Distributed Energy Resources

Why Utilities Need to Develop Strategies Now

Prepared by

THE SHPIGLER GROUP
STRATEGY MANAGEMENT CONSULTING SERVICES

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Executive Summary

Electric systems throughout the world are facing many challenges. With much of today's transmission and distribution infrastructure installed in the 1950s, 60s, and 70s, many grid components have reached the limits of useful life and will need to be upgraded to allow for the bidirectional flow of energy between generation sources and consumption. Pressure on prices from increasing commodity costs, consumption growth and a decline in working inventories is expected to continue. Deployment of capital to meet load growth and reliability needs may become increasingly difficult. Government mandates, proposed carbon caps, and regulations that limit growth in existing and new generation sources are augmenting environmental concerns. At the same time, a number of other factors are occurring that call for new electric utility operational characteristics. Some of the new factors facing electric utilities include increased deployment of renewable generation, the high capital cost of managing peak demands, and large investments in grid infrastructure for reliability and smart grid initiatives.

This confluence of factors has triggered a tremendous level of interest in Distributed Energy Resources (DER) within the utility sector. While traditional transmission and distribution networks allow for the delivery of electricity to end users over distance, integrated resource tools that incorporate new approaches for demand management allow for the management of the same electricity over shifting time periods. By contrast to the legacy grid infrastructure, this approach allows for the generation and consumption of energy to occur at different times, thus allowing greater flexibility in grid operation – flexibility that can generate value by grid operators. Overall resource planning approaches can help balance variable generation and, properly deployed and integrated, can help increase electric grid reliability and asset utilization.

Distributed Energy Resources can support these objectives. A well designed program can fill needs by delivering a variety of services, including:

- Voltage support
- Reactive power support
- Power factor correction
- Enhanced reliability through the addition of a backup power source
- Transmission and distribution capital deferral
- Transmission congestion relief
- Distribution network optimization to reduce outages
- Wider and deeper adoption of renewable energy
- Frequency regulation and ancillary services
- Peak shaving
- Backup power sources
- Power quality assurance
- Reduced negative impact on existing generation (baseload bottoming, ramp rate control)
- Greater support for intermittent generation resources like wind and solar (curtailment avoidance, smoothing, shifting, flexible discharge for peakers)
- Improved efficiency of existing generation assets

- Reduced reserve and availability requirements
- Optimized efficiency (reduced fuel use and emissions)
- Reduced O&M
- Maximized value and profit of existing utility assets
- Optimized future generation mix and transmission grid by region

In spite of the variety of potential benefits, the utility industry is still trying to evaluate the optimal approach with respect to DER. To be certain, the financial implications of DER programs can differ widely among utilities depending on several factors:

- The reliability of the utility's current system
- The nature of the relationships with the state regulatory commission, including incentives that may already be in place
- Past legacy systems that have been implemented
- Geographic and territorial parameters
- The types of products offered (e.g. gas, electric)
- The extent of vertical integration across the supply chain
- Regional differences in load profiles and pricing

Nevertheless, financial modeling has demonstrated the viability of various DER systems for many utilities, once the defining characteristics of the utility are accounted for. This is despite the fact that conventional central generation is still cheaper than DER components when measured on a $/kW basis. This is accomplished by matching the resources to the needs of the utility in each situation. In short, often times utilities can leverage the inherent flexibility and scalability of DER to create a positive business case while positioning themselves for the future.

The Role of Distributed Energy Resources

There are multiple technologies that enable distributed generation and energy storage applications. A number of cost-effective systems and solutions exist today and others are expected to emerge and mature in the next 2-5 years. The cost and technical characteristics of the equipment drive their use and impact potential. Implementing distributed resources offers the opportunity to reduce the amount of energy lost in transmitting electricity because the electricity is generated and delivered close to consumption, perhaps even in the same building. This also improves the management of energy flow on power lines, which could reduce the size and number of power lines that need to be constructed in the future.


[1]

Cogeneration configurations are available with heat recovery from the gaseous exhaust. Cogeneration, also known as Combined Heat and Power (CHP), utilizes otherwise wasted exhaust heat as useful thermal output, typically steam. The steam may be used either for space heating or space cooling. CHP applications are driven by grid price and installed cost, but NOx emissions can provide a strong barrier to implementation, especially in non-attainment areas. Furthermore, CHP applications can provide lower CO_2 emissions by offsetting fuel for boilers.

Photovoltaics, small wind turbines and fuel cells have very low levels of NOx, CO, and CO_2 emissions. In addition to the remote power applications, customers who are environmentally inclined may purchase these applications with an aim toward reduced emissions. Reciprocating engines were among the first DG technologies and are typically used for power generation, continuous power, or backup emergency power. Both spark and compression ignition engines

[1] Courtesy of Electric Power Research Institute.

have gained widespread acceptance in almost every sector of the economy. Distributed generation from reciprocating engines offers electrical efficiencies of around 40%, compared to the 30% (after transmission losses) of centralized power stations. When used in conjunction with CHP, it increases the overall fuel conversion efficiency to more than 80%, further reducing CO_2 emissions and costs. Microturbines can be used for stand-by power, power quality, and reliability in addition to cogeneration applications. Most microturbine units are designed for continuous-duty operation and are recuperated to obtain higher electric efficiencies. In an era of both increasing power outages and rising demand for premium power, many businesses may look to install DG units to protect against the risks associated with power outages. Combustion turbines have relatively low installation costs, low emissions, and infrequent maintenance requirements. However, their low electric efficiency has limited turbines to primarily peaking unit and CHP applications for industrial and large commercial market segments. Cogeneration installations are particularly advantageous when a continuous supply of steam or hot water is desired and NOx emissions can be managed with post-combustion treatment processes. Stirling engines are often considered for CHP applications; however, they can also be used in solar power generation, where their ability to convert solar energy to electricity is more efficient than the non-concentrated photovoltaic cells. They have low electrical efficiencies and are therefore best in CHP applications or in use with renewable fuels.

Energy storage can improve power quality through voltage support, reactive power support, power factor correction and can enhance reliability through the addition of a backup power source. In an economically strained environment, utilities typically look for ways to defer capital investments while preserving reliability. In the near term, it is possible that these devices will be deployed to areas with high levels of congestion or failure in order to defer upgrades while minimizing outage minutes. In a carbon constrained environment, they can be used to maximize the peak coincidence factor of renewables.

Similar to distributed generation technologies, the technical and operational features of energy storage often define their potential uses. Above ground CAES systems are capable of providing energy arbitrage, system capacity, and ancillary services. They are also an attractive option in urban areas to defer distribution investments for small areas with rapid growth. Lead acid batteries have much higher energy densities, but a shorter cycle life, which limits their application for energy management. However, they are some of the oldest and most developed battery technologies due to their low cost and popular storage choice for power quality and UPS applications. Improved lead acid batteries could change the economics for utility applications.

The sodium-sulfur (NaS) battery has a high energy density, high efficiency of charge/discharge, long cycle life, and is fabricated from inexpensive materials. Its high operating temperature makes it primarily suitable for large-scale non-mobile applications like grid energy storage. Flow batteries are normally considered for relatively large, stationary applications, like load leveling, where the battery is used to store cheap night-time electricity and provide electricity when it is more costly to produce. They can also store energy from renewable sources such as wind or solar for discharge during periods of peak demand, shave peaks by meeting demand with stored energy, and provide uninterrupted power supply (UPS) whenever the main power fails. They can even be used to replace lead-acid batteries and diesel generators that are being used for UPS and small telecom applications. The main advantages of Li-ion batteries, compared to other advanced batteries, are their low weight and compact size, high energy density, high efficiency, and long cycle life. Li-ion batteries applied in utility distributed energy storage systems can serve as a distributed battery storage system to buffer power and, when connected to a power source, can be used to locally mitigate power outages for short periods of time.

Managing peak capacity is one of the greatest challenges for electric utilities. The system has to be built and managed to handle a needle peak of 200-400 hours per year. Each year, utility investments in grid upgrades and expansions are increasing along with congestion. Applications like demand response and energy efficiency programs are attractive because they give the utility the ability to proactively address this issue with minimal investment, but distributed generation and energy storage are also being pursued as a more definitive way to reshape the demand curve. Portable systems like substation upgrades have even been used to defer near-term capital expenses.

On an increasing basis, DER is being implemented in the form of a virtual power plant. In the virtual power plant approach, distributed generation, energy storage, and demand response (DR) are equipped with automated management and control systems technology so that they can be aggregated at a scale which is as significant as a central station power plant. The underlying assumption is that these resources are replacing a power plant and acting as one on a local distribution level (i.e. providing energy and capacity values, and providing spin, ancillary, renewable integration, peak leveling, and islanding capabilities). This capacity is available to be dispatched by grid operators, bid into markets, or used to provide relief when emergency grid conditions occur.

While no one expects that virtual power plants will completely displace central station generation, the emergence of new technologies have enabled the realization of greater reach in their deployment. Each element of Distributed Energy Resources – distributed generation, energy storage, and demand response – have been around for a number of years. What makes things different now is a combination of the lower costs and increased technical capabilities of the underlying technology solutions, coupled with the greater capabilities of network design. With new developments in cloud-based and distributed control center applications that take advantage of information and communication technologies and Internet of Things (IoT) devices, it is now easier to aggregate the capacity of underlying distributed resources.

Scenario Analysis

A well designed resource planning portfolio can be used as a vital program in operating the power grid. Targeted programs enable the provision of system services throughout utility operations and can even be considered by non-vertically integrated utilities for distribution support functions. The advancement of technologies and systems makes this more of a reality than ever before. Appropriate system planning through detailed modeling helps identify the right path to pursue prior to making system design decisions.

We may consider three potential strategies utilities may employ with respect to the adoption of Distributed Energy Resources and evaluate the likely outcome of each.

Passive Strategy without Regulatory Intervention

In this scenario, utilities continue to take a hands-off approach with respect to DER resources – shunning investments in energy storage, engaging in distributed generation only through net metering arrangements, and only moderately utilizing demand response program options. Where does this lead?

In the short term, there is not much change from the status quo for utilities that employ this passive approach. However, the longer term implications are troublesome. Over time, it is certain that more and more customers will deploy their own distributed generation options, typically wind and solar. As these customers are taken off the grid, the remaining burden for rate recovery falls on the shoulders of remaining customers. This results in higher electric rates, closing the gap with higher cost renewable energy. With the pricing closer to parity, additional customers are likely to pursue DG options, putting further stress on rates. This cycle continues, with the remaining customers paying higher and higher rates – potentially even higher than DG. In the end, utilities' position as the low cost supplier of electricity is no longer certain.

This "death spiral" scenario is one that has been discussed at length within the utility sector. While few believe that this option is likely to be terminal for the industry, we can be sure that some utilities will be placed in an unattractive pricing scenario if new technologies are not accounted for.

Passive Strategy with Regulatory Restructuring

Today, utilities are the default providers of electric services to customers. However, imagine a scenario in which utilities lose their hold on the customer relationship. How would this happen?

The previous scenario portrays a world in which the vacuum of DER activity is ultimately filled by proactive customers employing distributed generation assets for themselves. What if third party providers fill that void instead? If utilities are unwilling to deploy DER resources as part of their overall resource strategy, that would open up the market for new entrants to do so themselves. Already, we see third party providers taking ownership of blocks of energy and selling them back to utilities. A number of developers of energy management systems are similarly exploring options as well. If these providers now take ownership of the customer relationship, it would dramatically reshape the nature of the industry.

In a world where significant numbers of customers have relationships directly with 3rd party energy marketers, we can expect to see dynamic competitive markets open up that don't involve the incumbent utility. In effect, this dynamic would result in a new shape of energy deregulation – one that extends the definition of retail energy providers. In this world, it is likely that the incumbent utility takes on the role of wires provider, providing a commodity regulated service with even more stringent earnings caps.

Active Strategy

Instead of letting the market develop, utilities take an active role in the deployment of Distributed Energy Resources. While in the past the list of applications where DER offers demonstrable benefits was somewhat limited, technology has developed and costs have gotten significantly lower. So, that list of viable applications gets longer each day. As it does, utilities will want to own and control those resources rather than letting the market dictate terms to them.

Customers will continue to deploy their own distributed generation assets. Third party marketers will continue to explore ways to expand their reach. However, these players have only limited capabilities relative to utilities. Consider the advantages that utilities have:

- Utilities can deploy resources at scale while other players are limited in their deployment options
- Utilities have the benefit of sourcing a mixture of DER resources to optimize resource utilization rather than having a static resource output
- Utilities can vary their DER utilization over time based on the needs of the grid on a moment-by-moment basis; other providers can simply deliver their portion and let utilities utilize based on system requirements
- Utilities can deploy modest levels of DER today and can ramp up based on needs while other players need to make commitments to deploy today that are not nearly as scalable

In short, incumbent utilities have tremendous advantages when it comes to DER – as long as they take action now. While tomorrow's business model of energy delivery may change shape, as long as utilities lead they stand to drive that change rather than having to react to it. When we consider the fates of past incumbent players in the transportation and telecom industries when innovation drove changes in the core business model, we can see that those who were well positioned thrived while those who let others lead typically faltered.

The Economics

Electricity generation is the process of converting non-electrical energy to electricity. For electric utilities, it is the first process in the delivery of electricity to consumers. Centralized power generation became possible when it was recognized that alternating current power lines could transport electricity at very low costs across great distances by taking advantage of the ability to raise and lower the voltage using power transformers. Electricity has been generated at central stations since 1881. Electricity is produced by large centralized power stations, which is then delivered to the point of consumption via the power grid. The first power plants were run on water power or coal, and today production relies mainly on coal, nuclear, natural gas, hydroelectric, and petroleum.

While large centralized plants can generally produce cheaper electricity than typical sources of decentralized generating sources, there are still some cost and system benefits associated with DER. Today's central power plants require large and sporadic investments that may range from hundreds of millions to billions of dollars. They also require investments in transmission infrastructure. Transmitting electricity over long distances results in large supply losses and high capital costs for the grid. Large plants also need spinning reserves to cover potential power plant trips. The reserve needs are typically 10 - 20% above the peak consumption. Some decentralized power plant technologies are small enough to be located at the point of consumption with limited environmental impact. Their size also means that often they are the only option when power is needed in remote or rural locations that do not have access to the larger grid.

At the same time, utility interest in energy storage applications is expanding due to the convergence of several issues, including the rising cost of conventional generation and delivery assets, increased load growth, the need to integrate large amounts of renewable resources, the need to address weak points in the power delivery system, and the simple fact that many new storage solutions are ready for widescale use. Larger scale energy storage is positioned to play a key role in renewables integration because it can assist in achieving reliability standards, meeting frequency and ramping requirements for an otherwise intermittent generation source. Smaller-scale distributed energy storage systems, like batteries, are more appropriate for arbitrage, peak shaving, backup power, outage mitigation, grid support, and power quality assurance.

Although successful DER applications can involve stand-alone configurations, their economic viability is significantly enhanced through interconnection with the utility grid. The complexity is justified because adding intermittent renewables and energy storage devices to the grid and making the load they carry dispatchable creates many opportunities for utilities. In addition, it is likely that demand response applications will drive the near-term innovation for interconnection and integration needs. The electrical connections of advanced load control and two-way communicating management functions will be similar to what is needed, at least from a commercial and residential level, for Distributed Energy Resources.

When properly designed, a DER program can offer significant financial and operational benefits. Consider the case of an analysis of a DER-driven Virtual Power Plant that targeted 12.7% of capacity over a ten-year period from three asset categories:

- Utility-Owned Distributed Generation – Molten Carbonate CHP, Solid Oxide fuel cells, NG reciprocating engines, combustion turbines with CHP
- Customer-Owned Distributed Generation – photovoltatics, Stirling Engines with MicroCHP, microturbines with CHP, controllable demand
- Utility-Owned Energy Storage – Sodium Sulfur and Zinc Bromine flow batteries

The results for this gradual deployment of a variety of DER resources was demonstrated to be very strong[2]:

Deployment Requirements	Utility Owned DG CapEx	$400.1 MM
	Customer Owned DG CapEx	$91.2 MM
	Utility Owned ES/DR CapEx	$460.7 MM
Financial Results	Net Present Value	$1,013.9 MM
	Internal Rate of Return	34.90%
	Peak Funding Requirements	$297.7 MM
Operational Results	Ten-Year Total Installed Capacity	1,504 MW
	Ten-Year Usage Reduction	657,661 MWh
	CO2 Emissions Eliminated	18,662,333 Tons

This business case demonstrates that viable opportunities do exist, when proper planning is put into place. Each utility will want to evaluate its own options and build its own business case prior to implementing a plan. Nevertheless, we can see a wide variety of programs that utilities are currently exploring:

- DER can be applied for many purposes, including grid upgrade deferral, reliability improvement, load shifting and bulk arbitrage, renewables integration and output firming, and to supply ancillary services.
- Weak grids and long rural feeders are driving some utilities to consider DER. Demand continues to increase as the infrastructure ages, requiring extensive renewals and upgrades to distribution assets. Deferring these investments is especially attractive in situations where builds can take a long amount of time or utilities cannot recover the costs of new transmission or distribution lines through traditional regulated returns.
- The costs of planned and unplanned outages can become significant beyond a certain number each year. Utilities facing regulatory penalties for excessive outages are looking at DER options to provide islanding capabilities on long isolated feeders in remote areas.
- Managing peak demand has long been a challenge for utilities. Smoothing the demand profile allows for more efficient generation and reduces the need for expensive peaking

[2] The Shpigler Group. "Distributed Generation and Energy Storage Systems in a Smart Grid: Characterization and Analysis".

plants. Distribution utilities are looking for options to improve the systems load factor which is generally underutilized. Using DER to shift load is particularly attractive for utilities with small or poorly interconnected transmission systems, small systems with little generation, and systems with higher nuclear penetrations.

- Regulatory encouragement for renewable energy has brought about the installation of wind and solar farms, which are typically located in remote areas with radial distribution networks. These networks often have insufficient capacity to move all the generated energy to demand centers, which can also cause grid stability issues with a lack of frequency and voltage regulation. Utilities with weaker infrastructure, little interconnection and large wind resources are installing storage to maximize the renewable benefits while minimizing instability.
- Vertically integrated utilities used to provide their own ancillary services, but today these services can be provisioned by market participants. DER systems can be used to provide several of these services and first movers in this field will gain a significant advantage over potential competitors.

Summary

Analysis conducted in a variety of utility DER investigations has demonstrated that integrating distributed generation, energy storage technologies, and variable demand into existing utility operations can offer solid financial returns – given the right deployment strategy. As performance metrics improve and costs continue to drop, we see additional opportunities for progressive utilities.

Utilities that have been challenged with decreases in reliability due to rapid localized growth or aging equipment and are in need of costly repairs should look to distributed generation and energy storage technologies. These can be located at substations or feeder locations to provide backup power, islanding and load leveling capabilities.

In environments where regulators offer incentives for specific technologies, like customer-owned devices or energy efficiency programs, utilities should look to encourage adoption by those customers that would have the greatest impact on peak (e.g. C&I customers). Depending on the level of revenue loss from on-site generation, additional incentives or capitalization may be required to offset an imbalance in benefits.

Utilities should focus on targeting applications that help reduce costs like deferring capital investments. The "substitute" technology needs to be cost-effective (i.e. cheaper than their existing peak production costs) and commercially available. Utilities that have not adopted a variable pricing program to offset losses from more expensive peak production cycling should look to demand response programs and energy storage devices to reduce production costs and improve asset utilization. Not unexpectedly, demand response programs have some of the lowest costs given their overall impact and should be pursued in areas with steep demand curves to improve their return on investment. Other areas, which have a more level demand curve, may want to focus on developing cheaper generation sources and reducing line losses through the use of utility-owned distributed renewables.

Regardless of the specifics of each utility's operating characteristics, however, it is important for each utility to develop a robust DER plan. Such a plan should be rooted in the economic and operational realities that exist today while providing a platform for the future.