Evolving power systems in the age of solar power

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The Rise of Solar and Distributed Energy

Traditionally, large power plants, fuelled by coal, hydro or gas, generated electricity that was distributed via a centralized grid to end user. Now, with the rise of new energy such as solar and wind and technology such as distributed energy generation, the picture has changed.

Solar power has become the fastest-growing source of global energy. The global solar market installed an impressive 98.9 gigawatts of new capacity in 2017 according to SolarPower Europe, increasing by 29.3% in comparison to the 76.5 gigawatts in 2016.[i] As many households generate their own electricity via rooftop solar photovoltaic (PV) panels, distributed energy emerges as a major player in energy distribution. Distributed energy refers to electricity generation at or near where it will be used, such as rooftop solar PV units, natural gas turbines, micro turbines, wind turbines. North America distributed energy generation market size was valued at USD 26 billion in 2016 and is expected to continue to grow.[ii] Electricity Network Transformation Roadmap (ENTR) projected that over 40% of energy customers will use distributed energy by 2027. By 2050, that figure will grow to more than 60%.

Several factors are driving the growth of distributed energy. First and foremost, the past two decades has seen a significant drop in the costs of solar modules. Residential rooftop PV systems have decreased by more than 60% in the past few years, declining from about $9.15 per watt in 2004 to about $3 in 2017. Bloomberg New Energy Finance (BNEF) expects 34% fall in PV module prices in 2018.[iii]

Technology improvements, consumer awareness and government incentives continue to bolster distributed energy growth. In addition to improvements in technology, which have created new applications and market segments that previously were not viable, rising awareness regarding clean energy resources is also likely to augment the demand for distributed energy generation systems. Renewable energy plays a key role in alleviating rise in greenhouse gas emissions and these systems are more affordable than conventional electricity generation. Thus, demand for clean energy coupled with economical pricing of the product is anticipated to positively

influence the market over the forecast period. Incentives and schemes by governments, such as feed-in-tariff in Asia Pacific and North America, are expected to fuel the demand for distributed energy generation systems.

China has led the world in new solar installations in the past five years. It installed 53 GW in 2017, up from 34.5 GW in 2016, representing 53% of the global solar market. Such rapid growth was supported by guaranteed electricity prices, set by the government. But as the cost of subsidies has been growing unsustainably and manufacturers have expanded rapidly to meet demand, the risk of overcapacity has grown. Hence, China decided to reduce feed-in tariff by RMB 0.05 per kWh (~0.7 ¢) for centralized PV, starting June 1, 2018.[iv] The cuts are a clear signal from government that the sector needs to become less dependent on subsidies and shift its focus from rapid scaling toward technological improvements to further cut costs. Consequently, China's PV demand is estimated to drop significantly by 40% to 31.6 GW in 2018.[v]

Decline in Grid Profitability

Another trend associated with the rise of solar power is the drop in grid profitability, resulting from a mismatch between expenses and revenues. For one thing, grid revenues are decreasing as more households are generating their own electricity via rooftop PV, thus paying less utility bills and even selling back to the grid excess power their PV system generates.

Rising costs, driven by decrease in capacity factors and increase in fixed costs, are also a concern. Over the past 15 years, OECD countries invested on average 0.2% of GDP per year in the development and refurbishment of the grid. In the US alone, for example, that amounts to $40 billion annually. It is projected that $1 trillion to $2 trillion in combined grid investment will be required across all OECD nations from 2014 to 2035.[vi]

As we've discussed in the China case, solar power depends heavily on subsidies. There are two types of subsidies. The first is an open subsidy, meaning that users can sell power back to the grid at a price that exceeds the wholesale price through net energy metering (NEM) or feed-in tariff (FIT). The second subsidy is a hidden subsidy. As customers use the solar power generated at their premises, the amount of energy they buy from the grid decreases, which lowers their

overall bill, thereby cutting the grid funding. Given that these customers are still using the grid (a fixed cost), the reduction in what they pay for it is essentially a hidden subsidy.

Amid changes in the energy market, utilities and regulators must adopt new approaches to ensure a robust and reliable electric grid. Utilities must reduce the fixed costs of grid operations, develop investment plans that reflect the rapidly changing industry landscape, and push for a new pricing model. Regulators, meanwhile, must strike a balance between subsidizing renewable energy sources and ensuring a robust and reliable grid.

Need for Market Design Evolution

In today's world, with constant advancements in technology and with the focus around clean, green and sustainable energy, there is a need for consistent evolution of power markets. The demand for affordable, reliable, and locally sourced electricity is on the rise, driven partly by public policy shifts towards reducing environmental and health related impacts of electrical supply. Furthermore, the energy industry is shifting rapidly towards usage of renewables and integrating them seamlessly into the grid is a constant challenge. Therefore, power market design needs to evolve to ensure grid penetration of renewables.

There are three primary principles around which market design is centered, namely adequacy, energy and ancillary services.

Adequacy. This principle basically ensures there is adequate investment in capacity to ensure that future demand growth is met with enough lead-time. Things like scarcity pricing, capacity markets, energy efficiency and some combination of all these is important in an approach to ensure adequacy.

Energy. This is the most important transaction in energy markets. Dispatch resolution, which basically means that energy is delivered when needed and is always available is one part of this. Fast ramp up and down times are also encouraged, as they can reduce fluctuations in the market. Another core part of this is forecast integration. Focus needs to be on accurate forecasting of demand and that needs to be integrated into energy plans to prevent unprecedented problems.

Ancillary Services. Ancillary services are basically support services that bridge the gap between supply and demand. Variable renewable energy also increases the need for various ancillary services, since there is uncertainty in wind and solar energy. Since the impact of renewables and their integration into the grid is significant, ancillary services like voltage control, co-optimization, primary frequency response etc need to be top-notch.

We need to avoid market designs with high complexities, since overly complex designs could lead to frequent market revisions, and also create conflict between markets. Investment is a major player in power markets too, as capital costs associated with energy resources are high. Encouraging increased participation is vital as the energy scenario is ever changing and evolving. Ensuring market depth is also a challenge to 21st century power market design. Most of the available energy is sold through bilateral contracts, which are long-term contracts. This energy is purchased years in advance, leaving little room for flexibility, which is an issue. It also reduces participation by investors in the power market.

Bridge Markets and Emerging Technologies

Demand Side Management. It refers to policies that are intended to either reduce or shift electricity consumption in order to achieve broader system and societal benefits. There are two types of programs: energy efficiency and demand response programs.

An example of energy efficiency is a utility incentivizes users to switch from lightbulbs to more energy-efficient LEDs, or to install a slightly more expensive but ultimately way more efficient water heater. These are the things that are going to reduce your electricity consumption pretty much all the time.

Demand response programs are intended to incentivize users to reduce electricity consumption at a system peak. An example of this would be you participating in a program for your utility where you get a small payment and in return the utility installs a device on your air conditioner that allows them to cycle it on and off when system loads are high, allowing them to avoid the use of less efficient and more polluting plans. This can shift demand from one time of day to another or reduce demand at a given time.

Integrated Distributed Generation. Distributed generation is not directly included in wholesale power markets, but integrating it into the grid, impacts the market by reducing demand at either a given time or overall and increasing energy efficiency.

Clarifying Role of Storage. Efficient use of storage could reduce curtailment. Storage can be used in three roles, namely generation, transmission and distribution. Traditionally, policies have been set up in a way that storage could only be used in one manner. If we could expand the role of storage to allow it to be used in more than one role, we could greatly benefit from that and bridge wholesale power market design with emerging technologies.

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