Appendix 2

Maturity Assessments and Methodology

18 September 2020

GridWise ENERGY SOLUTIONS

farrierswier

Disclaimer

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Contents

Glossary and abbreviations

Term	Definition
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AESCSF	Australian Energy Sector Cyber Security Framework
API	Application Programming Interface
ARENA	Australian Renewable Energy Agency
AS/NZS	Joint standard developed by Standards Australia and Standards New Zealand
BESS	Battery energy storage system
C&I	Commercial and industrial customers
DEIP	Distributed Energy Integration Program: a collaboration of government agencies, market authorities, industry and consumer associations aimed at maximising the value of customers' DER for all energy users
DER	Distributed Energy Resources: non-registered resources connected to the distribution system that generate electricity or manage electricity demand
DERMS	Distributed Energy Resources Management System
deX	Decentralised energy exchange
DMO	Distribution Market Operator
DNSP	Distribution Network Service Provider
DPV	Distributed solar PV
DSO	Distribution System Operator
EMT	Electromagnetic transients
ESB	Energy Security Board
EVs	Electric vehicles
FCAS	Frequency control ancillary services
Functional areas	The key capabilities required for effective DER technology integration
Hosting capacity	The amount of DER that can be accommodated within a DNSP's network, or the relevant part of the network, without adversely affecting security, reliability or power quality
HV	High voltage

Term	Definition
Integration	In simple terms, integration is the process of bringing together and uniting separate things into a comprehensive and cohesive whole. In the context of this paper, "integration" of DER technology covers the actions needed so that DER devices, the services DER can provide and DER-related systems and data become a cohesive part of the broader electricity system and energy markets
LV	Low voltage
MW	Megawatt
NEM	The National Electricity Market, which covers New South Wales, Queensland, Victoria, South Australia, the ACT and Tasmania
Operating envelope	The technical limits DER must operate within to maintain the security, reliability and power quality of the distribution network and broader electricity system. Operating envelope relates to the local distribution network in this context.
RERT	AEMO's Reliability and Emergency Reserve Trader function
SCADA	Supervisory Control and Data Acquisition System
TNSP	Transmission Network Service Provider
TRL	Technology Readiness Level
UFLS	Under frequency load shedding
VPP	Virtual Power Plant: a collection of aggregated DER devices working in a coordinated manner to generate or consume energy or provide other services
V2G	Vehicle to grid
WEM	Wholesale Electricity Market for the South West Interconnected System of Western Australia

1. Introduction

1.1 PROJECT CONTEXT

The Australian Renewable Energy Agency (ARENA) has worked with farrierswier and GridWise Energy Solutions to develop a State of Distributed Energy Resources (DER) Technology Integration Report. This project created a functional framework for DER technology integration to then conduct a maturity assessment and prepare a baseline report. The report informs stakeholders of the contributions made towards DER technology integration by current and recent ARENA and non-ARENA projects, programs and trials. This technical integration focus recognises but excludes the analysis of broader market, grid and customer regulation projects already being considered by other parties.

1.2 ROLE OF MATURITY ASSESSMENTS IN THE PROJECT

The assessment method and baseline assessments contained in this appendix draw on two prior stages of work that are captured in to other appendices:

- the DER technology integration functional framework
- the consolidated project templates that collate data across the chosen DER integration projects, programs and trials.

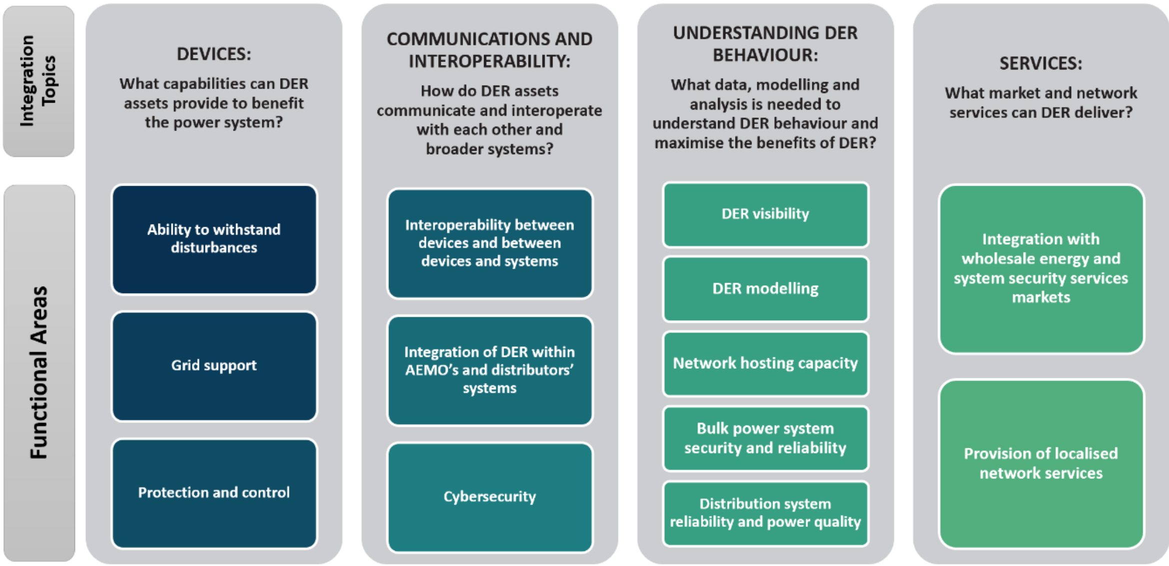
The maturity assessments in this appendix are farrierswier and GridWise Energy Solutions' baseline DER technology integration maturity assessments for each of the functional areas identified in the functional framework.

2. Maturity assessment method

2.1 PURPOSE OF MATURITY ASSESSMENT

The purpose of this DER integration maturity assessment exercise is to enable stakeholders to have a clear and consistent understanding of the maturity of DER technical integration. This assessment is applied across the functional areas in the Final DER Functional Framework and the key capabilities needed for maturity of each functional area. This functional framework is summarised in Figure 2.1.

Figure 2.1: DER technology integration functional framework

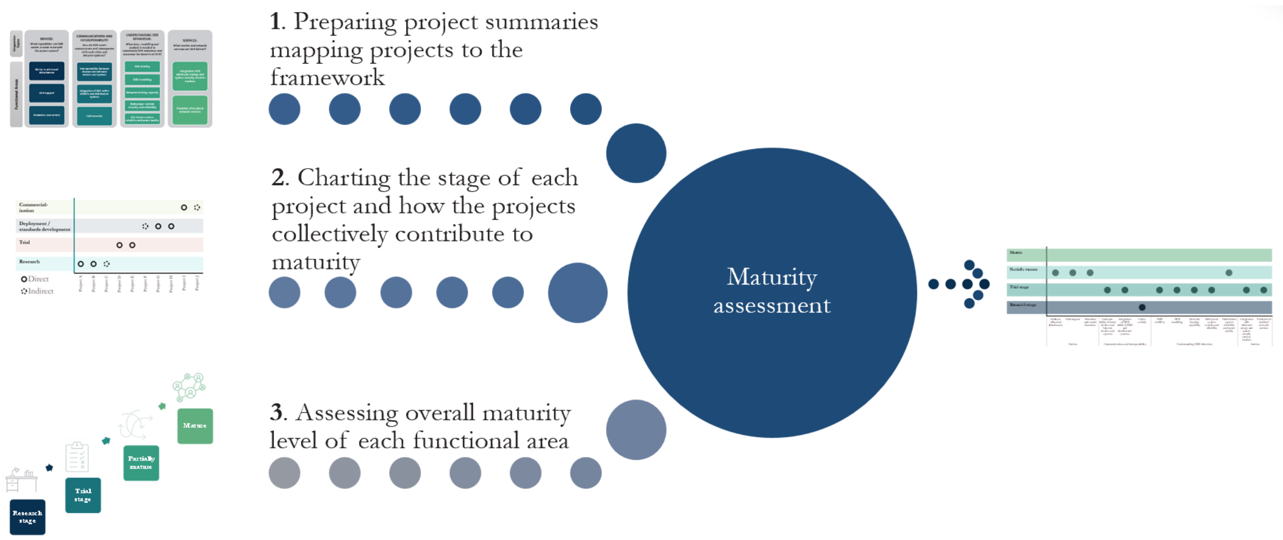


Certain functional areas include an assessment of a wide range of sub-capabilities, for example "Grid support" includes the ability of devices to provide frequency control and voltage control and to participate in emergency control schemes. These sub-capabilities are discussed in the functional area assessments where relevant.

2.2 OVERVIEW OF ASSESSMENT APPROACH

The assessment approach has three steps as illustrated in Figure 2.2 and explained in the following sections.

Figure 2.2: Overview of mapping and assessment approach



The maturity assessment is:

- carried out for each functional area, and is *not* applied to individual DER technologies, markets, or jurisdictions
- performed having regard to all projects collectively contributing to each functional area, rather than assessing the maturity of individual projects, and considering the substantive contributions of project outcomes not equal weightings of projects by number
- assessed as at project completion, assuming the project delivers its stated objectives, and is *not* an assessment of maturity as at today
- assessed based only on the 50 selected projects and is reliant on the project contact's mapping of each project to the relevant functional areas.

A list of the projects is included at Appendix A. The charts in the maturity assessments in sections 3 to 6 below use short names to refer to each project, with Appendix A setting out the project's short name, full name, lead organisation and a summary of the project.

The qualitative assessment includes farrierswier and GridWise Energy Solutions' rationale based on the assessment considerations explained in section 2.5.1 below. The overall assessment of maturity is based on the rating framework in section 2.5.2 and is not simply based on the number of projects shown in each functional area in the charts produced in step 2.

An important objective of this assessment is also to identify gaps in maturity, relative to the key desired capabilities. The assessments for each functional area set out in sections 3 to 6 seek to identify what we do know, what we do not know, and what would be valuable to know.

2.3 STEP 1 | PREPARING PROJECT SUMMARIES

The project summaries collate data across the chosen DER integration projects, programs and trials. The information in these summaries was provided by the contact for each project. This data enabled farrierswier and GridWise Energy Solutions to prepare a baseline DER technology integration maturity assessment for each of the functional areas by setting out how the projects contribute to each functional area.

2.4 STEP 2 | CHARTING THE STAGE OF EACH PROJECT AND HOW THE PROJECTS COLLECTIVELY CONTRIBUTE TO MATURITY

The project mapping exercise identified the number of projects contributing to each functional area by project stage as well as a high level description of their respective contribution. These inputs were used to perform a qualitative assessment of the overall maturity of each area using the assessment framework in Section 2.5.2 below and the key desired capabilities for each area as set out in the functional framework.

To inform this exercise, we prepared charts to illustrate where the projects contribute to the overall maturity of a functional area. This illustration is necessarily simplified. These charts were prepared by classifying each project into one of five project stages defined in the table below. This was done once for each project, and used for all functional areas rather than reassessed for each functional area. The charts group *standards development* and *deployment* together in the charts because not all functional areas involve standards, and where they do, these are generally developed in advance of deployment at significant scale for a given integration capability and are an important requirement for increased maturity.

Project stage definitions
Commercialisation | The technology has been proven to work and is being commercialised for widespread sale and deployment. Equivalent to ARENA's Commercial Readiness Index (CRI) levels 2 to 6.
Deployment | The technology has been proven to work and is being deployed at a significant scale in Australia, eg deployed across an entire network area or used by a significant number of customers outside of a trial. Equivalent to level 8 to 9 on the Technology Readiness Level (TRL) index adopted by ARENA (see https://arena.gov.au/assets/2014/02/Technology-Readiness-Levels.pdf).
Standards development | Development or amendment of Australian Standards or other types of standards or industry guidelines. Note that: • some standards development projects include a significant amount of research but have not also been classified as "research" • not all functional areas involve standards.
Trial/pilot | Trials/pilots/demonstrations where the technology is tested at a limited scale in a real-world environment. Equivalent to TRL 6 to 7. Note that all of the trial/pilot projects include a significant amount of research but have not also been classified as "research".
Research | Includes desktop research, simulations and laboratory testing. Equivalent to TRL 1 to 5.

The charts also illustrate whether a project's contribution to a given functional area is direct or indirect. This is primarily to aid stakeholders in identifying which projects are most directly relevant to the functional area. It reflects several circumstances:

1. A number of projects identified that they made only partial contributions to a given functional area.
2. Some projects identified that they made contributions to a large number of functional areas, but the project was more directly focussed on some functional areas than others.
3. This distinction supports ease of stakeholder navigation through the underlying project summaries.

A further series of charts was also used to inform the *breadth of use* maturity consideration. These illustrate how widely the technology component or integration aspect is being used across the assessed projects. These charts for each functional area included charts showing the numbers of technologies covered by DER type, and the jurisdictions or energy markets covered.

2.5 STEP 3 | ASSESSING OVERALL MATURITY LEVEL OF EACH FUNCTIONAL AREA

Having regard to all the mapped projects for a given functional area, the assessment then looked at the scope of the mapped projects and how they collectively advanced DER technology integration maturity. This involved applying:

- a suite of maturity assessment considerations
- a maturity rating framework.

2.5.1 Maturity assessment considerations

The maturity assessment takes account of:

1. **Understanding of issues and technology options** | Are there clear definitions and common agreement on the underlying issues and integration challenges the technology is seeking to resolve? Is there common agreement on the preferred solution to those issues? Where there are a range of potential technology solutions to those issues, are all of the relevant potential solutions being explored?

2. **Stage of relevant projects** | At what stage are the projects that relate to the use of technology or aspect of integration, e.g. research, trial/demonstration projects, commercial deployment? This draws on the charting in step 2.

3. **Breadth of use** | How widely is the technology component or integration aspect used in the market? Has its use been demonstrated in relation to all relevant types of DER or has its use to date been limited to specific types of DER? Where there may be relevant differences between states/territories or network areas, has it been used in a range of locations?

4. **Standards and specifications** | Do well specified technical standards suitable for Australia exist? If not, is it expected these will be determined in the near term?

5. **Performance** | Has it been demonstrated that the integration solution performs according to the required standards? Are there any significant known issues or gaps in knowledge?

6. **Cost** | Is the cost of implementation (for preferred integration solution) across Australia well understood?

7. **Ease of implementation and adaptability** | How easy or difficult will the implementation be, relative to current market practices and industry systems and processes? Is the preferred integration solution adaptable to changes in DER technology, uptake or customer preferences?

8. **Dependencies** | Is maturity dependent on the maturity of other functional areas? For example, a high level of maturity in DER visibility will be a precondition for maturity in DER modelling or network hosting capacity.

Limitations to this assessment

Consistent with the project scope, the DER maturity assessment framework does not take account of broader customer, market design, regulatory or policy questions.

The maturity assessment is based on the expected outcomes on completion of the assessed projects. DER products and the technologies, systems, services and markets for DER integration are not static, which means that:

- when applying this framework in future, it may be necessary to test whether new information changes the required functional areas or what it would take to achieve maturity against the functional areas, and
- future changes may affect the maturity ratings reached in this initial baseline maturity assessment.

2.5.2 Maturity rating framework

The following table sets out the DER maturity ranking framework.

Rating	Features
Mature	• Used commercially in the marketplace in Australia, and potentially internationally • Where relevant, standards that are suitable for the Australian market have been adopted in Australia and are complied with by a sufficient proportion of existing and new DER devices • Has been in use for long enough that most of its initial faults and inherent problems have been removed or reduced by further development • Available at a competitive cost in some use cases • All desirable capabilities are met for all relevant forms of DER • All desirable capabilities are available in all parts of the NEM and WEM where they would have significant benefits
Partially mature	• Desirable capabilities and main technology options for delivering most of those capabilities are well-defined and understood, although there may be multiple potential options and no current agreement on the optimal approach and end-state • Where relevant, standards that are suitable for the Australian market have been adopted in Australia • Trials/pilots are underway for most of the desirable capabilities • Not all capabilities have seen widespread use in Australia. May or may not be a fully mature technology component internationally • Some, but not all, desirable capabilities are widely available, and/or desirable capabilities are only available for some forms of DER, and /or in some parts of the NEM or WEM • Reasonable confidence that the technology component will be available a competitive cost in the medium term or sooner
Trial stage	• Some of the desirable capabilities and main technology options for delivering those capabilities are well-defined and understood, but for a significant number of capabilities those issues are not well-defined or there is significant disagreement amongst relevant stakeholders • Trials/pilots are underway for some of the desirable capabilities • Most capabilities have not seen widespread use in the marketplace • Still has performance or cost issues that prevent users from getting the full benefit of the technology and/ or being able to economically deploy the technology. Development effort may be on-going to seek to reduce or remove problems and/or reduce cost • May be uncertainty that the technology component will be available a competitive cost
Research stage	• May be some trials, but no widespread trials or commercial use of most of the relevant capabilities and technologies • Significant research and development effort still required to determine the desirable capabilities, sequencing and/or the technology required to deliver those capabilities

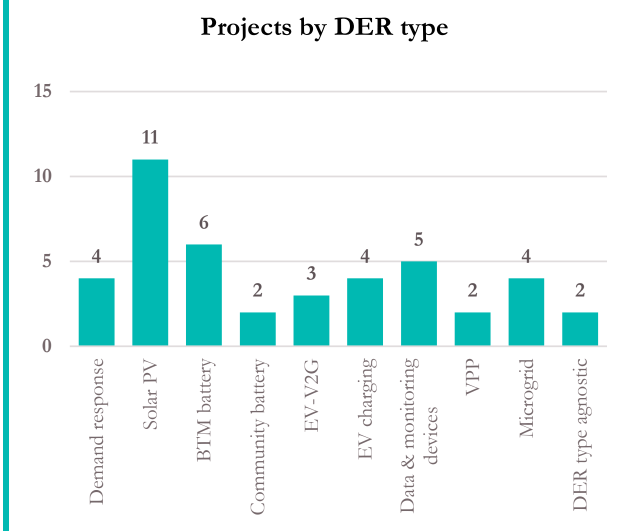
When applied, this rating framework is adapted to the particular characteristics of each functional area.

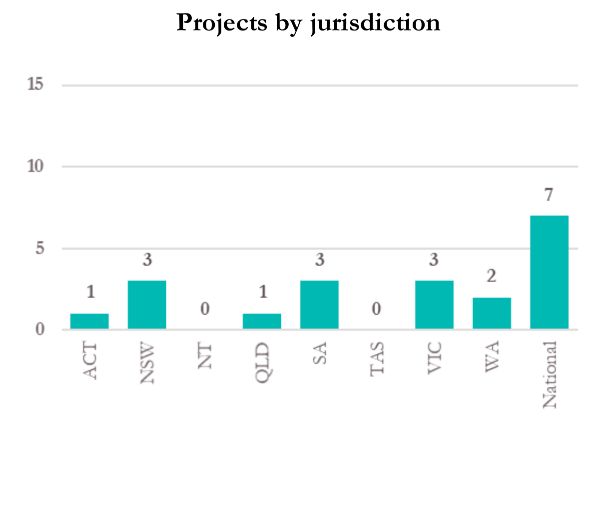
3. Devices

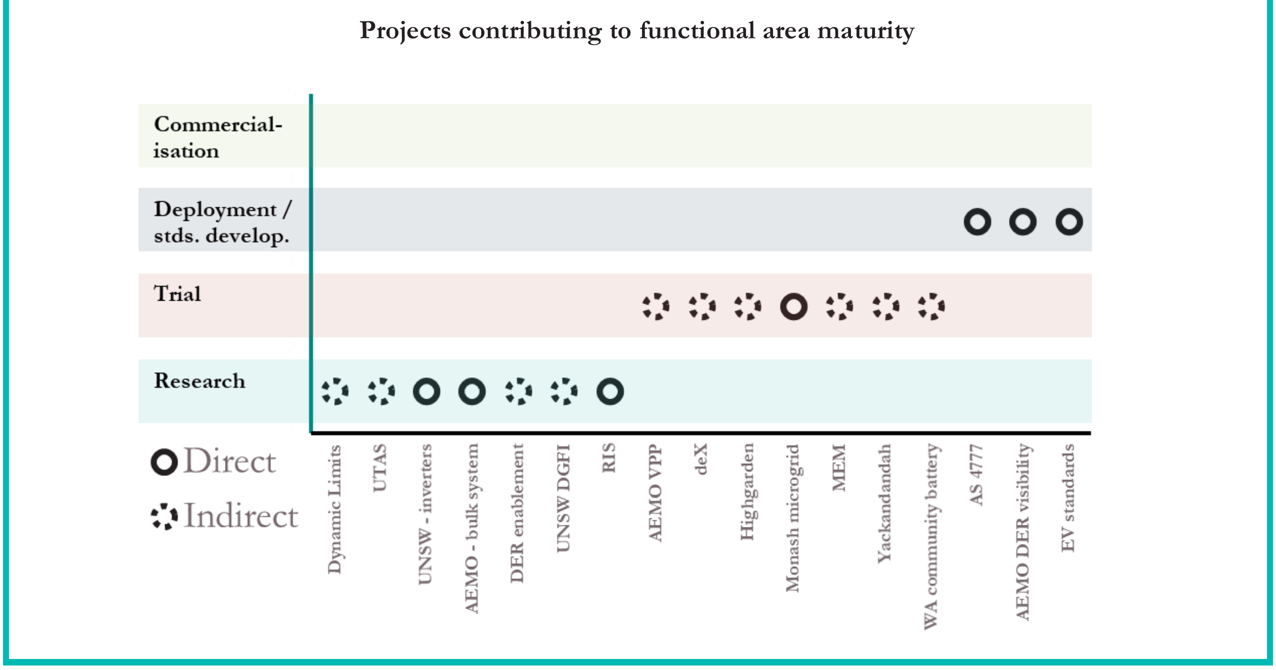
3.1 ABILITY TO WITHSTAND DISTURBANCES

Description: **The ability of DER devices to withstand (ie not disconnect during) power system disturbances**

Maturity level: **Partially mature**







Discussion: Data collected in areas of high DER penetration shows that the voltage and frequency response of DER devices varies. For abnormal system conditions and in the event of system disturbances, this varied response can cause degradation in power system performance. Reliability and system security can be adversely impacted both at the local network and bulk power system level.

A number of initiatives are currently underway to:

- understand the current capabilities of DER devices

- derive empirical evidence on the need for improved capabilities
- improve the ability of DER devices to withstand power system disturbances, particularly variations of voltage and frequency outside of normal operating bands.

AEMO has a significant program of work underway on the impact of DER on bulk power system operations in collaboration with several other parties. AEMO analysed distributed solar PV (DPV) disconnection behaviour from a sample of monitored systems for bulk power system disturbances during high levels of DPV generation. This data was provided on an anonymised basis by Solar Analytics as part of the *Enhanced reliability through short term resolution data around voltage disturbances* project. This analysis was further validated through laboratory bench testing of individual inverters conducted by UNSW.

The findings from these projects as well as benchmarks set by updated international standards such as IEEE 1547 and national implementations 2016 update to the European Network Code for Generators (most notably, Germany and Denmark) have led to the Standards Australia work on a revised AS/NZS 4777.2. The Standards Australia technical committee EL-042 – Renewable Energy Power Supply Systems and Equipment is undertaking a revision of AS/NZS 4777.2, which has requirements for improved withstand capabilities (including multiple voltage disturbances, rate of change of frequency and voltage phase shift) for inverters connected to the low voltage distribution network.

There is consensus amongst stakeholders that the desirable capabilities and main technology options for delivering most of those capabilities are well-defined and understood, as has been demonstrated by major DER vendors in international jurisdictions. This is particularly the case for DPV and to some extent behind the meter batteries, although the understanding of the issues continues to evolve as DER penetration increases and more data is obtained regarding the performance of devices during disturbances. However, it is unclear if additional capabilities will be needed from emerging types of DER such as electric vehicles and vehicle-to-grid systems.

The Standards Australia AS/NZS 4777.2 revision process is well underway with the standard expected to be published by March 2021. However, there are potential limitations as standards are voluntary documents, and only mandatory if called up in regulation. Revised governance arrangements for DER technical standards are currently being considered by the ESB, AEMO and AEMC. The ESB and governments have also recognised that improvements are required in the level of compliance with standards, as demonstrated by studies by AEMO of the behaviour of DER devices during disturbances. The development and implementation of an improved compliance framework being considered by the ESB but not yet determined.

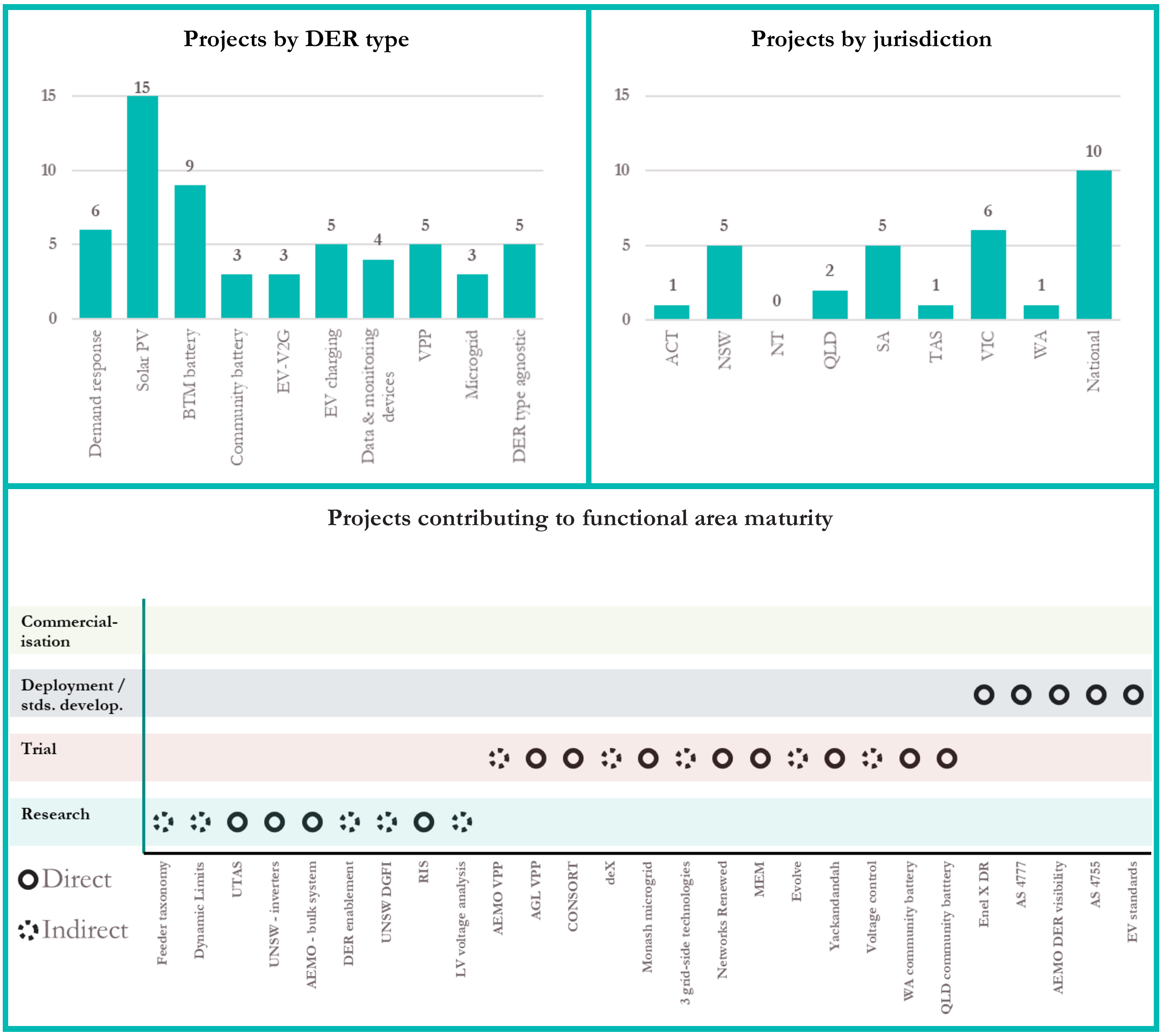
Improving the capability of existing DER devices is also a challenging issue that is yet to be resolved, with standards generally only applying to new DER systems. Trials and empirical data collected by AEMO and DNSPs have demonstrated that a sizeable portion of the existing fleet does not meet current requirements. We expect that this existing fleet will not be able to meet the higher requirements in the revised standard and will need to be grandfathered. This results in a long lead time to improve the capabilities of the overall DER fleet.

These challenges around standards compliance and the capabilities of the existing DER fleet are the primary reasons why we have assessed the maturity level of this functional area to be partially mature on completion of the projects and initiatives currently underway.

3.2 GRID SUPPORT

Description: The ability of DER devices to respond to power system disturbances in a manner that (1) limits or prevents any adverse impacts caused by the DER themselves and (2) provides additional grid support that benefits overall grid security and reliability

Maturity level: Partially mature



Discussion: As the penetration of DER increases in Australia's distribution networks, the cumulative effect of DER devices and their ability to provide grid support is becoming increasingly important. This includes:

- frequency control: DER's ability to respond autonomously to changes in system frequency to support frequency regulation and, potentially, provision of Fast Frequency Response
- voltage control: DER's ability to provide voltage / reactive support autonomously to changes in local area voltages, whether they are distribution, sub-transmission or transmission level nodes
- participation and coordination with existing and potential new emergency frequency control schemes to maintain system security.

A number of initiatives are currently underway to:

- understand the current grid support capabilities of DER devices
- derive empirical evidence on the potential need for improved capabilities
- improve the ability of DER devices to provide grid support, particularly in response to voltage and frequency variations.

Some of the significant projects and initiatives include:

- AEMO's *DER impact on bulk power system operations* initiative, in coordination with the ARENA-funded UNSW *Addressing barriers to efficient renewable integration* project, are together evaluating the benefit DER inverter systems can provide in grid support. UNSW is performing laboratory testing of grid supporting functions such as volt-var and volt-watt response of commercial off-the-shelf rooftop PV inverters.
- The *CONSORT* project evaluates orchestration of household batteries to obey and even alleviate distribution voltage and congestion constraints, making use of Reposit Power home energy management systems. Building on this work, the University of Tasmania led *Optimal DER Scheduling for Frequency Stability* project is assessing whether such DER orchestration can also provide frequency support to the bulk power system.
- Community battery initiatives in Queensland and WA are assessing whether co-locating community scale energy storage in areas of high DER penetration will not only allow increased DER hosting but also enable local area voltage management and thermal constraint mitigation.
- Standards Australia is undertaking a revision of AS/NZS 4777.2, which includes provision of sustained frequency response and revised set-points and limits to match electricity distributor and grid operator requirements. Standards work has also commenced for electric vehicles (EVs) through the *DEIP EV Grid Integration Standards Taskforce*, but is in very initial stages.

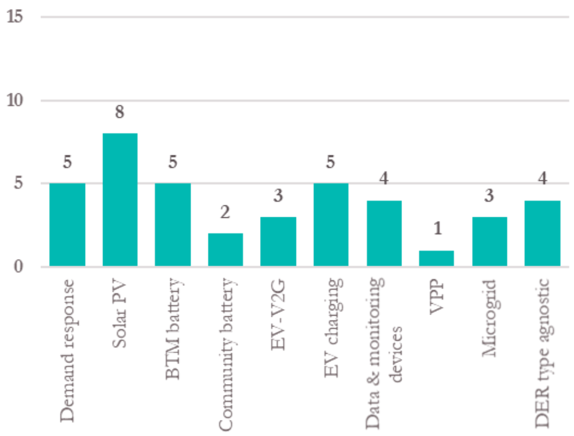
The desirable capabilities and main technology options for delivering most of those capabilities are reasonably well understood, as demonstrated by the current projects and overseas experience. However, as with the two other functional areas related to device capabilities (ability to withstand disturbances; protection and control), there are acknowledged limitations in relation to standards, including proposed reforms to governance arrangements for DER technical standards, compliance issues, and a long lead time to improve the capabilities of the overall DER fleet given that standards generally only apply to new devices.

3.3 PROTECTION AND CONTROL

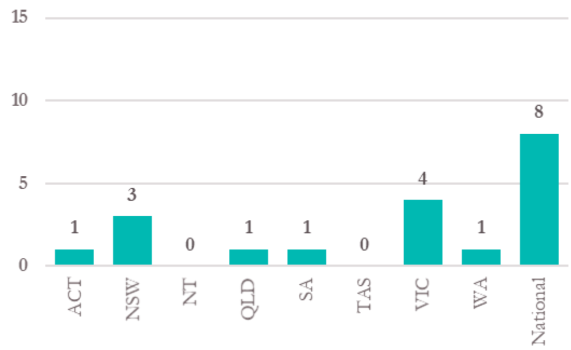
Description: The ability of the DER, particularly inverter connected DER, to coordinate its device protection with upstream feeder and transformer protection

Maturity level: Partially mature

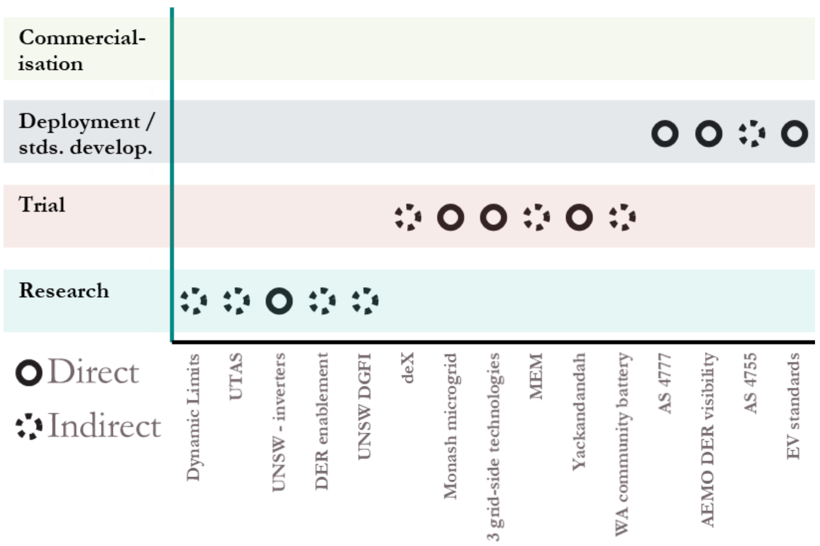
Projects by DER type



Projects by jurisdiction



Projects contributing to functional area maturity



Discussion: Low voltage (LV) distribution networks have traditionally been planned, designed and operated for managing a one way flow of power from the transmission system to load. The protection and control of such networks have reflected this design. As DER penetration, particularly distributed solar PV, increases across Australia, power system protection and coordination of protection schemes on these LV networks has become an increasing challenge for DNSPs. With very high penetration of DER, some LV networks have seen large fluctuations in voltages and reverse power flow back into the high voltage (HV) network.

The underlying technical issues in this functional area are well understood and most of the current projects are focussed on developing new capabilities and solutions to address these known challenges.

Some of the significant projects include:

- The UNSW *Addressing barriers to efficient renewable integration* project is performing laboratory testing of commercial rooftop PV inverters to check operation during grid disturbances, fault propagation, and temporary interruptions.
- Projects such as the *Monash Microgrid*, Jemena's *Demonstration of Three Dynamic Grid-Side Technologies* and the *Yackandandah microgrid SWER trial* are developing and testing solutions for protection and control in a high DER penetration scenario.
- New regulatory requirements arising from AEMO's *Visibility of DER* project and the recently implemented DER Register will also require static DER device settings data pertinent to protection and control to be collected and shared with DNSPs and AEMO through the DER register.
- Finally, significant upgrades to the existing AS/NZS 4777.2 standard are being planned for the near term addressing requirements related to safe distribution network operation and bulk power system disturbances.

The Standards Australia AS/NZS 4777.2 revision process is well underway with the standard expected to be published by March 2021. However, there are potential limitations as standards are voluntary documents, and only mandatory if called up in regulation. As discussed in relation to the ability to withstand disturbances functional area, revised governance arrangements for DER technical standards are currently being consulted on, and there are also acknowledged issues related to compliance with standards and long-lead times to improve overall fleet capability given standards generally only apply to new devices, which contribute to the partial maturity rating.

To progress to the next level of maturity, improved DER capabilities mandated through standards and regulation will need to be matched with more advanced and fit for purpose network side solutions that look beyond traditional techniques for LV / HV network protection and control. In particular, solutions that are adaptive to changing levels of DER penetration and different types of DER (eg increased penetration of electric vehicles and vehicle-to-grid technologies) will become critical, and for this, more effective coordination between the DER fleet and networks will be needed.

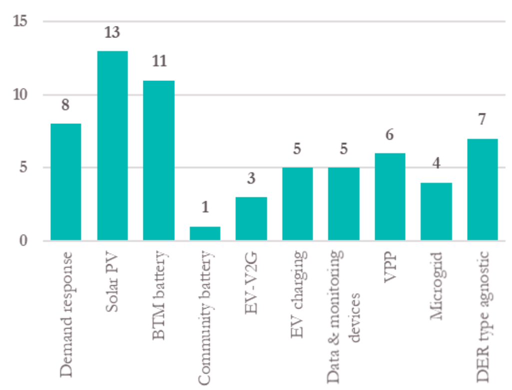
4. Communications and interoperability

4.1 INTEROPERABILITY BETWEEN DEVICES AND BETWEEN DEVICES AND SYSTEMS

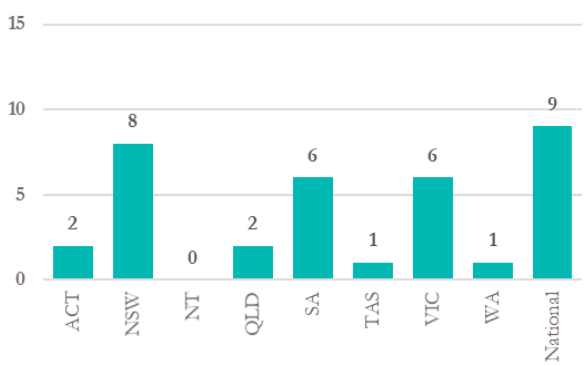
Description: **The ability of all parties who need to interact with DER devices to communicate and exchange information with those devices and with each other. This includes a common understanding between parties regarding what information will be shared, the format for the information and how it is to be used**

Maturity level: **Trial stage**

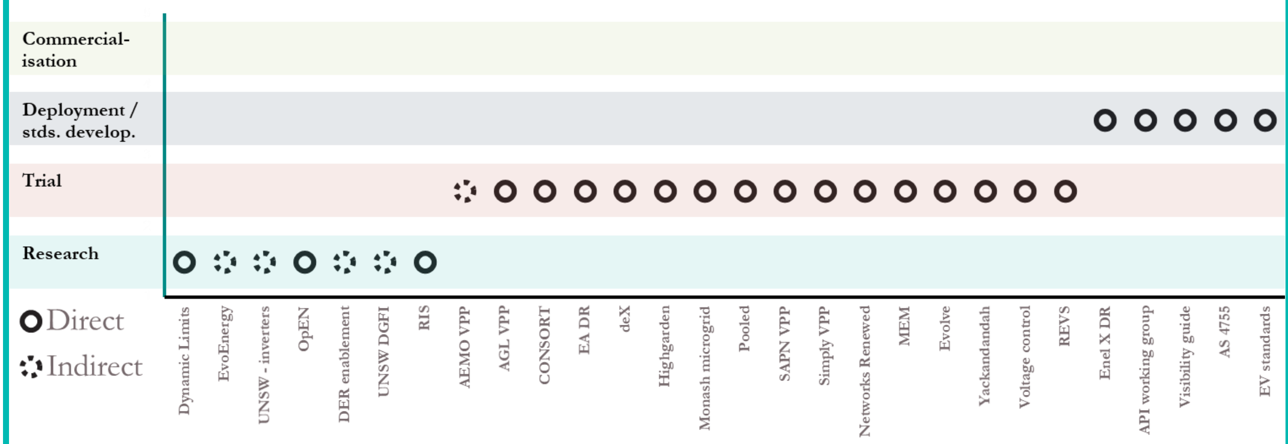
Projects by DER type



Projects by jurisdiction



Projects contributing to functional area maturity



Discussion: Increasing the interoperability of DER devices and the systems they communicate with is a key focus of many current projects. As with DER visibility, stakeholders agree that improved interoperability is a key prerequisite for effective DER integration. As visibility of DER-related data starts to improve, agreement on common ways to communicate and exchange data with DER devices and systems is a critical building block for unlocking the benefits of DER for all consumers.

There are currently no standards or industry agreement on what DER data should be shared or the format for data exchange. The only current standard related to DER interoperability is AS/NZS 4755, which is currently being updated and applies to remotely controlled demand response from a range of residential DER devices, but its focus is device level capability requirements rather than information exchange standards.

Industry is making good progress towards the adoption of voluntary standards for information exchange through the following collaborations:

- the *DER Visibility and Monitoring Best Practice Guide*, which aims to establish a common static and dynamic near real-time data set to be collected for new behind the meter DER
- the *DER Integration API Working Group*, which is working to develop and implement an industry standard application programming interface (API) for sharing DER-related data, including:
  - a Use Case document that will set out agreement on who generates what data, the specifications for that data and who needs access to that data; and
  - an Australian implementation guide to the IEEE 2030.5 international standard to facilitate the sharing of data between parties (IEEE 2030.5 sets out a standard communications protocol for DER integration applications)
- the recently established *DEIP EV Data Availability taskforce*, which is investigating electric vehicle (EV) data needs and potential standards.

There are close linkages between these initiatives and current trials and programs that are advancing interoperability issues, particularly projects related to VPPs and network hosting capacity. The API Working Group was established as a collaboration between the organisations involved in several ARENA-funded VPP trials with the aim of adopting a consistent approach to interoperability issues. Developing and demonstrating APIs and communications systems for exchanging information to enable distributed optimisation of DER is a key area of focus for several current projects, including *CONSORT*, *Evolve*, *deX*, the *EnergyAustralia demand response program*, *My Energy Marketplace*, and the VPP projects led by Simply Energy, SAPN and AEMO.

AEMO is also examining the role of interoperability of DER devices in maintaining bulk power system security and reliability. The *Distributed PV (DPV) stream of the Renewable Integration Study* is considering the potential need for curtailment of DPV during extreme system conditions and the opportunities for more fine-tuned control and coordination of DER to enable efficient DER integration. At the distribution level, *Open Energy Networks* considered the potential for new Distribution System Operator and/or Distribution Market Operator roles to assist with interoperability by facilitating the management and communication of distribution network constraints and the development of distribution markets.

These projects are making good progress towards increased maturity in interoperability, albeit from a relatively low base. The key requirement needed to progress to partial maturity is common understanding on the information that is to be shared and the format and method for sharing that information, through some combination of industry agreement or standards. Given Australia's size and reliance on overseas DER equipment manufacturers, any such standards or agreed frameworks will need to be consistent with international approaches but applied to Australian conditions (for example, like the approach being taken by the API Working Group in developing an Australian implementation guide to the IEEE 2030.5 standard). The ESB's current work on Governance of DER technical standards and the AEMC's current consideration of AEMO's rule change request on Technical standards for DER are likely to affect how standards on DER interoperability are determined in the future.

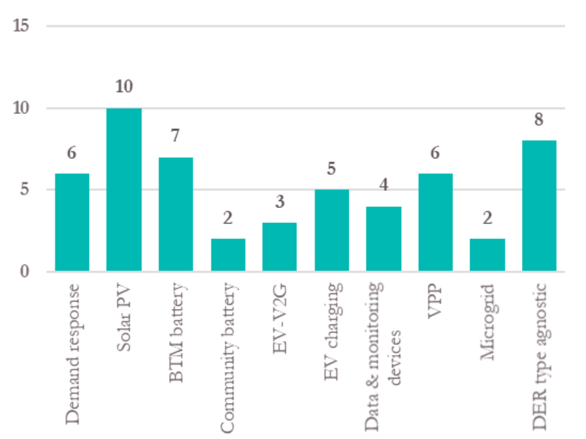
Once there is agreement on what information will be exchanged and how, the technology to implement that data exchange capability needs to be deployed at a wider scale. As DER penetration increases, and the availability and exchange of DER data increases, a number of stakeholders have suggested that closer attention may also need to be paid to the ability of current telecommunications networks to meet the requirements for time-sensitive access to large volumes of DER data, especially in regional areas. Different technology approaches are likely to be necessary to address these issues in different areas.

4.2 INTEGRATION OF DER WITHIN AEMO'S AND DISTRIBUTORS' SYSTEMS

Description: The system and infrastructure (eg IT) requirements necessary for AEMO and network service providers' systems to utilise the capabilities provided by DER and manage the potential impacts of DER in a coordinated and integrated manner

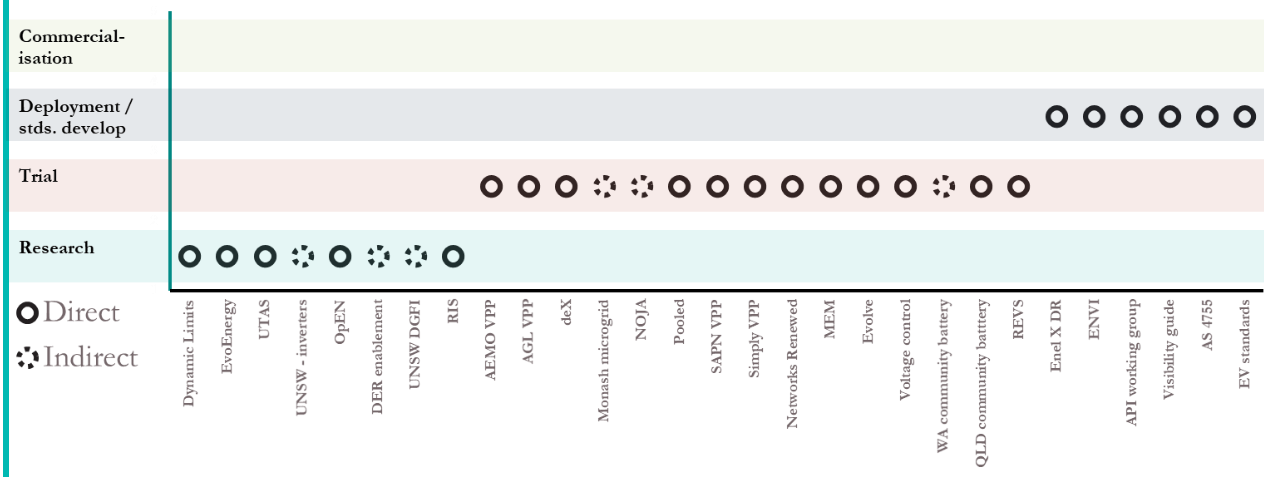
Maturity level: Trial stage

Projects by DER type



Projects by jurisdiction

Projects contributing to functional area maturity



Discussion: As DER penetration increases, it has a greater impact on how AEMO and DNSPs manage the grid and there is an increasing need for AEMO and DNSPs to integrate DER systems and data into a wide range of their systems in order to manage the potential impacts of DER and utilise the new capabilities DER can provide. The previous functional area on "interoperability" relates to how to communicate with DER devices. This functional area involves the capabilities needed by AEMO and DNSPs to integrate DER data within their respective systems.

Improved maturity in this area of system integration relies on improved maturity in the DER visibility and interoperability functional areas so that AEMO and network operators have increased visibility of DER and the ability to access DER data and communicate with DER devices or aggregators. The projects discussed in the maturity assessments of those two functional areas are therefore also relevant here, especially the collaborative industry processes that are seeking to reach agreement on what data is to be collected and how it is to be shared.

Increased maturity in system integration is also a key enabler for greater maturity in other functional areas, for example integration with wholesale markets and bulk power system security and reliability.

DNSPs are involved in a variety of trials and research projects related to the integration of DER data into a range of their systems. For example:

- several projects including *the SAPN advanced VPP grid integration* project are trialling capabilities for integrating data from VPPs and other forms of aggregated DER into DNSPs' systems
- multiple projects are seeking to integrate DER data into DNSPs' systems with the objective of assessing and increasing distribution network hosting capacity. For example:
  - Evoenergy's *DER integration and automation* project is demonstrating integration between the GreenSync deX DER platform and Evoenergy's Distributed Energy Resources Management System (DERMS), with the aim of unlocking existing network hosting capacity to enable consumers to gain more value from their DER
  - the *Evolve* project by Zeppelin Bend (a collaboration between industry, academia and government) has a focus on the development of software systems that will be integrated with the operational technologies used by DNSPs and the systems used by aggregators to manage DER, including trials in NSW and Queensland to develop new algorithms and capabilities to identify and ease distribution network congestion
- *Open Energy Networks* developed a Smart Grid Architecture Model (SGAM) blueprint describing the required functionality and interactions between different parties involved in DER optimisation
- the *Expanded Network Visibility Initiative (ENVI)* is being deployed across the Queensland distribution network to use a Distribution System State Estimation algorithm drawing on multiple different data sources (network asset registers, SCADA, distribution transformer monitors, advanced metering, premise-level measurements and statistical network usage data) to improve network visibility and provide the ability to perform automated simulation and assessment functions
- SAPN's *closed loop voltage control trial* is integrating data from DER into SAPN's network systems to provide active management of voltage
- The *Townsville community scale battery storage project* is integrating a community battery into Ergon's distribution network.

AEMO has several initiatives focussed on DER integration into the bulk power system. The *VPP demonstrations project* is examining how VPPs utilising multiple technologies can be integrated into market systems for the provision of frequency control ancillary services (FCAS). The *Distributed PV (DPV) stream of the Renewable Integration Study* recommends a range of actions to keep the power system operating securely at very high levels of DPV generation and integrate the future DPV fleet into the bulk power system.

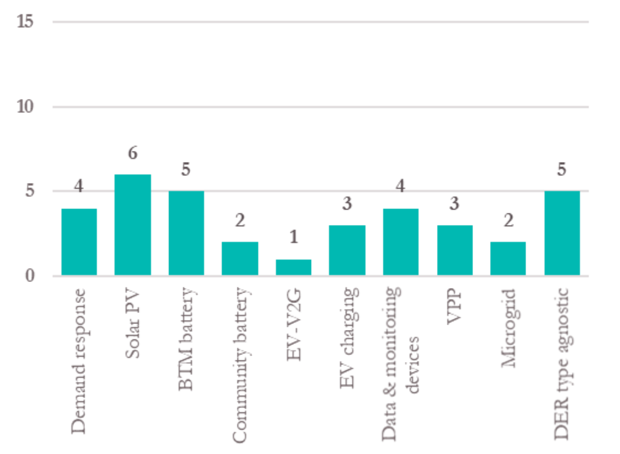
Most of these projects are relatively small-scale trials or are being undertaken in a sandbox environment. To progress to the next level of maturity, the current projects would need to be broadened to cover a wider range of DNSP and AEMO systems and move towards DER integration being more of a business-as-usual part of those systems. A range of technology solutions are likely to be required to integrate DER into the array of current systems, with the appropriate nature, scale and timing of system changes likely to vary between DNSPs. As noted above, improved DER visibility and interoperability will be a prerequisite for improved system integration.

4.3 CYBER SECURITY

Description: **The protection of devices and systems from unauthorised modification, theft or damage to the hardware, software or information on them or the misuse of the services they provide. The ability to be resilient to and detect, respond and recover from, a malicious cyber security event.**

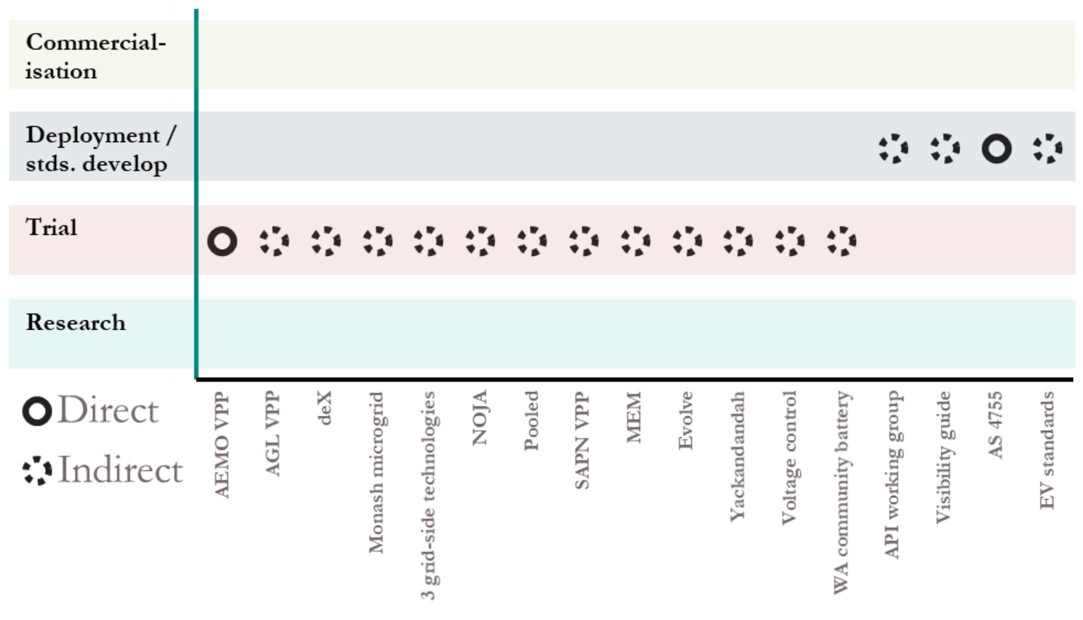
Maturity level: Research stage

Projects by DER type



Projects by jurisdiction

Projects contributing to functional area maturity



Discussion: While several trials contain a cyber security element, there are currently no projects dedicated to cyber security issues related to DER. Other sectors such as telecommunications and banking have relatively advanced capabilities and technologies for cyber security and protection, however the targeted application of those technologies to the current portfolio of DER projects appears to be a significant gap.

Energy businesses appear to be well-aware of cyber security issues and their impact on the sector. The Australian Energy Sector Cyber Security Framework (AESCSF) applies to the energy sector more broadly. The AESCSF was developed by AEMO, the Australian Cyber Security Centre, Critical Infrastructure Centre and the Cyber Security

Industry Working Group. The AESCSF contains maturity indicator levels, security profiles and a criticality assessment tool for assessing the cyber security capability and maturity of participants in the energy sector. In December 2018, AEMO published a summary report into the cyber preparedness of the National and WA Wholesale Electricity Markets based on results of organisations' assessments under the AESCSF. However, the AESCSF is relatively high-level and does not specifically address DER cyber security issues.

AEMO's *VPP demonstrations project* has a workstream related to cyber security where VPP participants are completing a cyber security questionnaire that is a "lite" version of the AESCSF questionnaire. This will be used to understand how VPPs address cyber security risks and whether any uplifts are required, and will feed into AEMO's work on proposed DER minimum standards. AEMO has also worked with Standards Australia and other parties to develop new cyber security requirements for the proposed update to the AS/NZS 4755 standards for residential demand response. The recently established *DEIP EV Grid Integration Taskforce* is also investigating gaps in relevant EV standards and identifying international standards that may be suitable for adoption in Australia, including in relation to cyber security issues.

Several other trials also include a cyber security element, for example the *Evolve* project includes cyber security penetration testing, the *Indra Monash smart microgrid* includes a cyber security assessment and the development of a cyber security framework, and the *NOJA Power intelligent switchgear* project is investigating how data can be used to detect cyber security attacks on networks.

Applying our maturity assessment framework, we consider that this functional area remains at the research stage. Although there are some trials addressing specific topics within the cyber security domain, in each case cyber security is a relatively small aspect of a broader project and there are no widespread trials of the relevant cyber security capabilities and technologies. None of the projects we reviewed are focussed on DER-specific cyber security issues, and the work that is being undertaken by the above projects is relatively specific to certain types of DER projects.

Significant research and development effort is required to understand how significant an issue DER cyber security is, and to more fully define the desirable capabilities for maturity and the technology options for implementing those capabilities. Cyber security is an area where a coordinated approach across the sector is important, as cyber security of the DER ecosystem relies on the cyber security posture of all parties involved and is only as resilient as the weakest link. For example, the effectiveness of specific cyber security controls at the DER device level relies on controls being applied in a consistently secure manner at the remote agent or aggregator level.

We are aware of at least one proposed project with a significant cyber security element that will help improve maturity. However, as at the time of publication of this report, funding for that project had not been confirmed or announced so it has not been included.

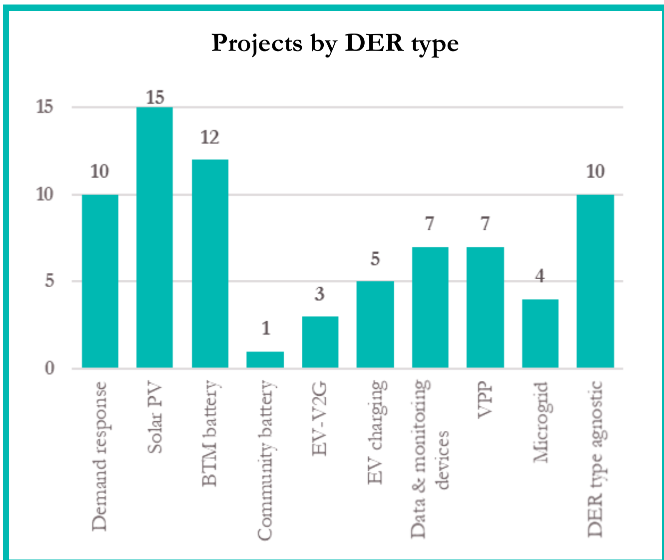
Improving cyber security preparedness has been recognised as an important issue by other bodies. It was a recommendation of the 2017 *Finkel Review into the Future Security of the National Electricity Market*, which recommended that the ESB prepare an annual report on cyber preparedness in the NEM. The ESB's *2019 Health of the NEM report* lists this recommendation as complete, based on AEMO's December 2018 cyber preparedness report under the AESCSF but notes, "The conclusions were that the current regulatory provisions were inadequate to address cyber security risk. This is an important conclusion given the independent hackers and sovereign states that are known to have accessed some electricity systems internationally causing system interruptions. A national response is needed and the Commonwealth Government is developing a national strategy. They will lead the approach in the electricity sector, supported by AEMO." The Commonwealth Government recently published *Australia's Cyber Security Strategy 2020*.

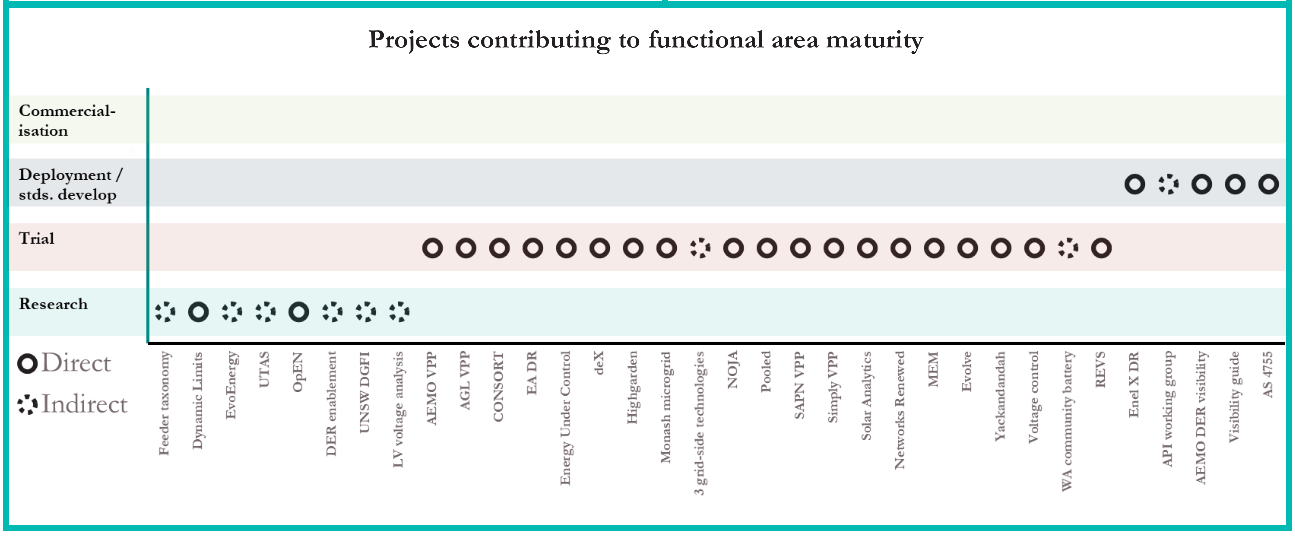
5. Understanding DER behaviour

5.1 DER VISIBILITY

Description: The ability to monitor where DER is installed and how it is capable of behaving in real-time so the benefits of DER can be maximised and the potential impacts on the local distribution network and the wider electricity system can be managed. This functional area includes what data is needed and how is it captured and stored

Maturity level: Trial stage





Discussion: Increasing the visibility of DER is widely acknowledged by stakeholders to be a key building-block for effective DER integration. A large number of trials are currently trialling a diverse set of technologies to improve DER visibility, but the scope and breadth of these projects is relatively narrow.

The current level of DER visibility is relatively limited, with AEMO, DNSPs and service providers having little or no visibility of data regarding most existing DER. As a result of AEMO's *Visibility of DER* project and a rule change by the AEMC, a DER Register was launched in March 2020. The DER Register is limited to static data that is collected at the time of installation of new DER devices and does not contain the full set of data needed to understand how the DER fleet is likely to behave in real-time.

Other than the DER Register, there are no current standards specifying what DER-related data should be collected and how it should be stored, or industry agreement on those matters. However, a range of projects are advancing those issues, including:

- The industry-led *DER Visibility and Monitoring Best Practice Guide* aims to establish a common static and dynamic near real-time data set to be collected for new behind the meter DER.
- The *DEIP EV Data Availability taskforce* is investigating electric vehicle (EV) data needs, including options for an EV data repository.

A significant number of projects are working on the technology and data required to improve DER visibility. Many DER service providers and equipment providers are developing and trialling technologies to improve the visibility of a broad range of behind the meter DER devices, including real-time device or circuit level monitoring of DER, associated Application Programming Interfaces (APIs) and intelligent controllers. Examples include projects led by Wattwatchers, GreenSync, Solar Analytics, Flow Power and NOJA Power.

The four VPP trials, the *Realising Electric Vehicle-to-Grid Services* project, several demand response projects and a number of related initiatives are improving the visibility of the DER devices participating in VPPs and demand response programs, including improving understanding of AEMO's and DNSPs' data needs for VPPs and aggregated demand response. There are also three projects demonstrating technologies for near real-time visibility of DER devices in microgrids (*Project Highgarden* in WA, and the *Indra Monash microgrid* and *Yackandandah* in Victoria).

Several projects are focussed on DER-related data to assist DNSPs manage their networks with high penetrations of DER, including *Open Energy Networks*, *Networks Renewed*, *Dynamic Limits*, the SAPN *closed loop voltage control* trial and *NOJA Power intelligent switchgear*. Some projects are also providing important information to AEMO to help it manage bulk power system security, most notably the Solar Analytics Enhanced reliability through short term resolution data around voltage disturbances project.

Regional differences in addressing the DER visibility challenges are evident due to widespread availability of smart meter data in Victoria and limited availability in other jurisdictions.

The large number of projects related to this functional area is promising given its importance to DER integration. Increased maturity in this area is a key prerequisite for increased maturity in several other functional areas.

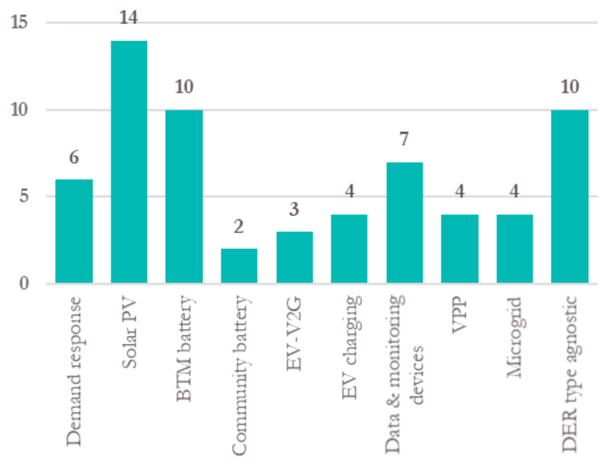
However, almost all current projects are relatively small-scale trials. A much broader deployment of the relevant technologies is necessary to move to the next level of maturity. An increased level of industry consensus or standardisation on what data is to be collected and how it is to be stored and shared would also assist improved maturity. It is also likely to be more challenging and expensive to improve the visibility of existing DER, meaning that there is likely to be a long lead-time to improve the visibility of the majority of the DER fleet if most improvements to visibility only apply to newly installed DER.

5.2 DER MODELLING

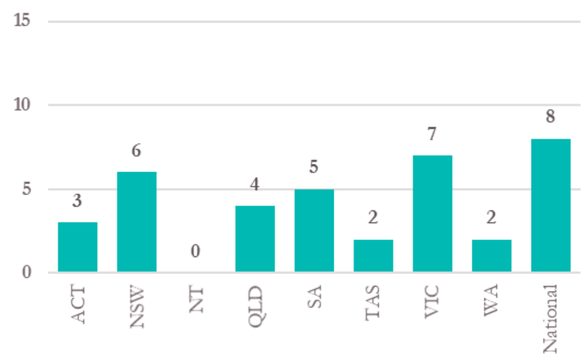
Description: **All aspects of data validation and models necessary to assess the technical impacts and benefits of DER at an individual level and in aggregate, including integration of DER models within broader system models**

Maturity level: **Trial stage**

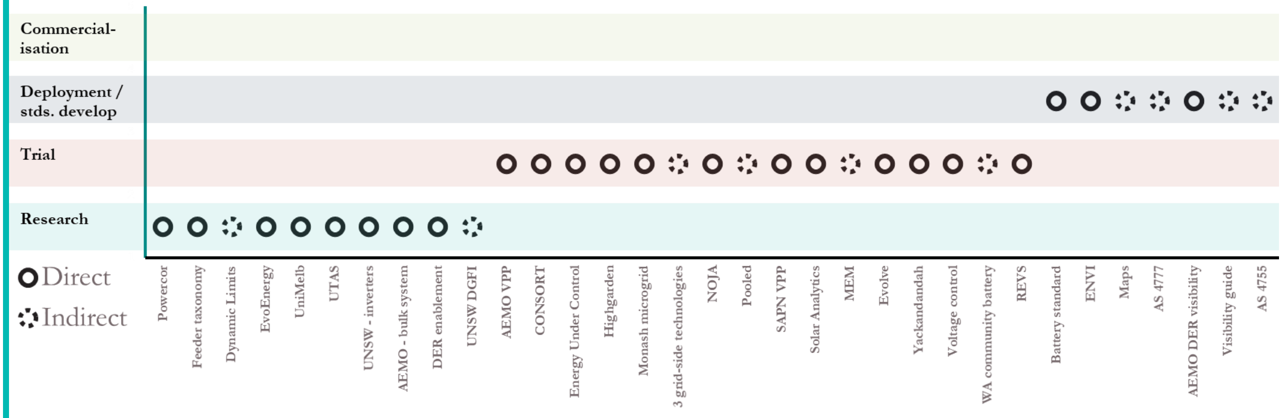
Projects by DER type



Projects by jurisdiction



Projects contributing to functional area maturity



Discussion: As DER visibility improves, numerous projects are starting to use the resulting data in DER modelling to more accurately understand the impact of DER on local distribution networks and bulk power system performance.

Enhanced static and real time DER data can feed into models that serve diverse objectives including:

- steady-state and dynamic representation of DER inverter characteristics for network planning purposes
- short term and long term forecasts for DER native generation and export at the connection point to inform operational planning, including how DER generation is affected by events such as cloud cover and the impacts of unpredicted DER operation
- detailed electromagnetic transients (EMT) models necessary for assessing complex system security issues related to system strength and post-event analysis.

- the ability to accurately model and assess DER impacts will enable networks to more accurately set and manage network hosting capacity limits and in turn help manage system security and reliability.

All of these important objectives are interlinked and we have observed that there are a considerable number of projects directly or indirectly contributing towards improved maturity in this functional area. Examples include:

- Powercor's *DER hosting capacity study*, University of Melbourne's *Advanced planning of PV-rich distribution networks* study and CSIRO's *Feeder taxonomy* are developing better models of the low voltage networks that can be used to assess network hosting capacity and network reliability and security issues.
- Other initiatives such as the *ENVI* project, *Evolve*, SAPN's *Advanced VPP grid integration* project and EvoEnergy's *DER integration and automation* project (through integration with the deX platform) are utilising the localised DER data to better model operating constraints and network operating envelopes. These projects are developing capabilities in real time DER modelling and are good examples of collaboration between vendors, DER aggregators and DNSPs to better model and analyse DER behaviour.
- At the bulk power system level, AEMO's *Renewable Integration Study* and *DER impact on bulk power system operations* initiatives have collated empirical evidence of DER responses during power system disturbances in South Australia and other areas of high DER penetration. The UNSW *Addressing barriers to efficient renewable integration* project is collaborating with AEMO to model and understand impacts of grid disturbances on DER. This joint effort is working towards representing DER behaviour and impacts across various timescales within various modelling contexts, for example examination of load available for shedding through under frequency load shedding schemes and the development of DER models for dynamic power system studies.
- We also note that ARENA recently announced a new project where Solcast will develop a nowcasting tool to assist DER forecasting in South Australia for AEMO and network providers using weather models, but that project was not announced in time to be included in this report.

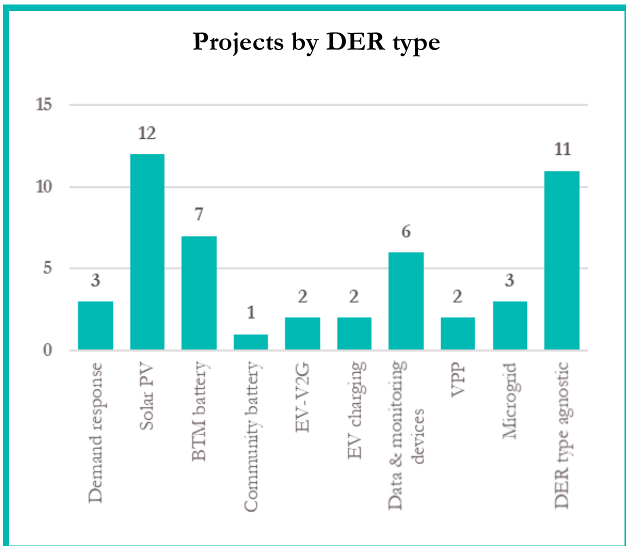
The large number of projects related to this functional area indicates the importance placed on it by various stakeholders. Increased maturity in this area will be an important enabler for improved maturity in several other functional areas including network hosting capacity, bulk power system security and reliability, and distribution system reliability and power quality.

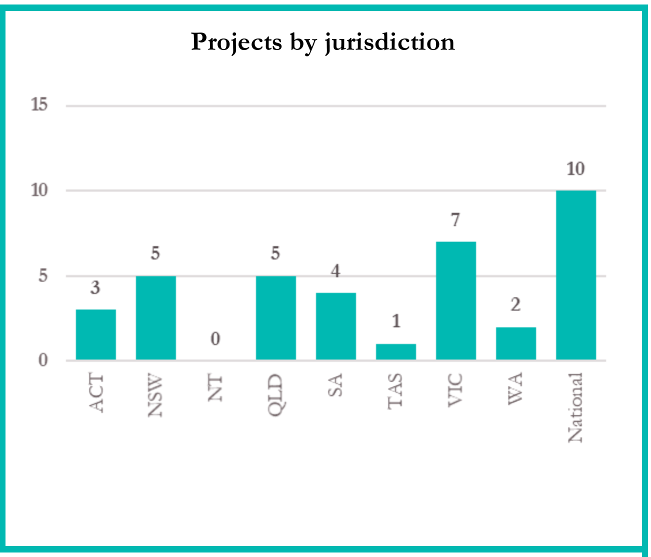
However, most of the projects are still at the trial stage and a wider deployment of the relevant technologies is necessary to move to the next level of maturity. An increased level of industry consensus or standardisation of modelling approaches and methodologies would also assist maturity. Another critical aspect of maturity is that while the market is gaining an improved understanding of DER models for solar PV and energy storage systems, models for other DER types such as electric vehicle-to-grid systems or aggregated residential demand response are in very early stages of development. It is foreseeable that as new forms DER emerge, DER modelling capabilities will need to rapidly adapt to these too. The current level of maturity of DER modelling can be contrasted with modelling of large-scale generating systems during their planning stage or in operations, which is a sophisticated exercise with models of varying complexities available for different applications. Even with very high penetration of DER in some areas, a similar understanding and commercial availability of advanced DER models is currently lacking.

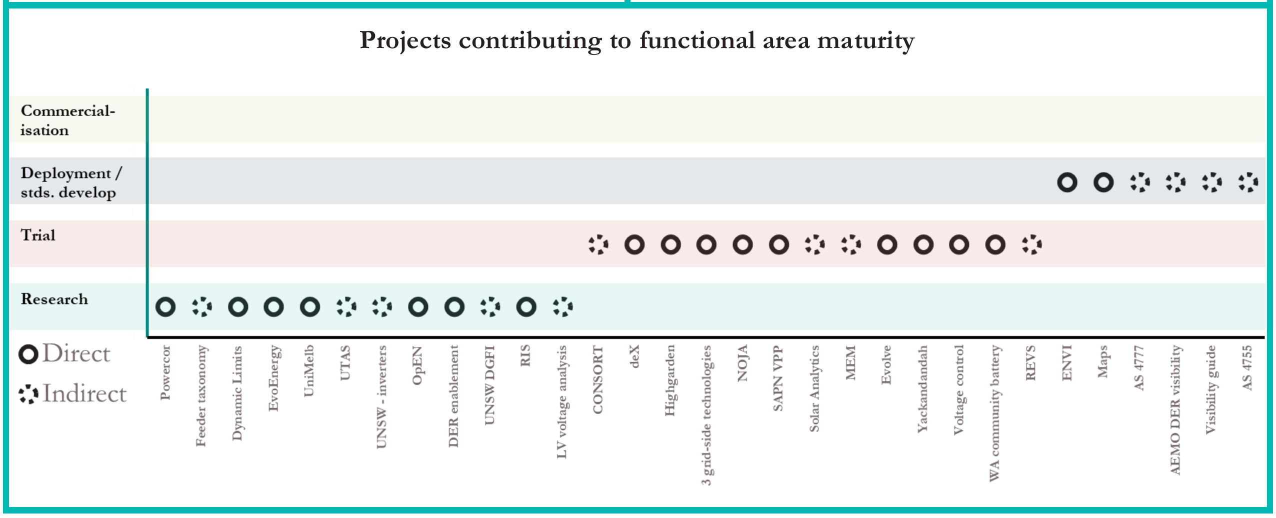
5.3 NETWORK HOSTING CAPACITY

Description: **Determining and communicating the amount of DER that can be accommodated within a DNSP's network, or the relevant part of the network, without adversely affecting thermal and voltage limits, power quality and reliability**

Maturity level: **Trial stage**







Discussion: A significant number of research projects and trials are examining technology solutions and data requirements for assessing, communicating and improving network hosting capacity.

The projects cover most of the key desirable capabilities for maturity and can be grouped broadly as follows:

- **Assessing network hosting capacity:** Several projects are focussed on assessing network hosting capacity. They include trials of a range of technologies in different network areas to improve visibility and modelling of low and medium voltage networks to estimate hosting capacity and generate what various projects call "operating envelopes", "dispatch constraints" or "dynamic limits" for the amount of DER the network can support while maintaining security, reliability and power quality. Most of those projects are currently limited to relatively small-scale trials, but one has progressed to broader deployment – the *Expanded Network Visibility Initiative (ENVI)*, which is being deployed across the entire Queensland distribution network.
- **Communicating network hosting capacity**: A number of projects include work on communications and interoperability-related issues so that network capacity limits can be communicated to DER service providers and integrated into VPPs and other DER aggregation systems. There is close collaboration between several of the

projects on these issues. There are no current standards that are directly applicable to this area, but several standards and DER visibility projects are indirectly relevant.

- **Increasing network hosting capacity**: DNSPs, universities and equipment vendors are leading a number of research projects, trials and simulations testing different technologies to increase hosting capacity, e.g. technologies to manage voltage issues so that the network can host increased amounts of DER before voltage limits are reached.

These projects involve DNSPs from every state and territory in the NEM. Project Highgarden and the WA community batteries project are also demonstrating technology solutions in WA.

A number of these projects were part of a recent ARENA funding round devoted to network hosting capacity and are still at a relatively early stage.

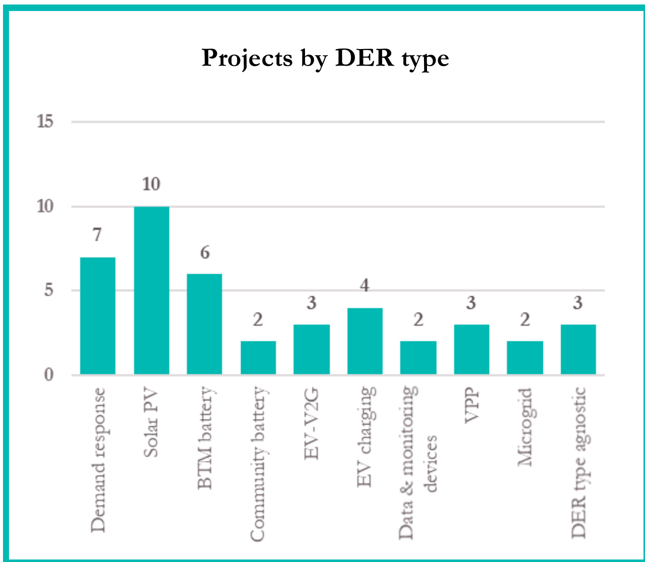
Based on these projects, it is likely that a range of different technology solutions will be needed, with the most suitable solution varying in different parts of the network. Broader national projects including the CSIRO *National LV feeder taxonomy study* and UTS *Network opportunity maps* will assist with scalability.

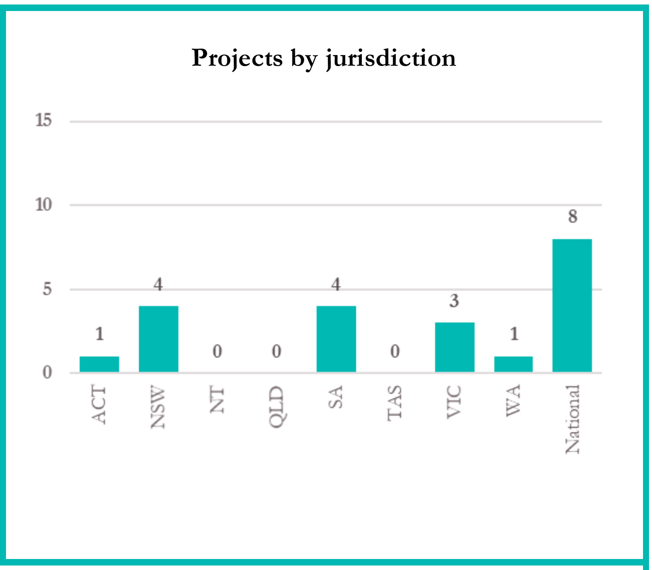
Increased maturity in this area will make a major contribution to effective DER integration. Parts of the network are already reaching their hosting capacity limits and DNSPs are having to limit the connection of additional DER or impose limits on DER exports. It is currently very difficult to set these limits accurately, or adjust them in a dynamic manner, due to very limited information regarding the LV network. These limits will become increasingly common and increasingly severe over time as DER penetration increases, unless network hosting capacity can be more accurately estimated, more efficiently managed and allocated, and increased though a range of technologies.

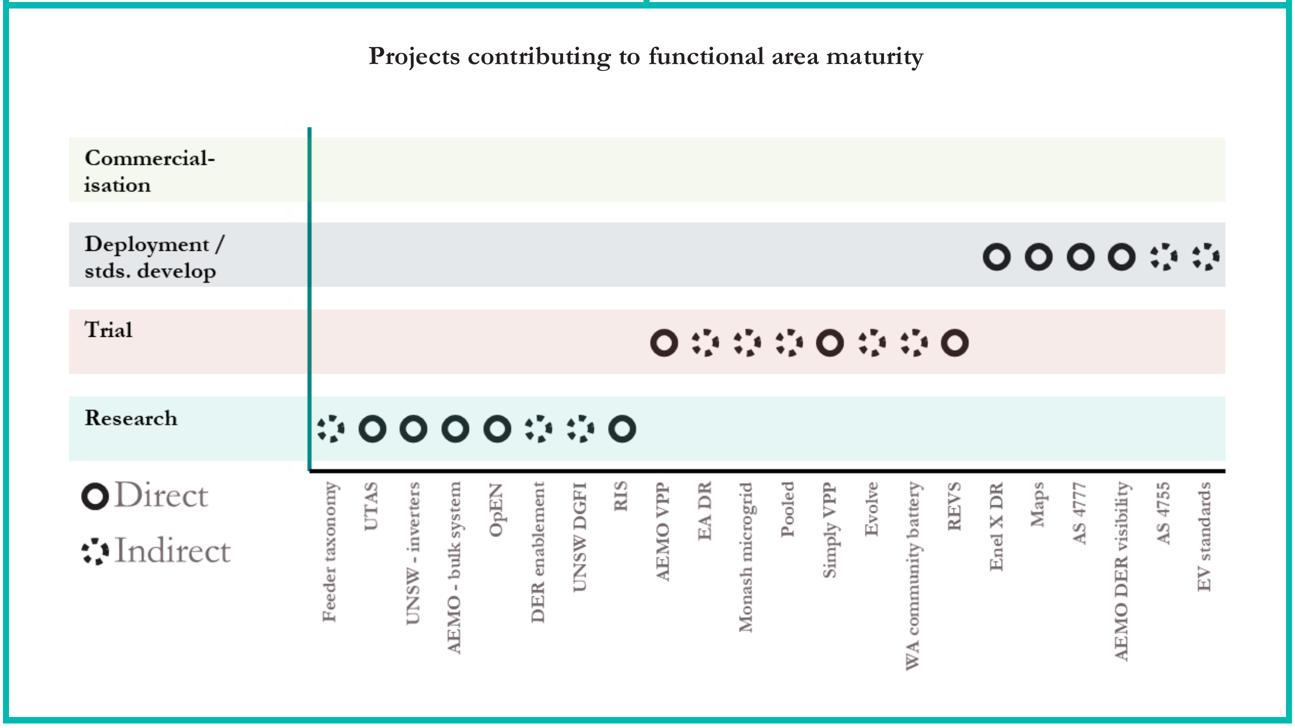
5.4 BULK POWER SYSTEM SECURITY AND RELIABILITY

Description: The technical processes and methodologies required by TNSPs and AEMO to adequately assess the operational impact of DER both individually and in aggregate and how DER can contribute to overall system security, reliability and resilience

Maturity level: Trial stage







Discussion: A number of projects are increasing our understanding of the impacts on the bulk power system of high levels of DER, which in most instances is not monitored or controlled.

The reliability and power quality issues related to the low voltage distribution network have long been identified as major limiting factors that need to be addressed for effective DER integration. In contrast, the impacts on the bulk power system and the technical capabilities required to manage the bulk power system in jurisdictions such as South Australia with very high levels of DER uptake are less well understood, but considerable progress has been made recently. Australia is at the cutting edge of DER adoption internationally so there are limited overseas experiences to draw from on these issues.

This functional area covers the operational impacts of DER on bulk power system security, reliability and resilience in relation to the following areas:

- frequency control and support
- voltage management
- system strength
- managing minimum load
- dispatchability and ramp rates
- impact on under-frequency load shedding (UFLS) systems
- system restoration.

The current trials are focussing on certain sub-areas such as frequency control and support, managing minimum load and dispatchability. Other areas such as system strength and system restoration, while critical, are not being actively assessed in current trials and are more at the stage of research projects.

AEMO, as the system operator, is leading the efforts on understanding these impacts on bulk power system planning and operations. AEMO's *Renewable Integration Study* and *DER impact on bulk power system operations* initiatives have collated empirical evidence of DER responses during power system disturbances in South Australia and other areas of high DER penetration. The Solar Analytics *Enhanced reliability through short term resolution data around voltage disturbances* project has provided granular DER data during power system disturbances to AEMO. The Solar Analytics data along with the inverter bench testing and DER modelling work performed at UNSW have assisted AEMO in understanding emerging issues such as those related to increasing contingency sizes following network events and reduction in daytime system load profiles.

Projects such as the UTAS *Optimal DER scheduling for frequency stability* project and AEMO *VPP demonstrations* are aiming to further understand the mechanisms by which DER can assist in maintaining grid frequency stability and participate in contingency frequency control ancillary services (FCAS) markets. Demand response by commercial and industrial (C&I) customers to provide reserve capacity during constrained periods through the Reliability and Emergency Reserve Trader (RERT) market mechanism is an area where the technical capabilities are well defined and projects have moved beyond trial stage to commercial deployment. Examples are the *Enel X demand response project* and the C&I part of the *EnergyAustralia demand response program*.

Even with the above initiatives and projects, there is general consensus amongst stakeholders that this functional area needs further evaluation and the full extent of DER impacts need to be better understood. The capabilities and potential technical solutions to manage bulk power system reliability and security in a high DER penetration scenario are being trialled but these are not well-defined. AEMO is also considering how best to integrate the learnings from its trial programs into longer term "business as usual" functions within AEMO, supporting AEMO operations teams to integrate DER into their models, and delivery of their system operation functions.

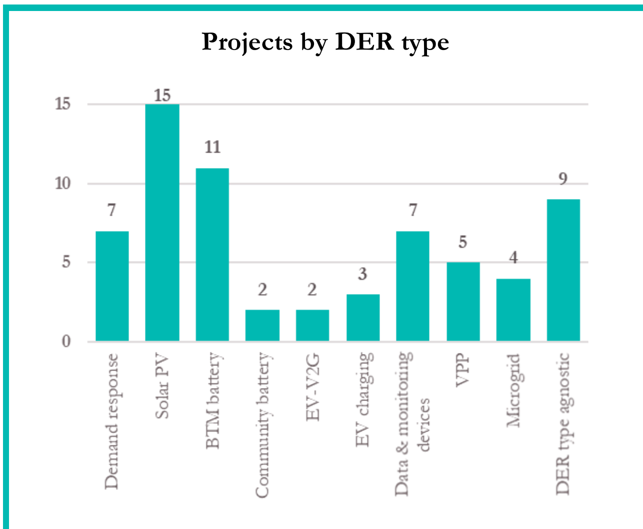
This functional area may be affected by future market reforms, most notably the ESB's work on two-sided markets and ahead markets, or the potential adoption of distribution system operator (DSO) or distribution market operator (DMO) models as explored in the *Open Energy Networks* project.

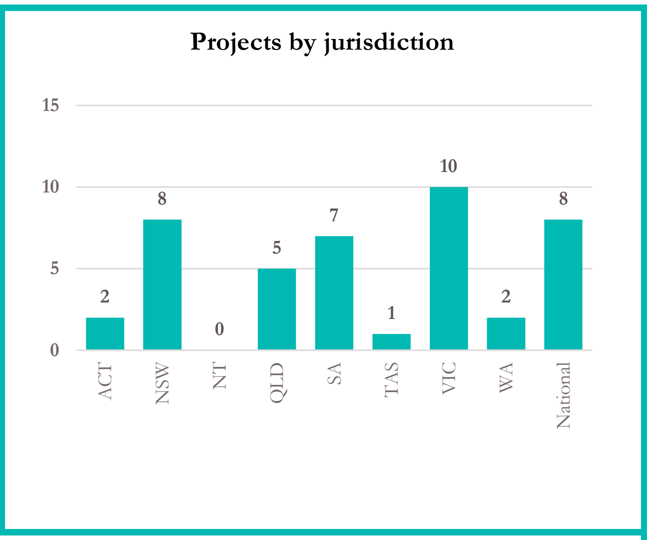
In order to progress to a "partially mature" level, there needs to be further investigation and a wider consensus on the technical challenges, desired capabilities and proposed solutions.

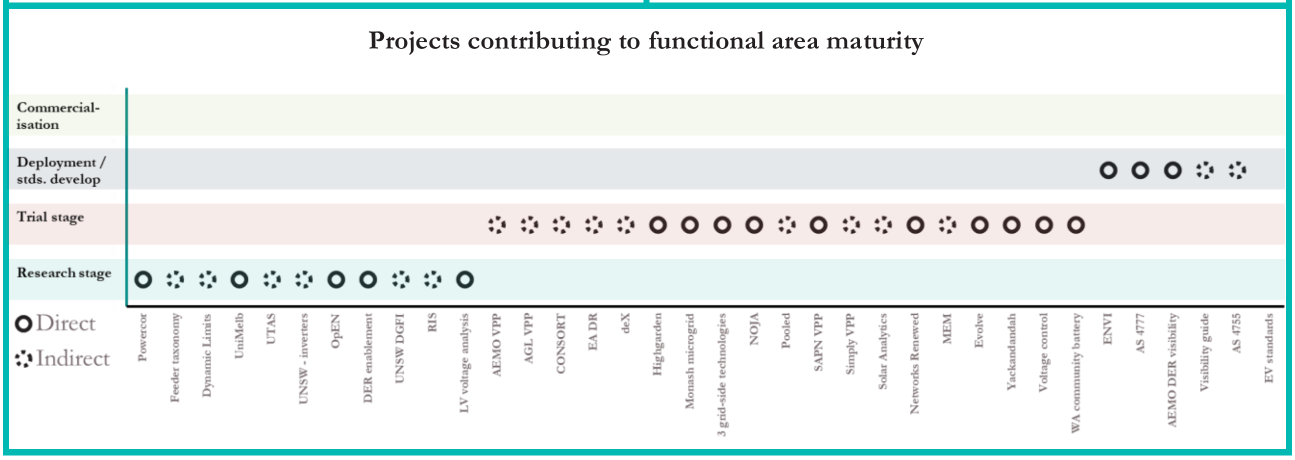
5.5 DISTRIBUTION SYSTEM RELIABILITY AND POWER QUALITY

Description: The technical processes required by DNSPs to maintain local distribution network power quality related to voltage fluctuations and harmonic voltage or current distortions and enable more efficient management of distribution network reliability and power quality

Maturity level: Partially mature







Discussion: As DER penetration has increased to high levels, particularly solar PV in parts of South Australia and Queensland, the local distribution networks have experienced a degradation in power quality performance. This usually manifests in voltage fluctuations, over-voltage conditions and high harmonic current distortion requiring DNSPs to take steps to maintain power quality. In some instances, where reverse power flow on low voltage (LV) feeders and distribution transformers has been observed, power system protection and coordination of protection schemes have become a challenge.

As a result of widespread challenges in this area, this functional area has been one of the most researched and trialled areas in our assessment. A variety of network side and DER / customer side solutions are being evaluated.

- In Victoria, trials led by DNSPs (Citipower/Powercor, AusNet Services and Jemena) have attempted to utilise the existing smart metering infrastructure to better detect emerging distribution network issues and develop network side solutions such as LV phase rebalancing, distribution transformer tap adjustments and feeder reconfigurations.
- Other DNSPs such as Horizon Power and SAPN are partnering with customers either directly or indirectly through DER aggregators to manage distribution network constraints in near real time. Horizon's *Project Highgarden* and SAPN's *Advanced VPP grid integration* trial with Tesla and Energy Locals are integrating customer

DER monitoring and control within DNSP systems to maximise hosting capacities while maintaining adequate levels of network reliability and security.

- Some trials such as *Networks Renewed*, the *Yackandandah microgrid SWER trial*, the *Indra Monash microgrid* and *Project Highgarden* have assessed the types of solutions that are likely to succeed in a microgrid or isolated grid operation. Such networks present a unique set of challenges due to the need to manage voltage and frequency without reliance on the system services accessible in a large interconnected network. At the same time, they provide opportunities to assess solutions in island mode and without external influencing factors.
- Technology vendors such as GridQube (*ENVI*), Zepben (*Evolve*) and NOJA Power are trialling and implementing innovative solutions that will assist DNSPs in better managing these power quality and reliability issues in their respective networks.
- Significant upgrades to existing standards – AS/NZS 4777 for inverter connected DER systems and AS/NZS 4755 for residential demand response equipment – are under development that will assist networks and DER devices to better support each other and utilise advanced DER functionality to better manage network power quality and reliability.

With the above initiatives and projects, the desirable capabilities and main technology options for delivering most of those capabilities are well-defined and understood. There is reasonable confidence amongst stakeholders that the technology components will be available in the medium term or sooner and widespread adoption is feasible.

However, there are currently multiple potential options and no common agreement on the optimal approach and end-state. There also seems to be significant geographical variation in the solutions. For example, the trials in Victoria rely heavily on the available smart meter data to which other jurisdictions currently have limited access. DNSPs in SA, QLD and WA are at the bleeding edge of distribution system reliability issues due to high DER penetration and the trials in these jurisdictions are advancing innovative solutions to solving them (for example, Project Highgarden in WA, the SAPN Advanced VPP grid integration and closed loop voltage control projects in SA, and ENVI in Queensland). More work is required on how best to integrate the learnings from trial programs into longer term "business as usual" functions to move to the "mature" level.

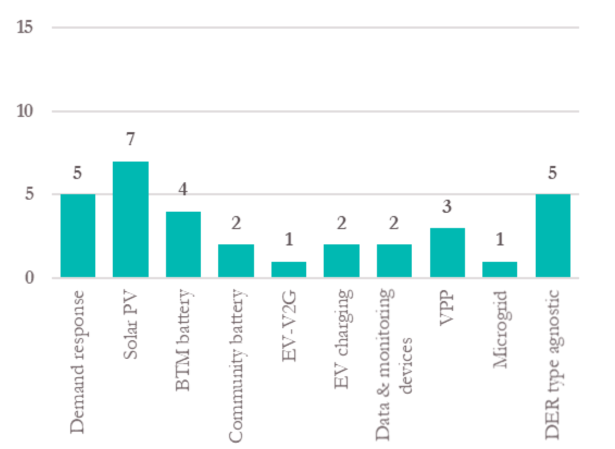
6. Services

6.1 INTEGRATION WITH WHOLESALE ENERGY AND SYSTEM SECURITY SERVICES MARKETS

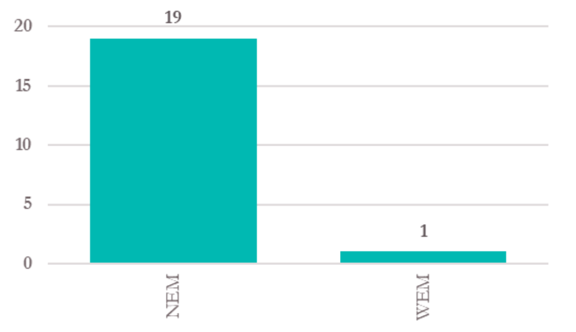
Description: The ability for DER to participate in current and future markets for wholesale energy and system security services

Maturity level: Trial stage

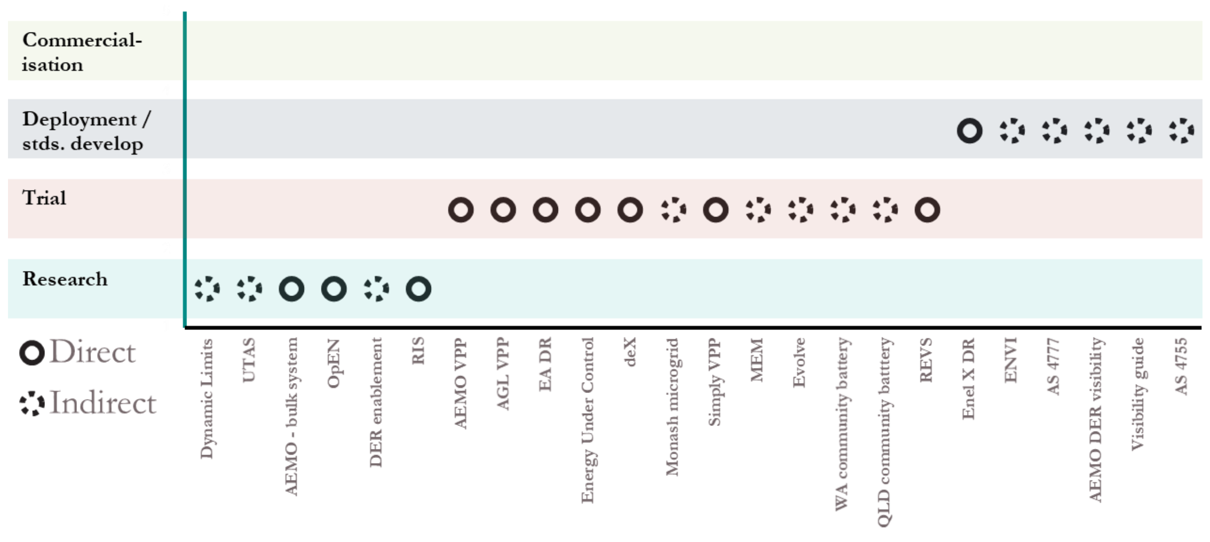
Projects by DER type



Projects by market



Projects contributing to functional area maturity



Discussion: A range of trials have made considerable progress in understanding the capabilities and technology options for using aggregated DER to provide services into wholesale markets. However, most of these projects have not yet progressed beyond trials. The projects also do not yet cover the full range of types of DER or the full suite of wholesale and system security services – this is a functional area where the level of maturity varies markedly between different types of DER and different services.

Several trials involve Virtual Power Plants (VPPs), focussing on residential batteries and solar PV systems:

- A number of battery and solar VPPs are trialling different technology approaches and are well-coordinated. There are linkages between those trials and the requirements of AEMO and distribution networks through the AEMO VPP demonstrations project and projects by several parties related to network hosting capacity.
- The VPP projects are primarily providing wholesale energy services and contingency frequency control ancillary services (FCAS). The technical requirements for the provision of these services by a VPP are now relatively well understood and demonstrated. At least one party (Amalgamated Energy Services, a related company of Reposit Power) has moved beyond trial phase to commercial provision of all six contingency FCAS services outside of any trial project. The technical capabilities for the provision by a VPP of other services, including regulating FCAS, are not yet proven.
- As with most functional areas, electric vehicle (EV) projects are under-represented. The use of EVs and associated vehicle-to-grid (V2G) capability to provide wholesale and system security services has not yet been tested. It will be the subject of the recently announced *Realising Electric Vehicle-to-Grid Services* project in the ACT, which will be the first time an EV-based VPP has provided FCAS.

The other main area covered by the projects is demand response:

- Demand response by commercial and industrial (C&I) customers to provide wholesale energy and Reliability and Emergency Reserve Trader (RERT) services to AEMO is the area where the technical capabilities are most fully defined and where projects have moved beyond trial stage to commercial deployment. Examples are the *Enel X demand response project* and the C&I part of the *EnergyAustralia demand response program*.
- Demand response using aggregated DER from residential customers is less advanced commercially. Compared with C&I customers, installing the necessary communications and control equipment to enable a fleet of aggregated residential demand response equipment to respond sufficiently quickly and accurately to provide services such as FCAS is more complex and expensive relative to the revenue that can be earned. Additional customer engagement and behavioural issues also have to be addressed. But there are several promising trials. The current revision of AS/NZS 4755 will also assist maturity by updating standards for residential demand response capabilities.

Almost all the projects that we assessed are focussed on the NEM. The *WA community battery project* is the only project included in our group of trials that is directly investigating the provision of market services in the WEM. We are aware of a major proposed WA trial that would advance the maturity of these issues in the WEM but has not yet been announced so is not included in this report. Horizon Power's *Project Highgarden* is also considering related issues in the North West of WA.

There are considerable interactions between the level of maturity in this area and other functional areas. Increased maturity in the DER visibility and interoperability functional areas will help progress maturity in this area. There are different views amongst stakeholders regarding the efficient balance between (a) mandating capabilities in devices (i.e. aiming for a higher level of maturity in the three device-related functional areas so that all devices can automatically support system security and reliability or can be controlled to do so when needed) and (b) increased DER visibility, modelling and integration with markets so aggregated DER can be rewarded for providing services that support security and reliability.

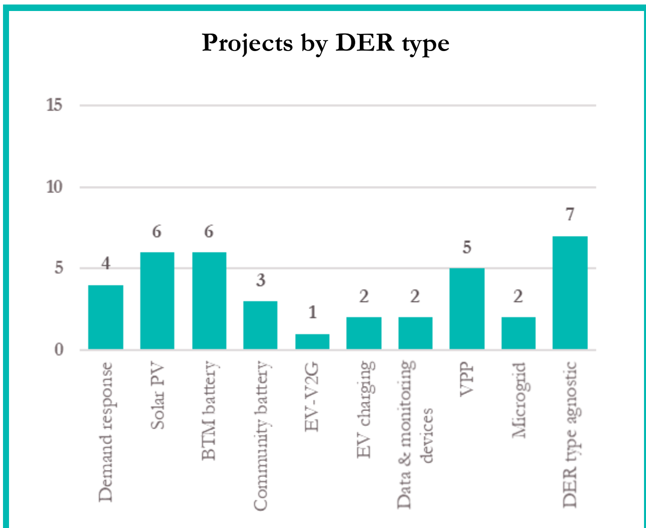
This functional area is likely to be affected by future market reforms, most notably the ESB's work on two-sided markets and ahead markets, the AEMC's recent introduction of a wholesale demand response mechanism and work by the market bodies on system security services. Those reforms could change the current suite of wholesale and system security services, the ability of DER to provide some of those services, and/or the incentives for the provision of some of those services by DER.

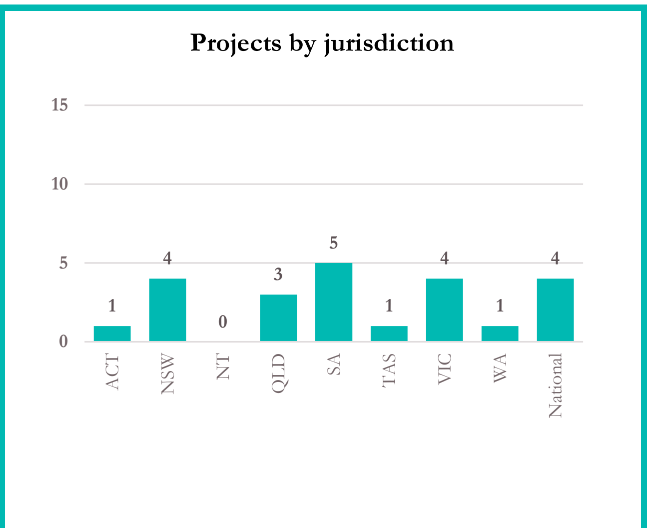
This is a functional area where a lot of progress has been made in recent years and there are a number of promising trials. To progress to the partially mature stage, the technology that is the focus of current trials needs to be scaled up to move into broader commercial deployment. There also needs to be a more even level of demonstrated capability across the full range of DER types, services and markets.

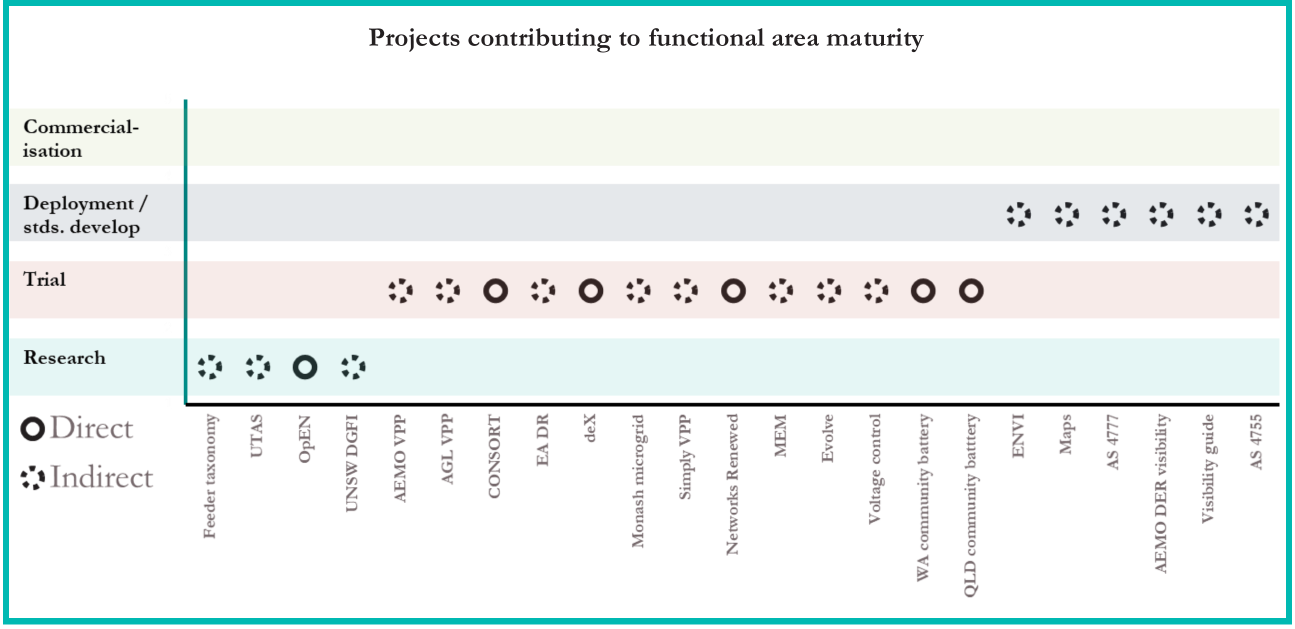
6.2 PROVISION OF LOCALISED NETWORK SERVICES

Description: The ability of DER to provide services to network service providers to enable them to operate their networks more efficiently and/or maintain or improve reliability and power quality

Maturity level: Trial stage







Discussion: Several projects are trialling a range of complementary approaches for using DER to provide network services to DNSPs to enable them to maintain reliability and power quality, host increased levels of DER and avoid or defer traditional network augmentations.

The ability of larger forms of DER such as embedded generation to provide network support services by reducing peak demand to delay or avoid the need for a traditional network augmentation has been well understood and demonstrated for some time. Several projects are trialling extending that capability to small-scale DER using aggregated solar PV systems, batteries and demand response. For example, GreenSync's deX platform is being used by VPPs to provide network services. There are also some well-established DNSP programs using that capability, such as Energy Queensland's PeakSmart air-conditioner demand response program, which were not included in this report due to our focus on more recent projects.

Community battery projects in WA and Queensland are also demonstrating how community batteries can be used to defer traditional network investment as well as provide other services. For example, the *WA community batteries* project has used community batteries to defer distribution transformer upgrades.

Several trials are also using the capabilities of aggregated DER to provide voltage and frequency support services to DNSPs to maintain power quality. Examples include the *CONSORT Bruny Island battery trial* and the *Optimal DER scheduling for frequency stability* project in Tasmania and the *Networks Renewed* project in NSW and Victoria. This type of network support service is likely to become more important in the future as increased DER penetration results in DNSPs facing increased challenges managing the network during periods of minimum demand, in addition to the traditional use of network support services to help manage peak demand.

Open Energy Networks (OpEN) examined the potential for the introduction of Distribution System Operator (DSO) and Distribution Market Operator (DMO) roles to enhance the provision of network services by DER service providers. It included an assessment of how, depending on the framework adopted, network support services could be procured directly by DNSPs, AEMO or a third party. OpEN's Interim Report on required capabilities and recommended actions recommended that steps be taken to trial new approaches to markets for network services and increase visibility of bilateral network service agreements. We understand that trials to test these markets are under development and new projects may be announced shortly.

These projects are providing a good understanding of the capabilities and technology options for using DER to provide a range of network support services. To progress to the next level of maturity, the use of DER to provide network services needs to move from trials and small-scale projects to broader commercial deployments covering a variety of different types of DER, network locations and network support services.

Appendix A Project list and short names

Project name	Project short name	Lead organisation	Summary of the project
Addressing barriers to efficient renewable integration	UNSW - inverters	UNSW	The project will focus on the assessment of inverter performance and modelling related to frequency control, ancillary services, and electricity market rules/operating procedures. By using bench testing, UNSW will directly test the response of a range of PV and storage inverters to disturbances of different kinds on the network. In addition, the installation of high-speed disturbance recorders on key distribution network feeders will monitor and record behaviour during power system disturbances. Results from this will provide detailed information that can be used to develop a "composite PV-load model". This model can be used by AEMO and TNSPs to more accurately represent the behaviour of load with embedded PV. This model is critical for all system security studies, including determining network stability limits, and frequency control requirements.
Advanced Planning of PV-Rich Distribution Networks Study	UniMelb	University of Melbourne	This project will develop analytical techniques to assess the residential solar PV hosting capacity of electricity distribution networks by leveraging existing network and customer data. This project will also produce planning recommendations to increase solar PV hosting capacity using non-traditional solutions that exploit the capabilities of PV inverters, voltage regulation devices, and battery energy storage systems.
Advanced VPP grid integration	SAPN VPP	SA Power Networks	The project aims to show how higher levels of energy exports to the grid from customer solar and battery systems can be enabled through dynamic, rather than fixed, export limits, and to test the value this can create for customers and VPP operators. The Project has implemented an interface (API) to exchange real-time and locational data on distribution network constraints ("operating envelopes") between SAPN and the Tesla SA VPP, enabling the VPP to optimise its output to make use of available network capacity.
AGL Virtual Power Plant	AGL VPP	AGL	The AGL VPP is installing and connecting behind the meter (BTM) solar battery storage systems across 1,000 residential premises in Adelaide, to be managed by a cloud-based control system. The batteries will be able to "talk" to each other through a cloud-based platform using smart controls, forming a connected system that will be able to operate as a 5MW solar power plant. The primary aim of the project from a knowledge sharing perspective is to understand the various value pools that BTM batteries are able to access, and what barriers may exist to their realisation.

Project name	Project short name	Lead organisation	Summary of the project
Battery storage system performance standard	Battery standard	DNV GL	The objective of this project is to produce a draft performance standard for Battery Energy Storage Systems (BESS) connected to domestic/small commercial PV systems. The draft standard will comprise a series of performance testing protocols and performance-metric reporting methods for manufacturers and system integrators. This is to ensure that end users are better informed regarding the expected performance of a BESS in order to compare systems on a like-for-like basis. The draft standard will be submitted to Standards Australia.
Closed loop voltage control trial	Voltage control	SA Power Networks	The project is establishing voltage control techniques at zone substations to boost network hosting capacity and provide demand response services. A key goal is to determine whether closed-loop substation voltage control, which has been demonstrated successfully in Victoria, can be achieved in other states without access to ubiquitous smart meter data. The scope includes establishing capabilities to optimise network voltage by automatically controlling substation tap positions to deliver an efficient solution to increase network hosting capacity for large numbers of customers and establish capabilities that will unlock voltage-optimisation based demand management on SAPN's network. It will also demonstrate how network visibility can be enhanced by combining data from a variety of distributed data sources with data science.
Consumer Energy Systems Providing Cost-Effective Grid Support	CONSORT	ANU	The CONSORT Bruny Island Battery Trial successfully developed and demonstrated an innovative automated control platform that enables consumers with battery systems to provide support to a constrained electricity network. At the heart of CONSORT is a platform called Network Aware Coordination (NAC). The NAC's primary task is to automatically coordinate household energy systems (in a non-intrusive way) enabling them to adhere to and alleviate network constraints. DER owners are automatically and fairly rewarded for the support they provide.
Decentralised Energy Exchange (deX) Program	deX	Greensync	Decentralised Energy Exchange (deX) is a market-enabling digital platform that aims to provide electricity networks with better coordination and control of the increasing volume of DER in the electricity grid. deX also aims to enable consumers to get more value from their DER assets by being rewarded for participating in grid services. deX forms the layer between DER and the grid through Application Programming Interfaces (APIs). It aims to allow technology manufacturers and other platform owners to integrate their technology with deX so that consumers can register their DER. Retailers and network operators will then be able to view, coordinate and contract available DER for a variety of energy services.

Project name	Project short name	Lead organisation	Summary of the project
DEIP EV Gird Integration Standards Taskforce	EV standards	AEMO	This project will identify relevant EV grid integration standards gaps and any international standards that may be candidates for adoption/modification to cater for the identified gaps. This will enable effective engagement and influence in relation to EV standards development in Australia and internationally. The absence of comprehensive EV grid integration standards increases the risk of an inefficient transition to electrified transportation for consumers, potentially leading to additional costs and reduced uptake of EVs. Notable standards gaps include charger performance and capability, interoperability and cybersecurity.
Demonstration of three grid-side technologies	3 grid-side technologies	Jemena	The project is demonstrating how increasing the visibility of LV networks can help manage grid power and voltage fluctuations. Three grid-based technologies are being assessed: • Dynamic phase switching of customer loads on LV feeders to help mitigate localised over-voltage challenges caused by concentrated DER assets • Dynamic power compensation to adjust the output voltage and mitigate load unbalance challenges at distribution transformers • Battery energy storage with Virtual Synchronous Generator capability to mitigate potential power quality and network stability challenges caused by very high DER penetration.
DER Enablement Project	DER enablement	Renew	This project aimed to identify the range of technical problems associated with DER feed-in, understand the range and costs of remediation options, and – as much as possible – identify the types of approaches that deliver maximum customer benefit while remediating the problems in different types of networks and at different levels of DER penetration. This would then give guidance to consumer advocates and other stakeholders seeking to engage in the development of DER enablement policies and practices, including DNSP price reviews.
DER Hosting Capacity Study	Powercor	Powercor	The project aims to demonstrate the issues faced by Australian distribution networks in maintaining security and quality of supply in the context of increasing DER penetration. It will also assess potential mitigation options, based on analysis of implementation cost vs benefit (ie additional PV hosting capacity created). This will provide a basis for more informed discussion between industry and academia using actual network data and a publicly available power system analysis software.

Project name	Project short name	Lead organisation	Summary of the project
DER impact on bulk power system operations	AEMO - bulk system	AEMO	This is an ongoing program of work focussed on the bulk power system implications of increasing DER uptake – when challenges may emerge, how these challenges might be addressed and, where necessary, mitigation measures. As penetrations increase, the aggregated impact of this fleet affects almost all core duties of the bulk system operator in some way due to performance during disturbances, ongoing reduction in the daytime system load profile, an increasingly large source of renewable generation, and an increasingly large source of generation that cannot be curtailed. The current focus, given high levels of penetration in the NEM and SWIS today, is on passive distributed PV (DPV). Work to date has mainly centred on the South Australian region given its high share of DPV generation relative to local underlying demand, and weak interconnection with the NEM – with other regions to follow. Similar work was undertaken for the South-West Interconnected System in 2019.
DER Integration and Automation	EvoEnergy	Evoenergy	The project will demonstrate how collaboration between a Distributed Energy Resources Management System (DERMS) and the GreenSync Decentralised Energy Exchange (deX) platform can unlock existing network hosting capacity to enable consumers to gain more value from their energy assets (such as solar, batteries and electric vehicles).
DER Integration API Technical Working Group	API working group	ANU	The DER Integration API Technical Working Group is comprised of organisations actively developing DER integration capabilities. These organisations are pursuing this initiative to support the development and implementation of an industry standard application programming interface (API) for programmatically sharing data amongst the organisations in the Australian electricity sector. One key output will be an agreement on the use cases for DER Integration, including who generates what data, with what specifications and who needs access to that data. The other key output will be an agreed API specification, allowing data to be programmatically transferred between parties.
DER Visibility and Monitoring Best Practice Guide	Visibility guide	Solar Analytics as contact for industry working group	The Best Practice Guide has been developed by the DER industry to specify the data required to enable the transition of our electricity network to a high penetration DER grid. The guide aims to establish a common static and dynamic (near) real time data set collected for new DER installed behind the meter on the low voltage electricity network. It also aims to increase confidence in the quality and performance of DER through the provision of this real time system performance data to DER owners and authorised industry entities.

Project name	Project short name	Lead organisation	Summary of the project
Digital Grid Futures Institute	UNSW DGFI	UNSW	The UNSW Digital Grid Futures Institute brings together UNSW's researchers and major partners across industry, government, research institutions and the community to advance the blueprint for future energy systems globally. The Institute is undertaking a range of research on DER technology integration issues including microgrids, VPPs, the smart meter and home appliances testing lab, peer to peer trading, smart home energy management and the real time digital simulator lab.
Dynamic Limits DER Feasibility Study	Dynamic Limits	Dynamic Limits	The study explored implementing dynamic operating envelopes for DER to better manage voltage and thermal constraints on electricity networks. The study examined existing approaches to managing network capacity constraints, investigated the general technical feasibility of implementing a dynamic DER control scheme, and undertook a site-specific analysis, examining implementation on feeders experiencing constraints. The focus was on the management of local network constraints so that the hosting capacity of electricity networks is unlocked, further enabling DER orchestration activities.
Enel X Demand response project	Enel X DR	Enel X	Enel X (formerly EnerNOC) will develop a 50 MW portfolio (30 MW in VIC and 20 MW in NSW) to be used as dispatchable short notice Reliability and Emergency Reserve Trader (RERT) reserves by AEMO. The portfolio will primarily consist of Commercial & Industrial customers and the reserve provided will be from load curtailment. Enel X has installed its own metering technology (Enel X Site Server) at customer sites and will use these meters to monitor site load and remotely initiate a safe load reduction for dispatch events. Enel X customers are capable of implementing load curtailment within 10 minutes of receiving dispatch instructions from Enel X.
EnergyAustralia Demand Response Program	EA DR	Energy Australia	The program involves the deployment of up to 20MW of demand response (DR) in NSW and 30 MW in VIC/SA. During times of critically low reserves, AEMO will call upon EnergyAustralia to deliver the reserve capacity through a combination of direct load control and behavioural demand response. EnergyAustralia is working with household, commercial and industrial customers to deliver reserve capacity. This includes emerging DR mechanisms, such as voluntary behavioural demand response, direct load control, and on-site generation and battery storage.

Project name	Project short name	Lead organisation	Summary of the project
Energy Under Control	Energy Under Control	Flow Power	The project involves the rollout of Flow Power's kWatch® Intelligent Controller. The Controller gives customers live data feeds, alerts and integration of onsite equipment. The Controller allows participating businesses to reduce their demand in minutes when Flow Power is called on by AEMO under the Short Notice RERT. By providing SMS and email alerts, the kWatch® Intelligent Controller gives Flow Power a clear and fast communication channel with participants, who receive participation payments in addition to a revenue stream if they are called upon to shift power use. Customers have the choice to integrate equipment with the Controller, meaning the customer could control energy intensive equipment from the kWatch® portal.
Enhanced Reliability through Short Term Resolution Data around Voltage Disturbances	Solar Analytics	Solar Analytics	Increased penetration of DER are leaving power system operations vulnerable to the operating behaviour of a multitude of diverse, distributed generators. AEMO has identified a need for short time resolution data around voltage disturbances to understand DER behaviour and improve dynamic modelling. Solar Analytics will work with AEMO and Wattwatchers to develop automated data acquisition and delivery. The project aims to increase visibility and improve modelling capability in a world-first analysis of individual load and generator responses in the event of short time resolution voltage disturbances.
Evolve DER project	Evolve	Zeppelin Bend	The project aims to increase the network hosting capacity of DER by maximising their participation in energy, ancillary and network service markets, while ensuring the secure technical limits of the electricity networks are not breached. The project has a strong focus on the development of working software systems that will be integrated with the operational technologies used by distribution networks, and the systems used by aggregators to manage DER under their control. Through multiple demonstrations and trials in NSW and Queensland, the project will develop new algorithms and capabilities to identify and ease congestion within the distribution network. This will be achieved through the calculation and publication of operating envelopes for all DER connected to the distribution network.
Expanded Network Visibility Initiative (ENVI)	ENVI	GridQube	This initiative expands the use technology developed and demonstrated in the ARENA project "Increasing Visibility of Distribution Networks" to the entire distribution network of Queensland. At its heart sits a novel Distribution System State Estimation algorithm that draws on multiple different data sources (network asset registers, SCADA, distribution transformer monitors, AMI, premise-level measurements and statistical network usage data) to provide complete network visibility from zone substations down to every customer connection point in the network.

Project name	Project short name	Lead organisation	Summary of the project
Indra Monash Smart Microgrid Project	Monash microgrid	Indra and Monash University	The Indra Monash Smart City will demonstrate how smart and renewable technologies can be integrated at the Monash University Clayton embedded network to maintain power quality and test market driven responses and business models. Indra's Active Grid Management platform will provide real-time monitoring and control over the grid-connected assets, and a Transactive Energy Market is being developed to orchestrate DER in response to market signals and constraints to add value to customers, market participants and the electricity grid.
Intelligent Switchgear	NOJA	NOJA Power	The project aims to reduce the complexity and cost of connecting renewables to the grid and increase the hosting capacity of distribution networks by developing, demonstrating and industrialising an economical intelligent switchgear. This device can capture high-resolution real-time network data and can provide protection, control, and monitoring solutions to facilitate the connection of renewables to the grid. The Intelligent Switchgear and trial deployments will generate significantly more granular power system data than is currently available and will help improve the visibility and modelling of the power system.
My Energy Marketplace	MEM	Wattwatchers Digital Energy	Wattwatchers aims to build, operate and deploy the "My Energy Marketplace" (MEM), a consumer-facing energy data platform, designed to securely collect, process and productise vast amounts of energy data. The MEM will deploy smart energy management solutions to 5,000 homes and small businesses plus 250 schools. It will enable consumers to participate in the evolving "New Energy" marketplace, including aggregation for Demand Response and VPPs, and will unlock access to DER visualisation and control sourced from behind-the-meter, consumer-owned assets. The MEM will source data from Wattwatchers hardware, smart meters, inverters, EV chargers and sensors, and provide energy data software applications. It will provide aggregators, DNSPs and other services providers with access to granular consumer energy data and visibility of DER.

Project name	Project short name	Lead organisation	Summary of the project
National low-voltage feeder taxonomy study	Feeder taxonomy	CSIRO	The study aims to produce the first national low-voltage network taxonomy that outlines the real-world characteristics of the distribution system. It will provide improved data required to identify nationally representative consequences on the low-voltage power system of DER integration possibilities, supporting assessment of DER integration design options. Depicting how power flows through the low voltage system will help with the design and assessment of the technologies and systems that can enable maximal uptake of DER across Australia. It will also enable users to test the value proposition of innovative technological solutions through desktop-based simulation, by highlighting how they contribute to the stability, reliability and performance of networks across Australia.
Network Opportunity Maps	Maps	University of Technology Sydney	The project creates NEM-wide online maps of electricity network constraints to help better inform network investments and increase the use of renewable energy. Developing a system that creates annually updated maps of network constraints for the entire NEM assists DER project developers target locations of the grid where renewable energy, energy storage and demand management can be cost-effective alternatives to network augmentation.
Networks Renewed	Networks Renewed	University of Technology Sydney	The project investigated pathways to increase the amount of renewable energy in Australia by paving the way for small-scale solar PV and battery storage installations to improve the quality and reliability of electricity in distribution networks. Two demonstrations focussing on voltage management recruited 90 customers in three locations across NSW and VIC under new commercial models for network-related businesses. The project tapped into new, “smart” inverter technologies that can better control PV panels and storage, offering a suite of new business opportunities. There is an emerging perception that small-scale solar PV may negatively impact the performance of Australian electricity networks by increasing voltage variability. Networks Renewed addressed this perception and clearly demonstrated that solar PV and batteries can be a valuable resource for businesses that manage electricity networks; changing the problem into a solution.

Project name	Project short name	Lead organisation	Summary of the project
Open Energy Networks	OpEN	Energy Networks Australia and AEMO	The aim of this project was to explore the role of distribution-level markets to support DER integration and optimisation, specifically to see if a distribution market framework would be able to provide benefits to consumers in the NEM. This project leveraged the UK's Open Networks Project by starting with three strawmen of distribution market frameworks. After extensive industry consultation a fourth option was added incorporating aspects of the two most likely frameworks. The project also sought feedback from a group of key customer representatives and included a cost benefit analysis of each of the final four frameworks.
Optimal DER Scheduling for Frequency Stability	UTAS	University of Tasmania	This project will investigate how best to schedule DER on distribution networks so that they are capable of providing power system frequency stability services while ensuring the distribution network always operates within technical constraints, but also while reflecting the motivations and primary functionality desired by DER owners. The project will also demonstrate, via detailed modelling, the frequency response capabilities of a range of inverter-interfaced DER and flexible loads, and the extent to which they can assist with frequency stability in power systems with decreasing conventional generation.
Pooled Energy Demonstration Project	Pooled	Pooled Energy	The project provides retail electricity and swimming pool automation to pool owners as part of an on-going service. The energy consumption of the pools is managed from a central Network Operating Centre in such a way as to help off-load and stabilise the grid. The pool-automation controller enables discretionary demand management activities at the customer site. A central control system aggregates available discretionary load and performs demand management activities to assist during times of extreme electricity grid-stress.
Project Highgarden	Highgarden	Horizon Power	The project has installed a variety of DER technologies for households and businesses in Carnarvon, WA. Technologies include energy meter devices connected to the internet to send and receive data, solar PV, batteries and inverters with remote monitoring and control devices. Horizon Power will use collected data and customer interaction with the technology to inform new retail models that could enable and incentivise customers to participate in the provision of energy services to the grid.

Project name	Project short name	Lead organisation	Summary of the project
Realising Electric Vehicle-to-grid Services (REVS)	REVS	ActewAGL Retail	This project seeks to unlock the full economic and grid benefits of vehicle-to-grid (V2G) services in Australia. It includes demonstration, data and analysis of the availability, reliability and performance of V2G frequency support and how this creates value for users, fleet managers, retailers, networks, the system operator, and thereby to all electricity customers. It also seeks to provide the definitive reference on current V2G capabilities, opportunities, barriers, and recommendations, including economic, technical, and social domains.
Renewable Integration Study – Distributed PV stream	RIS	AEMO	The Renewable Integration Study is the first stage of a multi-year plan to maintain system security in a future NEM with a high share of renewable resources. The Stage 1 RIS report investigates challenges to operating the power system at very high instantaneous penetrations of wind and solar generation. It recommends actions and reforms needed to keep operating the NEM securely, now and as the power system transitions. The distributed solar PV (DPV) stream of the RIS concentrated on the impact of increasing penetrations of passive DPV generation on the power system, exploring key challenges for both the distribution networks and bulk power system, how these challenges might be addressed, and "no regrets" actions to better integrate the future DPV fleet within the bulk system in a secure manner.
Simply Energy Virtual Power Plant	Simply VPP	Simply Energy	The project will deliver over 1,200 batteries to South Australian households. The project will employ a centrally managed network of energy storage systems installed behind the meter that can be collectively controlled to deliver benefits to households and the local community. The project will develop the GreenSync decentralised energy exchange (deX) platform to a commercial scale. The project aims to demonstrate that by integrating in a VPP the open sourced distributed energy market platform software, deX Platform, value can be generated for customers. This will be explored by using the VPP hardware and software to test the ability of the VPP to trade in the wholesale electricity market, FCAS market and in the provision of network services.

Project name	Project short name	Lead organisation	Summary of the project
Townsville Community Scale Battery Storage Project	QLD community battery	Yurika	Yurika is installing Queensland's first community scale, grid-connected, battery energy storage system (BESS). Located in Bohle Plains, Townsville, Yurika's 4MW / 8MWh BESS will commence operation in 2020. It will provide network support to Ergon Energy throughout Townsville's hot summer months. The system may help keep electricity prices down by allowing Ergon Energy to explore the potential to defer investment in network infrastructure in the area. In addition, the project expects to create value by charging when prices are low and discharging the stored energy back into the grid when electricity prices are higher. The system will also help maintain the frequency of the national grid by providing contingency FCAS during frequency disturbance events. The battery will add to the capacity of Yurika's Virtual Power Plant (VPP), building on the 130MW of existing capacity already supporting Queensland's Ergon and Energex networks.
Updated standards for demand response from residential loads	AS 4755	AEMO and Standards Australia	AEMO is actively participating in the development of standardised residential load flexibility capabilities, through the current revision of AS 4755. AS 4755 sets out minimum device level capability requirements for remotely coordinated demand response from residential household appliances and smart devices – such as air conditioners, pool pumps, hot water systems, batteries and other energy storage, as well as electric vehicle supply equipment. This is seen as a key enabler for establishing a truly "two-sided" future power system and market by enhancing the predictability and verifiability of residential demand response, and therefore to facilitating the range of services this might be able to provide.

Project name	Project short name	Lead organisation	Summary of the project
Updated standards for DER inverter capability and performance	AS 4777	AEMO and Standards Australia	This program of work covers AEMO's work to better understand DER performance requirements for secure bulk power system operation and the Standards Australia process to revise AS/NZS 4777.2. AEMO's work comprised: • Analysis of DPV disconnection behaviour from a sample of monitored systems (provided on an anonymised basis by Solar Analytics) for bulk power system disturbances during periods with levels of DPV generation. This analysis was further validated through laboratory bench testing of individual inverters conducted by UNSW Sydney. • Learnings from the "next iteration" of uplift in smart inverter standards internationally, in particular the 2018 update to the US national standard for DER connection (IEEE 1547) and national implementations 2016 update to the European Network Code for Generators (most notably, Germany and Denmark). Many DER systems are connected to the grid using inverter energy systems, with requirements for the function and performance within the technical envelope specified in AS/NZS 4777.2: 2015 – Grid connection of energy systems via inverters, Part 2: Inverter requirements. Standards Australia is working with AEMO and a broad range of other stakeholders to revise AS/NZS 4777.2 to address the key challenges of increasing of rapid DER uptake, to ensure aggregate behaviour of these systems is aligned with wider power system objectives, as well as distribution level protection, power quality, and safety requirements.
Virtual power plant demonstrations	AEMO VPP	AEMO	AEMO currently has no visibility of how VPPs operate. This project will test a new technical specification for VPPs to deliver Frequency Control Ancillary Services in the NEM, enabling VPPs to capture new value streams that could be shared with their customers. AEMO will also augment its systems to receive operational data from VPPs to observe their behaviour, including how VPPs respond to wholesale energy market prices or deliver local network support services. AEMO will use this data to improve its operational forecasting of VPPs, and identify further changes required to integrate VPPs into market frameworks at large-scale, including potential regulatory reforms.

Project name	Project short name	Lead organisation	Summary of the project
Visibility of DER	AEMO DER visibility	AEMO	AEMO's Visibility of DER report outlined how a lack of visibility of DER devices will impact two of AEMO's core responsibilities in managing the NEM: maintaining power system security and reliability and delivering information to support efficient market outcomes. It proposed regulatory changes to address information gaps. The work formed the basis for a COAG Energy Council rule change request for the development of a DER register. The AEMC made its final rule in September 2018 for AEMO to establish a register of DER in the NEM, including small scale rooftop solar and battery storage systems. AEMO launched the DER Register in March 2020. Data availability and access has also been identified as a key gap for the future integration of electric vehicles. Information on chargers, vehicles and consumer behaviour is often not collected – where data is collected, it can be spread across many organisations or government bodies with access limited due to privacy or commercial considerations. To help address this gap, AEMO is leading the DEIP EV Data Availability taskforce towards establishing a central repository (or other means) of capturing this data to facilitate informed decision making during the transition to electrified transportation
Voltage analysis of the LV distribution network in the Australian NEM	LV voltage analysis	UNSW	The project involved the analysis of voltage data from 12,617 site-specific power and voltage monitoring devices throughout the low voltage network in NEM. The analysis included the correlation between voltage and PV export for different DNSPs and according to PV installation density, and the potential for PV curtailment as measured by the frequency of voltage being outside the present standard limits by PV installation density. The project also included a comprehensive literature review and recommendations regarding further work, enhancing voltage visibility and improved voltage management.
Western Power Community Batteries	WA community battery	Western Power	Western Power and Synergy connected a community battery (420kWh) in the City of Mandurah, Western Australia. The project accesses multiple value streams in the one solution, including network, energy market and customer offerings. The battery was installed downstream on an LV network that has high penetration of solar. This meant that the requirement to upgrade the distribution transformer has been deferred and the traditional network solution has been substituted by a solution that has additional benefits.

Project name	Project short name	Lead organisation	Summary of the project
Yackandandah SWER Trial	Yackandandah	Mondo	The initiative will establish a microgrid in Yackandandah to help cut energy bills for residents and help the community achieve their 100 per cent renewable energy target. The project will increase the number of houses with solar PV and batteries on a Single Wire Earth Return powerline and include control technology to manage network security. The project also measures the benefits for consumers taking part in the Sanatorium Road Microgrid – such as energy savings and more reliable supply. The project demonstrates Mondo's ability to operate a microgrid and bring value to the network by monitoring and controlling DER, as well as providing insights on data collected, and electrical engineering concepts involved in microgrid operation.