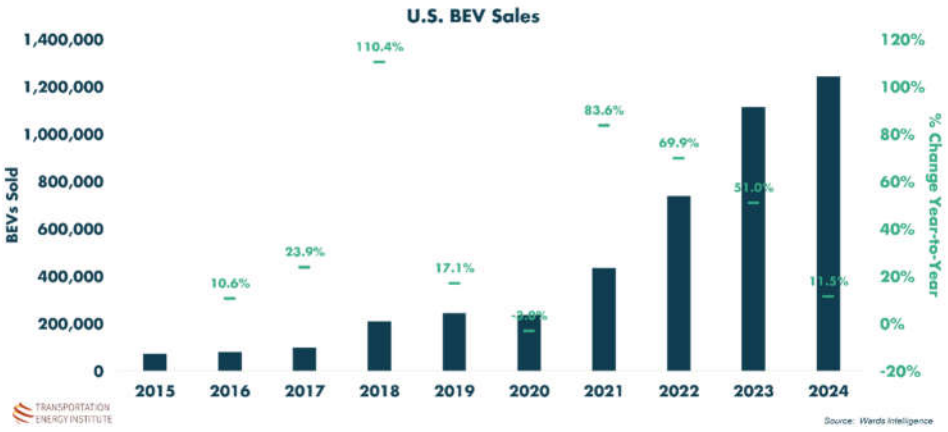
Electric Vehicle Council | March 2025

Future Proofing and Optimizing EV Charging Sites

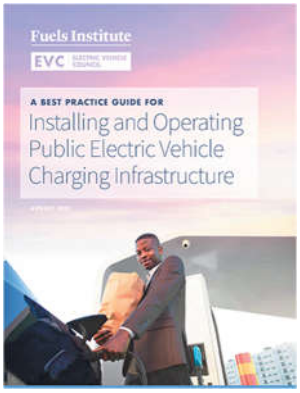
Over the past 200 years, on-road transportation has evolved to include fuel refining, networks of pipelines, terminals, bulk storage, and fuel retailing sites spanning inner cities to rural and interstate highways. The total number of on-road internal combustion engines (ICE) is roughly 280 million on U.S. roads today. This complex network of liquid fuel energy production to ultimate consumption has taken many decades to evolve. Electrifying transportation will likely evolve in a similar fashion as it strives to meet consumers demands. Building an infrastructure that mirrors the ubiquity and reliability which has been developed to fuel traditional ICE is no small task. Technological advancements have created a myriad of paths which can be taken in pursuit of building out charging infrastructure. Consumer and charging operator's demands are still evolving. If these demands are met intelligently, grid optimization and overall emission reductions can and will improve.

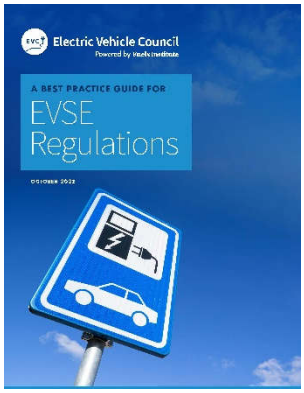
Although it will take decades for electric vehicles (EV) to displace 100% of traditional ICE vehicles in the U.S., growth in EV sales show strong demand with an expected 1.9 million EVs sold in 2024, an 11.5% increase from 2023. The global transition to EVs is well underway, driven by consumer demand, environmental concerns, policy indicators, and technological advancements. As EV adoption accelerates, the demand for robust, reliable, and scalable charging infrastructure becomes increasingly critical. Building out an infrastructure that mirrors the ubiquity and reliability which has been developed to fuel traditional ICE is no small task.



This whitepaper explores the concept of futureproofing and optimizing EV charging sites, emphasizing the necessity of building infrastructure and software that can adapt to evolving technological, regulatory, and consumer demands. By planning, stakeholders can avoid the pitfalls of under preparedness, ensuring that EV charging sites remain functional, efficient, and relevant in the years to come.

Preceding this paper, the EV Council has published and assisted with guidance on the basics of establishing charging infrastructure. All reports are free to download and can be found at the following links:





Understanding the Need for Futureproofing Sites

Market Growth Projections

The electric vehicle market is expected to grow exponentially in the coming years. According to the International Energy Agency (IEA), the global electric car stock surpassed 10 million in 2020, and this number is projected to reach 230 million by 2030. This growth will result in a corresponding increase in the need for accessible, reliable, and efficient charging infrastructure. Failure to account for this surge could lead to bottlenecks, limiting the ability of EV users to recharge conveniently and potentially slowing the adoption of electric vehicles.

Decision Making Process

Many businesses have begun going down the path to meet EV consumer needs, but the U.S. only has a fraction of the public charging infrastructure that will be required. Creating an effective business model for charging-as-a-service is difficult and filled with pitfalls. For those taking the first steps down this path, the EV Council created guidance and a toolkit within the *Installing and Operating Public EV Charging Infrastructure* report. This holistic report provides potential site hosts the advantage of learning from other's past experiences. Following a checklist (below) helps to minimize delays and soft-costs and can expedite the company's decision-making process.

Summary of Considerations for Potential Site Hosts

ASSESSING THE BUSINESS CASE	UTILITY ENGAGEMENT	AUTHORITY HAVING JURISDICTION (AHJ) ENGAGEMENT
☐ Assess the public policy environment.	☐ Research what utilities in the AHJ are doing on EV charging and developing stations and whether they own stations.	☐ Determine which codes and ordinances apply to the site, including construction and electrical installation.
☐ Evaluate potential sites.	☐ Assess if the utility provides make-ready infrastructure.	☐ Research who is in charge of permitting at the AHJ, what permitting requirements are in place, and what the permitting timeline and process entail.
☐ Assess which site host ownership model is preferred.	☐ Communicate early with the utility while assessing the business case to determine what it may need from the organization to plan any infrastructure upgrades.	☐ Research the AHJ's expedited permitting process, if applicable.
☐ Assess what kind of charging the organization wants to provide and what hardware and software might be needed.	☐ Understand the utility's interconnection requirements, timeline, and inspection process.	☐ Review the local AHJ require a site installation plan and anything else needed in the application submission package.
☐ Estimate installation, operational, and maintenance costs.	☐ Research the utility's fee structure.	☐ Research local zoning, building code, or parking requirements that need to be incorporated into the planning process.
☐ Estimate insurance and warranty costs.	☐ Determine if a specific person/ team can work with the organization through the project development process.	☐ Research any requirements governing the operation of EVSE.
☐ Project soft costs as best as possible.	☐ As applicable, determine which party retains environmental attributes (credits) if/when they are generated.	
☐ Consider future-proofing.		
☐ Review available incentives from a state, a utility, the Volkswagen settlement, or AHJs.		
☐ Assess what kind of fees the organization wants/needs to charge.		
☐ Assess demand/return on investment (ROI).		
☐ As applicable, determine which party retains environmental attributes (credits) if/when they are generated.		

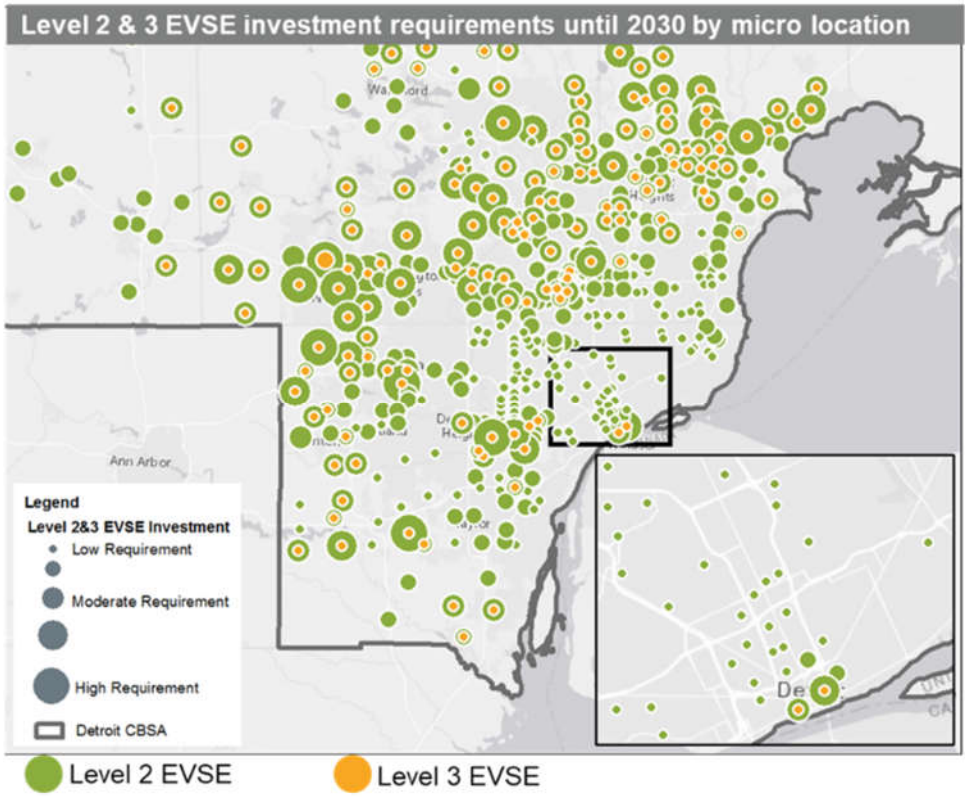
Source: *https://www.transportationenergy.org/research/reports/installing-and-operating-public-electric-vehicle-c (page 2)*

Site Selection

In 2021, the Electric Vehicle Council released its EV Charger Deployment Optimization report which focused on state-level public changing demands. The research results show the importance of understanding, at a state and local level, the markets which are in immediate need to those that could not yet support charging infrastructure. Historically, public charging development has occurred in suburbs and along highway corridors. These sites typically had the advantage of available real estate. As the used EV market grows and EVs become less expensive, urban areas, which are currently "charging deserts", will now need public charging infrastructure. These locations will most likely have less real estate and serve multifamily housing where at-home charging is not an option.

Understanding current public charging needs allows charge point operators (CPO) the ability to limit financial risks that may occur if the charging infrastructure is not used and ultimately becomes a stranded asset. Furthermore, by understanding what is driving consumers to use certain charging infrastructure in certain areas, the CPO can begin to predict where the EV market will grow, and which communities will need more public charging.

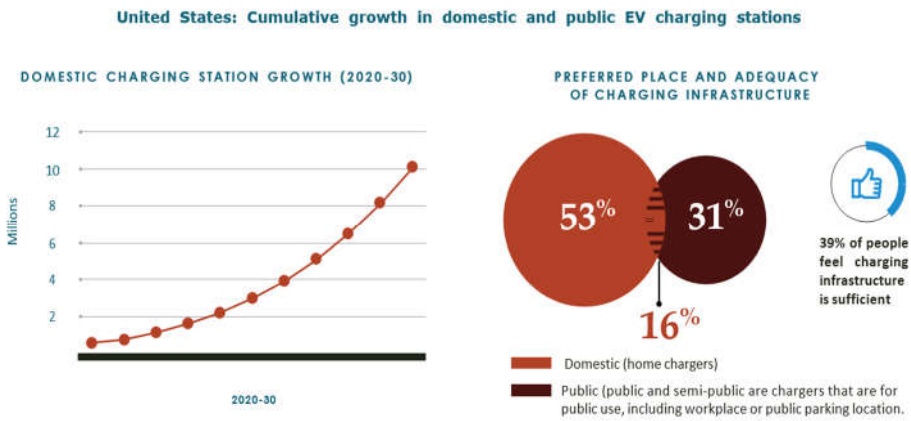
Detroit, MI: Map of Electric Vehicle Supply Equipment Installation Requirements by 2030



Source: *https://www.transportationenergy.org/research/reports/ev-charger-deployment-optimization (page 42)*

As Federal funding options begin to establish highway charging, many in high density urban areas will likely need more fast charging options as EV growth continues, even though 39% of EV drivers feel we have enough today, according the 2022 study.

U.S. Electric Vehicle Supply Equipment Installation Growth



Source: *https://www.transportationenergy.org/research/reports/ev-charger-deployment-optimization (page 26)*

Many internationally recognized sources believe that an adequate ratio of EV to public charger is less than 15. Nationally, however, when the EVC study was drafted in 2021-2022, there were currently 19.7 EVs to every one charger station. Many more public charging sites have

been installed since 2021 but the number of EVs on the road has also increased. The EV Council research clearly shows that there is an immediate demand for more public charging in most regions and provides insights into potential future development demands.

Plug-in Electric Vehicles to Public Charging Stations (July 2021)

STATE	TOTAL RATIO	LEVEL 2	LEVEL 3
California	29.0	41.4	96.3
Florida	19.3	26.0	74.0
Texas	21.5	28.7	86.4
New York	14.8	18.1	82.8
Washington	21.1	27.6	89.8
New Jersey	30.2	47.8	81.6
Arizona	31.1	42.4	116.1
Illinois	21.1	27.9	86.3
Massachusetts	15.5	18.6	92.6
Colorado	16.4	23.3	55.2
Oregon	18.4	24.4	75.4
Georgia	12.7	16.8	52.1
Pennsylvania	17.1	22.2	75.2
Maryland	13.5	18.7	47.9
Virginia	13.8	21.1	40.0
Top 15	**22.4**	**30.7**	**83.3**
National	**19.7**	**26.9**	**73.5**

Source: *https://www.transportationenergy.org/research/reports/ev-charger-deployment-optimization (page 23)*

Meeting the charging infrastructure demands, however, are not without risk. Regardless of government funding programs, financial risks for building out the necessary charging infrastructure still exist. Careful planning is required to limit operational financial risks and avoid stranded assets that are under-utilized or outdated. This paper includes insights into the evolving technologies that can help CPOs limit risks and build enduring critical infrastructure.

Building out public charging infrastructure first requires a deep understanding of the consumer's needs. The majority of EV drivers have the ability to "fuel-up" at home so this adds a nuance to the charging-as-a-service business model.

User Experience

As the EV market evolves, so too will user expectations. Futureproofing involves ensuring a seamless user experience, from easy-to-use interfaces and reliable payment systems to amenities such as Wi-Fi and comfortable waiting areas. Charging sites should also be equipped with software that allows for easy updates and the integration of new services, ensuring that the user experience can evolve along with technology and market trends.

In a recently published EV Council survey of site hosts and EV drivers, Electric Vehicle Market Insights, the Council found that charging site operators would be able to reach (or activate) 94% of EV drivers by offering a bundle of site features including highly visible chargers, multiple chargers, visible security cameras, prepared food, 24/7 access, and a children's playground onsite. And although most drivers did not find wait-times excessive, this may change dramatically if charger up-time issues are not resolved, and EV adoption grows exponentially.

Applications such as the Charging Analytics Program evaluate utilization of chargers and enable analysis of certain site features that may be correlated with such utilization. This can help site hosts and CPOs adapt their offer to better satisfy changing consumer demands. The program is already providing insights into charging environments that vary drastically. While inner-city public charging may consist of quicker "topping-off" events, interstate travelers and apartment/condo occupants are more likely to take their time and charge to 80%+.

Collecting and Evaluating Key Data

Once sites have been selected, partnerships established, and equipment deployed, a re-focus on the customer and their charging experience should begin immediately.

- Evaluate the operability of existing platforms to identify areas for improvement, particularly in customer experience.
- Primary Data Points for Evaluating Customer Satisfaction:
    - Charger Availability: Measure the uptime of charging stations to ensure they are operational when users need them. Frequent outages or long downtimes can significantly impact customer satisfaction.
    - Charging Speed and Reliability: Monitor the actual charging speed delivered versus the expected or advertised speed. Variability or slower-than-expected charging can frustrate users. Collect consumer responses to charge times and offer drivers explanations (EV limitations, managed charging environment, EVSE specs, etc.) as to why charge times may vary to manage expectations.
    - Ease of Use: Gather data on user interactions with the charging station's interface, including how intuitive the process is for starting a session, making payments, and receiving status updates.
    - Wait Times: Track how long customers wait to access a charger, particularly during peak times. Long wait times can lead to dissatisfaction. You may want to employ a reservations/booking program to manage expectations and traffic flows.
    - Payment Options: Evaluate the range and reliability of payment methods offered, ensuring they meet customer expectations for convenience and security. Site cellular hot-spot back-ups, or other connectivity redundancy, may be helpful.
    - Customer Support: Collect feedback on the availability and effectiveness of customer support services, including response times and the ability to resolve issues.
    - Pricing Transparency: Assess whether customers understand the pricing structure and if they feel the cost is fair relative to the service received. Providing online (QR code) pricing information may create opportunities to educate consumers on issues such as demand charges and/or time of use changes in pricing.
    - Feedback Mechanisms: Analyze the channels through which customers can provide feedback and how responsive the platform is to user concerns and suggestions.
    - Identify missing data points and eliminate unproductive data that does not contribute to site reliability or user satisfaction.

By integrating these specific data points into the evaluation process, charging site operators can gain deeper insights into customer experiences and make targeted improvements that enhance satisfaction and loyalty, while increasing the profitability of the overall site amenities.

Software Considerations

To remain relevant, charging sites must be able to integrate emerging technologies seamlessly. This includes fast charging stations capable of delivering higher power levels, wireless charging pads that provide convenience without cables, and infrastructure that supports V2G technologies. Future-proofing also involves using software and management systems that can be updated over time, enabling the integration of new payment methods, user interfaces, and grid management solutions.

Example of a Software and Management System:

Cloud-based software and management systems should be capable of expansion over time. A system should enable integration of new payment methods, user interfaces, and advanced grid management solutions.

Key Features

Scalable and Upgradable Platform:

- The platform must allow charging site operators to add new chargers and locations to their network.
- A software platform must consider and deploy new features to meet user expectations and improve profitability of the site.

Integration of New Payment Methods:

- Payment methods, including RFID cards, fleet cards, digital wallets, plug-and-charge, and credit cards.
- Software should be capable of supporting a rewards program if so desired.
- Review any potential roaming agreements that allow drivers to charge across networks.
- Determine benefits of tying EV payments into the in-store payment system.

Dynamic User Interface (UI):

- User interface that can collect customer feedback on the charging experience.

- Regular updates ensure that the UI remains intuitive and easy to navigate, enhancing the overall user experience and ensuring that it meets the evolving needs of EV drivers.
- Supporting retail loyalty programs and digital promotions within the charging UI and app ecosystem.

2. **Advanced Grid Management Solutions:**
   - Software should integrate with smart charge management technologies, enabling advanced grid management capabilities such as demand response, load balancing, and energy storage integration.
   - Ideally, the system can manage energy use in real-time, optimizing charging sessions based on grid conditions, energy prices, and site-specific energy generation (e.g., solar power).
   - Depending upon dwell times, support for new grid management strategies, such as vehicle-to-grid (V2G) technology, which allows EVs to return energy to the grid during peak demand periods, further enhancing grid stability and efficiency.

Data Analytics and Reporting:
- A comprehensive data analytics and reporting tools for site operators, offering insights into charger usage, energy consumption, and user behavior – particularly into in-store behavior providing a true ROI analysis of the customer.
- Integration of data into the Charging Analytics Program will provide comparative analysis of sites across the U.S.

Remote Management and Support:
- A cloud-based system allows for remote monitoring and management of charging stations. Site operators can perform software updates, troubleshoot issues, and configure settings from anywhere, ensuring that the infrastructure is always operating at peak efficiency.

Flexibility and future-proofing capabilities are essential for modern EV charging networks. Having the ability to integrate new payment methods, update user interfaces, and manage grid interactions dynamically can create a robust solution for site operators looking to stay ahead of the curve. As EV adoption grows, these types of systems will be crucial in supporting a scalable, user-friendly, and technologically advanced charging infrastructure.

Open Charge Point Protocol (OCPP)

The Open Charge Point Protocol (OCPP) is an open, universal standard for communication between EV charging stations and central management systems. Developed by the Open Charge Alliance, OCPP is widely adopted across the globe and serves as the de facto communication protocol for many EV charging networks. Charge point operators should understand the differing versions when designing a system.

To limit the disruption that comes with new EVSE provider mergers or going out of business, standard practices must exist so someone is not left with unserviceable charging assets. At a minimum, software platforms should be standardized and transferrable to any new operator:

Interoperability:
- OCPP ensures that chargers from different manufacturers can communicate seamlessly with various backend management systems. This interoperability is crucial for network operators who manage diverse fleets of charging stations, as it allows them to integrate new chargers without being locked into a single vendor's proprietary system.
- By supporting a wide range of hardware and software configurations, OCPP minimizes compatibility issues that can lead to downtime, ensuring that chargers remain operational and accessible to users.

Remote Monitoring and Control:
- OCPP enables comprehensive remote monitoring and management of charging stations. Network operators can track the status of each charger in real-time, receive alerts about potential issues, and perform remote diagnostics and troubleshooting.
- This capability allows operators to quickly address any technical problems, reducing the likelihood of prolonged outages and enhancing overall uptime.

Flexibility and Future-Proofing:
- OCPP's open standard nature allows for continuous updates and the integration of new features, such as dynamic load balancing, demand response, and energy management functions. As technology evolves, OCPP-compliant systems can be updated to support new functionalities, ensuring that the charging network remains robust and adaptable.
- This flexibility helps maintain high uptime by allowing the charging infrastructure to evolve alongside technological advancements, reducing the risk of obsolescence.

Data Collection and Analysis:

- OCPP facilitates detailed data collection on charger performance, usage patterns, and energy consumption. This data is vital for predictive maintenance, allowing operators to identify and address potential issues before they lead to downtime.
- By leveraging data analytics, operators can optimize charger availability and ensure that the network is consistently meeting the demands of EV drivers.

When installing new equipment, providers may state that the equipment is OCPP-ready but the CPO may want more details.

History of OCPP

The **OCPP** has gone through several versions, each adding new features and improving upon the previous versions. The main versions of OCPP are:

OCPP 1.2 (Released: 2010)

- Basic functionality for charging station management.
- Limited support for remote monitoring, configuration, and control.
- Support for simple charging operations and meter values.

OCPP 1.5 (Released: 2013)

- Added support for smart charging features.
- Introduced SOAP (Simple Object Access Protocol) as a communication method.
- Enhanced support for meter data and transaction handling.

OCPP 1.6 (Released: 2015)

- One of the most widely adopted versions.
- Support for both SOAP and WebSocket communication protocols.
- Features added for:
  - Smart Charging Profiles
  - Security enhancements
  - Remote start/stop of charging sessions
  - Improved diagnostics and firmware management
  - Support for reservations and connector-level control.
- **Variants:** OCPP 1.6-J (JSON over WebSocket) and OCPP 1.6-S (SOAP).

OCPP 2.0 (Released: 2018)

- Significant improvements in security and extensibility.
- Enhanced support for:
  - Plug and Charge (ISO 15118 integration)
  - More granular transaction management
  - Advanced smart charging features.
- Introduction of device management and monitoring capabilities.
- Built-in support for certificate-based authentication and encryption.

OCPP 2.0.1 (Released: 2020)

- Incremental improvements over OCPP 2.0.
- Fixed bugs and improved clarity in the specification.
- Fully backward-compatible with OCPP 2.0.
- Enhanced security features, including support for TLS.

Differences Between Versions

- **OCPP 1.x:** Focused on the foundational aspects of charging station management with basic security.
- **OCPP 2.x:** Introduced more robust security mechanisms, advanced features like Plug and Charge, and interoperability with modern EV standards.

Current Adoption

- OCPP 1.6 and 2.0.1 are the most widely used versions today.
- OCPP 2.0.1 is preferred for newer deployments due to its advanced features and robust security.

Each version has been developed to address the evolving needs of the EV charging industry, with a strong emphasis on interoperability and open standards.

ChargeX Consortium

The National Charging Experience Consortium (ChargeX Consortium) is a collaborative effort between Argonne National Laboratory, Idaho National Laboratory, National Renewable Energy Laboratory, electric vehicle charging industry experts, consumer advocates, and other stakeholders. Funded by the Joint Office of Energy and Transportation, the ChargeX Consortium's mission is to work together to measure and significantly improve public charging reliability and usability by June 2025. For more information, visit chargex.inl.gov. The initiative aims to standardize best practices, enhance charger communication protocols, and promote the development of reliable and user-friendly charging networks and EVs. The ChargeX Consortium has begun phasing this work over to standard setting bodies. It is very likely that the work completed under ChargeX will become standardized practices and implemented by EV charging industry stakeholders in the near future. Steps should be taken by CPOs, charger manufacturers, and EV manufacturers to understand these best practices and implement them to the best of their ability when building new charging infrastructure:

Standardization of Best Practices:

- ChargeX advocates for the adoption of standardized best practices for charging infrastructure payment systems, network connectivity, and diagnostics that should be taken into account during design, installation, operation, and maintenance of EV chargers. By following these standardized procedures, network operators can reduce the incidence of operational failures and ensure consistent charger performance.
- Standardization also facilitates easier troubleshooting and maintenance, as operators and technicians are working within a common framework.

Enhanced Communication Protocols:

- ChargeX supports the development and refinement of communication protocols, such as OCPP and ISO 15118, to improve the reliability of data exchange between chargers and their backhaul communications networks and between chargers and EVs. This enhanced communication reduces the likelihood of miscommunication, reduces the effort and time required for EV drivers to start charging sessions, and provides increased visibility to errors to speed problem resolution, reduce downtime, and increase charging session success. The consortium has also developed thorough test procedures that industry stakeholders can use to ensure that chargers and EVs communicate with each other successfully prior to coming to market.

Focus on Metrics to Improve the Public Charging Experience:

- ChargeX emphasizes the importance of industry employing a robust set of key performance indicators (KPIs) that measure the EV driver charging experience. The consortium defined, verified, and published a suite of KPIs that allow the industry look beyond uptime, which is just one measure of performance. By defining and encouraging operators to monitor and report on these metrics, ChargeX drives continuous improvement in charging reliability.
- The initiative also promotes transparency, encouraging CPOs and EV manufacturers to share data with each other and users, which builds trust and confidence in the charging network.
- Improving durability of equipment. ChargeX is testing adapters, connects, and inlets to generate data to share with industry to improve the
  durability and reliability of hardware in the field.

Collaborative Problem Solving:

- ChargeX fosters collaboration among industry stakeholders, including charger manufacturers, network operators, and EV manufacturers, to address common challenges that affect charger uptime and the charging experience that individual companies cannot overcome on their own. Through this collaboration, the initiative helps develop solutions that enhance the overall reliability and usability of the charging infrastructure.

OCPP and ChargeX are instrumental in ensuring that EV charging stations maintain high levels of uptime and session success, which is critical for providing a reliable and seamless charging experience for EV drivers. OCPP facilitates interoperability, remote management, and data-driven maintenance, while ChargeX drives standardization, improved communication protocols, and industry collaboration. Together, they contribute to the creation of a robust and future-proof EV charging infrastructure that can meet the growing demands of the EV market.

Technological Advancements

Technological innovation in EVs and charging technology is rapid and creates an environment where no one has a crystal ball. Thoughtful planning, however, will limit risks associated with adopting new tech solutions for today's demands and into the near future. Solid-state batteries will charge faster. Vehicle-to-grid (V2G) may improve site profits where longer dwell times exist. Consumer loyalty programs will grow. These are just some of the knowns coming at industry at the time of this report. New advancements will be required for new opportunities. In order to avoid stranded charging assets, charging sites must be designed with the flexibility to incorporate such advancements without requiring substantial overhauls.

Industry has already provided noteworthy examples of advancements that can improve the charging ethos. One example is provided below.

Modular Charging System

A modular charging system is a flexible and scalable system designed to provide power to various devices or equipment, often in an adaptable, customizable manner. Meeting current and potential growth without over-investing is a tricky task. Modular systems can provide a relatively low initial cost impact and allow for growth when and if needed.

Example and Key Features

Scalability:

- It can start with a single charging unit and expand to include multiple high-power chargers as demand increases. This is possible due to its modular architecture, which allows operators to add more charging modules without significant additional infrastructure or grid upgrades.
- A unit can provide up to 350 kW of power, which can be distributed between two charging points. This means that the system can support fast charging for multiple vehicles simultaneously, reducing wait times and improving user satisfaction.

Flexibility:

- The system supports a wide range of charging configurations, from single units to multi-unit clusters. This flexibility makes it suitable for various site conditions and power availability, allowing site operators to tailor the installation to their specific needs.
- The modular nature of the system also means that it can be adapted to different power levels, ranging from 150 kW to 350 kW, depending on the site's power capacity and the expected charging demand. Note that some sites may not require more than 50 kW, further improving on the number of available charge points.

Ease of Installation and Maintenance:

- Modular design simplifies both the initial installation and any future expansions. The charging units can be pre-configured and tested, reducing on-site installation time and minimizing disruption.
- The system is also designed for ease of maintenance, with modular components that can be easily swapped out or upgraded, ensuring that the charging infrastructure remains up-to-date with the latest technology without requiring a complete overhaul.

Integration with Renewable Energy and Storage:

- The system can be integrated with renewable energy sources, such as solar panels, and battery storage systems. This integration helps to offset grid demand during peak usage times and provides a more sustainable charging solution.
- By incorporating energy storage, the system can manage load demands more effectively, reducing the risk of grid overload and lowering operational costs.

Future-Ready Technology:

- The system should be designed with future-proofing in mind. It should support a wide range of charging standards, including NACS (North American Charging System), CCS (Combined Charging System) and, perhaps, the lesser used CHAdeMO, and be compatible with upcoming vehicle-to-grid (V2G) technology. This ensures that the infrastructure remains relevant as EV technology evolves.
- Additionally, the system's software should be capable of remote updates, allowing for continuous improvement and the addition of new features over time.

Impact and Results: Modular charging systems have been successfully deployed in various high-demand locations, providing scalable and reliable charging solutions. Its modular design has enabled site operators to expand their infrastructure as EV adoption increases, without the need for costly and time-consuming upgrades. This approach has proven to be cost-effective and efficient, making it a preferred choice for large-scale EV charging networks.

The modular charging system exemplifies many of the best practices for a CPO looking to start small and expand as needed. Its scalability, flexibility, and future-ready design make it an ideal solution for site operators looking to invest in infrastructure that can grow with the market and adapt to emerging technologies. As the demand for EV charging continues to rise, modular systems will play a crucial role in meeting the needs of the evolving EV ecosystem.

Cost Controls: Distributive Energy/Renewables/Battery Storage

As the adoption of electric vehicles (EVs) accelerates, the demand for reliable and efficient charging infrastructure grows, placing increased pressure on the electrical grid. The early stages of infrastructure buildout have taught us that utility demand charges are a primary obstacle to creating a profitable charging business model. Integrating battery energy storage systems (BESS) and renewable energy sources into EV charging sites offers a practical solution for managing peak grid demand, enhancing sustainability, and improving overall site resilience. This section explores how these technologies work together to create a more robust and future-proof EV charging ecosystem.

A smart charge management system is an integrated solution—often combining software, hardware, and communication technology—that intelligently monitors, controls, and optimizes the charging process for EVs. By analyzing real-time data such as grid demand, energy prices, and individual charging needs, these systems can schedule and distribute power more efficiently and reduce costs for the operator.

A primary goal in introducing BESS is to curb costs associate with utility demand chargers and to accelerate installation when utilities are not able to service a site quickly. For more information on demand charges, see the EV Council's research Demand Charge Mitigation Strategies for Public EV Chargers published in March of 2024.

The Role of BESS in EV Charging Infrastructure

BESS are designed to store electricity, either from the grid, power generators, or from renewable sources, and discharge it when needed. In the context of EV charging, BESS can be used to manage energy demand, reduce grid dependency, and provide backup power in case of outages.

Benefits of BESS in Grid Management:

- Peak Shaving and Demand Management:
    - BESS can store electricity during off-peak hours when energy is cheaper and discharge it during peak hours when demand (and energy costs) is high. This process, known as peak shaving, helps to reduce the strain on the grid during times of high EV charging activity and can lower operational costs for charging site operators.
    - By managing demand more effectively, BESS helps to prevent grid overloads and reduces the risk of power outages that could disrupt charging services.
- Enhanced Grid Resilience:
    - BESS can act as a buffer between the grid and the charging stations, providing a stable and reliable power supply even in the event of grid fluctuations or interruptions. This capability is particularly valuable in areas with unstable grid infrastructure or in regions prone to power outages.
    - In case of a grid failure, BESS can provide backup power to ensure that critical charging services remain operational, which is crucial for maintaining user confidence and preventing perishables from spoiling.
- Cost Optimization:
    - By reducing reliance on the grid during peak demand periods, BESS can help charging site operators avoid costly demand charges imposed by utilities. These savings can be significant, especially in regions with high electricity prices or strict demand charge policies.
    - Additionally, BESS allows operators to take advantage of time-of-use pricing by charging the batteries when electricity rates are low and discharging them when rates are high, further optimizing operational costs. Should an arbitrage scenario exist with the utility, selling back to the grid may improve overall economics.

Integrating Renewable Energy Sources

Renewable energy sources, such as solar and wind power, offer a sustainable way to generate electricity for EV charging stations. When combined with BESS, these sources can provide a consistent and reliable power supply while reducing the environmental impact of EV charging.

Benefits of Integrating Renewable Energy:

- Sustainability and Reduced Carbon Footprint:
  - By incorporating renewable energy sources into EV charging sites, operators can significantly reduce the carbon footprint associated with charging EVs. Solar panels, for example, can generate clean energy directly on-site, which can be used to power the chargers or stored in BESS for later use.
  - This integration supports broader environmental goals and can be a key selling point for eco-conscious consumers who prioritize sustainability in their vehicle choices.
- Grid Independence and Energy Security:
  - Renewable energy generation on-site can reduce dependence on the grid, particularly during peak demand periods or in areas with limited grid capacity. This can enhance the energy security of the charging site and ensure a more consistent power supply.
  - In remote or off-grid locations, renewable energy sources combined with BESS can enable completely autonomous EV charging stations, making EV charging accessible in areas where grid infrastructure is lacking or unreliable.
- Financial Incentives and Regulatory Compliance:
  - Many governments offer financial incentives, such as tax credits, rebates, and grants, for the installation of renewable energy systems. These incentives can offset the initial investment costs and improve the return on investment for charging site operators.
  - Additionally, integrating renewable energy can help operators comply with increasingly stringent environmental regulations and policies that mandate or incentivize the use of clean energy in commercial operations.
  - By reducing the carbon intensity of the charging events, it is likely that compliance and voluntary credit programs will prosper and yield greater revenue.

Synergy Between BESS and Renewable Energy

Maximizing Efficiency and Reliability:

- Energy Storage and Management:
  - The synergy between BESS and renewable energy sources is a key factor in maximizing the efficiency of EV charging sites. BESS allows the storage of excess renewable energy generated during periods of high production (e.g., sunny or windy days) and its use during periods of high demand or when renewable generation is low.
  - This energy management capability ensures that renewable energy is utilized to its fullest potential, reducing waste and enhancing the overall sustainability of the charging site.
- Grid Services and Demand Response:
  - BESS, combined with renewable energy sources, can provide grid services such as demand response and frequency regulation. By adjusting energy consumption based on grid conditions, charging sites can participate in demand response programs, providing additional revenue streams while supporting grid stability.
  - These systems can also feed excess energy back into the grid, particularly during peak production periods, contributing to grid balance and potentially earning credits or payments from utilities.
- Future-Proofing and Scalability:
  - As EV adoption grows, the demand on charging infrastructure will increase. BESS and renewable energy integration provide a scalable solution that can grow with this demand. By planning for future expansion and incorporating these technologies from the outset, site operators can ensure that their infrastructure remains resilient and adaptable to evolving energy needs.

The integration of BESS and renewable energy sources into EV charging sites is a powerful strategy for enhancing grid management, reducing environmental impact, speeding deployment time when 480v access and permitting are obstacles and improving the overall resilience of the charging infrastructure. These technologies not only provide immediate benefits in terms of cost savings and sustainability but also offer a future-proof solution that can adapt to the growing demands of the EV market. As the transition to electric mobility continues, the role of BESS and renewable energy in EV charging infrastructure will become increasingly vital in supporting a reliable, efficient, and sustainable energy ecosystem. Under these models, voluntary carbon market(VCM) credits will be exceptionally valuable as they meet requirements under the “high integrity” VCM credit market definition due to their improved emission impacts.

A successful EV charging network and business offering must make money for the CPO. Most agree that government funding is finite, and industry must create the environment in which capex/opex are not only maintained, but profits are high enough to incentivize more and improved services. All opportunities and technologies must be assessed through the lens of profitability.

Emerging Technologies

As EV technology continues to evolve, charging infrastructure must be prepared to integrate new advancements. This includes ultra-fast charging, which could reduce charging times to just a few minutes, and AI-driven grid management systems that optimize energy distribution and reduce operational costs. Wireless charging is another emerging technology that could revolutionize the convenience of EV charging, especially in urban areas.

Market Dynamics

The rise of autonomous vehicles, the expansion of shared mobility services, and the increasing adoption of electric trucks and buses will all impact the demand for charging infrastructure. These shifts will require a more dynamic and flexible approach to site design and operations, with an emphasis on scalability and the ability to serve a diverse range of vehicle types and use cases.

Conclusion

Future-proofing and optimizing EV charging sites is a complex but necessary endeavor to ensure the long-term success and adaptability of the EV ecosystem. By addressing the key topics outlined in this whitepaper—planning and design, technical reliability, consumer demands, and energy demand mitigation—site hosts can make informed decisions that balance immediate needs with future growth and technological advancements. As the EV market continues to expand, the strategies developed by this working group will be essential in guiding the development of resilient, scalable, and sustainable charging infrastructure.

Stakeholders in the EV charging industry must begin planning and investing in future-proofing strategies now to meet future demand and technological challenges. By embracing the principles outlined in this whitepaper, charging site operators, technology providers, and policymakers can ensure that the infrastructure built today will continue to serve the needs of tomorrow's electric vehicle users.

Electric Vehicle Council
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About the Electric Vehicle Council

The Electric Vehicle Council is a non-advocacy organization whose mission is to coordinate the efforts of organizations actively engaged in supporting the deployment of EV charging infrastructure. The EV Council works to distribute existing research and education materials to amplify and enhance its value to the market, as well as conducts original research to fill gaps in knowledge and further educate interested stakeholders concerning the opportunities, challenges, and successful strategies associated with the installation and operation of EV charging stations.
For more information on the Electric Vehicle Council and a current list of members, please visit:
https://www.transportationenergy.org/councils/electric-vehicle-council