Overcoming Renewable Challenges

Part 3 of a Series

AMERICAN SOLAR ENERGY SOCIETY

By Jake Anderson

Anderson Optimization, in partnership with ASES, is continuing its series in which we examine the implications of an electricity grid based predominantly on renewable energy. In our last article, "Migration Toward a Distributed Grid," in the Spring 2018 issue of Solar Today, we discussed the rising trend of distributed generation and its implications.

In this article, we discuss the impact of renewable penetration from a grid integration perspective. While a predominantly renewable grid is an admirable goal, there are significant drawbacks to renewables that must be overcome to meet this future.

As we outlined in our last article, smaller, distributed renewable facilities are relatively inexpensive and built in a more rapid timeframe than traditional facilities. However, a fragmented model of generation has also arisen due to the way that renewable energy interacts with the grid.

Unlike traditional generation, renewable energy (without accompanying technologies such as storage) is inherently non-dispatchable, which means that an operator can't manually turn generation on or off. Solar panels automatically generate electricity when there is sunlight, and when this occurs, the energy flows into the grid regardless of an operator's actions. Since renewable power flows immediately into the grid, too much development can lead to an oversupply of electricity on the grid, which may cause transmission congestion.

Congestion occurs when electricity is unable to haul to a demand center because transporting power lines are at capacity. When this happens, energy effectively gets stuck at the node of generation where it may end go unused and wasted. This is also a serious issue because the produced energy is devalued due to the oversupply, which can drive significant price variances in the real-time energy markets.

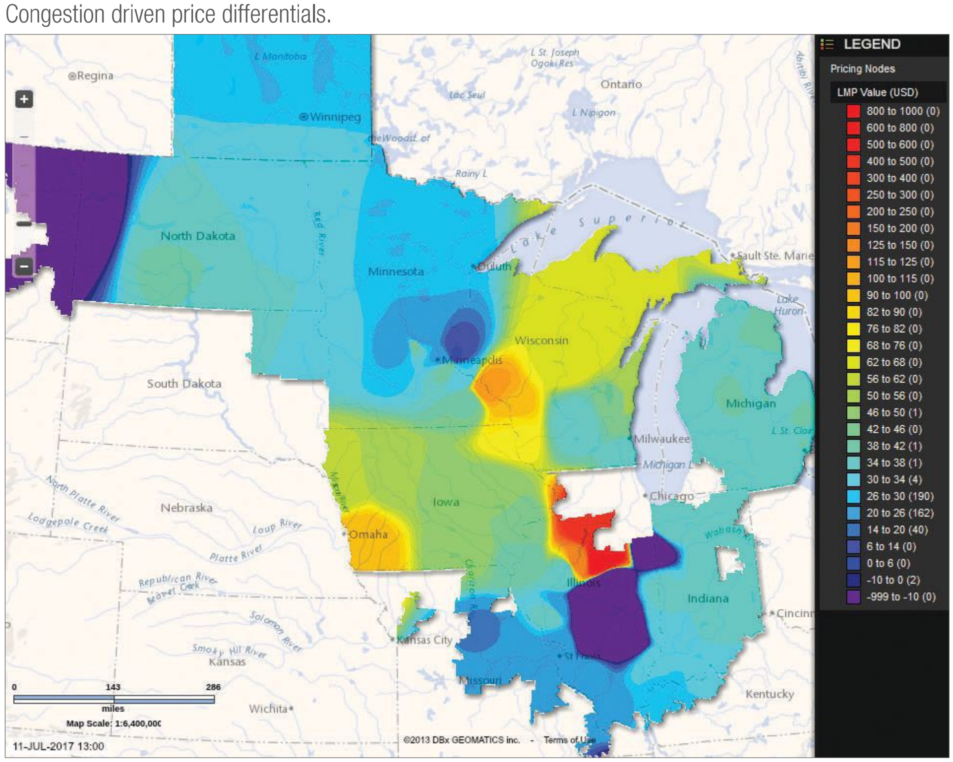
Congestion and the Markets

As energy loses its value, it can lead to negative pricing and curtailment. When energy has no value and simply isn't used, it is wasted, which negates the economic and environmental advantages of renewables.

To illustrate this issue, congestion driven price differentials can be seen in the chart below.

In southern Illinois, energy is negatively priced (purple), whereas in northern Illinois, energy is in the highest pricing tier (red). This indicates that there is significant supply in southern Illinois, but due to transmission issues, the energy is unable to haul to the northern

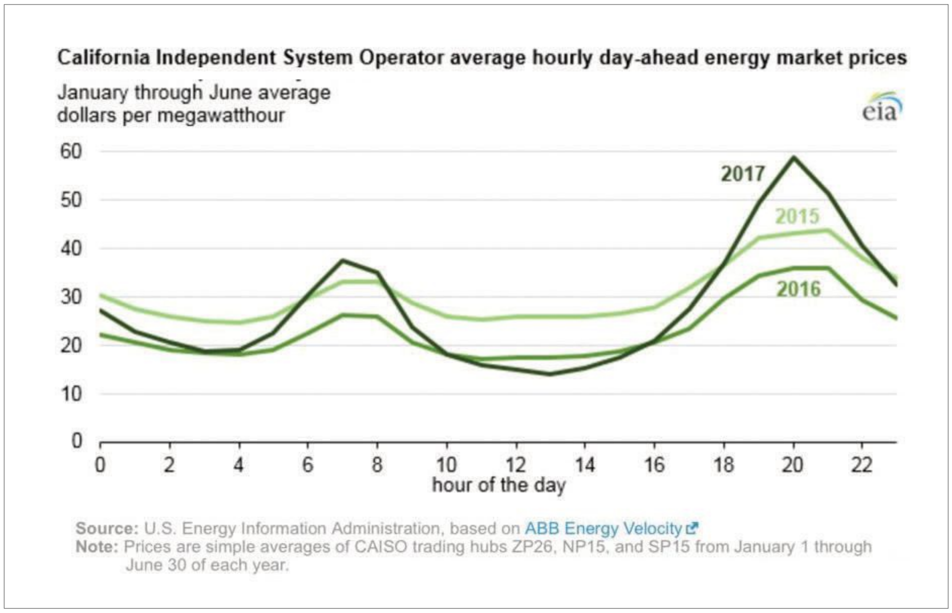
Congestion driven price differentials.



Right: © TebNad

Illinois load, which renders the electricity literally worthless.

Clearly, congestion is a significant financial burden on power systems as it reduces the value of power, and it can necessitate extremely expensive transmission infrastructure investments. As renewable energy continues to gain prominence, this is a key issue that developers, utilities, and RTOs must focus upon.



The duck curve is also a unique problem in that it is a direct, negative externality of renewable penetration.

Oversupply and the Dreaded Duck Curve

Aside from congestion, non-dispatchability has historically made a renewable grid unrealistic due to its reliance upon the availability of a renewable resource e.g. sunlight or wind. While this creates an obvious need for other forms of generation when resources aren't available (e.g. nighttime), another key drawback to renewables is the phenomenon known as the duck curve.

As renewable penetration increases, it drives load spikes in the morning and evening with a load reduction in the afternoon when renewable energy (primarily solar) is most prevalent. This trend is outlined in the graph above, which shows the impacts of rapid solar adoption in California.

While this issue may not seem significant, it forces traditional plants into aggressive daily ramping, which is expensive. Additionally, while traditional power plants are dispatchable, they aren't really meant for constant starting and stopping, so this is also a significant operational burden.

The duck curve is also a unique problem in that it is a direct, negative externality of renewable penetration. Simply adding renewables to the grid will only make this problem worse, so it is clear that the renewable energy industry will need complementary solutions to truly attain a grid of the future.

Planning for Renewables

Between congestion, uneven generation patterns, and duck curves, it is clear that simply developing as much renewable generation as possible is an infeasible approach for creating a grid of the future. It is necessary to utilize new planning practices to ensure that a renewable grid is developed in the most effective manner possible. Utilities must implement modern modeling practices to create optimal plans and strategies for proper, mass scale renewable integration. While macro level grid modeling has always been a key component of integrated resource and transmission planning processes, traditional methodologies often aren't built to handle the complexities of a modern grid.

Traditional models typically use hourly analysis intervals, which are less feasible for renewables as weather can significantly fluctuate in that timeframe. This creates the need for sub-hourly modeling. Historical practices also don't always quantify the inherent uncertainty of renewables and other dynamic grid technologies such as storage. As these systems gain adoption, it is increasingly necessary to quantify the associated uncertainty so that realistic confidence intervals can be derived. Additionally, historical modeling practices often don't have significant distribution network focus, which is also becoming necessary with increased distributed generation.

Luckily, utilities, the Department of Energy, as well as the broader commercial energy industry understand that these gaps exist and are putting significant focus on improving these areas. Utilities are beginning to dedicate internal resources to revamping planning and modeling practices, the DOE has released several grants to fund research, and in industry, companies such as ours are developing new modeling and planning solutions. With these combined efforts, the energy industry is making necessary efforts to evolve its practices to effectively integrate renewable energy.

Maximizing Renewable Impact

Improved grid modeling will allow for more seamless renewable planning and decrease integration issues such as congestion. However, planning alone can't fix operational drawbacks of renewable energy that drive the duck curve and the simple fact that you can't generate solar power at night. To fix these issues, new technologies such as storage and differing operational practices will become increasingly necessary, and we will discuss these opportunities in an upcoming article. While transitioning to a grid based predominantly on renewables sounds wonderful in theory, it is clear that there are significant challenges aside from simply installing as many panels and turbines as possible. It will take a concerted effort from virtually every stakeholder group (consumers, commercial energy industry, regulators, utilities, government, etc) and significant support from complementary services such as storage and grid modeling research to attain a predominantly renewable future. ■

About Anderson Optimization

Anderson Optimization is a young company that develops software solutions focused on power system modeling and optimization as well as renewable integration. Their software simulates the energy grid and electricity markets for utility planning purposes and to help renewable developers automate their new project siting efforts. To learn more, visit www.andersonoptimization.com.

If you have questions or comments throughout the series, feel free to reach out to Shaun Mehr, smehr@ases.org or Jake Anderson, jake@andersonopt.com, and we will work to incorporate your ideas into the series.

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