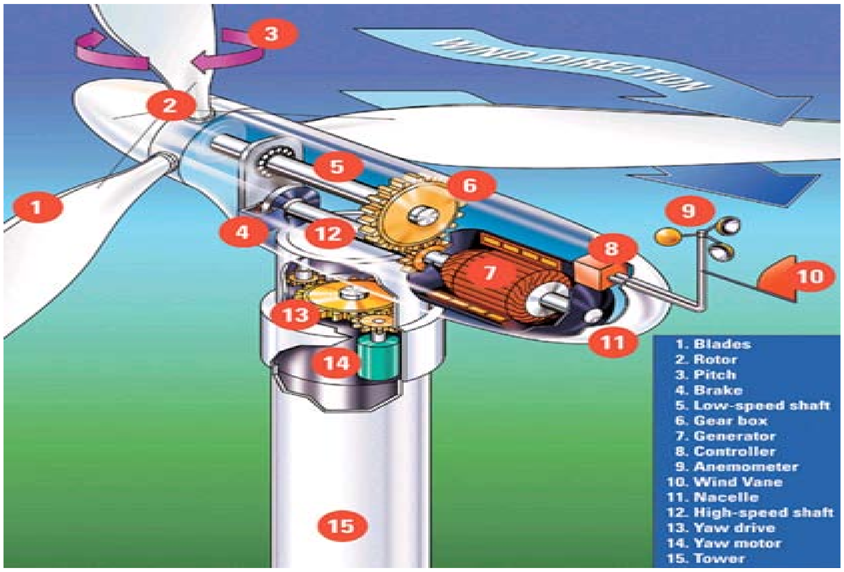
Modern 1.5 MW Wind Turbines



[*20% Wind Energy by 2030; Increasing Wind Energy's Contribution to U.S. Electricity Supply*, 45]

Exhibit 2.2

Internal Mechanisms



[*Wind Turbine Gears*, http://www.kidwind.org/images/lessons_diagram.jpg]

Current wind turbine technology is very deliberate in its design standards to have the ability to have some type over control over its efficiency. The most common and recognizable wind turbines have tri-bladed rotors with approximate diameters of 70 to 80 meters, are perched on top of 60 to 80 meter towers, and have an average installed capability of 1.6 MW of generation, similar to the turbines seen in Exhibit 2.1 [44]. In general, most industrial-sized wind turbines will begin generating power in winds that are blowing at a little more than 5 meters per second; maximum, optimal efficiency for electric power generation in these turbines is approximately 12.5-13.4 meters per second, and at winds blowing approximately 22 meters per second, the turbine will autonomously pitch the blades to stop generation in order to protect the machine from mechanical damage [44]. The same systems that pitch the blades of the turbine to prevent mechanical damage at high wind speeds are also extremely beneficial in enhancing efficiency and output. Blades have the ability to rotate around the rotor in order to better adjust to the wind (called blade pitch), and move to face the wind by rotating the nacelle around the tower (called controlling the yaw). Wind sensors on the nacelle not only control the physical movement of the entire nacelle, but also corroborate with sensors located on the generator and drive-train to control the blade pitch controller, which fundamentally regulates power output and rotor speed to avert mechanical and structural failure.

Though current wind turbine technology is advanced and efficient, potential improvements do exist to increase the efficiency and cost-effectiveness of the technology, ultimately increasing the desirability and marketability of wind energy. Upgrades could potentially be made to each and every aspect of turbine technology, but most concerted efforts have focused around rotors, blades, and towers. Rotors are the primary structural aspect of current technology that is being targeted for development, and rightfully so; the rotor is the foremost device in terms of capturing wind energy. Multiple design and structure changes have been proposed, but one of the most practical ideas lies in making changes to the autonomous controls within the rotor that will allow loads distributed from the rotor to the rest of the turbine to be suppressed, allowing for larger rotors and more energy capture without throwing off the balance of the entire turbine system. In terms of making changes to the blade and tower structures, most of the ideas for innovative technological upgrades have revolved around different physical blade designs and higher towers (as per there is more wind at higher elevations – a 10% increase in wind speed at a higher elevation equates to a 33% increase in available electric power). However, the high capital costs associated with these designs currently makes them economically nonviable.

Legislative and Political History

Roots of Policy

After the oil crisis of the 1970's passed, the concern for the future of energy in the United States became a serious issue. Legislation was developed and one of the first large pieces of energy legislation that came out was the Public Utility Regulatory Policies Act (PURPA) of 1978, which mandated that electric utilities buy alternative energy generation from even the smallest source renewable producers, as long as these generators were considered qualified under the legislation [*Production Tax Credit for Renewable Electricity Generation*]. Furthermore, as part of the Energy Tax Act of 1978, the Investment Tax Credit (ITC) was established, which provided a 10% Federal tax abatement to individuals willing to invest in the wind and solar energy projects, which require large amounts of upfront capital. However, one issue with the initial ITC was that it applied only to initial capital investment, and not to plant operation and energy generation.

PURPA and the ITC paved the way for what is now known as the Production Tax Credit (PTC). The PTC was created as part of the United States Energy Policy Act of 1992, and was thought to be the necessary spark to encourage the expanded development and use of renewable energy technology for electrical energy generation [*Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States*, 2]. The original PTC was designed to provide a generation-based credit, not solely an investment tax credit, and was set to last for the first 10 years of the project's existence. At first, the PTC paid 1.5 cents per kilowatt-hour (kWh) for renewable generation, which at the time included biomass projects beginning in 1993 and wind plants or farms installed between 1994 and the middle part of 1999. The credit was also adjusted for inflation in future years. Initially, only wind and certain types of approved biomass projects were eligible for the PTC; other alternative energy generators, such as solar and geothermal, only received a type of investment tax credit [*Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States*, 2].

The energy demands in the United States have been very historically dominated by conventional fossil fuels, and the environmental, economic, and societal costs of fossil-fuel based energy dependence are significantly detrimental. In terms of governmental incentives, these types of energy have typically received the most benefit, as they are the most prevalent forms of existing technologies and can quickly and easily meet high energy demands. However, continuing questions about peak oil and energy security, especially in the past few decades, have made the PTC a catalyst in the battle to promote renewable energy generation. Not only do renewable energy sources such as wind provide long-term energy security, but also long-term cost reduction, as the capital-intensive renewable projects basically pay for themselves, while fossil fuel energy generators always require just that – fuel – which is always going to be a significant cost.

Political Limitations

The main problem with not seeing immensely drastic results with the implementation of the PTC is its irregularity, in which at numerous times the legislation has lapsed and created what is known as a “boom and bust” cycle in terms of wind energy development, as seen in Exhibit 2.4. Since its inception, the PTC has been renewed five different times; however, only two of these renewals occurred before the PTC expired. The PTC has been allowed to expire on three different occasions, which have caused short spurts of wind development caused by periods of very limited development. Even when the PTC has been renewed, it has been for short 1-2 year time periods as seen in Exhibit 2.3, and have come with specific eligibility requirements that have also hindered additional development. For example, as of 2007, the inflation-adjusted rate of the PTC was 2 cents per kWh for wind and closed-loop biomass; but, in order for these projects to be considered for the PTC, they must be completed by the end of 2008. Furthermore, the PTC can be diminished if a certain renewable project receives any other type of governmental grant, tax-exempt bond, or any type of government subsidy [*Using the Federal Production Tax Credit to Build a Durable Market for Wind*

Power in the United States, 2-3]. Currently, and as will be discussed later, the PTC has been extended through 2012, which may put an end to some of the aforementioned irregularity issues and create some sort of short to medium-term market stability [*Tax Breaks for Businesses, Utilities, and Governments*].

Exhibit 2.3

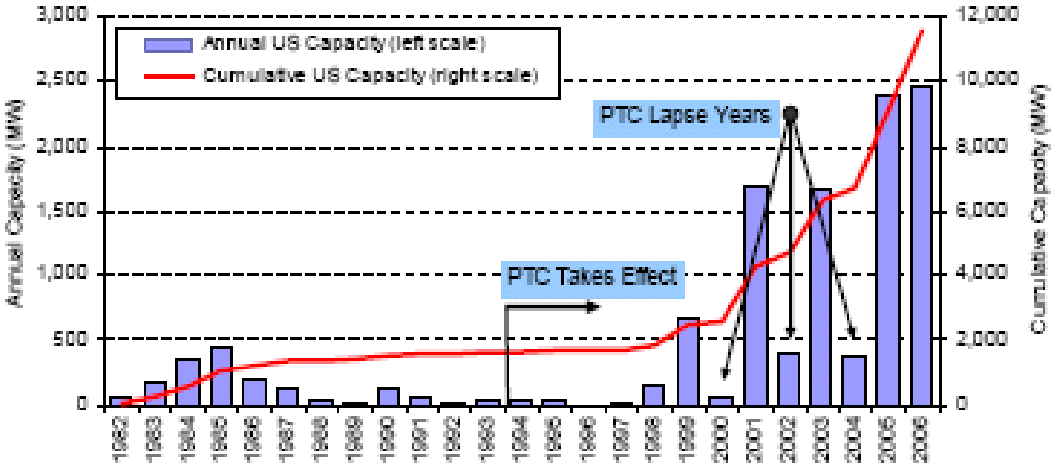
Legislative History of the PTC

Legislation	Date Enacted	PTC Eligibility Window (for wind)	PTC Lapse Duration	Effective Duration of PTC Window (considering lapses)
Section 1914, Energy Policy Act of 1992 (P.L. 102-486)	10/24/92	1994-June 1999	n/a	80 months
Section 507, Ticket to Work and Work Incentives Improvement Act of 1999 (P.L. 106-170)	12/19/99	July 1999-2001	6 months	24 months
Section 603, Job Creation and Worker Assistance Act (P.L. 107-147)	03/09/02	2002-2003	2 months	22 months
Section 313, The Working Families Tax Relief Act, (P.L. 108-311)	10/04/04	2004-2005	9 months	15 months
Section 1301, Energy Policy Act of 2005 (P.L. 109-58)	08/08/05	2006-2007	None	24 months
Section 201, Tax Relief and Health Care Act of 2006 (P.L. 109-432)	12/20/06	2008	None	12 months

[*Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States*, 2]

Exhibit 2.4

"Boom and Bust" Cycles of Wind Development



[*Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States*, 3]

Additional Market Drivers

The market for wind energy is obviously enhanced when the PTC is in effect, but there are other governmental policies that strongly encourage renewable energy development in the United States. Federal funds meant to serve as market drivers for renewable energy have come from many different departments and agencies. Even the United States Department of Agriculture (USDA), an agency that would not be thought of to provide funding for energy projects, provided $44 million dollars of grants and loan guarantees to renewable energy projects including wind. Under the 2008 Farm Bill, the USDA extended these guarantees, and funding is even expected to increase in the future [*2008 Wind Technologies Market Report*, 50]. This demonstrates that, even at somewhat limited levels, potential funding and subsidies exist across many divisions of the federal government.

Recent Policy Extensions[2]

Under the Emergency Economic Stabilization Act of 2008, many energy tax incentives were created or extended to encourage the continued, economically feasible growth of renewable energy in the United States. One of these programs, the Clean Renewable Energy Bond (CREB) program, originally created under the Energy Policy Act of 2005, provides an opportunity for investors to receive bonds with a 0% interest rate, and only requires investors to pay back the principal amount of their investment. The bondholder, who provides the “loan”, in turn receives federal tax credits instead of the interest they would receive from a traditional loan. The CREB program, which is targeted at State, municipal, and tribal governments, received $800 million dollars of new

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[2] All of the material for this section has been taken from *The Emergency Economic Stabilization Act of 2008: Energy Tax Incentives* unless otherwise noted.

renewable energy bonds through the Stabilization Act of 2008 to finance renewable energy facilities that are consistent with the types of energies that receive the federal PTC (wind, geothermal, hydropower, etc.). However, the bill only extended the date for available CREBs until December 31, 2009, so like many of the policies surrounding renewable development, the timetable for development at economically desirable levels is limited (Note: the federal PTC was extended and slightly modified through the Emergency Economic Stabilization Act of 2008, but in terms of wind energy the extension was only valid through January 1, 2010; however, it was once again extended through the American Recovery and Reinvestment Act through 2012, which will we be discussed later)

The Investment Tax Credit (ITC) did receive a significant extension through the Stabilization Act of 2008, as seen in Exhibit 2.5. Small wind energy projects were added as a category that would be available to receive a 30% ITC that was extended through January 1, 2017. Furthermore, a 10% ITC for microturbines was extended through December 31, 2016. The ITC, as previously mentioned, is especially appealing to investments rooted in wind energy, as most of the cost of installed wind energy is incurred in acquiring capital to literally install the project. Depending on the size of the actual turbines, the site for development, and a number of other factors, the ITC may be more effective in spurring development than the PTC.

Exhibit 2.5[3]

Main Provisions of Emergency Economic Stabilization Act of 2008

CREB	Appropriated $800 million. Extended to 12/31/2009.
ITC (Small Wind)	30% ITC extended through 1/1/2017.
ITC (Microturbines)	10% ITC extended through 12/21/2016.

Effect of the ARRA

Some recent policy that has had an enormous effect on wind energy, and truly the entire United States economy at large, is the American Recovery and Reinvestment Act (ARRA) of 2009. The ARRA, colloquially known as the "stimulus" or the "bailout", appropriated almost $800 billion dollars to encourage the development of numerous aspects of the American economy, including a significant amount dedicated to the Department of Energy (DOE) for renewable and clean energy implementation and development. Overall, the DOE received $36.7 billion dollars from the recovery, and the Office of Energy Efficiency and Renewable Energy (EERE), which holds most of the money accessible to wind energy, received $16.6 billion dollars of this for numerous research and development projects. Also included in the DOE appropriation, among other funding, was $4 billion dollars in loan guarantees for renewable energy, which in terms of wind energy will likely appeal to investors trying to build capital for investments [*Department of Energy Recovery Act Funding*]. Exhibit 2.6 provides a full breakdown of funding.

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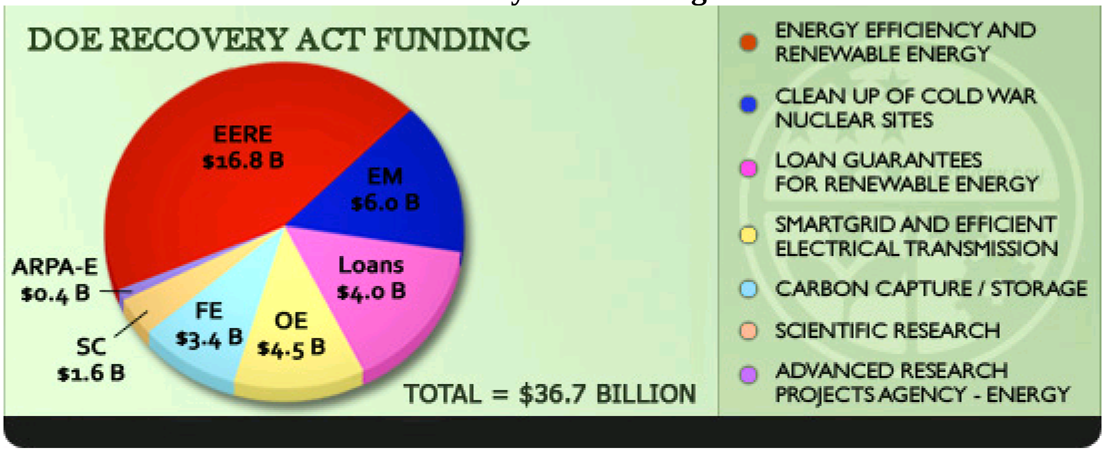
[3] Data obtained from *The Emergency Economic Stabilization Act of 2008: Energy Tax Incentives*.

Exhibit 2.6

Recovery Act Funding



[*Department of Energy Recovery Act Funding*]

Besides increasing the rate of the PTC to 2.1 cents per kWh and extending the PTC through 2012, which was the most significant aspect of wind energy policy extended through the ARRA, other programs and federal funding initiatives in relation to wind energy have extensively benefited from the ARRA. Many of the same policy initiatives that successfully benefited wind energy through the Stabilization Act of 2008 were included, revised, and enhanced through the ARRA, creating some of the best opportunities for renewable energy development in history. One of these revisions, in relation to the PTC, was the option for investors to forego the PTC for a 30% ITC, and (for any projects in-service by the end of 2010 or projects that begin construction before the end of 2010 and come online by the end of 2012) also allows these projects to instead take an equivalent 30% cash grant through the Treasury [*2008 Wind Technologies Market Report*, 29]. The ARRA also removed the “double dipping” penalty, in which projects that received other federal subsidies besides the ITC or cash grant had the latter awards reduced in value. Now, full value of these programs is given to eligible projects, whereas past projects would have been somewhat restricted in regards to receiving funding from just one of the initiatives.

The ARRA also made additions to many crucial programs, many of which had recently been addressed through the Stabilization Act of 2008, that are going to be significant to the continuation of viable wind energy in the near future, as seen in Exhibit 2.7.

Exhibit 2.7[4]

2009 ARRA Allocations

PTC	Extended through 2012 at 21 cents per kWh
ITC	30% ITC also provided as optional 30% upfront cash grant through Treasury
ITC (Small Wind)	Removed capped dollar amount previously implemented by Stabilization Act of 2008
MTC	Created to serve as a 30% ITC for qualified manufacturers of renewable technology; capped at $2.3 billion
Loan Guarantee Program	Program expanded and appropriated $6 billion for implementation
CREB Program	$1.6 billion appropriated (in addition to $800 million added by Stabilization Act of 2008)

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[4] Data obtained from *2008 Wind Technologies Market Report*, 51.

International Policies[5]

Many foreign countries have similar policies to those in the United States to help spur the advancement and development of renewable energy generation. Europe has especially had a spike in development, partially due to the European Renewables Directive, which set country-by-country production numbers in terms of the amount of electricity generation a country should receive from renewable sources, based on that country's renewable potential. These directives, along with individual policies within the many countries of Europe, have made Europe a model for the world in terms of innovative policies directed at stimulating widespread renewable growth and generation.

France, who currently sits third in the European wind market, has its own set of aggressive policies that, when coupled with the European Renewables Directive, makes the continued outlook of wind expansion in France very promising. With a 21% target for renewable generation, France obviously has a lot of renewable generation potential. With the implementation of a feed-in tariff system in 2001-2002, which guaranteed an 8.2 Euro-cent per kWh tariff on wind generation – much higher than the United Stated PTC – wind energy saw a favorable forecast in France. Though France still does have the feed-in tariff, the law was amended in July 2005 to only allow the tariff applicable to wind farms constructed in designated regional "Wind Power Development Zones", which does somewhat limit the tariff's effectiveness across the country [34-35].

Germany, like France, also has a feed-in tariff system to help promote renewable generation. The German tariff, which has been in effect since 1991, pays the tariffs out on a generation percentage basis, in that only qualified wind projects between a 60% and

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[5] All of the material for this section has been taken from *Global Wind 2007 Report* unless otherwise noted.

150% reference yield as determined by the German government receive the tariff. Over a 20 year period, the average tariff ranged from 8.19 Euro-cent per kWh to a 5.17 Euro-cent per kWh, depreciating at a rate at 2% per year. Like France, Germany does slightly limit the tariff in that it can only be applied to qualified projects; however the lucrative amount the tariff offers still gives those potentially qualifying projects incentive for development [36].

Siting and Transmission

Two of the more serious issues often overlooked, especially with wind energy, are that large amounts of land needed, and that the land needs to be fairly accessible to existing electricity transmission for wind to be affordable. Wind turbines simply cannot be erected anywhere; first of all, they are obviously too large, and secondly, they need to be put in places where the wind blows sufficiently. Many times, potential wind sites are located in isolated areas of raw and undisturbed wilderness in which existing infrastructure does not exist, which makes the assembly of turbines in these areas nearly impossible, let alone the economic costs of connecting any generation to the grid. These are all problems that have to be thoroughly analyzed and scrutinized when discussing wind development, because if there is no place to put the energy and no way to transmit its electrical generation, then no amount of subsidy or tax will make any difference.

As previously mentioned, one of the main players with wind development is where it can literally be placed. The biggest factor in siting is that the resource – wind – has to be readily available; no wind, no electricity, no money. Spending millions of dollars on development at a site for wind energy is completely useless if turbines are placed in an area where the wind does not blow sufficiently. Wind is unlike hydroelectric generation, in that penstocks can be opened and closed to maximize the value of its energy output, while wind energy depends 100% on whether or not the wind is blowing. This is a major issue of resource scarcity. These unpredictable variables then subsequently narrow down the potential places for optimal wind development; but do these places even exist anymore? Have the few most potentially productive sites already been developed? Even if these sites do exist and the locations are fairly accessible, will permits be given to develop the site, or will there be opposition from interest groups and environmentalists? Again, a place with no wind means no electricity, which means no revenue; a serious problem considering the investment.

The potential for wind development faces many challenges even if potential sites do still exist and permits are available for site development. One of these problems, as alluded to earlier, is a problem facing many environmental initiatives – the problem of NIMBY, or "Not in My Backyard." Sure, everyone loves the idea of moving away from dependence on fossil fuels, but if that means erecting a wind turbine near someone's home, all of a sudden the idea of wind energy becomes stupid. Probably the most notable example of this is the Cape Wind project in Massachusetts, in which a large reason the project was abandoned was due to strong opposition from the wealthy summer residents of Cape Cod and the nearby islands of Martha's Vineyard and Nantucket. These people did not want large, offshore wind turbines disrupting their already million dollar views, even though the resource potential was very high. The easy answer to a problem such as this would be to then place the proposed wind farm on land, even if the location has sub-optimal wind resources. However, what if the proposed land site then has an environmental interest group strongly object because of the potential of bird kills? Or what if a group of hunters objects the wind farm because there is trophy hunting in the area and hunting will no longer be allowed on site for safety reasons? Issues such as these can cause serious delays in finding sites, obtaining permits, and can eventually cancel projects, all which inevitably waste enormous sums of money and need to seriously be taken into account when planning potential sites.

The problem of sub-optimal wind sites was mentioned earlier, but even if there are existing, undeveloped sites that could yield sustainable wind generation, these sites open up an entirely new issue; infrastructure and transmission. Roads are not likely to be readily available for use at these sites, and considering roads are necessary for the transportation, on-site construction, and maintenance of the turbines, they will have to be built. This raises more questions; are permits for the construction of these roads going to be granted? If so, how are these roads going to be funded? Are the costs of these roads budgeted into expenditure costs for the project? Will the construction of these roads be subsidized? Inevitably, if it is not possible to get a permit to build a road to the actual development site, then the project itself will never exist.

An issue that parallels the problems of infrastructure in regards to the isolation of potential wind development sites is the grid connectivity and transmission of the electricity. Like with roads, transmission lines and substations do not typically exist on top of a mountain range or in the middle of prairies. Therefore, transmission and grid infrastructure will also have to be built to service new developments. But what if the distance this energy has to be transmitted makes the cost of these infrastructure projects unreasonable? Even if the costs are subsidized in the future, the ability for transmission and grid upgrades is presently non-existent (Note: The ARRA does include provisions to spur new transmission, which include, but are not limited to, loan guarantee programs and transmission R+D, though the results of these provisions have yet to be seen) [*2008 Wind Technologies Market Report*, 51]. In the end, the ITC and PTC are completely worthless to new wind developments if the superseding costs of transmission and transmission development are financially unreasonable.

The siting battle, at times, can be a lose-lose situation for wind energy development, and renewable development as a whole. For example, large-scale solar energy projects in Arizona, where the energy potential is incredibly high, are stalling because of transmission issues. There is a lot of potential generation, but no way to efficiently and economically transmit it. With wind, a similar issue surrounds what was to be the world's largest wind farm in the Texas Panhandle; financed by famed energy investor T. Boone Pickens, the wind farm had to be put on hold due to the lack of transmission lines in the Panhandle, an issue that is not expected to be resolved in the near future ["T. Boone Pickens Cuts Order for Wind Turbines, Puts Panhandle Wind Farm on Hold."]. With wind, the generation battle may be won at one site, but at the same time, the transmission battle is lost, as per the above examples; vise versa, in one area, the transmission battle may not be a problem, but the generation potential may not sustain the investment.

The siting and transmission problems for the development of many fossil-fuel technologies are, by and large, much easier than it is for wind energy. Though most people would not want a coal-fired power plant or combined cycle gas turbine (CCGT) plant in the field next to their house, most probably would not mind having one on the outskirts of their town or city; almost as if as long as it is out of sight, it is out of mind.

As we already know, that cannot be said of wind farms. Furthermore, connecting one of these fossil-fuel plants to the grid is going to be a lot easier if it is on the edge of town rather than if it is on top of a mountain, which cannot be said for a wind turbine. The construction of one of these plants would also be a lot easier, as roads would likely already exist, and as already mentioned, transmission and grid connection would be a lot less expensive than wind. This then raises a serious question; why not subsidize a CCGT plant instead of wind energy? Not only is this electric generation more reliable than wind, it is more convenient, the most efficient technologies already exist, and siting and transmission problems are virtually non-existent.

Realistically, these are all hypothetical situations, but the reality of the fact is that all of these questions need to be asked about our current and future energy economy. Other questions such as the value of building a CCGT plant and guaranteeing electric generation to support load versus the greenhouse gas emissions avoided by not building one are questions and issues that need to be addressed. In the end, all of these hypothetical, but very real scenarios need to be evaluated and overcome in order to ensure the most economically and environmentally efficient method of electrical generation is provided.

After reviewing the information and data surrounding these historical and institutional aspects of wind energy, the evidence suggests that continued and expanded policies that provide economic subsidization and incentives for wind energy will be necessary for future large-scale investment and sustained development to be economically competitive with fossil-fuel based electric generation.

Theoretical and Analytical Framework of the Study

In this chapter, we provide analytical framework for evaluating the impact of subsidy on the viability of the development of wind and other renewable energy sources in comparison to existing fossil-fuel based generation. First, we examine a basic cost-benefit analysis for investment in both wind and conventional fossil-fuel generation. We then discuss the issue of subsidies versus taxes, and differences these two policies could potentially have on investment. Next we discuss some potential issues of social resistance and the actual value humans put on renewable energy, especially if it may interfere at all with their daily lives. Finally, we will discuss the intermittency issue, and problems associated with the installation of renewable energy and problems that arise due to the many variables that play into actual electrical generation from these sources. These are all fundamental issues that must be addressed in order to ensure the best, and most dependent, return on energy investments in the future.

Basic Cost-Benefit Analysis of Investment

Being the premise of the study, it is imperative to understand the essential elements that must going into an analysis of costs between fossil-fuel and wind electrical energy generation. First, it is important to understand the net present value calculations in the study, and what exactly they boil down to. Though the net present value calculations that are examined depend on the different variables and scenarios in which they are calculated under, they primarily depend on the discount rate, the life expectancy of the project, and how future costs are translated when combined with capital costs to determine the present value of cost. Net present value in itself basically represents the value of an investment; those investments with higher net present values therefore have higher overall return on investment. The present value of cost figure used in this study can be defined as “the current discounted value of a stream of costs over time”; effectively, these figures are a representation of the combination of all of the factors mentioned above – discount rate, life expectancy, and capital costs – to determine the net present value of the cost of investment, which is critical in comparing two similar investments and establishing which one is more valuable. In this study, higher present value of costs simply means higher costs, and represents less valuable investments.

For fossil-fuel generation, the constants are just that; fairly constant. Certain costs and benefits are almost guaranteed. First, there will be capital expenditures to simply obtain the components for and assemble the actual generation facility. These capital costs are also going to cover purchasing the actual site and any infrastructure, namely site costs and transmission developments, that are necessary for bringing the plant into operation and onto the electrical grid.

The next set of costs are going to be fuel costs, as some type of fuel is a necessity to create energy from a fossil-fuel generation facility. These costs, however, are not as constant, as there are likely to be variables, such as changes in supply and demand and new developments and increased extraction of reserves that can cause prices to rise and fall in short periods of time. Finally, annual operations and maintenance (O+M) costs are going to add to the present value of cost for fossil-fuel generation.

The costs for wind energy may be more predictable. Similar to fossil-fuel facilities, the initial capital costs for wind are going to involve turbine components, siting costs, and infrastructure and transmission costs. Annual O+M costs are also a factor in the cost of wind energy, and are generally lower than those of fossil-fuel facilities due to turbines only needed annual services (lubrication, etc.). However, for wind energy, a major factor is the fact that the fuel cost is going to be 0; wind is free, fossil-fuels are not. Though the price of fuel with wind energy will constantly be 0, the fuel itself – the wind – will play a serious role in the end benefit for wind energy, as we will see later.

Examining the benefit aspect, another constant for fossil-fuel based generation is the guaranteed electrical output its facilities provide. With the flip of a switch, gas turbines can be turned on and within a short amount of time produce baseload power, which provides an assured benefit in the revenue from the sale of that electricity. Therefore, when these facilities are producing electricity, they are guaranteed a return on investment. Wind generation, however, is not guaranteed such a return due to the simple fact that generation from wind turbines is dependent on the wind, which cannot be turned on with the flip of a switch. With the lack of guaranteed output from wind energy, there is no guaranteed benefit. This fact is why subsidies are essential to wind energy; though subsidies are needed because output is variable, they are needed more so because of the fact that there likely will not be enough output to justify the capital costs of the project. Therefore, these subsidies guarantee a return on investment by either reducing upfront capital costs or making up for time that the wind is not blowing and generating electricity by making the revenue from when the wind is blowing higher.

The Issue of Subsidy vs. Tax

Energy subsidies such as the PTC can be valued purely as a credit, as it rewards electrical energy generators that use wind for electrical energy generation and output. The purity of this credit falls into its relation to other tax-based policies regarding energy, such as a potential carbon tax for CO_2 emissions. As it can be assumed, this tax would act as a penalty for electrical energy producers that emit large-scale amounts of $CO_{2,}$ which would be set at a maximum amount and stringently regulated. Therefore, the fact that the potential exists for a producer to be rewarded for renewable output as opposed to taxed for CO_2 emissions and pollution output would make it seem that the existence of the PTC should spawn development, assuming such a policy as a carbon tax were enacted.

The theoretical value of the PTC as a subsidy comes into play when comparing it with a straight carbon tax. The PTC is realistically the complete opposite of a tax; it is a tax credit. Obviously, as previously discussed, a tax is a levy and literally a toll imposed for some type of action; in this case, electricity generators using fossil-fuels are facing potential profits and revenues from generation being seized through a tax solely based on by-products from the type of fuel they use to create electricity. This outcome then makes investments in wind energy more appealing and plausible, as generation with wind induces a tax credit, while fossil-fuel based generation induces a straight tax. This means that the viability of the PTC and subsequent wind development solely depends on other types of energies being taxed and wind energy not being taxed. This begs the question: if a carbon tax were to be established, would it be established to eradicate fossil fuel use all together, or only to the point where it can be seriously regulated through only a few large generators? Some municipalities have successfully implemented such taxes, such as Boulder, Colorado, whose Climate Action Plan taxes residential, commercial, and industrial properties that purchase electricity from fossil-fuel generation sources at the rates of \$0.0049/kWh (\$21 annually), \$0.0009/kWh (\$94 annually), and \$0.0003/kWh

($9,600 annually), proving that it is possible to successfully deter fossil-fuel generation from energy markets [Climate Action Plan Tax].

When looking at renewable wind energy as a whole, especially in relation to the PTC and also a potential carbon tax, the current energy situation and dependence in the United States must be strictly analyzed in terms of the criteria in which it is evaluated on. The value of wind energy has to be looked at in a few different ways. Is it valued solely as a renewable form of energy that will provide electricity at cost-efficient rates, all while sustaining our national energy security and preserving environmental health, or is it valued as a *necessary* form of energy, as fossil fuel resources, which our country is based on, continue to be depleted at alarming rates? Ultimately the switch to more renewable energies such as wind are going to have to be made, as common knowledge suggests fossil fuels are most certainly a finite resource. However, the value of this energy, right now, needs to be defined in regards to its environmental preservation and energy security qualities, as these factors provide most of the rationale behind the subsidies that currently make it viable.

The Intermittency Issue

One of the major problems regarding renewable energy generation, and one of wind energy's biggest enemies, is the problem of intermittency and guaranteed output. Investors in wind energy typically have to address a few major issues when they first begin the exploration process of developing a site for wind energy generation. One of these issues, and potentially the single most pressing economic issue surrounding wind energy development, is the massive upfront capital cost associated with purchasing the necessary equipment to erect wind farms. When looking at the PTC, investors generally approach these potential investments with large amounts of risk and uncertainty, as the PTC only subsidizes generation, not initial investment. Therefore, once the massive capital costs have been spent to install wind projects, there is no guarantee of return on investment; if the wind does not blow, turbines do not generate electricity, and therefore the PTC has lost all of its inherent value.

The truth behind no guarantee on a net benefit from wind energy development can be rationalized through the fact that there is no control over actual wind. Being a form of solar energy, wind is caused by numerous environmental factors; different topographical features and abnormalities on the surface of the earth, uneven heating of the atmosphere by the sun, and so on. Therefore, the ability to predict where and when the wind will blow is next to impossible. The aforementioned uncertainty of return on initial investments rides mainly on the idea that the wind is not always going to be blowing, and it is not always going to be blowing in a spot where wind turbines are sited. Considering the amount of capital necessary to make investments in wind, and the main subsidy coming only based on the amount of electrical generation that is output, the literal blowing of the wind determines whether or not such a large capital investment will have future net benefits. This can often be a daunting reality for investors to overlook, especially when dealing exclusively with the PTC, which again only subsidizes generation. This may not be as big of a turnoff if investors elect to opt for the ITC; however, the overriding issue that there is a large scarcity aspect with wind is not something that can be overlooked.

The issue of intermittency in regards to wind energy cannot be oversimplified. When the wind does not blow, wind turbines will not spin, and electricity will not be generated. No generation means no applicable PTC, and subsequently no revenue or net benefit from the investment in a wind energy development project. If wind energy was a large part of the American electricity load, the intermittency issue would be even more significant, as if the wind did not blow for an extended period of time, serious blackout issues would occur across the country. This is a major issue with making renewable energy systems a leader in electricity generation in this country.

This issue with making renewable energy systems a majority in terms of our reliance on electricity demands can be manifested in the fact that most of the significant renewable systems in place in the United States are weather-related (wind, solar, hydroelectric). This can be problematic solely because, as stated earlier, most of the weather patterns in the world are related. If the wind is not blowing to help generate electricity at a wind farm, there is a very good chance that storms containing rain are not moving into an area. Less rain then equates to less water necessary for hydroelectric generation. When the wind is not blowing, it could affect the amount of solar radiation and energy that reaches the earth's surface, depending on cloud cover in the atmosphere. This simultaneously affects the amount of energy collected by photovoltaic and other solar energy cells. This cyclical domino effect in regards to the weather at times can severely diminish the amount of electricity generated by already small amounts of renewable energy systems across the United States. Therefore, a solution to these issues will have to be developed in order for renewable energy systems to effectively support large quantities of electric load and take a lead in the energy demands of this country.

One solution to the intermittency problem does not lie so much in developing a way to have the wind constantly blowing around the globe, but rather alleviate some of the burden on wind generators who are expected to deliver certain amounts of generation at certain times. As is the case in Texas, if certain guarantees of output are not delivered by a wind generator, the costs of providing backup power are distributed evenly amongst all other generators. However, if coal, nuclear, or gas generators cannot meet and deliver load guarantees, they themselves are responsible for paying for the backup generation [“Natural Gas Tilts at Windmills in Power Feud", 1-2]. This system helps in not only reducing lost costs these renewable generators would have to pay to ensure backup for their generation guarantees, but would also aid in terms of revenues generated from the sale of the generation they do output and applicable subsidies they receive from that output, which otherwise might have to go directly to repaying the costs of backup generation and not to defraying the capital costs of the project.

The intermittency problem is not currently a major issue in the American energy economy because a majority of the energy is this country is not relied upon from renewable energy sources. Even if renewable energy was the backbone of American electrical generation, technology already exists in the form of fossil-fuel generation that can instantly create electricity to meet load demands across the country. This is a large debate, as how can a paradigm shift towards large scale renewable energy future for this country be delivered when right now small scale developments must have fossil-fuel generation plants as backup generation sources? The wind, rain, and sun can not be turned on with the flick of a switch so that existing renewable technologies can generate electricity; however, as previously mentioned, a coal burning or natural gas fossil-fuel plant can be turned on and soon after be creating electricity to keep up with load demands. Other subsidies may be developed to help make this problem less of a drawback, but at the end of the day the issue at hand will be the fact that electrical generation with renewable energy systems may not be able to handle the load, and this too is a major issue that needs to be overcome for renewable energy sources, especially wind, to continued to be marketable and desirable in the United States.

Empirical Tests of the Applying Variables that Affect the Present Value of the Cost of Energy

In this chapter, we examine different scenarios involving multiple variables, such as the ITC, PTC, and potential carbon taxes that will affect wind energy development in the United States. First, we will look at the empirical framework for our tests, and the data that will serve as a baseline for the test models. Next, we will use this data to make a central comparison between wind and CCGT electrical generation, and the present value of cost for each generation source without any externalities. Then we will analyze the effects of applying current and potential subsidies, taxes, and variable fuel prices on the cost comparison of the two central generation sources, and how these policies do and could, if implemented, affect the present cost of value for both projects.

Empirical Framework

First, the baseline comparison for these numerous scenarios will be installed capacity of 500 megawatts (MW) of electrical energy generation, one source being a combined cycle gas turbine (CCGT), fueled by natural gas, and 500 MW of wind-generated electrical energy. This roughly equates into one CCGT natural gas power plant and 333 1.5 MW standard wind turbines. Therefore, if one wished to erect 333 1.5 MW wind turbines, and wishes to know strictly what the economic cost of this project would be, the constants for this situation would be as follows[6]:

- Turbine Capital Costs: Capital costs for the components of one, 1.5 MW wind turbine are approximately $1,000,000
- Station Costs: Station costs, which can be defined as the permitting, infrastructure, and transmission development necessary for turbine development, cost approximately $350,000

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[6] Numbers derived from *Wind Turbine Design Cost and Scaling Model*, Pgs. 38-39

- Operation and Maintenance Costs/Land Lease Costs: These costs, per turbine per year, are approximately $50,000, and will increase at a constant rate of 0.5% per year to compensate for annual maintenance, depreciation in equipment due to age, constant repair, etc.
- Fuel Costs: Fuel costs will be $0, barring any unprecedented tax or tariff on wind capture
- The wind turbines will be operational 363 days out of the year, as they will be shut down 2 days out of the year for maintenance

These constants bring the total capital cost per turbine to approximately $1,350,000 per turbine erected, along with the additional O+M costs and land costs of $50,000 per year. In this scenario, the installed cost per turbine per kilowatt (KW) would be approximately $933. It is, however, important to note that these are all prices not yet exposed to any type of subsidy, including the PTC or ITC. Another important fact to reiterate is that with wind energy, the fuel cost is $0, because wind is free.

When looking at a CCGT plant, many of the same costs are going to be experienced as with wind turbine development, but as previously mentioned, one of the major added costs is the cost of fuel. The cost of natural gas, as with most fossil fuels, is extremely variable, and can shift rapidly and unexpectedly. As a baseline for this comparison, we will assume the following constants for the one, 500 MW CCGT power plant[7]:

- CCGT Plant Capital Costs: Capital costs for the gas turbines, heat recovery equipment, grid connectivity, plant siting, and permitting are approximately $500,000,000
- Operation and Maintenance Costs: The fixed O+M costs, not including fuel costs, are approximately $15,000 per MW-year, which equates to $7,500,000 per year; these costs will rise at a constant of 2.5% per year (see Appendix 2 for calculations)

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[7] Numbers derived from "New Combined Cycle Gas Turbine (CCGT) Generation Resource, Cost, and Performance Assumptions"

- Operational Fuel Costs: Fuel costs will be congruent to the current commercial price of \$10 per 1000ft^3 of natural gas [*Natural Gas Prices*, Nov. 2009] and will rise at a constant of 2% per year (see Appendix 2 for calculations)
- The CCGT plant will be operational 360 days out of the year, and will be shut down 5 days out of the year for maintenance

Fossil-Fuel and Wind Energy Central Comparison

First, it must be noted that all numbers and figures produced from the models in these empirical tests are being expressed in real terms; essentially, it is being assumed inflation will affect all present and future scenarios at equal levels. For our first two scenarios, we examine a realistic cost-analysis of the economics behind developing and installing the 500 MW wind farm and a 500 MW CCGT plant. In the model for the wind project, previous assumptions result in the initial capital cost being \$449,550,000. The initial capital cost was then broken down into annual costs over a timeframe of 25 years – which can be assumed to be the life expectancy of the project – and were the summation of annual fuel costs and annual O+M costs. Since annual fuel costs are \$0 for wind, the annual cost increased parallel to O+M costs at 0.5%. Under these conditions, the present value of cost for this project is seen in Exhibit 4.1 (also see Appendix 1):

Exhibit 4.1

Present Value of Cost for Unsubsidized Wind*

Discount Rate	Present Value Of Cost
0.01	838.1
0.03	755.2
0.05	695.7
0.10	606.4

*Costs expressed in millions of dollars

Similarly, in the model for the CCGT plant, the assumed conditions resulted in the initial capital costs being $500,000,000. Like in the wind model, the annual costs for the CCGT plant were also broken down over the life expectancy timeframe of 25 years, and were also the summation of annual fuel and O+M costs; however, unlike the wind model, the CCGT model had to take into account fuel costs greater than $0. Under these conditions, the present value of cost for this project is seen in Exhibit 4.2 (also see Appendix 2):

Exhibit 4.2

Present Value of Cost for CCGT*

Discount Rate	Present Value Of Cost
0.01	762.8
0.03	702.8
0.05	660.4
0.10	598.1

*Costs expressed in millions of dollars

When comparing the present cost of value for these two energy projects, we first must remember that the present cost of value is defined as "The current discounted value of a stream of costs over time" [Tietenberg, 620]. As it stands with these baseline figures, we can determine that currently, at no equivalent discount rate is the cost of the wind project less than the cost of the CCGT plant. Even though in this particular model the O+M for the wind project seems significantly lower, it is due to its application on a turbine by turbine basis; the difference in the cost is made up by the sheer number of turbines – 333 – that the O+M costs must be applied to. The fact that the O+M costs will rise at a slower rate (0.5% per year) do not take away from the large number of turbines that must be serviced, and compared to just one or two large gas turbines, and in the end that is what creates the disparity in cost.

The Effect of Applying Existing and Potential Policies

ITC

Though the previous models would do nothing but support the argument that renewable energy is simply not feasible or practical when compared to fossil-fuels, the reality of the entire energy debate is that policies exist that make renewable energy development much more viable. When some of these policies are introduced into the models, they essentially do their job in that they make wind energy costs competitive with costs of fossil-fuels. One such example is the ITC, which, when used as a 30% grant through the ARRA option, makes the amount of capital expenditures on a project substantially less [*2008 Wind Technologies Market Report*, 7]. As seen when comparing the present value of cost from both the ITC-impacted costs and the CCGT costs, the ITC makes all the difference in making wind economically practical. In the model, the applied 30% ITC drives down the initial capital cost for the wind project to the point where, even though O+M costs remain extensive, the stream of costs becomes lower than that of the CCGT (see Appendix 3, 4). The present value of cost when comparing the wind costs with the applied ITC and the CCGT can be seen in Exhibit 4.3:

Exhibit 4.3

Comparison of Costs: Wind with Applied ITC and CCGT*

Discount Rate	Wind with 30% ITC Present Value Of Cost	Wind with 16% ITC Present Value Of Cost	CCGT Present Value Of Cost
0.01	703.2	766.1	762.8
0.03	620.3	683.2	702.8
0.05	560.9	623.8	660.4

*Costs expressed in millions of dollars

Considering the 30% ITC provides developers for a substantial amount of their capital to be eradicated, it is important to realize its limitations. If the current ITC is diminished to any point where it falls below the level of providing a 16% upfront grant for capital costs, it reaches its critical value in that the CCGT then becomes more economically viable than the wind project when both projects costs are at a 1% discount rate, as seen in Exhibit 4.3 (also see Appendix 4). Though this is not the current policy, it is not unrealistic that existing policies could not be renewed or funding could be eliminated, which would again severely hinder the economic practicality that the ITC currently provides wind development.

PTC

When inserted into a model developed around the idea that, at best, a 500 MW installed wind project will capture 30% of its rated capacity, the existing PTC at 2.1 cents per kWh more than serves its purpose in aiding to reduce capital costs associated with wind energy development [*2008 Wind Technologies Market Report*, 50; Appendix 7]. After taking into account these conditions, as well as the original parameters of the baseline wind model, the 2.1 cent PTC was then applied to the resulting number of kWh (1,306,800,000), and resulted in an over two-thirds reduction in the present value of cost as compared to the unsubsidized wind costs. The present value of cost when comparing wind with the applied PTC and CCGT can be seen in Exhibit 4.4 (also see Appendix 3).

Exhibit 4.4

Comparison of Costs: Wind with Applied PTC and CCGT*

Discount Rate	Wind with 2.1 cent PTC Present Value Of Cost	Wind with 0.0025 cent PTC Present Value Of Cost	CCGT Present Value Of Cost
0.01	233.7	766.1	762.8
0.03	277.3	698.3	702.8
0.05	309.0	649.7	660.4

*Costs expressed in millions of dollars

These numbers also symbolize that, under the ARRA policy accords, if investors are willing to risk more on expected generation, the subsidy kickback can be significantly more from the PTC than the ITC, which, as previously stated, pays 30% of the upfront capital costs of investment (see Appendix 3).

As per the case with the ITC, the PTC also has its own set of limitations that can potentially affect its value as a subsidy in aiding widespread wind development. Information in Chapter 2 poses the issue of decreased wind development when the actual PTC policy is allowed to lapse, which is set to happen again in 2012 [*2008 Wind Technologies Market Report*, 7]. Obviously if the PTC is allowed to lapse investors will lose out, as the PTC is based on generation, unlike the ITC grant. Similarly, if the actual value of the PTC is diminished, it eventually will no longer harbor benefits for development. In this model, the critical value for the PTC is at or below $0.025 cents at a

1% discount rate, in which CCGT costs fall below that of wind with the applied, but diminished PTC, as seen in Exhibit 4.4 (also see Appendix 7).

CARBON TAX AND FUEL COSTS

Another scenario that makes wind economically competitive with CCGT projects is a carbon tax, which effectively taxes carbon dioxide (CO_2) emissions from fossil-fuel generation, and has been a topic of debate in the past in the effort to move towards renewable and sustainable energy in this country. As discussed in Chapter 2, the city of Boulder, Colorado charges residential, commercial, and industrial users a certain tax rate for their purchase of electricity from fossil-fuel generation sources. Similarly, a blanket carbon tax could be introduced to tax fossil-fuel generation sources for their respective CO_2 emissions, per ton per year in order to make electrical generation from said sources more expensive, which would inevitably drive up the demand for renewable energy. In this model, if a CO_2 tax of $15 per ton of CO_2 emitted is enacted, it almost exponentially increases the present value of cost for generation, as seen in Exhibit 4.5.

Exhibit 4.5

Present Value of Cost for CCGT with Applied Carbon Tax*

Discount Rate	Present Value of Cost
0.01	1,761.6
0.03	1,488.6
0.05	1,293.3

*Costs expressed in millions of dollars

Though for the initial model the commercial price of natural gas was set at $10 per 1000ft³, the expanded use of technologies such as hydrofracturing have made potential natural gas reserves, such as the Marcellus Shale in New York, more of a reality for development and increase the rate of extraction. In Appendix 5, a model constructed under these parameters shows that a 50% drop in the cost of commercial natural gas – from \$10 per 1000ft³ to \$5 per 1000ft³ - would subsequently make the cost of the CCGT even more economically viable than unsubsidized wind than it was when natural gas cost \$10 per 1000ft³. As seen in Exhibit 4.6, though the present cost of value for the CCGT does drop considerably if fuel costs are significantly diminished, it is important to note that the overall cost is still fairly high due to the constraints of large expenditures on annual O+M.

Exhibit 4.6

Present Value of Cost for CCGT with \$5/1000ft³ Fuel Costs

Discount Rate	Present Value of Cost
0.01	737.0
0.03	684.7
0.05	647.2

*Costs expressed in millions of dollars

When looked at individually, the carbon tax itself makes CCGT costs skyrocket; likewise, when natural gas prices are cut in half, it makes CCGT costs fall, making it even more economically viable than wind. However, as seen in Exhibit 4.7, when examining CCGT costs when natural gas is at \$5 per 1000ft³, coupled with varying carbon taxes at \$5, \$10, and \$15 per ton of CO_2 emitted, the combination of these two variables changes the scenario. Compared to unsubsidized wind costs at a 1% discount rate, CCGT costs in these situations only become economically viable when they are at a discount rate of 7%, natural gas costs are \$5 per 1000ft³, and the carbon tax is diminished to \$5 per ton. At this rate, the cost was \$793.4 million; however, the important thing to note is that the CCGT cost is discounted 7%. If unsubsidized wind is discounted to that rate, its cost drops to $652.2 million, once again becoming more economical than CCGT development.

Exhibit 4.7

Present Value of Costs for Different Natural Gas Prices and Rates of Carbon Taxation Compared to Unsubsidized Wind*

Discount Rate	NG $5/1000ft³ Tax=$15 per ton	NG $5/1000ft³ Tax=$10 per ton	NG $5/1000ft³ Tax=$5 per ton	NG $2/1000ft³ Tax=$5 per ton	NG $2/1000ft³ No Tax	Unsubsidized Wind
0.01	1741.6	1408.7	1075.7	1063.7	730.8	838.1
0.03	1473.1	1211.1	949.2	939.9	678.0	755.2
0.05	1281.0	1070.0	859.0	851.6	640.6	695.7
0.07	1140.7	967.1	793.4	787.4	613.7	652.2

*Costs expressed in millions of dollars

It is also important to continually note that in this comparison wind costs are unsubsidized; in any of these scenarios, if subsidized wind energy is compared to CCGT costs with the aforementioned reduced fuel costs and carbon taxes, the practicality of wind development becomes even more heightened. For example, if the costs for wind with the applied PTC are compared with CCGT costs under the $5 per 1000ft³ of natural gas/$5 per ton carbon tax scenario at a 1% discount rate, the results are astonishing; the present value of cost for wind is over $1.5 billion dollars less than that the present value of cost for the CCGT plant. Even if natural gas costs are driven all the way to $2 per 1000ft³ and the carbon tax is completely eliminated, the present value of cost for subsidized wind energy is still more economically viable than costs associated with the CCGT plant (see Appendix 3).

Conclusion

The analysis of the effect that subsidies and tax credits have on the economic viability of wind energy in comparison to that of fossil-fuel based CCGT generation reveals that these subsidy and incentive-based economic policies are in fact necessary for the realistic development of wind energy in the United States. Looking back to the first baseline comparison between an unsubsidized wind project and a CCGT plant, the present value of cost for CCGT generation will always be more valuable unless wind is discounted by some type or subsidy or tax credit, while the CCGT costs only make wind economically viable when they are subsequently mandated to pay a carbon tax that taxes the CO_2 emissions from their electrical generation.

For example, the large amounts of wind energy development seen during periods in which the PTC is in effect are a harbinger of how imperative it is for these subsidies and tax credits to be available to wind developers in order for continued development to happen. When this federal subsidy was not renewed, development trends would plummet downwards; when the policy was renewed, development would then again increase almost exponentially. This data and the indications drawn from the tests performed in this study seem to provide conclusive evidence as to why this phenomena is true, as the vast upfront capital costs for wind energy projects end up increasing the present value of costs to the point that without guaranteed subsidization of these costs – either on the front end with a subsidy such as the ITC or on the backend with the PTC – the future widespread development of wind energy in the United States is highly unlikely.

The evidence drawn from the tests in this study not only prove that economic subsidization is crucial for wind development, but also suggests that some type of financial penalty must be enacted for fossil-fuel generation plants. These penalties would most likely need to occur in the form of an emissions tax that would tax the greenhouse gas emissions from the generation of electricity at these facilities, much like the carbon tax seen in different models of this study. The enacting of these types of policies would, when coupled with subsidies aimed at renewable energy development, make the economic feasibility of renewable projects drastically more viable than those of new fossil-fuel projects. These policies could also potentially see future benefits and support from the environmentalist community, as the environmental benefits from the mitigation of fossil-fuel emissions from these generation sources would be seen as a victory in the push towards a more sustainable energy economy and future.

In future studies, there are limitations from this study that may need to be addressed and recognized to fully realize the costs and benefits from both wind and fossil-fuel electrical energy generation. In regards to the federal subsidies that serve as a backbone to the empirical tests in this study, the addition of any applicable state and local subsidies may make renewable projects more economically feasible than they appear in the data generated from models in this study. Though any state or local subsidies would likely be vastly smaller than subsidies at the federal level, these subsidies would result in differentiated costs as determined from the models in the study, so it is important that this fact is noted.

The intermittency issue in regards to the output of wind energy is also a topic that needs to be further investigated when discussing potential ways to improve the design of the empirical tests for this study. Realistically, installing 500 MW of wind energy is assuming that the 500 MW of installed capacity is going to always output at 100% of its rated capacity; however, the sheer nature of wind energy has in the past suggested that at any given moment only 30% of that rated capacity is being captured. This variably turns a 500 MW installed wind farm into a 150 MW wind farm. In order to ensure 500 MW of output under these circumstances, it would call for three times the amount of capital costs, which would likely have an adverse effect on the influence of subsidies and the overall economic viability of wind energy in comparison to fossil-fuels.

The actual revenues from the output of both wind and fossil-fuel based electrical generation must also be taken into account in future studies, as the amount of revenue created from the sale of electricity from wind energy is not as determinable as it is from fossil-fuel generation. Fossil-fuel generation sources can realistically produce energy throughout the day, resulting in these facilities having the benefit of taking in higher revenues during peak load times, such as early in the morning or later in the evening. Wind energy does not have that luxury. Wind generation occurs only when the wind is blowing, and if the wind only blows between 2 A.M. and 5 A.M., the price wind farms receive for their electrical generation will likely not be enough to justify the capital costs for development. Until innovations such as battery storage technology become readily available and can hold large amounts of electrical generation, and sell that generation during peak load periods, it will still be very hard for renewable energy sources to profit extensively from their output. However, if developed, this technology could benefit renewable energy sources immensely in maximizing future revenues, which is an issue that could be examined in detail in a future study.

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