White paper

Navigating the renewable boom
Three ways to utilize data and analytics to design a successful development project

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Introduction

Clean energy has risen to the forefront of public policy and social awareness

There are currently two major Federal Energy Regulatory Commission (FERC) orders, two major Environmental Protection Agency (EPA) regulations, and various federal- and state-level policies that all impact the use of renewable energy. At the same time, China now leads the global market in solar panel production and rare-earth mining, which recently caused production gluts that drove prices even lower for renewable project development. As a result, wind and solar generation continue to become more economically competitive with traditional fuels.

With this new demand for, and the cheaper supply of, wind and solar generation the market is rapidly saturating. Utility-scale wind capacity has grown by an average of 15% annually since 2011 and solar capacity has grown by an average of almost 75% annually in the same period. Solar also continues to grow in the residential sector.

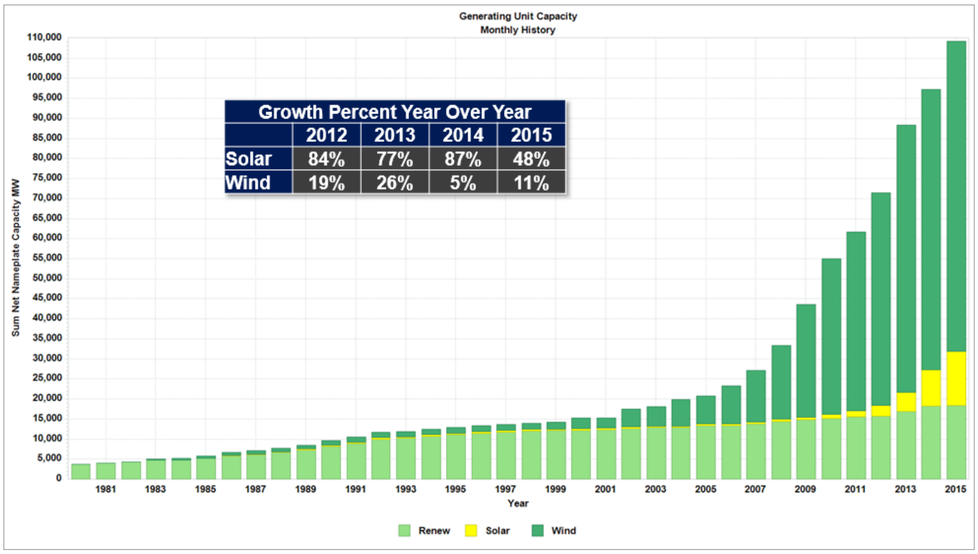

Figure 1: Growth percent year over year[1]

The number of developers and owners is growing too. Since 2000, the number of renewable generation owners has skyrocketed from less than 150 to more than 4,000. This saturation not only creates significantly more competition but also increases concerns regarding grid reliability and maintenance. Both of these contribute to the need for more sophisticated analytics to minimize grid impact and navigate the competitive landscape.

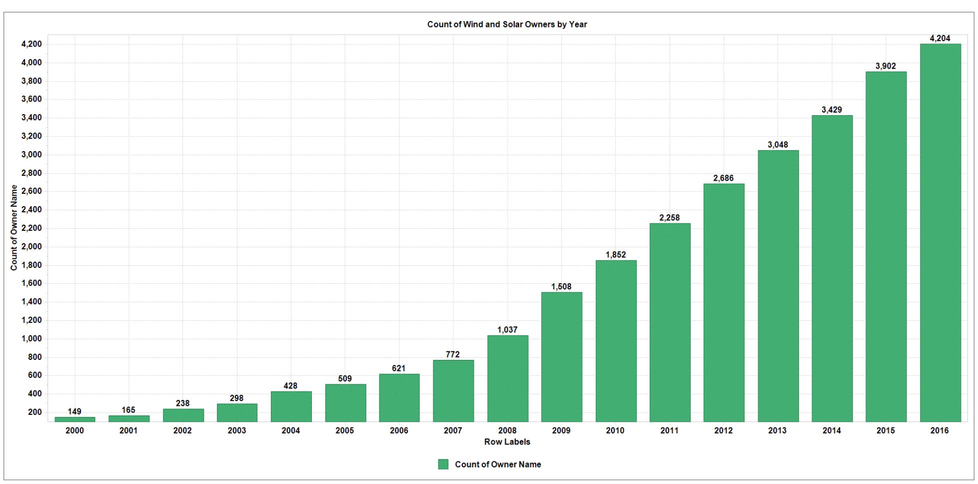

Figure 2: Count of wind and solar owners by year[1]

Analytics help to shelter projects from political uncertainty

Historically, most wind projects depended on the wind Production Tax Credit (PTC) of \$0.023 / kWh. This incentive, introduced in the 1992 Energy Policy Act, promoted efficiency in energy production along with new technologies, and with great success[2,3]. However, the tax credit saw turbulence from potential expirations, despite being extended in 2015 to carry some level of tax relief through 2019 for projects beginning construction. The PTC's impact on developments can be seen when looking at times that it reached potential expiration. In the long term, developers will need to enhance analysis to reduce their dependence on the tax credit, which may not always exist.

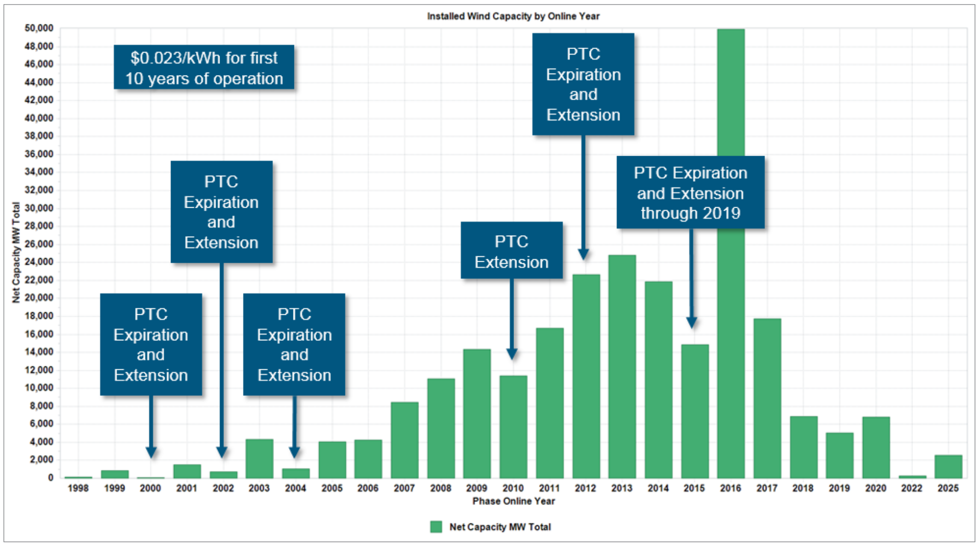

Figure 3: Drop in wind project development in association with potential PTC expiration[2,4]

Another issue with renewable development relates to the fuel source – or lack thereof. Central North America sees more consistent and usable wind, while the southwestern portion of the US harnesses more solar potential, but these facts don't always dictate the performance of a project in those areas. Building in one of these areas may make sense, but there are many influences to consider such as transmission needs, permitting friendliness, Renewable Portfolio Standards and interconnection.

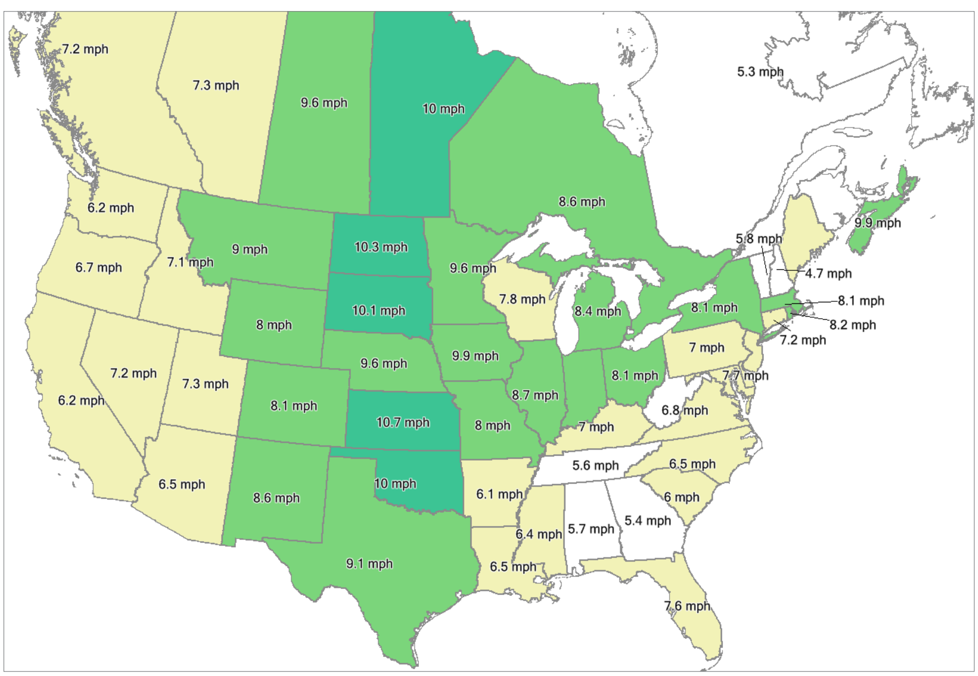

Figure 4: Average wind speeds, 2015[1]

Better analysis and a true understanding of implications is needed

Ultimately, market competition continues to rise, tax support continues to decrease and the variable complexities remain the same. With so much information available now it is impossible to collect, clean, and analyze effectively; however, development requires more sophisticated analysis to properly place a project, determine its financial viability and limit its impact on the grid's reliability. This in-depth research falls into three main categories:

1. **Siting – Does the site have strong resource availability?** How will the generated energy flow to demand points? How will a resource connect to these lines and with how much competition? Can the appropriate permits and clearance be approved?
2. **Financial assessment – Will this project be curtailed regularly?** Can a power purchase agreement (PPA) be negotiated? After the PPA expires, can revenue recovery continue in the merchant energy market? What do these values look like in the future? Will Renewable Portfolio Standards help?
3. **Interconnection approval – What is the system impact of interconnection?** How does interconnection change the pricing spreads?

This paper addresses these topics with the use of online tools from ABB that support renewable development projects with clean and organized investment-grade data, market-specific analytics and unbiased fundamental forecasts to understand the project today and far into the future.

1 Siting: The project needle in the siting haystack

Using analytics to choose the best location for a renewable project

Determining the site, an early step in the overall project development process, is one of the largest contributing factors to project viability. So how do you determine the best site? A key factor is resource potential.

Identifying resource potential is a process that relies on a deep dive into extremely localized weather patterns, often incorporating tools like anemometers or solar radiation sensors measuring for wind shear, cloud cover, solar irradiance and more. While these vary location, taking a larger-scale approach can actually save time and headaches by narrowing locational options.

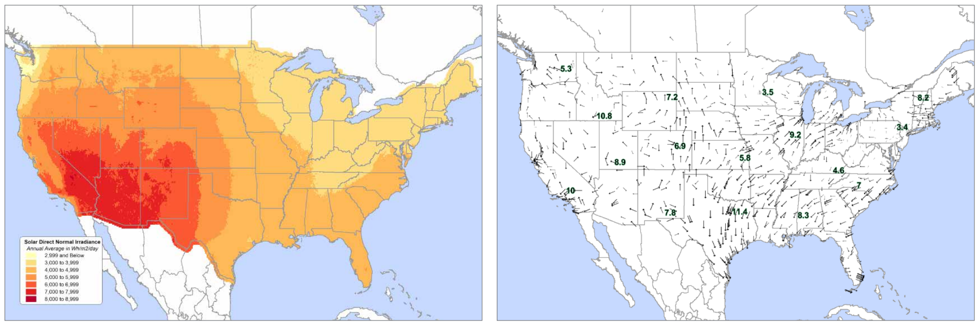

Figure 5: Measuring factors such as solar irradiance and wind shear help in identifying resource potential for a possible project site[1]

ABB's Velocity Suite allows developers to identify irradiance, potential cloud cover and horizontal impacts. As an example, consider two solar facilities on opposite sides of the US: Hyder Solar, a 36-megawatt PV solar farm located in sun-rich southwestern Arizona and operated by Arizona Public Service Co, produces energy for itself with a long-term power purchase agreement. Apple Data Center, a 40.74 megawatt (in 2014) PV facility located across the country in North Carolina, produces energy for onsite use, but also sells to Duke Energy in North Carolina.

The solar facilities are very similar but are in areas with varying solar irradiance. The chart in Figure 6 below displays monthly solar irradiance for each location in 2014 alongside each plant's respective capacity factor, displaying a strong relationship between the solar potential and the energy output. There is roughly 8,000 megawatt hours of generation difference between the two sites from photovoltaics over the year, which could mean hundreds of thousands of dollars.

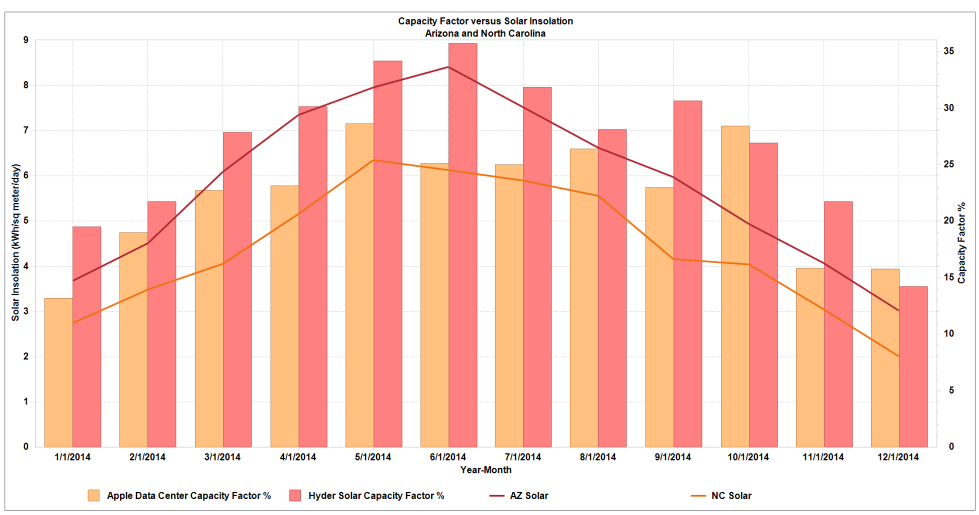

Figure 6: Capacity factor versus solar insolation at two US solar facilities[1]

This holds true for wind facilities as well, but with more resource variables. While solar depends on the angle of the sun and cloud cover, wind turbines must consider wind availability, speed, direction and more. The wind rose, or circumflex chart, covers these topics with one understandable graphic. The wind rose in Figure 7 below displays wind variables for an area near the Iowa / Minnesota border using data from Velocity Suite.

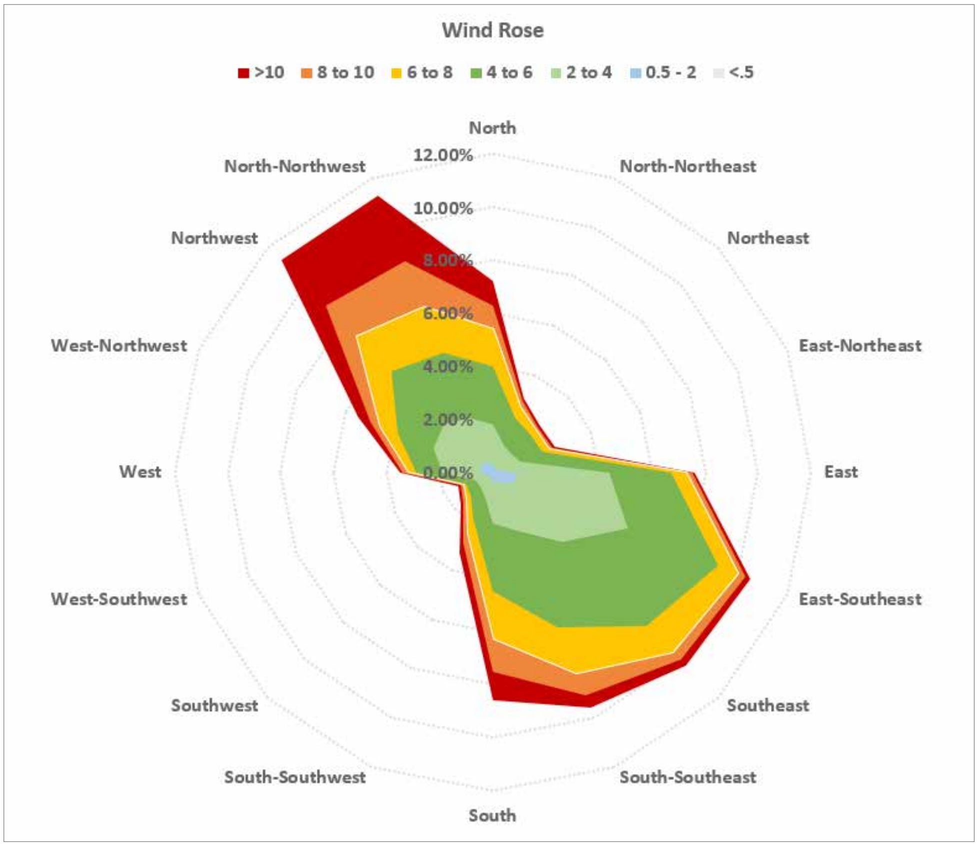

Figure 7: Wind rose or circumflex chart[5]

Wind developers apply this information to determine general direction as well as anticipated maintenance, emergency shutdown potentials and, in particular, energy output from their facility. Traditionally, this data is difficult to collect and filter, but using sophisticated analytical tools allows for easy collection, with cleansed data being reported from trusted weather services including NASA.

The site selection process progresses – and so does the complexity

A look at real-world examples

As the process continues, developers must perform more complex analysis surrounding connectivity, transmission, competition and political landscape. These needs all require high-quality data as well as high-quality geospatial analysis. **To explain the importance of these needs, we've identified three potential states to build: Nevada, Wisconsin and New York.** Each state shows potential for specific renewable resources. Nevada receives large amounts of high-quality solar exposure, southern Wisconsin receives varying levels of wind penetration and New York shows potential for both, though to a lesser degree.

As we assess our sites, it's best to consider the voltage class of infrastructure, the capacity of the substations to connect to, potential competition and how easily permits can be acquired. Figures 8 through 11 on the following pages, from ABB's Velocity Suite, quickly and easily illustrate voltage, capacity, permitting and competition.

The state of Nevada holds benefits and drawbacks for renewable developers. The sun shines regularly there, with less cloud cover than other regions, but with much less wind potential. Being largely covered by desert, finding space to build is not as difficult as finding where to send it. Las Vegas remains the major demand area for the state unless you plan to export energy to California. This explains the large number of solar facilities surrounding the southern portion of the state.

Most states, counties or cities require some level of permitting, but the large number of canceled projects here may be cause for concern. The map in Figure 8 below shows 29 cancelled solar projects with only eight proposed as of March 2016. The number of project cancellations could suggest a more challenging permitting process or may also address a smaller amount of low-voltage transmission that other, more densely populated, areas may hold. This does not necessarily preclude projects here, but definitely influences the final decision of potentially sending energy out of the state and hedging against one of California's trading hubs.

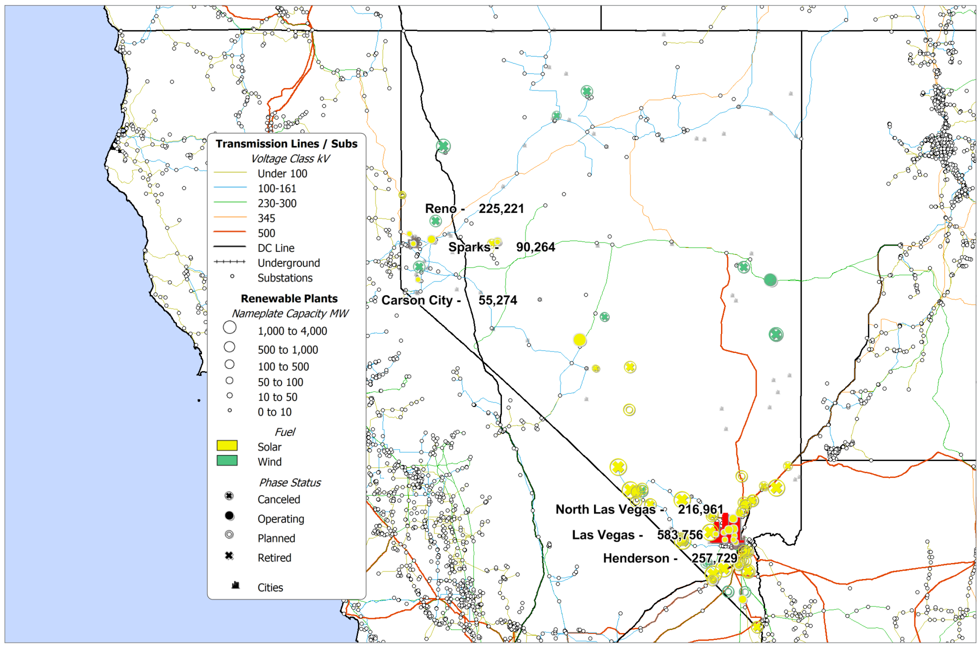

Figure 8: Map of Nevada showing key considerations for project developers, such as infrastructure, capacity and competition[1]

Wisconsin shows a slightly different picture, as depicted in Figure 9 on the following page. Wisconsin has many connectivity options, decent wind potential in the southern half of the state and multiple demand zones in or around the state. A more robust, lower-voltage system supports renewables here as well. The number of cancelled projects in Wisconsin (24 since 2005) is still cause for concern, but there are more proposed, permitted and with applications pending in 2016 and 2017, which may show potential.

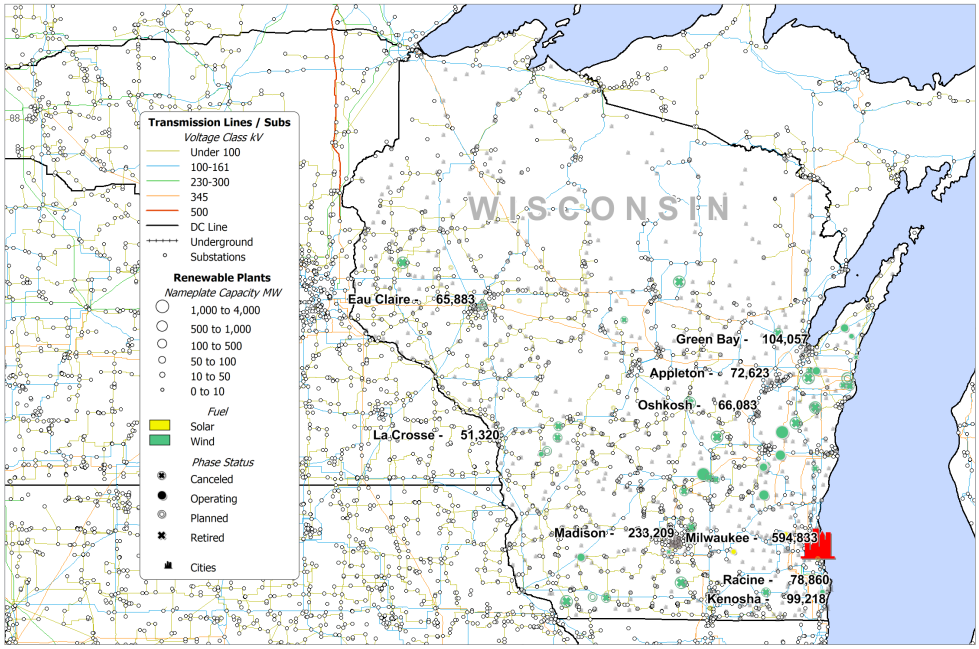

Figure 9: Map of Wisconsin showing key considerations for project developers, such as infrastructure, capacity and competition[1]

Finally, consider New York, depicted below in Figure 10. Though this states receives less sun and wind in comparison to others, it hosts open land and transmission upstate. Getting energy to demand zones may pose future problems, but the state appears to have a strong renewable energy appetite with few cancelled projects.

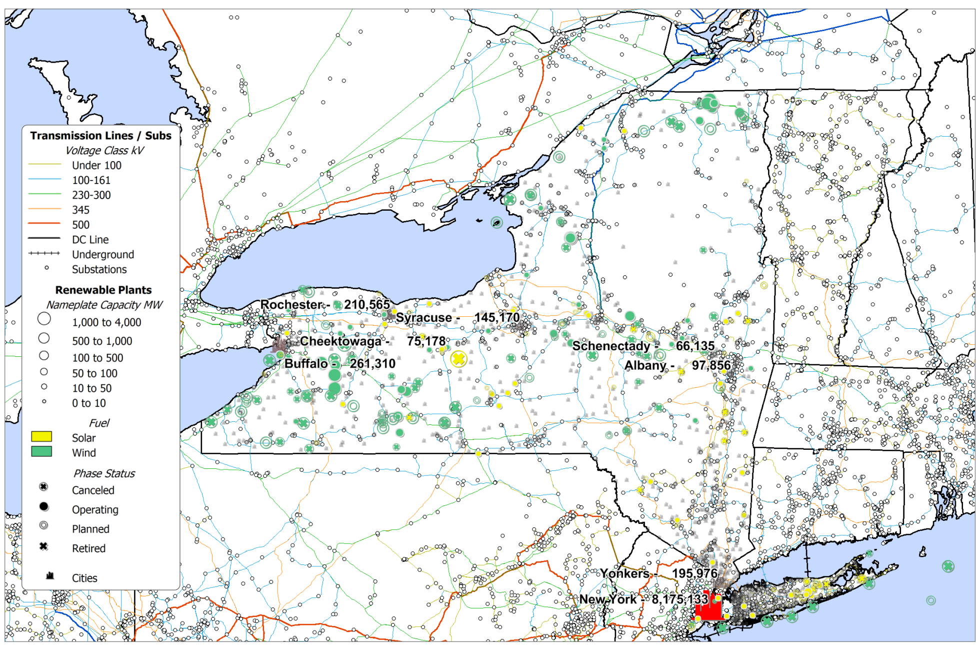

Figure 10: Map of New York showing key considerations for project developers, such as infrastructure, capacity and competition[1]

Western New York benefits from mixed sun and wind patterns, which allows for strong development potentials. This explains the large number of operating and proposed facilities in this small area.

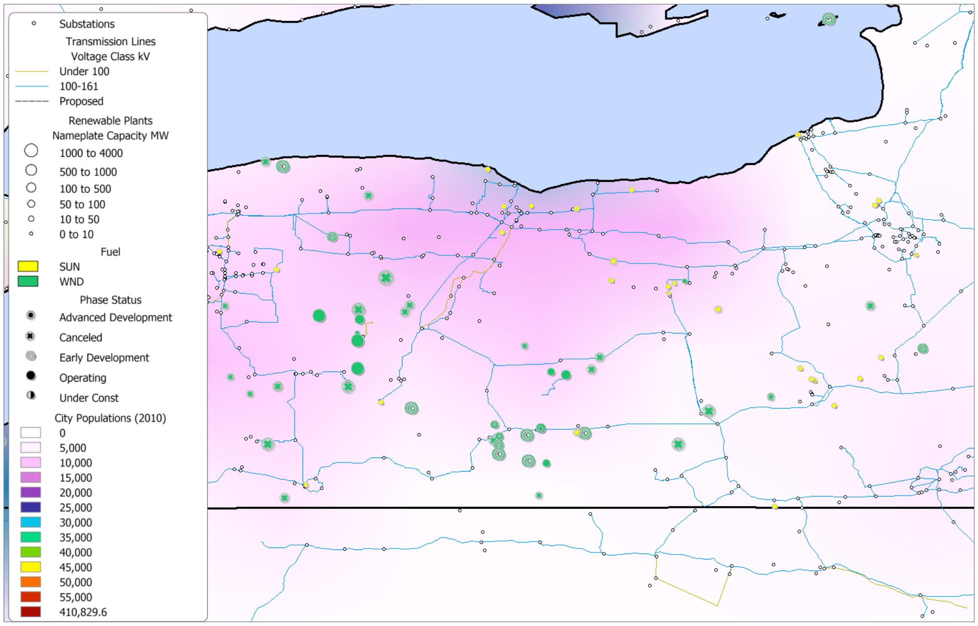

Figure 11: Steuben County, New York; an example of grid connection issues[1]

Albeit friendly competition, the need to connect to the grid is a very real issue. Take Steuben County, for example, highlighted above in Figure 11. This small geographic area hosts seven different proposed projects and 987 megawatts of potential capacity from wind and solar. Many of these projects connect in the same area as well. In reviewing the New York ISO interconnection queue, 450 megawatts of wind energy are connected or will be connected into Bennett substation with a max voltage of 115 kV. This is just one example of the resource and demand existing, but not the ability to move the energy.

These examples explain just some of the main needs when siting a renewable project. With ABB's experience and tools, we were able to speed the decision-making process, saving time and potential money. As we continue our analysis, we will review the financial implications to determine the best site and revenue potential.

2 Financials: Put your financials where your analysis is

How a site may influence the revenue potential and power purchase agreement negotiations

Continuing the analysis of western New York as a potential project site, a new variable must be considered: money. The ultimate determining factor in project likelihood is financing – no project gets off the ground without the proper financing and revenue potential. We will review New York ISO's (NYISO) nodal pricing patterns to further narrow down to an ideal site.

Sometimes during site identification, you may come across what appears to be the perfect site – great resource potential, easy permits, open transmission capacity – yet no other projects have been proposed there. You should ask why. It may not be financially viable. Heavily-congested areas may prevent a renewable facility from ever releasing its clean energy.

The map in Figure 12 on the following page illustrates pricing pockets in New York. These nodal prices dictate the locational price paid to a generator for the energy they produce. It also demonstrates the relationship between these price pockets and the factors previously discussed.

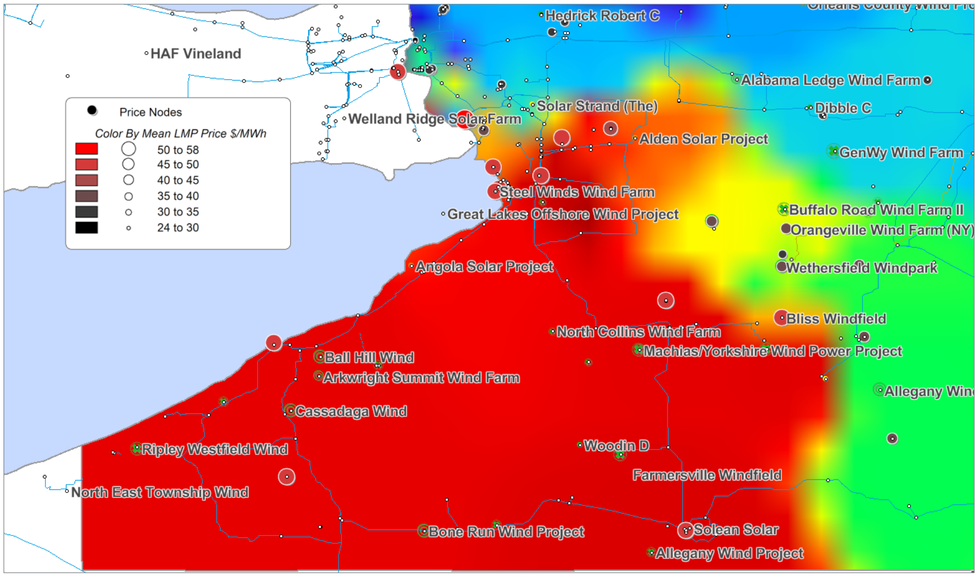

Figure 12: Pricing pockets in New York[1]

The far west portion of New York shows consistently higher average prices for 2015. This area saw average prices of about $45.0 / MWh compared to the average prices up north at around $25.0 / MWh. Over the course of a year, that results in almost a $200,000 difference for one megawatt produced. Despite the nine different cancelled projects in this area with only four proposed and one operating, the high potential revenue warrants a deeper dive into the area's suitability for potential projects. **Why are prices so high in an area with such low demand?** Understanding congestion around a potential site can help explain such a paradox.

Congestion determines curtailment potential, helps begin revenue forecasts and provides the necessary understanding for interpreting later analyses like interconnection impact. ISOs report congestion at a flowgate level with a shadow price in dollars per megawatt hour. Basically, this is a systematic way of explaining how energy flow increases on one transmission facility because of overload or issues on one or more other facilities. The cost for that energy to change flow is monetized with a shadow price. The chart in Figure 13 shows hourly shadow prices for NYISO during 2015. This illustrates the magnitude of congestion on the system at different times during the year.

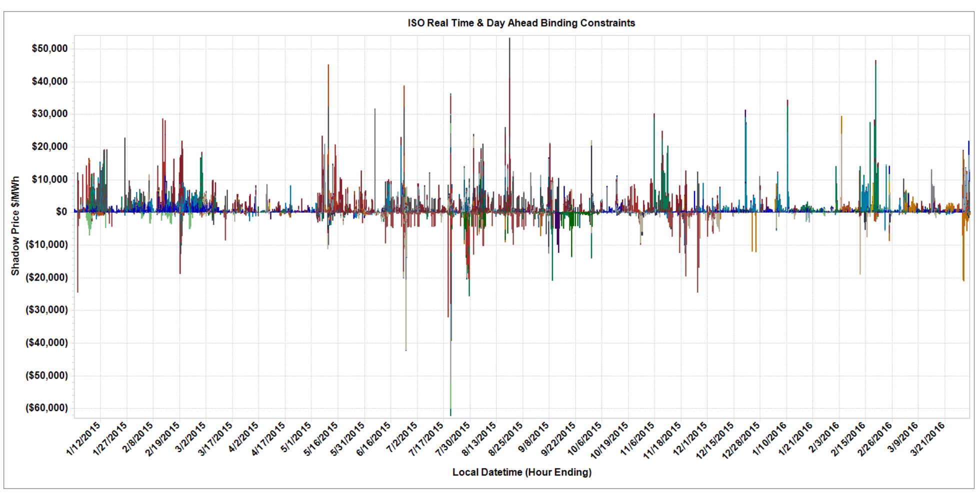

Figure 13: Hourly shadow prices for NYISO during 2015[1]

The question becomes, which constraints impact prices in western New York? For our purposes, we have chosen to start with a simple correlation between constraints and nodal prices in this region. Combining this with a regression or distribution factor approach often creates the actual relationships between constraints and the pricing patterns, though we will be focusing on identifying the constraints for this paper.

Flowgate	Correlation
ADIRNDCK 230 MOSES 230 1 L/O TWR:MASSENA MMS1 & MMS2	(0.2351)
E179THST 138 HELLGT_E 138 1	(0.0347)
EGRDNCTY 138 NEWBRDGE 138 1	0.0016
EGRDNCTY 138 VALLYSTR 138 1 L/O BUS:BARRETT 292&459&G2&IC9-12	0.0162
ELWOOD 138 GREENLWN 138 1 L/O NRTHPORT-ELWOOD___138_681	0.0659
ELWOOD 138 NRTHPORT 138 1 L/O NRTHPORT-ELWOOD___138_678	(0.1372)
FARRAGUT 345 GOWANUS 345 1	(0.0412)
GOWANUS 138 GREENWD 138 1 L/O SCB:GOWANUS(2):41&42231	0.0238
HUNTLEY 230 SAWYER 230 1 L/O PACKARD_-SAWYER___230_77	(0.1477)
LEEDS 345 HURLYAVE 345 1 L/O TSA:CE75 91&92	0.1384
New Scotland Leeds	(0.0042)
NIAGARA 230 PACKARD 230 1 L/O TWR:PACKARD 62 & BP76	0.4673
NRTHPORT 138 PILGRIM 138 1 L/O NRTHPORT-PILGRIM__138_679	0.0986
NRTHPORT 138 PILGRIM 138 2 L/O NRTHPORT-PILGRIM__138_677	0.0852
PACKARD 230 SAWYER 230 1 L/O PACKARD_-SAWYER___230_77	0.6335
PACKARD 230 SAWYER 230 1 L/O PACKARD_-SAWYER___230_78	0.2697
PLSNTVLY 345 LEEDS 345 1 L/O ATHENS__-PLSNTVLY_345_91	(0.0024)
PLSNTVLY 345 LEEDS 345 1 L/O TSA:CE80 91&301	(0.0432)
PLSNTVLY 345 LEEDS 345 1 L/O TSA:CE81 91&303	(0.1384)
PLSNTVLY 345 LEEDS 345 1 L/O TSA:CE82 91&305	(0.1384)
RAINEY 138 VERNON 138 1	0.0463
SCRIBA 345 VOLNEY 345 1 L/O SCRIBA__-VOLNEY___345_21	0.2591
SCRIBA 345 VOLNEY 345 1 L/O SCRIBA__-VOLNEY___345_21-SV	0.2553

Figure 14: Correlation between constraints and nodal prices in western New York[1]

This allows us to identify the constraints with the largest impact on pricing patterns. In the case of western New York, most congestion in 2015 can be attributed to four main constraints, all surrounding a select few substations.

NIAGARA 230 PACKARD 230 1 L/O TWR:PACKARD 62 & BP76	0.4673
PACKARD 230 SAWYER 230 1 L/O PACKARD_-SAWYER___230_77	0.6335
SCRIBA 345 VOLNEY 345 1 L/O SCRIBA__-VOLNEY___345_21	0.2591
SCRIBA 345 VOLNEY 345 1 L/O SCRIBA__-VOLNEY___345_21-SV	0.2553

Figure 15: Four main constraints in western New York in 2015[1]

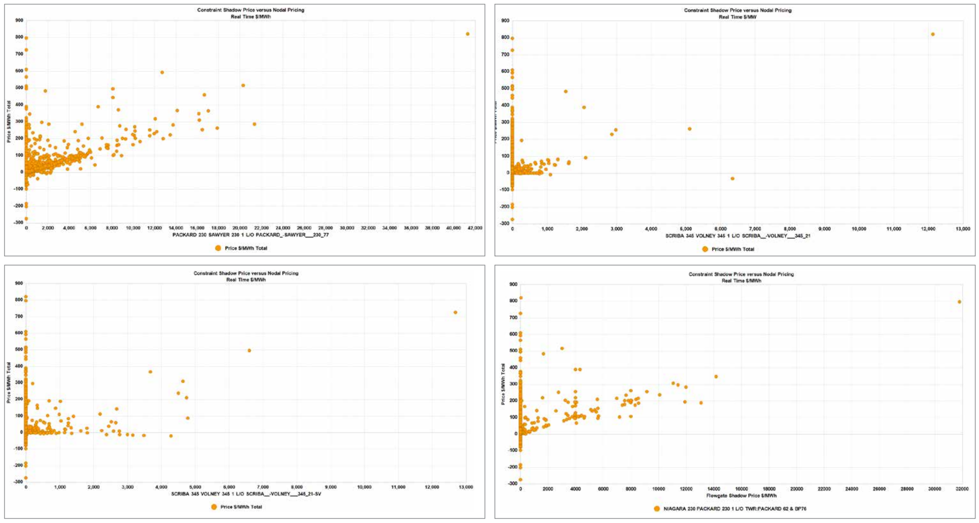

Figure 16: Constraint shadow prices versus nodal pricing at the four main constraint sites in 2015[1]

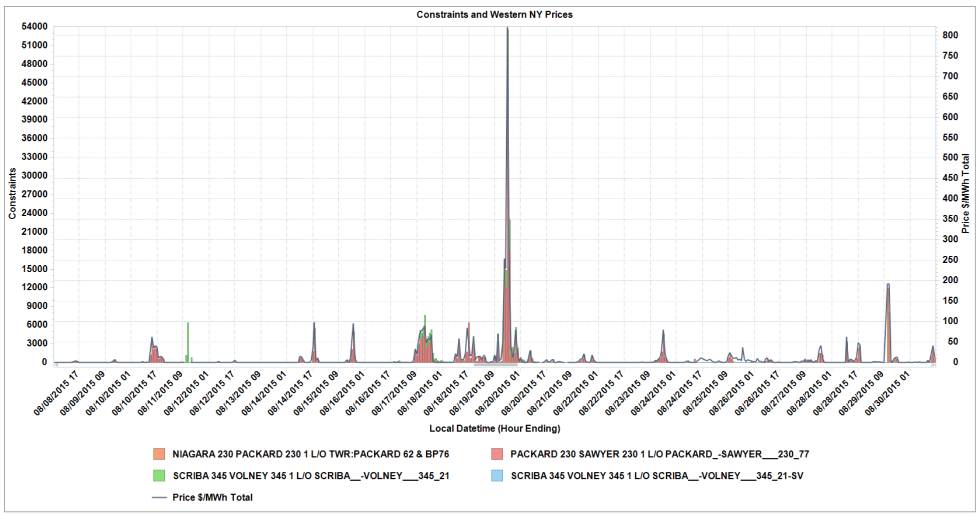

Figure 17: Constraints and western New York prices in 2015[1]

This type of research may not be currently performed by renewable project developers, but holds a pivotal piece of the puzzle. We can now determine the likelihood of curtailment or strong revenues with this deeper understanding of the system, which better facilitates power purchase agreements and post PPA merchant performance. It also allows for a better understanding of proposed transmission impacts in the area.

The map in Figure 18 on the following page illustrates the price pocket in western New York with the four driving constraints and currently proposed transmission upgrades. These upgrades may help the flow of energy in the region. Knowing these constraints helps to determine their origin and frequency, which helps track projected transmission outages or regular events that may increase the likelihood of these constraints. Ultimately, this all reduces project risk, aids with financing and identifies future performance for the renewable project.

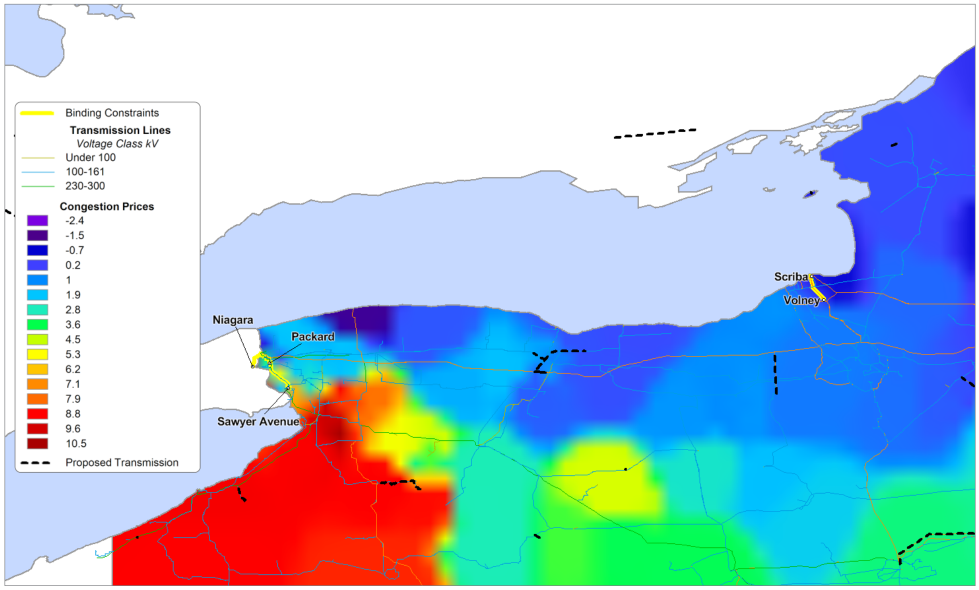

Figure 18: Price pocket in western New York with the four driving constraints and proposed upgrades[1]

With an understanding of the past, the focus turns to a dynamic future

Current processes measure nodal prices, as we have, with additional reference to a nearby trading hub. This identifies localized risk versus broader risk. The final step is to apply this hub spread and pricing to a forward curve with potential resource output for a fully formed, long-term outlook of project viability.

The issue arises when using the forward curve, which dictates the cost paid now for energy in the future. This does not take into account the full market changes between now and a hypothetical "then." Instead, using a true fundamental forecast provides an idea of how the market expects to change going forward. The forecast helps because it takes into account all market influences like load growth, generator attributes, retirements and proposed units, fuel forecasts, emissions, renewable portfolio standards and transmission topology buildouts.

Figures 19 and 20 on the following page are images from the ABB North American Reference Case depicting the expected change in resource mix by region and even projected energy prices under different scenarios. The different US regions show differing rates, but similar trends. All regions expect to retire some level of coal and oil to be replaced with gas or renewable generation. Identifying these trends helps to determine areas with the greatest need for renewable generation to be paired with the greatest resource potential, and other details reviewed earlier in this paper.

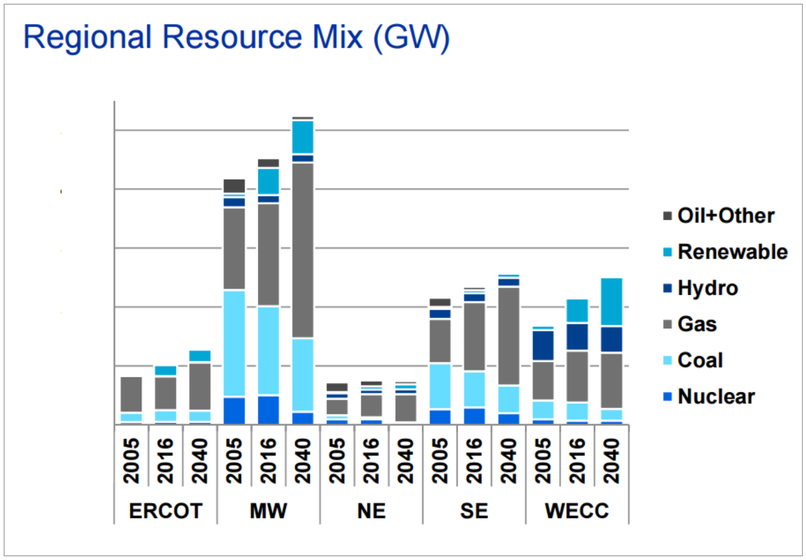

Figure 19: Regional resource mix from ABB's Fall 2015 Reference Case

The most beneficial portion of a forecast like the ABB Reference Case comes from the sensitivity variations. This report not only forecasts a base case for future prices, but also includes different versions of the future to account for different outcomes like rising gas prices, lower gas prices, and different types of environmental adjustments like the inclusion of the EPA Clean Power Plan.

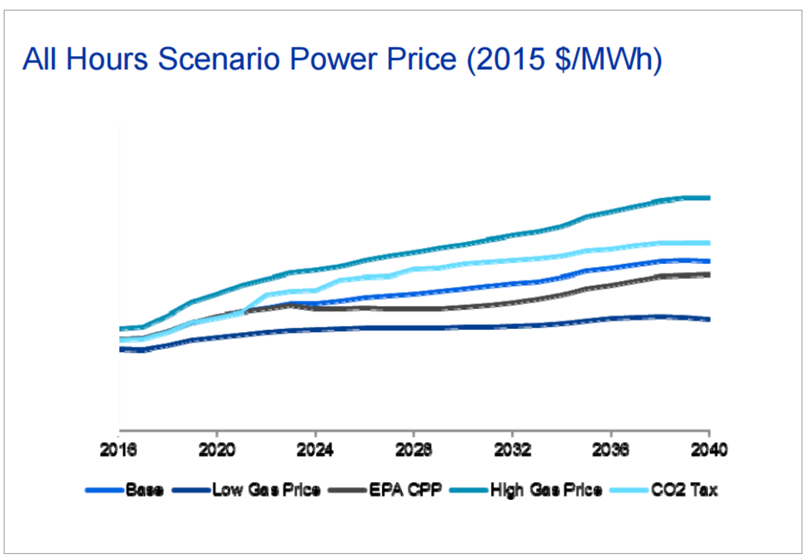

Figure 20: All hours scenario power price from ABB's Fall 2015 Reference Case

These price variations from a 25-year, zonal, fundamental forecast, as opposed to a forward curve, provides the highest level of confidence in future revenue potential.

Combining these forecasted values with a nodal and hub price provides the most realistic and measurable expectation for project revenues, which helps with power purchase negotiations and sets expectations for merchant generation revenue post-power purchase agreement. This takes us to the final major step in renewable development: grid connection and the right to do so.

3 Interconnection: What will actually happen when this facility goes live?

Performing economic interconnection studies for revenue expectations and grid impact

The last section of this paper explains grid interconnection, a process that involves an interconnection request to an Independent System Operator (in most cases), and depends on the ISO's analysis of the project's feasibility with grid reliability studies. Additionally, sometimes overlooked but equally important, is the economic impact. Both hold value.

To reach this point, a developer has scrutinized their site and crunched the numbers; however, the grid isn't simple. ISO regions involve complex bidding processes with locational pricing, and components that are always changing. To best estimate the interconnection impact, developers should run scenarios with a production cost model. For our purposes, we conducted this analysis with ABB's PROMOD software.

With its origins dating back to 1975, PROMOD has been used throughout the energy market for simulating different grid studies. This tool takes another fundamental approach similar to the ABB Reference Case, but has the ability to forecast at a nodal level, accounting for constraints and a new dispatch with the unit being introduced. By utilizing security-constrained unit commitment and economic dispatch, we can simulate the reality of the market as closely as possible. Running this model creates forecasts for unit generation, nodal or zonal prices, constraints and congestion, among other outputs. These allow the user to add specific project attributes to review the potential revenues and system impact.

For this analysis, we performed three simulation studies for New York, New England and eastern PJM. The simulations were run as a base case with unchanged simulation data, as a solar scenario with the addition of a 17 MW solar facility in NYISO zone B and finally with a wind scenario adding a 16.2 MW wind facility in place of the solar facility.

The simulations were designed to first identify aggregate impacts to prices in western New York. The chart in Figure 21 on the following page shows 2017 projected values aggregated to monthly values. The orange and green bars represent solar or wind generation for the month in megawatts. The respectively colored lines represent the average difference in dollars per megawatt hour for prices in western New York each month. As an example, a $0.12 reduction in price during the month of July resembles that reduction averaged over each hour of the month among all nodes in this region. This attributes to $0.12 * 24 hours * 31 days * ~60, which equals greater than $5,000 in monthly production cost reduction for this region.

Figure 21: Western New York simulations with proposed wind or solar facilities[6]

Additionally, we can review the potential revenues for each project in this region by analyzing the hours and quantity of generation hourly with the region's respective cost. These values show the true revenue differences between each project. The grid in Figure 22 below shows the true revenue potential, accounting for hours of operation and price changes. These values truly identify the difference in project revenue potential; with this economic study, the results push strongly towards the development of a wind facility in this region, despite all other analysis.

Month	Wind Total Revenue	Solar Total Revenue
January	$ 221,143	$ 101,471
February	$ 220,870	$ 79,426
March	$ 182,534	$ 92,556
April	$ 123,031	$ 95,920
May	$ 86,280	$ 76,741
June	$ 82,928	$ 129,245
July	$ 152,003	$ 254,882
August	$ 79,973	$ 84,709
September	$ 77,826	$ 87,949
October	$ 96,008	$ 61,055
November	$ 137,540	$ 56,068
December	$ 196,683	$ 49,009
Grand Total	**$ 1,656,820**	**$ 1,169,031**

Figure 22: Revenue potential, accounting for hours of operation and price changes[7]

These analysis points highlight just some of the grid impacts from potential project siting. Other analysis includes, but is not limited to, detailed constraint impact, curtailment details and the impact to the broader system. By incorporating a sophisticated production cost model into the analysis developers can reach a point of higher comprehension for project status and potential.

Conclusion

Renewable developers need sophisticated tools to perform detailed analyses
The energy market continues to shift more rapidly and more dramatically than ever before. Technology shapes the industry, from the generation of energy to reduced consumption and ever-changing market designs.

As the world focuses on efficiency and a reduced environmental impact, the generation, transmission and consumption of energy on a macro or micro scale share responsibility for these common goals. Part of this responsibility includes the use of technology in planning and implementation. Proper planning will lead to these goals while still maintaining the system's reliability and remaining economically feasible.

About Velocity Suite

ABB's Velocity Suite is an investment-grade data and analytics solution that is considered the industry standard for energy resources data, supporting over 250 companies in the energy, financial and consulting disciplines. Velocity Suite enables quick evaluation of market activities and industry dynamics across commodities through a single integrated solution. Questions that previously required a string of complex, tedious tasks can now be answered by simply selecting a few items across a set of pre-built applications supported by a team of 40 analysts that stand ready to provide excellent customer service, training and expertise.

About PROMOD

ABB's PROMOD is an hourly market simulation tool that is used by energy regulators, generation companies, traders, and grid operators to forecast:

- The market price of power
- How generators are going to operate in the market
- How plants will react to regulations
- Future revenues and costs
- Transmission congestion

PROMOD can also perform transmission congestion analysis and economic transmission expansion/siting analysis.

For more information on these and other ABB solutions, click here.

Contact us

Sources

1. ABB Velocity Suite
2. http://energy.gov/savings/renewable-electricity-production-tax-credit-ptc
3. http://www.seia.org/sites/default/files/ITC%20101%20Fact%20Sheet%20-%201-27-15.pdf
4. http://www.fool.com/investing/general/2014/10/05/is-americas-renewable-energy-revolution-about-to-f.aspx
5. ABB Velocity Suite and Microsoft® Excel®
6. ABB Velocity Suite and ABB PROMOD
7. ABB PROMOD and Microsoft Excel

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Bret provides technical sales support for ABB's Velocity Suite, Reference Case and PROMOD solutions. He has experience analyzing Independent System Operator markets, energy regulation, congestion hedging, renewable integration and market forecasts.

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Our enterprise software portfolio offers an unparalleled range of solutions for asset performance management, operations and workforce management, network control, and energy portfolio management to help customers reach new levels of efficiency, reliability, safety and sustainability. We are constantly researching and incorporating the latest technology innovations in areas such as mobility, analytics and cloud computing.

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