

The Battle for Supremacy at the Grid Edge



by **Alan Ross** CRL, CMRP
Managing Editor of APC Media
alan.ross@apc.media

At steering committee meetings for the first IEEE PES Grid Edge Conference, recently held in San Diego, one of the first things that we had to agree on was the definition of the grid edge. As a representative of the IEEE Smart Grid Program, I was an advocate for referring to it mostly as grid modernization as we have been moving to a smarter grid through standards developed as long as 20 years ago. There are some who consider Grid Modernization and Smart Grid as synonymous terms. They are not. More simply, grid edge refers to the 'edge' of the electricity network, the point at which we connect to the network and electricity reaches our homes and businesses.

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It has also been called the 'low voltage' network, where the massive pylons, cables, and substations that make up the physical infrastructure of our energy system finally reach us. But in a grid that is rapidly moving from step-down to step-everywhere with solar, wind, electrification of transportation, microgrids, and new forms of battery systems; the definition must include all of these changes. So the grid edge now refers to sources of supply and demand, not just demand.

While the grid edge is undergoing a radical transformation, for purposes of this article we will focus on three main trends: electrification, decentralization, and digitalization. These major trends are creating new opportunities and challenges for various stakeholders in the electricity sector, such as utilities, regulators, customers, and technology providers. We will explore how these trends are shaping the battle for supremacy at the grid edge in North America and beyond.



Alan Ross CRL, CMRP, is the Managing Editor of APC Media. Alan has decades of experience in the power systems industry and is one of the greatest reliability experts out there.

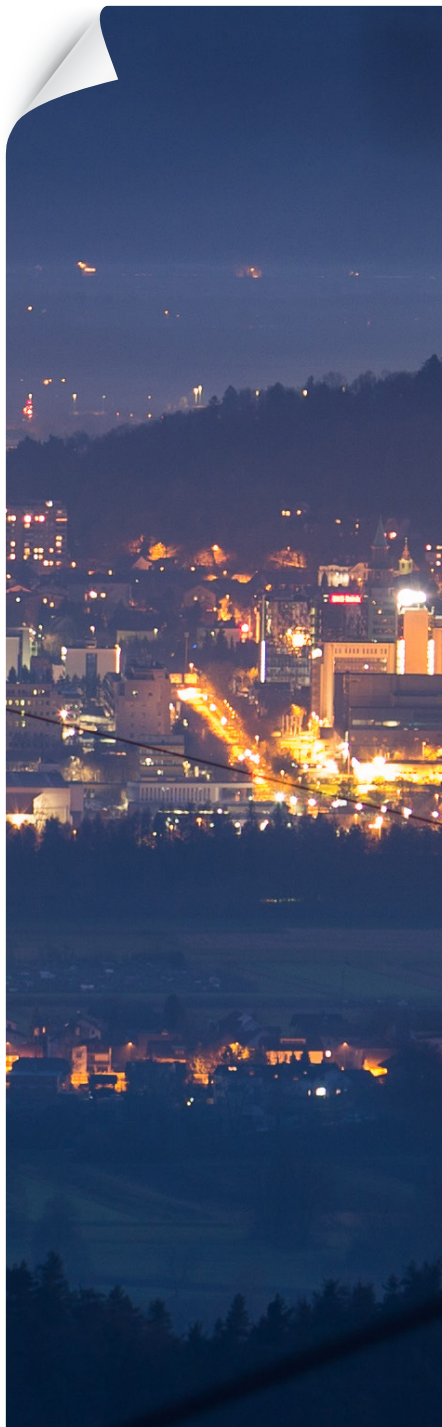
Electrification

Electrification is the process of replacing fossil fuels with electricity as the primary energy source for various end uses, such as transportation, heating and cooling, and industrial processes. Electrification can reduce greenhouse gas emissions, improve energy efficiency, and enhance energy security. As much as it is a solution for decarbonization, it is also bringing tremendous challenges to the market.

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According to a report by McKinsey & Company, electrification could account for more than 20% of final energy demand in North America by 2050, up from 6% today. The main drivers of electrification are:

- The falling costs and increasing availability of renewable energy sources, such as solar and wind, which can provide clean and cheap electricity for various applications.
- The rising consumer demand for electric vehicles (EVs), which offer lower operating costs, better performance and environmental benefits compared to conventional vehicles. EVs also have the potential to provide grid services through vehicle-to-grid (V2G) technology, which allows them to store excess electricity or feed it back to the grid when needed.
- The development of new technologies and business models that enable electrification of hard-to-abate sectors, such as heavy-duty trucks, aviation, and industrial processes. For example, hydrogen fuel cells, synthetic fuels and power-to-x solutions can provide zero-emission alternatives to fossil fuels.



Electrification poses both opportunities and challenges for grid edge players. On one hand, it can create new sources of revenue and value for utilities, technology providers and customers. For example, utilities can offer new services such as EV charging infrastructure, smart home solutions and demand response programs. Technology providers can leverage their expertise in digital platforms, data analytics and distributed energy resources (DERs) to enable electrification. Customers can benefit from lower energy bills, improved comfort and convenience, and greater control over their energy consumption.

On the other hand, electrification can also increase the complexity and uncertainty of grid operations and planning. For example, utilities will have to cope with higher peak demand, greater variability and bidirectionality of power flows, and increased cybersecurity risks. Regulators will have to design new policies and incentives that balance the interests of different stakeholders and ensure reliability, affordability, and sustainability of electricity supply. Customers will have to adapt to new behaviors and expectations regarding their energy use.

Decentralization

Decentralization is the shift from **centralized power generation**, which can best be described as step-down, from large generation, through transmission to distribution at the grid edge, to **distributed power generation** and delivery. Decentralization is enabled by the rapid deployment of DERs, such as rooftop solar panels, battery storage systems, microgrids and community energy projects. DERs can provide local power supply, reduce transmission losses, lower carbon emissions, enhance resilience and empower customers.

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According to a report by Wood Mackenzie, DER capacity in North America is expected to grow from 132 gigawatts (GW) in 2020 to 387 GW in 2025, representing a compound annual growth rate (CAGR) of 24%. The main drivers of decentralization are:

- The declining costs and improving performance of DER technologies, which make them more competitive with conventional power sources.
- The increasing customer demand for DERs, which offer greater choice, autonomy, and participation in the electricity market.
- The supportive policies and regulations that encourage DER adoption, such as net metering, feed-in tariffs, tax credits and clean energy mandates.

Decentralization also creates both opportunities and challenges for grid edge players. On one hand, it can unlock new value streams and business models for utilities, technology providers and customers. For example, utilities can leverage their existing assets and customer relationships to become DER aggregators, integrators, and orchestrators. Technology providers can offer innovative solutions that enable DER optimization, interoperability, and monetization. Customers can benefit from lower energy costs, higher reliability, and environmental stewardship.

On the other hand, decentralization can also disrupt the traditional roles and responsibilities of grid edge players. For example, utilities will have to deal with reduced revenues from conventional power sales, increased competition from new entrants and changing customer expectations. Regulators will have to balance the need for grid stability, fairness, and innovation in a more dynamic and decentralized environment. Customers will have to manage their own DER assets and participate in new markets and platforms.



Digitalization

Digitalization is the process of applying digital technologies and data analytics to enhance the efficiency, flexibility and intelligence of grid edge operations and services.

Digitalization is enabled by the widespread adoption of smart meters, smart appliances, smart thermostats, smart inverters, and other internet-of-things (IoT) devices that generate massive amounts of data about grid conditions and customer behavior.

According to a report by Navigant Research, global spending on grid edge digital technologies is expected to grow from \$14 billion in 2019 to \$32 billion in 2028, representing a CAGR of 9%. The main drivers of digitalization are:

- The increasing availability and affordability of digital technologies, which offer improved functionality, scalability, and interoperability.
- The growing demand for digital services, which offer enhanced visibility, control, and optimization of grid edge resources.
- The evolving regulatory frameworks that support digital innovation, such as data privacy, cybersecurity, and interoperability standards.

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Digitalization also offers both opportunities and challenges for grid edge players. On one hand, it can enable new capabilities and value propositions for utilities, technology providers and customers. For example, utilities can use digital technologies to improve grid management, customer engagement, and service differentiation. Technology providers can use digital platforms to provide end-to-end solutions that integrate hardware, software, and services.



Customers can use digital applications to access real-time information, personalized recommendations, and tailored incentives.

On the other hand, digitalization can also raise new issues and risks for grid edge players. For example, utilities will have to invest in upgrading their IT infrastructure, skills, and culture to cope with the increasing complexity and velocity of data. Regulators will have to ensure data security, privacy, and quality in a more connected and open ecosystem. Customers will have to trust their data providers, service providers and devices to deliver reliable and beneficial outcomes.

Conclusion

At the recent Grid Edge Conference and Expo and the DistribuTECH Conference and Expo, it was apparent that the grid edge is transforming rapidly due to electrification, decentralization, and digitalization. While there are many other factors at play, these three trends alone, are creating new opportunities and challenges for various stakeholders in the electricity sector. The battle for supremacy at the grid edge will depend on how well these stakeholders can adapt to these changes and collaborate with each other to create value for themselves and society.

To make this transformation process more reliable and sustainable we must apply the principal of collaboration, where different stakeholders work together to create the “new grid”, where society as a whole, wins. As a passionate IEEE member and member of the Grid Edge steering committee, that is exactly what we strove to provide, and based on the feedback, that is what those attending experienced.

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