A scalable approach to **residential EV management**

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Introduction

Electric vehicles (EVs) are on the rise. Today, there are more than 5 million EVs on the road globally. By 2030, that number is estimated to be more than 20 million in the U.S. alone[1]. North America has seen upwards of 250% growth in EV sales in just the last four years[2].

Navigant predicts that by 2030 **more than 80% of charging infrastructure will be residential**. In addition, over 40% of energy demand from all EVSE deployed (workplace, public, fleet, etc) will come from home charging[3].

EVs have the potential to create both opportunities and challenges for utilities. Unlike traditional internal combustion engine (ICE) vehicles, a large percentage of EV fueling takes place at a driver's home.

While this represents a significant energy sales and decarbonizartion opportunity for utilities, it also poses formidable capacity and stability risks to the grid. EVs will exacerbate the load balancing and management challenges that utilities are facing today with the proliferation of renewables. However, as more customers install residential charging solutions that have the ability to capture charging behavior and provide load management capabilities, the risks to the grid can be mitigated over time.

[1] IEA Global EV Outlook Technology Report- May 2019, https://www.iea.org/reports/global-ev-outlook-2019

[2] InsideEVs EV Sales Scorecard https://insideevs.com/news/343998/monthly-plug-in-ev-sales-scorecard/

[3] Navigant EV Charging Equipment Market Overview Report https://www.navigantresearch.com/reports/ev-charging-equipment-market-overview

Challenges for utilities

System load. A single EV, when charging, can potentially double a home's load. As EVs proliferate across the utility network and reach commercial scale, they are expected to increase overall system load significantly. In response, utilities will need to revamp th eir energy procurement, generation, and distribution strategies to support this new paradigm. System overloading due to EV charging (particularly in the evening) could also result in a sag in feeder voltage.

Pockets of congestion. EV adoption is typically concentrated in locational clusters. This poses the risk of overloading distribution equipment, including transformers that are connected to the specific feeder or substation. Left unmanaged, this can cause significant reliability, load, and voltage issues for the grid. This is a challenge utilities grapple with today, even before EV adoption reaches critical mass.

New peaks. In addition to an increased load magnitude, utilities will also see new load shapes, with crests and troughs at unprecedented time intervals. Early data shows new evening peaks in the case of residential charging and a secondary midday peak in the case of charging at workplaces, necessitating a new approach to peak load management.

It is critical that utilities adopt solutions that can monitor and control EV charging in real-time, both to mitigate the distribution challenges posed by EVs unconstrained operation and to leverage their potential as flexible assets.

Opportunities for utilities

EV charging is inherently flexible

The rise of EVs provides many opportunities for utilities as well. Customer using smart chargers to charge their EVs can be recruited into various types of programs that help mitigate challenges that utilities face in exchange for a financial incentive. These chargers can provide critical data in real-time that can help inform the program strategy. For example, data from smart EV solutions provider, ChargePointTM confirms that EV charging behavior provides flexibility for managed charging.

Low charging activity throughout the day for residential charging

As shown in the chart below, there is a spike in the number of charging sessions beginning around 4:00 PM when customers arrive home from work, school and other daily activities. The peak charging time for residential charging occurs between 6:00 PM and 8:00 PM. After 11:00 PM, charging starts to meaningfully trend downward. The least common time of day for residential charging is from 2:00 AM - 5:00 AM, since by this time the EV is almost always fully charged. This provides a wide window for utilities to tap into for load flexibility during the day.

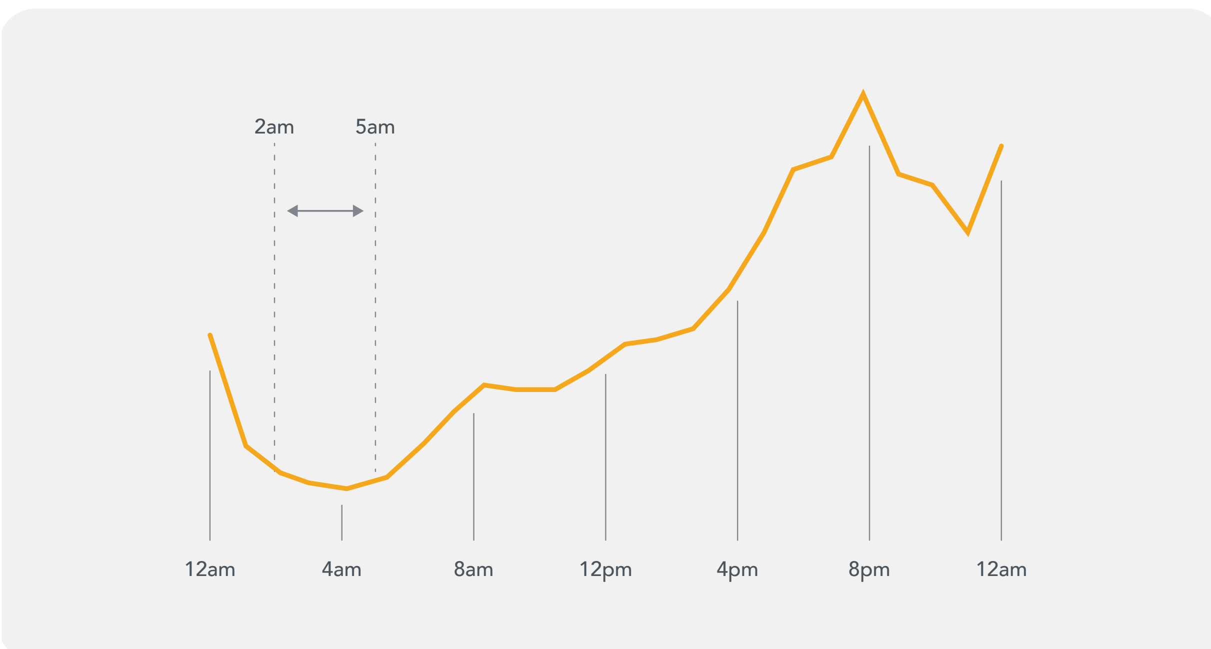

Figure 1: Residential charging activity | Source: ChargePoint and EnergyHub

On average, EV drivers get a full charge in about two hours

On most days, EVs do not require a full charge. Despite being plugged in for over 10 hours, on average, an EV battery is only actively charging for just over two hours. This concentrated charging in a short time window results in a sharp peak. This also indicates that utilities have a window of over eight hours to stagger charging.

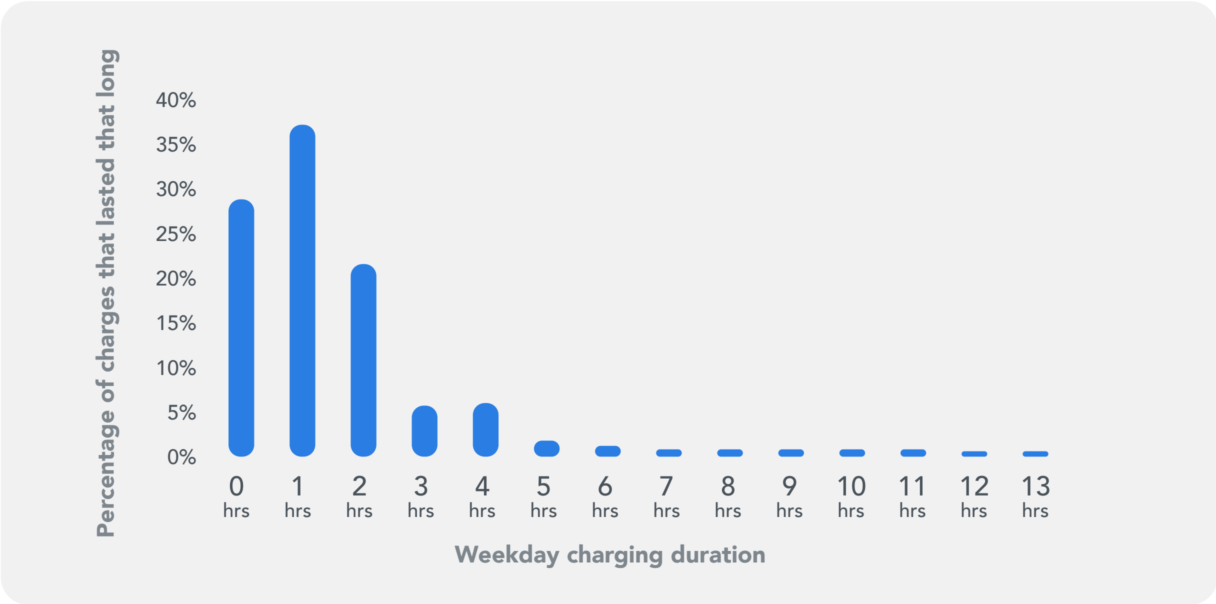

Figure 2: Weekday charging duration | Source: ChargePoint and EnergyHub

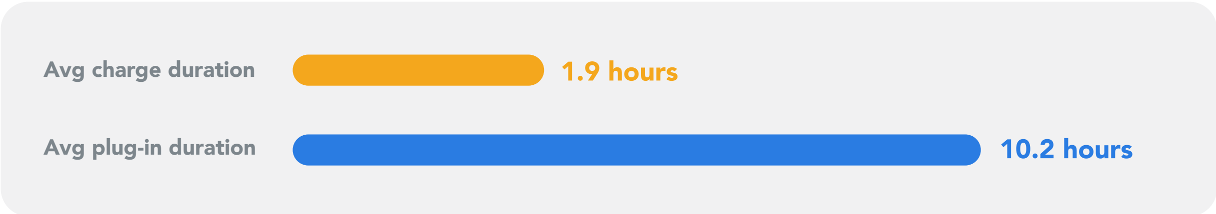

Figure 3: Weekday plug-in versus charging duration | Source: ChargePoint and EnergyHub

EVs are capable of both real and reactive power control

In addition to consuming real power, EVs are capable of both injecting and consuming reactive power and thus are uniquely positioned to respond to a majority of grid services in the future, that go beyond load control - including voltage support and power factor correction.

Utilities partner with their customers to ensure a safe and reliable grid

Electric utilities are ultimately tasked with promoting and powering EV adoption uptake and are using this trend to deepen customer relationships by serving as trusted advisors in the shift to electric mobility. They are incentivizing adoption of EVs and EV charging solutions through rebates and special rates, educating their customers, and enabling the deployment of charging stations across their network.

Simultaneously, the same utilities are implementing EV management programs to mitigate the potential risks to the grid. The next section will discuss the three primary types of EV management programs that exist today.

The three phases of EV management

Utilities across the U.S. are seeking to get ahead of the curve by laying the foundation for various configurations of customer-centric EV load management programs. These programs hold the promise of future scale, both in number of EVs and the number of constraints and use cases expected. Over 50 utilities across the U.S. have adopted special Time-of-Use (TOU) rates that incentivize off-peak charging. Pioneering utilities are going a step further and launching programs that provide utility operators with direct control of customer-owned EV charging solutions in exchange for financial incentives to participate. These initiatives not only incentivize the adoption of EVs but also lay the foundation for mitigating the risks they pose to grid infrastructure and operations, ensuring the safe and reliable operation of a robust grid that supports an EV future.

When designing these programs, multiple exploratory questions inform strategies that will most effectively engage customers.

- Where are customers charging?
- Do they own an EV charger?
- How likely are customers to buy an EV charger?
- How likely are customers to respond to price signals?
- What incentive structures and levels should utilities offer?
- Are customers willing to let utilities manage their rate of charging and or schedules in exchange for incentives?

Utilities are adopting a phased “crawl, walk, run” approach to understand EV charging behavior to inform the development of new managed charging solutions. Given the dynamic nature of the challenges and constraints that underpin the EV-utility relationship, utilities require solutions that create flexibility for the grid while enabling customer choice.

- **Crawl phase** is to enable EV-specific time-of-use (TOU) rates
- **Walk phase** is active event-based peak management
- **Run phase** is holistic managed charging, that is, optimizing charging in an automated fashion, taking into account real-time grid and market constraints

Figure 4: Phases of EV management | Source: EnerguHub

A distributed energy resource management systems (DERMS) platform is the ideal solution to empower utilities to unlock these EV-enabled network, market, and customer opportunities in concert with other DERs and grid assets.

Underlying all three phases is a robust data monitoring engine that gathers and analyzes EV charging data in real-time from all connected brands of EVs and smart EV charging solutions. This requires the system to have the ability to integrate with multiple EVs and EV charging cloud services platforms through open protocols or custom integrations. The data monitoring engine helps inform strategy and design of utility initiatives. Questions such as what time of day is best suited to engage customers to what magnitude of load management is required can be answered by analyzing charging patterns and associated customer behavior.

Situational awareness of EVs (and other DERs) informs the DERMS' AI-enabled control optimization framework. This takes into consideration device and customer-level constraints and parameters. Optimized control of EVs entails asset modeling, aggregation optimization, and ultimately autonomous control.

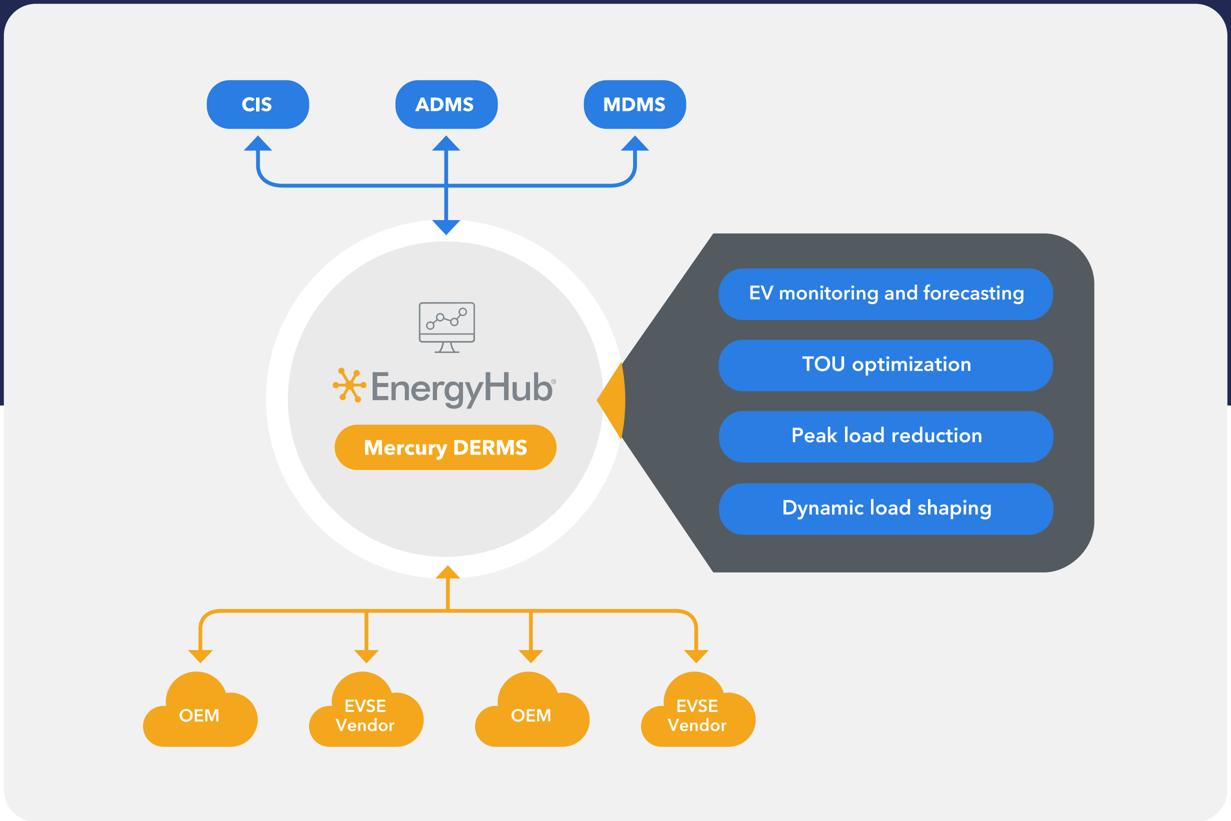

Figure 5: The Mercury DERMS for EV management | Source: EnergyHub

1. Crawl: TOU Rate Enablement

In order to prevent system coincident peaks resulting from clustered EV charging sessions, over 50 utilities in the U.S. have either implemented EV-specific rate structures, including pilots and fully implemented programs4. These rates are designed to incentivize customers via rebates to move charging away from peak times. To operationalize TOU programs, utilities are implementing DERMS platforms that can not only gather EV charging data and track related incentives, but also market the rates to customers and subsequently provide robust reporting.

TOU programs can help inform customer engagement strategies for future scenarios, including the propensity of customers to participate and how this propensity changes with varying levels and types of incentives.

Baltimore Gas & Electric implementing an EV-TOU rate
In response to the Maryland Public Utilities Commission asking utilities to prepare for the adoption of 300,000 EVs by 2025, BGE deployed EnergyHub's Mercury DERMS to lay the foundation for an EV-TOU rate. BGE is gathering and analyzing charging data to inform a TOU program that incentivizes off-peak charging by granting customers access to a preferred rate during certain portions of the day. This charging data is provided at a 15 minute granularity from customers' Level 2 charging equipment (from Chargepoint and Enel X), aggregated by EnergyHub's Mercury DERMS.

However, while TOU and critical peak pricing can be an effective first step to broadly shaping load, the coarse price signals they send are insufficient to prevent coincident charging and the distribution-level problems it creates. The next phase delves into how utilities can more directly affect the charging patterns of EVs.

[4] SEPA, Residential Electric Vehicle Time-Varying Rates That Work: Attributes That Increase Enrollment
https://sepapower.org/resource/residential-electric-vehicle-time-varying-rates-that-work-attributes-that-increase-enrollment/

2. Walk: Peak Load Management

As EV adoption scales as forecasted, TOU rates are likely to exacerbate a second evening peak. Data shows that TOU customers (or their smart charging solution) wait until the start of the off-peak period to begin charging. To manage this, utilities will need to take a more active control-based approach to peak management.

This phase entails customers providing utilities limited access to modulate the rate of charge in exchange for a financial incentive, analogous to the evolution of demand response from behavioral and rate-based usage recommendations to active thermostat control. This can take the form of a bill rebate or discount on charging equipment. Once the utility has access to EV chargers through a DERMS platform, it can schedule point in time events for peak reduction and load shifting by curtailing and intelligently staggering the charging of EV cohorts while ensuring customers get the charge they need.

Eversource's managed charging program

In 2019, Eversource launched an innovative new EV management program, leveraging EnergyHub's Mercury DERMS platform integrated with ChargePoint. By applying the bring-your-own-device (BYOD) model to Level 2 networked residential charging solutions, Eversource has access to customer charging data and the ability to control residential charging at peak times. The below chart illustrates typical behavior during a peak event. Eversource is further analyzing charging data to inform advanced load control strategies for future program years, such as managed overnight charging. In parallel, Eversource is also testing customer engagement and retention strategies through incentive design.

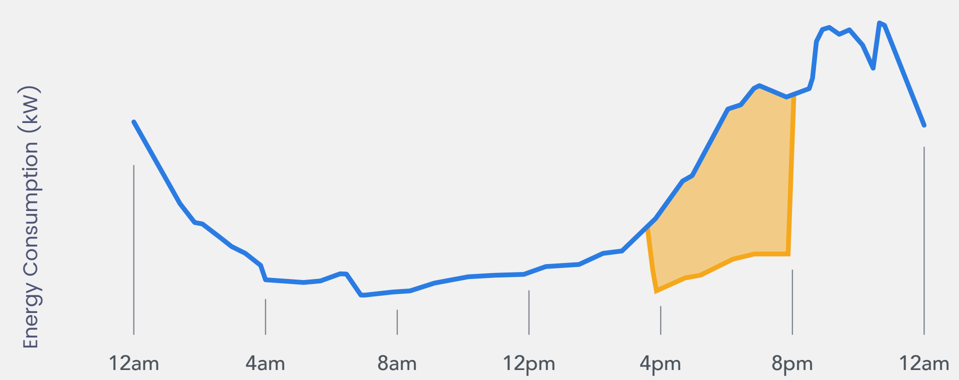

Figure 6: EV peak reduction event | Source: ChargePoint and EnergyHub

The optimization engine generates and updates forecasts, based on the latest aggregation state, and uses them to identify the optimal portfolio of individual EV-specific charging schedules. EV-specific models are used to forecast individual vehicle charging under a range of scenarios to inform control strategies.

3. Run: Dynamic Load Shaping

Autonomous managed charging is a state of EV charging management that dynamically takes into account grid and market conditions and optimizes charging patterns multiple times a day in concert with other DERs in a way that delivers stacked value for the utility. This could help meet utility needs such as congestion management, renewable firming, and voltage management.

In addition to proactively optimizing charging schedules to mitigate peaks and system overloading conditions, utilities would also be able to tap into the operational flexibility of EVs for voltage management. For instance, system overloading by the coincident charging of EVs (likely in the evening) could result in a sag in the feeder voltage. The DERMS can call upon inverter-based DERs to inject reactive power and counterbalance this condition.

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Critical to the seamless execution of this phase is the integration of the DERMS with other utility systems that manage the physical infrastructure of the grid like the ADMS or EMS. Integration would allow the DERMS to manage EVs in concert with other DERs and distribution assets to fulfill utility objectives. With this in place integration, the DERMS provides the ADMS ongoing situational awareness on EVs and other DERs, which informs the grid service request that the ADMS then makes from the DERMS, on an ongoing basis.

Conclusion and recommendations

Utilities across the U.S. are exploring various solutions to operationalize EV charging management programs. Some are deploying point-solutions that are EV-specific, while others are taking a more forward looking approach by adopting DERMS as an ideal solution to unlock EV-enabled network and customer opportunities in concert with other DERs.

As utilities explore the crawl, walk, run approaches to manage charging, they should look to a solution that can scale and advance at their pace. The Mercury DERMS is a platform built to support the dynamic and iterative nature of EV programs. It enables customer choice, manages multiple brands and classes of DERs at scale, and integrates with complementary utility systems to unlock value across the utility value chain.

EnergyHub's Mercury DERMS delivers the ability to manage EVs as part of a multi-DER grid service strategy. Mercury's optimization models are technology-agnostic, built around a resource's grid capabilities. This capability transforms the diversity of a DER portfolio directly into a strength, with widely varying resource profiles complementing each other. If utilities plan ahead and deploy a DERMS, they can benefit from the many opportunities provided by the growth of EVs and evolution of driver behavior. This will pave the way for them to achieve their strategic goals, extract operational grid value, and ultimately deepen relationships with their customers.

ChargePoint

ChargePoint has been committed to making it easy for businesses and drivers to go electric since 2007, with the largest EV charging network and most complete set of charging solutions available today. ChargePoint designs, develops and manufactures complete, integrated charging stations and software solutions for every charging scenario: from home and multifamily to workplace and fleet. To date, ChargePoint's network has grown to more than 111,700 places to charge with drivers plugging in approximately every two seconds while delivering more than 77 million charges. By providing scalable solutions that are UL-listed, ENERGY STAR® and CE (EU) certified, adding latest software features and expanding electric mobility with minimal disruption to business, ChargePoint is creating the new fueling network to move all people and goods on electricity.

For more information, visit the ChargePoint press room or contact the North America press office at media@chargepoint.com.

EnergyHub

EnergyHub is the distributed energy resources (DERs) management platform for utilities. EnergyHub's Mercury DERMS allows utilities to partner with their customers to deliver more powerful demand side management and grid services using the industry's leading ecosystem of DERs. Our Bring Your Own Device service makes millions of existing connected homes available to utilities for demand response without a single truck roll. Over 45 utilities rely on EnergyHub's platform to operationalize various configurations of programs and services. EnergyHub is an independent subsidiary of Alarm.com (NASDAQ: ALRM), the leading platform for the intelligently connected property.

For more information, visit www.energyhub.com.