Electric Vehicles

Is the energy sector ready?

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With electric vehicles (EVs) moving rapidly towards common use, seamless integration will require the right energy resources to be available in the right places to match demand. Here we explore what actions need to be taken to ensure there are no barriers to customers' uptake of EVs so that the cost impact is managed and the benefits from EVs to the energy market are fully captured.

Electric Vehicles (EVs) could replace traditional vehicles, despite the portion of EVs being less than 0.1% of new car sales in Australia, according to a new field of evidence. **Bloomsburg New Energy Finance** predicts that the purchase price of EVs will be cost competitive with traditional vehicles by 2024. A number of international car manufacturers have announced they will cease production of internal combustion cars. And the Clean Energy Finance Corporation suggests that in Australia EVs will account for 100% of all new vehicles sold by 2040, and 95% of all vehicles by 2050.

Widespread adoption of electric vehicles will have a significant impact on the economy and on society as a whole, and will create new challenges and opportunities for the future, not least for the energy markets. This paper sets out our initial thinking on the challenges and opportunities of EVs for the National Energy Market. It draws on KPMG analysis for Infrastructure Victoria on the energy market impacts of 100% penetration of EVs fast forward by 30 years under different scenarios relating to vehicle ownership and technology adaption. KPMG's full report for Infrastructure Victoria is available here.

The energy markets in Australia are in a state of transition, and a multitude of factors will impact energy markets going forward, including the pace of technological change, changing customer behaviour, the ageing of existing infrastructure and government policy on emissions. A clear regulatory and policy framework needs to be put in place to ensure that EVs are efficiently integrated into the evolving energy markets. Without this, it could cause significant additional disruption through the potential impacts on the electricity system from charging and potentially discharging. Effective integration means that there are no barriers to customers' uptake of EVs, the cost impact is managed and the benefits from EVs to the energy market are fully captured.

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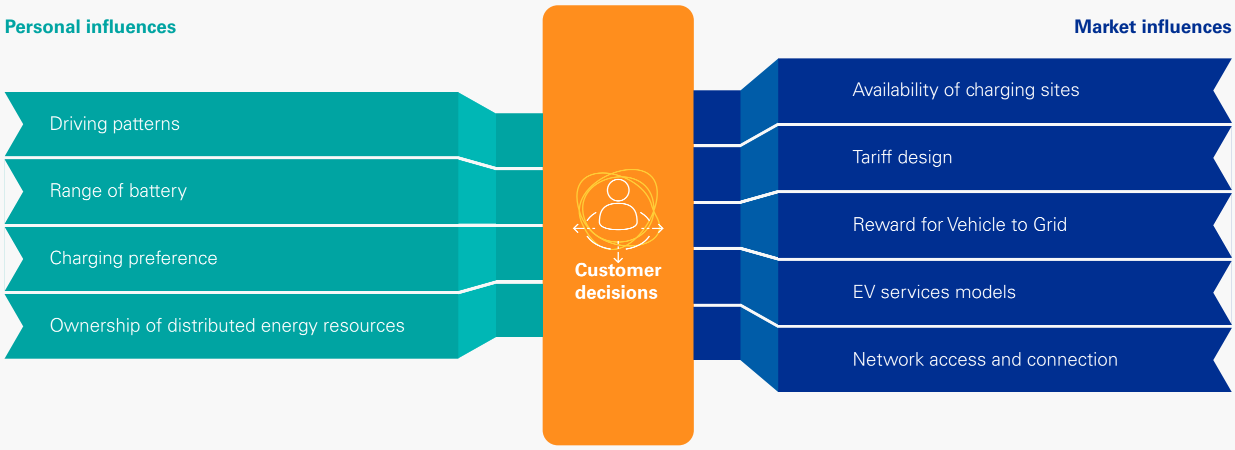
Factors that will influence EV charging behaviour

The impact of EVs on the energy markets is a function not only of the total amount of electricity required to keep EVs on the road, but also of when, where and how that electricity is required.

For example, if EV charging is concentrated in the early evening, when overall demand for electricity is already very high and renewable energy is not readily available, then this will have very different impacts on the energy markets than if EV charging occurs in the middle of the night when electricity demand from other sources is lower, and/or during the day when the sun is shining. Similarly, if charging occurs in areas of the network that are already constrained, this will have different impacts than if it occurs in areas with spare capacity.

Many factors will influence the 'when', 'where' and 'how' of EV charging. Some factors are personal, like how you use your car. For example, do you drive back and forth to work or school during typical commuter hours, or only use your car for the occasional trip to the shops? Some factors are market driven, like the availability and type (e.g. fast versus slow) of charging infrastructure along main roads or at parking lots, work places and shopping centres. The range and interaction of these factors can make it difficult to forecast with any certainty how much electricity will be required when, at what locations and from what type of infrastructure. EV drivers will want to charge in the most convenient way possible, meaning at home when available, and using easy access public stations if necessary.

Figure 1: Factors influencing customer charging behaviour



The load and peak demand impact of Electric Vehicles

The cost of EVs to the energy markets is a function of both the contribution of EVs to peak demand, and the total electricity consumption of EVs. Peak demand is the highest amount of demand for electricity across all customers over a defined period of time. Consumption is the total amount of electricity consumed over a defined period of time. To some extent, consumption from EVs outside of peak hours may be able to be met by ramping up generation at existing power plants, or by targeting consumption to hours of the day when there is ample energy being generated, especially from renewable sources.

Peak demand requires 'dispatchable' generation or storage capacity. That is, capacity that can 'turn on' when it is required. Peak demand currently occurs in the early evening, when standalone renewable energy is not generally readily available. The more that EV charging is concentrated into this peak, the more new dispatchable capacity will be required. Based on trials of EVs overseas, unmanaged (or non incentivised) charging will naturally concentrate around the evening, when many EV owners return home for the day and plug in their car.

The charts below show the hourly demand profile for Victoria in a scenario where every vehicle is an EV which is privately owned. The chart on the left shows the cumulative charging profile where the EV drivers are exposed to a price incentive to discourage charging at peak times. The chart on the right shows the profile in the absence of any incentive on charging. This shows that non incentivised charging can significantly increase the peak demand relative to managed (or incentivised) charging under a scenario of where all vehicles are electric and remain privately owned.

KPMG analysis on Victoria shows that 100% uptake of EVs by 2046 will increase total electricity consumption by about 50%. Existing generation capacity will not be able to absorb this extra consumption, and new generation capacity will be required, especially if the dispatchable capacity installed to meet peak demand is in the form of storage (or peaking gas plants which operate only a limited amount of time) and not base load generation.

The investment challenge will be substantial. We estimate that additional generation capacity to meet demand for electric vehicles in an incentivised charging scenario, could be 12,669 MW, or 120% of the existing installed capacity of the Victorian system. This increases to 15,513 MW in a non-incentivised scenario.

Consumption

100% uptake of EVs in 2046 will increase total electricity consumption by **~50%***

*As shown in KPMG analysis on Victoria.

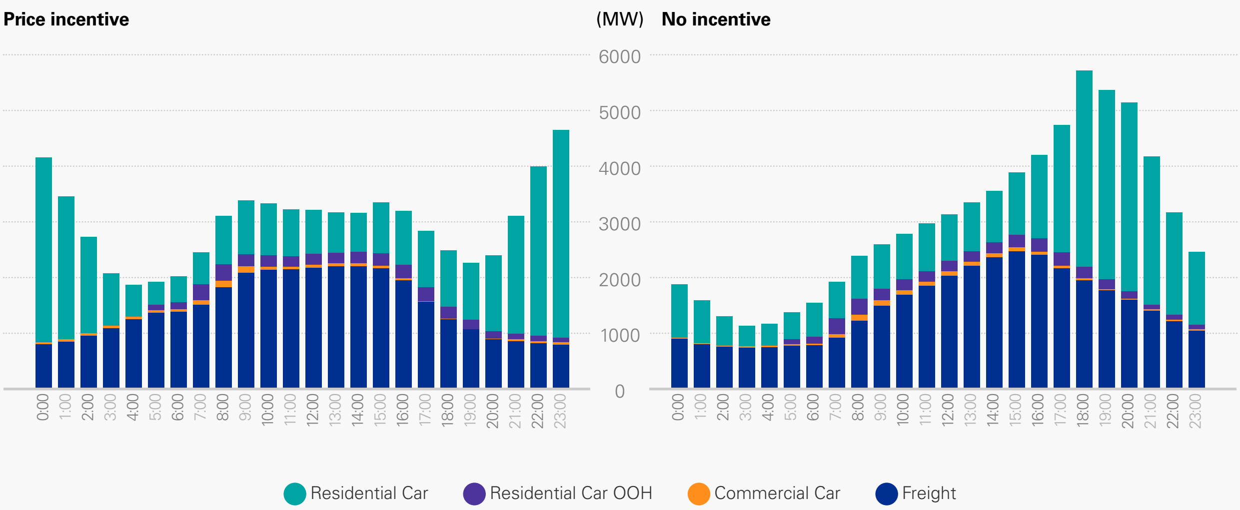
Capacity

Additional generation capacity to meet demand for electric vehicles is estimated at **12,669MW,** or **120%***

* Of the existing installed capacity of the Victorian system in an incentivised charging scenario.

If significant EV uptake is unmanaged and occurs in the relative near term, before dispatchable storage technologies like large scale batteries and pumped hydro become fully commercialised, then this could place increased pressure on proven technologies like gas fired generation to meet the increase in peak demand. This highlights the importance of ensuring that there are appropriate mechanisms in place and policy certainty to maintain reliability and promote efficient investment signals.

Figure 2: Hourly energy demand profile for Victoria

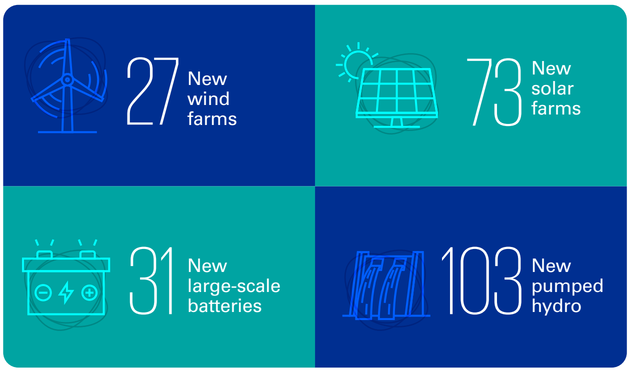


The cost of EVs to the energy markets

KPMG analysis suggests that a scenario of every driver having an electric vehicle would require up to $6.3 billion extra investment in generation and storage capacity for Victoria. Expanding this out to the National Electricity Market (NEM), this suggests that EVs could cost up to $22.5 billion for the NEM as a whole.[1] Our analysis found that over 20% could be saved by altering the charging behaviour through pricing incentives—this equates to $5 billion at the NEM level.

If generation and dispatchable capacity to serve EV comes solely from renewable sources, this would require a substantial number of generation installations. For Victoria, in the absence of incentivised charging, we estimate that 234 new installations would be needed over the next 30 years.[2] At the NEM level, this could equate up to 800 plus new installations across the east coast.

Required generation installations in Victoria

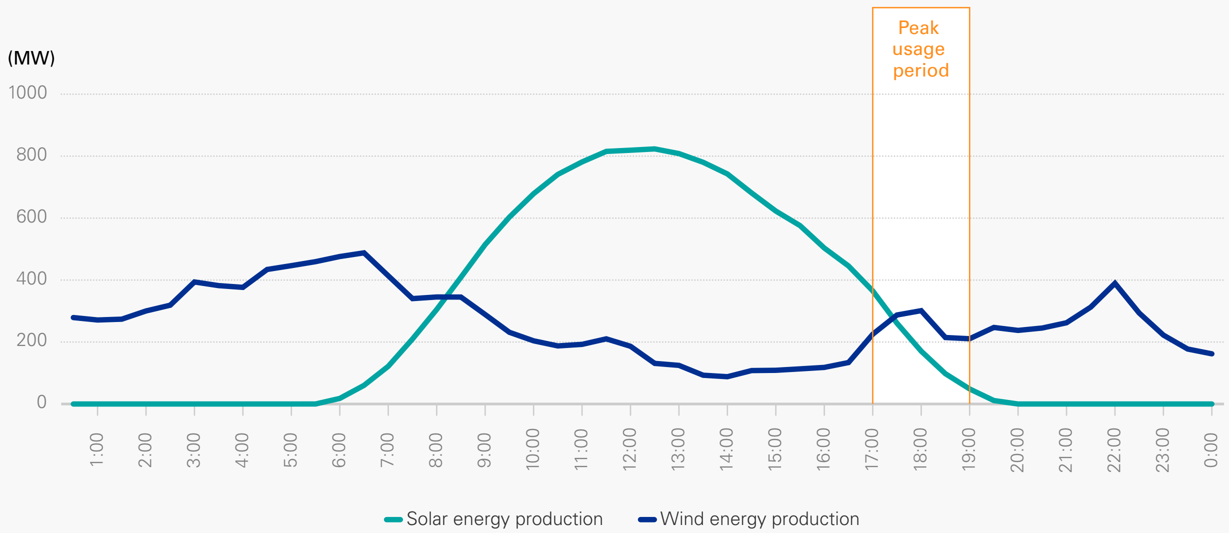


It is relevant to note that managing charging into periods with abundant renewable energy could reduce the required investments, for example by encouraging charging when the sun is shining. As noted, renewable energy by itself cannot be relied upon to be available during the current early evening peak. The figure below shows that the bulk of renewable production occurred at times when system demand was low. The uptake of EVs can aid in addressing this mismatch through encouraging the charging of EVs during periods of high renewable generation.

We also found that the demand from EV charging could lead to a 25% increase in the value of electricity networks to account for the investment to provide the extra capacity needed. However, average network prices could fall due to better asset utilisation if charging is incentivised.

The impacts on electricity networks will be more than the costs associated with augmenting the network to serve additional peak demand. Distribution networks could incur costs associated with managing the network security impacts and/or supporting electricity exports from EV batteries onto the grid, or with communication and associated trading technology to help support the capture of potential market benefits from EVs. Further, as distribution capabilities and assets vary geographically, there will be localised impacts of EV charging, where the size, timing and particular location of isolated loads can have significant effects on network reliability as a whole. That is, the impact on the distribution networks are likely to vary significantly at the local 'street level'. Another concern is that, unlike other items that impact distribution assets the EV can move around the grid.

Figure 3: Victorian wind and solar production on a typical summer day



The potential benefits of EVs for the energy markets

EVs have the potential to offset some of the costs to the energy markets, either by shifting demand (charging your vehicle earlier or later in the day) or as a source of supply and ancillary services from the batteries within EVs (so called vehicle to grid or V2G). Utilising the flexibility of EVs could help avoid new investments, and also help manage the integration of increasing levels of renewables into the grid. In order for the benefits of EVs to be realised, it needs to be technically possible for EVs to participate in this way with appropriate economic incentives in place.

Realising the full benefits of vehicle electrification will necessitate a systems level approach that treats vehicles, buildings, and the grid as an integrated system. V2G only makes sense if the vehicle and power market are matched and co ordinated. New businesses, such as aggregators, which to date have played a limited role in the NEM, could help solve co ordination problems and remove complexity in decisions away from the individual vehicle owner.

Impacts under shared fleet ownerships

The costs and benefits of EVs will differ to some extent depending on the EV ownership model. This is because privately owned EVs will have a different charging behaviour than 'on demand' EVs with a shared fleet ownership model (i.e., where customers can rent a vehicle or call an automated "robo-taxi"). The overall amount of electricity required is likely to be higher under a shared automated fleet due to the extra kms driven of the fleet returning to their home depot.

KPMG analysis shows that fewer dispatchable generation and network investments will be required under a shared fleet ownership model, as less charging will occur in the peak hours. The benefits could also potentially be relatively easier to capture for a fleet owner than a private owner. However, the impact on networks could be more material in a fleet ownership scenario, unless there are signals in place from the network to encourage efficient decision making on location of depots and the use of fast chargers.

Regulatory challenges

EVs present a number of regulatory challenges, not least because of the range and interaction of factors that influence charging, which will make it difficult to forecast how much electricity will be required when and at what locations. This uncertainty will make it difficult for network businesses to reliably predict the extent of the impacts on the grid of EVs, especially in the initial period of uptake. This creates a challenge, because the current regulatory framework is based on the principle that the regulator will only allow forecast network expenditure when there is sufficient robust evidence that justifies customers paying for that expenditure.

Another challenge is ensuring that enough transmission capacity is available to transport energy to customers and businesses. This is especially relevant if a significant uptake of EVs is to be powered by renewable energy, as wind and solar farms are often located in different locations from conventional power plants. We understand that in Victoria the current state of the grid together with a high renewable energy target of 40% by 2025 is already creating some challenges, with wind and solar farms facing a risk of having their generation capacity curtailed.

There is insufficient retail price signals to influence charging and careful consideration also needs to be given to tariff design, including:

- whether separate tariffs specific for only the electric vehicle load should be offered. Such tariff arrangements may not be permitted under the current regulatory arrangements and will depended heavily on the metering arrangements
- whether distribution and transmission costs arising from EVs should be levied on EV owners only, or on the general consumption base.

The penetration of electric vehicles will introduce new businesses into the energy sectors. Managing the impacts of electric vehicles will require facilitating co ordination and co optimisation of decisions across a range of diverse businesses. Tariffs alone may be insufficient to encourage such co ordination and regulatory action and solutions will be required. In our view the regulatory arrangements are not ready to deal with the uptake of electric vehicles.

Going forward

EVs will have significant impacts on, and create new challenges for, the energy markets.

Government is likely to have a key role to play in managing the energy market impacts and facilitating the provision of charging infrastructure. This may take the form of subsidising charging infrastructure, providing infrastructure in areas the private sector neglects, supporting interoperability and potentially in standards development.

Whilst the rate of EV uptake is uncertain, it is unlikely to be slow and linear. Rather, it is likely to follow an s curve of consumer adoption, where at some point buying a traditional car no longer makes sense. At this point, EV adoption is anticipated to rapidly increase until the market is close to saturated.

Having a clear regulatory and policy framework in place for EVs before this happens will be key to ensuring that EVs are efficiently integrated into the evolving energy markets. The challenges identified need to be resolved in a predictable and robust manner to facilitate the investment and business models to get the appropriate infrastructure responses.

References

1 In May 2017, the AER reported that Victoria had 2.8 million electricity customers out of a total of 9.8 million in the NEM, or 28%.

2 Assumed average size of wind farm and solar PV farm is 140 MW and 75 MW based on existing and committed wind and solar farms in Victoria, as reported by AEMO (March 2018).

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