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Utility Death by PV? No – Challenges and Mitigation Strategies

By Jeff Ihnen

In recent months, there have been many articles and opinions describing the Grim Reaper at the door of conventional electric utility companies. The reaper's poem is titled "The Utility Death Spiral" and it goes like this:

These days central utility systems
are governed so there are no victims.
Here comes PV.
I declare it will be
so quick they won't know what hit 'em

The elements of the centralized utility death spiral include:

· The price of distributed generation including rooftop solar photovoltaic (PV) installations is declining such that after all incentives, it's cost competitive with utility-delivered power.
· Utilities have fixed rate-base investments on which they need return on investment for their suppliers of operating capital – debt and equity.
· As rooftop PV erodes utility sales, they must raise rates to cover their fixed costs.
· This in turn makes PV more affordable for more end-users, and the cycle repeats into a death spiral.

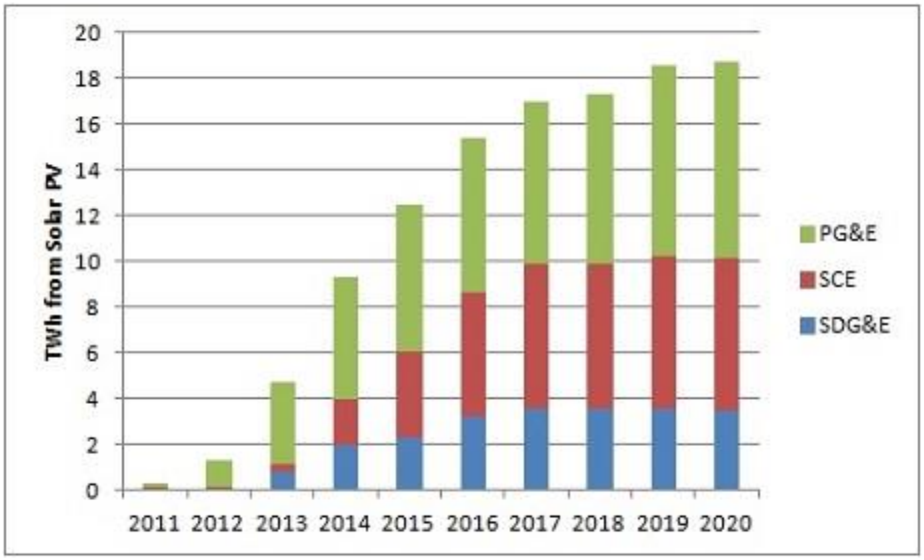
It isn't that simple.

As the solar PV market gains the penetration required to affect utility sales, incentives and tax breaks become very expensive for ratepayers and taxpayers. Moreover, new challenges for reliable grid control arise. These costs and associated complexities introduce a disturbing counter-vortex to the utility death spiral.

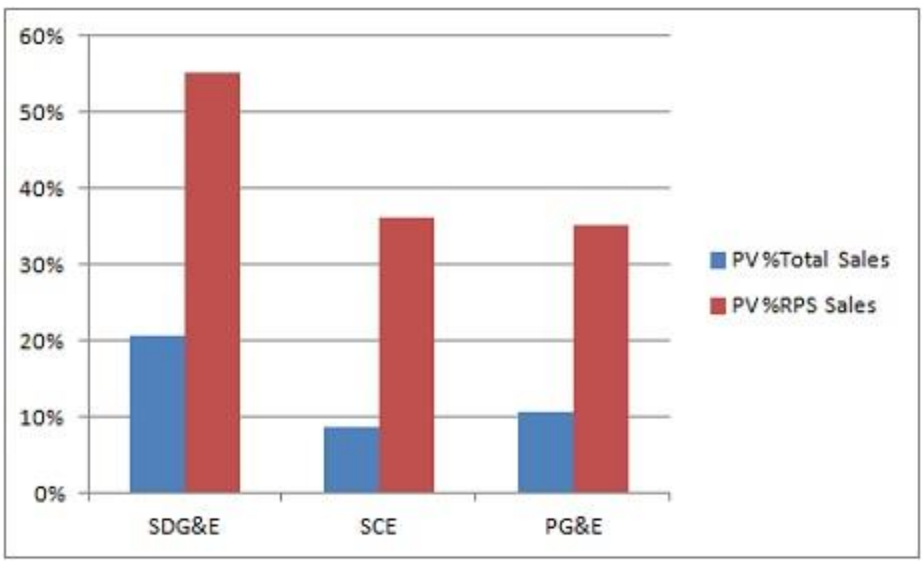
Early Adopters

California represents the nation's first foray into utility-sales erosion territory, and is therefore a good case study for the rest of the country. The California Renewables Portfolio Standard (RPS) calls for 33 percent of electrical energy to be produced by renewable sources by 2020. Currently, renewables make up about 23 percent of energy sold.

The path from 23 to 33 percent renewables is planned to be achieved almost entirely through solar PV. The aggressive ramp up of solar PV is shown in the chart below.

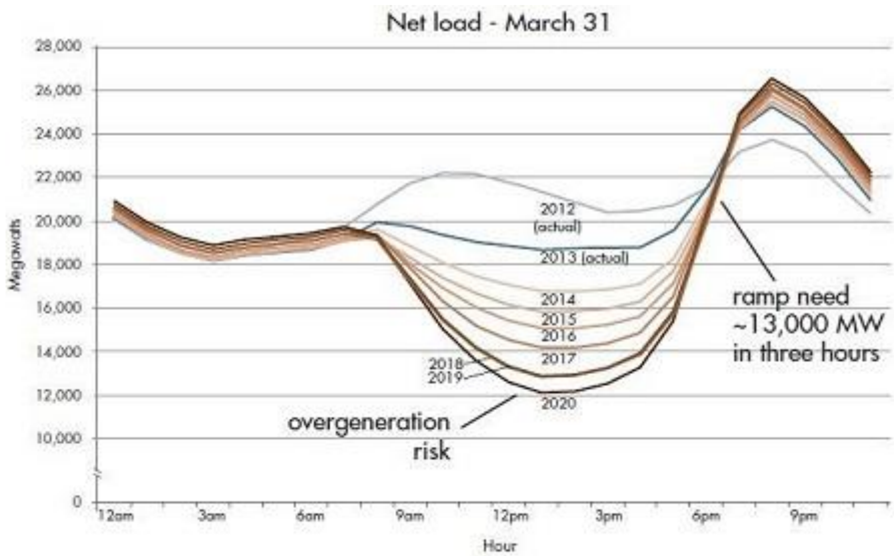


The next chart gives context to solar PV generation in relation to total RPS portfolio sales, and total utility sales, once the renewables targets are met in 2020.



Considering the sun doesn't shine half the time and at peak times, solar PV generation (power) can be almost triple the share of energy produced over the entire year. In other words, if PV produces 20% of San Diego Gas and Electric's annual electrical energy, peak solar generation may be almost 60% of the supply at that given moment. This provides one major challenge for these aggressive RPSs.

What does this entire PV supply look like over time from the vantage point of the grid and the California ISO that manages supply to meet demand? Succinctly, a duck, as depicted below by a series of curves representing the net load to be met by conventional sources.



The duck chart demonstrates the impact of aggressive penetration of solar PV into the resource mix for the state. As the sun rises, solar PV generation increases rapidly and the opposite occurs as the sun sets. Therein is challenge number two.

Challenges: Discuss
There are at least two considerable challenges for maintaining reliable power supply with such heavy doses of solar PV. The first is risk presented by high shares of PV even in steady state during peak solar power supply. The second is the rapid and large increase in power required by conventional sources to meet peak demand as the sun sets. These are shown on the duck chart as overgeneration risk (belly) and ramp need (neck).

Overgeneration
At first glance it would seem there is no overgeneration risk – just look at the chart! There is plenty of demand to pick up the PV supply.

It isn't that simple. The conventional grid with centralized generating stations is robust with sufficient spare capacity in operating generators. Plus, "spinning reserves" almost instantly pick up spikes in demand or sharp drops in supply, such as a large turbine generator going down. Additionally, these rotating devices have built-in governors to maintain speed, and thus alternating current at precisely 60 Hz.

As the portion of electricity supplied by spinning machinery including steam turbines, combustion turbines, and internal combustion engines decreases, the response to a lost generator is more challenging. There is less immediate spare capacity in other sources that can pick up a sudden drop in supply due to a tripped generator. The solar PV panels are pumping power at 100 percent all the time. They provide no reserve capacity for these cases and they have no automatic frequency response. This is a challenge.

Additionally, the grid was designed with centralized supply flowing to distant customers. When flow reverses from customer sites, portions of the distribution system can experience over-voltage. The solar PV power needs to go somewhere and when there is localized insufficient demand, it will push up the voltage until it can dissipate its supply. This can cause a loss of voltage control. Another challenge.

Ramp Need
A second significant challenge to the PV expansion is it does nothing to reduce peak demand, as demonstrated in the duck chart. The peak rises and the trough deepens. Combined, these features result in the projected 13,000 MW daily ramp. To put this into perspective, this is about 25 modern coal plants that need to come online in three hours. This is largely predictable but mix in variable wind generation, and any rapid transient increases risk compared to steady state operation.

Cost Effectiveness
Electric customers think a kWh saved or displaced should be worth the incremental amount they would otherwise pay. This isn't a problem on a small scale impacting only 1-2 percent of sales. It does become an issue when 10-20

percent of total utility sales are provided by distributed generation and customers are net metering back to the grid (selling their excess generation). To net meter, customers must use the utility's distribution system. In the Midwest, it costs an average of about $40 per household per month, just to provide the path over which electricity is delivered (poles, wires, substations). Customers will need to be educated that generation is only about half the cost of delivered energy.

Mitigating the Challenges
There are many suggested ways to mitigate these challenges. Some are familiar and tested. Some add cost. Others are new and costly and some will not work.

Energy efficiency and demand response are obvious strategies. This would seem to be a boon for residential efficiency and DR since the peak occurs as people leave their place of work, schools and so forth, to return home or visit their favorite watering hole or restaurant.

Demand response for everything from water heaters, to freezers and clothes dryers, and certainly space cooling may be warranted. Another strategy could be the use of incentives to switch major energy using appliances from electric to natural gas – particularly those that are likely to contribute to the duck's head. Typically fuel switching is an issue but this is an exceptional situation.

Other suggestions have included:
· Orienting PV panels to the west for later peak generation. Problem: this exacerbates the steepness of the ramp.
· Substituting a few hours of thermal storage to displace PV generation. Problem: this either erodes reaching the goal of 33 percent electric generation, or encourages the use of electricity for heating water and increases owner cost. Neither is preferred.
· Requiring new cooling systems to have thermal storage. Problem: more cost.
· Deploying electrical energy storage. Problem: more cost.
· Solar PV curtailment. Problem: a wasted, costly resource.

Closing Remarks
Solar PV generation seems like a perfect fit for sunny climates as a means to produce energy during peak times and reduce peak demand. However, depending on load shapes, large scale PV in some cases will shift peaks to different times and in other cases may not affect peaks at all. The bottom line is, rapid shifts to renewable energy can be costly. It is best to incentivize supply and demand to shape both curves for a better match to best capitalize on renewable energy sources.

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