DERs Role in a More Reliable, Sustainable, and Resilient Power System

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Executive Summary

Distributed Energy Resources (DERs) and Distributed Generation (DG) are often used interchangeably. DERs, however, are a broader category, encompassing assets that generate electricity and demand-side management (DSM) programs, protocols, and tools. This paper will focus on the outlook for DG/DERs in an environment where projected load growth is suddenly robust and where the need for more generation capacity is unavoidable.

DG/DERs have historically recognized advantages and concerns. These have led to DG playing a complementary role to centralized power generation. However, new conditions in many power markets are raising the possibility that DG may play a more prominent role. This paper will review pros/cons attributed to DG/DERs, discuss new conditions prevailing in power markets, and assess the likelihood that DG's role may grow in the near term and the post-2030 era.

A systematic review of DG's traditional benefits and drawbacks reveals why it has largely been a niche play complementary to central power generation. DG offers power users several advantages, including added resiliency in the face of grid outages, the ability to adopt types of generation suited to local conditions, and the ability to progress low-carbon solutions faster than centralized providers. However, DG generally has not overcome a cost disadvantage rooted in its smaller scale capacity versus centralized power. When the DG in question is wind or solar, their intermittency can complicate grid integrity and reliability. Thus, despite considerable government subsidy support, DG today provides less than 10% of U.S. generation nationwide.

Two new power market conditions may be changing DG’s value proposition and growth outlook: 1) Extensive and unexpected electricity demand (load) growth is challenging central utilities ability to meet customers’ requirements, and 2) Transmission and distribution (T&D) and connectivity bottlenecks have led to project delays that motivate innovative and well-capitalized customers to explore means of acquiring energy more quickly via PPAs, acquisitions, or onsite DG projects. DG's advantages in this environment arise from its flexibility, scalability, and ability to bring capacity online more quickly. In doing so, DG can circumvent many T&D bottlenecks and connectivity delays. Leveraging DERs to a greater extent could mobilize new capital, land access, and project execution capacities outside the traditional centralized generators. These conditions lead to the following principal research findings, questions posed, and exciting areas for further exploration.

- **Demand-side challenge #1:** The US power system’s new high-load growth environment is a function of a specific set of High-Load customers: AI/Data Centers/Tech and Manufacturing. With AI queries consuming ten times the power of traditional searches and consumers/corporates rapidly incorporating AI across their workflows, the compounding of computing power needed is staggering. These High-Load customers require large blocks of firm power (up to 100 MW - 1 GW) per data center/large manufacturing facility. They

face competitive pressure to get to market quickly, and their mandates to grow and innovate clash with T&D bottlenecks and connectivity constraints.

- **Demand-side challenge #2**: Many customers have publicly stated Net Zero goals. At the same time, the power they require must be high-quality and firmly available 24/7/365 to avoid disruption of their facilities or damage to their equipment. Intermittent renewables cannot efficiently or economically serve this load even if backed up by battery storage.

- **Supply-side challenge #1:** Many centralized power generators have Net Zero goals, public commitments, and increasing legal requirements with costly fines for coming up short. To meet these goals, utilities have been retiring larger capacity, dispatchable power plants (e.g., fossil-fuel facilities) and replacing said retirements with a mix of lower capacity renewables and storage while adding highly efficient combined-cycle natural gas plants. This mix, while presenting significant financial and project execution challenges, seemed feasible to meet customers' needs in a low-load growth environment. However, the new higher load growth outlook suggests utilities may be seriously stressed to execute their requirement to service market demands and decarbonize their generation.

- **Supply-side challenge #2:** The same T&D and connectivity bottlenecks impacting customers 'time-to-market' are impeding centralized power suppliers from delivering the power these customers seek – highlighting the need for investments in process efficiencies and T&D infrastructure investments. To mitigate these challenges exacerbating, we recommend increased transparency between High-Load customers and utilities to enable more robust and accurate long-term supply and demand planning.

- **Collectively, these challenges support a case for new High-Load customers to consider adopting DERs located near their facilities.** Such solutions may sidestep the T&D/connectivity bottlenecks and offer flexibility to customize the generation mix used to meet capacity requirements and sustainability goals. The "true" economics of DER solutions circumventing the bottlenecks may now be more competitive when factoring in mitigated T&D and interconnection costs and time. Examples of technology and manufacturing companies evidencing this trend will be discussed.

- **In considering such DG solutions, new High-Load customers face this dilemma: Can they simultaneously progress towards their Net Zero goals while assuring they obtain the reliable and high-quality power their operations require at an acceptable cost?** Their Net Zero goals would direct them towards DG solutions based on renewables and storage. However, the intermittency issues associated with this approach and the embedded challenge of supplying 24/7/365 high-quality power must also be mitigated.

- **To secure the firm's needed power strictly from renewables and storage, new High-Load customers would have to significantly "overbuild" DG and storage assets to**

address their intermittency, capacity factors, and other limitations. This approach would add considerably to the otherwise low levelized cost of energy (LCOE) of renewables, potentially eliminating their economic feasibility.

- **New High-Load customers are likely to adopt one of several DG models for reconciling their power needs and low-carbon goals:**
    1. Build renewables + storage DG near their facility for onsite consumption and supplement it with utility PPAs.
    2. Build renewables + storage, sell all the power to the utility while buying the power they need and Renewable Energy Certificates (RECs) under utility PPAs.
    3. Build a natural gas-fired DG with a hydrogen-compatible turbine, planning to evolve it to hydrogen-fired as the hydrogen supply chain and infrastructure ecosystem matures. A later adoption of carbon capture is a variant of this alternative.
    4. Initiate options 1 or 2 above but keep the PPA short enough in duration in anticipation of building a nuclear small modular nuclear reactor (SM) when that technology matures.

    Various hybrids of these alternatives are possible. The choice of model will vary by location depending upon many factors, such as the unique customer energy needs, the availability of land and gas supplies, and the condition of the centralized power providers.

- **New High-Load customers' determination to progress towards their Net Zero goals should not be underestimated.** Case studies of tech players and manufacturers detailed at the end of this report provide evidence that these customers are already adopting a range of DER solutions and utility partnerships to secure needed power not at odds with their climate goals. The cases show firms like Amazon, Apple, Google, Microsoft, et al. taking risks and committing capital to honor their public sustainability commitments.

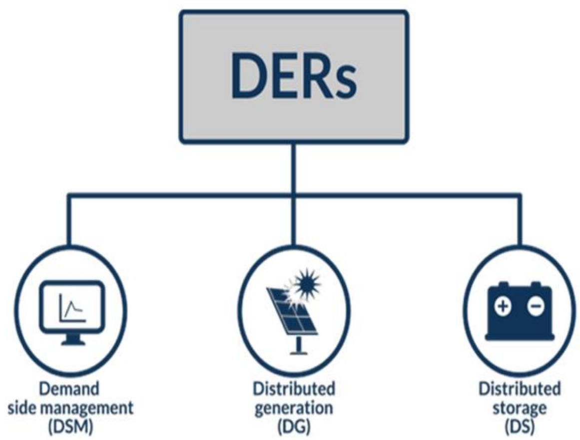
- **Thus, the New High-Load customers may not be satisfied with solutions that leave them dependent on fossil fuel-fired supplies. Rather, expect these customers to seek lower-carbon solutions over time.** They will be a significant force for innovation in power generation, and their longer-term DG projects may pilot and build out a mix of renewables and storage, nuclear, hydrogen, and carbon capture. Additional efficiencies, resilience, and economies can be realized by combining these with DSM programs, aggregating DG projects via virtual power plants, and exploring microgrid solutions.

- **Continued nuclear, hydrogen, and battery innovation will be integral to a future distributed energy paradigm. Customers may undertake First-of-a-Kind (FOAK) projects to commercialize promising new technologies.** These High-Load customers exhibit risk appetites, strong balance sheets, capable management, and time-to-market economic incentives – all critical ingredients for driving the energy transition forward.

Introduction & Background

What are Distributed Energy Resources (DERs)?

In contrast to the traditional model of electricity generation, which relies on large-scale, centralized power stations coupled with extensive transmission networks, DERs historically have comprised all manner of small-scale, modular energy generation (DG) plus storage and DSM technologies all located behind the customer meter. Over time, the mix of these resources has evolved. Initially consisting of hydrocarbon-fueled electric power and thermal heating systems used by the industrial, healthcare, technology, and essential public service sectors, DERs now incorporate residential solar systems, community microgrid infrastructure, and larger-scale power systems for energy-intensive data management. Within the United States, DER capacity had historically been limited to 10 megawatts (MW). Today, the advent of artificial intelligence and the onshoring of advanced manufacturing drive larger-scale, behind-the-meter DER development. A report by Wood Mackenzie posits that U.S. distributed energy resource capacity will grow by 217 GW through 2028. (*Martucci, 2023) (Wood Mackenzie, 2023*)



The chart above shows three core components of DERs: distributed generation (DG), distributed storage (DS), and demand side management (DSM or DM). (*Energy Knowledge Base, DER*) This paper will examine the logic behind manufacturing and data centers increasingly considering DERs in their energy strategy. We begin by assessing the historical pros/cons associated with a Distributed versus a Centralized power generation model. Our discussion will examine how DERs may unlock new corporate energy models for High-Load customers in today's market environment. We will touch on the drivers behind these trends, their advantages, and limitations, and what the growth of this model means for the evolution of power systems. Finally, our findings will highlight areas where further research is needed to accelerate our path to a more reliable, sustainable, resilient, economical, and flexible power system.

Historic Pros/Cons of DG

Traditional Benefits - DG Augments Centralized Development

We observe the most significant growth in solar farms in locations without environmental constraints (land, sunlight, wiring/cabling, etc.) on utility-scale solar generation (e.g., Virginia, Dallas, California, etc.) (*Newmark, 2023*). California's geography and environmental conditions lend themselves well to large-scale solar projects, as demonstrated by The Desert Sunlight Solar Farm - a 550 MW solar farm on ~3,900 acres of land. Utility-scale renewable projects such as this one are not always feasible.

DG proponents have long asserted extensive benefits, mainly where constraints exist on large-scale power development projects. DG can draw upon the collective resources of individuals, communities, and corporations to develop smaller-scale, geographically diversified, and purpose-specific power generation resources. By amalgamating these smaller generation capacities together, sizable loads can be generated. When such DG assets connect to the existing power grid, they can reduce utility companies' burden to build unfeasibly large renewable projects, unessential T&D infrastructure, and new fossil fuel capacity. DG introduces optionality and flexibility into customers' ability to augment the power they receive from the grid.

First, we will examine commonly purported benefits of DG/DERs:

1. **Enhanced Reliability**
   In certain circumstances, DG resources may improve reliability on a network scale. DG increases the diversity of power supply options available to the grid during periods of peak demand and unforeseen disturbances. For example, in cases of peak demand, states may use temporary pricing signals to shift energy consumption patterns away from grid-supplied to customer's localized DG power. In the case of sudden, unforeseen disturbances due to grid faults and failures, utility operators may rely on alternative "distributed spinning" reserve capacity to supplement offline capacity.

2. **Power Quality**
   Electrical imbalances threaten equipment and operational capabilities for technologically advanced systems sensitive to micro-second perturbations in electrical flow, voltage surges and sags, frequency excursions, harmonics, flicker, and phase. Power quality is thus an essential component of business operations - especially for data centers and technology companies. DERs can improve quality outcomes significantly through voltage support and reactive power, employing storage and power-conditioning capabilities.

   Centralized generation addresses power quality differently. To assure power quality and frequency regulation, central generation prioritizes "momentum," i.e., the inertial response provided by the rotational inertia of traditional power plants. These plants use large rotating machines, i.e., flywheels, which store kinetic energy as they spin. This stored energy provides a crucial buffer against sudden imbalances between supply and demand, helping to maintain the grid's frequency at its nominal value (e.g., 50 or 60 Hz). The rotational inertia slows down the rate of frequency change during disturbances, giving grid operators time to deploy additional resources and stabilize the frequency. This buffering effect is essential for ensuring stable power quality, which is vital for the proper operation of electrical devices and the overall reliability of the grid.

Maintaining power quality becomes more challenging as the grid increasingly incorporates renewable energy sources like wind and solar, which lack inherent rotational inertia. Here, DERs can play a significant role in addressing these challenges. Integrated energy storage systems can provide quick dispatchable power and fast frequency response – supporting local grid stability and mimicking the effects of traditional rotational inertia. By strategically deploying DERs, the grid can maintain stable frequency and voltage levels, ensuring a reliable power supply as it transitions to a more sustainable energy future.

3. **Increased Grid Resiliency**

Electric power is essential to the functioning of society. Grid resiliency is, therefore, a matter of national security – with diversification and redundant energy systems necessary to mitigate systemic risk. Traditional centralized infrastructure may be vulnerable to terrorist attacks, natural disasters, or other unforeseen malfunctions. In these situations, a failure to meet energy needs for a significant time can threaten the entire critical infrastructure network. When Winter Storm URI hit the ERCOT Texas grid in 2021, there were reports that the whole ERCOT grid was minutes away from failing - had it failed, damage to Texas' considerable industrial plants would have been incalculable.

The ability of proximate DERs to communicate with and support small networks of interconnected loads in microgrid "islands" can insulate demand centers from outage events impacting central grid infrastructure. North Carolina has explored utilizing solar and battery storage solutions to provide 48 hours of critical power to government-managed facilities during prolonged grid outages from hurricanes and flooding. The National Resource Council has stated that distributed generation and storage resources may lead to a more flexible grid where islanding to maintain critical loads is easier. Storage technology advancements will further boost realized resiliency benefits.

Renewable DG provides another resiliency benefit by diversifying the energy supply chain risks associated with fossil fuels for traditional central generation and uranium for nuclear. Periodically, coal, uranium, petroleum, and natural gas supplies have been disrupted by natural events, wars, and embargoes. At these times, fuel costs can soar for power plants that use these fuels. This happened recently in Europe when natural gas prices climbed to hundreds of dollars per MBTU in the wake of Russia's invasion of Ukraine. During such crises, DG wind and solar assets continue to produce much-needed power capacity at an affordable cost. Energy storage, such as batteries, can be another redundancy measure to meet short-term disruptions to centralized fossil fuel or nuclear generation.

4. **Mitigated T&D and Interconnection Fees**
   Reductions in required T&D infrastructure can result in significant cost savings from land acquisition, easements and rights-of-way, construction, and operations/maintenance. To illustrate the magnitude of T&D costs, a 2006 American Electric Power 550-mile transmission and distribution project was estimated to cost $940,000 per mile (*AEP, 2027*) Duke Energy plans to spend $36 billion through 2027 to update its transmission and distribution (T&D) system (*Duke energy to spend big on T&D, 2023*)

5. **Accelerated Clean Energy Deployment**
   According to the Energy Information Administration (EIA), the most recent DG investments have been in renewable energy sources, with solar energy representing 70-80% of the capacity. Connectivity study queues and T&D bottlenecks have recently constrained utility-scale renewables projects and independent power producers' projects. The capability of capital-rich firms to build and deploy DGs allows them to bypass often extensive interconnection queue waiting periods. Additional capacity may be brought online more rapidly, and utility providers spared the need to develop additional capital-intensive generation facilities and accompanying infrastructure.

6. **Positive Social Externalities**
   The proliferation of DERs can also provide social benefits: increased energy jobs, choice, and access.
   - DER jobs are typically concentrated near where they are deployed. Sales, design, and installation of DERs are more employment-dense than larger-scale power generation projects. This can boost overall employment in the solar and renewable sectors. (Jaeger)
   - DERs allow direct public participation in the clean energy transition. Technology choice, deployment, and operational modes may all be tailored to a local environment, creating a more informed and empowered consumer base of homeowners, communities, and businesses.
   - DERs can be deployed in areas where energy service offerings have previously been limited. This can increase social equity by extending critical infrastructure to previously disadvantaged communities and fostering economic growth opportunities.

7. **Cost Synergies**
   Costs are highly variable depending on DER geography and quality characteristics. Smaller-scale DG systems often do not offer pure generation unit cost advantages relative to traditional centralized power generation. After accounting for transmission and distribution-related savings, DG's all-in-power costs may be more competitive. Their

small-scale and dynamic interconnectedness can offer cost efficiencies as "virtual power plants" compared to traditional utility offerings.

Traditional Cons / Limitations

1. **Cost & Economic Viability**
   The most significant historical limitation of DG adoption has been the cost of power. Traditional power generation has been based on large-scale and improved technology. Nuclear plants can provide 1-2 GWs of power per project with a capacity factor approaching 95%. Today's combined cycle natural gas plants can provide up to a GW of power with an 80-85% capacity factor. While the cost of renewable energy technologies has decreased, their capacity factor remains in the 25-45% range for utility-scale projects. DG renewable projects then come in on an even smaller scale. Thus, when the initial investment in renewable DG is spread over their output, including the backup storage and generation needed, the resulting unit costs typically compare unfavorably with centralized generation. Here, it is essential for power economics to be compared on an "apples to apples" basis. Renewable DG's expense should not be just their LCOEs when producing; all backup power costs should also be incorporated in the comparison with the centralized power plant.

   Government incentives and subsidies often influence the economic viability of DG. While these incentives can be uncertain due to shifting political agendas and policy changes, they have generally supported DG adoption, and a good portion of rooftop and community solar panels have been constructed based on their support (*Lazard, 2020*). Despite this government support, DG sources of all types still need help to match the unit costs of much larger scale centralized and partly depreciated plants delivering power over established, sunk-cost transmission and distribution.

2. **Intermittency**
   Intermittency is a primary limitation if the DG is wind or solar. Unlike traditional power plants that provide a consistent and dispatchable energy output, renewable DG depends on environmental conditions. For instance, solar power depends on sunlight availability, which varies with weather conditions and time of day. Similarly, wind power is dependent on wind patterns that can be unpredictable. The intermittency of these energy sources is an issue for all users. Still, it poses a unique challenge for manufacturing plants and data centers that require stable and reliable power to maintain operations. Renewable DG necessitates integrating energy storage systems or backup power sources to mitigate the risk of power interruptions. Such adaptations add complexity and cost to DG deployment, especially in commercial settings (*Denholm et al, 2021*).

3. **Energy Spatial Density**
   Energy spatial density is another critical factor affecting the adoption of large-scale utility-level DG for local generation and consumption. Traditional fossil fuels, such as coal and natural gas, have a high energy density, meaning they can produce much energy from a relatively small plant footprint. In contrast, renewable energy sources often have a lower energy density. Solar panels and wind turbines require significant space to generate the same energy that a traditional power plant can produce from a much smaller footprint. These larger land needs for renewables can be a substantial limitation and render solar/wind projects physically or economically impractical in regions where space is at a premium or limited.

4. **Power Quality (Negative)**
   As DERs like solar panels, wind turbines, and battery storage systems become more prevalent, power quality concerns arise due to the differences between traditional centralized power generation and decentralized DERs. A primary concern is voltage fluctuations, which occur because of renewable energy sources' intermittent and variable nature. For example, solar power output can change rapidly with cloud cover, leading to sudden drops or spikes in voltage. Inconsistency in the yield from renewable DERs complicates the maintenance of grid frequency, which must remain within a narrow range for stable operation. Deviations in frequency risk causing blackouts or infrastructure damage.

   Power quality issues such as voltage sags, swells, and harmonic distortion can cause malfunctions, data errors, and even damage critical infrastructure. To mitigate these challenges, sophisticated power conditioning and control systems are essential. Examples of implementing advanced grid controls include smart inverters, voltage regulators, and advanced control systems that can dynamically adjust to changing conditions. These systems must be capable of smoothing out fluctuations and maintaining consistent voltage and frequency levels, which can increase the complexity and cost of integrating DERs into commercial operations (Bollen & Hassan, 2011). Addressing these power quality concerns as DER adoption grows is vital for sustaining a stable, high-quality power supply to critical industrial and commercial assets.

5. **Grid Integration**
   Utilities have standardized processes to ensure the grid can reliably handle capacity additions without compromising stability, reliability, or service. The need for infrastructure upgrades, advanced metering and control systems, energy storage, and compliance with regulatory requirements drives the expenses associated with integrating small and large-scale DERs into the grid. While small-scale integrations may be costly per unit due to the need for individualized systems and upgrades, large-scale integrations involve substantial capital investments in grid reinforcement, advanced management systems, and large-scale energy storage solutions. The overall cost-effectiveness of integrating DERs depends on

factors such as the scale of deployment, existing grid infrastructure, and the specific technologies employed.

Integrating large-scale Distributed Generation, such as utility-scale solar or wind farms generating hundreds of megawatts (MWs), involves significant expenses driven by several factors. These include substantial grid reinforcement and expansion for increased power generation, investments in grid stability and frequency regulation systems, and integration of advanced grid management technologies to balance supply and demand. Additionally, large-scale projects face stringent regulatory and compliance requirements, which add to the costs, as do the extensive energy storage systems required to buffer the variability of renewable energy generation. Despite these expenses, the price per MW for large-scale DG may still be lower than that of small-scale systems.

Findings: Historic Pros/Cons

While DERs offer significant potential for sustainable energy generation and contribute to grid resiliency, several limitations have hindered their widespread adoption. Cost, intermittency, space requirements, and power quality are challenges that must be addressed for DG to play a larger role in power systems. Additionally, regulatory barriers and needed grid upgrades further complicate the deployment of DGs and DERs. Collectively, these constraints have rendered DERs more of a niche application than a supplier of baseload power for markets. However, power market conditions began to change dramatically in 2023. Will these new conditions alter the relationship between centralized generation and DG? We take up this topic below.

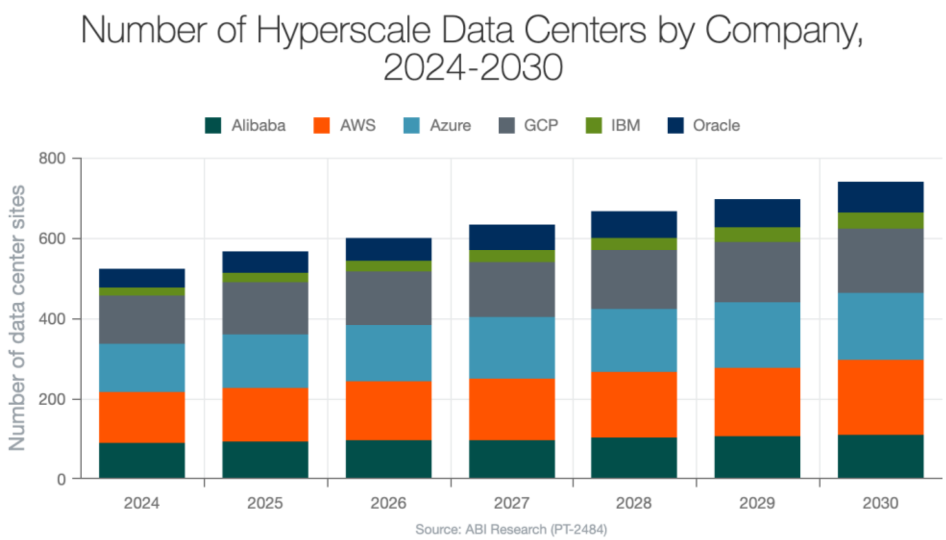
Today's New Market Conditions

Energy Demand & Load Growth Trends

According to Glen Snider, Duke Energy Managing Director of Carolinas Integrated Resource Planning and Analytics, economic development in the manufacturing and technology industries has led the Carolinas load growth demand forecasts to far exceed even previously high-load case scenarios. Other state utilities acknowledge the acute need for greater capacity. For instance, Georgia Power recently released an updated load growth estimate for 2022 through the winter of 2030/2031, seventeen times greater than what had been forecasted in their 2022 Integrated Resource Plan (*Georgia Power IRP*, *2023*). In addition to massive capacity growth, many large-scale projects require a load capacity factor greater than 90%, necessitating near-constant generation supply to maintain system reliability. *(Ford 2024) (Kimball 2024) (Load factor: What is it? What should it be? 2022)*

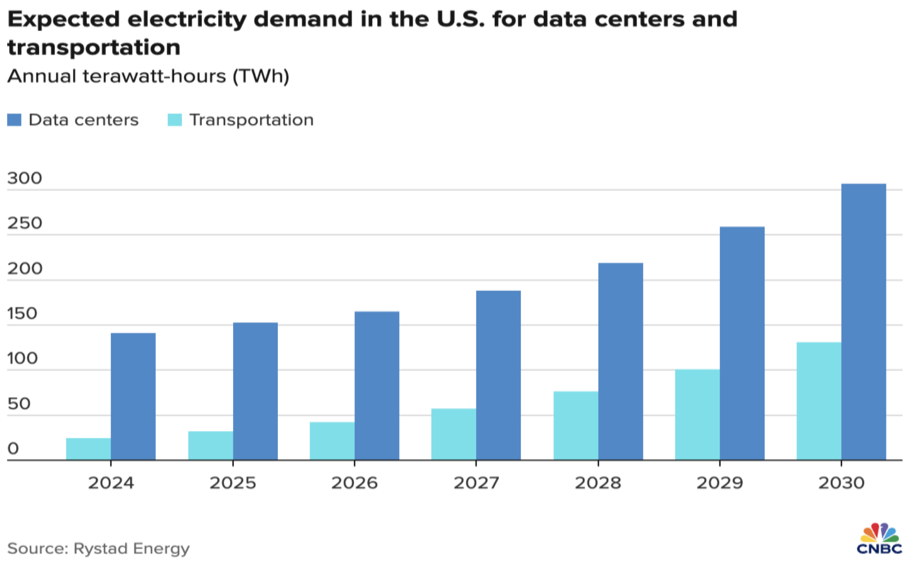
Data centers, advanced computing infrastructure, and the electrification of manufacturing are driving this demand and are trends that are projected to continue robustly into the future. Data centers underpin critical storage, processing, and information management systems that are the backbone for many other technologies and business operations. Changes in mobility are another factor, as households and businesses replace internal combustion engine vehicles with Electric Vehicles (EVs).

Large data centers typically have a capacity of 20 - 100 MW. Hyperscale data centers are 100 - 150 MW+ (occupying ~10,000 sq ft+). Colocation data centers are multi-tenant data centers. Today, large and mega-sized colocation facilities account for only 28% of total data centers worldwide. However, that number is estimated to grow to 43% by 2030 *(How Many Data Centers Are there and Where Are They Being Build? 2024).*



(How Many Data Centers Are there and Where Are They Being Build? 2024)

Data center demand is driven by many factors, including the rapid expansion of digital services, the proliferation of Internet of Things (IoT) devices, 5G technology, the increasing reliance on cloud computing, and the incorporation of AI into company workflows. The IoT revolution has led to a surge in connected devices, from smart home appliances to industrial sensors. These devices generate massive amounts of data that must be processed, analyzed, and stored, driving demand for data centers. According to industry estimates, IoT devices are expected to reach 75 billion by 2025, significantly contributing to data center demand. The deployment of 5G networks promises higher data speeds and more reliable connections, enabling the growth of data-intensive applications such as augmented reality (AR), virtual reality (VR), and autonomous vehicles. These technological advancements require substantial data center support to handle the increased data traffic and technology infrastructure.



(Kimbal, 2024) Electricity Demand for US Data Centers & Transportation from 2024-2030

The applications of AI technology across industries are still maturing. The chart above reinforces its projected continued growth and expansion. The other chart component – transportation electricity demand projects – highlights the ongoing significance of the EV shift. AI and data analytics rely on the processing, storing, and analyzing large unstructured data sets – which is computationally intensive. The shift towards remote work and digital collaboration tools that rely heavily on data center infrastructure to provide their services (i.e., Zoom, Microsoft Teams, Slack) further elevate data center demand. Compounding this data traffic and hosting demand is the increasing ubiquity of personal streaming services for entertainment. These services require data center resources to simultaneously deliver high-quality streaming experiences to millions of users. The growth of e-commerce, accelerated by the COVID-19 pandemic, has also been a tailwind. E-commerce platforms require robust data center infrastructure to manage transactions, store customer data, and ensure seamless user experiences. The rise of edge computing, which involves processing data closer to its source to reduce latency, will drive the need for smaller, distributed data centers.

The volume of data generated globally is increasing exponentially. International Data Corporation (IDC) predicts the Global Datasphere will grow to 175 zettabytes by 2025. Goldman Sachs Research projects a 160% increase in data center power demand by 2030, even with expected efficiency improvements (Goldman Sachs, 2024). Goldman Sachs has forecast that some 47 GW of new data center capacity may be built in the U.S. through the rest of this decade, creating the need for a dramatic expansion in energy capacity and DER infrastructure.

Utilities have been tracking and anticipating the scale-up of battery-powered vehicles (EVs) for some time. They reflect these impacts in their forecasts as seen in the above chart. Unanticipated AI/Tech/Manufacturing high load growth on top of load growth from EVs significantly challenge utilities’ execution capabilities. The question is then whether and to what extent DERs can alleviate these stresses.

Environmental - Meeting Climate Goals as Energy Needs Grow

An already strained energy situation complicates ambitious corporate and government renewable energy pledges. The juxtaposition of unexpected, considerable load growth atop existing decarbonization plans presents significant challenges. The path to power decarbonization runs through retiring fossil fuel plants. These, however, provide large-scale dispatchable power at a cost and availability sought by manufacturers and data centers. Renewables plus storage offers, at best, only a partial replacement for the power lost when coal, gas, or nuclear plants retire.

In the near and medium term, the goals of reliable, low-cost power and zero carbon conflict. Customers may be forced to make compromises with stated goals or wait for the power they need. Investor, shareholder, and ecosystem tailwinds will likely drive corporates to invest significant resources and investment in needed innovation to reconcile the goals.

In the near term, customers feeling time-to-market urgency may opt for deploying a combination of DG solutions - fossil fuels, renewables, storage - while seeking to secure long-term utility PPAs. Over time, these customers may drive innovation by deploying next-generation nuclear power, hydrogen, and other high capacity DERs onsite. A critical element here will be the ability of traditional utilities to keep up with both power demand and decarbonization requirements. To the extent they struggle, customers able to deploy substantial resources may step into the breach the gap and drive DER deployment.

As of November 2022, thirty-six states have implemented Renewable Portfolio Standards (RPS) that require electricity utilities to provide their customers with a defined minimum share of electricity from renewable sources. Notable examples include California, which has mandated 60% renewable energy by 2030 and 100% by 2045 and New York's Clean Energy Standard (CES) requiring 70% renewable energy by 2030 and zero-emission electricity by 2040.

Apple and Google announced plans to become carbon-neutral across their business operations and supply chains by 2030. Technology giants like Apple, Google, and Microsoft have committed to powering their global operations entirely with renewable energy. These companies have executed PPAs with renewable energy providers to ensure a stable, long-term supply of green energy. Climate goals and demonstrated adherence to these goals are strategic priorities companies are increasingly evaluated upon - either for proactive positive market differentiation or mitigation of legislative/reputational risk.

Another critical component of corporate energy strategies is improving their energy efficiency. For data centers, this involves upgrading to energy-efficient equipment, implementing advanced energy management systems, adopting cutting-edge cooling technologies, and optimizing server utilization to reduce energy consumption.

Corporations increasingly adopt integrated energy strategies to support their decarbonization goals while accommodating high-load growth. These strategies involve a combination of strategic energy procurement, demand management, and investment in innovative technologies. For instance, data center operators use hybrid energy models combining on-site renewable energy generation, renewable PPAs, or grid-supplied energy. This approach enhances energy security and ensures a flexible and resilient energy supply that can adapt to varying load demands.

As seen above, reliance on fossil fuel plants may not be avoided in the near term for various business activities that require such stable and high-quality power. In such cases, corporate decarbonization commitments may prioritize purchasing RECs and offsets to mitigate their emissions and satisfy public sustainability commitments. Many companies are also exploring carbon capture technologies that captures emissions at their source and store them underground, preventing them from entering the atmosphere. Companies in heavy industries, such as steel and cement manufacturing, invest in CCS to offset emissions that cannot be eliminated through energy efficiency or renewable energy alone. Some corporations are exploring the potential of green hydrogen – produced through electrolysis using renewable energy – as a clean energy source for industrial processes and transportation; this will be explored further in the hydrogen section of this report.

Corporate decarbonization efforts are influencing supply chain practices. Companies increasingly require their suppliers to adhere to stringent environmental standards and report on their carbon footprints. This holistic approach ensures that sustainability commitments are upheld throughout the value chain, creating a ripple effect beyond the corporations themselves.

Furthermore, corporations are actively participating in sustainability initiatives and collaborations. Industry-wide coalitions and partnerships, such as the Renewable Energy Buyers Alliance (REBA) and the Science Based Targets initiative (SBTi), provide platforms for companies to share best practices, set ambitious targets, and advocate for supportive policies. Companies can amplify their impact through these collaborations.

These initiatives illustrate the dedication of these customers to reaching their carbon reduction goals. That said, the competitive imperatives of the AI/data center race involve severe time-to-market challenges. Many firms realize market share is a fundamental success metric in industries where network effects are often critical to profitability and survival. Accordingly, firms may have to prioritize securing the power they need over immediate progress on their climate goals.

These trends may influence DG deployment in at least two ways. First, customers, frustrated by T&D bottlenecks and connectivity queues, may be driven to secure their power close to their facilities. This possibility, discussed below, would drive DG deployment at a much larger scale. However, these customers' needs for highly reliable and high-quality power could force them to implement DG projects powered by not only renewables but also fossil fuels like natural gas. Recent conversations with Morgan Stanley indicate they are seeing precisely that development materializing in customer discussions on needed capital raises. Examples of customers' proactive

DER development, energy procurement strategies, and investments in emerging innovative technologies will be discussed in the corporate examples section.

Aging Transmission & Distribution (T&D) Infrastructure

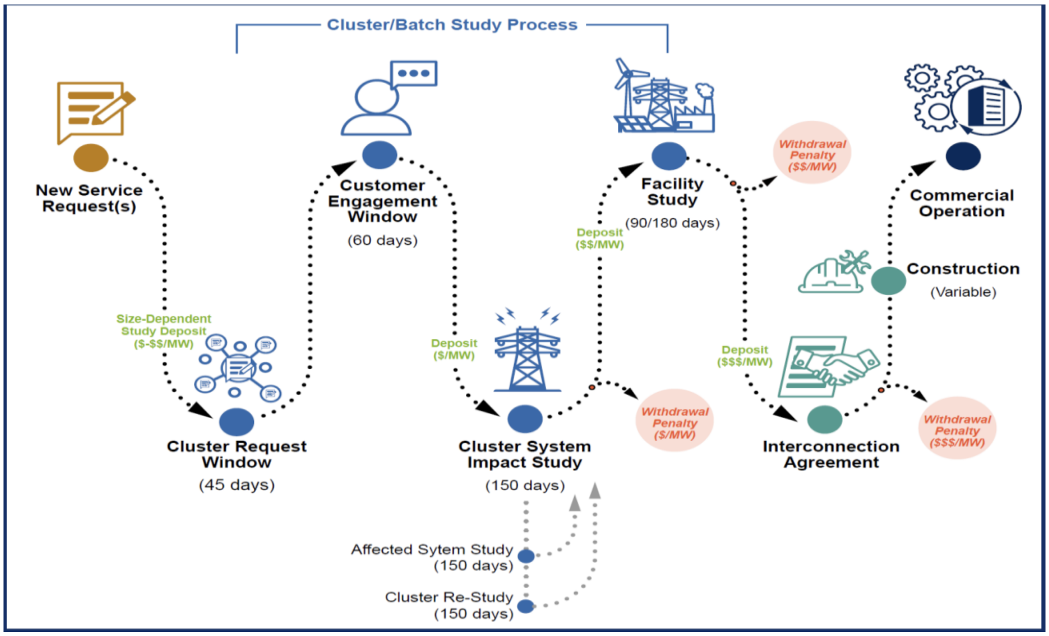
As noted, grid interconnection obstacles are becoming a significant driver of DG deployment, even as they remain the key obstacle to further centralized renewable power development. New-generation resources are reliant on legacy infrastructure. The American electric grid, the interconnected power system's backbone, originated in the late 19^{th} century when independent power producers in the Western United States began to recognize the cost-saving and energy efficiency benefits that sharing capacity could provide. Subsequent power availability concerns propelled a rapidly industrializing private sector to build larger-scale interconnected systems. By 1962, ten "power pools" of investor-owned utilities, known as the North American Power Systems Interconnection Committee (NAPSIC), had developed the capabilities of coordinated cooperation. Political support followed, and by 1967, Eastern and Western systems were connected to create the first-ever coast-to-coast grid. (Cohn, 2019)

The following decades saw dramatic economic, social, technological, and political growth, all underpinned by this vast, interconnected power grid. More recently, however, climate initiatives and paradigm-shifting increases in capacity demand have exposed an electricity grid's limitations that have not fundamentally changed since the early 1960s. As one example, the challenges posed by adding more intermittent renewable generation as part of decarbonization efforts have intensified the need for power sharing across multiple U.S. markets.

Consequently, the U.S. electric grid, the backbone of much progress, has recently become a bottleneck for the next growth phase. According to the Wall Street Journal, the American Society of Civil Engineers found that 70% of T&D lines are into the latter half of their anticipated 50-year useful life. The US is projected to face a $200 billion shortfall in funding needed for critical grid infrastructure investments by 2029.

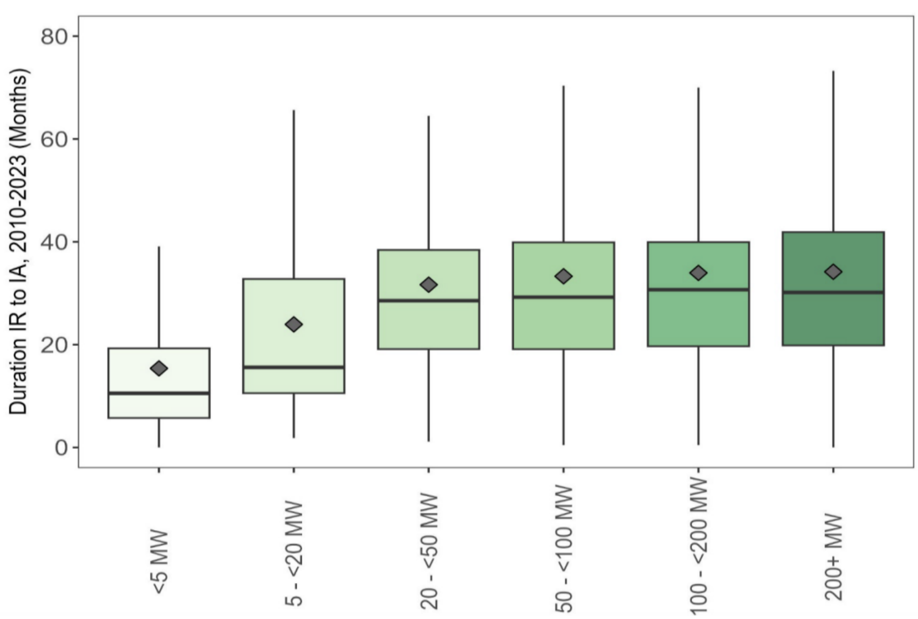
The drive to achieve decarbonization via deploying more renewable generation has exposed the massive backlog of interconnection requests and associated studies delaying customers' access to capacity. To understand this dynamic, one must appreciate the complexity of the interconnection process.

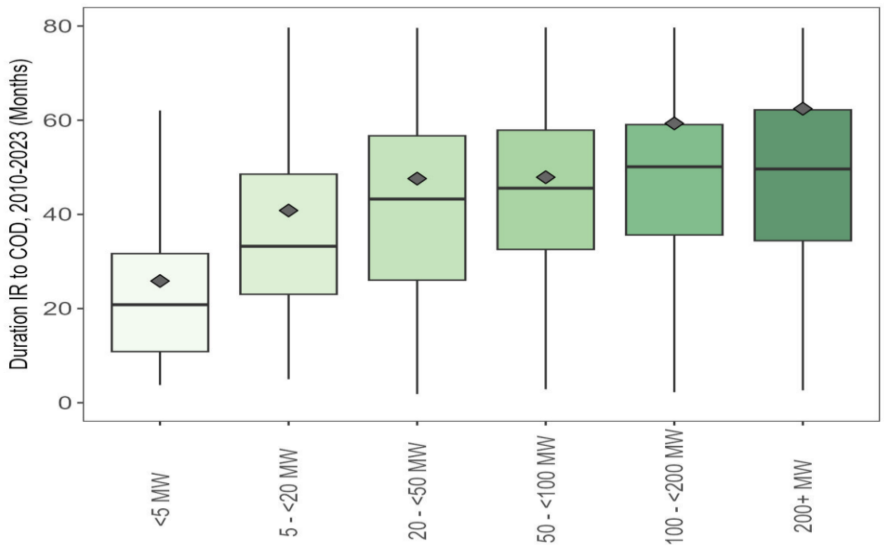
The interconnection queue process is a vital component of grid maintenance. Managed by Independent System Operators (ISOs) or utility companies, this process begins when a developer submits an Interconnection Request (IR), entering the project into a structured queue. This process aims to evaluate the potential impacts of the new project on the grid, ensuring that it can be connected without compromising reliability or efficiency. A series of studies are conducted to identify necessary transmission upgrades and allocate costs. The developer typically bears these crucial inputs to their project costs and economics. This process generally takes ~30 months and culminates in an Interconnection Agreement (IA). This legally binding contract outlines the technical and financial responsibilities for connecting the new capacity to the grid. A graphical depiction of this Interconnection Queue process appears below:



Overview of Interconnection Queue Management Process *(Lawrence Berkeley National Laboratory, 2024)*

This interconnection bottleneck has been especially damaging to the economics of large, utility-scale renewables projects. The two figures below show a positive correlation between the magnitude of the project (MW) and the time it takes to get interconnection approved; after approval, it similarly takes longer for the projects to become commercially operational.





While fundamentally necessary to maintain grid integrity, the interconnection queue process is now characterized by a significant backlog. This backlog and High-Load customers' frustrations with accessing needed capacity was exacerbated by communication siloes between the supply and demand side of the equation. The queue of projects awaiting a connection to the grid is around 2,600 GW, twice our current generation capacity of ~1,300 GW. (*Volcovici, 2024*) Most of the interconnection queue comprises solar/ (solar + storage), as can be seen in the graph below (*Lawrence Berkeley National laboratory, 2024*):

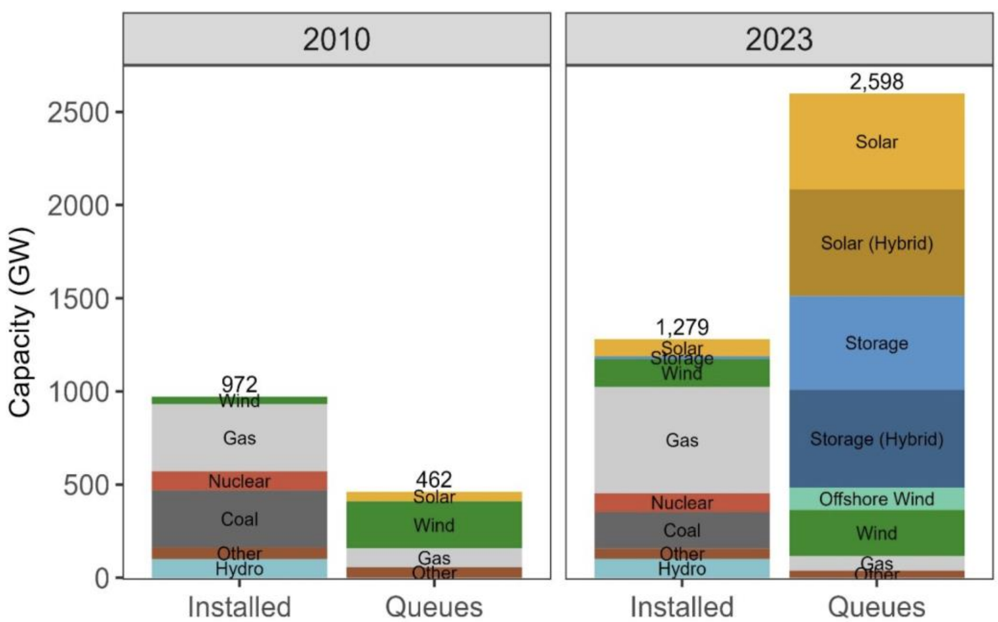
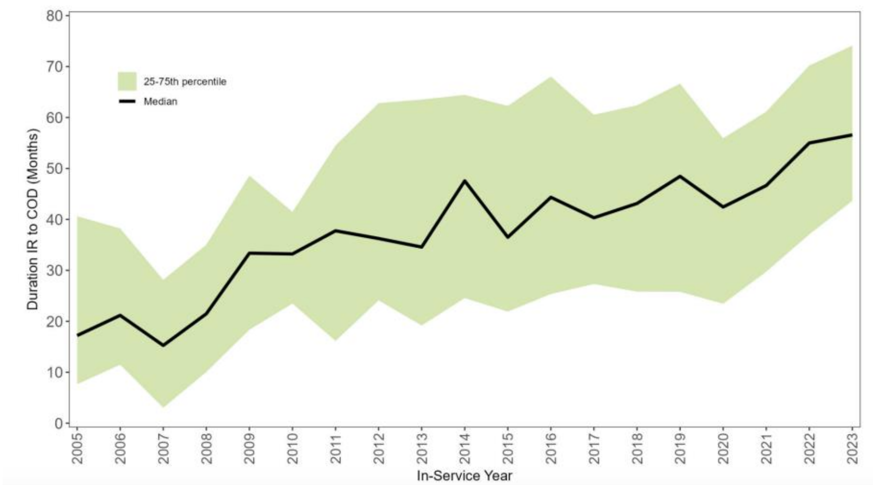


Figure 1: Installed U.S. electric generating capacity compared to interconnection queue capacity (2010 and 2023)



**As a final depiction of this T&D bottleneck, the graph shows an upward trendline in project completions from initial interconnection request to operationality. The duration now approaches a median of 5 years, with many running longer.*

This bottleneck may be the most critical new fact as regards the future of DGs and DERs. Consider this constellation of factors: 1) AI/Tech/manufacturing firms are urgently requesting massive blocks of new firm power; 2) these same firms have ambitious Net Zero goals important to their reputations with their investors, customers, and the public; 3) utilities and independent power producers are struggling to build utility-scale renewables + storage sufficient to serve this demand due to the massive connectivity bottleneck.

The Problem & DERs Evolving Role

These time-to-market constraints from the interconnection queue bottleneck lead those seeking large new blocks of power to 1) work with utilities and independent producers to secure sufficient future supplies, hoping these generators can add enough new capacity to service customers' needs, or 2) explore ways to locate new capacity near to their facilities, thus working around the T&D bottleneck and queues. The second choice holds great significance for the future of DG and DERs.

To foresee which choice is the most likely, we must first consider today's DG economics and then whether utilities will be able to meet these customers' needs.

DG & DER Utilization - Trends & Economics

Historically, commercial, and industrial (C&I) users have enjoyed discounted power prices versus those charged to retail. For example, Duke charges C&I customers $0.03-0.05/kWh wholesale prices while retail pays $0.11-0.13/kWh. T&D costs can add $0.02-0.04/kWh to these costs. DG costs historically have approximated or slightly exceeded the retail power prices. Hence, DG's typical cost disadvantage has been $0.02-0.08/kWh.

Calculation:

- *DG best case: lowest retail price (0.11) – highest C&I (0.05) - highest T&D (0.04)*
- *DG worst-case: highest retail price (0.13) – lowest C&I (0.03) - lowest T&D (0.02)*

Locating power generation near customer facilities can eliminate much of the T&D charges and ensure the customer's power availability when the new facility starts. This not only supports the customer's "get to market" strategy but mitigates the risk of cost overruns at the facility caused by delays in power availability.

An unanswered question is whether the AI/Tech/manufacturing customers will continue to enjoy discounted power prices. Whereas their load demand was desired by utilities in the low growth era, that will not be the case in the future. Indeed, utilities may need to charge these customers substantially higher prices to support the new facilities they must build to meet their demands. One "canary in the coal mine" example of this was the recent PJM Capacity Market Auction results. The auction cleared at a staggering $269.92/MW-day for most of the PJM footprint, representing a nearly tenfold increase from the $28.92/MW-day in the previous year's auction. Prices soared even higher in certain zones like Baltimore Gas & Electric (BGE) and Dominion, reaching $466.35/MW-day and $444.26/MW-day, respectively. These results send the "new load demanders" a message that historic C&I power pricing may be a thing of the past.

At this juncture, the historic cost advantage of centralized power versus DERs has narrowed and may not exist when factoring in "time-to-market" and execution risk. Accordingly, technology and advanced manufacturing firms may increasingly consider DGs and DERs as alternative ways to meet their substantial energy demands.

DERs Evolving Role - Tailwinds

The enormous, unanticipated load growth and established decarbonization plans drive major utilities into unchartered financial and project execution territory. As an example, Duke Energy's 2023 Net Zero Plan (targeting 2050) envisioned building 40 GW of renewables, 10 GW of storage, 10 GW of Combined Cycle and Combustion Turbine Natural Gas, 2 GW of Small Modular Nuclear Reactors (SMRs), and a similar amount of Offshore Wind. This plan was created before the new load growth phenomenon was recognized.

However, new plans have been drawn up and forecasts updated. Duke now envisions more natural gas, SMRs, and offshore wind to meet the new demand. Plans, however, are not the same as delivering projects. Utilities will face many challenges in execution, including securing power price increases needed to attract capital, obtaining financing via repeated trips to capital markets, and staffing up to execute the launch of new projects simultaneously while retiring many existing plants. Can they do all of this? In theory, yes, but when one considers the inevitable frictions such as potential project cost overruns, the T&D and queue bottlenecks, and the inevitable reaction of consumers and regulatory commissions to raising power prices – delays and unsatisfied customers are not unlikely outcomes.

The North Carolina Utilities Commission (NCUC) recognized the potential for such frictions when it reviewed Duke Energy's proposed implementation of NC House Bill 951 (the Law requiring an NC Net Zero plan). The Commission carefully provided "offramps" on its timetable, i.e., potential approved delays in Duke's implementation plans due to emerging reliability or cost issues. Since this approach was adopted before the new demand loads were manifest, the likelihood of such offramps being used can only be considerably greater.

With utilities under such pressure, what does this imply for DG and DER adoption? It means that customers projecting the new load must consider not only the advantages DERs historically offer and the benefits of circumventing the T&D bottlenecks but also the risks that even if they contract with utilities for the power they need, those utilities may not deliver on time or at the promised cost.

How, then, can these customers hedge these risks? Investing in dedicated generation projects near their site is a consideration. Drawing upon the considerable support available from the government will be a crucial component of this process; here, they can learn from projects developed by leading utilities. NextEra Energy's 550 MW Desert Sunlight Solar Farm is one example. Numerous incentives and conditions were provided to enable project success, including $1.46B in federal government loan guarantees, 3,761 acres of federal land permitting, and an optimal desert environment near existing grid infrastructure. AI/Tech/manufacturing customers taking on similar challenges can and should avail themselves of the many varied incentives available from both federal and state governments. These incentives and the savings associated with avoiding T&D costs may overcome the historic cost disadvantage impeding DER developments.

The Federal Government also recognizes the significance of rapid and thoughtful grid revitalization and has sought to address this interconnection bottleneck through initiatives to streamline the planning and transmission development phases. The Federal Energy Regulatory Commission (FERC) Order 1920 is one such policy that requires more comprehensive transmission planning and mandates the consideration of clearly defined benefits when evaluating proposed transmission facilities. Another, Order 1977, also establishes a federal transmission siting authority for strategically critical economic corridors and streamlines development by narrowing the definition of legitimate stakeholder interest groups. (*Charles River Associates, 2023)*

Power Quality Requirements Will Influence the Composition of DER Solutions

As noted, AI/Tech/manufacturing customers require high-quality power delivered on demand 24/7/365. Renewables or renewables + storage solutions cannot pragmatically meet this requirement. Consequently, customers considering a DER solution face a dilemma - how can they get the power their operations require while delivering on their decarbonization promises?

There are several models they can adopt to address this dilemma:

1. They can build renewables and storage DERs near their facility and supplement it with a utility PPA for backup power.
2. They can build the same renewables and storage solution but sell all the power to the utility while buying all the power they need plus Renewable Energy Certificates (RECs) under the utility PPA.
3. They can build a natural gas-fired DER with a hydrogen-compatible turbine and plan to evolve it to hydrogen-fired as those supplied become available.
4. They can initiate options 1 or 2 above but keep the PPA short enough in duration in anticipation of building a nuclear SMR when that technology is proven.

Various hybrids of these alternatives are also possible.

Considering the variety of power sources offered by the above options reminds us not to equate DERs with renewables plus storage. DERs encompass 'all of the above,' i.e., all distributed resources close to load demand. The DERs likely to be deployed by high-load growth customers will be a mix of generation types plus storage and demand management options. Perhaps more importantly, the dedication of these customers to their Net Zero goals is likely to drive innovation and technology adoption of new low-carbon solutions. There is a short and long-term path ahead, and we will likely see a mix of the above.

Conclusion

DER's value proposition have strengthened as energy markets supply and demand have fallen out of equilibrium due to surging demand from High-Load customers seeking large blocks of capacity (preferably clean) to achieve their business objectives. This imbalance is demonstrated by demand expectations growing 40% over the next twenty years, data centers projected to consume 508 terawatt hours of electricity per year, and the 5+ year delay for companies to receive new capacity from the grid. (Michaels, 2022)

In this high-load growth environment, DERs become increasingly compelling due to their ability to rapidly onboard and coordinate new capacity. The scope and pace of this adoption will depend on utilities' success in managing the stresses and challenges of this unprecedented power demand. If High-Load customers cannot access the power they need in a timely manner, they may be driven to proactively seek their own power generation out of time-to-market and business growth priorities. Historic risk takers - private industry - may be more willing to move aggressively on independent natural gas projects as well as first-of-a-kind SMR, hydrogen, geothermal, or other innovative power projects. Traditional utilities' focus on "keeping the lights on" requires them to be more careful when rolling out innovative new technologies.

Innovations in generation and storage technology can pave the way for new energy models – giving firms enhanced control over their capacity, energy mix/attributes, diversification, sustainability goals, and time-to-market. Accelerated DER adoption would reduce the burden on centralized grids by backing up the grid with more local generation and storage. Customers will enjoy improved resilience as their DER solutions help ensure continuous power supply even during grid outages.

DERs may be leveraged for DSM, organized to form VPPs, or aggregated to achieve microgrids of meaningful scale that can operate independently of/or complementary to the grid. (*Portland General Electric, 2020) (NREL, Microgrids at NREL*). High capacity demands and constrained supply amplify the traditional benefits of DERs - bringing flexibility, stability, efficiency, and resiliency to customers and the energy system. (*IEA, 2020*)

The following examples are offered as illustrations of the main points summarized above. These cases demonstrate the intention of these customers to reconcile power needs with their commitment to decarbonization. Note the persistent theme of companies primarily achieving their sustainability commitments through long-term renewable PPAs with utilities/renewable developers as offset purchases, while complementing these strategies with onsite renewables and storage. The next question that our discussion begets and acknowledged to be beyond our current scope is - will breakthroughs in energy innovation such as fusion technology lead to viable large-scale DER off-grid strategies by High-Load customers? This question is exploratory in nature, and it is too early to tell how energy science and market realities will unfold.

Recent Trend: Corporate Examples

High-load technology customers that leverage data centers, and heavy manufacturing are seeing a rise in greenhouse gas emissions. Data centers primarily rely on grid-supplied energy and leverage onsite DERs and diesel or natural gas generators for backup power. Companies like Amazon, Apple, Dow Chemical, Google, Microsoft, and others are leading the way in demonstrating how DERs can be leveraged to develop more diversified, clean, and resilient energy strategies. However, the overall contribution of DERs remains modest compared to centralized power. The following examples illustrate how these firms lead the way with "First of a Kind" DG and DER ventures.

Amazon

Amazon was the world's largest corporate buyer of renewable energy for the last four years. In 2023, Amazon matched 100% of its electricity consumption with renewable energy sources (leveraging RECs). Even though reaching carbon net zero through its renewable energy projects, including solar farms, wind farms, and rooftop solar projects (enabling more than 28 GW capacity over more than 500 projects) as well as RECs/offsets, Amazon's emissions from direct operations rose 7% from 2022-2023. Amazon emitted 68.8 MtCO2e in 2023. Amazon owns some 17.77 million sq ft and leases another 20.434 million sq ft of data centers (Amazon 10-k), with 31% of the market share in cloud computing.

Amazon plans to build a massive data center footprint in Northern Virginia. The area's peak demand could double by 2040 to satisfy this power need. Some believe there will be delays in the retirement of fossil fuel plants or even new fossil fuel capacity brought online (likely natural gas) to meet this demand. It is paradoxical that as we seek to transition to a decarbonized future, we may go backward before we go forward. *(Nation, 2024) (The Dirty Energy Fueling Amazon's Data Gold Rush)*

Amazon Web Services (AWS) uses AI and machine learning models to optimize how battery systems charge and discharge energy back to the grid. At Baldy Mesa, a solar farm (1,197 acres; 150 MW solar with 75 MW of battery storage; located in California) enabled by Amazon, though developed, owned, and operated by AES, pairs a solar project with a battery storage system to provide a steady supply of carbon-free energy (Amazon, 2024) This facility uses AWS ML insights to minimize energy use and costs. Likewise, Duke Energy, which operates one of the most extensive energy grids in the U.S., uses AWS ML to run its Intelligent Grid Services applications, which analyze massive electricity supply and demand datasets across connected assets to optimize energy efficiency. Processing this data on AWS allows Duke Energy to forecast future needs and proactively modernize the power grid, integrate carbon-free energy sources, and prepare for an increasingly electrified world.

Amazon began using custom electric delivery vehicles from Rivian in 2021 and plans to have them in more than 100,000 cities across the U.S. by 2030. Amazon advocates investment, innovation, deployment, and application of grid-enhancing technologies (GETs) – hardware and software – that can be added to the existing power grid to make it more efficient. These technologies increase capacity, flexibility, and resiliency to relieve congestion and avoid increased rates for ratepayers.

Amazon co-founded the Emissions First Partnership (EFP), which advocates for carbon accounting that more precisely measures the impact of emissions on a company's energy consumption and generation. The Greenhouse Gas Protocol, the most used carbon-accounting standard, has helped encourage companies to enable new carbon-free energy projects; it does not account for emissions avoided from grid modernization technologies such as battery storage projects.

In March 2024, Amazon began diversifying its energy portfolio by procuring nuclear power as an additional carbon-free energy source - purchasing, from Talen Energy, a $650 million nuclear-powered data center campus next to the 960 MW Susquehanna nuclear power plant. Amazon's hiring of nuclear engineers emphasizes its committed intentions in this space. Claiming that Amazon's electricity arrangement allows it to benefit from the power grid without contributing to its maintenance costs, utility companies have raised objections to the Federal Energy Regulatory Commission (FERC).

Apple

According to Data Center Dynamics, Apple operates seven data centers as of 2024 and an undisclosed number of colocation deployments. In 2023, it used 2.34 terawatts of electricity, up from 2.14 terawatts in 2022. Apple produced 16.1 MtCO2e in 2023. Colocation data centers (US and international) account for ~20% of Apple's information technology (IT) footprint. However, their outsourced third-party energy specific details were not specified. Apple's cloud services leverage AWS and Google Cloud Platform (GCP) (*Moss, Data Center Dynamics, 2024*).

Its data center in Maiden, North Carolina, exemplifies the innovative use of off-grid distributed energy resources (DERs) to meet substantial power demands while minimizing reliance on the traditional grid. Between 60 and 100 percent of the data center's energy use is produced by two 20 MW solar arrays, an 18 MW solar array, 10 MW of biogas fuel cells, and ~12% is sourced by wind *(Open Doors, 2024) (Power Technology, 2023) (Moss, Data Center Dynamics)*. Apple's data center complex in Prineville, Oregon, is powered by 60 percent wind, 38 percent solar, and two percent micro-hydro (low-impact hydropower). (*Datacenter Dynamics, Moss, 2024*). This approach is a model for how other companies with significant resources and energy needs can leverage DERs to customize their energy mix, enhance reliability and redundancy, and accelerate their time to market.

According to Apple's Newsroom, they support about 1.5 gigawatts of renewable electricity worldwide to power all corporate offices, data centers, and retail stores spanning 44 countries. Apple has issued $4.7 billion in Green Bonds, using the proceeds to help finance its global clean energy solution expansion and emissions reduction projects. The company has invested directly in nearly 500 MW of solar and wind in China and Japan to address upstream supply chain emissions, funded a 320 MW, 2300-acre IP Radian Solar project in Brown County, TX., and reforestation projects in Brazil and Paraguay. Additionally, they prioritize reducing their scope 3 supply chain emissions by calling on their suppliers to decarbonize Apple-related operations by 2030. (*Apple, 2024*)

Dow Chemical (Dow)

Dow's total emissions were 101.6 MtCO2e in 2022. Dow's operations require approximately 10 GW of energy from fuel to produce heat, power, and steam from more than 80 gas turbines, steam turbines, boilers, and over 200 furnaces - powering ~100 sites worldwide. Dow's manufacturing operations require 24/7/365 power, heat, and steam supply. (*Dow, Path2Zero*)

Dow has shown a commitment to renewables as a component of their holistic energy strategy. They purchased 1 GW of renewable power capacity through utility PPAs, approximately 40% of their total purchased electricity (*Dow, Path2Zero*) However, beyond economics, renewables are not technically feasible to meet Dow's operational requirements as they cannot deliver the high temperatures and high-pressure heat and steam required by Dow's manufacturing processes(*Dow, Path2Zero*) As a thought experiment, Dow explained that 4 GW of energy they generate in power and heat would take over 10 million solar panels or 1,240 wind turbines covering tens of thousands of acres. On top of this, there would be significant land and resource costs for the large quantity of energy storage required to firm up the renewables, compensating for their inherent intermittency (*Dow, Path2Zero*).

Dow is actively exploring and investing in carbon capture and storage (CCS) to mitigate emissions at its source as it looks to hydrogen as a future fuel. This is an example of them working to transform an emissions byproduct into a future cleaner generation fuel. As the hydrogen ecosystem matures, Dow is proactively investigating infrastructure upgrades and exploring concepts for hydrogen circularity that would improve the sustainability of their operations. (*Dow, Path2Zero*)

Dow's Seadrift Texas project plans to replace existing gas-fired energy assets with advanced small modular nuclear reactors (SMRs) to reduce emissions while providing a reliable supply of electricity and steam to the site. Central to this strategy is a partnership with X-Energy. X-Energy's Xe-100 reactor will provide carbon-free electricity and high-temperature process heat essential for Dow's chemical manufacturing operations. (*Dow, Advanced Nuclear Reactor Project in Seadrift Texas*). The flexibility and modular nature of SMRs will enable them to be deployed in various industrial settings and scaled to meet project capacity requirements. This project demonstrates Dow's proactive steps toward decarbonization, aiming to reduce its greenhouse gas emissions and enhance energy reliability. By investing in SMR technology, Dow is helping mature a critical technology core for High-Load customers to achieve long-term emissions reduction goals.

Google

As of 2017, Google signed agreements with 20 wind and solar projects, bringing its cumulative renewable PPAs to more than 2.6 GW and matching 100% of its global consumption for operations. However, Google is falling off track with increasing energy demands outpacing renewable generation PPAs and carbon offsets/REC purchases. Google used 23 terawatt hours of electricity to power its operations in 2023 *(Google Emissions Jump 48% in Fiver Years Due to AI Data Center Boom, 2024)* with 35 owned data centers (*Zhang, 2024*). Google's GHG emissions increased by 13% from 2022-2023 to 14.3 MtCO2e (*Statista*). Since 2019, Google's GHG emissions have increased by almost 50%, which the company attributes explicitly to the rise of AI. (*Google Environmental Report, 2024*)

Google is attempting to create a 115 MW new geothermal project in Nevada - working with the utility NV Energy and renewable developer Fervo Energy. This project is an example of Google leveraging a clean transition energy tariff (CTT) to finance this innovative geothermal project. Google would receive credit for the project's energy and generation capacity on electric bills for its Nevada data centers, offsetting demand charges associated with those facilities. The tariff intends to motivate the development of more carbon-free dispatchable energy resources by allowing energy users to recoup the difference between the cost of these capital-intensive resources and lower-cost options like solar or natural gas.

In 2023, Google announced an agreement with EDPR to develop a 500 MW solar portfolio across 80 projects within the deregulated PJM service territory to power its Ohio data centers (EDP Renewables, 2023). Initial funding comes from Google's purchase of renewable energy credits that grant it the right to the environmental and social benefits of the electricity generated from the project. The plan then calls for this utility-scale power generation to be broken up into "community-solar sized chunks" that are more easily integrated into the existing grid because they can connect to lower voltage distribution instead of transmission grids. Furthermore, they can be strategically located in areas with higher concentrations of energy-burdened households. In aggregate, these community solar projects will compensate for Google's data center energy demands while also serving a social justice mission to offset the cost of electricity within the communities in which they are developed. A planned community impact fund and revenue-sharing agreements are of further benefit. This case study is a prime example of a US corporate sponsorship of distributed solar generation.

Google ended its mass purchasing of carbon offsets and stopped claiming its operations as carbon neutral as of July 2024. As Google's energy consumption needs continue to rise and they pause on carbon offsets/REC purchases – it will be interesting to see how Google leverages first-of-a-kind emerging technologies, mature technologies, and utility PPA partnerships to meet its energy and sustainability goals in the future.

Meta

Meta consumed 14.9 terawatt hours of electricity in 2023, having ~20 data centers operational (~13 under construction). Meta's data centers and offices are supported by 100% renewable energy (via PPAs and RECs) - achieving net zero emissions for their operations. Meta's corporate renewable energy portfolio features over 11.7 GW contracted globally with above 6.7 GW in the US – making Meta the most prominent corporate buyer of renewables in the US in 2023. In 2022, Meta produced ~8.5 MtCO2e. As a result of the renewable energy they have procured, Meta reduced operational emissions by 5.1 million tons of CO2e in 2023.

Meta deeply invested in renewable solar and wind PPAs in Iowa, Ireland, Tennessee, Arizona, Texas, and Missouri, among other places. Developers working with the tech giant to build utility-scale projects include Silicon Ranch, EDP, Avangrid, RWE, and Arevon.

Meta's recent partnership with Salt River Project (SRP) and Ørsted exemplifies the strategic use of DERs to power its Mesa data center, advancing its renewable energy goals and broader sustainability commitments. Through a contract with Ørsted, Meta will receive most of the solar energy generated by the Eleven Mile Solar Center, a 300 MW solar farm paired with a 300 MW, four-hour battery energy storage system under construction in Pinal County, Arizona. This project is set to be the largest solar-plus-battery installation on SRP's grid. In addition to the Eleven Mile Solar Center, Meta is securing energy from other solar projects, including the West Line Solar Facility and the upcoming Brittlebush Solar Facility.

In addition, Meta partnered with Sage Geosystems to deliver up to 150 MW of new geothermal baseload power to support its data center growth. This will be the first use of next-generation geothermal power east of the Rocky Mountains – planned to be online and operational in 2027. Geopressured Geothermal System (GGS) technology's ability to harness geothermal energy virtually anywhere promises a new era of reliable, sustainable, carbon-free clean energy baseload power and enhanced grid stability.

In its 2024 sustainability report, Meta said that it has started pilots of renewable diesel, also known as hydrotreated vegetable oil (HVO), for its backup power generators as an alternative to diesel.

Microsoft

Microsoft required 24 terawatt hours of energy in 2023, having 200 data centers representing 25% of the market share in cloud computing. Microsoft emissions increased 29% above 2020 baselines to ~15.4 million metric tons (*Statista*). Renewable sources power fifty percent (50%) of Microsoft's electricity use. In 2021, Microsoft launched a 100/100/0 clean energy goal to cover 100% of its electricity consumption in its buildings and data centers globally with renewable energy by 2025. Microsoft is committed to going carbon-negative by 2030 and is moving aggressively to meet these goals.

In May 2024, Microsoft signed a landmark PPA with Brookfield Renewables for 10.5 GW of renewable energy capacity. The PPA, one of the largest ever signed by a corporation, will enable Microsoft to procure renewable energy from a diverse portfolio of wind and solar projects across multiple geographies. This move helps Microsoft reduce its carbon footprint and provides significant financial and operational stability through long-term energy cost predictability. This agreement supports the development of new renewable energy projects, thereby contributing to the global transition to clean energy. Microsoft's 10.5 GW PPA exemplifies how strategic renewable energy procurement can drive corporate sustainability, demand predictability, and accelerate the greening of the grid.

In August 2024, renewable energy provider Pivot Energy announced a 5-year agreement with Microsoft to develop 500 MW of community-scale solar energy projects across the US between 2025 and 2029. The agreement will allow Pivot to acquire around 150 solar projects in 100 communities across 20 states. Microsoft will buy the RECs from the project, with the first projects expected to begin at the end of 2024. (*Shaw, 2024*)

In September 2024, Constellation Energy and Microsoft announced a new, 20-year fixed price, PPA that will see the restart of the Three Mile Island nuclear facility in Pennsylvania – home of the worst commercial nuclear accident in U.S. history in 1979. Constellation will spend ~$1.6 billion to restart the Unit 1 reactor, adding 835 MW of carbon-free, reliable baseload power. Microsoft will purchase the entire amount to match the power its data centers consume within the PJM Interconnection region. The project still requires U.S. Nuclear Regulatory Commission review and approval. It would come online in 2028 and run until at least 2054. It showcases the private sector's role in driving and paying for critical new investments.

Technology & Policy Innovation

Energy Storage

Energy storage systems are essential for load balancing and peak shaving, storing excess energy during periods of low demand and releasing it during peak hours, thus alleviating grid strain and minimizing the need for additional power generation capacity (*Denholm et al., 2010*). Energy storage also facilitates the integration of renewable energy sources into the grid, smoothing out the intermittency of solar and wind power and making these sources more reliable and grid-friendly (*IEA, 2014)*. AI can optimize energy storage operations by predicting future energy needs and making real-time adjustments to storage, dispatch, and charging schedules (*Wang et al., 2020*). Moreover, as data centers are anticipated to consume up to 8% of US power by 2030, energy storage can help mitigate transmission constraints by providing localized power sources, reducing the need for costly grid upgrades, and allowing more flexible siting of data centers (*Shehabi et al., 2016*). Energy storage can also support off-peak AI operations, shifting energy-intensive tasks to off-peak hours to reduce grid strain during peak periods and lower operational costs (*U.S. Department of Energy, 2018*). Furthermore, it enhances resilience by providing backup power during grid outages, ensuring the continuity of critical operations (*Divya & Ostergaard, 2009*). In conclusion, energy storage will be instrumental in managing the power surge from AI, offering flexibility, stability, and efficiency to the electrical grid, and is increasingly crucial for a reliable and sustainable energy future (*BNEF, 2019*).

Fuel Cells

Fuel cells generate electricity by converting chemical energy from a fuel (such as hydrogen, natural gas, or biogas) into electrical energy through a reaction with oxygen. Different types of fuel cells exist; proton exchange membrane (PEM) fuel cells, solid oxide fuel cells (SOFC), and molten carbonate fuel cells (MCFCs), are the primary ones with benefits and tradeoffs.

PEM fuel cells main benefit is their quick ramp up time making them well suited for backup power and smaller applications. Whereas PEM fuel cells ramp up rapidly, SOFCs and MCFCs can take many hours making them impractical for emergency and time-sensitive power needs. SOFCs and MCFCs advantages are higher efficiency, versatility of fuel inputs, and higher operating temperatures that are valuable in certain industrial use cases. ability to use a variety of fuels, making them ideal for larger-scale industrial applications.

SOFCs are among the most efficient fuel cell technologies, achieving 60% or more electrical efficiencies. SOFCs operate at high temperatures, typically around 600°C to 900 °C. Their high operating temperature make them ideal for providing a steady load, such as in manufacturing plants or data centers where continuous, reliable power is essential. MCFCs operate at a slightly lower temperature range of around 600°C to 700°C. SOFCs and MCFCs are effective for baseload power generation and can utilize waste heat in CHP applications. Limitations to SOFCs include high costs, execution risk around ramp-up times, sensitivities to thermal cycling, and capacity limitations – typically ~10MW.

Natural gas-fueled SOFCs or MCFCs are attractive for medium to large-scale applications due to the widespread availability and relatively low cost of natural gas and are cleaner than diesel generators. Hydrogen-fueled fuel cells are cleaner and emit only water and heat as byproducts. While hydrogen technology holds great promise for decarbonizing our power systems and enhancing the flexibility and resilience of the grid as a DER, significant challenges remain. These include the efficiency and cost of production, storage and transportation difficulties, safety concerns, the need for extensive new infrastructure, and the technology's economic viability. Addressing these limitations will require continued innovation, policy support, and investment in technology improvement and infrastructure to unlock the full potential of hydrogen in our energy system.

Fuel cells' high efficiency and low emissions make them attractive as companies seek to meet stringent sustainability goals. However, high upfront costs, execution risks, and scale limitations of ~10MW limit the size of impact they can have on meeting data center/manufacturing high baseload energy needs. Currently their use case is primarily complementary for DSM efficiencies or backup power. The technologies are gaining tracking and maturity through implementations with tech companies like Google and Microsoft – paving the way for innovations in scale and economics that could help move the needle toward a more distributed energy future.

SMRs

Recent innovations in nuclear energy, particularly in developing Small Modular Nuclear Reactors (SMRs), are promising for higher capacity Distributed Energy Resources (DERs) that can aid corporates in meeting their climate needs onsite. SMRs will typically have an output of 300 MW compared to a typical nuclear reactor capacity of 1-2 GW. Companies like Nuscale, Terrapower, and GE Hitachi are pioneering these technologies; however, it is important to note that these technologies are 10-15 years from commercialization and there remain many technical, regulatory, and execution risks to realizing their benefits as DERs.

SMRs are exciting longer-term explorative possibilities for high-load growth customers to meet their significant and tailored energy needs. Further research is needed to mature and prove the safety, regulations, economic, and other logistical considerations of SMRs. The ability to scale SMRs modularly and complement them with onsite solar/wind paired with fuel cells and long-duration batteries presents a picture of the future energy system that could look much more distributed.

Policy: Tariff Design – Aligning Incentives

In the evolving energy management landscape, manufacturing companies are increasingly looking to Distributed Energy Resources (DERs) to reduce their reliance on grid electricity, particularly during peak demand periods often referred to as "magic hour" rates. However, many of these companies encounter significant barriers in so-called "poison pills" embedded in utility interconnection contracts in which customers pay more than wholesale rates for their energy from the grid. These provisions, which include high interconnection charges, standby fees, demand ratchets, or mandatory sell-back at discounted rates, can make it economically unfeasible for manufacturing facilities to invest in DERs despite the potential benefits of reduced energy costs and lower carbon emissions.

The rationale behind these "poison pills" / higher rates is rooted in the need for utilities to maintain grid reliability and ensure cost recovery. Even if a manufacturing company generates most of its electricity on-site, it still requires the grid as a backup source. Utilities argue that they must invest in and maintain infrastructure to provide this backup power on demand, which incurs fixed costs. To cover these costs, utilities impose standby fees or capacity reservation charges, ensuring they can recover the expenses of being ready to supply power, even if it is needed only intermittently. While this approach protects the utility's financial stability, it can discourage companies from adopting DERs, as the high costs associated with these provisions can negate the economic benefits of reducing grid reliance. It also stands at odds with the spirit of new state legislative and regulatory requirements such as the NC Net Zero plan. Innovative policies that derisking the economics of DER deployments and grid interconnection could help drive adoption and innovation here.

This impact is pronounced during peak demand periods when energy costs are the highest. Manufacturing companies seeking to offset these "magic hour" rates with clean energy face a tough decision: pay significant fees to build DERs and maintain grid backup, pay the elevated rates during peak periods, or pursue load-shaving DSM strategies leveraging existing carbon-intensive assets such as diesel or natural gas generators .This dynamic disincentives companies to invest in renewable energy and storage solutions, ultimately slowing progress toward broader energy transition goals.

Lack of communication between corporates and utilities and inability to find a common ground has led to a situation where companies mitigate these magic-hour rates through onsite diesel generators anyways and utilities must still plan and allocate for the customer's full power load and revenue – much of which does not materialize during these higher cost periods. Increased communication and alignment of incentives have the potential to improve outcomes for all parties.

Tariffs and regulatory policy changes are needed to address these challenges and better align utility incentives with the broader energy sustainability goals. One approach could be the development of more nuanced standby tariffs that accurately reflect the reduced frequency of grid use by companies with substantial on-site generation. Another potential reform is the introduction of performance-based regulation, where utilities are rewarded for supporting customer investments in DERs that contribute to grid resilience and sustainability.

While poison pills in utility contracts protect utilities' financial interests and ensure grid reliability, they also present a significant barrier to the adoption of DERs by manufacturing companies and other corporates. By reevaluating these provisions and implementing policy changes that recognize the value of distributed generation, it is possible to create a more supportive environment for clean energy investments. This approach would enable manufacturing facilities to manage their energy costs better, contribute to collective peak load reduction, and accelerate the transition to a sustainable energy future.

Emerging Themes

These examples illustrate how companies are today leveraging utility renewables, PPAs, RECs, and localized DERs to meet their energy demands and sustainability goals. However, if they are ultimately to be successful in satisfying both a growing need for power and their Net Zero commitments, there will need to be progress on tariff structures. There is also a need for FOAK incentives for corporate/utility energy partnerships and generation technology innovation.

The fact that renewables plus battery storage cannot satisfy the firm power needs of today’s High-Demand customers emphasizes the need for additional generation technologies to mature. Thus, investment in the development of technologies like hydrogen, fuel cells, battery storage, SMRs, and fusion will be critical. AI and Improvements to predictive models and DSM programs for companies can complement these while also enhancing grid stability.

As the generation capacity of individual DERs grows to hundreds of MW, their appeal to corporate onsite generation will likely increase. Growing the quantity and energy density of DER projects would accelerate project timelines, reduce reliance on grid capacity and eliminate some T&D buildouts, while avoiding the lengthy interconnection processes. Corporations, utilities, renewable developers, and engineering, procurement, and construction (EPC) firms must then be more transparent in communicating their power needs and energy plans so that utilities are well-positioned for long-term capacity and infrastructure planning.

While it may seem that today’s High-Demand customers are complicating the Energy Transition, the case studies above suggest this will not be the case longer-term. Rather, the case studies underscore how committed these firms are to sustainable energy goals and Net Zero plans. They have the risk appetites and balance sheets to support the innovation paths for an ‘All of the Above’ DER/DG approach. The case studies also show them to be flexible and creative in forging partnerships and hybrid solutions. This augers well for these customers and the utilities serving them undertaking the reforms and technology developments needed to reconcile growing electricity demand and de-carbonization over time.

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