Guidehouse INSIGHTS

White Paper

Powering Resilient EV Infrastructure

Why Dual Purpose Microgrids Enable Today's Clean Transportation Systems

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Introduction: EVs and Dual Purpose Microgrids

According to Guidehouse Insights, North American investments in smart grid upgrades are expected to reach over $25 billion from the beginning of 2019 through 2021. However, US grid reliability indicators are expected to decline at the same time, largely a function of major events such as the California wildfires of 2019 and 2020 and the Texas ice storm of 2021. As the impacts of climate change accelerate, extreme weather events are likely to continue, further challenging overall grid reliability.

The increasing penetration of renewable energy and the electrification of buildings and transportation pose additional challenges to the grid. These challenges further strain capital planning and real-time grid operations to balancing supply and demand with grid support services such as peaking capacity, demand response, and other ancillary services. What does this mean for the electric vehicle (EV) market, poised for major growth in the coming decades? An unreliable grid not only threatens business continuity and inconveniences consumers, but it also threatens the resilience of transportation networks.

Among the solutions to this grid reliability challenge is the dual purpose microgrid. Essentially, it is a local power system that can overcome long-duration power outages and provide services to the larger grid and wholesale power markets. The dual purposes are power resilience at an EV charging site and revenue-generating power services to the larger grid.

A traditional microgrid will island during a grid outage, ideally sustaining power throughout a long-duration outage such as those experienced in California in 2019 and 2020 and in Texas in 2021. Dual purpose microgrids are distinguished from traditional microgrids in also supplying service to the grid operator, generating a cost-offsetting revenue stream. In effect, the revenue from these grid services reduces the costs for resiliency. The added benefit of resiliency to the site owner similarly reduces the cost of the microgrid asset supplying grid services. Thus, the most enhanced use of the microgrid asset reduces costs for both purposes.

Dual purpose microgrids are critical to making the transition to a low carbon energy future a commercial reality.

Dual purpose microgrids are critical in making the transition to a low carbon energy future a commercial reality, especially when considering a growing wave of fleets and consumers are on the verge of adopting EVs. Electrification of the transportation sector is a new and significant load for utilities, and many are unprepared to keep pace. Dual purpose microgrids will be critical in helping fleet operators, fast charging site operators, and utilities ensure the grid can handle the increasing EV fleets while reducing the need for capital.

This white paper investigates the potential of using dual purpose microgrids to overcome the significant challenges faced by fleets, fast charging site operators, and utilities with electricity poised to become the standard for road transportation energy.

EV Demand on The Rise

Driven by significant cost declines and leaps in technological capabilities, EVs have made significant gains in on-road vehicle markets. Over the last decade, the gains have primarily concentrated in the high volume passenger car and crossover markets. The momentum here has sparked huge investments in battery and charging technology improvements that now enable EVs to satisfy demands for medium and heavy duty commercial vehicles.

The momentum is so strong that solutions have even emerged to enable electrification of the most energy intensive on-road vehicle operations—long-haul trucking—before 2030. As Figure 1 shows, one solution for long-haul trucking, the megawatt charging system, is being designed by a group of key industry players; theoretically, it could one day enable charge capacities up to 4.5 MW. Initial designs are expected to debut in the second half of 2021 and will enable power capacities around 1 MW per vehicle.

Figure 1 Ergonomic and Fit Tests of Megawatt Charging System Connectors

(Source: National Renewable Energy Laboratory)

With major government, investor, and corporate stakeholders increasing pressure on suppliers for net-zero emissions solutions, availability of a wide range of EV options in all vehicle classes has expanded and the business case has improved. As the market has matured, purchase costs have declined and customer sacrifices to range and limited access to recharging infrastructure have abated. Meanwhile, the operational cost savings of EVs—significantly lower energy and maintenance costs—and government incentives remain. Combined, the incentives and savings often produce lower net costs for vehicle ownership than other conventional or alternative fuel powertrains. Fleets and consumers worldwide now rapidly implement the transition toward electricity. However, without more resilient electrical infrastructure, the momentum could slow.

Getting to Net-Zero Emissions

The impetus for electrification has been to reduce emissions of all sorts—particulate matter, nitrous oxides, noise, and greenhouse gases (GHGs). While reducing all emissions is important, reducing GHG has been the primary need. Hence (as Table 1 shows), governments around the world have designed policies to get the automotive and fueling industries to increase vehicle emissions efficiency and reduce energy carbon intensity, respectively.

Table 1 Major Policies Benefiting Plug-in EVs by Region

Region	Efficiency Standards	Zero-Emissions Vehicle Mandates	Regional Internal Combustion Engine Bans	City Internal Combustion Engine Bans	Fuel Carbon Intensity
North America	X	X	X		X
Europe	X		X	X	X
China	X	X	X	X	
OECD Asia Pacific	X		X		
Rest of World	X		X		

Note: Color coding indicates *policy impact—lighter shades reflect low coverage, weak enforcement, or aspirational targets; darker shades reflect the opposite.*

(Source: Guidehouse Insights)

On top of governments' climate actions, a wave of investor and consumer sentiment now pushes corporations to adopt climate action plans. The Science Based Targets initiative has logged nearly 1,000 corporate commitments. The initiative represents a means by which corporations can verify that their emissions reduction commitments are in line with targets climate scientists indicate are needed to keep climate conditions within bounds of the recent geological record, preventing potentially catastrophic climate changes. Corporations that adopt climate plans look at their own emissions and those of their suppliers. This makes service provider fleet GHG emissions a criterion for competitive assessment—encouraging greater uptake of emissions reduction solutions.

When it comes to emissions reduction solutions, EVs are often the most economically attractive. The EV powertrain is the most efficient way to convert energy into traction—as much as 3.5 times more efficient than the internal combustion engine—which makes for cheap energy relative to conventional petroleum fuels and other alternative fuels, such as natural gas and hydrogen. The electric powertrain is also simple compared with other conventional and alternative powertrains, lowering maintenance costs. Beyond the in-vehicle advantages EVs offer, electricity is also the most likely pathway by which energy may become GHG-free through solar and wind, and other near-zero (and even negative) GHG sources like renewable natural gas. Hence, in a policy and business environment increasingly sensitive to GHG reductions, EVs are expected to eventually surpass competitors.

The Market Is Responding

The effect of an increasingly sensitive GHG business environment is already apparent. During the 2020 COVID-19 pandemic, production lines halted, oil prices briefly became negative, and the global vehicle market contracted by 15%. Contrarily, EV sales grew in almost every global region and nearly doubled in Europe. Electric bus adoption continued to grow worldwide—as evidenced by the size of the US electric bus fleet more than doubling in 2020—and major parcel delivery fleets promised huge investments in electrification, as Table 2 demonstrates.

Table 2 Electric Delivery Truck Investments from International Parcel Distributors

Company	Investment	Supplier
Amazon	Deployment of 100,000 electric delivery trucks in North America by 2030	Rivian
UPS	Deployment of 10,000 electric delivery trucks by 2024; option secured to deploy an additional 10,000	Arrival
DHL	Acquisition of electric delivery truck manufacturer in 2014 that produced over 13,000 vehicles; DHL is currently evaluating bids for the operation after announcing plans in 2020 to cease production	StreetScooter
FedEx	Plans for all-electric delivery fleet by 2040	Multiple
FedEx	Initial order of 500 BrightDrop EV600 electric vans	General Motors
FedEx	Deployment of 1,000 electric delivery trucks in California	Chanje

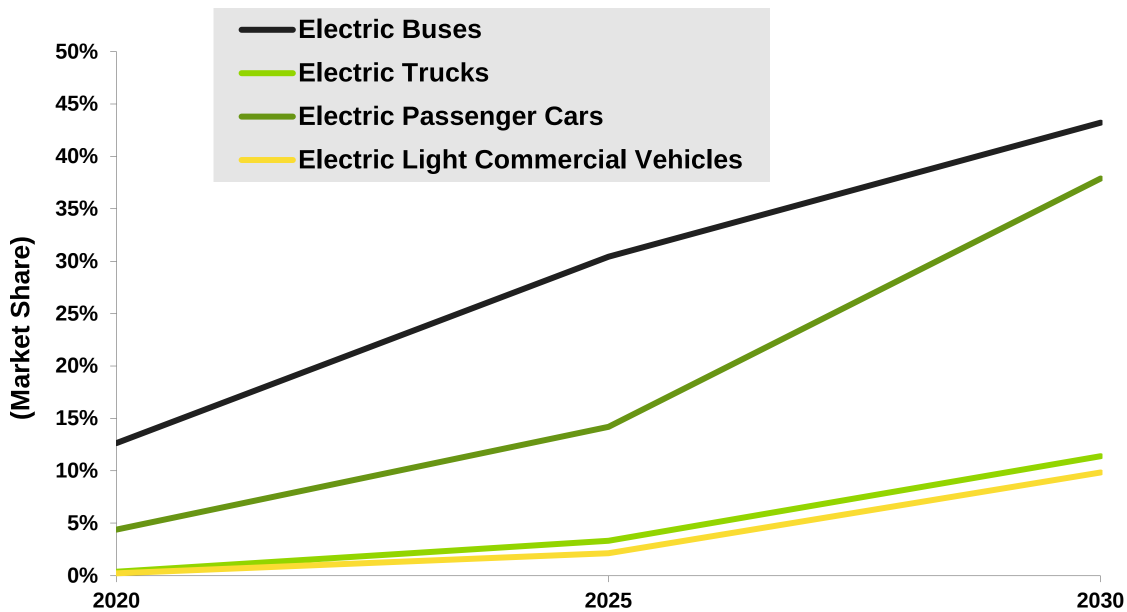
(Source: Guidehouse Insights)

With the road quickly electrifying, many automakers have made plans to only manufacture EVs. Jaguar aims to do so by 2025; Cadillac, Volvo, and MINI by 2030; and General Motors by 2035. Meanwhile, suppliers of heavy trucks—PACCAR, Volvo Trucks, and Daimler AG, among others—have begun to deploy semitrucks to North America, and Tesla is not far behind.

185 Million EVs by 2030

The electrification trend is significant and transformative. In Guidehouse Insights' report *Market Data: Light Duty EVs*, sales of plug-in hybrids and battery EVs in the next decade are likely place 185 million EVs in use worldwide by 2030. This translates to around 10% of all vehicles expected to operate in that year. To get there, Guidehouse Insights expects EV share in new vehicle markets will reach 43% for buses, 38% for passenger vehicles, and 10% for light commercial vehicles and for medium and heavy duty commercial trucks by 2030 (as Chart 1 shows).

Chart 1 EV Market Share by Segment, World Markets: 2020, 2025, 2030



(Source: Guidehouse Insights)

The EV fleet will not only be much larger by 2030, but it will also be able to charge at much faster rates from much denser charging infrastructure. Upcoming light duty EVs increasingly feature 11 kW or 22 kW capacity alternating current onboard chargers and 800 V battery architectures that enable direct current charging up to 350 kW, accelerating charging 3-4 times from the chargers of the last decade. Additionally, the introduction of electric semitrucks facilitates charging technologies with capacities over 1 MW, potentially up to 4.5 MW. By 2030, the next generation of charging infrastructure is expected to lead the market. Guidehouse Insights predicts that of the 100 million charge points needed by 2030, only around 15 million are installed now.

The Grid Is Pressed to Prepare

To keep up with the electrical capacity upcoming charging technologies can deliver and the demands of EV fleet operators, numerous grid upgrades are needed: electricity needs to be more reliable, capacity upgrade design-and-builds need to move more quickly, cost structures need to be adapted to incentivize good EV charging behavior for the grid, and net-zero emissions energy sources need to be standardized.

Power Outages Threaten Policy Objectives

Due to volatile weather patterns exacerbated by climate change and cybersecurity breaches of grid infrastructure, grid reliability has declined despite massive investments. As a result, major vulnerabilities are apparent in an increasingly interconnected and electrified world. This poses significant threats for EV adoption as fleet managers and drivers not connected to distributed energy resources (DER), worry their EVs could be stranded when the grid goes down. As states move to meet renewable energy, grid modernization and clean transportation goals, increased power outages and declining reliability jeopardize each of these policy initiatives.

Slow Grid Upgrades Impede the Transition

Upgrading the capacity of grid distribution assets takes anywhere from a few months to several years. Unsurprisingly, the time it takes depends on the capacity upgrade required, and higher capacity requirements take more time. At the extreme, deployment of charging sites for long-haul semitrucks are likely to require capacities over 10 MW. Such capacities likely require the development of new substations that could take 2 to 4 years to design and build. For heavy commercial vehicle fleet managers, the lengthy grid capacity expansion periods pose significant uncertainties for electrification plans and could delay corporate adoption and compliance with emissions reduction targets.

Out-Dated Rate and Market Regulatory Structures Waste EV Potential

Many incumbent grid demand management rate structures are not designed for the load profiles EV charging creates, which leads to increased costs and challenges for commercial EV charging site hosts. Additionally, many incumbent grid management and retail structures were not designed to access the value EVs can provide the grid via vehicle grid integration technologies. These technologies use the flexibility of EV charging loads to provide ancillary grid services ranging from demand response to frequency regulation. Enabled by new digital technologies, the exchange of data between grid and vehicle can be used to increase the efficiency of both the transportation and energy sectors. However, current grid pricing structures are slow to change and limit the potential.

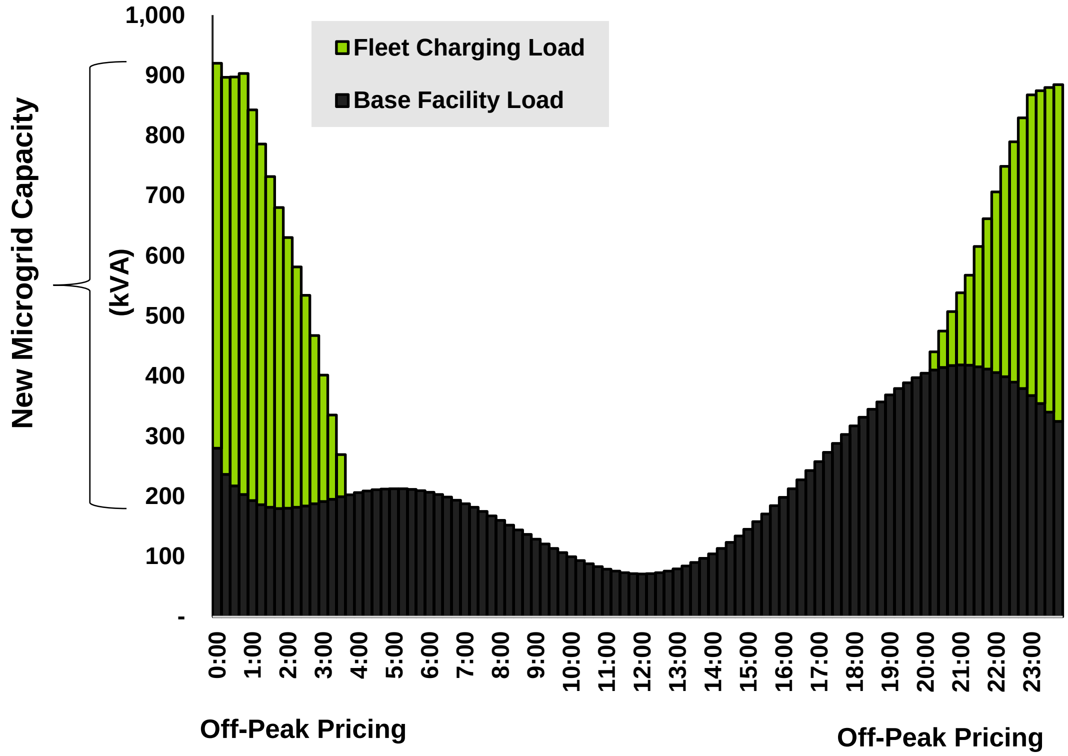
Fossil Powered Electricity Is Contrary to the Primary EV Purpose

While EVs have numerous benefits over competing alternatives, their critical advantage is emissions reduction potential. In attaining the goals of corporate climate action plans, the energy efficiency and partial GHG emissions reductions of EVs charged from the average grid mix is not enough. Companies and fleet operators demand and expect new load growth from transportation to be satisfied with net-zero emissions sources. There are many net-zero emissions sources beyond solar and wind. Some are calculated as even having negative emissions (meaning the source removes more GHG from the environment than it produces), such as renewable natural gas generated from the breakdown of waste in dairy farms. Utilities and regulators must address opportunities to integrate and scale these sources into the grid generation mix.

Microgrid Solutions Are Emerging

With the significant challenges utilities face—the uneven deployment of EV charging infrastructure across their system and a host of equity, cost-shifting, and technology issues—it is not surprising that the job of preparing for massive growth in EVs falls into the laps of third-party solutions providers. They can use microgrids to supplement or offset the grid upgrades for EV charging with generation, storage, and power management solutions on the customer side of the meter. As Chart 2 shows, a fleet of EVs can dramatically increase a property's load profile, warranting a significant utility-capacity upgrade. Microgrids decrease the size of the grid capacity upgrade and improve power reliability, keeping electricity costs low—or at least predictable.

Chart 2 Microgrids Enhance Onsite and Utility Capacity to Reduce Costs



Note: Assumes 100 medium duty electric vans with 100 mile daily routes charging at 10 kVA, vehicles begin charging sessions during nightly off-peak pricing period.
(Source: Enchanted Rock-Guidehouse Insights)

The concept of microgrids is hardly new. Early microgrids were typically remote systems installed in locations that lacked traditional grid infrastructure or where such infrastructure in emerging economies could not deliver reliable electricity services 24/7. Many of these pioneering systems were deployed by utilities in regions such as Alaska, which has more microgrid online capacity than any other state. Many of these systems were also heavily dependent on diesel generation.

However, the technologies bundled together to create microgrids have made tremendous progress within the past decade. From DER assets to supporting infrastructure, such as switchgear and digital grid-edge intelligence, the components that comprise a microgrid are now a commercial reality. Business model innovation is also advancing at a rapid rate.

The market drivers for microgrids all fall under one theme: reduced costs and improved performance. Microgrids are not a single technology but an aggregation and optimization platform. There are many components that need to work together for the microgrid to deliver its potential value in the form of resiliency, economics, and sustainability. An explosion of distributed generation and other DER assets now challenge the economies of scale that have driven electric utilities to focus on large, centralized power plants (e.g., coal or nuclear plants) for more than a century.

If new business models can be considered a new technology, these microgrid enablers are the primary focus of innovation today.

Third-party solution providers include large international technology companies, which often repurpose technologies used on larger utility distribution networks, and smaller startups and innovators building solutions from the bottom up. As the commodity costs of standardized DER assets deployed within microgrids continue to decline, a much greater emphasis is now placed on controls, cloud-native software for data analytics and financial innovation.

Financial innovations include new business models that shift investments from an upfront capital expense to a longer-term operating cost, capture new revenue streams from the provision of grid services, or both. If new business models can be considered a technology, these microgrid enablers are the primary focus of innovation today. Large investors have recently discovered the microgrid market and invest in both projects and companies.

Utilities also increasingly deploy microgrids, generally siting these systems to help bolster their distribution networks. However, regulators have rejected many utility proposals to rate base microgrids. The primary issue can be simplified to this question: Do the benefits of a microgrid flow to all a utility's ratepayers or just a select few? Though utilities are generally less opposed to microgrids than they may have been 10 years ago, when they perceived the technology as a threat, they do not lead the industry in terms of innovation or deployment. Meanwhile, third-party solutions providers grow in number and sophistication. A vibrant ecosystem of providers has emerged, including Enchanted Rock, which has developed a value proposition of the dual purpose microgrid that revolves around low capital costs for resiliency and supplemental capacity through capture of significant grid service revenue.

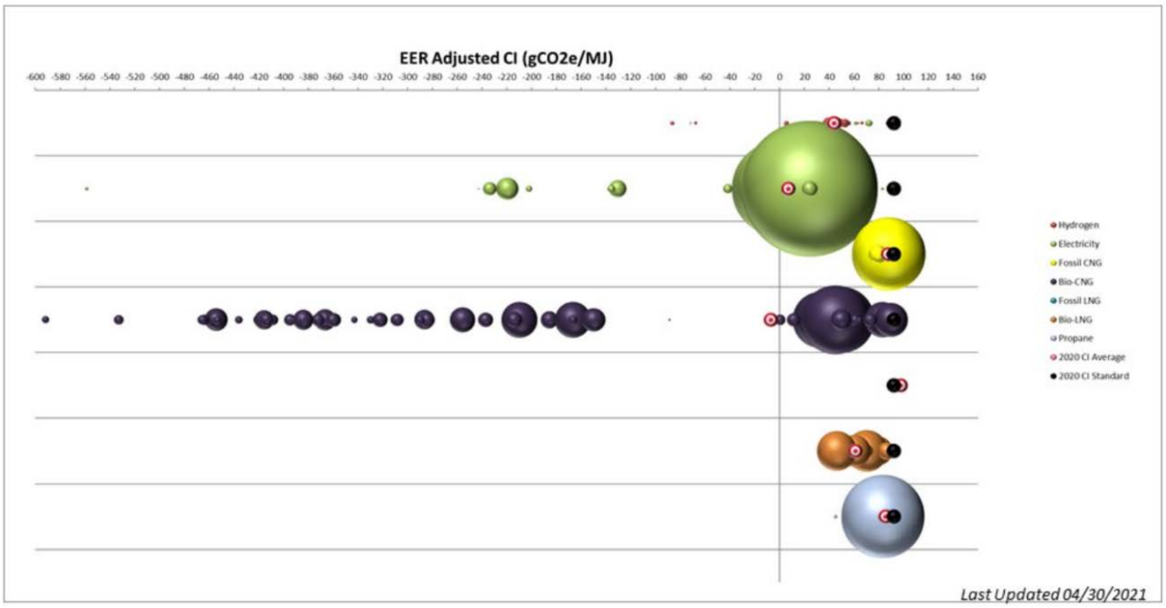
Keeping Capital Costs Low Is Key

The upfront costs to deploy fast charging sites and electrify commercial fleets are significant and risky. EV technologies continue to evolve, and consumer patterns for charging are not yet well-understood, creating potential for fast charging sites to go under-used or for the charging technologies to become obsolete. For fleet managers, high upfront costs can also reduce available capital to maintain vehicle turnover rates, which has cascading impacts on controlling maintenance costs, maintaining predictable vehicle up-times, and ensuring driver satisfaction—all essential for accelerating adoption of fleet electrification.

Microgrids come in many forms and leverage different DER technologies but they can also become complex and increase costs, which in some cases may seem redundant with existing grid infrastructure. The more modular and standard the solution, the lower the cost to own and operate and the greater the market uptake, especially when reliability and resiliency upgrades are needed within a short time period. Considering the extraordinary challenges of the transportation market, microgrid assets need maximized utilization through dual purposing, low costs, and high power for long durations. While a variety of DER technologies can be used to achieve the former, addressing the needs of low costs and high power for long durations is not as common. Historically, such attributes have been found in diesel generators, which is an anathema to the goals of fleet electrification.

Renewable natural gas is an alternative to diesel. Enchanted Rock's microgrid solutions use natural gas infrastructure and compact, modular generators. This keeps equipment costs and space requirements low relative to other microgrid technologies, such as solar arrays combined with stationary battery energy storage systems. Additionally, when hybridized with battery storage and fueled by renewable natural gas, the solution provides emissions reductions benefits, as Figure 2 shows. The solution can achieve low capital costs for reliability while maintaining the emissions reduction objectives of the transportation electrification movement.

Figure 2 2020 Volume-Weighted Average Carbon Intensity by Fuel Type for Non-Liquid Fuels



(Source: Low Carbon Fuels Standard)

Conclusions and Recommendations

While the momentum for transportation electrification is strong, charging service providers, fleet managers, and utilities still face significant adoption challenges. EV technologies are immature, and their costs are high. The constraints of battery range and charge time require improving the efficiency of EV charging across time, space, and grid capacity. Meanwhile, customer demands to see net-zero emissions require enhancing renewable generation capacity further, which drives stronger demand for flexible loads and clean generation assets to help balance intermittent renewable generation.

An even more fundamental challenge is the availability of reliable electricity. As climate change impacts accelerate and both renewable energy and electrification grow, threats to grid reliability are expected to increase over time. Stranding EVs during power outages could have major negative impacts on a wide array of essential services and daily life. The aggressive EV adoption targets set in states, such as California, only make sense if the EV infrastructure is made more resilient. The fastest and most economical way to accomplish this goal is through dual purpose microgrids.

Transportation electrification requires EVs, chargers, after-sales services, and power management services between the meter and the EV's charger. The latter includes DER and microgrid technologies and will be increasingly important as transportation electrification scales. If onsite energy storage already embedded in EVs, smart charging controls, stationary storage, and clean fuel-based generators are combined into a dual purpose microgrid, cost-effective resiliency can be achieved in a targeted manner. There are multiple ways dual purpose microgrids support transportation electrification:

- **Local Resiliency:** Dual purpose microgrids can provide partial or full EV charging facility backup power to ensure the EV fleet is charged—even during grid outages.
- **Capital Cost Savings:** Financing models to spread the initial equipment investments over the life of the assets and services (resiliency and grid) reduce the capital burdens of already tight budgets.
- **Energy Cost Savings:** Dispatching microgrid assets, including enhancing the batteries in EVs, can help reduce utility tariffs such as demand charges and peak power pricing. Dual purpose microgrids can also capture new revenue streams via the provision of grid support services.
- **Utility Infrastructure Gap Filling:** Dual purpose microgrids can also provide temporary onsite capacity in advance of planned utility grid reinforcements. This approach would decouple the timing of fleet electrification and fast charging site development from local utility capacity additions, which often encounter delays to regulatory approval and deployment.
- **Net-Zero Emissions:** Powered by renewable energy technologies, energy generation technologies used in dual purpose microgrids can have significant emissions reduction benefits.

With the oncoming wave of EVs, utilities should consider deployment of dual purpose microgrids as non-wire alternatives to transmission and distribution upgrades. Utility deployments can protect the distribution grid from pockets of EV load growth where utility visibility is low, such as residential neighborhoods. It can also protect the resiliency needs of larger transportation electrification projects, such as those of public transit agencies and delivery fleets. As the EV market expands into increasingly powerful needs, utility adoption of microgrids will be critical to enable timely deployment of significant capacities.

To spur development of microgrids regardless of utility actions, utility regulators must create more standardized interconnection processes. To a lesser degree, they must create greater flexibility in justifying the implementation of behind-the-meter microgrids, especially if supporting critical infrastructure—including EV charging. At the same time, regulators must continuously pave the way for DER participation in grid service markets. Rightsizing interconnection requirements is a critical component to ensure smaller DER capacities that meet minimum capacity thresholds do not have to meet the same requirements of much larger capacity assets.

Beyond the auspices of utilities and the grid, state and federal regulators need to improve market conditions for the development of low carbon fuels such as renewable natural gas. Technology agnostic policies that put a price to carbon, like California's Low Carbon Fuel Standard, are critical to reducing transportation emissions. These policies make the development of renewable resources with emissions reduction benefits highly economically attractive.

While grid and energy market regulations continue to evolve, fleet managers and charging infrastructure developers need to consider resiliency solutions, but they will be hesitant regarding upfront costs. Providers who can increase the development and use of resiliency assets in multiple channels and shift upfront cost pricing to as a service pricing will be well-positioned to serve the growing needs of transportation electrification resiliency.

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Scope of Study

Guidehouse Insights has prepared this white paper, commissioned by Enchanted Rock, to provide an overview of the dual microgrid concept as a critical component to enabling transportation electrification. It provides a summary of the transportation electrification trend and how this trend intersects with the challenges an increasingly vulnerable grid poses charging service providers, fleet managers, and utilities. It then demonstrates how dual purpose microgrids can mitigate the reliability challenge faced by stakeholders while keeping costs low and reducing GHG emissions to zero.

Sources and Methodology

Guidehouse Insights' industry analysts use a variety of research sources in preparing research reports and white papers. The key component of Guidehouse Insights' analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Guidehouse Insights' analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Guidehouse Insights' reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

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