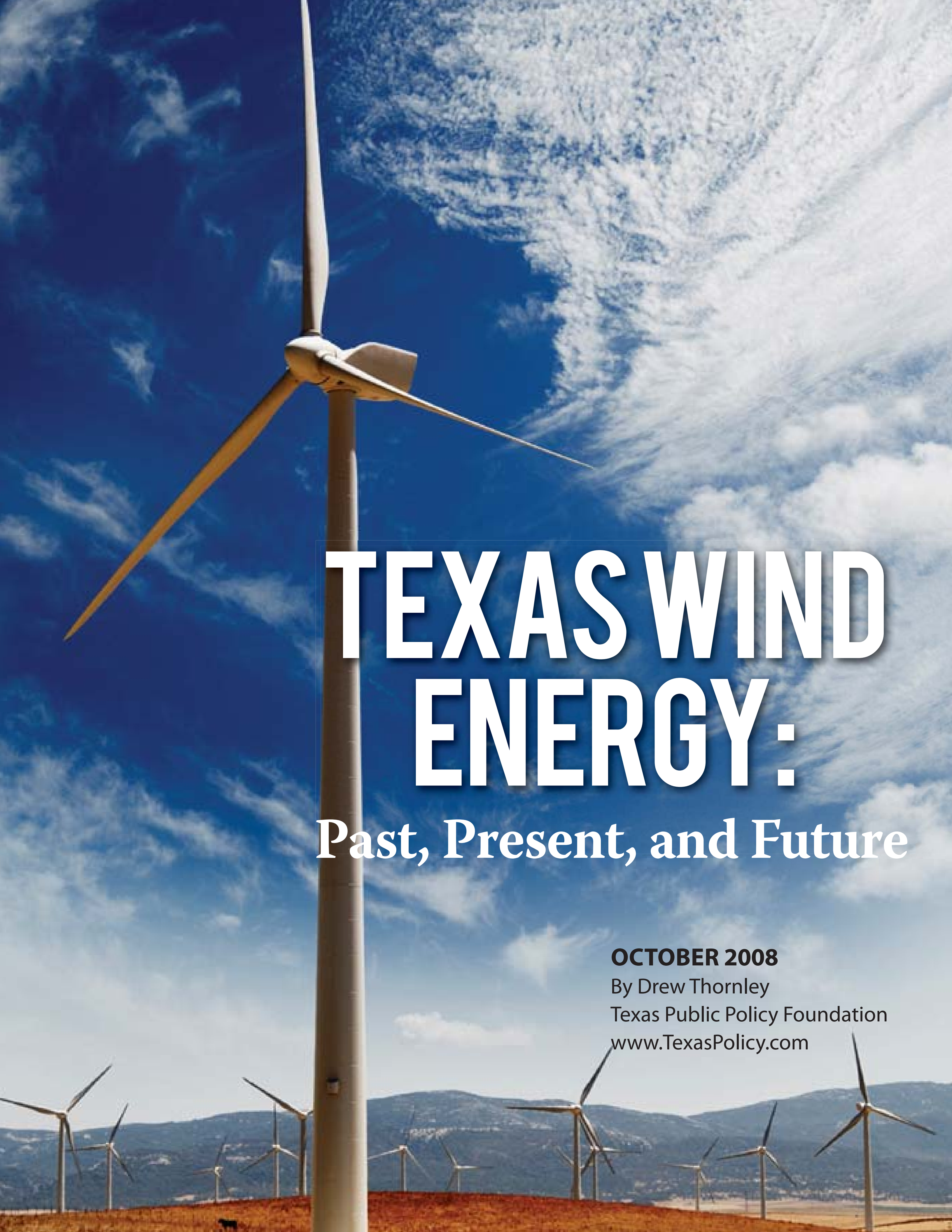

TEXAS WIND ENERGY:

Past, Present, and Future

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Executive Summary

Texas is a growing state with growing energy needs. A crucial issue is how to develop and allocate the state's vast natural resources so that Texans have reliable and affordable energy. Wind energy is an increasingly important part of this equation, as Texas leads the nation in installed wind-power capacity. But myriad questions and challenges confront wind energy's expansion, namely wind's intermittent nature, the lack of large-scale electricity storage, and the limitations on electric transmission.

The greatest impediment to wind's large-scale contribution to our energy supply is its intermittent nature. The wind must blow in order for wind turbines to produce power. In Texas, however, wind blows the least during the summer months when we need power the most. The Electric Reliability Council of Texas (ERCOT) relies on about 8.7 percent of wind power's installed capacity when determining available power during peak summer hours.

Due to wind's intermittency, wind turbines have much lower capacity factors—measures of generating units' actual energy output divided by the energy output if the units operated at its rated power output 100 percent of the time—than conventional (thermal) power sources. As such, wind is not a baseload resource and cannot deliver a large portion of the demand for energy.

Second, electricity cannot currently be stored on a commercial scale. This lack of adequate large-scale electricity storage amplifies the effects of wind's variability and lack of correlation with peak demand. Without adequate wind-power storage, wind-generating units must be backed up by units that generate electricity from conventional sources. In Texas' case, that means natural gas, a fuel source with extreme price volatility. Thus, wind energy is an inherently less valuable resource than fuel sources requiring no backup.

Another major issue surrounding wind-energy development is electric transmission capacity. More specifically, the infrastructure does not exist to move electricity from the areas of Texas most suitable for wind energy generation—West Texas and the Panhandle—to the state's metropolitan centers. Texas' electric customers should be particularly concerned, as they will foot the bill for these new transmission lines.

The distinction between wind and wind energy is critical. The wind itself is free, but wind energy is anything but. Cost estimates for wind-energy generation typically include only turbine construction and maintenance. Left out are many of wind energy's costs—transmission, grid connection and management, and backup generation—that ultimately will be borne by Texas' electric ratepayers. Direct subsidies, tax breaks, and increased production and ancillary costs associated with wind energy could cost Texas more than $4 billion per year and at least $60 billion through 2025.

Wind, like every other energy resource, has its pros and cons, and there is no doubt that wind power should be part of Texas' energy supply. Texas needs a variety of fuel sources, plus concerted efforts at conservation and efficiency, in order to meet its energy needs. However, wind energy should only be employed to the extent it passes economic cost-benefit muster. Instead of subsidizing private wind development and imposing billions of dollars in new transmission costs upon retail electric customers, Texas policymakers should step back and allow the energy marketplace to bring wind power online when the market is ready. Texas electricity consumers will reap the benefits of such a prudent path.

Introduction

Texas' population is projected to increase from 24.3 million to 29.7 million by 2020 and to 40.1 million by 2040.[1] The Electric Reliability Council of Texas (ERCOT),[*] which manages 85 percent of the state's electric load, estimates the average annual growth rate for peak energy will be 1.8 percent over the next 10 years (for a total of 374,740,989 MWh of energy in the ERCOT region in 2018) and 1.59 percent from 2008 to 2025.[2] ERCOT projects a total peak-energy demand requirement[†] of 99,093 megawatts (MW) by 2028, up from 2008's summer peak demand forecast of 64,927 MW.[3]

Texas has growing energy needs and is home to vast natural resources. A crucial issue is how to develop and allocate these resources to provide Texans with reliable, affordable energy. Wind energy has become an increasingly important part of this equation, as Texas leads the nation in installed wind-power capacity and has abundant wind resources.

But wind energy faces myriad questions and challenges relating to adding additional capacity and transmission limitations. This paper explores these issues, with the goal of facilitating a conversation on Texas wind-energy development that will ultimately lead to wind's finding its proper role in Texas' fuel-supply mix. With due diligence and an informed discussion on the benefits and limitations of wind energy, Texas can employ wind energy to its optimal level, both economically and technologically.

Wind Energy Basics

Utility-sized turbines ranging from 100 kilowatts to several megawatts harness wind energy by converting wind's kinetic energy to electricity. These turbines are grouped into large wind farms, which produce power for electric grids.[‡] Since wind is a renewable resource, energy generated from wind turbines is considered renewable energy. As described by the National Renewable Energy Laboratory (NREL):

> Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a *rotor*. A blade acts much like an airplane wing. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called *lift*. The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called drag. The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity.[4]

With over 5,000 units installed worldwide,[§] GE's 1.5-MW wind turbines are the most widely used turbines in the United States.[¶] Specifications of GE's 1.5 MW Series turbine, "the largest wind turbine assembled in the United States,"[5] include the following:[6]

[*] "The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to 21 million Texas customers—representing 85 percent of the state's electric load and 75 percent of the Texas land area." *See* "Company Profile," http://www.ercot.com/about/profile/.

[†] Total demand is considered as peak demand plus a 12.5 percent reserve margin.

[‡] For a detailed explanation of how wind turbines deliver power to an electric grid, *see* "How Wind Turbines Work," U.S. Department of Energy, http://www1.eere.energy.gov/windandhydro/wind_how.html. *See* also "FPL Energy: How Wind Turbines Work," http://www.fplenergy.com/portfolio/wind/turbines.shtml.

[§] GE Energy: http://www.gepower.com/prod_serv/products/wind_turbines/en/index.htm. GE is one of the world's leading wind turbine suppliers with over 8,400 worldwide wind turbine installations comprising more than 11,300 MW of capacity. With wind manufacturing and assembly facilities in Germany, Spain, China, Canada, and the United States, GE Energy's current product portfolio includes wind turbines with rated capacities ranging from 1.5 to 3.6 megawatts. *See* http://www.gepower.com/businesses/ge_wind_energy/en/index.htm.

[¶] "AWEA 2008 Annual Rankings Report" (Apr. 2008) http://www.awea.org/AWEA_Annual_Rankings_Report.pdf. For more on GE's 1.5-MW turbine, *see* GE Energy: http://www.gepower.com/prod_serv/products/wind_turbines/en/downloads/ge_15_brochure.pdf.

- Turbine Height: 328 feet, from bottom of tower to tip of highest blade
- Turbine Weight: 185,000 pounds (92.5 tons)
- Foundation: Each wind turbine foundation consists of a concrete octagonal footing 47 ft. in diameter and 7 ft. deep. Concrete: 294 cubic yards—439 tons per foundation.
- Tower Height: 263 feet
- Tower Weight: 190,000 pounds (95 tons)
- Blade Length: 112 feet
- Blade Weight: 35,000 pounds

The largest installed wind turbines in the country (and in Texas) stand up to 150 meters tall and have rated capacities of 3 MW.[7] Within each rated capacity, the length of the blades and height of the towers can vary to accommodate specific location and wind-speed needs. Larger, taller turbines catch better winds at higher elevations and are more powerful because of the larger area swept by the blades; advances in technology, such as sophisticated power electronics and high-tech materials, also increase productivity.[8]

Wind Energy in the United States and Texas

Wind generates less than 1 percent of our nation's electricity supply. According to the Energy Information Administration, wind's percentage of total net[*] generation was 0.44 percent in 2005, 0.65 percent in 2006, and 0.77 percent in 2007.[9] EIA's projection for wind's percentage of total U.S. electric generation in 2030 is 2.36 percent.[10]

In 2007, 2 percent of Texas' energy resulted from wind.[†] According to the Texas Comptroller of Public Accounts,

> The Electric Reliability Council of Texas (ERCOT), which manages the state's largest power grid, reports that wind energy accounted for 2.9 percent of the electricity generated in its region in 2007. However, due to the variable and seasonal nature of wind energy as well as seasonal fluctuations in demand for energy, the proportion of energy from wind tends to vary month-to-month. For example, in 2007 wind accounted for 1.4 percent of electricity generated in July and 4.3 percent in December. Wind accounted for 4.5 percent of the electricity generated in ERCOT in January 2008, compared with 1.9 percent the previous January.[11]

In 2007, the U.S. installed 5,021 MW of wind-power capacity, bringing its total installed capacity to 16,596 MW at year's end.[12] Though Germany has the most installed wind capacity (22,000 MW), "that position is likely to be usurped by the United States, if not this year then next."[13] With 5,077 installed megawatts, as of December 31, 2007, FPL Energy is the U.S.' leading wind power developer.[‡] FPL Energy is also the largest wind energy developer in Texas, with 13 wind projects totaling 2,103.7 installed MW, as of March 31, 2008.[14]

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* "The term 'net' reflects the fact that some of the electricity produced by a generating unit is used *by* that generating unit (lights, pumps, scrubbers, precipitators, etc.)." *See* "Electric Industry Terms Important in Understanding Two of the Critically Important Limitations of Electricity from Wind Energy," Glenn Schleede (17 Feb. 2008).

† "AWEA 2008 Annual Rankings Report" (Apr. 2008) http://www.awea.org/AWEA_Annual_Rankings_Report.pdf. By contrast, Minnesota and Iowa get close to 5 percent of their electricity from wind power. *See* "Wind Power—Clean AND Reliable," AWEA, http://www.awea.org/utility/pdf/Wind_and_Reliability_Factsheet.pdf. "Much has been written about Denmark's success as the world's wind power pioneer. But the regularly repeated claim—that Denmark generates 20 percent of its electricity demand from wind sources—is highly misleading. That 20 percent of electricity is not supplied continuously from wind power. Denmark's wind supply is so variable that it relies heavily on neighbors Norway and Sweden, taking their excess production. In 2003, its export figure for wind power electricity production was as high as 84 percent, as Denmark found it could not absorb its own highly variable wind output capacity into its domestic system." *See* "Overblown: The Real Cost of Wind Power," Peter Glover and Michael Economides, *Energy Tribune* (2 Apr. 2008) http://www.energytribune.com/articles.cfm?aid=842.

‡ "AWEA 2008 Annual Rankings Report" (Apr. 2008) http://www.awea.org/AWEA_Annual_Rankings_Report.pdf. Iberdrola is the second-largest U.S. developer, with 1,644.5 MW installed.

Texas' wind boom began in 1999, with the passage of Senate Bill 7,[15] which included Texas' first renewable portfolio standard (RPS).[*] The RPS mandated that the state's competitive electric providers install 2,000 MW of new renewable energy capacity by 2009. Each competitive provider's share of the mandate was its share of total competitive energy sales. The 1999 RPS was met in just over six years.[16]

In 2005, the Texas Legislature passed Senate Bill 20 (SB 20),[17] which increased Texas' renewable portfolio standard to a 5,880-MW mandate by 2015 and a 10,000-MW target by 2025.[†] SB 20 includes a target of 500 MW from non-wind sources,[‡] a clear indication that wind is expected to meet the majority of the RPS mandate and target.[§]

Texas' RPS also includes an REC trading program,[¶] which will continue through 2019. As described by the Texas State Energy Conservation Office (SECO),

> The renewable energy capacity required by the electricity sellers can be provided directly or through the REC market. One REC represents one megawatt-hour of qualified renewable energy that is generated and metered in Texas. If a utility earns extra credits, it can sell the credits to utilities who need credits to meet the RPS requirements. This enables electricity providers that do not own or purchase enough renewable energy capacity to purchase credits instead of capacity.[18]

Texas' RPS requires additional (i.e., new) generating capacity of 5,000 MW and a "cumulative installed renewable capacity" (i.e., existing plus new) of 5,880 MW. Existing facilities are defined as those placed in service before September 1, 1999.[19] As of October 14, 2008, there were 6,589.6 MW of total renewable energy capacity in Texas: 297.6 MW from existing facilities, and 6,292 MW from new facilities (*see* Table 1).[20] Of the total, 6,272 MW were generated by wind facilities: 115.8 MW from existing wind facilities and 6,156.2 MW from new wind facilities (accounting for 98 percent of all new renewable energy capacity in Texas).[21]

[*] In addition to environmental concerns, a common impetus for renewable portfolio standards/mandates is energy independence, but, according to Robert J. Michaels, "A renewable portfolio standard is irrelevant to promises of energy independence and security. Over 95 percent of our power comes from domestic or nearby sources: coal (49 percent), gas (20 percent), uranium (20 percent), and water (7 percent). None of these resources is insecure or held hostage by foreign actors." *See* "Hot Air and Wind," Robert J. Michaels, *National Review Online* (20 Dec. 2007) http://www.cato.org/pub_display.php?pub_id=8858.

[†] One purpose of Texas' RPS is "to ensure that the cumulative installed generating capacity from renewable energy technologies in this state totals 2,280 megawatts (MW) by January 1, 2007, 3,272 MW by January 1, 2009, 4,264 MW by January 1, 2011, 5,256 MW by January 1, 2013, and 5,880 MW by January 1, 2015, with a target of at least 500 MW of the total installed renewable capacity after September 1, 2005, coming from a renewable energy technology other than a source using wind energy, and that the means exist for the state to achieve a target of 10,000 MW of installed renewable capacity by January 1, 2025." *See* PUCT Substantive Rule Section 25.173(a)(1).

[‡] "Of the renewable energy technology generating capacity installed to meet the goal of this subsection after September 1, 2005, the commission shall establish a target of having at least 500 megawatts of capacity from a renewable energy technology other than a source using wind energy." *See* SB 20 (2005), http://www.capitol.state.tx.us/tlodocs/791/billtext/pdf/SB00020F.pdf (Page 3). *See* also PUCT Substantive Rule Section 25.173(a)(1). "Currently wind represents the bulk of renewable energy development occurring under the Texas RPS, largely due to wind's relatively low cost and the abundance of exceptional wind resources in the state. In an effort to diversify the state's renewable generation portfolio, SB 20 includes a requirement that the state must meet 500 MW of the 2025 target with non-wind renewable generation. This provision indirectly promotes solar power and biomass in Texas and provides farmers and ranchers with new revenue sources from the use of crops and animal waste to produce energy." *See* "Texas Renewable Portfolio Standard," State Energy Conservation Office, http://www.seco.cpa.state.tx.us/re_rps-portfolio.htm.

[§] "As of 2004, of the estimated 2,335 megawatts of renewable energy use attributable to state renewable standards, 2,183 megawatts (93 percent) were generated by wind. Thus, a renewable portfolio standard is, in reality, a mandate for wind power." *See* "Gone with the Wind: Renewable Portfolio Standard Threatens Consumers and the Industrial Heartland," CEI On Point, William Yeatman and Myron Ebell (12 June 2007).

[¶] "The REC trading system created great flexibility in the development of renewable energy projects." *See* "Texas Renewable Portfolio Standard," State Energy Conservation Office, http://www.seco.cpa.state.tx.us/re_rps-portfolio.htm.

Table 1: Texas' Renewable Energy Capacity**

Technology Type	Existing Renewable Energy Capacity (MW)	New Renewable Energy Capacity (MW)
Biomass	0.0	32.5
Hydro	178.5	33.1
Landfill Gas	3.3	69.1
Solar	0.0	1.2
Wind	115.8	6,156.2
Total	297.6	6,292.0

**Note: As of October 14, 2008.

Table 2: Installed Wind Capacity by Year

Year	Texas	California	United States
1999	180	1,646	2,500
2000	181	1,646	2,566
2001	1,096	1,714	4,261
2002	1,096	1,822	4,685
2003	1,293	2,043	6,374
2004	1,293	2,096	6,740
2005	1,995	2,150	9,149
2006	2,739	2,376	11,575
2007	4,296	2,439	16,596

Texas leads the nation in installed wind-power capacity. The 1,557 MW added in 2007 brought Texas' total capacity to 4,296 MW by the end of 2007.[22] (California, second in total capacity, added 63 MW in 2007, for a total of 2,439 MW by year's end.[23]) In 2006 and 2007, more electric capacity was added from wind power than from all other types of power plants combined.[24] Table 2 charts MW of wind capacity installed in Texas, in California, and nationwide from 1999 to 2007.[25]

As of June 30, 2008, Texas remained the nation's leader in installed wind-power capacity, with 5,604.65 MW installed. California remained second in installed capacity, with 2,483.83 MW.[26]

Texas' RPS has artificially inflated Texas' demand for wind energy, a position with which the Texas Comptroller of Public Accounts agrees:

> The RPS creates demand for all renewable energy sources—such as wind, solar, biomass, hydropower and geothermal power—by requiring companies that sell electricity to retail customers to support renewable energy generation.[27]

Though the RPS is "clearly a valuable catalyst historically for new wind-energy development,"* Texas has encouraged development in other ways. SB 20 (2005) required the Public Utility Commission of Texas (PUCT) to des-

* Email from Mike Sloan, President, Virtus Energy (1 Apr. 2008) "State tax incentives alone are often not sufficient to encourage substantial wind power development without other supportive public policies such as renewable energy purchase mandates, renewables portfolio standards, or system-benefits charges." *See* "Analyzing the Interaction Between State Tax Incentives and the Federal Production Tax Credit for Wind Power," Ryan Wiser, Mark Bolinger, and Troy Gagliano, Ernest Orlando Lawrence Berkeley National Laboratory (Sept. 2002) http://eetd.lbl.gov/ea/EMS/reports/51465.pdf. *See* also "Strategies for Supporting Wind Energy: A Review and Analysis of State Policy Options." Rader, N. and R Wiser, Washington, D.C.: National Wind Coordinating Committee, 1999.

ignate Competitive Renewable Energy Zones (CREZ) and required electric transmission infrastructure to be constructed, in order to move renewable energy from these CREZ zones to the markets where energy is most needed. The PUCT subsequently designated five CREZs, located in West Texas and the Panhandle. (Discussion of CREZ transmission follows in the Benefits and Challenges of Wind Energy section.)

The Legislature's mandating CREZ designation and subsequent transmission construction has played a major role in Texas' wind-energy investment and construction boom, giving developers assurance that transmission lines will be built to connect CREZ zones to the electric grid. Additionally, the PUCT is exploring how to prioritize dispatch among wind generators and among wind and non-wind generators, though the going presumption is that wind generators will enjoy dispatch priority on CREZ lines.[28] (Further discussion of CREZ dispatch priority is found in the following Dispatch Priority section.)

Wind Energy: Benefits & Challenges

As with all energy sources, wind energy has benefits and drawbacks. Thus, a closer look at the virtues and challenges of wind energy and wind-energy development is in order.

Reliability/Capacity

Due to its intermittent nature, wind is not a baseload energy resource. This is the most important issue regarding wind energy's contribution to the energy supply.

In a study on wind integration's impacts on ERCOT's ancillary services, GE Energy reports,

> Wind generation has technical characteristics which inherently differ from those of conventional generation facilities. Conventional generation can be controlled, or 'dispatched', to a precise output level. The primary energy source for wind generation, however, is inherently variable and incompletely predictable. Thus, electrical output of wind generation plants cannot be dispatched.[29]

For wind turbines to produce power, the wind must be blowing, but because the wind does not blow constantly, a wind turbine has a capacity factor—a measure of a wind turbine's actual energy output divided by the energy output if the machine operated at its rated power output 100 percent of the time*—lower than traditional power sources. According to the American Wind Energy Association (AWEA), "A reasonable capacity factor would be 0.25 to 0.30. A very good capacity factor would be 0.40."† The Nuclear Energy Institute reports the following average capacity factors for 2007:[30]

- Nuclear: 91.8 percent
- Coal (steam turbine): 71.8 percent
- Natural gas (combined cycle): 43.3 percent
- Natural gas (steam turbine): 16.0 percent
- Oil (steam turbine): 19.6 percent
- Hydro: 27.8 percent
- Wind: 30.4 percent
- Solar: 19.8 percent

* Stated similarly, capacity factor is "an after the fact measure with the percentage determined by dividing the actual (metered) output (in kWh or MWh), divided by the nameplate capacity (in kW or MW) times the number of hours in the period for which the calculation is done… A 1 MW (1,000 kW) wind turbine that produces 2,190,000 kWh of electricity during a year has achieved a capacity factor of 25 percent. That is 2,190,000 kWh divided by 1,000 kW x 8760 hours; or 2,190,000 divided by 8,760,000 = .25)." "Electric Industry Terms Important in Understanding Two of the Critically Important Limitations of Electricity from Wind Energy," Glenn Schleede, February 17, 2008.

† "How Does A Wind Turbine's Energy Production Differ from Its Power Production?" AWEA, http://www.awea.org/faq/basicen.html. Regarding the capacity factors of wind turbines in the United Kingdom, *The Times of London* reports, "According to government statistics, the average load factor for turbines in 2006 was 27.4 percent." *See* "Wind farms turn huge profit with help of subsidies," Jonathan Leake, *The Times* (London) (27 Jan. 2008) http://www.timesonline.co.uk/tol/news/environment/article3257728.ece. "A 'load factor' of just over 30 percent is recommended for a wind farm to be economically viable. However, many of Britain's onshore farms have been running at around 20 percent, with some in urban areas dropping as low as 9 percent. (Consulting engineer Jim) Oswald believes that overly relying on wind power will result in major power failures across the U.K. and an increase of up to 50 percent in electricity bills. While nothing comes close to the capricious aspect of nature itself, the industry also still suffers from some severe technical difficulties." *See* "Overblown: The Real Cost of Wind Power," Peter Glover and Michael Economides, *Energy Tribune* (2 Apr. 2008) http://www.energytribune.com/articles.cfm?aid=842.

Energy analyst Glenn Schleede writes, "Wind turbines have low capacity factors because they are dependent on wind speed. They start producing a small amount of electricity with a wind speed about 6 or 7 miles per hour (mph), reach 'rated' capacity around 31 mph and cut out around 56 mph. Therefore, their output is inherently *intermittent*, *volatile,* and *unreliable*."[*]

Schleede distinguishes "factor" from "value:"

> In fact, the real capacity value of a wind turbine is the kW or MW of generating capacity that is available at the actual time of peak electricity demand on the electric grid serving the area. The real capacity value of a wind turbine or 'wind farm' is generally less than 10 percent of nameplate capacity and often 0 percent or slightly above—simply because, at the time of peak electricity demand, the wind isn't blowing at a speed that will permit the turbine to produce any or much electricity.[†]

A February 2008 Texas power emergency is evidence of wind's variable nature:

> A cold front blew through West Texas on Feb. 26, temporarily lifting wind production. When it subsided, wind speeds dropped, turbines slowed and productivity dropped by 80 percent to 300 megawatts from about 1,700. The situation was exacerbated by greater-than-expected energy demand and by lower availability of some fossil-fuel units. To get the system back in balance, the grid operator declared an emergency and tapped big customers who had agreed to be cut in exchange for cash payments. The problem 'showed us we need much better wind forecasting tools,' said Kent Saathoff, vice president of system operations at the Electric Reliability Council of Texas, a quasi-public, nonprofit corporation that operates most of the state's high-voltage transmission system. Currently, ERCOT accepts estimates of energy production from turbine owners or their agents. Texas now is working on building up its own computer capacity and monitoring to improve forecasting. It isn't clear how much the effort will cost. Shortages degrade reliability and push up prices. Wholesale power prices surged to $1,055 a megawatt hour in West Texas on Feb. 26 versus $299 elsewhere in the state. In a long-planned move, Texas on Saturday raised its price ceiling to $2,250 a megawatt hour from $1,500. Two days later, it hit the ceiling for the first time as wind produc-

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[*] "Electric Industry Terms Important in Understanding Two of the Critically Important Limitations of Electricity from Wind Energy," Glenn Schleede (17 Feb. 2008). Schleede says, "Wind turbines are 'intermittent' and neither reliable nor dispatchable because they are dependent on wind speed." Id. Writes Dr. Sterling Burnett, "Because wind is an intermittent resource, wind farms must rely on conventional power plants to back up their supply. Wind farms generate power only when the wind is blowing within a certain range of speed. When there is too little wind, the towers don't generate power; but when the wind is too strong, they must be shut down for fear of being blown down. And even when they function properly, wind farms' average output is less than 30 percent of their theoretical capacity." *See* "Wind Power: Red Not Green," H. Sterling Burnett, Ph.D., NCPA Brief Analysis #467 (23 Feb. 2004). "Wind turbine electrical generation faces one serious challenge: inconsistent supply. Wind velocity is highly variable, and so the electricity generated by the turbines is highly variable too. As the Tennessee Valley Association pointed out in 2002, wind-speed variations can be extreme, 'from less than 10 mph to more than 35 mph within a single second, and bursts of up to 70 to 100 miles per hour.' Such wind fluctuations will cause equally unpredictable levels of electricity generation, from surges of 160 megawatts in high winds to no juice at all when the air is calm." *See* "Air Power: Don Quixote tilted at windmills. We can use them to increase our energy supply." Pete du Pont, *The Wall Street Journal* (25 Apr. 2007) http://www.opinionjournal.com/columnists/pdupont/?id=110009980. Robert Zubrin writes that "wind power is intrinsically unreliable. When the wind speed drops in half, power output drops by a factor of eight, so wind simply cannot provide the baseload power." *See* "Windmill Plan Offers Slim Energy Pickens," Robert Zubrin (9 Aug. 2008) Pajamas Media, http://pajamasmedia.com/blog/windmill-plan-offers-slim-energy-pickens/.

[†] "Electric Industry Terms Important in Understanding Two of the Critically Important Limitations of Electricity from Wind Energy," Glenn Schleede (17 Feb. 2008). According to the Lawrence Livermore National Laboratory's Gene Barry, "even if future development reduces their cost substantially, widespread deployment of solar and wind power in the future will face the fundamental difficulty that they are intermittent, requiring demand flexibility, backup power sources, and very likely enough electricity storage for days to perhaps a week." *See* "Present and Future Electricity Storage for Intermittent Renewables," Gene Berry, Lawrence Livermore National Laboratory, http://www.pewclimate.org/docUploads/10-50_Berry.pdf. Bernard Viau writes that wind turbines "rarely produce when needed…what they produce is often unused because not storable, and…thermal power stations have to be constantly on hand to balance wind-derived electricity over the national grids." *See* "Money Blowing in the Wind," Bernard Viau, Centre for Media Alternatives (18 Oct. 2007).

> tion again trailed off. 'Demand was going up as wind production was going down, so it amplified the effect,' said Dan Jones, the state's independent electricity-market monitor.*

As "the inherent variability and imperfect predictability of wind generation adds to the variability and prediction errors of system load,"[31] ERCOT continually works to improve its wind-forecasting capabilities. To this end, ERCOT is preparing to move from a zonal to a nodal market. A zonal market consists almost entirely of bilateral contracts, with ERCOT coordinating ancillary services in 15-minute intervals. In a nodal market, ERCOT controls dispatch by sending price signals to generators every five minutes. Saathoff writes,

> ERCOT currently uses its own wind generation forecast to manually determine system generation adequacy for the rest of the operating day. This assists in deciding whether we need to bring available off-line conventional generation on-line. In nodal operation the wind forecast will be incorporated into our computer systems to automatically make both day-ahead and intra-day unit commitment decisions.[32]

However, ERCOT has begun using its new wind forecast model in the current zonal market but ERCOT's wind-forecasting equipment will not be fully operational until the nodal market arrives (arrival date currently unknown).

A recent wind surge in Oregon highlights the possible risks that wind's variability and wind forecasting pose to power systems. After winds "jumped far beyond levels forecast by wind-farm operators,"[33] Columbia Basin river managers—the federal Bonneville Power Administration—cut back on hydropower, spilling excess water over dams.[34] As reported by *The Oregonian*, wind energy "has increased stress on the hydropower system, which is used to balance wind's variability."†

Pete DuPont writes,

> Wind power systems are also less efficient than other power sources. Because of wind speed changes, turbines cannot generate over time more than about 30 percent of their capacity. For half the days in Germany in 2004, wind plant output was less than 11 percent of rated capacity; in California at the time of peak demand in July 2006, turbines generated 10 percent of capacity, and Texas generates about 17 percent. In contrast, coal and natural gas plants generate at a little better than 70 percent of capacity, and nuclear plants at more than 90 percent.[35]

* "Finding Where the Wind Blows: Officials Beef Up Forecasting for Popular but Fickle Power Source," Rebecca Smith, *The Wall Street Journal (6* Mar. 2008). Writes *The New York Times Magazine*, "At 6:30 p.m. on Feb. 28, residents in West Texas came home from work and turned on their appliances—at precisely the moment when the wind died down in local wind farms. Power plummeted by more than half. The grid neared collapse." *See* "Good Turnoffs," *The New York Times Magazine* (20 Apr. 2008).

† "Wind surge poses a risk to salmon and reveals flaws in BPA's power-regulating system," Gail Kinsey Hill, *The Oregonian* (5 July 2008) http://www.oregonlive.com/news/oregonian/index.ssf?/base/news/1215226547277170.xml&coll=7. An August 2008 article in the journal *Energy Policy* reports that, in Britain, wind-power swings of 70 percent are to be expected in winter and "will require individual generators to go on or off line frequently, thereby reducing the utilisation and reliability of large centralised plants. These reductions will lead to increases in the cost of electricity and reductions in potential carbon savings." *See* "Will British weather provide reliable electricity?" James Oswald, Mike Raine, and Hezlin Ashraf-Ball, Energy Policy, Volume 36 (2008). Europe's offshore wind turbines also provide examples of the problem of wind's volatility and variability: "They start generating electricity when the wind speed reaches nine miles per hour, and have to shut down if it exceeds 55 mph. They generate electricity somewhere between 70 percent and 90 percent of the time, but in lower wind speeds much less than their capacity. According to an analysis by Denmark's Incoteco energy consulting firm, for 54 days in western Denmark in 2002, wind-power systems 'supplied less than 1 percent of demand.'" *See* "Air Power: Don Quixote tilted at windmills. We can use them to increase our energy supply." Pete du Pont, *The Wall Street Journal* (25 Apr. 2007) http://www.opinionjournal.com/columnists/pdupont/?id=110009980. *See* also "Why wind power works for Denmark," Incoteco, (May 2005) http://www.incoteco.com/upload/CIEN.158.2.66.pdf. For more on wind energy's contribution to meeting Denmark's electricity needs, *see* "A Problem With Wind Power," Eric Rosenbloom (5 Sept. 2006) http://www.aweo.org/ProblemWithWind.html.

Finally, in Texas, wind blows the least when power is needed the most: during the summer.[*] ERCOT relies on about 8.7 percent of wind power's capacity when determining available power during peak summer hours.[†]

Power and Energy magazine, however, takes issue with the term "intermittent," calling it a "term out of the distant past." *P&E* writes,

> To most people, the term intermittent means a random sort of unpredictable on-off behavior. This term is usually used in a negative sense. The understanding conveyed is that the output of the plant cannot be predicted and that it rapidly goes from no-load to full-load conditions, or vice versa. While this view was prevalent after looking at the output of a single wind turbine, before we had sufficient data to understand the behavior of large, modern wind plants, it is no longer the case. We now know that the output of wind plants varies very little in the time frame of seconds, more in the time frame of minutes, and most in the time frame of hours. The typical standard deviations of the step changes at the one-second, ten-minute, and one-hour time frames vary from approximately 0.1 percent to 3 percent to 10 percent of rated capacity, which is far from intermittent. A good wind plant output forecast can also predict the changes that will occur with a good degree of accuracy most of the time. As a result of this improved understanding of the behavior of wind plants, we are making a transition away from the term intermittent to *variable output*, which describes much more accurately the nature of the quantity with which we are dealing.[36]

FPL Energy also counters claims of wind's unreliability:

> While wind energy generation cannot be precisely scheduled based on demand, sophisticated monitoring and wind resource analysis allow wind developers to estimate with a high degree of certainty 'when' and 'how much' wind energy is available in a particular region during a specific month or year, so customers can plan their resource balance accordingly.[37]

Wind-energy advocate Paul Gipe writes, "The reliability of wind turbines, measured in terms of availability to make electricity when the wind is blowing, is better than 98 percent."[38] And, according to the AWEA, "Modern wind turbines are equipped with high-tech computers and power electronics that process over 200 types of data, from wind speeds and oil temperature to voltage dips on the grid. 'Smart' wind turbines can help make the electricity transmission system more reliable."[39]

However, considering that wind often blows less or more than the grid needs or can handle, it is difficult to accept that intermittent wind power can increase grid reliability. As reported by the Texas Comptroller,

> Too little wind is a problem on some days, but on other days heavy winds can generate too much power. When the wind blows hard and wind turbines produce more electricity than the grid can

[*] According to FPL Energy, Texas' peak season for wind is spring. *See* "FPL Energy: Frequently Asked Questions," http://www.fplenergy.com/renewable/contents/faqs_wind.shtml#cost.

[†] "Texas ratepayers' price tag for new wind-power lines in billions," R.A. Dyer, *Fort Worth Star-Telegram* (3 Apr. 2008). Gleen Schleede writes that the "right speed range" for wind turbines "is most likely to be at night and in winter—not on hot weekday summer afternoons of July and August when electricity demand is highest." *See* "No, President Bush did NOT state that wind could supply 20 percent of U.S. Electricity," Glenn Schleede (2 Feb. 2007). "Wind behaves similar to load in that it is 'variable,' meaning its output rises and falls within hourly and daily time periods; and it is 'non-dispatchable,' meaning its output can be controlled only to a limited extent." *See* "Wind Power—Clean AND Reliable," AWEA, http://www.awea.org/utility/pdf/Wind_and_Reliability_Factsheet.pdf. "Wind generation in Texas has a diurnal component of variation that tends to be anti-correlated, or out-of-phase, with the daily load curve. Wind generation output tends to be the greatest at night and least in the daytime, with wind generation tending to drop sharply in the morning when load is rising quickly, and increase sharply in the evening when load is dropping. The inverse-phase relationship appears to be stronger in the summer than during other seasons." *See* "Executive Summary: Analysis of Wind Generation Impact on ERCOT Ancillary Services Requirements," GE Energy (28 Mar. 2008).

> accommodate, the producers in West Texas shut down the wind turbines… Since wind is a variable source of energy production, wind power plants typically cannot control their power delivery times as precisely as do plants powered by fossil fuels. The electric system already must be capable of responding to swings in electrical usage by customers—swings of as much as 25,000 MW in a single day…Furthermore, the existing (transmission) network was not designed to accommodate variable forms of power.[40]

Wind energy's intermittency poses challenges for the ERCOT grid.* "Because electric energy cannot be easily or economically stored on a large-scale basis, the amount of power generation must be exactly matched, on a near-instantaneous basis, to the amount of customer load demand."[41] Energy consultant David White writes, "Electricity differs from other forms of energy, and cannot be stored directly on an industrial scale. Consequently, generation and demand have to be balanced on the grid continuously, and second by second."† Thus, ERCOT is a "balancing energy market." Wind's intermittency, and the fact that load is predicted more accurately than wind levels, pose problems for ERCOT's grid managers who constantly seek to maintain balance on the grid.‡

Richard Baxter,[42] Senior Vice President of Ardour Capital Investments, LLC, writes,

> even 'stable' demand periods have their own challenges as a change in the output of one generator requires the immediate and opposite change in another generator, both in scale and at the same rate of change. Wind's variable nature is the heart of the issue here, not necessarily in scale, but in the speed of its change (its ramp rate), where it can have a large impact on grid stability. Wind farms transitioning from full off to full on (and vice versa) can be quite dramatic. If those wind farms are concentrated in certain remote areas, this fluctuating output can have an outsized and detrimental impact on the carrying capacity of the grid in those areas.[43]

Wind's unreliability is also reason to question claims by wind-energy proponents regarding wind powering "the equivalent of" a certain number of homes. For example, according to the AWEA, "16,818 megawatts (MW) of wind power plants were in place in the U.S. at the end of 2007, serving the equivalent of 4.5 million average households. By the end of 2008, AWEA expects that number to jump to over 22,000 MW, which can serve the equivalent of over 5.5 million average households."[44]

This necessarily begs the question of whether such determinations and estimations account for wind's intermittency (not to mention line loss during transmission§). In other words, can 3-4 MW of wind power truly meet the electricity needs of one million households, when wind power is only available to the electric grid a fraction of the day? Stated differently, if no other power sources were available to the grid or as back-up power sources for wind turbines, would these households' whole needs be met? The answer is undoubtedly no.

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* More information on wind energy's impact on the ERCOT grid follows in a later section.

† "Reduction in Carbon Dioxide Emissions: Estimating the Potential Contribution from Wind-Power," David White, Commissioned and published by the Renewable Energy Foundation (Dec. 2004) www.windaction.org/documents/225. "Part of the mistaken belief that wind can be a reliable source of electricity comes from a misapprehension of what the 'grid' is. The national grid is not a machine for churning out electricity. It is more like a high-wire act—the Flying Wallendas balancing six people on a bicycle 50 feet above the ground. Electricity must be consumed the moment it is generated; there are no methods for storage on an industrial scale. This means that supply and demand must constantly match within about 5 percent. Otherwise there will be power 'dips' or 'surges,' which can cause brownouts, ruin electrical equipment, or even bring the whole system crashing down…Putting windmills on the grid is a little like the Flying Wallendas' hiring a new crew member to shake the wire while they are doing their balancing act." *See* "Tilting We Will Go? Windmills are not an energy policy," William Tucker, *National Review*, (18 Aug. 2008).

‡ ERCOT's "system clock" is kept at 60 hertz.

§ *See* information on transmission line loss in "Transmission" section to follow.

Whatever nuances one places on wind's intermittent nature, the reality is that if wind does not blow, wind turbines do not produce electricity. This inescapable fact is the reason for the qualifier ("when the wind is blowing") in the 98 percent availability statistic. Further reality is that wind is most likely to blow at night and in colder months, when electricity demand is lower than during summer days.

Particularly in the absence of future advances in wind-power storage and better wind-forecasting tools, wind power is at the mercy of wind, and wind energy is inherently less valuable, energy resource wise, than conventional energy sources.

Storage

A major impediment to large-scale wind-energy production is the lack of commercially-viable storage for wind power. According to CERA,

> Electric power cannot be easily and economically stored on a large scale. It has to be produced when it is to be consumed. Therefore, power systems need plants that can respond, or be 'dispatched,' when called upon to meet the fluctuating demand for electricity.…A variety of batteries and technologies for storing power are under development but currently have high costs or unresolved performance limitations.[45]

The lack of adequate large-scale electricity storage highlights wind's variability and its lack of correlation with peak demand.[*] Because there is presently no adequate wind-power storage system, wind-generating units must be backed up by traditionally-fueled electric-generating units, and, thus, wind energy is currently an inherently less valuable resource than fuel sources requiring no backup.[†]

The potential benefits of adequate electricity storage include improved grid response, reduced grid connection costs, higher amounts of renewable resources, and increased value of renewable resources.[‡] ERCOT's Bill Bojorquez says, "From an operational perspective, [storage] allows wind to produce energy and not be subject to curtailments…It allows us to integrate more wind onto the grid when we need it and not waste it."[46] Clearly, adequate storage would increase the role that wind could play in the energy-supply mix, as excess wind power could be stored for later use, specifically when energy demand exceeds wind supply.

Richard Baxter says several electricity storage technologies "are currently in use or being evaluated for use in conjunction with renewable energy resources," including flywheels, flow batteries, and compressed air energy storage (CAES).[§47]

[*] "The prospects for wind power could be greatly enhanced if cost-effective storage could be implemented." *See* "Where to store wind-powered energy? Under water!" Matthew Knight, CNN.com (8 Apr. 2008). "Without major advances in ways to store large quantities of electricity or big changes in the way in the way regional power grids are organized, wind may run up against its practical limits sooner than expected." *See* "Wind energy turns out to have a complication: reliability" Matthew L. Wald, *International Herald-Tribune* (28 Dec. 2006).

[†] "Fossil-fuelled capacity operating as reserve and backup is required to accompany wind generation and stabilise supplies to the consumer. That capacity is placed under particular strains when working in this supporting role because it is used to balance a reasonably predictable but fluctuating demand with a variable and largely unpredictable output from wind turbines. Operating fossil capacity in this mode generates more CO2 per kWh generated than if operating normally." *See* "Reduction in Carbon Dioxide Emissions: Estimating the Potential Contribution from Wind-Power," David White, Commissioned and published by the Renewable Energy Foundation (Dec. 2004) www.windaction.org/documents/225.

[‡] "Electricity storage and Renewables?" Gerard Thijssen, KEMA Transmission & Dist. Consulting, http://www.electricitystorage.org/pubs/2002/Lisbon_May_2002_KEMA.pdf. According to Richard Baxter, "From the grid operational viewpoint, storage can have two important impacts for wind power facilities. First, it has the potential to provide dispatchability for the wind assets—allowing the developer to potentially gain a higher value for the wind output as it is now a more reliable resource for the grid operator. Secondly, storage enhances grid reliability and a more efficient operation of power generation assets by providing a rapid and flexible response capability to larger scale wind output. When wind power is changing rapidly, one of the most valuable impacts storage can have in support of the power grid is to act as a 'shock absorber' for the system. As significant (100 MW+) amounts of wind power then come online or offline, storage can act more rapidly than power facilities in balancing the load. This allows the power facilities to ramp either up or down in a more economical and less damaging manner." Email from Richard Baxter (24 July 2008).

[§] "CAES facilities store energy in compressed air that is held in underground chambers. Electrical motors drive compressors that charge (compress the air into) the cavern; this air is then used to power an air expander/gas turbine for power production during peak price periods of the day. Using the compressed air allows all of the energy output of the gas turbine, minus the compressors, to generate electricity (normally, the precompression of air in a gas turbine absorbs two-thirds of the power output of the combustion stage)." *See* "Compressed Air Energy Storage," Technology Focus, Ardour Capital Investments, LLC (Sept. 2007).

Worldwide, two CAES units are in operation, albeit not in conjunction with utility-scale wind generation.* Gene Barry writes that CAES and pumped hydroelectric storage

> are currently economic for utilities when relying on natural geologic formations and the cheapest, most abundant substances (i.e., elevated water and compressed air). In these situations the cost of energy storage capacity can be very low (<$5/kWh1). Unfortunately the scale and location-specific nature of energy storage in natural formations is likely to render it of limited benefit to small scale distributed renewables.†

A report by NREL's Paul Denholm takes a much more positive view of CAES:[48]

> Compressed air energy storage (CAES) can be economically deployed in the Midwestern U.S., an area with significant low-cost wind resources…In the Midwestern U.S., which contains a large percentage of the nation's low-cost wind resources, flat terrain, and lack of water makes compressed air energy storage (CAES) more suitable for new wind energy storage projects…A baseload wind system must incorporate a large-scale energy storage system capable of quickly responding to the variations of wind turbine generation. Compressed air energy storage (CAES) is a hybrid generation/storage technology well suited for this application.

Baxter is also keen on the prospects for CAES: "Besides pumped-hydro storage, CAES is the only other technology in commercial operation capable of providing large-scale storage deliverability (above 100 MW) for use in the wholesale power market." But Baxter says, "Hindering further deployment of this technology is its perceived unconventional nature…and its significant up-front site development costs, in the form of prefeasibility tests and underground excavation."[49]

However, the wind industry is not yet convinced about the promise of large-scale wind-energy storage. Baxter says,

> Many involved with wind energy have been aware of energy storage technologies for some time but have been sceptical (sic) of their technological maturity and cost effectiveness, so they have waited to see tangible results of successful operation of these technologies in the field before incorporating them in their plans.[50]

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* The first unit was developed in 1978 in Huntorf, Germany, and a second unit was completed in 1991 in McIntosh, Alabama. Initial plans for Shell-Luminant's 3,000-MW wind farm in Briscoe County, Texas, included a CAES plant that uses salt beds for storage. *See* "Wind in a Bottle," Bridget Mintz Testa, *Mechanical Engineering Magazine* (May 2008) http://www.memagazine.org/contents/current/features/windina/windina.html. "'The wind in West Texas is highest in the morning, especially before dawn, and it drops around 8 a.m. to 10 a.m.,' said Bill Bojorquez, vice president of system planning for the Electric Reliability Council of Texas, the organization responsible for managing the state's electrical grid. 'It's the opposite of when demand is up.' Electricity can't be stored on the grid, so wind generators must shut down just when their power production is peaking. 'There are challenges with the 6,000 MW of wind available today,' Bojorquez said. 'So this 3,000 MW plant would be a significant challenge, especially when concentrated in one area.' If the wind slows or stops when the grid is relying on that power, then other generation capacity must quickly kick in to 'follow the wind'—that is, pick up the slack." Id.

† "Present and Future Electricity Storage for Intermittent Renewables," Gene Berry, Lawrence Livermore National Laboratory, http://www.pewclimate.org/docUploads/10-50_Berry.pdf. "CAES systems are based on conventional gas turbine technology and utilize the elastic potential energy of compressed air [6,14]. Energy is stored by compressing air in an airtight underground storage cavern. To extract the stored energy, compressed air is drawn from the storage vessel, heated, and then expanded through a high-pressure turbine that captures some of the energy in the compressed air. The air is then mixed with fuel and combusted, with the exhaust expanded through a low-pressure gas turbine. The turbines are connected to an electrical generator." *See* "Improving the technical, environmental and social performance of wind energy systems using biomass-based energy storage," Paul Denholm, National Renewable Energy Laboratory (24 Aug. 2005) http://www.nrel.gov/docs/fy06osti/38270.pdf. *See* also "Study of electric transmission in conjunction with energy storage technology," Desai N., Nelson S., Garza S., Pemberton D., Lewis D., Reid W., et al., Texas State Energy Conservation Office (2003) www.seco.cpa.state.tx.us/seconews_wind%20storage.pdf, and "High-capacity factor wind energy systems." A.J. Cavallo, J Sol Energy Eng 1995; 117:137–43.

Baxter also notes that,

> According to Rick Walker, president of Sustainable Energy Strategies, Inc., energy storage technologies are appealing to those in the wind industry, but concern about their cost effectiveness remains an issue. In general, energy storage technologies are not yet sufficiently mature on cost-effectively coupling wind energy with energy storage other than in perhaps some isolated circumstances. Another essential point is that to reach such a cost-effective level of technological maturity, there needs to be a series of successful demonstration projects that show a reduction in the cost of energy storage. CAES has not been shown to be economically viable, on a commercial scale.[51]

Batteries are another possible source for wind-energy storage, but the prospects for their use in large-scale electricity storage are small.[*] Berry writes,

> Batteries are very modular and are therefore technically well-suited to use with small scale distributed renewables. The chief difficulty of battery technology is short life (~1000's of cycles equivalent to 3-5 years in daily use) which, given…their capital cost ($100-200/kWh of storage capacity), can make storing electricity in batteries at least as expensive as generating electricity.[†]

However, if large-scale storage were available to wind farms, then the cost of wind energy would arguably increase, as a result of using such storage technology. According to the AWEA, wind-power storage is not cost effective: "Storing electricity is currently significantly more expensive than using dispatchable generation. In the future, through advances in technologies such as batteries and compressed air, energy storage may become cost-effective."[52] Additionally, all forms of electricity storage lose some amount of stored electricity, adding to the real cost of electricity.

Engineering and technological advances may provide a cost-effective way to store wind energy for later use. If so, wind will become a more significant energy resource, as its intermittency will not pose as big of a challenge as it does today. However, adequate storage does not exist; and, until it does, lack of storage will continue to pose a major challenge to wind energy's contribution to meeting our energy needs.

Transmission

Another major issue surrounding wind-energy development is the current lack of, and the future need for, electric-transmission capacity. A great deal of time and expense will be required to transmit energy from the areas of Texas most suitable for wind energy generation—West Texas and the Panhandle—to the eastern areas of the state that need energy the most—the I-35 corridor and the upper Texas Gulf Coast.[‡] The costs to build adequate transmission should be of particular concern to Texas' electric customers, as the costs of building new transmission lines to carry electricity from wind farms to load (demand) centers are part of the true cost of wind energy that will be borne by electric ratepayers.

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[*] "Among man-made energy storage systems, the most well-known is the battery, used today to store electricity from solar photovoltaic systems located where the grid is not available to back up solar power. Batteries are electrochemical energy storage devices which can be relatively efficient (~70-80%) if charged and discharged at moderate rates." *See* "Present and Future Electricity Storage for Intermittent Renewables," Gene Berry, Lawrence Livermore National Laboratory, http://www.pewclimate.org/docUploads/10-50_Berry.pdf.

[†] "Present and Future Electricity Storage for Intermittent Renewables," Gene Berry, Lawrence Livermore National Laboratory, http://www.pewclimate.org/docUploads/10-50_Berry.pdf. "In the future, predominantly solar or wind power systems will likely require energy storage for days to approximately a week, with or without connections to the electric grid… It appears that in the short term (through approximately 2020), intermittent renewables will either depend upon the grid for back-up power or use batteries for energy storage."

[‡] These costs do not include the cost of building turbines or transmission stations. According to FPL Energy, capital costs for wind turbines are $1,500-$2,000 per kilowatt hour of nameplate capacity. *See* "FPL Energy: Frequently Asked Questions," http://www.fplenergy.com/renewable/contents/faqs_wind.shtml.

Texas' utilities are allowed to recover transmission costs, as well as a reasonable return on their capital investment.[53] This is true for both CREZ and non-CREZ transmission expenditures. As the new CREZ lines are placed into service, the transmission-owning utilities will request adjustments to their wholesale rates (which are charged to load-serving entities), in order to account for their transmission investments. These rate increases are ultimately passed on to consumers as permitted by state statute.

Wind farms "must be near high-voltage transmission lines…that can carry power over long distances. Moreover, these transmission lines must have the capacity to handle the additional generation."[*] The permitting process for a high-voltage transmission line on new rights-of-way runs from 6 to 18 months, and, once the permitting process is complete, construction takes from 9 months for short-distance lines and substation upgrades to two years for long-distance (i.e., over 100 miles) lines.[54] To date, high-voltage transmission lines have cost up to $1.5 million per mile.[†]

In response to a request from the PUCT to study the costs of various wind energy transmission plans, ERCOT released its CREZ Transmission Optimization Study on April 2, 2008.[‡] The study estimated costs for the transmission lines and transmission substations needed to carry wind power from West Texas wind farms to the IH-35 corridor and beyond. Costs were estimated for each of the four scenarios of wind generation designated by the PUCT.

The four scenarios contained totals of 12,053, 18,456, 24,859 and 24,419 MW of installed wind generation (after adjustment for the 6,903 MW of wind generation that was either in-service or had signed interconnection agreements at the time the scenarios were finalized for the study), distributed among five CREZs in West Texas and the Texas Panhandle. The projected overnight costs (i.e., capital costs less interest, inflation, and escalation costs due to increased material and labor costs) of these plans are $3.78 billion, $4.93 billion, $6.38 billion, and $5.75 billion, respectively.[§] Because these are overnight cost estimates, they do not include escalating labor and material costs or financing costs during construction. Thus, the installed costs,[¶] which will be used to establish future transmission rates, should be considerably higher.

[*] "A Global Leader in Wind Energy," FPL Energy, http://www.fplenergy.com/renewable/pdf/NatLeaderWind.pdf. "Siting a wind farm can be challenging. We must find just the right combination of wind conditions, power transmission lines and land to accommodate the wind farm. FPL Energy pursues potential wind farms in areas where the wind blows steadily, consistently and unobstructed for much of the time. The ideal average wind speed is approximately 25 to 35 miles per hours. Wind facilities must also be near high-voltage transmission lines that can carry power over long distances. These transmission lines must have the capacity to handle the additional generation." *See* "FPL Energy: Siting and Development," http://www.fplenergy.com/portfolio/wind/siting_develop.shtml. Ward Marshall, a Texas wind farm marketer for Babcock & Brown, says at least a year's worth of lead time—to collect meteorological data and observe avian migratory periods—is required to locate wind sites. *See* "Wildcatting for Wind: The Texas Experience from Turbine to Market," Video, The University of Texas School of Law Continuing Legal Education.

[†] According to ERCOT, 138-kV lines cost $1 million per mile, while 345-kV lines cost $1.5 million per mile. *See* Competitive Renewable Energy Zones (CREZ) Transmission Optimization Study, ERCOT System Planning (2 Apr. 2008).

[‡] Competitive Renewable Energy Zones (CREZ) Transmission Optimization Study, ERCOT System Planning (2 Apr. 2008). Senate Bill 20 required that CREZ zones be designated in the best areas in the state and that an electric transmission infrastructure be constructed to move renewable energy from those zones to markets where people use energy. ERCOT was charged with assessing Texas' wind resources, as well as potential transmission solutions for Texas' wind-generation challenges. *See* "Texas Renewable Portfolio Standard," State Energy Conservation Office, http://www.seco.cpa.state.tx.us/re_rps-portfolio.htm.

[§] Estimates were calculated in 2007 dollars, so the estimates should be considered low for 2008. Cambridge Energy Research Associates calculated costs for each CREZ scenario using an increase of 7.5 percent over 2007 dollars, in order to reflect the rise in capital costs since 2007. For Scenario 2—the CREZ scenario selected by the PUCT and estimated by ERCOT to cost $4.93 billion—CERA calculated 2008 costs of $5.3 billion and $753 million for transmission and collection, respectively. CERA estimates a total transmission/collection cost of $524/kWh for Scenario 2. *See* "Comparing the Full Cost of Wind Generation to Other Options in Texas" (Table 2), Cambridge Energy Research Associates (25 July 2008). As these are transmission-cost estimates, ERCOT's cost estimates exclude non-transmission costs of wind energy development, such as turbine construction, equipment transportation and installation, and turbine maintenance.

[¶] Installed costs include gathering (collection) costs, labor and material escalation costs, and financing costs.

Table 3: ERCOT CREZ Optimization Study Transmission Scenarios

Scenario	MW	Overnight Cost*	Miles†	Cost/Mile
1	12,053	$3.78 billion	1,831	$2,064,445.66
2	18,456	$4.93 billion	2,376	$2,074,915.82
3	24,859	$6.38 billion	3,036	$2,101,449.28
4	24,419	$5.75 billion	2,489	$2,310,164.72

In addition to these transmission cost estimates, collection (or gathering) costs for each scenario are estimated to be $410-530 million, $580-820 million, $720 million-1.03 billion, and $670-940 million, respectively.‡ These, too, are overnight costs.

Transmission/collection costs per mile for each scenario are represented in Table 3:[55]

On July 17, 2008, the PUCT, by a vote of 2-1, chose Scenario 2 for the building of CREZ transmission lines.§ As reported by the Associated Press,

> The plan still needs to receive final approval later this year from the PUC. The transmission lines would not be up and running for three to five years. Who would build them and other details have yet to be worked out….PUC Commissioner Julie Caruthers Parsley was the lone dissenter, arguing the plan may add too much power for the electric grid to handle. She also worried it could delay other projects, such as construction of nuclear reactors.[56]

The final order was issued August 15, 2008.[57] According to the order, "the major transmission improvements identified in the CREZ Transmission Optimization Study for Scenario 2 are necessary to deliver the energy generated by renewable resources in the CREZs, in a manner that is most beneficial and cost-effective to the customers."[58]

With regard to right-of-way costs, "Transmission cost estimates were developed with stakeholders, including representatives of major TSPs in ERCOT, based on cost experience from recent projects. As such, these costs generally reflect the total costs of developing transmission projects. However, these costs do not include higher ROW costs that are likely to be incurred in congested or urban areas."[59] These costs are not unique to wind energy, however. ROW costs result from any type of generation that causes additional transmission lines to be built.

* Includes the costs of transmission substations, whether new or upgraded.

† An aspect of all electric transmission, regardless of the energy source, is the loss of electricity during transmission. Line losses, which are a function of the line's impedance (resistance) and the level of electric current transmitted on the line, are proportional to the impedance of a transmission line. In other words, the longer the line, the larger the impedance and the higher the losses. Thus, for the long transmission distances that will be required to carry electricity from West Texas wind farms to load centers, line losses will exceed losses that occur on shorter transmission lines. Energy losses also occur during the distribution of electricity. According to the EIA, from 1990-2006, the average estimated loss in the supply and disposition of electricity in Texas was about 5.5 percent. *See* "Texas Electricity Profile, 2006 Edition," Energy Information Administration, Table 10, Supply and Disposition of Electricity, 1990 Through 2006 (Million Kilowatthours), http://www.eia.doe.gov/cneaf/electricity/st_profiles/texas.html. William Tucker writes, "Normal transmission lines—of 138 kilovolts (kV) and 345 kV—lose about 10 to 15 percent of their wattage every 1,000 miles." *See* "Tilting We Will Go? Windmills are not an energy policy," William Tucker, *National Review* (18 Aug. 2008).

‡ Collection costs are estimates of the costs of the equipment needed to connect wind generation to the new CREZ substations.

§ For more on the PUCT's decision, *see* "Texas approves major new wind power project," Jim Vertuno, *Associated Press* (17 July 2008) http://apnews.myway.com/article/20080717/D91VR9N80.html.

Table 4: CREZ Cost Estimates (Over 40 Years)

Scenario	CREZ Transmission & Gathering (Oncor customers)	CREZ Transmission & Gathering + LTSA (Oncor customers)	CREZ Transmission & Gathering (CenterPoint customers)	CREZ Transmission & Gathering + LTSA (CenterPoint customers)
Residential Customers	$80.38	$123.88	$87.73	$135.20
Hospital	$891,562	$1,374,010	$741,847	$1,143,279
Convenience Store	$1,336	$2,058	$1,137	$1,753
Grocery Store	$18,701	$28,817	$15,922	$24,537
Big-box Store	$23,071	$35,555	$22,530	$34,722

ERCOT's estimates included the use of 138-kV and 345-kV transmission circuits but not the more expensive 500-kV or 765-kV lines.* Additionally, "The planning-level costs of new transmission lines were estimated using straight-line lengths for the purposes of this study. It is likely that, during the routing process for individual transmission lines, the overall length of a line may increase from these straight-line estimates, due to land use and similar considerations."[60] Thus, transmission costs were estimated using a best-case-scenario approach.

It is clear that $4.93 billion is a low estimate. *The Houston Chronicle's* business columnist, Loren Steffy, agrees: "The costs and uncertainty of wind simply aren't worth the amount of investment. Five billion is just the beginning. The true costs make it clear: Wind is overblown."[61]

Energy consultant Jeffry C. Pollock quantified the rate impact of future transmission investment on various customers.† Taking into account rising material and labor costs, interest/financing costs, and routing issues, the installed cost for CREZ Scenario 2 is estimated to be $7.8 billion ($3,282,828.28 per mile).[62] Pollock has also approximated (1) ratepayers' share of the cost of new CREZ transmission/gathering costs and (2) new CREZ transmission/gathering costs plus ERCOT's long-term system assessment (LTSA) costs (*see* Table 4).‡ As transmission costs are passed through to consumers over the life of

* "Preliminary analyses of conductor costs and line ratings indicated that 765-kV circuits would be more cost-effective than 500-kV circuits. As a result, several plans using 765-kV circuits were developed for Scenarios 2 and 3. These plans were several billion dollars higher in cost than the 345-kV-based plans for these scenarios. Once a 345-kV solution for Scenario 2 was shown to be reliable using transient stability analysis, work on the more expensive 765-kV solutions for this scenario was discontinued. Similar to HVDC circuits, 765-kV circuits provide advantages, both in terms of cost and system reliability, for long-range power-flows. However, as with HVDC, 765-kV circuits also have disadvantages for certain applications. Because of the high potential power-flows on 765-kV circuits, a significant amount of transmission capacity must be present at locations where the 765-kV circuits terminate near load centers. Also, due to the costs of 765-kV substations, it is more expensive to tap into an existing 765-kV circuit to connect new generation (both wind and thermal) sources. Similarly, the higher capacity of each circuit results in a reduced number of total new ROWs, which can be an advantage in areas like east Texas where ROWs are becoming increasingly harder to site, but can also be a disadvantage in west Texas, where reduced numbers of ROWs can result in fewer possible locations where new generation can be added to the existing transmission system.…The total estimated costs of these plans are $9.10 billion for Scenario 3, and $9.42 billion for Scenario 4.…The plan for Scenario 3 includes 1,880 miles of new 765-kV right-of-way, 1,435 miles of new 345-kV right-of-way, and 85 miles of new 138-kV right-of-way. The plan for Scenario 4 includes 1,810 miles of new 765-kV right-of-way, 1,660 miles of new 345-kV right-of-way, and 100 miles of new 138-kV right-of-way." Competitive Renewable Energy Zones (CREZ) Transmission Optimization Study (Pages 31-32), ERCOT System Planning (2 Apr. 2008). American Electric Power (AEP) touts the virtues of 765-kV transmission lines and proposes an advanced interstate electric-transmission system employing 765-kV lines. *See* "AEP INTERSTATE PROJECT: 765 kV or 345 kV Transmission," American Electric Power (24 Apr. 2007).

† Rate impacts were based on estimated installed costs developed by Scott Norwood. Docket No. 33672, Direct Testimony of Scott Norwood on behalf of the Steering Committee of Cities Served by Oncor.

‡ LTSA costs are costs to build and/or upgrade facilities necessary for increased transmission and generation capacity. For a detailed report on ERCOT's LTSA cost projections, *see* "Long Term System Assessment For the ERCOT Region," ERCOT System Planning (Dec. 2006) http://www.ercot.com/news/presentations/2006/Attch_A_-_Long_Term_System_Assessment_ERCOT_Region_December_.pdf.

the transmission lines, Table 4's estimates are measured in additional dollars per year for an estimated 40-year lifespan of the new transmission under Scenario 2.[63]

Because all ERCOT load-serving entities will share the burden of the transmission costs, in proportion to their relative load,[64] "higher transmission and [other] charges associated with new wind generation will increase the electricity costs paid by all consumers," according to Pollock.[*] But others feel higher transmission costs will be offset by the fuel-cost savings that result from wind's displacement of conventional sources of fuel. According to Michael Goggin, an electricity-industry analyst at AWEA, "the money saved by decreasing fossil fuel use with new wind energy would drastically outweigh the cost of the new transmission."[65] Paul Sadler, executive director of The Wind Coalition, agrees:

> This investment will pay for itself in two years and will displace more expensive energy, offering a savings to Texas consumers of about $3 billion per year. . . . Transmission costs will be more than offset by the savings realized from lower fuel costs as we bring additional wind capacity onto the grid.[66]

However, claims such as these rely on two assumptions: that wind energy is cost-free and that increased use of wind energy will decrease the use of fossil fuels. Regarding the former, several of the true costs of wind energy—such as transmission costs, grid-management costs, and the costs of wind-energy subsidies—are excluded by wind-energy advocates. Regarding the latter, due to Texas' growing population and energy needs and the fact that intermittent wind power must be backed up by fossil-fuel energy sources, it is not true that wind energy will lessen our use of fossil fuels on a MWh-for-MWh basis. It is true that every MWh generated by a wind turbine is one less MWh that must be provided from fossil fuels, since the total load served does not change. Thus, whatever conventional generating unit is "on the margin" at the time wind energy is produced—whether natural gas (most likely) or coal (usually during low-load, off-peak hours)—most likely will be reduced and will, as a result, run less efficiently.

But often during periods of low load levels, absent any wind generation, conventional generating units are backed down, sometimes to their minimum generation levels. If wind generation is available, some of those conventional generating units might be shut off rather than run at minimum, inefficient levels. But some units cannot be cycled off at night and then brought back on again in the morning. Thus, if sufficient wind capacity is connected to the system, the grid may curtail some wind energy at night, in order to ensure sufficient thermal generation is available to meet peak load the following day.

Dispatch Priority

Though transmission costs will be spread throughout the entire ERCOT grid, it is currently unclear what dispatch priority conventional power producers will have on the CREZ transmission lines.[†] The PUCT's final order in the CREZ docket (PUCT Docket No. 33672) has the following to say regarding dispatch priority:

> Although the Commission is not addressing curtailments and dispatch priority issues in this docket, the Commission does state that, as a matter of policy, there is an expectation that no nuclear facilities will be curtailed during periods of high wind generation. The GE study included the determination that increased wind energy production is primarily offset by a decrease in the production of combined-cycle gas turbine plants. However, during periods of light load and high wind levels, plants utilizing other sources of generation may see significant

[*] "Cost of wind power generating controversy," R.A. Dyer, *Fort Worth Star-Telegram* (17 Sept. 2007). Glenn Schleede agrees: "The cost of building new electric transmission capacity…is passed on to electric customers in their monthly bills." *See* "No, President Bush did NOT state that wind could supply 20 percent of U.S. Electricity," Glenn Schleede (2 Feb. 2007).

[†] Energy consultant Jeffry C. Pollock says that transmission costs 37 percent more on a per-unit basis for renewable resources than for conventional resources. According to Pollock, the ERCOT-wide transmission rate per billion dollars of transmission investment is $3.20-$3.30/kW-year for CREZ (i.e., renewable) transmission and $2.35-$2.40/kW-year for non-CREZ (i.e., conventional power) transmission. Email from Jeff Pollock (12 Aug. 2008).

> turndowns, as well. Given the unique characteristics of nuclear energy production, during periods of light load and high wind levels, it is sound policy to prohibit the back-down of nuclear power plants. The Commission also has the expectation that staff, ERCOT, and system participants will address the effects of light load and high wind levels on other forms of generation, in particular, recognizing the future critical role that coal generators utilizing 'clean' coal and carbon capture and sequestration technologies may occupy in ERCOT. This issue is most appropriately resolved in a currently ongoing Commission project addressing dispatch prioritization in the CREZ zones.[67]

Nothing states that conventional generators will not have access to CREZ lines. In fact, in its rule implementing SB 20, the PUCT states,

> While the objective of a CREZ is to increase the amount of renewable resources on the grid and provide necessary transmission for those resources, ERCOT will include existing and anticipated fossil-fueled units in its study of potential CREZs, and the commission may take all resources into account when evaluating the choices and seeking transmission solutions. The commission's mandate is to encourage renewable energy development by placing transmission infrastructure in places advantageous to renewable energy generation resources in a manner that is most beneficial and cost-effective to the customers. Physical access to the transmission network must remain open to any technology, however.[68]

However, the issue of CREZ dispatch priority—both among wind-power generators and as between wind and non-wind generators—remains unsettled. The PUCT has not issued a proposed ruling on CREZ dispatch priority (PUCT Project No. 34577[69]) and just recently submitted a request for public comments, which were due to the PUCT no later than September 29, 2008.[70]

Specifically, the PUCT sought comments "on the feasibility and efficiency of the use of auctioned CRRs (congested revenue rights) to effectuate dispatch priority from the CREZs and impede over-development of the CREZ transmission lines" and "on the requirement that CREZ developers post collateral for the transmission system improvements that will be made to transmit energy from the CREZs to other parts of the state."[71] Regarding CRRs, the PUCT writes,

> CRRs are the standard approach for market participants to manage congestion risks in the nodal market, and CRRs could be used to provide a priority to CREZ developers, without introducing distortions in the economic dispatch of the nodal market. An auction could be conducted well in advance of the completion of CREZ transmission facilities and used to allocate CRRs to CREZ developers. In real time, the CRRs would provide CREZ resources revenue equal to the nodal price differences between the CREZ and other points on the ERCOT system. Because bids in the real-time energy market would reflect the value of production tax credits and renewable energy credits, the price differentials should also reflect these values. From a planning perspective, wind developers would consider the results of the auction for CRRs in making decisions 'about whether to develop generation resources in west Texas and at what level.[72]

As stated in the PUCT's request for comments,

> The concern that led to the initiation of this rulemaking is that wind developers might build wind generation in west Texas that significantly exceeds the capacity of the CREZ transmission, imperiling developers' investment in wind generation in CREZs. . . . The objective of this rulemaking is to accord the CREZ developers a priority in the use of the transmission system or an equivalent right that will protect their investment, if possible, through the normal operation of real-time market mechanisms and by deterring the development of generation in west Texas by other developers.[73]

In the event that transmission is built but wind energy is not developed as planned—and thermal resources cannot connect to the CREZ lines or have not built plants near the lines—ratepayers will pay for large amounts of transmission capacity not heavily utilized.

Hidden Costs

Wind is free—there is currently no property right to wind—but wind energy is expensive. In fact, it is "the most expensive form of generation we have in Texas."*

According to Baxter,

> Wind is not a typical energy source. It is variable, and the best wind resources generally require longer-distance transmission of the power than for other forms of generation. These considerations raise the cost of utilizing this resource. Even relatively recent estimates put the cost of integrating wind energy into the grid at 5 percent-30 percent of the cost of generation.[74]

In a report compiled for Ontario (Canada) electricity consumers, Keith Stelling writes, "Energy experts report that industrial wind power is proving to be exceptionally expensive to consumers once required backup and additional infrastructure are factored in." [75]

Stelling attributes the high cost to (1) the need to maintain backup generating reserve to cover times when the wind does not blow, (2) the need to stabilize the grid when wind produces power that is not needed by current demand, and (3) government subsidization and tax benefits for the wind industry.

Construction of wind farms is expensive, relative to construction of conventional plants, as attested to by FPL Energy:

> As a rule of thumb, wind construction costs for wind-powered electric generators are considerably higher than those of fossil-fuel plants on a per megawatt of capacity basis. It costs about $1.5 million to $2 million per megawatt of capacity generated by wind facilities compared to $800,000 per megawatt of capacity for a natural gas plant.[76]

From a market perspective, high capacity cost is not necessarily problematic, if the cost is recoverable in the market. For example, at expected market prices for the power they generate, coal and nuclear plants will likely recover high capital costs and a reasonable return over the life of their assets. However, the large subsidies that wind-power facilities receive distort the economic reality of wind energy.

Cost estimates for wind-energy generation (not including costs of building and maintaining wind turbines) often exclude many of wind energy's costs, such as the following:

- Wind-energy transmission costs;
- Grid-connection and grid-management costs;
- The costs of backing up wind turbines with traditional power sources;
- Lost tax revenues from federal and state subsidies and tax breaks.

The backup generation and grid-related costs of wind energy will also be passed on to ERCOT ratepayers. Adding 11,553 MW of wind generating capacity to take advantage of the CREZ transmission capacity could increase ERCOT's system production costs by $1.82 billion per year.† Direct subsidies, tax breaks, and increased production/ancillary costs associated with wind energy could cost Texas more than $4 billion per year and at least $60 billion through 2025 (*see* Appendix for calculation of estimates).

* "Wind might have a big impact on our wallets," Loren Steffy, The *Houston Chronicle* (19 July 2008) http://www.chron.com/disp/story.mpl/business/steffy/5896507.html. "Each megawatt of wind power costs about $53 to generate, making it more expensive than coal, nuclear or natural gas generation, according to data from the Electric Reliability Council of Texas, the state's grid operator. Even with economies of scale, it's still going to be more expensive than other sources, based on projections by the American Wind Energy Association." Id.

† Direct Testimony of Scott Norwood (Page 23), PUC Docket No. 33672 (23 May 2008) http://interchange.puc.state.tx.us/WebApp/Interchange/Documents/33672_1157_584949.PDF.

The True Cost of Wind Energy

T. Boone Pickens says we should replace natural gas with wind for generating electricity. The Sierra Club sees wind and other renewable energy sources as replacements for coal.

However, a careful look at the costs of wind energy in Texas reveals that Texas consumers and taxpayers ought to think twice about making the move to wind energy.

Cost of Selected Texas Wind Energy Subsidies*

Wind Generation Subsidy	Peak Annual Cost	Total Cost 2008-2025
CREZ Transmission (state)	$1,326,000,000	$17,901,000,000
PTC (federal)	789,937,795	9,027,173,625
RECs (state)	126,932,400	1,436,163,947
Total	**$2,242,870,195**	**$28,364,337,571**

The three major subsidies for the Texas wind industry are: 1) the building of transmission lines through the Competitive Renewable Energy Zones (CREZ) process, 2) the Production Tax Credit (PTC), and 3) Renewable Energy Credits (RECs). These three subsidies will total about $2.24 billion dollars annually when wind generation has reached the state's 2025 target of 10,000 MW of installed capacity.

The total cost of subsidies through 2025 is likely to exceed $28.36 billion. Of that, about $20.1 billion will be borne directly by Texas consumers and taxpayers. The rest will be paid for by U.S. taxpayers in other states.

If the full cost of this subsidy were apportioned over the approximately 6.5 million Texas industrial, commercial, and residential users, it would run about $309 per electric customer. Looking at the portion of the subsidy affecting only residential consumers, the peak annual value of these three subsidies would range from approximately $109 to $138. If we factor out the PTC (paid by taxpayers, not consumers), we can expect actual residential electric bills to increase on average from about $71 to $89 annually.

It is important to remember that the above costs are the minimum costs associated with Texas' policy of promoting—and mandating—wind energy. This paper details many other real costs that cannot be as easily quantified as these subsidies. They include the management of ERCOT ancillary services—including backup thermal generation, disruptions of service due to unreliability, and additional tax breaks. One additional cost that can be more easily quantified is the increase in generation costs that come from adding 11,553 MW of wind energy to ERCOT—this could run as high as $1.82 billion per year.

The bottom line: The cost of subsidies, tax breaks, market disruptions, and increased production/ancillary costs associated with wind energy in Texas could top out at more than $4 billion per year, and total at least $60 billion through 2025.

– Bill Peacock, Director, Center for Economic Freedom

* See Appendix for more information on the costs of wind energy and how these numbers were calculated.

Referring to research performed by Glenn Schleede, Stelling reports,

> The true cost of electricity from wind is much higher than wind advocates admit. Wind energy advocates ignore key elements of the true cost of electricity from wind, including: (i) The cost of tax breaks and subsidies which shift tax burden and costs from 'wind farm' owners to ordinary taxpayers and electricity customers. (ii) The cost of providing backup power to balance the intermittent and volatile output from wind turbines. (iii) The full, true cost of transmitting electricity from 'wind farms' to electricity customers and the extra burden on grid management.[77]
>
> Various other subsidies shift large amounts of cost from 'wind farm' owners to ordinary taxpayers and electricity customers. The wind industry benefits from subsidies in addition to the tax breaks mentioned above. Other subsidies are in the form of artificially created, high price 'markets' for wind generated electricity. These include guaranteed markets for electricity which result from (i) insidious 'renewable portfolio standards' mandated by several states that require electricity suppliers to obtain some share of their electricity from 'renewable' sources,[*] (ii) additional markets due to mandated purchases of 'green electricity' by federal and state government agencies, and (iii) state programs requiring or encouraging electrical utilities to offer 'green' electricity at premium prices. Electricity customers can elect to pay premium prices but these programs generally do not attract enough 'volunteers' to pay the utilities' costs of buying the 'green' electricity and administering the program. The cost not recovered from customers paying premium prices is then spread across all of the utility's customers and hidden in monthly electricity bills.[78]

Additionally, unlike conventional-power generators, wind-energy providers do not have to pay ERCOT for generation-schedule deviations.[†] This is no small perk for Texas' most intermittent energy source, and it distorts wind energy's price, relative to conventional power prices. The result of this is that non-wind generators, and primarily customers, must bear the cost of ERCOT's deploying regulation and other reserves when there are large deviations from their schedules.[‡]

All of these costs contribute to wind energy's higher-per-kilowatt-hour cost, compared to conventional fuel sources, such as coal. Thus, statements that over the past two decades "the cost of wind energy has dropped about 80 percent"[§] are misleading, as wind subsidies and incentives are most missing from such determinations.[¶] Robert Michaels, economics professor at California State University-Fullerton, and adjunct-scholar at the Cato Institute, writes,

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[*] Power suppliers may provide the renewable capacity directly or through the purchasing of renewable energy credits.

[†] "Some grid owners or managers have applied penalties to electric generator owners or operators who deliver more or less electricity to a transmission system than was bid into the system. Often these penalties are designed to (a) encourage generating companies to help keep the grid in balance by delivering amounts of electricity promised, when promised, (b) pay for costs imposed when electricity delivered differs from contracted amounts, and (c) discourage 'gaming.'" *See* "The True Cost of Electricity from Wind Power and Windmill 'Availability' Factors," Glenn Schleede (April 2003) http://www.windaction.org/documents/2510.

[‡] These deviations may also subject ERCOT to penalties from North American Electric Reliability Corporation (NERC) if the deviations cause problems meeting certain reliability standards.

[§] http://www.fplenergy.com/renewable/contents/faqs_wind.shtml#cost. "The cost of wind has decreased significantly from 30 cents per kilowatt-hour (kwh) in the 1980s to FPL Energy's cost today of 4 to 7 cents per kwh. This cost is competitive with other forms of power generation. Also, since there is no fuel cost volatility, the long-term price of wind energy is stable." http://www.fplenergy.com/portfolio/wind/benefits.shtml.

[¶] Additionally, an 80 percent drop in cost for an emergent technology over 20 years is not particularly impressive, considering that today's run-of-the-mill computers probably outperform the several-million-dollar supercomputers from the late 1980s.

> According to the U.S. Energy Information Administration, wind's costs per kilowatt-hour hit bottom in 2002 and have since increased by 60 percent. In 2004, the levelized cost of a coal-fired kilowatt hour was 3.53 cents, compared to 4.31 cents for nuclear, 5.47 for gas and 5.7 for wind. According to a study by Gilbert Metcalf of Tufts University for the National Bureau of Economic Research, removing subsidies to nuclear and wind power takes the former to 5.94 cents and the latter to 6.64.[79]

A recent report from Cambridge Energy Research Associates (CERA) weighs in on the true costs of adding wind to the ERCOT grid.

> The levelized cost of coal-fired generation is estimated at $74 per megawatt-hour (MWh) given the fuel costs, capital costs, and a typical capacity factor… The levelized cost of gas-fired power from a CCGT (combined-cycle gas turbine) ranges from $87 to $111 per MWh, depending on the assumed capacity factor (at $10 per million British thermal units [MMBtu] natural gas price).[*] Onshore wind (nonfirm) generation levelized costs range from $85 to $114 per MWh, also depending on the capacity factor.[†]

A June 2008 report on the United Kingdom's renewable-energy goals (15 percent of energy from "green" power by 2020) is instructive for examining the true costs of wind energy. The Center for Policy Studies (United Kingdom) estimates that the 2020 renewable-energy target would cost each U.K. household an extra £4,000. According to *The Telegraph*, the report was "embarrassing for the Government coming 24 hours before ministers launch their 'green revolution' that recommends building thousands of turbines."[80] Also, Denmark touts its use of (heavily-subsidized) wind energy, despite having the highest household electricity prices in Europe.[81]

Incentives/Subsidies

Generous government subsidies and tax breaks encourage wind-energy development by creating profitable investment opportunities for private wind developers, who often recoup their investments in a matter of months. *The Houston Chronicle's* Steffy writes that "Wind power is an open trough of government subsidies, tax credits and state mandates. Taken together, it's a massive corporate welfare effort that means big money for the wind-power developers and big costs for the rest of us."[‡] This reality is not unique to Texas. According to *The Times* (London),

> LAVISH (emphasis original) subsidies and high electricity prices have turned Britain's onshore wind farms into an extraordinary moneyspinner, with a single turbine capable of generating £500,000 of pure profit per year. According to new industry figures, a typical 2 megawatt (2MW) turbine can now generate power worth £200,000 on the wholesale markets—plus another £300,000 of subsidy from taxpayers. Since such turbines cost around £2m to build and last for 20 or more years, it means they can pay for themselves in just 4-5 years and then produce nothing but profit.[§]

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[*] "The price of gas is based on CERA's outlook for gas prices at the Katy Hub in Texas over the 25-year life of the plant and is equal to $10 per MMBtu in average nominal terms. This is equivalent to $9.10 per MMBtu in levelized nominal terms." *See* "Comparing the Full Cost of Wind Generation to Other Options in Texas" (Table 2), Cambridge Energy Research Associates (25 July 2008).

[†] "Comparing the Full Cost of Wind Generation to Other Options in Texas" (Table 2), Cambridge Energy Research Associates (25 July 2008). According to the 2008 Texas State Energy Plan, the levelized cost of wind-power generation in Texas is $112/MWh. *See* "2008 Texas State Energy Plan," Governor's Competitiveness Council (July 2008).

[‡] "Wind might have a big impact on our wallets," Loren Steffy, *The Houston Chronicle* (19 July 2008) http://www.chron.com/disp/story.mpl/business/steffy/5896507.html. "For every $100 million of investment, wind-power developers have received more than $74 million in federal tax credits and other benefits, according to a recent study by Bernard Weinstein and Terry Clover, professors of applied economics at the University of North Texas. In Texas, we ladle on additional state and local incentives, including corporate income tax breaks and local property tax abatements." Id.

[§] "Wind farms turn huge profit with help of subsidies," Jonathan Leake, *The Times (London)* (27 Jan. 2008) http://www.timesonline.co.uk/tol/news/environment/article3257728.ece. "Despite U.K. wind industry subsidies of over $500 million, so far such a massive investment has only provided less than 0.5 percent of the U.K.'s electricity needs." *See* "Overblown: The Real Cost of Wind Power," Peter Glover and Michael Economides, *Energy Tribune* (2 Apr. 2008) http://www.energytribune.com/articles.cfm?aid=842.

Not surprisingly, wind-industry advocates view wind-energy subsides quite favorably. According to SECO, "Federal and state incentives have long been viewed as a means of supporting renewable energy technological developments and to help reduce the up-front cost of purchasing renewable energy systems. As a result, wind-based electricity is becoming increasingly cost-competitive with fossil-fueled electricity."* Mike Sloan, president of Virtus Energy, agrees: "Based on current incentives and regulations prevailing in the energy sector, wind power is competitive today in many states."†

However, the only reason wind energy can generously be referred to as "competitive" is because of the financial help it receives via government incentives and subsidies. As illustrated by Table 5, in 2007, wind energy received $724 million in federal subsidies, valued at $23.37 per megawatt hour.[82] "By contrast, normal coal received 44 cents, natural gas a mere quarter, hydroelectric about 67 cents and nuclear power $1.59."[83]

The financial handouts available to wind developers are so generous that, in Texas, many wind-energy producers "will offer wind power at no cost or even pay to have their electricity moved on the grid, a response commonly referred to as 'negative pricing.' Wind providers have an incentive to sell power even at negative prices because they still receive the federal production tax (PTC) credit and renewable energy credits."[84]

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* "Wind Energy Incentives," State Energy Conservation Office, http://www.seco.cpa.state.tx.us/re_wind-incentives.htm. "States and the federal government have developed incentives for wind energy investors. For example, in fourteen states a turbine purchaser does not pay state sales tax for their wind energy system. Small projects are often exempted from state permitting procedures. Some states also provide low-interest loans for wind projects, exemption from property taxes, and accelerated rates of depreciation for renewable energy equipment. At the federal level, the U.S. Department of Agriculture offers a grant program for eligible wind projects. Also, the Clean Renewable Energy Bond (CREB) program is a new federal financial incentive created in the Energy Policy Act of 2005. CREBs are tax credit bonds with an interest-free finance rate that are available to municipal utilities and electric cooperatives for renewable energy projects. These and other incentives may help to reduce your wind project costs." *See* "Know Your Economics," *Windustry*, http://www.windustry.org/wind-basics/learn-about-wind-energy/wind-basics-know-your-economics/know-your-economics. "Wind energy has captured the imagination of the public and is touted by many as the fastest growing energy source in the world. All of this is driven by government mandates—tax credits and 'renewable portfolio' laws that require utilities to buy non-fossil sources of power." *See* "The Case for Terrestrial (a.k.a. Nuclear) Energy," William Tucker, *Imprimis* (Feb. 2008). Incentive-/Subsidy-driven wind investment is not unique to the U.S. In Denmark, "The building of wind turbines has virtually ground to a halt since subsidies were cut back…countries like Denmark are far ahead of the United States and others in overall use of green power, mostly because of government support." *See* "Denmark leads the way in green energy—to a point," James Kanter, *International Herald Tribune* (21 Mar. 2007) http://www.iht.com/articles/2007/03/21/business/green1.php. According to Peter Maegaard, the executive director of the Nordic Folkecenter for Renewable Energy, a nonprofit group, if higher subsidies had been sustained, Denmark could generate almost 1/3 of its electricity from windmills, as opposed to one-fifth. Id. "Researchers in Denmark…believe that wind power shaved 1 billion kroner ($167m) off Danish electricity bills in 2005. On the other hand, Danish consumers also paid 1.4 billion kroner in subsidies for wind power." *See* "Cheap alternatives," *The Economist* (5 July 2007). "The scale of Denmark's subsidies was such that in 2006-07 the government increasingly came under scrutiny from the Danish media, which claimed the subsidies were out of control." *See* "Overblown: The Real Cost of Wind Power," Peter Glover and Michael Economides, *Energy Tribune* (2 Apr. 2008) http://www.energytribune.com/articles.cfm?aid=842. "Despite U.K. wind industry subsidies of over $500 million, so far such a massive investment has only provided less than 0.5 percent of the U.K.'s electricity needs. In August 2007, the BBC's Radio 4 "Costing the Earth" program reported that the government's financial incentives were encouraging wind industry firms to take advantage of massive government subsidies and build wind farms on non-viable sites across the mainland." Id.

† Testimony before the House Select Committee on Energy Independence and Global Warming, Mike Sloan (20 Sept. 2007). "With continued government encouragement to accelerate its development, this increasingly competitive source of energy will provide a steadily growing share of U.S. electricity…" *See* "The Difference Wind Makes," American Wind Energy Association, http://www.awea.org/pubs/factsheets/The_Difference_Wind_Makes.pdf. Wind power "is the renewable energy resource that is closest to the market costs of conventional energy, given current federal subsidies." *See* "Gone with the Wind: Renewable Portfolio Standard Threatens Consumers and the Industrial Heartland," CEI On Point, William Yeatman and Myron Ebell (12 June 2007). "The notion that an RPS will include a 'portfolio' of renewable energy sources is misleading—wind energy is the only economically viable renewable energy source given current technologies." However, pointed out above, the reason wind energy is "economically viable" is because of the generous subsidies and tax breaks it receives. Without these financial incentives, wind energy would not be economical.

Table 5: Renewable Energy Generation and Subsidies

Fuel	FY 2007 Net Generation (billion kWh)*	Subsidy & Support Value (million dollars)	Subsidy & Support Per Unit of Production (dollars/MWh)
Coal	1,946	$854	$0.44
Natural Gas & Petroleum Liquids	919	$227	$0.25
Nuclear	794	$1,267	$1.59
Biomass (and biofuels)	40	$36	$0.89
Geothermal	15	$14	$0.92
Hydroelectric	258	$174	$0.67
Solar	1	$14	$24.34
Wind	31	$724	$23.37

A closer look at federal and Texas incentives to wind-energy developers illuminates the economic reality of wind energy.

a. Federal

According to the Texas Comptroller, "Wind energy has high up front capital costs that currently make it dependent on federal subsidies."[85] Two major federal incentives for private wind-farm development are the production tax credit (PTC) and an accelerated depreciation method for wind-generating equipment.

Created by the *Energy Policy Act of 1992* (at the value of 1.5 cents/kilowatt-hour and adjusted annually for inflation), the PTC provides a federal income tax credit for wind generation for the first 10 years of a wind facility's operation. The current value of the credit is 2 cents/kWh of electricity produced. The credit applies only to utility-scale wind turbines, not smaller turbines used to power individual homes or businesses."†

A direct relationship exists between wind-energy investment and whether the PTC is in effect or has lapsed/expired. Each year that the PTC lapsed (2000, 2002, 2004), wind-energy investment dropped considerably from the prior year:

- 1999-2000: 93 percent drop in wind-capacity installation
- 2001-2002: 73 percent drop in wind-capacity installation
- 2003-2004: 77 percent drop in wind-capacity installation

The PTC was set to expire on December 31, 2008, but was renewed for one year as part of the recently enacted $700 billion *Emergency Economic Stabilization Act of 2008*. The new expiration date is now December 31, 2009. Prior to its renewal, wind-energy developers were in limbo regarding current and future projects. According to the AWEA,

> Since investment decisions are being made today for new wind power projects that are not expected to be completed until next year, wind energy companies are already reporting a decrease in in-

* Total FY 2007 net generation (billion kWh): 4,091. *See* "Federal Financial Interventions and Subsidies in Energy Markets 2007," http://www.eia.doe.gov/oiaf/servicerpt/subsidy2/pdf/chap5.pdf (Page 106).

† http://www.awea.org/legislative/#PTC. The PTC applies to electricity produced by a qualified wind facility placed in service after December 31, 1992, and before January 1, 2009.

> vestment as a result of the uncertainty surrounding tax policy. If Congress does not act soon to extend the PTC, companies will stop making investments in projects not expected to be completed before the end of the year.[86]

"The federal production tax credit has been the main driver behind wind energy expansion," writes the Texas Comptroller.[87] Clearly, the main reason for wind-energy investment is the PTC, which artificially increases the wind-energy supply.

Wind-energy advocates are vociferous supporters of the PTC, fearing another lapse in the tax credit.[*] The AWEA calls the PTC "a critical factor in the financing of new wind farms."[†] SECO calls the PTC "the most important federal financial incentive encouraging investment in wind power, a critical factor in financing new wind farms."[‡] SECO writes,

> Without assurances of the PTC's continued support, accelerated wind development will remain intermittent…the American Wind Energy Association (AWEA) advises that a long-term extension of the tax credit is vital to sustain this growth and to avoid a boom-and-bust cycle in the wind industry.[§]

This boom-and-bust cycle was attested to by Sloan, during his testimony before the House Select Committee on Energy Independence and Global Warming:

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[*] On July 30, 2008, renewable-energy legislation that, among other things, would have renewed the PTC for one-year failed a procedural vote in the Senate. The bill needed 60 "yes" votes to move forward but received just 51. The bill can be brought up again. *See* "Bill renewing clean energy credits fails vote," *Reuters* (30 July 2008) http://www.reuters.com/article/environmentNews/idUSN3048726220080730.

[†] "Energy Bill Extends Wind Power Incentive through 2007," AWEA News Release (29 July 2005) http://www.awea.org/news/energy_bill_extends_wind_power_072905.html. We see a similar situation in Europe, with favorable legislative conditions spurring wind energy investment. "Wind has delivered the most promising results out of all renewable energy technologies so far, with 57 GW of total capacity installed in the EU by the end of 2007. In order to ensure that this trend continues, we need to have a secure and favourable EU legislative framework," EU Energy Commissioner Andris Piebalgs told delegates at the opening session of the European Wind Energy Conference (EWEC) in Brussels. *See* "With ambitious EU legislation, wind energy can provide huge benefits to Europe," The European Wind Energy Association, http://www.ewea.org/index.php?id=60&no_cache=1&tx_ttnews[tt_news]=1310&tx_ttnews[backPid]=1&cHash=b962b59976.

[‡] "Wind Energy Incentives," State Energy Conservation Office, http://www.seco.cpa.state.tx.us/re_wind-incentives.htm. "Together, the PTC and the Texas Renewable Portfolio Standard have spurred wind industry growth in the state." According to Mike Sloan, "Texas has achieved success with wind power through a package of effective state policies that complement available federal policies in delivering significant results. These policies include: 1) Education through Deliberative Polls 2) An effective market catalyst through a Renewable Electricity Standard (RES), 3) Renewable Energy Credits (REC), 4) Competitive Renewable Energy Zones (CREZ), 5) Appropriate producer incentives such as the federal Production Tax Credit (PTC) and state property tax abatements." *From* Testimony before the House Select Committee on Energy Independence and Global Warming, Mike Sloan (20 Sept. 2007). Sloan says, "The success of the Texas wind industry is a leading example of how government leadership combined with well-conceived policies can effectively catalyze clean energy development." Id. Glenn Schleede writes, "Undoubtedly, the growth of wind generating capacity in Texas was due largely to (a) the Texas Renewable Portfolio Mandate, (b) the generous federal wind Production Tax Credit…(c) the generous federal 5-year double declining balance accelerated depreciation deduction for wind generating equipment, and (d) Texas political leaders' and regulators' willingness to approve construction of substantial additional transmission capacity to move electricity from 'wind farms' to places where the electricity is needed—but with the costs borne by electric customers, not by 'wind farm' owners." *See* "No, President Bush did NOT state that wind could supply 20 percent of U.S. Electricity," Glenn Schleede (2 Feb. 2007).

[§] "Wind Energy Incentives," State Energy Conservation Office, http://www.seco.cpa.state.tx.us/re_wind-incentives.htm. "The PTC enables utilities, wind energy developers and manufacturers to invest billions of dollars each year in equipment and facilities associated with the generation of electricity from renewable energy resources, such as wind, geothermal, biomass and hydropower. Since investment decisions are being made today for new wind power projects that are not expected to be completed until next year, wind energy companies are already reporting a decrease in investment as a result of the uncertainty surrounding tax policy. If Congress does not act soon to extend the PTC, companies will stop making investments in projects not expected to be completed before the end of the year." *See*"Legislative Priorities," AWEA, http://www.awea.org/legislative/#PTC. "The wind energy industry is very much driven by policy, which today includes a burgeoning array of tariff and fiscal support initiatives (such as the January 2008 European proposal for a directive on the promotion of the use of energy from renewable sources) that together create a stable global environment for continued sector growth and investor appetite." *See* "Wind power: rising costs are unlikely to derail new build plans," Alex Desbarres, *Energy Business Review* (31 Mar. 2008) http://www.energy-business-review.com/article_feature.asp?guid=3C3C770A-F8F4-44AB-A7FB-80FBD6B41DE6.

Table 6: MACRS Depreciation

Tax Year	Depreciation Allowed (5-year, 200% DB)	Depreciation Allowed (Bonus System)
1	20%	60%
2	32%	16%
3	19.2%	9.6%
4	11.52%	5.76%
5	11.52%	5.76%
6	5.76%	2.88%

> The Federal Production Tax Credit (PTC) has played a critical role in the effectiveness of the Texas RES. Examination of the history of Texas' wind development indicate an extreme boom-bust cycle directly tied to the availability of the PTC. Even for Texas, the most attractive wind development market in the country, the years following PTC expiration in 1999 and 2001 resulted in statewide wind installations of *zero MW*.[88]

Installed wind capacity dropped nationwide during each of the three years the PTC was not in effect (93 percent drop in 2000, 73 percent drop in 2002, 77 percent drop in 2004), but the decline was even more drastic in Texas:

- 2000: 1 new MW
- 2002: 0 new MW
- 2004: 0 new MW

Even with Texas' RPS mandate and the financial incentives with which Texas entices wind-energy developers, wind-energy investment in Texas would be minimal or non-existent without the PTC. Without government handouts, wind energy is not an economical investment and cannot survive. It is, thus, not surprising that the wind industry fights hard for the PTC's renewal.

In addition to the PTC, the federal government incentivizes wind energy development through a special depreciation treatment for wind-generating devices. Under the Modified Accelerated Cost-Recovery System (MACRS), businesses may recover investments in certain property through depreciation deductions. The MACRS establishes a set of class lives for various types of property,* ranging from three to 50 years, over which the property may be depreciated. For wind property placed in service after 1986, the current MACRS property class is five years.†

A 5-year, double-declining-balance, accelerated depreciation method (5-yr., 200 percent DB) is used. In addition, the federal *Economic Stimulus Act of 2008*, enacted in February 2008, included a 50 percent bonus depreciation provision for eligible renewable-energy systems acquired and placed in service in 2008. If property meets certain requirements, the owner is entitled to deduct 50 percent of the adjusted basis of the property in 2008.[89] Under these methods, allowed deductions are as listed in Table 6.

Private wind developers are not the only recipients of federal funding. The federal government's Renewable Energy Production Incentive (REPI) provides incentive payments to qualifying renewable-energy generators (not-for-profit electrical cooperatives; public utilities;

* According to Database of State Incentives for Renewables & Efficiency, these properties are "Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Solar Thermal Process Heat, Photovoltaics, Landfill Gas, Wind, Biomass, Renewable Transportation Fuels, Geothermal Electric, Fuel Cells, CHP/Cogeneration, Solar Hybrid Lighting, Direct Use Geothermal, Anaerobic Digestion, Microturbines." *See* "Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation," Database of State Incentives for Renewables & Efficiency, http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=US06F&State=Federal&currentpageid=1.

† Id. The five-year MACRS period also applies to solar and geothermal devices.

state governments; commonwealths; territories of the United States, the District of Columbia, Indian tribal governments, or a political subdivision within; and native corporations that sell the facility's electricity) that sell electricity to other entities.[90] Qualifying facilities are eligible for annual incentive payments of 1.5 cents per kilowatt-hour (1993 dollars and indexed for inflation) for the first 10-year period of their operation, subject to the availability of annual appropriations in each federal fiscal year of operation.[91]

In addition to federal subsidies to wind developers, the federal government spends millions of dollars each year to finance wind-energy research and development (R&D). Whereas the PTC reduces the federal government's tax revenues by millions of dollars, federal wind-energy R&D expenditures are payments from federal tax revenues for wind R&D activities. The amounts of money appropriated in fiscal years 2006, 2007, and 2008 for the DOE's Wind Energy Program,[92] as well as the amount requested by the DOE for fiscal year 2009, are as follows:[93]

- FY 2006 Appropriated: $38,857,000
- FY 2007 Appropriated: $48,659,000
- FY 2008 Appropriated: $49,545,000
- FY 2009 Requested: $52,500,000

According to the Texas Comptroller,

> Research and development funding at the U.S. Department of Energy contributed over $38.3 million to wind subsidies in 2006. The U.S. Department of Agriculture's Renewable Energy Systems and Energy Efficiency programs accounted for approximately $5.1 million in federal subsidies to wind in 2006. …In addition, the U.S. Department of Energy's Renewable Energy Production Incentive program pays governmental and non-profit electrical cooperatives for producing power using renewable energies, including wind. Facilities are paid per kilowatt hour, up to the amount allocated by federal appropriations. Wind energy received an estimated $2.8 million from this program in 2006. A total of $4.8 million was distributed across all renewable energies in 2006. Tax subsidies accounted for nearly 90 percent of federal wind subsidies in 2006.[*]

b. State & Local

Like federal incentives, state and local subsidies and incentives attract wind-energy development in Texas:[†]

- Texas extends a franchise tax exemption to qualified manufacturers, sellers, or installers of solar energy devices. (Wind projects/devices are included in the definition of "solar energy devices.")[94] "The franchise tax is Texas' equivalent to a corporate tax; their primary elements are the same. There is no ceiling on this exemption, so it is a substantial incentive for solar manufacturers."[95]

- Texas allows for a corporate deduction from the state's franchise tax for renewable energy sources.[96] Businesses may deduct the system's total cost from the company's taxable capital or, alternatively, take 10 percent of the system's cost off the company's income; both taxable capital and a company's income are taxed under Texas' franchise tax.[97]

- Under House Bill 1200 (2001), school boards may reduce the property values of large renewable electric-energy projects in their communities. HB 1200 cre-

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[*] "The Energy Report," Texas Comptroller of Public Accounts (May 2008) http://www.window.state.tx.us/specialrpt/energy/pdf/28-Government-FinancialSubsidies.pdf (Chapter 28, Page 388).

[†] "State policies to support wind power have historically been a critical driving force in the growth of the renewable energy market in the United States." *See* "Analyzing the Interaction Between State Tax Incentives and the Federal Production Tax Credit for Wind Power," Ryan Wiser, Mark Bolinger, and Troy Gagliano, Ernest Orlando Lawrence Berkeley National Laboratory (Sept. 2002) http://eetd.lbl.gov/ea/EMS/reports/51465.pdf. For a database of states' incentives for wind-power development, *see* Database of State Incentives for Renewables & Efficiency, http://www.dsireusa.org/. For a list of Texas' state incentives for renewable energy (including wind energy), *see* "Texas Incentives for Renewable Energy," Database of State Incentives for Renewables & Efficiency, http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=TX&RE=1&EE=0.

ated the *Texas Economic Development Act*,[98] which allows school districts to offer a tax credit and an eight-year limitation on a property's appraised value for the maintenance and operations portion of the school district property tax. Texas school districts have since approved more than 70 wind-energy projects for reduced property values.[*]

- Additionally, Texas offers a 100 percent property tax exemption on the appraised value of an on-site solar, wind, or biomass power generating device:[99] "A person is entitled to an exemption from taxation of the amount of appraised value of his property that arises from the installation or construction of a solar or wind-powered energy device that is primarily for production and distribution of energy for on-site use."[100] However, this exemption does not apply to large-scale wind farms, since they don't produce energy for on-site use. The exemption is primarily for renewable facilities installed on the customer's premises to serve his own load.

It is possible to get a general idea of the costs to consumers from Texas' wind generation.[†] These are also costs that are generally not—yet should be—included when calculating the cost of wind energy. In 2006, the PTC was 1.9¢/kWh, and ERCOT-region wind generation totaled 6,341,451 MWh.[101] If the PTC covered all wind production, the PTCs from the ERCOT region alone cost taxpayers over $120 million in 2006.[‡] Using the current PTC value of 2¢/kWh, the number jumps to just under $128 million. If Texas' wind generation jumps to 10,000,000 MWh, and we use the current PTC value of 2¢/kWh—recall that the PTC is indexed for inflation—then the lost federal revenues from ERCOT-region wind generation total $200 million.

RECs' total cost would be similarly calculated. An REC is 1 MWh generated by wind per year. Using an approximation of the current price of an REC, the value of RECs in 2006 was about $28.54 million.[§] Assuming 10,000,000 MWh of wind generation and keeping the REC value at $4.50, the value jumps to $45 million.

Assuming Texas meets its RPS target of 10,000 MW of installed wind-power capacity and that the average annual capacity factor for the 10,000 MW is 30 percent, wind generation would total 26,280,000 MWh (=10,000 [MW] * 8,760 [hours in a year] * 0.30 [capacity factor]). Keeping the values of the PTC and RECs at 2¢/kWh and $4.50, respectively, lost revenues from the PTC would total $525.6 million, and the costs of RECs would be near $118.26 million.

Of course, many people want to increase the use of wind energy even more than the Texas targets currently call for, in order to replace fuels like coal and natural gas. So what would it cost if wind energy displaced all coal-fired electric generation in Texas? In 2006, coal accounted for 36.5 percent of Texas' electric generation,[102] and ERCOT's

[*] "The Energy Report," Texas Comptroller of Public Accounts (May 2008) http://www.window.state.tx.us/specialrpt/energy/pdf/11-WindEnergy.pdf (Chapter 11, Page 175). "Whether county governments and school districts can continue to grant abatements and property value limitations is in question, however, due to a January 29, 2008, Texas Attorney General opinion concerning Section 312.402(a) of the Tax Code. The opinion concluded that "fixtures and improvements owned by the wind turbine company as personal property would not be 'real property' that may be the subject of a tax abatement agreement under section 312.402(a). On February 27, 2008, the Texas Comptroller of Public Accounts raised a different issue with respect to school district tax limitation agreements under Chapter 313 of the Tax Code, which could also affect wind farms. The Office of the Attorney General has until August 26, 2008, to respond to the Comptroller's request for an opinion on this matter." Id. For details on House Bill 1200, *see* "Appraised Value Limitation and Tax Credit," Texas Comptroller of Public Accounts, http://www.window.state.tx.us/taxinfo/proptax/hb1200/.

[†] Original estimates received via email from Jeff Pollock, J. Pollock & Associates (9 Apr. 2008). Estimates revised upward, based on data from "Energy By Fuel Types For 2006" (Microsoft Excel spreadsheet), Electric Reliability Council of Texas (updated 9 Jan. 2007). REC prices are published by Evolution Markets. *See* http://new.evomarkets.com/index.php?page=Emissions_Markets.

[‡] Nationally, wind generated 22,327,644 MWh. Thus, the total cost to taxpayers was roughly $424 million.

[§] Texas REC prices initially were in the $15-$20 range, but as of July 2008, they were in the $4-to-$5 range. Thus, an REC value of $4.50 was used in this calculation. Neither the PUCT nor ERCOT keeps track of current or historical REC prices.

total load (energy consumption) was 306,000,000 MWh. Thus, coal generated roughly 111,690,000 MWh. If wind had completely displaced coal in 2006, then (using the PTC value above), lost revenues from the PTC would total over $2.23 billion. Since RECs costs are capped, those would not increase. But both transmission and production costs would grow significantly. A full cost analysis is beyond this study's scope, but it is safe to say that displacing coal-fired generation with wind energy would add tens of billions of dollars to the $60 billion wind is already going to cost us through 2025.

Many believe incentives and subsidies are justified, providing the impetus that wind-energy development needs. In other words, industry would not invest in wind (and other renewable energies) on its own. The reason is because wind energy is not economical without subsidies and incentives.

The history of the direct relationship between subsidies—particularly the federal PTC—and wind-energy investment leads to the conclusion that were the playing field level (i.e., if the energy market, not the government, picked winners and losers), wind energy would not be a viable player in the energy-supply mix.[*]

Breakdowns/Maintenance/Repair

Breakdowns and mechanical issues pose challenges for wind farms and often result from the rush to build wind farms. These issues were the topic of "The Dangers of Wind Power: As wind turbines multiply around the globe, the number of dangerous accidents is also climbing, causing critics to question overall safety," an August 2007 *Business Week* article asserting that the rush to build wind farms has led to mechanical problems with the turbines: "It is precisely the industry's prodigious success that is leading to its technological shortcomings."[103] The article mentions several instances of "technical hitches" with wind turbines:

> In December of last year, fragments of a broken rotor blade landed on a road shortly before rush hour traffic near the city of Trier.
>
> Two wind turbines caught fire near Osnabrück and in the Havelland region in January. The firefighters could only watch: Their ladders were not tall enough to reach the burning casings.
>
> The same month, a 70-meter (230-foot) tall wind turbine folded in half in Schleswig-Holstein—right next to a highway.
>
> The rotor blades of a wind turbine in Brandenburg ripped off at a height of 100 meters (328 feet). Fragments of the rotors stuck into a grain field near a road.

More examples of breakdowns can be found. In February, Edison Mission Energy[†] filed with the U.S. Securities and Exchange Commission that turbine blades it purchased from Suzlon Energy Ltd. have begun splitting at three Midwest wind farms. Suzlon subsequently recalled 1,251 blades, while Edison cancelled an order for 150 turbines. Suzlon's chairman denied that the turbine cracks stem from any fundamental design flaw, pointing out that only 45 blades have cracked. Vivek Kher, a Suzlon spokesman, "blamed the cracks on the Midwest's unexpectedly violent changes in wind direction,"[104] which simply highlights the unpredictability of wind.[105]

Also in February, Denmark's climate minister, Connie Hedegaard, began investigating the collapse of two wind turbines[‡] in one week. "In first of the two collapses, near the city of Århus, a 10-year-old windmill began spinning out of control during high winds. A recording of the explosion-like collapse shows one of the wing blades breaking off, casting debris into the three other wings and shearing the 60-metre tower nearly in half."[106]

Energy Tribune reports,

> In August 2007, Germany's Der Spiegel reported the rising incidence of 'mishaps, breakdowns and accidents' associated with ever-larger turbines. When one rotor blade broke away in Old-

[*] This relationship is explored in detail in the "Incentives/Subsidies" section.

[†] Edison Mission Energy is a unit of Edison International. *See* "Edison Mission Group," http://www.edison.com/ourcompany/eme.asp.

[‡] The collapsed turbines were manufactured by Vestas, which initiated an internal investigation.

> enburg in northern Germany, an examination of six other turbines was ordered. The results proved so alarming that the authorities immediately ordered four to be shut down. The same Der Spiegel article noted that manufacturers' claims that turbines would last for 20 years have proven hollow. Indeed, it appears that they are not allowing time for proper stress-testing procedures.

And on September 15, 2008, a Vermont wind turbine collapsed from high winds.[107] The Industrial Wind Action Group (IWA) reports,

> Turbine #10 at the Searsburg wind energy facility in Searsburg, Vermont experienced a catastrophic failure on when one of the blades came in contact with the turbine's tower causing it to buckle during high winds. This turbine's 28-ton nacelle and 3-blade rotor assembly crashed to the ground scattering debris several hundred feet from the structure. Approximately 20 gallons of heavy oil spilled from the unit when its fluid reservoirs were damaged. The 11-turbine Searsburg facility was brought online in 1997 and according to preconstruction documents, the Zond Z-P40-FS turbines had an expected lifespan of 30 years.[108]

According to IWA's executive director, Lisa Linowes, "Wind developers today tout life expectancies of industrial wind turbines that exceed 20 years, but the fact remains that estimates of the functional lifespan of modern utility-scale wind turbines are speculative and cannot be substantiated since so far very few have been operating for 10 years."[109]

FPL Energy, on the other hand, says, "Wind energy is one of the safest energy technologies with several built-in safety features."[110] Given the tens of thousands of wind turbines currently in operation around the world, the few incidents reported do not yet seem to constitute a major problem. Furthermore, none of these incidents has occurred in Texas. Conventional generators have failures, too, including fires and the loss or breakdown of turbine blades and other equipment.

Environmental Issues

Both environmental benefits and concerns accompany wind-energy development. As a result, wind energy finds support and opposition from environmental and conservation groups.*

The spinning of wind-turbine blades produces no pollution.† According to Michael Goggin,

> Wind energy provides a number of environmental benefits…Emissions of carbon dioxide (CO2) from Texas' electricity generation sector fell by 2 percent from 2000 to 2006, during which time wind energy grew from producing 178 MW to 3,000 MW. In contrast, CO2 emissions from the electric sector increased by 25 percent from 1990-2000, before wind energy became a major part of Texas' generation mix. Based on the results of recent studies by ERCOT and GE, adding 11,600 MW of wind

* For example, in April, a proposed wind farm in Scotland was rejected by the Scottish Executive, after opposition from parties concerned about the wind farm's impact on the environment. "The Scotsman reported that 'environmental agencies welcomed the news' of the massive wind power project's demise, thanks to concerns about impacts on rare peat bog and birdlife habitat…The Lewis wind farm's impact on the landscape would have been substantial - with 181 turbines each standing 140 metres tall, erected on massive concrete bases drilled into the fragile peat surface and connected by dozens of miles of new stone roads, this was unavoidable…The Lewis project, although supported by the Western Isles Council, received 11,000 objections from members of the public, with only 100 comments in favour. Lewis Wind Power responded to the news of its project's refusal by saying that it was 'bitterly disappointed'. Similarly, the British Wind Energy Association—environmentalists all—is furious that £5m has been wasted on a failed scheme, and warns that this will damage investor confidence in new wind projects." *See* "Green v green," Mark Lynas, *The Guardian* (24 Apr. 2008).

† "Wind-generated power produces no air or water emissions, creates no solid waste by-products and does not deplete natural resources such as coal, oil or gas. Wind is also a renewable resource, which means that the supply will not run out." *See* "FPL Energy: Benefits of Wind Energy," http://www.fplenergy.com/portfolio/wind/benefits.shtml. "Wind energy requires no mining, drilling, or transportation of fuel, and does not generate radioactive or other hazardous or polluting waste." *See* "The Difference Wind Makes," AWEA, http://www.awea.org/pubs/factsheets/The_Difference_Wind_Makes.pdf.

> energy in Texas would reduce CO2 emissions by 22 million tons per year, sulfur dioxide emissions by 18,000 tons per year, and nitrogen oxide emissions by 8,000 tons per year.[111]

But correlation does not mean causation. The rise in the use of wind power and the controlling of CO2 emissions may not be as intimately connected as some claim. In other words, the former is not necessarily the main cause of the latter. A more plausible explanation for the controlling of CO2 emissions in Texas is the displacement of coal by natural gas for electric generation. Natural gas burns cleaner than coal, and, about half of Texas' electricity comes from natural gas—Section 39.9044 of SB 7 provides that 50 percent of the MW of generating capacity installed after January 1, 2000, use natural gas[*]—while wind contributed just 2 percent to Texas electricity generation in 2007.[112]

However, the PUCT has not implemented any rules to enforce the 50 percent-natural gas requirement. Furthermore, the recent rapid increase in energy prices in Texas is largely due to the rapid rise in the cost of natural gas, so more natural gas is not necessarily beneficial to ratepayers.

Though the spinning of wind turbines produces no pollutants or greenhouse gases, it is misleading to claim that wind energy is "pollution free" or "100-percent clean:" (1) The production, transportation, and maintenance of turbines,[†] (2) the production of the concrete[‡] and steel that form the foundations of the turbines, and (3) the running of conventional power sources to back up the turbines all emit pollutants and greenhouse gases.[§]

Another environmental issue arising from wind-energy development is that wind farms require large amounts of land—vastly more than is required to produce an equivalent amount of energy from conventional power sources.[¶] This disrupts animal habitats and reduces the amount of suitable farm land, at least by an amount equal to the area occupied by the bases of the turbines

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* "It is the intent of the legislature that 50 percent of the megawatts of generating capacity installed in this state after January 1, 2000, use natural gas." *See* Enrolled Version of SB 7 (1999) http://www.capitol.state.tx.us/BillLookup/Text.aspx?LegSess=76R&Bill=SB7.

† The AWEA counters, "Emissions from the manufacture and installation of wind turbines are negligible. The 'energy payback time' (a measure of how long a power plant must operate to generate the amount of electricity required for its manufacture and construction) of a wind farm is 3 to 8 months, depending on the wind speed at the site – one of the shortest of any energy technology." *See* "The Difference Wind Makes," AWEA, http://www.awea.org/pubs/factsheets/The_Difference_Wind_Makes.pdf. "According to the Alliance to Save Energy, a 600-megawatt offshore wind farm would annually save the emission of 2.5 billion pounds of CO2 [carbon dioxide], 29 million pounds of sulfur dioxide, and nine million pounds of nitrous oxide." *See* "Air Power: Don Quixote tilted at windmills. We can use them to increase our energy supply." Pete du Pont, *The Wall Street Journal* (25 Apr. 2007) http://www.opinionjournal.com/columnists/pdupont/?id=110009980.

‡ The foundation of GE's 1.5 MW Series turbine consists of a concrete octagonal footing 47 feet in diameter and 7 feet deep. 439 tons of concrete go into each foundation. *See* "Colorado Green: 162 MW Wind Power Project," http://www.ppmenergy.com/pdf/Colorado_Green_Fact_Sheet.pdf.

§ Dr. Sterling Burnett writes, "Bringing a conventional power plant on line to supply power is not as simple as turning on a switch; thus most of the fossil fuel power stations required to supplement wind turbines are not 'redundant,' but must run continuously, even if at reduced levels. When combined with the CO2 emitted and pollutants released in the manufacture and maintenance of wind towers and their associated infrastructure, substituting wind power for fossil fuels does little to reduce air pollution." *See* "Wind Power: Red Not Green," H. Sterling Burnett, Ph.D., NCPA Brief Analysis #467 (23 Feb. 2004). "But of course when the grid power kicks in to make up for a lack of wind, the coal, oil, and gas plants will emit their normal pollutants." *See* "Air Power: Don Quixote tilted at windmills. We can use them to increase our energy supply." Pete du Pont, *The Wall Street Journal* (25 Apr. 2007) http://www.opinionjournal.com/columnists/pdupont/?id=110009980.

¶ "Wind farms that produce only a fraction of the energy of a conventional power plant require 100 times the acreage. For instance: (1) Two of the biggest wind 'farms' in Europe have 159 turbines and cover thousands of acres; but together they take a year to produce less than four days' output from a single 2,000 MW (mill. watt) conventional power station—which uses one percent as much space. (2) A proposed wind farm off the Massachusetts coast would produce only 450 MW of power but require 130 towers and more than 24 square miles of ocean. (3) A comparison of 'footprints' is telling: to produce 1,000 MW of power, a wind farm would require approximately 192,000 acres, or 300 square miles; a nuclear plant needs less than 1,700 acres, or 2.65 square miles (within its security perimeter fence); and a coal powered plant takes up about 1,950 acres, 3.05 square miles." *See* "Wind Power: Red Not Green," H. Sterling Burnett, Ph.D., NCPA Brief Analysis #467 (23 Feb. 2004). "In addition, windmills are large and require lots of land. The biggest now stand 65 stories tall—roughly the height of New York's Trump Tower—and produce only six megawatts, or about 1/200th the output of a conventional power plant." *See* "The Case for Terrestrial (a.k.a. Nuclear) Energy," William Tucker, *Imprimis* (Feb. 2008).

but possibly by more.* ("Property owners leasing land for wind-turbine development receive a steady income, while landowners with transmission towers and lines passing through their land receive only a one-time payment."[113])

FPL Energy contends "you can farm or graze up to" a turbine's base,[114] writing,

> A wind farm in open, flat terrain generally requires about 40 acres per megawatt of installed capacity. As little as 1 percent of that total acreage is needed for turbines and access roads, meaning as much as 99 percent remains free for other uses, such as farming or ranching.[115]
>
> The land surrounding wind turbines can typically be used in traditional ways at the same time that electricity is being produced…This means the vast majority of the acreage is undisturbed and can be used productively for farming, ranching, or for other purposes…When the facility ends operation, the land can be restored to its original condition.[116]

Sterling Burnett, however, claims that one cannot farm up to the base of a wind turbine, as turbines dry out the soil beneath them.† Additionally, says Burnett, "Regular wind-tower maintenance requires miles of paved roads, increasing runoff and reducing soil moisture absorption. The damage to wildlife habitat is often greater than that from technologies associated with conventional fossil fuels."‡

Thousands of birds and bats are killed each year by wind-turbine blades.§ "Wind farms must be located where the wind blows fairly constantly. Unfortunately, such locations are often prime travel routes for migratory birds, including protected species like Bald Eagles and Golden Eagles,"[117] writes Burnett.

At the Altamont Pass, California, wind farm "At least 22,000 birds, including some 400 golden eagles, have collided with wind turbines (or been electrocuted by power lines) there, leading some to call the machines 'Cuisinarts of the air.'"[118] Commenting on Altamont Pass, Burnett writes,

* For more on wind farms' impacts on land and animals, *see* "A Problem With Wind Power," Eric Rosenbloom (5 Sept. 2006) http://www.aweo.org/ProblemWithWind.html.

† Phone interview of H. Sterling Burnett, Ph.D., Senior Fellow, National Center for Policy Analysis (26 Mar. 2007). Though not yet an issue in Texas, offshore wind farms pose potential environmental problems of their own. "Deepwater wind-farm technology also has its critics, who say the turbines can encroach on shipping lanes and harm seabird sanctuaries." *See* "Can Wind Power Find Footing in the Deep?" Guy Chazan, *The Wall Street Journal* (29 Nov. 2007). "They can also be prohibitively expensive, because they require long undersea transmission lines to hook turbines up to the grid system." Project Beatrice, a wind farm project that began with the world's largest wind turbines (its blades are each longer than a football field), "has cost $90 million—or about $9 million per megawatt of installed generating capacity. By comparison, a gas-fired power station costs less than $1.5 million per MW installed to build." Id. In 2004, wind turbines at Horns Reef, about 10 miles off the Danish coast, "broke down, their critical equipment damaged by storms and salt water. Vestas, a Danish manufacturer, fixed the problem by replacing the equipment at a cost of €38 million, or $50 million. But Peter Kruse, the head of investor relations for Vestas, warned that the lesson from Horns Reef was that wind farms at sea would remain far more expensive than those on land. 'Offshore wind farms don't destroy your landscape,' Kruse said, but the added installation and maintenance costs were 'going to be very disappointing for many politicians across the world.'" *See* "Denmark leads the way in green energy—to a point," James Kanter, *International Herald Tribune* (21 Mar. 2007) http://www.iht.com/articles/2007/03/21/business/green1.php.

‡ "Wind Power: Red Not Green," H. Sterling Burnett, Ph.D., NCPA Brief Analysis #467 (23 Feb. 2004) http://www.ncpa.org/pub/ba/ba467/. Roads might be gravel roads, as opposed to paved roads.

§ In addition to being killed by turbine blades, new research says that air-pressure changes, caused by wind turbines, cause bats' lungs to over-inflate, resulting in death. As reported by Montreal's *The Gazette*, "Their lungs fill with fluid and they can no longer breathe," says Erin Baerwald, of the University of Calgary, lead author of a report on bat deaths released by the journal *Current Biology*. According to *The Gazette*, "Biologists have also been at a loss to explain why the bats are dying. Baerwald, whose team has picked up as many as 188 dead bats a day at Summerview, says half the corpses show no outward sign of injury or contact with the blades. And some of the bats they find are still alive, but are unable to fly and have blood in their mouths and noses." *See* "Wind farms sucking life from bats," Margaret Munro, Canwest News Service (28 Aug. 2008) http://www.canada.com/montrealgazette/news/story.html?id=0394e643-9ce9-4b26-a115-21f31c6dd61d. *See* also "Wind turbines make bat lungs explode," Catherine Brahic, NewScientist.com (25 Aug. 2008) http://environment.newscientist.com/article/dn14593-wind-turbines-make-bat-lungs-explode.html.

> Among the birds killed there each year are protected raptors, including golden eagles, red-tailed hawks, American kestrels, and burrowing owls… The bird death issue is complicated by the fact that commercially viable wind farms must be situated in areas where the wind blows as frequently and steadily as possible. These locations tend also to be major flyways for raptors and migratory birds. Even worse, the farms can actually lure birds to their grisly deaths. Rats, mice, and other rodents utilize turbine bases as nesting grounds, which in turn attracts birds of prey. When the birds of prey circle above their intended meal, they are sliced to death in midair by the spinning turbine blades. The Audubon Society, a party to the lawsuit settled last year, noted among the birds deaths are between 456 and 1,129 raptors killed each year, including 75 to 116 golden eagles killed annually.[*]

Wind-farm proponents dismiss avian-death arguments as misleading. The AWEA writes,

> For every 10,000 birds killed by human activities, less than one death is caused by a wind turbine.
>
> Wind energy development's overall impact on birds is extremely low compared with other human-related activities. No matter how extensively wind is developed in the future, bird deaths from wind energy are unlikely to be ever more than a small fraction of bird deaths caused by other human-related sources, such as cats and buildings.
>
> Despite the minimal impact wind development has on bird and bat populations in most areas, the industry takes potential impacts seriously…avian studies are routinely conducted at wind sites before projects are proposed. Pre-construction wildlife surveys are now common practice throughout the industry.[†]

Lastly, an emerging issue is the possible negative impact of wind turbines on human health. *The Oregonian* reports,

> Dr. Nina Pierpont of Malone, N.Y., coined the phrase 'wind turbine syndrome' for what she says happens to some people living near wind energy farms. She has made the phrase part of the title of a book she's written called *Wind Turbine Syndrome: A Report on the Natural Experiment*.…Her research says wind turbines should never be built closer than two miles from homes.…Concerns also are coming out of Europe about low-frequency noise from newly built wind turbines. For example, British physician Amanda Harry, in a February 2007 article titled "Wind Turbines, Noise and Health," wrote of 39 people, including residents of New Zealand and Australia, who suffered from the sounds emitted by wind turbines. According to Pierpont, 8 of the 10 families in her study moved out of their homes.…Pierpont's research suggests 'everyone with pre-existing migraines' developed headaches by living near the wind.[119]

But correlation does not equal causation, and many are unconvinced by Pierpont's findings. Mike Logsdon, director of development for Invenergy, the company developing the wind farm highlighted in *The Oregonian* article, does not find Pierpont's findings credible.[‡] "We've had a

[*] "Altamont Pass Settlement Fails to Reduce Bird Kills," H. Sterling Burnett, *Environment & Climate News* (Mar. 2008) http://www.heartland.org/Article.cfm?artId=22774. Burnett references a lawsuit filed by environmentalists, citing a 2004 California Energy Commission report estimating 1,766 to 4,721 birds have been killed by Altamont wind turbines each over, over the 27-year life of the wind farm. The AWEA writes, "Raptor kills (of eagles, hawks, and owls) are a problem at one large older wind farm in California, in Altamont Pass, built in the 1980s. Wind farm operators there have worked with wildlife officials and experts to reduce the impacts on raptors, and those efforts continue today." *See* "Wind Power Myths vs. Facts," AWEA, http://www.awea.org/pubs/factsheets/050629_Myths_vs_Facts_Fact_Sheet.pdf.

[†] *Id.* For more information from the AWEA on the avian-death issue, *see* Mick Sagrillo's "Putting Wind Power's Effect On Birds In Perspective," http://www.awea.org/faq/sagrillo/swbirds.html.

[‡] For more on Dr. Pierpont's findings on wind turbine syndrome, *see* "Wind Turbine Syndrome," Dr. Nina Pierpont, Testimony before the New York Legislature Energy Committee (7 Mar. 2006) http://www.savewesternny.org/docs/pierpont_testimony.html. For more information on the potential adverse health impacts from wind turbines, *see* the Industrial Wind Action Group documents at http://www.windaction.org/documents/c43/.

number of other wind farms over the country and residents living by them and never had any problems," said Logsdon.[120] Moreover, no public health issue was raised during the planning process for the wind farms at issue.

Impact on Energy Supply and the Electric Grid

Perhaps the greatest virtue of wind energy, from a fuel-cost perspective, is that wind is free.[*] Combined with the financial help the PTC provides wind-energy developers (*see* Incentives/Subsidies section), the free nature of wind as a fuel source leads to wind energy's extremely low marginal cost; and considering the high cost of oil and natural gas—the latter being the dominant fuel source in Texas—wind as a free fuel source is highly attractive.[†]

But wind energy's impact on the fuel efficiency of conventional power sources must be considered. Power plants burn fuel most efficiently when operating at maximum generating capacity. David White writes that

> the accommodation of wind-generated power into the…power system is more complex than simply shutting down fossil-fuelled capacity whenever the wind happens to be blowing. Starting up and shutting down a power plant may take minutes or hours, depending on the type of plant, while power may be needed in seconds, and firm [always available] thermal generation cannot be treated in this way if the lights are to be kept on. Consequently, any calculation of the CO2 emissions reduction from wind must take into account the quantity of conventional generating capacity that has to be retained in varying states of readiness while the wind-generated power is taken into the grid.[‡]

In general, as more wind is added to the energy mix, conventional plants save on fuel costs, yet they sell less energy, and their costs per MWh go up. Consequently, they operate less efficiently and charge more per MWh. By contrast, the closer conventional plants operate to maximum capacity, the more efficiently they burn fuel and produce power.

Wind proponents also proffer that wind's contribution to the energy supply—no matter how large or small—directly substitutes for contributions from finite fossil fuels.[§] Paul Sadler points out that coal, natural gas, and petroleum are "finite resources"[121] and that every kilowatt of renewable energy, such as wind energy, prolongs the lifespan of fossil fuels.

* "Wind facilities, once constructed, have no fuel costs because the wind is free, and there is little in the way of maintenance expense." *See* "FPL Energy: Economics of Wind Energy," http://www.fplenergy.com/portfolio/wind/economics.shtml.

† "Wind is 'inflation-proof' – once a wind plant is built, the cost of energy is known, and is not affected by fuel market price volatility." See "The Difference Wind Makes," AWEA, http://www.awea.org/pubs/factsheets/The_Difference_Wind_Makes.pdf. For more on potential natural gas savings from employing more wind energy, *see* "Renewable Energy Can Help Alleviate Natural Gas Crisis: A National Renewable Electricity Standard Conserves Natural Gas, Reduces Natural Gas Prices, and Can Save Consumers and Businesses Money," Union of Concerned Scientists, http://www.ucsusa.org/assets/documents/clean_energy/NG_Impacts_Fact_Sheet-Final.pdf

‡ "Reduction in Carbon Dioxide Emissions: Estimating the Potential Contribution from Wind-Power," David White, Commissioned and published by the Renewable Energy Foundation (Dec. 2004) www.windaction.org/documents/225. "Thermal power stations constantly have to keep additional spinning [standby] reserve capacity equal to the maximum total power of windmills (e.g., for the case when too high wind speed stops full power operating windmills). This makes the thermal plants run inefficiently and increases fuel consumption (emissions)." *See* "Estimation of real emissions reduction caused by wind generators," O.Liik, R. Oidram, and M. Keel, Tallinn Technical University, 2003.

§ "Wind power is an affordable source of electrical energy, especially when developed in conjunction with the federal wind production tax credit. Unlike fossil fuel generation, much of the cost of wind power is for upfront capital expenses; fuel over the life of the wind plant is free. Wind energy prices may be locked-in for years with little exposure to risks such as environmental compliance, energy security or fuel price fluctuation. Wind power is a natural complement to existing electric generation; use of wind energy can save money for consumers and help extend the availability of precious fossil resources." *See* "Wind Power," The Wind Coalition, http://www.windcoalition.org/wind_power.php. "To generate the same amount of electricity as today's U.S. wind turbine fleet (16,818 MW) would require burning 23 million tons of coal (a line of 10-ton trucks over 9,000 miles long) or 75 million barrels of oil each year." See "The Difference Wind Makes," AWEA, http://www.awea.org/pubs/factsheets/The_Difference_Wind_Makes.pdf.

The Nuclear Option

Texas' role as the leading energy producing and consuming state in the nation offers the opportunity for Texas to significantly influence the national debate over the future of energy generation. The national debate today is largely centered on two things: how to generate electricity within the context of the concern over climate change and how to achieve energy independence from foreign oil.

Using compressed (and domestic) natural gas (CNG) to fuel our vehicles is one way that advocates promote to achieve energy independence. However, to do that without significantly increasing the cost of natural gas, we would need to reduce the amount of natural gas used to generate electricity. This is where wind comes in, as a replacement for natural gas in generating electricity.

Similarly, the Sierra Club believes wind energy should play an important role in generating electricity. However, they see wind as a replacement for coal. The Club's web site says "coal-fired power plants and the pollution they release every day are a major threat to human health and our environment. We need to act now to clean up dirty coal power through pollution reductions that can protect our families now, not in two decades. We also need to reduce our dependence on dirty coal by retiring and replacing these plants with clean energy alternatives like wind, solar, and improvements in energy efficiency."[122]

The problem with these proposals is that they ignore the costs and the lack of reliability of wind noted elsewhere in this study. We can never hope to achieve energy independence or address climate change concerns with wind energy.

Another option for achieving the same objectives is nuclear energy. William Tucker, the author of *Terrestrial Energy: How Nuclear Power Will Lead the Green Revolution and End America's Long Energy Odyssey*, points out that we can generate tremendous amounts of electricity from small quantities of fuel.

Of course, the big debate over nuclear energy is what to do with nuclear waste because, in the U.S., recycling nuclear waste is illegal. But Tucker says, "Basically, there is no such thing as 'nuclear waste.' … The French have complete recycling. So what's left when all this reprocessing is done? Essentially nothing. All of France's nuclear waste from 25 years of producing 75 percent of its electricity is stored beneath the floor of one room at Le Hague. The lifetime output for each French citizen would fit in a soda can. That's what the incredible energy density of nuclear power can do for the environment."[123]

Tucker makes the case that "Nuclear power is humanity's next great industrial advance. It's going to give us a whole new, clean source of energy that will scale to our industrial society. It will even give us enough electricity to convert our transportation sector to electric or hydrogen cars. It will free us from foreign oil, provide enough good jobs for tens of thousands of construction workers and highly skilled nuclear operators and engineers—and cure global warming as well!"

Once again, Texas is taking a leading role in the national energy debate as it pursues the nuclear option. Several plants are undergoing permitting or being considered for construction in Texas. But whichever direction we take in powering our future energy needs, we should let markets—rather than government mandates—lead the way.

– Bill Peacock, Director, Center for Economic Freedom

However, a kWh of electricity generated by wind does not necessarily displace a kWh from other sources. Due to the volatility and intermittency of wind, wind turbines must be backed up by conventional power sources, immediately ready to ramp up when wind power is inadequate for the grid. "This means that the unit(s) providing the backup service may be operating in an automatic generation control mode, running at less than peak capacity, and/or running in spinning reserve mode," says Schleede.[124]

Natural gas is a peak energy resource that can be brought online quickly, making it a prime backup resource for wind turbines.* Thus, most wind energy production will replace natural gas generation. However, the amount of gas-fired energy saved remains to be seen, because whether or not ERCOT will take all of the wind energy produced depends on installed wind capacity and how much wind the grid can accommodate. ERCOT will surely curtail wind generation, if necessary to maintain the reliability of the transmission system.

On a day-to-day basis, dispatchable (mostly natural gas) units will be required to make up the difference between what wind units generate and what ERCOT predicts (12-24 hours in advance) these units will generate. Some of these units will need to be on-line (i.e., committed) resources operating at minimum capacity, while others, mostly quick-start units, may be off-line. Schleede writes, "Depending on wind conditions, the amount of backup capacity may have to equal the peak capacity of a 'wind farm.' That is, if wind conditions exceed the cutout speeds,† the entire output of the 'wind farm' could be lost."[125]

Additionally, as stated in GE Energy's ancillary services study for ERCOT, "Addition of wind generation resources increases the amount of variability and unpredictability that must be addressed in system operations."[126] Thus, as more wind is added to the ERCOT grid, more ancillary services are needed.

ERCOT's ancillary services include the following:

- Responsive Reserve: Also known as "spinning reserve," responsive reserve is capacity set aside for certain extreme situations. Under this ancillary service, ERCOT buys unused capacity from generators.
- Balancing Energy: Under this ancillary service, ERCOT buys from generators energy needed for the grid.
- Regulation: This is the ability of a generator to ramp up and down with load. The amount of regulation ERCOT needs will depend upon such factors as the availability of quick-start units, the scheduling of thermal resources (e.g., natural gas and coal), the amount of electricity storage, the responsiveness of loads, and the ramping capability of existing thermal resources.
- Non-spin Service: Under this ancillary service, generators agree to provide a certain amount of energy to the ERCOT grid within 30 minutes.
- Black Start: This is the capability of a generating unit to come online when the grid is down (i.e., blackout).

More ancillary services are needed as wind is added to the grid because the ability to forecast energy load is better than the ability to forecast wind generation. Since generation must equal load at all times, the more wind energy a grid utilizes, the more backup generation it needs in case of an emergency situation.‡

* Bridget Mintz Testa writes, "That capacity can't be coal or nuclear, because 'quick' is not in those facilities' start-up or shutdown vocabularies. Instead, additional natural gas facilities, which can start and stop fast, would have to take up the slack, 'almost megawatt for megawatt,' (Bill) Bojorquez said. New wind power in Texas might increase total available megawatts, 'but it's not a great help in terms of having to build other sources for peak load and for following the wind,' Bojorquez said." *See* "Wind in a Bottle," Bridget Mintz Testa, *Mechanical Engineering Magazine* (May 2008) http://www.memagazine.org/contents/current/features/windina/windina.html.

† Cutout speeds are the high wind speeds at which wind turbines automatically shut down, in order to avoid damage to the turbines.

‡ "Unlike conventional generation, the electrical output of wind generation plans cannot be dispatched" but rather "is inherently variable and imprecisely predictable. Thus, addition of wind generation resources increases the amount of variability and unpredictability that must be addressed in system operations." *See* "Executive Summary: Analysis of Wind Generation Impact on ERCOT Ancillary Services Requirements," GE Energy (28 Mar. 2008). To access the GE Ancillary Services Study, *see* http://www.ercot.com/content/news/presentations/2008/Wind_Generation_Impact_on_Ancillary_Services_-_GE_Study.zip.

The addition of wind to the ERCOT grid also potentially jeopardizes ERCOT's ability to maintain its 12.5-percent reserve margin, which is ERCOT's standard measure of available capacity above the capacity needed to meet ERCOT's normal peak demand levels. As more wind comes online, conventional power plants lose energy sales. As ERCOT is an energy-only market—where producers are paid for generation and ancillary services, rather than for building capacity—the question becomes whether conventional sources will lose enough in energy sales to cause them to curtail their building of the additional capacity needed to maintain reserve margins.

Furthermore, in a rapidly-growing state with increasing energy needs, the building of wind farms does not eliminate the necessity of building new conventional—and replacing outdated—power sources. Given Texas' expanding population and energy needs and the limitations of current technologies, in order to supply Texans with affordable, reliable energy, Texas must build coal, natural gas, and nuclear power plants. Wind is an energy supplement, not a replacement.

Job Creation

Finally, wind-energy development in Texas will undoubtedly create both temporary and non-temporary jobs.[*] NREL estimates that 6 to 10 permanent operations-and-maintenance jobs and 100 to 200 short-term construction jobs are created for every 100 MW of installed wind capacity.

However, it remains to be seen whether wind-energy development will result in a net gain in employment in Texas. For example, overreliance and overinvestment in wind energy might lead to the non-replacement of old conventional power plants or to the foregoing of building new conventional power plants. The resulting higher energy prices for businesses and consumers could lead to a net loss in employment, negating whatever employment benefits increased wind energy production might have.

The Texas Comptroller writes, "As with other energy projects, wind projects can strengthen rural economic development by bringing economic activity to areas of the state with few other industries."[127] Often, the significant investment in wind turbines in rural locations provides much-needed ad valorem tax revenues for schools,[†] cities, and counties.

Policy Recommendations

Energy Prudence and Realism

- Delay further legislative renewable-energy mandates, insofar as (1) the complete costs of renewable technologies are currently unknown, (2) large-scale wind power's impacts on the electric grid are unknown, and (3) current technology does not allow for commercial storage of electricity. A more measured, calculated approach to meeting energy demand—after performing exhaustive accountings of wind energy's true costs, both in terms of costs to electric ratepayers and in terms of grid management—is necessary to ensure Texas continues to have a reliable supply of electricity at the lowest possible cost to consumers.

[*] *See* "Wind Energy Update" (Page 22), Larry Flowers, National Renewable Energy Laboratory (23 Jan. 2008) http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/wpa/wpa_update.pdf. Also, Vestas Wind Systems, the world's top supplier of wind turbines, is opening its North American research center in Houston. The Danish company says the center will be operating within two years and will create about 100 jobs. *See* June 2, 2008, Vestas press release, http://www.vestas.com/files//Filer/EN/Press_releases/VWS/2008/080602-PMUK-06.pdf.

[†] SECO writes, "Texas schools earn millions on wind generated on state land, depending on how many megawatts are produced and the current price of electricity. Texas schools benefit from the increase in wind farms, because like oil and gas production on state lands, wind farms on state lands are required to pay land usage fees plus a portion of revenues to the State's Permanent School Fund, which is constitutionally dedicated to the schoolchildren of Texas. The wind industry is creating thousands of jobs and millions of dollars in royalty income for landowners, for communities and for the Texas Permanent School Fund. From only one wind farm located on state land in West Texas (Texas Wind Power Project), the Permanent School Fund has earned more than $750,000 since installation in 1995. The project is expected to earn more than $3 million for state schools and create $300 million in increased economic activity over the 25-year lease period." *See* "Texas Wind Energy," State Energy Conservation Office, http://www.seco.cpa.state.tx.us/re_wind.htm.

Energy Neutrality

- Government should not pick energy-supply winners and losers. The federal government's ethanol mandate and Texas' mandate that 50 percent of new generation come from natural gas are but two examples of why government's picking fuel-supply winners is a flawed policy, as corn-based ethanol and rising natural gas prices have contributed to higher food costs (nationally and globally) and higher electricity rates (statewide), respectively.

  - Repeal the Renewable Portfolio Standard (SB 20),[128] and do not pass additional RPS mandates. No new renewable mandates should be placed on Texas' energy producers. Texas' RPS has clearly done its job of spurring wind-energy investment, as Texas is now the nation's leader in installed wind-power capacity.

  - Repeal the Natural Gas Mandate. Section 39.9044 of Senate Bill 7,[129] Texas' mandate that 50 percent of new generation come from natural gas, should be repealed. It is a perfect example of why government's picking fuel-supply winners is a flawed policy. Though natural gas prices were low when SB 7 was passed in May 1999, prices have roughly quadrupled since.[130]

- The PUCT should not grant wind generators—or any power generators—automatic dispatch priority on CREZ lines. Such favoritism violates energy neutrality and replaces the market's superior ability to allocate resources most efficiently. The goal of PUCT Project #34577[131] should be to dispatch power according to generators' abilities to provide reliable and affordable electricity. In considering affordability, all of the costs that an energy resource places upon the grid and, thus, upon ratepayers, should be taken into account when determining how big a slice of the transmission-capacity pie a certain generator receives.

- Repeal PURA Section 35.004(d), under which transmission costs are distributed among all ERCOT load-serving entities, in proportion to their relative load (a.k.a. postage-stamp allocation).[132] This cost-sharing regime should be replaced by a system whereby companies that add costs to the electric grid—whether via wind, solar, coal, nuclear, natural gas, or any other fuel source—should alone bear these costs. Costs incurred from building new wind-transmission lines and keeping generation facilities ready to back-up wind-generation facilities should be paid by the wind-energy producers responsible for these costs. This will provide the energy market and electric consumers with a more accurate cost of wind energy.

Conclusion

Wind power is, and will continue to be, part of Texas' energy supply; but as Texas' population and energy needs grow, the key question is what role wind should play in the energy-supply mix. Wind, like every other energy resource, has its pros and cons, and there is no doubt that wind power should be part of Texas' energy supply. Texas needs myriad resources, as well as concerted efforts at conservation and efficiency, in order to meet its energy needs.

However, Texas' policymakers must thoroughly examine both the benefits and limitations of wind energy, particularly issues of reliability, transmission, and cost. As opposed to getting ahead of markets and technology, wind energy should be employed to the extent technologically feasible and economically worthwhile. Instead of subsidizing and incentivizing private wind development and imposing billions of dollars in new transmission costs upon retail electric customers, Texas' policymakers should step back and allow the energy marketplace, free from government interference and subsidy, to bring wind power online when the market is ready.

Wind power is not an energy-supply panacea but rather a supplement with the potential to play a beneficial role in Texas' energy mix for years to come. With proper restraint from policymakers and with proven technology and cost-efficiency leading the way, wind will find its appropriate place in, and become an increasingly important part of, Texas' diversified energy portfolio. Texas' electricity consumers will reap the benefits of such a prudent path.

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Appendix: Calculating the True Cost of Wind Energy

The three major subsidies for the Texas wind industry are: 1) the building of transmission lines through the Competitive Renewable Energy Zones (CREZ) process, 2) the Production Tax Credit (PTC), and 3) Renewable Energy Credits (RECs).

Table 1 shows the calculation of the cost of these subsidies. The costs of RECs, the PTC, and CREZ construction were calculated through 2025 because this is the year that the Texas Legislature set for reaching the target installed capacity for wind generation of 10,000 MW. Additionally, it is a short enough time frame to ensure a reliable estimate, and yet long enough to help portray the cumulative impact of wind energy subsidies on Texas consumers and the Texas economy.

Table 1: Calculation of Wind Energy Subsidies

Renewable Energy Credits				Production Tax Credits			CREZ Costs	Total	TX Total	TX Consumer Total
Year	Target	RECs	REC Cost	MWhs	PTC Credit	PTC Cost				
2008	2280	6,431,242	28,940,587	13,000,000	0.0200	260,000,000		288,940,587	50,855,869	28,940,587
2009	3272	9,229,396	41,532,281	13,894,541	0.0204	283,448,640		324,980,921	65,424,038	41,532,281
2010	3272	9,229,396	41,532,281	14,789,082	0.0208	307,731,226		349,263,507	67,470,806	41,532,281
2011	4264	12,027,550	54,123,975	15,683,624	0.0212	332,871,735	331,500,000	718,495,711	413,681,583	385,623,975
2012	4264	12,027,550	54,123,975	16,578,165	0.0216	358,894,773	663,000,000	1,076,018,748	747,375,053	717,123,975
2013	5256	14,825,704	66,715,669	17,472,706	0.0221	385,825,583	994,500,000	1,447,041,252	1,093,736,733	1,061,215,669
2014	5256	14,825,704	66,715,669	18,367,247	0.0225	413,690,068	1,326,000,000	1,806,405,737	1,427,585,417	1,392,715,669
2015	5880	16,585,834	74,636,251	19,261,788	0.0230	442,514,802	1,326,000,000	1,843,151,053	1,437,935,623	1,400,636,251
2016	5880	16,585,834	74,636,251	20,156,329	0.0234	472,327,049	1,326,000,000	1,872,963,300	1,440,448,484	1,400,636,251
2017	6704	18,910,107	85,095,481	21,050,871	0.0239	503,154,780	1,326,000,000	1,914,250,261	1,453,506,169	1,411,095,481
2018	6704	18,910,107	85,095,481	21,945,412	0.0244	535,026,690	1,326,000,000	1,946,122,171	1,456,192,638	1,411,095,481
2019	7528	21,234,380	95,554,711	22,839,953	0.0249	567,972,214	1,326,000,000	1,989,526,925	1,469,428,831	1,421,554,711
2020	7528	21,234,380	95,554,711	23,734,494	0.0254	602,021,548	1,326,000,000	2,023,576,259	1,472,298,833	1,421,554,711
2021	8352	23,558,653	106,013,940	24,629,035	0.0259	637,205,667	1,326,000,000	2,069,219,608	1,485,723,717	1,432,013,940
2022	8352	23,558,653	106,013,940	25,523,576	0.0264	673,556,342	1,326,000,000	2,105,570,283	1,488,787,699	1,432,013,940
2023	9176	25,882,927	116,473,170	26,418,118	0.0269	711,106,162	1,326,000,000	2,153,579,332	1,502,411,986	1,442,473,170
2024	9176	25,882,927	116,473,170	27,312,659	0.0275	749,888,552	1,326,000,000	2,192,361,722	1,505,680,936	1,442,473,170
2025	10000	28,207,200	126,932,400	28,207,200	0.0280	789,937,795	1,326,000,000	2,242,870,195	1,519,515,898	1,452,932,400
Total			1,436,163,947			9,027,173,625	17,901,000,000	28,364,337,571	20,098,060,310	19,337,163,947

For more on the costs of wind energy, please see the Foundation's publication, "The True Cost of Wind Energy" at www.texaspolicy.com.

About the Author

Drew Thornley, policy analyst in the Center for Economic Freedom and the Center for Natural Resources, joined the Foundation in September 2007.

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