Executive Insights

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Preparing the Grid for the Uptake of Electric Vehicles

Electric vehicles (EVs)[1] are on the cusp of wide-scale adoption. Governments around the world are introducing incentives, targets and tightening fuel regulations. Concurrently, car manufacturers are improving technology, lowering prices and producing more models to give consumers greater choice, making EVs even more attractive for early adopters. Currently, there are more than 4 million EVs globally. This number is expected to grow rapidly to 50 million by 2025 and 125 million by 2030.[2]

As the demand for EVs increases, so will the requirement for charging infrastructure. Although early adopters have tended to charge at home, as EVs become more prevalent, there will be a need for a greater volume and variety of available charging options, as shown in Figure 1, especially for those who do not have access to charging in the home or workplace. The International Energy Agency estimates that by 2030 the number of public and private charging stations required globally will exceed 130 million units, which is close to 30 times the current stock.

This level of growth provides an unprecedented opportunity for network owners, operators and energy retailers. EVs are one of the few growth drivers for many developed energy markets, and they may enable utility companies to build closer customer relationships.

Figure 1
Electric vehicle charging infrastructure

	AC Level One	AC Level Two	DC Fast Charge	DC High Power
Power required	1.9kW	2.5 to 19.2kW	50kW	350kW
Charge time	~16 hours	~2-12 hours	~20-40 minutes	~6-8 minutes
Grid connection	Residential	Residential	Public	Direct to grid

Note: Charge time based on a 40kWh battery size. DC High Power — Charge time is applicable when EVs are capable of this charging speed
Source: L.E.K. and Tritium analysis

However, EVs also come with a number of challenges, namely the increased peak demand at a localized level, increased network management complexity and power quality impacts.

This report explores why utilities need to start responding now and describes a five-step action plan for responding to this impending change.

Preparing the Grid for the Uptake of Electric Vehicles was written by **Tim McGrath,** Partner, and **Natasha Santha**, Principal, in L.E.K.'s Melbourne office. **David Finn**, CEO and Co-Founder, Tritium, **Nathan Dunlop**, Head of Market Strategy, Tritium.

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Impact on the energy grid

The growing demand for energy from EVs is likely to affect the grid in three ways: (i) increased overall consumption, (ii) increased peak demand and (iii) greater unpredictability. Of these, the most important is the impact on peak demand and how this is managed, particularly at a localized level.

1. Increased overall consumption

The expected increase in overall energy demand is relatively modest in the short to medium term. In 2017, the estimated electricity demand from all EVs was 54TWh, equating to just 0.3% of global electricity demand. With 125 million EVs anticipated to be on the road in 2030, assuming a similar level of battery energy efficiency as today, the overall EV share of energy demand increases to 6.3% in 2030. Even though by 2030 every fifth vehicle sold globally is likely to be electric, the car parc (total vehicle population) takes approximately 15 years to churn over. A country that has a 20% EV share of new car sales in any given year will only benefit from a corresponding change of 1.3% of the overall car parc. At full EV penetration the impact will be significant, but this is not expected for a considerable time.[3]

2. Increased peak demand

What is more impactful is the expected increase in peak demand, particularly at a localized level see Figure 1. Statistics of sales of EVs to date have shown there is a "clustering" effect, where some suburbs, streets and locations have a higher proportion of EV ownership.[4] This is likely to persist into the future with back-to-base charging locations for shared and/or autonomous vehicles and a greater number of road-side banks of high-powered charging infrastructure. Clusters of EVs have the potential to overload local electricity infrastructure, especially the feeder lines (i.e., the poles and wires down the street).

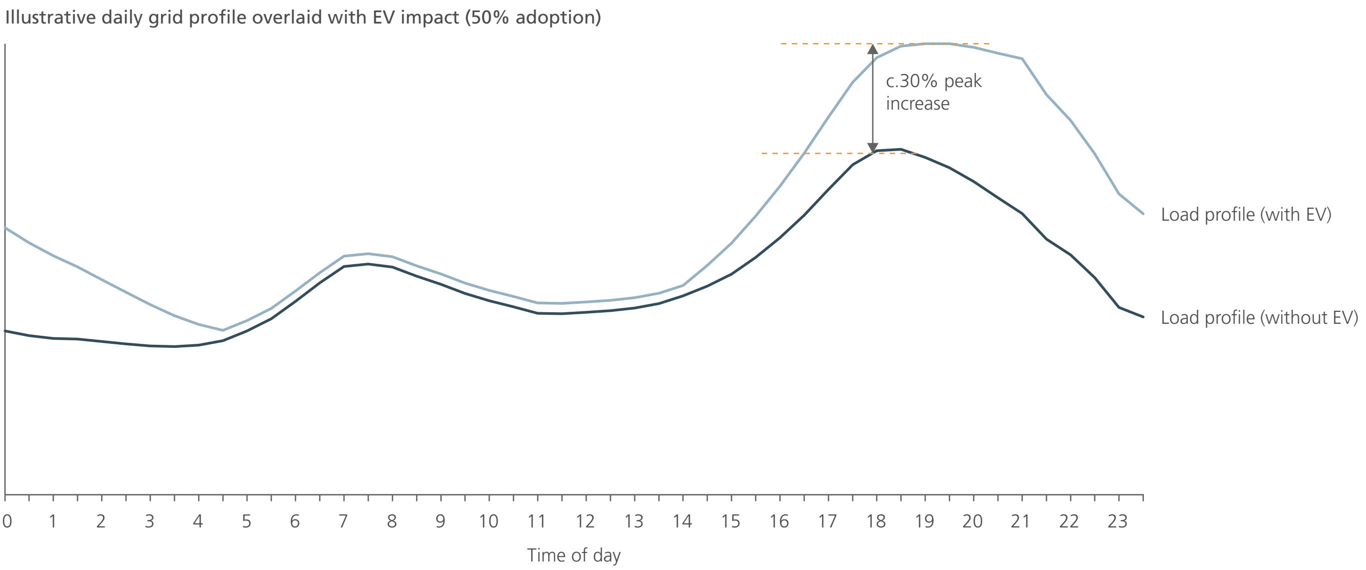
If utilities are not proactive in managing or incentivizing residential charging in lower-demand times, localized peak demand will increase. Owning an EV will increase a household's electricity consumption by about 50%.[5] If multiple houses on a single street decide to charge simultaneously, there may be insufficient capacity in the feeder lines to deliver the required level of power. The timing of this scenario eventuating will vary and could take longer in regions where the cost economics and acceptance of EVs are less than internal combustion engine vehicles.

High-power charging may be more manageable for network operators. High-power chargers, providing up to 350kw each, are typically installed as a group of chargers. While these groups of high-power chargers equate to very large (1MW+) connections, the charger owners will deploy the appropriate infrastructure adjacent to the charging equipment at the time of installation. The large, high-power chargers and their associated equipment will be connected into the medium-voltage-level grid, which has a much higher power level typically used for commercial and industrial connections that can better accommodate non-linear, large power demands.

From a systemwide perspective, the impact on peak demand is expected to be less pronounced than it is at the local level. EV owners will likely have varied charging patterns, which ultimately averages out the peakiness. For example, some owners will top up charge every day at work or at home overnight, others will fully charge at fast-charging stations, and fleet owners of shared and

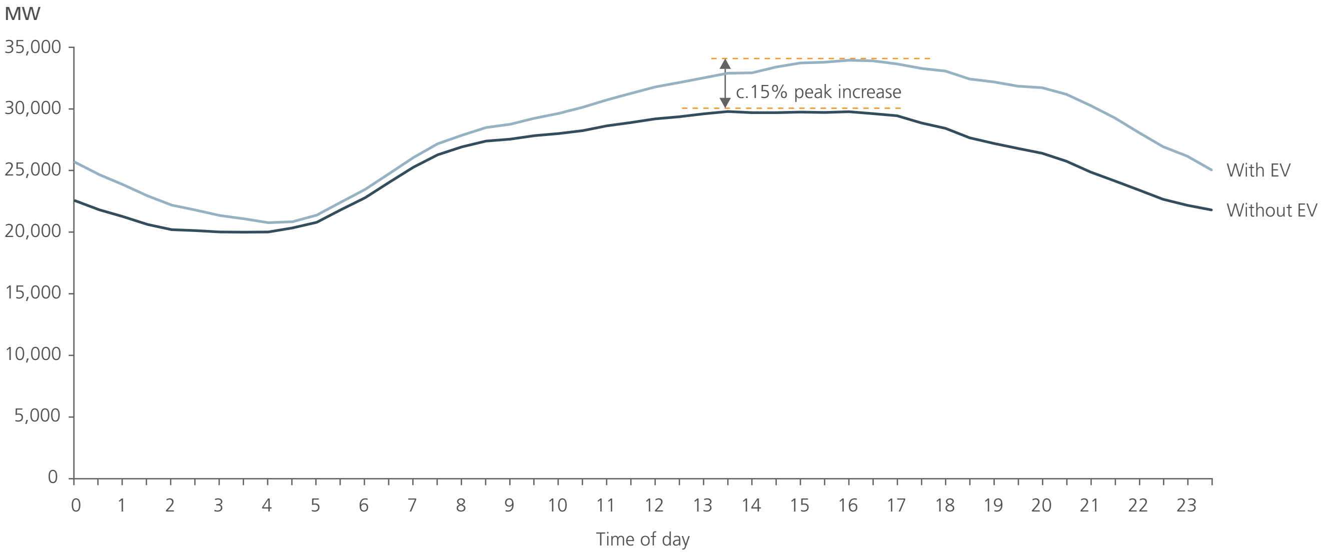
Figure 2

Local grid unmanaged EV impact (50% adoption scenario)



Source: L.E.K. and Tritium analysis

Figure 3
EV impact on the Australian electricity network (50% EV adoption)[6]



Source: L.E.K. and Tritium analysis

autonomous vehicles are likely to charge back at base using high-powered charging during the day or slow charging overnight.

Putting these various load curves together, for example in Australia, if the car parc consisted of 50% EVs, the overall increase in peak demand could be c.15%, as shown in Figure 3, if charging times are not managed. Given the expected pace of adoption, this will take time to eventuate, allowing grid owners to prepare for the impending change.

3. Greater unpredictability

Consequently, EV charging has the potential to reduce grid predictability and increase network management complexity. Network owners need to be prepared to manage local grid impacts regarding both power quality and any increased asset stress.

Charging has an element of randomness, and drivers will recharge their vehicles at different locations and for varying lengths of time whenever required. This unpredictability creates nonlinear power demand, and coupled with increasing distributed power generation (e.g., solar PVs), the local-level network has never been more challenging to manage.[7]

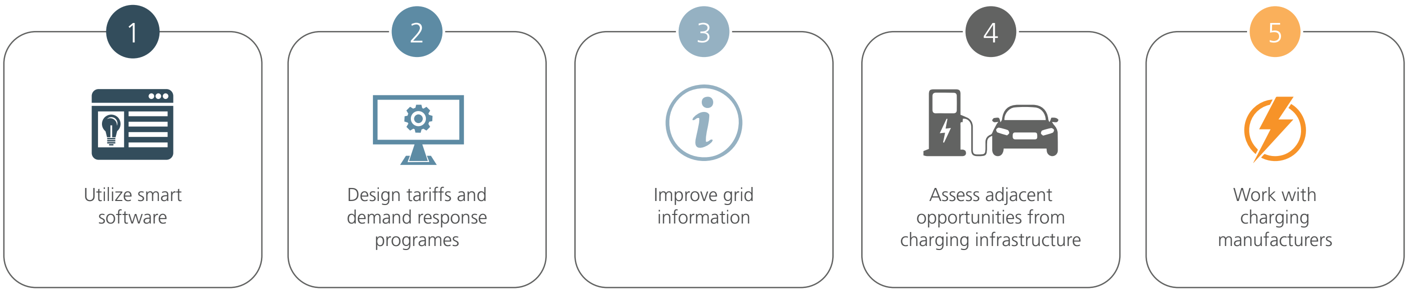
Nonlinear and unpredictable load demands of EV charging, if unmanaged, can increase the risk of stress on localized network areas, especially on aging infrastructure. This could decrease asset lifetimes and increase replacement rates of assets and consumables such as transformers, fuses and cabling.[8]

Opportunity for utility companies

There are several opportunities for utilities if they are able to proactively manage and mitigate the above grid impacts:

1. EVs represent an opportunity for increased demand, offsetting the stagnation in energy demand expected across a number of developed countries.
2. They facilitate the integration of intermittent generation sources such as renewables. EVs are essentially a flexible demand-side market participant, which can help balance instantaneous supply.
3. EVs have the potential to increase the value of the regulated asset base through new network connections and upgrades, conversely also reducing the risk of stranded assets.
4. They offer the potential for new unregulated revenue streams that come from owning and managing EV charging assets and related advanced metering products.
5. They allow grid owners that typically have low interaction with their customer base the opportunity to develop increased customer trust and closer relationships. Innovative EV-related products can also be bundled with related and existing offers (e.g., solar and batteries) to increase customer stickiness.
6. Lastly, as more EVs are capable of supporting bidirectional charging (vehicle to grid technology), this presents the opportunity for EVs to become a dynamic, flexible new energy source. Utilities could encourage EV owners to charge up from excess intermittent sources like solar and wind at times of low demand, and then use the energy stored in the vehicle to power their houses when they need it or sell it back to the grid.

Figure 4
Five-step action plan for utility companies



Five-step action plan for utility companies

Utilities need to be proactive in planning for a future scenario of significant EV adoption, especially in a world where spending capex on additional infrastructure at the cost of the consumer is no longer a palatable response. If utilities are not prepared and this transition is not managed effectively, they could become a barrier to scale EV adoption. Figure 4 summarizes what can be done in response:

1. **Utilize smart software:** Power quality impacts at the residential feeder level could be alleviated using smart software. Managed charging uses software to schedule home charging throughout the night, avoiding the risk of many EV owners all plugging in during the evening peak. Some utilities are learning from air conditioning incentive programmes and are beginning to subsidise home charging equipment if the customer is happy to give the network operator some control over when the charger is used.
2. **Design tariffs and demand response programes:** Utilities need to begin preparing incentive structures to manage residential chargers, such as time-of-use EV tariffs that can shift customer charging behavior to alleviate local feeder stress. For example, advanced use of tariffs and developments in car technology from New York utility Con Edison enables EV drivers to charge anywhere in the Con Edison service territory, be identified and earn rewards for charging outside of peak hours.
3. **Improve grid information:** Provide clear and detailed information publicly to businesses and entrepreneurs looking to invest in and install public charging infrastructure. For example, PG&E, a Californian utility, has created an interactive mapping tool for network capacity highlighting the locations on their network where existing equipment has capacity and is ready to be utilized for EV charging.[9] Utilities that can provide useful location information can reduce network investment and quicken approval cycles, ensuring that infrastructure owners can deploy rapidly and keep up with market demand.
4. **Assess adjacent opportunities from charging infrastructure:** Utilities should begin to explore whether there are other opportunities that arise from the deployment of charging infrastructure, such as stationary storage. The deployment of battery storage at charging locations may have the potential to reduce grid augmentation costs and enable charger deployment in areas of the network that would otherwise be prohibitive.
5. **Work with charging manufacturers:** Utilities are key to the transition to e-mobility, and they must quickly understand their role and how to work alongside new industry stakeholders. Collaboration and joint research will enable utilities to be at the forefront of emerging vehicle, charging and grid integration technologies. For example, the U.S. Department of Energy is facilitating such collaboration, recently announcing over US $8 million in funding designed to bring together research institutions, utilities, automakers and charger manufacturers to work on the future of electric vehicle extreme fast charging.[10] We expect to see more of these collaborations as the market develops.

The transition to EVs presents challenges but also significant opportunities for utilities organizations, but only if they define and execute their participation strategies ahead of the upcoming EV revolution.

Endnotes

[1] Electric vehicles include battery electricity vehicles and plug-in hybrid electric vehicles, including passenger light-duty vehicles, light commercial vehicles, buses, trucks, and two- and three-wheelers.

[2] IEA Global EV Outlook 2018.

[3] Infrastructure Victoria — L.E.K. Consulting Advice on Automated and Zero Emissions Vehicles Infrastructure, October 2018.

[4] http://www.nature.com/articles/s41560-017-0074-z

[5] Assumes average household using 5,700kWh of electricity per year, and the average EV consumer using c.3,000kWh electricity per year driving c.15,000km per year.

[6] AEMO – Australian NEM load 31 January 2018.

[7] Burnham, A., Dufek, E. J., Stephens, T., Francfort, J., Michelbacher, C., Carlson, R. B., Tanim, T. R. (2017). Enabling fast charging — Infrastructure and economic considerations [Abstract]. Journal of Power Sources, 367, 237-249.

[8] Shareef, H., Islam, M. M., Mohamed, A. (2016). A review of the stage-of-the-art charging technologies, placement methodologies, and impacts of electric vehicles. Renewable and Sustainable Energy Reviews, 64, 403-420.

[9] PG&E site information for electric vehicle direct current fast chargers: (https://www.pge.com/en_US/about-pge/environment/what-we-are-doing/electric-program investment-charge/direct-current-electric-vehicle-fast-chargers.page)

[10] https://www.energy.gov/articles/department-energy-announces-80-million-investment-advanced-vehicle-technologies-research

About the Authors

Tim McGrath

Tim McGrath is a Partner and leads L.E.K. Consulting's Melbourne office. He also leads the Energy and Environment practice and Organization and Performance practice in Australia. Tim has over eight years of experience working with clients in the energy and utilities sectors in Australia and has led seminal strategy and performance improvement projects across all parts of the value chain.

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Natasha Santha is a Principal in L.E.K.'s Melbourne office. Natasha is part of L.E.K.'s New Mobility and Transport & Travel practices. Natasha regularly advises governments and corporations on strategic, policy and commercial issues relating to transport, aviation and infrastructure. She has also worked extensively across the energy value chain, including in renewable technologies and alternative fuels.

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David Finn is the CEO and Co-founder of Tritium, a Brisbane-based technology company specializing in the design and manufacture of DC fast-charging solutions for electric vehicles. As CEO, David aligns the company's products and technology development with emerging market needs. He has led the company to grow from 10 employees to over 250 in the four years from 2014 to 2018.

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Nathan Dunlop is the Head of Market Strategy at Tritium. Nathan focuses on crafting strategic responses to emerging opportunities within the electric vehicles industry. Prior to Tritium, Nathan was a strategy consultant focused on strategic growth opportunities within the utilities sector.

About L.E.K. Consulting

L.E.K. Consulting is a global management consulting firm that uses deep industry expertise and rigorous analysis to help business leaders achieve practical results with real impact. We are uncompromizing in our approach to helping clients consistently make better decisions, deliver improved business performance and create greater shareholder returns. The firm advises and supports global companies that are leaders in their industries — including the largest private and public sector organizations, private equity firms, and emerging entrepreneurial businesses. Founded more than 30 years ago, L.E.K. employs more than 1,400 professionals across the Americas, Asia-Pacific and Europe.

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About Tritium

Tritium is a fast-moving technology company specializing in the design and manufacture of DC fast-charging solutions for electric vehicles. Established in Australia in 2001 to provide power-electronic systems and battery energy-storage applications, it launched its first DC fast charger (Veefil-RT) in 2014. In just four years, Tritium has developed into a leading global DC fast-charging supplier, with installations in 26 countries. Tritium's headquarters and main manufacturing plant are in Brisbane, Australia, and the company has further sales, R&D and manufacturing facilities in both California, USA, and Amsterdam, The Netherlands.

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