

Shape-shifting: Why a turbine’s shape is your most important asset

What happens when you combine technology experts and a development shop? You unlock powerful market insights that change the energy game. Vestas and Steelhead have done just that with our in-depth comparison of turbine performance in saturated wind markets. Spoiler alert: not all turbines are created equal and it’s time the wind industry—from developers to off-takers—takes a closer look.

In today’s highly competitive and wind-saturated markets, some turbines have an overlooked advantage potentially worth over \$10 million on a standard wind belt project. The shape of a turbine’s production—how much energy it produces at which wind speeds—can drastically impact the average price of the electricity it generates. This is especially true in wholesale markets with a high proportion of wind production. While developers tend to compare turbine models using cost of energy, they often neglect the value of the energy these turbines produce. Let’s dive into production shape and its importance in wind markets, how it affects the value an off-taker extracts from a PPA contract, and why most developers fail to consider shape when selecting turbines.

What is production shape and why does it matter in traditional wind markets?

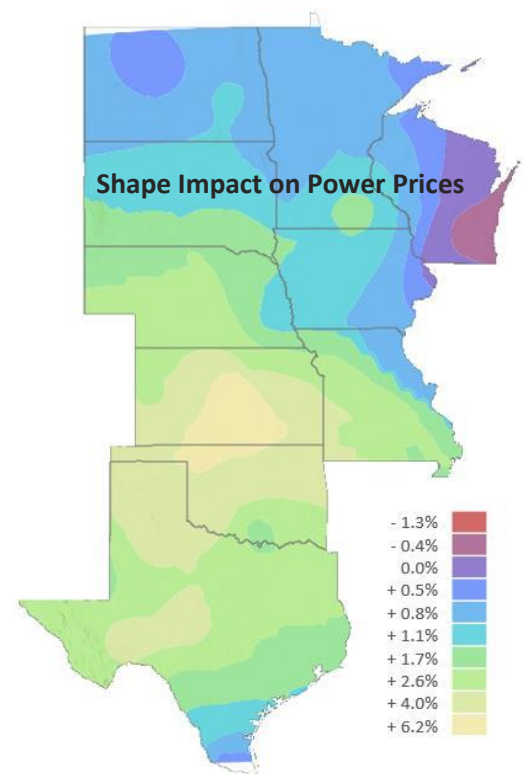
Different turbines produce slightly different amounts of energy at different wind speeds. The shape of this production over all possible wind speeds is referred to as the turbine’s power curve or production shape. The shape of a turbine’s production has a noticeable impact on the value of the energy in wind-saturated markets because power prices are typically negatively correlated with wind speed. When the wind blows in a highly saturated wind belt market like SPP South or ERCOT, the market is flooded with energy from countless wind parks, driving prices down. The effect of production shape in SPP and ERCOT is illustrated in the map to the right; yellow and green regions show where production shape plays the largest role in value of energy.

The more closely the production of these clustered wind parks matches, the more the electricity supply versus demand balance is skewed, the lower prices fall, and the less valuable the electricity becomes. On the flipside, when wind speeds are low, very few parks can produce meaningful energy. In a market with many wind parks feeding the grid, these low wind hours constrict electricity supply and drive energy prices up. Therefore, a turbine’s production shape determines what prices it captures for the energy it produces.

How can shape affect the off-taker’s bottom line?

So how do we address over-saturation driving down prices? When a turbine’s power curve is shifted slightly to prioritize generation at lower wind speeds, it can capture significantly higher prices and the extra value is passed on to the off-taker during the project’s PPA years.

Figure 2 illustrates the principles behind this effect using an Oklahoma site as an example. The grey line illustrates the average real-time electricity price at the SPP South hub during a range of wind speeds in 2019. In general, as wind speed



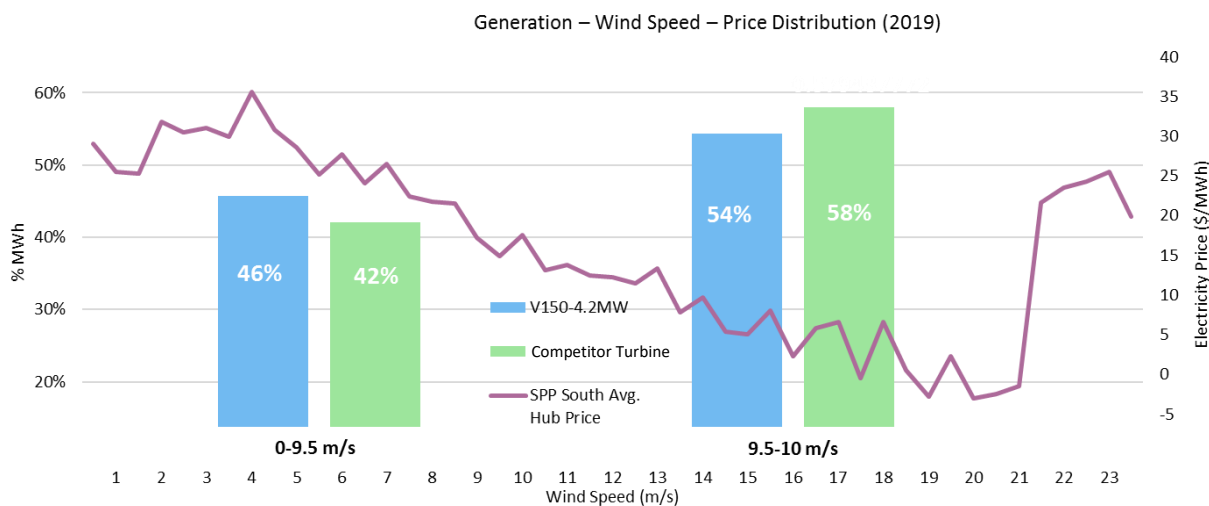
increases, electricity price plummets. At the same time, you have two competing turbines. The Vestas turbine produces 46% of all the energy it produces from 0-9.5 m/s, while the competitor turbine produces only 42% of its energy at these wind speeds.

Conversely, during higher wind-speed ranges, from 9.5-23 m/s the Vestas turbine produces only 54% of the energy it produces, while the competitor produces 58%. The Vestas turbine is producing a much larger share of its energy during far more valuable, low wind hours than its competitor. Producing more energy during more valuable times translates to energy that is worth more.

We’ve completed this analysis for all our key turbines and found similar results. With our new [Enventus](#) turbines and incorporation of the importance of shape in new product development, we expect this relative advantage will only grow and widen across markets.

2020 Berkeley Lab research validates the driving factors behind the shape effect, describing how turbines that capture a higher market value of energy “tend to shift generation from high wind hours—when wholesale power prices are more likely to be depressed by an oversupply of wind generation—to lower wind hours, when there is generally less wind generation and so less suppression of local wholesale power prices.”¹

Figure 2



You might be wondering how much value this actually creates on a project level and how much is passed along to the off-taker. We analyzed the effect of higher and lower realized prices in our propriety project model using average inputs for a 200 MW wind belt park. We estimated that for every 1% you can increase realized price, the total value of a project over its lifetime increases by \$2.3 million.

Of this \$2.3 million of total value created, 65% is passed directly to offtake during the years a project is under a PPA contract. In fact, during PPA years, the value from generation with a higher realized price is passed on entirely to the off-taker (as illustrated in Figure 3). In SPP, the gap between Vestas turbines

¹ Wisner, R., Millstein, D., Bolinger, M., Jeong, S., & Mills, A. (2020). “The hidden value of large-rotor, tall-tower wind turbines in the United States”. *Wind Engineering*. <https://doi.org/10.1177/0309524X20933949>

and their direct competitors averages close to 5%. A 5% higher realized price means around \$7.5 million of extra value is captured by the off-taker.

This effect is generally driven by high amounts of wind energy concentrated in a region. This is confirmed by the same Berkeley Lab research, “Above 5-15% wind penetration... these turbines provide meaningful incremental market value that grows with penetration.”² For reference, wind penetration is estimated at 14-18% in the two major wind belt markets.

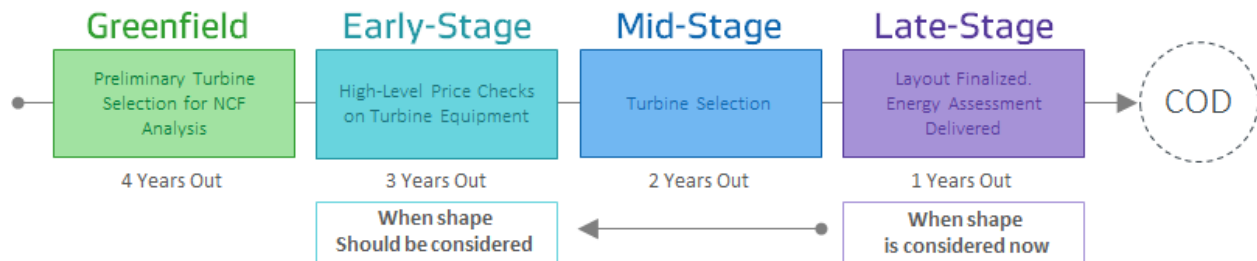


Figure 3

Why aren't we thinking about shape?

So, why do developers focus on COE and not value of energy? We think several factors are at play here: this effect is generally considered too late in the development process, value of energy is a relatively new concept not well understood by developers, and much less of the value created is captured by the project owner versus the off-taker. Typically, developers assume a generic wind shape across all turbine models until after a turbine model has been selected, obscuring the difference in value captured by different turbine models. This is illustrated below with a basic project timeline. Furthermore, most turbine manufacturers simply consider the cost of energy created, and not its value. By focusing on how cost is distributed over a turbine's generation, developers take a project owner-centric approach to turbine selection and fail to recognize the extra revenue that differentiates turbine models and makes a project far more valuable to an off-taker.

WTG-Specific shape typically not incorporated until after WTG selection.



² Wisner, “The hidden value”

Like turbines, not all developers are created equal

Steelhead, in partnership with Vestas, is uniquely suited to recognize and maximize this value for off-takers. As a development shop and a turbine manufacturer, we intimately understand how this effect works both from a technology and market perspective and consider the impact far earlier in the process than a typical developer.

Our turbines are uniquely suited to producing superior power curves because they excel in low wind conditions with better blade length to generator ratios and superior blade aerodynamics. Meanwhile, our sophisticated analysis is poised to help off-takers make smarter decisions and realize greater value from the projects they partner with.

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