WHITE PAPER / **FORECASTING UTILITY PEAK DEMAND**

Understanding the long-term impacts of electric vehicle charging

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The number of electric vehicles on U.S. roads will increase rapidly over the next 20 years, requiring utilities to accurately forecast the effects charging will have on long-term utility peak demand. New forecasting methods that measure EV coincident peak demand can be used to accommodate this rapid growth.

The number of electric vehicles (EVs) on U.S. roads is expected to increase dramatically in the next 5 to 20 years. To prepare for this growth, it's critical for utilities to understand the full effect EV charging will have on long-term peak demand.

Utility peak demand is important because utilities must own generation assets or have power purchase contracts for enough generation capacity to satisfy their annual peak demand, plus a reserve margin. Planning and building new generation resources costs millions of dollars and often takes several years. Trying to obtain generation capacity from the market in a shortage situation can be even more expensive and generally results in higher rates for utility customers.

Accordingly, utilities require accurate peak demand forecasts to effectively manage energy costs, allocate capital budgets and plan for the long term. But most current forecasting methods don't adequately account for the rapid adoption of electric vehicles. In this paper, we'll discuss two approaches to forecasting long-term utility peak demand and EV coincident peak demand that address the unique challenges of this growing market.

■ **Not since the onset of air conditioning has one single factor figured so prominently in long-term forecasts of utility peak demand.**

Growth of the EV market

Determining how EVs will impact a utility's long-term peak demand requires an understanding of EV growth and localized EV penetration. In most areas, EVs have not yet achieved a high enough level of penetration to substantially affect a utility's daily or annual peak demand. However, we are on the cusp of an EV revolution. The Edison Electric Institute (EEI) estimates the number of EVs on the road will reach 18.7 million by 2030, up from roughly 1 million at the end of 2018. It took approximately eight years to sell the first million EVs, but EEI projects the next million will be on the road in less than three years.

Soon, the anticipated growth in EVs will have a significant impact on utility peak demand. Herein lies the forecasting problem. Most long-term forecasting methods rely on historical trends continuing, but historical EV loads are not indicative of future EV loads. Therefore, they need to be accounted for separately when forecasting utility peak demand over the long term.

Specifically, econometric forecasting assumes that the historical relationship between the dependent variable (utility peak demand) and independent variables — for example, economic, demographic or other variables — will continue. In other words, it assumes future growth in long-term utility peak demand is likely to be influenced by the same factors that have influenced its growth in the past. Since historical EV loads are not indicative of future EV loads, utilities must use other forecasting methodologies when forecasting utility peak demand over the long term.

Why peak demand is important

Utility peak demand is a utility's maximum energy load during a specified time period, typically 15 minutes. It is measured in megawatts (MW) and stated daily, annually or both. Daily utility peak demand is important because a utility dispatches its cheapest generation first — after accounting for must-run resources such as renewable energy — to meet its load requirements. As a utility's load increases throughout the day, it is forced to dispatch more expensive generation resources. So, on any given day, the most expensive generation typically runs when the demand is the highest.

EV coincident peak demand is the portion of utility peak demand caused solely by EV charging. This is the sum of all the demand of EVs charging at the time of the utility peak demand. EV coincident peak demand accounts for a portion of a utility's historical utility peak demand and is implicitly forecasted to grow at the same rate as the utility peak demand forecast, absent any adjustments.

For example, if a utility's internal forecast expects long-term utility peak demand to grow at 2% per year, then EV coincident peak demand would also be expected to grow at 2% per year. The problem with this is that nearly all EV industry experts expect much larger long-term growth for EVs and EV charging than the growth that is typical for a utility's traditional peak demand.

Limits of internal forecasting

In Figure 1, the blue line shows a typical long-term utility peak demand growth projection of 2%. Implicit in that forecast is the assumption that EV coincident peak demand will also grow at 2%, as indicated by the orange bars. Considering the dramatic historical growth in EV coincident peak demand before 2019, this assumption is simply not realistic.

According to Consumer Reports, 361,307 EVs were sold in the U.S. in 2018. This represented an 81% increase over 2017. Unless it is specifically accounted for, the large anticipated growth in EV charging and EV coincident peak demand will not be factored into a utility's internal long-term utility peak demand forecast.

In Figure 2, the gray bars illustrate an example of the historical EV coincident peak demand before 2019 combined with the utility's internal 2% forecast of EV coincident peak demand after 2019. The gray bars provide a more realistic forecast of future EV coincident peak demand and, when compared side by side, show the forecasted peak demand missed by utilities in internal utility peak demand forecasts. This demonstrates the necessity of forecasting EV coincident peak demand separately from utility peak demand.

The 'full forecast' approach

To develop a forecast that accurately accounts for the impact of EV charging, utilities must develop two long-term utility peak demand forecasts:

- Utility peak demand without EVs, which is a traditional econometric long-term utility peak demand forecast that assumes we live in a world without EVs.
- EV coincident peak demand, which is a long-term forecast of the portion of peak demand caused solely by EV charging.

Once completed, these two forecasts can be added together to develop a more realistic long-term utility peak demand forecast.

Utility peak demand without EVs

First, the historical EV coincident peak demand must be estimated for each historical year EVs were present. Vehicle registrations can be researched to determine the historical number of EVs. Next, the past charging behavior of EV drivers and the amount of power required for charging must be researched and analyzed.

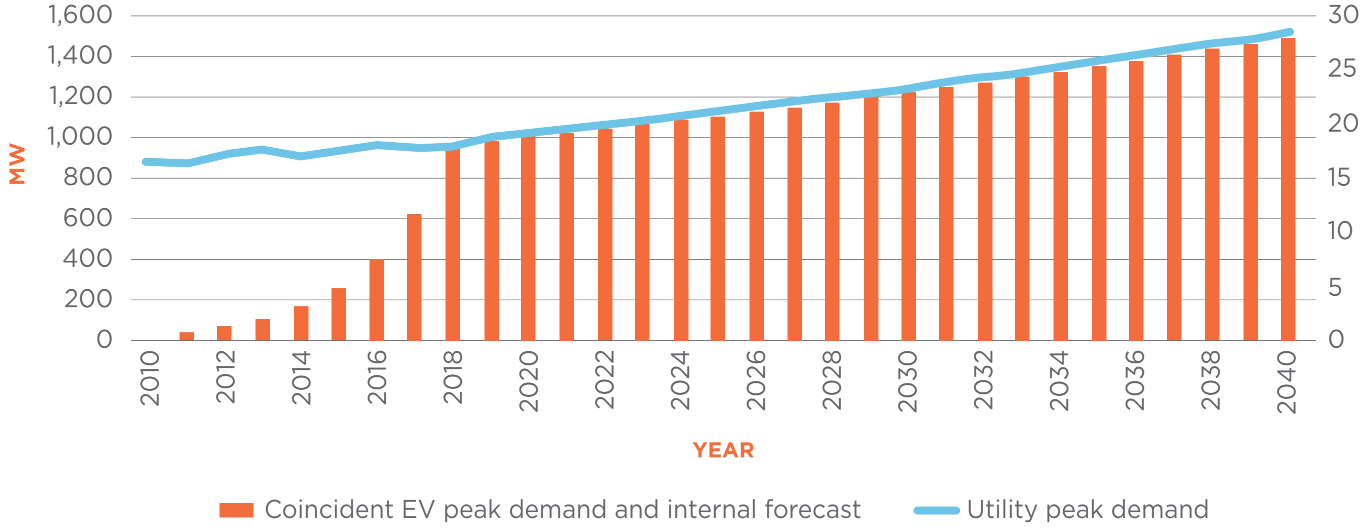

Figure 1: *Coincident EV peak demand and utility peak demand: internal forecasts.*

For example, consider a utility in the Midwest with a summer peak that occurred at 5 p.m. on a weekday in August. The service territory penetration of EVs and EV charging patterns would need to be analyzed to estimate the historical EV coincident peak demand that occurs about that time on weekdays in August. The same exercise would then be completed for each year going back to when there were practically no EVs — such as 1997, when the first mass-produced hybrid vehicle was released.

Finally, the historical EV coincident peak demand would be subtracted from the utility's historical utility peak demand each year to determine the utility peak demand without EVs. This number then becomes the foundation for the forecast of utility peak demand without EVs.

Regression analysis is one of the most widely applied statistical methods of modeling time series data for forecasting energy and peak demand. In this technique, the historical variation (the dependent variable) is explained statistically by the historical variation in one or more other variables (the independent variables). This is a way to model cause and effect. For example, when the population of a utility's service area increases, the number of its residential consumers increases.

The forecast of utility peak demand without EVs can now be made with industry-standard economic, demographic and other variables using regression analyses. It's important to use economic and demographic variables and forecasts based on the utility's service territory instead of the state as a whole because growth can vary significantly from one area to another.

EV coincident peak demand: method 1

The full forecast approach assumes that vehicle sales in the utility's service territory will grow at the same rate as the population in that territory. The historical vehicle and EV registrations obtained above for the prior year provide a starting point for determining this rate. Next, we can obtain the historical population and published population forecasts for the utility's service territory. Finally, we can apply forecasted population growth to the historical vehicle registrations to obtain the vehicle forecast for the territory, knowing that historical growth in vehicle sales should be comparable to historical vehicle sales and historical population growth.

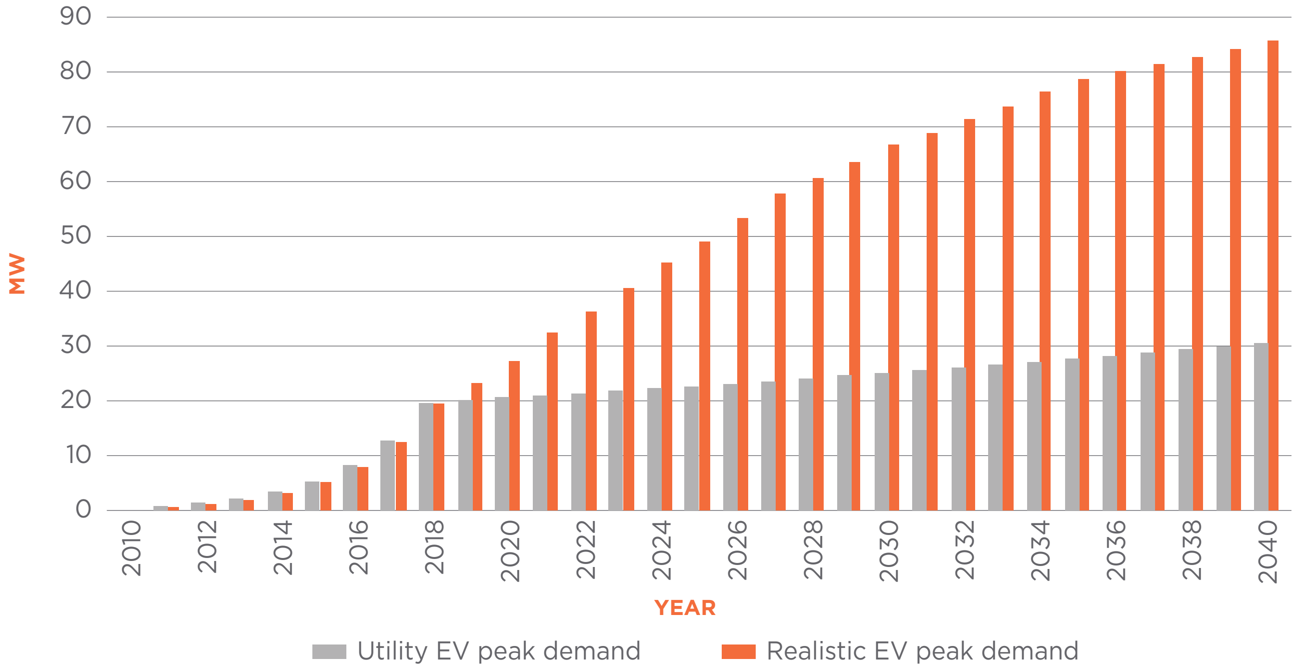

Figure 2: *Peak demand forecasts.*

Various sources provide long-term EV growth projections. For example, the EEI predicts that 20% of new vehicle sales will be electric vehicles by 2030, while the Electric Power Research Institute (EPRI) predicts that number could be as high as 38%. A fair approach is to merge historical EV growth with these longer-term EV growth projections. The next step is to apply the estimated percentage of new EV sales to the forecast of new vehicles in the utility's service territory, as developed above. In-between years would need to be interpolated. Now, we have an EV forecast for the utility's service territory.

Next, the forecasted number of EVs in the utility's service territory, estimated charging quantities and the future charging behavior of EV drivers must be analyzed together to develop the forecast of EV coincident peak demand.

EV coincident peak demand: method 2

Alternatively, the annual growth rates from the EV forecast for the utility's service territory can be applied to the last year of historical EV coincident peak demand. This provides the forecast of EV coincident peak demand, which can then be added to the utility peak demand without EVs to obtain a better utility peak demand forecast. Comparing the EV coincident peak demand forecast to the new utility peak demand forecast shows the impact of EVs on utility peak demand. This method assumes both similar charging patterns and that EVs would require the same quantity of power to charge in the future as in the past.

The 'short forecast' approach

The short forecast approach for estimating long-term EV coincident peak demand provides a simpler technique. Instead of producing a new forecast of utility peak demand without EVs from econometric variables and regression analyses, the short forecast approach relies on the utility's internal peak demand forecast.

To get started, the historical EV coincident peak demand would be determined for the prior year as described above. Then an EV coincident peak demand forecast would be developed using one of the two methods described above. Next, the utility's internal peak demand forecast annual growth rate (typically 2%) would be applied to the prior year's EV coincident peak demand to develop the utility's implicit forecast of EV coincident peak demand. Lastly, the utility's implicit forecast of EV coincident peak demand (2%) would be subtracted from the higher and more realistic forecast of EV coincident peak demand. This difference represents the effect of EV charging growth on utility peak demand — an impact that is not accounted for in the internal peak demand forecast. The difference should then be added back to the utility's internal utility peak demand forecast.

Managed charging and other considerations

Both the full forecast approach and the short forecast approach assume EV charging patterns at the time of the utility peak demand do not change over time. For example, if it is estimated that 15% of EVs are currently charging at the time of the utility peak demand, 15% of EVs will be estimated to be charging at the time of the utility peak demand going forward. However, since utilities have the incentive to minimize their utility peak demand, they will structure rates and engage customers in other ways to reduce EV charging at times when their annual peak might occur. In the Midwest this would be approximately 4 p.m. to 6 p.m. on hot summer days.

Research has shown that most light duty EV charging occurs at home. When no incentive exists, people recharge their vehicles after they arrive home from work. Since EV charging has the potential to increase the load of a home on the distribution network, it is critical to prevent the EV load from coinciding with the utility's daily peak. Time of use (TOU) rates can be created to encourage consumers to change their charging habits.

Fleet, mass transit and public station operators must mitigate the peak load of their facilities to avoid costly demand charges from the electric utility. Managing EV load in this situation can be accomplished by optimizing charge schedules, implementing load management systems and working with the electric utility to determine the optimal rate schedules for EV charging.

As with any new product or technology, the various costs associated with EVs will go down over time. EVs will be produced more efficiently, battery technology will improve, EVs will travel longer distances, larger EVs will become more common, EV communication protocols will evolve, EVs will be used as a source of power more frequently, and utilities will learn how to better manage charging behavior through rates and other measures. Recent research from the Smart Electric Power Alliance, titled "A Comprehensive Guide to Electric Vehicle Managed Charging," provides a more detailed look at the current state of managed charging.

Conclusion

In the near future, it will be essential for utilities to accurately forecast the effect EV charging will have on long-term utility peak demand. Not since the onset of air conditioning has one single factor figured so prominently in long-term forecasts of utility peak demand. Underestimating this demand would have costly implications for both utilities and their customers. Once future EV penetration and charging load are better understood, utilities can more accurately estimate and manage the EV coincident peak demand to minimize the impact to utility peak demand. With the right technology and proper management, EV load can even become a strategic asset.

Biographies

Jon Summerville is a senior consultant for financial analysis and rate design at 1898 & Co., part of Burns & McDonnell. With more than 20 years of experience in the utility industry, Jon specializes in depreciation studies, RFPs for power supply, economic studies and load forecasts. He has served as a project leader for projects analyzing complex developments, long-term forecasts, valuations, power purchase agreements, rate cases, acquisitions, depreciation studies and useful life assessments.

Travis Bouslog, PE, is a strategy and innovation manager at 1898 & Co. Travis provides clients with innovative solutions through product development, investments and strategic partnerships. His team assists clients across a number of different markets, including helping develop solutions for light-, medium- and heavy-duty EVs.

Doug Houseman is a principal consultant for power at 1898 & Co. With nearly four decades of engineering and consulting experience, Doug has overseen advanced metering infrastructure, distribution and substation automation, enterprise asset management, distributed energy resources and distribution management infrastructure projects around the world. He is a member of the Gridwise Architecture Council and chair of the IEEE PES Intelligent Grid and Emerging Technology Coordinating Committee.

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