Distributed Energy Integration Program – Electric Vehicles Grid Integration

May 2021

Vehicle-Grid Integration Standards Taskforce – Key Findings

Important notice

PURPOSE

The Vehicle-Grid Integration Standards Taskforce was established by the Distributed Energy Integration Program (DEIP) - Electric Vehicle Grid Integration Working Group to provide a basis for informed decision-making by identifying relevant vehicle-grid integration (VGI) standards gaps and developing an understanding of the international VGI standards landscape.

The purpose of this publication is to support informed decision-making on the development of VGI standards by summarising:

- Gaps in VGI standards from an Australian perspective,
- The approach taken by selected international VGI standards, and
- Input from a range of stakeholders on the potential development of comprehensive VGI standards.

ACKNOWLEDGEMENTS

AEMO acknowledges the support, co-operation and contribution of Taskforce members in the identification of potential VGI standards gaps and the review of the international VGI standards landscape summarised in this publication. AEMO prepared this report on behalf of the Taskforce to summarise the group's findings, and wishes to thank all the organisations and individuals who contributed their valuable time and expertise to this effort:

- ACE Electric Vehicle Group
- AI Group (Australian Industry Group)
- Australian Energy Regulator (AER)
- CSIRO
- Deloitte
- Horizon Power
- EVOS
- NHP Electrical Engineering Products Pty Ltd
- RMIT University
- Standards Australia
- Tritium

Specifically, AEMO wishes to thank eMobility consultancy Evenergi for its work in preparing the initial draft of this report.

DISCLAIMER

AEMO and Taskforce members have made reasonable efforts to ensure the quality of the information in this publication but cannot guarantee that information, forecasts and assumptions are accurate, complete or appropriate for your circumstances. This publication does not include all of the information that an investor,

Executive summary

The transition to electrified transportation represents a nexus of the transport, energy, and infrastructure sectors, and will require close collaboration between industry, government, and regulatory bodies to ensure an efficient transition across these closely coupled sectors[1]. Preparing now in a coordinated fashion, before wide-scale electric vehicle (EV) uptake begins, will enable the effective integration of EVs and create value for Australian consumers and industry stakeholders.

In 2019, the Distributed Energy Integration Program (DEIP) EV Grid Integration Working Group ('Working Group') identified[2] that the absence of comprehensive Vehicle-Grid Integration (VGI) standards could increase the risk of an inefficient transition to electrified transportation for consumers, potentially leading to additional costs and reduced uptake of EVs. The Working Group then established a VGI Standards Taskforce ('Taskforce') to provide a basis for informed decision-making during this transition by identifying relevant VGI standards gaps and developing an understanding of the international VGI standards landscape.

The Taskforce followed a collaborative and exploratory process to capture input from a broad range of energy and transport sector stakeholders. AEMO collated and assessed input with the help of eMobility consultancy Evenergi and prepared this report on behalf of the Taskforce to summarise the findings. AEMO thanks all the organisations and individuals who contributed their valuable time and expertise to this effort.

The Taskforce does not take a position for or against additional standardisation, and instead focuses on developing a basis for informed discussion on this complex topic. By highlighting potential gaps in the domestic standards landscape alongside candidate international standards, the Taskforce aims to demonstrate the need for deeper investigation by standards bodies, government, and industry as to the merits and risks associated with standardisation in this space.

The Taskforce's work focused on three areas identified as key priorities for the energy sector: charging interoperability, energy and services market integration, and disturbance performance and grid support. A key consideration for each of these focus areas is how they apply to EVs that act purely as a load, as opposed to bi-directional (V2G) applications.

Key takeaways

- Any decision to introduce VGI standards must be made from the perspective of EV and non-EV consumers with consideration to the costs incurred across the electricity, transport, and infrastructure sectors.
- Standardisation might help reduce the risk of significant augmentation and operational costs of incorporating large numbers of vehicles into the electricity system, but might also add cost to vehicle and electric vehicle supply equipment (EVSE – commonly referred to as 'chargers') development or reduce their availability in the Australian market. These impacts will be highly dependent on the area and manner of standardisation.
- Vehicle standards will influence a different supply chain to EVSE standards, and standards imposing hardware requirements will have different cost impacts to those which carry firmware requirements.
- Generally, time is available for comprehensive and collaborative discussion on these matters, noting that DER standards are evolving on a tighter timeline and may also influence the EV sector.

[1] See https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--10.pdf.

[2] See https://arena.gov.au/assets/2020/05/electric-vehicle-grid-integration-working-group-post-workshop-summary-pack.pdf.

Focus area 1: Charging interoperability

This explores how different charging configurations might influence interoperability standards, and whether any specific configurations might limit interoperability opportunities. Standardisation is discussed from the position of alignment with global norms. Many international standards are available that specify communications pathways between the electricity system and EVs via EVSE, however no single set of standards has yet become dominant worldwide. Communications direct to the vehicle are mainly managed through bespoke, privately-owned systems.

The decision about whether to standardise interoperability requirements for EVs and/or EVSE requires careful consideration and close collaboration across industry, as there could be both positive and negative impacts on EV consumers in terms of product cost, availability, and compatibility, as well as on EV and non-EV consumers in terms of network costs.

- Establishing a standardised communications protocol from electricity system actors directly to EVs may be challenging, due to a lack of established candidate standards in that space and the international norm of using bespoke protocols for that purpose.
- Standardising communications from electricity system actors to EVSE might rely on an interoperable protocol existing between EVSE and EVs (such as ISO 15118 or IEC 61851), particularly for alternating current (AC) EVSE where the EV itself has control over the charging rate in accordance with limits set by the EVSE. Decisions in this space need to be made from a framework perspective to ensure consistency with other sectors, such as the common payment platform being discussed within the National Low and Zero Emissions Vehicle (LZEV) working group reporting to the Infrastructure Transport Ministers Meeting.

Focus area 2: Energy and services market integration

This explores where standards might help enable participation of EVs in energy and services markets. Most regulation of device performance and communication protocols is implemented via market rules, however a noteworthy exception is Australian Standard AS/NZS 4755. This demand response standard is of interest to the Taskforce due to a recent Council of Australian Governments (COAG) recommendation to expand its scope to include EVSE.

- Communications standards like IEEE 2030.5, OpenADR, and ISO 15118 could work with AS 4755.2 to provide a complete interoperable demand response framework for EVs, including communications, information exchange, response specification, cybersecurity requirements, and test procedures.
- Industry, government, and the relevant standards committees need to work together to establish a clear pathway to meet the requirements of the 2019 COAG Regulation Impact Statement (RIS) decision to apply AS/NZS 4755, or an equivalent international standard, to some categories of EVSE from 2026. This work should include engagement with the E3 technical working group which will be established to determine, by mid-2022, whether an equivalent international standard can be used in place of AS/NZS 4755.

Focus area 3: Disturbance performance and grid support

This explores whether current and emerging feature sets of EVs and EVSE could play a role in supporting grid operation, and whether standards might influence or enable this capability. If these devices were to have inherent, autonomous capability to support power system operation, it may be possible to avoid operating the system in a more costly manner to accommodate their additional demands. Operating costs are borne by all electricity consumers, not just EV owners, so efficient operation of the system is of key importance to a wide range of stakeholders.

AS/NZS 4777.2 is an established standard applicable to bidirectional V2G inverters, including both stationary and on-vehicle inverters. However, no established Australian or international standards have been identified in relation to disturbance performance and grid support capability for unidirectional chargers, which will likely make up the majority of the charging fleet for many years to come. The Taskforce recommends the Working Group continues to investigate whether any provisions in AS/NZS 4777.2 or emerging international standards may be relevant to future discussion on unidirectional chargers’ capability to respond to grid conditions.

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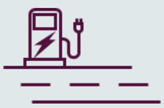
1. Introduction

In recent years, the energy system has seen a significant increase in distributed energy resources (DER). DER are consumer-owned devices that, as individual units, can generate or store electricity or have the capacity to actively manage energy demand. These include devices such as solar photovoltaic (PV) systems, batteries, and electric vehicle supply equipment (EVSE)[3].

The number of electric vehicles (EVs) on Australian roads is predicted[4] to increase dramatically over coming years, presenting both opportunities and challenges for Australia's electricity sector. An EV rollout that is supported by appropriate market frameworks, regulation accepted by industry, and infrastructure that meets consumer expectations will enable an effective energy system designed to meet future needs. An uncoordinated integration of EVs would pose significant challenges to the energy system and increase costs.



An EVSE is a stationary device[5] which delivers energy between an electricity network and an EV. While these devices are commonly known as 'chargers' or 'charging stations', the term EVSE is used in this report to avoid confusion with charging equipment built into the vehicle.

Before wide-scale EV adoption begins, industry and government stakeholders have an opportunity to coordinate their activities to deliver value to consumers and reduce future costs. As part of the Distributed Energy Integration Program (DEIP)[6], AEMO has been working with key industry and government stakeholders to establish the DEIP EV Grid Integration Working Group ('Working Group'), providing a forum for collaboration and coordination of EV activities.

The Working Group has identified[7] that the absence of comprehensive Vehicle-Grid Integration (VGI) standards could increase the risk of an inefficient transition to electrified transportation for consumers, potentially leading to additional costs and reduced uptake of EVs. To address this issue, the Working Group established a VGI Standards Taskforce ('Taskforce'). This report, drafted with the assistance of eMobility consultancy Evenergi, captures the views of the Taskforce and outcomes of its assessment of the domestic and international standards landscape.

The Taskforce does not take a position for or against additional standardisation, and instead focuses on developing a basis for informed decision-making on this complex topic.

By highlighting potential gaps in the domestic standards landscape alongside candidate international standards, the Taskforce aims to demonstrate the need for deeper investigation by standards bodies, government, and industry as to the merits and risks associated with standardisation in this space.

The Taskforce's work has been exploratory and collaborative in nature and focuses on three areas identified as key priorities for the energy sector:

- Energy and services market integration.
- Charging interoperability.
- Disturbance performance and grid support.

[3] More information can be found at https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program.

[4] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo.

[5] IEC 61851-1 defines four modes of EV charging, including Mode 2 which utilises a portable EVSE in the form of a cable that connects the EV to a standard wall socket via a protective device. For the purposes of this report, EVSE refers to stationary devices consistent with Mode 3 and Mode 4 charging where a dedicated device is installed at the premises where charging occurs.

[6] See https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/.

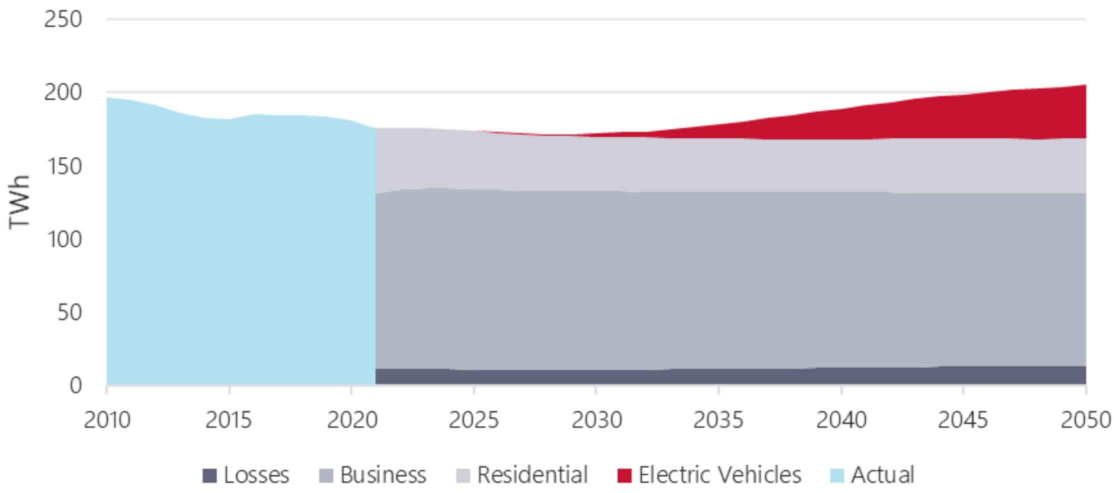
[7] See https://arena.gov.au/assets/2020/05/electric-vehicle-grid-integration-working-group-post-workshop-summary-pack.pdf.

The *Vehicle-Grid Integration Standards Taskforce – Key Findings* report provides direction for future VGI standards efforts and a basis for DEIP, the Working Group, and wider industry to engage with governments, industry, and standards bodies to progress discussion on whether and where standardisation might lead to positive outcomes for consumers.

2. Background

AEMO's 2020 *Electricity Statement of Opportunities* (ESOO)[8] Central scenario shows EVs are predicted to be the fastest growing energy demand category in the National Electricity Market (NEM) from the mid-2020s. EV demand is forecast to add over 1 terawatt hour (TWh) of new consumption to the NEM each year from the late 2020s, approaching a level of additional demand that will equal total residential consumption by 2050, with similar EV uptake growth predicted in Western Australia's Wholesale Energy Market (WEM) from the mid-2020s. Figure 1 shows the projected growth of EV energy consumption in the NEM alongside other sectors of demand.

Figure 1 NEM operational consumption, 2020 ESOO Central scenario



Although uncertainty exists around the adoption curve for EVs, there is little debate that they will ultimately play an important role in the future of mobility. The ESOO Central scenario projects EVs to capture 20% of new vehicles sales share by the early 2030s, while a scenario assuming moderate intervention forecast a 50% sales share by the same date. Internationally, vehicle manufacturers have made significant commitments toward electrifying their model line-up over the next decade. This will influence model availability in Australia, where most vehicles are imported. Domestic examples of vehicle electrification trends include the New South Wales Government's commitment to move its bus fleet to 100% electric and the introduction of grants for fleets to shift to EVs[9].

The 2020 ESOO incorporates vehicle sales and penetration projections developed by CSIRO[10], as shown in Figure 2.

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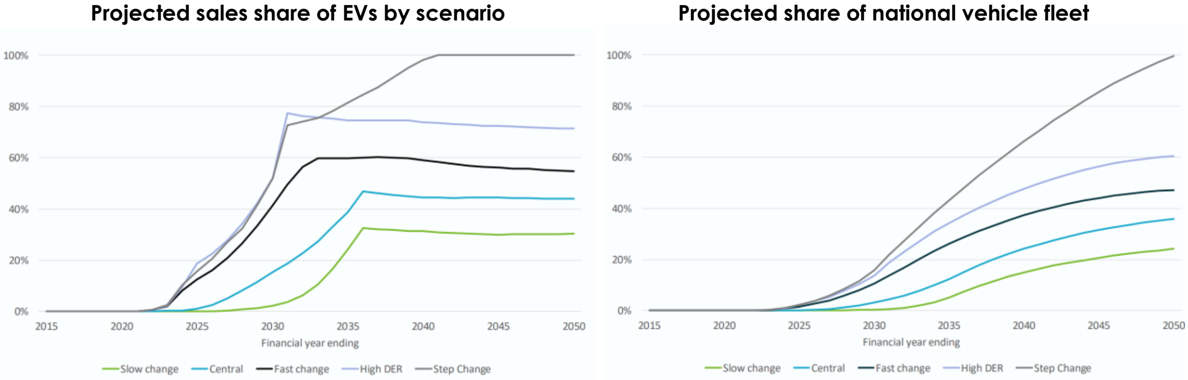
[8] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo.

[9] See https://energysaver.nsw.gov.au/business/discounts-and-incentives/battery-electric-vehicle-fleets.

[10] See https://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2020/CSIRO-DER-Forecast-Report.

Figure 2 CSIRO EV uptake projections



Source: CSIRO, Projections for small-scale embedded technologies, at https://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2020/CSIRO-DER-Forecast-Report.

A rapid uptake of EVs, while representing a significant new source of demand, also represents a significant opportunity for consumers to maximise the value of their DER and minimise their costs. Any increase in peak demand driven by EVs would – under traditional capacity management techniques – require additional network investment to manage this increase in load. However, this cost impact could be tempered through demand shifting and load balancing functionality established through markets, price incentives, and mechanisms for management of charging and discharging to the grid. An effective utilisation of EV charge management could offer all consumers a reduction in electricity costs through improved grid asset utilisation and reduction in peak demand-driven grid augmentation investment. In turn, EV users could be rewarded for the services they provide to the energy system.

The importance of rewarding consumers for their contribution to demand management was highlighted in the 2017 Independent Review into the Future Security of the National Electricity Market[11] undertaken by the Expert Panel led by Dr Alan Finkel, AO (the Finkel Review). The Finkel Review recommended that the Council of Australian Governments (COAG) Energy Council consider the regulatory framework, data exchange mechanisms, and incentives to integrate DER. The Finkel Review also noted a critical role for proof-of-concept demonstration projects and the importance of greater collaboration across industry and market institutions.

Industry representatives on the Taskforce acknowledged the benefits and importance of coordinated EV charging, but noted that an absence of domestic activity in the VGI standards landscape (compared to international activity) represents a barrier towards achieving this. This has created uncertainty around whether Australian standards or international standards will shape the market going forwards.

The Taskforce also discussed whether standardisation is likely to occur and over what timeframe, noting that a broad range of support functions would need to be in place to facilitate any formally established standards. These functions might include testing, compliance, audit, and certification bodies, which would all require regulation or legislation to establish a complete standards framework.

The window of time available before EV uptake drives demand for installation of private and public EV chargers at scale creates the opportunity to ensure that investment decisions around network and charging infrastructure are aligned with consumer interest. Standardisation could play a role in meeting this opportunity, but only if it occurs in a consultative manner with the best interests of consumers as a core focus. The remainder of this report sets the scene for ongoing discussion and potential development of VGI standardisation, with a focus on priority areas identified by the Taskforce.

[11] See https://www.energy.gov.au/publications/independent-review-future-security-national-electricity-market-blueprint-future.

3. Process and acknowledgements

Since December 2019, VGI standards have been explored collaboratively through the DEIP EV Working Group VGI Standards Taskforce. AEMO has summarised the Taskforce's work in this report, and thanks all organisations and individuals who contributed considerable time and expertise toward these efforts, including:

- ACE Electric Vehicle Group
- AI Group (Australian Industry Group)
- Australian Energy Regulator (AER)
- CSIRO
- Deloitte
- Horizon Power
- EVOS
- NHP Electrical Engineering Products Pty Ltd
- RMIT University
- Standards Australia
- Tritium

Specifically, AEMO wishes to thank eMobility consultancy Evenergi for its work in preparing the initial draft of this report.

3.1 EV Grid Integration Working Group

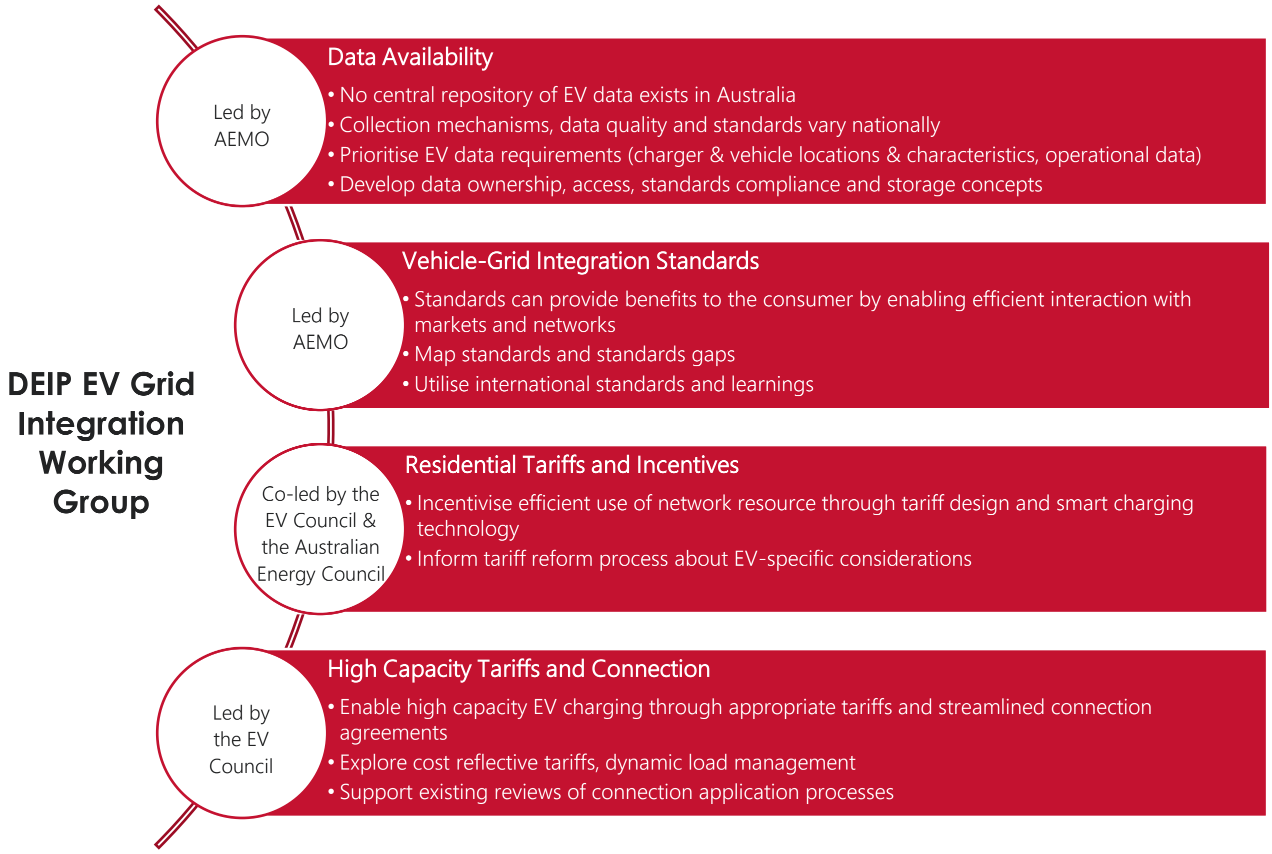
The DEIP EV Grid Integration Working Group was established in 2019 to help facilitate the efficient integration of EVs into existing networks and markets. The Working Group aims to:

- Provide a central forum for key industry and government stakeholders to collaborate and coordinate EV activities
- Approach EVs from an energy sector perspective together with transport and infrastructure partners
- Promote policy and regulatory development before wide-scale EV adoption begins

To progress these objectives, four taskforces were established under the Working Group for 2020, as shown in Figure 3.

The term 'grid integration' in the Working Group context represents the ways EVs and EVSE (individually or collectively via an aggregator) influence and interact with the electricity system. Further information on vehicle-grid integration is available in Section 4.

Figure 3 DEIP EV Grid Integration Working Group Taskforces



3.2 Vehicle-Grid Integration Standards Taskforce

3.2.1 Terms of reference

The Working Group developed Terms of Reference for the Taskforce to help guide its activity. The premise of the Taskforce is that the absence of comprehensive VGI standards could increase the risk of an inefficient transition to electrified transportation for consumers, potentially leading to additional costs and reduced uptake of EVs. The Taskforce aims to provide a basis for informed decision making during this transition by identifying relevant VGI standards gaps and developing an understanding of the international VGI standards landscape. Table 1 details the scope and objectives of the Taskforce.

Table 1 Summary of Taskforce scope and objectives

Scope	• Identify relevant EV grid integration standards gaps alongside any candidate international benchmarks, to effectively engage and influence EV standards development in Australia and internationally
Objectives	• Locate gaps in the EV grid integration standards landscape in Australia where the absence of a standard may lead to negative impact on consumers • Catalogue international standards that may be candidates for adoption/modification to cater for the identified gaps

3.2.2 Taskforce membership and workflow

AEMO reached out to the Working Group members and their contacts in May 2020 to invite participation in the Taskforce, with participants electing their chosen levels of commitment:

- *Members* – able to commit to attend regular meetings and contribute time/expertise to progress Taskforce deliverables.
- *Attendees* – able to contribute through attendance at workshops or via surveys and consultation.
- *Observers* – included on the mailing list for Taskforce proceedings.

Taskforce Members met every four weeks between June 2020 and March 2021 to progress the development of this report. Due to the disruption caused by COVID-19, the Taskforce did not run any additional events or workshops. Attendees and Observers were kept informed and consulted via email.

4. Vehicle-grid integration

Wide-scale uptake of EVs will have broad impacts across the transport, infrastructure, and energy sectors, and will lead to closer coupling of these sectors. These impacts need to be managed and outcomes optimised across all sectors, but the energy sector needs specific focus due to the potential scale of impacts on electricity systems and networks, and the interaction between EVs, EVSE, and existing electricity infrastructure.

4.1 Defining grid integration

VGI encompasses the ways EVs and EVSE (individually or collectively via an aggregator) influence and interact with the power grid. This includes:

- Both unidirectional charging (the EV's battery charges from grid-supplied and/or locally-generated electricity) and bidirectional vehicle-to-grid (V2G) connection (the EV's battery can also export electricity to the grid or other behind-the-meter loads).
- The capability to coordinate or influence charging and bidirectional interactions between EVs and the grid.
- Communication and data exchange measures to execute coordinated or uncoordinated charging and discharging of EVs.

Successfully integrating EVs with the grid means optimised and balanced outcomes for consumers, energy, transport, infrastructure, and the environment. At a high level, this may include:

- Enabling transport consumers to transition to EVs with the choice to participate in energy and services markets.
- Enabling wide-scale EV uptake while maintaining a secure and reliable electricity system.
- EVs supporting electricity system operation through demand management and services provision.
- Improved network utilisation leading to more efficient use of infrastructure and lower costs to all electricity consumers.
- Electricity system flexibility, adaptability, and cost being balanced against transport flexibility, adaptability, and cost, without loss of consumer choice in participation.
- Ensuring clear, accessible requirements for bidirectional power flows from EVs/EVSE.

While VGI offers many opportunities, it also presents challenges for all consumers, market operators, infrastructure owners and operators, mobility operators, network service operators, and energy retailers.

4.2 Impact and stakeholders

The primary stakeholder of focus for the Taskforce has been the consumer, both those who do or may one day own EVs, and those that may not. This is important, because an uncoordinated uptake of EVs could increase network costs that would also be borne, in part, by consumers who are not contributing to this need for additional investment. Along with flexibility and choice, the cost of electricity is of key importance to consumers. The National Electricity Objective (NEO), reflecting this point, is: "to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to: price, quality, safety, reliability and security of supply of electricity; and the reliability, safety and security of the national electricity system". A key focus of AEMO is ensuring that the NEO is considered in any product or service offered to consumers of electricity.

Increased EV uptake and integration will provide both opportunities and challenges for the power system. The footprint of electricity markets increases as energy for transport becomes more dependent on the grid for support. Increased and clustered EV charging demand that is uncoordinated may increase peak demand on the system, create local infrastructure hotspots, modify the shape of the demand curve, and impose capacity challenges on distribution networks.

In the worst-case scenario, excessive uncoordinated integration of EVs (without standards or market-driven solutions) into the electricity system could potentially introduce capacity challenges and voltage and frequency imbalances, inject harmonics, and influence transmission and distribution losses, which in turn, increase the cost and complexity of keeping the network stable and reliable.

If grid integration is managed well, the potential load-shifting, energy arbitrage, and grid-support capabilities of EVs and EVSE could support consumers in maximising the value of their investment and a more flexible and cost-effective electricity system. Coordinated charging and discharging may also help manage the intermittency associated with renewable generation by leveraging the flexibility and storage capacity of EVs. Charging coordination, coupled with the provision of grid services from EVs, could also improve network and generation asset utilisation and could be an effective means to delay or reduce the need for power system augmentation. This outcome would benefit all grid-connected consumers, regardless of EV usership, through lower power bills reflecting lower capital investment in grid augmentation and lower operating reserves.

Standards might help facilitate coordinated VGI, but may come at an unexpected cost if they are overly burdensome for the automotive and/or energy industries, particularly at an early stage of the market where EV penetration is low, public infrastructure investment is nascent, and market signals from governments vary. Similarly, implementation of standards may prove costly if consumer interests are not fully understood and accounted for. A balance must be struck between forward planning standards that will provide social benefits in future versus creating potential barriers for industry participants and consumers today.

While the charging preferences of future consumers are difficult to predict, it is likely that a significant proportion of EV-grid connections will be via a standard General Purpose Outlet (GPO) alternating current (AC) wall socket[12], with another substantial proportion being home charging via a dedicated, unidirectional, AC EVSE[13]. Many of these EVSE will carry only basic disconnect functionality, without a standardised minimum set of 'smart' capabilities to interact with the grid. In the situation where the consumer determines that GPO charging is adequate to meet their needs, it may be possible to coordinate charging through influencing the decision making processes of that consumer through incentives, or by implementing interoperability functionality within the vehicle itself.

Some Taskforce stakeholders raised concern with requiring standardised interoperability capability within the EV itself. This concern related to the challenges associated with implementing and certifying vehicles to meet domestic standards, given the large international supply chain and the relatively small size of the Australian EV market. Concerns raised include the potential for increased purchase costs to consumers, and reduced model availability if vehicle manufacturers decide not to certify some products for the domestic market where the economics do not justify this activity (noting that certification of new models of high volume vehicles for the Australian market occurs today). This is a key area for continued investigation and exploration to ensure power system efficiency and security under a high proliferation of EVs, and to understand the total

[12] Consistent with Mode 2 charging as defined in IEC 61851-1.

[13] Consistent with Mode 3 charging as defined in IEC 61858-1.

cost/benefit of providing grid interoperation capability built into the vehicle itself versus delivering the functionality via EVSE.

Table 2 summarises the identified key VGI stakeholders alongside the opportunities and challenges they might face.

Table 2 Opportunities and challenges of key stakeholders in VGI landscape

Stakeholder group	Benefits of a well-orchestrated VGI standards implementation	Challenges if there is un-coordinated VGI standards implementation
Consumers (both EV and non-EV) and fleets	• A safe and reliable EV ownership experience • Potential cost savings by EV users participating in grid-services and energy markets • Lower network costs for all electricity consumers	• Grid-connection constraints emerge leading to increased costs • Complex and unsatisfactory EV ownership • Increased network costs for all electricity consumers, with a cross subsidy paid by non-EV owners
Market operator	• Reduced peak demand and ancillary services requirements • Potential load balancing, energy storage, flexibility of grid-connected EVs assists with market coordination	• Unmanaged and uncoordinated grid integration of EVs can increase system operating cost and impact system security and reliability
Network service providers	• Reduced network operating cost • Potential of flexible and grid-friendly operation of EVs to mitigate adverse effects imposed by increased and unmanaged EV charging • Increased load factor leading to more preferential utilisation of existing network assets	• Capacity challenges for network operators including overloading, local voltage fluctuations and harmonic injections
Retailers and aggregator	• New revenue opportunities • New product opportunities	• Inability to bring new products to market in a competitive manner • Market hedge risks
Vehicle/ component manufacturer	• Limited product redevelopment • First-to-market value	• Unnecessary or prohibitively expensive localisation costs where domestic requirements differ from international norms • Reduced customer product satisfaction
Charge Station Operators (CSO)	• Efficient and consistent interaction with network service providers (NSPs) lowers transaction costs • Clear compliance standards reduce development product costs and increase competition • Broader business model though a generally more favourable case for EVs	• Lower commercial success due to reduced product innovation opportunities and increased transaction costs • Limited business case for DER market participation – if local firmware development is required it may both serve to increase cost and diminish revenue
Management platform operators	• Clarity around hardware and protocol requirements • Wider market reach	• Costly implementations • Multiple protocol requirements leading to redundant or duplicate hardware and multiple certification processes
Mobility service operators	• Lower operating costs resulting in improved consumer pricing • Better visibility and monitoring of assets • Interoperability between providers	• Slow market entry • Implementation of own de facto standards
Regulatory bodies	• Improved ability to forecast and plan	• Administrative burden

4.3 Timing

The penetration of EVs in Australia before 2025 is predicted to remain low and is unlikely to significantly impact electricity system operations outside of charging hotspots on the distribution network. As such, the emergence of potential opportunities or challenges at a system-wide scale will not be felt for some years, allowing for a considered and collaborative approach to VGI and any associated standardisation.

However, rapid uptake of other types of DER, such as PV and battery storage systems, has triggered the need to investigate interoperability standards for DER as a near-term priority. Any standardisation of DER interoperability requirements needs to consider the impact of these standards on EVs and EVSE. Interoperability is discussed further in Section 5.

Should any standardisation of VGI take place, EVs and EVSE sold into the market prior to standards being established may not be capable of compliance with these future requirements, potentially leading to legacy equipment remaining in circulation for many years. Mitigating this point somewhat is the expectation that EVs and home-based EVSE are projected to have useful lifetimes in the order of 10 years, and can be replaced in a relatively straightforward way, thereby limiting the potential size of this legacy fleet. Both these factors should be considered when assessing the timeline for introduction of any VGI standards.

The impact of EV load at times of peak demand is not uniform across the network. As outlined in previous reports that study the potential impact of EVs on distribution networks[14], the emergence of potential network hotspots may be driven by more than just the absolute growth of demand. Drivers of potential network impacts include:

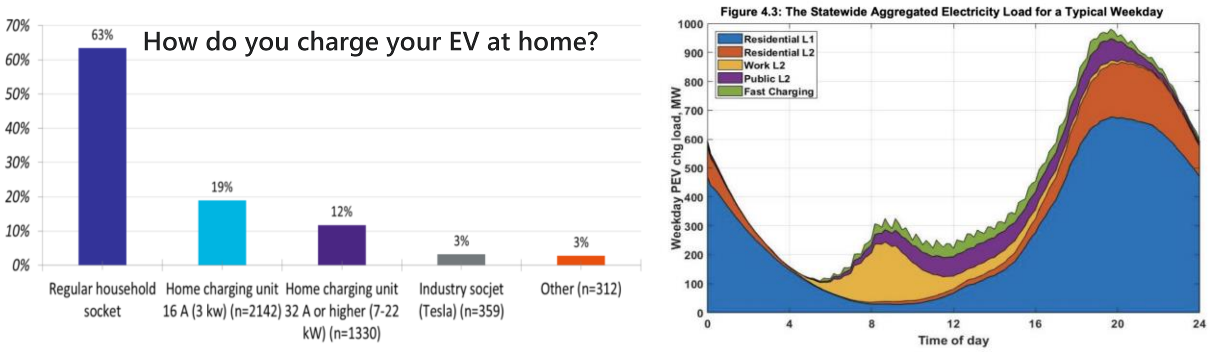
- The coincidence and localisation of demand due to demographic concentrations of potential buyers.
- Coincidence of demand from various typologies of chargers in a region (for example, an electrified bus depot in a region with a high concentration of other types of EV).
- Seasonal peaks caused by movement of EV load, such as in regional holiday areas that may attract EV drivers in concentrated tourism peaks, but where network infrastructure is designed for low population densities.
- The potential for consumers to use existing GPOs for home charging rather than installing dedicated charging hardware.
- The requirement for high-capacity chargers for journey enablement in remote areas where network capacity is already constrained.

Experience from more mature EV markets demonstrates that consumer preference is towards low-cost charging, leading to a general tendency to charge at home via a standard GPO rather than investing in a dedicated home-based EVSE. Figure 4 shows survey results from Norway and modelled 2025 EV charging demand in California, demonstrating a significant preference for home charging via a GPO (denoted 'Residential L1'). However, care needs to be taken when extrapolating overseas studies to Australia, due to differences in driving behaviours, living arrangements, and evolving consumer preferences.

The Taskforce discussed the need to ensure that if standardisation occurs, it proceeds at a speed and in a manner that avoids reducing the competitiveness of the EV industry or impeding consumer flexibility and choice. Many stakeholders raised this as a significant risk, particularly where a standard might lead to changes to vehicle design or additional hardware requirements which could add cost or impose a barrier to entry to the Australian market while EV sales remain low. Other stakeholders questioned the magnitude of this impact in comparison with other Australian-specific vehicle and electrical appliance requirements. Standards development processes will need to continue to work closely with industry to better understand cost drivers and the true impact of any Australian-specific requirements.

[14] Evenergi, 2019, at https://arena.gov.au/assets/2019/03/managing-the-impacts-of-renewably-powered-electric-vehicles-on-distribution-networks.pdf.

Figure 4 Charging preferences in mature EV markets



Sources: Norsk elbilforening – Norwegian EV owner survey 2017 https://elbil.no/wp-content/uploads/2016/08/EVS30-Charging-infrastrucure-experiences-in-Norway-paper.pdf; Projected distribution of Charge Points in 2025 by Scenario and Planning Region according to a study conducted by the California Energy Commission and NREL in 2017 https://www.nrel.gov/docs/fy18osti/70893.pdf.

Despite the potential for hotspots, in the short term these will not drive significant, market-wide network augmentation. There is generally considered to be time for a robust process to establish standards in Australia based on global best practice and alignment across industry; some stakeholders, however, hold the position that some areas of standards need to be progressed in the short term, such as communication and interoperability standards which are already developing for other forms of DER.

Key takeaways

- Any decision to introduce VGI standards must be made from the perspective of EV and non-EV consumers with consideration to the costs incurred across the electricity, transport, and infrastructure sectors.
- Standardisation might help reduce the risk of significant augmentation and operational costs of incorporating large numbers of vehicles into the electricity system, but might also add cost to vehicle and EVSE development or reduce their availability in the Australian market. These impacts will be highly dependent on the area and manner of standardisation.
- Vehicle standards will influence a different supply chain to EVSE standards, and standards imposing hardware requirements will have different cost impacts to those which carry firmware requirements.
- Generally, time is available for comprehensive and collaborative discussion on these matters, noting that DER standards are evolving on a tighter timeline and may also influence the EV sector.

4.4 Focus areas

The Taskforce used the DER Technology Integration Functional Framework[15] developed by GridWise and Farrierswier to identify relevant focus areas for VGI standards.

From an initial set of six functional areas, the Taskforce identified three areas of focus, shown in Figure 5.

In refining the three focus areas, the Taskforce identified a number of topics as out of scope (see Table 3).

[15] See https://arena.gov.au/assets/2020/05/der-technology-integration-functional-framework.pdf.

Figure 5 Identification of VGI standards focus areas

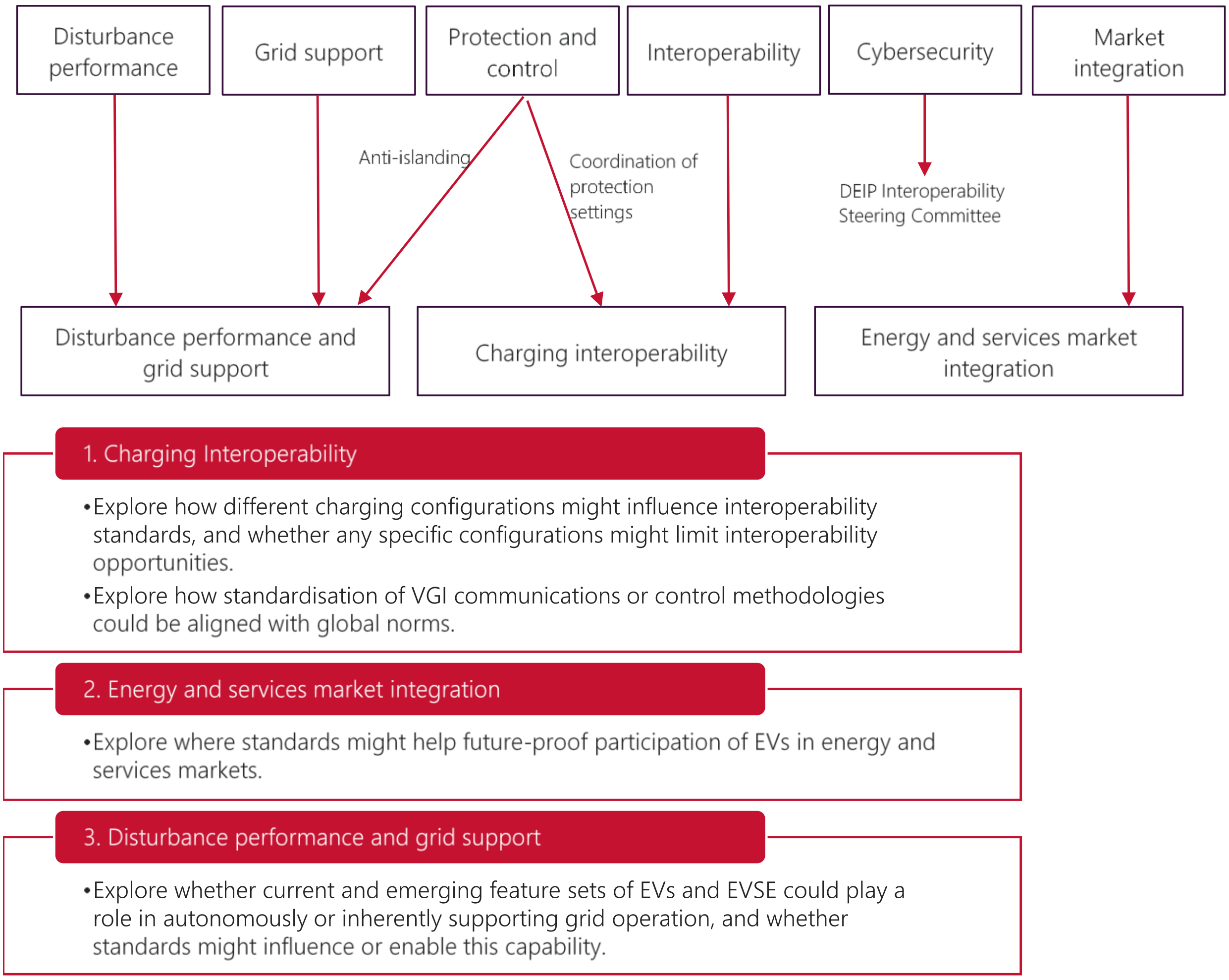


Table 3 Out of scope topics

Topic	Functional area	Reasoning
Remote monitoring and control of device protection settings	Protection and control	Most EV charging equipment does not yet have protection settings to adjust, and this functionality is already under discussion in other forums such as the DEIP Interoperability Steering Committee.
Telecommunications network requirements	Interoperability	Existing telecommunications infrastructure and standards were deemed appropriate for most VGI applications. Other forums exist to discuss situations where these networks may not be suitable, such as during a black start situation.
Cybersecurity	Cybersecurity	Cyber security across the energy sector is currently under consideration by the Commonwealth Government in collaboration with industry stakeholders. In parallel, the DEIP Interoperability Steering Committee will undertake a work program designed to identify the minimum cyber security requirements that will be needed to support the integration and participation of DER in Australia's energy system.

5. Focus area 1: Charging interoperability

This focus area aims to explore how different charging configurations (such as home-based AC charging, AC fast-charging, and direct current [DC] ultrafast-charging) might influence interoperability standards, and whether any specific configurations might limit interoperability opportunities. This section addresses technical interoperability considerations, such as how various devices and actors communicate with each other using standard protocols. Functional interoperability, including the instructions which are sent along these communications links, is addressed in Section 6.

The Taskforce does not express a position as to whether standardisation of interoperability is necessary at this time or in the future, however many Taskforce members expressed the view that any standardisation of communications or control methodologies should be aligned with global standards wherever possible. Interoperability standards for DER are currently developing both internationally and domestically, so the Taskforce believes this is a timely moment to consider how EVs/EVSE will integrate into the broader DER landscape.

5.1 Scope

The specific topics within the scope of this focus area include:

- Communication and information exchange between EVs/EVSE and involved stakeholders to facilitate EV participation in markets/grid services via remote and coordinated monitoring and control.
- Relaying network operating envelopes (specifying technical limits of operation to maintain grid reliability, security and power quality) to sites with behind-the-meter EVs/EVSE and other DER.
- Methods defining type and format of data exchange among involved parties.
- Network requirements for effective control.

Standards in this area are expected to specify protocols for communication, data format, and information exchange mechanisms for system-wide coordination, so that a large volume of devices, components and systems can work together and exchange information. Interoperability is considered across all charging configurations, from home-based GPO charging up to highway ultrafast-charging, noting that requirements could differ significantly between configurations.

5.2 Impact

Interoperability using standardised communication protocols could provide a pathway toward enabling market and network requests for demand shaping to be fulfilled by EVs. A common and interoperable communication platform would enable aggregators and network service providers (NSPs) to broadcast support requests and operating envelopes to EVs and/or EVSE at a whole-of-system level using a single common language. Standardisation could also ensure that EVs and/or EVSE have a minimum level of capability to respond to signals from any of these parties with a degree of portability, lowering the barrier to entry for new entrants and simplifying customer transfer within a competitive market.

However, an interoperable communication platform might also be achieved via market-driven solutions without standardisation. Aggregators and other technology providers could facilitate interoperability via bespoke (not standardised) solutions operating on portions of the EV fleet, with upstream communication to NSPs and market operators coordinated via separate mechanisms. This situation would provide a degree of flexibility for technology providers who would be free to implement novel communications solutions, but might impact on the level of competition available when compared to a standardised solution.

It is important to note that the total available response from EVs may be reduced where only a portion of EVs or EVSE have the capability to respond to market requests, regardless of whether standardisation is used to enable those requests. Similarly, low penetration of devices capable of standardised market integration could reduce consumers' choice of service provider by limiting the portability of these devices to respond to signals from competitive providers. Any decision to standardise in this space should consider the potential impact on total available response and consumer choice, particularly where that decision might influence consumers' preferences to charge via a wall socket without a dedicated EVSE.

The scale and effectiveness of market response to unlocking the benefits of interoperability is yet to be determined. During development of this report a number of pre-market solutions were noted, indicating the importance of a timely assessment in this space. It is recommended that standardisation of interoperability is explored further by the Taskforce in order to quantify any potential benefit of such an approach.

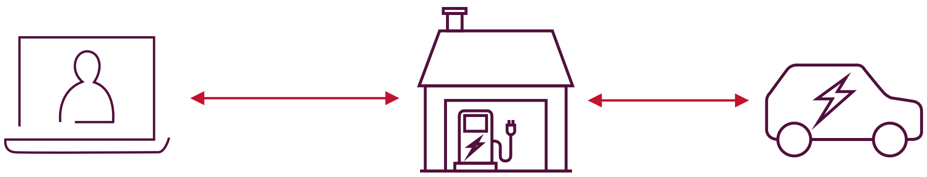
Interoperability of EVs alongside other DER

While EVs share many characteristics with other forms of DER, two key aspects require additional consideration:

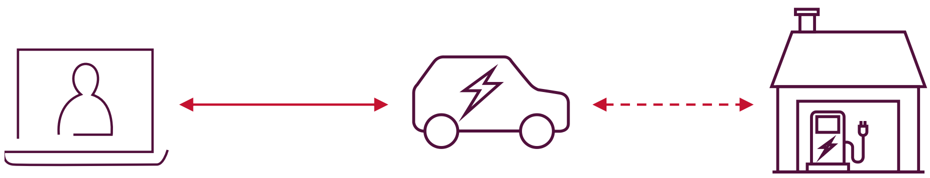
- **Mobile demand** – the key difference between EVs and other forms of network load is that EVs are not stationary devices. As such, there can be multiple pathways for electricity system interoperability: directly to the vehicle itself, via the stationary EVSE, or indirectly via influencing consumer decision-making (such as text-message delivered offers to manually delay charging). If standardisation of interoperability is to be pursued, there may be a need to understand standards for communications with the vehicle as well as the EVSE, as well as between the vehicle and the EVSE. Regardless of whether standardisation is applied, additional layers of intelligence will be required to identify the location or presence of an EV in order to enable interoperability alongside other forms of DER.

Figure 6 Interoperability pathways to mobile devices

Interoperable EVSE relays messages between electricity system and the vehicle



Interoperable vehicle communicates directly with electricity system, and optionally with EVSE to identify site-specific data



Market incentives or other signals influence consumers' charging decisions

- **Pluggable infrastructure** – unlike hardwired DER devices, EVs have the ability to use existing GPO (wall socket) infrastructure, enabling them to plug in and charge at almost any network location. According to a recent report[16] by the Electric Vehicle Council, in Australia over 80% of charging events occur at homes and a significant portion of EV users (86% according to the survey) identify home charging as important. Experience from more mature EV markets demonstrates that consumer preference is towards cost-effectiveness, with this manifesting as a general tendency to charge at home via a standard GPO, rather than investing in a dedicated EVSE at home[17,18]. Observing mature EV markets and noting that a large portion of Australians live in separated lodgings with private parking, charging via a GPO is likely to continue to be the way that many Australian EV users charge vehicles at home for the foreseeable future.

  Market integration of devices without a dedicated, stationary connection point could prove challenging, even where the vehicle itself is acting as the grid interoperating device. Any standardisation of EV interoperability would need to consider whether GPO charging is a viable use case for market integration, and also whether standardisation might influence consumers' choice of charging method.

5.3 Australian standards landscape

No ratified Australian standard was identified that explicitly specifies communication, data exchange and interoperability requirements for system-wide coordination and interaction between EVs and the electricity system, although a draft of AS/NZS 4755.3.4 (discussed further in Section 6.3.1) was written in 2013 and includes an interface specification for remote agents. Within DEIP, the Interoperability Steering Committee[19] is currently considering the specific requirements around interoperability capabilities for DER, including EVs, and is the appropriate forum to continue this discussion.

5.4 International context

The VGI interoperability standards landscape is evolving rapidly, with a diverse range of standards developing across multiple jurisdictions. This report does not attempt to present a comprehensive catalogue of relevant international standards, and instead focuses on key candidates that may be suitable in an Australian context. Direct comparison between standards is challenging due to differences in coverage and intended application; a comprehensive assessment would be required prior to adoption and is outside the scope of this report.

Figure 7 highlights the standards investigated by the Taskforce and indicates their approximate coverage. Note that standards relating to interoperability between EVSE and Charge Station Operators (CSOs), and between CSOs for the purposes of payment portability are out of scope for this Taskforce, however some standards in that space are shown here due to their relevance to VGI interoperability.

Table 4 summarises technical key features of each of the standards identified in this focus area by the Taskforce.

[16] See https://electricvehiclecouncil.com.au/wp-content/uploads/2020/08/EVC-State-of-EVs-2020-report.pdf.

[17] Projected distribution of Charge Points in 2025 by Scenario and Planning Region according to a study conducted by the California Energy Commission and NREL in 2017, at https://www.nrel.gov/docs/fy18osti/70893.pdf.

[18] Norsk elbilforening – Norwegian EV owner survey 2017, at https://elbil.no/wp-content/uploads/2016/08/EVS30-Charging-infrastrucure-experiences-in-Norway-paper.pdf.

[19] See https://aemo.com.au/consultations/industry-forums-and-working-groups/list-of-industry-forums-and-working-groups/deip-isc.

Figure 7 Coverage of major international communication and interoperability standards investigated by the Taskforce

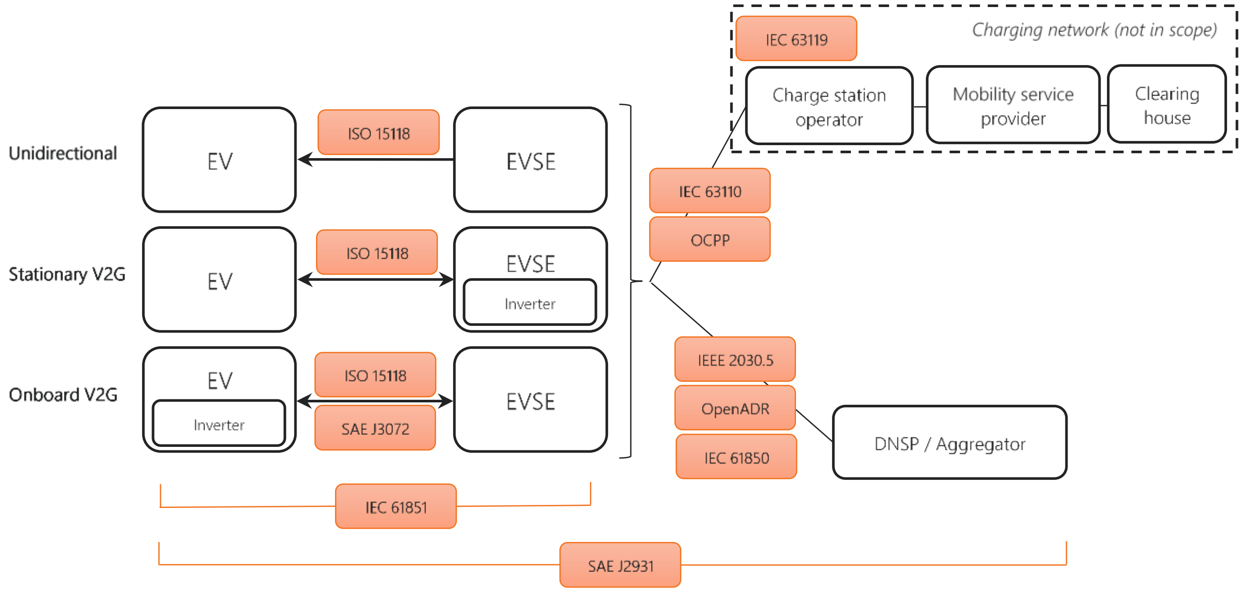


Table 4 Key technical features of major international communication and interoperability standards

Standard	Coverage	Status	Key features
ISO 15118	Communication between EVSE and EV	Active, with ISO 15118-2 specifying network and application protocol requirements. A second generation of these requirements is under development as ISO 15118-20	• Enables EVSE to manage charging/discharging by communicating instructions over a conductive or wireless link to the EV • Calls up elements of IEC 61851 in relation to the physical EVSE to EV connection
SAE J3072	Communication between EVSE and on-board V2G inverter	Active	• Defines the communication framework between the EVSE and the onboard inverter
IEC 61851	Physical and communication specifications for EVSE to EV conductive charging	Active	• Defines the key EV charging modes (AC and DC) • Specifies physical and communications requirements for the 'pilot wire' which carries information between the EV and EVSE, including a PWM signalling technique to allow the EVSE to restrict the charge rate of the EV
OpenADR (IEC 62746-10-1)	Communication between demand response assets (including EVSE) and aggregators/NSPs/market operators	Active, administered by OpenADR Alliance (IEC 62746-10-1 administered by IEC)	• IEC 62746-10-1 provides a formalised standards pathway for the OpenADR 2.0b protocol • Defines a communications framework to interact with demand response assets

Standard	Coverage	Status	Key features
IEEE 2030.5	Communication between DER devices (including EVSE) and aggregators/NSPs/market operators, as well as between devices on a Home Area Network (HAN)	Active	• Also referred to as Smart Energy Profile 2.0 (SEP 2.0) • Recent versions of the standard allow for interoperation with ISO 15118
IEC 61850	Communication between grid assets, including EVSE	Active	• Originally developed for use within electrical substations • IEC TR 61850-90-8 describes object model for eMobility
Open Charge Point Protocol (OCPP)	Communication between EVSE and the CSO	Active, administered by the Open Charge Alliance	• Provides CSO with a means of remotely managing EVSE • Recent versions of the standard allow for interoperation with ISO 15118
IEC 63110	Communication between EVSE and the CSO	Under development	• Primary focus is charging management from perspective of CSO, but provides interoperability pathways to other grid operations standards such as IEC 61850 • Standard is being developed with close liaison to OCPP team
IEC 63119	Communication between CSOs, mobility service providers and clearing houses	Under development	• Provides billing, roaming and similar services
SAE J2931	Communication upstream of the EV to multiple devices and actors	Active	• Establishes the requirements for digital communication between EVs, EVSE, energy service provider, advanced metering infrastructure, and home area network

The Taskforce was not able to identify any demonstrated application of formal standards specifying communications from a remote agent directly to the vehicle without using the EVSE as an intermediary, however IEEE 2030.5 does consider this use case and might prove relevant for this communications pathway in the future. Taskforce members understand that bespoke protocols developed by vehicle and equipment manufacturers are widely used to perform this function but are not publicly documented or made available for third parties to utilise.

Analysis and feedback from Taskforce members identified ISO 15118 as the leading international standard for EV to EVSE communication, as it offers a comparatively more advanced communication framework than IEC 61851. For example, ISO 15118 defines requirements for charging load management; metering and billing which are not covered in IEC 61851, thereby making the ISO 15118 framework more relevant for smart charging applications. It is noteworthy that ISO 15118, including the proposed second-generation requirements in ISO 15118-20 that specify smart charging, grid support and V2G functionality, has not yet established widespread adoption in Australia.

IEEE 2030.5, OpenADR, and IEC 61850 are candidates for further investigation for their role in establishing a communication and data exchange framework between EVs (via EVSE) and DNSPs/aggregators. Within DEIP, the Interoperability Steering Committee is investigating suitable communications protocols for DER more generally, with IEEE 2030.5 proving to be a lead contender. However, OpenADR (and its formalised version, IEC 62746-10-1) is well established in demand response applications internationally and may also prove relevant for VGI purposes.

Key takeaway

Many international standards are available that specify communications pathways between the electricity system and EVs via EVSE, however no single set of standards has yet become dominant worldwide. Communications direct to the vehicle is predominantly managed through bespoke, privately-owned systems.

Further detail on the standards discussed in this section can be found in Appendix A1, as well as a summary of other key standards in the EV landscape.

5.5 Standards development

Most of the standards listed in Table 4 are under active development, with ISO 15118-20 of particular interest to some Taskforce members due to its proposed smart grid functionality.

Within Australia, the National Low and Zero Emissions Vehicle (LZEV) working group reporting to the Infrastructure Transport Ministers Meeting is currently working with industry to assess the need for national interoperability standards for charging infrastructure from the perspective of common payment platforms and motorist accessibility. While out of scope for the Taskforce, this work is of interest due to the potential of protocols such as OCPP and IEC 63110 to also play a role in the VGI standardisation landscape.

OCPP is a widely used protocol in the EVSE to CSO domain. OCPP is not administered by an internationally recognised standards body, but work is underway to develop a similar standard in the form of IEC 63110. The Taskforce should continue to monitor the development of this standard as well as the work underway in the LZEV working group to ensure any decisions on interoperability consider the latest developments internationally and domestically.

National Low and Zero Emissions Vehicle (LZEV) working group

In November 2018, the Transport and Infrastructure Senior Officials Committee agreed to establish a national working group with representatives from the Commonwealth and state and territory governments and Austroads to develop a national work program to address the barriers to the uptake of LZEVs. As part of this program, Queensland's Department of Transport and Main Roads is leading development of two feasibility studies:

- Developing interoperability standards such as common payment platforms that improve motorist accessibility to LZEV charging infrastructure.
- Developing data sharing and exchange standards for LZEV charging infrastructure and energy data, while preserving personal privacy and commercial confidentiality.

Recommendations from this work will be considered by representatives from the Infrastructure and Transport Ministers Meeting group.

5.6 Further considerations

Taskforce members indicated that the vehicle component supply chain typically designs their products to cater for a broad range of international standards requirements within a single generic part. Therefore, any standardisation of communication links to these vehicles would risk impacting on vehicle model availability within Australia unless international norms were followed. Standardisation of communication links to EVSE might not have the same impact from a vehicle perspective, but would also need careful investigation to ensure both the transport and energy industries are able to achieve a cost-effective, interoperable suite of products and services.

A major challenge with interoperability standardisation is that there is a broad range of candidate standards which are not all well aligned with each other, and each standard carries different capabilities across overlapping coverage areas. Selection of any given standard therefore needs to consider a wide range of other standards to assess at a framework level, as well as whether industry can deliver on a technical solution to meet the proposed framework.

Key takeaways

The decision about whether to standardise interoperability requirements for EVs and/or EVSE requires careful consideration and close collaboration across industry, as there could be both positive and negative impacts on EV consumers in terms of product cost, availability and compatibility, as well as on EV and non-EV consumers in terms of network costs.

- Establishing a standardised communications protocol from electricity system actors directly to EVs may be challenging, due to a lack of established candidate standards in that space and the international norm of using bespoke protocols for that purpose.
- Standardising communications from electricity system actors to EVSE might rely on an interoperable protocol existing between EVSE and EVs (such as ISO 15118 or IEC 61851), particularly for AC EVSE where the EV itself has control over the charging rate in accordance with limits set by the EVSE. Decisions in this space need to be made from a framework perspective to ensure consistency with other sectors, such as the common payment platform being discussed within the LZEV working group.

6. Focus area 2: Energy and services market integration

This focus area explores where standards might help future-proof participation of EVs in energy and services markets. This includes the functional aspects of interoperability, such as the instructions and queries that are sent across communications channels to facilitate market integration. Technical interoperability, including the ways in which devices and actors establish communication across these channels, is covered in Section 5.

The Taskforce does not express a position as to whether standards are necessary to facilitate market integration. However, it is recognised that standards already exist in Australia that will influence the integration of EVs into energy and services markets. This section explores the potential impact of these standards and highlights where they might interact to influence the development of EVSE.

6.1 Scope

The scope of this focus area includes the following topics:

- Demand response service provision.
- Participation in wholesale energy markets, reserve services, and ancillary service markets.
- Rules, technologies, and communication protocols for EV participation in energy/service markets.

The standards in this area cover market participation behaviours of EVs as well as protocols for communication, information exchange, and device performance to facilitate system-wide coordination of EVs within energy and services markets.

6.2 Impact

By capturing the flexibility of EVs through facilitating their participation in energy and services markets, it may be possible to reduce the cost of operating the electricity system. Conversely, if EVs are not able to participate in these markets, it may be difficult to harness or incentivise flexible charging behaviours, leading to less efficient system operation.

Market participation can be financially attractive for EV owners, due to the incentives for providing various market-driven services and the access to low-cost energy that active market participation can provide.

Increased market participation by EVs could reduce the overall system and network operating cost for all consumers, with or without an EV, by facilitating more efficient use of shared infrastructure.

Standardisation can help facilitate market participation by increasing the number of devices being deployed with market integration capability. However, standards are not the only pathway to capture charging flexibility; for example, a text message to owners' mobile phones might provide a simple way to incentivise a shift in their charging behaviour, and would not require a new device standard to implement. Programs such as Energy Australia's 'PowerResponse', Powershop's 'Curb Your Power', and United Energy's 'Summer Saver' have all used this method to incentivise targeted demand reduction behaviour at a whole-of-household level. Similar schemes could be used to specifically target EV charging behaviour, based on financial or other incentives.

Consumer participation

In addition to EVSE (and/or EVs) being capable of communication with a back-end DER control system, market or program participation will rely on consumers enrolling or opting in to an aggregation plan or control scheme. Uptake rates of such schemes will vary based on the incentives available and the degree of flexibility offered to the consumer. Lessons can be learned from existing schemes, however consumers' ability to modify their charging behaviour, and the value they place on maintaining their preferred behaviour, will not necessarily align to those experienced with other appliances such as air conditioners and hot water services. Generally, the capacity available to a scheme at a given time will be influenced by:

1. The total number of installed devices in the relevant asset class.
2. The proportion of those devices targeted by the scheme.
3. The proportion of targeted devices compatible with the scheme.
4. The proportion of consumers who own a suitable device, are enrolled in the scheme, and choose to participate at the time of the event.
5. The proportion of the enrolled devices operating in a suitable state at the time of the event.

As a specific example, the above factors can be used to assess the available capacity of response from EVs operating within a hypothetical demand response scheme:

1. EV uptake is projected to increase significantly from the mid-2020s, growing the total installation pool.
2. Home-based charging is likely to remain popular and represents a more deferrable charging option than public charging, where the consumer may have firmer time constraints on satisfying their charging requirements. This makes home charging a potential target for demand management schemes.

3. The operator of the demand response scheme would need to select an appropriate interoperability pathway (see Figure 6), and a communications protocol if the scheme is to be automated. Standardisation of communications protocols would potentially increase the pool of compatible devices available to automated schemes.
4. Consumers' choice to enrol in the scheme will be influenced by many factors, including the incentives available and their level of flexibility with regards to charging. Consumers are likely to be more flexible regarding EV charging than they are for home cooling, considering the immediacy of thermal comfort.
5. Due to the flexible nature of charging, consumers who are interested in minimising their charging costs are likely to respond to broad existing incentives such as time-of-use tariffs, and consumers with rooftop solar may seek to align their charging with their PV generation. These consumers are also likely to be receptive to incentives to enrol in demand response programs, however their existing behaviour makes it less likely that they will be charging (and therefore available to respond) at the time of an event during the late-afternoon peak demand period. This represents a key difference between EV charging and home cooling; given that summer peak demand periods are typically driven by widespread operation of air conditioners, a large proportion of them are likely to be available at the time of a demand response event.

Design of aggregation plans and control schemes will need to take these characteristics into account to maximise participation rates and to achieve a predictable response from the scheme. Further investigation is required to determine appropriate incentives to encourage consumers to enrol in aggregation or control schemes for EV charging. The Working Group has established a Residential Tariffs and Incentives taskforce to explore this area for home-based charging.

The Working Group previously identified 'Understanding Consumers' as a valuable area of future activity[20] and imperative to informed decision-making in this focus area. Such a body of work would undertake outreach to EV using and non-EV using consumers of a diverse range of backgrounds to understand the potential for engaging in market-supporting activities through EV ownership, including the level of intervention deemed appropriate by consumers and the necessary level of incentive and education to achieve engagement.

6.3 Australian standards landscape

In this focus area, most regulation of device performance and communication protocols is implemented via market rules, such as those governing the connection of large-scale generation to the grid. However, AS/NZS 4755 is a standard designed to facilitate demand response from specific categories of consumer devices, through market or non-market mechanisms. In late 2019, the COAG Energy Council agreed[21] to introduce AS/NZS 4755 (or an equivalent international standard) to certain types of EVSE from July 2026[22]. The decision Regulation Impact Statement (RIS) states that an E3 technical working group will be established to determine, by mid-2022, whether an equivalent international standard can be used as an alternative to AS/NZS 4755. This decision RIS was preceded by a consultation RIS[23].

AS/NZS 4755 specifies the minimum demand response capabilities of smart devices, including the ability to increase, decrease, stop, and start using power (sometimes at variable rates). The standard specifies various Demand Response Modes (DRMs) for different equipment classes. For example, DRM 1 for an air conditioner turns the compressor off and DRM 2 reduces its operation to 50% of rated capacity. The standard provides the capability for large aggregations of DER – both generation and load – to respond in a predictable manner and achieve different levels of standardised dispatch targets. Equivalency in this manner is critical as it means generation and load will respond in the same manner and can dispatch in controlled and understood ramps, just as large-scale generating plants are required to do for system balancing purposes.

[20] See https://arena.gov.au/assets/2020/05/electric-vehicle-grid-integration-working-group-post-workshop-summary-pack.pdf.

[21] See https://www.energyrating.gov.au/news/smart-demand-response-decision-ris-approved.

[22] See page 66 in https://www.energyrating.gov.au/sites/default/files/2020-01/smart_appliance_decision_ris.pdf.

[23] See https://www.energyrating.gov.au/sites/default/files/documents/Consultation%20Paper%20-%20Smart%20Demand%20Response%20Capabilities%20for%20Selected%20Appliances_0.pdf.

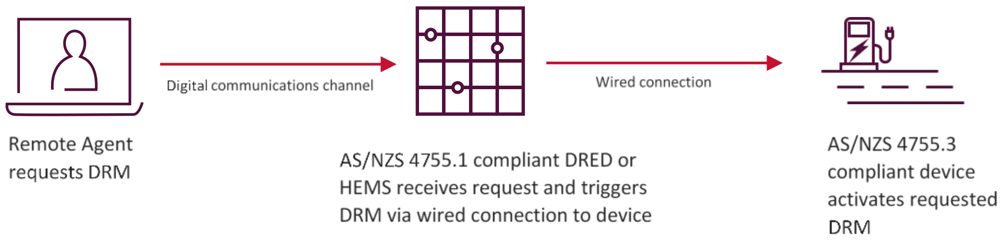
There are two compliance pathways to consider within the AS/NZS 4755 framework:

- AS/NZS 4755.1 pathway, using a Demand Response Enabling Device (DRED).
- DR AS 4755.2 proposed pathway, using communications protocols built-in to the appliance.

6.3.1 Existing AS/NZS 4755.1 pathway

The AS/NZS 4755.1 pathway involves specific electrical appliances (such as air conditioners and pool pumps) activating DRMs in response to triggers from a separate DRED, hardwired to a connector on the appliance. In this pathway, the DRED must comply with AS/NZS 4755.1, with the appliance conforming to the appropriate part of AS/NZS 4755.3. Alternatively, DRMs on AS/NZS 4755.3 electrical appliances can be activated by a Home Energy Management System (HEMS) acting as a DRED, so long as it is connected to, and electrically compatible with, the physical interface on the appliance.

Figure 8 DRM activation using AS/NZS 4755.1 pathway



Key dates relating to this pathway include:

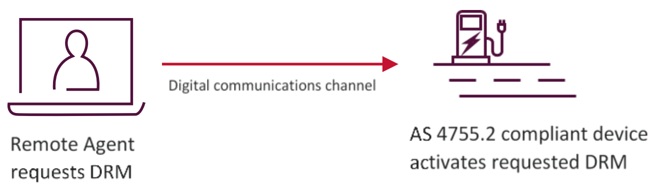
- AS/NZS 4755.1 was published in April 2007 and established the basic architecture of a DRED that could be separate to or integrated in electrical appliances.
- AS/NZS 4755.3.1 was published in December 2008 and introduced operational instructions and connections specific to air conditioners.
- A draft version of AS/NZS 4755.3.4 was released for public comment in 2013 and proposed operational instructions and connections for EVSE. This version was never released for implementation, so at this time there is no pathway available to use a AS/NZS 4755.1 DRED to activate DRMs on EVSE.
- COAG Energy Council requested Standards Australia to 'expedite completion and publication of AS/NZS 4755.3.4' in the October 2019 decision RIS.

Taskforce members noted that if AS/NZS 4755.3.4 were to be established, a compliant solution would likely require development of EVSE hardware unique to Australia. This might lead to consequent cost and consumer choice impacts, given Australia makes up a small portion of the global EVSE market.

6.3.2 Proposed AS 4755.2 pathway

The proposed AS 4755.2 pathway would provide a mechanism for electrical appliance to activate DRMs without the need for a separate DRED. Under this mechanism, the essential cyber security, communications, and operational instructions of the DRED would be supported by the electrical appliance itself. Since a DRED would not be required, this pathway would not require a dedicated physical interface on the appliance to activate the standardised DRMs and deliver the predictable electrical response.

Figure 9 DRM activation using AS 4755.2 pathway



While AS/NZS 4755.1 operates in conjunction with AS/NZS 4755.3 parts, AS 4755.2 would operate with appendices covering individual appliance types to define specific behaviours. There are draft appendices covering air conditioners, pool pumps, hot water heaters, and battery storage systems; however, an appendix for EV charging equipment in AS 4755.2 is yet to be included. The current draft of standard AS 4755.2 is structured such that it has the potential to cover EVs in future. COAG Energy Council requested Standards Australia to 'expedite completion and publication of AS 4755.2' in the October 2019 decision RIS.

6.4 International context

Participation in energy and services markets is typically governed by market rules[24], especially in countries with higher DER penetration rates. The NEM is no exception; the Wholesale Demand Response (WDR) guidelines[25] will define the mechanism for market participation either directly or via demand response service providers. Some market rules, such as California's 'Rule 21' governing generation facilities connected to a distribution system, call up standards to implement elements of the communications pathway.

Functional features of key standards relevant to this focus area identified by the Taskforce are summarised in Table 5.

Table 5 Functional features of international standards relevant to energy and services market integration

Standard	Purpose	Key features
IEEE 2030.5	Defines an application layer to enable remote management of end user energy assets	• Also referred to as Smart Energy Profile 2.0 (SEP 2.0) • Specifies functionality in areas such as demand response, load control and time of day pricing for a range of controllable DER devices, including EVs • Includes capability for grid services and market interactions of DER
OpenADR (IEC 62746-10-1)	Defines communications framework to interact with demand response assets	• IEC 62746-10-1 provides a formalised standards pathway for the OpenADR 2.0b protocol • Provides a two-way information exchange model for dynamic price and reliability signals • Used widely in commercial and industrial demand response applications, but also applicable for EVSE and HEMS
OCPP	Defines an application layer to enable remote management of EVSE by a CSO	• Smart charging functionality implemented from version 1.6 onwards, enabling remote charging management such as demand response • Interoperable with ISO 15118 from version 2.0.1
ISO 15118	Defines a communications interface between an EV and EVSE	• Enables EVSE to manage charging/discharging by communicating instructions over a conductive or wireless link to the EV • ISO 15118-20 (under development) will include provisions for grid assistive smart charging and frequency control • Market signals would need to be conveyed via another protocol such as IEEE 2030.5 or OpenADR

Additional detail on these standards can be found in Appendix A1.

[24] See https://www.nrel.gov/docs/fy19osti/70630.pdf.

[25] See https://www.aemc.gov.au/sites/default/files/documents/final_determination_-_for_publication.pdf.

6.5 Standards development

While many of the standards listed in this report are under active development, the upcoming changes relating to AS/NZS 4755 were identified as a key area of interest to the Taskforce. Discussion focused on several open areas of consideration:

- How the 2019 COAG decision to apply AS/NZS 4755, or an equivalent international standard, to EVSE will be finalised, including:
  - The process by which candidate international equivalent standards will be assessed.
  - The legislative instrument that will be used to call up the standard.
- Whether an AS/NZS 4755.3 DRED-based requirement for EVSE will be introduced – noting that many stakeholders consider this pathway a poor choice due to the resulting need to produce Australian-specific hardware to comply with the interface specification.
- Whether AS 4755.2 will be introduced in time for the July 2026 compliance date for certain categories of EVSE, and how an appendix to specify appropriate communications methods for EVSE will be developed

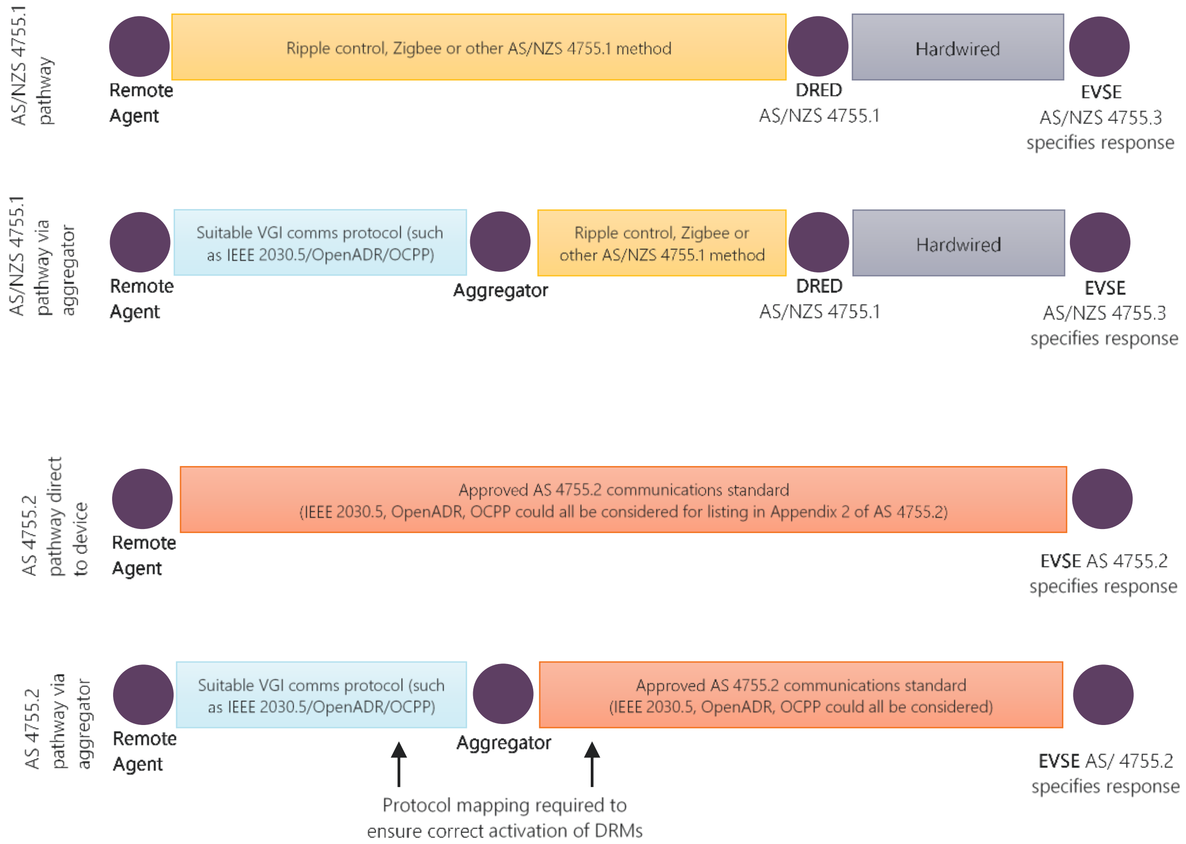
Utilising the AS 4755.2 pathway would allow EVSE manufacturers to implement DRMs via a communications channel built into the device rather than requiring a AS/NZS 4755.1-compliant DRED. Given that many smart EVSE already include communications capability, this option was considered a preferential option by many Taskforce members, as it could avoid the need to develop an Australian-specific hardware design (which might lead to reduced model availability or higher product cost to consumers).

Application of AS 4755.2

- AS 4755.2 specifies the behaviour of DER devices providing demand response services. It leaves the communication framework between the remote agent and the DER device open, but specifies the minimum information which is required to be conveyed in the demand response command as well as the physical capability and test procedures of the device providing demand response.
- Conversely, communications standards such as OpenADR, OCPP and IEEE 2030.5 define the communication and information exchange protocols to transmit demand response commands between remote demand response agents and the DER device (which could be a vehicle, an EVSE or a local management system, such as home energy management system), but do not specify the response itself.
- Appendices can be added to AS 4755.2 to detail appropriate communications methodologies or standards (such as OpenADR, OCPP, or IEEE 2030.5), which can then be used to satisfy compliance

AS 4755.2 and demand response communication standards are not interchangeable, but they could be complementary as indicated in Figure 10. It is key to note that interoperability between these standards is crucial for them to function together as part of a framework. Many of the standards in this section can provide load control functionality independently, however they require a standard such as AS 4755.2 to deliver standardised response capabilities.

Figure 10 Comparison of potential demand response standards pathways



Key takeaways

- Communications standards like IEEE 2030.5, OpenADR, and ISO 15118 could work in conjunction with AS 4755.2 to provide a complete interoperable demand response framework for EVs, including communications, information exchange, response specification, cybersecurity requirements, and test procedures.
- Industry, government, and the relevant standards committees need to work together to establish a clear pathway to meet the requirements of the 2019 COAG RIS decision to apply AS/NZS 4755, or an equivalent international standard, to some categories of EVSE from 2026. This work should include engagement with the E3 technical working group which will be established to determine, by mid-2022, whether an equivalent international standard can be used in place of AS/NZS 4755.

6.6 Further considerations

The recent Federal Energy Regulatory Commission (FERC) Ruling 2222[26] (September 2020) in the US enables behind-the-meter DER, including EVs, to participate in the regionally organised wholesale capacity, energy, and ancillary services markets alongside traditional resources. The FERC decision requires regional grid operators to detail how aggregators will register and operate DER in these markets, which may or may not include the application of formal standards. Ongoing attention to the outcome of this decision could help inform the development of Australian DER policy, including standards development within this focus area.

[26] See https://www.ferc.gov/sites/default/files/2020-09/E-1-facts.pdf.

OpenADR is increasingly being adopted in many countries for demand response and other energy/service market messaging. Research to date has not identified any international standards implementations that specify minimum demand response capabilities in terms of operations and physical response. Australia has approached this by separating communication and physical response requirements with the AS/NZS 4755 framework. This creates a pathway for equipment to have a set of minimum capabilities that can be activated by remote agents over an appropriate communication channel.

7. Focus area 3: Disturbance performance and grid support

This focus area explores how current and emerging feature sets of EVs and EVSE interact with grid operation. The feature sets in this section relate to autonomous or inherent capability of EVs and EVSE, as opposed to the previous two sections which focus on remotely managed capability. The Taskforce does not express a position as to whether additional standards are needed in this space; the intent is only to outline the functioning of any power system and how this operation may be influenced by the high uptake of EVs for awareness and consideration. The Taskforce also notes that Australian standards already exist that regulate aspects of disturbance performance and grid response modes for V2G bi-directional chargers.

7.1 Scope

The scope of this focus area includes the autonomous specifications and capabilities of EVs and EVSE that may enable them to withstand power system disturbances and perform in a way that does not exacerbate the disturbances. The scope also includes the capabilities of EVs and EVSE to deliver grid-support functionality during normal grid conditions.

Disturbance withstand capabilities in this focus area include capability to withstand voltage and frequency disturbances, delivering fault ride-through capability to ensure uninterrupted operation during power system faults both in the vicinity of, and remote from, the equipment.

Further to disturbance withstand, this focus area includes autonomous grid-support capabilities such as:

- Voltage response, such as autonomously changing active and/or reactive power to help maintain:
  - Voltage balance between phases.
  - Voltage levels within desired network voltage levels.
- Post-interruption performance specifying how EVs/EVSE behave after an interruption of supply.

7.2 Impact

Undesirable operation of many similar grid-connected devices during a disturbance can negatively impact power system security by exacerbating the disturbance, especially when AEMO/NSPs have limited visibility of the location and capacity of the assets. Maintaining system security under these conditions at high EV penetration levels might necessitate operation of the power system with additional operating margin to account for potential sudden mass disconnection of generation or load, increasing costs which are ultimately passed on to consumers. Similarly, large numbers of EVs charging under normal grid conditions without providing autonomous grid responsiveness might necessitate additional investment in network infrastructure to maintain network operating parameters, again increasing costs passed on to all consumers.

Further, distribution networks have a limited capacity to host additional load or generation, necessitating augmentation investment or device curtailment once voltage or current capacity limits are reached. This situation is already evident in areas of high PV penetration, where voltage rise issues can trigger inverters to shut down at times of high net generation. Under these conditions, DNSPs may place limitations on consumers seeking to install new PV systems, or network augmentation may be triggered. Grid-support mechanisms such as volt-var response can assist by enabling more efficient use of the available hosting capacity and are a relevant consideration for EV charging.

Key takeaway

Performance standards are one way to achieve disturbance performance and autonomous grid support capability from devices such as EVs and EVSE. If these devices were to have inherent, autonomous capability to support power system operation, it may be possible to avoid operating the system in a more costly manner to accommodate their additional demands. Operating costs are borne by all electricity consumers, not just EV owners, so efficient operation of the system is of key importance to a wide range of stakeholders.

7.3 Australian standards landscape

The Australian standard for grid connection of energy systems via inverters, AS/NZS 4777.2:2020, specifies the expected performance and behaviour of grid interactive inverters connected at low voltage (such as households or small-scale commercial) and the necessary tests for compliance. This standard is called up by distribution network service provider (DNSP) network connection agreements, meaning that only compliant inverters will be approved for connection to the network. The standard includes flexibility to allow DNSPs to determine response time parameters specific to their network, within ranges defined by the standard. AS/NZS 4777.2 applies in conjunction with the regulations, service, and installation rules of the relevant DNSP as well as the AS/NZS 3000 wiring rules.

AS/NZS 4777.2 applies to grid interactive inverters (that inject power into the grid), including bidirectional V2G inverters. Unidirectional chargers do not contain a grid-injecting inverter and are therefore not covered by this standard. High capacity inverters or high voltage connections outside the scope of AS/NZS 4777.2 may require specific negotiation with the DNSP.

The key requirements/specifications covered in AS/NZS 4777.2:2020 include:

- Harmonic current distortion limits.
- DC current injection limits.
- Balanced current injection requirements.
- DRED equivalent to AS/NZS 4755.1.
- Volt-watt, volt-var, and volt balance requirements.
- Ramping limits.
- Active anti-islanding protection requirements.
- Passive anti-islanding protection requirements, including under- and over-voltage protection, and under- and over-frequency protection.

- Frequency response requirements.
- Disturbance withstand capability including short voltage and frequency excursions, voltage phase shift, multiple disturbances, and rate of change of frequency (RoCoF).
- Measurement accuracy requirements.

AS/NZS 4777.2:2020 includes a three default settings schedules suitable for application to a range of Australian networks, as well as a range of acceptable settlings that may be used to suit particular use cases. The DNSP is responsible for specifying any settings outside the defaults.

7.4 International context

Most regional NSPs have distribution grid codes specifying the disturbance withstand and grid-support requirements for grid-connected DER assets. These distribution grid codes do not generally consider performance requirements for load-only DER, and typically focus on generation DER.

In many North American jurisdictions, a standards-based approach is implemented to apply the relevant distribution grid code. Where standards are adopted partially or in their entirety, network operators generally include some additions and implementation prescriptions. IEEE 1547, UL 1741 and UL 62109 define standards for DER interconnection with electric power systems interfaces and specify requirements for inverters, converters, controllers, and interconnection system equipment used for grid-integration of DER assets. Specifically for EVs, SAE J3072 defines interconnection requirements for onboard V2G inverters. However, it only focuses on information exchange between the inverter and EVSE, including configuration management of the onboard inverter. The performance requirements of the inverter need to be governed by a separate standard or grid code used in conjunction with SAE J3072.

The landscape across Europe is slightly different to that in Australia and the US. Most countries use specific grid codes defining the grid-support framework for DER, due to the complexities of country-to-country interconnection.

Appendix A1 contains a catalogue of relevant national and international standards, and briefly summarises coverage of standards by specific topics of this focus area.

7.5 Standards development

EV interaction with the grid falls under three main categories:

- Unidirectional charger (considered to make up the majority of the charger fleet).
- Stationary V2G (inverter built into EVSE, DC connection between EV and EVSE).
- Onboard V2G (inverter built into EV, AC connection between EV and EVSE).

AS/NZS 4777.2:2020 was published in December 2020 and specifically notes that it is applicable to inverters used for V2G. The standard has a 12-month implementation timeframe, and as such all new devices connected subsequent to 18 December 2021 require certification to this standard.

The requirements specified in this standard are applicable to both V2G interconnection of EVs via a stationary EVSE and mobile V2G interconnection where an onboard inverter exports power from the vehicle via a pluggable connection. Following the recent publication of AS/NZS 4777.2, further investigation will be required by industry to understand its impact on on-vehicle inverters and the mechanisms that will apply the standard to this category of inverters (such as network connection agreements).

The Working Group can play a role in connecting the energy sector with the automotive industry to better understand the impact of AS/NZS 4777.2:2020 on V2G EVSE, particularly regarding the costs and benefits associated with the implementation of this standard. However, it is worth noting that because it is an established standard, the Working Group does not have any specific influence on AS/NZS 4777.2, over and above what any other stakeholder does.

Key takeaway

AS/NZS 4777.2 is an established standard applicable to bidirectional V2G inverters, including both stationary and on-vehicle inverters. However, no established Australian or international standards have been identified in relation to disturbance performance and grid support capability for unidirectional chargers, which will likely make up the majority of the charging fleet for many years to come. It is recommended that the Working Group continues to investigate whether any of the provisions within AS/NZS 4777.2 or emerging international standards may be relevant for future discussion on the capability of unidirectional chargers to respond to grid conditions.

Appendix A1 provides a list of identified international standards that cover or partially cover topics aligned with this focus area, along with notes on coverage and potential applicability of the standard.

7.6 Further considerations

The US jurisdiction of California recently amended[27] California Public Utilities Commission Rule 21[28] to clarify specifications for the interconnection of bi-directional EVs. The amendment discusses SAE J3072 and recommends alignment between this standard, which covers grid integration of onboard V2G inverters, and other standards such as IEEE 1547. Some Taskforce stakeholders consider SAE J3072 as a key standard for further consideration by industry and believe onboard AC inverters to be a potentially important part of the future VGI landscape. The impact of applying standards to vehicles is discussed further in Section 4.2, and is a relevant consideration for SAE J3072 or any other standard applicable to onboard V2G inverters.

In addition to implementation, standard compliance was an area identified as important by the Taskforce. AEMO has previously identified that only 60% of the grid-connected rooftop PV inverters installed since 2016 comply with the mandatory requirements of AS/NZS 4777.2 and regional distribution grid codes[29]. Compliance will be a key element to consider as EV uptake rises, to ensure any applicable devices are performing in the expected manner.

8. VGI standardisation landscape

Standardisation is a broad topic, with a variety of formal and informal pathways available to progress the development and implementation of standards. Once a standard has been developed, it is also necessary to address the legislative or regulatory instruments that specify how that standard will be applied. Additionally, multiple support functions including testing, compliance, audit, and certification bodies are necessary to establish a complete standards framework. This section contains a brief overview of potential pathways relevant to VGI standardisation.

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[27] See https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M345/K380/345380320.PDF

[28] See https://www.cpuc.ca.gov/Rule21/.

[29] See https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/standards-and-connections/as-nzs-4777-2-inverter-requirements-standard.

8.1 Formal standardisation pathways

Australian Standards are voluntary specifications and procedures developed by consensus aiming at establishing a minimum quality and safety requirements of products, services, or systems. Many standards are mandated and adopted into legislation at a state or federal level.

Standards Australia facilitates the development of internationally harmonised standards and other solutions that make a positive contribution to Australia. As Australia's peak standard body, Standards Australia represents Australia at the major global standard development organisations, such as the International Electrotechnical Commission (IEC) and the International Organisation for Standardization (ISO).

To avoid unnecessary duplication, Standards Australia's policy is to use existing international standards as a foundation for adoption and modification to deliver a net benefit to the Australian community. The Standards Australia standards development process is based on three internationally recognised principles:

- Openness and transparency of process.
- Consensus.
- Balance of representation.

IEC and ISO standards are preferred standards for potential adoption or modification, due to their alignment to the recognised principles listed above. Other than IEC and ISO, there are regional and international organisations developing and recommending EV standards and practices. These include the Institute of Electrical and Electronics Engineers (IEEE), the Society of Automotive Engineers (SAE), and Underwriters Laboratories (UL) in the US.

Standards Australia recently signed a memorandum of understanding with IEEE for standards adoption, which may open the door for increased adoption of IEEE standards.

Table 6 captures the major IEC/ISO/AS/IEEE committees and subcommittees working in the EV standardisation landscape.

Table 6 Major standards committees relating to EVs

Committee	Organisation	Focus and scope	Relevant standards
TC 69	IEC/ISO	• General (for example, safety, EMC, construction, testing) and functional requirements (such as charging modes) for electrical power/energy transfer systems for electric road vehicles and electric industrial trucks • Communication between the EV and supply equipment • Management of the corresponding infrastructure in view of offering associated value-added services • Australia is a participating member of the IEC 63119 committee	IEC 61851 IEC 63119 ISO 15118
TC 23/SC 23H	IEC	• Plugs, socket-outlets and couplers for industrial and similar applications, and EVs • Connection products intended for the connection of EVs to the supply network and/or to dedicated supply equipment • Australia is a participating member of the IEC 62196 committee	IEC 62196
TC 21/SC 21A	IEC	• Product and test specifications for all secondary cells and batteries of sealed and vented designs containing alkaline or other non-acid electrolytes	IEC 62133

Committee	Organisation	Focus and scope	Relevant standards
EM-001	Standards Australia	• Prepares and adopts standards for EVs to pave the smooth entry of EVs into the Australian market • Aligns Australian EV landscape with the international community and represents Australia in various international standardisation committees, especially IEC and ISO committees related to EVs	AS IEC 61851 AS IEC 62196
EL-042	Standards Australia	• Renewable energy power supply systems and equipment	AS/NZS 4777
EL-054	Standards Australia	• Remote demand management of electrical products	AS/NZS 4755
TEC Standard committee	IEEE	• Identify standardisation gaps and opportunities in transportation electrification • Promote transportation electrification standards and standardisation efforts	IEEE 2030.5

8.2 Alternative standardisation pathways

Developing national consensus Standards is a structured and potentially time-consuming process. However, there are instances where a normative or informative technical document is required, and traditional consensus standardisation may not deliver a solution in the needed timeframes. A document supported by a lower level of consensus and transparency may meet the needs of stakeholders, provided there are no misunderstandings and the document is clearly differentiated from an Australian Standard (AS).

While Standards Australia provides a robust pathway for creation and adoption of standards, alternative pathways to adoption of standards other than Australian Standards are not uncommon where an existing standard is not a perfect fit for the Australian context, or where the timeline to formal adoption is incompatible with the needs of the market. Each option strikes its own balance of flexibility, compatibility and consensus and may ultimately be an optimum option.

8.2.1 Managed pathways of standardisation

Table 7 presents a snapshot of some of the available managed pathways of standardisation highlighted in Standards Australia's Standardisation Guide 003[30], including Australian Standards and other lower consensus publications.

Table 7 Standards Australia process requirements

Product type	Transparency	Consensus
Australian Standard (AS)	High – Public Comment (PC) required	High – Ballot is required
Australian Interim Standard (AS (Int))	Medium – Peer review only (PC not required)	High – Ballot is required
Australian Technical Specification (SA TS)	Medium – Peer review only (PC is optional)	Low – Limited peer review
Australian Technical Report (SA TR)	Low – No PC required	Low – Informal endorsement is required
Handbook (SA HB)	AS only: Medium – Peer review only (PC not required)	Low – Limited peer review

[30] See https://www.standards.org.au/getmedia/d9da035d-2fbc-4417-98c1-aa9e85ef625d/SG-003-Standards-and-Other-Publications.pdf.aspx.

Interim Australian Standard

An Interim Standard is a provisional Standard with a two-year life. It is prepared in a subject field where not all requirements have been finally determined, or where national consensus is anticipated but has yet to be realised. An Interim Standard provides both a guide to the direction that future standardisation in the specified field may take and a mechanism to collect public feedback on the subject.

Interim Standards may be used in a new area of technology where there may not be full agreement on final technical solutions. Developed using a formally constituted technical committee, an Interim Standard follows the same process as that used to develop a 'full' Standard, except that there is normally no Public Comment phase since the Interim Standard itself is publicly available and therefore a vehicle for eliciting public feedback.

Australian Technical Specification

A Technical Specification is a normative document that has been subject to a limited form of transparency and does not have the support of the full consensus process normally associated with an Australian Standard.

A Technical Specification may be prepared in a field where the subject matter, or a related aspect such as the regulatory environment, is undergoing rapid change and where speed of delivery, rather than full consensus, is of paramount importance. In such cases, it would normally be expected that an Australian Standard would eventually be developed to supersede the Technical Specification.

Another possible application is where the required level of stakeholder consensus to support an Australian Standard may not be possible. While Handbooks normally meet this need, sometimes the national interest may be better served by providing the public with access to information which has achieved a certain degree of stakeholder agreement, in a document that has a lesser status than a Standard.

Handbook

A Handbook is an informative document that may be used to support a Standard or a group of Standards already in place. It may either aid implementation or provide additional information to users of the Standard(s). In some circumstances a Handbook may be produced where there is no Standard and no technical committee, but the content is considered to be in the public interest.

It should be noted that Handbooks represent the views of the author(s) and there could be other, equally valid, points of view on the subject. The technical content of a Handbook is normally developed by a single author or by a selected group of experts, rather than by a constituted technical committee. In cases where consensus cannot be reached following the development of a draft Standard, the committee may elect to publish the document as a Handbook so that users gain the benefits of the committee's deliberations.

A Handbook can also be developed in conjunction with an industry association which would take responsibility for the bulk of the drafting work.

Whichever approach is taken, a Handbook is subject to a peer review process. Peer reviewers are normally taken from appropriate committee(s) but could also include external technical experts.

Currently, the DEIP Application Programming Interface (API) Working Group is in the process of finalising the drafting of an 'Australian Implementation Guide for 2030.5', which is a critical step for progressing interoperability and will accelerate standardisation of approach. Work is also being undertaken between the API Working Group and Standards Australia to have this Implementation Guide published on an accelerated pathway as a Handbook utilising the Standards Australia platform. The timeline to market availability through this development angle is in the order of 3-6 months.

8.2.2 Non-managed pathways of standardisation

There are alternative pathways to standardisation that are not formalised and managed in the same way as those listed above. Such pathways offer the fastest pathway to standardisation, but they come with the greatest risk that standardisation is not achieved, and may lead to unpredictable outcomes.

De facto industry adoption of an international standard

A de facto standard is a custom or convention that has achieved a dominant position by public acceptance or market forces and by definition does not require a process to agree, but rather comes into existence through other forces. The choice of a de facto standard tends to be stable in situations in which all parties can realise mutual gains, but only by making mutually consistent decisions.

The QWERTY letter layout was one of several options for the layout of letters on typewriter keys. It was developed to prevent adjacent keys from jamming on early and later mechanical typewriters. It became a de facto standard because it was used on the most commercially successful early typewriters, and is now used on devices which have no moving parts such as touchscreens.

More recently, the Australian vehicle industry made a commitment to harmonise national EV charging standards in lieu of a formally recognised standard. '*FCAI Technical Statement on EV Charging Standards for Public Recharging Infrastructure*' states that Federal Chamber Of Automotive Industries (FCAI) member companies have agreed to provide vehicles and EVSE capable of operating with infrastructure that adopts the standards listed in Table 8 on all new models introduced from 1 January 2020.

Table 8 Standards listed in FCAI Technical Statement on EV Charging Standards for Public Recharging Infrastructure

Category	Standard	Description
General	IEC 61851-1	Electric vehicle conductive charging system, general requirements
AC charging	AS IEC 62196-2	Plugs, socket-outlets, vehicle connectors and vehicle inlets Configuration Type 2
DC charging	IEC 62196-3	Configuration AA (CHAdeMO), or Configuration FF (CCS Type 2)

A viable pathway to de facto adoption of a standard is simply a recognition or informal agreement process by industry that a certain standard is 'best practice' and can be followed or adapted in lieu of a more formal pathway or established standard. Such a pathway requires no formal decision-making framework and is therefore the most rapid means to achieve a quasi-standardised outcome. It is understood that the automotive industry is further moving away from CHAdeMO and towards CCS Type 2 as a de facto DC Charging standard in the near future due to market forces.

It is noteworthy that the de facto adoption of standards was raised as high risk by several Taskforce members. Some involved in the process take the position that such pathways do not exist and that, by definition, standardisation requires a framework for formal acceptance.

Incentivised alignment to a standard

In some cases, a standard can be introduced proactively through a considered policy initiative by organisations funding behavioural change programs, such as non-government organisations (NGOs) and relevant government departments. For example, the Solar Homes Program in Victoria released a 'Notice to Market' requiring industry suppliers wishing to participate in the program to increase the capability of inverters supplied to the market.

Specifically, all grid-connected inverters supplied to market through the Solar Homes Program must be certified to IEC 62116 and have volt-var and volt-watt response modes available. IEC 62116 "provides enhanced testing procedures for protection against 'islanding' faults", which it claims is "an emerging requirement in regions with high penetration of DER".

This pathway effectively removes many of the consensus development processes of standardisation, while retaining flexibility. Incentivised alignment to a standard does not provide a mandatory pathway, and consumers are able to choose to participate in the program or to utilise inverters that do not conform to IEC 62116 outside of the government program.

The key benefit of this pathway is time-to-market, where there is an immediate need or where a standard is slowly traversing the formal pathway but action is needed now in certain areas (for example, high penetration DER in the context of this Solar Homes Program example).

8.3 Benefits of various standards pathways

The most appropriate pathway to standardisation is likely to be determined by the criticality of specific attributes. As such, a combination of various pathways may be determined to be the best pathway to market for standardisation.

It has been raised during this process that the timing of interoperability considerations, such as communication standards and protocols used between aggregators and devices, is more critical than the timing of some other considerations due to the pace of change in the broader DER sector. Timing considerations such as these are relevant when deciding on a suitable pathway.

Developing a standard does not create a requirement to conform with the standard. It is only in applying the standard in regulation, or in codes called up by regulation, that a standard generally gains traction. Beyond having a standard enacted through regulation, in an environment where enforcement of regulations is lax and especially where commercial disincentives exist, voluntary conformity to standards may not achieve desired penetration.

9. Key findings

The number of EVs on Australian roads is predicted to increase dramatically over coming years, presenting both opportunities and challenges for Australia's electricity sector. An EV rollout that is supported by appropriate market frameworks, regulation accepted by industry, and infrastructure that meets consumer expectations will enable an effective energy system designed to meet future needs. An uncoordinated integration of EVs would pose significant challenges to the energy system and increase costs.

Coordinated charging is recognised as an important factor in enabling an efficient transition to electrified transportation for consumers. Uncertainty in the VGI standards landscape is seen by Taskforce members as a potential barrier to widespread coordinated charging, risking additional costs and reduced uptake of EVs compared with a more clearly defined landscape. This report seeks to identify potential gaps in the VGI standards landscape that might lead to negative impacts on consumers, and focuses on current and developing standards from both domestic and international frameworks.

There are multiple pathways to achieving standardisation, ranging from formal recognition of a standard within the domestic regulatory framework, through to informal adoption through market forces. These pathways are discussed further in Section 8. Taskforce members expressed the importance of investigating international standards to promote efficiency across a global marketplace, but also recognised that unique Australian standards exist to manage specific aspects of DER grid integration that are not replicated globally.

The Taskforce does not take a position for or against additional standardisation, and instead focuses on developing a basis for informed decision-making on this complex topic.

Key takeaways

- Any decision to introduce VGI standards must be made from the perspective of EV and non-EV consumers with consideration to the costs incurred across the electricity, transport, and infrastructure sectors.
- Standardisation might help with reduce the risk of significant augmentation and operational costs of incorporating large numbers of vehicles into the electricity system, but might also add cost to vehicle and EVSE development or reduce their availability in the Australian market. These impacts will be highly dependent on the area and manner of standardisation.
- Vehicle standards will influence a different supply chain to EVSE standards, and standards imposing hardware requirements will have different cost impacts to those which carry firmware requirements.
- Generally, time is available for comprehensive and collaborative discussion on these matters, noting that DER standards are evolving on a tighter timeline and may also influence the EV sector.

The Taskforce followed a collaborative process to identify key VGI standards focus areas, shown in Figure 11.

Figure 11 VGI standards focus areas

1. Charging Interoperability

- Explore how different charging configurations might influence interoperability standards, and whether any specific configurations might limit interoperability opportunities.
- Explore how standardisation of VGI communications or control methodologies could be aligned with global norms.

2. Energy and services market integration

- Explore where standards might help future-proof participation of EVs in energy and services markets.

3. Disturbance performance and grid support

- Explore whether current and emerging feature sets of EVs and EVSE could play a role in autonomously or inherently supporting grid operation, and whether standards might influence or enable this capability.

Within these focus areas, remote monitoring and control of device protection settings, telecommunications network requirements, and cybersecurity were deemed important but out of scope for the Taskforce due to their specific consideration in other forums.

9.1 Charging Interoperability

Interoperability between EVs/EVSE and the electricity system is discussed in Section 5. Interoperability with an EV could be via several pathways:

- Interoperable EVSE relays messages between the electricity system and the vehicle.
- Interoperable vehicle communicates directly with the electricity system, and optionally with EVSE to identify site-specific data.

- Market incentives or other signals influence consumers' charging decisions.

Many international standards are available that specify communications pathways between the electricity system and EVs via EVSE, however no single set of standards has yet become dominant worldwide. Communications direct to the vehicle are predominantly managed through bespoke, privately-owned systems.

Device standards relevant to this report broadly fall into three categories:

- Standards covering communication between EVs and EVSE, such as ISO 15118, IEC 61851 and SAE J3072.
- Standards covering communication between the electricity system and EVSE, such as IEEE 2030.5, OpenADR and IEC 61850.
- Standards covering communication between a CSO and EVSE, such as OCPP and IEC 63110.

Australian regulation does not currently mandate standards in the above categories. However, some standards, such as OCPP, are widely used by industry and could be considered de facto standard due to market forces.

Key takeaways

The decision about whether to standardise interoperability requirements for EVs and/or EVSE requires careful consideration and close collaboration across industry, as there could be both positive and negative impacts on EV consumers in terms of product cost, availability and compatibility, as well as on EV and non-EV consumers in terms of network costs.

- Establishing a standardised communications protocol from electricity system actors directly to EVs may be challenging due to a lack of established candidate standards in that space and the international norm of using bespoke protocols for that purpose.
- Standardising communications from electricity system actors to EVSE might rely on an interoperable protocol existing between EVSE and EVs (such as ISO 15118 or IEC 61851), particularly for AC EVSE where the EV itself has control over the charging rate in accordance with limits set by the EVSE. Decisions in this space need to be made from a framework perspective to ensure consistency with other sectors, such as the common payment platform being discussed within the LZEV working group.

9.2 Energy and services market integration

Section 6 explores where standards might help future-proof participation of EVs in energy and services markets. In this focus area, most regulation of device performance and communication protocols is implemented via market rules, however a noteworthy exception is AS/NZS 4755. This demand response standard is of interest to the Taskforce due to a recent COAG recommendation to expand its scope to include EVSE.

There are two compliance pathways to consider within the AS/NZS 4755 framework:

- AS/NZS 4755.1 pathway, using a DRED.
- DR AS 4755.2 proposed pathway, using communications protocols built-in to the appliance.

Proposed AS 4755.2 compliance pathway

- AS 4755.2 specifies the behaviour of DER devices providing demand response services. It leaves the communication framework between the remote agent and the DER device open, but specifies the minimum information which is required to be conveyed in the demand response command as well as the physical capability and test procedures of the device providing demand response.
- Conversely, communications standards such as OpenADR, OCPP, and IEEE 2030.5 define the communication and information exchange protocols to transmit demand response commands between remote demand response agents and the DER device (which could be a vehicle, an EVSE or a local management system, such as home energy management system), but do not specify the response itself.
- Appendices can be added to AS 4755.2 to detail appropriate communications methodologies or standards (such as OpenADR, OCPP, or IEEE 2030.5), which can then be used to satisfy compliance.

Internationally, standards such as IEEE 2030.5, OpenADR, OCPP, and ISO 15118 provide functionality relevant to energy and services market integration. These are all under active development and may be suitable for consideration under the upcoming review and implementation processes for AS/NZS 4755.

Key takeaways

- Communications standards like IEEE 2030.5, OpenADR, and ISO 15118 could work in conjunction with AS 4755.2 to provide a complete interoperable demand response framework for EVs, including communications, information exchange, response specification, cybersecurity requirements, and test procedures.
- Industry, government, and the relevant standards committees need to work together to establish a clear pathway to meet the requirements of the 2019 COAG RIS decision to apply AS/NZS 4755, or an equivalent international standard, to some categories of EVSE from 2026. This work should include engagement with the E3 technical working group which will be established to determine, by mid-2022, whether an equivalent international standard can be used in place of AS/NZS 4755.

9.3 Disturbance performance and grid support

Section 7 explores the autonomous or inherent capability of EVs and EVSE with respect to their interaction with grid operation. Performance standards are one way to achieve disturbance performance and autonomous grid support capability from devices such as EVs and EVSE.

If these devices were to have inherent, autonomous capability to support power system operation, it may be possible to avoid operating the system in a more costly manner to accommodate their additional demands.

Operating costs are borne by all electricity consumers, not just EV owners, so efficient operation of the system is of key importance to a wide range of stakeholders.

Key takeaway

AS/NZS 4777.2 is an established standard applicable to bidirectional V2G inverters, including both stationary and on-vehicle inverters. However, no established Australian or international standards have been identified in relation to disturbance performance and grid support capability for unidirectional chargers, which will likely make up the majority of the charging fleet for many years to come. It is recommended that the Working Group continues to investigate whether any of the provisions within AS/NZS 4777.2 or emerging international standards may be relevant for future discussion on the capability of unidirectional chargers to respond to grid conditions.

9.4 Future work

The Taskforce's work has been exploratory and collaborative in nature, and seeks to provide direction for future VGI standards efforts and a basis for DEIP, the Working Group and wider industry to engage with governments, industry and standards bodies to progress discussion on whether and where standardisation might lead to positive outcomes for consumers.

Gaining insight into consumer behaviour, preferences, and influences is critical to inform VGI standards decision-making. The Taskforce discussed the need to understand the broad range of consumers who could be affected by VGI standardisation and noted that some groups will have differing and at times opposing views. For example, some EV-owning consumers may value flexibility in their charging behaviour, whereas other groups may place a higher value on low-cost energy. Non-EV consumers and the impacts of un-coordinated charging on network costs must also be part of the discussion. Opportunities and challenges of key stakeholders in the VGI landscape are detailed further in Table 2.

The Working Group will explore current EV customer insights activities in 2021 with the aim of identifying potential studies and activities to address consumer insights gaps. Insights valuable to VGI standards might include:

- Consumers' preferences relating to engaging in market-based participation models.
- The level of acceptance of demand management activities.
- The level and type of incentive necessary to achieve consistent consumer engagement.

Standardisation is a broad topic, where the regulatory and commercial considerations are as important as the technical detail of the standard itself. Multiple support functions including testing, compliance, audit, and certification bodies are necessary to establish a complete standards framework.

By beginning comprehensive and collaborative discussion on these matters now, before wide-scale EV uptake begins, the energy and transport sectors can take the time to investigate VGI standardisation in detail. However, it is important to note that that DER standards are evolving on a tighter timeline than VGI-specific standards, which may influence the EV sector due to the value of harmonising standards across a broad range of DER. The Working Group will continue to engage with the DEIP Interoperability Steering Committee to ensure VGI considerations are fully explored within the DER context.

Organisations or individuals with an interest in the work presented in this report are welcome to reach out to AEMO at electricvehicles@aemo.com.au.

A1. Coverage of identified VGI standards

The Taskforce limited its assessment to standards maintained by the major international standards organisations shown in Figure 12.

Figure 12 Major international standards organisations

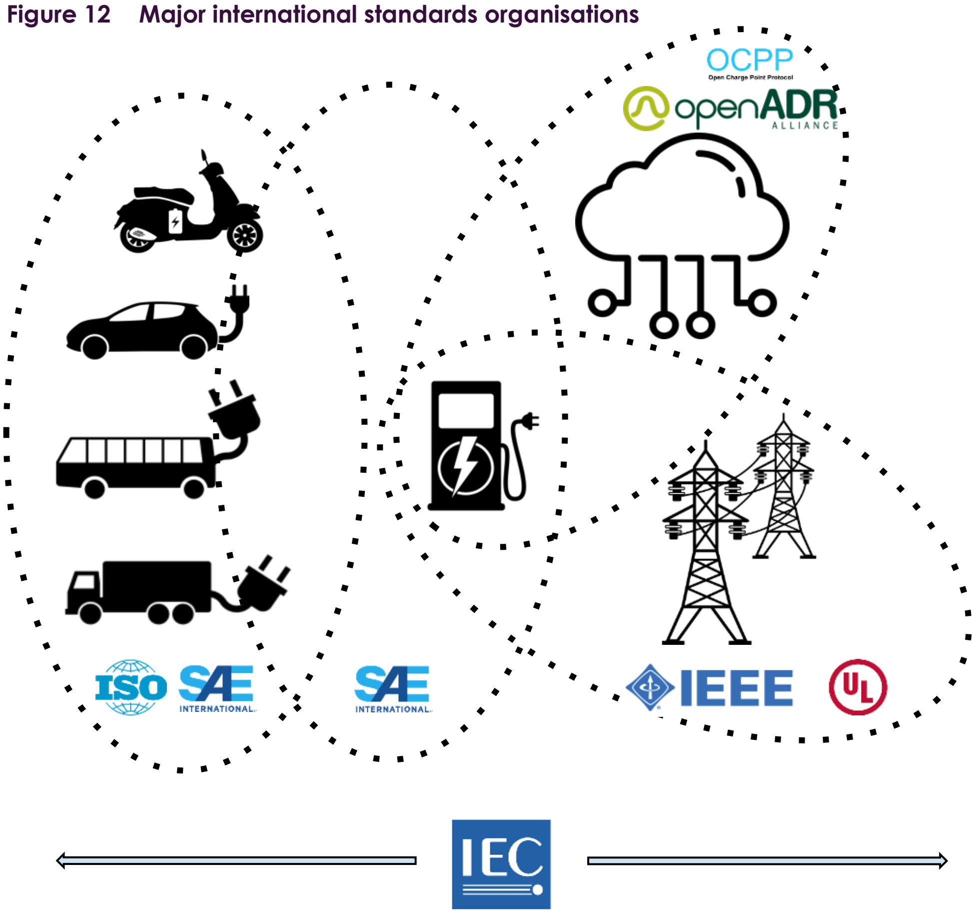

Table 9 provides detail on standards identified by the Taskforce as having relevance to VGI. This does not mean that these standards are suitable for use in an Australian context, but they are provided here for reference as an indication of the international VGI standards landscape.

Table 9 Standards identified as relevant to VGI

Standard	Focus area	Notes
IEC 61850	• Charging Interoperability	• Defines communication protocols for intelligent electronic devices at electrical substations • Has evolved over time to also cover DER devices
IEC 61851	• Charging Interoperability	• Covers standard conductive charging systems • Applies to both onboard and off-board EV charging (up to 1000 VAC and 1500 VDC

Standard	Focus area	Notes
	• Disturbance Performance and Grid Support	• Defines the key EV charging modes (AC and DC) • Specifies physical and communications requirements for the 'pilot wire' which carries information between the EV and EVSE • Parts include: – IEC 61851-1: General requirements – IEC 61851-21-1: EV on-board charger EMC requirements for conductive connection to AC/DC supply – IEC 61851-21-2: EMC requirements for off-board EV charging systems – IEC 61851-23: DC EV charging station – IEC 61851-24: Digital communication between a DC EV charging station and an EV for control of DC charging
IEC 61980	• Charging Interoperability	• Wireless power transfer / inductive charging standard for EVs • Parts include: – IEC 61980-1: General requirements – IEC 61980-2: Specific requirements for communication between electric road vehicle (EV) and infrastructure – IEC 61980-3: Specific requirements for the magnetic field wireless power transfer systems
IEC 62351	• Charging Interoperability	• Cybersecurity standard to support a suite of IEC standards including IEC 61850 • Incorporates end-to-end encryption and system monitoring
IEC 63110	• Charging Interoperability	• Management of EV charging and discharging infrastructure • Covers communication framework between EVSE and CSO/CSP • Primary focus is charging management from perspective of CSO, but provides interoperability pathways to other grid operations standards such as IEC 61850 • Standard is being developed with close liaison to OCPP team
IEC 63119	• Charging Interoperability	• Defines information exchange for EV charging roaming services • Currently under development • Applicable to high-level communication involved in information exchange between different CSOs and mobility service providers, with or without a clearing house platform
IEC 63243	• Charging Interoperability	• Interoperability and safety of dynamic wireless power transfer for EVs • Currently under development by IEC TC 69
ISO 15118	• Charging Interoperability • Energy and Services Market Integration	• Defines a digital communication protocol between EV and EVSE for a range of charging configurations, including wired (AC and DC), wireless and pantographs • Facilitates bidirectional energy transfer, load management and smart charging • Enables EVSE to manage charging/discharging by communicating instructions over a conductive or wireless link to the EV • ISO 15118-20 (under development) will include provisions for grid assistive smart charging and frequency control • Market signals would need to be conveyed via another protocol such as IEEE 2030.5 or OpenADR • Calls up elements of IEC 61851 in relation to the physical EVSE to EV connection
SAE J2293	• Charging Interoperability	• Specifies on/off-board EVSE requirements for grid charging • SAE J2293-2 discusses the communication requirement and network architecture for EV charging

Standard	Focus area	Notes
SAE J2847 & SAE J2836	• Charging Interoperability	• Specifies communication requirements between an EV and charging infrastructure – SAEJ2847 specifies the communication requirements – SAEJ2836 defines the use cases and provides the testing infrastructure
SAE J2931	• Charging Interoperability	• Establishes the requirements for digital communication between EVs, EVSE, energy service provider, advanced metering infrastructure, and home area network
SAE J3072	• Charging Interoperability	• Establishes interconnection requirements for onboard V2G AC inverters. • Defines the communication framework between the EVSE and the onboard inverter
ANSI / CTA-2045	• Charging Interoperability	• Defines a standard interface for DER load control • Defines an interface between a DER device and a communications module, including the physical port as well as electrical and logical properties • CTA-2405 compliant DER devices enable service providers to perform load control functions using communications protocols of their choice by attaching a suitable communications module to a standard hardware interface
IEEE 2030.5	• Charging Interoperability • Energy and Services Market Integration	• Defines an application layer to enable remote management of end user energy assets • Covers communication between DER devices (including EVSE) and aggregators/NSPs/market operators, as well as between devices on a Home Area Network (HAN) • Specifies functionality in areas such as demand response, load control and time of day pricing for a range of controllable DER devices, including EVs • Also referred to as Smart Energy Profile 2.0 (SEP 2.0) • Recent versions of the standard allow for interoperation with ISO 15118 • Applicable across a wide range of devices, from small thermostats to an aggregator head-end
OCPP	• Charging Interoperability • Energy and Services Market Integration	• Defines an application layer to enable remote management of EVSE by a CSO • Developed by the Open Charge Alliance (OCA), OCPP is considered the de-facto standard for charging infrastructure interoperability • Smart charging functionality implemented from version 1.6 onwards, enabling remote charging management such as demand response • OCPP2.0 also offers the option to support plug-and-charge for electric vehicles supporting the ISO 15118 protocol.
OpenADR / IEC 62746	• Charging Interoperability • Energy and Services Market Integration	• Defines a communications framework to interact with demand response assets • Covers communication between demand response assets (including EVSE) and aggregators/NSPs/market operators • Provides a two-way information exchange model for dynamic price and reliability signals • IEC 6276-10-1 provides a formalised standards pathway for the OpenADR 2.0b protocol • Used widely in commercial and industrial demand response applications, but also applicable for EVSE and HEMS • Administered by OpenADR Alliance (IEC 62746-10-1 administered by IEC)
IEEE 1547	• Disturbance Performance and Grid Support • Charging Interoperability	• Covers interconnection of DER up to 10MVA with electric power systems • Specifies functionality and communications requirements across a wide range of DER devices
UL 1741	• Disturbance Performance	• Covers disturbance performance and grid support requirements of inverter-interfaced grid-connected DER, such as voltage and frequency ride-through

Standard	Focus area	Notes
	and Grid Support	• Closely tied to IEEE 1547 in the California market
UL 62109	• Disturbance Performance and Grid Support	• A harmonised version of the international PV power conversion standard IEC 62109, based on UL 1741 • UL 62109-2 addresses the inverter-specific requirements, such as total harmonic distortion, DC injection, voltage and frequency control, system isolation protection, labelling and documentation
SAE J2894	• Disturbance Performance and Grid Support	• Requirements for power quality and testing of EVs

Table 10 shows each of the focus areas discussed in this report alongside some of the key standards identified by the Taskforce as having coverage in these areas. Further investigation would be required to determine the level of coverage and any applicability to the Australian standards landscape.

Table 10 Standards identified as relevant to taskforce focus areas

Focus area	Components	Standards identified
Disturbance performance and grid support	Response to voltage disturbance	IEEE 1547 UL 1741, UL 62109 AS/NZS 4777.2
	Response to frequency deviations	IEEE 1547 UL 1741, UL 62109 AS/NZS 4777.2
	Fault ride-through capability	IEEE 1547 AS/NZS 4777.2
	Anti-islanding protection	IEEE 1547 UL 1741, UL 62109 AS/NZS 4777.2
	Frequency control support	IEEE 1547 UL 1741, UL 62109 AS/NZS 4777.2
	Autonomous voltage control (Volt-Var support)	IEEE 1547 UL 1741, UL 62109 AS/NZS 4777.2
	Under-frequency load shedding support	IEEE 1547 UL 1741, UL 62109 AS/NZS 4777.2
	Operation during harmonic voltage distortion, unbalanced voltage conditions and disturbance caused by phase angle shift	UL 62109
	Post-interruption support (gradual ramp-up)	UL 1741

Focus area	Components	Standards identified
Charging interoperability	Guidelines/measures for communication and information exchange between EVs/EVSE Relay network operating envelopes (specifying technical limits for EV operation to maintain grid reliability, security and power quality) to EV aggregators and service providers Protocols defining type and format of data exchange among involved parties	IEC 61851, IEC 61968, IEC 63110, IEC 63119, IEC 63243, IEC 62351 ISO 15118 OCPP OpenADR IEEE 2030.5 AS/NZS 4755 SAE J3072 SAE J2931
Energy and services market integration	Demand response communications	OpenADR IEC 62746 IEEE 2030.5 AS/NZS 4755
	Standardised demand response modes	AS/NZS 4755

Abbreviations

This document uses many terms that have meanings defined in the National Electricity Rules (NER). The NER meanings are adopted unless otherwise specified.

Term	Definition
AC	Alternating current
AS/NZS	Australian/New Zealand Standard
COAG	Council of Australian Governments
CSO	Charge station operator
DC	Direct current
DEIP	Distributed Energy Integration Program
DER	Distributed energy resources
DNSP	Distribution network service provider
DRED	Demand Response Enabling Device
DRM	Demand Response Mode
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
GPO	General purpose outlet
HEMS	Home energy management system
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
NEM	National Electricity Market
NEO	National Electricity Objective
NSP	Network service provider
OCPP	Open Charge Point Protocol
UL	Underwriters Laboratories
V2G	Vehicle-to-grid
VGI	Vehicle-grid integration
WEM	Wholesale electricity market