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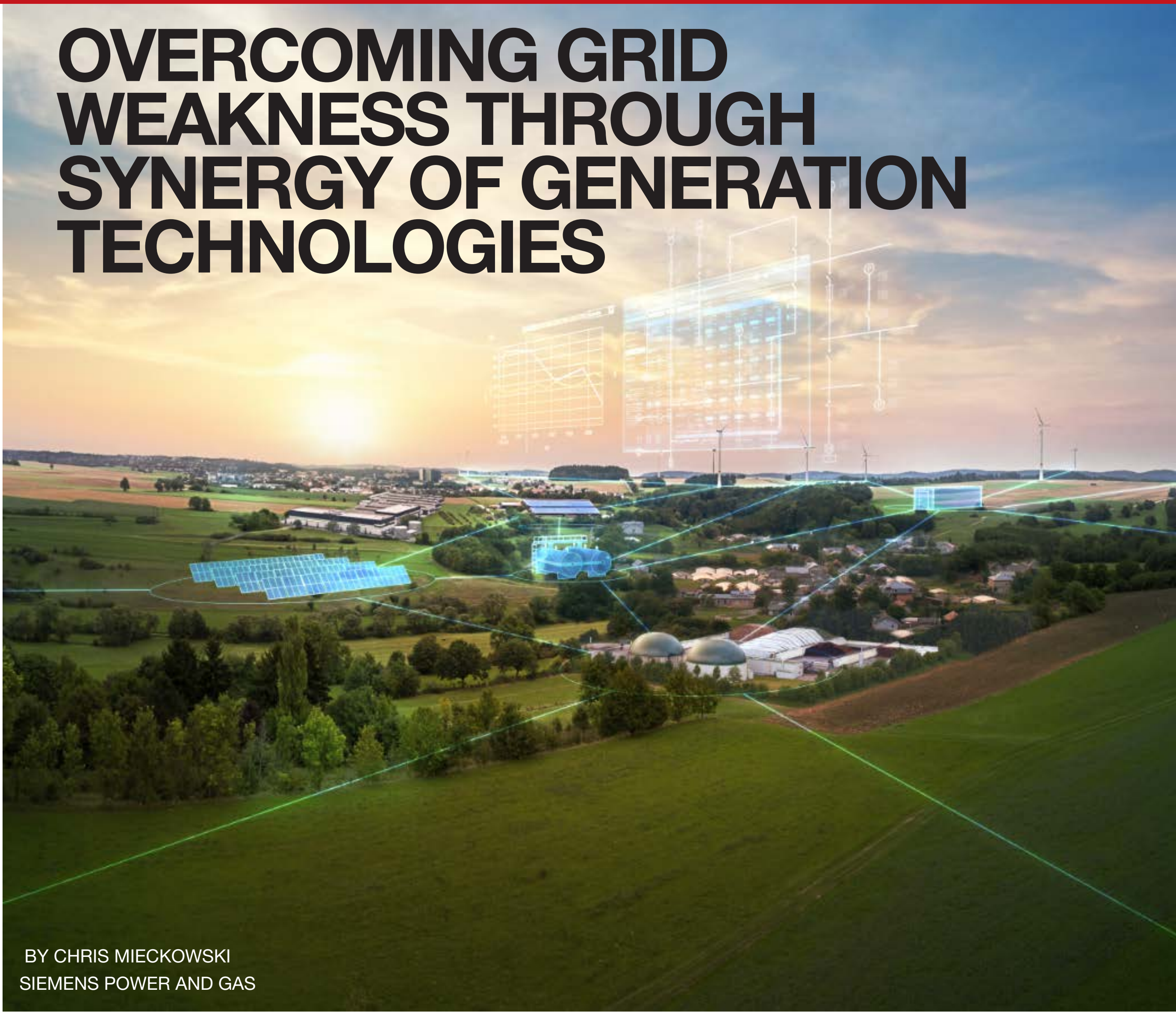
OVERCOMING GRID WEAKNESS THROUGH SYNERGY OF GENERATION TECHNOLOGIES



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SIEMENS POWER AND GAS

The Big Picture

Over the past several years the energy landscape has undergone dramatic changes in both the generation side and the demand side. To better understand the challenges faced by the grids of today (and the future), let's look at the situation over time from the perspective of the grid operators.

In the simplest terms, the role of the grid operators is to exactly balance two independent variables in real-time: supply—the production of electricity by generators—and demand—the load that consumers place on the grid. A mismatch in these two variables in either direction could result in frequency fluctuations and ultimately lead to blackouts and/or damage to equipment if not quickly corrected. To accomplish this, grid operators control supply (generation) to exactly match demand. Today, there can be some control over demand in the way of demand response resources, but for discussion purposes let's assume that demand is driven solely by the individual consumers and their independent agendas.

A Glimpse into the Past

Historically (10-plus years ago), demand on the grid was relatively predictable. Hourly load forecasts were fairly accurate, and future demand growth was loosely correlated to GDP growth, which could be estimated relatively well. Generation, on the other hand, was less predictable. While renewable integration was limited or non-existent, generation resources could still fail; forced outages were driven by a number of factors including natural disasters. To maintain grid stability, grid operators employed mitigation measures such as installed capacity targets and reserve margins, based on empirical data of possible failures and a tolerance level to overcome specific scenarios (e.g., 100 year events). Spinning and non-spinning reserve resources were employed to compensate for a potential immediate loss of generation on the grid. These measures resulted in a reliable grid system.

The Supply and Demand of Today

Fast forward to today. Environmental stewardship is at an all-time high and we, as humans, bear the responsibility of generating our electricity as efficiently as possible. In other words, we need to make the best use of the resources we have available, including renewable resources. First let's address some other industry developments. On the generation side we are regulating emissions to a higher degree. This forces older, traditionally baseload generation to decide whether to invest (sometimes substantially) in new emissions control technology, repower their facility with new generation to become compliant, or to simply retire the resource altogether.

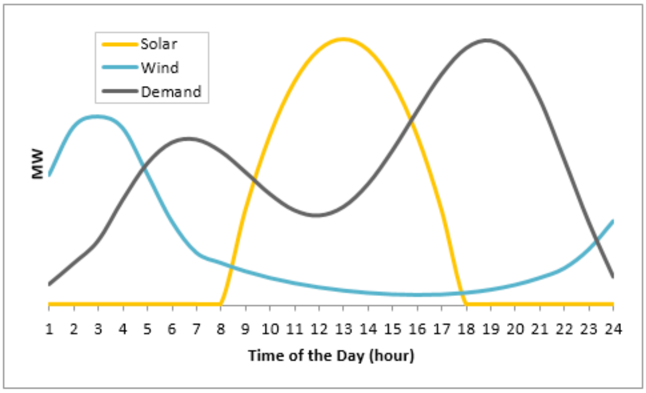
On the demand side, consumer loads are getting more efficient. Even though population is increasing, in some areas load growth is actually negative because advances in technologies make loads more efficient. We're using the power smarter which compensates for the added number of consumers. Additionally, now more than ever we, as a society are dependent on energy. Where a loss of power 10-plus years ago was a nuisance or inconvenience, now it becomes intolerable. This means that grids need to maintain a high level of reliability, as well as increase their resiliency to respond and recover from loss of power events like natural disasters faster than ever before.

Increasing renewable penetration has brought about unique challenges. For discussion purposes let's refer to only solar and wind generation. Solar generation is available when the sun is shining. Wind generation is available when the wind is blowing. The actual production of each of these resources is completely indiscriminate of demand. In other words, the power is generated without regard to whether it is needed or not—it is uncontrollable. Let's assume for a minute that was the only change in our scenario. That means grid operators are taking in one hand the demand, which we said is relatively predictable, and in the other hand generation, which previously had a level of manageable unpredictability.

With the introduction of a large amount of uncontrollable renewable energy, the mitigation methods get more complicated. Additionally, renewable targets continue to increase in many markets. We already determined that demand is growing minimally (if at all) so there isn't a need for additional capacity. In order to meet the targets imposed on the market, utilities and generators need to replace less efficient (but controllable) megawatts with renewables, further driving retirement of older, less efficient (typically baseload) generation.

It's Only a Matter of Time (Shifting)

In general, grids typically attempt to utilize renewable energy as much as possible, so they use a minimum level of conventional (non-renewable) generation and then all the renewable generation possible. Final trimming/balancing can be performed with fast power units like combined cycle Flex-Plants or simple cycle aeroderivatives like an SGT-A65. In theory this concept works very well. In practice, two main characteristics of renewable generation present problems to solve.

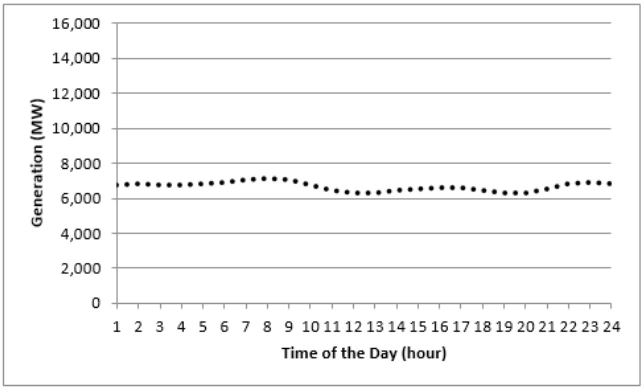


Firstly, demand peaks in the early evening, when most people are getting home from work. Solar generation peaks around noon and wind generation peaks overnight. This means that when we need the power most, renewable generation sources are either not producing anything, or an insufficient amount of electricity. Then, at times when we don't need as much electricity, renewables hit their peaks. Unfortunately, this (barring the incorporation of another technology) often results in a use-it-or-lose-it scenario.

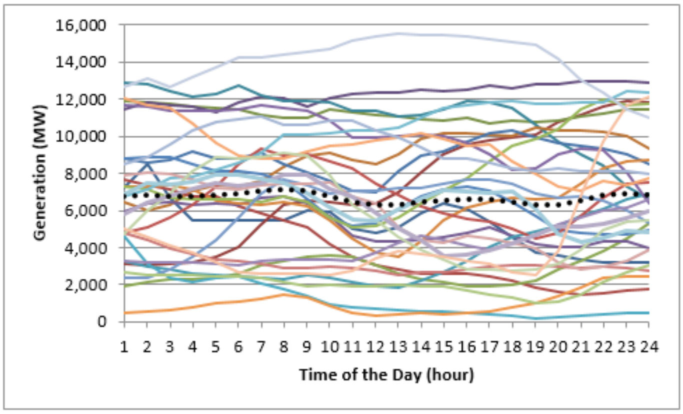
The only way for grids to overcome this is to continue to employ dispatchable, or controllable generation during times of peak need. No matter how many more solar panels or wind turbines we install we still would not make use of a large percentage of their generation. This issue manifests itself in the debate of megawatts versus megawatt-hours. For example, imagine a grid that has a peak demand of 1,000 MW for a four hour period in the afternoon. If we installed 1,000 MW worth of solar panels we could argue that we are 100 percent renewable—in that we have enough renewable generation to meet our peak demand. This is a purely theoretical view of the situation. In practicality, if that demand is from 5pm to 9pm solar generation will be at (or near) zero. This means that over the course of a day, we had a peak demand of 4,000 MWh (1,000 MW x 4 hours). Renewable generation was zero MW-hours (or near). The result of this is that we were basically zero percent renewable. Even though we have enough installed capacity of renewables, the shift in time between demand and production prevents us from full utilization. Unfortunately this can't be solved with additional renewable generation because as you add solar panels the megawatts increase (vertically on the chart), but not horizontally. No matter how many solar panels you have, they still won't harness energy when the sun isn't shining so the horizontal coverage remains the same (until we can start harnessing moon beams).

Statistically Speaking, There is a Problem with Averages

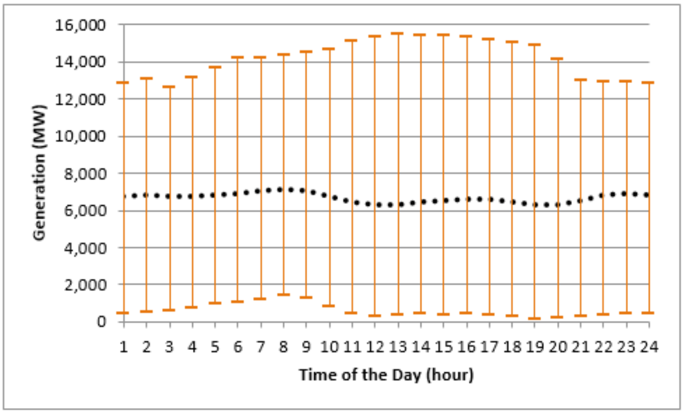
Secondly, renewable generation is inherently stochastic. In other words, we can analyze, estimate and predict renewable production but at the end of the day it is a random, uncontrollable event. Often, when we look at renewable production we look over the course of a month or a year and average out the production, which produces a stable, predictable output.



Unfortunately, the grid needs to be balanced instantaneously, not on averages. To examine this scenario, let's look at wind production in MISO on an hourly basis over the course of a month.



Now if we incorporate this into a more realistic view, we can see that to predict wind generation scenarios accurately, you need to consider a window rather than a simple line. Looking again at March, with the average line and then maximum and minimum wind generation, we see:



Now, in addition to the shift in production versus demand, we also see a challenge in the hourly variability of the generation. This creates a further need for rapid response (dispatchable) units.

You Had One Job...

There was a time in the not too distant past where generation resources could thrive by being good at one thing. For example, high baseload efficiency was great for baseload generation. Many plants were built to be started up a few times per year and run for hundreds of hours at full load. This is what they were designed for, and they performed well. Other plants were focused on peaking needs, so they were designed to be fast-starting and ramping. Doing this well allowed them to succeed as peaking resources. Unfortunately these days will most likely remain in the past.

The conversation between OEM's and generators used to be, "What is most important, baseload efficiency, fast-start ability, maximum turndown, or ramp rate?" The response was a single answer that matched the particular need at that time. Now the answer has changed to "Yes". In other words, generators can't afford to be good at just one thing anymore. Baseload generation is being asked to ramp up and down, and shut down and start up quickly, and turn down to minimum load. Peaking assets are being asked to start more often and run longer at baseload. The once clear demarcation between peaking, intermediate, and baseload resources is now gray and muddy.

Tools of the Trade

Let's get back to the basics for a moment. Just like generation assets were historically asked to do one thing, particular technologies became very good at doing one thing. The strengths and weaknesses of these technologies made the decision for generators relatively easy. If you wanted maximum efficiency with baseload generation then you went with a gas turbine based combined cycle plant. Simple cycle peaking plants were aeroderivative gas turbines. Smaller CHP plants and distributed generation resources were small gas turbines or reciprocating engines.

One Plus One Equals....Three?

The grid (and energy markets) is asking generators to be more capable than they have in the past. Generation owners are also finding that the only way to get a respectable return on their investment is to diversify revenue streams. In other words, not necessarily make more money doing what they've been doing in the past, but make different money. Tap into markets they haven't traditionally participated in, like the ancillary services markets. In order to accomplish this successfully, generation assets have to increase their flexibility to a level that pushes, and in most cases exceeds the capabilities of an individual technology. This is where the synergy of generation...or the SynerGen concept is born.

By intelligently combining two (or more) different technologies, weaknesses can be overcome and the result can exceed the capabilities of either technology on its own. For instance, gas turbines are dispatchable, reliable, and economical...but not instantaneous. Conversely, battery storage systems are instantaneous and have zero emissions during discharge, but they aren't sustainable in that they eventually run out of power. Combining these two technologies presents an asset that is instantly dispatchable and can run as long as needed. However, to fully unlock the potential of this hybrid solution we must go beyond simple collocation. The units must be fully integrated with each other to maximize performance.

And the Answer is...

The answer is that this problem requires more than an answer. It requires a solution. If someone asks you to help them build something and you show up with just a hammer, you're providing an answer. And that answer may be right some of the time. But, if you show up with a full toolbox…now you're delivering a solution.

The difference is that the answer is the final result. The solution is the comprehensive process that delivers an answer customized to the specific problem. Each plant, each project, each location is a different problem with different boundary conditions. This means there is no simple answer that solves all of the various problems. Instead, we need to approach each problem —each project with a comprehensive solution methodology that will deliver the right answer for that project. The future is here and the way to maximize revenue now and be fully prepared to adapt to wherever the market goes is to SYNERgize your GENeration.

About the author:

Chris Mieckowski has more than a decade of power plant experience, with a specialization in plant optimization. He is currently the Global Director of Solutions Portfolio Marketing at Siemens Power and Gas. Prior to joining Siemens, Chris was the Director of Business Development at Stellar Energy. Chris has also worked for GE and Kiewit, holding roles in product line management, early contract involvement and project engineering. He began his career with nine years in the U.S. Navy, starting as a Nuclear Electrician and completing his service as an officer. Chris holds a B.S. in Engineering from the U.S. Naval