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Putting the Wind at Our Backs: Assessing U.S. Potential for 20% Wind Energy by 2030

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Executive Summary

The discussion surrounding the future of energy, particularly in the United States, has gained significant momentum in recent years for an obvious reason — it's daunting. Our dependence on fossil fuels has positioned our nation in an undesirable predicament with a questionable future. With the associated consequences, principally Climate Change, it is essential that energy be addressed as a primary national concern. Renewables need to flip the switch.

In 2006, George Bush called for greater energy efficiency and a more diverse energy portfolio, spurring a Department of Energy study into U.S. potential for 20% Wind Energy by 2030. The subsequent report demonstrated that achieving this goal of 20% is in fact viable given the United States' abundant wind resources – and the associated benefits are significant. Truly establishing wind energy as a significant sector of our electricity supply would help to address many critical national and global issues – air pollution, water supply, energy security, energy dependence, and Climate Change. The balance of this paper will explore these benefits as well as the challenges currently limiting the expansion of wind energy from transmission issues to economics to social obstacles.

While a substantial portion of wind energy opposition is founded on misconceptions (that will be addressed in this paper), there are a number of real issues that need to be met, including regulatory limitations, lack of transmission infrastructure, and a general need for further industry investment. It ultimately comes down to a matter

of necessity. Fossil fuels are not sustainable and the longer we prolong the transition to renewable power, the greater the consequences are likely to be. With a proper action plan, driven primarily by pricing carbon and establishing strong public support for renewable energy, the United States has true potential to meet 20% wind by 2030 – the implications of which will be momentous and worldwide.

I. Setting the Stage

A. Carbon County

Wyoming's ironically named Carbon County is currently the proposed breeding ground for one of the world's largest wind farms — with a capacity of 2500 MW and the potential for significantly reducing carbon emissions in the area.[1] Approximately 150 years ago, Carbon County, not so ironically named after all, became home to some of the earliest coal mines in the nation, and was named for its extensive coal deposits. While coal mining is still a major industry in Wyoming as a whole, producing roughly 450 million tons annually (the highest in the nation), the recent focus-change, from coal to wind power generation in Carbon County, reflects a mounting national and global concern — our energy future.[2]

B. The Dilemma

Times have changed. Today, because of our growing consumption trends over the past one hundred years, we face a major energy dilemma in the United States. As Wes Jackson says, "We came here as poor people on rich land, but now we are rich

[1] "Putting Wind to Work for Carbon County." *Power Company of Wyoming*. Power Company of Wyoming LLC, 2012. Web. 15 Mar 2012.
[2] United States. Energy Information Administration. *Annual Coal Report*. Washington, DC: EIA, 2011. Web.

people on poor land."[3] While Jackson's statement was directed at the agricultural potential of American soils, it also holds true for the energy potential we have beneath our soils. Ever since this potential -- in the form of rich coal, gas, and oil reserves -- beneath our feet was first realized in the late 1700's, we started to exploit it and never turned back. Throughout the United States' relatively brief history, our fossil fuel dependency has followed an exponential trend. Consequently, our fossil fuel reserves have been depleted exponentially, our reliance on foreign (and unstable), resource-rich regions has increased exponentially, and carbon dioxide concentrations in the air have increased exponentially to unprecedented levels — leaving current (and future) generations of Americans with a myriad of problems. These trends are not sustainable.

(1) Depletion of Local Reserves

The very nature of the word "nonrenewable" immediately calls into question the sustainability of America's current fossil fuel dependency. In 1956, M. King Hubbert proposed the rather intimidating bell-shaped curve—representative of fossil fuel production in a given region over time.[4] Most commonly associated with oil, but reflective of natural gas and coal as well, Hubbert's curve suggests that no finite resource can sustain exponential growth. While Hubbert's contributions were largely projections of the future and thus, subject to criticism, the fundamental concept illustrated by the bell-shape is a harsh reality — peak oil, peak coal, and peak gas exist. And as experts generally agree, following our current trajectory, these peaks are

[3] Jackson, Wes. *Consulting the Genius of the Place: An Ecological Approach to a New Agriculture*. Berkeley, CA: Counterpoint, 2010. Print.

[4] Hubbert, M. King. "Nuclear Energy and The Fossil Fuels." *Drilling and Production Practice: American Petroleum Institute*. (1956): Web. 15 Mar. 2012. pp. 36

approaching in the not-so-distant future, and in the case of oil, have probably already been met.

According to a study recently published by the Oil & Gas Journal, which assumes we are able to recover all of the most optimistic estimates of fossil fuel reserves at a constant production rate, the world will be without natural gas in 147 years, oil in 43 years, and coal in 417 years.[5] In reality though, considering extraction limitations and increasing consumer demand particularly from developing nations, these estimates are likely to be even lower.

The "peak" problem is an indisputable energy concern facing not only the United States, but also the entire globe. While these peaks may not expose themselves to current generations, the consequences of reaching them in the future, without any significant modifications to our energy tendencies, will be dire. But even with complete disregard for future generations, our current fossil fuel dependency in the United States still poses serious immediate concerns.

(2) Energy Dependence and Geo-Political Challenges

The above projections for the remaining availability of fossil fuels were projections that include all parts of the earth. Considering foreign relations and international politics, significantly more complications arise. With regard to energy consumption as a whole, the United States is currently roughly 70% self-sufficient.[6] However, the large majority of that is due to our relatively abundant coal supply, which,

[5] "World Oil Reserve News and Resources." *Exploration & Development: Reserves.* Oil & Gas Journal, 2012. Web. 15 Mar 2012.
[6] Facelli, Jonathan. "Pedaling Our Way to Energy Independence." *Humanist.* 2009: n. page. Web. 15 Mar. 2012.

compared to natural gas and oil, is far worse for the environment. The main problem with regard to U.S. energy dependence arises from our demand for oil. Currently, the U.S. produces roughly 40% of the oil it consumes and we hit peak production in 1970.[7] As demand for oil continues to grow, our reliance on imports grows as well. Being heavily dependent on major oil suppliers in some of the most unstable regions of the world — Saudi Arabia, Venezuela, and Nigeria — poses a tremendous risk for political unrest and thus, energy uncertainty. Becoming more energy independent, facilitated by a shift away from fossil fuels, would provide the U.S. with much more energy stability in the future — not to mention significant other benefits.

(3) Greenhouse Gases & Climate Change

Perhaps the most sensitive of subjects when it comes to energy consumption is climate. Climate Change has the potential to drastically impact all of Earth's inhabitants and, as experts now almost unanimously agree, the burning of fossil fuels is the leading contributor to Climate Change. While skeptics may argue that the Earth's natural climatic cycles, known as the Milankovitch cycles, are responsible for what we are currently going through, both science and history suggest otherwise. Based on these cycles, our globe should currently be entering an Ice Age.[8] Therefore, the observed trend of ambient global warming is more than anomalous. Furthermore, the rate at which the recent rise in global temperatures has occurred far exceeds any warming trend Earth has ever experienced throughout geologic history. The recent marriage

[7] Goodstein, David. *Out of Gas: The End of the Age of Oil*. New York: W.W. Norton & Company, 2005. Print. pp. 17

[8] "Where are we currently in the natural Milankovitch cycle?." *OSS Foundation*. Open Source Systems, Science, Solutions, 2012. Web. 15 Mar 2012.

between mankind and greenhouse gas, particularly carbon dioxide, provides the only explanation. Over the past two hundred years or so, as humans (and Americans in particular) became increasingly dependent on the burning of fossil fuels, the carbon dioxide concentrations in the atmosphere have spiked considerably, the effects of which are becoming increasingly apparent and problematic.

A 2008 EPA study of global sea levels concluded that the average sea level worldwide has increased at a rate of approximately 0.6 inches per decade since 1870 — the latter part of the Industrial Revolution. Furthermore, in recent decades this increase has accelerated to more than an inch per decade, correlating with our increased greenhouse gas emissions.[9] Recent modeling by the Intergovernmental Panel on Climate Change (IPCC), estimates that the global average sea level will rise between 7.2 and 23.6 inches by 2100 — assuming ice flow from Greenland and Antarctica continue at the rates observed from 1993-2003.[10] While there is still considerable uncertainty regarding the magnitude and rate of change due to a limited understanding of ice sheet dynamics, the implications of any such rise, particularly on coastal and polar regions, are grim.

Other anticipated climatic effects along our current trajectory include more severe storm weather, severe droughts, increased local temperatures, and ocean acidification — all of which have the potential for drastically altering habitats across the globe, impacting all of Earth's inhabitants.

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[9] United States. Environmental Protection Agency. *Climate Change Indicators in the United States*. Washington, DC: EPA, 2010. Web. pp. 6

[10] United States. Environmental Protection Agency. *Future Sea Level Changes*. Washington, DC: EPA, 2011. Web.

In a 2011 interview, Malcolm Bowman, a distinguished oceanography professor at Stony Brook University, uttered these words while peering out at the Manhattan skyline: “it’s hard to imagine the dangers lying ahead.”[11] New York City, the capital of the world, has always faced climatic risks – high winds, storm surges, heat waves, tropical storms, etc.[12] As our climate changes, the frequency and magnitude of these events will become considerably more severe. With increased temperature, heightened sea levels, and thus, more severe storm surges, Bowman projects that along our current trajectory, major flooding in some areas of the city will become as routine as snow storms in the winter. “We could even have flood days, the way we have snow days now.”[13] The map below shows neighborhoods in New York City that are particularly vulnerable to storm surges – a threat that lies in the not so distant future.

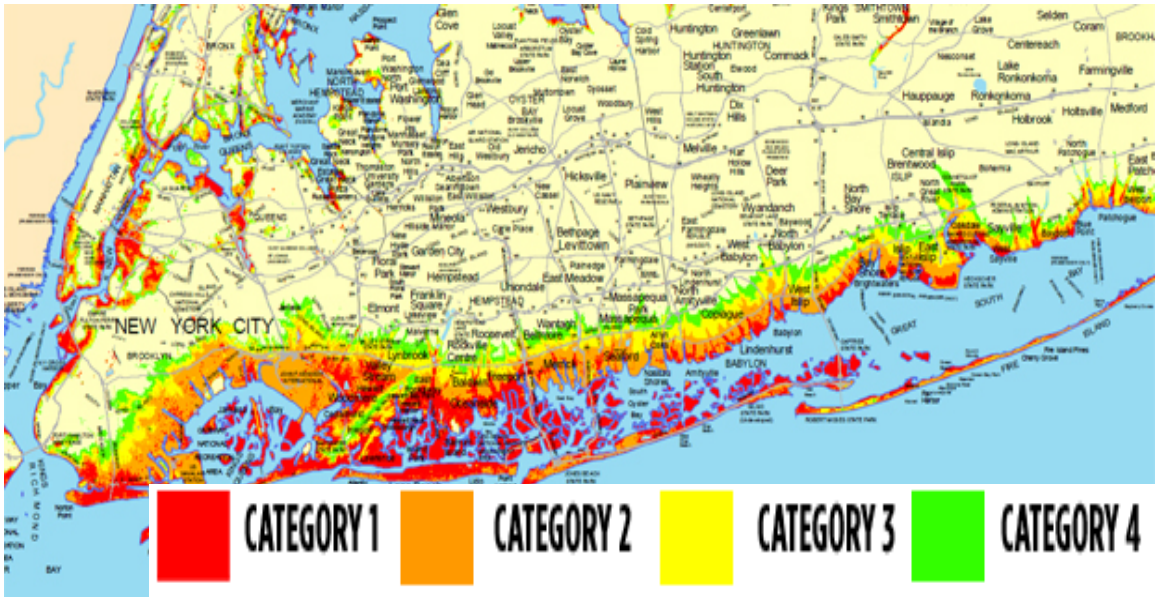

Figure 1: High-risk coastal regions of New York City to potential storm surges

[11] Bowman, Malcolm. "Sea Level Rise Could Turn New York Into Venice, Experts Warn." *WNYC News*. Interview by Jim O'Grady. 19 Feb 2011. New York. 2011. Web.
[12] NYC. Plan NYC. *Climate Change*. New York City: 2012. Web.
[13] Bowman, Malcolm. "Sea Level Rise Could Turn New York Into Venice, Experts Warn." *WNYC News*. Interview by Jim O'Grady. 19 Feb 2011. New York. 2011. Web.

New York City and many other coastal regions will undoubtedly have to devote much of their attention and resources to cautionary urban design in the years to come to address these risks. Additionally though, the movement toward clean, renewable energy is equally important in alleviating the potential for disaster in the future.

Without any significant modifications to our current use of fossil fuels, scientists generally believe the associated effects, only some of which were mentioned above, will become progressively more apparent within this century, on a global scale. The U.S., being a leader in fossil fuel consumption second only to China (see Figure 2), has immense potential to reduce greenhouse gas emissions, and thus, mitigate global Climate Change. Making significant modifications to our current energy scheme is essential.

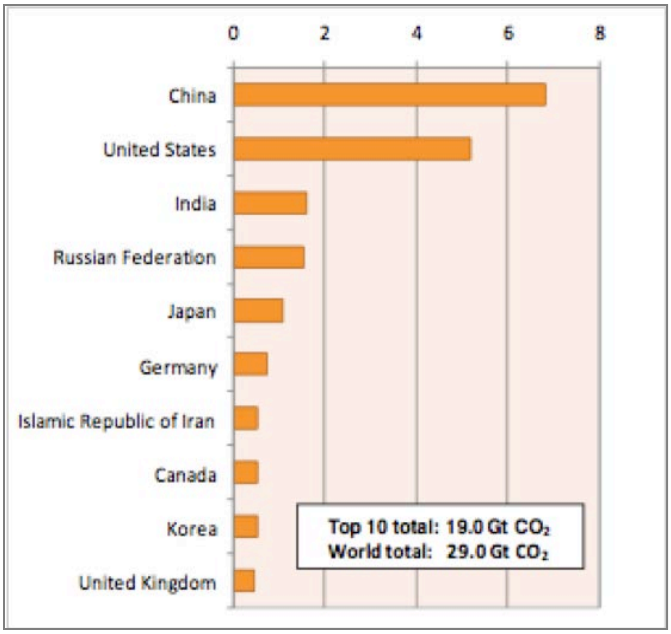

Figure 2: CO_2 Emissions by Leading Countries (Giga- tons)

Historically speaking, in the blink of an eye, humans (and disproportionately, Americans) are destroying the earth. As the consequences associated with our current fossil fuel reliance, from Climate Change to energy dependence, become more and more apparent, so does the need for change. Clean, renewable energy must supply our long-term energy needs. The longer we prolong the transition to this sustainable future, the harder we will be hit by the wrath of irresponsible fossil fuel consumption. While it is unlikely that renewable energy, particularly wind power, will supply a

significant portion of our energy needs in the immediate future, overcoming the challenges currently limiting its expansion is something that needs to be addressed now. Wind energy in the U.S., if properly developed and supported, would have a significant and meaningful impact on the reduction of fossil fuel consumption and, therefore, the associated consequences.

C. Wind Power Through Time

Just like the sun, wind has always played an integral role in life on Earth. For thousands of years, wind was the driving force (literally) behind "human discovery, conquest, and trade," as it provided the only method for spanning long stretches of ocean.[14] Progressively though, this long-time, seemingly harmonious marriage between wind and the ocean has been phased out by steam and gas-powered engines. On land, today's modern turbines can most effectively trace their ancestry back to medieval Europe. England constructed the world's earliest known windmill, called a post-mill, in 1137, and from there, the invention spread to Spain, France, Belgium, Holland, Denmark, and German and Italian territories. Centuries later, the windmill was essential in the early development of the United States. Its ability to pump water, mainly for agricultural purposes, allowed for considerable expansion, particularly in the Western region of the country. As the windmill evolved, and became progressively more essential in powering communities, "the windmill [also] seemed to express an underlying harmony for the village and a harmony with nature as well." It became a

[14] Righter, Robert. *Windfall: Wind Energy in America Today*. 1st ed. Duncan, OK: University of Oklahoma Press, 2011. Print. pp. 4

common ground for public gatherings, ceremonies, celebrations, and mourning.[15] For centuries, the iconic windmill offered both tangible and symbolic value. But then, as fossil fuel potential was realized at the start of the Industrial Revolution, the windmill, emblematic of the cyclic harmony between power and nature, was largely phased out by combustion and human manipulation of science.

Due to increasingly effective techniques of extraction and generation of fossil fuels, together with governmental support, the use of wind energy, particularly in the U.S., was nearly completely absent until the latter part of the 20th century. Therefore, today, largely as an outgrowth of the Industrial Revolution, our society finds itself powered by, and dependent upon, a booming fossil fuel industry. Unfortunately for us, that industry is becoming increasingly unsustainable. This is where modern wind energy comes in.

As growing skepticism of the sustainability of our fossil fuel dependency began to take form in the late 1900's, heightened largely by the oil crisis of 1973, wind energy began to emerge as a potential alternative. Throughout the 1980's and 90's significant wind projects took form and by the end of 2003 the United States' wind generating capacity was over 6 billion kilowatt-hr — concentrated primarily in Texas and California. In recent years, the amount of electricity supplied by wind in the U.S. has continued to grow. Generation has increased from about 6 billion kilowatt-hr in 2000 to about 95

[15] Righter, Robert. *Windfall: Wind Energy in America Today*. 1st ed. Duncan, OK: University of Oklahoma Press, 2011. Print. pp. 6

billion kilowatt-hr in 2010, currently comprising about 2% of our electricity — only scratching the surface of its full potential.[16]

As Robert Righter remarks in his historic account of wind energy in America, *Windfall*, "it is the marriage of wind power and electricity that promises to impact out energy future."[17] Because of this compatibility, wind power currently makes up the world's fastest growing electricity generation technology, and is now used commercially in 83 different nations. While approximately 70% of the global installed wind capacity is located in Europe, a 2008 study suggests that the United States ranks number one in wind energy potential. Utilizing this resource to make up a significant percentage of our electricity needs, as other countries have successfully done — Denmark (21%), Portugal (18%), and Spain (16%) — would offer substantial social and environmental benefits.[18] The time to act is now.

Overcoming the numerous challenges currently limiting the expansion of wind energy should be a paramount goal for the United States. In modern society, while the average American may not be personally impacted by our current energy dilemma (besides occasional gasoline price fluctuations), drastic consequences are looming not far off if serious modifications do not take place. The United States has enormous potential to reduce global fossil fuel consumption, and doing so could go a long way to ensuring a desirable future. With proper support and development, the United States can overcome the numerous challenges that are currently limiting wind's potential, all

[16] United States. Energy Information Administration. *Today In Energy*. Washington, DC: EIA, 2012. Web.
[17] Righter, Robert. *Windfall: Wind Energy in America Today*. 1st ed. Duncan, OK: University of Oklahoma Press, 2011. Print. pp. 11
[18] "Renewables 2011." *Renewable Energy Policy Network for the 21st Century*. (2011): n. page. Web. 15 Mar. 2012. pp. 11

the way from production to transmission to consumption. By doing so, the United States would once again demonstrate its global leadership on one of the most critical issues for mankind and help to ensure a more promising global future for all.

The balance of this paper will address: (a) the potential for the U.S. to generate 20% of its electricity from wind energy by 2030; (b) the many benefits that will result from this increased focus on the production of wind energy; and (c) the various challenges we are likely to face in meeting the 20% wind energy goal and the actions required to meet these challenges. This paper will conclude with a specific action plan to meet 20% wind energy in the U.S. by 2030. The United States, with its entrepreneurial spirit, supported by an effective collaboration between the public and private sector, is uniquely well-positioned to meet these challenges and face the future with the "wind at our backs."

II. Achieving 20% Wind Energy by 2030 – Assessing the Benefits and Addressing the Challenges

A. 20% by 2030

In July 2008, after 2 years of extensive in-depth analysis and research, the U.S. Department of Energy, in a joint effort with industry, government, and researchers, released a groundbreaking report entitled *20% Wind Energy By 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. The report explores the costs, issues, and potential outcomes associated with a 20% wind scenario, as compared to a scenario in which no new wind capacity is installed in the United States beyond 2006. Stated in the introduction of the report, "the 20% Wind Scenario is not a prediction of the

future. Instead, it paints a picture of what a particular 20% Wind Scenario could mean for the nation."[19]

In modeling such a scenario, a considerable number of assumptions regarding the future of U.S. electric generation and transmission were required. These assumptions, obtained from various technical experts and task forces, include projections on future costs and performance of various generation technologies, projected growth rates of wind energy, and transmission expansion costs. While the report acknowledges that some of the assumptions may be viewed as optimistic, the results of the study suggest that the U.S. has affordable wind energy resources to meet and even exceed the proposed 20% by 2030.

According to the US Energy Information Administration's (EIA) 2007 Annual Energy Outlook Report, U.S. electricity demand will grow by 39% from 2005 to 2030, reaching roughly 5.8 billion mega-watt hours in 2030. In order to supply 20% of this demand, wind energy would have to reach a capacity of more than 300,000

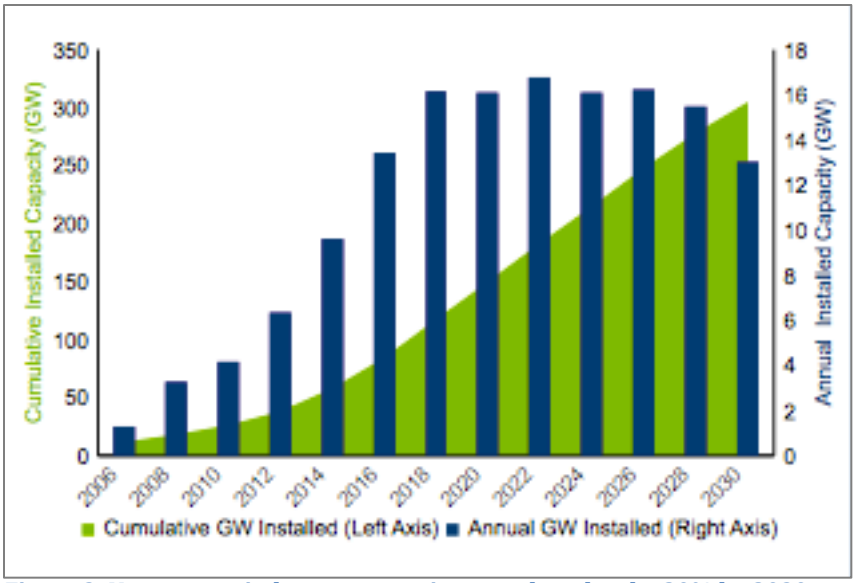

Figure 3: Necessary wind energy capacity growth under the 20% by 2030 scenario.

[19] United States. Department of Energy: Energy Efficiency and Renewable Energy. *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE, 2008. Web. pp. 2

megawatts.[20] This scenario would require new wind power installations to increase by more than 16,000 MW per year through 2018, and continue at this rate through 2030 (as shown in Figure 3).

Today, roughly 5 years after the DOE's study was concluded, U.S. installed wind capacity is at roughly 44,000 MW. Even if progress on wind energy were to halt over the next 6 years, leading up to 2018, and then start growing at the projected 16,000 MW per year rate, wind capacity would still come very close to reaching 20% by 2030. And as you can see in the figure below, the likelihood of U.S. wind energy coming to a halt in coming years is slim to none.

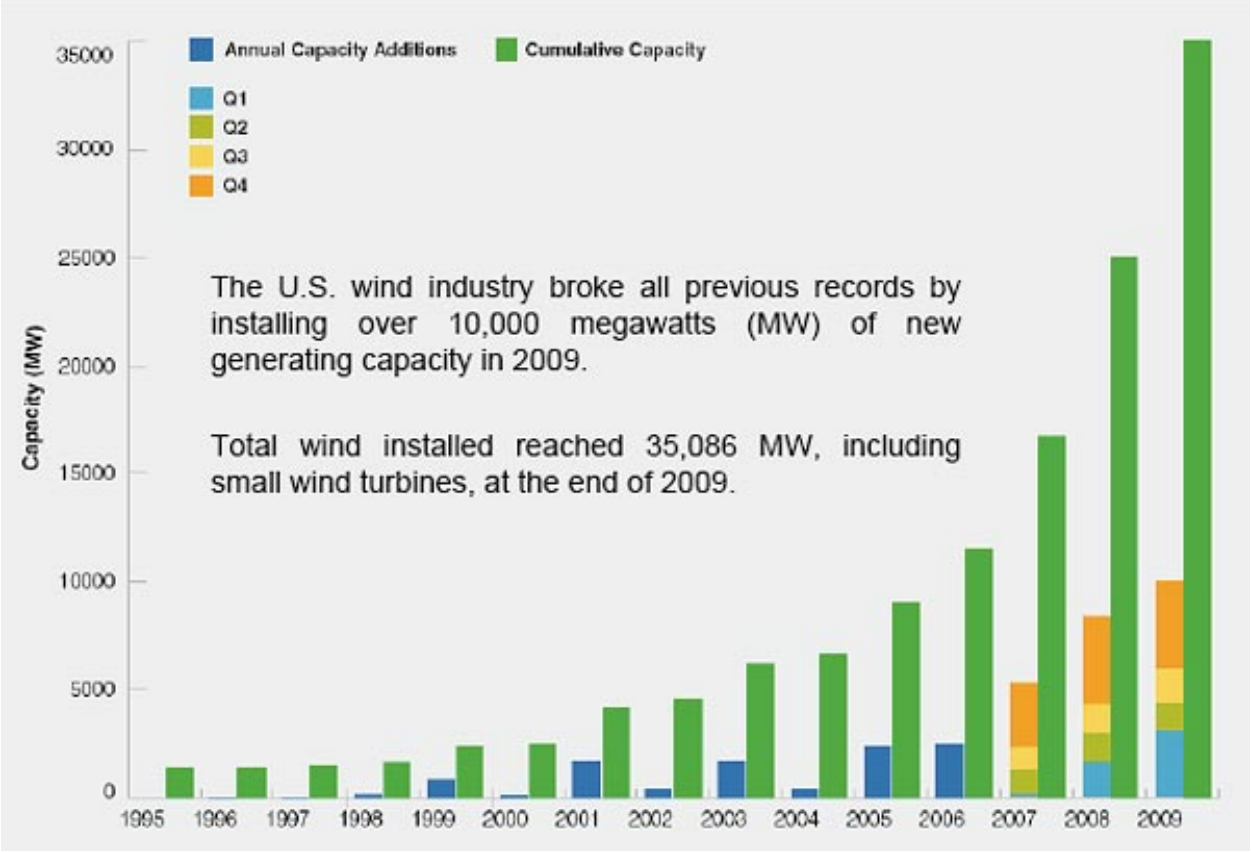

Figure 4: Wind Energy Growth 1995 - 2009

[20] (See 19)

So there is much to be hopeful for. Still, reaching a growth rate of 16,000 MW per year by 2018 and maintaining it, requires overcoming significant challenges currently facing the wind industry — environmental, delivery, siting, cheap extraction of abundant shale gas, etc. These challenges will be addressed in detail later in this report. For now though, let's look at the many benefits that will result from an increased focus on wind energy.

B. Benefits of 20% by 2030

Beyond purely marking a hopeful path to a sustainable long-term energy future, the 20% by 2030 scenario has tremendous potential to simultaneously benefit the environment, economy, and society in the coming years -- addressing some of the major global issues we are currently facing.

(1) Energy Stability & Price Stability

Today, there is a growing acknowledgment that in order to ensure a stable energy market in the future, diversification of our nation's energy mix is essential. Providing stable alternatives, such as wind, prevents a supply disruption on a single energy source from drastically disrupting the national economy. Furthermore, developing indigenous alternative energy with known costs eliminates the threat of fossil fuel volatility. As electric utilities acquire wind projects, "the price of energy is expected to remain relatively flat and predictable for the life of the wind project…"[21] In the case of coal and gas-fired electricity, a considerable portion of the cost is attributed to the fuel, for which prices are commonly unpredictable. This instability, even in the form of slight

[21] United States. Department of Energy: Energy Efficiency and Renewable Energy. *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE, 2008. Web. pp. 17

changes in availability and cost, can have a drastic impact on manufacturers, consumers, and the entire U.S. economy, as we have seen numerous times throughout history — e.g. the "Arab oil embargo" of 1973, the 2000-2001 electricity market problems in California, and the natural gas price spikes following Hurricane Katrina in 2005.[22]

Achieving 20% wind by 2030 could eliminate 50% of electric utility natural gas consumption by 2030 (shown in Figure 5), greatly reducing our reliance on foreign sources, and the associated risks. This is especially important considering our declining domestic natural gas sources. Given our current dependency on natural gas, as our domestic reserves decline, U.S. imports could quadruple by 2030. The large majority of these imports would be coming from unstable areas in the Middle East (Iran, Qatar) as well as Russia, where there is risk of political unrest and thus potential for "indirect adverse effects on our [U.S.] economy." Furthermore, with rising energy demands from China, India, and other developing nations, competition for these sources poses additional risks. Under the 20% scenario though, wind energy could displace 11% of U.S. total natural gas consumption, or 60% of expected gas imports in 2030, considerably alleviating our dependence on foreign sources. Our current reliance on unstable regions for their fossil fuel sources (particularly for oil in the Middle East), poses tremendous risk to our energy stability, and

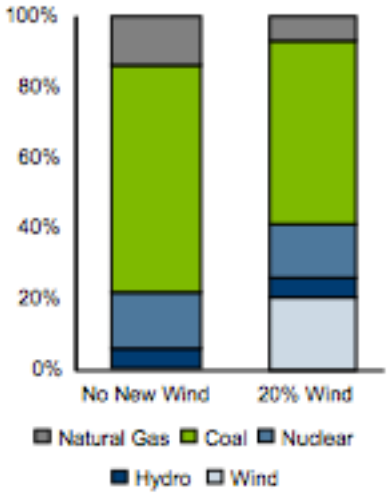

Figure 5: Percent electric utility by sector

[22] United States. Department of Energy: Energy Efficiency and Renewable Energy. *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE, 2008. Web. pp. 18

> "Although the electric sector does not rely heavily on petroleum, which represents one of the nation's biggest energy security threats, diversifying the electric generation mix with increased domestic renewable energy would still enhance national energy security by increasing energy diversity and price stability."[23]

(2) Economic Impacts

Beyond price stability, a prosperous wind industry could also expand manufacturing, create jobs, and generate considerable local revenues. Assuming that 30-80% of turbine components are manufactured domestically, reaching 20% wind energy by 2030 would result in the creation of 30,000 manufacturing jobs across the country. As the table below shows, more than 16,000 manufacturing firms have technical potential to enter the wind turbine market.[24]

NAICS Code	Code Description	Total Employees	Annual Payroll ($1000s)	Number of Companies
326199	All Other Plastics Products	501,009	15,219,355	8,174
331511	Iron Foundries	75,053	3,099,509	747
332312	Fabricated Structural Metal	106,161	3,975,751	3,033
332991	Ball and Roller Bearings	33,416	1,353,832	198
333412	Industrial and Commercial Fans and Blowers	11,854	411,979	177
333611	Turbines, and Turbine Generators, and Turbine Generator Sets	17,721	1,080,891	110
333612	Speed Changer, Industrial	13,991	539,514	248
333613	Power Transmission Equip.	21,103	779,730	292
334418	Printed Circuits and Electronics Assemblies	105,810	4,005,786	716
334519	Measuring and Controlling Devices	34,499	1,638,072	830
335312	Motors and Generators	62,164	2,005,414	659
335999	Electronic Equipment and Components, NEC	42,546	1,780,246	979
Total		**1,025,327**	**35,890,079**	**16,163**

Figure 6: Turbine Components Manufacturing Industry

[23] (See 22)

[24] United States. Department of Energy: Energy Efficiency and Renewable Energy. *Advantages and Challenges of Wind Energy*. Washington, DC: DOE, 2011. Web.

And while these firms span the entire country, they are most heavily concentrated in populous regions and the states that have suffered most heavily from a loss of manufacturing jobs in recent years — the implications of which would undoubtedly spur needed economic growth.

Furthermore, the creation of wind farms, particularly in rural areas, creates a new source of income for landowners, as power plant owners must make rent payments for the use of the land. A recent DOE study suggests that lease payments in rural areas will generate over $600 million for landowners in rural areas, not to mention added local tax revenues projected to exceed $1.5 billion annually by 2030.[25] Again, the implications of such development would undoubtedly spur much needed economic growth, while simultaneously providing a clean, sustainable source of energy.

(3) Water Conservation: "Killing Two Birds with One Stone"

As Robert and Edward Ayres mention in their book entitled, Crossing the Energy Divide: "A Google search at the time of this writing (2008) turned up 68 million references to "oil wars" and 137 million references to "water wars"."[26] Water is becoming increasingly recognized as a leading global issue, now commonly projected to be the root of the next World War. With mounting concern, regarding both our energy and water future, it is critical to analyze the implicit link between the two resources. The continued growth of U.S. communities is significantly increasing demands on water supplies and services. Consequently, a corresponding demand for electricity is required

[25] (See 24)

[26] Ayres, Robert, and Edward Ayres. *Crossing the Energy Divide: Moving from Fossil Fuel Dependence to a Clean-Energy Future*. Upper Saddle River: Wharton School Publishing, 2010. Print. pp. 146

to power the growing water infrastructure. This link presents a major problem, especially in the arid regions of the nation, but wind energy may be the answer.

Traditional generation of electrical power is one of the largest consumers of water in the United States and globally. In 2005, roughly 201,000 gallons of water were used by U.S. thermoelectric power plants each day—comprising roughly 49% of total water withdrawals for the nation.[27] This water is primarily used for cooling purposes, and consequently cannot be released back into the environment due to its obtained heat. This long-standing link between traditional power generation and water use is largely responsible for the major dilemma we face today, making wind an attractive option.

Even compared to other renewable sources, wind power generation requires a relatively miniscule amount of water. Therefore, wind may offer arid communities a means of economically meeting expanding energy demands without increasing the demand load on valuable local water supplies. Furthermore, wind energy, unlike conventional sources, has the capability of targeting energy production towards essential water needs, such as irrigation. Ultimately, as shown in Figure 7, wind energy as an alternative means of electricity generation has the potential to conserve billions of gallons of water in the coming years.

Wind Energy (MW)	**Water Savings** (billion gallons withdrawn)	**Water Savings** (billion gallons consumed)
1,200	3.15	1.89
3,000	7.88	4.73
4,000	10.51	6.31

Adapted from *The Wind/Water Nexus: Wind Powering America* (DOE 2006)

Figure 7: Water Savings due to Increased Wind Energy

[27] United States. Geological Survey. *Thermoelectric Power Water Use*. USGS, 2012. Web.

With projected increased pressure on water resources due to population growth and global Climate Change, the 20% wind by 2030 scenario has the potential to offset much of the associated consequences tied to the current link between water and electricity generation.

Additionally, extensive research is currently going into the possibility of wind-powered desalination and the future of this industry appears bright. A 2006 report put out by the National Renewable Energy Laboratory, based on the research of GE's Global Research Facility in Niskayuna, NY, concluded that an Integrated Wind Energy/Desalination System could produce water at prices competitive with conventional desalination methods, which require vast inputs of energy and, ironically, water itself.[28] Because desalination is an energy intensive process, utilizing renewable energy sources, such as wind (and solar PV), will greatly reduce the required fossil fuel and water inputs while simultaneously producing clean water. This type of technology has proven successful in areas such as Sydney and Perth, Australia and projects are well underway in the United States. A proposed wind-powered desalination plant in Mitchell County, Texas is anticipated to produce roughly 750,000 gallons of potable water per day, supplying the water needs of Colorado City.[29] The implications of such technology -- and more generally, the shift from fossil fuels to renewables -- are immensely positive with regard to our water and energy future.

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[28] United States. Department of Energy: National Renewable Energy Laboratory. *Integrated Wind Energy/Desalination System*. Niskayuna, NY: GE Global Research, 2005. Web. pp. 131

[29] Vanderlaan, Jon. "Desalination plans move forward in Mitchell County." *Odessa American* 22 Jul 2011, n. pag. Web. 15 Mar. 2012.

(4) Air Pollution Reduction

In the discussion on alternative energy, greenhouse gases (and increasingly, water) are consistently at the forefront (and rightfully so). But our current fossil fuel dependency is affecting the air we breathe beyond the carbon dioxide emissions we are constantly hearing so much about. Air pollution, primarily from sulfur dioxide, nitrogen oxides, and mercury, is a commonly overlooked problem with fossil fuel-based energy.

The following table shows the contribution of fossil fuel electric power plants to the total air pollution in the U.S.

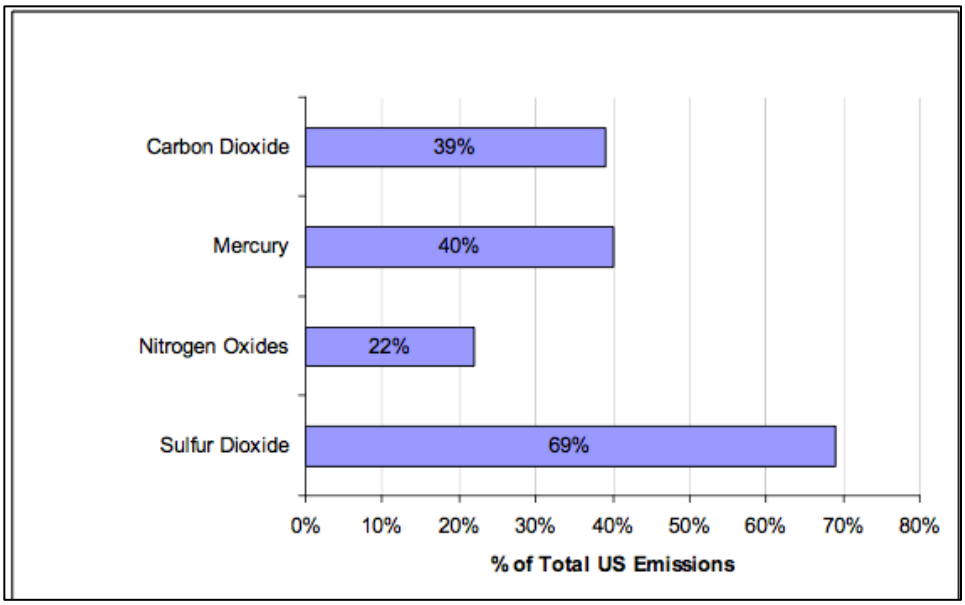

Figure 8: Air pollution in U.S. from Fossil Fuel Electric Power Plants (by pollutant)

Fossil fuel power generation, particularly coal, is the leading source of sulfur dioxide emissions in the U.S. Sulfur dioxide and nitrogen oxides (another product of fossil fuel generation) are major contributors to particulate pollution, smog, and acid rain, all of which have considerably negative implications on human and environmental health. According to the DOE's report, roughly "58.3 million Americans suffer from chronic

exposure to particle pollution."[30] Furthermore, coal-fired power plants are also the leading source of mercury emissions in the United States — the consequence of which is mercury deposition in bodies of water and accumulation in food chains. Despite implementation of various cap and trade policies surrounding air pollution in recent years, the problem persists and could be significantly alleviated under the 20% wind scenario.

In contrast to fossil fuels, wind power generation produces zero direct air emissions. Through deeper integration of wind energy into our electricity mix, a considerable portion of air emissions from already existing fossil fuel plants would be displaced, and the need to build and operate new fossil fuel plants would drop significantly. Furthermore, even in projects where wind does not reduce the level of total air emissions below the general emissions cap, any emissions displacement due to increased wind power generation would lower pollution control costs faced by facilities. The associated savings could facilitate compliance with emission reduction goals.[31] Ultimately, wind energy presents major air quality benefits with respects to conventional pollutants, but even more importantly, greenhouse gases.

(5) Greenhouse Gases (GHG) and Climate Change Mitigation

The growing recognition of Climate Change, particularly as a function of fossil fuel combustion and greenhouse gases, has positioned wind energy as an increasingly attractive alternative. The potential of wind to supply the projected increased electricity

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[30] United States. Department of Energy: Energy Efficiency and Renewable Energy. *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE, 2008. Web. pp. 109

[31] Jacobson, D. United States. Department of Energy: National Renewable Energy Laboratory. *Wind Energy and Air Emission Reduction Benefits: A Primer*. Golden, CO: NREL, 2008. Web. pp. 5

demands in the coming decades while greatly reducing GHG emissions, has given the industry considerable attention in both the public and private sector. And rightfully so. According to the EIA, the U.S. emits roughly 6,000 million metric tons of carbon dioxide each year. By 2030, this number is expected to rise to 7,900 million metric tons — 40% of which is directly attributed to the electric power sector.[32] The implications of such a rise are dire. Reducing the nation's cumulative carbon footprint must be a central focus of government, industry, and consumers for years to come, and clean, alternative energy is crucial.

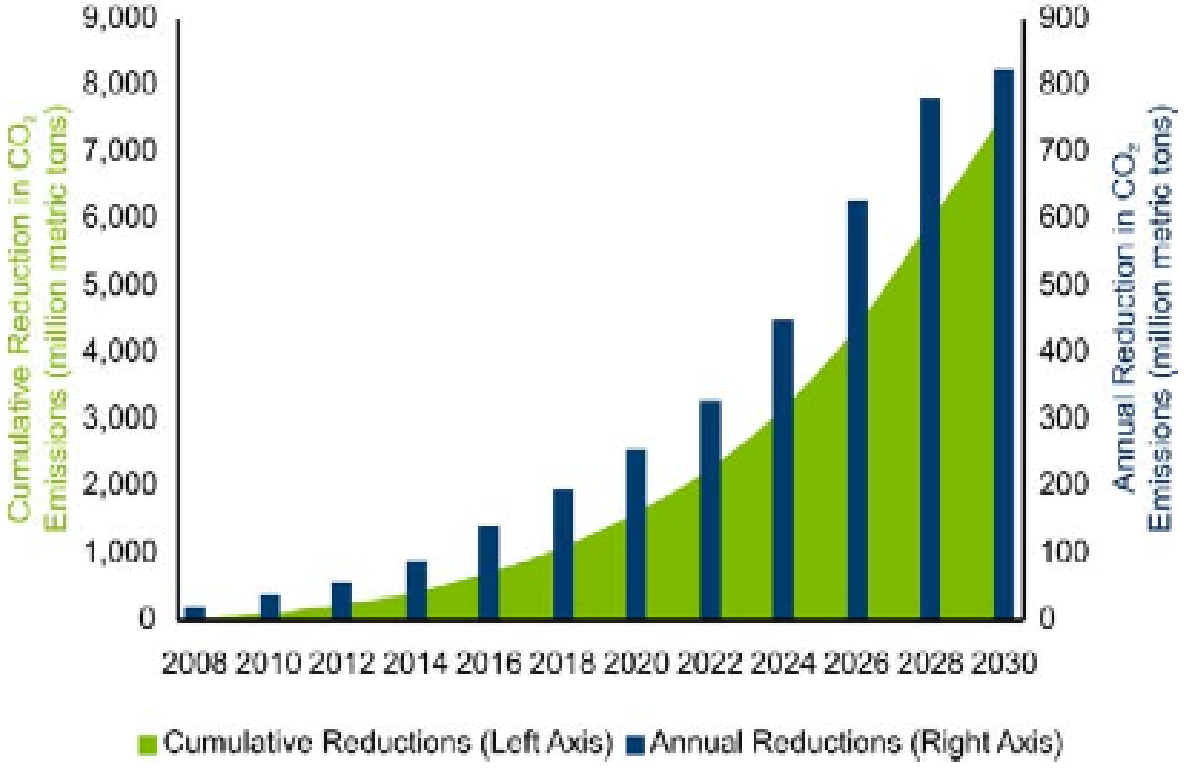


Figure 9: Carbon Reductions in the 20% wind by 2030 scenario

[32] United States. Department of Energy: Energy Efficiency and Renewable Energy. *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE, 2008. Web. pp. 14

As illustrated above:

> "Under the 20% Wind Scenario, a cumulative total of 7,600 million metric tons of CO2 emissions would be avoided by 2030, and more than 15,000 million metric tons of CO2 emissions would be avoided through 2050."[33]

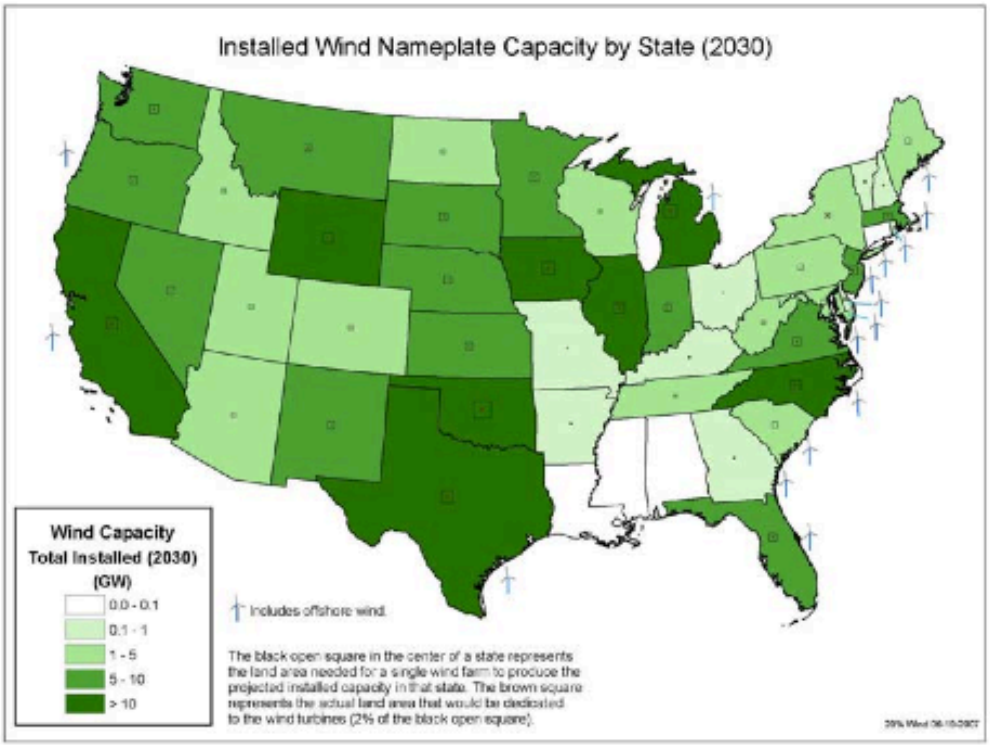
Avoiding such emissions could go a long way toward Climate Change mitigation, not only in the sense of numbers, but also by setting a global example. The United States has true potential to integrate wind power, a clean, economically viable energy source, as a substantial sector of its energy mix — the benefits of which could be insurmountable when considering the global problems we face today.

[33] (See 32)

C. U.S. Potential

"The U.S. has abundant wind resources"

The tangible potential truly does exist. As previously mentioned, according to a 2008 study, the United States ranks number one in wind power potential--primarily a function of geography. Under the 20% scenario, the land based footprint of turbines and associated infrastructure would require just 1,000 to 2,500 km^2 of land—slightly less than the area of our smallest state, Rhode Island. The projected distribution can be seen in the map below.[34]



Land Requirements

Altogether, new land-based installations would require approximately 50,000 square kilometers (km^2) of land, yet the actual footprint of land-based turbines and related infrastructure would require only about 1,000 to 2,500 km^2 of dedicated land—slightly less than the area of Rhode Island.

The 20% Wind Scenario envisions 251 GW of land-based and 54 GW of shallow offshore wind capacity to optimize delivered costs, which include both generation and transmission.

Wind capacity levels in each state depend on a variety of assumptions and the national optimization of electricity generation expansion. Based on the perspectives of industry experts and near-term wind development plans, wind capacity in Ohio was modified and offshore wind development in Texas was included. In reality, each state's wind capacity level will vary significantly as electricity markets evolve and state policies promote or restrict the energy production of electricity from wind and other renewable and conventional energy sources.

Figure 10: Wind Capacity by State – 46 states would have substantial development by 2030

[34] United States. Department of Energy: Energy Efficiency and Renewable Energy. *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE, 2008. Web. pp. 10

The resources are available. The technology exists. It is just a question of overcoming the surrounding impediments. In particular, reaching the nation's wind potential will depend primarily upon: the relative economics of wind energy compared to other available sources, policies to support wind development, and overcoming actual and conceived concerns of effectively integrating wind energy into our electricity stream — all the way from generation to consumption.

III. The Challenges

A. Societal Dogma and the Immediate Gratification of Fossil Fuel

A fundamental challenge currently facing the wind industry is societal. There is a persistent dogma that exists in American society, which largely undervalues the future and instead puts significantly more weight on immediate gratification. In the case of fossil fuel-based energy, many of the associated consequences are intangible to contemporary Americans, making it extremely difficult to inspire drastic change. Renewable sources, such as wind, have positive implications for the future, but in terms of 'now,' are perceived by a large percentage of Americans (albeit, shrinking) as an inefficient and cost-ineffective alternative to conventional fossil fuel sources. The point we must integrate into our societal philosophy (and soon) is that without considerable change in our current energy scheme (not to mention other precautionary measures to Climate Change), in the not so distant future we will be hit by the associated consequences, and we will be hit hard. There needs to be a shift in the value we attach to a single kilowatt-hr today, to incorporate the true 'price' of that kilowatt-hr with regard to climate mitigation and the future. Unfortunately though, in recent years this dogma

has been reinforced with the discovery of abundant domestic natural gas reserves and advanced drilling technologies to utilize this gas. A report by the Potential Gas Committee illustrated that "estimated natural gas reserves rose to 2,074 trillion cubic feet in 2008, from 1,532 trillion cubic feet in 2006."[35] This is quite worrisome to the future of wind energy and renewable energy in general. America needs to reduce its carbon footprint.

The recent discovery of domestic natural gas, particularly in the Marcellus shale formation, presents an utterly intricate energy issue. In 2000, shale gas represented only 1% of U.S. natural gas supplies, while today, it is 30% and rising.[36] Proven shale gas reserves are estimated to have the capabilities of supplying our nation with domestic energy for over 100 years. This of course is quite appealing with regard to energy independence. Not so much, however, in the light of Climate Change. While natural gas is significantly better for our environment than burning coal, it is still a fossil fuel. Its combustion still produces carbon dioxide, which is still a greenhouse gas. Greenhouse gas still promotes Climate Change, which is still an immense threat to the well being of our planet. This is something we cannot lose sight of. Not to depreciate the major breakthroughs in the world of natural gas, but our nation must strike a proper balance with the immediate gratification of such fuels as shale gas, and the positive future implications of renewable sources, such as wind.

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[35] Mouawad, Jad. "Estimate Places Natural Gas Reserves 35% Higher." *New York Times* [New York City] 17 Jun 2009, n. pag. Web. 15 Mar. 2012.

[36] Brooks, David. "Shale Gas Revolution." *New York Times* [New York City] 3 Nov 2011, n. pag. Web. 15 Mar. 2012.

To solidify renewable energy's position on this seesaw of immediate and future interests, public perception must shift in two distinct ways. Firstly, conventional fossil fuel sources must be made into a less attractive long-term option. Secondly, renewable energy must be made into a more attractive immediate option. With regard to wind, doing so requires overcoming considerable, yet manageable, impediments that are currently limiting its expansion. The remainder of this chapter will outline the distinct challenges and misperceptions facing the wind industry all the way from the point of power generation to the point of its consumption. In reading this section it is important to keep in mind that any assessment of the value and extent of wind energy must start with certain established facts:

1. Combustion of fossil fuel is by far the leading contributor of greenhouse gases in our atmosphere, which experts now almost unanimously agree are a leading cause of Climate Change.

2. Continued reliance on fossil fuels will require us to remain dependent on the most unstable region on Earth.

3. Fossil fuels are a finite resource and in the long run, their continued use is unsustainable.

4. To make renewable energy (wind in particular) successful in the future, integration into our energy scheme must begin now.

B. Generation

(1) Wind Turbine Technology

The stochastic nature of wind presents a very fundamental issue. As the speed of the wind changes so does the energy output of the turbine. This, for a long period of time, was a major detriment to wind energy's appeal. However, in recent years wind turbine technology has improved exponentially and efficiency has followed. In a talk at Union College (Schenectady, NY) earlier this year, Vic Abate, vice president of GE's Renewable Energy division, commented on this trend. Abate recalled that just a few decades ago, only roughly 1 out of every 3 installed GE turbines would be effectively running post-construction. Today, 98.6% of GE turbines are able to produce power, supplying a considerable (and growing) portion or our global energy. This increased technology has enabled wind to enter the mainstream electric market. Current U.S. wind generation runs at roughly 5 cents per kilowatt-hr, which is directly comparable to the current price of coal production. Roughly ten years ago, as Abate noted, wind power ran about 15 cents per kilowatt-hr. In effect though, many subsidies for wind and other renewable energy sources are temporary while subsidies for conventional sources are permanent. In order for wind to maintain a position in the mainstream energy market, a long-term commitment to the industry is essential – both in the form of subsidies and investment in improved technology/infrastructure.[37] While achieving 20% wind by 2030 would require continued technological progress, the amount needed is almost guaranteed following our current trajectory. As far as power generation goes, wind energy is increasingly positioning itself as a truly competitive alternative.

[37] "U.S. Energy Subsidies." *American Wind Energy Association*. (2010): n. page. Web. 15 Mar. 2012.

Nonetheless though, wind's geographic variability makes siting particularly important, which presents numerous challenges.

C. Turbine Siting Concerns

(1) Not In My Backyard – NIMBYism

In recent years, the NIMBY philosophy, the general opposition to development of our natural landscape, has become a hot topic issue in the energy arena, particularly in the case of wind. As the modern wind turbine has grown to a size comparable with a Boeing 747 commercial airliner, it comes to no surprise that a considerable number of Americans see wind farms as having no place on our natural landscape, especially in areas that are near to them. Furthermore, as the majority of our wind resources are located in the heart of our country, which many perceive as a pristine, undeveloped piece of wilderness, there is heightened resistance to development. This, along with other NIMBY rationale, presents a major problem for wind projects, as opposition can cause considerable delays adding to costs and in some cases even rendering the project no longer economically viable.

According to a recent report from the US Chamber of Commerce, local opposition is responsible for the delay or abandonment of nearly half of America's proposed wind projects.[38] Considerable potential is being rejected. This prolongs our unsustainable dependence on fossil fuels. Unquestionably, NIMBYism needs to be addressed. Reasoning for local opposition, however, varies and while legitimate concerns (which will be touched upon later in this report) need to be addressed at a

[38] Lacey, Stephen. "NIMBYism Kills 45% of Clean Energy Projects." *CleanTechnica*. N.p., 24 Oct 2011. Web. 15 Mar. 2012.

governmental level, there is a considerable portion of anti-turbine NIMBYism stemming from misperceptions of the industry.

In recent years, extensive research has gone into assessing the noise production of turbines and wind farms, which has been a major source of opposition to proposed projects. There is now conclusive understanding that the magnitude of turbine noise was being largely misperceived. A recent study by General Electric, concluded that at a distance of 300 meters (the closest a turbine will typically be placed to a home), "a turbine will have a sound pressure level of 43 decibels," which is slightly higher than the sound produced by most refrigerators. Furthermore, at a distance of 500 meters, noise levels drop to 38 decibels, which in most regions would be lost in the midst of background noise (40-45 decibels).[39] Nonetheless, wind farms in quiet areas, particularly in the still rural regions of the country, may warrant legitimate complaints from local residents which should be addressed. However, as these cases are already rare, and advances in turbine technology are making for quieter power generation, the foundation of such complaints is likely to diminish over time.

Other common misconceptions and exaggerations that contribute to local opposition to wind projects include claims regarding negative health effects from the turbines, generally referred to as "wind turbine syndrome." Proposed symptoms of this "syndrome" include epilepsy caused by the visual flicker from the spinning blades and headaches from the associated noise. While research continues, as of now there is no conclusive evidence of this phenomenon. Even so, such complaints are halting progress on wind projects across the nation, seriously limiting our potential. These

[39] "GE Reports." *How Loud is a Wind Turbine?*. GE, 18 Nov 2010. Web. 15 Mar 2012.

ideas, which are being misperceived by many as legitimate truths and thus a legitimate source of opposition, in reality, are simply fabricated worries with no scientific backing. The fundamental NIMBY notion that wind turbines ruin the aesthetic of our natural landscape is where the greater problem lies. It ultimately boils down to the question of what's worth more?

An interesting aspect of NIMBYism toward wind energy is that it often is pitting environmentalists against one another. The same advocates of renewable energy are opposing wind development when it comes, so to speak, into their "backyard." Withholding my own opinions regarding the symbolic beauty of a rotating turbine, it simply comes down to the question of what's better -- tainting the view of our mountaintop vistas and open prairies with some wind turbines or poisoning the Gulf of Mexico, relying on the most unstable region in the world for our oil needs, cutting the entire tops off mountains to reach the coal inside, poisoning our air, irrevocably changing our climate, etc. The bottom line is that no form of energy generation is completely harmless to the environment. This point will be reiterated throughout the remainder of this paper, but it is particularly relevant to the NIMBY discussion.

(2) Ecological Issues

Another major source of opposition to turbine construction that often pits environmental proponents against one another relates to ecological issues – particularly pertaining to avian species. There is strong opposition from animal rights groups and bird activists that cite avian mortality as an unacceptable effect of wind power. Again though, much of this opposition is misinformed. As experts have shown, bird mortality

caused by turbines is greatly exceeded by mortality caused by other manmade structures. A recent study by the American Wind Energy Association (AWEA) concluded that mortality caused by turbines constituted only 1/10 of unnatural bird mortalities. As shown in the following table, bird mortalities involving wind turbines range from 10-40 thousand per year, which compared to other manmade structure, such as windows and power lines, is quite low.[40]

Man-made structure/technology	**Associated bird deaths per year (U.S.)**
Feral and domestic cats	Hundreds of millions [source: AWEA]
Power lines	130 million -- 174 million [source: AWEA]
Windows (residential and commercial)	100 million -- 1 billion [source: TreeHugger]
Pesticides	70 million [source: AWEA]
Automobiles	60 million -- 80 million [source: AWEA]
Lighted communication towers	40 million -- 50 million [source: AWEA]
Wind turbines	**10,000 -- 40,000** [source: ABC]

Figure 11: Unnatural Avian Mortalities caused by Manmade Structures

Still, such worries have caused considerable delays with wind projects and again it comes down to a question of what's better – killing a few birds (not to be insensitive but rather resolute) or facing the associated consequences of our current fossil fuel

[40] Carey, Ellen. "Rhetoric vs. Reality: Wind Energy and Birds." *American Wind Energy Association*. AWEA, 1 Mar 2011. Web. 15 Mar 2012.

dependence. By the way, the BP oil spill is estimated to have killed nearly 6,000 birds in a matter of days.[41]

(3) Cape Wind

One particular project that comes to mind when considering delaying potential due to opposition is the Cape Wind project off the coast of Massachusetts. Cape Wind, originally proposed in 2001, will likely be America's first offshore wind farm with 130 turbines capable of producing up to 420 megawatts of clean, renewable energy and supplying the surrounding region with the majority of its electricity. Significant delays, chiefly from environmental and NIMBY opposition, have however added considerably to the costs and denied clean power production for over a decade. After numerous environmental impact and risk assessments, much of the associated concerns have been scientifically dismissed. However, opposition persists regarding Native American land rights, as local tribes believe the turbines would "disturb spiritual sun greetings and possibly ancestral artifacts and burial grounds on the seabed."[42] Other constraints have arisen from the fishing industry, which claims development will substantially impact productivity. Ultimately, it comes down to tradeoffs. As Governor Deval Patrick put it, "America needs offshore wind power and with this project, Massachusetts will lead the nation."[43] Today, construction is projected to begin in 2013, and while there is still substantial opposition by local residents and other affected entities, the need for clean

[41] "How Does the BP Oil Spill Impact Wildlife and Habitat?." *Gulf Oil Disaster*. National Wildlife Federation, 2012. Web. 15 Mar 2012.
[42] Daley, Beth, and Martin Finucane. "Interior secretary approves Cape Wind plan, nation's first offshore wind farm." *Boston Globe* [Boston] 28 Apr 2010, n. pag. Web. 15 Mar. 2012.
[43] Seelye, Katharine. "Regulators Approve First Offshore Wind Farm in U.S.." *New York Times* [New York City] 28 Apr 2010, Web. 15 Mar. 2012.

power greatly outweighs the desire for an 'uninterrupted' waterfront view, fishing zone, etc.

Both onshore and offshore wind power present tremendous potential for our nation's energy future. Unlike numerous other alternative sources of energy, wind energy generation, with the proper support, is ready to be competitive. As discussed above, a large portion of opposition to the industry derives from misperceptions. In terms of power generation, wind turbines are entering the mainstream market, becoming increasingly capable of competing with conventional sources of electricity, both economically and with respects to efficiency. The main problem faced by the wind industry though, is what to do with the power after it is generated.

D. Transmission

(1) Our Outdated Grid

"[The grid is] the most significant long-term barrier to continued wind power expansion."

-America Wind Energy Association

Sometime in mid-afternoon on August 14, 2003, a power station just off of Lake Erie, in an effort to ramp up production beyond typical levels, responded by crashing. The cascading failures that followed, a domino-effect of short-circuited lines, rendered the U.S. Northeast (and Ontario, Canada) victim to one of the most severe blackouts in history. By 4:06pm on that hot summer day, 265 power plants were forced to shut down "with no place to park their electricity," leaving more than 50 million people in eight states and Ontario without power. The blackout cost 6 billion dollars. With the events of 9/11 still lingering in the government's mind, this incident sparked the fear that the

grid was immensely vulnerable to a terrorist attack. Coupled with the need to incorporate renewable electricity, the blackout provided strong motivation for grid reform.

Electricity plays an essential role in modern American society, and one that is rapidly growing. Currently, electricity comprises roughly 40% of our national energy consumption. With increasing awareness of the consequences of fossil fuel combustion, along with advanced electric technology (e.g. electric vehicles), this percentage is expected to rise significantly in the near future, putting considerably more pressure on the grid. Our grid, considered by the National Academy of Engineering as the greatest engineering achievement of the last century, is largely outdated. As Joel Achenbach points out in his National Geographic article entitled *The 21st Century Grid*, current grid technology is

> "…too old. It's reliable but not reliable enough, especially in the United States, especially for our mushrooming population of finicky digital devices…And at the same time that it needs to become more reliable, the grid needs dramatic upgrading to handle a different kind of power, a greener kind."[44]

Our current grid, a response to the Industrial Revolution, was designed for dispatchable sources of energy, such as coal. Therefore, conventional grid operations are largely based around the ability of electricity resources to generate power up to their full rating whenever they are scheduled to do so.[45] The intermittency of wind poses a fundamental problem. Because wind power, unlike coal and natural gas, is stochastic in nature and

[44] Achenbach, Joel. "The 21st Century Grid." *National Geographic*. July 2010: pp. 122
[45] Piwko, Richard. "Wind Energy Delivery Issues." *IEEE Power & Energy Magazine*. Nov/Dec issue (2005): pp. 47

dependent on the magnitude of wind at a given time and place, effectively integrating it into our grid, on a large scale, requires a substantial (albeit worth-while) re-vamping.

(2) Bulk Transmission

At first glance, today's grid system (pictured below) may appear similar to our extensively planned out interstate highway system. In reality though, our grid "consists of largely separate regional "interconnections" that evolved from a patchwork of local utilities as they established links with their neighbors." In the United States, these interconnections are typically referred to as the Western, Eastern, and Texas interconnection. Together, these three distinct entities consist of more than 150,000 miles of high-voltage transmission lines carrying power from roughly 5,400 power plants owned by over 3,000 utilities.[46] Renewable sources (i.e. hydroelectric, wind, and solar

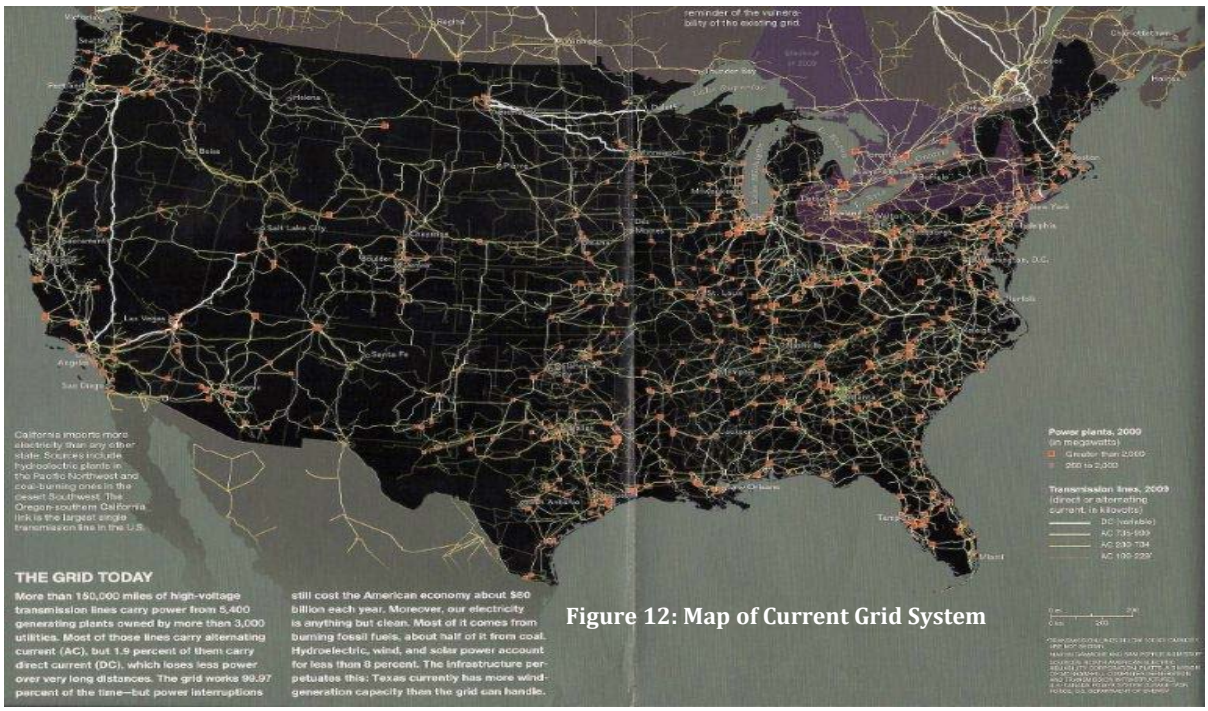

Figure 12: Map of Current Grid System

[46] Achenbach, Joel. "The 21st Century Grid." *National Geographic*. July 2010: pp. 127

power) account for less than 8 percent of the integrated power and this is largely a result of outdated transmission infrastructure. The overwhelming majority of transmission lines, roughly 98%, carry alternating current (AC). The remaining 2% carries direct current (DC), which loses significantly less power over long distances – a characteristic especially relevant to wind energy.[47]

The majority of our nation's abundant wind resources are located in remote regions of our country. Our current transmission infrastructure cannot effectively transfer power from these regions over long distances to areas of high demand—typically cities located in coastal regions. For this reason, Texas, for instance, currently has more clean wind generation capacity than the grid can manage. And so our reliance on fossil fuel-based electricity persists. In order to effectively integrate renewable sources of energy, wind in particular, into our grid system, considerable investment needs to go towards updating our transmission infrastructure. This involves creating more grid capacity, preferably in the form of high-voltage DC lines that can efficiently move power from the point of generation to the point of consumption –a phenomenon referred to as "bulk transmission."

This seemingly simple solution of adding grid capacity, however, presents several complications – perhaps the most obvious of which is economical. The U.S. Department of Energy estimates that infrastructure development, targeting wind energy, would run upwards of $20 billion. Furthermore, projections suggest that, "construction of efficient and open-transmission marketplaces and green-power-plant infrastructures would

[47] (See 47)

require about a trillion dollars over the next 15 years."[48] Much of these costs would fall on the backs of taxpayers, which creates obvious problems. Bulk transmission would require another public sacrifice though – land.

As previously mentioned, NIMBY opposition has denied considerable potential for wind-related development and this opposition is not limited to the turbines themselves. The DOE suggests that achieving 20% wind by 2030 would require adding roughly 12,000 miles of new transmission lines (see map below).[49]

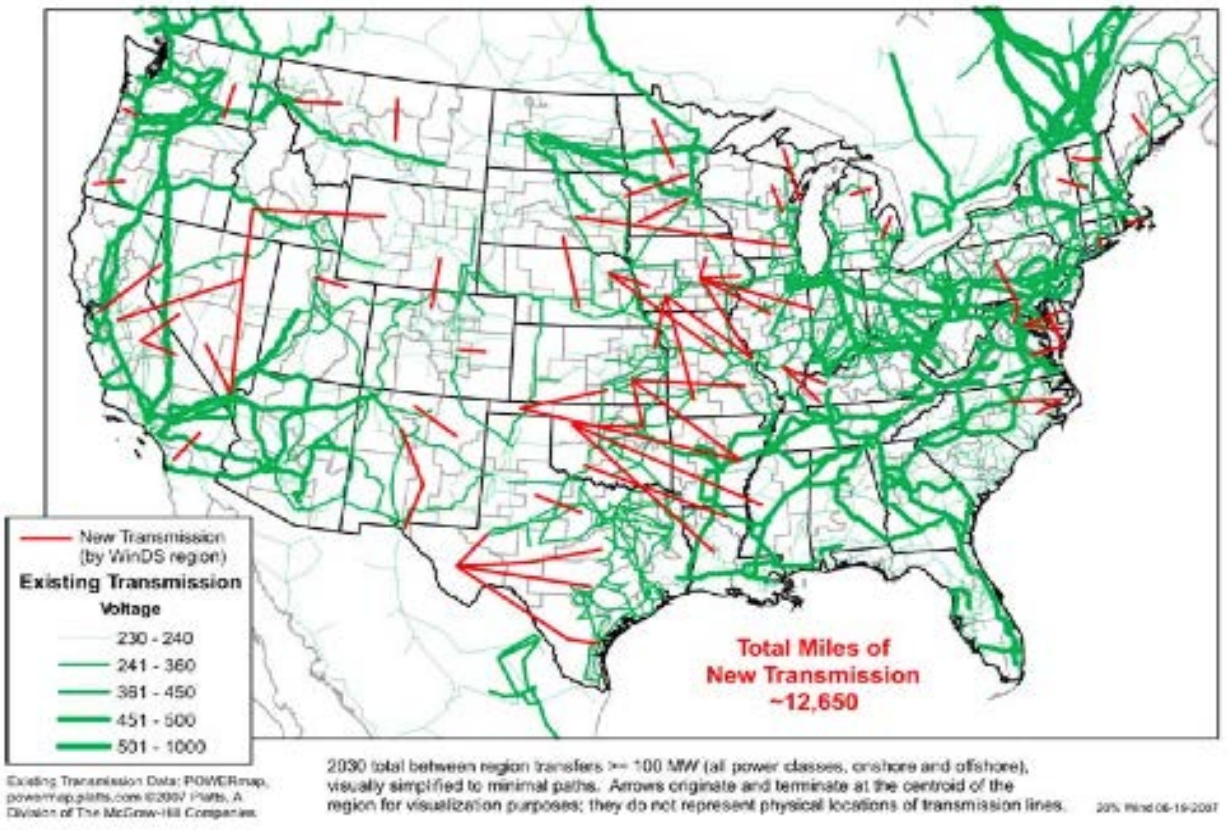

Figure 13: Proposed Transmission Lines for 20% wind by 2030

[48] Righter, Robert. *Windfall: Wind Energy in America Today*. 1st ed. Duncan, OK: University of Oklahoma Press, 2011. pp. 74

[49] United States. Department of Energy: Energy Efficiency and Renewable Energy. *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE, 2008. Web. pp. 95

Local opposition to increased transmission is a major barrier that will have to be overcome in ensuring wind energy's success. Transmission companies will have to be more active in identifying and addressing local complaints, which will be detailed further on in this paper. Ultimately though, increasing grid capacity is essential in addressing wind's variable nature, but it is no silver bullet.

(3) Storage

Despite the obvious positive implications of adding grid capacity, many wind advocates believe that the answer to wind integration is storage — that is, creating a mechanism that can store electricity and readily add it to the grid in response to demand.[50] While there remains to be a truly viable means of storing wind-powered electricity, the idea of energy storage is not a foreign one. Both hydropower and battery storage are rapidly advancing technologies that could push renewables forward in the near future. Furthermore, a recently constructed wind farm, The Iowa Stored Energy Park, is experimenting with the use of air compressors to drive storage of wind electricity. The basic function of the technology goes as follows:

> "…when the wind is blowing but demand is low, the electricity from the wind will drive a large air compressor. The compressed air will be inserted into a sandstone cavern where it will remain under pressure. When electricity demand is high, compressed air will be released and mixed with natural gas to drive a conventional combined-cycle turbine"[51]

[50] Makansi, John, *Lights Out: The Electricity Crisis, the Global Economy, and What It Means to You* (New York: John Wiley, 2007), pp. 20-21

[51] Righter, Robert. *Windfall: Wind Energy in America Today*. 1st ed. Duncan, OK: University of Oklahoma Press, 2011. pp. 74

This technology, expected to be in operation within the next 5 years, is projected to be roughly 50% more fuel-efficient than a turbine alone (without compressed air) -- potentially a break-through in electricity generation. Storage, ultimately, will allow us to regulate and control wind energy, making it infinitely more reliable and compatible with the grid. And grid integration is key. While nearly everyone acknowledges the need for a smarter and cleaner grid, utility companies fear the intermittency of wind and thus fossil fuels continue to supply our electricity needs. However, storage and an updated power grid have the potential to eliminate that fear and make wind energy competitive with conventional electricity sources. The grid is key.

(4) Creating a 'Smarter' Grid

In recent years, the federal government has invested considerable money into the grid – the stimulus package allocated $4.5 billion to smart grid technology and another $6 billion to new transmission lines. Furthermore, nearly all major utility companies have invested in smart grid projects of their own. Continued investment needs to drive further progress. Not only will a smart grid present great opportunity for wind and renewable power integration but it could also help to prevent blackouts in two ways. Firstly, a smarter grid will provide immediate and detailed feedback on the status of the grid to operators. This will allow operators to stay ahead of cascading failures and respond to incidents accordingly. Secondly, a smart grid will allow operators to balance supply and demand more effectively. The conventional grid was designed with respect to the supply side, but did "very little to control demand."[52] "Demand management" not only has major positive implications for power stability, but could also

[52] Achenbach, Joel. "The 21st Century Grid." *National Geographic*. July 2010: pp. 136

help the grid to handle intermittent renewable sources, such as wind. Due to its stochastic nature, wind power has not always available during times of peak demand. Limiting this peak, however, alleviates this dilemma. Ultimately, by creating a single unified power grid, capable of supporting wind power, and driven by smart grid dynamics, the United States can effectively manage its abundant wind resources. While this requires considerable governmental intervention on the federal level, public support is just as critical. As the power industry, as Ted Craver of Edison International states, will likely face "more change in the next ten years than we've seen in the last hundred" … "at least now the rest of us are starting to pay attention."[53]

E. Public Support & Power Consumption

Public support of wind energy is crucial to its success. Throughout the past couple of decades, industry issues, some real and some conceived, have largely turned the public off to wind. This lack of public support has played a major role in limiting wind energy's expansion in the United States. In recent years, however, polls have revealed that the American public is progressively embracing wind power. In 2009, 70-80% of the public were in favor of wind energy expansion, which is a major increase from a decade prior.[54] However, when development makes its way toward one's property or wallet, that support may very well cease. Furthermore, as a general lack of understanding of the industry still persists, there is a strong possibility that support will fade. Thus, deeper support and understanding of wind energy needs to be integrated into societal philosophy. And this needs to stem from the harsh realities associated with our current

[53] Achenbach, Joel. "The 21st Century Grid." *National Geographic*. July 2010: pp. 138
[54] Klick, Holly. "Public Understanding of and Support for Wind Power." *American Association for Public Opinion Research*. (2009): Web. 15 Mar. 2012. pp. 1

fossil fuel dependency. In the upcoming years, the public's role, not only in supporting wind development and encouraging governmental subsidies, but also in the *consumption* of power, will greatly determine the industry's success. Power consumption by the public will play just as vital a role in wind energy's future as power generation and delivery.

Again, a smarter grid offers tremendous potential. One key feature of smart grid technology is providing consumers with real-time energy data, encouraging customers to consume less and when demand is low. The latter component, referred to as demand management, could go a long way in eliminating the need for conventional power plants to ramp up production when energy demand is high. Instead, this will allow intermittent sources of power, such as wind and solar, to effectively supply our energy needs with clean, renewable power – minimizing wasted power generation. In order to fully and effectively address our fossil fuel dependency though, curbing our consumption habits is critical.

Modern Americans are consumers by nature. We live for convenience and in today's world convenience is fueled by energy – cars, gizmos, gadgets, etc. The unsustainable nature of this fuel, however, has landed us in a complicated limbo. Our culture has become so anti-sacrifice and pro-convenience that in doing so we have ironically positioned ourselves in a place where sacrifice is now necessary but nearly impossible. It's a catch-22 and the only way out is to redefine our meaning of convenience.

Today, largely due to our consumption habits over the past hundred years, we are surrounded by a myriad of daunting global issues. Beneath our feet, our diminishing fossil fuel reserves remind us of the true meaning of nonrenewable. Overseas, continued political unrest in resource abundant nations, particularly in the Middle East call into question both our energy and national security. And at the same, above our heads, looms the still darkening cloud of Climate Change. Plainly speaking, it's scary. When we think of convenience, we must consider the harsh realities under the seemingly pleasant surface. If not, these realities are going to keep nearing the surface and eventually 'convenience' will simply become a luxury of the past. Change is necessary and even small changes in our personal consumption habits can go a long way in protecting our nation against the consequences of fossil fuel dependency. Again, deeper integration and understanding of our energy dilemma is fundamental to securing a sustainable energy future. The following section will outline a specific action plan to help the United States achieve 20% wind energy by 2030, helping to secure this sustainable energy future. Driven through continued public and governmental backing, the United States, with its entrepreneurial spirit and abundant wind resources, has tremendous potential to achieve 20% wind by 2030 – setting a much-needed global example.

IV: Action Plan: Achieving 20% Wind Energy by 2030 in the United States

Since the 1970's, when energy policy truly established itself on the political agenda, the United States government has had significant trouble passing effective legislation. As Graetz says in his largely historical account of energy in the United States, The End of Energy, "we have failed miserably at managing the intersection of

our politics and science."[55] Going forward, science needs to be a substantial driving force in policy decisions. Today, science, among other things (energy and national security), is telling us we need to shed our dependence on fossil fuels. In the coming decades, there will be significant change to our energy landscape, in the United States and worldwide. Through a proper action plan, the United States has immense potential to become a global leader in pursuing a sustainable energy future.

The move to a more sustainable energy future, supported by 20% wind energy, is something that cannot happen overnight. An appropriate action plan must be in place to address our near-term energy needs while simultaneously strengthening the foundation for 20% wind by 2030 – our long-term needs. While renewable energy sources, such as wind power, are not likely to make up a huge sector of our energy needs in the coming years, the *way* we use conventional sources of energy is a key area of concern. The following plan will outline crucial measures for working up to 20% wind energy by 2030 in the United States. Such a plan must at once make renewable energy a more appealing short-term option and conventional fuel a less attractive long-term option. Incorporating this ideology into our fundamental culture will allow for a smooth transition to a clean-energy future.

A. Putting a Price on Carbon and Removing Killer Subsidies

The price we currently pay for conventional fuel (e.g. at the gas pump) is too low. While it's something that is difficult for people to hear, it is a fundamental problem that needs to be addressed if we want to shed our dependence on fossil fuel and avoid the

[55] Graetz, Michael. *The End of Energy: The Unmaking of America's Environmental, Security, and Independence*. Cambridge: The MIT Press, 2011. Print. pp. 263.

associated consequences. In the latest World Energy Outlook Report, the International Energy Agency (IEA) concluded that in 2010 the world spent $409 billion on subsidizing the production and consumption of fossil fuels compared to a mere $66 billion of subsidies for renewable energy. Estimates project that, in theory, phasing out these subsidies could accomplish "about half the reduction in greenhouse gas emissions needed to meet the goal of preventing average world temperatures from rising more the 2 degrees Celsius."[56] Ultimately, as long as fossil fuels are cheap to produce and consume, our dependence will persist. By gradually phasing out subsidies and imposing a carbon tax to more accurately reflect the true price of fossil fuels, consumers will be forced to consume more responsibly, and renewable sources, such as wind energy, will become an increasingly attractive alternative.

Unfortunately, since the "rise and spread of the antitax movement…from the stagflation of the 1970s," passing such legislation has been troublesome because of the costs to citizens.[57] However, following a tax scheme in which the created revenue is in part returned to the taxpayers (based on income), and in part put toward further development of clean energy, would at once minimize the financial burden to the people while both encouraging renewable energy and efficient consumption. While such legislation has been unable to pass through Congress in the past, the energy arena today presents new opportunities. According to a recent report by the Pew Center,

> "the global clean energy economy represents a $2.3 trillion opportunity over the next ten years if G-20 countries

[56] Yglesias, Matthew. "Dirty Money." *Slate* 26 Jan 2012, n. pag. Web. 15 Mar. 2012.
[57] Graetz, Michael. *The End of Energy: The Unmaking of America's Environmental, Security, and Independence*. Cambridge: The MIT Press, 2011. Print. p. 256.

> significantly strengthen their clean energy policies, such as by putting a price on carbon."[58]

The United States, largely because of our skewed subsidization of fossil fuels, has fallen behind in this industry, now ranking 17th in the world in its percentage of GDP from the clean energy sector. As the Pew Center concluded, the U.S. is one of three countries (along with India and the UK) with the "most to gain from adoption of aggressive clean energy policies" – (i.e. creation of jobs and increased capital).[59] Ending fossil fuel subsidies and putting a price on carbon is not without economic benefits and the implications for our environment and energy/national security are immense. Accordingly, an appropriate carbon tax must attempt to take into effect the negative implications of fossil fuels, from Climate Change to security. Accurately reflecting such a complex issue presents an obvious difficulty but imposing any such tax will push us in the right direction. Furthermore, a carbon tax, compared to cap-and-trade legislation or other carbon policies, will be much easier to administer, predict, and adapt as necessary. Ultimately, phasing out fossil fuel subsidies while simultaneously introducing a carbon tax will require strong leadership but, along with other necessary changes, will provide the regulatory framework to attract renewable energy and curb our consumption of fossil fuels.

B. Updating an Outdated Regulatory Framework

Effective energy legislation, capable of achieving 20% wind energy by 2030, must appeal to the interests of all of the invested entities – utilities, transmission

[58] Brutoco, Rinaldo, and Madeleine Austin. "The Market Is Lying: Why We Must Tax Carbon, Not Subsidize It." *Truth-Out*. 8 July 2011: n. page. Web. 15 Mar. 2012.
[59] (See 59)

companies, residents, etc. Implementing a carbon tax will provide an incentive for these entities to re-align their interests more closely with that of the wind industry (and renewable industry in general). However, because our current energy plan is so highly dependent on fossil fuels, much of the regulatory framework is outdated with regard to clean power. Truly establishing a regulatory foundation that can support 20% wind energy by 2030 requires adapting current regulation accordingly. In particular, increased wind energy development will require both putting a price on carbon while also updating PURPA, the Public Utility Regulatory Policy Act originally passed in 1978.

PURPA, originally intended to encourage competition between alternative energy sources and further integrate renewable power into the grid, has been largely unsuccessful in achieving its goals. Technically, PURPA only calls for renewable sources if they are financially competitive with conventional sources, and has no provision regarding the avoided externalities (e.g. pollution, greenhouse gases). For this reason, because fossil fuel prices have remained relatively low, PURPA has limited renewable integration. While imposing a carbon tax and phasing out subsidies on fossil fuels will go a long way toward making renewable sources, particularly wind, cost-competitive, independently updating the framework would provide more certainty that renewable sources find their way into the grid.

PURPA must be adapted to remove the unfair advantage given to conventional polluting sources. As referred to in Ayres' Crossing the Energy Divide, an appropriate updated regulation requires at least three basic changes. Firstly, the "avoided cost" requirement, that allows a facility to enter the market only if it can generate power for less than what it would have cost for the utility to produce the power, must be

eliminated. Secondly, competing facilities must be allowed to sell power to the grid at higher prices than the utility's price if they generate carbon-free power, or power with other pollution-reduction advantages. Finally, PURPA should be amended to require that every utility purchase carbon-free power "from anyone who can deliver it, at a price no less than the utility's own retail price in that location (and higher than that price if emissions free)."[60] This re-alignment will ultimately eliminate the monopoly utility companies have on the power grid, enabling wind energy to enter the mainstream market on a large scale. In conjunction with a carbon tax and phase-out of fossil fuel subsidies, appropriately updating PURPA will create the necessary regulatory framework to enable wind energy infrastructure to expand and meet 20% of U.S. electricity needs by 2030.

C. Industry Investment and Revamping the Grid

Creating a regulatory foundation to grow upon is only the first step toward achieving a sustainable energy future, supported by 20% wind energy by 2030. As previously mentioned, the major impediment on wind energy's success in the U.S. is our outdated power grid – the problem of transmission infrastructure. While the installed wind capacity in the United States is rapidly growing and re-aligning PURPA will allow for this power to more readily enter the grid, truly capturing and utilizing our abundant wind resources, particularly in the remote regions of the country, will require

[60] Ayres, Robert, and Edward Ayres. *Crossing the Energy Divide: Moving from Fossil Fuel Dependence to a Clean-Energy Future*. Upper Saddle River: Wharton School Publishing, 2010. Print. pp. 164-165

considerable infrastructural investment. Again, properly reflecting the 'true' price of carbon may be the answer.

As previously alluded to, imposing a carbon tax scheme where a percentage of the created revenue was put toward investment in the renewable industry could mean significant growth in wind energy infrastructure. However, a carbon tax could generate wind industry investment in a much different, and perhaps more significant, way – the utilities. Utility companies in America represent an overwhelming proportion of our domestic economy. By imposing a carbon tax and phasing out subsidies on fossil fuel sources, utility companies will have a major incentive to invest in renewable energy. And where better for the money to come from. Coupled with the already growing support and investment in renewable energy we've seen from Washington, DC in recent years, utility companies could help cover much of the upfront costs of the needed transmission infrastructure.

As projected by the DOE, in achieving 20% wind by 2030, infrastructure development will likely require upwards of $20 billion. A carbon tax could certainly generate a considerable portion of the necessary investment. Furthermore, phasing out the subsidies of fossil fuels presents an obvious opportunity for further wind industry investment. As previously mentioned, annual fossil fuel subsidies run over $400 billion. Directing even a small portion of this capital towards wind energy development would provide the necessary investment for achieving 20% wind energy by 2030. Of course, the difficulty of imposing such a change, given our deep investment in the fossil fuel industry, should not go understated. Modern America is built around fossil fuels.

Changing this harsh reality, and truly enabling wind development through the necessary means (discussed above) will require a fundamental societal shift.

D. The Most Important Piece of the Puzzle – Public Support & Awareness

Public opinion matters. It is a driving force in political decisions, governmental action, and change. In achieving 20% wind energy by 2030, the role of the public is the most important piece of the puzzle. To reiterate from an earlier section, there are a few established facts that need to be considered in the discussion of our energy future:

1. Combustion of fossil fuel is by far the leading contributor of greenhouse gases in our atmosphere, which experts now almost unanimously agree are a leading cause of Climate Change.

2. Continued reliance on fossil fuels will require us to remain dependent on the most unstable region on Earth.

3. Fossil fuels are a finite resource and in the long run, their continued use is unsustainable.

4. To make renewable energy (wind in particular) successful in the future, integration into our energy scheme must begin now.

These concepts need to be integrated into our societal philosophy. Increasing awareness, through directed learning in early education and increased publicity, is a fundamental step in garnering wind industry support.

Creating a government agency to take on this responsibility, by providing educational services and publicity campaigns to increase awareness, could gain the

necessary support to overcome the impediments currently limiting wind energy. Increased support would alleviate many of the problems due to NIMBYism, industry misperceptions, etc. Furthermore, this would encourage the necessary shift in energy policy – removing the unfair advantage given to fossil fuels. Accordingly, the necessary funding for such an agency, again, could come from avoided fossil fuel subsidies and carbon tax revenue – both of which would be accepted more readily by increasing public awareness. Ultimately, establishing an agency devoted to increasing public awareness of energy will help to garner support for the wind industry, which unquestionably has influence on further development.

Beyond encouraging further development though, increasing public awareness would also directly impact consumption behavior, which is a critical step going forward. As Jimmy Carter illustrated during the 1970s energy crisis, it is ineffective to merely ask the public to curb its energy use. Rather the government's role in curbing consumption should come in the form of raising awareness. With a more sound understanding of the consequences of fossil fuels, consumers will naturally make more responsible energy decisions. Furthermore, providing detailed energy information on products and services to inform consumers of the associated 'energy cost' would encourage consumers and producers to make more responsible decisions, ultimately reducing fossil fuel use and encouraging renewable sources.

This concept is a key component of the current smart grid technology, which provides real-time energy information to customers to influence their consumption behavior. However, it could be utilized on a much larger scale further integrating energy into our societal philosophy. For example, consider a trip to the grocery store. If items

were required to have an energy rating, reflective of the associated embodied energy (positively adjusted for renewable inputs), consumers would have incentive to choose the more “energy-friendly” option. Consequently, producers would be encouraged to make products with a more appealing energy rating. These energy ratings, of course, would be reinforced by the price of the product as a function of a carbon tax, simply adding extra-incentive to reduce fossil fuel consumption and thus, promote renewable energy. Nonetheless, implementing this concept across the market will establish energy as a primary public concern, which is essential in creating a more sustainable energy future.

Achieving 20% wind energy by 2030 unquestionably will require significant change. Establishing strong public support for the industry, particularly in opposition to the fossil fuel industry, is essential in driving the necessary change. Increasing public awareness and understanding of the true energy impacts that our day-to-day decisions make are keys going forward. In order to truly ensure a sustainable energy future, supported by 20% wind, energy must position itself into the central philosophy of modern society, in America and worldwide.

E. Energy – A Global Issue

Energy is an immensely complex issue because, plainly, it affects everyone and everything. Truly effective federal legislation must address global implications. Particularly, putting a price on carbon as suggested above, would have obvious implications on international trade. Increased prices for domestic products and services would present significant opportunities for exporting countries without a carbon tax.

This could be very problematic for the U.S. economy and thus, would have to be addressed as part of a carbon tax policy.

Numerous policies have been suggested to create a level playing field so to speak, including border tax adjustments, trade bans and tariffs. Prohibiting, or at least placing a high tax on, the importation of carbon-intensive goods would help to reflect the true cost of the product. This type of policy would simultaneously protect the domestic economy while encouraging other nations to join the effort and put a price on carbon. The United States, as the number one importing country in the world, has immense potential to drive global change and the time is now. By providing both market incentive and global leadership in the energy arena, the U.S. is uniquely well positioned to initiate the necessary movement to a more sustainable energy future.

F. In Conclusion

The above action plan outlines essential interconnected steps in working towards 20% wind energy in the U.S. by 2030, as well as the widespread implications such a plan would have on the global energy future. To summarize in 5 simple steps:

In order to effectively achieve 20% wind energy by 2030, the U.S. government should:

1. Place price on carbon by phasing out fossil fuel subsidies and imposing a carbon tax.

2. Update outdated regulatory framework to allow for the expansion of wind energy and promote renewable power in general -- particularly, PURPA.

3. Increase industry investment by directing revenue from carbon tax and avoided fossil fuel subsidies to industry needs (i.e. transmission infrastructure).

4. Create an agency with responsibility of increasing public awareness to the consequences of fossil fuels and positive implications of wind (and other renewable) energy (through energy ratings, education services, etc.), ultimately integrating energy into the core of societal philosophy.

5. Impose trade restrictions on countries to encourage carbon pricing and promote a more sustainable global energy future.

Implementing these 5 fundamental steps in the coming years will create the necessary foundation, allowing for both 20% wind energy in the US, and more importantly, a significantly more "energy-friendly" world by 2030. In the coming years, energy is likely to establish itself at the forefront of policy, economics, and even casual conversion. The United States, as a global leader, has a truly unique opportunity to ensure a more desirable global future, putting "the wind at our backs."

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