FEATURES

Wind Farms—A Valuation Primer

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ABSTRACT

Wind farm development requires acres of land per megawatt of electrical power generated. Real estate appraisers already play an important role in the land entitlement process, but is there a financeable asset once these capital-intensive projects are built? This article is intended as a primer for real estate appraisers who may be asked to assist in siting or valuing large, utility-scale renewable energy projects. The implications of public policy, including Renewable Portfolio Standards (RPSs) and other mandates or incentives, are examined.

Wind power is in a class by itself as the greatest terrestrial medium for harvesting, harnessing and conserving solar energy.

R. Buckminster Fuller[1]

This article addresses the real estate implications of renewable energy policy, with a focus on the maturing technologies evidenced by large, utility-scale wind projects being built today. It also discusses infrastructure challenges that may impede comprehensive conversion of this resource into electric power.

Environmental considerations aside, two economic facts can be said to drive energy policy in the United States: (1) we lead the world in consumption of energy, and (2) we no longer are self-sufficient in meeting our energy needs. Consumption will only grow, but reliance on fossil fuels creates climate concerns and leaves the United States hostage to the vagaries of world oil markets.[2]

The preferred solution for policy makers, in alliance with an increasingly influential environmental lobby, is development of renewable sources of energy.[3] Wind energy farms now account for over 35 gigawatts (GW) of electrical power generation in the United States, and 2009 saw a record number of turbine installations. However, in terms of overall power generation, installed wind projects have barely achieved 1.5% of domestic power generation.

The U.S. Department of Energy (DOE) published its *20% Wind Energy by 2030* study in 2008. The study examined the feasibility of setting a national goal of using wind energy to generate at least 20% of the nation's electricity consumption by 2030. This goal represents a ten-fold increase in wind energy generating capacity (to over 300 GW).[4] While the wind resource is available on land and offshore, serious transmission and supply-chain constraints must be overcome to achieve that goal.[5]

This article will first give an overview of the wind industry, describe how wind farms work, and then explore how the larger utility-scale projects can be valued as a specialized real estate use.

1. *New York Times*, January 17, 1974.
2. U.S. Department of Energy, *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply* (July 2008), available at http://www1.eere.energy.gov/windandhydro/printable_versions/wind_2030.html.
3. Ibid., 226. *Renewable energy* is energy derived from resources that are regenerative or that cannot be depleted. Types of renewable energy resources include wind, solar, biomass, geothermal, and moving water.
4. Ibid.
5. Ibid., 76.

Overview of the Economics of the U.S. Wind Industry

The history of wind farm development in the United States cannot be understood without recognition of the role of public policy in shaping demand. The contribution of real estate to the generation of wind energy is a necessary, but somewhat incidental component to the process.

The U.S. wind energy business got its start in California during the 1970s when spikes in oil prices forced policy makers to look for alternative fuel sources. In the intervening forty years, the wind industry has continued to be driven by federal policies that offer significant financial incentives for its development. This public policy is supported by national goals to achieve energy independence, coupled with environmental goals to reduce the U.S. carbon footprint in a time of concern over climate change. However, growth in the wind energy business is very much contingent on government funding.

Limited wind farm development proceeded apace (thanks to tax credits) beginning in the 1980s, but stalled through the 1990s when electric utility restructuring disrupted energy pricing and the tax credit programs began to expire.[6] Since 1999, however, installed wind capacity has grown every year. The American Wind Energy Association (AWEA) provides a graphic snap shot (Figure 1) of installed wind power over the past decade (2000—2009).

Capital Costs and Tax Credits

Absent significant tax credits—Investment Tax Credits (ITCs) or Production Tax Credits (PTCs)—it is unclear to what extent pure market forces would have propelled utility-scale wind energy production to compete with fossil fuels. In essence, while the fuel, i.e., wind, is free, the capital costs to build wind farms are significant.

An alternative financing mechanism used in parts of Canada is the Feed-in Tariff (FIT). Under a FIT system, regional or national electricity companies are obligated by governments to buy renewable electricity (electricity generated from renewable sources such as solar photovoltaics, wind power, biomass, and geothermal power) at above-market rates. These rates differ between the different forms of power generation, depending on the capital cost and commercial maturity of each technology. At this date and given the weak post-recessionary economy, surcharging electricity rates to pay for renewables is a tough sell to consumers.

Capital costs to build utility-scale wind, on a dollar per megawatt basis ($/MW) of electrical power produced, still exceed capital costs for conventional thermal power plants (burning coal or natural gas).[7] Electricity generated by offshore wind may come on line in the United States as early as 2012, but its costs are significantly higher than onshore farms.

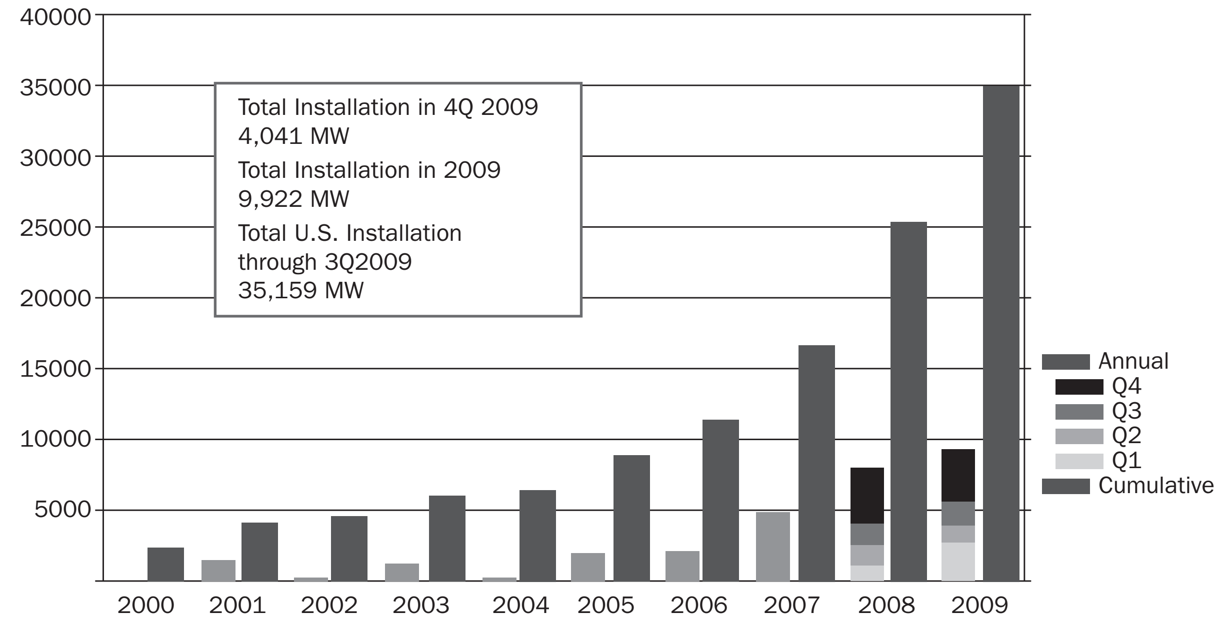
Figure 2 shows the relative ranges of cost per kilowatt hour ($/kW) for different power sources. The light shaded block show the cost ranges 2003—2004 compared with costs for similar facilities in 2008. Wind costs have not increased as much. Further, the graph shows how wind is less expensive per kW than solar or other renewables, and it is becoming competitive with some types of thermal. However, it should be noted, almost all forms of energy production are supported by some type of federal incentive or special government regulation (from oil-depletion allowances to the monopsony[8] status of many public utilities).[9]

Throughout the Industrial Revolution and well into the late-twentieth century, falling or moving water was the dominant renewable energy resource exploited in the United States. Today, hydroelectric power accounts for about 7% of electricity generated nationwide.[10] While the energy source—flowing water—is free and replenished naturally by rain and snows, the costs for new dams and reservoirs now seem prohibitive. Although only about 30% of the hydrocapacity for generating electricity has been tapped, most hydropower projects today are aimed at reducing marine impacts and improving efficiencies with turbine designs. Because of the costs to mitigate environmental concerns and the multiple purposes served by hydroelectric dams (including flood control, irrigation and recreation) no direct cost comparisons are available for this energy resource.

Figure 3 illustrates how tax credits and their expirations have periodically slowed wind farm development. Conversely, in 2009 there was a spike in

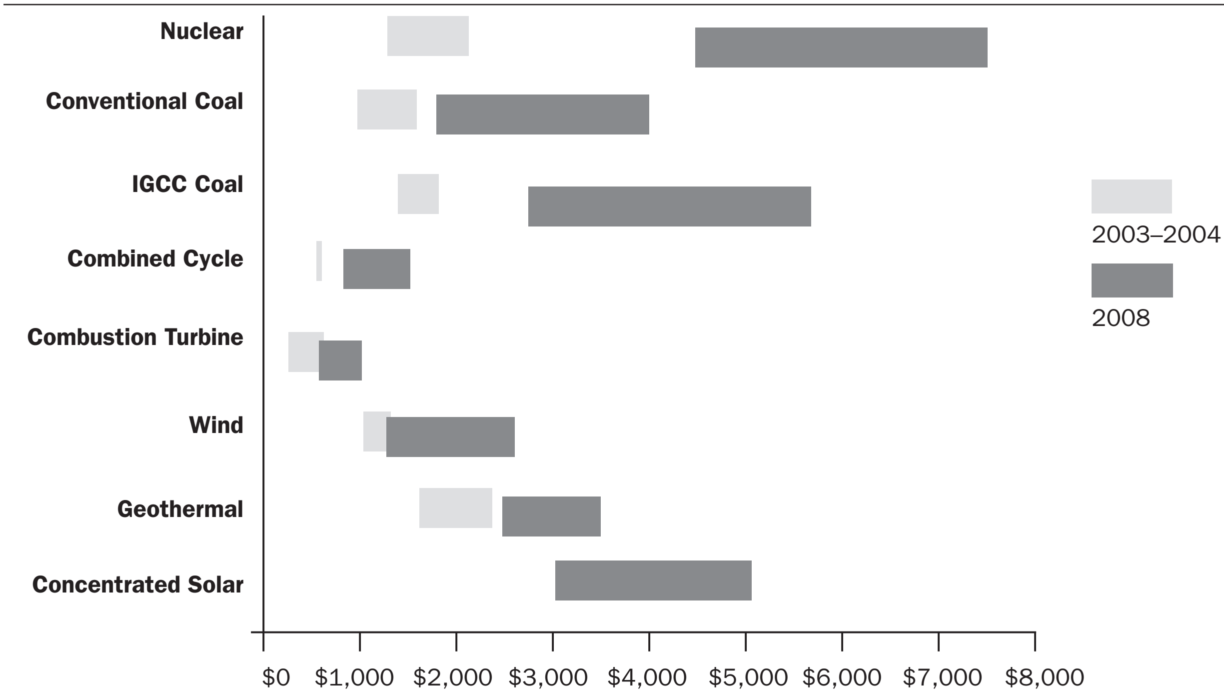
6. Steven J. Herzog, "Wind Energy: Power and Policy," *The Appraisal Journal* (January 1999): 24–28.
7. Ibid.
8. Used in this context, a *monopsony buyer* refers to a single buyer seeking the goods or services of several sellers. Thus, a utility company may have a choice as to what kind of energy resource to use.
9. Hydroelectric power costs are not shown in Figure 2 because there have been few, if any, permitted electric power generating dams in past thirty years in the United States, due largely to a prohibitive environmental permitting process.
10. U.S. Geological Survey, http://ga.water.usgs.gov/edu/wuhy.html.

Figure 1 Growth in U.S. Wind Industry, 2000-2009



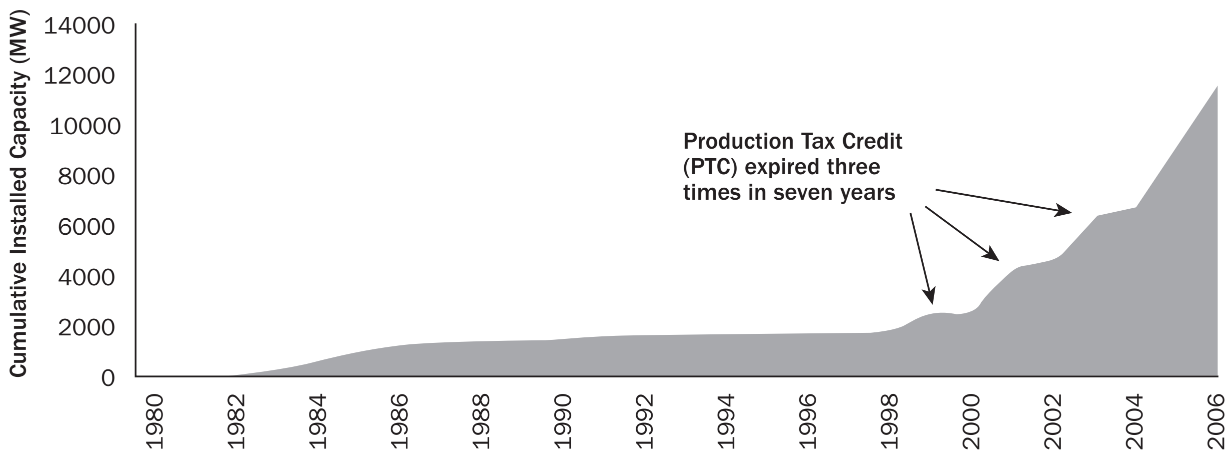
Source: Ron Lehr, "Project Economics Overview" (AWEA Wind Power Siting Workshop, Denver, Colorado, February 17—18, 2010).

Figure 2 Estimated Capital Cost of New Generation



Source: Federal Energy Regulatory Commission, *Increasing Costs in Electric Markets* (staff report, June 19, 2008), 11.

Figure 3 Estimated Capital Cost of New Generation



Source: U.S. Department of Energy, *20% Wind Energy by 2030,* 5.

new wind farm construction as a result of the extension of the Production Tax Credit through 2012 as part of the 2009 Recovery Act/Stimulus Bill. New utility-grade installations at the end of 2009 had increased total installed capacity in the United States by nearly 14%.

Renewable Energy Standards

While federal tax credits are designed to support the supply of renewable energy projects such as utility-scale wind projects, the Renewable Portfolio Standards (RPSs; also referred to as Renewable Energy Standards), ensure demand.

Although the goals of RPSs may vary from state to state, in general they require retail electricity suppliers and load-serving entities (i.e., utility companies) to purchase a minimum quantity of eligible renewable energy. These standards promise to stabilize the renewable energy industry by ensuring threshold levels of demand at the state level. Figure 4 shows which states have renewable energy mandates, and Table 1 summarizes the RPS provisions by state.

Of the states that have adopted mandatory RPSs, the performance goals as a percentage of electricity sales vary from 10% by 2015 in Michigan and North Dakota to 40% in Maine by 2017. California had a 20% goal by 2010 and is struggling to expand its transmission capacity amidst a state government fiscal crisis. Most states that have adopted RPS have set a 20%–25% goal within a ten- to fifteen-year time frame.[11]

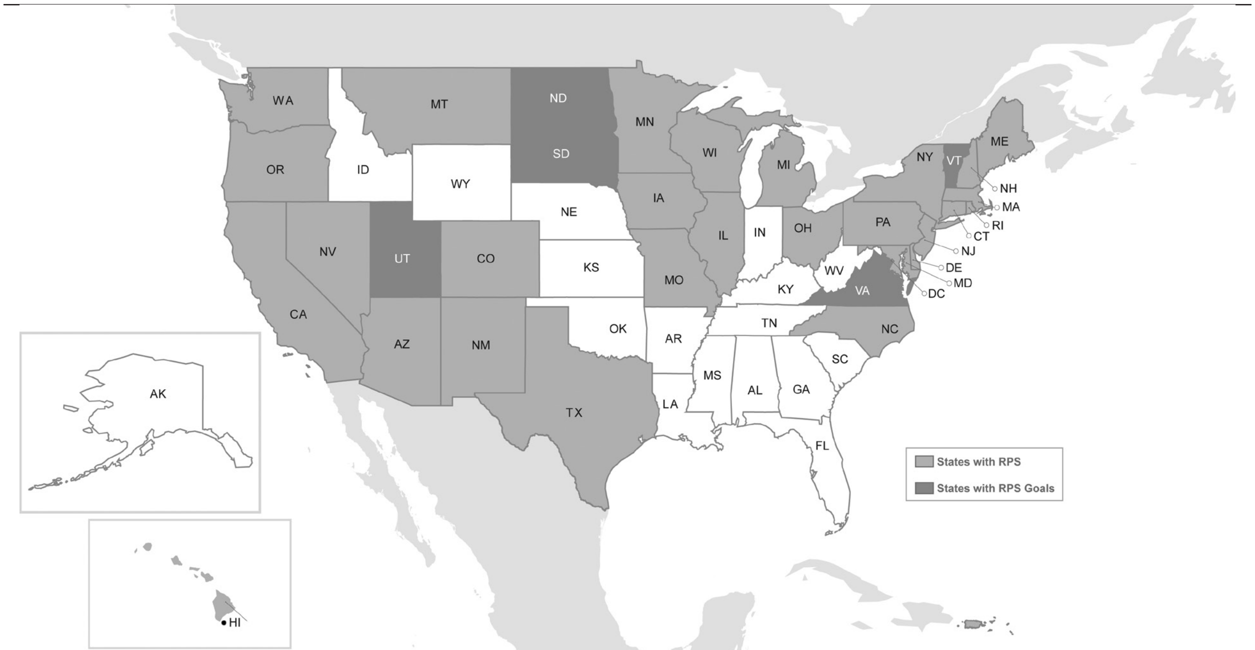
Compliance with an RPS entails owning a facility or its output generation, purchasing a Renewable Energy Certificate, or purchasing bundled renewable electricity. RPS requirements are most commonly applied to investor-owned utilities and electric service providers. It is unusual for mandatory RPS requirements to extend to municipal utilities and cooperatives, as these entities are predominately self-regulated. However, some states have included provisions for municipal utilities and cooperatives to voluntarily join the RPS program or to self-certify.

What qualifies as *renewable energy* for utility-scale projects? Although specific statutes vary from state to state, renewable energy generally includes the following:

- Wind energy, with electricity generated by farms or clusters of wind machines referred to as turbines.
- Solar energy; solar technology varies and is maturing, but utility-scale projects typically rely on photovoltaic devices, often arrayed as ground or roof-mounted panels.
- Geothermal energy, which relies on hydrothermal resources, concentrated in California, Alaska, and Hawaii.
- Biomass energy from wood, corn, landfill gases, garbage, and ethyl-alcohol fuels; this still uses nascent technology and is not necessarily energy efficient.
- Water energy (hydropower); wave action offshore power production is in this classification but is still experimental.

11. U.S. Environmental Protection Agency, *Renewable Portfolio Standards Fact Sheet*, available at http://www.epa.gov/chp/state-policy/renewable_fs.html.

Figure 4 **States with Renewable Portfolio Standards Requirements**



Source: Database of State Incentives for Renewable Energy (DSIRE) last accessed March 2009, www.dsireusa.org

Wind and solar power, while accounting for only a fraction of renewable energy produced in the United States today, encumber a significant amount of real estate. Solar panels, arrayed on rooftops or groundmounted, consume six to ten acres of land per megawatt (MW) of potential or nameplate power generated.[12] Although a wind turbine platform and its network of access roads will actually displace less than one percent of the land taken up for staging, the wind developer may need 50 to 100 acres per MW, depending on the topography and how the wind blows.

Thus, solar photovoltaic projects will consume hundreds of acres to achieve utility-scale efficiencies, whereas wind farms encumber acreage by the thousands. Nevertheless, building photovoltaic projects cost $3 to $5 million per MW of installed power,[13] while wind turbine manufacturers indicate installed costs of $1 to $2 million dollars per MW.

The Department of Energy (DOE) reports that wind power now represents the second largest new source of electric capacity additions to the United States; wind trails new natural gas plant development, but is ahead of coal. In 2009, the United States was second in the world behind China in new installations, with 9,922 MW added. For perspective, at an average nameplate rating of 1.75 MW per turbine installed approximately 5,600 machines were installed in the United States in 2009.

According to DOE, in order for the United States to meet the goal of 20% wind power by 2030, it is necessary to install 7,000 wind turbines per year. Implementation would require a robust supply chain, new transmission, a skilled workforce, and a compressed permitting period. However desirable, achieving this goal must be considered problematic, because the nation has yet to address transmission congestion and lack of transmission capacity.[14] Transmission, typically via a network of overhead

12. The Department of Energy defines a *nameplate rating* as the maximum continuous output or consumption in megawatts (MW) of an item of equipment as specified by the manufacturer. In fact, the actual output may be less. For example, a 2 MW rated wind turbine may only generate 30% of its nameplate capacity over time, based on the variability of wind and many other factors. A nameplate is physically attached to the equipment indicating its capacity.

13. Paul Wormser, Senior Director, Engineering, SHARP Electronics Corp.

14. See Andrew Mills, Ryan Wiser, and Kevin Porter, *The Cost of Transmission for Wind Energy: A Review of Transmission Planning Studies* (Ernest Orlando Lawrence Berkeley National Laboratory, February 2009).

Table 1 Renewable Portfolio Standards Requirements

State	Target (% of electricity sales)	Specific Provisions (% of electric sales)
AZ	15% by 2025	4.5% by 2012 from distributed energy resources
CA	20% by 2010	
CO	IOUs† 20% by 2020; electric cooperatives and municipal utilities 10% by 2020	IOUs 0.4% solar by 2020
CT	27% by 2020	4% energy efficiency and CHP‡ by 2010
DC	20% by 2020	0.4% solar by 2022
DE	20% by 2019	2.005% solar by 2019
HI	20% by 2020	
IA	105 MW by 2025	
IL	25% by 2025	18.75% wind by 2013
MA	Class I: 4% by 2009 (+ 1%/year after); Class II: 3.6% renewable, 3.5% waste energy by 2009; APS: 5% by 2020 increasing by 0.25% each year after.	Class II: 3.6% renewable, 3.5% waste energy by 2009
MD	20% by 2022	2% solar by 2022
ME	30% by 2000; 10% new by 2017	
MI	10% by 2015	
MN	Xcel Energy (utility) 30% by 2020; other utilities 25% by 2025	Xcel Energy: 25% wind
MO	15% by 2021	0.3% solar retail sales by 2021
MT	15% by 2015	
ND*	10% by 2015	
NH	23.8% by 2025—16.3% new	0.3% solar by 2025
NJ	22.5% by 2021	2.12% from solar by 2021
NM	IOUs 20% by 2020; rural electric cooperatives 10% by 2020	Wind: 4%; solar: 4%; biomass and geothermal: 2%; distributed renewables: 3% by 2020 (IOU only)
NV	20% by 2015	1% solar by 2015
NY	24% by 2013	0.154% customer-sited by 2013
OH	25% by 2025 (12.5% renewable energy)	1% solar by 2025
OR	Large utilities (>3% state's total electricity sales) 25% by 2025	Smaller utilities 5–10% by 2025 (depending on size)
PA	18% by May 31, 2021 (8% renewable energy)	0.5% solar by 2025
RI	16% by 2020	
SD*	10% by 2015	
TX	5,880 MW by 2015	At least 500 MW from renewables other than wind
UT*	20% by 2025	
VA*	12% of 2007 sales by 2022	
VT*	20% by 2017; total incremental energy growth between 2005–2012 to be met with new renewables (10% cap)	
WA	15% by 2020	
WI	10% by December 31,2015	

* States with RPS goals that are not mandatory requirements. See, Database of State Incentives for Renewable Energy (DSIRE), accessed March 2009, http://www.dsireusa.org.

† Investor-owned utilities

‡ Combined heat and power

power lines linked to substations, is how power is moved from its source to the load. The longer the distance, the higher the transmission cost. Transmission planning studies are being pursued by public and private interests, but funding such a new green highway remains unresolved.

Entitlement: Land Use and Siting Challenges for Wind Farms

The successful entitlement of land[15] for wind farm development requires a lengthy and collaborative process where real estate consultants, if not appraisers, may play an important, albeit peripheral role. Appraisers are often asked to participate in the permitting process when expert opinion is necessary to advise siting authorities on local property value impacts.

Three geographic characteristics will dictate placement of utility-scale renewable energy projects: (1) availability of the resource, (2) availability of land, and (3) proximity to the power grid. Since, solar takes less land and is seen as less obtrusive than wind, the appraiser or real estate valuation consultant will more likely encounter the challenges of siting a utility-scale wind project rather than a solar project.

The availability of consistent winds as a resource has been mapped by DOE. The best winds are typically found offshore the coasts and in the Great Lakes. Offshore wind has been successfully developed in Europe, but poses significant environmental concerns that have yet to be resolved in the United States. The best land-based wind sites within the United States run from Texas through the Great Plains. As mentioned, the big challenge in deploying more wind energy across the central United States is transmission capacity, a topic beyond the scope of this article.

Assuming the wind, land, and connection to the grid have been identified, a complex array of environmental, aviation, and land use challenges must then be resolved before a site can be entitled for a wind farm. Wind farm developers will generally tie up the land through acquisition or contingent leases, but may still need expert real estate appraiser opinions on whether the proposed wind farm will adversely affect surrounding property values.[16]

Wind Farm Valuation Scope of Work

Utility-scale wind farms are occasionally bought and sold, but not as real estate investments. Most sales involve an enterprise laden with intangibles. Projects may include a future pipeline with entitled capacity, and of most importance, power purchase agreements (PPAs), whereby a utility has committed to buy the power that the wind farm may generate. The PPA is a long-term contract and often at a fixed rate. Once a PPA is in place, investors will seek to monetize such an asset.

Monetizing an installed wind farm raises the issue, is this real estate, personal property, or an enterprise that includes intangibles?

While installed wind turbines are properly considered machines, they are attached to the land and have useful economic lives of 20–25 years (with routine maintenance). This poses an interesting question for tax-assessing jurisdictions. Most assessors rely on the cost approach for special purpose properties.

Some states do not assess personal property, but developers might agree to a pilot program or payments in lieu of taxes, in exchange for siting entitlements. In Illinois agreements are made county by county, so that a developer might pay property tax based on a fixed percentage of cost.

But even if the turbines are considered personal property, what becomes the highest and best use of the land? As an enterprise or business, can a case be made that an entitled wind farm generates a residual return to the land that may eclipse land value in its alternate use (typically agricultural)? In fact, energy land sales in Southern California have established significant premiums for entitled tracts slated for solar development and in close proximity to transmission capacity.

This section of the article will discuss the valuation issues and suggest a cash flow analysis as a starting point to address feasibility, if not highest and best use. The typical assumptions and data needs of the appraiser or valuer are identified. It must acknowledge that this is an enterprise valuation where the real estate is incidental to the PPA and other exogenous incentives that may be in play. However, under defined circumstances, a positive present value (PV) generated by the model might be construed as a premium attributable to entitlements, if not a land residual.

15. As used here, *entitlement of land* refers to the securing of rights to use or develop the land through the permitting process. Entitlements are transferable and have value.

16. See Ben Hoen, et al., *The Impact of Wind Power Projects on Residential Property Values in the United States: A Multi-Site Hedonic Analysis* (Ernest Orlando Lawrence Berkeley National Laboratory, December 2009). See also P. Barton DeLacy, "A LULU of a Case: Gauging Property Value Impacts in Rural Areas," *Real Estate Issues* (Fall 2004): 13–20.

Case Study

For illustration, assume there is a hypothetical proposed utility-scale wind farm with the following attributes:

- 10,000 acre site in rural area, where third-party engineering studies have confirmed sufficiency of the wind resource, suitable topography, and feasible tie-in to a regional power grid.
- Entitlement for wind; often the necessary studies are commissioned simultaneously and may take one to two years to complete, so the appraiser will have to assume a permit as an extraordinary assumption.
- 200 MW nameplate capacity, requiring placement of one hundred 2.00 MW turbines. Turbine sizes today vary from 1.5 to 3.0 MW, with hub heights between 280 and 300 feet. (See Figure 5 for example.)

A discounted cash flow model provides the best tool to test feasibility. Key inputs include:

- Land cost
- Construction costs, including site entitlements studies, off-site costs, and installed costs of wind turbines
- Any ITC or PTC offsets or other subsidies
- Permitting and construction schedule
- Projected installed power output and projected PPA rate
- Reversion

The appraiser can now run the model and test for feasibility. But be careful, even with a PPA in place (the long-term agreement to buy generated power), the present value may not be positive without significant subsidy for the up-front capital costs.

The Highest and Best Use Investigation

No matter whether the valuation is of the underlying land alone, or of the project as an enterprise, the valuer must analyze the highest and best use (HBU) of the site. Does the proposed site have unique attributes that make it particularly well-suited for a wind project? Such an analysis will rely heavily on technical studies prepared by third-party experts.

Specialized firms will typically have validated the wind resource, identified turbine placement, and addressed any environmental issues. The valuer should be familiar with the expert's credentials and experience before stipulating to the third-party findings. It is not unusual for a large-scale wind project to trigger an environmental impact statement. This can take months if not years to be adopted, but the drafts often provide very thorough data on site attributes. Again, the appraiser may simply stipulate to draft findings or make extraordinary assumptions. Much depends on the permitting jurisdiction.

Generally, by the time a valuer is asked to assess the HBU of a site, wind readings have been monitored for over a year, the project site has been assembled, and environmental (and sometimes cultural) areas of sensitivity have been identified. But since developers often try to proceed along parallel paths in pursuit of all permits, the valuer may need to make a series of assumptions (if not stipulations). Some assumed conditions may continue as hypothetical, pending field investigations performed by others.

Hence, the physical suitability of the site for wind development may be a given while the permitting is in process, perhaps as an extraordinary assumption. The real challenges to feasibility are external to the project and have nothing to do with the real estate; namely (1) the presence of a power purchase agreement, and (2) the eligibility of the developer for production tax credits or other subsidies to offset construction costs. The PPA is contingent on the existence of a monopsony buyer with an appetite to purchase renewable energy within a possible RPS ceiling. The tax credits or subsidies require a development entity with sufficient profits from other operations to buy the tax credits. The serendipity of this occurrence will be assumed in the present example.

Development of a Feasibility Model

In the event that the appraiser is engaged to estimate land value while the permitting or entitlement process is ongoing, that estimation will necessarily consist of a series of extraordinary assumptions. First, capital construction costs must be compiled. At a minimum these include the following:

- Site value at acquisition cost or based on sales comparison approach pre-entitlement
- Site improvements and infrastructure, such as roads, utility extensions, and substations
- Installed turbine costs; for example a 2 MW turbine may have an installed cost of $1 million per MW nameplate capacity, or $2 million

In a discounted cash flow (DCF) model, these costs will be incurred prior to operation.

At the expiration of the PPA, a reversion might be the trended as-is land value. The scrap value of

Figure 5 A 1.5 MW turbine has a hub height of about 280 feet

Note size of turbine in relation to car.
Source: Author's files

the turbines might cover demolition and removal of the machines.

The appraiser would stipulate to a multiple-year timetable, with initial years allocated to the entitlement process. At least a year may be needed to get an environmental impact statement accepted by appropriate agencies, even on a fast track.

Erection of the turbines can be the least time-consuming phase of development. The 100-turbine second phase of Maple Ridge, in north-central New York, was completed in a single building season once permits were in place. A multiple-year development period assumes orders for turbines would be made on a parallel path with ongoing permitting and site preparation. Therefore, construction costs may be staggered depending on circumstances. Revenue would start upon completion.

Revenue projections would be based on a bid price set in the power purchase agreement. This price, typically stated in terms of cents per kilowatt hour of power, is applied to the net annual production capacity of the wind farm. The buyer and the seller (the utility company and the wind developer) must agree on the sustained power output of the farm and the price to pay for the term of the agreement. The *strike price* is the industry term for the agreed on land price, contingent on securing necessary entitlements (i.e., permits). The negotiated price has nothing to do with the real estate and everything to do with where the parties believe commodity energy prices will go over twenty years. Nevertheless, that net income stream (something like a bond) can be discounted to net present value at an appropriate discount rate to yield a residual land value.

In the current example, the specifications are as follows:

Wind Farm Specification	
A Turbine size (MW)	2 MW
B Number of turbines	100
Nameplate capacity in MW (A × B)	200 MW
Installed cost per MW	$1,000,000
Entitled acres	10,000 acres
Strike price ($/acre)	$1,500

The potential revenue that such a wind farm might generate can now be calculated, assuming agreement on output. The PPA is based on estimated production capacity in megawatt hours of the wind farm. This is calculated based on the number of hours in a year (24 × 365 = 8,760) multiplied by the nameplate rating capacity of the wind farm (200 MW) times the net capacity factor (here projected at 30%).

The net capacity factor is another given and is based on the meteorological wind studies that measure how much of the year the winds blow sufficiently to actually produce the nameplate level of power.

The output calculations of the power purchase agreement are shown in Table 2. Loss to conversion and curtailment estimates (Lines H and J in Table 2) are common industry adjustments that would be stipulated to by the appraiser based on turbine specifications. Such adjustment factors will vary with technology and by manufacturer.

After the gross production capacity is computed (525,600 MW hours), this figure is reduced by conversion loss and curtailment (the wind equivalent of vacancy and bad debt) to get to a net production capacity of 465,156 MW hours.

The net production in megawatt hours would then be applied to the bid price of power, typically quoted on a cents per kilowatt hour basis. Here, the projected unit base rate or bid price is $0.09 per kilowatt hour. In the discounted cash flow (DCF), the base rate is multiplied by 1,000 to get an equivalent megawatt rate ($0.09 × 1,000 = $90.00). For this example, it is projected that the rate will be fixed for the 20-year term with no escalations. Thus, annual top-line revenues would be 465,160 MWh × $90.00/MWh = $41,864,040. Against this would be charged a typical operations and maintenance allowance, which is projected here at 1.5¢ per kWh and then trended at an inflation rate of 2% per annum.[17]

At this date there is little market guidance to support selection of an appropriate discount rate to apply to the cash flows. Since this is fundamentally an enterprise valuation, the appraiser could consider a weighted average cost of capital technique. Once in place, the PPA might be treated like a bond. However, the uncertainty inherent with entitlement, coupled with volatility in the energy markets, compels the appraiser to consider a significant risk factor whatever method is used.

For sake of simplicity and to demonstrate the functionality of the model, a 10% discount rate is

17. Estimates of operations and maintenance costs are typically provided to the appraiser by the developer. As wind farms proliferate, it is likely that industry sources will provide more compelling data.

Table 2 Output Calculations for Power Purchase Agreement

A	Number of turbines	100
B	Turbine rating (nameplate MW)	2 MW
C	System peak rating (A x B)	200 MW
D	Average daily hours of operations	24
E	Days in year	365
F	Net capacity factor	30.0%
G	Production capacity in MW hours (MWh) (C x D x E x F)	525,600 MWh
H	Percentage loss to conversion AC to DC	5.0%
J	Curtailment	6.5%
K	Net production in MW hours (G - (H + J))	465,156 MWh

used in the current example. This rate probably understates the risk for a proposed project and overstates the discount applicable to a mature wind farm, already in operation.[18]

This discounted cash flow model can also be used to test for an internal rate of return (IRR), using these known costs and cash flows. A feasible project will generate a positive net present value at some IRR or yield rate. That yield rate can then be compared with alternate development scenarios for the site. (See the Appendix for the DCF calculations.)

The construction costs in this example may be summarized as follows:

Construction Cost	
Turbine ($/MW)	$1,000,000
System nameplate capacity	200 MW
Turbine construction costs	$200,000,000
Infrastructure:	$50,000,000
Land costs:	$15,000,000
Total project costs	$265,000,000

Here, the construction costs have been staggered over two years, with land acquisition and infrastructure accruing in year one and turbine construction in year two. The reversion calculation is based on an initial site acquisition of $1,500 per acre for 10,000 acres. These calculations are summarized in Table 3.

Note that strike price refers to the site acquisition, but is used within the industry to reflect the fluidity of some deals.

This model, as presented demonstrates how an operational wind farm might generate a positive present value. Here, the present value of $19,386,553 represents almost a 30% return to the land. How can this return be characterized? Since the cost of the land is already factored in, this return might best be construed as a premium attributable to the land entitlements. Alternatively, this premium might be considered as the developer's profit or incentive.

To generate a higher return, there would need to be lower capital costs or offsetting tax credits. Of course, without such offsets to the capital costs, this number can go negative.

The initial results are summarized as follows:

Entitlement Premium Analysis	
NPV of DCF	$19,386,553
Entitled acres	10,000
NPV/acre	$1,939
Initial land value ($/acre)	$1,500
Premium per acre	$439
Premium as % of strike price	29%

18. A case can be made to discount the land reversion at a different rate than the revenue from the PPA; however, that would depend on the situation at hand.

Table 3 Reversion Calculation

Entitled acres	10,000
Strike price ($/acre)	$1,500
Average annual inflation	2%
MV reversion	$23,700,000
Reversion year	23
Discount rate	10%
Discount factor	0.111678
NPV reversion	$2,646,772

The residual present value generated by this model has been characterized as a premium attributable to the successful entitlement of the land for a wind farm. Those entitlements included the successful demonstration of a sustainable wind resource, the securing of necessary permits, cost-effective connection to the grid, and future sale of the power to be generated to a local utility. Alternatively, this present value could simply be a test for feasibility given this complex combination of assumptions.

Conclusions

Utility scale wind and solar energy developments will encumber more of the U.S. rural landscape as Renewables Portfolio Standards (RPSs) proliferate. These standards mandate retail electricity suppliers to procure minimum quantities of eligible renewable energy. State-by-state passage of RPSs, converging federal tax policies and maturing technologies promise to realize the ambitions of the environmental movement for a greener America. So long as the wind development industry remains fragmented, opportunities to monetize these special purpose developments should abound.

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Additional Reading

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Appendix

Wind Farm—Land Residual DCF

		0	1	2	3	4	5	6	7	8	9	10	11	12
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Revenue														
Total Energy Generation (MWh)				465,156	465,156	465,156	465,156	465,156	465,156	465,156	465,156	465,156	465,156	465,156
Unit Base Rate ($/MWh)	$0.09/kwh			$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00
Total Revenue		$0	$0	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040
Operating Expenses														
Operations & Maintenance				(7,259,225)	(7,404,409)	(7,552,497)	(7,703,547)	(7,857,618)	(8,014,770)	(8,175,066)	(8,338,567)	(8,505,339)	(8,675,445)	(8,848,954)
Unit Base Rate ($/MWh)	$0.015/kwh			($15.61)	($15.92)	($16.24)	($16.56)	($16.89)	($17.23)	($17.57)	($17.93)	($18.28)	($18.65)	($19.02)
Subtotal OE		$0	$0	($7,259,225)	($7,404,409)	($7,552,497)	($7,703,547)	($7,857,618)	($8,014,770)	($8,175,066)	($8,338,567)	($8,505,339)	($8,675,445)	($8,848,954)
Net Operating Income (EBITDA)		$0	$0	$34,604,815	$34,459,631	$34,311,543	$34,160,493	$34,006,422	$33,849,270	$33,688,974	$33,525,473	$33,358,701	$33,188,595	$33,015,086
Less Capital Costs		(65,000,000)	(200,000,000)	0										
Cash Flows		($65,000,000)	($200,000,000)	$34,604,815	$34,459,631	$34,311,543	$34,160,493	$34,006,422	$33,849,270	$33,688,974	$33,525,473	$33,358,701	$33,188,595	$33,015,086
Discount Rate/ Factor	10%	1.000000	0.909091	0.826446	0.751315	0.683013	0.620921	0.564474	0.513158	0.466507	0.424098	0.385543	0.350494	0.318631
NPV/Annual CF		($65,000,000)	($181,818,182)	$28,599,021	$25,890,031	$23,435,245	$21,210,978	$19,195,739	$17,370,027	$15,716,155	$14,218,073	$12,861,223	$11,632,400	$10,519,624
Net Present Value (CF + Reversion)		$19,386,553												

Item Category

A	Turbine size (MW)	2
B	Number of turbines	100
	System nameplate capacity (MW)	200
	Annual hours	8,760
C	Net capacity factor	30%
	Net production in MW hours (A × B × C)	525,600

Item Construction Cost

Turbine ($/MW)	$1,000,000
System nameplate capacity	200
Turbine construction costs	$200,000,000
Infrastructure	$50,000,000
Land costs	$15,000,000
Total project costs	$265,000,000

Entitlement Premium Analysis

NPV of DCF	$19,386,553
Entitled acres	10,000
NPV/acre	$1,939
Initial land value	$1,500
Premium per acre	$439
Premium as % of strike price:	29%

Reversion Calculation

Entitled acres	10,000
Strike price ($/ac)	$1,500
Avg. ann. Inflation	2.00%
MV reversion	$23,700,000
Reversion year	23
Discount rate	10%
Discount factor	0.111678
NPV reversion	$2,646,772

Wind Farm—Land Residual DCF (continued)

		13 2023	14 2024	15 2025	16 2026	17 2027	18 2028	19 2029	20 2030	21 2031	22 2032	23 2033
Revenue												
Total Energy Generation (MWh)		465,156	465,156	465,156	465,156	465,156	465,156	465,156	465,156	465,156	465,156	
Unit Base Rate ($/MWh)	$0.09/kwh	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	$90.00	
Total Revenue		$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$41,864,040	$23,700,000
Operating Expenses												
Operations & Maintenance		(9,025,933)	(9,206,452)	(9,390,581)	(9,578,393)	(9,769,960)	(9,965,360)	(10,164,667)	(10,367,960)	(10,575,319)	(10,786,826)	0
Unit Base Rate ($/MWh)	$0.015/kwh	($19.40)	($19.79)	($20.19)	($20.59)	($21.00)	($21.42)	($21.85)	($22.29)	($22.73)	($23.19)	
Subtotal OE		($9,025,933)	($9,206,452)	($9,390,581)	($9,578,393)	($9,769,960)	($9,965,360)	($10,164,667)	($10,367,960)	($10,575,319)	($10,786,826)	$0
Net Operating Income (EBITDA)		$32,838,107	$32,657,588	$32,473,459	$32,285,647	$32,094,080	$31,898,680	$31,699,373	$31,496,080	$31,288,721	$31,077,214	$23,700,000
Less Capital Costs												
Cash Flows		$32,838,107	$32,657,588	$32,473,459	$32,285,647	$32,094,080	$31,898,680	$31,699,373	$31,496,080	$31,288,721	$31,077,214	$23,700,000
Discount Rate/ Factor	10%	0.289664	0.263331	0.239392	0.217629	0.197845	0.179859	0.163508	0.148644	0.135131	0.122846	0.111678
NPV/Annual CF		$9,512,030	$8,599,764	$7,773,888	$7,026,298	$6,349,643	$5,737,258	$5,183,101	$4,681,692	$4,228,063	$3,817,711	$2,646,772

Web Connections

Internet resources suggested by the Y. T. and Louise Lee Lum Library

Alternative Energy–Wind Power (news and information about wind energy technologies)
http://www.alternative-energy-news.info/technology/wind-power/

American Wind Energy Association
http://www.awea.org/

GE Energy–Wind Energy
http://www.gepower.com/businesses/ge_wind_energy/en/about_wind.htm

National Renewable Energy Laboratory–Wind Research
http://www.nrel.gov/wind

U.S. Department of Energy
Energy Efficiency & Renewable Energy: Buying Clean Electricity
http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10400

Energy Efficiency & Renewable Energy: Wind & Water Power Program
http://www1.eere.energy.gov/windandhydro/

Energy Information Administration: Energy Calculator
http://www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html

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http://www.windpowermonthly.com/