White Paper

The Shifting Economics of Wind

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Shareables

- Power market factors will become increasingly important to the economics of wind going forward as opposed to raw capacity factor.
- This opens up project opportunities in non-traditional areas where better market prices and more favorable wind shapes exist.
- Two such example areas are upper Michigan and coastal Texas, but others exist.

Executive Summary

The phase-out of the Production Tax Credit (PTC) over the next few years will reshape the geography of wind development. As the PTC winds down and PPAs become less available, developers will increasingly have to consider market factors in siting of wind, and the criteria for finding the best sites for wind projects will change. The high value of PTC credits has led wind developers to seek sites with the highest possible outputs, with less consideration of market pricing or wind shape. This has led to an abundance of wind in the middle of the country and in some cases depressed local electricity prices as wind capacity saturates markets. Going forward, locational market and resource considerations open up new geographies for further projects, if wind developers take note.

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Currently, wind economics in many cases depend on very high capacity factors to maximize monetization of the PTC. On a volumetric basis, at full ~$23/MWh the PTC may comprise fully half of a wind plant's revenue stream. However, PTC credits will reduce to around $19/MWh for plants beginning construction in 2017 and to just $14/MWh in 2018. As the potential revenues from the PTC decrease, projects will need to make up a greater portion of their returns from realized energy prices. In the market, this means a combination of both wind resource and hourly price shape. And while the PTC is indifferent to geography, price and shaping are much more location-specific.

Market pricing matters...

Currently, a large majority of wind projects are located in a handful of states in the so-called "wind belt" from the Texas Panhandle up through southern Minnesota, where capacity factors are the highest. However, market pricing in many of these regions is depressed. As the PTC wanes and market-based off-take contracts grow in importance, these regions begin to look much less attractive.

Take two hypothetical plants in MISO, for example, as shown in Exhibit 1 below. Though around-the-clock (ATC) pricing at Minnesota hub is depressed compared Michigan hub (lower by over $8/MWh), with full PTC benefits, plant economics in MN are comparable or better with a higher capacity factor (CF). Further, even in the case of total revenue indifference for the project, the tax equity sponsor may have leverage to try to maximize its share of PTCs at the expense of merchant energy revenues, and push for the higher CF site.

However, without the PTC, the plant in Michigan can make up for a large hypothetical 16% lower output (8 percentage points lower CF) and still generate greater revenues:

EXHIBIT 1. REPRESENTATIVE ECONOMICS OF TWO PLANTS IN MISO

State	Example CF%	2018 Hub ATC Forwards ($/MWh)[1]	2018 Energy + PTC Revenues with Full PTC ($/kW)[2]	2018 Energy Revenues ($/ kW) Without PTC
MN	**50%**	**$25.2**	**$207.8**	**$109.4**
MI	**42%**	$33.4	$206.3	$121.7

[1] Forwards traded as of 4/17/17 according to OTCGH

[2] Calculated using a realized-price adjustment factor of 97.0% for MN and 99.0% for MI as calculated over 2011-2015 average for several representative plants against hub day-ahead pricing (see next section for additional info).

Source: ICF, SNL, NREL

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...But Market Prices are Not the Whole Story

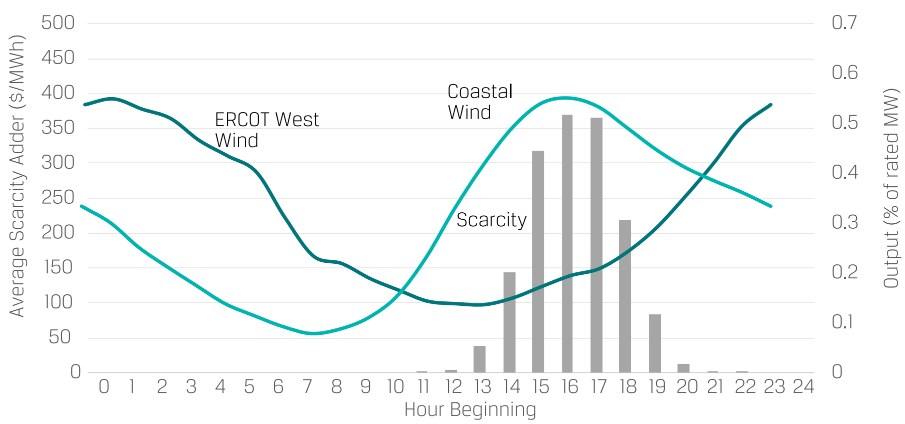
While hub pricing is important, the most important metric becomes realized price, and simply looking at hub ATC pricing may obscure true revenues. Realized price is the average price that the plant gets for every MWh – that is, while ATC price is the average across all hours, realized price is the average when the plant is producing. This takes into account both the hourly shape of market prices and also the hourly shape of wind plant output.

Texas is a prime example of the importance of looking beyond flat ATC prices. ERCOT runs an energy– only market that depends on administrative price spikes to take the place of capacity revenues in other markets – this makes the energy price particularly volatile in summer peak hours.

Further, while most of the wind development in Texas has been in the West region (where wind output is highest overnight), there are sites on the southern Gulf Coast where wind peaks during the afternoon.

Exhibit 2 plots representative output from Coastal plants as compared to an inland plant in the West region, along with price spikes during summer peak, showing how a plant in the Coastal region can capture these price spikes much more effectively:

EXHIBIT 2. OUTPUT OF REPRESENTATIVE WIND SITES IN ERCOT WEST VS COASTAL SOUTH[3]



[3] Output compared against Average Scarcity Adder under System Equilibrium Conditions in August 2015

Source: ICF, ERCOT

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Exhibit 3 shows the influence of this dynamic on plant revenues. Scarcity pricing has been depressed recently in ERCOT, so higher capacity factors and the PTC have trumped this realized price differential. However, as the market moves into equilibrium, scarcity realization can have a very large influence:

EXHIBIT 3. REPRESENTATIVE ECONOMICS OF TWO PLANTS IN ERCOT

Zone	Assumed CF%	2012-2016 Average ATC Market Price ($/MWh)	2012-2016 Average Plant Realized Price ($/MWh)	2012-2016 Average Energy + PTC Revenues ($/kW)
West/ Panhandle	**50%**	$28.4	**$26.1**	$215.2
Coastal South	**45%**	**$29.3**	$31.3	**$214.2**

Zone	Assumed CF%	System Equilibrium Average ATC Market Price[4] ($/MWh)	System Equilibrium Average Plant Realized Price ($/MWh)	System Equilibrium Average Energy Revenues w/o PTC ($/kW)
West/ Panhandle	**50%**	$34.6	**$28.8**	$126.3
Coastal South	**45%**	$35.5	**$40.5**	$159.5

[4]Assumes energy prices without scarcity as equal to 2012-2016 historical average. Historical prices were stripped of scarcity, and then hourly simulated scarcity prices were added back in totaling $70/kW-yr (in the approximate range of net CONE for a new gas plant). In reality, under equilibrium conditions, the energy price absent scarcity would be both slightly higher overall and even more concentrated in peak hours as high-cost units run more often, so the difference in realized price could be even greater. Historical prices are used for comparison.

Source: ICF, SNL

Again, in a case that looks indifferent under historical conditions with the full PTC (or leans in the favor of tax equity), without the PTC and under evolving system conditions, the non-traditional site shows better economics.

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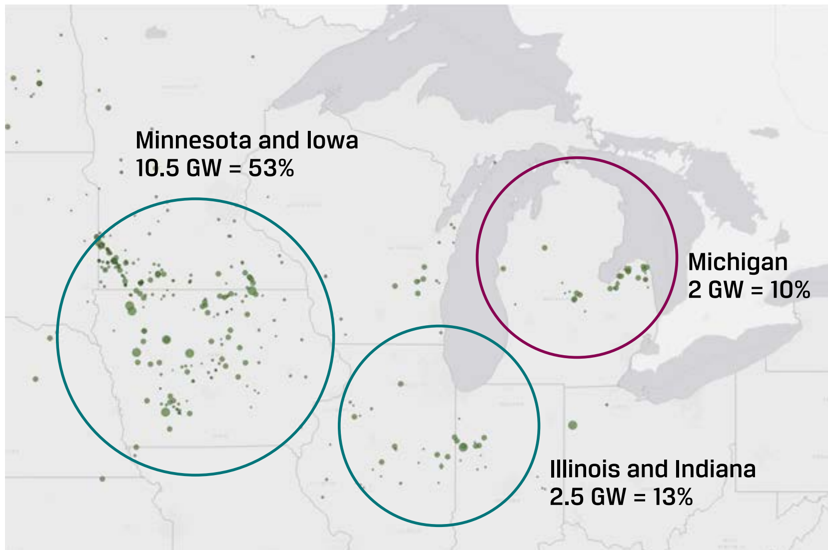
Shifting Priorities, Shifting Geographies

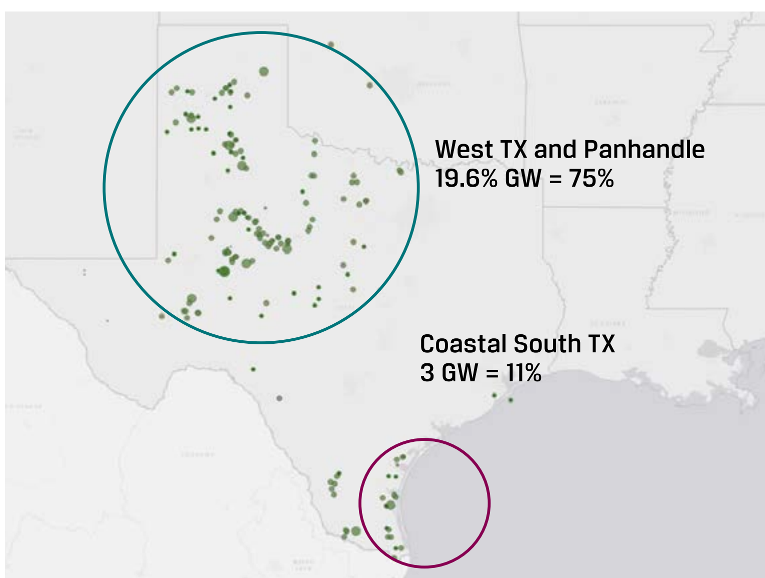
While other factors will continue to shape the geography of wind development (permitting concerns, transmission, state incentives, etc.), the calculus of returns absent the PTC will open up new opportunities for developers in less-traditional areas. Three such candidate areas are shown in the maps below. Developers will have to start paying greater attention to these market and locational factors to find success going forward.

EXHIBIT 4. EXISTING AND UNDER-CONSTRUCTION WIND PROJECTS IN UPPER MISO



Source: SNL

EXHIBIT 5. EXISTING AND UNDER-CONSTRUCTION WIND PROJECTS IN ERCOT



Source: SNL

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