Distributed energy technologies challenge conventional thinking around grid planning

Grids | New storage and renewable energy technologies offer a potentially disruptive alternative to costly, unpopular investment in grid infrastructure improvements. Alex Eller looks at the opportunities for non-wire alternatives to maintaining transmission and distribution networks

Credit Scott Dreger/Southern California Edison

Innovations in new distributed energy technologies are challenging conventional thinking around the most effective ways to serve electricity customers and utilise grid infrastructure. These innovations in hardware, software and business models are helping to drive the overall transition to a more resilient and intelligent energy system that aims to deliver cleaner and more efficient electricity to an increasingly engaged customer base.

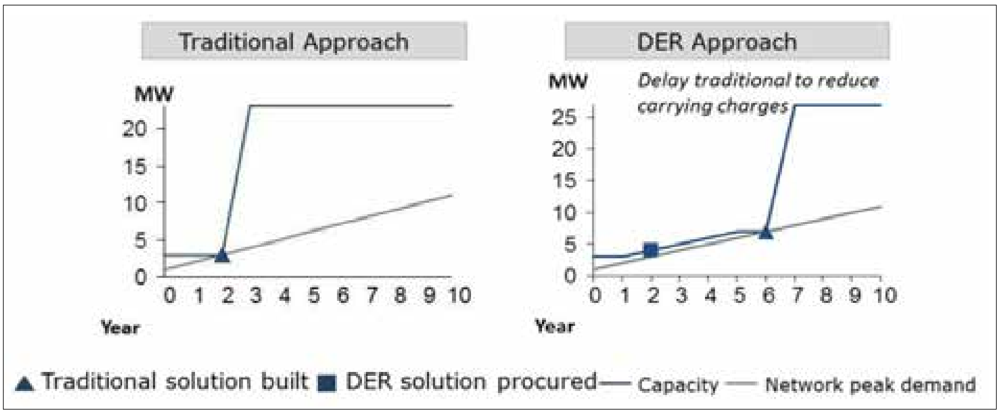
Maintaining and upgrading transmission and distribution (T&D) networks represents one of the most significant expenses for electric utilities and traditionally there were few alternatives to costly investments in expanded capacity. The new generation of less expensive and more intelligent distributed energy resources (DER) and energy storage technologies located on both the T&D grid and customers' properties has opened the door to a compelling array of new options for how to best utilise existing infrastructure. These technologies will disrupt the conventional T&D industry by maximising the value and efficiency of existing grid assets while empowering customers to participate in the management of the grid. This article will explore the overall drivers of T&D upgrades and the challenges facing these projects as well as new alternatives, with a focus on diverse non-wire alternative (NWA) projects, their benefits and challenges and the emerging trend of using purely energy storage to defer costly upgrades [1].

Energy storage is among the emerging technologies challenging conventional thinking on grid improvements

A need for upgrades

The electric T&D system is a constantly evolving machine that requires continual monitoring, maintenance and upgrades. Traditionally, the required upgrades to the T&D system were relatively easy to predict and could utilise a consistent and standard set of grid equipment and infrastructure to meet growing electricity demand. Rapidly evolving technologies and evolving customer demands have made predicting and performing grid upgrades much more complex in recent years. There are three primary issues driving the need for T&D upgrades:

- **Congestion and generation curtailment:** The growing amounts of variable renewable generation have exacerbated



Source: Consolidated Edison

Figure 1. The value of a non-wire alternative or energy storage/DER approach to defer T&D upgrade

congestion challenges in many areas, leading to the curtailment of energy. Actual rates of curtailment vary considerably in markets around the world. The highest average curtailment rates have been seen in China, where some provinces have wasted nearly 39% of wind generation due in part to limited transmission capacity [2].

- **Load and peak demand growth:** Typically, increasing demand for electricity and load growth has closely followed overall economic development. However, load growth rates have decreased or remained flat in many developed economies in recent years, while the dynamics of peak demand periods on the grid continue to evolve. Some utilities are experiencing decreasing overall load growth rates, yet increasing growth in their peak demand. New sources of load, notably EVs, are expected to reverse the trend toward decreasing electricity demand growth over the coming years. This new load growth will be variable and often concentrated in specific areas, providing an advantage for more flexible NWA-type solutions.
- **Reliability:** Improving reliability is a particular concern for commercial and industrial (C&I) customers, which often place a premium on reliability as they risk significant financial losses from an outage. Utilities are increasingly focused on improving reliability in the face of competition from third-party energy service providers targeting C&I customers. Furthermore, the overall resilience of the grid is becoming a greater focal point for governments and regulators in the face of both natural disasters and physical and cyber security threats. The diversification and expansion of the grid can reduce the potential effects of these events.

Building new T&D infrastructure has been the default solution to issues facing the electricity grid for decades. However, there are many challenges to upgrading grid infrastructure, particularly large-scale transmission projects. These challenges include concerns from local communities, the time required to develop and build projects, uncertainty around future load growth and demand patterns, and the rising costs to build new infrastructure in both urban and remote areas. Given these challenges, the falling costs of energy storage and DER technologies are presenting an increasingly economical alternative to conventional T&D projects.

Innovations in grid management and DER technologies have presented a new set of possibilities to maximise the use of existing grid infrastructure and defer or entirely avoid costly upgrades. At the same time, many utilities are seeking to engage customers and provide more value-added services in response to growing competition. Creative solutions to address infrastructure needs at a lower cost with greater customer and environmental benefits, known as NWAs, are being tested around the world. Navigant Research defines an NWA as:

"An electricity grid investment or project that uses non-traditional T&D solutions, such as distributed generation, energy storage, energy efficiency, demand response (DR), and grid software and controls, to defer or replace the need for specific equipment upgrades, such as T&D lines or transformers, by reducing load at a substation or circuit level."

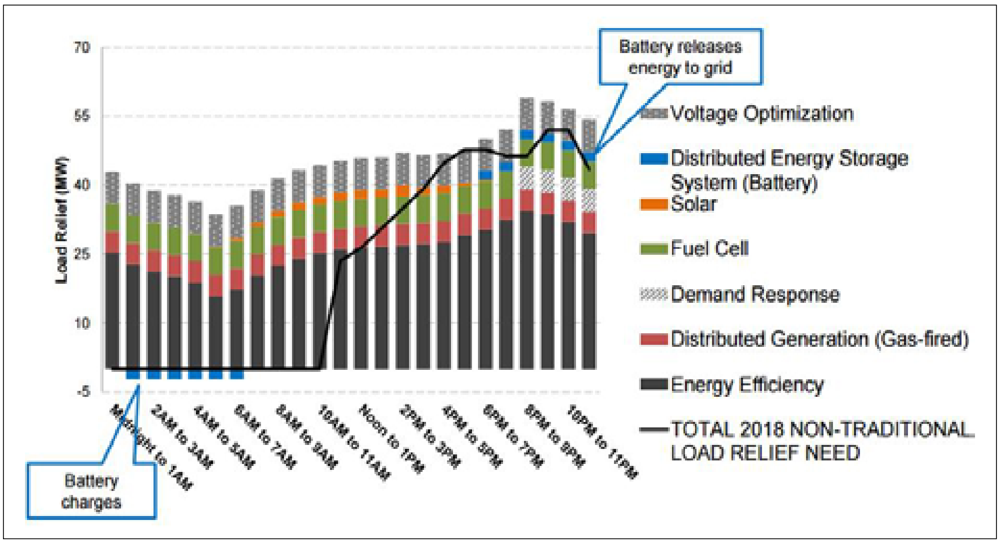
Overall, the major advantage is the greater flexibility provided by NWAs compared to traditional investments. A DER-based approach to meeting load growth can more closely match actual conditions on the grid without unnecessary investments. The graphic below illustrates how a DER approach can better match growing demand and defer a much larger investment.

Driving growth

Although there is a wide range of specific factors leading to the development of NWA projects, there are five primary drivers in the market which also represent some of the fundamental changes underpinning the shifts in this industry and the challenges to the traditional utility business model. These drivers include:

- **Regulatory policies:** Regulations and policies can provide incentives to utilities to implement more NWAs, such as allowing the sharing of economic benefits between customers and shareholders rather than all savings going to customers. Many of these policies are designed to reduce the environmental impact of electricity generation and usage by limiting the need for new power plants and T&D infrastructure.
- **Economics:** By far the most significant economic benefit of an NWA is the deferral benefit of the large capital investment. Traditional T&D upgrades have risen in cost and complexity in recent years, while DER technologies and grid management software and communications have seen dramatic price decreases.
- **Utility customer engagement:** Faced with competition from customer-owned DER technologies and third-party energy service providers, utilities are working to offer new solutions and improve customer engagement.
- **Load growth uncertainty:** Short-term investments in NWAs can defer much larger infrastructure investments, giving a utility time to assess whether the infrastructure investment is truly required and to investigate other potential options.

To date, most NWA projects developed have been in the US and the list of projects is expected to grow quickly. New York utility Consolidated Edison (Con Edison) was one of the early pioneers of NWA strategies. The utility began geographically targeting energy efficiency investments in 2003 when growing demand caused several distribution networks to approach peak capacity. These efforts evolved into the well-known Brooklyn Queens Demand Management Programme (BQDM) [3]. This programme intends to use many forms of DER to defer or avoid costly T&D infrastructure projects, specifically a new US$1 billion substation for the Brooklyn/Queens area, a region



Source: Consolidated Edison

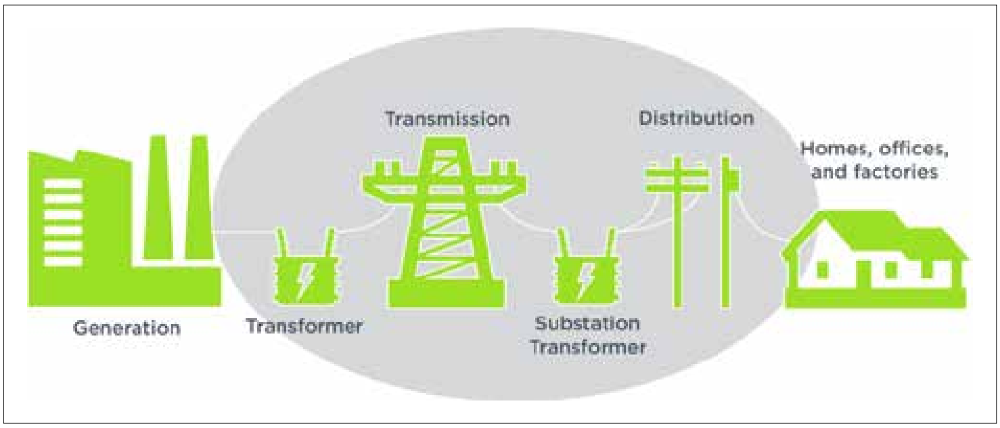
Figure 2. Anticipated BQDM 2018 Portfolio.

expected to see significant demand growth. The BQDM programme is expected to spend US$200 million on demand-side load management (DSM) programmes to shed 52MW of load – 41MW from the customer side and 11MW from non-traditional, utility-side measures. Figure 2 illustrates the anticipated resource portfolio of the programme in 2018, highlighting the diversity of DER being utilised.

On the West Coast of the US, two of the largest grid operators and electricity providers, Bonneville Power Administration (BPA) and Pacific Gas & Electric (PG&E), are also exploring NWAs [4]. While BPA has been evaluating NWA options for many years, its first commercial project was announced in May 2017, aiming to avoid replacing a large and expensive transmission line in Oregon and Washington. After almost 10 years of planning the upgrade with strong public opposition and increasing project costs, BPA decided instead to implement various NWA options, including energy efficiency, DR, rooftop solar and possibly energy storage to avoid the large transmission system investment. PG&E in California has also been experimenting with NWAs for many years, with a focus on targeted DSM efforts. Using DSM to defer investments in T&D capacity frees up constrained capital to fund other, more valuable projects for its system. Furthermore, PG&E believes that engagement with a DSM programme significantly increases customer satisfaction.

Risk aversion hinders widespread adoption

Despite the advantages and growing popularity of NWA programmes, significant barriers remain to more widespread adoption. As with many new electrical grid technologies, the level of confidence utilities have in the new programmes is crucial. Although early results have been promising, many utilities do not yet have enough faith in NWA programmes to overcome the traditional preference and expertise with T&D investments. This lack of faith is the result of both an institutional resistance to change within many organisations and the fact that prevailing rate recovery mechanisms for utilities typically do not encourage alternatives and innovation. If there is no regulatory pressure in place, there are few reasons why a utility would pursue an NWA. There is a higher perceived risk associated with these types of short measure life projects



Source: Navigant Research

Figure 3. Transmission and distribution breakdown

compared to a traditional equipment upgrade that is built to last 20 years or more. In addition, a T&D upgrade aligns with the historical experience of a utility. Thus, they may be more comfortable implementing a poles and wires upgrade.

Much of the hesitation to embrace NWAs stems from the challenges with engaging customers and being able to effectively guarantee a necessary amount of load reduction. Investments in energy efficiency, DR and solar PV have proven effective at reducing load in select areas; however, they do not guarantee the level of reliability and control that utilities demand. Although customers may typically respond to a DR signal to reduce demand, they often can override that signal and continue their normal operations. Due to this inherent unreliability, new technologies such as distributed generation and energy storage have emerged as more expensive but advantageous components of an NWA portfolio.

The increasing popularity of energy storage in NWA programmes and as a single-technology alternative to conventional T&D investments stems from the reliability and flexibility of storage systems on the grid [5]. Utilities prefer direct control over critical assets that are used to serve peak demand and ensure the capacity of grid infrastructure is not exceeded. As a result, energy storage is typically seen as a more reliable form of load reduction compared to NWAs composed of customer-side DER. Centralised, utility-scale energy storage systems (ESSs) in particular fit more with traditional utility investment models and technical expertise. ESSs provide added flexibility with the variety of services they can provide when not needed to support T&D infrastructure, including frequency regulation, voltage support, spinning reserves, outage mitigation and effectively integrating renewable generation. Another advantage of energy storage is that the technology can be sized appropriately to meet grid needs and can be sited in numerous locations to deliver maximum benefits—either in front of customers' meters on the T&D grid or behind-the-meter (BTM).

Transmission-level ESSs designed to relieve congestion have been relatively rare to date due to the large storage capacity required to alleviate these issues. Distribution-level ESSs have been the most common type of T&D deferral projects to date. These systems are frequently built at substations or specific points of congestion on the distribution grid to defer investments and improve reliability by isolating outages. Many distribution-level systems have been relatively small pilot projects initially, but utilise modular designs allowing for storage capacity to be expanded over time.

BTM energy storage to defer T&D investments is more complex and dynamic than transmission or distribution-level systems, although it has the potential to be far more disruptive to the industry. BTM energy storage for T&D deferral includes systems located in both C&I and residential buildings that utilise advanced software and virtual aggregation to provide targeted congestion relief for grid operators. The primary advantages of BTM storage providing T&D deferral are potentially lower costs to utilities and the ability to offer more visibility and control at the edges of the grid. BTM storage for these applications is currently a nascent market, with several key challenges including:

- Relatively high upfront costs for customer acquisition in some situations
- Small amount of storage capacity per system
- Concerns regarding the reliability of load reduction with customer or third-party owned systems.

Momentum evident, despite barriers

As with NWA programmes in general, there are several barriers standing in the way of energy storage being widely used to defer T&D investments. Despite recent advances, the technology and market remain quite new and immature, resulting in a conservative approach from often risk-averse utilities. Fully understanding and analysing the value of these energy storage projects is also challenging as the complex nature of the technology –including its ability to provide multiple services at different times – is not captured in many grid modelling and simulation systems. Furthermore, there is a major variation in the costs to upgrade T&D infrastructure. Energy storage and NWAs are typically only a cost-effective alternative when T&D projects face high costs due to challenging terrain, population density, real estate costs, weather constraints and other issues.

While barriers to widespread growth remain, both NWAs and storage-specific projects to defer T&D investments are gaining significant momentum with a variety of new projects being developed around the world. In addition to the NWA projects already discussed, energy storage projects for T&D deferral are growing in popularity and have recently been announced in Arizona, California, Massachusetts and Australia. These new projects are utilising several different business models to match the necessary technical and financial solutions with a customer's needs and available resources. The innovations happening in this market are helping drive the overall transition to a more intelligent, dynamic and distributed energy system the promises to improve efficiency, empower customers, and reduce environmental impact.

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