White Paper

Repowering Opportunities Aren't Gone with the Wind...Yet

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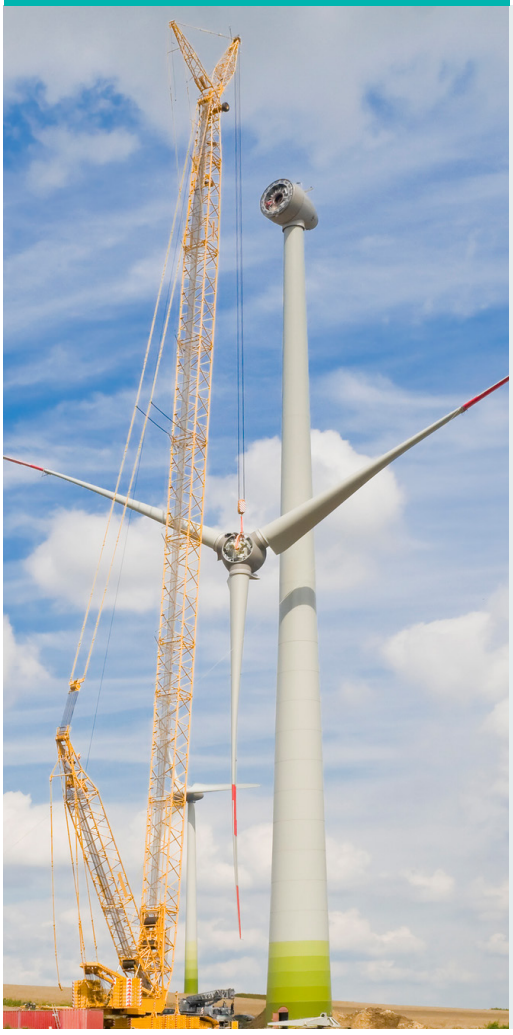

Shareables

- ICF estimates at least another 15 GW of wind projects as potential candidates for repowering.
- 2018 offers more opportunities aided by appropriate due diligence and creative strategies to improve economics.
- Don't wait until November 2018 to start your repower feasibility analysis.

Executive Summary

Interest in partial repowering has increased dramatically, with 2,136 MW of partial repowering completed in 2017. In 2018, with over 15 GW of operating wind projects ripe for repowering across the US, asset owners and developers will look to cash in on what may be the last opportunity for significant production tax credits. However, decreasing margins demand a more careful look at project capital costs, O&M, and energy production gains. With careful homework and creative strategies in a few of these key areas, projects can find continued returns in 2018.

Partial Repower Candidates

- Expiring Tax Benefits
- 1+ MW Turbine Technology
- 80m+ Hub Height
- High Maintenance Costs
- OEM Out of Business
- Recontracting Advantages

Before we dig into the opportunity at hand, let's first define what we mean by the term "repower", which can be taken to mean several different things. This discussion will focus on partial repower which is differentiated from "full repower" or "refurbishment". For the purpose of this paper, "partial repower" means replacing the nacelle, hub, and rotor of a turbine while reusing the existing tower, foundation, and balance of plant facilities (to the extent possible). In order for a partial repower project to qualify for renewed PTCs, the new investment in the project must be at least 80% of the fair market value of the facility.

Many project owners have found that a partial repower is able to meet this requirement. Likely candidates for partial repower include:

- Projects installed from approximately 2003 to 2010, many of which have, or will soon come to the end of their PTC lives;
- 1.5+ MW class machines with 80 meter towers;
- Projects with issues like high maintenance costs or underperformance; and
- Turbines whose manufacturers are no longer in business.

ICF estimates there is at least 15 GW of operating wind projects that might be good candidates for repower, noting some of these are likely already in the works.

So what about 2018? Is it too late?

For repower projects that haven't locked in the PTCs yet, 2018 offers an opportunity to capture 60% of the PTC value. Even with the reduced level, we see that repowering can make economic sense and deliver returns for investors/owners. ICF established a base case after-tax economic scenario for a partial repower project, taking the following assumptions:

- Increased project capacity
- Captured energy prices of about $24/MWh, flat in real terms
- Capital expenditure of $950/kW
- Increased net capacity factor
- Decrease in O&M cost
- Recapture of 60% PTCs for 10 years
- 10-year extension of asset life

In this case, the investment in partial repowering achieves an after-tax Internal Rate of Return (IRR) of 11.0%. Let's take a look at some of the knobs and levers that can affect the economics of a repower project.

Estimated Energy Production

Energy production gains can be a major factor driving the economics of the investment. For example, our model shows IRR gains/losses of about 0.8% for each percentage point of capacity factor, so it's important to be confident in the new production level.

Fortunately for potential partial repower projects there is a good body of data that is generally available for actual historical operations at the site (unlike, in some cases, new builds). Knowing how the current project performs contributes to a greater level of comfort when it comes to estimating how the newly repowered project might perform. Still, methodologies for repower energy assessments can vary across the industry and among turbine suppliers, developers, and consultants. There are a few common options when it comes to developing energy assessments for partial repower projects:

1. A variation of an operation energy production estimate that translates the current project's performance to the expected performance of the newly repowered project.
2. The same methodology as a pre-construction wind resource assessment and energy production estimate, where raw met tower data is used to calculate the wind resource across the site. The newly repowered project is then modelled as if it were a greenfield site.
3. A hybrid approach that comprises a combination of the two aforementioned methodologies. This involves using the operational data from the existing plant while also modeling the newly repowered project using pre-construction methods.

Depending on the data available, consider getting multiple estimates: one from your turbine supplier and one from a third-party consultant. If there are differences, work to reconcile and understand them.

Capital Costs

Turbine suppliers will often offer a capital cost for a repower project where the supplier is also responsible for the installation of the new equipment. The key question here is "what does that include?" Repower projects already have much of the necessary infrastructure in place, so there's little risk in missing something like access road costs; however, other civil costs—including intersection improvements for delivery; crane walks and pads; road restoration; and, most critically, turbine foundations—may or may not be included. Conducting a detailed analysis of the existing foundations is critical to understanding whether they can really support the new nacelle and rotor for the intended life of the newly repowered project.

One alternative strategy is to consider a more traditional wind construction arrangement: the balance-of-plant provider covers installation and construction scope, while the turbine suppliers only supply and deliver the equipment. This approach better aligns the experience of the turbine supplier and the construction company, and may reduce risk of overlooked costs or scope items.

Capital costs are, of course, a critical parameter for economics. As an example a $75,000 retrofit to an existing turbine foundation amounts to about $40 per kW of capital cost (for a 1.85 MW machine). Using our base case, the additional $40 per kW for the foundation retrofit brings our IRR from 11.0% down to 10.0%.

Operations and Maintenance Costs

One of the exciting potential benefits of partial repower is that it could get an owner out from underneath a high-maintenance or underperforming asset. According to the 2016 DOE Wind Technologies Report[1] —which shows median annual O&M costs by project age and commercial operation date—installations from 1998 to 2005 that have been operating for at least 10 years have median O&M costs ranging from about $42 to $65 per kW per year. Contractual O&M costs for today's new projects might range from $15 to $25 per kW per year.

It's important to make sure that the costs related to the current project, as well as the costs of a newly repowered project (including balance-of-plant maintenance), are well understood. The O&M cost delta is a significant driver in the economics of a repower project: a $5/kW-yr difference in our base case makes for a difference in IRR of 1.4%.

Contracting, Pricing, and Interconnection

Plant offtake circumstances range widely. Just as with new projects, the risks and economics of a repower project will be driven, in part, by how the increases in energy production can be contracted, hedged or exposed to merchant pricing. At a high level, a few key points to consider are:

- Potential for re-contracting or for the expansion of an existing contract: the increase in energy production may be economically competitive against a new plant, with shorter construction time and less risk. The end of an existing contract could be a good time to consider repowering to increase leverage in obtaining a new contract.
- On pricing, we show that the economics are feasible in the mid-$20/MWh range for captured price (we used $24/MWh, flat real terms). The economics are highly sensitive to this, of course: a $1/MWh shift makes about a 0.4% difference in IRR. Absent a full power purchase agreement (PPA), the usual wind pricing considerations apply, especially nodal basis, price shape, and curtailment; however, the repowered project benefits again from having actual historical data to reference.

[1] https://emp.lbl.gov/sites/default/files/2016_wind_technologies_market_report_final_optimized.pdf

- Interconnection capacity: Repowering turbines may increase the maximum output of the plant. Depending on the location and market, it may be better to reapply for an increased interconnection agreement, or remain on the existing one.
    - Depending on interconnection requirements, consider repowering a portion of the turbines. As an example, say you have a 200 MW project consisting of 133 1.5 MW turbines. Consider repowering 125 of those turbines with 1.6 MW machines, leaving the remaining 1.5s (resulting in effectively a 212 MW project), and then curtailing on the occasions when output exceeds 200 MW. This will increase energy production and net capacity factor (based on the 200 MW interconnect), but will come with additional O&M costs for maintaining the older machines. An option like this may also require updated interconnection studies and interconnection agreements, which can be a long process.

Now's the Time to Start

A detailed repower feasibility study takes time—a detailed foundation analysis alone can take several months—so project owners shouldn't wait until November to start evaluating the repower potential of their existing assets. In addition to starting early, consider a few things in evaluating a repower project to make sure you're adopting the right approach, especially if it's on the economic bubble.

- On energy production, do careful analysis and get multiple opinions. Consider alternative option such as leaving some of the existing turbines operating to increase production.
- Spend extra time on your capital cost estimate to make sure you don't have any scope gaps. Consider a more traditional wind construction arrangement with a balance-of-plant provider doing all the installation and covering all construction scope, while the turbine suppliers only supply and deliver the equipment.
- Evaluate whether repowering fits within an existing contract and interconnection agreement, and consider the potential for capacity expansion and re-contracting as part of project evaluation.
- For O&M, consider contracting O&M out for longer terms to add certainty. Analyze the scope of the contract carefully.

Good planning and execution become even more critical as PTC capture reduces in 2018; however, opportunities still exist and it is possible for owners to potentially benefit from partial repowering before the PTC fades away.

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