THE MOBILITY HOUSE

Automated Load Management

The Technical Guide For EV Fleet Charging

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Introduction

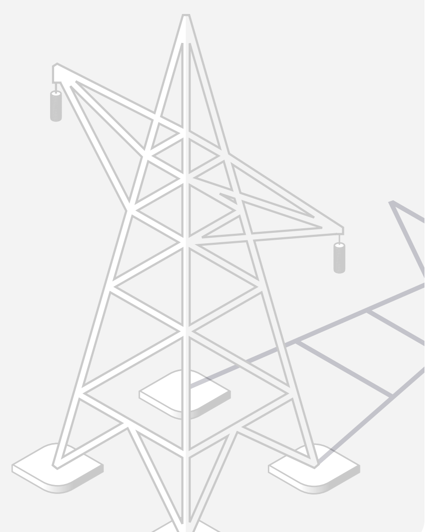
Charging electric vehicle fleets requires more and more energy at sites that previously needed very little. Costly and time-consuming grid expansions are often the greatest obstacle to charging project implementations.

However, utility upgrades may be deferred or avoided by implementing a proven technical solution, known as automated load management (ALM). ALM will play a critical role in accelerating EV charging implementations by enabling the installation of charging stations with a total nameplate electrical power rating that collectively exceeds the site grid connection capacity. This will allow EV fleets to get the maximum charging potential out of their electrical infrastructure by strategically distributing power across multiple chargers.

This technology will be crucial to the energy transition.

“Natural disasters, such as cyclones, earthquakes, hurricanes, wildfires, and severe storms—and the power outages resulting from these disasters—have affected millions of customers and cost billions of dollars. The growing severity of wildfires and extreme weather events in recent years has been a principal contributor to an increase in the frequency and duration of power outages in the U.S.”

- California Public Utilities Commission

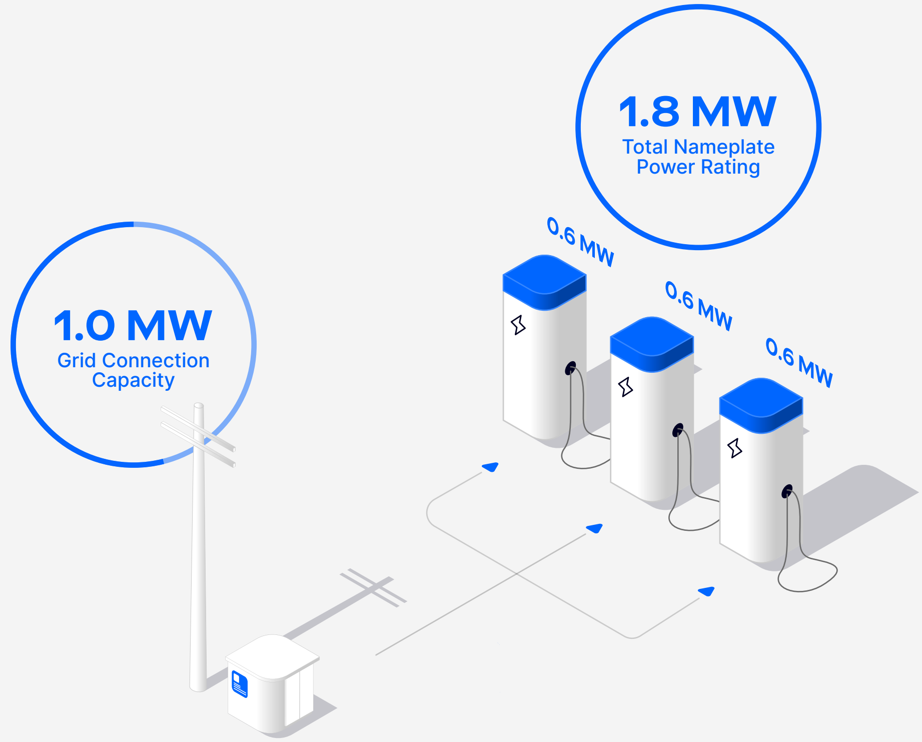


“Automated load management (ALM) is the use of software or other behind-the-meter technologies to strategically share charging capacity across multiple charging ports at the same charging site, helping safely connect multiple charging ports whose total nameplate load would otherwise exceed the rated capacity of the customer connection. By using ALM, customers can avoid or defer the need to upgrade certain distribution system infrastructure to accommodate the new EV charging load.”

- Vehicle-Grid Integration Council (VGIC)

ALM offers fleet electrification project managers a flexible, cost-effective, and expedited energization process by mitigating the need for new infrastructure from the utility. Costly infrastructure upgrades can be minimized or avoided entirely by appropriately sizing electrical equipment based on planned usage, rather than sizing for maximum potential load plus a safety factor. This paper describes the value of ALM systems for electric fleets, how ALM compares to alternative options, how it works, and suggests a framework of how to plan and permit a system with your local authorities.

Figure 1: Oversubscribing nameplate charger capacity above the grid main connection using ALM



The Challenge

The exponential increase of energy demand from electric vehicle fleets is coinciding with an unprecedented shortage of grid components, preventing timely and cost-effective utility equipment upgrades.

443% Average Increase
in lead times for distribution transformers

A consortium of electrical and construction industry organizations* confirmed and detailed this worrisome trend in a 2022 letter to Congress. The consortium wrote that "[At this time] transformer production is not meeting demand and that demand is expected to continue to increase in the coming years. Between 2020 and 2022, average lead times to procure distribution transformers across all segments of the electric industry and voltage classes rose 443 percent. The same orders that previously took two to four months to fill are now taking on average over a year".

The CEO of American Public Power Association, Joy Ditto, recently told Utility Dive that "the average price for distribution transformers may have doubled or tripled…" and "Ditto also noted that outliers can be much higher. A small utility in Tennessee paying $2,400 for a transformer now faces a $24,000 bill, she said."

These short- and long-term barriers show that the current challenges in procuring electrical equipment, such as transformers, are not going away any time soon.

*The consortium includes the following member organizations: National Rural Electric Cooperative Association (NRECA), American Public Power Association (APPA), Edison Electric Institute (EEI), National Association of Home Builders (NAHB), Leading Builders of America (LBA), and Associated General Contractors of America (AGC)

How Does ALM Work?

Using an automated load management system allows operational flexibility while potentially saving costs and time on grid upgrades.

This solution, implemented as a part of a charge management system (CMS), allows the project manager to install a higher capacity of charging stations with a smaller grid upgrade, or even without an upgrade. ALM systems provide more operational flexibility because they can dynamically react in real time to changing conditions while minimizing the amount of grid infrastructure needed.

Implementing an ALM system begins with planning and modeling. The project team will compile detailed information on the site's electrical conditions, such as available electrical load capacity and utility rate structures. This data will be combined with fleet information such as route schedules, vehicle types, and number, to model the charging system and evaluate how much capacity can be installed with or without ALM, and with or without a grid upgrade. Modelling will help the project team decide what equipment is needed, establish a charging plan that serves the fleets' operational needs, and the peak demand of that
system, which will be needed to inform the utility of the project's power needs.

Once installed and commissioned, the ALM system must be limited based on 80% of the total load minus the maximum possible supplemental load. Some ALM systems can monitor and react to non-EVSE loads in real-time, while others can not. If not, the charging load must be limited based on the total load minus the maximum possible supplemental load. If the ALM system does monitor and react to non-EVSE load, the charging load limit can be dynamically adjusted in real-time all the way up to the set point.

The ALM system will allow unlimited charging until the site's actual load approaches the set point. If the actual load approaches the set point, then the ALM system will reduce the charging power to maintain the load below the set point. The distribution of power to individual chargers is determined by the proprietary charging logic of the charge management system:

- In its simplest form, it may equally distribute power across all chargers
- At a higher level of complexity, it may consider which vehicle plugged in first
- At a sophisticated level, it may consider each individual vehicle's scheduled departure and route cycle requirements
- It could also allow for prioritization of one vehicle over another

Both the reliability and performance of an ALM system can be improved with the installation of a local controller, connected to charging loads with hard-wired connection. This configuration significantly decreases the risk of connection loss, as compared to cloud-based systems. The ALM intelligence and feedback control systems can continue running on the controller, even in the event of internet outage. This allows the hardening of failure points as it moves the optimization "closer" to the EVSEs. Having a local controller connected to EVSEs by ethernet or fiber cable also minimizes latency, or delays in the communication of data, as compared to a wifi-based system. Local controller based ALM systems can achieve speeds of control of 4 to 14 second reaction times, significantly faster than the 2x nominal value of a fuse at 20 seconds.

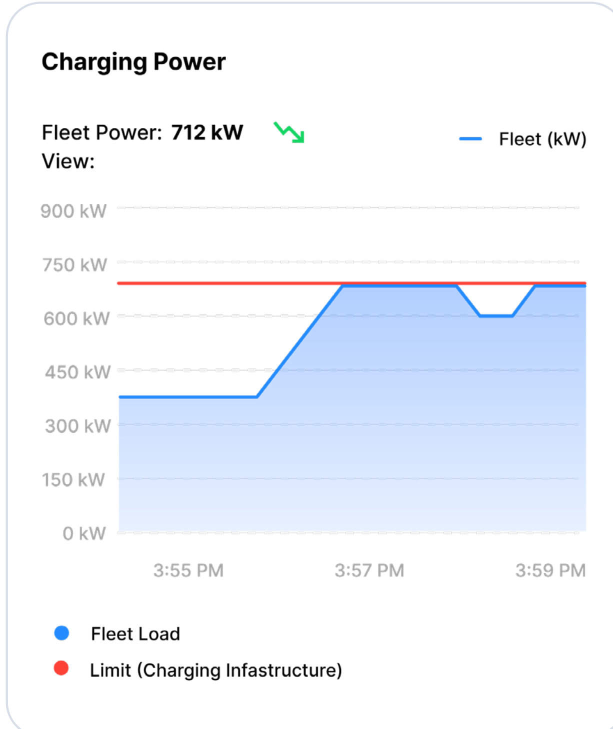
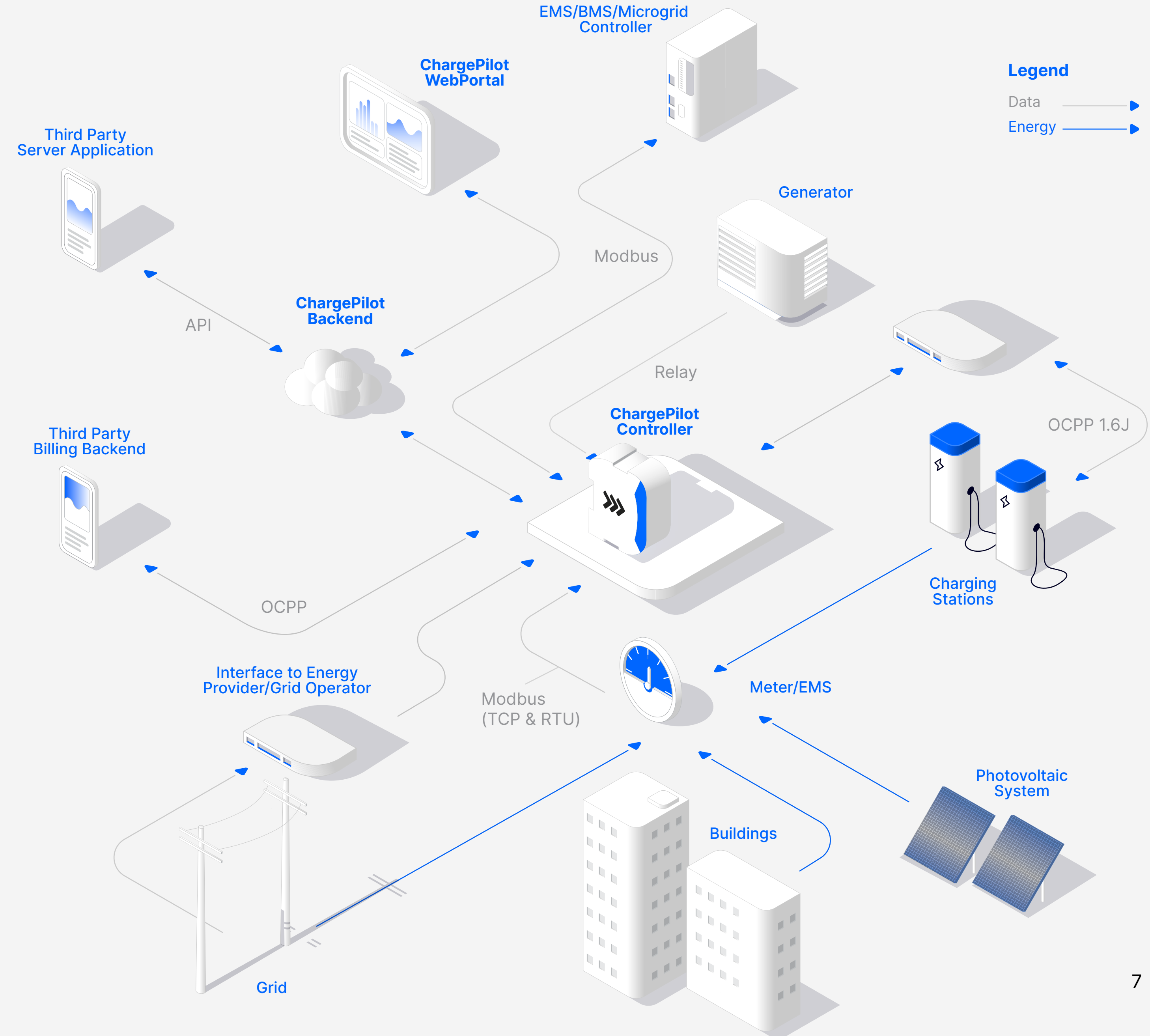


Figure 2: Simulated charge management dashboard view of ALM at work

The ability to monitor and control loads that is inherent to ALM-capable charge management systems can also allow for the implementation of charging logic that optimizes a fleet's charging schedule to minimize energy costs according to the local utility rate structure. This can include optimizing vehicle charging to reduce demand charges which are based on the max load seen at a given site for a set period of time or avoiding the peak hours of a time-of-use rate. However, not all ALM systems are able to optimize for your utility rates in real time, as ChargePilot® does.

Figure 3: The ChargePilot® Ecosystem



Advantages of Local Optimization

Local Optimization is the fundamental system architecture of safe load management.

More fleet charging sites are now adopting local optimization for power control and load management, especially as UL 3141 and the 2026 National Electrical Code are expected to integrate a local controller requirement into their standards. Unlike cloud-based optimization, local optimization brings load management onsite. Instead of relying on external servers, fleets charging with local optimization experience less risk of interruption, more dynamic responsiveness, and higher fleet uptime. All of which guarantee a reliable, resilient, and efficient fleet charging experience.

Low-Risk Charging Expect simple and smooth charging, even when network connectivity is interrupted or slow. Charging optimization continues, even in cases where a cloud-based system would need to rely on fallback functions or disrupt charging entirely. In extreme cases, network interruption can cause catastrophic failure such as fire at the electrical panel. With fewer failure points between the charger and controller and reduced reliance on external servers, local optimization guarantees fleet operators reduced risk to vehicle readiness and enhanced safety due to system integrity.

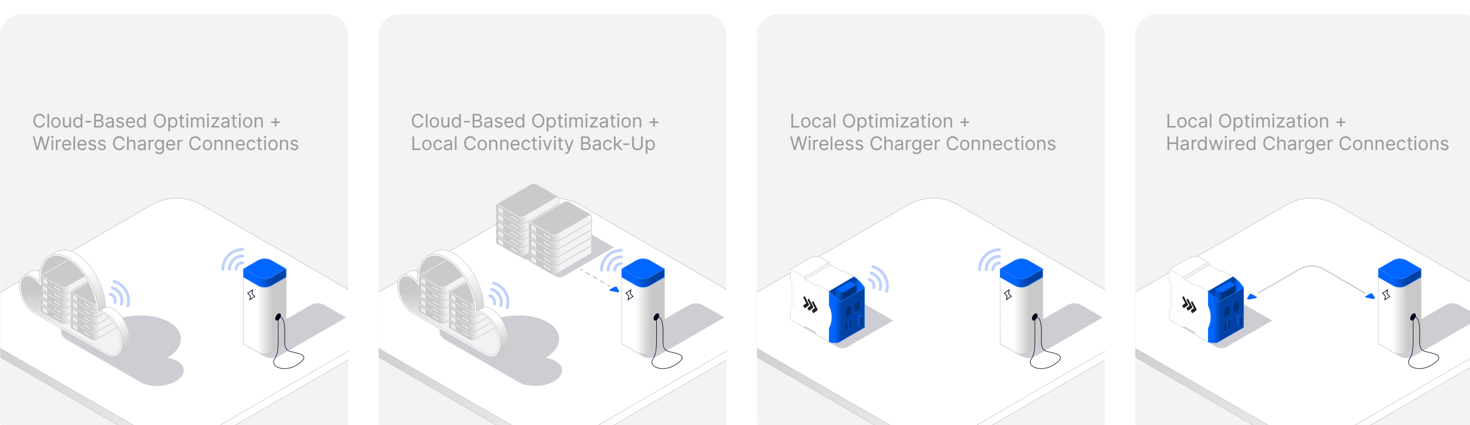
Real-Time Responsiveness With local optimized charge management, chargers dynamically respond to real-time changes at the site. From fluctuating grid capacity to incoming fleet vehicles in need of charging, chargers optimize for fleet efficiency and electrically engineered safety.

High Fleet Uptime Get more out of your fleet-charger ecosystem by minimizing charger downtime and maximize fleet uptime for consistent performance and cost savings.

Least Reliable

Figure 5. CMS Configurations Ranked by Reliability

Most Reliable



Case Study

A real example of how a transit agency in Southern California is meeting its electrification goals with the help of ALM.

The agency has committed to a full transition of their fleet to electric buses within the next decade, in accordance with state mandates. For the first phase of their transition to a fully electric fleet, they found that their intended charging depot site had an electrical panel with a capacity of 1400 amps, equivalent to a 1.1 MW total load. They intended to install 10 Heliox Flex 180 kW chargers, with a total nameplate capacity of 1.8 MW. If they didn't use an automated load management system, the NEC would require that the site's overcurrent protection and other infrastructure be built to 2.25 MW, requiring costly and time-consuming upgrades to the site's electrical connections.

ALM, provided by the industry-leading charge management system ChargePilot®, allowed them to proceed without delay. The grid limit was set to 80% of the existing panel, and if the total charging load should ever approach the threshold, ChargePilot® automatically balances the load to prevent the triggering of the breaker.

Exactly which chargers are reduced and by how much is determined by a variety of factors including but not limited to each vehicle's current state of charge, time until departure, manual prioritization of the vehicle or charger, and minimum charging threshold.

The transit agency has now installed its 10 chargers, they are currently in operation, and they avoided any utility upgrades for this phase of the charging implementation.

International Case Study: An Post, the National Postal Carrier of Ireland

- 100 sites
- 774× 32 amp single phase
- All light duty electric vehicles: vans, small trucks, and cars
- Automated load management allows EVSE nameplate rating to exceed panel capacity by: 192.8% (Average) or 734.8% (Max)
- Estimated upgrade avoidance across all sites: 50 MW

The Alternatives

If ALM is not integrated into the planning process, there are generally three options for the design of electrical infrastructure, each with varying degrees of added project expense, delay, or downsizing:

1 Wait and pay for a grid upgrade

2 Derate the chargers indefinitely

3 Install fewer chargers

1 Build New Electrical Infrastructure

Without the use of ALM, the fleet operator would need to upgrade all infrastructure to serve full nameplate ratings of the charging installation plus a 25% safety factor, including distribution transformer, service conductors, overcurrent protection devices, and service equipment. Since Electric Vehicle Supply Equipment (EVSE) is considered to be "continuous load," without ALM, these pieces would each need to be sized according to the relevant section of the NEC – see table 1 below.

Table 1: References in NEC 2023 for EV- related infrastructure sizing

Type of Equipment	Load Calculation Without ALM	Load Calculation With ALM (Section 625.42 A & 750.30)
Service Conductors	125% of Nameplate Load (Section 230.42)	125% of EMS Set Point
Overcurrent Protection Devices (branch and feeder)	125% of Nameplate Load (Section 625.41)	125% of EMS Set Point
Distribution Transformer	Nameplate Load * Safety factor (not determined by NEC) (Section 220.57)	EMS Set Point * Safety factor (not determined by NEC)
Service Equipment	Sum of load on branch circuit (Section 220.40)	125% of EMS Set Point

The oversizing of electrical equipment to accommodate a safety factor of 25% has a significant impact on project costs, as larger equipment costs significantly more. For example, to install four new 150kW chargers without ALM, a 750 kW panel would need to be installed.

2 Derate the Capacity of Charging Stations

If a fleet operator wants to preserve the desired vehicle to charger ratio, without an upgrade and without ALM, they will need to derate each charger indefinitely. In this scenario, each individual charger is set to operate at a fixed lower power. The sum of these limits follows the same nameplate calculations as above. This option limits operational flexibility as fleets are not able to optimize charging to the real-time circumstances of chargepoint-level power consumption. For example, a fleet may have a 500kW panel on site, with 400kW available for charging according to the 125% rule. They want to install four 150kW chargers by derating them to 100kW each. In this scenario, if three vehicles are plugged in then they will each only charge at 100kW, leaving 100kW of available power unused.

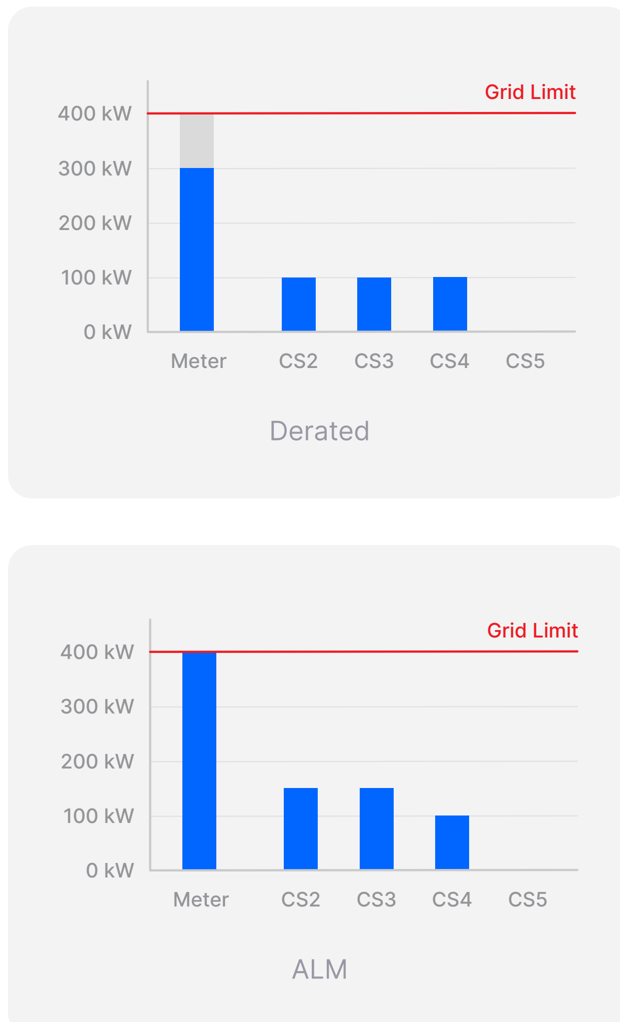
400kW – (100kW*3) = 100kW leftover unused power capacity

3 Install Fewer Chargers

The final option is to install fewer chargers. Having fewer chargers available puts constraints on the operational efficiency of the fleet, as vehicles will have to be manually moved in and out of chargers, to allow for the rotational charging of the fleet.

This not only adds to the dedicated staff hours required to operate a fleet, especially during off-hours, but also introduces the opportunity for human errors to occur. Public chargers, employee home charging, or on-route charging stations can fill the charging gap for certain types of vehicles and use cases, but each come with their own challenges.

Figure 4: Derating chargers alternative



ALM in the National Electrical Code (NEC)

The National Electrical Code (NEC) has addressed automated load management systems for EVs since 2014.

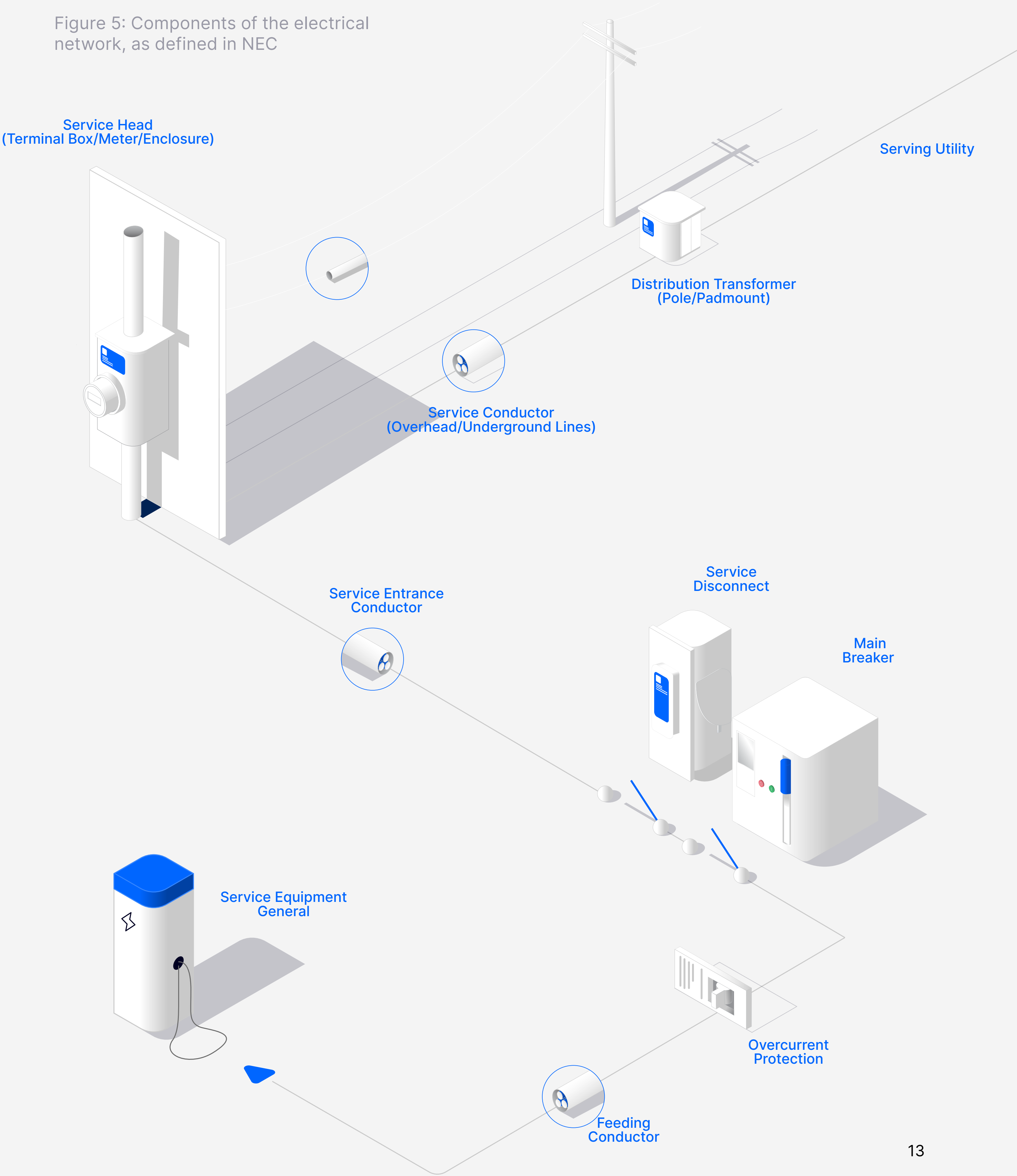
In the 2023 NEC, subsection 750.30 is updated to define an automated load management system as an “energy management system” (EMS). An energy management system affects how each of the various types of equipment must be rated.

Per section 625.42A, when an EMS is managing EVSE load, the maximum equipment load on a service and a feeder shall be the maximum load permitted by the EMS. This includes service equipment, such as the service conductors, and grounding equipment, as well as the feeder conductors and overcurrent protection devices. This maximum load allowed by the EMS is called the “EMS set point,” and can be lower than or equal to the maximum load of the circuit. This maximum load of the circuit must still follow the 80% rule. Given that this EMS set point is then used in load calculations as shown in Table 1 rather than the full combined nameplate rating of equipment, this provision of the NEC allows fleet electrification teams to use electrical equipment of a significantly smaller size, potentially enabling cost and time savings for the project.

NEC 625.42A also defines the electrical load for transformers as the limit set by the energy management system. As transformers can constitute the bulk of a project’s electrical utility equipment costs and currently have long purchasing lead times, reducing the size of the needed transformer and possibly even removing the need for a new transformer can lead to significant cost and time savings.

It is important to note that in the 2023 NEC, subsection 750.30 states that in case of EMS failure, all chargers must revert to 0A. However, an existing function- ality in the optional smart charging profile of the OCPP 1.6J standard may be used in the future to allow for pre-determined safe default levels of charge to allow EVs to continue charging at lower levels until EMS control is reestablished. Previous versions of the NEC such as 2017 and 2020 do not have this requirement.

Figure 5: Components of the electrical network, as defined in NEC



How to Secure Approval for your ALM System

Permitting an EVSE installation should be undertaken by experienced professionals such as an EPC or Consulting firm. This rough outline is meant to set expectations of how the process could go, although specifics will vary by jurisdiction.

Once you have your system designed, the first step is to contact the authority having jurisdiction (AHJ), which could be your local building inspector, to determine what permits are needed for the specific project.

The AHJ is the entity responsible for enforcing building codes, fire codes and electrical codes, and other regulations in a given area, often the local municipality. The AHJ will then provide information regarding what documentation is needed. These might be blueprints or diagrams showing how electricity will be used on site. Additionally, there may be required documentation explaining the use of load management on site such as the technical documentation describing the energy management system and site plans that show how the energy management system ties into the overall site design. This is also the right moment to contact the utility account manager to inform them of the project plans.

The next step is to obtain and file a permit application from the local building department or other authorized agency. This form will need to be completed by an electrician or licensed contractor who can provide detailed plans and specifications about the plan to install any new wiring, equipment, systems, etc. The forms should also include a description of all existing components so they can ensure everything meets safety requirements before installation begins, including information regarding the energy management system.

After the forms are completed, submit applications along with any required documents to obtain approval from both state and local authorities before beginning work onsite. This could include obtaining approval from a master electrician, depending upon the jurisdiction.

Next comes inspection by a qualified inspector who must approve all installations before energizing them for use. They may require additional testing for systems such as the energy management system. Make sure that any necessary inspections take place throughout various stages of work including initial installation, mid-way inspection when 50% complete, and final inspection before commencing operation. Once approved, the inspector will issue a certificate that allows the energization of your project and confirms it complies with relevant codes & regulations including National Fire Protection Association (NFPA) 70: National Electric Code (NEC).

The Mobility House does not submit permitting for projects, but we can refer preferred partners with deep experience. The Mobility House is always available to provide language and consultation on projects that include ChargePilot®.

Proposed Process to Work with the Authority Having Jurisdiction (AHJ) to Implement Automated Load Management

01 Contact the local AHJ to find the applicable Building and Electrical Codes for your area.

Have a pre-submittal meeting to gather all requirements

02 Determine what version or year of NEC applies to your area (ALM is only allowed for EV installations in NEC 2014 or later)

03 Work with an engineering or consulting firm to make a charging project plan, including information such as:

Results of a charging simulation to evaluate what type of chargers and how many do you need (take into account your operational and route needs)

What is the current grid capacity of the site

Current peak load of equipment and buildings already onsite and new load expected to be added

Cost of additional grid infrastructure in both ALM and Non-ALM situations

Any other infrastructure onsite and the relevant electrical diagrams

Submit information on the ALM system of your choosing to AHJ and local utility provider

The applicable section of either the NEC (625.40-42 and 750.30) or the Canadian Electrical code (probably 86-300 and 8-106, but see if your specific case is covered by the specific type of building described such as 8-202 or 8-206 or 8-208)

UL certification of the local controller and cut sheet of controller

Summary statement of how the system works, such as the following example:

ChargePilot®'s local controller is connected to the four 450kW ABB chargers via ethernet cabling and communicates with the chargers through Open Charge Point Protocol (OCPP). Using the programmed grid capacity limit for the site, the local controller optimizes the distribution of energy to the chargers and ensures that the chargers never pull more energy than is available at the site.

Examples of previous ALM sites

Other product information on the ALM system such as the product brochure and technical documentation

04 Submit permitting applications

Plan Review

Permission Granted

05 Have electrical circuits installed by a certified professional

Any AHJ inspections that are required

06 Final AHJ Inspection

07 Energization

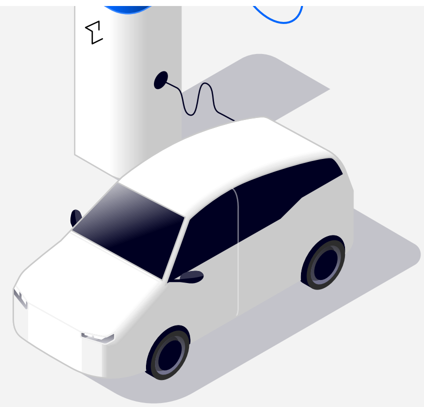
Conclusion

ALM remains one of the best technologies in your toolkit, if you are looking to rapidly electrify your fleet and do so in a cost-effective way.

It is a proven technology, described and regulated in the NEC, that can help facilitate the rapid scaling of electric fleet depot charging, setting us on course for a more sustainable and economically feasible future.

The Mobility House is a world leader in smart charging solutions.

Our technology platform ChargePilot® enables reliable and efficient charging of electric vehicle fleets and vehicle grid integration using intelligent charging and energy management. ChargePilot® has been implemented in more than 1200 charging depots across North America, Europe, and Asia with leading electric bus operators, delivery service fleets and on corporate campuses. For more information, visit mobilityhouse.com.



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