The U.S. Wind Production Tax Credit – Evaluating its Impact on Wind Deployment and Assessing the Cost of its Renewal

by

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S.B. Materials Science and Engineering
Massachusetts Institute of Technology, 2011

SUBMITTED TO THE ENGINEERING SYSTEMS DIVISION IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN TECHNOLOGY AND POLICY
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2013

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Submitted to the Engineering Systems Division
on May 10, 2013 in Partial Fulfillment of the
Requirements for the Degree of Master of Science in
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ABSTRACT

The desirability, viability, and cost effectiveness of policies designed to incentivize growth of the wind energy industry are subject to widespread debate within the U.S. government, wind industry groups, and the general public. Specifically, extension of the wind production tax credit (PTC) is routinely contested whenever a scheduled expiration approaches. While proponents of the policy argue that the policy is necessary for the wind energy industry to continue to expand, opponents contend that the wind energy industry no longer needs the PTC in order to remain viable.

This thesis evaluates alternative wind energy incentive policies, the short- and long-term effect of the PTC on wind capacity and generation, and the ten-year projected costs and cost effectiveness associated with three PTC renewal options based on future wind capacity and generation projections. The primary lesson is that unless the wind energy industry grows at an exceptionally rapid pace over the next ten years, PTC renewal involves a tradeoff between total cost and cost effectiveness. If overall wind capacity continues to grow at an even faster pace than over the preceding ten years, allowing the PTC to expire at the end of 2013 is the cheapest and most cost effective option in terms of dollars per gigawatt of wind capacity installed or per kilowatt-hour of power generated from wind energy. If the wind industry performs at or below most current projections, renewing the PTC over the long-term is the most expensive, but most cost effective option. However, a more sustainable option could be achieved if the PTC and its frequent expirations and extensions are replaced with a long-term, predictable, and simple tax policy that is not a recurring source of uncertainty for the entire industry.

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Acknowledgments

Thank you to Dr. Frank O'Sullivan for serving as an advisor, guide, and mentor throughout my two years in MIT's Technology and Policy Program. His advice, encouragement, and expertise were instrumental in my research and completion of this thesis. I additionally appreciate his flexibility in allowing me to independently craft and pursue a research topic of particular interest to me.

I would like to thank the MIT Gordon Engineering Leadership Program for funding my thesis research through a teaching assistantship. I also truly appreciate the efforts of Michael Tarkanian, who provided me with the opportunity to serve as a teaching assistant for an enjoyable and interactive class and allowed me to develop, introduce, and oversee a new leadership training curriculum to supplement the class.

Thank you to my mom, dad, and two brothers, Allen and Brad. Their unconditional encouragement, love, and support are instrumental in all of my endeavors.

Lastly, I would like to thank my fiancée, Colleen, for supporting me through the challenges and enjoying all of the great memories we made during our years in Boston. She has made every seemingly mundane moment over the last six years priceless.

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Chapter 1. Introduction

The wind energy industry has enjoyed a period of rapid and sustained growth over the preceding decade, both in the United States and worldwide. In 2012, the U.S. installed more new wind capacity than in any previous year, and more new wind capacity was installed globally in 2012 than in any other year. Additionally, the U.S. and global markets have continued to generate more power from wind energy than in the previous year for every year since 1999. This growth has led to a rapid increase in the contribution of wind energy to the overall energy mix and has made it one of the most vital energy sources to the future viability of renewable energy.

As wind energy becomes a greater factor in the renewable energy mix, policies affecting its feasibility and growth play an increasing role in shaping the energy landscape and impacting the economic incentives associated with renewable energy production and consumption. One policy in particular, the U.S. wind PTC, has become the centerpiece of a massive campaign on behalf of the wind energy industry to secure a tax credit for the generation of wind energy. The PTC has been up for renewal multiple times over the course of its existence. Each time it is up for renewal, proponents of the policy tend to argue that its extension is necessary to the continual growth of the wind energy industry in the U.S. The dramatic reduction in newly installed wind capacity during previous wind PTC expirations is frequently cited as evidence of this trend. After the rapid and sustained growth recently enjoyed by the wind energy industry, however, opponents of the PTC have argued that the PTC is no longer necessary for the viability of the wind energy industry in the U.S., particularly as the most recent expiration approached at the end of 2012. With the PTC extended for only one additional year – it is currently scheduled to expire at the end of 2013 – this debate will only intensify as the end of 2013 approaches.

Given the frequent recurrence of wind PTC expirations and extensions, a more rigorous analysis of the U.S. wind energy market, the consideration of alternative strategies for incentivizing the expanded generation of wind energy, the short- and long-term effects of the PTC on wind industry growth, and a framework for evaluating the benefits and costs associated with PTC renewal are necessary to shape the debate over the future of the PTC. This thesis provides such context and a framework for evaluating extension of the PTC at various levels and over various lengths of time, as well as three case studies, each evaluating one possible PTC renewal scenario that could occur once the current PTC expires at the end of 2013.

To this end, the thesis proceeds as follows. Chapter 2 provides context for the rapidly growing U.S. wind energy market. Chapter 3 details the legislative history of the wind PTC, including its original passage into law and each subsequent expiration and extension. A comparison of incentives provided to nonrenewable energy industries in the U.S. to those provided to renewable energy industries is included in Chapter 4. Chapter 5 explains the benefit that can be attained through effective incentive mechanisms for the expanded generation of wind energy. Chapter 6 provides additional renewable energy incentive mechanisms that can be used in place of or in addition to the wind PTC, and Chapter 7 provides examples of policies that employ these incentive mechanisms. The short-term impacts of wind PTC expirations on wind capacity and generation in the U.S. are detailed in Chapters 8 and 9, respectively. Chapters 10 and 11 provide estimates for the total installed wind capacity and the annual wind power generation that would have been attainable in 2012 had none of the previous PTC expirations, and the subsequent dramatic year-to-year decrease in wind installations, occurred. These quantities are referred to as the "missing" capacity and generation, respectively. Chapter 12 features three case studies that project the wind capacity and annual wind generation attainable under three PTC renewal options, as well as the associated total costs and cost effectiveness of each policy. Finally, Chapter 13 provides recommendations for improving public policy decision making specifically as it pertains to incentivizing the expansion of the wind energy industry.

Chapter 2. The Growing United States Wind Energy Market

The U.S. wind energy market has sustained a period of substantial growth over the last ten years. Domestic wind capacity, wind power generation, and contribution by wind power to the overall power mix have all increased rapidly throughout the past decade. These trends are also generally reflected in the global wind energy market.

Wind Installations

Annual installations of wind capacity in the U.S. and globally are now at or near their highest levels ever. In 2012 alone, over 13 gigawatts (GW) of wind capacity was installed in the U.S., representing the largest domestic wind capacity increase in any single year – a 30 percent increase over the second-highest annual increase, which occurred in 2009 – and more than the previous two years combined. The U.S. now has over 60 GW of installed wind capacity, which is a 3,400 percent increase over the domestic installed wind capacity in 1996. Annual U.S. wind capacity additions and U.S. cumulative wind capacity over the years 1996-2012 are shown in Figure 1.

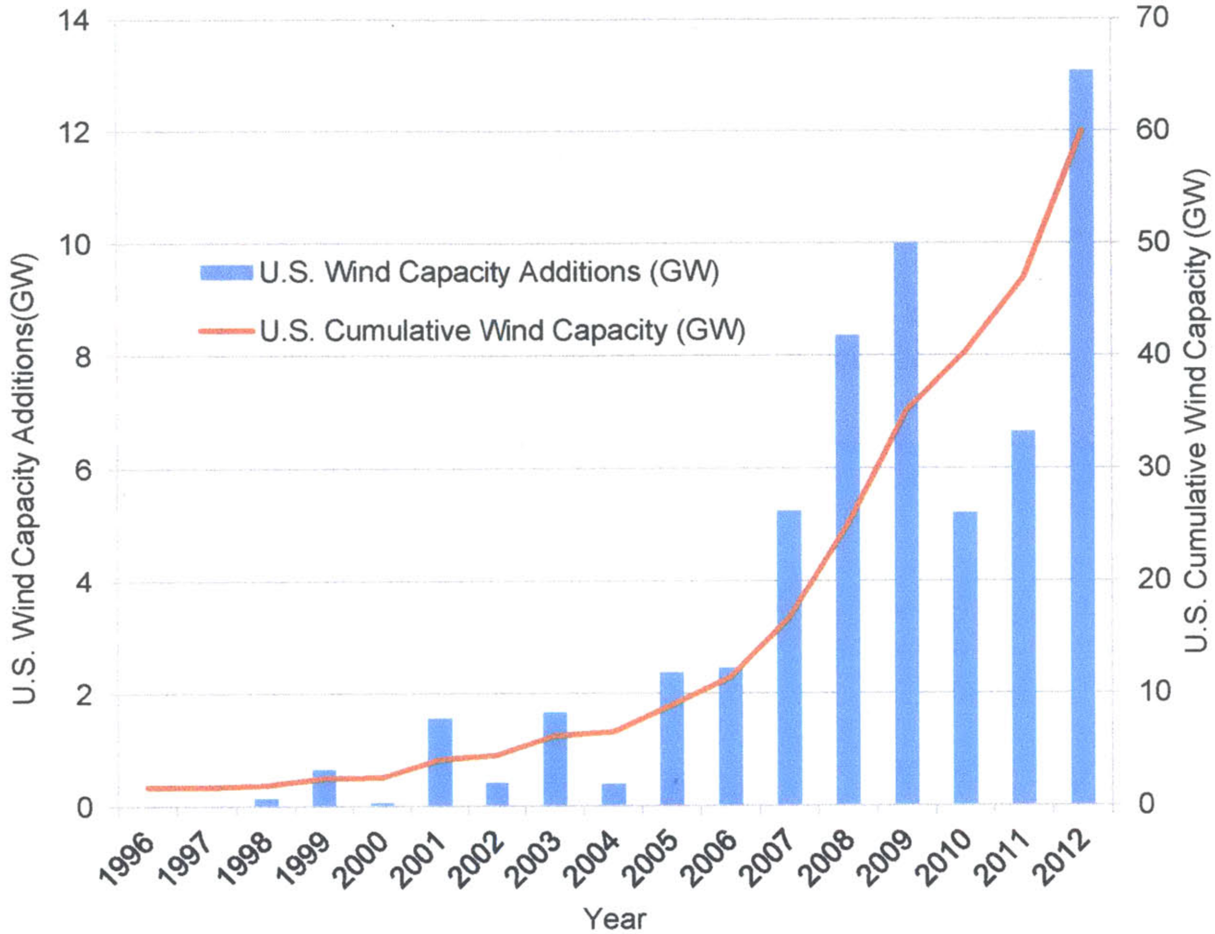

Figure 1. Annual additions and cumulative growth in U.S. wind capacity, 1996-2012 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012) (Bolinger & Wiser, 2008).

A similar rapid increase in wind energy capacity is observed globally over the past ten years. In 2012, over 44 GW of wind capacity was installed globally. This figure is the largest global wind capacity increase in any single year and marks the eighth consecutive year during which the global installation total was higher than that of the previous year. A total of over 282 GW of wind capacity are now installed worldwide – a 4,500 percent increase over the global installed wind capacity in 1996. Annual global wind capacity additions and global cumulative wind capacity over the years 1996-2012 are shown in Figure 2.

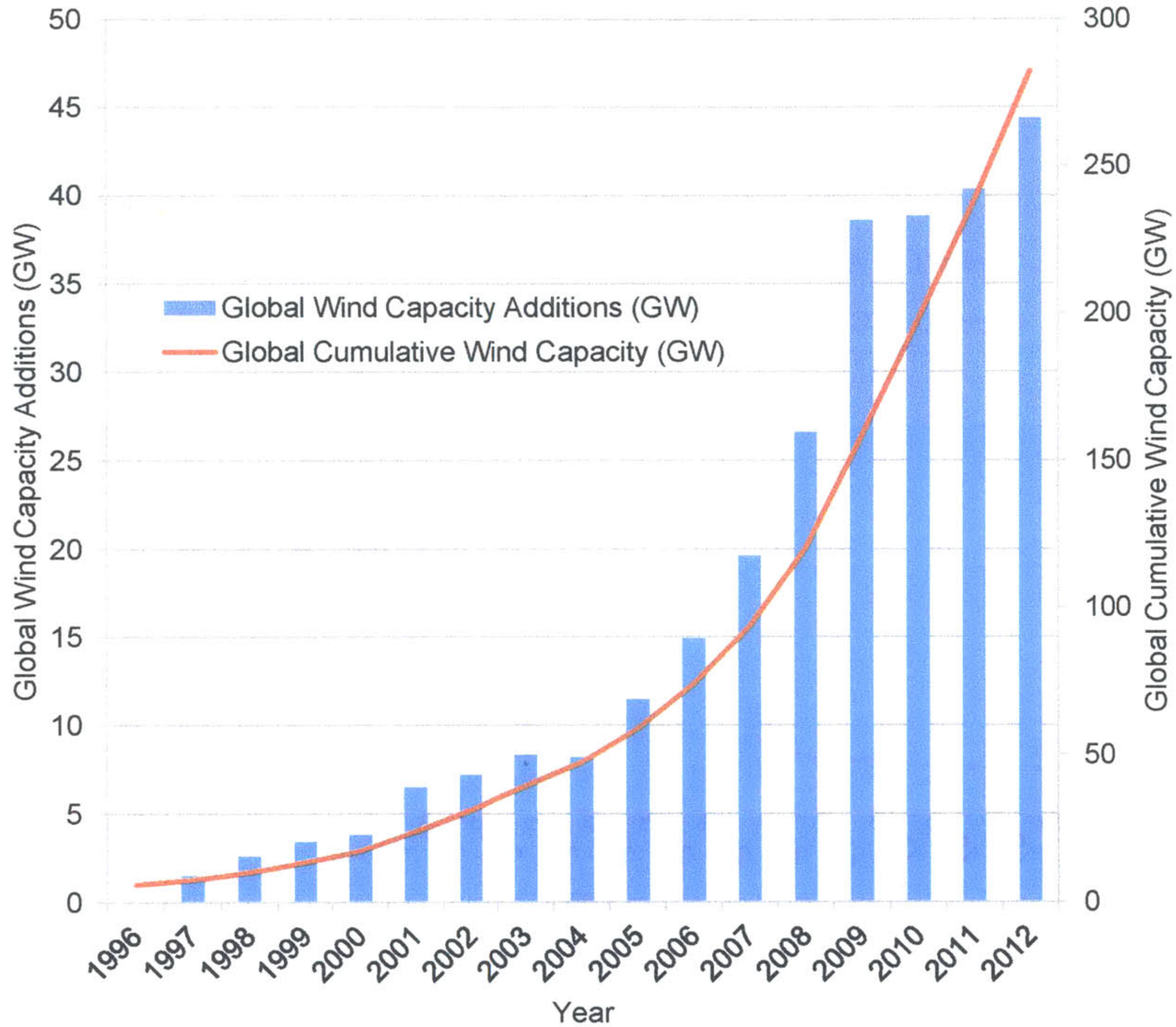

Figure 2. Annual additions and cumulative growth in global wind capacity, 1996-2012 (Global Wind Energy Council, 2013) (Bolinger & Wiser, 2008).

The U.S. has been a major contributor to the rapid increase in global wind capacity. In the 17 years between 1996 and 2012, the U.S. accounted for at least 15 percent of annual global wind capacity additions on ten occasions, with seven of those instances occurring after 2004. Furthermore, after accounting for an all-time low of less than 14 percent of global cumulative wind capacity in 2004, the share of global cumulative wind capacity installed in the U.S. has steadily increased to over 21 percent in 2012. That the rapid expansion of wind energy capacity in the U.S. throughout the last decade has not led the U.S. to account for a greater share of globally installed wind capacity is a testament to the "increasingly global spread of the wind power market" (Bolinger & Wiser, 2008). The U.S. share of annual global wind capacity additions and global cumulative capacity over the years 1996-2012 is shown in Figure 3.

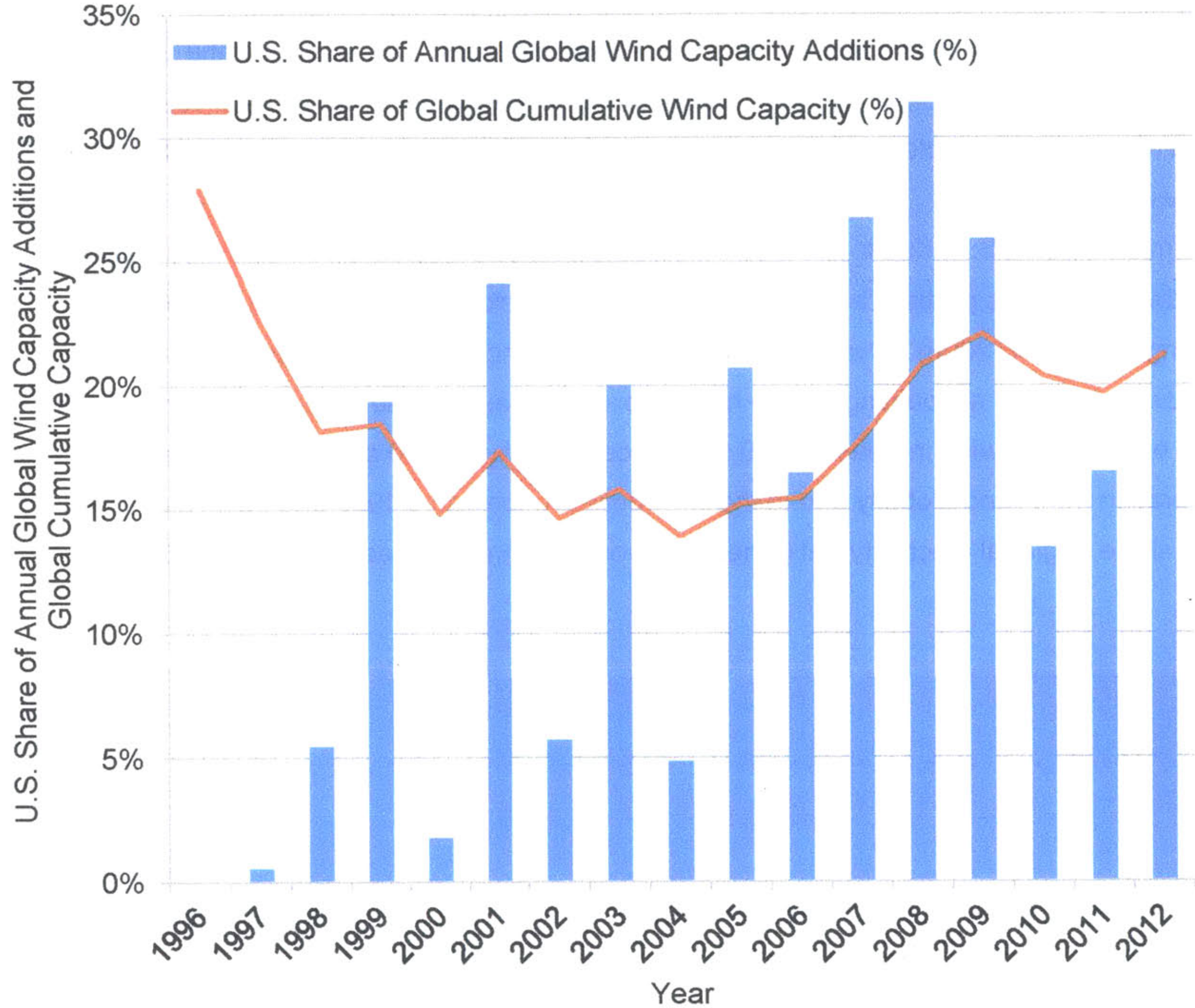

Figure 3. U.S. share of annual global wind capacity additions and global cumulative capacity, 1996-2012 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012) (Global Wind Energy Council, 2013) (Bolinger & Wiser, 2008).

Electricity Generation from Wind Energy

The rapid increase in installed wind capacity in the U.S. and globally has, not surprisingly, resulted in a rapid increase in electricity generated by wind power domestically and internationally. Annual electricity net generation by wind is now at its highest level ever in both the U.S. and worldwide. From 2010 to 2011, the most recent year for which complete U.S. Energy Information Administration (EIA) wind power generation data is currently available, the

U.S. increased its electricity generated from wind energy by 25 billion kilowatt-hours (kWh) – its highest ever annual increase. Nearly 120 billion kWh of electricity was generated from wind energy in the U.S. in 2011, which is a 27 percent increase over its 2010 total and a 4,200 percent increase over its 1990 total.

Despite the rapid increase in electricity generated from wind energy in the U.S., the U.S. share of annual global electricity generated from wind energy fell sharply in the 1990's and remained relatively stable, hovering between 18 percent and 28 percent, in the first decade of the twenty-first century. The reduced share of global electricity generated from wind energy occurring in the U.S. is due to the faster increase in electricity generated from wind power worldwide, which is partially a result of rapid global diffusion of wind energy technology (Bolinger & Wiser, 2008). Over 342 billion kWh of electricity was generated from wind energy worldwide in 2010, accounting for the highest ever annual increase. Electricity generated from wind energy worldwide increased by 9,600 percent between 1990 and 2010. The electricity net generation from wind globally and in the U.S. between the years 1990 and 2011 as well as the U.S. share of global electricity net generation from wind in each year is shown in Figure 4.

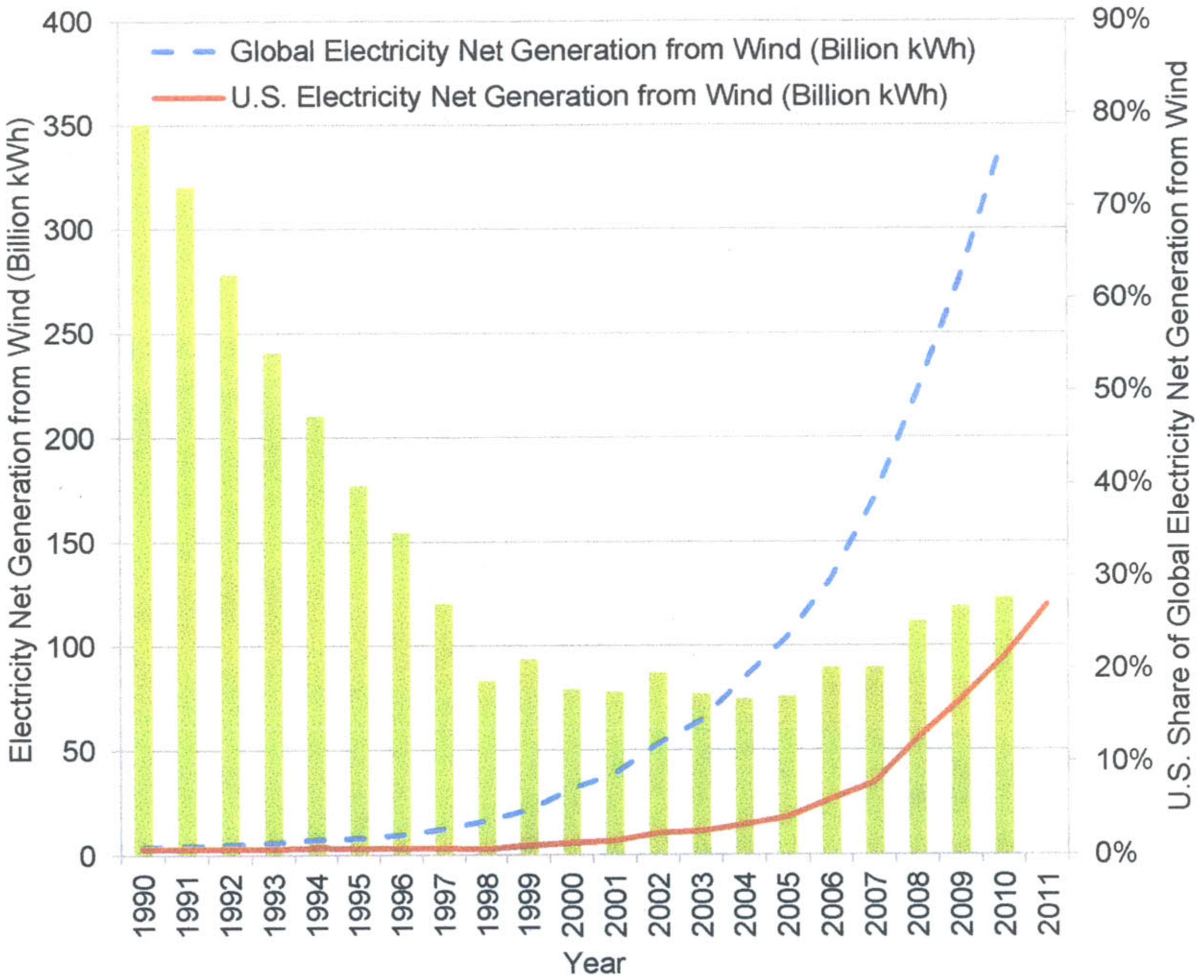

Figure 4. Global and U.S. electricity net generation from wind and the U.S. share of global electricity net generation from wind, 1990-2011 (United States Energy Information Administration, 2012).

Contribution of Wind Energy to the Power Mix

In the U.S., wind energy has also grown in its contribution to the domestic power mix since 1990. Electricity net generation in the United States has generally increased since 1990. As Figure 5 shows, annual domestic electricity net generation increased in all but four years between 1990 and 2011. Overall, net electricity generation increased by a total of over 35 percent between 1990 and 2011, or an average of slightly less than 2 percent per year. Figure 5 also shows the contribution to annual domestic electricity net generation by energy source. While accounting for less than 3 percent of the electricity generated in the U.S. in 2011, wind energy became the fifth largest source of energy for electricity generation and exhibited the second-largest increase of any energy source between 2007 and 2011 in terms of total energy supplied for electricity generation. Only natural gas achieved a greater increase in energy supplied over those years (United States Energy Information Administration, 2012).

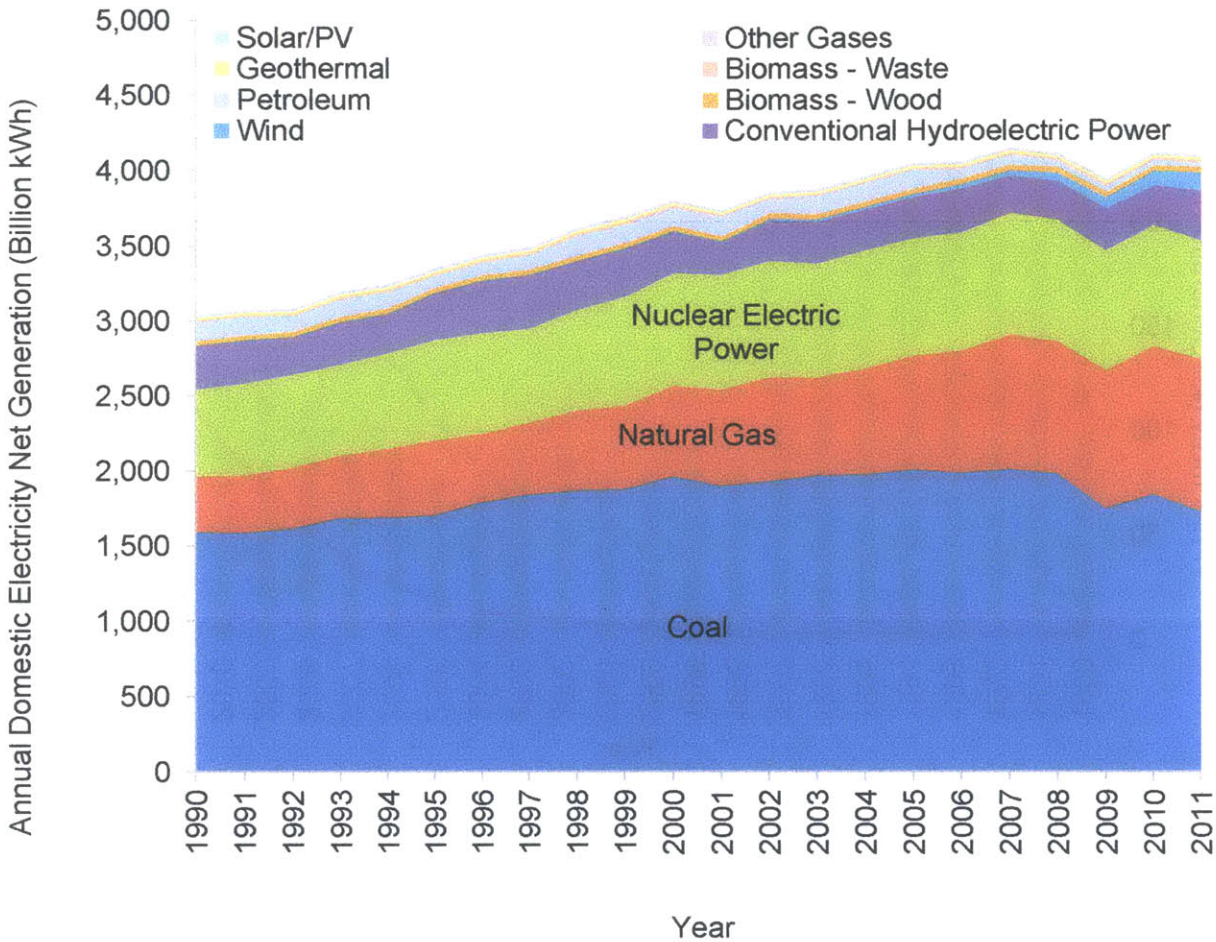

Figure 5. Annual electricity net generation in the United States by source, 1990-2011 (United States Energy Information Administration, 2012).

While electricity net generation has recently increased at a modest average of less than 2 percent per year to reach a total annual demand of over 4,100 billion kWh in 2011, the growth in the portion of electricity net generation supplied by renewable energy sources has outpaced the growth of total generation. Between 1990 and 2011, net electricity derived from all renewable sources increased by nearly 46 percent (United States Energy Information Administration, 2012). Within the rapidly growing renewable energy field, wind energy has experienced particularly pronounced growth. Electricity derived from wind power increased more than 42-fold between 1990 and 2011, accounting for nearly 72 percent of the overall growth in electricity generated from renewable sources during those years. Wind now accounts for more electricity generation than any other non-hydroelectric renewable energy source (United States Energy Information Administration, 2012). The growth of electricity generated by all non-hydroelectric renewable sources between 1990 and 2011 is shown in Figure 6.

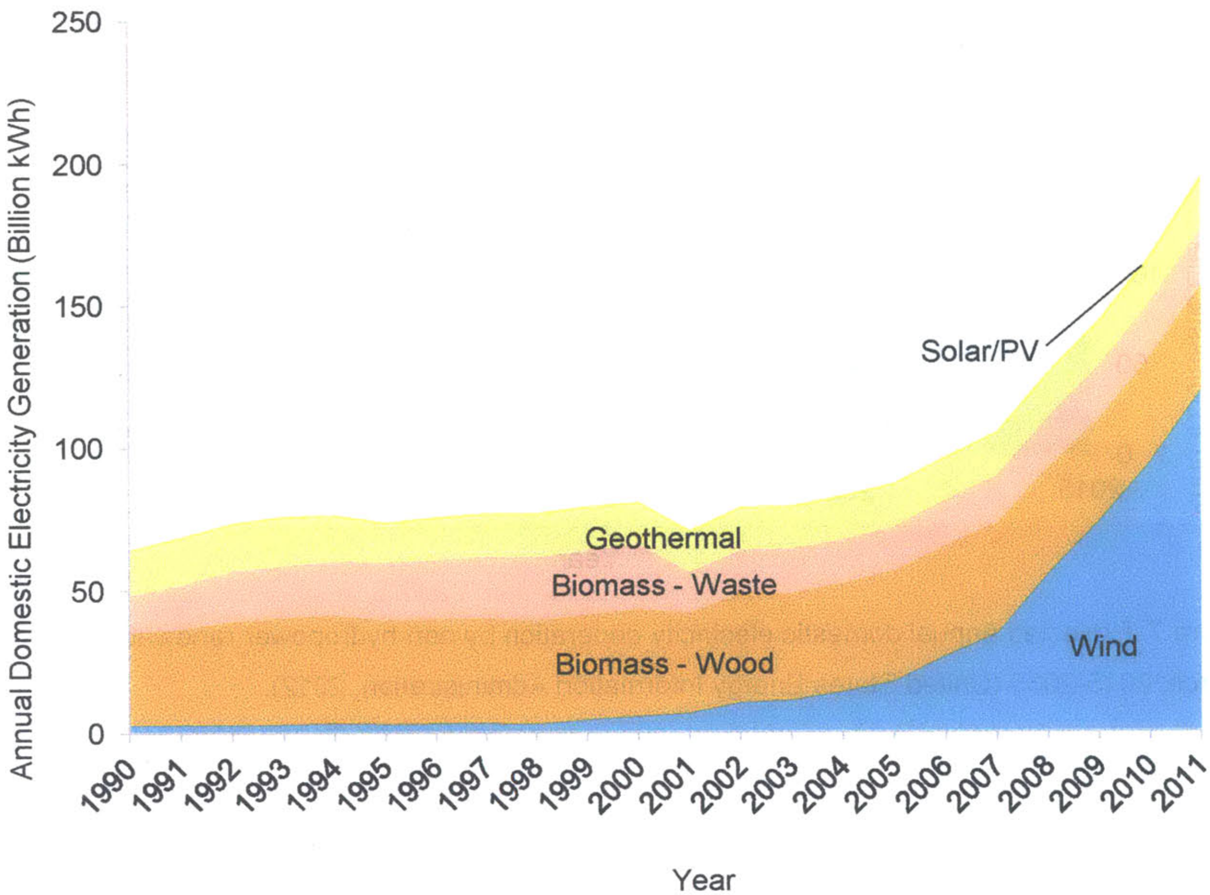

Figure 6. Annual domestic electricity net generation from non-hydroelectric renewable sources in the U.S., 1990-2011 (United States Energy Information Administration, 2012).

Projections of domestic electricity generation indicate that several major sources of renewable energy will continue to grow over the next twenty years, with wind continuing to account for the largest share of non-hydropower renewable electricity through 2035 (United States Energy Information Administration, 2012). Projected electricity generation for non-hydropower renewable energy sources for the years 2015 to 2035 are shown in Figure 7.

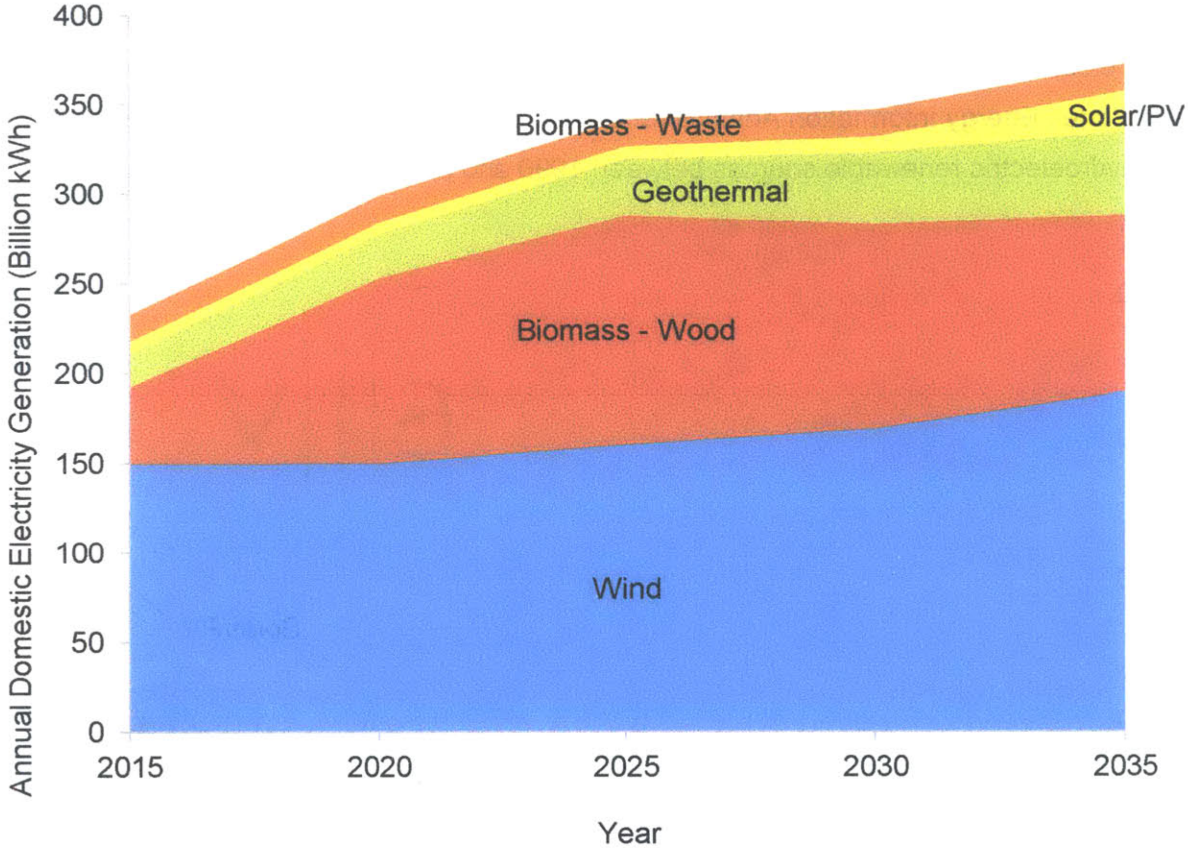

Figure 7. Projected annual domestic electricity generation by non-hydropower renewable energy source, 2015-2035 (United States Energy Information Administration, 2012).

No nonrenewable energy source was close to matching the 4,200 percent growth in electricity derived from wind energy between 1990 and 2011. During that time, electricity generated from natural gas came closest (172 percent), followed by nuclear electric power (37 percent), coal (9 percent), and petroleum, which actually decreased its contribution to the energy mix, accounting for 0.69 percent of U.S. electricity generation in 2011 (United States Energy Information Administration, 2012).

All major renewable energy sources grew in terms of electricity generation between 1990 and 2011, but none kept pace with the rapid growth of electricity generated from wind energy. Solar/photovoltaic (PV) energy came the closest to matching wind's increased contribution to the energy mix (394 percent), followed by waste biomass (49 percent), wood biomass (14 percent), conventional hydroelectric power (11 percent), and geothermal energy (8 percent) (United States Energy Information Administration, 2012). The total U.S. electricity generation by source in 1990 and 2011, as well as the change in annual U.S. generation between 1990 and 2011 and the share of annual U.S. electricity net generation as of 2011 are shown in Table 1. The U.S. domestic power mix as of 2011 is shown in Figure 8.

Table 1. Change in annual U.S. electricity net generation by energy source between 1990 and 2011, total generation by source in 1990 and 2011, and the share of annual generation by source as of 2011 (United States Energy Information Administration, 2012).

Energy Source	Total U.S. Generation, 1990 (Billion kWh)	Total U.S. Generation, 2011 (Billion kWh)	Change in Annual U.S. Generation, 1990-2011 (%)	Share of Annual U.S. Electricity Net Generation, 2011 (%)
Wind	2.79	119.75	4,194.15	2.92
Solar/PV	0.37	1.81	394.16	0.04
Natural Gas	372.77	1016.59	172.72	24.76
Biomass – Waste	13.26	19.79	49.21	0.48
Nuclear Electric Power	576.86	790.23	36.99	19.25
Biomass – Wood	32.52	36.95	13.60	0.90
Conventional Hydroelectric Power	292.87	325.07	11.00	7.92
Coal	1594.01	1734.27	8.80	42.24
Other Gases	10.38	11.27	8.53	0.27
Geothermal	15.43	16.70	8.20	0.41
Petroleum	126.46	28.16	-77.73	0.69

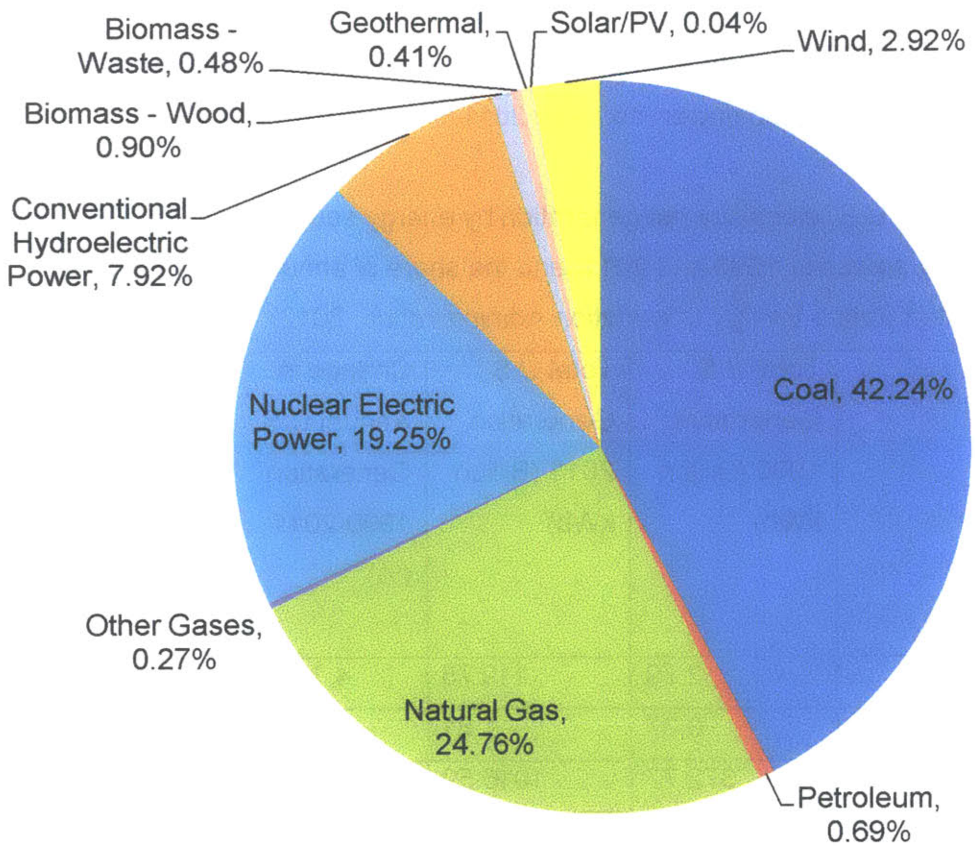

Figure 8. U.S. power mix, 2011 (United States Energy Information Administration, 2012).

While wind energy accounts for less than 3 percent of the total electricity generated in the U.S. on an annual basis, it now accounts for 61 percent of the electricity generated from renewable sources annually in the U.S. The non-hydroelectric renewable energy mix in the U.S. in 2011 is shown in Figure 9.

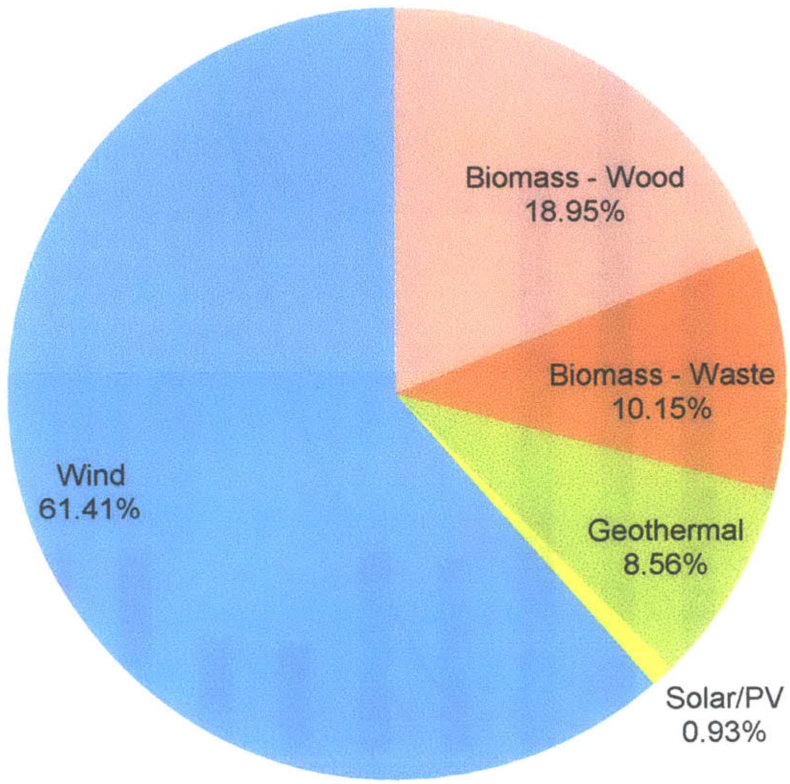

Figure 9. U.S. non-hydroelectric renewable power mix, 2011 (United States Energy Information Administration, 2012).

In addition to increasing its contribution to the U.S. power mix at a faster pace than any other source between the years 1990 and 2011, wind energy has accounted for a significant portion of new deployments in recent years. For each of the years between 2006 and 2010, wind energy accounted for at least 30 percent of the total electric capacity added in the U.S., peaking in 2009, when it accounted for 66 percent of all capacity additions (United States Energy Information Administration, 2012). The total annual domestic capacity additions from wind and from all other sources, as well as the corresponding percentage of all capacity additions provided by wind between 1999 and 2010 are shown in Figure 10.

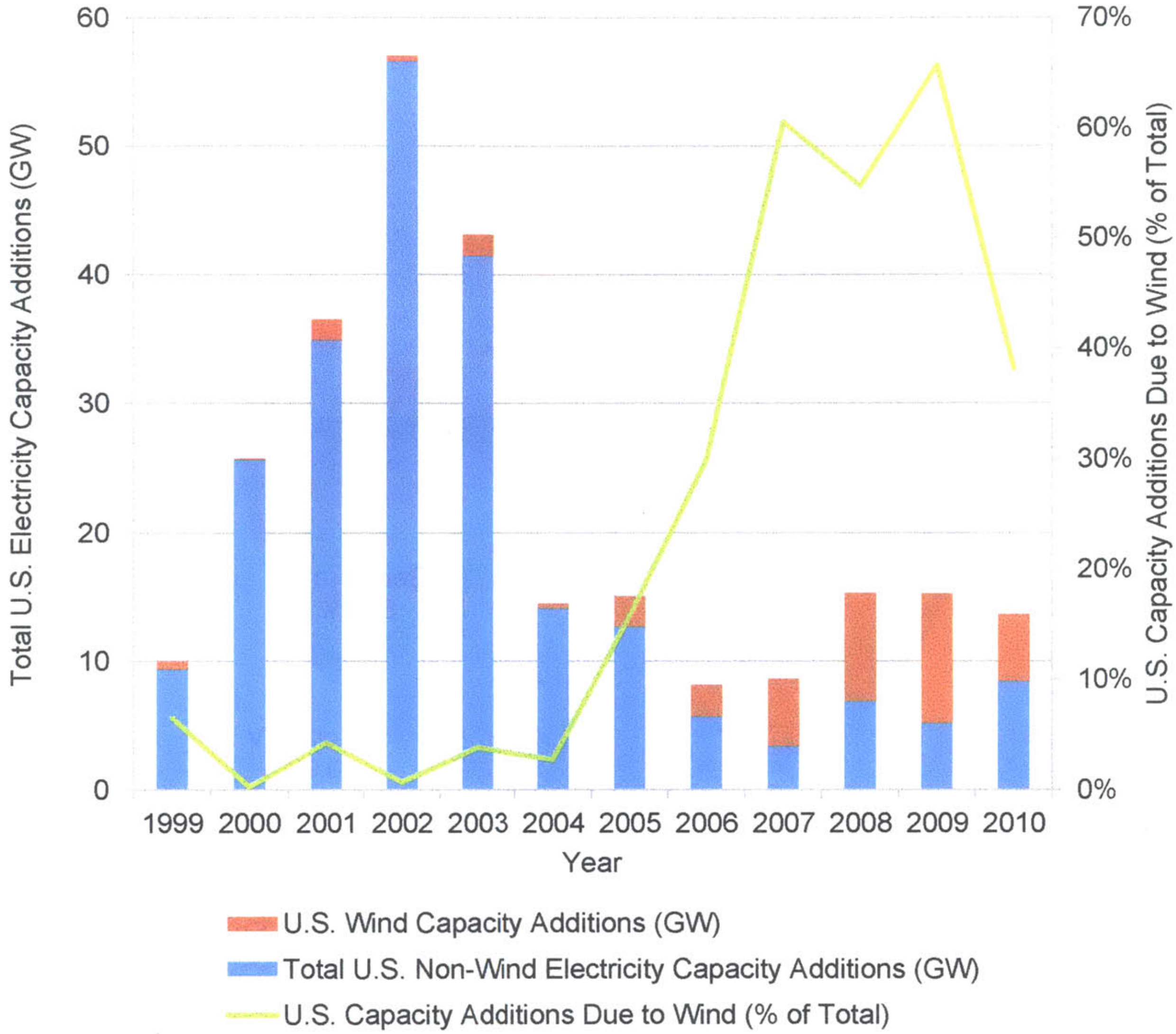

Figure 10. Relative contribution of wind energy in annual domestic capacity additions, 1999-2010 (United States Energy Information Administration, 2012).

Drivers of Wind Energy Growth

Major factors facilitating the significant growth of wind energy, both in nameplate capacity and in its contribution to electricity generation, include federal tax incentives such as the renewable energy PTC, state-level policies such as renewables portfolio standards, and cost and environmental concerns associated with nonrenewable energy sources (Bolinger & Wiser, 2008). The wind PTC "provides a ten-year, inflation-adjusted credit against income taxes" for wind energy facilities. As of 2013, the value of the wind PTC is 2.2 cents/kWh. The importance of the wind PTC to wind facility owners is revealed by a calculation of the pretax revenue provided to wind facility owners by the PTC. Assuming a particular wind project owner falls within the 35 percent federal income tax bracket, the 2.2 cents/kWh PTC provides [(2.2 cents/kWh)/(1-0.35)] cents/kWh, or $34/megawatt hour (MWh) of pretax revenue, available only for the first ten years of the wind project. Over 20 years, "the typical modeled life of a wind project," the incentive amounts "to roughly $20/MWh of pretax revenue, which in turn means that if the PTC were not available, wind power prices would have to rise by about $20/MWh" for the wind facility owner to obtain the same return without the PTC as can be obtained with the PTC (Bolinger & Wiser, 2008). Thus, the wind PTC has been an important contributor to the economic feasibility of wind energy production.

The recent and dramatic growth of wind energy capacity and generation in the U.S. relative to other sources of energy, the greater share of total U.S. power provided by wind energy, and the facilitation of such growth by policies such as the wind PTC underscore the growing impact that these and other policies affecting the wind industry have on the overall U.S. energy outlook.

Chapter 3. A History of the Wind Production Tax Credit

Since 1992, producers of various renewable energy sources in the U.S. have been provided a tax incentive in the form of the PTC. As one component of the *Renewable Electricity, Refined Coal, and Indian Coal Production Credit*, the PTC has been a source of economic and regulatory uncertainty for the U.S. wind industry. Since it was originally enacted as a component of the *Energy Policy Act of 1992* (Database of State Incentives for Renewables & Efficiency, 2013), the wind PTC has endured a series of expirations and renewals that have introduced substantial uncertainty in the wind energy market. Over its 20 year history, it has expired and been retroactively extended five times, each expiration having detrimental effects on the wind energy market in overall capacity and in market predictability. The PTC was extended on two additional occasions in anticipation of a scheduled expiration. Each renewal has been for four years or less, with the most recent PTC renewal providing only a one year extension. It is currently scheduled to expire on 1 January 2014. The effective start and end dates, as well as any associated expirations that occurred before the PTC was renewed, are displayed in Table 2. Note that in each instance the PTC expired, the eventual extension was applied retroactively to wind facilities placed in service during the expiration. Hence, some dates fall within an effective PTC range and within a period of time during which the PTC expired for the purposes of this table. A more detailed legislative description of each PTC extension follows.

Table 2. Effective start and end dates for the wind PTC and expirations during which the PTC was not in effect (United States Congress, 2013).

Act	Effective Start Date	Effective End Date	Expiration
Energy Policy Act of 1992	1 January 1994	30 June 1999	N/A
Ticket to Work and Work Incentives Improvement Act of 1999	1 July 1999	31 December 2001	170 Days (1 July 1999 – 17 December 1999)
Job Creation and Worker Assistance Act of 2002	1 January 2002	31 December 2003	68 Days (1 January 2002 – 9 March 2002)
Working Families Tax Relief Act of 2004	1 January 2004	31 December 2005	278 Days (1 January 2004 – 4 October 2004)
Energy Policy Act of 2005	1 January 2006	31 December 2007	None
Tax Relief and Health Care Act of 2006	1 January 2008	31 December 2008	None
American Recovery and Reinvestment Act of 2009	1 January 2009	31 December 2012	48 Days (1 January 2009 – 17 February 2009)
American Taxpayer Relief Act of 2012	1 January 2013	31 December 2013	1 Day (1 January 2013)

Energy Policy Act of 1992

The wind PTC was introduced in 1992 as part of the *Energy Policy Act of 1992* (P.L. 102-486), which passed the House of Representatives by a 363-60 vote, passed the Senate by a 93-3 vote, and became public law on 24 October 1992. In sec. 1212(e)(1), the bill allocated payments "to the owner or operator of any qualified renewable energy facility ... based on the number of kilowatt-hours of electricity generated by the facility through the use of solar, wind, biomass, or geothermal energy" (United States Congress, 1992). The payment for any facility was 1.5 cents per kilowatt-hour "adjusted for inflation for each fiscal year beginning after calendar year 1993" (United States Congress, 1992).

Production Tax Credit Expiration in 1999

The wind PTC enacted in 1992 was allowed to expire in 1999. According to the *Energy Policy Act of 1992*, the term "qualified facility" refereed to "any facility owned by the taxpayer which is originally placed in service after 31 December 1993 ... and before 1 July 1999" (United States Congress, 1992). Without further legislative action, no wind facilities placed in service after the July 1999 expiration would qualify for the PTC.

Ticket to Work and Work Incentives Improvement Act of 1999

The *Ticket to Work and Work Incentives Improvement Act of 1999* (P.L. 106-170), which passed the House by a 418-2 vote and the Senate by a 95-1 vote and was enacted on 17 December 1999, extended the wind PTC for three additional years. Sec. 507(a)(3)(A) specifically changed the definition of a "qualified wind facility" to include "any facility owned by the taxpayer which is originally placed in service after 31 December 1993 and before 1 January 2002" (United States Congress, 1999). The act also extended the PTC to include electricity produced by closed-loop biomass facilities and added a PTC for poultry waste facilities (United States Congress, 1999).

Job Creation and Worker Assistance Act of 2002

After expiring at the beginning of 2002, the PTC was again extended on 9 March 2002 by the *Job Creation and Worker Assistance Act of 2002* (P. L. 107-147). The bill passed the House by a 417-3 vote and the Senate by an 85-9 vote and extended the wind PTC to include any facility placed in service before 1 January 2004 (United States Congress, 2002).

Working Families Tax Relief Act of 2004

The PTC was once again extended on 4 October 2004 by the *Working Families Tax Relief Act of 2004* (P.L. 108-696), which passed the House by a 339-65 vote and the Senate by a 92-3 vote. It extended the PTC to include facilities placed in service by 1 January 2006 (United States Congress, 2004).

Energy Policy Act of 2005

The *Energy Policy Act of 2005* (P.L. 109-058), signed on 8 August 2005, included the third consecutive two-year extension of the PTC. After passing the House by a 275-156 vote and the Senate by a 74-26 vote, the act extended the PTC to include facilities placed in service by 1 January 2008 (United States Congress, 2005). The *Energy Policy Act of 2005* also expanded the PTC to apply to certain hydropower facilities (United States Congress, 2005).

Tax Relief and Health Care Act of 2006

The *Tax Relief and Health Care Act of 2006* (P.L. 109-432) was signed into law on 20 December 2006. The bill passed the House by a 367-45 vote and the Senate by a 79-9 vote and only extended the PTC for one year by applying the PTC to facilities placed in service by 1 January 2009 (United States Congress, 2006).

American Recovery and Reinvestment Act of 2009

The *American Recovery and Reinvestment Act of 2009* (P.L. 111-16) passed the House by a 246-183 vote and the Senate by a 60-38 vote, both votes taking place largely along party lines. It was signed into law on 17 February 2009 and extended the PTC to apply to all wind facilities placed in service by 1 January 2013 (United States Congress, 2009).

American Taxpayer Relief Act of 2012

The *American Taxpayer Relief Act of 2012* (P.L. 112-240), which was signed into law on 2 January 2013, extended the wind PTC to apply to all wind facilities placed in service by 1 January 2014 (United States Congress, 2013). The bill passed the House by a 257-167 vote and the Senate by an 89-8 vote.

The Existing Wind Production Tax Credit

The existing wind PTC is included on IRS Form 8835, *Renewable Electricity, Refined Coal, and Indian Coal Production Credit.* It shows the current rate of the production tax credit is 2.2 cents per kWh produced for all wind energy facilities (Department of the Treasury Internal Revenue Service, 2012). The 2012 version of IRS Form 8835 is shown in the Appendix.

Chapter 4. Incentives for Nonrenewable Energy Production in the United States

Evidence that consistent, reliable energy policies can facilitate a stable energy market is demonstrated by the U.S. policy approach to fossil fuels. In contrast to the sporadic policy approach to wind energy is the clear, consistent policy signal provided to fossil fuels. Many energy incentives, including the well depletion allowance and the expensing of intangible drilling costs, are permanent components of the Internal Revenue Code and have been in place since before 1940 (American Wind Energy Association, 2011). Partially due to these permanent policies, electricity derived from fossil fuels has experienced consistent growth over several decades. In fact, since 1950, annual domestic fossil fuel consumption in electricity production has increased over the previous year in 50 out of 62 years (United States Energy Information Administration, 2012). Importantly, many of the decreases in fossil fuel consumption corresponded with economic contractions, indicating that demand for electricity is subject to economic fluctuations. The repeated expirations and renewals of the PTC have subjected the wind industry to both economic fluctuations and policy fluctuations. While several contributing factors explain the consistent growth of fossil fuel use in electricity production over the last six decades, it is clear that long-term, permanent tax incentives benefit the industry by providing policy predictability and stability that is not provided to the wind industry.

The history of permanent fossil fuel tax incentives and how they evolved is evidence that a permanent tax structure can be secured for the wind industry. While the tax code as applied to fossil fuels has remained relatively stable for several decades, there was a period of rapidly changing incentives for fossil fuels before consistent incentives were renewed for the long term. The well depletion allowance originated in 1913 as an arbitrary "five percent deduction of the gross value of [mining and oil] products." By 1916, industry representatives "lobbied Congress that the five percent deduction was insufficient to account for capital lost to depletion." What followed was the revised depletion provision of 1916, which replaced the five percent deduction with "a reasonable allowance for actual reduction in flow and reduction." Industry representatives then claimed that "their costs were too low to generate a meaningful depletion unit to affect their taxes" and that oil producers should be allowed to "revalue their investment to consider not only what the land originally cost..., but what the discovery of oil there was worth." Congress answered in 1918 with a policy known as "discovery depletion," which "granted the privilege of depletion based on revaluation to new discoveries" rather than based on the original worth of the land. The depletion allowance was again adjusted in 1926 to encourage drilling by providing a uniform 27.5 percent depletion allowance for natural gas and oil. The depletion allowance then went unchanged for 43 years, and it has been modified only slightly since then (Independent Petroleum Association of America, 2012) (Shulman, 2011).

Some aspects of the fossil fuel industry may make its regulatory evolution atypical. For example, the long-term tax incentives for oil exploration and production began to form during and shortly after World War I, a war that required the U.S. to rapidly expand its domestic access to energy in order to meet urgent military objectives. Hence, the fossil fuel industry lobbied Congress that consistent tax incentives were vital to the nation's interests. Furthermore, fossil fuel extraction necessarily leads to the depletion of assets in that as the fuel is extracted, the resource is depleted. Most industry operations involve the natural devaluation of assets and capital over time, but few industries experience the rapid and permanent depletion of assets to the extent of fossil fuel industries (Shulman, 2011). These characteristics of oil and gas industries provided leverage to lobbyists who argued for consistent and generous tax incentives.

Despite differences between the fossil fuel and wind industries, the turbulent origins of fossil fuel tax incentives provide evidence that wind energy may eventually obtain a consistent, long-term tax policy. Because of the differences between the industries, however, there may be little for the wind industry to learn directly from the history of oil and gas tax incentives. The military and national security benefits provided by oil and gas were perhaps the most consequential characteristics in securing support. Today's wind industry provides economic arguments in favor of long-term tax incentives similar to those offered by early twentieth century oil and gas industries, but wind energy does not provide an urgently needed resource for national security purposes. If there is anything for the wind industry to learn from the oil and gas industries, it is to emphasize the long-term national security advantages associated with domestic renewable energy.

Divergent Policies toward Conventional and Renewable Energy Sources

Today, there is a widespread concern in the renewable energy industry that there is a lack of industrial equity between conventional and renewable energy industries. "U.S. government subsidies for oil, natural gas and coal have totaled over $500 billion from 1950 to 2006," and in 2007 alone, fossil fuels received over $5 billion in energy incentives, while incentives for all renewable energy sources totaled about $1.2 billion. Such a discrepancy leads the American Wind Energy Association (AWEA) to allege that there is an "un-level playing field" in the area of U.S. energy incentives. It claims that the established industry benefits from energy production incentives that far exceed those provided to the emerging industry, thereby giving the emerging industry little hope of competing with the established industry without a change in policy. While the AWEA uses this controversy to support renewal of the wind PTC, the controversy is evidence of a greater underlying discrepancy in energy incentives – the fossil fuel industries benefit from incentives that "are permanent in the tax code and have been in place since the 1920's" in some cases, while the wind PTC has never been in effect for more than seven consecutive years without need for a renewal (American Wind Energy Association, 2011).

The long-documented policy differences between the fossil fuel industry and renewable energy sources, highlighted by renewable energy industries as evidence of an "un-level playing field," is primarily motivated by inertia – the older industry benefits from essentially permanent tax incentives that have been in place for decades while the newer industry struggles to secure a more predictable policy. Opponents of the wind PTC point out that wind and other renewable energy sources are not at an unfair disadvantage when current production level is considered. In fact, in 2010, renewable electricity industries "received 21 percent of the federal energy benefits while accounting for less than 3 percent of domestic energy production that year, when oil and gas, which provided 49 percent of U.S. energy production, received less than 8 percent of these benefits." (Styles, 2012) (United States Energy Information Administration, 2011). Although these data do not account for projected future production levels, they do not appear to support claims that Congress disproportionately favors fossil fuels over renewables in terms of current production. Therefore, the fossil fuel incentives persist not necessarily because of disproportionately favorable treatment but because they are essentially permanent in the tax code, while the wind industry incentives remain temporary because of the perpetual binary argument between PTC expiration and extension. The result is an imbalance in regulatory stability in competing industries that inhibits natural, long-term growth in the wind energy industry.

Chapter 5. The Benefit of Effective Wind Energy Incentive Mechanisms

Promoting the wind energy industry is beneficial for the country's welfare because of the environmental benefits offered by wind energy and the technical potential for wind power in the U.S. "Electricity generation is the largest industrial source of air pollution in the U.S.," and increased wind energy reduces demand for energy generated from fossil fuels. In fact, "wind power alone could lower emissions by 150 million tons of carbon dioxide [by] 2020, avoiding nearly 33 percent of expected emission increases in the electric sector." Additionally, "[w]ind power requires no mining or drilling, and [e]missions from the manufacture and installation of wind turbines are negligible." (American Wind Energy Association, 2008). While several other renewable energy sources offer environmental benefits, the wind industry is among the most technically advanced and promising sources of near-term environmental benefits. Wind power technologies collectively rank second in terms of total potential generation in the U.S., only behind solar power technologies (Lopez, et al., 2012). Wind capacity in the U.S., however, is currently 45 times greater than total installed solar capacity (United States Energy Information Administration, 2012), indicating that the solar power industry is not yet poised to deliver the substantial environmental benefits that wind energy can provide. Therefore, long-term tax incentives that benefit the wind industry are particularly beneficial.

Chapter 6. Existing Renewable Energy Incentive Mechanisms

Policymakers have available to them a variety of mechanisms designed to incentivize the increased use of renewable energy sources. Policy mechanisms can incentivize renewable energy inputs, such as the building of renewable energy facilities or the manufacture of renewable energy equipment, or they can directly incentivize quantifiable indicators of renewable energy growth, such as by incentivizing increased renewable energy capacity or increased renewable energy production. Renewable energy incentive mechanisms can also directly and indirectly incentivize a combination of any of these indicators. The effectiveness of an incentive mechanism is highly dependent on the extent to which the policy directly addresses any market failures that impede increased use of a technology (Gillingham & Sweeney, 2010). Several existing renewable energy incentive mechanisms include the renewable energy production tax credits, feed-in tariffs, fixed tariffs, and auction and quota systems.

These are only a few of the many existing and proposed policy mechanisms for incentivizing wind power development. They were chosen based on the availability of information associated with their use and effectiveness and their use in countries which have greatly increased their installed wind capacity over the preceding decade.

Production Tax Credits

PTC's are performance-based tax policy mechanisms that directly incentivize energy production from specific renewable energy sources. A PTC is simply a tax credit provided to facilities that produce energy from qualifying renewable sources based on number of kilowatt-hours produced and sold (Department of the Treasury Internal Revenue Service, 2012). PTC's can also indirectly incentivize the building of renewable energy facilities because facilities often must be placed in service before a specified deadline in order to qualify for the tax credit over a number of subsequent years. While such a requirement does not directly incentivize the building and placing in service of a renewable energy facility, it can incentivize facility operators to expedite the construction of a facility in order to place the facility in service prior to a specific deadline and qualify for the tax credit over the following years.

There are several notable benefits offered by PTC's. First, by directly reducing the cost to produce and sell renewable energy, the PTC incentivizes the end product of renewable energy sources. As such, it is difficult for facility operators to manipulate the PTC or earn a tax credit without legitimately providing consumers with energy derived from renewable sources. An additional benefit of the PTC is that it is cheap and simple for policymakers to administer and for facility operators to understand. In most cases, it is a constant inflation-adjusted monetary credit for each kilowatt-hour produced and sold over a period of time for all qualified facilities. The clear, concise, and simple nature of most PTC's minimizes administrative or compliance costs to qualified facilities.

The primary drawback of the PTC is that its simplicity begets a lack of permanence. Because it is straightforward, it can be terminated and reinstated without significant strain on administrative resources. As is discussed below, the U.S. wind PTC has experienced repeated, short-term expirations and renewals. An additional weakness of PTC's is that they can be criticized as costly to other taxpayers because they are selectively applied to specific industries that policymakers consider favorable. Because the PTC is an independent tax policy that applies only to specific industries, it can be criticized as a handout for favored firms or industries. While a PTC is intentionally designed to assist specific industries, renewable energy producers would receive the same monetary benefit from equivalent reductions in existing taxes, such as sales or income taxes. Plant developers pay sales taxes on goods and services consumed during plant construction and plant owners pay federal and state taxes on the income from power sales during plant operation (Navigant Energy, 2011). A long-term reduction of these tax rates, which are uniformly levied against all firms, would reduce the cost of producing renewable energy without favoring one firm energy source over any other. Any competitive advantage gained by renewable energy industries specifically as a result of the PTC would be negated, however, as producers of conventional energy would also benefit from lower sales or income tax rates.

Feed-In Tariff

Feed-in tariffs, as applied to renewable energy sources, are long-term purchase agreements that "require electric utilities to purchase electricity from ... often small renewable energy generators ... at a specified price" per kWh (Butler & Neuhoff, 2008) (Couture, et al., 2010) (Gillingham & Sweeney, 2010). "These purchase agreements are typically offered within contracts ranging from 10-25 years and are extended for every kilowatt-hour of electricity produced." Feed-in tariff payment levels can depend on several factors, including the location and the size of the project, the quality of the resource, subsequent installations, or the type of technology. Effective feed-in tariffs typically guarantee access to the electrical grid, provide long-term purchase agreements that remain in effect for 10-25 years, and provide payments that account for the costs of generation (Couture, et al., 2010).

A feed-in tariff is an appropriate renewable energy incentive mechanism when utilities are likely "to favor their own generation over generation from outside renewable energy suppliers." Vertically integrated utilities that can "exercise market power by favoring their own electricity generation facilities over other small generation facilities, including renewable energy facilities," are unlikely to purchase electricity from an outside renewable energy generator without the requirement imposed by a feed-in tariff. In order for a feed-in tariff to be economically efficient, the price must be set at "the wholesale market price for electricity, adjusted for risk and intermittency, [thereby preventing] any distortions from a price that does not correspond with the market" (Gillingham & Sweeney, 2010).

Feed-in tariffs provide many economic advantages as renewable energy incentive mechanisms. Because they tend to remain in effect for at least ten years, they provide investors with a secure, predictable, and stable market. Also, because feed-in tariffs are performance-based, they only incur costs if facilities are brought into operation. Furthermore, they provide reduced transaction costs, secure fixed-price benefits for customers, and "enhance market access for investors and participants." Economic disadvantages associated with feed-in tariffs include that they "can lead to near-term upward pressure on electricity prices," they "do not directly address the high up-front [capital] costs" often incurred in renewable energy projects, the payment levels mandated by feed-in tariffs "are frequently independent from market price signals," and they "do not encourage direct price competition between project developers" (Couture, et al., 2010).

Fixed Tariff

While a feed-in tariff can be set to fluctuate (i.e., Germany's feed-in tariff set the mandated price of power generated from renewable sources to reflect electricity prices during the preceding year, as described below), a fixed tariff much more rigidly sets the price at which power generated from renewable sources must be purchased. The primary advantage of fixed tariffs is that they provide a high level of predictability and stability for public energy supply companies who choose to or are required to purchase energy produced from renewable sources, even if that stability is not reflective of dynamic electricity prices. The primary disadvantages are that this lack of price flexibility may impose higher costs on energy supply companies and, in turn, consumers, the mandated prices provide little incentive for project developers to reduce their operating costs, and any reduction in costs achieved by renewable energy facilities cannot be transferred to consumers without a change in policy.

Auction

Broadly speaking, an auction system used to incentivize the use of power from renewable sources consists of potential project developers bidding on energy prices at which they would develop a project and a centralized process to award contracts to the lowest bidders (Butler & Neuhoff, 2008). A primary advantage of the auction system is that potential project developers are encouraged to compete on a price-competitive basis. While the energy price at which the lowest bidders agree to develop a project may not be as low as the current energy price, it is expected that contracts would be awarded to the lowest bidders that contribute to the centralized planning authority's renewable energy goals, barring any unusual decisions. A disadvantage associated with the auction system is that there is no enforcement mechanism to guarantee contract winners follow through on their plans by financing and completing the awarded projects (Butler & Neuhoff, 2008).

Quota

A quota system simply requires that the portfolios of electricity supply companies maintain a specified fraction of renewable energy sources, lest they pay a monetary penalty that is often awarded to electricity supply companies that do meet the requirement (Butler & Neuhoff, 2008). The primary advantage of the quota system is that it provides electricity supply companies to select the exact composition of their renewable energy portfolio based on cost-competitiveness, reliability, or any other criteria deemed appropriate. The primary disadvantage of the quota system is that some electricity supply companies may find it more advantageous to pay the fine than to meet the renewable energy requirement.

Chapter 7. Specific Uses of Wind Energy Production Incentive Mechanisms

Many nations have attempted to incentivize the growth of wind power through incentive mechanisms such as those introduced in the previous chapter. Here, we will look at use of the PTC in the U.S., Germany's use of a feed-in tariff and a fixed tariff, and the use of an auction and quota system in the United Kingdom (U.K.).

United States: Production Tax Credit

In the U.S., a renewable electricity PTC is currently in place for wind energy, closed-loop and open-loop biomass, geothermal energy, landfill gas, municipal solid waste, qualified hydroelectric energy, and certain marine and hydrokinetic sources of energy. After the original wind PTC remained in effect for five and a half years, the PTC has never been renewed for a length of time greater than four years. There are several reasons that two to four year extensions have become the status quo and a longer-term policy has not been implemented. First, Congress expanded PTC eligibility to additional renewable energy sources that are not as technologically developed or as scalable as wind energy. For example, in extending the PTC through the *Ticket to Work and Work Incentives Improvement Act of 1999*, Congress extended PTC eligibility to poultry waste. In 2004, PTC eligibility was extended to geothermal energy, landfill gas, solid waste combustion, open-loop biomass, and solar energy, and in 2005, it was extended to certain hydropower facilities. As these renewable energy sources generally provide less promise as significant components of the nation's near-term renewable energy portfolio, the costs of a long-term PTC are not justified as in the nation's best interest. Rather than passing separate PTCs with varying expiration dates, Congress combined the PTCs and provided all of the eligible sources of energy, including wind, with similar, if not identical expiration schedules. While there was no procedural requirement for the PTCs to be linked in such a manner, Congress did so despite the wide range of cost effectiveness, technological maturity, and scalability of the various energy sources. Thus, two to four years has become the standard length of time for renewable energy production tax credit extensions.

An additional reason that two to four year extensions have become standard is that, with the exception of the *American Recovery and Reinvestment Act of 2009*, none of bills that included extensions were in danger of losing in either house of Congress. With widespread bipartisan support for all of the bills, of which the wind PTC extensions were only a tiny component, there was no need for minor components of the bills to be adjusted in order to gain votes. While this widespread congressional support may also suggest flexibility to adjust policies without losing votes, all of the bills involved many other policies that were more politically visible than the PTC. Hence, there was relatively little congressional attention paid to renewable energy lobbying efforts and very little motivation for any member of Congress to consider other PTC options.

There is considerable evidence favoring a more consistent, predictable wind energy tax policy over the status quo of repeated expirations and renewals of the wind PTC. First, economic evidence indicates that the expiration and renewal cycle interferes with consistent, natural growth in domestic wind capacity. The six renewals and four temporary expirations throughout the twenty year history of the PTC have created an artificially volatile market for wind energy, resulting in industry booms and busts almost entirely attributable to unpredictable tax policy rather than to economic conditions and evolving technological capabilities. In fact, during each of the three most recent PTC expirations, which occurred in 2002, 2004, and 2010, the rate of wind capacity additions slowed nearly to a halt. During these years, annual newly installed wind capacity fell by 73 percent, 78 percent, and 43 percent, respectively, from the previous year. Between 2000 and 2011, however, overall wind capacity installations increased by an average of 159 percent each year over the previous year (Energy Efficiency & Renewable Energy, 2011). A strong correlation between the legislative status of the PTC and the installation of new wind capacity is indicated by the significant discrepancy between years during which the PTC did not expire and years during which it expired. This correlation is shown in Figure 11.

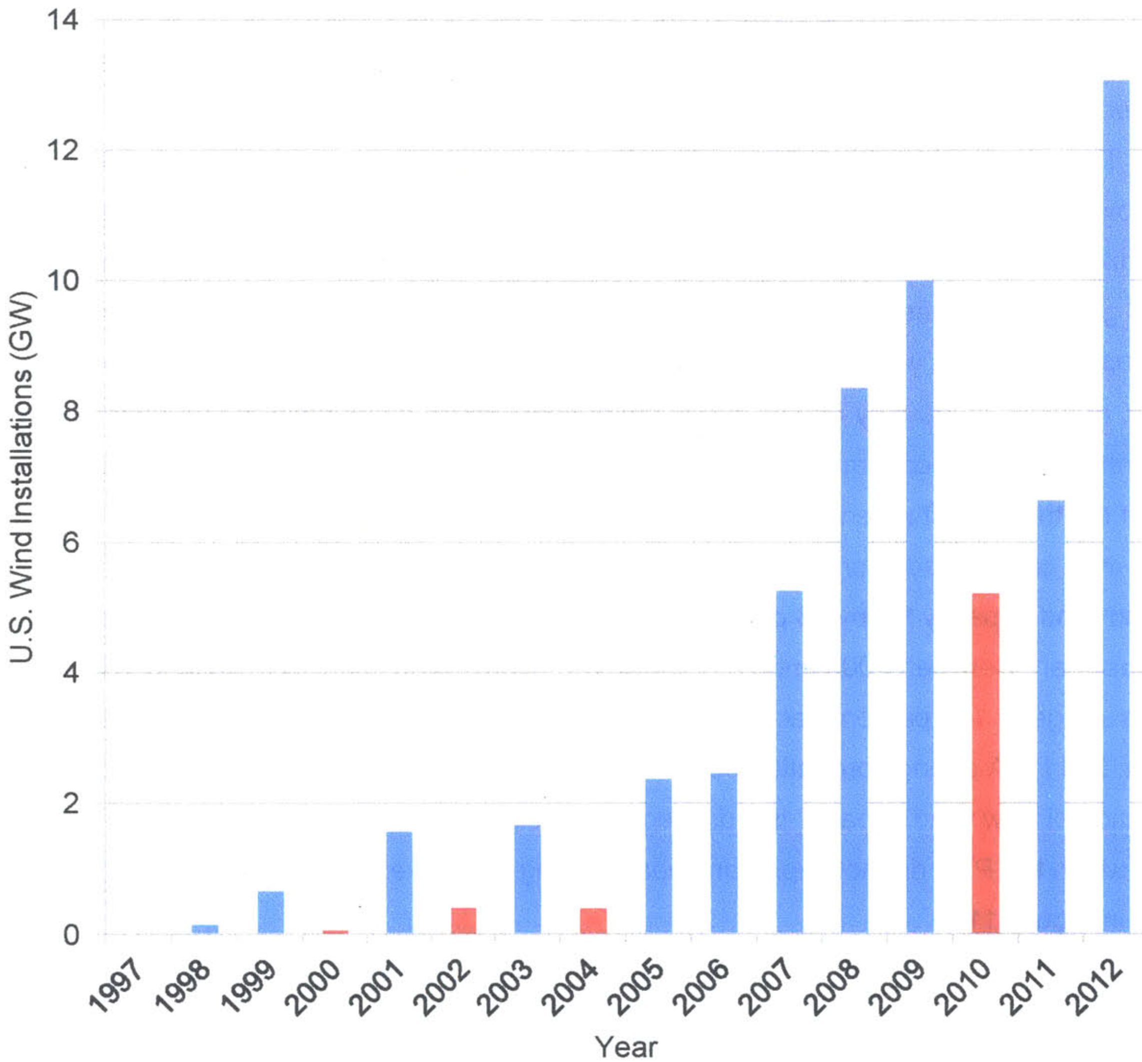

Figure 11. Annual U.S. wind capacity installed in years during which the PTC did not expire (blue) and years during which it expired (red), 1997-2012 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

Germany: Feed-In Tariff to Fixed Tariff

For the years 1990-1999, Germany utilized a feed-in tariff scheme, known as StreG, to incentivize wind power development. Under StreG, public energy supply companies were required to purchase power generated from renewable sources "at 90 percent of the average price of electricity as charged to final consumers in the previous year. Renewable producers would exploit all technologies and sites until the marginal cost of renewable electricity was equal to this price" (Butler & Neuhoff, 2008).

However, as German electricity prices fell in the late 1990's, so, too, did the payments required for power generated from renewable sources under StreG. As a response to these falling required payments, StreG was replaced with a fixed tariff mandated by the German Renewable Energy Act (Erneuerbare-Energien-Gasetz, or EEG). For the wind industry, the fixed tariff came into effect in the year 2000 and "was set at €0.091/kWh for the first five years of operation and at €0.0619/kWh for the subsequent 15 years. An allowance is made for the quality of the site; plants that fail to meet 150 percent of a reference yield receive a higher payment for a longer period. For investment that occurs after 2002, the tariffs are reduced by nominal 1.5 percent for each subsequent year, in order to take account of technological progress and incentivize early investment" (Bolinger & Wiser, 2008).

For the years during which StreG was in effect (1990-2000), Germany added more wind capacity than it added in the previous year in all instances but one, the exception being a 15 percent drop from capacity added in 1995 to capacity added in 1996. Cumulative wind capacity in Germany increased from 55.06 megawatts (MW) in 1990 to 4.44 GW at the end of 1999 – nearly an 8,000 percent increase (Molly, 2011). The StreG did not include a specific target capacity; its intended purpose was to "increase the share of electricity [in Germany] derived from renewable sources" (Butler & Neuhoff, 2008).

Soon after the EEF came into effect, Germany experienced its three best years in terms of added wind capacity. 2001, 2002, and 2003 still rank as the top three years for wind installations in Germany (Molly, 2011). Since reaching a high of 3.238 GW added in 2002, the capacity added in each year has somewhat tapered off. Germany has experienced several years during which installations fell relative to the previous year, but it still managed a five-fold increase in its cumulative installed wind capacity between 2000 and 2012 (Molly, 2011) (German Wind Energy Association, 2012). EEG aimed "to double the 2000 contribution of renewable sources [to the overall power mix]," but it was not associated with any specific targets for wind energy generation (Butler & Neuhoff, 2008). The annual German wind capacity installed and the cumulative installed wind capacity in Germany for the years 1990-2012 are shown in Figure 12 (Molly, 2011) (German Wind Energy Association, 2012).

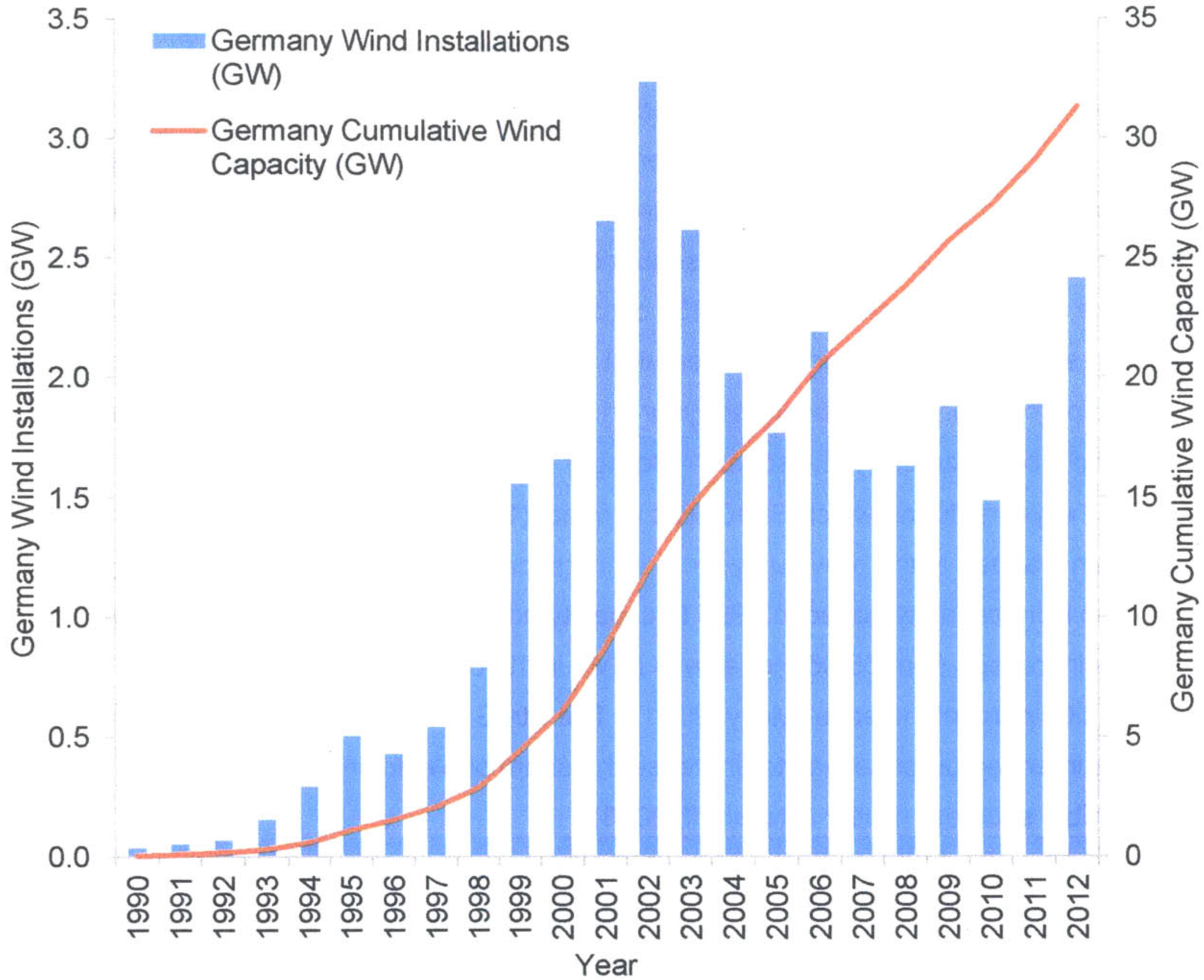

Figure 12. Annual Germany wind capacity installed and cumulative installed wind capacity, 1990-2012 (Molly, 2011) (German Wind Energy Association, 2012).

United Kingdom: Auction and Quota

In the 1990's, the U.K. incentivized the development of wind and other renewable energy sources through a tendering program known as the Non-Fossil Fuel Obligation (NFFO). Under NFFO, renewable energy developers submitted bids to the Department of Trade and Industry (DTI) indicating "the energy price at which they would be prepared to develop a project." The DTI evaluated all bids submitted, allocated target capacity levels for various renewable energy sources, and awarded contracts. Regional electricity companies were required "to purchase all NFFO generation offered to them and to pay the contracted price for this generation. The difference between the contracted price and the pool selling price, which represented the subsidy to renewable generation, was reimbursed using funds from the Fossil Fuel Levy" (Butler & Neuhoff, 2008).

During the years for which the NFFO was in effect, the price of wind energy fell by 68 percent, nearly falling as low as the pool price. However, many project developers – particularly those who submitted and were thus constrained by the lowest bids – did not follow through on their project development plans. As a result, "the average price of awarded contracts that resulted in projects was likely to be higher" than the overall average price of awarded contracts (Butler & Neuhoff, 2008).

The target of the NFFO was "1,500 MW declared net capacity (DNC) [of renewable energy generation] by 2000. DNC is the equivalent capacity of a baseload plant that would produce the same average annual energy output" (Butler & Neuhoff, 2008). The NFFO target was not met, and by the end of 2001, the last full year for which the NFFO was in effect, the U.K. had installed only roughly 500 MW of wind capacity. For wind energy facilities, the DNC is calculated by Equation 1 (Butler & Neuhoff, 2008).

Equation 1

$$0.43 \times (IC - OEPC) = \mathrm{DNC}$$

IC: Installed Capacity

OEPC: Onsite Electrical Power Consumption

The NFFO remained in effect until April 2002, at which point the Renewables Obligation (RO) replaced it. Under the RO, electricity supply companies must purchase Renewable Obligation Certificates (ROCs), which correspond to one MWh of power generated from a renewable source, based on their total energy sales. Beginning in 2002, energy supply companies were required to purchase ROCs equal to 3 percent of overall generation. This percentage increases to 15.4 percent by 2015. "Any electricity company that does not obtain sufficient ROCs has to make buy-out payments (£30/MWh in 2002-2003, rising annually in line with inflation). These buyout payments are recycled back to suppliers that have presented ROCs, hence increasing the value of producing renewable energy if the quota is achieved" (Butler & Neuhoff, 2008).The U.K. has seen roughly 88 percent of its cumulative wind capacity installed while the RO was in effect. Its capacity increased from less than 1 GW at the end of

2002 to 5.378 GW by the end of 2010. The annual U.K. wind capacity installed and the cumulative installed wind capacity are shown in Figure 13 (RenewableUK, 2011) (United States Energy Information Administration, 2012).

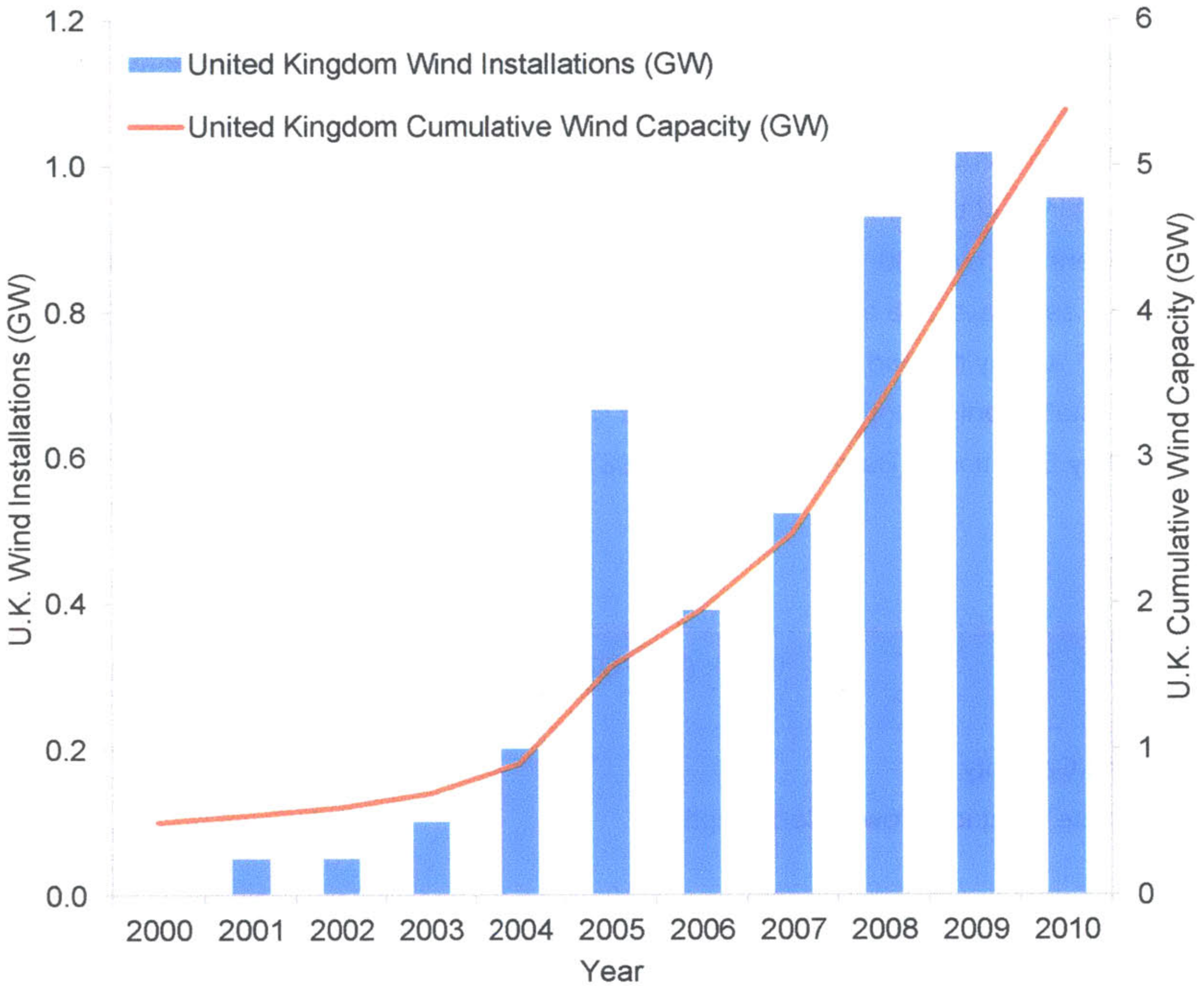

Figure 13. Annual U.K. wind capacity installed and cumulative installed wind capacity, 2000-2010. Data for years 2000-2004 are visually estimated and are not considered to be precise data (RenewableUK, 2011) (United States Energy Information Administration, 2012).

Chapter 8. The Short-Term Impact of Wind Production Tax Credit Expirations on Wind Capacity Additions

The short-term impact of wind PTC expirations on wind capacity additions is a heavily contested issue and one that bears significant implications for future wind energy policy. Many interest groups have highlighted the severe negative consequences that PTC expirations have on installation trends. For example, the AWEA claims that "in the years following [a wind PTC] expiration, installations dropped between 73 and 93 percent" from the previous year. Specifically, the AWEA claims that U.S. wind installations fell by 93 percent from 1999 to 2000, by 73 percent from 2001 to 2002, and by 77 percent from 2003 to 2004 (American Wind Energy Association, 2012). These apparently rounded figures differ only slightly from the calculated percentages based on data provided by the AWEA in its Annual Wind Industry Report for Year Ending 2008 and its U.S. Wind Industry Fourth Quarter 2012 Market Report. Based on data provided in these publications, the installation decreases were 90, 74, and 76 percent in 2000, 2002, and 2004, respectively. Additionally, installations fell by 48 percent between 2009 and 2010, the fourth year during which the PTC expired (American Wind Energy Association, 2009) (American Wind Energy Association, 2012). These large reductions in installations are understandably concerning to the wind industry and to policymakers interested in incentivizing sustainable growth in the wind energy industry. However, these data are without the context of long-term U.S. and global installation trends. They do not account for domestic or global economic or technological stimuli that may have effected installations in particular years even if the PTC had remained in effect.

In order provide context for the actual short-term impact of wind PTC expirations on installations, the deviations from the long-term U.S. wind installation trend must be evaluated and compared to deviations from installation trends experienced more broadly and in specific, comparable wind energy markets that are not directly impacted by PTC expirations in the U.S. First, the long-term installation trends for the U.S., the entire world with the U.S. data removed, the European Union (EU), and Germany are plotted. U.S. installation data is plotted with global and EU data, which control for general economic trends and global wind energy industry trends that may impact U.S. installations, regardless of the status of the PTC, so as to isolate the effect of wind PTC expirations on U.S. installations. Additionally, the comparison of U.S. installation trends to German installation trends provides a simple, though inexact counterfactual to the U.S. wind economy. While the U.S. and Germany have both experienced rapid growth in the wind energy industry between the mid-1990's and today, the German regulatory incentives for wind energy installations have been more consistently applied than the wind PTC in the U.S. The installation data for each sample is shown in Figure 14.

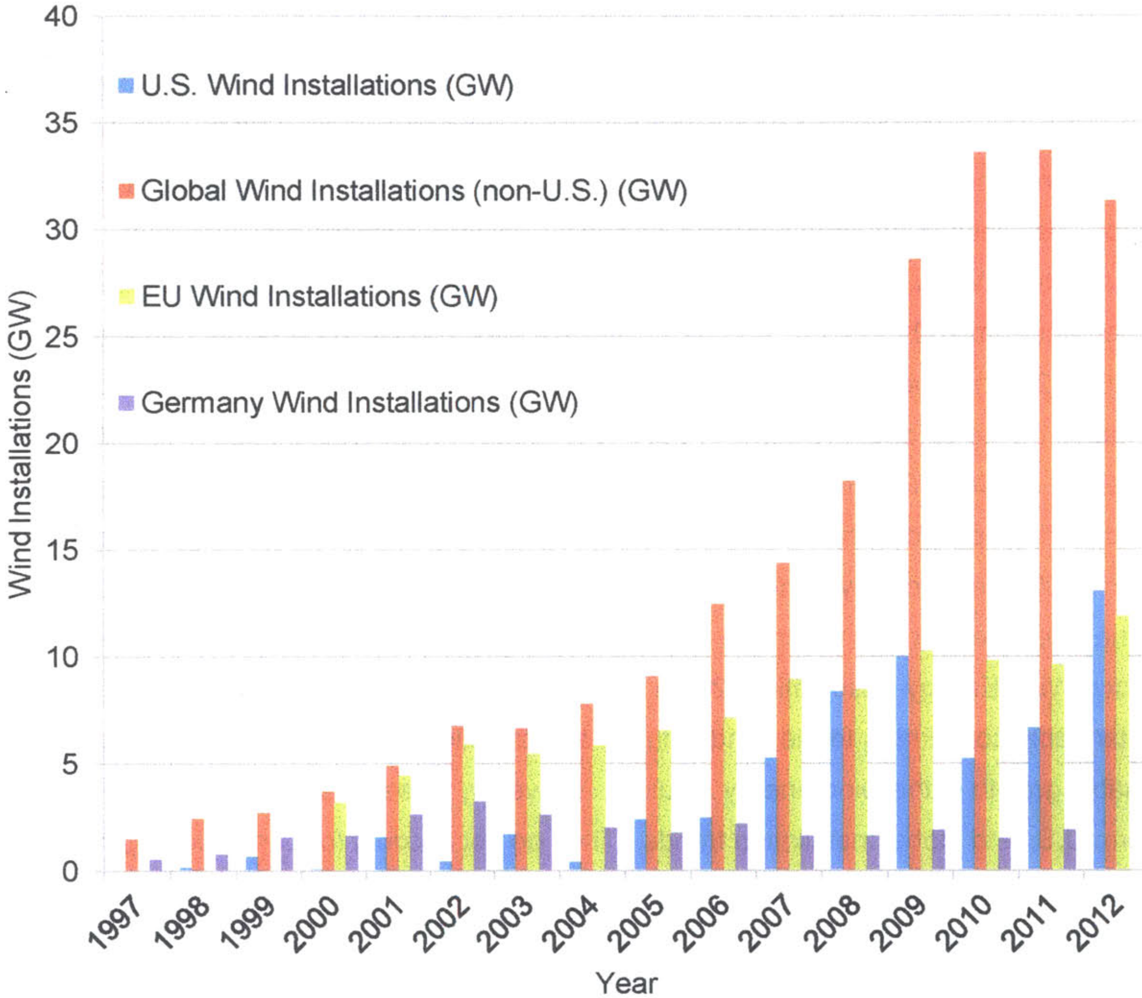

Figure 14. Wind installations in the U.S., EU, Germany, and globally with U.S. data removed, 1997-2012 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012) (Wilkes & Moccia, 2013) (Molly, 2011) (Global Wind Energy Council, 2013).

With the annual installations for each sample plotted, the long-term installation trend for each sample can be established. The long-term installation trends are shown in Figure 15.

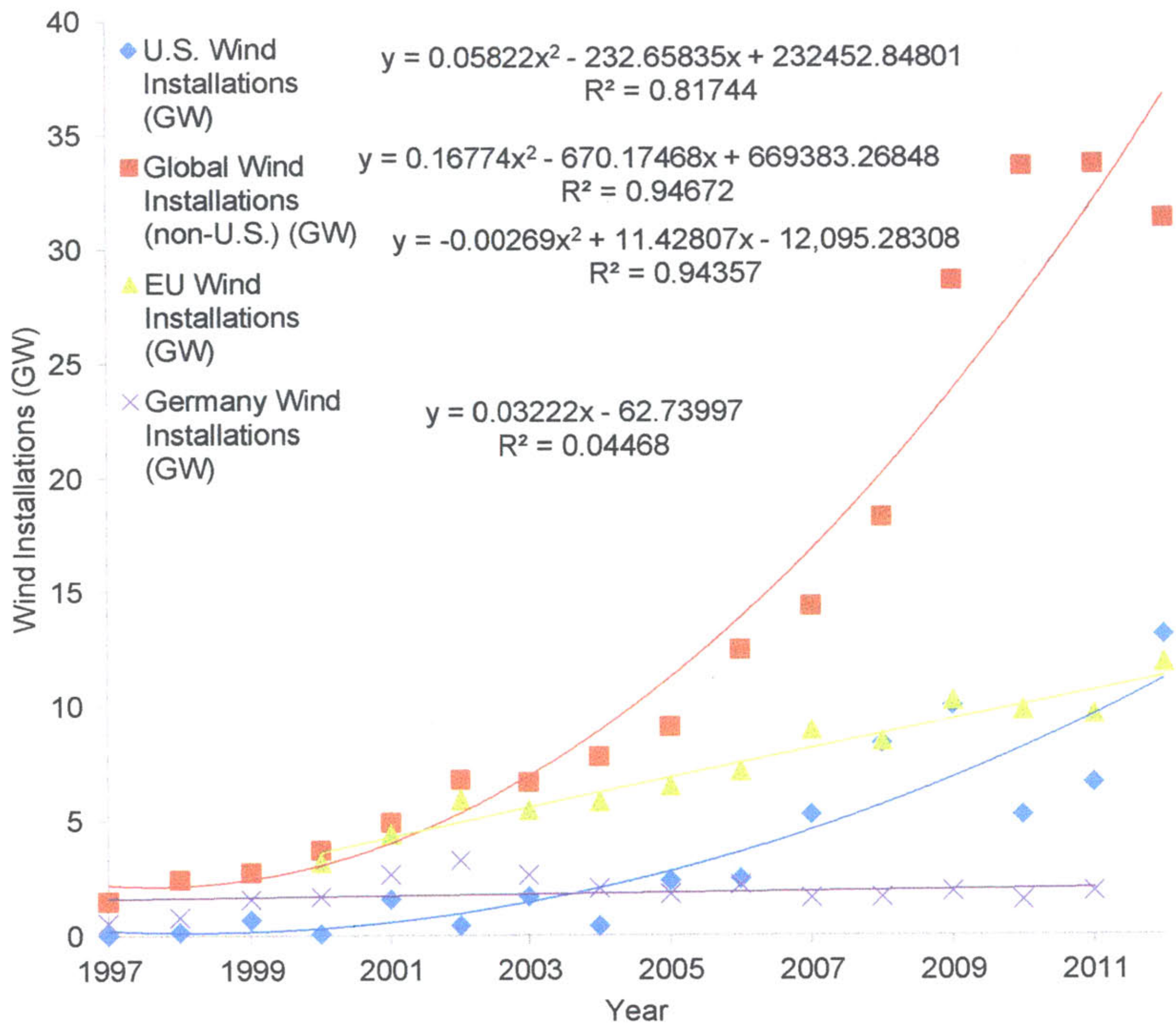

Figure 15. Long-term wind installation trends and trend lines for the U.S., EU, Germany, and globally with U.S. data removed, 1997-2012 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012) (Wilkes & Moccia, 2013) (Molly, 2011) (Global Wind Energy Council, 2013).

Using the calculated long-term installation trends, the "projected" installations for each sample can be calculated for each year. These projections represent the installations that would be completed by each sample in each year if their installations were exactly in accordance with their respective long-term installation trends. Hence, effects of acute stimuli, such as wind PTC extensions, on installation projections in specific years are minimized.

From this data, there are two evaluations that can take place in order to better understand the effect of PTC expirations on U.S. wind installations. First, the simple observation that "in the years following [a wind PTC] expiration, installations dropped between 73 and 93 percent" (American Wind Energy Association, 2012) from the previous year must be further refined to reflect the deviations from the long-term trends in each of these years, rather than only the year-to-year change. That U.S. installations fell sharply from one year to the next does not necessarily account for long-term trends that may have positive or negative effects on the pace of installations. Hence, these observations could understate or exaggerate the actual effect of wind PTC expirations on installations. In order to more thoroughly evaluate the effect of PTC expirations on installations, the percentage of projected installations actually installed in the U.S. in each year during which the PTC expired is calculated. Then, the result can be subtracted from 100 percent to find the U.S. installation deficit, or the amount by which the U.S. fell short of its long-term installation trend, for years during which the PTC expired. A positive result indicates that the U.S. fell short of its long-term trend in a specific year, whereas a negative result, or negative installation deficit, indicates that the U.S. exceeded its long-term trend for that year. For example, the U.S. installation deficit in can be calculated as shown in Equation 2.

Equation 2

$$\left(1-\frac{\Delta Capacity}{Projected\;\Delta Capacity}\right)\times 100\% = ID$$

ΔCapacity: U.S. Wind Installations (GW)
Projected ΔCapacity: Projected U.S. Wind Installations (GW)
ID: U.S. Installation Deficit (%)

The result of Equation 2 provides an estimate of the short-term impact of PTC expirations on installations that accounts for long-term trends that are not as thoroughly reflected in simple comparisons of new installations to the previous year's total. These two estimates for years during which the PTC temporarily expired are shown in Table 3.

Table 3. U.S. installation reductions relative to previous year versus calculated U.S. installation deficit for each year during which the wind PTC expired (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

Year	2000	2002	2004	2010
U.S. Installation Reductions Relative to Previous Year (%)	89.83	73.72	76.27	47.87
Calculated U.S. Installation Deficit (%)	78.82	57.12	80.88	36.38

As the results show, the U.S. year-to-year installation reductions experienced during each PTC expiration somewhat exaggerate the effect of the PTC on reducing new installations below the long-term U.S. trend, with the exception of 2004, when the calculated U.S. installation deficit was slightly greater than the simple year-to-year reduction from 2003 to 2004. During the other three expirations, the installation reduction was between 11 and 17 points greater than the calculated U.S. installation deficit. An additional notable result was that the 2010 expiration had the least severe impact on wind installations. Based on year-to-year installation reductions, the 2010 expiration was less severe than any other expiration by 26 points, and based on the calculated installation deficit, it was less severe than any other expiration by 21 points, indicating that the U.S. wind energy industry may have become better equipped in 2010 to continue installing new capacity despite the economic and regulatory uncertainty injected by a PTC expiration. Alternatively, after the three expirations and renewals that occurred before 2010, the wind industry may have become accustomed to the PTC ultimately being renewed and retroactively applied and, as a result, it reduced installations less drastically than during previous expirations.

While the above calculation of the U.S. wind installation deficit for individual years somewhat controls for long-term trends that affect the pace of installations, it does not control for global economic and technological conditions that broadly impact the wind energy industry in multiple economies during particular years. Disregarding the performance of the wind energy industry in other economies relative to their respective long-term trends during PTC expirations in the U.S. could also lead to an understated or exaggerated effect of PTC expirations on the U.S. wind energy industry.

Therefore, in a further evaluation of the effect of wind PTC expirations on the U.S. wind installations, the newly installed capacity in the U.S. in 2000, 2003, 2004, and 2010 – the years during which the wind PTC expired – relative to its long-term trend can be compared to the performance of the wind industry in other economies during the same year relative to their respective long-term trends in order to isolate the effect of the wind PTC expirations on U.S.

installations. More precisely, the percentage of projected wind installations in the U.S. in a specific year can be divided by the percentage of projected wind installations in a different sample for the same year in order to obtain a ratio of wind installations relative to projections for two samples – an "installation deficit ratio". For example, the U.S./EU installation deficit ratio can be calculated using Equation 3. A U.S./EU installation deficit ratio below 1 would indicate that the EU performed better during Year Y relative to its long-term trend than the U.S. performed during Year Y relative to its long-term trend, whereas a ratio above 1 would indicate that the U.S. performed better than the EU during Year Y relative to their respective long-term trends.

Equation 3

$$\frac{\left(\frac{\Delta U.S.\,Capacity}{Projected\ \Delta U.S.\,Capacity}\right)}{\left(\frac{\Delta EU\ Capacity}{Projected\ \Delta EU\ Capacity}\right)} = \frac{U.S.}{EU} IDR$$

ΔEU Capacity: EU Wind Installations (GW)
Projected ΔEU Capacity: Projected EU Wind Installations (GW)
U.S./EU IDR: U.S./EU Installation Deficit Ratio

The U.S./Global (non-U.S.), U.S./EU, and U.S./Germany installation deficit ratios for 2000, 2002, 2004, and 2010 are shown in Table 4.

Table 4. U.S./Global (non-U.S.), U.S./EU, and U.S./Germany installation deficit ratios for years during which the wind PTC expired (American Wind Energy Association, 2009) (American Wind Energy Association, 2012) (Wilkes & Moccia, 2013) (Molly, 2011) (Global Wind Energy Council, 2013).

Year	2000	2002	2004	2010
U.S./Global (non-U.S.) Installation Deficit Ratio	0.176	0.339	0.220	0.527
U.S./EU Installation Deficit Ratio	0.240	0.360	0.205	0.650
U.S./Germany Installation Deficit Ratio	0.228	0.287	0.222	0.673

As shown in Table 4, the U.S. wind installations in 2000 were between 17.6 percent and 24.0 percent what they would have been if the U.S. had kept pace with non-U.S. global installations, EU installations, and German installations, relative to their respective long-term trends. In 2002, the range was 28.7 percent - 36.0 percent, in 2004, the range was 20.5 percent - 22.2 percent, and in 2010, the range was 52.7 percent - 67.3 percent.

Taken together, the results in Table 3 and Table 4 indicate that wind PTC expirations do indeed, as claimed by the AWEA, have deleterious effects on U.S. wind capacity installations. During the 2000, 2002, and 2004 expirations, U.S. installations were well below long-term trend projections and well below the new installation rate achieved worldwide, in the EU, and in Germany, relative to their respective long-term installation trends. However, both analyses also show that the most recent expiration, 2010, was the one during which the pace of new U.S. wind installations was least slowed by the expiration. During 2010, U.S. installations were closer to projected installations than during any previous expiration, and U.S. installations were higher compared to global, EU, and German installations relative to their respective projections. As mentioned earlier, it may have become more feasible over time for the U.S. wind industry to continue adding capacity during PTC expirations, the industry may be more likely to add capacity during an expiration in anticipation of the eventual renewal and retroactive application of the PTC, or a combination of these two factors may explain the higher rate of new U.S. installations during the most recent PTC expiration relative to previous expirations.

Chapter 9. The Short-Term Impact of Wind Production Tax Credit Expirations on Wind Power Generation

Through their effect of slowing the annual rate of wind capacity increases, wind PTC expirations may also slow the rate of change in electricity generated from wind energy each year. In order to test for this effect, a similar analysis to that which is used to evaluate the short-term impact of PTC expirations on capacity additions is used to evaluate the short-term impact of expirations on wind energy generation.

Just as the deviations from the long-term U.S. wind installation trend are evaluated and compared to deviations from installation trends experienced in other wind energy samples that are not directly impacted by PTC expirations in the U.S., the long-term U.S. wind energy generation trend can be evaluated and compared to the generation data from other samples. First, the long-term trends in annual changes in wind energy generation for the U.S., the entire world with the U.S. data removed, the EU, and Germany are plotted. Again, the global and EU data control for general economic trends and global wind energy industry trends while the German generation data provides a rough counterfactual to the U.S. wind economy. The change in annual wind energy generation for each sample is shown in Figure 16.

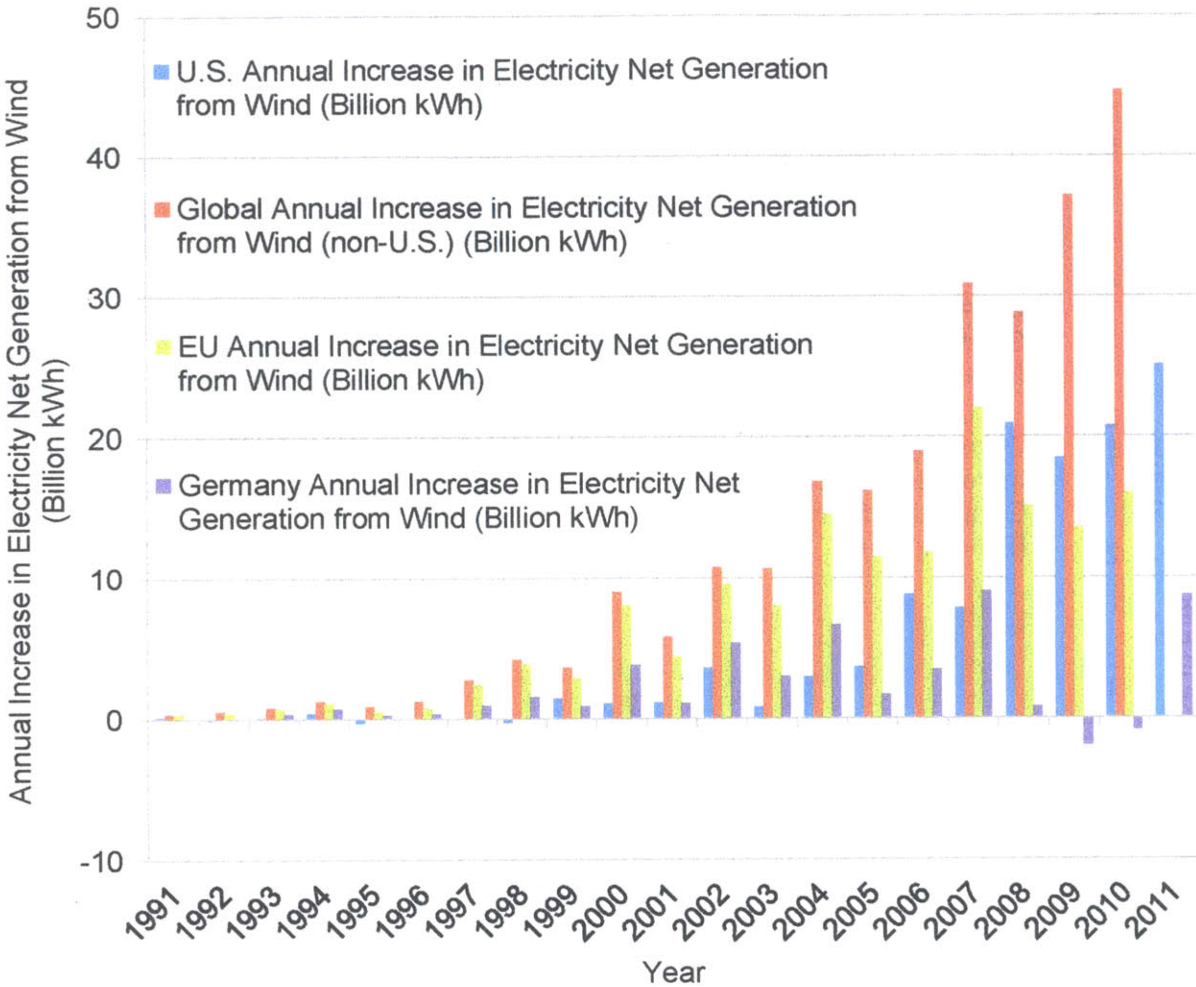

Figure 16. Annual increase in electricity generated from wind energy for the U.S., EU, Germany, and globally with U.S. data removed, 1991-2011 (United States Energy Information Administration, 2012).

With the annual increases in electricity generated from wind energy for each sample plotted, the long-term annual change in generation trend for each sample can be established. The long-term generation trends are shown in Figure 17.

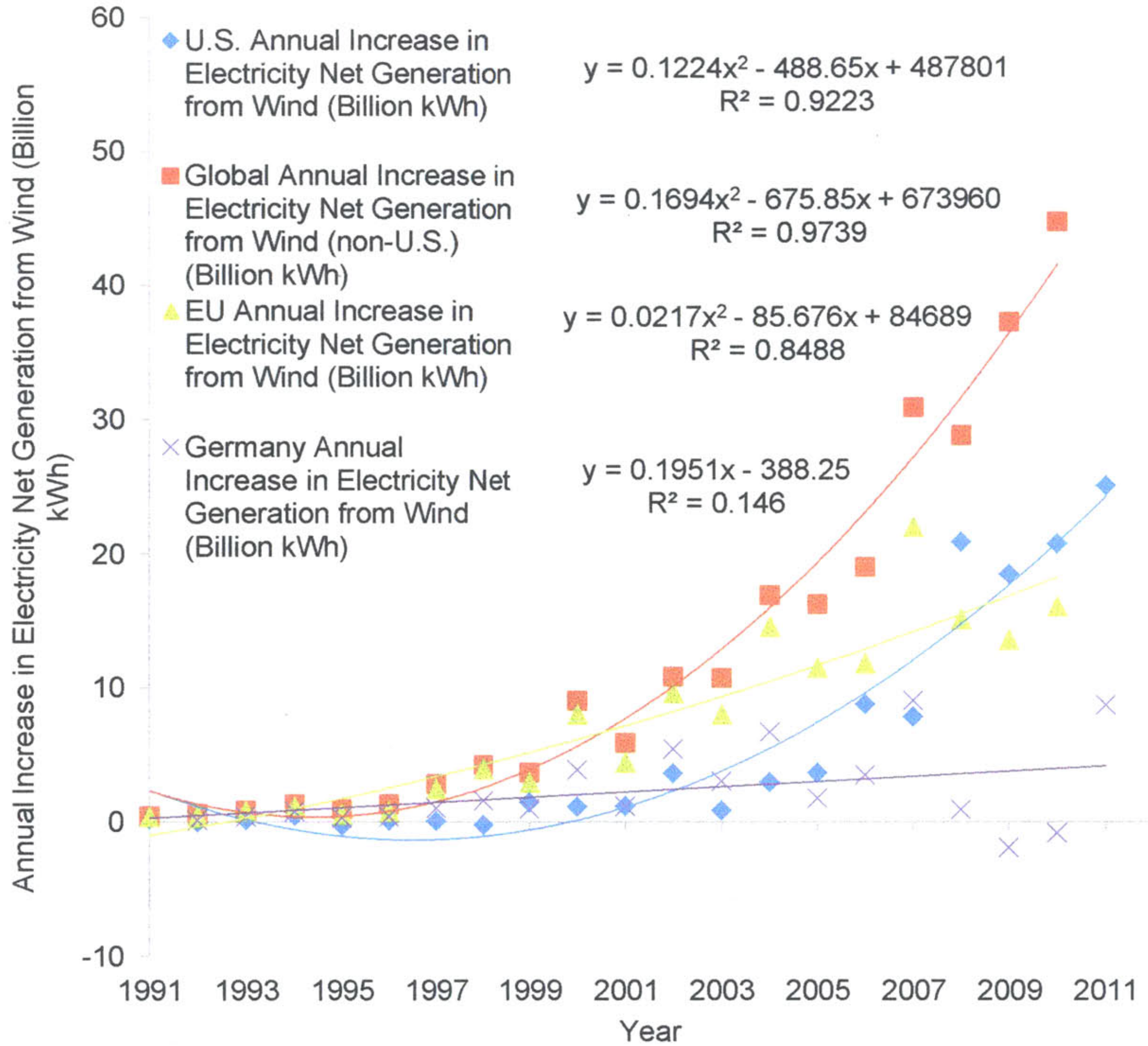

Figure 17. Long-term trends and trend lines for annual changes in electricity generated from wind energy in the U.S., EU, Germany, and globally with U.S. data removed, 1991-2011 (United States Energy Information Administration, 2012) .

Using the calculated long-term annual changes in generation trends, the "projected" increase in electricity generated from wind energy for each sample can be calculated for each year. These projections represent the increase in generation that would occur for each sample in each year if their generation increases were exactly in accordance with their respective long-term generation trends.

The two evaluations that were used to study the effect of PTC expirations on installations can also be used to quantify their effect on electricity generated from wind energy. First, in order to control for the effect of other stimuli on the contribution of wind energy to electricity generation, the "generation increase deficit" is calculated for the U.S. for each year during which the PTC expired. Similar to the installation deficit, the generation increase deficit is the percentage of projected electricity generated from wind energy that is actually generated subtracted from 100 percent. The generation increase deficit indicates the amount by which a sample deviated from its long-term generation trend. A positive result indicates that the sample fell short of its long-term trend in a specific year, whereas a negative result, or negative generation increase deficit, indicates that the sample exceeded its long-term trend for that year. For example, the U.S. generation increase deficit can be calculated as shown in Equation 4.

Equation 4

$$\left(1 - \frac{\Delta Generation}{Projected\ \Delta Generation}\right) \times 100\% = GID$$

ΔGeneration: U.S. Increase in Electricity Generated from Wind Energy in (Billion kWh)
Projected ΔGeneration: Projected U.S. Increase in Electricity Generated from Wind Energy (Billion kWh)
GID: U.S. Generation Increase Deficit (%)

The result of Equation 4 provides an estimate of the short-term impact of PTC expirations on the year-to-year increase in electricity generated from wind power that controls for long-term trends. The calculated U.S. generation increase deficits for years during which the PTC temporarily expired are shown in Table 5.

Table 5. Calculated U.S. generation increase deficit for each year during which the wind PTC expired (United States Energy Information Administration, 2012).

Year	2000	2002	2004	2010
Calculated U.S. Generation Increase Deficit (%)	-590.79	-51.88	47.04	1.39

During the first two PTC expirations, the U.S. actually added more power generated from wind energy than it would have added if it had been in exact accordance with its long-term generation trend. However, during the more recent expirations in 2004 and 2010, the generation increase deficit was positive, indicating that the wind energy industry did not add as much power generation as it would have if it had stayed consistent with long-term trends.

While the above calculation of the U.S. wind generation increase deficit for individual years somewhat controls for long-term trends that affect the pace of generation increases, it does not control for global economic and technological conditions that broadly impact the wind energy industry in multiple economies during particular years. Therefore, the second test used to evaluate the effect of PTC expirations on installations is also needed to gain a fuller understanding of their impact on electricity generated from wind energy. In a manner similar to the installation deficit ratio test, the percentage of projected electricity generated from wind power in the U.S. in a specific year can be divided by the percentage of projected generation in a different sample for the same year in order to obtain a ratio of generation relative to projections for two samples – a "generation deficit ratio." For example, the ratio of U.S. percentage of projected generation to EU percentage of projected generation can be calculated using Equation 5. A U.S./EU generation deficit ratio below 1 would indicate that the EU performed better during a year relative to its long-term trend than the U.S. performed during that year relative to its long-term trend, whereas a ratio above 1 would indicate that the U.S. performed better than the EU during the year relative to their respective long-term trends.

Equation 5

$$\frac{\left(\frac{\Delta U.S.Generation}{Projected\ \Delta U.S.Generation}\right)}{\left(\frac{\Delta EU\ Generation}{Projected\ \Delta EU\ Generation}\right)} = \frac{U.S.}{EU}GDR$$

ΔEU Generation: EU Increase in Electricity Generated from Wind Energy (GW)
Projected ΔEU Generation: Projected EU Increase in Electricity Generated from Wind Energy (GW)
U.S./EU GDR: U.S./EU Generation Deficit Ratio

The U.S./Global (non-U.S.), U.S. /EU, and U.S./Germany generation deficit ratios for 2000, 2002, 2004, and 2010 are shown in Table 6.

Table 6. U.S./Global (non-U.S.), U.S. /EU, and U.S./Germany generation deficit ratios for years during which the wind PTC expired (United States Energy Information Administration, 2012)

Year	2000	2002	2004	2010
U.S./Global (non-U.S.) Generation Deficit Ratio	4.612	1.480	0.513	0.927
U.S./EU Generation Deficit Ratio	5.423	1.330	0.388	1.136
U.S./Germany Generation Deficit Ratio	4.859	0.870	0.267	-3.787

As shown in Table 6, there is very little evidence of a consistently observable short-term impact of PTC expirations on additional wind energy generation in the U.S. when controlling for global economic stimuli.

Chapter 10. Missing Wind Capacity as a Result of Wind Production Tax Credit Expirations

While the previous sections provide some context for the effects of wind PTC expirations on U.S. wind capacity growth and generation increases for the years during which the expirations occur, they do not necessarily indicate whether the expirations create any lasting negative consequences for the wind industry. The specific years of expirations appear to negatively affect wind capacity growth and generation increases, but the above calculations do not distinguish detrimental effects on the wind industry that have lasting consequences from the possibility that wind installations were simply delayed until the wind PTC was inevitably renewed so as to qualify for the wind PTC.

In order to quantify the lasting effect of PTC expirations on wind installations, the current installed wind capacity must be compared to the theoretical total capacity that would be installed in the absence of all previous PTC expirations. The difference between these two numbers – the "missing wind capacity" – is the amount of additional wind capacity that would be installed by the end of 2012 had the PTC expirations not occurred. To make such a calculation, there must be a control for the possibility that the addition of wind capacity that would have taken place during a wind PTC expiration was merely delayed until the following year, without a reduction in the total capacity that was to be installed over the long term. Such a scenario would lead to a boom-and-bust cycle that does not reduce the long-term total installed capacity from what it would have been had the PTC never expired. Visual observation of Figure 11 reveals the possibility that frequent PTC expirations do create a boom-and-bust cycle for wind energy installations, but it does not reveal the missing capacity, if any, that resulted from the expirations.

Given the U.S. cumulative wind capacity data for each year, the following method of estimating the theoretical installations that would have occurred in the years during and immediately following wind PTC expirations is used. First, two-year wind capacity increases are calculated for each two-year period. The two-year capacity increase is simply the increase in installed wind capacity over a two-year period (i.e., the two-year capacity increase for 2001 is the difference between installed wind capacity at the end of 2001 and the installed capacity at the end of 1999). Next, the two-year capacity increase is put in terms of a percentage increase over the two-year period to obtain the two-year wind capacity trend. The two-year capacity trends for years immediately following PTC expirations are then divided by two and evenly allocated to the year during which the expiration occurred and the following year. This step rests on the assumptions that, all else equal, the rate of installation increase that occurred during the two-year period that began with a PTC expiration would have occurred consistently throughout the two-year period rather than concentrated in the year following the expiration, as happened in reality, and that the rate of installation increase that occurred in all other years would have occurred without previous expirations.

For example, the U.S. cumulative wind capacity for the years 1999-2005 and the one-year wind capacity increase expressed as a percentage are shown in Table 7. The years and respective data during which the wind PTC expired are underlined.

Table 7. U.S. cumulative wind capacity measured in GW and one-year wind capacity increase (%) with years and respective data during which the wind PTC expired underlined, 1999-2005 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

Year	1999	<u>2000</u>	2001	<u>2002</u>	2003	<u>2004</u>	2005
U.S. Cumulative Wind Capacity (GW)	2.512	<u>2.579</u>	4.147	<u>4.559</u>	6.228	<u>6.624</u>	8.998
U.S. One-Year Wind Capacity Increase (GW)	-	<u>0.067</u>	1.568	<u>0.412</u>	1.669	<u>0.369</u>	2.374
U.S. One-Year Wind Capacity Increase (%)	-	<u>2.67</u>	60.80	<u>9.93</u>	36.61	<u>6.36</u>	35.84

Next, the two-year wind capacity increase, the increase in installed capacity that occurred over the two-year period ending during the year, is calculated for each year. The results are shown in Table 8.

Table 8. U.S. two-year wind capacity increase (GW) calculations with years and respective data during which the wind PTC expired underlined, 1999-2005 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

Year	1999	2000	2001	2002	2003	2004	2005
U.S. Cumulative Wind Capacity (GW)	2.512	2.579	4.147	4.559	6.228	6.624	8.998
U.S. One-Year Wind Capacity Increase (GW)	-	0.067	1.568	0.412	1.669	0.369	2.374
U.S. Two-Year Wind Capacity Increase (GW)	-	-	1.635	1.980	2.081	2.065	2.770
U.S. One-Year Wind Capacity Increase (%)	-	2.67	60.80	9.93	36.61	6.36	35.84

The two-year wind capacity trend can then be calculated for each year. For example, the calculation for the two-year wind capacity trend for Year Y is shown in Equation 6.

Equation 6

$$\frac{Two-Year\ \Delta Capacity\ Year\ Y}{Capacity\ Year(Y-2)} = Two-Year\ Capacity\ Trend\ Year\ Y$$

Two-Year ΔCapacity Year Y: U.S. Two-Year Wind Capacity Increase for Year Y (GW)
Capacity Year (Y-2): U.S. Cumulative Wind Capacity for Year (Y-2) (GW)
Two-Year Capacity Trend Year Y: U.S. Two-Year Wind Capacity Trend for Year Y (%)

The U.S. two-year wind capacity trends for years 1999-2005 are shown in Table 9.

Table 9. U.S. two-year wind capacity trend calculations with years and respective data during which the wind PTC expired underlined, 1999-2005 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

Year	1999	2000	2001	2002	2003	2004	2005
U.S. Cumulative Wind Capacity (GW)	2.512	2.579	4.147	4.559	6.228	6.624	8.998
U.S. One-Year Wind Capacity Increase (GW)	-	0.067	1.568	0.412	1.669	0.369	2.374
U.S. Two-Year Wind Capacity Increase (GW)	-	-	1.635	1.980	2.081	2.065	2.770
U.S. One-Year Wind Capacity Increase (%)	-	2.67	60.80	9.93	36.61	6.36	35.84
U.S. Two-Year Wind Capacity Trend (%)	-	-	65.09	76.77	50.18	45.30	44.48

Then, in order to obtain an estimate of the U.S. projected wind capacity that would have occurred in each year had the PTC not expired, the two-year capacity trends for years following an expiration are divided equally to the two preceding years. Doing so attributes the rate of increase in wind capacity equally over the two years, rather than concentrated in the year following the expiration as actually occurred, as evidenced by the one-year wind capacity increases. Examples of these calculations for Year Y, a year during which the PTC expired, and Year Y+1, are shown in Equation 7 and Equation 8.

Equation 7

$$Projected\ Capacity\ Year\ (Y-1) \times \left(1 + \frac{Two - Year\ Capacity\ Trend\ Year\ (Y+1)}{2}\right) = Projected\ Capacity\ Year\ Y$$

Projected Capacity Year (Y-1): U.S. Projected Wind Capacity without PTC Expirations for Year (Y-1) (GW)

Projected Capacity Year Y: U.S. Projected Wind Capacity without PTC Expirations for Year Y (GW)

Equation 8

$$Projected\ Capacity\ Year\ Y \times \left(1 + \frac{Two - Year\ Trend\ Year\ (Y+1)}{2}\right) = Projected\ Capacity\ Year\ Y + 1$$

Finally, the appropriate estimation method is used to estimate the U.S. projected wind capacity for each year without any past wind PTC expirations. For years 1996-1999, the actual U.S. cumulative wind capacity data are used because the first PTC expiration did not occur until 2000. For years 2000-2005 and 2010-2011, the above equations are used – for 2000, 2002, 2004, and 2010, Equation 7 is used, and for 2001, 2003, 2005, and 2011, Equation 8 is used. For years 2006-2009 and 2012, the projected wind capacity is found by keeping constant the rate of capacity increases that took place in each respective year according to the U.S. cumulative wind capacity data, but applying those rates to the projected wind capacity for each respective preceding year in the absence of past PTC expirations. The projected wind capacity that would have been installed without PTC expirations for the years 1999-2005 is shown in Table 10.

Table 10. Projected U.S. capacity without PTC expirations based on two-year installation trends, 1999-2005 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

Year	1999	2000	2001	2002	2003	2004	2005
U.S. Cumulative Wind Capacity (GW)	2.512	2.579	4.147	4.559	6.228	6.624	8.998
U.S. One-Year Wind Capacity Increase (GW)	-	0.067	1.568	0.412	1.669	0.369	2.374
U.S. Two-Year Wind Capacity Increase (GW)	-	-	1.635	1.980	2.081	2.065	2.770
U.S. One-Year Wind Capacity Increase (%)	-	2.67	60.80	9.93	36.61	6.36	35.84
U.S. Two-Year Wind Capacity Trend (%)	-	-	65.09	76.77	50.18	45.30	44.48
Projected U.S. One-Year Capacity Increase (%)	-	32.545	32.545	25.09	25.09	22.24	22.24
Projected U.S. Capacity without PTC expirations (GW)	2.512	3.330	4.413	5.520	6.905	8.441	10.318

The resulting U.S. projected wind capacity without PTC expirations, along with the U.S. cumulative capacity data that was actually installed, are displayed in Figure 18.

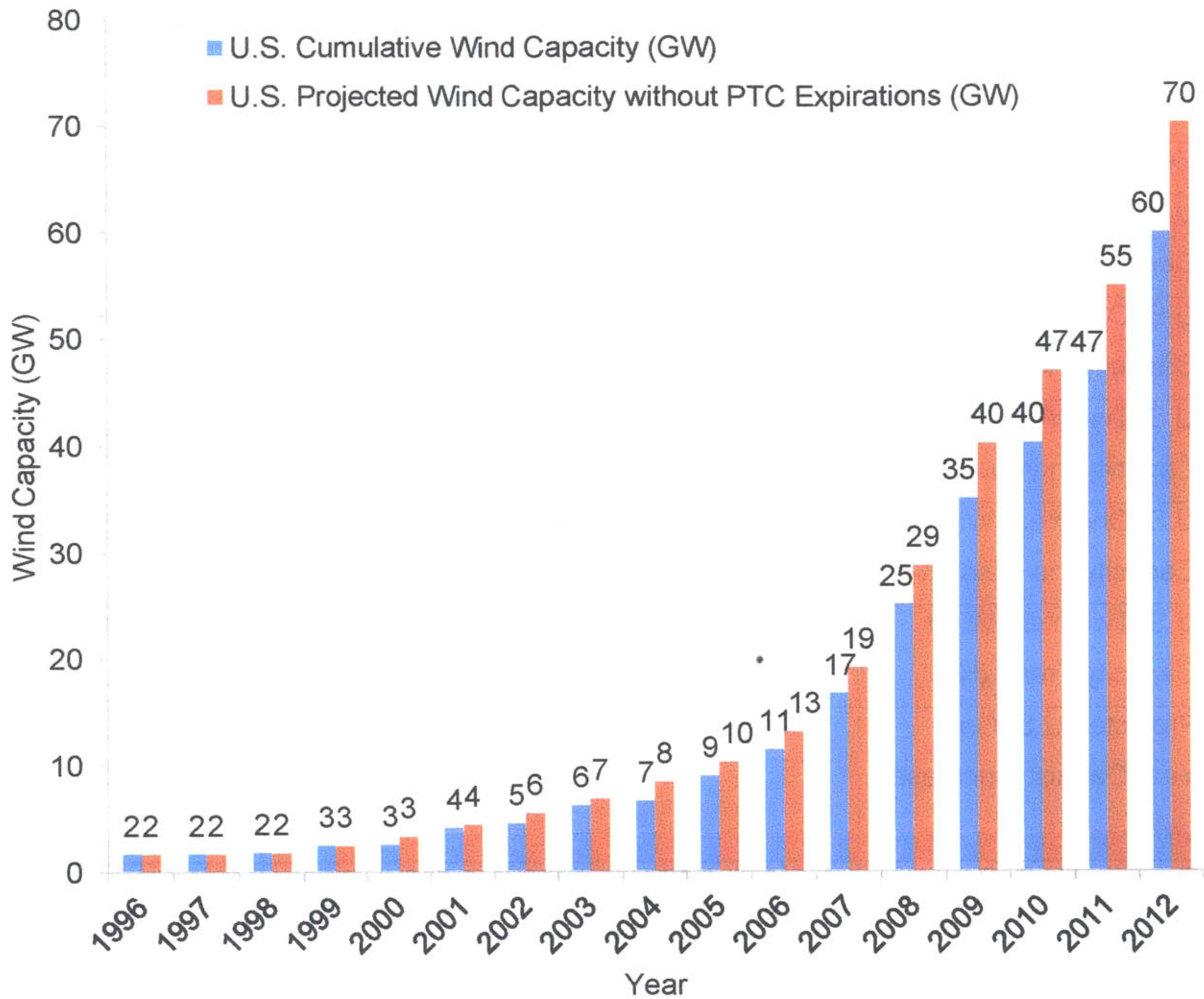

Figure 18. U.S. cumulative wind capacity (GW) (blue) and U.S. projected wind capacity without PTC expirations (GW) (red), 1996-2012 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

According to Figure 18, based on the assumptions, data, and estimation process detailed above, as of 2012, the U.S. cumulative wind capacity is 60 GW, whereas its projected wind capacity without PTC expirations is 70 GW. Therefore, as of the end of 2012, the U.S. has 10 GW of missing wind capacity as a result of the wind PTC expirations that occurred in 2000, 2002, 2004, and 2010.

Chapter 11. Missing Wind Power Generation as a Result of Wind Production Tax Credit Expirations

As a result of the detrimental effect wind PTC expirations had on U.S. installed wind capacity in 2012, the wind PTC expirations can be expected to have had a similarly negative impact on the total wind power generation in 2012 relative to what could have been achievable had the expirations not occurred. In order to test for this effect, a similar analysis to that which is used to evaluate the long-term impact of PTC expirations on installed capacity is used to evaluate the long-term impact of expirations on wind energy generation.

The causal relationship between wind PTC expirations and wind power generation is not as readily apparent as the impact of expirations on wind installations. From the standpoint of wind facilities, there is no disadvantage to generating wind power during a PTC expiration relative to generating wind power when the PTC is in effect, so long as the wind facility began operation before the expiration. It is possible, however, that the reduced rate of capacity growth experienced during expirations could hinder the increased generation of wind power in future years. Therefore, to test for this effect, the "missing wind generation" in 2012 – the amount of additional wind power that would be generated in the U.S. on an annual basis had the PTC never expired – can be calculated by a similar method by which the missing wind capacity is calculated above.

First, two-year wind power generation increases are calculated for each two-year period, and the two-year generation increase is put in terms of a percentage increase in order to obtain the two-year wind generation trend, as shown in Equation 9.

Equation 9

$$\frac{Two - Year\ \Delta Generation\ Year\ Y}{Generation\ Year\ (Y-2)} = Two - Year\ Generation\ Trend\ Year\ Y$$

Two-Year ΔGeneration Year Y: U.S. Two-Year Electricity Net Generation from Wind Increase for Year Y (Billion kWh)

Generation Year (Y-2): U.S. Electricity Net Generation from Wind for Year (Y-2) (Billion kWh)

Two-Year Generation Trend Year Y: U.S. Two-Year Wind Generation Trend for Year Y (%)

The two-year generation trends for years immediately following PTC expirations are then divided by two and evenly allocated to the year during which the expiration occurred (Equation 10) and the following year (Equation 11). As in the missing capacity calculations, it is assumed that, all else equal, the rate of generation increase that occurred during the two-year period that began with a PTC expiration would have occurred consistently throughout the two-year period and that the rate of generation increase that occurred in all other years would have occurred without previous expirations.

Equation 10

$$Projected\ Generation\ Year\ (Y-1) \times \left(1 + \frac{Two - Year\ Generation\ Trend\ Year\ (Y+1)}{2}\right) = Projected\ Generation\ Year\ Y$$

Projected Generation Year (Y-1): Projected U.S. Electricity Net Generation from Wind without PTC Expirations for Year (Y-1) (Billion kWh)
Projected Generation Year Y: U.S. Projected Electricity Net Generation from Wind without PTC Expirations for Year Y (Billion kWh)

Equation 11

$$Projected\ Generation\ Year\ Y \times \left(1 + \frac{Two - Year\ Generation\ Trend\ Year\ (Y+1)}{2}\right) = Projected\ Generation\ Year\ (Y+1)$$

Once again, the appropriate estimation method is used to estimate the U.S. projected wind power generation for each year without any past wind PTC expirations. Projections for the years 1996-1999, the actual U.S. electricity net generation from wind data are used because the first PTC expiration did not occur until 2000. For years 2000, 2002, 2004, and 2010, Equation 10 is used, and for 2001, 2003, 2005, and 2011, Equation 11 is used. For years 2006-2009 and 2012, the projected wind power generation is found by keeping constant the rate of generation increases that took place in each respective year according to the U.S. electricity net generation from wind data, but applying those rates to the projected wind power generation for each respective preceding year in the absence of past PTC expirations.

The projected electricity net generation from wind that would have occurred without PTC expirations for the years 1999-2005 is shown in Table 11.

Table 11. Projected U.S. electricity net generation from wind without PTC expirations based on two-year installation trends, 1999-2005 (United States Energy Information Administration, 2012).

Year	1999	2000	2001	2002	2003	2004	2005
U.S. Electricity Net Generation from Wind (Billion kWh)	4.488	5.593	6.737	10.354	11.187	14.144	17.811
U.S. Annual Increase in Electricity Net Generation from Wind (Billion kWh)		1.105	1.144	3.617	0.833	2.956	3.667
U.S. Two-Year Electricity Net Generation from Wind Increase (Billion kWh)	-	-	2.249	4.761	4.450	3.789	6.623
U.S. One-Year Increase in Electricity Net Generation from Wind (%)	-	24.63	20.45	53.69	8.05	26.42	25.93
U.S. Two-Year Wind Generation Trend (%)	-	-	50.12	85.12	66.05	36.60	59.20
Projected U.S. One-Year Increase in Electricity Net Generation from Wind (%)	-	25.06	25.06	33.025	33.025	29.60	29.60
Projected U.S. Electricity Net Generation from Wind without PTC Expirations (Billion kWh)	4.488	5.613	7.019	9.337	12.421	16.098	20.863

The resulting U.S. projected wind power generation without PTC expirations and the U.S. electricity net generation from wind data are displayed in Figure 19.

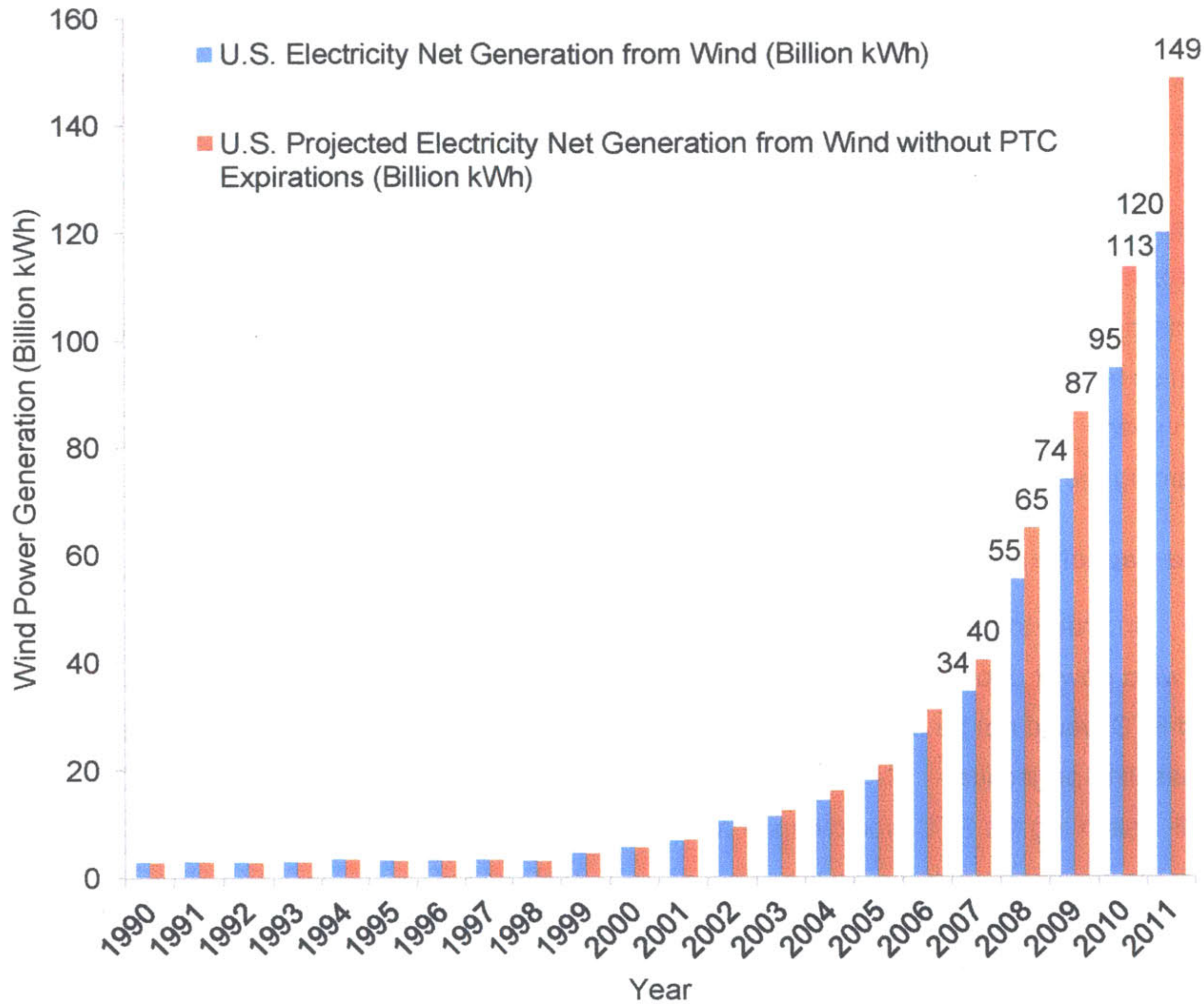

Figure 19. U.S. electricity net generation from wind (Billion kWh) (blue) and U.S. projected electricity net generation from wind without PTC expirations (Billion kWh) (red), 1990-2011 (United States Energy Information Administration, 2012).

According to Figure 19, based on the assumptions, data, and estimation process detailed above, as of 2011, the U.S. electricity net generation from wind was 120 billion kWh, whereas its projected U.S. electricity net generation from wind without PTC expirations was 149 billion kWh. Therefore, as of the end of 2011, the U.S. had 29 billion kWh of missing wind power generation per year as a result of the wind PTC expirations that occurred in 2000, 2002, 2004, and 2010.

Chapter 12. Projected Wind Deployment and Costs Associated with Three Wind Production Tax Credit Renewal Options

While the previous chapter deals solely with the level of wind capacity and generation that were lost due to PTC expirations, much of the policy debate surrounding the wind PTC and its repeated expirations and short-term renewals centers on the cost of the PTC imposed on "U.S. taxpayers in the form of foregone federal tax revenue" (Wiser, et al., 2007). Without the wind PTC, wind facilities would be required to pay an additional 2.2 cents in taxes for every kWh generated. Based on the EIA's International Energy Statistics, the wind energy industry saves approximately $2 billion per year through the PTC (United States Energy Information Administration, 2012). Given the size of the subsidy and the associated implications for wind facilities and the U.S. Treasury, the amount of tax credit projected to be claimed by the industry each year – the "annual cost" of the wind PTC –must be a central factor in future policymaking regarding the wind PTC.

Wind Capacity and Generation Projections

In order to forecast the cost of the wind PTC under various renewal or expiration options, EIA wind power deployment projections, which were developed with the assumption that the wind PTC would not be extended to apply to wind energy capacity added after 2012, are used as baseline projections. EIA projections for U.S. wind power generation for the years 2012-2023, assuming the PTC would expire at the end of 2012 are shown in Figure 20.

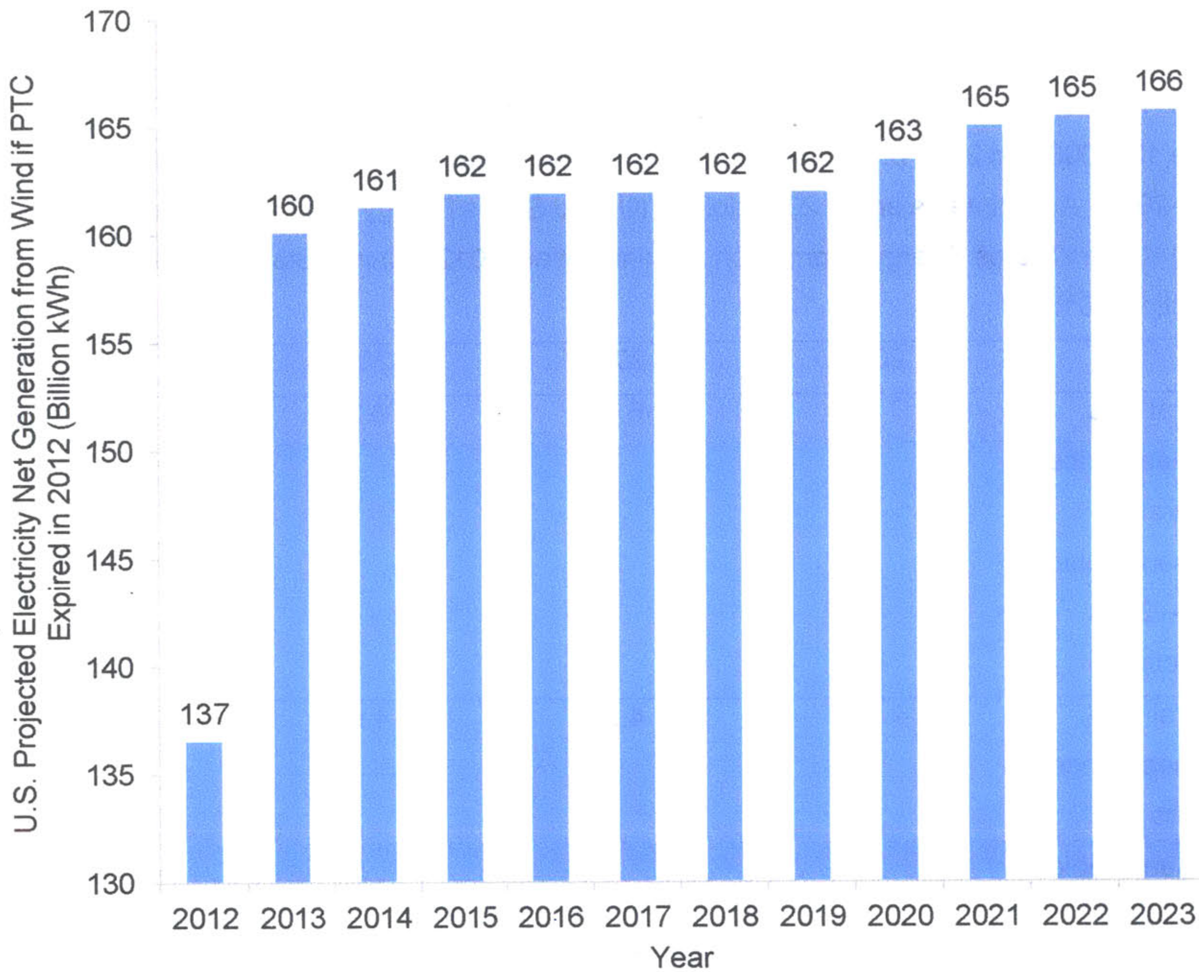

Figure 20. U.S. projected electricity net generation from wind for 2012-2023 if the PTC expired in 2012 (United States Energy Information Administration, 2013).

As can be seen in Figure 20, there is a noticeable decline in the rate of growth of U.S. wind power generation beginning in 2013. After increasing by over 4,100 percent between 1990 and today, wind power generation in the U.S. is expected to grow by only 3.5 percent between 2013 and 2023. There are several factors that contribute to this projected lack of growth after a prolonged period of rapid growth. In addition to the uncertainty regarding the status of the wind PTC after its scheduled expiration on 1 January 2014, the wind energy industry faces challenges from "continued low natural gas and wholesale electricity prices" (Energy Efficiency & Renewable Energy, 2011) (United States Energy Information Administration, 2013). In fact, natural gas price projections through 2025 have declined over the last several years. Projections of natural gas wellhead price in dollars per thousand cubic feet made in 2008 versus projections made in 2012 are shown in Table 12 (United States Energy Information Administration, 2008) (United States Energy Information Administration, 2012).

Table 12. 2008 and 2012 projections of natural gas wellhead price in dollars per cubic foot, 2010-2025. All estimates are in 2012 dollars (United States Energy Information Administration, 2008) (United States Energy Information Administration, 2012) (United States Bureau of Labor Statistics, 2013).

Year	2010	2015	2020	2025
Natural Gas Wellhead Price (dollars per thousand cubic feet) – 2008 Projections	7.21	6.10	6.20	6.67
Natural Gas Wellhead Price (dollars per thousand cubic feet) – 2012 Projections	4.16*	4.24	4.93	6.57

*The actual natural gas wellhead price in 2010 is used because it is a known figure when the 2012 projections are made rather than a projected figure, as it is when the 2008 projections are made.

Additionally, "inadequate transmission infrastructure in some areas, modest electricity demand growth, existing state policies that are insufficient to support future wind power capacity additions at the levels witnessed in recent years, growing competition from solar energy in certain regions of the country," the "relative costs of alternative generation sources," and the continued lack of a "federal renewable or clean energy standard" contribute to the projected lack of growth in installed wind capacity between 2013 and 2023 (Energy Efficiency & Renewable Energy, 2011) (United States Energy Information Administration, 2013).

The EIA projections for U.S. wind capacity also reflect a notable decline in their rate of growth between now and the year 2023. U.S. wind capacity additions, assuming the PTC was to expire at the end of 2012, are shown in Figure 21.

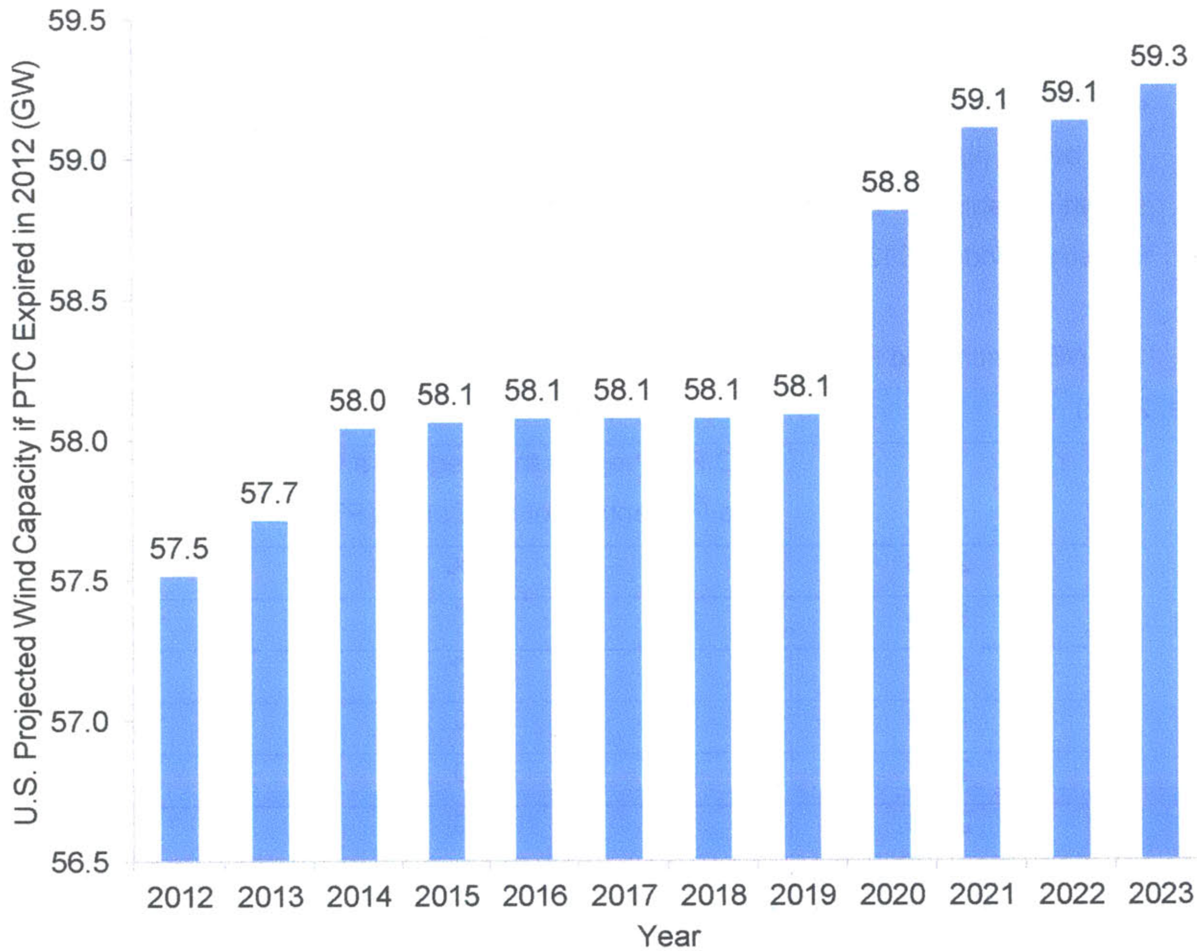

Figure 21. U.S. projected wind capacity for 2012-2023 if PTC expired in 2012 (United States Energy Information Administration, 2013).

While the above projections of U.S. wind capacity and wind power generation were made with the assumption that the PTC would expire at the end of 2012, they are used as baseline projections for three PTC renewal options for the purpose of comparing wind deployment, overall cost, and cost effectiveness of each of them. Given that the PTC is currently scheduled to expire at the end of 2013, the three renewal options are as follows:

- Option 1: The PTC is renewed for a minimum of ten years, remaining in effect until at least 2023.
- Option 2: The PTC is renewed according to an AWEA phase out plan, proposed by Denise A. Bode, CEO of AWEA, in a letter to the Chairpersons and Ranking Members of the U.S. Senate Committee on Finance and the U.S. House of Representatives

Committee on Ways and Means. In her letter, Bode proposes "that a PTC beginning with 2.2 cents per kilowatt-hour, or 100 percent of the current level for projects that begin construction in 2013" can be gradually lowered over the following five years until the level of PTC credits is reduced to 0 percent of the current level, effectively ending the PTC over a number of years. The specific proposed PTC levels for years 2014-2018 are shown in Table 13. Bode claims that this plan "would sustain a minimally viable industry" (Bode, 2012).

Table 13. AWEA estimated PTC levels needed to keep the wind industry minimally viable (Bode, 2012).

Year	PTC For Projects that Begin in a Given Year as a Percentage of the Current PTC Level
2013	100
2014	90
2015	80
2016	70
2017	60
2018	60
2019 and Onwards	0

- Option 3: The PTC expires indefinitely at the end of 2013. With no further legislative action, Option 3 will occur.

In order to compare the potential outcomes of these three options, projections are made for wind capacity and generation for the years 2013-2023 for each option. Capacity projections are made first because of the direct impact of the status of the PTC on installations in a given year. Because capacity data is available through 2012 (American Wind Energy Association, 2009) (American Wind Energy Association, 2012), capacity projections for all options are for installed capacity for the years 2013-2023. Generation projections are then made to reflect capacity projections because the PTC primarily impacts generation through its effect of installations. Because generation data is available through 2011 (United States Energy Information Administration, 2012) and none of the three options involve the PTC expiring before the end of 2012, EIA's projected generation for 2012 is used for all three options, and generation projections are made for 2013-2023.

Beginning with EIA's capacity projections, which were made with the assumption that the PTC would expire at the end of 2012, projections are made for capacity in Option 1. Capacity projections for Option 1 are calculated by adjusting the EIA's projected rate of capacity increase for each year by a correction factor based on the impact of the absence of the PTC in 2010, the most recent PTC expiration, on installations. Option 1 capacity projections for each year are calculated as follows in Equation 12.

Equation 12

$$\frac{\left(\frac{Projected\ \Delta Capacity\ Year\ Y\ (EIA)}{Projected\ Capacity\ Year\ (Y-1)\ (EIA)}\right)}{\tau} \times Capacity\ Year\ (Y-1) + Capacity\ Year\ (Y-1) = Capacity\ Year\ Y$$

Projected ΔCapacity Year Y (EIA): Projected U.S. Wind Installations in Year Y based on EIA Projections (GW)

Projected Capacity Year (Y-1) (EIA): Projected U.S. Wind Capacity in Year (Y-1) based on EIA Projections (GW)

τ: Capacity Correction Factor Based on Absence of PTC in 2010 = 63.62%

Capacity Year (Y-1): Projected U.S. Wind Capacity in Year (Y-1) with PTC Extension through at Least 2023 (GW)

Capacity Year Y: Projected U.S. Wind Capacity in Year Y with PTC Extension through at Least 2023 (GW)

The method for calculating capacity projections for Option 2 varies by year. Because the PTC is not reduced to below 100 percent of its current value until 2014, the projected capacity for 2013 is calculated by the same method (Equation 13), and is therefore equal to, the projected capacity for 2013 under Option 1. Then, for years 2014-2018, the years during which the PTC is still available, but at less than its current value, capacity is projected by adjusting the EIA's projected rate of capacity increase for each year by a correction factor based on the level of PTC that is still available. The calculation for projected capacity for years 2014-2018 under the AWEA phase out plan is shown in Equation 14. For years after 2018, capacity projections are consistent with the EIA's projected rate of capacity increase, but based on the projected 2018 installation total if the PTC had been phased out according to the AWEA's proposal rather than if the PTC had expired at the end of 2012. The calculation for projected capacity for years 2018-2023 under Option 2 is shown in Equation 15.

Equation 13

$$\frac{\left(\frac{\mathit{Projected}\ \Delta \mathit{Capacity\ Year\ Y}\ (\mathit{EIA})}{\mathit{Projected\ Capacity\ Year}\ (Y-1)\ (\mathit{EIA})}\right)}{\tau} \times \mathit{Capacity\ Year}\ (Y-1) + \mathit{Capacity\ Year}\ (Y-1) = \mathit{Capacity\ Year\ Y}$$

Capacity Year (Y-1): Projected U.S. Wind Capacity in Year (Y-1) with AWEA Phase out Plan (GW)

Capacity Year Y: Projected U.S. Wind Capacity in Year Y with AWEA Phase out Plan (GW)

Equation 14

$$\frac{\left(\frac{\mathit{Projected}\ \Delta \mathit{Capacity\ Year\ Y}\ (\mathit{EIA})}{\mathit{Projected\ Capacity\ Year}\ (Y-1)\ (\mathit{EIA})}\right)}{\tau} \times \mathit{AWEA\ Phase\ Out} \times \mathit{Capacity\ Year}\ (Y-1) + \mathit{Capacity\ Year}\ (Y-1) = \mathit{Capacity\ Year\ Y}$$

AWEA Phase Out: The AWEA's Proposed PTC For Projects that Begin in a Given Year as a Percentage of the Current PTC Level

Equation 15

$$\frac{\mathit{Projected}\ \Delta \mathit{Capacity\ Year\ Y}(\mathit{EIA})}{\mathit{Projected\ Capacity\ Year}\ (Y-1)(\mathit{EIA})} \times \mathit{Capacity\ Year}\ (Y-1) + \mathit{Capacity\ Year}\ (Y-1) = \mathit{Capacity\ Year\ Y}$$

The method for calculating capacity projections for Option 3 also varies by year. Because it is assumed that wind capacity added during 2013 is still eligible for the PTC at 100 percent of its current value, the projected capacity for 2013 is again calculated by the same method as, and is therefore also equal to, the projected capacity under Options 1 and 2. This calculation is shown in Equation 16. Beyond 2013, capacity projections for Option 3 are consistent with the EIA's projected rate of capacity increase, but based on the projected 2013 installation total if capacity added during 2013 was eligible for the PTC rather than if the PTC had expired at the end of 2012. The calculation for projected capacity for years 2014-2023 under Option 3 is shown in Equation 17.

Equation 16

$$\frac{\left(\frac{Projected\ \Delta Capacity\ Year\ Y\ (EIA)}{Projected\ Capacity\ Year\ (Y-1)\ (EIA)}\right)}{\tau} \times Capacity\ Year\ (Y-1) + Capacity\ Year\ (Y-1) = Capacity\ Year\ Y$$

Capacity Year (Y-1): Projected U.S. Wind Capacity in Year (Y-1) with PTC Expiration in 2013 (GW)

Capacity Year Y: Projected U.S. Wind Capacity in Year Y with PTC Expiration in 2013 (GW)

Equation 17

$$\frac{Projected\ \Delta Capacity\ Year\ Y(EIA)}{Projected\ Capacity\ Year\ (Y-1)(EIA)} \times Capacity\ Year\ (Y-1) + Capacity\ Year\ (Y-1) = Capacity\ Year\ Y$$

The U.S. projected wind capacity for 2012-2023 for each of these three options is shown in Figure 22. The nearly nonexistent growth in wind capacity between 2014 and 2019 is due to projected "slow growth in electricity demand." Growth in electricity demand begins a modest recovery after 2019, though growth in electricity demand "remains relatively slow" through the end of the projection period, "as increasing demand for electricity services is offset by efficiency gains from new appliance standards and investments in energy-efficient equipment" (United States Energy Information Administration, 2013).

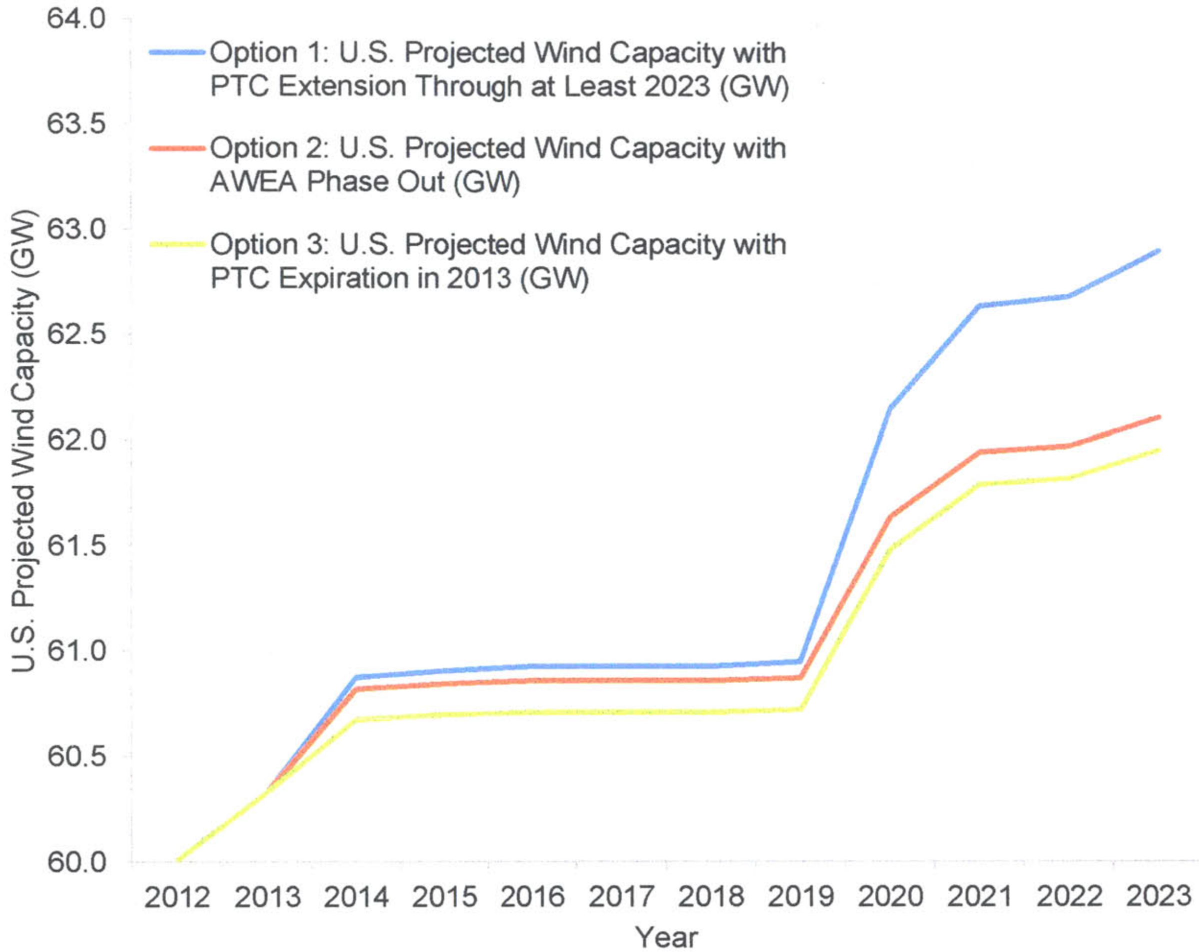

Figure 22. U.S. projected wind capacity for 2012-2023 if the PTC is extended through at least 2023, under the AWEA phase out proposal, and if the PTC expires at the end of 2013 (United States Energy Information Administration, 2013).

Based on the wind capacity projections above, U.S. electricity net generation from wind is projected for the same years and under the same three PTC renewal options. For Option 1, the projected generation for 2013 is calculated by adjusting the EIA's projected rate of generation increase by a correction factor based on the impact of the absence of the PTC in 2010, the most recent PTC expiration, on generation. This calculation is shown in Equation 18. Beyond 2013, because projected generation is expected to consistently reflect projected capacity in all three PTC renewal options, projected generation for years beyond 2013 under Option 1 is consistent with the ratio of projected capacity to projected generation if the PTC expired at the end of 2013. The calculation for projected generation in years 2014-2023 in Option 1 is shown in Equation 19.

Equation 18

$$\frac{\left(\frac{Projected\ \Delta Generation\ Year\ Y\ (EIA)}{Projected\ Generation\ Year\ (Y-1)\ (EIA)}\right)}{\upsilon} \times Generation\ Year\ (Y-1) + Generation\ Year\ (Y-1) = Generation\ Year\ Y$$

Projected ΔGeneration Year Y (EIA): Projected Increase in U.S. Electricity Net Generation from Wind in Year Y based on EIA Projections (Billion kWh)

Projected Generation Year (Y-1) (EIA): Projected U.S. Electricity Net Generation from Wind based on EIA Projections (Billion kWh)

υ: Generation Correction Factor Based on Absence of PTC in 2010 = 98.61%

Generation Year (Y-1): Projected U.S. Electricity Net Generation from Wind in Year (Y-1) with PTC Extension through at Least 2023 (GW)

Generation Year Y: Projected U.S. Electricity Net Generation from Wind in Year Y with PTC Extension through at Least 2023 (GW)

Equation 19

$$\frac{Projected\ Generation\ Year\ Y\ (2013\ Expiration)}{Projected\ Capacity\ Year\ Y\ (2013\ Expiration)} \times Capacity\ Year\ Y = Generation\ Year\ Y$$

Projected Generation Year Y (2013 Expiration): U.S. Projected Electricity Net Generation from Wind for Year Y with PTC Expiration in 2013 (Billion kWh)

Projected Capacity Year Y (2013 Expiration): U.S. Projected Wind Capacity for Year Y with PTC Expiration in 2013 (GW)

Capacity Year Y: U.S. Projected Wind Capacity with PTC Extension through at Least 2023 (GW)

Because the PTC is not reduced to below 100 percent of its current value until 2014, the projected generation for 2013 under Option 2 is again calculated by adjusting the EIA's projected rate of generation increase by a correction factor to account for the absence of the

PTC in EIA's projections (Equation 20). Then, again because projected generation is expected to consistently reflect projected capacity in each option, projected generation for 2014-2023 under Option 2 is consistent with the ratio of projected capacity to projected generation if the PTC expired at the end of 2013. The calculation for projected generation in years 2014-2023 under Option 2 is shown in Equation 21.

Equation 20

$$\frac{\left(\frac{Projected\ \Delta Generation\ Year\ Y\ (EIA)}{Projected\ Generation\ Year\ (Y-1)\ (EIA)}\right)}{v} \times Generation\ Year\ (Y-1) + Generation\ Year\ (Y-1) = Generation\ Year\ Y$$

Generation Year (Y-1): Projected U.S. Electricity Net Generation from Wind in Year (Y-1) with AWEA Phase out Plan (GW)
Generation Year Y: Projected U.S. Electricity Net Generation from Wind in Year Y with AWEA Phase out Plan (GW)

Equation 21

$$\frac{Projected\ Generation\ Year\ Y\ (2013\ Expiration)}{Projected\ Capacity\ Year\ Y\ (2013\ Expiration)} \times Capacity\ Year\ Y = Generation\ Year\ Y$$

Capacity Year Y: U.S. Projected Wind Capacity with AWEA Phase out Plan (GW)

For Option 3, it is again assumed that wind capacity added during 2013 is eligible for the PTC at 100 percent of its current value. Therefore, the projected generation for 2013 is calculated by the same method as, and is therefore also equal to, the projected generation under Options 1 and 2. This calculation is shown in Equation 22. Beyond 2013, generation projections for Option 3 are consistent with the EIA's projected rate of generation increase, but based on the projected 2013 generation total if capacity added during 2013 was eligible for the PTC rather than if the PTC had expired at the end of 2012. The calculation for projected generation for years 2014-2023 under Option 3 is shown in Equation 23.

Equation 22

$$\frac{\left(\frac{Projected\ \Delta Generation\ Year\ Y\ (EIA)}{Projected\ Generation\ Year\ (Y-1)\ (EIA)}\right)}{v} \times Generation\ Year\ (Y-1) + Generation\ Year\ (Y-1) = Generation\ Year\ Y$$

Generation Year (Y-1): Projected U.S. Electricity Net Generation from Wind in Year (Y-1) with PTC Expiration in 2013 (GW)
Generation Year Y: Projected U.S. Electricity Net Generation from Wind in Year Y with PTC Expiration in 2013 (GW)

Equation 23

$$\frac{Projected\ \Delta Generation\ Year\ Y(EIA)}{Projected\ Generation\ Year\ (Y-1)(EIA)} \times Generation\ Year\ (Y-1) + Generation\ Year\ (Y-1) = Generation\ Year\ Y$$

Note that while generation projections under Options 1 and 2 for years during which the PTC was expired are based on proportionality with added capacity in the same options, the comparatively minor assumptions made in the calculation of projected generation in Option 3 make this step unnecessary. In Options 1 and 2, PTC eligibility is extended to multiple years to which it is not applied in the EIA projections. These calculations account for the generation or capacity increase in 2010, that most recent year during which the PTC was expired (other than the one day for which it was expired in 2013). Because the generation deficit in 2010 (98.61 percent) is noticeably higher than the installation deficit in 2010 (63.62 percent), over reliance on these figures in projections could result in unreasonable divergence between projected installations and projected generation. Therefore, the 2010 installation and generation deficits are only used in the calculation of the first year for which a projection must be made – 2013. For subsequent years in Options 1 and 2, generation projections are kept in proportion with capacity projections. In Option 3, because the capacity and generation deficits are only needed to calculate one projection – 2013 – projections for later years are based only on EIA projections while controlling for the one additional year of PTC eligibility.

The U.S. projected electricity net generation from wind for 2013-2023 under each of the three options is shown in Figure 23.

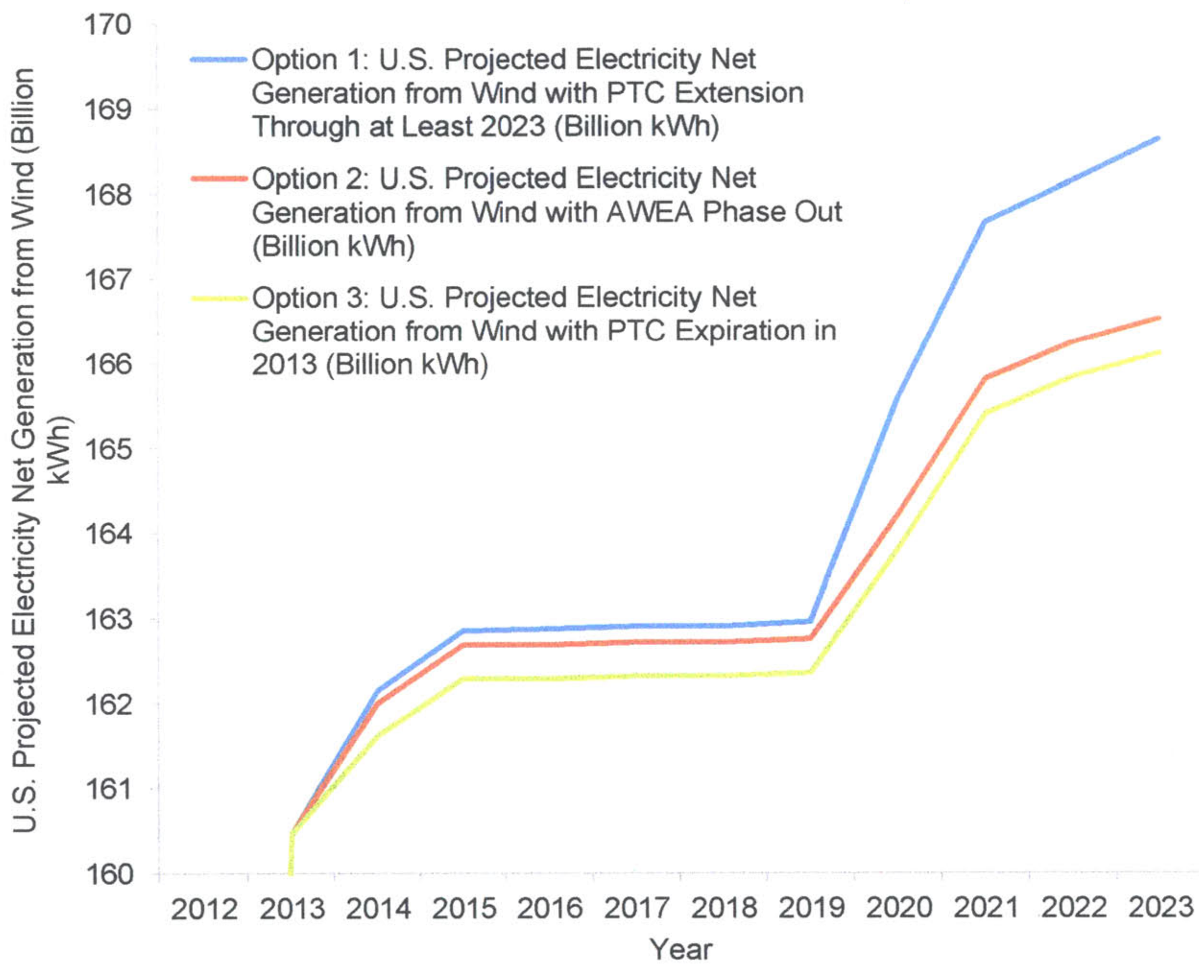

Figure 23. U.S. projected electricity net generation from wind for 2013-2023 if the PTC is extended through at least 2023, under the AWEA phase out proposal, and if the PTC expires in 2013 (United States Energy Information Administration, 2013).

The capacity and generation projections above provide reasonable, "medium-growth" estimates of future wind capacity and generation, provided that the primary source of error in these projections is the uncertainty regarding PTC eligibility. In order to account for the myriad other factors that could influence the addition of wind capacity or an increase in electricity generated from wind power, wind capacity and generation projections are made for a "low-growth" penetration scenario and a "high-growth" penetration scenario.

Low-Growth Penetration Scenario Capacity and Generation Projections

In the EIA projections, growth in U.S. projected wind capacity is nearly halted for the years 2014-2019, and growth in U.S. projected electricity net generation from wind is nearly stagnant for the years 2015-2019. The projections then anticipate a modest increase in the rate of growth of both wind capacity and wind generation beginning in 2019. For the "low-growth" penetration scenario, this recovery after 2019 is assumed not to occur, and rates of growth in capacity and generation are assumed to continue at the rates by which they increased during the years 2014-2019 and 2015-2019, respectively. Such a scenario could realistically occur if, among other factors, the expected economic recovery is not as dramatic as expected and fails to result in the increase in electricity demand that is currently projected.

Beginning with capacity projections, the low-growth penetration scenario projections for each of the three options are assumed to be equivalent to the medium-growth penetration scenario projections for each option for the years 2013-2019. Then, for the years 2019-2023, the annual rate of increase in capacity for each of the three options is assumed to be equivalent to the average annual rate of increase in capacity for each respective option between 2014 and 2019, the period during which capacity growth dramatically tapered off. These rates of increase are shown in Table 14.

Table 14. Increase and average annual increase in U.S. projected wind capacity, 2014-2019 (United States Energy Information Administration, 2012).

PTC Renewal Option	Increase in U.S. Projected Wind Capacity, 2014-2019 (%)	Average Annual Increase in U.S. Projected Wind Capacity, 2014-2019 (%)
Option 1: PTC Extension Through at Lease 2023	0.1199	0.0240
Option 2: AWEA Phase Out	0.0871	0.0174
Option 3: PTC Expiration in 2013	0.0775	0.0155

Using the average annual increase in U.S. projected wind capacity for each of the three options during 2014-2019 and extrapolating them to the years 2020-2023, the U.S. projected wind capacity for 2012-2023 for each of the three options in the low-growth penetration scenario is shown in Figure 24.

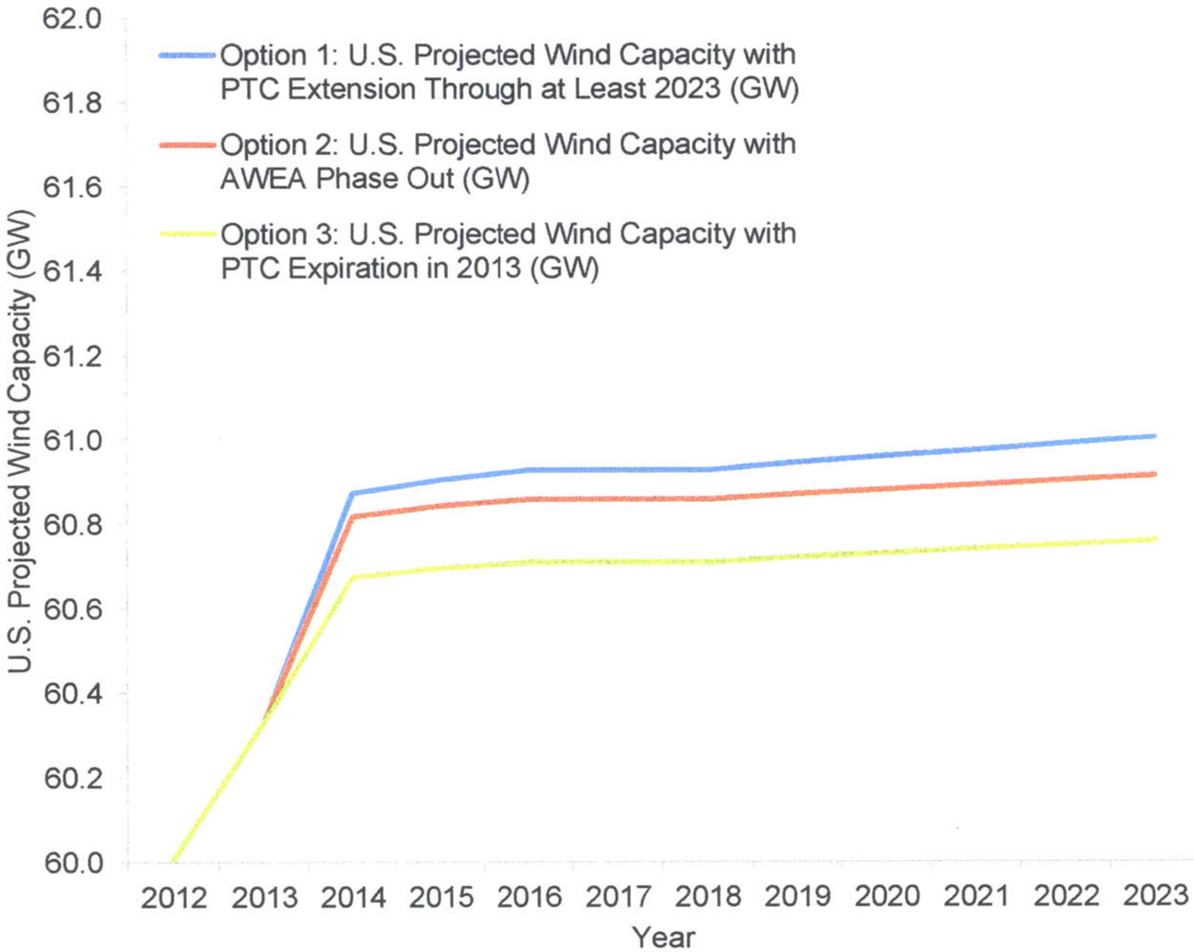

Figure 24. U.S. projected wind capacity for 2012-2023 in the low-growth penetration scenario if the PTC is extended through at least 2023, under the AWEA phase out proposal, and if the PTC expires in 2013.

Generation projections for the low-growth penetration scenario are also made by extending the rate of growth during a period of nearly inexistent growth in the EIA projections to further years. Projections for each of the three options are assumed to be equivalent to the medium-growth penetration scenario projections for each option for the years 2013-2019. Then, for the years 2019-2023, the annual increase in capacity for each of the three options is assumed to be the same as the average annual increase in capacity for each respective option between 2015 and 2019, the period during which growth in power generated from wind energy tapered off. These rates of increase are shown in Table 15.

Table 15. Increase and average annual increase in U.S. projected electricity net generation from wind, 2015-2019 (United States Energy Information Administration, 2012).

PTC Renewal Option	Increase in U.S. Projected Electricity Net Generation from Wind, 2015-2019 (%)	Average Annual Increase in U.S. Projected Electricity Net Generation from Wind, 2015-2019 (%)
Option 1: PTC Extension Through at Lease 2023	0.0633	0.0158
Option 2: AWEA Phase Out	0.0409	0.0102
Option 3: PTC Expiration in 2013	0.0386	0.0096

Using the average annual increase in U.S. projected electricity net generation from wind for each of the three options during 2015-2019 and extrapolating them to the years 2020-2023, the U.S. projected electricity net generation from wind for 2012-2023 for each of the three options in the low-growth penetration scenario is shown in Figure 25.

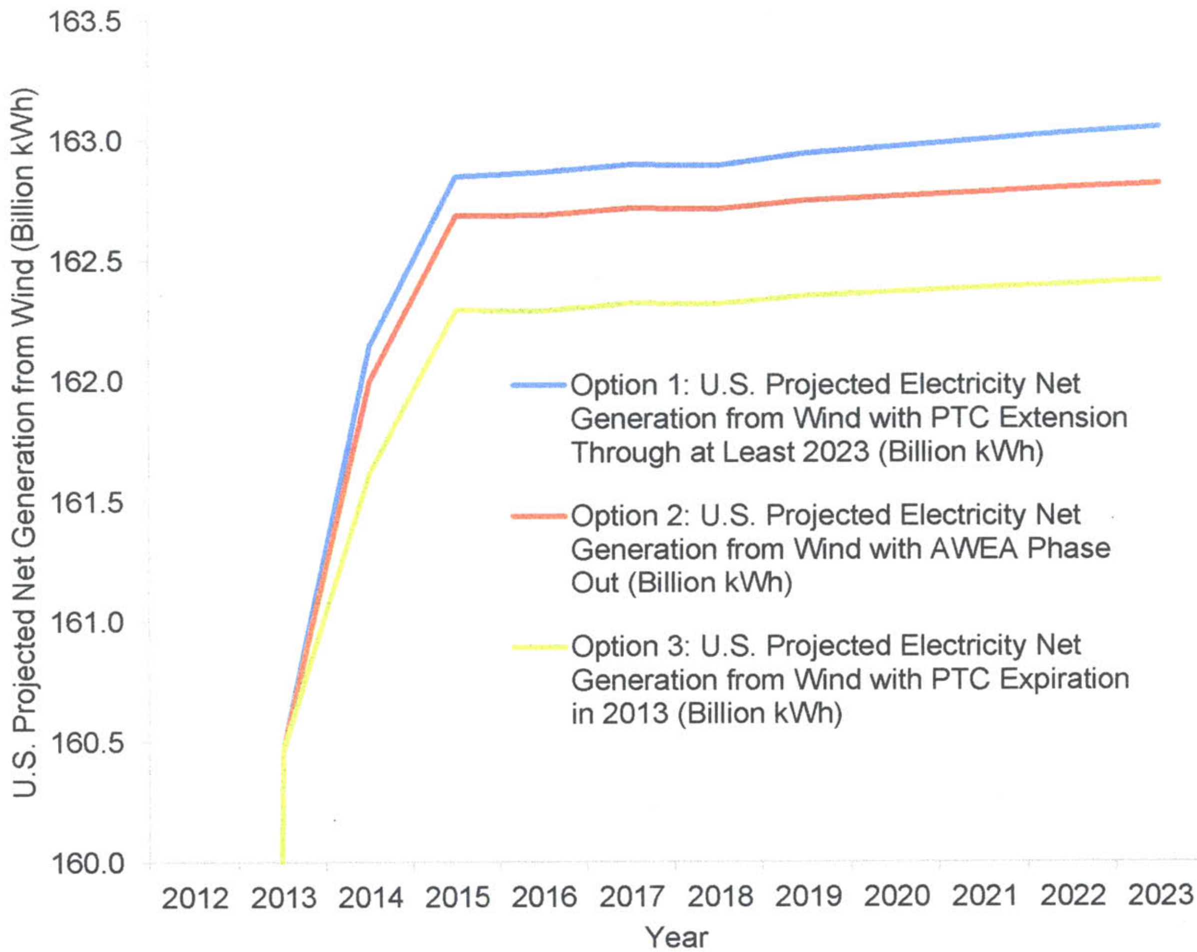

Figure 25. U.S. projected electricity net generation from wind for 2012-2023 in the low-growth penetration scenario if the PTC is extended through at least 2023, under the AWEA phase out proposal, and if the PTC is extended through 2013.

High-Growth Penetration Scenario Capacity and Generation Projections

The "high-growth" penetration scenario is based on the aim to generate 20% of U.S. electricity from wind energy by 2030. This goal originated in 2006 with a collaborative report "prepared by DOE in a joint effort with industry, government, and the nation's national laboratories... [that] considers some associated challenges, estimates the impacts, and discusses specific needs and outcomes in the areas of technology, manufacturing and employment, transmission and grid integration, markets, siting strategies, and potential environmental effects associated with a 20% Wind Scenario" (National Renewable Energy Laboratory, 2008). The 20% Wind Scenario is used for Option 1 in the high-growth penetration scenario. That is, in the high-growth scenario, it is assumed that the 20% Wind Scenario is attainable if the wind PTC is extended through at least 2023. Capacity projections from Options 2 and 3 are then calculated based on the Option 1 projections. Because the PTC is expected to remain in effect for the duration of 2013 under all three options, the projected capacity and generation for 2013 are consistent under all three options.

Beyond 2013, capacity projections for Option 3 are consistent with the rate of capacity increase necessary for the 20% Wind projections, but adjusted by a correction factor based on the impact of the absence of the PTC in 2010. The equation used for this calculation is shown in Equation 24.

Equation 24

$$\left(\frac{\Delta Capacity\ Year\ Y\ (20\%\ Wind)}{Capacity\ Year\ (Y-1)\ (20\%\ Wind)}\right) \times \tau \times Capacity\ Year\ (Y-1) + Capacity\ Year\ (Y-1) = Capacity\ Year\ Y$$

ΔCapacity Year Y (20% Wind): U.S. Wind Installations in Year Y in the 20% Wind Projections (GW)

Capacity Year (Y-1) (20% Wind): U.S. Wind Capacity in Year (Y-1) in the 20% Wind Projections (GW)

τ: Capacity Correction Factor Based on Absence of PTC in 2010 = 63.62%

Capacity Year (Y-1): Projected U.S. Wind Capacity in Year (Y-1) with PTC Expiration in 2013 (GW)

Capacity Year Y: Projected U.S. Wind Capacity in Year Y with PTC Expiration in 2013 (GW)

Option 2 capacity projections for the years 2014-2018 are based on the rate of capacity increase necessary for the 20% Wind projections, but adjusted by a correction factor based on the level of the PTC available for each year. This calculation is shown in Equation 25. The projected rates of increase in capacity for Option 2 for the years 2019-2023 are consistent with the projected rates of increase in capacity for Option 3 for the years 2019-2023 because for both options there is no PTC as of 2019. This calculation is shown in Equation 26.

Equation 25

$$\frac{\left(\frac{\Delta Capacity\ Year\ Y\ (20\%\ Wind)}{Capacity\ Year\ (Y-1)\ (20\%\ Wind)}\right)}{\tau} \times AWEA\ Phase\ Out \times Capacity\ Year\ (Y-1) + Capacity\ Year\ (Y-1) = Capacity\ Year\ Y$$

AWEA Phase Out: The AWEA's Proposed PTC For Projects that Begin in a Given Year as a Percentage of the Current PTC Level

Capacity Year (Y-1): Projected U.S. Wind Capacity in Year (Y-1) with AWEA Phase out Plan (GW)

Capacity Year Y: Projected U.S. Wind Capacity in Year Y with AWEA Phase out Plan (GW)

Equation 26

$$\frac{\Delta Capacity\ Year\ Y(Option\ 3)}{Capacity\ Year\ (Y-1)(Option\ 3)} \times Capacity\ Year\ (Y-1) + Capacity\ Year\ (Y-1) = Capacity\ Year\ Y$$

ΔCapacity Year Y (Option 3): U.S. Wind Installations in Year Y in the high-growth penetration scenario under Option 3 (GW)

Capacity Year (Y-1) (Option 3): U.S. Wind Capacity in Year (Y-1) in the in the high-growth penetration scenario under Option 3 (GW)

The U.S. projected wind capacity for 2012-2023 for each of these three options in the high-growth penetration scenario is shown in Figure 26.

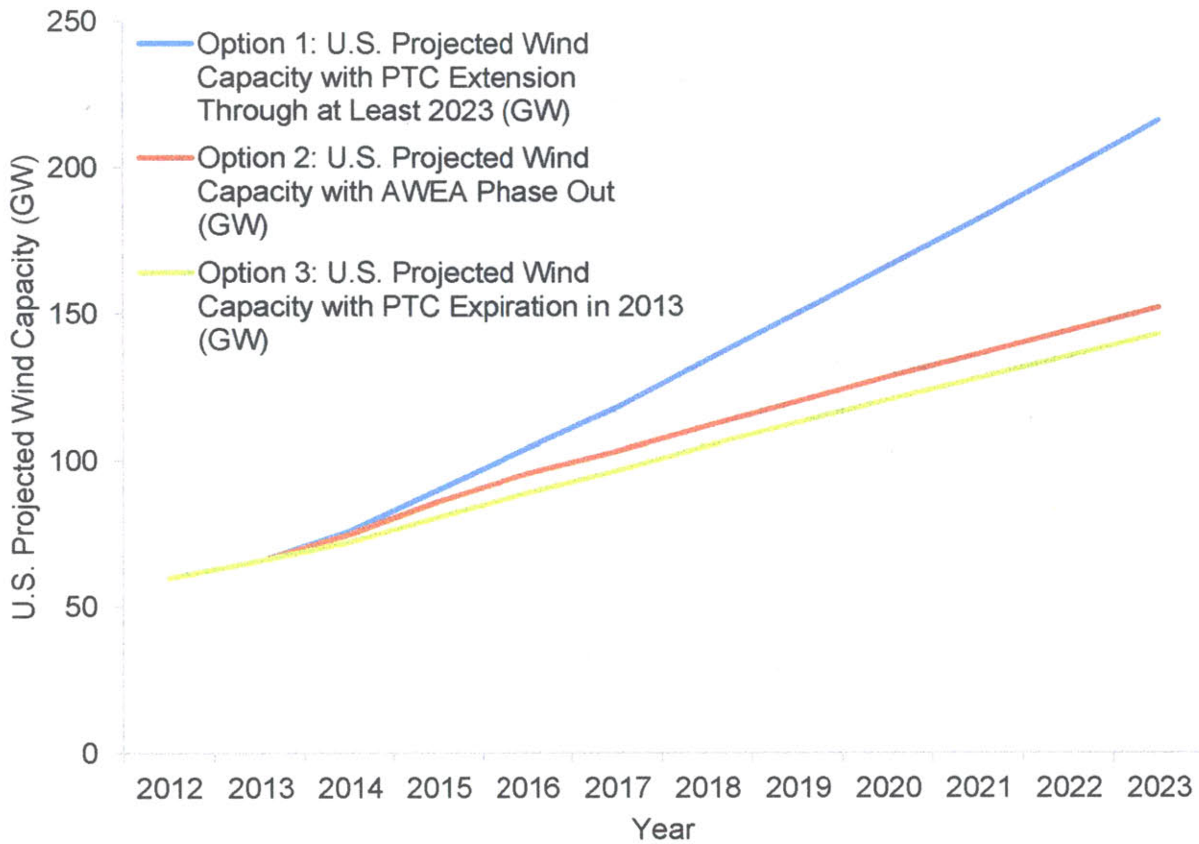

Figure 26. U.S. projected wind capacity for 2012-2023 in the high-growth penetration scenario if the PTC is extended through at least 2023, under the AWEA phase out proposal, and if the PTC expires in 2013.

While these projections are highly speculative regarding the market conditions and technology deployment necessary to meet the 20% Wind threshold, the projected capacity in the high-growth penetration scenario appears to be within reason based on the most optimistic projections currently available. For example, according to Navigant's *Impact of the Production Tax Credit on the U.S. Wind Market*, the cumulative installed wind capacity in the U.S. could reach 90 GW by 2016, the latest year through which the study projects, if the PTC is consistently in effect at least until the end of that year (Navigant Energy, 2011). In the high-growth projections under Option 1, the cumulative installed wind capacity in 2016 is projected to be approximately 17 percent higher than in Navigant's baseline projections.

Generation projections for the high-growth penetration scenario are also based on the 20% wind energy goal. While the 20% wind energy projections provide some guidance as to the capacity that must be added each year to reach the goal, they do not provide detailed generation targets for each year other than to say that by 2030, 1,200 terawatt-hours of electricity must be generated from wind energy annually in order to supply 20% of the total U.S. electricity demand (National Renewable Energy Laboratory, 2008). Therefore, generation projections for each option in the high-growth penetration scenario are based solely on proportionality with capacity projections in the corresponding option for the corresponding year.

The proportional relationship between capacity and generation is found by calculating the average ratio of additional generation to additional capacity for the years 2005-2011, a period of time that was largely free of the boom-and-bust cycle induced by repeated PTC expirations during the years 2000-2004, although one expiration did occur in 2010. The data for this calculation is shown in Table 16.

Table 16. U.S. annual increase in electricity net generation from wind, U.S. wind installations, and the ratio of new generation to new capacity, 2005-2011 (United States Energy Information Administration, 2012) (American Wind Energy Association, 2009) (American Wind Energy Association, 2012).

Year	2005	2006	2007	2008	2009	2010	2011	Average, 2005-2011
U.S. Annual Increase in Electricity Net Generation from Wind (Billion kWh)	3.667	8.779	7.861	20.913	18.523	20.766	25.094	15.086
U.S. Wind Installations (GW)	2.374	2.454	5.252	8.362	10.002	5.214	6.647	5.758
Ratio, New Generation/New Capacity (Billion kWh/GW)	1.545	3.577	1.497	2.501	1.852	3.983	3.775	2.676

The average ratio of new generation to new capacity for these years is 2.676, meaning that an average of 2.676 billion kWh of additional electricity was generated from wind energy for every 1 GW of wind installations that occurred between 2005 and 2011.

Given this average ratio, the projected wind capacity (GW) for each year is simply multiplied by 2.676 to obtain the projected generation (billion kWh) for the corresponding option and the corresponding year. The projected electricity net generation from wind for 2012-2023 in each of the three options in the high-growth penetration scenario is shown in Figure 27.

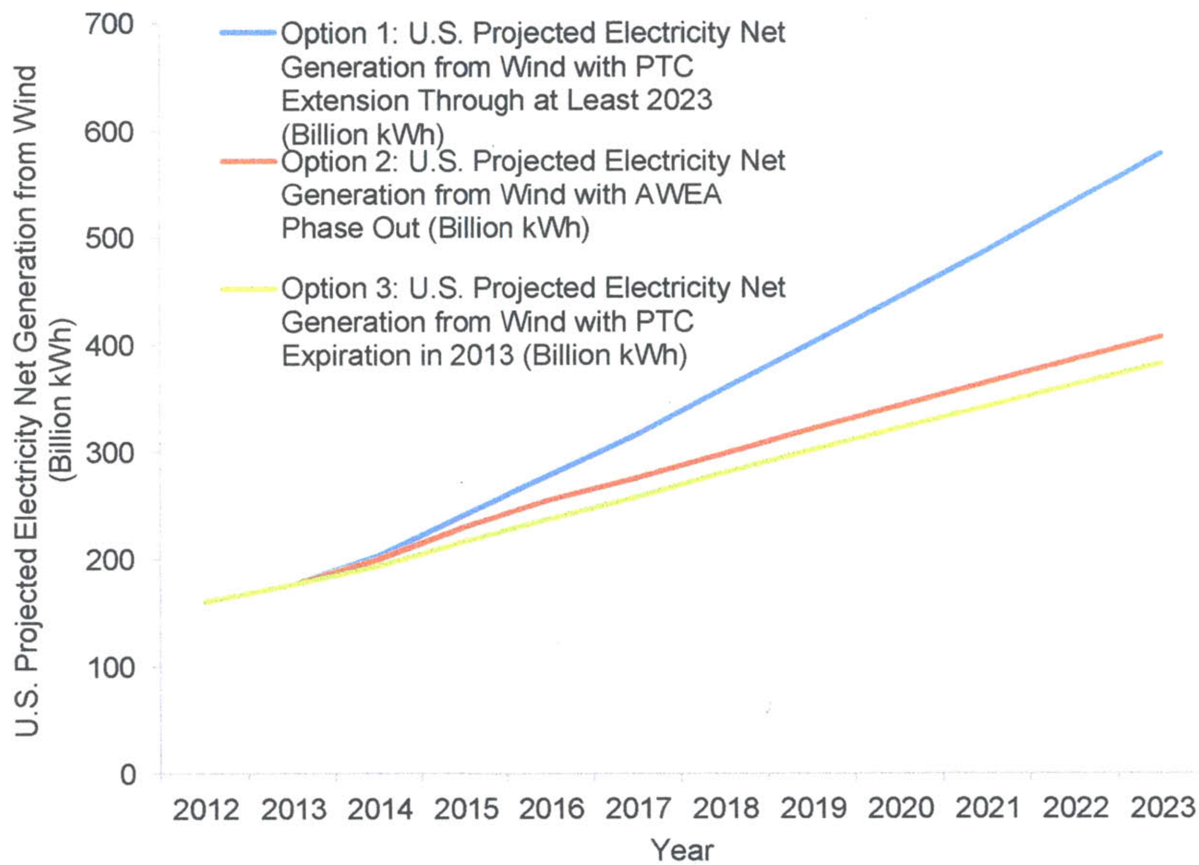

Figure 27. U.S. projected electricity net generation from wind for 2012-2023 in the high-growth penetration scenario if the PTC is extended through at least 2023, under the AWEA phase out proposal, and if the PTC expires at the end of 2013.

While this method of predicting future generation based on capacity projections includes many assumptions and relies on a simplified version of the actual relationship between installed wind capacity and wind energy generation, the results are not unreasonable for two primary reasons. First, the 20% wind plan implies that its capacity projections are necessary to generate 1,200 terawatt-hours of electricity from wind energy by 2030 (National Renewable Energy Laboratory, 2008). The generation projected in the calculations above for the year 2023 in Option 1, Option 2, and Option 3 is 577.958 billion kWh, 406.453 billion kWh, and 381.850 billion kWh, respectively. Although these generation totals are not rigorously correlated with the goal of 1,200 terawatt-hours of wind power generation by 2030, they appear to be within a reasonable range toward achieving that goal. Secondly, an estimated ratio of 2.676 billion kWh of generation per 1 GW installed appears to correspond with a reasonably attainable capacity factor of 30.53%. The calculation for attaining this capacity factor is shown in Equation 27. Note that the range of 2005-2011 includes seven years, one of which includes 366 days and six of which include 365 days, resulting in an average year length of 365 1/7 days.

Equation 27

$$\frac{2.676\ Billion\ kWh \times \frac{10^3 GWh}{Billion\ kWh}}{365\frac{1}{7} days \times 24\ hours/day \times 1GW} = 30.53\%\ Capacity\ Factor$$

Wind Production Tax Credit Cost Projections

The low-, medium-, and high-growth penetration scenario estimates are then used to evaluate the three options on overall cost and on cost effectiveness. Because PTC tax credits are dependent on generation, total cost projections are first calculated based on generation projections. Then, cost effectiveness projections can be put in terms of dollars per kWh of wind energy generated or in terms of GW of wind capacity installed. Because all three options account for the current PTC set to expire at the end of 2013 and assume the same capacity and generation projections for 2013, as explained above, cost projections are made for the ten year period beginning in 2014, the first year for which cost projections for the three options are not identical. Additionally, assuming a two percent annual inflation rate and a PTC credit of $0.022/kWh, the value of the PTC for years 2013-2023 is shown in Table 17.

Table 17. PTC values assuming a value of $0.022/kWh in 2013 and a two percent annual inflation rate, 2014-2023.

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
PTC ($/kWh)	0.022	0.022	0.023	0.023	0.024	0.024	0.025	0.026	0.026	0.027

Medium-Growth Penetration Scenario

Annual cost projections for the medium-growth penetration scenario are based on the projected changes in wind capacity and generation shown in Figure 22 and Figure 23. These annual cost projections are shown in Figure 28.

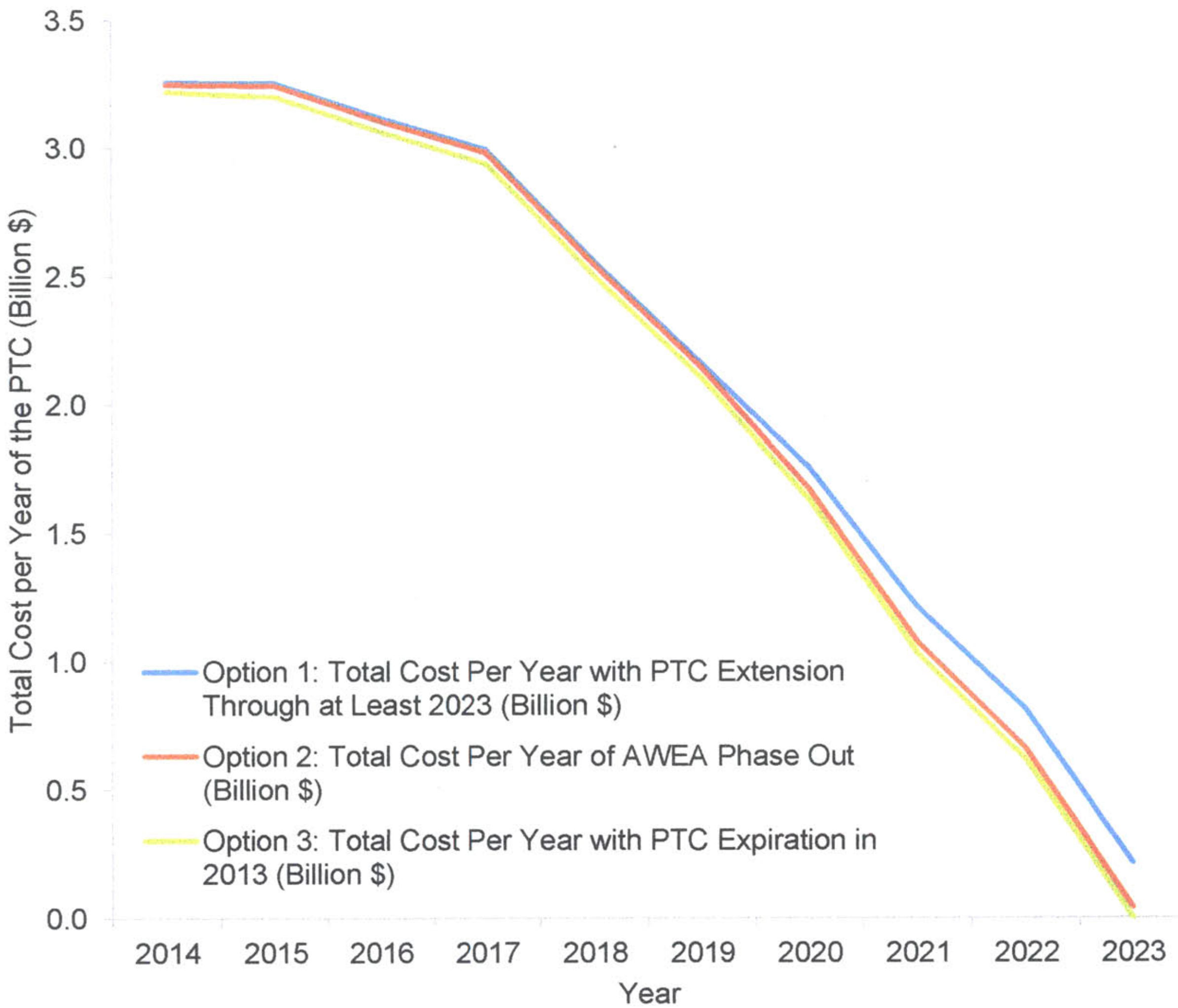

Figure 28. Total cost per year of the wind PTC for three renewal options in the medium-growth penetration scenario, 2014-2023.

As Figure 28 shows, there is a sharp decline in total cost of the PTC per year in all three renewal options which coincides with the sharp decline in year-to-year generation increases discussed above and shown in Figure 20. While the indefinite extension of the PTC carries the highest annual cost throughout the ten years, followed by the AWEA phase out plan, and the permanent extension of the PTC in 2013, the three options do not differ greatly in annual cost because of the expected decline in the rate of new installations, as shown in Figure 21. Due to the relative lack of capacity additions after 2013, the bulk of the power generated from wind energy any time after the year 2013 will be attributable to capacity that was added prior to the end of 2013 and is, therefore, eligible for PTC credits at the same level and for the same number of years under all three options; that is, generation that results from capacity that was added prior to the end of 2013 is eligible for PTC credits for the same ten years under all three options.

While the annual costs shown in Figure 28 show that annual PTC credits are projected to rapidly decrease in any of the three renewal options, the total cost of each option over the ten year period and the effectiveness of the PTC in terms of additional wind capacity or increased generation must also be considered. In order to compare the total cost and cost effectiveness of each option, the accumulated cost, the accumulated cost per billion kWh of additional electricity generated annually from wind energy, and the accumulated cost per GW of additional wind capacity are calculated for the years 2014-2023. Additionally, the projected electricity net generation from wind and the projected wind capacity in 2023 for the medium-growth penetration scenario are calculated. The results are shown in Table 18.

Table 18. Accumulated cost, accumulated cost per billion kWh of additional electricity generated annually from wind energy, and accumulated cost per GW of additional wind capacity for the years 2014-2023 and total electricity generated from wind energy and total installed wind capacity in 2023 under the three PTC renewal options and assuming the medium-growth penetration scenario.

PTC Renewal Option	Accumulated Cost, 2014-2023 (Billion $)	Accumulated Cost per Billion kWh of Additional Electricity Generated Annually from Wind Energy, 2014-2023 (Billion $)	Accumulated Cost per GW of Additional Wind Capacity, 2014-2023 (Billion $)	Total Electricity Generated from Wind Energy, 2023 (Billion kWh)	Total Installed Wind Capacity, 2023 (GW)
Option 1: PTC Extended Through at Least 2023	21.351	2.614	8.35	168.633	62.889
Option 2: AWEA PTC Phase Out	20.727	3.421	11.71	166.524	62.103
Option 3: PTC Expires in 2013	20.309	3.594	12.55	166.116	61.950

Option 1 has the highest accumulated cost over the entire ten year period – roughly $600 million more expensive than the AWEA phase out plan and more than $1 billion more expensive than if the PTC were to expire at the end of 2013. However, the rankings are inverted when evaluated on projected cost effectiveness, with Option 1 providing the lowest cost of credits per billion kWh of additional electricity generated annually from wind and the lowest cost per GW of additional wind capacity. Option 2 is the second cheapest in terms of cost effectiveness, followed by Option 3. These results reflect that even though Option 1 is the most expensive option in terms of foregone federal revenue that is instead credited through the PTC, the additional generation and capacity projected under Option 1 relative to the other two options make it projected to be the most cost effective option.

Low-Growth Penetration Scenario

Annual cost projections for the low-growth penetration scenario are based on the projected changes in wind capacity and generation shown in Figure 24 and Figure 25. These cost projections are shown in Figure 29.

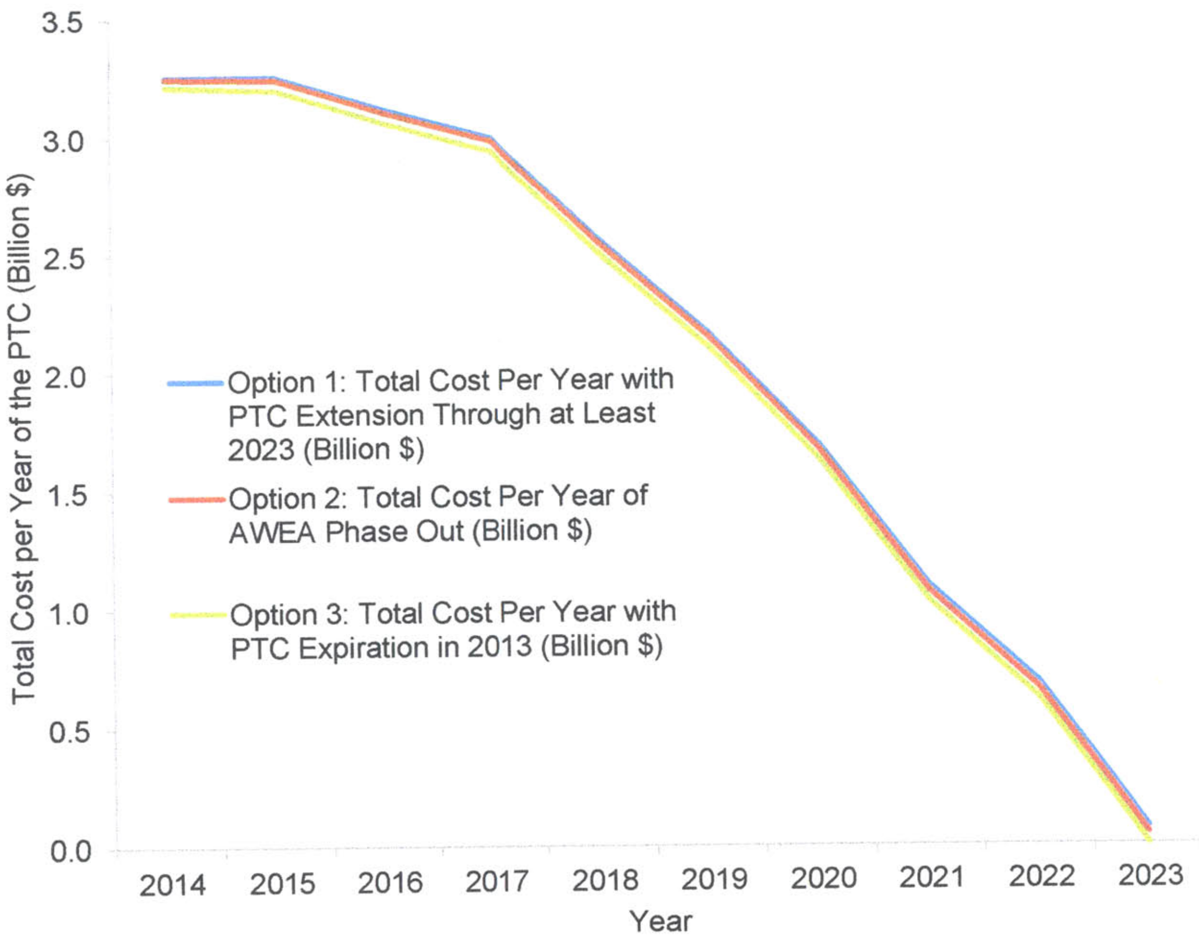

Figure 29. Total cost per year of the wind PTC for three renewal scenarios in the low-growth penetration scenario, 2014-2023.

As Figure 29 shows, the low-growth penetration scenario results in virtually identical annual costs of each of the three considered renewal options. While Option 1 carries the highest annual cost throughout the time period, followed by Option 2 and Option 3, respectively, all options are associated with a similarly rapid decline in annual cost of the PTC. The similarity of the costs results from, to an even greater extent than in the medium-penetration growth scenario, the decline in the rate of new installations and additional generation, as shown in Figure 24 and Figure 25. Just as in the medium-growth penetration scenario, the bulk of the power generated from wind energy any time after the year 2013 in the low-growth scenario is attributable to capacity that was added prior to the end of 2013 and is, therefore, eligible for PTC credits at the same level and for the same number of years under all three scenarios.

The accumulated cost, the accumulated cost per billion kWh of additional electricity generated annually from wind energy, and the accumulated cost per GW of additional wind capacity are calculated for the years 2014-2023. Additionally, the projected electricity net generation from wind and the projected wind capacity in 2023 for the low-growth penetration scenario are calculated. The results are shown in Table 19.

Table 19. Accumulated cost, accumulated cost per billion kWh of additional electricity generated annually from wind energy, and accumulated cost per GW of additional wind capacity for the years 2014-2023 and total electricity generated from wind energy and total installed wind capacity in 2023 under the three PTC renewal options and assuming the low-growth penetration scenario.

PTC Renewal Option	Accumulated Cost, 2014-2023 (Billion $)	Accumulated Cost per Billion kWh of Additional Electricity Generated Annually from Wind Energy, 2014-2023 (Billion $)	Accumulated Cost per GW of Additional Wind Capacity, 2014-2023 (Billion $)	Total Electricity Generated from Wind Energy, 2023 (Billion kWh)	Total Installed Wind Capacity, 2023 (GW)
Option 1: PTC Extended Through at Least 2023	20.890	8.072	31.11	163.054	61.003
Option 2: AWEA PTC Phase Out	20.727	8.809	35.65	162.819	60.913
Option 3: PTC Expires in 2013	20.309	10.413	47.79	162.416	60.760

Option 1 has the highest accumulated cost over the entire ten year period, followed by Option 2 and Option 3, respectively. Option 2 and Option 3 have the same accumulated cost for the time period as in the medium-growth penetration scenario because for the years during which newly installed capacity is eligible for the PTC under these options (-2018 in Option 2 and -2013 in Option 3), the generation projections are assumed to be equivalent in the low-growth penetration scenario and in the medium-growth penetration scenario. The rankings are inverted when evaluated on projected cost effectiveness, with Option 1 providing the lowest cost of credit per billion kWh of additional electricity generated annually from wind and the lowest cost per

GW of additional wind capacity. Option 2 is the second cheapest in terms of cost effectiveness, followed by Option 3.

High-Growth Penetration Scenario

Annual cost projections for the high-growth penetration scenario are based on the projected changes in wind capacity and generation shown in Figure 26 and Figure 27. These cost projections are shown in Figure 30.

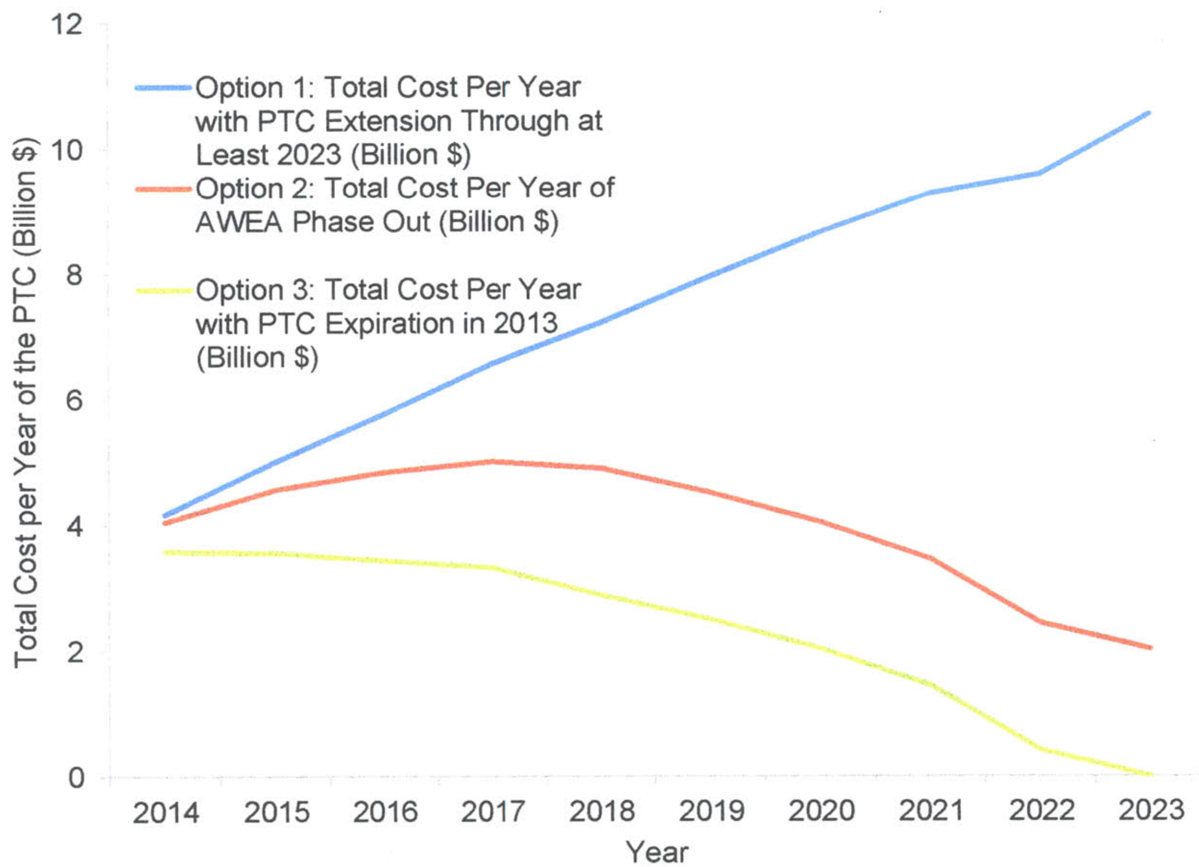

Figure 30. Total cost per year of the wind PTC for three renewal options in the high-growth penetration scenario, 2014-2023.

As Figure 30 shows, Option 1 annual cost projections are significantly higher than the annual cost projections for Option 2, which decline after the termination of the PTC in 2018, and those for Option 3, which decline for the entire period after the expiration of the PTC in 2013. The Option 1 cost projections are significantly higher and continually increasing because of the extension of the PTC at its full value over the entire period and the ambitions generation projections assumed in the high-growth penetration scenario. Although the generation projections for Option 2 are nearly as ambitious as those under Option 1, the annual cost of the PTC under Option 2 grows at a slower rate over the period for which the level of PTC credit is gradually reduced and then steadily falls after 2018, when new capacity is no longer eligible for the PTC. Finally, there is more differentiation in terms of annual cost of the PTC between the three options in the high-growth penetration scenario than in the medium-growth penetration scenario because in the high-growth scenario, new capacity continues to be installed at an increasing rate after 2013. These new installations are eligible for PTC credits under Option 1 and Option 2, but not under Option 3 in the high-growth penetration scenario. In the medium-growth penetration scenario and in the low-growth penetration scenario, the bulk of the power generated from wind energy after 2013 is attributable to capacity installed prior to 2013 and, therefore, results in a similar quantity of credits under all three options.

The accumulated cost, the accumulated cost per billion kWh of additional electricity generated annually from wind energy, and the accumulated cost per GW of additional wind capacity are calculated for the years 2014-2023. Additionally, the projected electricity net generation from wind and the projected wind capacity in 2023 for the high-growth penetration scenario are calculated. The results are shown in Table 20.

Table 20. Accumulated cost, accumulated cost per billion kWh of additional electricity generated annually from wind energy, and accumulated cost per GW of additional wind capacity for the years 2014-2023 and total electricity generated from wind energy and total installed wind capacity in 2023 under the three PTC renewal options and assuming the high-growth penetration scenario.

PTC Renewal Option	Accumulated Cost, 2014-2023 (Billion $)	Accumulated Cost per Billion kWh of Additional Electricity Generated Annually from Wind Energy, 2014-2023 (Billion $)	Accumulated Cost per GW of Additional Wind Capacity, 2014-2023 (Billion $)	Total Electricity Generated from Wind Energy, 2023 (Billion kWh)	Total Installed Wind Capacity, 2023 (GW)
Option 1: PTC Extended Through at Least 2023	74.749	0.186	0.498	577.958	216.007
Option 2: AWEA PTC Phase Out	39.861	0.173	0.464	406.453	151.909
Option 3: PTC Expires in 2013	23.155	0.113	0.302	381.850	142.713

Unsurprisingly, Option 1 again has the highest accumulated cost over the entire ten year period – roughly $35 billion more expensive than the AWEA phase out plan and $52 billion more expensive than if the PTC were to expire at the end of 2013. However, Option 1 is also the most expensive in terms of cost per kWh of additional electricity generated from wind power and cost per GW of additional wind capacity, followed by Option 2. In addition to providing the lowest overall cost, Option 3 provides the lowest cost per kWh of additional electricity generated from wind power and the lowest cost per GW of additional wind capacity in the high-growth penetration scenario.

Synthesis

The three case studies reveal tradeoffs that are associated with various PTC renewal options and the potential policy goals that can be balanced when evaluating the options. For example, if the primary policy goal is to minimize the accumulated cost of the wind PTC over the next ten years, of the three considered options, allowing the PTC to expire at the end of 2013 is the best option under all three growth scenarios. However, if the primary policy goal is to maximize the cost effectiveness of the PTC in terms of accumulated cost per billion kWh of additional electricity generated annually from wind energy and accumulated cost per GW of additional wind capacity, the three growth scenarios yield different results. In the low- and medium-growth penetration scenarios, extending the PTC through at least 2023 is the most cost effective option. In the high-growth penetration scenario, allowing the PTC to expire at the end of 2013 is the most cost effective option. Finally, if the primary policy goal is to maximize the increase in total installed wind capacity over the next ten years, extending the PTC at its full value is likely to yield the best results under any growth scenario.

Based on the differing ideal options designed to meet various policy objectives, the AWEA phase out option provides a tradeoff between accumulated cost and cost effectiveness, at least in the low- and medium-growth penetration scenarios. In these growth scenarios, the AWEA's phase out provides a compromise between minimizing accumulated cost and maximizing cost effectiveness.

Chapter 13. Recommendations: Improving Public Decision Making

The case of the repeated, short-term extensions of the wind PTC offers a teachable example of an opportunity to improve public decision making, not only as it relates to scientific and technological issues, but also as it relates to issues of economic and industry equity. An overview of the obstacles, the relevant controversies, the important actors, and the role of third party institutions reveals opportunities to improve public decision making on tax policies for emerging and expanding industries.

Obstacles

One obstacle to a long-term tax policy taking the place of the cycle of short-term wind PTC renewals is that the public discourse regarding wind energy policy is often framed as a binary argument between those in favor of extension of the wind PTC and those against it. The binary framing is dictated by Congress and the political motivations of its members. It is entirely logical for any candidate campaigning as a pro-free market, anti-special interest candidate to voice opposition to extension of the PTC. The candidate need not advocate for a more drastic option, such as immediate termination of the PTC because it is up for expiration every few years anyway. The natural counterargument for any candidate in favor of the PTC is to support its extension to a later expiration date. The length of time of the renewal is not significant in gaining votes because any renewal is more favorable to the industry than its scheduled expiration. As a result, other options, such as a long-term policy, are not prominently framed as part of the debate. The binary context of the PTC debate creates a difficult environment for wind energy stakeholders to advocate for a long-term tax policy to take the place of the PTC. In the argument either for or against the PTC, the wind industry and other stakeholders are forced to defend extension of the wind PTC in order to avoid losing one of the industry's most favorable existing tax policies rather than propose a new, more stable tax policy.

The binary PTC debate could be shifted as part of a broader Congressional policy to simplify the tax code through the reevaluation of multiple deductions and credits. It is unlikely that out of all of the tax credits in place and all the industries currently facing market uncertainty, Congress would be motivated to consider replacing the PTC. However, if Congress undertook a broader effort to simplify the tax code, the PTC would be an obvious opportunity to consider more stable options that would inject certainty and stability into the economy.

Relevant Policy Controversies

The primary policy controversy at issue is that which is discussed above at length – while the wind PTC is designed to facilitate growth of the U.S. wind energy industry, its repeated short-term renewals have introduced substantial uncertainty into the market, thereby interfering with the long-term organic growth of domestic wind energy capacity. As a result, wind energy providers face legislative uncertainty in addition to the economic uncertainty faced by all energy providers.

An additional policy controversy at issue is the claim that there is a lack of industrial equity between conventional and renewable energy industries. As discussed above, wind industry groups, such as the AWEA, claim that the established industry benefits from energy production incentives that are in excess of those provided to the emerging wind industry, thereby hindering the ability of the wind industry to compete with several long-established energy sources.

Positions and Interests of Important Actors

The AWEA is one of the most prominent advocates of the wind PTC. Until 2012, it did not make unified arguments for a PTC extension longer than five years or for replacing the PTC with a more consistent incentive mechanism. With the threat of the 2009 extension, the AWEA lobbied for a five-year extension (American Wind Energy Association, 2008). Instead, it received a four-year extension. With the threat of expiration at the end of 2012 looming, the AWEA wrote to Congress with a proposal to phase out the wind PTC over the coming years (Bode, 2012). The plan, detailed in Table 13, gradually reduces the level of PTC credits until generation resulting from capacity installed after 2018 is no longer eligible for the PTC.

U.S. taxpayers are also stakeholders, although their interests are considerably more diffuse and diverse than those of the AWEA. While the PTC provides a substantial economic benefit to windmill owners and workers associated with the wind power industry, any tax credit provided to one industry burdens other industries and taxpayers with a greater share of the U.S. federal tax burden and debt. However, partially due to the diffuse interests of taxpayers and to the small cost of the PTC to each individual taxpayer, there has been little to no significant opposition to a more permanent wind tax credit from the tax-paying public.

In the absence of significant public opposition to a permanent tax credit, several organizations that represent taxpayers and various economic and energy interests favor a permanent expiration of the wind PTC. For example, the Institute for Energy Research (IER), a not-for-profit organization that advocates for "freely-functioning energy markets," provides evidence that the PTC is a poor investment and should be allowed to expire permanently. IER argues that regardless of whether the PTC is extended, only 5 GW of wind power will "be installed in 2013, almost a two-thirds decline" from 2012. IER provides several possible explanations for the inevitable decline in newly installed wind capacity. First, there is growing competition from natural gas, which is now at its highest level of production in U.S. history. Second, many states have a lowered incentive to add wind capacity because "utilities in most of the states with renewable portfolio standards have enough wind capacity to meet their targets for the next few years." Furthermore, "there is more wind turbine manufacturing capacity than is forecast to be needed," indicating that many of the job losses projected in the wind industry are likely to occur regardless of whether the PTC is extended. Finally, given that extending the PTC will cost an estimated "$12 billion over the next ten years" and will save an estimated 46,000 jobs (Navigant Energy, 2011), each saved job costs "the tax payer over $260,000" (Institute for Energy Research, 2012). It is likely that the actual cost per saved job would be even higher because the study does not consider what portion of the 46,000 workers would become employed in another industry. Citing these examples, IER argues that the wind PTC is expensive to the taxpayer in terms of its effect on employment and its overall effect on industry growth.

Proponents of a more permanent tax incentive structure can offer several counterarguments for why domestic wind capacity can continue to rapidly increase in a stable tax environment. While competition from natural gas has increased dramatically in a few short years, the natural gas industry is in the midst of even broader regulatory uncertainty. The projections of future natural gas production are highly dependent on future regulations. Second, while some states have enough installed wind capacity to meet their wind energy targets for several years, some states are currently projected to fall short of their goals for 2020 or 2025, indicating that there may be opportunities in specific states to add wind capacity in the coming years. Finally, although job losses may occur with or without the PTC or an alternative long-term incentive, and although the PTC has the potential to save jobs at a high cost per job saved, the wind PTC is not a jobs program. There are many benefits associated with added renewable energy capacity, such as reduced greenhouse gas emissions and reduced dependence on foreign energy, that are not included in simple cost-per-job calculations.

Third Party Institutions

Many third party institutions have contributed to knowledge assessment in the debate over the wind PTC. The AWEA is notable for referencing third party institutions such as the

National Academy of Sciences (NAS), the Government Accountability Office (GAO), and the Congressional Research Service (CRS) to support its arguments in favor of extending the PTC. In the study "The Hidden Costs of Energy," the NAS estimates the monetary value of externalities such as "lung damage, asthma, and premature deaths from air pollution, birth defects from mercury fallout, and damage to timber harvests and ecosystem services from acid rain" associated with various sources of energy. The NAS explains that these "external effects associated with energy production and use are generally not taken into account" in decision-making. Its study found that in the electricity sector, "existing government subsidies and incentives are dwarfed by the hidden costs of pollution, largely from fossil fuels." The AWEA points to the NAS study as evidence that the externalities associated with fossil fuels are essentially "a hidden subsidy for polluting energy sources" substantially more expensive to the American taxpayer than the wind PTC (American Wind Energy Association, 2010).

The AWEA also references studies published by the CRS and the GAO. According to the CRS, "[f]or more than half a century, federal energy tax policy focused almost exclusively on increasing domestic oil and gas reserves and production. There were no tax incentives promoting renewable energy." In an analysis of federal electricity incentives, the GAO found that between fiscal years 2002 and 2007, "about $13.7 billion [in tax expenditures] was provided to fossil fuels and $2.8 billion [was provided] to renewables." The AWEA notes that while these policies created and continue to support "an abundance of affordable domestic energy," tax incentives for renewable energy sources are needed to address today's energy concerns.

These third party institutions provide pertinent information to the debate over the wind PTC, but among them, only the NAS, through its Board on Science, Technology, and Economic Policy, is equipped to sufficiently evaluate the myriad effects of the tax credit on the overall economy. However, it has not published a study specifically on the efficacy or efficiency of the PTC. Even if it were to publish such a study, their studies are often promoted by the stakeholders whose interests are supported by their findings and denounced as susceptible to outside influence, biased, or erroneous by those whose interests are refuted, perpetuating a policy stalemate. There is a need for studies which provide holistic economic projections and invoke confidence in the conclusions from all stakeholders.

The strategy employed by The H. John Heinz Center for Science, Economics, and the Environment can help fill this void and improve public decision making in cases where appraisal of economic, energy, environmental, and technological knowledge is required. Tax policy as applied to wind energy involves many complex and interrelated issues. Few independent industry players, interest groups, or policymakers can formulate a complete story of the economic merits of the wind PTC or any alternative tax policy. Although assessing alternative energy generation tax policies is not classically understood as an issue of "knowledge assessment" that the Heinz Center would consider, its approach to knowledge assessment can be applied to public decision making on issues of such complexity.

Two primary features of The Heinz Center's approach to knowledge assessment make it particularly applicable to the assessment of various wind energy tax policies. First, the inclusion of "economic expertise issues as well as other scientific expertise" is applicable to decision making in the area of energy tax policy (McCray, 2003). As the PTC is a tax policy that impacts an entire rapidly growing industry, assessments of the wind PTC or any alternative policy must incorporate economic expertise that enables consideration of broad economic and industry effects. Studies commissioned by third party organizations, however, often only project direct economic and industry effects and, therefore, have a tendency to overstate effects. For example, a study produced by Navigant Consulting, Inc., projects the impact of PTC renewal on manufacturing, construction, installation, operation, and employment (Navigant Energy, 2011). While it makes clear that total wind and wind-related employment will be positively impacted by PTC renewal, it does not consider how the changing tax incentives impact other industries which could potentially employ workers laid off from wind-related jobs. Additionally, few third party studies consider whether the dramatic decreases in newly installed capacity that occurred during past PTC expirations would occur if there was no possibility of PTC renewal. Some portion of the dramatic decreases may be explained by the wind industry merely delaying new installation until the industry-anticipated renewal of the PTC. Therefore, it is possible that new wind installations could occur at a much faster pace during a permanent expiration of the PTC than was experienced during the previous short-term expirations, during which the next extension was imminent. These examples indicate the possibility that Navigant's study overstates the negative long-term employment and economic impacts of a permanently expired PTC and the potential criticisms that can be offered by opponents of PTC extension. An emphasis on economic expertise could facilitate more realistic long-term economic projections and enhance credibility.

The Heinz Center's "direct and systematic" inclusion of "industry, environmental groups, government, and scientists" in its knowledge assessments could also provide a blueprint for effective knowledge assessment of various energy tax incentive policies. If conducted "in the open" with stakeholders from multiple renewable and nonrenewable energy industries and utilities, environmental groups, government leaders from multiple parties, and scientists from various fields, third party studies would be somewhat shielded from allegations of being unduly influenced by any particular party or stakeholder. Without these allegations, third party studies in the area of renewable energy tax incentives could gain credibility and acceptance and have a more measurable impact on decision-makers.

Finality

Congress and the wind industry must alter their approach to renewable energy PTCs in order to bring the process to finality by ending the frequent short-term renewals of the wind PTC that create artificial boom and bust cycles in the wind energy market. Finality could include replacement of the short-term PTC with a long-term policy, such as a ten-year PTC renewal, which, admittedly, would still entail considerable regulatory uncertainty but would reduce the frequency of potential expirations, or a feed-in tariff similar to the policy once in place in Germany. While a longer extension of the wind PTC would benefit industry by adding a degree of regulatory certainty, a 20-year feed-in tariff would offer an even more "secure and stable market for investors" (Couture, et al., 2010).

Congress must consider the detrimental effect of perpetual tax policy uncertainty on the organic growth of wind energy capacity in the U.S. As described above, the short-term renewals, subsequent expirations, and uncertainty of future renewals induce instability in the wind industry and subject the industry to policy uncertainty in addition to the economic uncertainty experienced by all industries. Additionally, Congress must consider the policy signal it provides to the wind energy industry by inducing short-term uncertainty into arguably the most favorable tax policy currently enjoyed by the wind industry. The constant expirations and renewals indicate a general lack of commitment to the wind industry on the part of Congress. Furthermore, Congress has motivation to replace the short-term wind PTC with a long-term policy for its own interests. Amidst the government's current emphasis on reducing the federal deficit over the next decade, Congress is critically analyzing many tax laws. With the uncertainty over the future status of the wind PTC resurfacing every few years, it is difficult for Congress to project the long-term revenue impacts of renewing the PTC. Without a long-term policy, Congress is unable to accurately predict when the PTC will be in effect over the long term or the projected growth of the industry each year, which affects the number of entities from which taxes will be collected. If the PTC were replaced by a ten-year tax policy, Congress would have a more accurate long-term projection of expected revenues from the wind industry.

Congress could make the counterargument that permanent PTC expiration is in their best interest because it will increase revenues. However, if the expiring tax credit causes a significant decrease in the number of new wind projects, as past expirations have, there will be fewer new projects from which to collect taxes, which could result in lower overall revenue than there would be with a long-term PTC renewal and a higher number of projects from which to collect taxes.

The wind industry must also modify its approach to lobbying and negotiating over the extension of the wind PTC. Currently, industry groups such as the AWEA spend significant resources advocating for short-term renewals of the wind PTC as its expiration nears. The industry continually advocates for short-term extensions primarily so as to maintain its tenuous bipartisan support, which the industry fears would not exist for a long-term policy. However, by continually advocating for short-term extensions, the industry subjects itself to regulatory uncertainty. Rather than advocating for a more consistent, predictable policy, the industry falls into the binary debate between PTC expiration and PTC extension. In doing so, the industry fails to attain a long-term policy and guarantees its favorable tax incentive will be at risk again in the near future, requiring time and resources to again be spent on a virtually identical debate every few years. To secure a more consistent tax policy, the wind industry must reduce its emphasis on PTC extensions and instead emphasize the need for a long-term tax policy that would be more conducive to sustained, organic growth of wind energy capacity in the U.S.

Uncertainties

There are many factors to consider in the evaluation of alternative tax incentives for renewable energy sources that go beyond the goal of attaining a more consistent economic environment. For example, the future costs and performance of conventional generation technology and wind technology may change the relative cost effectiveness of wind technology, thereby changing the value of tax incentives to the industry and to the taxpayer over time. There are also many non-economic impacts of the policy that are difficult to quantify. For example, there is widespread political and public interest in reducing dependence on foreign sources of energy. Increased deployment of renewable sources of energy such as wind provides an opportunity to inch toward the elusive goal of attaining energy independence. Additionally, increased deployment of renewable energy sources provides an opportunity to reduce consumption of fossil fuels, thereby reducing pollution and emission of greenhouse gases. The goals of energy independence and reduced emissions expose further uncertainty in the tradeoffs among renewable energy sources. The wind industry's total installed generation potential and current capacity are its primary advantages over other renewable sources, but other sources may offer significant advantages once they are further developed. The PTC has also come under heavy scrutiny in recent weeks due to the urgent desire of many members of

Congress to reduce the federal debt. These and many other considerations impact the characterization of the ideal tax incentive and may combine to produce outcomes that do not appear to be economically predictable or ideal for the wind energy industry or the American taxpayer.

Chapter 14. Conclusions

As evidenced by the success of the long-term U.S. fossil fuel incentives and consistent incentives such as Germany's wind energy feed-in tariff, the U.S. wind energy industry could benefit substantially from market and regulatory certainty that is not provided by the current wind PTC. Moreover, an expanded wind industry would provide the U.S. with substantial economic and environmental benefits. However, lack of a unified message on behalf of stakeholders and the simplicity of a binary argument between expiration and short-term extension of the PTC combine to prevent implementation of a long-term policy. Public decision making in this area could be improved through the expanded inclusion of economic expertise and the inclusion of stakeholders from multiple renewable and nonrenewable energy industries and utilities, environmental groups, government leaders representing multiple parties, and scientists from various fields throughout the policy development process. However, unless Congress ends its tendency to pass short-term PTC extensions only when the threat of expiration is near, the regulatory-induced boom and bust cycle in U.S. wind capacity installations will continue.

Appendix

Form **8835** — Department of the Treasury, Internal Revenue Service

Renewable Electricity, Refined Coal, and Indian Coal Production Credit

▶ Attach to your tax return.

▶ Information about Form 8835 and its separate instructions is at www.irs.gov/form8835.

OMB No. 1545-1362 — 2012 — Attachment Sequence No. 95

Name(s) shown on return | Identifying number

Part I — Electricity Produced at Qualified Facilities Placed in Service Before October 23, 2004

1	Kilowatt-hours produced and sold (see instructions)	× 0.022	1	
2	Phaseout adjustment (see instructions) $	×	2	
3	Credit before reduction. Subtract line 2 from line 1		3	
	Reduction for government grants, subsidized financing, and other credits:			
4	Total of government grants, proceeds of tax-exempt government obligations, subsidized energy financing and any federal tax credits allowed for the project for this and all prior tax years (see instructions)		4	
5	Total of additions to the capital account for the project for this and all prior tax years		5	
6	Divide line 4 by line 5. Show as a decimal carried to at least 4 places		6	.
7	Multiply line 3 by line 6		7	
8	Subtract line 7 from line 3		8	
9	Part I renewable electricity production credit from partnerships, S corporations, cooperatives, estates, and trusts		9	
10	Add lines 8 and 9. Cooperatives, estates, and trusts, go to line 11. Partnerships and S corporations, report this amount on Schedule K. All others, report this amount on Form 3800, line 1f (see instructions)		10	
11	Amount allocated to patrons of the cooperative or beneficiaries of the estate or trust (see instructions)		11	
12	Cooperatives, estates, and trusts, subtract line 11 from line 10. Report this amount on Form 3800, line 1f		12	

Part II — Electricity and Refined Coal Produced at Qualified Facilities Placed in Service After October 22, 2004 (After October 2, 2008, for Electricity Produced From Marine and Hydrokinetic Renewables), and Indian Coal Produced at Facilities Placed in Service After August 8, 2005

	13 Electricity produced at qualified facilities using:		(a) Kilowatt hours produced and sold (see instructions)	(b) Rate	(c) Column (a) × Column (b)		
a	Wind	13a					
b	Closed-loop biomass	13b					
c	Geothermal	13c					
d	Solar	13d					
e	Add column (c) of lines 13a through 13d and enter here (see instructions)					13e	

	14 Electricity produced at qualified facilities using:		(a) Kilowatt hours produced and sold (see instructions)	(b) Rate	(c) Column (a) × Column (b)		
a	Open-loop biomass	14a					
b	Small irrigation power	14b					
c	Landfill gas	14c					
d	Trash	14d					
e	Hydropower	14e					
f	Marine and hydrokinetic renewables	14f					
g	Add column (c) of lines 14a through 14f and enter here (see instructions)					14g	

15	Add lines 13e and 14g		15	
16	Phaseout adjustment (see instructions) $	×	16	
17	Subtract line 16 from line 15		17	
	Refined coal produced at a qualified refined coal production facility			
18	Tons produced and sold (see instructions)	× $6.475	18	
19	Phaseout adjustment (see instructions) $	×	19	
20	Subtract line 19 from line 18		20	
21	Reserved		21	
	Indian coal produced at a qualified Indian coal production facility			
22	Tons produced and sold (see instructions)	× $2.267	22	
23	Credit before reduction. Add lines 17, 20, 21, and 22		23	

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	Reduction for government grants, subsidized financing, and other credits:		
24	Total of government grants, proceeds of tax-exempt government obligations, subsidized energy financing, and any federal tax credits allowed for the project for this and all prior tax years (see instructions)	24	
25	Total of additions to the capital account for the project for this and all prior tax years	25	
26	Divide line 24 by line 25. Show as a decimal carried to at least 4 places	26	.
27	Multiply line 23 by the smaller of ½ or line 26	27	
28	Subtract line 27 from line 23	28	
29	Part II renewable electricity, refined coal, and Indian coal production credit from partnerships, S corporations, cooperatives, estates, and trusts	29	
30	Add lines 28 and 29. Cooperatives, estates, and trusts, go to line 31. Partnerships and S corporations, report this amount on Schedule K. All others: For electricity, refined coal, or Indian coal produced during the 4-year period beginning on the date the facility was placed in service, report the applicable part of this amount on Form 3800, line 4e. For all other production of electricity, refined coal, or Indian coal, report the applicable part of this amount on Form 3800, line 1f (see instructions)	30	
31	Amount allocated to patrons of the cooperative or beneficiaries of the estate or trust (see instructions)	31	
32	Cooperatives, estates, and trusts, subtract line 31 from line 30. For electricity, refined coal, or Indian coal produced during the 4-year period beginning on the date the facility was placed in service, report the applicable part of this amount on Form 3800, line 4e. For all other production of electricity, refined coal, or Indian coal, report the applicable part of this amount on Form 3800, line 1f	32	

Form **8835** (2012)

Figure 31. IRS Form 8835, Renewable Electricity, Refined Coal, and Indian Coal Production Credit (Department of the Treasury Internal Revenue Service, 2012).

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