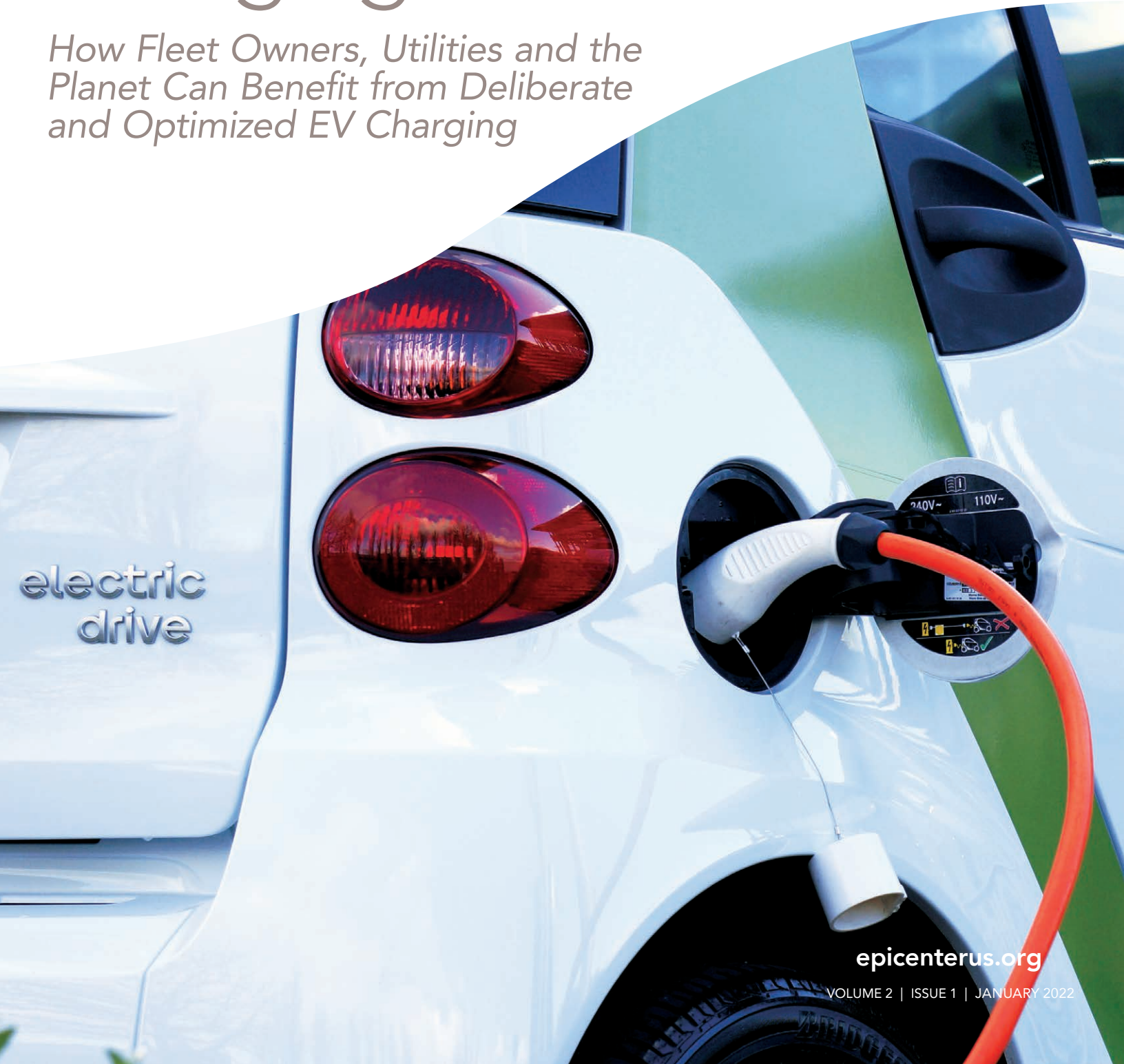


Charging Forward

How Fleet Owners, Utilities and the Planet Can Benefit from Deliberate and Optimized EV Charging



As vehicle fleets go electric, both fleet owners and utilities will need to think through how to charge them.

Introduction



The age of the electric vehicle (EV) is now. EVs have quickly advanced from their initial beachhead in the car-owning landscape—and the question is not *if* but *when* they will overtake their internal combustion engine (ICE) competitors. As more EVs come to market, their economic, performance and environmental benefits will become harder to ignore, accelerating growth.

EV adoption has continued its march forward despite COVID-caused headwinds, supply-chain snarls and the lapsing of some government subsidies. As they gain ground, EVs look to capitalize on this foothold in the personal-vehicle market by spreading into fleets as well. Delivery services, school districts, public transit organizations, car rental companies, construction firms and governmental entities across the nation are planning for inventories that include EVs. Taking that step introduces benefits and challenges to both fleet owners and the utilities that supply their power.

In addition to the environmental benefits, electric drivetrains have fewer moving parts and therefore fewer breakdowns and lower maintenance costs.

Jump on the Battery Bandwagon: The Context

Based on the benefits of EVs, the adoption by fleet owners is inevitable. BCG recently predicted that half the light vehicles sold worldwide by 2026 would be EVs.¹

The reasons are easy to understand. In addition to the environmental benefits, electric drivetrains have fewer moving parts and therefore fewer breakdowns and lower maintenance costs. Since they charge from the grid (which can draw from various energy sources and build in redundancy), EVs no longer rely on a gas supply that can vacillate dramatically or potentially prove unreliable. They can, as discussed below, charge at off-peak times when most energy users are in bed and electricity comes more cheaply. And because most fleets operate on a prescribed route or within a limited area, managed charging patterns make range anxiety an afterthought.

¹ Aakash Arora, Nathan Niese, Elizabeth Dreyer, Albert Waas, and Alex Xie. "Why Electric Cars Can't Come Fast Enough." April 20, 2021. <https://www.bcg.com/publications/2021/why-evs-need-to-accelerate-their-market-penetration>.

While EVs continue gaining ground in the passenger car market, manufacturers are creating larger versions. Over half the announced models globally are pick-up trucks and SUVs,² and a booming array of even larger electric vehicles will serve long- and short-haul functions. Public transit is taking note, as well: the Massachusetts Bay Transportation Authority launched a pilot project to test its first EV buses.³ An independent analysis predicts that “fully electrifying the MBTA’s buses would reduce the fleet’s [greenhouse gas] emissions by 97%, save the MBTA more than \$175 million in lifetime operating costs, and save area residents approximately \$9 million per year in avoided healthcare costs.”⁴

Meanwhile, government-owned fleets have begun the transition. New York City has declared its intent to completely electrify its ground vehicles by 2040.⁵ For the Big Apple, the decision was not purely for societal reasons: they estimate an EV total cost of ownership (TCO) at nearly \$1,000 less per year than a similar-model ICE sedan over a nine-year, 80,000-mile period of service.⁶ Across the country, other municipalities are setting EV targets and executing early projects, and the federal government is,⁷ as well.

Wide-scale battery electrification of rental inventories, long-haul delivery modes and corporate car fleets will arrive in the near term. As with any disruptive technology, the adoption of EVs at fleet level promises benefits and presents challenges. Intentionally and cooperatively confronting those challenges will allow fleet owners and utilities to achieve their goals.

For fleet owners, those goals are obvious. First is mission accomplishment: deliveries get made on time; patrol cars drive where police officers need them to; buses reliably transport students to and from school. Status quo ICE vehicles accomplish that goal nicely; EVs promise an additional environmental advantage and accompanying benefits in public sentiment. But for most fleet owners, financial considerations loom large. They will be much more willing to make an EV investment if they foresee a justifiable rate of return. Especially in the for-profit domain, a favorable balance of costs and benefits is crucial to a decision to adopt EVs at the fleet level.

Utilities, too, are crucial stakeholders in EV fleet transformation. In broad strokes, their goals are the same as fleet owners’: mission accomplishment and financial benefit. Their mission, however, is represented in grid resiliency and price stability: electrical customers have consistent access to the power they need when they need it, and prices remain affordable and predictable. The idea of economic benefit, too, is straightforward. The long-term benefit should outweigh



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²International Energy Agency. “Global EV Outlook 2021: Accelerating Ambitions Despite the Pandemic,” <https://iea.blob.core.windows.net/assets/ed5f4484-f556-4110-8c5c-4ede8bcba637/GlobalEVOutlook2021.pdf>.

³<https://www.mbta.com/projects/bus-electrification>, accessed 17 December 21.

⁴Sierra Club, TransitMatters, and Institute for Transportation and Development Policy, “Bus Electrification: Accelerating the Electrification of Bus Service in the Boston Metro Area,” September 2021, https://www.sierraclub.org/sites/www.sierraclub.org/files/press-room/MBTAReport_Final2.pdf.

⁵<https://www1.nyc.gov/site/dcas/agencies/fleet-sustainability.page>, accessed 17 December 21.

⁶<https://www1.nyc.gov/assets/dcas/downloads/pdf/fleet/Comparing-Sedan-Model-Costs-3-19.pdf>, accessed 17 December 21.

⁷<https://www.energy.gov/eere/femp/electric-vehicles-federal-fleets>, accessed 17 December 21.



the near-term costs that pay for the installation of new distribution hardware, for example. When the utility comes out ahead financially, shareholders realize acceptable returns.

By intentionally aligning their goals and working together to achieve them, both fleet owners and utilities can surmount the challenges to EV fleet adoption.

It's Not Easy Being EV: The Challenges

For fleet owners, an initial obstacle is the up-front capital costs, including purchasing the EVs and installing charging stations and additional infrastructure. For many organizations, though, a simple run-of-the-numbers convinces them of the long-term benefits.

Still, procuring EVs for a fleet is decidedly different from buying or leasing a fleet of ICE vehicles. "In the past, they often just looked at a catalog or talked with a sales rep, looked at the specs, and bought vehicles," says Electric Power Research Institute (EPRI) Senior Technical Executive Watson Collins. "Now they have more decisions to make. *How am I going to charge these vehicles? What infrastructure do I need? What are my costs? What are the utility rates?*"

Electrification entails rethinking aspects that have been automatic for decades. ICE fleets can reliably gas up at a fuel farm or with a mobile fuel truck, with established routines and pricing. As long as the entire inventory is topped off by the time vehicles are needed again, all is well. Whether operators refuel in the afternoon or dead of night, gas and maintenance costs stay pretty much the same.

That is not true for recharging a battery, however, and these differences can become an impediment if fleet owners do not learn about them. Unlike conventional ICEs, Collins says, "The general rule for EVs is: the slower you charge, the cheaper it is, the less expensive the infrastructure, and the better for the batteries."

Slow charging does not always meet fleet owners' needs or optimize their economic equation, though, so they must carefully consider the details of their charging situation. Another important consideration: unlike gas, the price of electricity often changes across a day. More-expensive peak pricing is in effect in the afternoon and evening when workers and students return home and spur electrical demand. When they go to sleep, the load drops, and so does the price of electricity. Demand charges, which are a kind of utility-imposed tariff on high usage, also complicate pricing: if a company exceeds a demand threshold for as little as 15 minutes, it may be penalized with higher pricing on each kilowatt for an entire billing cycle.

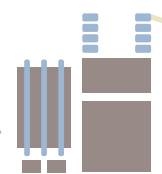
Therefore, fleet owners will not want to leave recharging to chance or whimsy. Deliberately planning the charging operation and executing it precisely will provide maximum benefit.

For utilities, fleet-scale EV adoption represents risk, as well as financial opportunities. Home-by-home EV charging may gradually

GENERATION



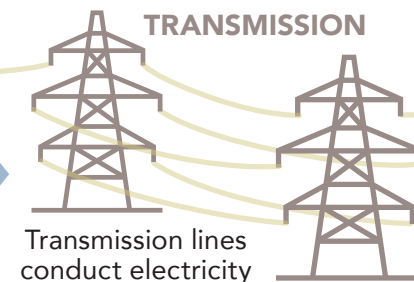
Power source generates electricity.



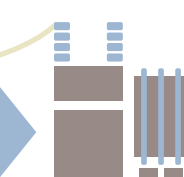
Step-up transformer increases voltage.



TRANSMISSION



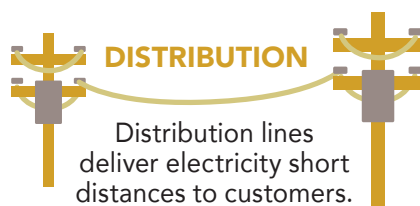
Transmission lines conduct electricity over long distances.



Step-down transformer decreases voltage.



Fleet electric vehicles (EVs) charge through EV chargers.



DISTRIBUTION

Distribution lines deliver electricity short distances to customers.



Figure 1. EVs receive electricity generated, transmitted and distributed by local utilities. Without careful planning and management, EV fleet charging may especially strain localized distribution resources.

increase pressure on the grid, but the centralized electrification of a fleet can impose a sudden, significant burden. Plugged into outlets distributed across a large city, 300 EVs will cause no concern. If they plug in simultaneously in a centralized motor pool, those same 300 EVs tax a utility's local infrastructure. The uncoordinated addition of several fleets in close proximity could undermine grid stability.

To prevent such problems, utilities must plan and modify the grid in locations where those fleets will charge. They need to carefully anticipate capacity needs to remove potential bottlenecks between the *generation* site, the *transmission* lines, the *distribution* channels, and the EV depot (see Figure 1 for the difference between generation, transmission and distribution). Even before today's supply chain snarls, such infrastructure entailed long lead times. Today's lead times have lengthened, which means that utilities must move early on grid enhancements to absorb fleet EV loads while avoiding unneeded infrastructure investments.

For EV fleet owners and utilities alike, significant learning curves loom. They will both attain maximum benefit by recognizing how intertwined their interests are and approaching the challenges in a coordinated, planned way.

Fleet Dreams (Are Made of This): The Solution

Investing in EVs will require fleet owners to change mindsets and procedures. In view of the significant benefits, though, the changes seem inevitable. "Autos are more complicated than horses," advises EPRI's Collins, "but people figured it out. They'll figure out EVs, too." Unlike the shift from horse to automobile, this change involves utilities, as well.

As fleet owners consider how to migrate to EV use—and utilities predict how they will deliver on increasing electricity demands—both will want

"The general rule for EVs is: the slower you charge, the cheaper it is, the less expensive the infrastructure, and the better for the batteries."

— Watson Collins,
EPRI Senior
Technical Executive



Fleet owners and utilities both seek the same goals for EV charging:

-  Performance
-  Grid reliability
-  Scalability
-  Financial benefit

to carefully consider how their charging systems and protocols can achieve an array of results. An assessment of solutions should account for the following goals.

Performance. Mission accomplishment remains the nonnegotiable requirement for any fleet vehicle. EVs must perform as expected, and that includes not only the vehicle itself, but also the charging regimen. Charging will need to accommodate vehicle use patterns. For delivery vehicles, that may mean overnight charging prior to first launch in the morning. For taxis or commuter buses, it may include distributed top-offs throughout the day.

Just as they have an expectation that devices plugged into a wall socket will function, fleet operators expect reliable recharging. Fleets and utilities both will want to consider redundancy in cases of brown- or blackout conditions to keep cars and trucks moving.

Grid Reliability. The hardest loads for a grid to handle are large ones placed simultaneously at the same location, which is what most unmanaged charging will likely cause. Many vehicle fleets operate during a standard workday, which means EVs would begin charging during the early evening, also the time of peak demand for the grid. In hotter states, summertime temperatures strain already-tight supply this time of day. Many fleets plug in at a centralized facility, causing load to spike in one part of the grid.

To prevent electricity disruptions, fleet owners should carefully plan and manage EV charging. Geographically distributed charging can alleviate problematic demand surges. Police officers commonly drive patrol cars home; charging them up there, too, can soften the brunt. Instead of colocating all school buses in a single yard, an independent school district may opt to charge them overnight at schools. Owners will need to work out security, maintenance and other considerations, but none of those is insurmountable.

The benefits of distribution hold across multiple fleets. If several different delivery services locate their centralized charging centers near one another, they may unintentionally combine to become a significant challenge to the grid. Coordination and planning are key.

Whether dispersed or centralized, charging that is well managed will support the grid. Long, slow charging during low-demand times (typically nighttime and early morning) are best. Across a fleet, optimizing protocols will direct staggered charging that calibrates electrical flow and helps preserve grid function.

Scalability. Both fleet owners and utilities want solutions that can scale up as EVs take an increasing share of the fleet and consumer vehicle population. “No one wants to keep putting a new band aid on every few years,” says Mark Braby, head of eMobility, payments, data for Itron, a company that develops technology for energy and water providers. “And it’s more complicated than just having an electrician put in a few more outlets.”

Companies will develop fleet-charging solutions with an eye to the future. How will their EV use patterns likely change in coming years? How can charging support those use patterns? What are the logistical, performance and financial ramifications of those future details?

Even more, utilities will also need to predict and coordinate upgrades. Physically scattered charging may delay significant transmission or distribution upgrades, even though fleet owners add EVs to the utility's demand. At some point, though, increased EV charging requirements will drive enhancements to the grid. Transformers, voltage regulators, capacitor banks, and other grid components represent expensive capital investments for utility companies, and they are long-lead items. Utilities will need to carefully plan their size and location to accommodate not just current EV charging needs, but also those to come.

In light of increasing power requirements, some utilities may encourage EV fleet owners who require centralized charging to locate in proximity with one another. If delivery vehicles must park at a warehouse to allow for overnight charging and loading, utilities may install localized electrical distribution components to service the area, rather than piecemealing components across a city.

Financial benefit. In the end, EV adoption will come from a compelling value proposition. Businesses well understand that value for ICE vehicles. Though the technology continues to improve, one initial prediction indicates an EV total cost of ownership up to 25 percent better than comparable ICEs by 2030.⁸

Companies will shave operating costs by charging smartly, since the price of electricity varies with when and where fleets are charged, as well as how quickly. Recall: slow, less-intense charging is less expensive. Distributed charging evades the risk of demand surcharge pricing. So can staggered (as opposed to concurrent) charging. Each of these elements factors into charge optimization across a fleet.

The most-successful EV fleet management will require the owner to both plan charging operations and manage them well. *On the charge planning side:* fleet owners should commit to charging locations only after careful deliberation and consultation with the utility (and perhaps coordination with other EV fleet owners). They should consider various charging profiles to determine which returns the best value. A plan to rotate EVs through charging stations may allow a company to buy fewer of those stations. Charging at low-kW levels will likely mean the owner can get by with a less expensive in-facility transformer, too.



Utilities will need to carefully plan the size and location of grid components to accommodate not just current EV charging needs, but also those to come.

⁸ Rob Bland, Wenting Gao, Jesse Noffsinger, and Giulia Siccario. "Charging Electric-Vehicle Fleets: How to Seize the Emerging Opportunity," March 10, 2020, <https://www.mckinsey.com/business-functions/sustainability/our-insights/charging-electric-vehicle-fleets-how-to-seize-the-emerging-opportunity>.

"Batteries are a great asset for the grid, since they can both add electricity or take it away—and they can respond within milliseconds."

— James Boston,
CPS Energy's manager,
strategic research
and innovation

Besides cheaper off-peak electricity and more-affordable infrastructure, well thought-out charging also promises decreased maintenance costs. Slow-charging profiles prolong battery and charger component life and require less labor.

Savvy owners can also take advantage of Distributed Energy Resources (DERs), which are small-scale power sources. Companies may combine their solar panels, battery storage or other generation methods with their EV charging apparatus to draw electricity directly from the local source, rather than from the electric company. In fact, many fleet EV operators will find the electron flow goes the other way, too: during peak demand, they can sell the extra charge in their EV batteries to the utility at a premium, then safely replenish those batteries off peak, when electricity costs drop.

"Batteries are a great asset for the grid, since they can both add electricity or take it away—and they can respond within milliseconds," says James Boston, San Antonio-based CPS Energy's manager, strategic research and innovation. For that reason, EV batteries that remain online may also provide fast responding regulation service (FRRS) as an ancillary offering. EV-provided FRRS can help maintain grid frequency, which represents a benefit to the utility as well as a potential revenue stream for the fleet owner.

On the charge management side: instead of leaving charging operations to chance, smart fleet owners will deliberately optimize them in accordance with decided-on rules. Given a set of designated protocols, an integrated hardware and software platform will assess individual EV charging needs and dynamically regulate electricity flow in accordance with future performance expectations. Besides manually connecting the EV to the charging station, no human operators will need to make decisions about the charging operation, which removes human error and increases efficiencies.

As utilities and EV fleet owners grow in mutual understanding, they may find that different pricing models take the place of current ones. There is already excitement about charging-as-a-service pricing, for example, as an alternative to today's per-kilo-watt pricing.

The most-promising solutions for EV fleet owners will also be the best solutions for local utilities, and vice versa. Both stakeholder types are interdependent as they move together into the era of electrified fleet vehicles. The best solutions will be those that feature:

Shared planning. Companies with EV fleets—and those considering procuring or expanding EV fleets—should begin early conversations with utility companies, advises EPRI's Collins. "Utilities haven't electrified fleets at this scale before, and they need to plan way in advance." The conversation, he adds, should include more detail than simply the number of vehicles. Charging profiles and other nuances are important:

“Lower-power charging has enormous implications for the costs of charging and infrastructure, both for the EV fleet owners and the utilities.”

That shared planning allows utilities to anticipate future load needs and design the future grid in accordance with them. Doing so allows for grid stability, which benefits both the utility and fleet owners.

Interoperability. Data sharing and application interoperability are important provisions for optimal EV charging. EV fleets are not destined to travel the bumpy road to interoperability suffered by supply chains and medical records, however. Instead, they can build interoperability into their systems from the start as a precondition.

The most-effective commercial charging systems will be hardware- and software-agnostic in order to offer the end customer choice and flexibility. An integrated charge-management platform should have command over any vendor’s charging station. To maximize benefit, it should also dovetail with the company’s transit-planning and transportation-management software, so that the system can understand current EV locations and battery statuses and recommend changes to plan, as needed.

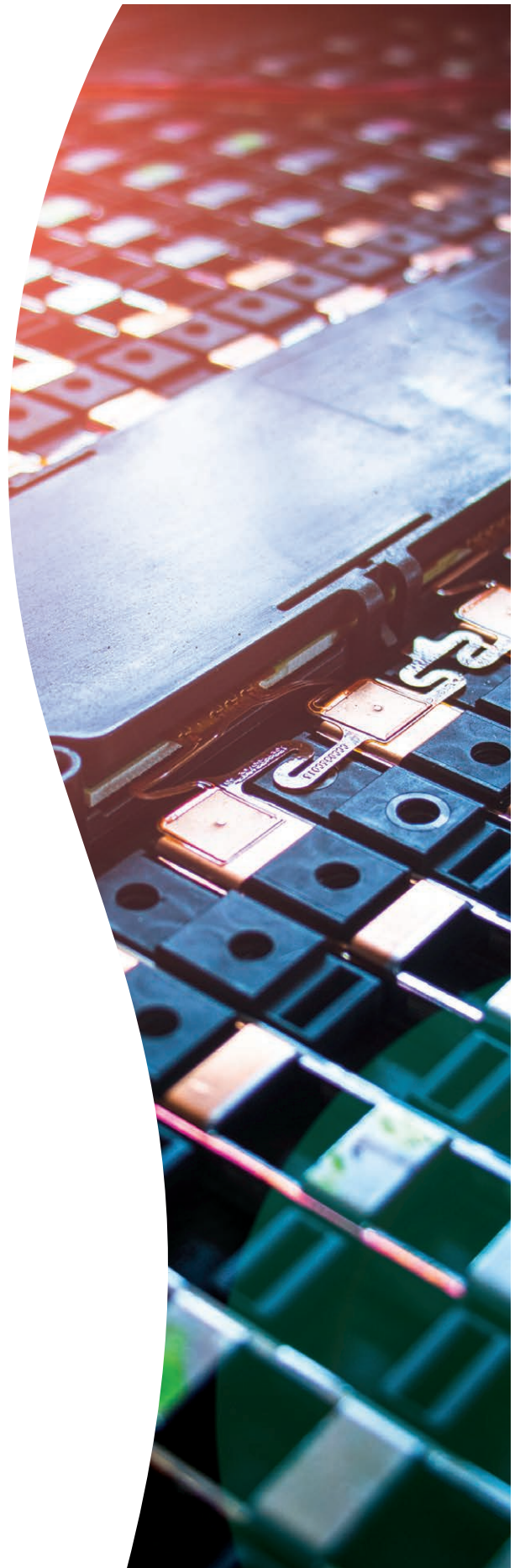
Truly transformational interoperability will link cloud-based, company-owned EV fleet charge optimizing platforms with utility-owned grid optimizing systems. At the utility level, this data sharing fosters grid stability by predicting near-term demand from fleet EV charging, as well as potential supply if residual EV batteries are needed to shore up generation capacity during peak demand periods.

The best solutions will coordinate between individual charging stations and between the charging stations and the utility, for the benefit of both. EV charging should be optimized in light of multiple metrics. An analysis of networked real-time data is key, and those analytics should inform both fleet energy management and grid management in order to promote grid stability and decrease costs for both parties.

Seeing Both Kinds of Green: An Analysis of the Benefits

Recent analysis by Itron has given added detail to the cost benefits of optimized EV charging. “We took a school bus use case and dove into the details to quantify the benefit of managed charging for both the end customer and utility,” says Itron’s Braby.

Itron’s analysis looked at a 100-vehicle fleet of school buses that serves a standard high school. Its commonsense assumptions about charging drew directly from current practices. For example, most school districts fuel and store buses overnight in centralized facilities. The unmanaged scenario assumes the same practice, with drivers parking their buses in the lot upon completion of their routes in the afternoon or early evening. Instead of gassing up the buses, though, operators plug them in before departing for the day. The bus batteries begin refueling immediately, and they continue at a standard flow until they reach full charge.



Itron performed the analysis based on the bus depot being serviced by a large public utility in California. "In terms of impacts on distribution systems, solar panel use and other aspects, our use case is a great proxy, since it signals the direction the entire country is going," says Braby. Analysis of four other representative utilities confirmed the findings.

Unfortunately, typical school bus plug-in time coincides with peak energy demand across American municipalities, when grids strain under pressure and electron flow is at its costliest. Furthermore, this is typically the time that solar generation starts to wane as the sun sets. All plugged in at about the same time, the buses place additional burden on generation, transmission and distribution capabilities. Their batteries' rate of charge is standard, no matter the strain on the grid or the cost of the electricity. Each bus stops charging when it has reached a full charge, typically in the middle of the night, when electricity is cheapest.

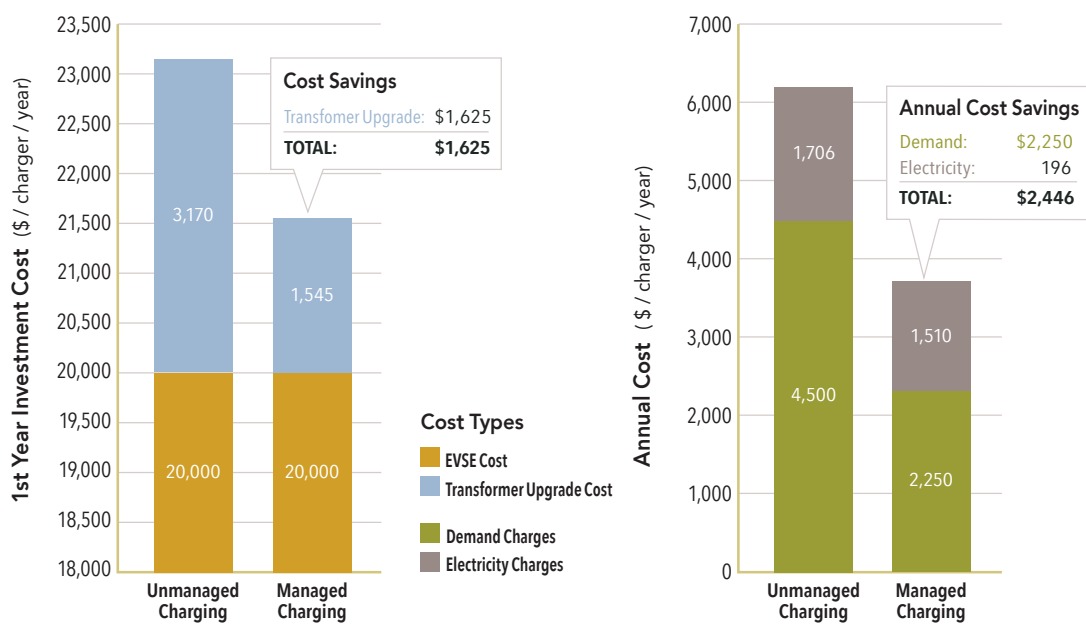


Figure 2. Managed EV charging saves the fleet owner over \$244,000 annually and minimizes up-front costs. Itron's projection shows that smaller equipment, less maintenance and off-peak pricing combine for an impressive 38% benefit over the lifespan of a 100-bus fleet and its 100 chargers.

In contrast, managed charging automates and optimizes overnight bus charging. Although buses plug in during the grid's peak-demand period, they do not begin drawing electricity then. (In fact, school districts could provide their buses' excess battery-stored electricity during this time as an added benefit to both them and the power company.) Buses wait to charge off-peak, at significantly cheaper rates and less stress on the grid. They fill up slowly and deliberately, cycling through in a way that places less stress on batteries and district-owned charging equipment. Charging

management algorithms ensure that buses have enough charge and are ready for their morning routes.

"We knew that managed charging would make a difference," Braby says, "but we didn't know how much of a difference." By using a smart charging management system, the representative school district could meet its needs with a smaller, less expensive transformer. Installing a 1650 kVA transformer instead of a 5000 kVA transformer gleaned an initial \$162,500 in savings (accounting for hardware and wiring costs, but not costs such as site surveys or grid impact assessments).

The school district saw continuing benefits, too. The smart charging software refueled batteries when electricity was plentiful and inexpensive, saving approximately \$244,000 annually (\$2,440 per vehicle). This represented a 38% benefit in savings versus unmanaged charging, as shown in *Figure 2*.

This use case, which assumed one EVSE charger per EV bus, provided impressive numbers. Itron modeling showed that plugging multiple buses into the same charger provides further up-front savings.

Itron analysis showed that utilities, too, enjoyed significant cost avoidance. When the school district outfitted its 100-bus depot with a smart charging management system, the utility saved approximately \$60,400 in costs annually or \$604 per charger per year, as *Figure 3* shows.

Those savings accrued from reduced distribution infrastructure (\$16,000 per year), reduced cost of distribution maintenance and replacement (\$9,000 per year) and a lower need for electricity (\$198,600 per year). Managed charging can save utilities more than 20% a year through targeted grid infrastructure investments and ongoing management.

These benefits are enhanced when an EV fleet’s charge optimization platform shares data and cooperates with the utility’s grid optimization platform. When that level of system-to-system collaboration occurs, both parties will realize even greater value.

Keeping Them on the Edge of Their Fleet: Conclusion

As EV technology continues its advance in American households, it is breaking into the commercial and rental fleet world. Although some fleet owners may purchase the same EVs as households do, how EV-owning businesses refuel those vehicles involves a decidedly different level of consideration.

Companies considering full-scale EV adoption already know the benefits of EVs themselves, among them lower cost of ownership, environmental benefits and increased social capital. But those companies leave money on the table if they procure the basic vehicles and charging equipment, yet fail to carefully consider the process of charging itself.

The best circumstance is one where fleet-operating companies and utilities start talking well in advance of EV procurement. This scenario allows both to appropriately locate and size infrastructure to provide the charge the companies will need while enhancing grid stability. Stakeholders can agree on charging protocols and ways DERs may contribute to grid capacity during peak demand.

After facilities have been built and EVs have been bought, fleet owners’ and utilities’ optimizing platforms collaborate on a managed charging profile that minimizes battery and equipment degradation, saves maintenance costs and allows EVs to draw electricity when it is most plentiful and least expensive. When that level of cooperation is achieved, we will live not only in a cleaner world, but also a more profitable one.

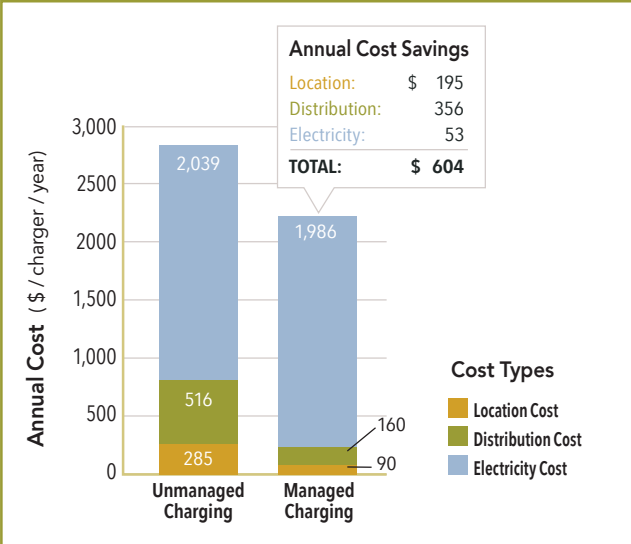


Figure 3: Managed EV charging saves the utility over \$600 per charger per year. Itron’s projection shows that the utility benefits from both decreased operations and maintenance costs and less-expensive grid components.



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