

Senate Select Committee on Electric Vehicles
Questions on Notice
Melbourne public hearing (Friday 31 August 2018)

Questions from Hansard –AEMO

Question No.	Asked by	Question
1.	Senator Patrick (pp. 71–72)	<p>Senator PATRICK: which means that about a year or two years ago, AEMO should have been working on these technical standards. I can't see in your submission any analysis on what you believe will happen in respect of loads across the system, perhaps with vehicles generating energy into the load, or what happens at six o'clock at night when people come home and turn on their air conditioners at the peak and then also charge their vehicles. Surely this has to be planned out properly so that we can manage those peaks and troughs that many witnesses have said are coming. There's nothing in your submission about this. It's like you're walking in the dark.</p> <p>Ms Mouchaileh: There are a couple of things I will note, which are around some of the work that we do around the forecasting and the more recent publication around the integrated system plan. I will touch on some of the activities which we're most happy to provide some further detail to the committee on. We did recently publish the <i>Electricity statement of opportunities</i>, where we did quite a bit of analysis around distributed energy resources and the uptake of electric vehicles.</p> <p>Senator PATRICK: When you say distributed energy resources, are you talking about cars that feed back into the grid?</p> <p>Ms Mouchaileh: Correct, or take from the grid.</p> <p>Senator PATRICK: As a consumer?</p> <p>Ms Mouchaileh: Correct. When I talk about distributed energy resources, I'm talking about resources that sit within the distribution system that either take energy from the system or provide it as a response in regard to an incentive that's provided to—</p>

Senator PATRICK: Isn't that anything that's connected to the grid?

Ms Mouchaileh: Yes, but when we're talking about distributed energy resources we're really talking about those resources you've got large scale that are connected to the transmission power system that we optimise, but you've also got resources that are connected to the distribution system. The market frameworks are needing to be adjusted to cater for their integration into the optimisation of the system and into the market. In terms of our forecasts and some of the planning we've done, recently we published two publications: the *Electricity statement of opportunities*, which does put some projections out based on—

Senator PATRICK: About electric vehicles?

Ms Mouchaileh: electric vehicles. We did some work with the CSIRO with respect to that analysis. It's got low, medium and high projections. The medium projections are that we're expecting about 650,000 electric vehicles in ten years, but that all depends on policies, cost and a number of other factors. There was analysis done in the ESOO. We also have an integrated system plan, which looks at the whole-of-system planning around transmission, and factors in where some of those resources are, both transmission connected and distribution connected. Going forward, we're looking to integrate distributed energy resources more into that plan. At the moment, we don't have a lot of visibility around where these resources are.

Senator PATRICK: Is there any chance that you can put some of that evidence before this committee? One of our functions is to go back and make recommendations to government. You are one of the key contributors to the operation of the market. Once again, there's almost no detail in here—

Ms Mouchaileh: I'm happy to provide that detail.

Senator PATRICK: about what you think the problems are. The devil's in the detail, and this is so high level and wishy-washy to almost be not very useful at all.

Ms Mouchaileh: I understand. I'm happy to provide you more detail around some of the analysis and also some of the activities to solve the problems we've identified around not only visibility but trying to provide the right incentives and optimise both the transmission and the distribution system so that some of the work that we're doing with Energy

Networks Association—

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can do that.' So, I'd be most grateful if you could perhaps come back and provide more information to the committee on that.

Ms Mouchaileh: I'd be happy to. And the one thing I would like to clarify is that we are getting on the front foot to try to solve some of the—distribute energy resources, and not just solar and batteries but also electric vehicles. That's why we have started a broader program. But I will give you the details of that program together with the information that you've requested.

2.	Senator Patrick (p. 72)	<p>Senator PATRICK: Finally, Norway's a country that's had significant uptake, so that might be a good place to go and look and see how that's affected their grid. Have you done that? Do you intend doing that?</p> <p>Ms Mouchaileh: Yes.</p> <p>Senator PATRICK: You have done it?</p> <p>Ms Mouchaileh: We meet with our counterparts overseas quite regularly. We recently went to Europe and met with quite a number of our European counterparts in the UK, Scandinavia and other parts of Europe to share experiences around what issues they're dealing with on the grid and how they're looking to integrate these resources into the way they operate the system. Through various partnerships we're in constant communication around challenges but also opportunities and actions to be taken in both an operational and a market incentive sense. So, yes.</p> <p>Senator PATRICK: Are they telling you there are variations in load across the network that are noticeable?</p> <p>Ms Mouchaileh: Yes.</p> <p>Senator PATRICK: So, can you perhaps also provide to the committee the information you've gathered on those overseas trips and then how you've taken that information to form policy, direction and advice?</p> <p>Ms Mouchaileh: Absolutely. I will do that. One example of that is that we sat down quite a lot with our UK counterparts to look at some of the work they're doing and the challenges, particularly around electric vehicles—probably solar is not so much of an issue there, but electric vehicles. They kickstarted a broad program with industry to look at integrating the resources into the system. We took those learnings and partnered with the Energy Networks Association and kickstarted a process in June to look at very similar issues, taking on some of the learnings and the methodologies that they've applied. That is one example where we've not only spoken to our counterparts but also taken the learnings and tried to integrate them into the work that we're doing, not alone but in partnership with others who are impacted by those same issues.</p> <p>Senator PATRICK: The committee has heard evidence from a number of government departments that didn't seem to know who was in charge. I was hoping that from AEMO we'd have some much more solid data. So, once again, I'd be very grateful if you could put something much more</p>
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		<p>substantial together that would inform the committee.</p> <p>Ms Mouchaileh: Sure. I'd be happy to.</p> <p>Senator PATRICK: Thank you.</p>
3.	Senator Patrick (p. 73)	<p>Senator PATRICK: You're saying that your job is to operate the market reliably. In 2016-17 there were 11 instances of the system being operated outside of secured limits for greater than 30 minutes. That's atrocious. That's like having the entire electricity system operating on luck, and it is well in breach of the rules. The statement that Senator Carr's making is quite relevant: you're not even coping now. Did the numbers get better for 2017-18?</p> <p>Ms Mouchaileh: In the recent electricity statement of opportunities that we released we highlighted a risk of supply shortfalls.</p> <p>Senator PATRICK: This is talking about ex post facto, where you have been operating the grid in an unsecure state for more than 30 minutes, in breach of the rules. In 2016-17 it was 11 times. Do you know what it was in 2017-18.</p> <p>Ms Mouchaileh: I will have to take that on notice. I don't have those numbers in front of me.</p> <p>Senator PATRICK: But that's not good, is it? And I presume the AER is prosecuting you in respect of breaches of the rules.</p> <p>Ms Mouchaileh: That is a question that you would have to put in front of the AER. I will need to come back to you with details on those events.</p>
4.	Senator Carr (p. 74)	<p>Senator KIM CARR: Then there's the other question about the existing administrative arrangements for people who want to hook up to the grid at the moment. We can argue the case about when the demand is going to reach a critical point into the future. You could question what year it's going to be. I don't think anyone on this committee would argue the toss that it is going to happen. I'd ask you to have a look, perhaps on notice, at submission No. 86, which talks about the problems of hooking up to the actual grid at the moment and the cost of that for individuals who are required to pay additional costs for increasing capacity for chargers at domestic residences. Is that the case?</p> <p>Ms Mouchaileh: I'm happy to take that on notice and look at that submission. I haven't looked at that submission.</p>

5.	Senator Rice (p. 75)	<p>Senator RICE: Does AEMO need more powers to be able to regulate what the potential impacts might be?</p> <p>Ms Mouchaileh: That is something that I'll need to take on notice. Some of the Finkel recommendations looked at some enhancements to some of the transmission planning and network planning arrangements, and the first step in that was the integrated system plan. We're very keen to continue to work with industry to enhance that so there is a whole-of-system planned for where resources need to go. So we'll continue to work with industry to enhance that. If we feel as though there are additional powers or regulatory changes that are required, we will work with the regulator and the commission to make sure that those things go through.</p> <p>Senator RICE: If you're going to take on notice whether you need more powers, can you also take on notice what further regulations may be required by you and/or by other agencies.</p>
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Senate Select Committee on Electric Vehicles

Responses to Questions on Notice for AEMO

Melbourne public hearing (Friday 31 August 2018)

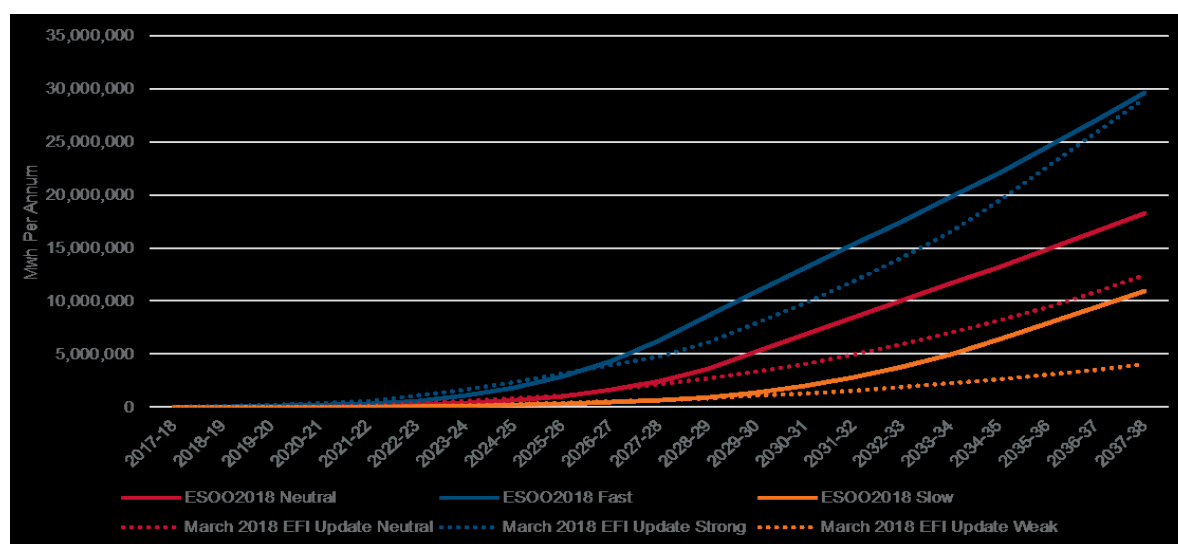
Question 1: provide further details on AEMO's work on Electric Vehicles

Distributed energy resources (DER), which includes not only rooftop solar systems and batteries but electric vehicles, is becoming a key driver of change across the energy landscape. In considering the system implication and reforms required, AEMO is taking a holistic approach to DER integration, rather than focusing on specific technologies.

AEMO analysis – electric vehicles

In July 2018, AEMO released its Electricity Statement of Opportunities (ESOO)¹ which presented its analysis on small scale embedded technologies, including electric vehicles. In the NEM (which covers Queensland, NSW, ACT, Victoria, Tasmania and South Australia), approximately 2,400 vehicles were sold in 2017, representing 0.2% of new light vehicles sales. As part of the development of the ESOO, AEMO engaged CSIRO to undertake analysis on embedded technologies – leveraging key trends domestically and internationally. CSIRO projects, based on this current level of uptake, and in the absence of any policy incentives, that the uptake of electric vehicles will continue to be relatively small in the next decade, with a projected 650,000 electric vehicles across the NEM in 2027-28. At that point, electric vehicles are projected to become cost-competitive with petrol vehicles, due to the falling cost of electric vehicles and economies of scale, driving accelerated electrification of transport. By 2037-38, 5.5 million residential and commercial electric vehicles NEM-wide are forecast in the neutral scenario, based on analysis provided by CSIRO. This has increased since the March 2018 Electricity Forecasting Insights Update which projected four million electric vehicles by 2037-38.

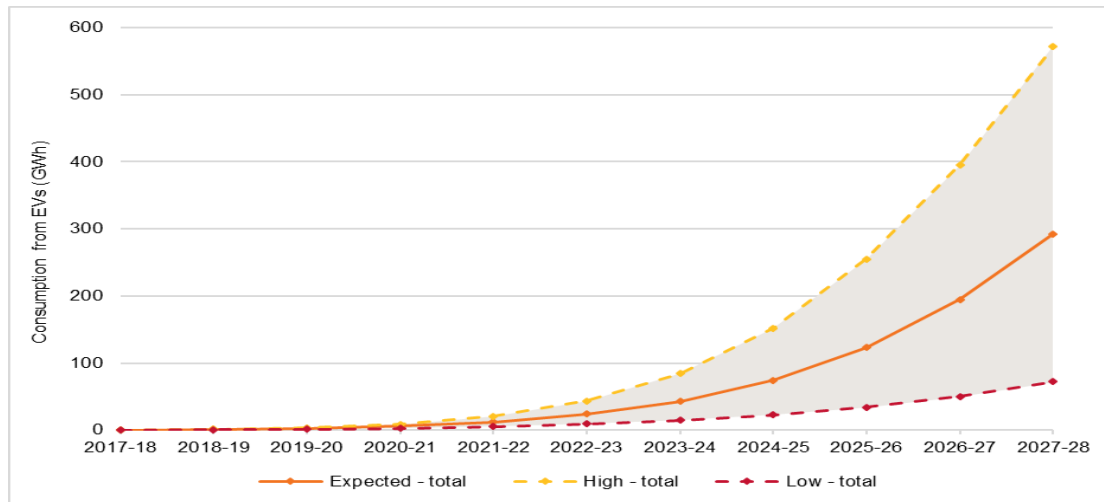
NEM electric vehicles annual consumption forecast (2017-18 to 2037-38).



¹ https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEM_ESOO/2018/2018-Electricity-Statement-of-Opportunities.pdf

For the Western Australia market, the figure below presents the projections presented in the WA Electricity Statement of Opportunities.

WA Market - Electric vehicle contribution to operational consumption, 2017-18 to 2027-28 financial year



These trends will change should policy incentives be proposed at either a national or local jurisdictional basis. The impact on the system is influenced not just by the size of the electric vehicle take up, but by charging and eventually discharging behaviour, and how they coincide with other DER activities – such as PV systems or the use of battery systems. All these components will impact infrastructure requirements, and system and market products.

Impact on the power system

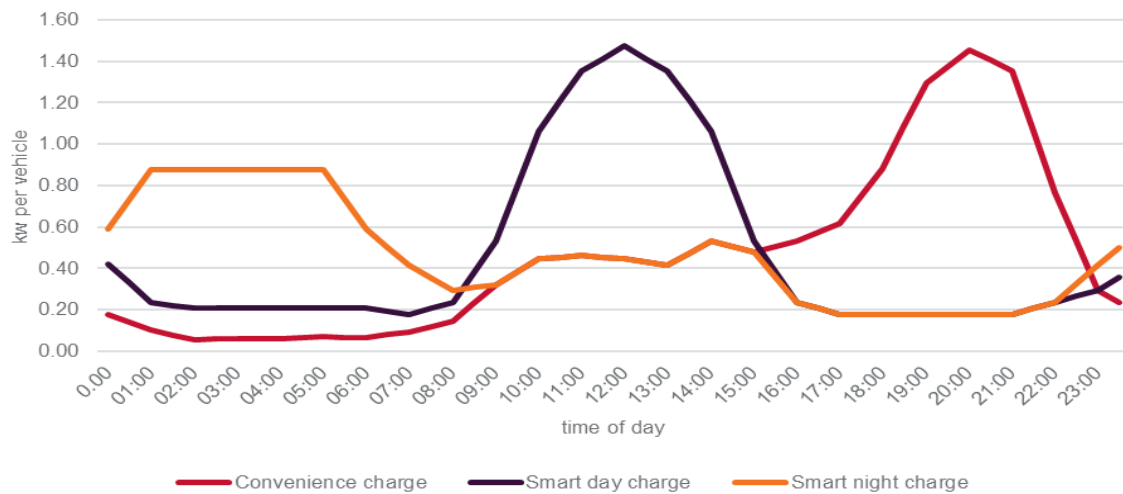
The impact of electric vehicles on the daily load profile and maximum demand depends on how and when they are charged. Charging is likely to be influenced by the availability of public infrastructure, tariff structures, energy management systems, and the driver's routine. For the 2018 ES00, AEMO assumed a weighting of three charge profiles (convenience charging, smart day charging, and overnight charging) – and assumed different proportions of each vehicle charging profile depending on the scenario.

Convenience charging is when vehicles are predominantly charged as soon as drivers get home, including during peak hours. Smart day charging is when vehicles predominately charge in the middle of the day during the solar trough. Overnight charging is when vehicles are predominately charged overnight, after the evening demand peak.

In the neutral demand scenario, the following is noted (see figure below):

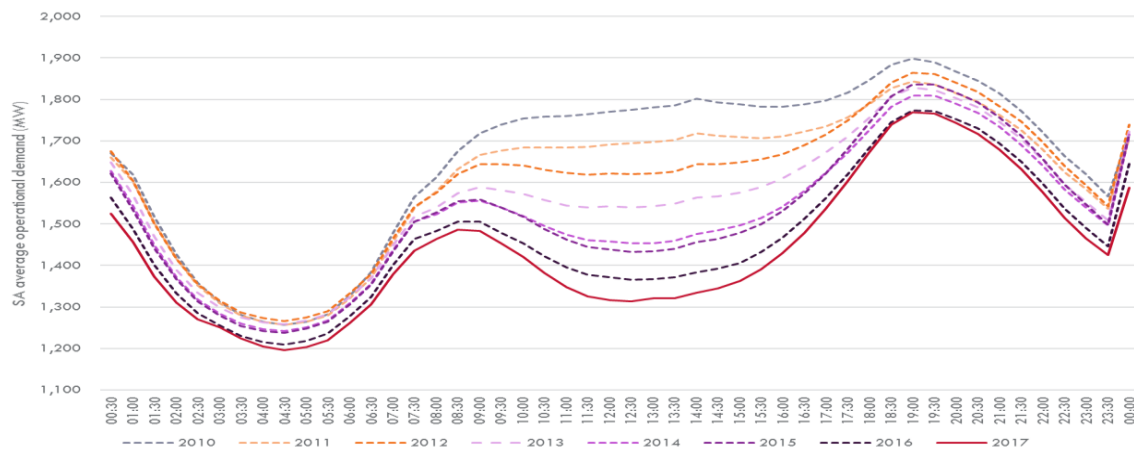
- In the first year, electric vehicles will be convenience charging, which may add to evening peak demand. This reflects the absence of any incentives to optimise charging to manage demand.
- As penetration increases, retail tariffs or load control will start to be adapted to manage impact on peak demand. Accordingly, AEMO scales down the proportion of vehicles using convenience charging, with more charging during the middle of the day or overnight rather than during grid peak demand. Vehicle to grid technology (electric vehicles sending power back to the grid when connected at time of peak demand) has not been considered and would be minimal in the 10-year horizon of the ES00.

Electric vehicle daily charge profile, residential user (weekday in February)

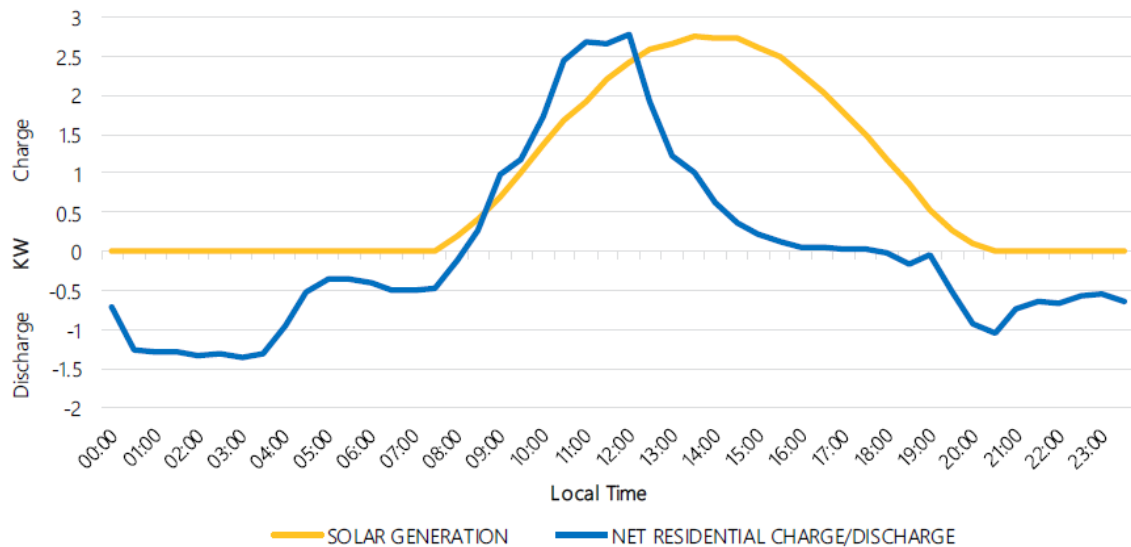


As noted previously, the impact on the system is influenced not just by the size of the electric vehicle take up, but by charging and discharging behaviour, and how they coincide with other DER activities – such as PV systems or the use of battery systems. The figures below show that the role of behind the meter resources (PV, batteries) in helping maintain system reliability, which depends on the future charge/discharge profile assumed for batteries. This overlaid with EV charging and discharging behaviour (above diagram) could mean either the “flattening” of the PV duck-curve or potentially high demand in the middle of the day depending on PV system availability and other generation resources available.

Effect of solar PV on load profile (example SA)



NEM battery charge and discharge profile overlaid with PV generation



In addition to the above, AEMO is working with a number of parties to better understand the impacts of DER on the power system, and specifically electric vehicles. This includes:

- **Trials:** works closely with ARENA and proponents to understand, through small scale trials, the impact of DER on the system and market to help inform regulatory and policy changes. AEMO is working with ARENA on the Evenergy project which is in early stage of development. The aim of this project is to undertake analysis on the impact of electric vehicle ownership and operation of energy usage in households within a particular geographic location. It includes comparisons of the energy usage for solar powered households against non-solar powered households. It is considering impacts on the grid and opportunities for stability services. A second stage of this project is considering ways to collect better information around usage patterns for intending EV purchasers. The second phase of the project will seek to address these findings with a large scale consumer outreach project including data collection from private users, fleets, and rideshare drivers. It will explore specific hot spots in more detail to understand network impacts, and will continue to invest in behavioural economic research to understand potential customer reactions to demand response interventions. Finally, it will seek to create a prototype of a network distribution engagement tool that will enable early engagement by potential owners and operators of charging equipment to understand network impacts, potential demand response and distribution generation opportunities.
- 1) **Infrastructure Victoria:** AEMO is engaged in this project. The project commission KPMG to provide advice on vehicle Infrastructure. The KPMG report on energy impacts and considers the impacts to the Victorian electricity system resulting from adoption of emerging transport technologies, such as zero emission vehicles and automate vehicles. <http://newsroom.kpmg.com.au/automated-vehicles-mobility-as-a-service-and-zero-emission-vehicles-the-future-of-transport-and-the-face-of-our-cities/>
- **International partnerships:** AEMO keeps on both an eye on emerging trends internationally and engages with its international counterparts. These are factored into AEMO's operational, forecasting and planning functions together with regulatory and market framework enhancements. Please refer to responses to question 2.

The charging behaviour for residential and commercial fleet users of electric vehicles will continue to evolve as incentives are introduced to help manage electric vehicles effectively within the power system. As more information is available, this work is expected to be factored into our ESOO analysis,

the Integrated System Plan to help inform network infrastructure requirements, and system/market redesign.

Distributed Energy Resources work program

AEMO has commenced a broad program of work aimed at integrating distributed energy resources into the system and market. To deliver this, AEMO is working closely with the Energy Networks Association (ENA), the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER), ARENA, and industry players. Key focus areas include:

- **DER visibility:** following the release of the rule changes, AEMO will establish a register of DER resources to inform operational and market processes to be implemented by end of 2019. This will capture resources such as demand response, solar, batteries and electric vehicles. A number of international counterparts are interested in this work – including UK and US who are similarly looking for ways to increase system visibility.

As part of the below initiatives (Open Energy Networks), AEMO is also exploring more granular visibility of distributed resources particularly as these resources are integrated into the grid and market dispatch processes.

- **Connection framework & Technical standards:** AEMO is working with the ENA to inform the development of a national framework for the connection of distributed resources. This is aimed at the timely and effective connection of these resources onto the grid and ensuring they meet appropriate network and power system needs. AEMO is also working with Standards Australia on the development of standards for distributed resources – these include AS4777 (standards review) and AS4755 (communication harmonisation). AEMO, in consultation with relevant parties including distribution network, is also reviewing the need for additional DER technical standards, including for electric vehicles. These are at the early stages of considerations.
- **Market access:** AEMO is working with the AEMC on changes to the regulatory regime to facilitate DER access to energy, ancillary and reserve markets. These regulatory framework reviews will be informed by a range of AEMO pilot programs.
- **Open Energy Networks:** AEMO and the ENA have commenced a body of work, in consultation with industry, to look at models that enable DER integration and optimisation considering both transmission and network constraints. Following the release of the consultation paper, AEMO and the ENA held a series of workshops across Australia. Feedback has been comprehensive. AEMO and the ENA has received over 60 submissions. AEMO will continue to work with industry to work through the details of the various models. A number of new functions are required to be developed within AEMO and network businesses including distribution system monitoring and planning, distribution constraint development, forecasting system, distribution level optimisation and dispatch, and wholesale-distribution optimisation. AEMO and the ENA expect to submit regulatory changes coming out of this process in mid-2019. This joint ENA and AEMO collaboration was informed and guided by the learning in the UK, which has similarly commenced a review of energy networks driven by the growth in electric vehicles.
- **Pilot programs:** AEMO is establishing a three-phased trial program. The first two phases are focused on enabling aggregated distributed resources to offer energy and frequency services into the market, with these resources being dispatch alongside other resources. The third phase aims to progress the trialling of a distributed market model and will work with distribution businesses to progress this.

Question 2: what information has AEMO gathered from international counterparts about the challenges they are facing and work they are undertaking?

A recent study completed by Energeia, for the Australian Renewable Energy Agency and the Clean Energy Finance Corporation², undertook an electric vehicle market study focusing on the business models, competitive dynamics and pricing of public charging infrastructure. The report presented some of the policy and regulatory levers used in other jurisdictions to influence EV uptake – such as purchase incentives, procurement targets, import regulation, fuel efficiency regulation, and global internal combustion engine vehicle bans. That report also highlighted that investment in public charging infrastructure, particularly Direct Current Fast Chargers (DCFC), is correlated with high levels of electric vehicle uptake globally, as evidenced by the impact of DCFC deployment in Norway.

In its 2017 electric vehicle study, the International Energy Agency (IEA)³ noted that as at 2016, over 750,000 sales world-wide, with 29% market share, Norway has incontestably achieved the most successful deployment of electric cars in terms of market share, globally. It is followed by the Netherlands, with a 6.4% electric car market share, and Sweden with 3.4%. The People's Republic of China, France and the United Kingdom all have electric car market shares close to 1.5%. In 2016, China was by far the largest electric car market, accounting for more than 40% of the electric cars sold in the world and more than double the amount sold in the United States.

In its report, the IEA also considers challenges and opportunities for the power system. It notes that depending on the electric car usage patterns, i.e. when, where and how much power is drawn from what type of charging infrastructure, higher shares of electric cars could have a sizeable impact on the capacity required at certain times and locations, with consequences for both adequacy and quality at different levels:

- at the generation/wholesale market level, where high demand and scarce capacity could increase prices
- at the transmission/system operator level, where stress on the system during peak times requires more system services, such as frequency control, and the need to maintain reserve power capacity
- at the distribution level, where the overloading of power lines and transformers and voltage drops could occur.

To manage these issues, the IEA identifies three approaches to managing this:

- One option is the buildout of charging infrastructure itself and deploying it both at locations and with technologies that minimise any negative impacts. At homes and businesses, connecting local charging points generally requires some form of connection from the low voltage grid, and the additional load could require subscribing to a higher power capacity tariff and/or reinforcement of the network at the point of connection. It is thus critically important to install charging points in areas where both the projected impact is low and the utilisation throughout the day is expected to be high, e.g. the Netherlands.
- second option is through incentivising end users to maximise self-consumption through solar systems installed on consumers' homes combined with the available storage and recharging infrastructure. As utilities transition to distributed energy, such business models could be

² <https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf>

³ <https://www.iea.org/publications/freepublications/publication/GlobalEVO Outlook2017.pdf>

deployed as an integrated service combining energy efficiency, distributed energy resources and the minimisation of EV charging costs – and, on the utility side, provide system benefits by reducing the impact of the charging profiles seen by the grid. The combination of reducing EV battery costs, increased EV uptake and spillovers into stationary battery technology will require regulators to monitor and balance the adoption by consumers of such distributed electric car charging options with networked charging.

- The third option, which appears to be evolutionary is the development of distributed markets. This is the work the UK is doing considering various approach to integrate resources into transmission and distribution system operation through appropriate constraint management and price signals.

In the United States, the National Renewable Energy Laboratory has been conducting a multi-year study on electrification. The analysis aims to understand how the potential for electrification might impact the demand side in all major sectors of the U.S. energy system: transportation, residential and commercial buildings, and industry. The demand-side analysis presented in this report is not intended to be predictive but is instead designed to provide foundational data to enable a thorough assessment of the isolated impacts of electrification. The key findings include:

- The buildings and industrial sectors generally see less potential for transformational change nationwide, but electrification in these sectors could acutely affect certain regions and end uses.
- Electrification has the potential to significantly increase overall demand for electricity, although even in the High scenario, compound annual electricity consumption growth rates are below long-term historical growth rates.
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- Widespread end-use electric technology adoption would result in substantial shifts in fuel, electricity, and total energy consumption.

In addition to keeping a watching brief on EV studies, AEMO has engaged with a number of its international counterparts to consider DER related issues. Some of these engagements include:

- G015 engagements: AEMO is a member of the G015 which include 19 grid operators around the world. We have used these engagements to discuss future market design requirements, integration of variable resources and distributed resources. We also have discussed issues around activating flexible market for distributed energy. A number of jurisdictions are at early stages of integration.
- Discussions with European counterparts on creation of flexible markets: we have had discussions with operators in the UK, Scandinavia and other parts of Europe to share experiences on distributed resources and integration. A number of them are at early stages of integrating distributed resources across wholesale and distribution markets. Most notable is the approach to UK has taken to these issues which were driven by EV. We have leveraged learnings from their process to conduct a similar Open Energy Networks collaboration with the ENA. We continue to be in contact to exchange learnings.
- In discussion with our counterparts in Spain and State Grid in China, they are considering monitoring of EV charging - mostly for demand forecasting of loads rather than utilisation of the resources back to the grid.

We are using these studies to help shape how we approach and solve issues identified in our DER program. A number of our international counterparts are also watching how we approach these issues in Australia given the high level of DER penetration.

Question 3: Details on the 11 events in 2016/17

AEMO undertook to provide details of the 11 instances in 2016-17 when AEMO assessed that the power system was not in a secure operating state for more than 30 minutes. AEMO published reports on each of these instances, as required under the National Electricity Rules (Rules). The reports are available on AEMO's website.

Clarification of AEMO's system security responsibilities

Implicit in the questions is a concern that the NEM power system was being operated contrary to the Rules at those times, or that the system was at risk of widespread blackouts. Neither was the case. The following information is provided to assist understanding of the conditions that can lead to the power system not being secure, and how AEMO manages those conditions.

Power system security and a 'secure operating state'

The power system is in a 'secure operating state' when its constituent parts are operating within their technical limits (advised to AEMO by the owners of that equipment), and should continue to do so immediately after any unexpected but 'credible' contingency event. Generally, the instantaneous failure (or 'trip') of any single generating unit or transmission line is considered credible.

There is a difference between 'secure limits' and a 'secure operating state'. Operating margins are built into power system security calculations at a number of levels. These inform AEMO's development of what are called 'secure limits'. Many of these are adjusted dynamically to preserve those margins as conditions change elsewhere in the interconnected system. However, operation outside secure limits does not necessarily indicate that the system is not in a secure operating state (and vice versa).

There is rarely a risk of widespread blackouts when the power system is not in a secure operating state. Typically, it presents the risk of localised disconnection of power system equipment if a credible contingency event were to occur. Equally, it is rare that security violations can be resolved using the blunt instrument of disconnecting customers (or load shedding).

AEMO's power system security responsibilities

Operation of any power system requires constant monitoring and response to actual and anticipated changes in customer demand and supply capacity, outages, faults, service reductions and environmental conditions. As the independent market and system operator, AEMO does not own or maintain any power system equipment. Its responsibilities are therefore limited to taking steps that are reasonable, practical and within AEMO's control.

Reflecting the limits of AEMO's role and the nature and complexity of power system operation, the Rules require AEMO to use reasonable endeavours to meet its power system security responsibilities. Those responsibilities include:

- In normal operation, operating the power system so it remains in a secure operating state to the extent practicable.
- When a contingency event occurs, taking all reasonable actions to adjust the conditions of the power system, where possible, with a view to restoring a secure operating state as soon as reasonably practicable.

AEMO adjusts power system flows and frequency control requirements every 5 minutes to maintain frequency balance and secure operation of power system equipment. This includes applying network constraints to restrict or prevent power flows in parts of the grid that are affected by outages or faults. These constraints are typically developed on advice from network service providers.

In addition to adjusting the dispatch of energy and frequency control services, other options available to AEMO to manage power system security include:

- Working with service providers to reschedule non-urgent outages.

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- Instructing NEM participants to take equipment out of service or bring it back into service if possible.
 - Requiring generation or load to be temporarily disconnected.

Significance of the 30-minute restoration timeframe

Because the concept of power system security requires continued operation allowing for the occurrence of a credible contingency, it follows that the operational 'buffer' will be reduced or eliminated if a contingency event actually occurs. In that case AEMO takes whatever action it reasonably can to restore that buffer as soon as practical. For this purpose, the Rules provide for a target maximum timeframe of 30 minutes.

It is important to be clear that this is a target that AEMO always seeks to meet. It is not, nor can it be, an absolute requirement to restore system security within 30 minutes. Therefore, AEMO does not breach the Rules when this target is not met. In some circumstances the levers available to AEMO will not be effective, or may themselves create more serious issues that must be managed. These are judgments that AEMO must make, requiring careful evaluation and consultation with affected network and generation operators.

AEMO must investigate and publicly report on any instance when it assesses the power system was not in a secure operating state for over 30 minutes, as a 'reviewable operating incident'. This reporting requirement applies whether or not the incident resulted from a contingency event.

The 11 events in 2016-17

In 2016-17 AEMO identified and reported on 11 instances where the power system was not in a secure operating state for more than 30 minutes. This number included incidents resulting from emerging requirements in the South Australian power system that were unprecedented in major grids anywhere in the world. To reduce the associated risks to system security, AEMO has subsequently implemented enhanced operational measures, and worked with other market institutions on changes to the Rules.

Of the 11 instances in 2016-17:

- There were four occasions when the power system was not restored to a secure operating state within 30 minutes after a contingency event. Three of those were non-credible events involving the instantaneous loss of multiple elements of transmission or generation plant. The triggers for those losses were severe weather conditions, and in one case an explosion, followed by unexpected or incorrect responses of protection systems installed on some of the equipment that subsequently tripped.
- In the remaining seven instances, AEMO assessed that the power system was not in a secure operating state because one or more technical limits could have been exceeded if a given credible contingency event had occurred. In almost all cases this outcome resulted from multiple concurrent outages of transmission or generation equipment.
- Four instances resulted from a shortfall in available generation capacity to provide the requisite level of grid support (system strength or frequency control) under particular power system conditions. In November 2016 AEMO implemented standing requirements to maintain system strength in the power system, if necessary by directing synchronous generators to operate. AEMO studies in this area are world-leading.
- Three instances resulted in automatic or AEMO-instructed disconnection of limited customer load to maintain system frequency and other parameters within limits. In all other cases load shedding either would not have addressed the problem, or was not a reasonable response.
- One event resulted in uncontrolled load shedding – the September 2016 SA blackout – however the system was in a secure operating state before the unexpected disconnection of multiple generators that led to frequency and voltage collapse within seconds.

Question 4: Submission No. 86 talks about the problems of hooking up to the actual grid and the cost of that for individuals who are required to pay additional costs for increasing capacity for chargers at domestic residences. Is that the case?

We have reviewed this submission (the author is not identified) and can provide the following:

- It is reasonable to consider that there will be a mix of home-based, shared community facilities and commercial charging, the proportion of which is likely to differ based on factors including location, population density and geography. For example, residents in an apartment block may only be able access shared or commercial charging infrastructure.
- It is possible that municipal charging points may be required, at least to support charging of non-public vehicles.
- Whilst the submission presents an argument that the range of electric vehicles is no longer a concern, there is a risk that we look only at the best-case-scenarios where drivers are always prepared ahead of time for their impending journey. A transition from petrol and diesel will be less likely if drivers are unable to embark on journeys having previously not planned for every eventuality. It is likely that on any moderately lengthy journey (e.g. Canberra to Melbourne), commercial infrastructure will be required.
- The advent of driverless cars is on the horizon. This opens up new possibilities for the method of owning, using and charging electric vehicles that is significantly different from the models operated for diesel and petrol vehicles in use today. It is reasonable to consider that driverless cars will rely on non-domestic charging infrastructure, particularly in urban areas.
- Capacity of the electricity grid – The submission comments that the grid is not capable of catering for a significant increase in demand and that considerable investment will be needed regardless of charge time:
- The submission correctly raises the concern that electric vehicle charging will add an increase to the demand of electricity.
- It is highly likely that grid infrastructure will need to be upgraded to accommodate electric vehicles regardless of their charging location. Recent work in New Zealand has identified localised network constraints caused by very low levels of EV adoption in long established, urban environments, which reach well beyond the customer's connection to the distribution network.
- EV adoption, and the generation and grid infrastructure to support it, needs to form an integrated plan, considering broader changes in the consumption, generation and storage of energy in the market.

In terms of connection frameworks for homes and distributed resources, distribution networks are currently responsible for connecting assets in line with their obligations in National Rules and state-based instruments. The Energy Networks Association is reviewing the DER connection frameworks and intends to develop nationally consistent approach to connection to minimise timely delivery of services. The cost of connections is guided by frameworks in the rules.

Question 5: Does AEMO need more powers to regulate the potential impacts? What further regulations may be required by AEMO or other agencies?

Today, AEMO is responsible for grid reliability and system security, operating the wholesale markets, and facilitating retail market processes to deliver outcomes for consumers. AEMO receives a range of inputs to optimise resources including from buyers and sellers together with transmission network limits. The system and market constructs of today were designed for a one-way system.

With distributed energy resources, the energy system has gone from one that was dominated by central large-scale, synchronous power plants, and passive consumption, to one which includes a multitude of resources and technologies of various sizes sitting within the distribution network and behind the meter. This in effect is creating a two-way system. It is essential that the system and market constructs, together with AEMO's roles and responsibilities, evolve for an increasingly distributed and digitally connected electricity system.

As regards DER specifically, the regulatory design should facilitate system security, efficient use of resources and effective competition. While not exhaustive, the key elements that need to evolve within the regulatory frameworks include:

- **Visibility of DER, including electric vehicles:** in mid-September 2018, the AEMC made a final rule, commencing 2019, that amends the National Electricity Rules to enable AEMO to establish a register of DER in the National Electricity Market. AEMO intends to extend this to capture electric vehicles given the impact the electrification can have on the grid and network investment. The DER register is an important first step in increasing system visibility. The next key step, highlighted by a number of stakeholders through the AEMC consultation process, is the need for more dynamic information on DER to inform network and system operations, and facilitate customer services and offerings.
- **Access to all resources to operate the grid and market:** AEMO should be able to access all resources, including DER, to operate the grid and market in a way that produces efficient, cost-effective outcomes for all consumers. DER, in aggregate form, should have direct access to energy, ancillary and reserve markets wherever possible. New products may be required to best signal and utilise resources during the day.
- **Coordinate DER between AEMO and the network to enable whole of system optimisation of resources:** the system and market need to extend beyond the wholesale transmission point into an integrated system and market dispatching and settling resources within the confines of transmission and distribution limits. AEMO and the ENA, in consultation with industry, are developing a proposal on how best to integrate resources into the system. AEMO has an important role in this given its current system and market operator functions.

AEMO's Integrated System Plan identified under a high DER scenario the potential for even greater use of DER to lower the total costs to supply, the net present value of wholesale resource costs reduced by nearly \$4 billion, compared to the neutral case. The ENA-CSIRO Network Transformation Roadmap estimate that by 2050, DER optimisation lower network charges by 30 percent compared to 2016, deliver annual savings of \$414 in average household electricity bills (compared with a business as usual pathway), and avoid over \$1.4 billion in network investment.

- **Whole of system planning:** in July 2018, AEMO released its first Integrated System Plan (ISP). The ISP is a cost-based engineering optimisation plan that forecasts the overall transmission system requirements for the NEM over the next 20 years. AEMO worked closely with the transmission network business to develop the ISP. The ISP can play an important role in taking a whole of system approach, considering DER and the implications for transmission and distribution system requirements. For example, in the context of electric vehicles, the ISP can be extended to consider the implications and locations of charging infrastructure on the

transmission and distribution system requirements, and work closely with network business to inform this. AEMO acknowledges it is working with the Energy Security Board, the AEMC and the Australian Energy Regulator to consider the appropriateness of regulatory checks needed when the ISP calls for certain investments in the system.