ena

energy networks association

UPDATE DECEMBER 2015

INTEGRATING RENEWABLES INTO THE GRID “STOCKTAKE” PROJECT

This is the second iteration of the Integrating Renewables into the Grid Stocktake Project

Revision No	Approved By	Date	Amendment
0	Stuart Johnston, Executive Director, Assets and Network Transformation	30/09/2014	New Document produced by MHC
1	Stuart Johnston, Executive Director, Assets and Network Transformation	30/10/2015	The following amendments have been made to this document: » Executive Summary » Background to the Project » All Charts and Tables updated to reflect refresh » Entire document (excluding reference to International projects) amended to reflect refresh

CONTENTS

EXECUTIVE SUMMARY

In 2014, the Australian Renewable Energy Agency (ARENA) commissioned a piece of work, called the "Stocktake" project to develop a central repository of all projects completed, underway or in planning in relation to the integration of renewable energy sources into distribution networks.

The resulting "Stocktake" collated and published information on various trials and studies on integrating renewables into the grid that have been undertaken around Australia, as well as a number of relevant international projects. The "Stocktake" has also resulted in bringing together the existing knowledge, experience, gaps and issues on the integration of renewables into the grid into a single repository. The original "Stocktake" and its subsequent publication and public release, was completed via the Energy Networks Association's (ENA) website, in December 2014.

To ensure that this important resource remains relevant and continues to evolve and grow to provide the industry with a lasting, relevant and readily accessible knowledge source, ARENA engaged ENA to publically host, update and manage the "Stocktake" database on an ongoing basis.

ENA has subsequently completed the first refresh of the "Stocktake" database; engaging with both new and existing industry stakeholders to add new projects and update existing projects. Industry stakeholders included; network operators, industry associations, governments, technology proponents, electricity retailers, and universities and research institutions.

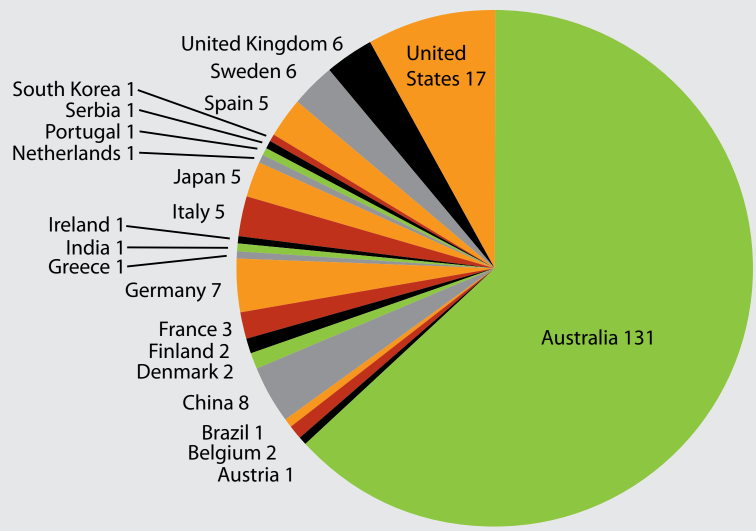
The first update included the addition of fifteen (15) new Australian projects and the update of twenty five (25) existing projects already in the database. It should be noted however that the first refresh (completed in October 2015) only included the addition of domestic projects.

The "Stocktake" database now includes a total of 208 projects: 131 from Australia, with 77 from overseas.

All projects contained within the database have been assessed against each of the defined objectives outlined in Table 1. This evaluation was undertaken in accordance with the assessment methodology previously established when the database was initially developed by Marchment Hill Consulting (MHC). The assessment was informed by a questionnaire completed by the project research proponent and with the assessment undertaken by the ENA.

In order to be included in the "Stocktake" database, projects must address or inform one or more of fourteen defined objectives relating to issues with the integration of renewable energy resources within the grid:

FIGURE 1 PROJECTS IN THE "STOCKTAKE": COUNTRY OF ORIGIN



Note: International projects have not been updated since 2014. The next stocktake refresh is planned for completion in October 2016.

TABLE 1 DEFINED OBJECTIVES THAT PROJECTS MUST ADDRESS OR INFORM TO BE INCLUDED IN THE DATABASE

ECONOMIC / COMMERCIAL OBJECTIVES

1. Measure or quantify the benefits and costs of renewable energy
2. Support the transition to an alternative network pricing approach
3. Create new business models to cater to the shift to a network with high levels of distributed energy resources.
4. Inform the regulatory environment for renewable energy
5. Engage customers to build their and the industry's understanding of distributed energy resources
6. Make the process of integrating renewable energy into the grid more cost-efficient
7. Improve internal practices and processes relating to the acceptance of distributed energy resources on the network

TECHNICAL OBJECTIVES

8. Establish control over, or otherwise influence, intermittent generation sources
9. Strengthen the network to manage higher renewable energy penetration
10. Smooth out intermittent generation output
11. Alter local load profile to match a desired level
12. Use distributed energy solutions to address network and system constraints
13. Store and organise information on customer renewable energy deployments.
14. Improve techniques for forecasting renewable energy output

All projects included in the "Stocktake" database have addressed at a minimum one of the objectives outlined above in a clear and compelling manner.

The objectives most commonly addressed by projects included in the database are:

- **Objectives 6** regarding cost efficiency;
- **Objective 3** regarding business models; and
- **Objective 9** regarding network security.

The objective that is least addressed by projects included in the database is **Objective 13** relating to the storing and organising information on customer renewable energy deployments

Australian projects that addressed Economic / Commercial objectives have been assessed as being marginally higher in relevance in an Australian context compared to the international projects that addressed issues in that area,, with many of these projects referring to the differing regulatory arrangements, economic conditions and industry structures that exist around the world. In respect to projects that addressed one or more of the technical objectives, the Australian and international projects were found to have a similar level of relevance for the Australia. "Stocktake"

This report, analyses the "Stocktake" content for how frequently projects of each kind appear, what results they encountered, how relevant they are to other entities in Australia, and what limitations exist to disseminating their lessons. With only 15 new projects added to the "Stocktake" database, only minor changes to the overall results or trends have occurred compared to the original published database.

1. GUIDE TO THE REPORT

SECTION 1

Describes the background and purpose for the "Stocktake" and the first refresh, and explains the essentials of how projects were assessed.

SECTION 2

Gives a broad overview of the projects that comprise this "Stocktake": where they came from, who led their implementation, and how they were funded.

SECTION 3

Analyses how frequently projects types appeared, what results were found, their relevance to other entities in Australia, and what limitations to disseminating their lessons were found.

SECTION 4

Identifies the top Australian projects.

2. ABOUT THE "STOCKTAKE"

2.1 BACKGROUND TO THE "STOCKTAKE"

Through its role in supporting the development and deployment of renewable energy technologies across Australia, ARENA has recognised that the integration of renewable energy generation in distribution networks is both 'a major challenge and opportunity for growth in the renewable energy sector'. The increased penetration of distributed generation technologies, however, does come with its challenges and risks for both networks and owners and operators of distributed energy resources.

ARENA therefore decided to develop a central repository of all projects completed, underway or in planning relating to the integration of renewable energy sources into distribution networks to assist in the facilitation of knowledge sharing across the industry

ARENA has subsequently engaged ENA to publically host, undertake management and refreshing/updating of the "Stocktake" database comprising of the existing knowledge and experience related to integrating renewables in distribution networks.

2.2 PURPOSE OF THE "STOCKTAKE"

The "Stocktake" is intended to:

» Help the industry understand the state of knowledge regarding the integration of renewables into the grid;

» Form an understanding of common opportunities and barriers by merging the results from projects across each of the objectives;

» Make it easier for networks and proponents to share information about how opportunities can be exploited, and barriers overcome;

» Avoid duplication of effort;

» Help ARENA to identify the most valuable opportunities for sharing knowledge and assess the case for funding additional sharing activities; and

» Help ARENA assess any future activities it may fund as part of its investment priority of integrating renewables into the grid.

2.3 REFRESH

The first refresh of the "Stocktake" database by ENA involved identifying and adding new projects on the integration of renewables into distribution networks in Australia that had either been conceived and/or instigated after the database was first published in September 2014, or were missed in the first project collection processor updating existing projects. It also included the updating of all projects currently held in "Stocktake" database whose status had changed since publication (i.e. projects underway at the time of the initial survey which have now delivered preliminary results or have been completed). This included contacting all existing project contributors for the existing database as well as identifying and contacting new contributors from across the industry who have not previously provided information for the "Stocktake".

Once a project was either added or updated, ENA followed the same method of assessing the relevance of the new project or the aspects of the existing project that had been updated in accordance with MHC's methodology for the original "Stocktake", including an assessment of relevance against each of the defined objectives.

The refresh completed in December 2015 was successful in the addition of 15 new projects and the updating of 25 current projects. .

As a result of the refresh, the "Stocktake" database now consists of 208 projects: 131 from Australia and the remainder from overseas. Projects gathered for this "Stocktake" were from a variety of sources, including network operators, industry associations, governments, technology proponents, electricity retailers, governments and academic institutions.

A second refresh is scheduled for October 2016.

2.4 SCOPE OF THE "STOCKTAKE"

This "Stocktake" covers projects that add to Australia's collective knowledge of integrating renewable energy into distribution networks. Projects in the "Stocktake" do not need to be directly involved in distributed renewable generation on the grid, nor do they need to be physical field-based activities. These include, but are not limited to:

- Projects that use energy storage and load control for the purpose of matching load to intermittent renewable energy over time;
- Projects that trial metering, communications and control technologies (e.g. 'smart inverters') that could make renewable energy better serve the grid;
- Projects that use pricing and information to increase the usefulness of renewable energy to customers;
- Projects that map constraints in distribution networks, building information that could be used to pinpoint where renewable generation is most needed;
- Projects that use embedded non-renewable generation to defer or avoid network augmentation, and have implications for how this might be similarly done using renewable generation;
- Projects that deploy network and control room technologies that can be used to manage higher penetrations of renewable energy; and
- Projects trialling new approaches with regulatory or market bodies or that gather evidence to support decisions by those bodies or policy-makers.

ARENA recognises the value of renewables connected to all points of the network,, however at this stage it has chosen to focus only on the distribution network and not the transmission network for the current "Stocktake" database (this may be reviewed and the database extended in future versions of the database). The focus of this "Stocktake", therefore, is with distributed renewable energy: relatively small-scale installations that are designed to connect to low or medium voltage distribution networks, as opposed to large, centralised renewable generators such as wind farms and concentrating solar plants (which typically connect directly to higher-voltage transmission networks).

CRITERIA FOR PROJECT INCLUSION

The following describes the logic for project inclusion in the database. This included:

- A list of **issues** relating to renewable energy in distribution networks which needed to be solved was generated
- An additional list of **objectives** a project might address/inform was created out of a need to solve the issues
- A project may test one or more **approaches** as a way to achieve its objectives

The issues that were considered, and the objectives which addressed them, fall into two main categories:

- **Economic / Commercial** issues: regulatory, commercial, economic, or political considerations that may help or hinder renewable deployment
- **Technical** issues that relate to the physical integration of renewable generation into the electrical system: managing power flows, voltage, frequency, system stability, etc.

Projects need not necessarily succeed in delivering their objectives. An approach which fails, and is learned from, can be just as informative as a success.

ECONOMIC / COMMERCIAL OBJECTIVES

1. Measure or quantify the benefits and costs of renewable energy
2. Support the transition to an alternative network pricing approach
3. Create new business models to cater to the shift to a network with high levels of distributed energy resources.
4. Inform the regulatory environment for renewable energy
5. Engage customers to build their and the industry's understanding of distributed energy resources
6. Make the process of integrating renewable energy into the grid more cost-efficient
7. Improve internal practices and processes relating to the acceptance of distributed energy resources on the network

TECHNICAL OBJECTIVES

8. Establish control over, or otherwise influence, intermittent generation sources
9. Strengthen the network to manage higher renewable energy penetration
10. Smooth out intermittent generation output
11. Alter local load profile to match a desired level
12. Use distributed energy solutions to address network and system constraints
13. Store and organise information on customer renewable energy deployments.
14. Improve techniques for forecasting renewable energy output

2.5 ASSESSMENTS OF RELEVANCE

Each project was assessed in regard to its relevance against each of the defined **objectives** that it addressed.

As part of the project questionnaire, respondents were asked which of the 14 objectives the project addressed or informed. For the objectives they selected, they were asked to describe how and to what degree the project addressed or informed the objective.

ENA assessed the relevance of each project to other entities in Australia based on this response and the other details provided by the respondent in the questionnaire.

The response was based one question, which was the same for each objective:

Does this project address or inform the objective in a way that would be relevant to other entities in Australia?

('Entities' include network companies, retailers, regulators, researchers, technology proponents, or consumer groups. 'Relevant' considers the applicability of the project to different physical locations, customer classes and regulatory environments.)

The purpose of the assessments is to help end users of the stocktake database find projects most relevant to them.

The assessment did not judge whether the project was successfully executed or not. The assessments exist to measure the relevance of the project to other entities that have one of the objectives in mind.

3. OVERVIEW OF INTEGRATION PROJECTS

Given the purpose of the "Stocktake" is to inform the Australian electricity sector, the majority of the projects have been sourced from Australia, as can be seen in Figure 2.

The remainder of the "Stocktake" comprises selected international projects of high importance from which lessons could be practically applied in Australia. The "Stocktake" database which includes the December 2015 refresh comprises of 208 projects: 131 from Australia and the remainder from overseas.

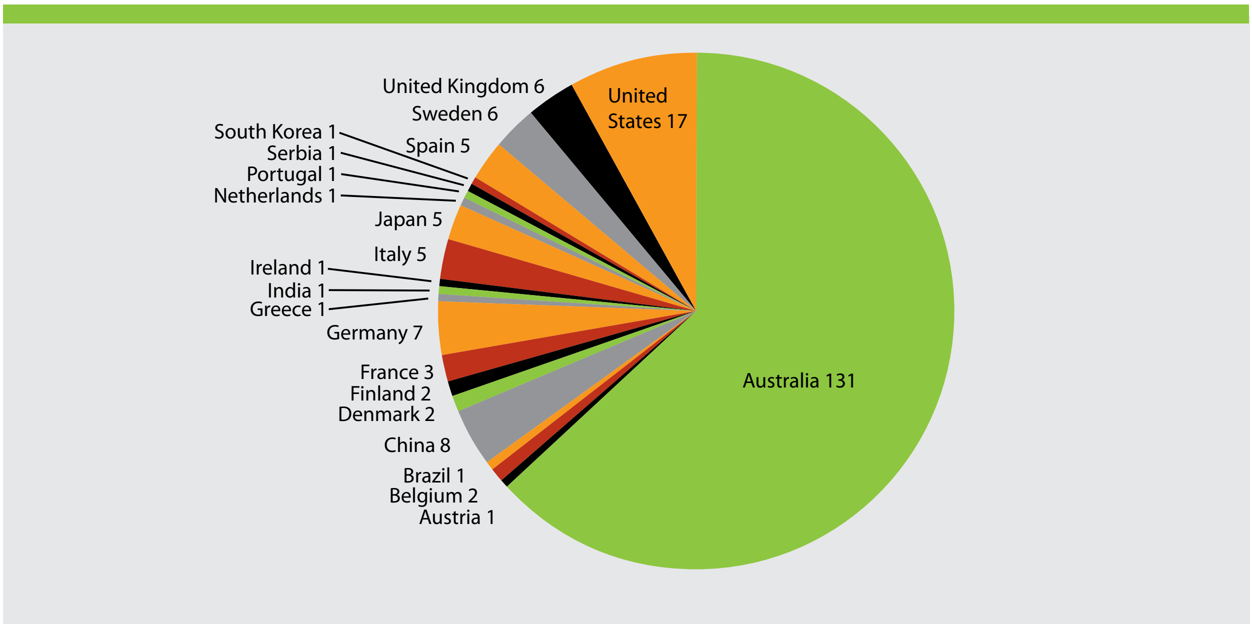
The December 2015 refresh only included identifying new domestic projects.

The refresh was successful in the updating of 25 previous projects and the addition of 15 new projects from around Australia.

Within Australia, the projects undertaken in the eastern states are the most strongly represented, roughly corresponding to their higher population and volume of electricity infrastructure. Queensland is moderately over-represented in this "Stocktake" relative to its population size, owing to the strong contributions of Ergon Energy and Energex and the amount of projects undertaken due to the high penetration of household PV systems in that state. The ACT also shows strongly, owing to the support of the ACT government to renewable energy initiatives.

Projects have been collected for the "Stocktake" from a variety of sources, including network operators, industry associations, governments, technology proponents, electricity retailers, governments and academic institutions. Figure 4 and Figure 5 show the percentage split for the number of projects contained in the "Stocktake" that come from each of these sources. Network Service Providers, Government organisations, and Academics have figured most heavily.

FIGURE 2: PROJECTS IN THE "STOCKTAKE": COUNTRY OF ORIGIN



Note: International projects have not been updated since 2014. The next stocktake refresh is planned for completion in October 2016.

When comparing the Australian and International charts differences were identified in regard to the composition of project sources. In Australia, projects were sourced from research organisations more often than from proponents., whilst internationally, the reverse is true. This disparity came from the respective willingness of proponents and researchers to participate in the study, and may possibly reflect a cultural difference.

Section 3 analyses these projects in detail, covering the questions of:

» Which objectives in the "Stocktake" did these projects most often address, and how well were these objectives addressed?

» Which approaches did these projects take, and how did this differ by objective?

» What results were most commonly found?

» How transferrable is the knowledge gained from these projects, and what barriers to transferability exist?

» How relevant were these projects to the "Stocktake"'s areas of knowledge, and how will they be progressed?

FIGURE 3: AUSTRALIAN PROJECTS IN THE "STOCKTAKE": STATE OF ORIGIN

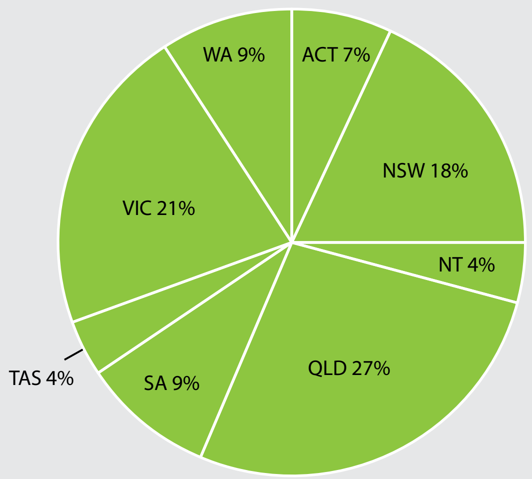


FIGURE 4: PROJECTS IN THE "STOCKTAKE": CATEGORIES OF RESPONDENT (AUSTRALIAN)

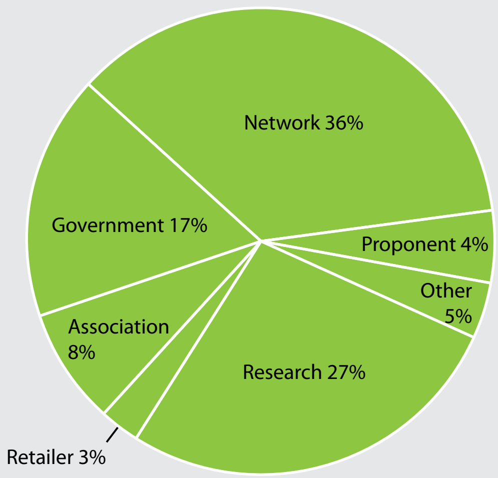


FIGURE 5: PROJECTS IN THE "STOCKTAKE": CATEGORIES OF RESPONDENT (INTERNATIONAL)

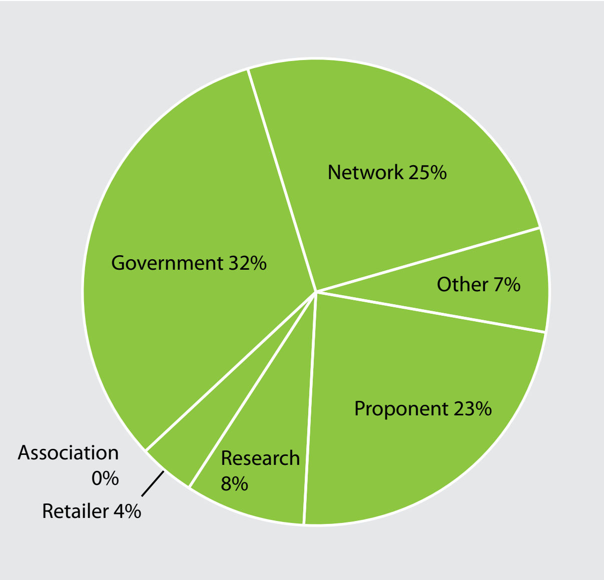


FIGURE 6: PROJECTS IN THE "STOCKTAKE": FUNDING SOURCE (AUSTRALIAN)

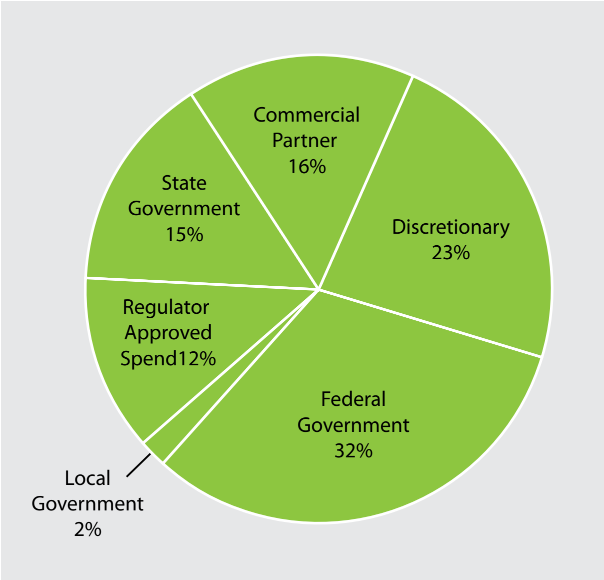
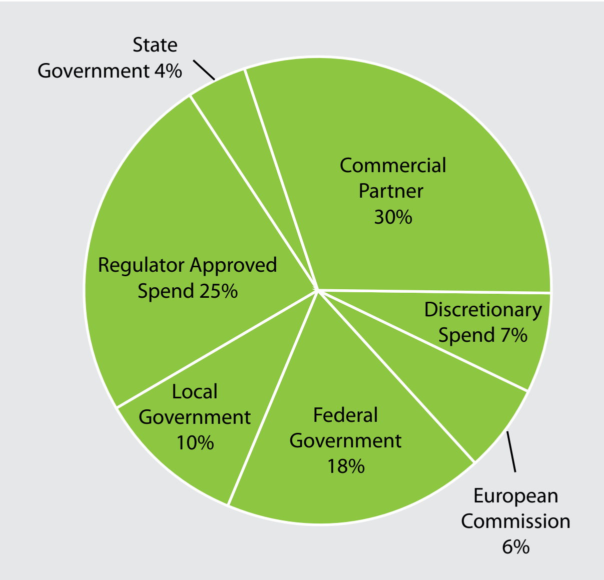


FIGURE 7: PROJECTS IN THE "STOCKTAKE": FUNDING SOURCE (INTERNATIONAL)



4. ANALYSIS OF PROJECTS

NOTE:

Throughout this section, there are charts that compare the number of projects that address various objectives, adopt various approaches, etc. However, a single project can count towards more than one objective or approach, and the totals in these charts therefore will not add up to the total number of projects in the database.

4.1 ADDRESSING THE OBJECTIVES

Figure 8 shows how many projects in the "Stocktake" addressed each of the defining objectives. Recall from section 1.4 that in order to be included in the "Stocktake", a project must address or inform one or more of these objectives.

The following four objectives were the most common objectives selected:

- Making the process of integrating renewable energy into the grid more cost-efficient **(#6)**
  - Example: Project 353: Mackay Sugar Cogeneration Plant by Mackay Sugar
  - Example: Project 252: Optimal deployment of renewable resources in a distribution network by Monash University
- Creating new business models to cater to the shift to a network with high levels of distributed energy resources **(#3)**
  - Example: Project 130: Re-deployable Hybrid Power by Laing O'Rourke
- Measuring or quantifying the benefits and costs of renewable energy **(#1)**
  - Example: Project 245: Future Grid Forum by CSIRO
  - Example: Project 264: Hybrid concentrating solar thermal systems for large scale applications, by CSIRO
- Strengthening the network to manage higher renewable energy penetration **(#9)**
  - Example: Project 355: Residential Storage Trial: Citipower and Powercor Australia
  - Example: Project 186 Smart Grid, Smart City project by AusGrid

Overall, there is a fairly even spread between Economic / Commercial projects **(objectives #1 to #7)** and Technical projects **(objectives #8 to #14).**

Assessments of relevance (see section 1.4) were applied to all projects in the "Stocktake". The results of this scoring can be seen in Figure 9.

Overall, projects attained on average a score of "**Medium"**, indicating that there was clear and compelling evidence that the project had or is addressing or informing an objective.

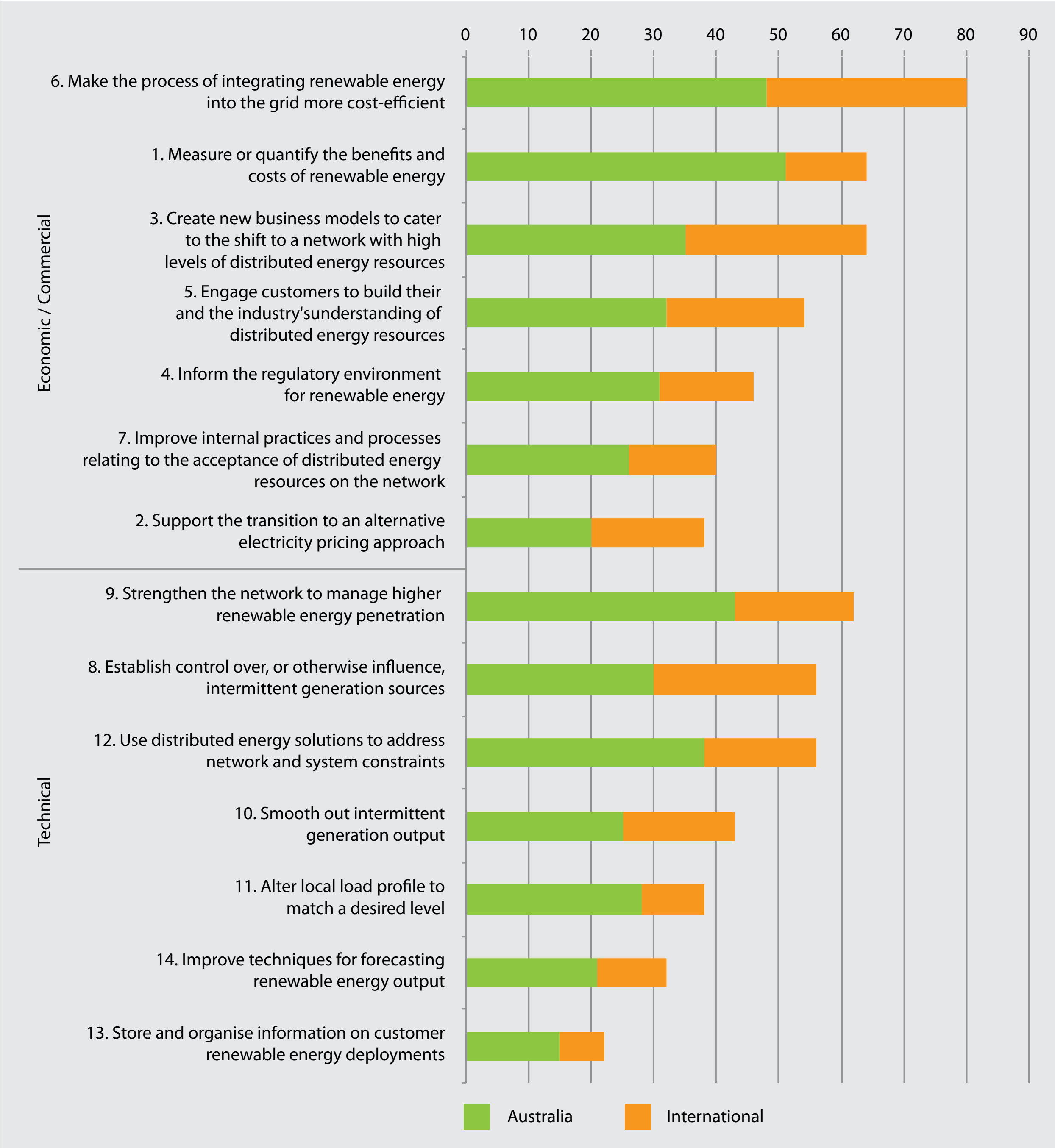
Australian projects scored marginally higher than International ones on Economic / Commercial objectives. An explanation for this is that many projects refer to the differing regulatory arrangements, economic conditions and industry structures which exist between countries. On Technical objectives, the Australian and International projects score on average the same.

Figure 9 shows that the technical objectives achieved on average higher scores than the economic / commercial objectives, indicating that they tend to be addressed in a way that is more useful for *other* entities (per the definition of the metrics).

Further analysis and follow-up questioning of project proponents has provided some explanations for this, including:

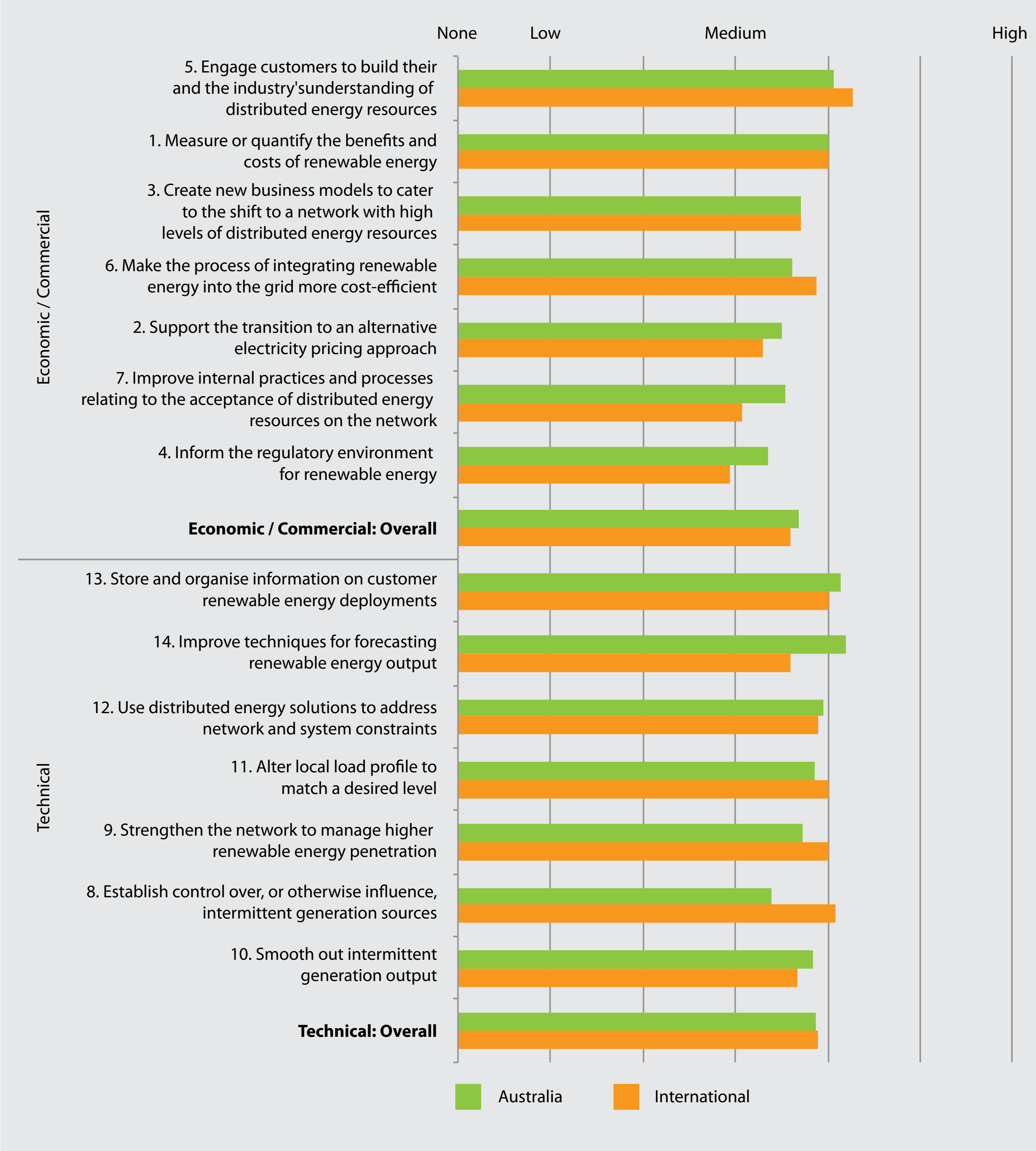
- There are more limitations to transferability associated with economic / commercial projects. These kinds of projects tend to be more dependent on local regulatory or industry arrangements, and are therefore less readily adaptable to the needs of other entities. Section 3.4 has more details.
  - Example: Project 239: Nyngan Solar Plant by AGL Energy Limited
  - Example: Project 251: ACT Community Solar Scheme by The Environment and Sustainable Development Directorate

FIGURE 8: NUMBER OF PROJECTS THAT ADDRESS EACH OBJECTIVE[1]



1 The objectives in this chart appear in descending order of the total number of projects that address them, within the Economic / Commercial and Technical categories.

FIGURE 9: AVERAGE PROJECT RELEVANCE TO EACH OBJECTIVE[2]



2 The objectives in this chart appear in descending order of average project relevance, within the Economic / Commercial and Technical categories.

Results for technical projects often included hard, quantitative results. Although quantitative results are not the only kind of evidence that were studied, their presence indicated *some* definite evidence which, per the definition of the assessment criteria, will merit higher relevance scores.

- Example: Project 196: King Island Renewable Energy Integration Project (KIREIP) by Hydro Tasmania. This project utilised existing renewable energy sources to increase average renewable energy penetration in the system to up to 65%).
- Example: Project 167: Isernia Smart Grid Project by Enel Distribuzione

Some respondents noted that economic / commercial projects tend to be more commercially sensitive than the more technical projects, and that the results provided to the "Stocktake" were abbreviated accordingly.

Figure 10 shows how many assessments of each level (low, medium, high) were given to projects against each objective. From this and the previous chart, it can be identified that some particular objectives relating to distributed energy integration stand out from the rest, for instance:

ENGAGE CUSTOMERS TO BUILD THEIR AND THE INDUSTRY'S UNDERSTANDING OF DISTRIBUTED ENERGY RESOURCES (#5)

A frequent area of investigation, these projects were assessed as highly relevant

» Example: Project 143: Perth Solar City by Western Power

» Example: Project 364: Network Transformation Roadmap by CSIRO and ENA

IMPROVE TECHNIQUES FOR FORECASTING RENEWABLE ENERGY OUTPUT (#14)

Projects addressing objective 14 were not a frequent area of investigation as these projects tend to be high-cost and require the involvement of specialists. Several comprehensive projects in the "Stocktake", however, have scored a HIGH rating.

» Example: Project 263: Machine learning based forecasting of distributed solar energy production by The Australian National University

» Example: Project 262: The ANU Solar Radiation and Cloud Measurement Network by The Australian National University

STORE AND ORGANISE INFORMATION ON CUSTOMER RENEWABLE ENERGY DEPLOYMENTS (#13)

This objective has been found to be addressed by a very small number of projects, however, the few projects that did address this issue were found to score highly.

» Example: Project 297: Global Energy Storage Database by the Department of Energy (US)

» Example: Project 270: Solar Resource Mapping for High Prospectively Regions by Geoscience Australia

SUPPORT THE TRANSITION TO AN ALTERNATIVE ELECTRICITY PRICING APPROACH (#2)

Few projects provided were found to address or inform this objective, and those that did tended to have a low relevance score.

» Example of a low-scoring project: Project 225: Stockholm Royal Seaport Project by Stockholm Municipality

» Example of a high-scoring project: Project 305: Modelling the impact of various tariff structures on distributed energy resource take-up and electricity pricing by SA Power Networks

INFORM THE REGULATORY ENVIRONMENT FOR RENEWABLE ENERGY (#4)

A high proportion of projects in the database were found to address this objective. However on assessment a majority of these were found to do so in a cursory way, usually producing information that may be of interest to a regulator, as a by-product of some other objective. These projects tend to do this largely through analytical or desk-based approaches.

However, of the projects that did address this objective quite thoroughly, the following are seen as the best examples:

» Example: Project 245: Future Grid Forum by CSIRO

» Example: Project 364: Network Transformation Roadmap by CSIRO and ENA

Therefore, some of these objectives stand out for reasons that are easily explained (e.g. high quality -relevance scores) balancing out low quantity (i.e. number of projects that address the objective). Other objectives stand out for reasons that suggest a great deal of work/lack of work, being done in their area.

In Figure 10 and Figure 11, differences in the distribution of scores between Australian and International projects can be noted. International Projects tend to attain a score of MEDIUM more frequently than Australian projects.

Having fewer high scores is not a comment on these projects' quality, but rather indicates some reservations about how relevant their results are to Australian entities.

FIGURE 10: DISTRIBUTION OF RELEVANCE AGAINST EACH OBJECTIVE (AUSTRALIAN)

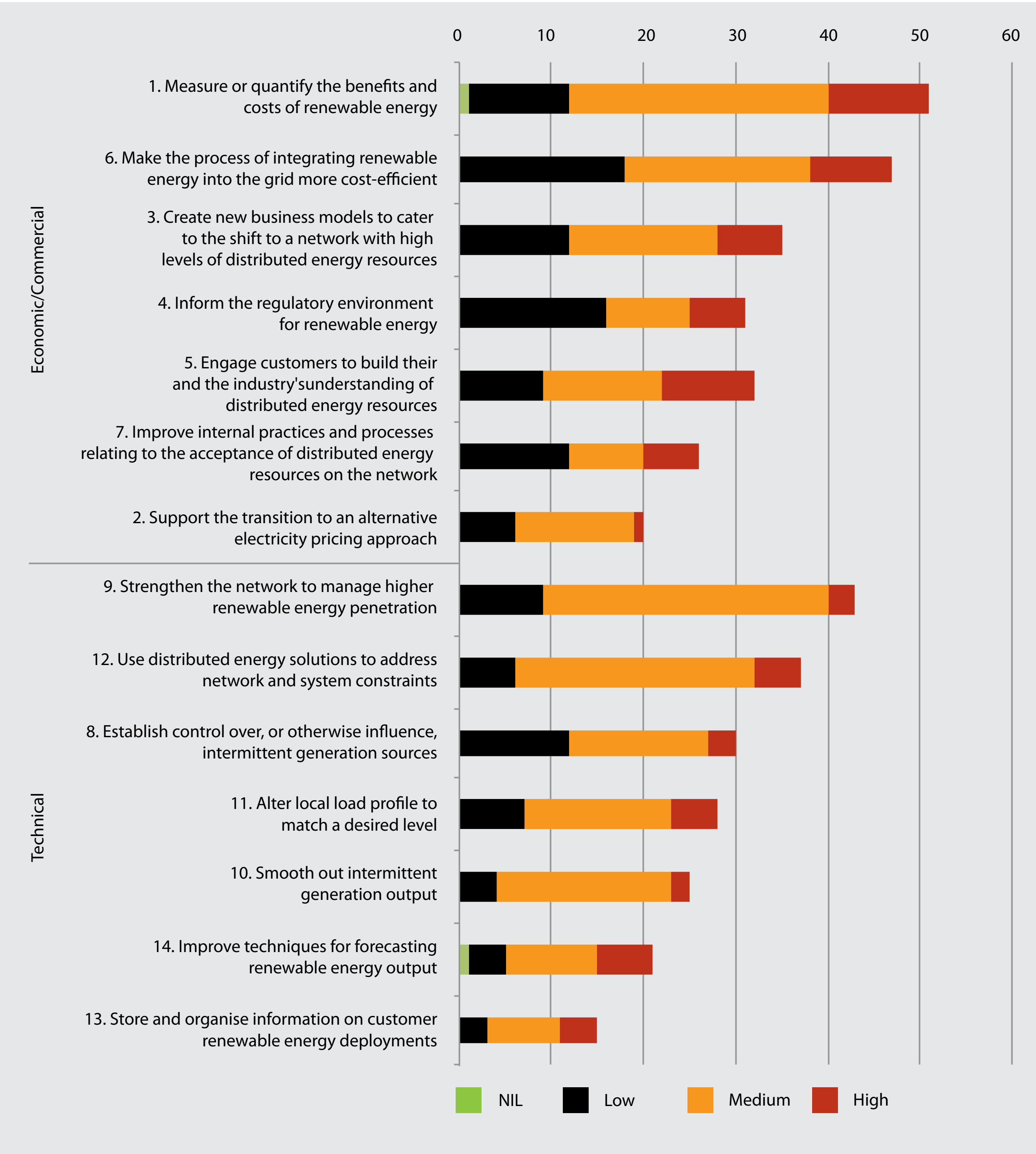
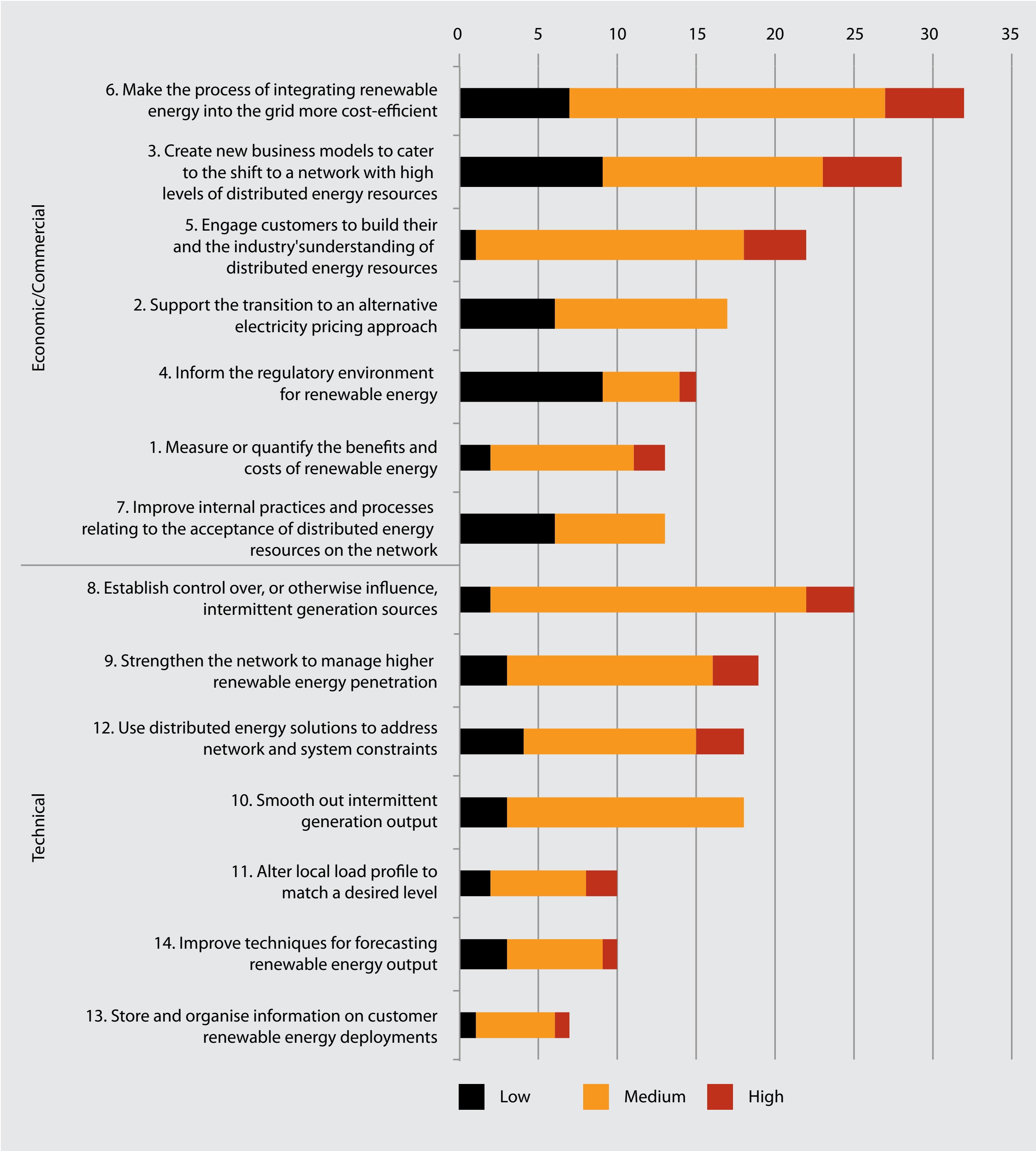


FIGURE 11: DISTRIBUTION OF RELEVANCE AGAINST EACH OBJECTIVE (INTERNATIONAL)



4.2 APPROACHES TAKEN TO ADDRESS OBJECTIVES

An examination of how the projects achieved their objectives was undertaken. The analysis included the categorisation of each respondent's description of their project's approach, i.e. how the project addressed or informed the objectives. This categorisation yielded a reduced set of approach types, with some commonality across projects:

Analysis	Desk-based analysis, research, and modelling
Commercial	Joint ventures between organisations, internal initiatives, and policy advocacy
Demand-Side	Influencing customer loads through pricing, incentives, and direct control
Engagement	Interviews and Surveys
Installation	Installing distributed energy resources on the network
Technical	Changing the operation of the network through new approaches or equipment upgrades

A subset of the most common approaches is shown in Figure 13. The most common approaches were:

» desk-based analysis (under the "Analysis" category) of the issues raised by increasing distributed energy penetrations, via modelling the electrical system or network; and

» Demonstration Projects (under the "Installation" category), often under a "smart grid" label, which usually involved some combination of distributed energy (usually solar PV, sometimes wind or cogeneration), bundled along with storage, and some form of customer-interactive incentive program.

Analytic and **Commercial** approaches, covering desk-based analysis, modelling, and internal initiatives / external arrangements between organisations, tended to predominate for:

» Measuring and quantifying the benefits and costs of renewable energy **(#1)**

» Improving techniques for forecasting renewable energy output **(#14)**

» Informing the regulatory environment for renewable energy **(#4)**

FIGURE 12: NUMBER OF PROJECTS ADOPTING EACH APPROACH TYPE

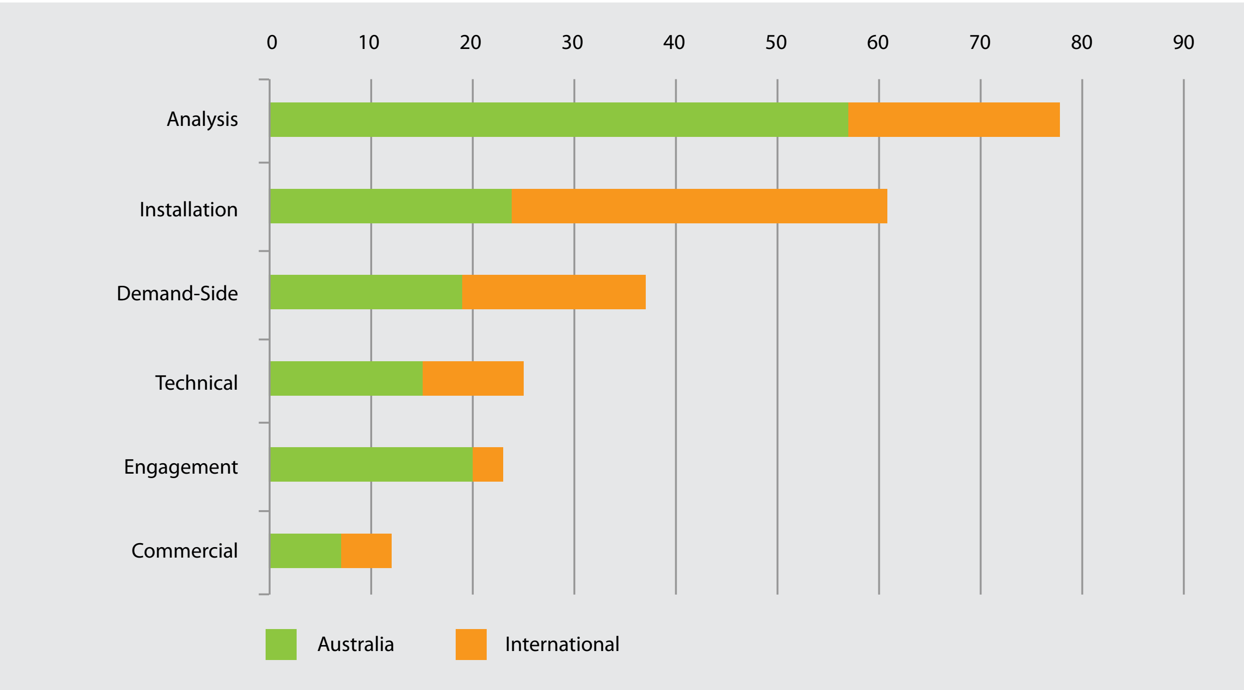
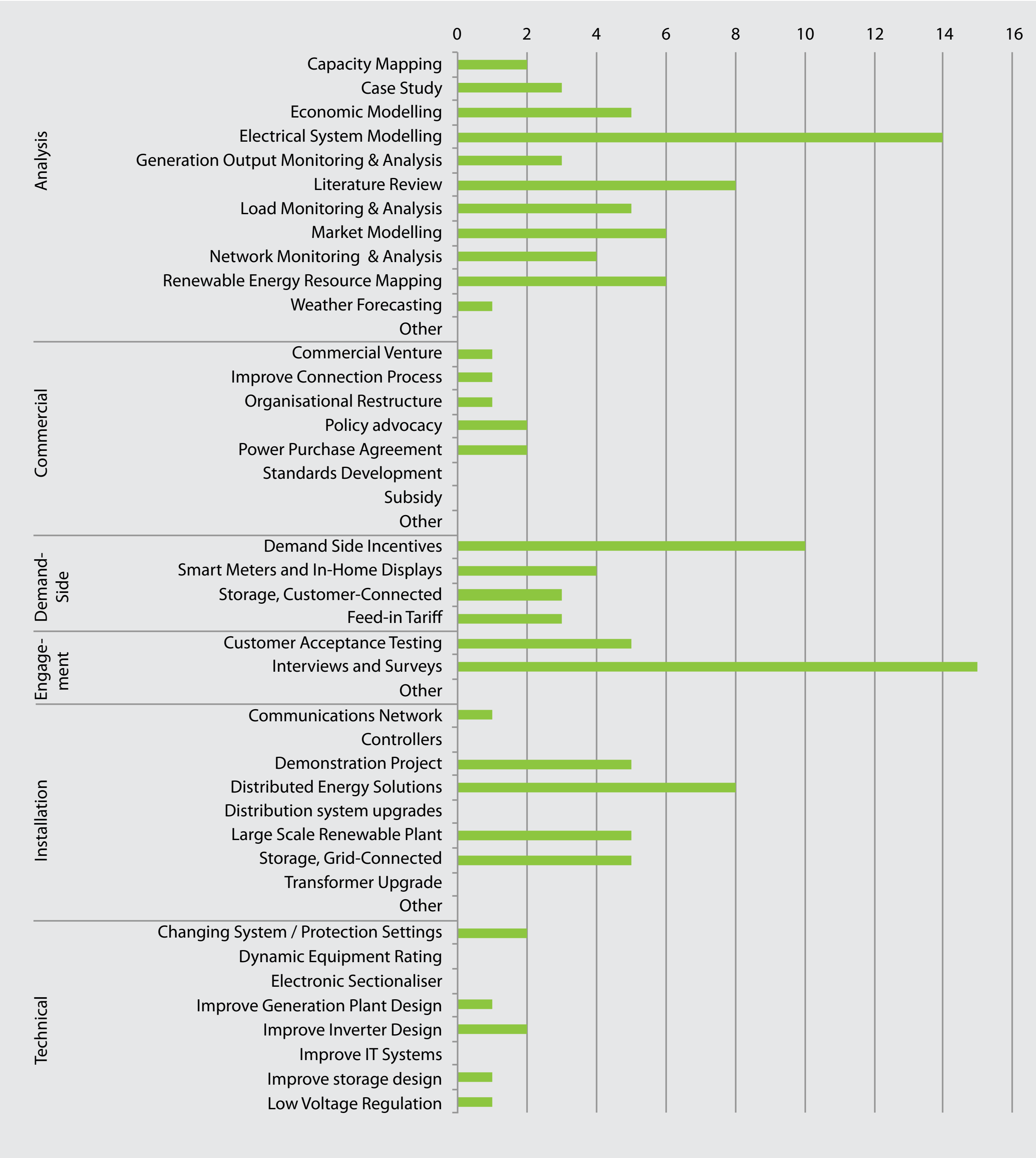


FIGURE 13: NUMBER OF PROJECTS ADOPTING EACH APPROACH



This finding is not surprising; as these approaches seem to be the natural fit for these objectives.

» Example: Project 129: Least-cost carbon abatement modelling by Melbourne Energy Institute

» Example: Project 262:The ANU Solar Radiation and Cloud Measurement Network by The Australian National University

» Example: Project 364: Network Transformation Roadmap by CSIRO and ENA

Demand-Side and **Engagement** approaches, covering incentivising pricing, information, and interviews directed at customers, tended to predominate for:

» Supporting the transition to an alternative electricity pricing approach **(#2)**

» Engaging customers to build their and the industry's understanding of distributed energy resources **(#5)**

» Altering local load profile to match a desired level **(#11)**

These objectives, being reliant on customer co-operation, would are well-served by these approaches.

Installation and **Technical** approaches, covering the deployment of generation, storage, and auxiliary equipment on the grid or behind the meter; and improving the design of existing grid components, tended to predominate for:

» Making the process of integrating renewable energy into the grid more cost-efficient **(#6)**

» Strengthening the network to manage higher renewable energy penetration **(#9)**

» Using distributed energy solutions to address network and system constraints **(#12)**

4.3 RESULTS REPORTED BY PROJECTS

Similar to the analysis of Approaches (see section 3.2), each respondent's description of their project's results has been analysed and categorised, i.e. whether the project was successful in addressing its own objectives, and why.

It should be noted that these results are self-reported: as the remit of this "Stocktake" does not include verifying the results of individual projects, and therefore can not be endorsed as findings of the "Stocktake". The most common results are shown in Figure 14.

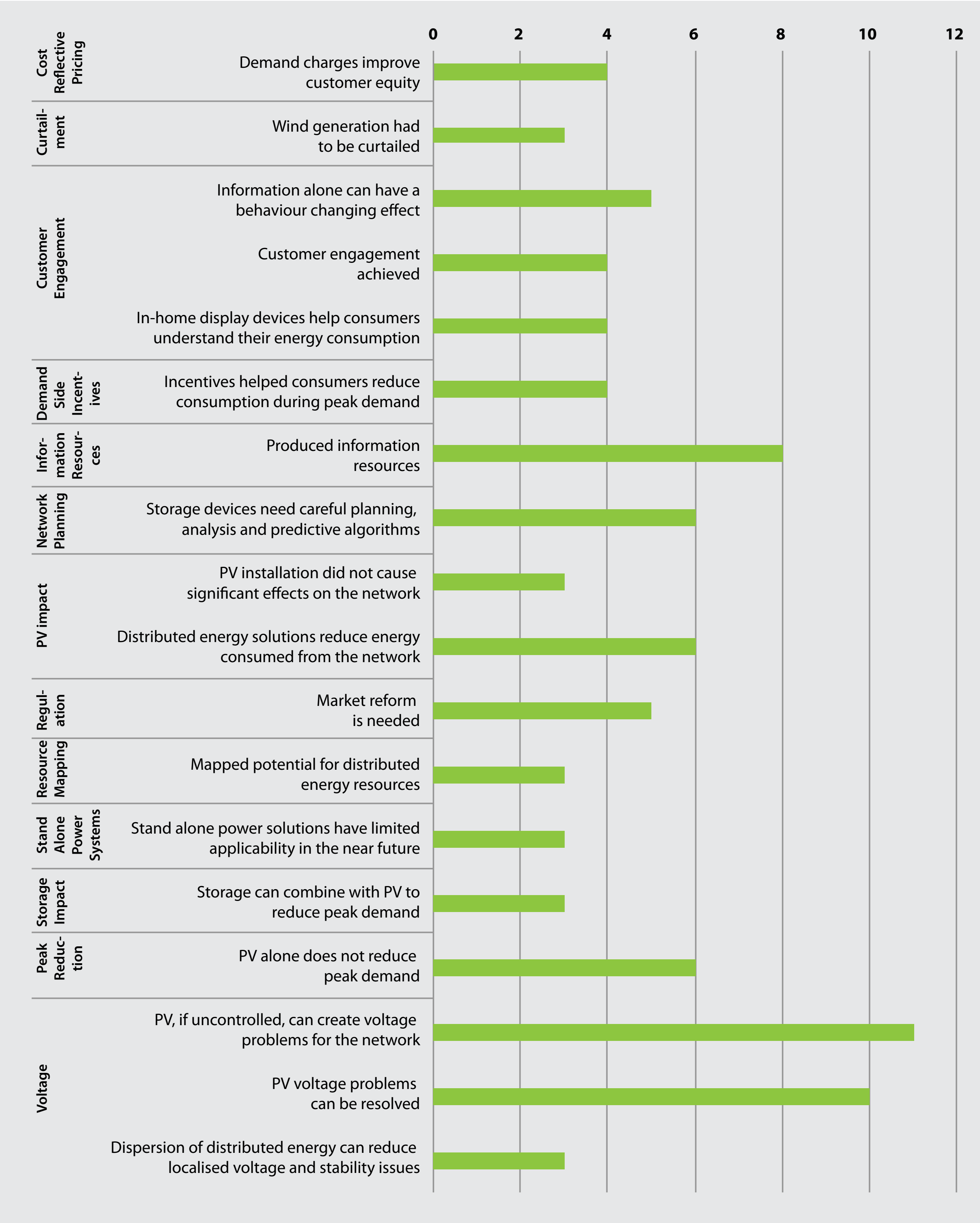
The most commonly reported results relate to the voltage problems caused by high penetrations of solar PV on existing distribution networks, and the means through which these issues can be addressed.

The "Stocktake" indicates that many projects were expressly commissioned to:

a. experiment with high local penetrations of solar PV
   – Example: Project 234: Analysis of High-Penetration Levels of PV into the Distribution Grid in California by NREL

b. experiment with ways to address the voltage problem.
   – Example: Project 158: SGSC: Active Volt-Var Control Project by AusGrid

FIGURE 14: NUMBER OF PROJECTS CLAIMING EACH TYPE OF RESULT



4.4 LIMITATIONS TO TRANSFERABILITY

Respondents were asked what limitations might affect the transferability of knowledge from their projects to (other) Australian entities, locations, networks, or contexts. In other words, could the results of their project be applied elsewhere?

As can be seen in Figure 15, 38% of the projects in the "Stocktake" nominated some such limitations.

It is encouraging that 62% of respondents see no limitations to the application of their projects' learnings to other environments.

Where limitations were identified, the most common reasons were due to:

» Project results being dependant on specific regulatory environments (31%); and

» Limits to the availability of the technology used (18%).

Figure 16 gives more detail on what type of limitations the projects in the "Stocktake" nominated.

FIGURE 15: EXISTENCE OF LIMITATIONS TO TRANSFERABILITY

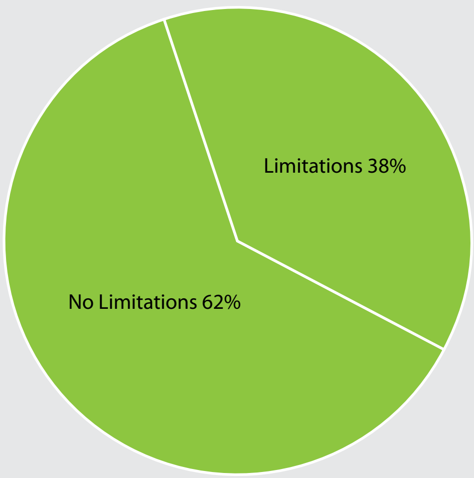
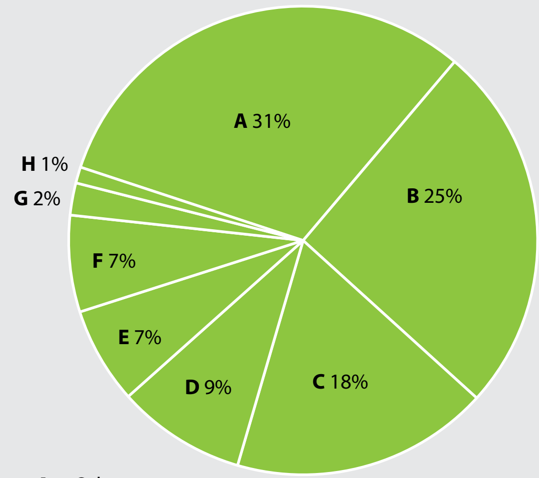


FIGURE 16: MOST COMMON LIMITATIONS TO TRANSFERABILITY[3]



A Other

B Project results dependent on specific regulatory environment

C Limits to availabilty of technology used 18%

D Project results dependent on specific customer load

E Project results dependent on specific specific funding situation

F Project results dependent on specific economic or industry structure

G Intellectual property concerns

H Project research outcomes involve addressing this question

3 'Other' covers such limitations as community acceptance, data resolution, and shareholder risk appetite.

4.5 FUTURE PLANS

Each of the projects future plans were categorised and analysed.

The categories were as follows:

» **Commercialise**: A project was completed successfully, and is now being converted into a commercial venture or a set of business-as-usual practices

» **Discontinue:** A project was completed, but there are no plans to take it further

» **No Decision**: A project reached a natural juncture or completion point, and its results are still being considered. No decision has been made yet on whether to continue it.

» **Trial to Continue**: A project is still ongoing; or else has reached its completion, but will be extended (if funding continues to be made available)

Figure 17 shows the breakdown between these categories.

As can be seen in Figure 17,a good proportion of the projects have yet to decide whether to proceed commercially or be discontinued. However this was expected as a number of the projects in the database had only commenced in the last few years, and are still ongoing.

Figure 18 demonstrates that much of the volume of discontinued projects fall into the categories of:

» Analysis (where it is natural for projects to have an end date, and unusual for them to be commercialised); and

» Engagement (which often falls into a similar category of information-gathering, and where commercialisation would be unusual).

FIGURE 17: PERCENTAGE OF PROJECTS WITH EACH TYPE OF FUTURE PLAN

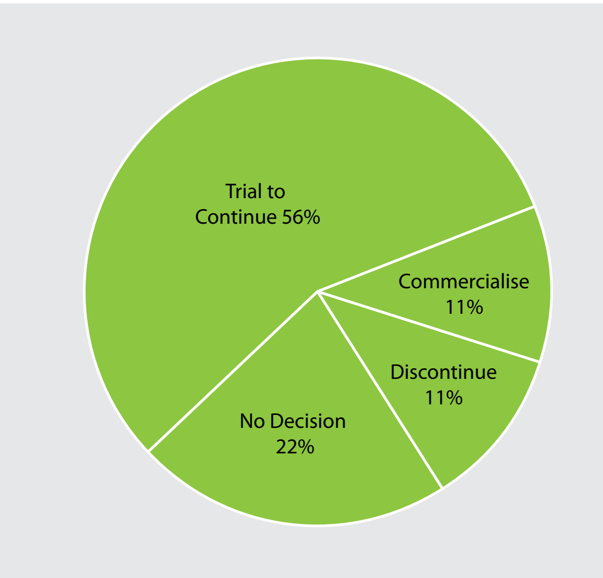
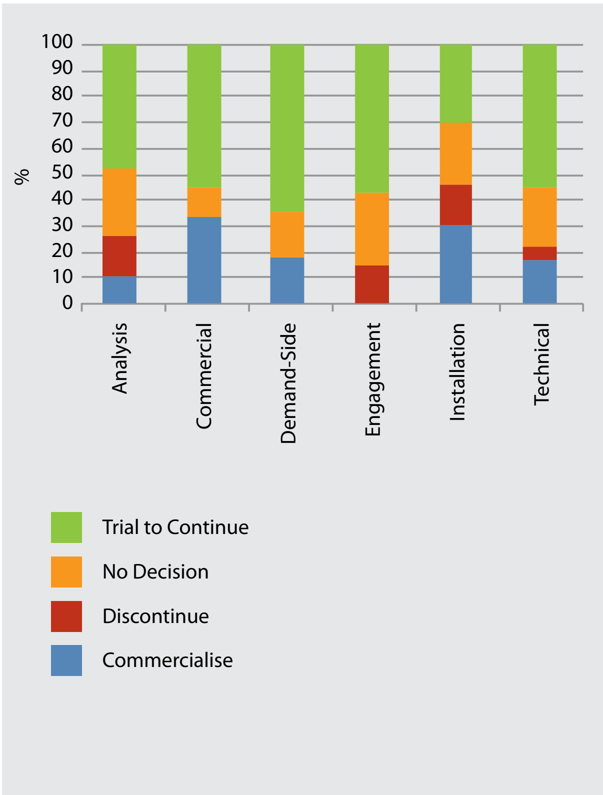


FIGURE 18: PERCENTAGE OF PROJECTS WITH EACH TYPE OF FUTURE PLAN, BY APPROACH TYPE



5 TOP FIVE AUSTRALIAN PROJECTS

The projects in this section were selected on the basis of scoring the most highly against the "Stocktake"s defined areas of relevance. Summaries of these projects are found below

5.1 PROJECT 196: KING ISLAND RENEWABLE ENERGY INTEGRATION PROJECT (HYDRO TASMANIA)[4]

The main aim of the King Island Renewable Energy Integration Project (KIREIP) is to increase renewable energy generation and reduce dependence on fossil fuels. To do this, KIREIP built on 15 years of operational experience of the King Island power system, with a history of progressively introducing renewable technology to displace increasing amounts of diesel fuel. This knowledge and experience were used to design a project and set of objectives that would allow 100% renewable energy penetration, trial energy storage and demand side management in order to save costly diesel fuel. The King Island grid had previously utilised significant amounts of wind energy, with an annualised average renewable energy use of around 33% and instantaneous penetration of up to 80%. KIREIP has used the existing renewable energy sources to increase average renewable energy penetration in the system to up to 65%. The designs developed and proven by KIREIP are readily applicable to similar sized remote power grids that rely on diesel fuel and have a reasonable source of renewable energy. The KIREIP team is aware of thousands of power systems that might benefit from the implementation of similar technology. This project is believed to be the world's first island grid of this size and has been successful in achieving sustained operation of the King Island power grid on 100% renewable energy, without support from conventional fossil fuelled generators.

5.2 PROJECT 316: PRIME PLC EVALUATION (ENERGEX)

The 2008 Energex Telecommunications Strategy defined a future telecommunications network comprised of three distinct sections, the Core, Intermediate and Edge networks. The Edge network is commonly referred to as the 'Last Mile' network and is the link into customer premises. One of the principal candidates for the Edge network is the power line carrier. Some of the benefits of power line carrier systems are that they use power lines as their communication medium and therefore have existing connections to customer premises.

As part of its Smart Grid Pilots & Trials, Energex ran a trial of adopting the PRIME PLC technology. The project was aimed at understanding the performance of PRIME PLC on typical Energex LV networks. The tests were designed to assess performance with regard to handling "typical" expected data traffic. Two types of expected data traffic were established and tested continuously including large volume data (e.g. energy/engineering profile data) and low volume/near real-time data (e.g. for control/pricing signals).

The initial results found that PRIME PLC performed sufficiently on Energex LV networks to merit further testing. Further testing would include optimisation techniques, more robust diagnostic/assessment tool development and testing on at additional sites.

5.3 PROJECT 245: FUTURE GRID FORUM (CSIRO)

Australia's electricity system is at a significant crossroads. Historically high retail electricity prices, widespread deployment of solar panels, greenhouse gas emissions abatement, slowly growing peak and a declining consumption in most states and territories are some of the major issues that have put it at this crossroads, and there are several potential future directions.

4 This project was part funded by ARENA

Each direction has far-reaching implications for the future electricity supply chain and would alter the electricity model in this country. Recognising the extraordinary circumstances of this time in the electricity sector's history, in 2012 CSIRO convened the Future Grid Forum, unique in composition (bringing together more than 120 representatives of every segment of the electricity industry, as well as government and community) and in approach (undertaking extensive whole-of-system quantitative modelling and customer social dimensions research to support its deliberations and findings).

Through the forum, four scenarios were explored and discussed: set and forget; rise of the prosumer, leaving the grid and renewables thrive. The four scenarios represent potential new directions for the development of the electricity sector as well as other information describing their impact and possible response options.

The result is Australia's first extensive whole-of-system evaluation that encompasses the entire energy chain from generation through to consumption.

5.4 PROJECT 186: SGSC: SMART GRID, SMART CITY PROJECT (AUSGRID)

Smart Grid, Smart City was a $100 million Australian government funded project, led by AusGrid and supported by its consortium partners.

The project tested a range of smart grid technologies; gathering information about the benefits and costs of implementing these technologies in an Australian setting. Up to 30,000 households participated in the project, which ran between 2010 and 2014.

AusGrid led a consortium of partners working together on this trial. EnergyAustralia, the Smart Grid, Smart City retailer partner, tested innovative technology and pricing offers. These products also made the most of new smart meters and were designed to give homes greater choice and control over their bills.

Building a smart grid involves transforming the traditional electricity network by adding a chain of new smart technology. Technologies include smart sensors, new back-end IT systems, smart meters and a communications network. Technologies and products are being tested on both the electricity network and within households.

The Smart Grid, Smart City consortium partners come from government, industry, and education industries.

5.5 PROJECT 265: PLANNING FUTURE ENERGY GRIDS: RENEWABLES (QUT)

This project aims to address the very unique and complex challenges of the Queensland electricity network as it faces the unprecedented growth in peak load and increase in new, intermittent and distributed energy generation in a carbon constrained future.

To do this, the project provides comprehensive, world-first planning and modelling tools and techniques, which enable more flexible network planning, to accommodate the increasing penetration of fluctuating and distributed generation. Consequently, it facilitates an improved network planning to enable embedded renewable generation to play a role in meeting the peak demand.

The proposed planning tool proved to be viable, and demonstrated significant network savings potential in several case studies on urban networks (Townsville) and rural SWER systems within the Ergon Energy network.

CONCLUSIONS

The initial development and continuing update of the "Stocktake" database is an important initiative between ENA and ARENA; it includes studies, trials and demonstration projects led by a wide range of proponents.

The database now contains the collated detailed information on over 208 renewable energy grid projects from across Australia. As such, it builds a picture of practical knowledge and experience related to the integration of renewable energy sources into distribution networks, and is a valuable resource for sharing information and parties considering new projects. The database is also valuable resource for ARENA and other government funding agencies, to refine future funding priorities in the area, whilst providing a location for networks and proponents to share information about how opportunities can be exploited, overcome barriers and knowledge gaps and avoid duplication of effort.

This report highlights that there are areas of research related to the integration of renewables, where Australian organisations lead the world, for instance in forecasting renewable energy generation. However, it also points to gaps where future research in Australia could valuably focus on sharing existing knowledge or further building our evidence base. Projects in several defined objective categories were found to be highly relevant to other participants and outcomes were easily transferable.

Other objective categories contain large knowledge gaps, which could be addressed through a targeted approach to such knowledge sharing: It is important however that the chosen approach has credibility with regulators and policy makers who would otherwise be critical in transitioning to new technologies or practices.

The ENA and ARENA are working together to ensure that the Stocktake remains a continuing resource with publically available, up to date information in the area. ARENA and the ENA's goal is for the stocktake to support collaboration between networks, research institutions, the renewables sector, technology developers, and other project proponents.

The ENA will lead delivery of the planned future editions of the stocktake, and with continuing stakeholder support, will seek to maintain the Stocktake so that it remains a comprehensive, relevant resource for the electricity sector to draw on in the future.

ENA and ARENA are currently working to ensure that the "Stocktake" continues to evolve and grow to provide the industry with a lasting, relevant and readily accessible knowledge source, for instance the development of an online tool to collect data including new projects, is critical and would assist in making this database more sustainable

This report highlights that successful approaches to energy storage and other emerging technologies should be actively shared between industry participants. Knowledge sharing could be facilitated to encourage otherwise reluctant participants to understand the benefits.

APPENDICES

HOW THE "STOCKTAKE" WAS UNDERTAKEN

APPROACH TO INFORMATION GATHERING

The following describes how ENA went about collecting information on the projects comprising this "Stocktake".

1. Initially **making contact with the CEO / MD (senior contact)** or appropriate senior executive of each organisation being targeted with an email letter or phone call. The letter:
   a. introduced the project, and made the points that
      i. It is of strategic importance to ARENA, and to the industry
      ii. It will give them an ongoing source of industry insight
      iii. It will be a great opportunity to have their work publicised and promoted
   b. secured their in-principle support
   c. located the specific people (**primary contacts**) in the organisation who can be regular points of contact
2. Contacting the **primary contact** via phone and with a follow-up letter. The letter:
   a. explained the "Stocktake", and provide a framework for the data on renewable energy integration approaches that we want to collect
   b. explained the various types of projects which we're looking for – in particular, that we're looking for both Technical and Economic / Commercial projects
   c. explained what's in it for them, namely:
      i. The final "Stocktake" will be made available to them; they will be able to see everyone else's project information, and as the "Stocktake" is updated over time it will give them an ongoing source of industry insight.
      ii. They will be able to benchmark their projects against those of their industry colleagues
      iii. It will be a great opportunity to have their work publicised and promoted
   d. included an assurance of confidentiality and disclosure options for any information that the organisation may be unwilling to see published
   e. requested that they fill out an attached inventory of projects that their organisation has participated in and nominating a **project contact**
3. Sending a questionnaire and an example questionnaire to the appropriate project contact for each project at each organisation.
4. In general maintaining frequent contact with each organisation throughout the information gathering process to make sure we're interpreting their data correctly.

APPROACH TO ELICITING DATA

Once the completed questionnaires were received from project contacts we:

» Reviewed and edited the project contact's questionnaire responses for clarity

» Requested for any pre-existing reports about the project, to complement the information they entered in the questionnaire.

» Organised the Approach and Results responses into Themes. This process effectively represented a "translation table" that groups multiple projects which share the same ideas, regardless of any difference in wording used to express these ideas.

» Undertook a relevance assessment for each project objective.

» Drafted a story for each project which is a high level narrative interpretation designed to let the reader quickly understand the project, without needing to piece it together from the other facts in the database. The story covers:
   - **Context**: When and where did this project originate? What situation were the network and its customers in before this project was designed? What complications or challenges, if any, existed?
   - **Purpose:** What did the project aim to achieve? What broader problem was it designed to solve?
   - **Activity:** What happened under the direction of this project? Who was involved? Barriers encountered?
   - **Results:** Did the project achieve its aims? What lessons were learned?
   - **Next steps** (if relevant) to continue or build on this work

APPROACH TO SENSITIVE INFORMATION

Stakeholders tend to share commercial-in-confidence information, if they believe it will be used properly.

The approach was to:

1. Clearly present the purpose of the "Stocktake" and the reasons we need this data in the initial communication. This will emphasise the facts that:
    a. The results will essentially be available to the industry itself for the purpose of sharing knowledge
    b. Results will not be published in a form that would conceivably compromise their future dealings with the regulator
    c. The availability of the "Stocktake" will not remove their remit to conduct their own trials in future; it will simply enable them to conduct more focused, valuable trials that add to the industry's collective knowledge base rather than duplicating it.
2. Encourage stakeholders to provide their information for full publication (in the first instance), subject to the standard confidentiality agreement
3. If stakeholders are still resistant, offer to (in order)
    a. Publish the information in the final public "Stocktake", but redact certain commercially sensitive portions (e.g. names of suppliers, or the identity of the network itself), which may (at the stakeholder's discretion) be made available on application to a nominated contact at their organisation
    b. Not publish the information in the final public "Stocktake", but make use of it in the synthesis of lessons and barriers of renewable energy integration, and make it available to ARENA to consider (but not publicise) when deciding on future funding opportunities
    c. Not publish the information in the final public "Stocktake", nor make it available to ARENA, but make use of it in the synthesis of lessons and barriers of renewable energy integration.

energy networks association

FURTHER INFORMATION

E: INFO@ENA.ASN.AU P: (+61) (0) 2 6272 1555