Integrating Renewables into the Grid: Stocktake project

Report B – Non-Confidential

Prepared for the Australian Renewable Energy Agency

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MARCHMENT HILL CONSULTING

vaasaETT

Disclaimer

This report ("Report B") has had some confidential information removed. It is intended for public distribution.

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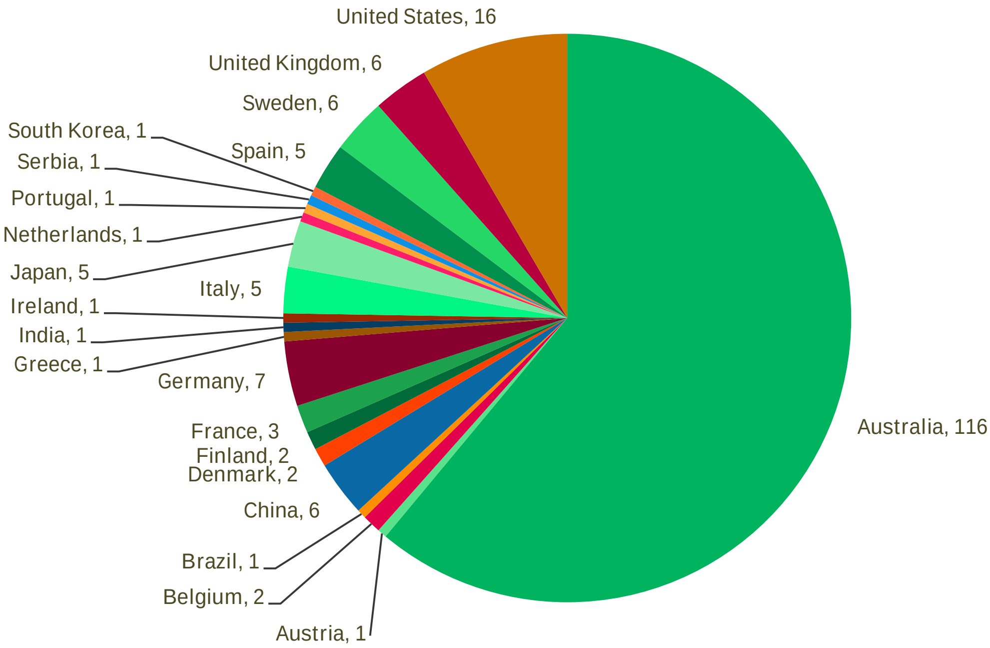
Executive Summary

Australia looks toward a future with a greatly expanded market share for renewable generation, including distributed renewable solutions. The increased penetration of distributed generation technologies, however, does not come without its challenges and risks. Our current electricity infrastructure is not designed to cope with the future increasing levels of electricity produced from fluctuating renewable energy sources. As a result a revised network infrastructure is required. Although the fundamental challenge remains the same – "power must be available when energy consumers need it" – the approach is becoming different.

Whilst these opportunities and challenges are easily identified there continues to be limited capacity in the market whereby stakeholders are able to either coordinate projects or share their knowledge, experience and ultimately results. ARENA has therefore decided to develop a central repository of all projects completed, underway or in planning relating to integrating renewable energy into distribution networks.

The objective of this stocktake is to build and share a detailed picture of knowledge, experience, barriers and near-term priorities in the sector for managing distributed energy resources in distribution networks.The final stocktake includes 176 projects: 116 from Australia and the remainder from overseas. We have gathered projects for this stocktake from a variety of sources, including network operators, industry associations, governments, technology proponents, electricity retailers, governments and academic institutions.



In order to be included in our stocktake, projects had to address or inform one or more of 14 defined objectives relating to issues with renewable energy in distribution networks which need to be solved:

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

For each of the defined objectives, MHC assessed whether the project addressed or informed the objective in a way that would be relevant to other entities in Australia. Each project thus received a set of 14 assessments of relevance: one for each defined objective. (Note: the purpose of these assessments is to let users find the projects in the stocktake most relevant to them. They are not intended to judge whether the project was successfully executed or not.)

Overall, projects on average addressed or informed these objectives clearly and compellingly.

The most common orientation of projects is toward these objectives:

- Making the process of integrating renewable energy into the grid more cost-efficient (#6)
  - Example: Project 167: Isernia Smart Grid Project by Enel Distribuzione
  - 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 290: Business Model Implementation Project by Ergon Energy
  - Example: Project 130: Redeployable 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 196: King Island Renewable Energy Integration Project (KIREIP) by Hydro Tasmania
- Example: Project 186 Smart Grid, Smart City project by AusGrid

Some other objectives are less well-addressed: notably, projects to do with Storing and organising information on customer renewable energy deployments (#13) are less than a third as common as those to do with cost efficiency (#6).

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

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. Encouragingly, however, the details of these projects reveal that this was not simply a case of "reinventing the wheel": the projects in our database under this category managed to resolve this problem in a variety of ways, under differing conditions. This may indicate that duplication was avoided via existing informal channels of knowledge exchange between industry players, and our own experience supports this view.

Our respondents were asked what limitations might hamper the transferability of knowledge from their projects to (other) Australian entities, locations, networks, or contexts: 60% of respondents saw no such limitations. Further, we have not tested the materiality of the limitations noted in the other 40% of the instances by observing whether a transfer is possible in practice; it seems quite possible with thoughtful consideration of their contexts and fine tuning their approach to be more generalizable, that lessons from those projects with identified transferability limitations may well be applicable in other environments.

Our report recommends the following priorities for knowledge sharing:

- Sharing successful approaches to integrating emerging technologies such as energy storage
- Facilitated knowledge exchange forums between retailers, networks, and large energy users
- Uncommon but easily transferable projects relating to alternative electricity pricing approaches; information on customer renewable energy deployments; and techniques for forecasting renewable energy output
- Overcoming perceived barriers to knowledge sharing on cost-benefit analysis and cost reduction
- Industry collaboration on knowledge gaps relating to alternative electricity pricing approaches; the regulatory environment for renewable energy; and internal practices and processes. This collaboration should also engage with the regulators and policy makers.

(On this last point, we have seen the value in our stocktake of projects that engage the regulator in the process of industry collaboration. International projects tend to more often include engagement with the regulator, and not to only to purely inform them: the regulator is often actively consulted about the project.)

Examples of future projects that may address these priorities can be found in section 5.2.

The energy network of the future will have to deal with many challenges: the necessary expansion of renewables, the integration of distributed energy resources, and the active participation of end consumers among other factors. The stocktake's analysis has confirmed that information and communication technologies (ICT) are a significant enabler for this energy revolution. The increasing requirements for metering and regulating the generation, transmission, storage and consumption of electricity can only be met by means of intelligent convergence of ICT and energy systems, as demonstrated in projects across different continents, from Germany's E-Energy initiative to South Korea's Jeju Island Smart Grid Test-Bed. A great number of projects around the globe have been investing effort in this area, especially in EU and Japan.

Guide to the Report

Section 1 describes the background and purpose for this stocktake, and explains the essentials of how we assessed the projects in it.

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 of each kind appear, what results they encountered, how relevant they are to other entities in Australia, and what limitations to disseminating their lessons we have found. It presents some potential underlying reasons for these findings, and lays the foundations for our recommendations later on.

Section 4, informed by these findings, identifies the industry trends, knowledge gaps and likely future developments in Australia and overseas.

Section 5 presents our recommendations to ARENA on general priorities for knowledge sharing across the industry, and suggests some specific potential projects that ARENA might take the initiative to fund over the coming years

1 About the Stocktake

1.1 Background to the Stocktake

Through its role supporting the development and deployment of renewable energy technologies across Australia, the Australian Renewable Energy Agency (ARENA) has recognised the integration of renewable energy generation in distribution networks as both *'a major challenge and opportunity for growth in the renewable energy sector'*. This opportunity is emphasised by the recent impact of renewable energy policy measures at both the federal (Clean Energy Act) and state (feed-in tariffs) level, together with a reduction in costs of key renewable generation technologies including wind and solar photovoltaic (PV). This combination of policy measures and reduction in costs has resulted in higher penetration rates of renewable generation across Australia's energy markets.

In the National Electricity Market (NEM) this was underscored by the uptake of rooftop solar PV where total installed capacity has recently reached 3,200MW, up from the 1,500MW in 2011/12.[1] This increased penetration and therefore contribution to meeting electricity demand is forecast to grow in the foreseeable future, albeit at a slower rate due to a reduction in feed in tariffs.

Australia now looks toward a future in which renewable energy will take up a much larger role, and promises to drastically lower our carbon emissions, reduce the health and safety risks associated with thermal generation, and reduce our dependence on finite fossil fuel supplies. The Future Grid Forum's strategic analysis led by the CSIRO has outlined various scenarios for how the future energy industry in Australia might conceivably change to meet the economic and social needs of Australia in 2050: all these scenarios feature a greatly expanded market share for renewable generation, including distributed renewable solutions. Some states and territories have also shown strong policy support for renewable energy, adding to the existing support structures at the federal level.

The increased penetration of distributed generation technologies, however, does not come without its challenges and risks. Network operators are faced with the challenge of balancing demand and supply across the network whilst a) maintaining its safety, quality and reliability of supply standards and b) recovering sufficient revenue commensurate of their overall investment. Meanwhile, investors in distributed generation are faced with barriers in:

- the regulatory process
- the development and approval of non-network solutions in place of network augmentation
- testing the technical and operational impacts of a technology
- commercialising a technically successful technology

[1] Australian Energy Regulator, State of the Energy Market 2013, Page 25

Whilst these opportunities and challenges are easily identified there continues to be limited capacity in the market whereby stakeholders are able to either coordinate projects or share their knowledge, experience and ultimately results. This was emphasised by the Smart Grid, Smart City program which called on further work to improve the ways in which stakeholders share knowledge and experience integrating smart technologies across Australia's electricity networks.

ARENA took into account these opportunities and challenges, and stakeholder feedback that a) there was a lack of needed co-ordination in this space; and b) a need to prioritise investment decisions. ARENA therefore decided to develop a central repository of all projects completed, underway or in planning relating to integrating renewable energy into distribution networks.

1.2 Purpose of the Stocktake

The objective of this stocktake is to build and share a detailed picture of knowledge, experience, barriers and near-term priorities in the sector for managing distributed energy resources in distribution networks. The stocktake is intended to:

- Help the industry **understand** the state of knowledge – the first step to improving it!
- Form a view of **common / thematic opportunities and barriers** by synthesising the stories from each approach
- Make it easier for **networks** and **proponents** to share information about how opportunities can be exploited, and barriers overcome
- **Avoid duplication** of effort ("reinventing the wheel")
- Help ARENA to identify the most valuable opportunities for **sharing knowledge** and assess the case for funding additional sharing activities
- Help ARENA assess any **future activities** it may fund as part of its investment priority of integrating renewables into the grid.

1.3 Scope of the Stocktake

This stocktake covers projects that add to Australia's collective knowledge of integrating renewable energy into distribution networks.

The following subsections unpack the semantics of this sentence.

1.3.1 "Projects"

Projects are not limited to physical, on-the-ground activities. We use the terms to cover a broader range of initiatives that include, but are not limited to:

- desktop studies
- developing analytic tools
- constructing databases

- customer surveys
- business model trials

1.3.2 "Integrating Renewable Energy"

Projects in our stocktake need not directly involve distributed renewable generation on the grid.

The stocktake also covers projects that do *not* directly involve renewable generation, but do contribute knowledge and experience that supports - or could be applied to - renewable energy network integration. 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
- Projects trialling new approaches with regulatory or market bodies or that gather evidence to support decisions by those bodies or policy-makers

1.3.3 "Distribution Networks"

ARENA recognises the value of renewables connected to all points of the network. It has chosen to focus on the distribution network and not the transmission network for this stocktake, simply because it had identified that renewable energy projects faced more problems at the low-voltage scale, and there existed no national framework for distribution networks governing how distributed energy resources ought to be connected.

The concern 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)

The stocktake considers projects "on both sides of the meter": those that connect at the customer premises, as well as those that connect to feeders on the network itself.

There is of course no firm division between what constitutes a distribution network versus a transmission network; only conventions. For simplicity, we are therefore working with projects undertaken by, or on the networks of, Australian and International Distribution Network Service Providers (DNSPs).

1.3.4 Criteria for Project Inclusion

The diagram below illustrates the logic of inclusion criteria:

- We began with a list of **issues** relating to renewable energy in distribution networks which needed to be solved
- Out of the need to solve these issues fell natural **objectives** that a useful project might address or inform
- A project may test one more **approaches** as a way to achieve its objectives

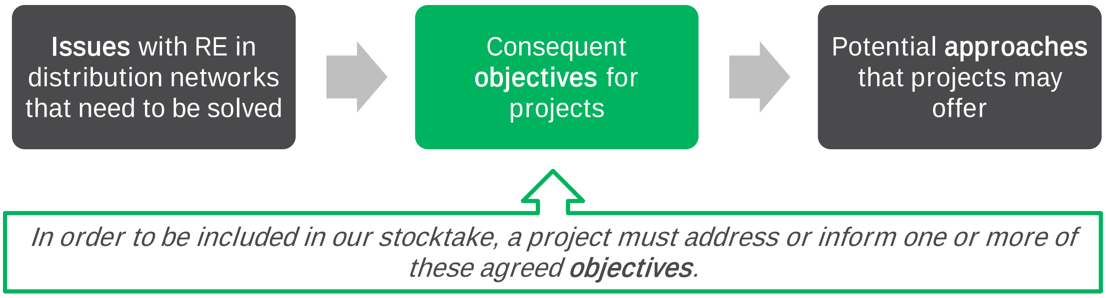


Figure 1: Conceptual framework for project inclusion

The issues we consider, and the objectives which address 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. A 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

1.4 Assessments of Relevance

Each project received an assessment of relevance against each of the defined **objectives** (see section 1.3.4 above).

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.

Based on this response, the other details provided by the respondent in the questionnaire and any supporting documentation, MHC then assessed the relevance of each project to other entities in Australia, with respect to each objective. The results were based on a simple 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' can 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 these assessments is to let users find the projects in the stocktake most relevant to them. They are **not** intended to judge whether the project was successfully executed or not. The assessments instead exist to measure the relevance of the project to other entities that have one of the objectives in mind.

A project may be completely successful on its own terms, yet tied to an unusual physical or regulatory environment that makes it largely impossible for other entities to adopt and learn from: it would be assessed as less relevant. Conversely, a project may have utterly failed to achieve its own goals, yet the reasons for its failure may be highly instructive to other entities: it would be assessed as more relevant.

The possible assessments are as follows:

Relevance Assessment	Description	Frequency
NONE	Does **not** inform or address the objective in a way that's relevant to other entities in Australia	The **most common** result. Most projects addressed only a few of the objectives; against the rest, they received a NONE.
LOW	Informs or addresses the objective, but in an **indirect or unclear** way	**Somewhat common**: in some cases, there was qualitative or limited evidence that the project addressed an objective
MED	Informs or addresses the objective **clearly and directly**	**Somewhat common**: in some cases, there was clear and compelling evidence that the project addressed or informed an objective
HIGH	Informs or addresses objective clearly and directly enough to constitute **essential knowledge** for other entities.	**Rare**. Only exceptionally informative projects received this assessment.

Each project thus received a set of 14 assessments of relevance: one for each defined objective.

1.5 Limitations to our Research

The knowledge gained in this sphere to date is surely impressive, but we have not yet created a perfect and complete picture of it. Our study has been limited by:

- **Time**: responses to our stocktake have continued to arrive up until the point of publication. A future refresh of this stocktake plans to capture these ongoing responses.
- **Resources:** This is particularly so in the international component of our stocktake, where the time-intensive nature of our research has made us focus on what we believe to be the most high-value targets, thus by necessity omitting many more.
- **Respondents' willingness to participate**: Our research has been dependent on the good will of the networks, researchers, policymakers, technology proponents, and other industry members who have told us about their work. For many legitimate reasons – lack of time, and confidentiality restrictions among them – some have been unable to contribute. Future plans for this stocktake should allow their projects to later be added.

1.6 Future Plans for extending the Stocktake

ARENA is working to ensure that the stocktake continues to evolve and grow beyond this initial stage to provide the industry with a lasting, relevant and readily accessible knowledge source.

Note: a description of how MHC undertook this stocktake can be found in Appendix 6.1.

2 Overview of Integration Projects

Given the purpose of our stocktake is to inform the Australian electricity sector, we have sourced the majority of our projects from Australia, as can be seen in Figure 2. The rest of the stocktake comprised selected international projects of high importance from which lessons could be practically applied in Australia. The final stocktake includes 176 projects: 116 from Australia and the remainder from overseas.

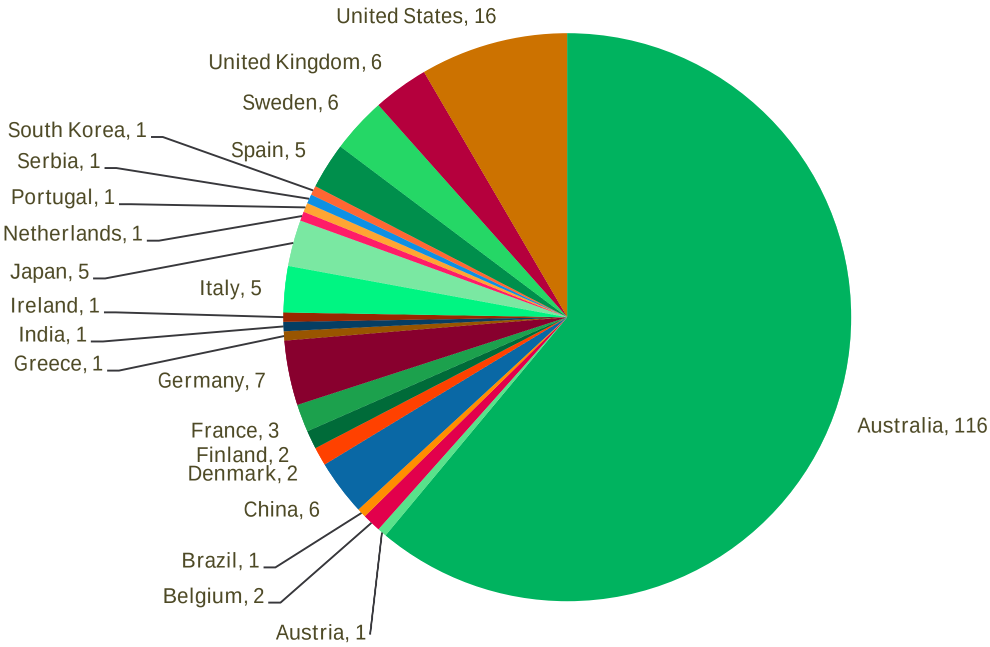


Figure 2: Projects in our Stocktake: Country of Origin

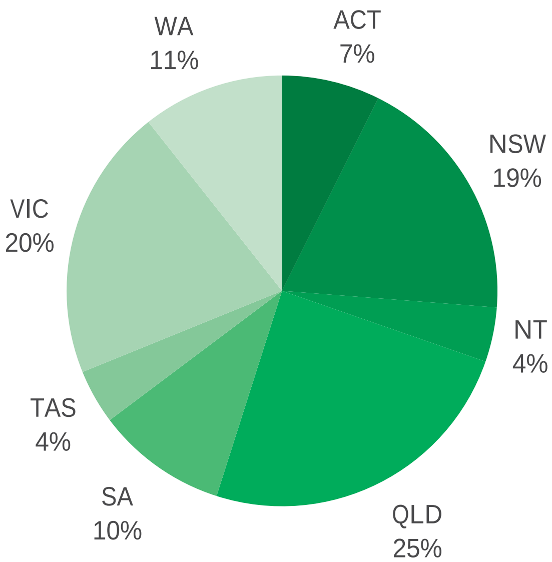


Figure 3: Australian Projects in our Stocktake: State of Origin

Within Australia, 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 size, owing to the strong contributions of Ergon Energy and ENERGEX, among others. The ACT also shows strongly, owing to the support that the ACT government has given to renewable energy initiatives. In future editions of the stocktake, we hope to see more information from the NT and WA in particular: there are substantial off-grid and fringe-of-grid needs in these areas, and we believe there may be many more projects to capture here.

The international projects in our database have predominantly come from Europe, more than any other continent. The principal reasons for this are that:

- European utilities are in many ways at the forefront of deploying smart grid technology, and examples of the most globally significant approaches to distributed energy resource integration can almost always be found among them (even if not exclusively).
- European utilities have on the whole been the most responsive and willing to share details of their most recent work
- We have chosen to emphasise diversity in the design of the projects in our stocktake, rather than diversity in their country of origin. This has led us to focus in some depth on the experiences and approaches of a single set of relatively collegiate organisations in order to capture the largest diversity of projects; this may seem paradoxical, but in doing so we have avoided repetitively documenting multiple examples of very similar projects (with very similar lessons) that have happened independently around the world. For example, there are many European projects that have been replicated in South America: capturing both the European and South American instance of these projects would have added unnecessary repetition to our results.

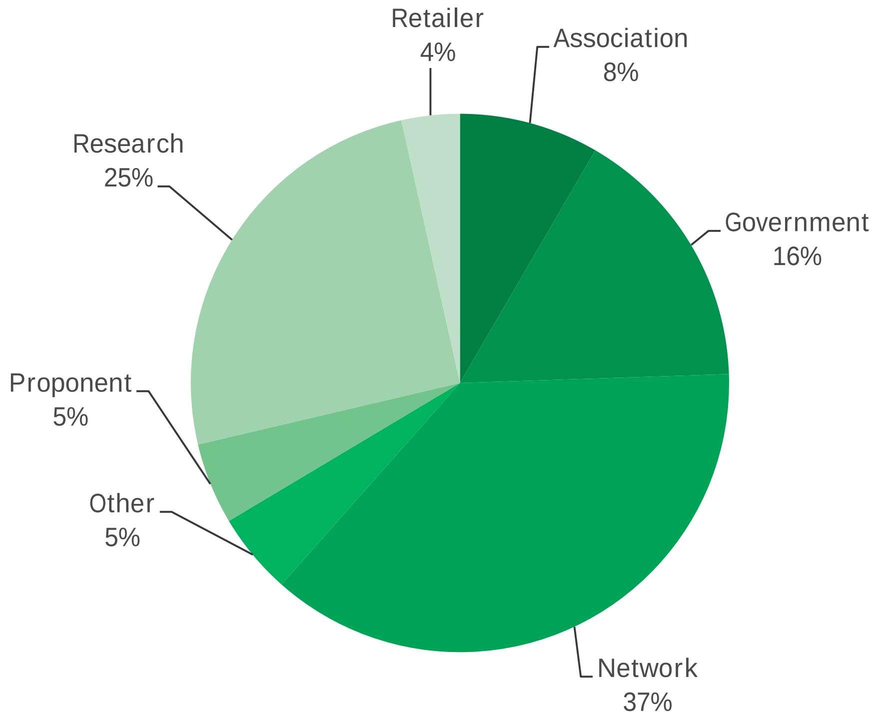


Figure 4: Projects in our Stocktake: Categories of Respondent (Australian)

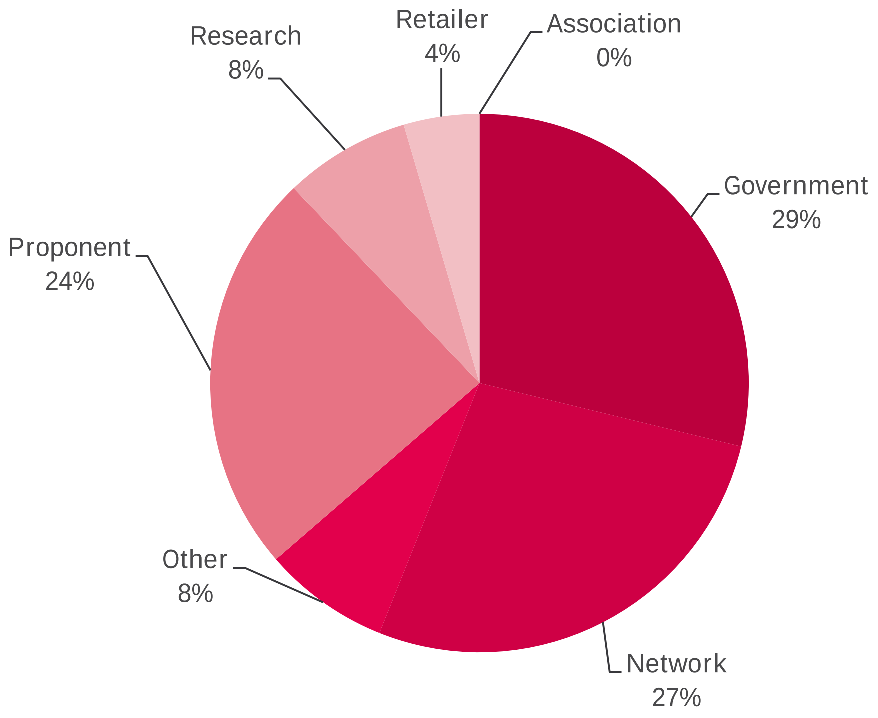


Figure 5: Projects in our Stocktake: Categories of Respondent (International)

We have gathered projects for this 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 in our stocktake that come from each of these sources. Network Service Providers, Government organisations, and Academics have figured most heavily.

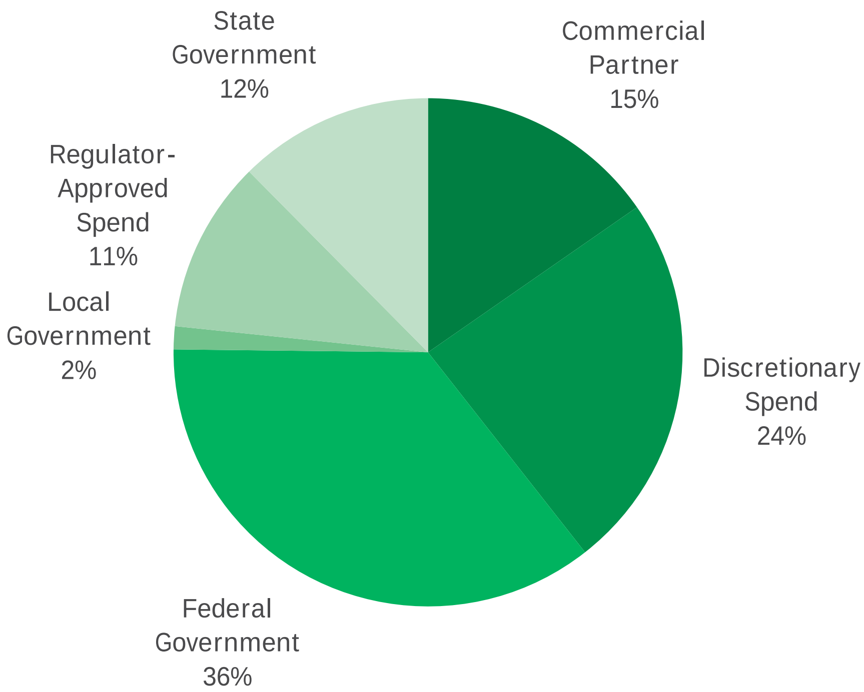


Figure 6: Projects in our Stocktake: Funding Source (Australian)

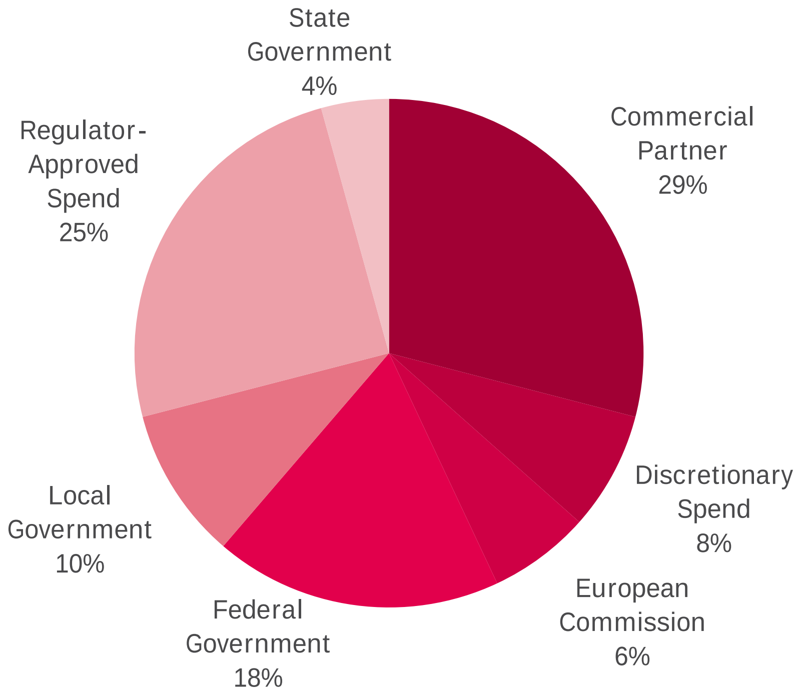


Figure 7: Projects in our Stocktake: Funding Source (International)

Some differences between the Australian and International charts stand out:

- In Australia, projects were funded by discretionary DNSP spend roughly twice as often as by regulatory-approved DNSP spend; for our international projects, the reverse is true. This could be due to the comparatively larger scale and higher profile of international projects in our database, which justified (or required) the seeking of regulatory funding.

- In Australia, projects were sourced from research organisations far more often than from proponents, internationally, the reverse is true. This disparity came from the respective willingness of proponents and researchers to participate in our study, and may just reflect a cultural difference.

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

- Which objectives in our stocktake did these projects most often address, and how thoroughly did they do so?
- 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 our stocktake's areas of knowledge, and how will they be progressed?

3 Analysis of Projects

Note: throughout this section, there are charts that compare the number of projects that address various objective, 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 our database.

3.1 Addressing the Objectives

Figure 8 below shows how many projects in the stocktake addressed each of our defining objectives. Recall from section 1.3.4 that in order to be included in our stocktake, a project must address or inform one or more of these objectives.

The most common orientation of projects is toward these objectives:

- 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 290: Business Model Implementation Project by Ergon Energy
  - Example: Project 130: Redeployable 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 323: Kitakyushu Smart Community Project by Kitakyushu City
  - Example: Project 186 Smart Grid, Smart City project by AusGrid

Some other objectives are less well-addressed: notably, projects to do with Storing and organising information on customer renewable energy deployments (#13) are less than a third as common as those to do with cost efficiency (#6).

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

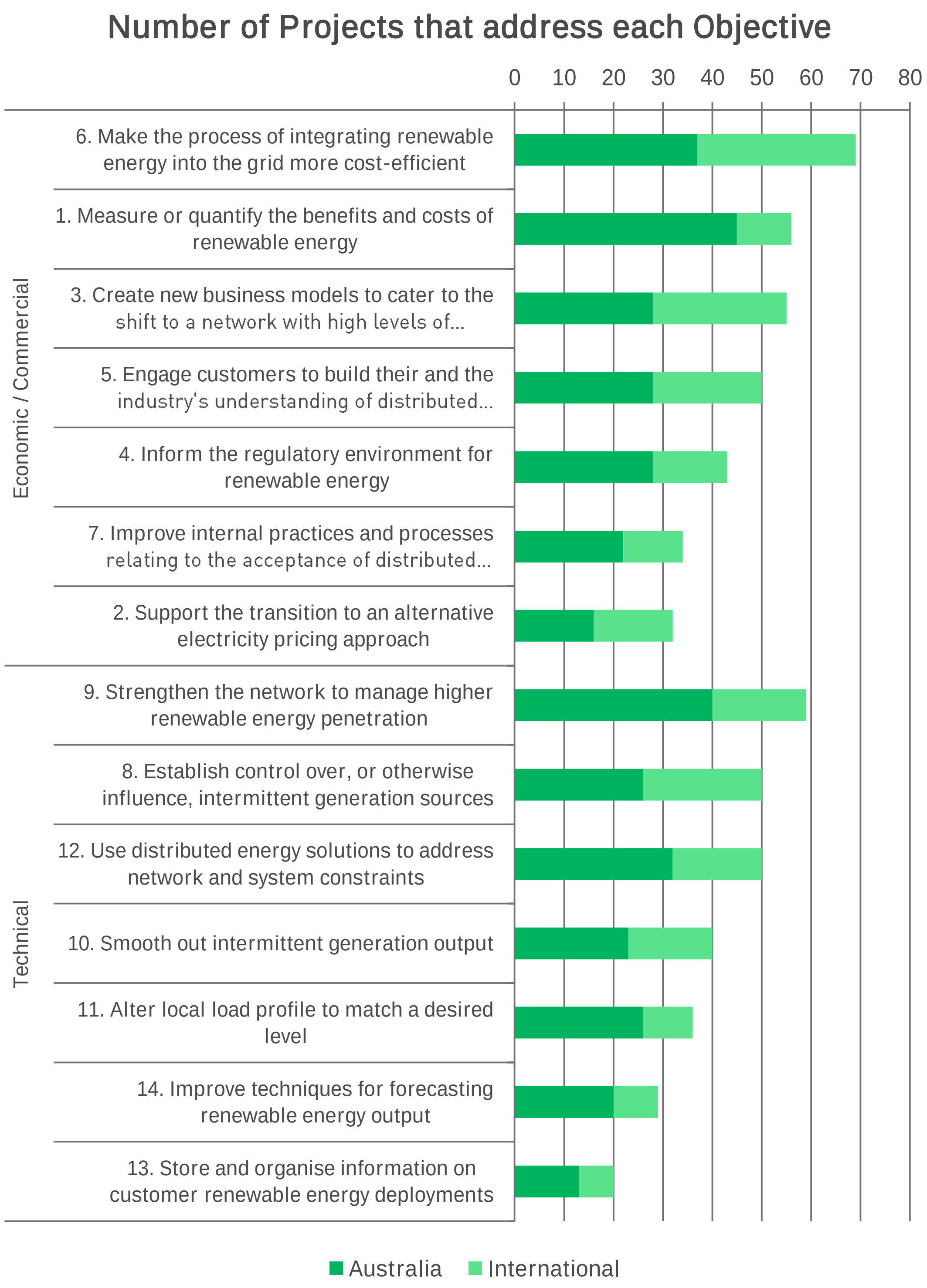


Figure 8: Number of Projects that address each Objective[2]

Our assessments of relevance (see section 1.4) were applied to the projects in the stocktake. The results of this scoring can be seen in Figure 9.

[2] 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.

Overall, projects scored on average close to **Medium**, indicating clear and compelling evidence that the project has addressed or informed an objective.

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

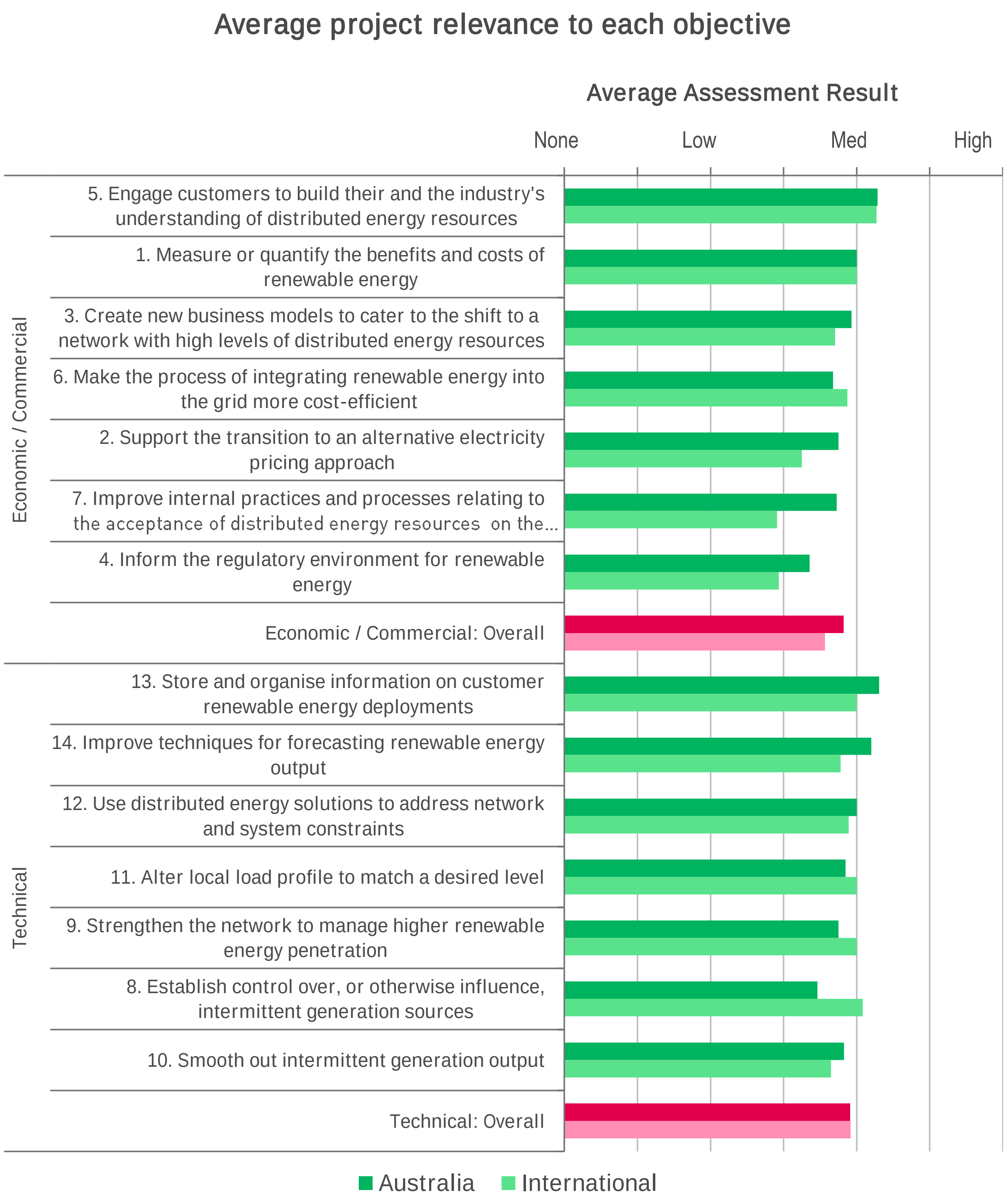


Figure 9: Average project relevance to each objective[3]

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

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

Deeper analysis and follow-up questioning has suggested some reasons for this fact:

- 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
- Results for technical projects more often included hard, quantitative results. Although quantitative results are not the only kind of evidence we looked for, their presence indicated *some* definite evidence which, per the definition of our 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, and that the results reported to us were abbreviated accordingly. We also believe, based on respondent feedback, that there may be a "tip of the iceberg" effect, where many more commercially-oriented projects than exist in this stocktake were simply not submitted, because of the perceived commercial risk to the organisation that conducted them.

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, we can identify some particular objectives relating to distributed energy integration that stand out from the rest, for instance:

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

A moderately frequent area of focus, with results that were assessed as highly relevant.

- Example: Project 143: Perth Solar City by Western Power
- Example: Project 316: PRIME PLC Evaluation by Energex

Improve techniques for forecasting renewable energy output (#14)

Not a frequent area of investigation: projects tend to be high-cost and require the involvement of specialists. Several comprehensive projects in our stocktake, however, have merited 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)

Again, not a frequent area of investigation. However, those few projects that addressed this area tended to score quite highly.

- Example: Project 297: Global Energy Storage Database by the Department of Energy (US)
- Example: Project 270: Solar Resource Mapping for High Prospectivity Regions by Geoscience Australia

Support the transition to an alternative electricity pricing approach (#2)

Few projects addressed or informed 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)

There have been many projects which touch on this objective, but do so in a cursory or tangential way, usually producing information that may be of interest to a regulator, as a by-product of some other objective. They tend to do this largely through analytical or desk-based approaches.

However, several projects did address this objective quite thoroughly:

- Example: Project 245: Future Grid Forum by CSIRO
- Example: Project 154: Reward Based Tariffs Trial by Ergon and Energex

Some of these objectives, then, stand out for reasons that are easily explained (e.g. high quality (i.e. relevance scores) balancing out low quantity (i.e. number of projects that address the objective). Others stand out for reasons that suggest a great deal of work, or a lack of work, being done in their area. We discuss these further in sections 4.1.1 (*What Areas of Knowledge have been most thoroughly investigated?*) and 4.1.2 (*What Gaps in Knowledge exist?*)

In Figure 10 and Figure 11 on the following pages, we can see some differences in the distribution of scores between Australian and International projects. International Projects tend to score MEDIUM more frequently than Australian projects; they score at the extremes (LOW and HIGH) less frequently. 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.

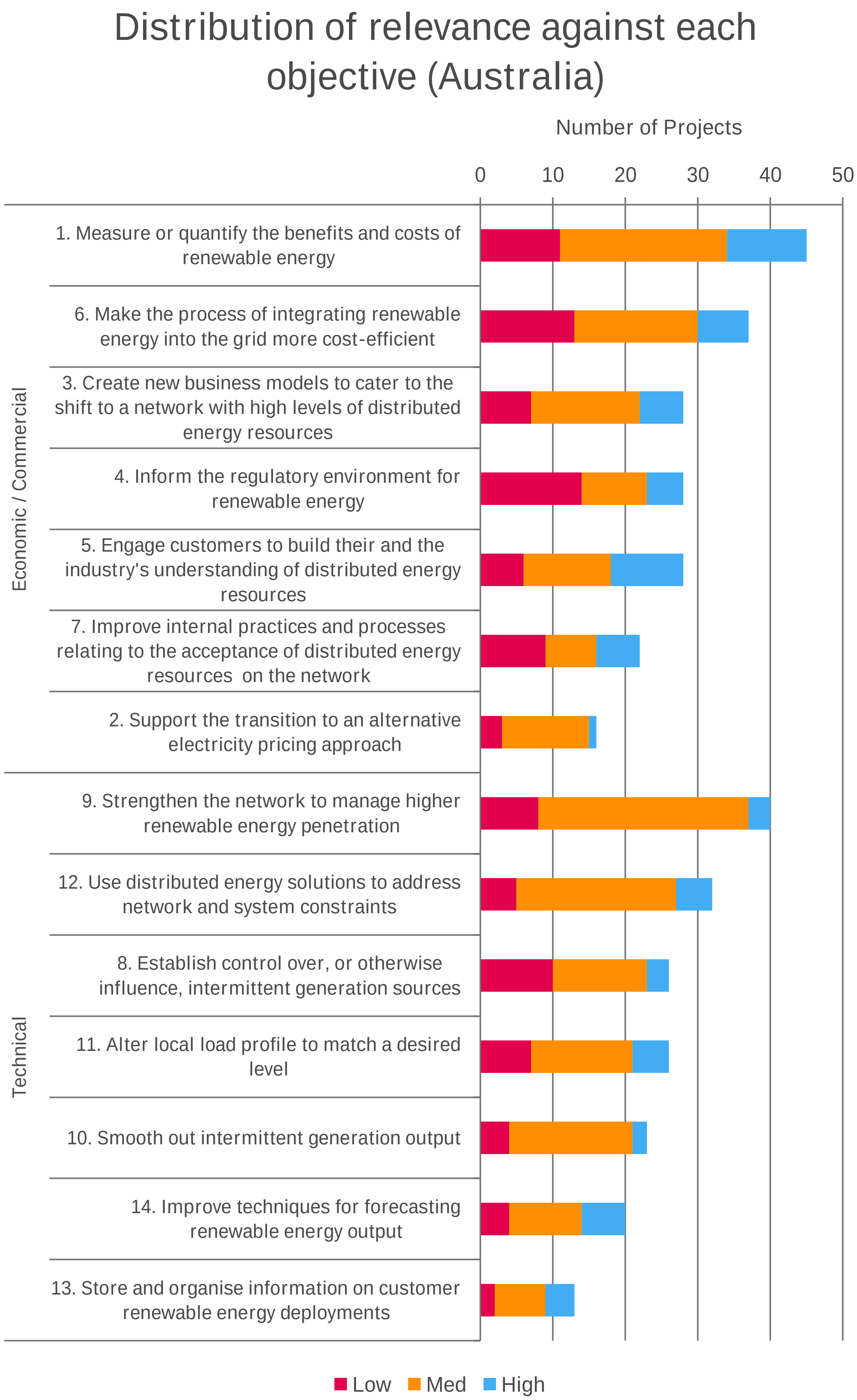


Figure 10: Distribution of relevance against each objective (Australian)

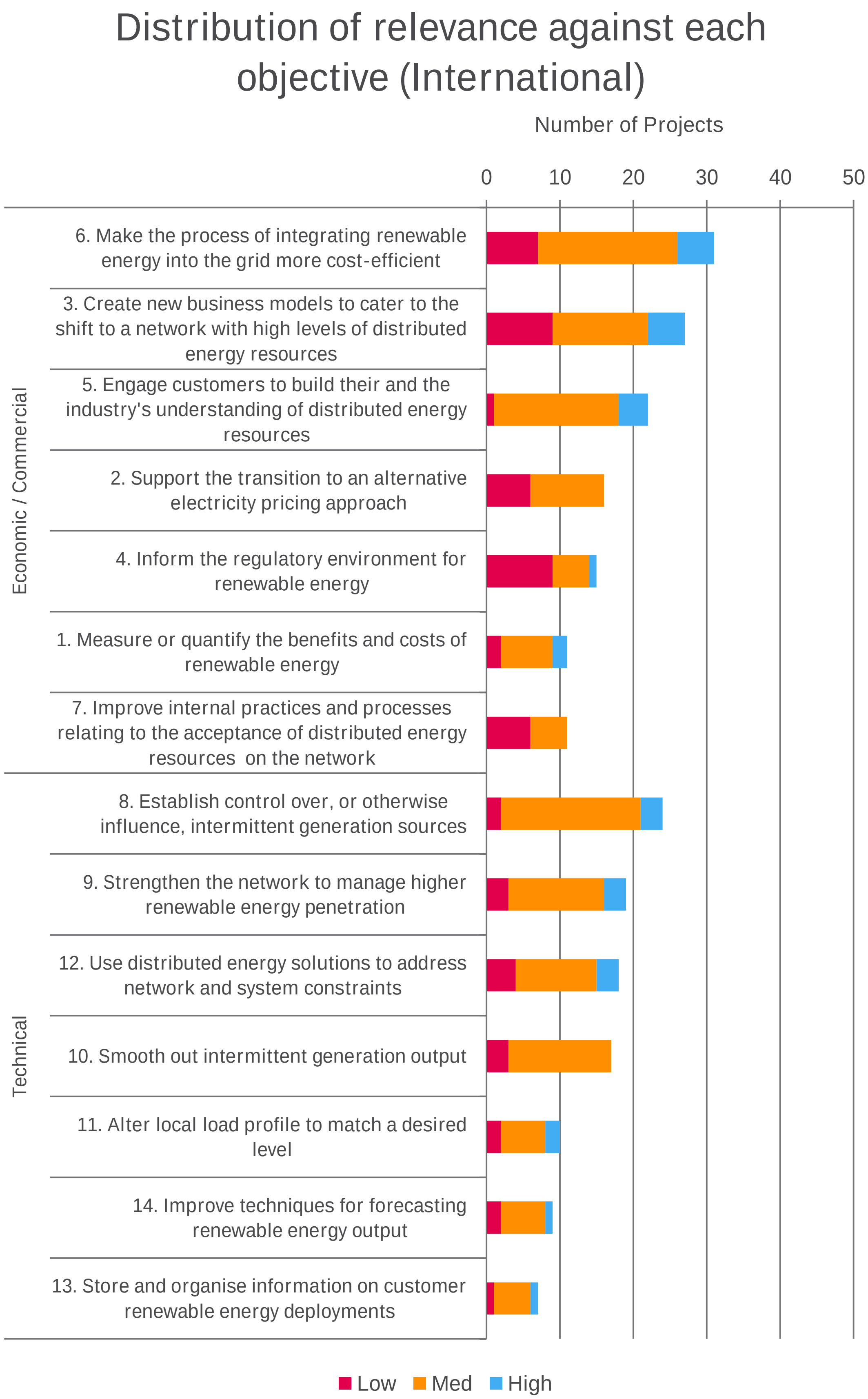


Figure 11: Distribution of relevance against each objective (International)

3.2 Approaches taken to address objectives

We turn now from examining what objectives our projects served (bearing in mind that these potential objectives were ours, rather than the project's), to an examination of *how* they achieved those objectives. We have analysed and categorised 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

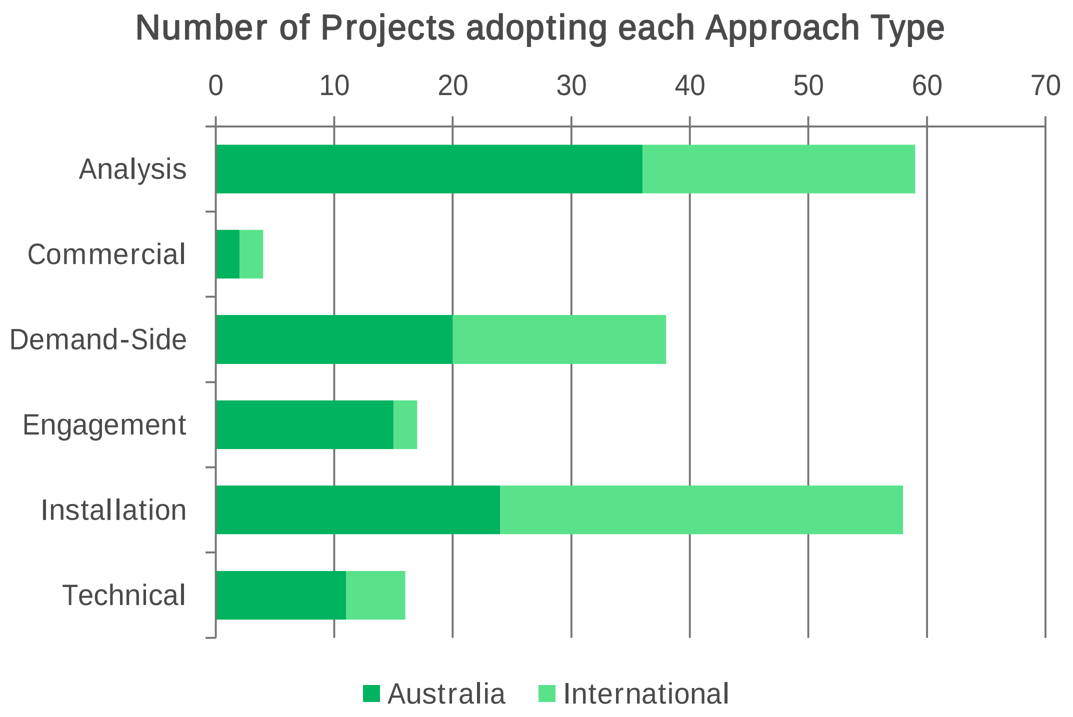


Figure 12: Number of Projects adopting each Approach Type

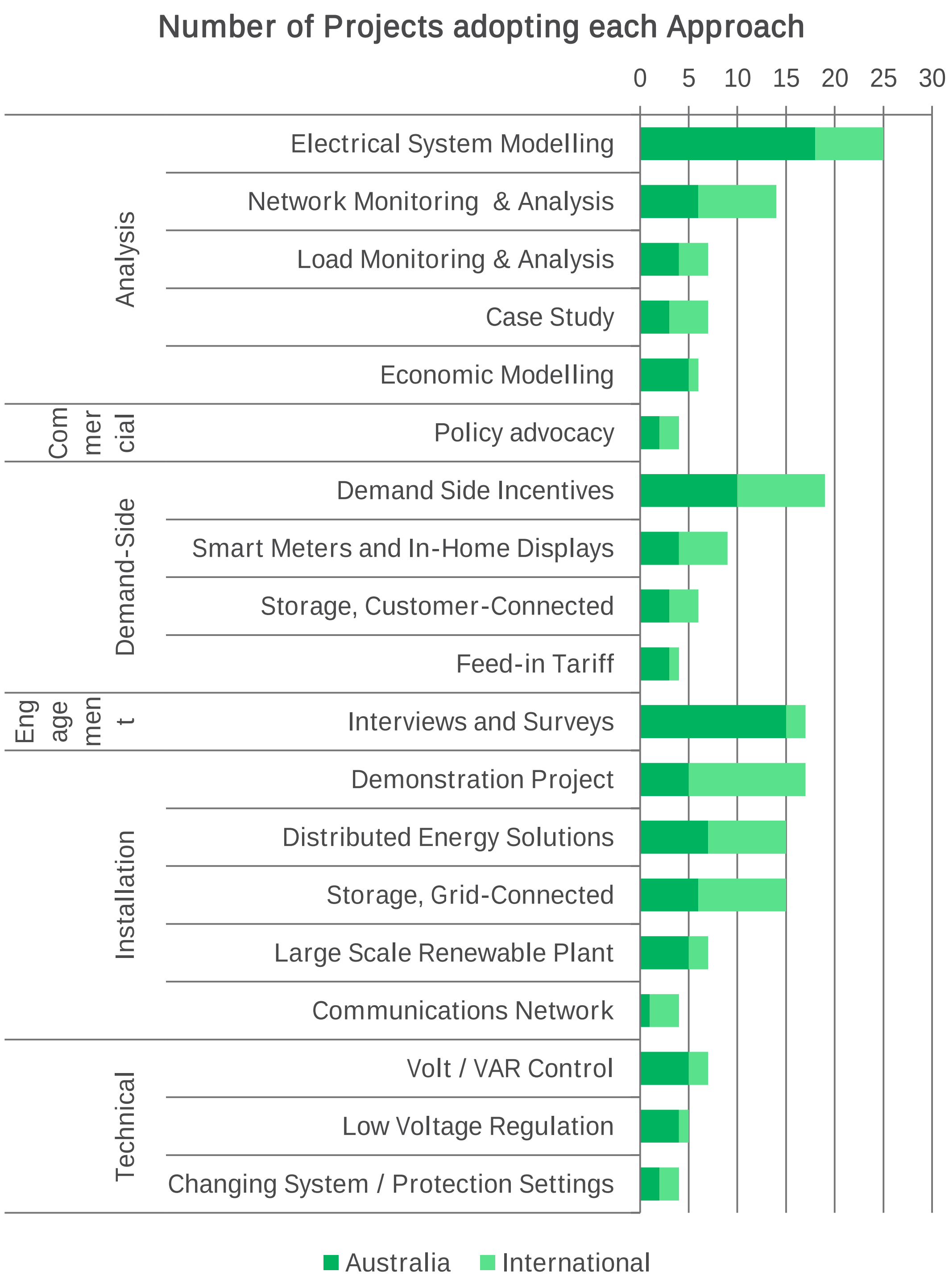


Figure 13: Number of Projects adopting each Approach

A subset of the most common approaches are shown in Figure 13 above. The most common overall 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.

A more enlightening picture emerges when we combine our analysis of the approaches that projects undertook, with the analysis of which objectives they addressed. The results can be seen in Figure 14.

	Analysis	Commercial	Demand-Side	Engagement	Installation	Technical
1. Measure or quantify the benefits and costs of renewable energy	0.61	0.07	0.14	0.13	0.27	0.07
2. Support the transition to an alternative electricity pricing approach	0.38	0.09	0.72	0.22	0.28	0.13
3. Create new business models to cater to the shift to a network with high levels of distributed energy resources	0.51	0.16	0.36	0.11	0.38	0.09
4. Inform the regulatory environment for renewable energy	0.67	0.09	0.35	0.26	0.33	0.09
5. Engage customers to build their and the industry's understanding of distributed energy resources	0.34	0.10	0.66	0.18	0.38	0.10
6. Make the process of integrating renewable energy into the grid more cost-efficient	0.55	0.06	0.22	0.09	0.49	0.20
7. Improve internal practices and processes relating to the acceptance of distributed energy resources on the network	0.56	0.21	0.21	0.15	0.21	0.21
8. Establish control over, or otherwise influence, intermittent generation sources	0.56	0.12	0.20	0.12	0.52	0.16
9. Strengthen the network to manage higher renewable energy penetration	0.68	0.05	0.15	0.12	0.44	0.46
10. Smooth out intermittent generation output	0.48	0.08	0.18	0.10	0.60	0.20
11. Alter local load profile to match a desired level	0.44	0.08	0.47	0.11	0.28	0.08
12. Use distributed energy solutions to address network and system constraints	0.48	0.08	0.24	0.12	0.42	0.26
13. Store and organise information on customer renewable energy deployments	0.35	0.00	0.30	0.25	0.20	0.05
14. Improve techniques for forecasting renewable energy output	0.97	0.03	0.07	0.10	0.31	0.17

Figure 14: Average Incidence of Approach Type for Projects Addressing each Objective[4]

Appendix 6.2 shows versions of this table that cover:

- Australian projects only
- International projects only
- Projects scoring HIGH only

[4] Note on interpretation: the cells in this table show the average number of times a project that addressed objective *x* also adopted approach *y*. Since projects can take multiple approaches of the same type, it is possible for these numbers to exceed 1 in some cases.

	Analysis	Commercial	Demand-Side	Engagement	Installation	Technical
Association	0.83	0.00	0.17	0.25	0.08	0.17
Government	0.48	0.11	0.41	0.11	0.48	0.18
Network	0.37	0.04	0.25	0.14	0.41	0.21
Other	0.67	0.08	0.17	0.00	0.17	0.25
Proponent	0.43	0.09	0.43	0.04	0.65	0.26
Research	0.73	0.05	0.10	0.22	0.24	0.22
Retailer	0.50	0.00	0.63	0.25	0.75	0.38

Figure 15: Average Incidence of Approach Type for Projects lead by each Organisation Type

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)

None of this is surprising; 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 254: FPDI: Review of Policies and Incentives by Clean Energy Council

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 seem to be well-served by these approaches. We note that

- "Informing the regulatory environment for renewable energy" is an objective that could also be well-served by Demand-Side and Engagement approaches, given that the regulator is the designated advocate for the customer, and that the process of regulatory reform pays close attention to evidence of customer wants and needs.
  - Example: Project 154: Reward Based Tariffs Trial by Ergon and Energex

    - Example: Project 319: BESOS Project by ETRA I+D

- "Measuring and quantifying the benefits and costs of renewable energy" could likewise be served well by more consultation with customers to ascertain the value they place on renewable energy solutions, rather than the purely analytic approaches which are mostly used to address this objective now.

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)

The first of these dot points is of interest, in that it indicates that utilities have tended to pursue efficiency gains through "building a better mousetrap" themselves, rather than relying on the market to provide solutions. In many cases this may be the most sensible approach to take.

- Example: Project 167: Isernia Smart Grid Project by Enel Distribuzione
- Example: Project 169: Orkney Island Smart Grid by Scottish & Southern Energy Power Distribution (SSEPD)

3.3 Results reported by Projects

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

We should note here that these results are self-reported: the remit of this stocktake did not include verifying the results of individual projects, and therefore we can't endorse them as findings of the stocktake.

The most common results are shown in Figure 16.

.

Figure 16: Number of Projects claiming each type of Result

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 shows 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

Encouragingly, however, the details of these projects reveal that this was not simply a case of "reinventing the wheel": the projects in our database under this category managed to resolve this problem in a variety of ways, under differing conditions. This may indicate that duplication was avoided via existing informal channels of knowledge exchange between industry players, and our own experience supports this view.

3.4 Limitations to Transferability

Our respondents were asked what limitations might hamper 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? Or did there exist limitations such as project results being dependent on a specific regulatory environment, funding situation, industry structure, or customer load?

As can be seen in Figure 17, almost half of the projects in our stocktake nominated some such limitations.

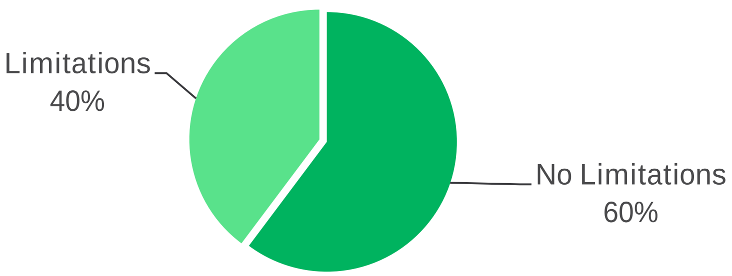


Figure 17: Existence of limitations to transferability

It is encouraging that 60% of respondents see no limitations to the application of their projects' learnings to other environments. Further, we have not tested the materiality of the limitations noted in the other 40% of the instances by observing whether a transfer is possible in practice; it seems quite possible with thoughtful consideration of their contexts and fine tuning their approach to be more generalizable, that lessons from those projects with identified transferability limitations may well be applicable in other environments.

Figure 18 gives more detail on what type of limitations the projects in our stocktake nominated.

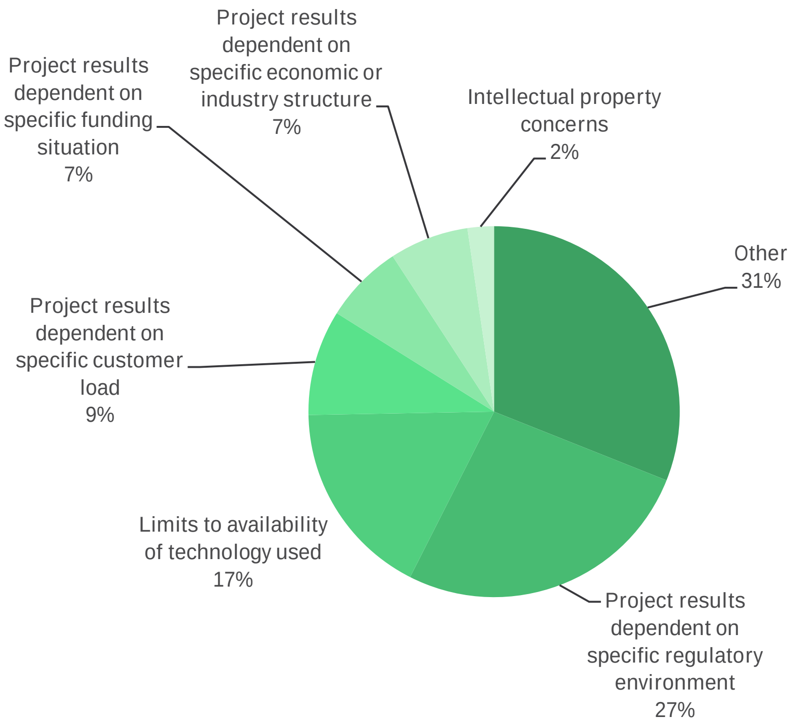


Figure 18: Most common limitations to transferability[5]

It is also possible that some respondents saw limitations as more important, or limiting, than they really were.

Once more, the picture becomes much more informative if we compare the existence of these limitations across different objectives, as in Figure 19.

[5] There is a large category of limitations under 'Other' here: this covers such limitations as community acceptance, data resolution, and shareholder risk appetite.

	Intellectual property concerns	Limits to availability of technology used	Project results dependent on specific customer load	Project results dependent on specific economic or industry structure	Project results dependent on specific funding situation	Project results dependent on specific regulatory environment	Other	**Total Incidence of Limitations per Project**
1. Measure or quantify the benefits and costs of renewable energy	0.02	0.11	0.07	0.07	0.05	0.13	0.32	0.77
2. Support the transition to an alternative electricity pricing approach	0.03	0.06	0.03	0.03	0.03	0.16	0.19	0.53
3. Create new business models to cater to the shift to a network with high levels of distributed energy	0.02	0.11	0.02	0.07	0.07	0.20	0.16	0.65
4. Inform the regulatory environment for renewable energy	0.00	0.07	0.02	0.07	0.07	0.16	0.14	0.53
5. Engage customers to build their and the industry's understanding of distributed energy resources	0.04	0.08	0.06	0.02	0.04	0.12	0.12	0.48
6. Make the process of integrating renewable energy into the grid more cost-efficient	0.01	0.10	0.06	0.04	0.04	0.14	0.16	0.57
7. Improve internal practices and processes relating to the acceptance of distributed energy resources on the network	0.03	0.12	0.12	0.06	0.06	0.29	0.24	0.91
8. Establish control over, or otherwise influence, intermittent generation sources	0.04	0.10	0.02	0.08	0.04	0.12	0.14	0.54
9. Strengthen the network to manage higher renewable energy penetration	0.03	0.15	0.05	0.03	0.05	0.10	0.19	0.61
10. Smooth out intermittent generation output	0.00	0.13	0.03	0.08	0.05	0.15	0.18	0.60
11. Alter local load profile to match a desired level	0.06	0.14	0.06	0.03	0.08	0.11	0.19	0.67
12. Use distributed energy solutions to address network and system constraints	0.04	0.06	0.02	0.06	0.02	0.10	0.16	0.46
13. Store and organise information on customer renewable energy deployments	0.00	0.15	0.00	0.00	0.05	0.15	0.05	0.40
14. Improve techniques for forecasting renewable energy output	0.00	0.17	0.00	0.03	0.07	0.03	0.21	0.52

Figure 19: Limitations to Transferability: by Objective[6]

We can see in Figure 19 that the most highly transferable lessons come from projects that address the objectives of:

- Engaging customers to build their and the industry's understanding of distributed energy resources (#5)
- Use distributed energy solutions to address network and system constraints (#12)
- Storing and organising information on customer renewable energy deployments (#13)

We can also see from Figure 19 that:

[6] Note on interpretation: the cells in this table show the average number of times a project that reported limitation *x* also adopted approach *y*. Since projects can take multiple approaches of the same type, it is possible for these numbers to exceed 1 in some cases.

- Intellectual property concerns seem largely immaterial, even when serving potentially sensitive objectives relating to pricing and business models (although, as noted in section 3.1, many truly commercially sensitive projects may not have been offered through the stocktake process)
- The variation in transferability between projects that serve each objective is largely due to one limitation: project results being dependent on a specific regulatory environment (either state or federal). This dependence is strongest for:
  - Creating new business models to cater to the shift to a network with high levels of distributed energy resources (#3)
  - Improving internal practices and processes relating to the acceptance of distributed energy resources on the network (#7)

The second of these points is surprising: why should the external, economic constraints of regulation affect the feasibility of implementing internal, cultural or process-based improvements? Reasons given by the projects in our stocktake included:

- the need for standardisation and coordination of policy
  - Example: Project 287: E-harbours Project by Municipality of Zaanstad
- The challenge [being] to articulate the capability of voltage control facilities and associated cost to the AER as a technically sound, cost effective solution that will facilitate the connection of PV
  - Example: Project 242: Volt VAR Strategy by Powercor & CitiPower
- Jurisdictions [needing] to offer a large-scale feed-in tariff for the schemes to be transferrable
  - Example: Project 257: ACT Large-scale Solar Feed-in Tariff Auction by Environment and Sustainable Development Directorate)

The least transferable lessons, according to our respondents, come from projects that address the objectives of:

- Measuring or quantifying the benefits and costs of renewable energy (#1)
- Improving internal practices and processes relating to the acceptance of distributed energy resources on the network (#7)
- Altering local load profile to match a desired level (#11)

The last of these is somewhat understandable: networks differ by customer demographics, load shape, feeder type, and many other characteristics: the approaches that solve a load problem in one context may not work in another. The first two seem to present a more surmountable problem: we see few reasons why an understanding of the benefits and costs of renewable energy should not transfer from one context to the next, or why better internal practices relating to renewable energy integration can't be widely learned from. We believe that lessons from those projects with identified transferability limitations may well in fact be applicable in other environments.

3.5 Future Plans

Finally, we have categorised and analysed the descriptions that each respondent gave us of their future plans for each project. Our 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 20 shows the breakdown between these categories of future plan.

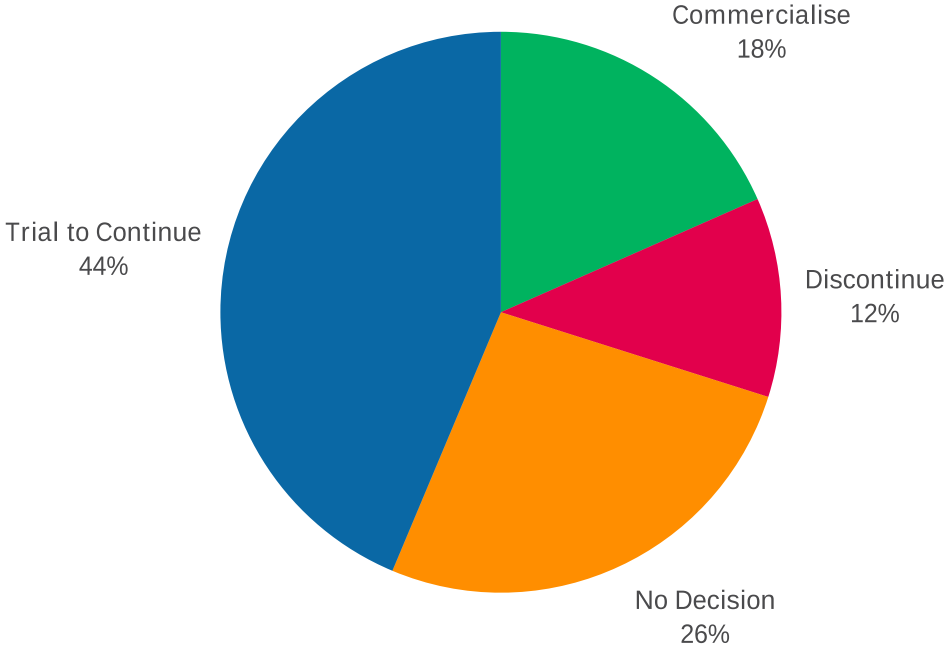


Figure 20: Percentage of Projects with each type of Future Plan

We can glean from this that the great majority of projects have not yet been conclusive enough to merit a decision to proceed commercially or else be discontinued: this is not very surprising, since most of the projects in our database were commenced in the last few years, and are still ongoing.

Figure 21 shows how the preponderance of plans varies by approach type. We can see that, encouragingly, much of the volume of discontinued projects falls 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 likewise unusual).

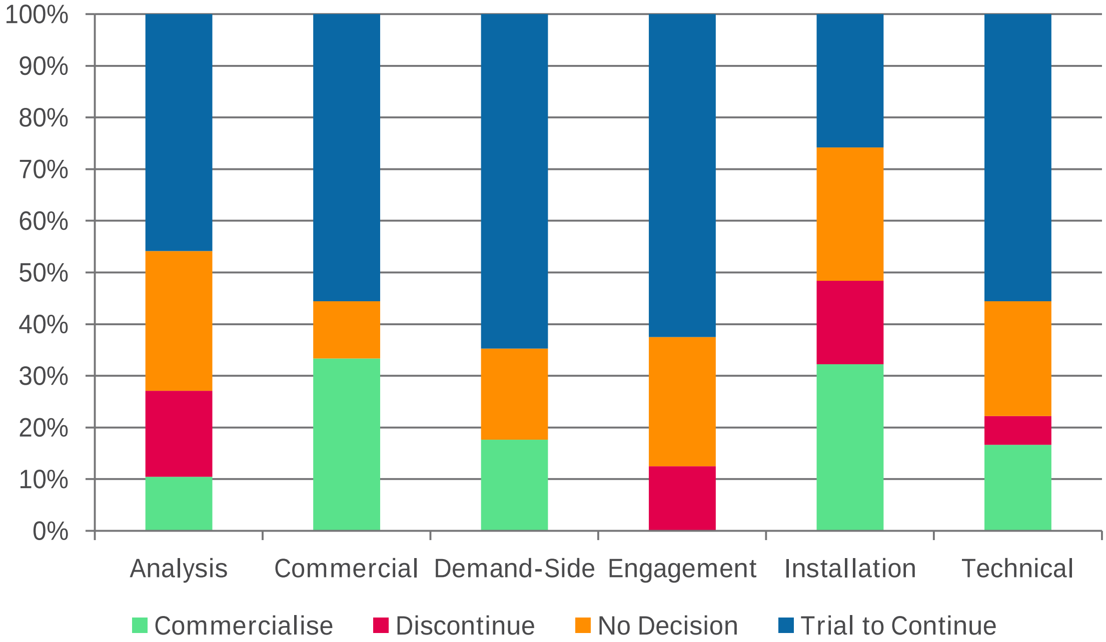


Figure 21: Percentage of Projects with each type of Future Plan, by Approach Type

3.6 ARENA-funded projects

Note: this section features only in the confidential report ("Report A")

4 Insights and Trends

4.1 Australian Trends

4.1.1 What Areas of Knowledge have been most thoroughly investigated?

4.1.1.1 Improving techniques for forecasting Renewable Energy output (#14)

These projects tend to be high-cost and require the involvement of specialists: although they are not commonly found, they tend to be thorough. Several comprehensive projects in our stocktake have merited a HIGH rating: we feel they present essential knowledge to the industry, which also happens to be highly transferable.

- 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
- Example: Project 114: Staged Development of an Interactive Australian PV Solar Mapping Resource by Australian PV Institute

Australia can share the fruits of research from overseas in this space.

However, we should draw a distinction between a few sub-specialties in forecasting:

- Short-term (minute-to-minute) forecasting knowledge is less advanced than long-term (day-to-day) forecasting knowledge
- Solar output forecasting is less well advanced than wind forecasting: for example, the Australian Solar Energy Forecasting System (ASEFS) is still quite basic.

4.1.1.2 Strengthening the network to cope with higher Renewable Energy penetration (#9)

This has been a frequent area of focus, with analytical (desk-based) work solidly backed up by field trials of new installations coupled with improved designs of network components. Much of this work has addressed voltage issues arising from distributed small-scale PV, and to a lesser extent network stability concerns (e.g. the ability of distributed generation to ride through network faults, or avoid islanding situations).

- Example: Project 186 Smart Grid, Smart City project by Ausgrid
- Example: Project 196: King Island Renewable Energy Integration Project (KIREIP) by Hydro Tasmania

However, most respondents reported some form of limitation to transferability on the results of their project, in large part technology-related: many of the projects in our stocktake relied on trial deployments that were not commercially widespread.

Nevertheless, we consider that the essential knowledge in this space has already been uncovered.

4.1.2 What Gaps in Knowledge exist?

4.1.2.1 Support the transition to an alternative electricity pricing approach (#2)

Few projects addressed or informed this objective, and those that did tended to have a low relevance score. We have seen some trials of time-of-use, critical peak and cost-reflective demand-based pricing, which are (usually) encouraging: customers are receptive to pricing reform, are willing to change their behaviour in ways that benefit the system, and inter-customer equity is improved.

- Example: Project 154: Reward Based Tariffs Trial by Ergon and Energex
- Example: Project 305: Modelling the impact of various tariff structures on distributed energy resource take-up and electricity pricing project by SA Power Network

However, there remains an unbridged gap between these results and a compelling push toward reform that could be acted on by a cohort of industry players, or implemented by a policymaker. Given the volume of work that's gone into Quantifying the Benefits and Costs of Renewable energy (#1) (see Figure 8 and Figure 9), this is probably not for lack of information; the problem is more likely to be that this information has not been acted on.

4.1.2.2 Inform the regulatory environment for Renewable Energy (#4)

There have been many projects which touch on this objective, but do so in a cursory or tangential way, usually producing information that may be of interest to a regulator, as a by-product of some other objective. They tend to do this largely through analytical or desk-based approaches.

- Example: Project 245: Future Grid Forum by CSIRO
- Example: Project 113: Impacts of PV, AC, and Other Technologies and Tariffs on Consumer Costs by Australian PV Institute

We have found little evidence of projects that expressly seek to assemble, empirically test and present a coherent alternative to the current regulatory arrangements – no projects in our database, that we are aware of, sought direct engagement with Australian regulators (the AER or the Western Australian ERA).[7]

[7] However, at least one project did engage with the AEMC (Project 188: The Impact Of Distributed Solar Generation On The Wholesale Electricity Market by Melbourne Energy Institute)

4.1.2.3 Improve internal practices and processes relating to the acceptance of Renewable Energy on the network (#7)

Few projects addressed or informed this objective. There is plenty of anecdotal evidence across the industry of the perceived need for Integrated Resource Planning, but the great preponderance of effort has been aimed at solving technical issues, and to a lesser extent customer-related and regulator-related ones.

With one exception, namely Ergon Energy (Project 290: Business Model Implementation Project), we have not found evidence that DNSPs have rigorously tackled the internal, cultural and organisational predispositions that have placed distributed energy solutions at a relative disadvantage to traditional network augmentation.

4.1.3 Likely future developments

4.1.3.1 Smarter and more Contestable Meters

Networks will soon no longer have a monopoly on metering services. The COAG Energy Council has also stated its view that current metering arrangements are inhibiting commercial investment in metering technologies (i.e. "smart", or AMI metering) that support the uptake of distributed energy resources.

Unlike the Victorian circumstance, we do not see the move to smart meters being a major program management task involving broad scale replacement of meter stock with AMI infrastructure. Rather, we see COAG's intent being that future meter upgrades should be customer-led, offered by retailers and third parties, and tied to innovative retail product offerings that consumers choose to adopt. The coming of this invigorated retail market will almost certainly include packages that make distributed energy solutions more integrated with the retail offering, and more consumer-friendly. A secondary driver for the replacement of accumulation meters with 'smart' meters could be locational, where a distribution network could potentially defer a network upgrade with the assistance of new tariffs. In this example, retailers may be engaged in managing the customer interaction and deploying those meters (although in fully contestable settings this would be logistically complex).

4.1.3.2 Embedded Metering and Microgrids

The push for demand response products and retail-exempted distributed energy sales arrangements (and even potentially a demand response market run through AEMO) will see further growth in the embedded metering market. These meters may not be registered as such but may nonetheless form a critical component of the demand response verification market opportunity.

In addition to that trend, it is clear that formal embedded networks or micro grids will emerge. Globally, this is seen as a large market opportunity measured in the billions of dollars in the years to come.

The most likely model for the emergence of embedded networks will be in new major industrial or commercial developments, and potentially for major residential developments, where the developer is seeking to secure larger and longer term revenue streams from that development. This may be augmented by a positioning to support a low carbon footprint for those communities.

4.1.3.3 RIT-D and non-network alternatives

The new RIT-D process also requires a more thorough assessment of non-network solutions (such as demand response, direct load control, embedded generation, energy and peak efficiency measures) as an alternative to capital augmentation for network investments greater than $5m.

The networks and their regulator are still learning how to negotiate in this framework, and properly assess non-network solutions. For now, we perceive that it has added some time and cost to the network planning and regulatory submission process, but not materially changed its outcomes.

The original intent of the RIT-D was a signal of a long-term regulatory trend away from network-related capex and opex, and toward distributed and demand-side solutions. The rules comprising the RIT-D will require some further modification, we believe, if it's to give effect to its aims of promoting non-network alternatives (including distributed renewable energy).

4.2 International Trends

By analysing the large number of international projects collected in this stocktake study, a general view is that the development of renewable integration and ICT[8] integration goes hand-in-hand. Although projects from different countries and regions are focusing on tackling their specific domestic or local renewable integration problems, a set of commonalities is observable, which includes:

- Encouraging more efficient and effective energy consumption via a two-way power information exchange.
  - Example: Project 165: MeRegio (Minimum Emission Region) by ENBW
- Providing high-quality energy products and various related services.
  - Example: Project 325: eTelligence Project by EWE AG
- Building an open system that allows for the easy incorporation and expansion of clean (green) technology including renewable energy, electric vehicles (EV) and other distributed energy resources.
  - Example: Project 180: Smart Grid Gotland by Vattenfall
- Creating new business model via cross-industry combination and convergence.

[8] Information And Communications Technology

- Example: Project 164: DERINT - Large scale virtual power plant integration by DONG Energy

4.2.1 Europe

The collection of European projects in the global stocktake shows a clear balance between the Commercial/Economic and Technical objectives, although the latter is somewhat more emphasized. In technical aspects, European projects focus primarily on establishing control over the intermittent distributed generation sources (59% of the projects). Utilization of distributed energy solutions to address network and system constraints (48% of the projects) and smoothing out intermittent generation output (41% of the projects) are becoming increasing important. This is well aligned with the European Union's ambitious targets to address climate change, energy security and economic competitiveness. By 2020 primary energy consumption must be cut by 20% across Europe and the share of renewable energy must be increased to 20%[9]. Without smart network management, the existing network will not be able to cope with a substantial increase in distributed and intermittent renewables. In some parts of Europe, this is already a reality.

It is important to note that despite the heavy research spending and investment on technology development and technical integration, making the process of integrating renewable energy into the grid more cost-efficient (62% of the projects) is an ultimate objective for most of the projects. However, quantifying the cost and benefit of the renewable integration and grid modernization is rarely addressed as a key objective (10% of the projects). Therefore, a holistic approach in evaluating commercial viability and economic benefit of the technical deployment is missing from the bigger picture.

Creating new business models to cater to the shift to distributed energy resources (55% of the projects) is another focused area, especially in Germany. Innovative concepts such as "Energy Marketplace", "Virtual Power Plant" and "Intelligent Load Manager" are created and experimented in various German projects.

4.2.1.1 Systematic integration of Renewables, ICT and Consumer Engagement/Citizen Participation

By looking at different EU projects, the core message is clear: the energy supply of the future is associated with the convergence of energy distribution and communication networks, and innovative solutions regarding ICT technologies and consumer engagement are essential to ensure the sustainable integration of renewables.

The leader in this area is Germany. It has been promoting the concept, "Internet of Energy" and the "Virtual Power Plant", through numerous national or EU funded projects, such as E-DeMa, eTelligence. As mentioned previously, ICT will assume the

[9] Note that this target is denominated on total *energy* consumption, not total *electricity* consumption. Assuming that non-renewable liquid fuels still form the majority of non-electric energy consumption, this implies that the proportion of electricity generated from renewable sources will have to be greater than 20%, in order to meet the overall target.

function of a key enabler for the technical restructuring of the German energy system. The convergence of ICT and energy technologies will make a strong contribution to the success of its national energy upgrade. The phrase "Internet of Energy" clearly describes the interconnection among the three spheres (Renewables, ICT and Consumer Engagement/Citizen Participation).

4.2.2 Asia

Similar to Europe, renewable integration development in Asia exhibits an equal emphasis between the Commercial/Economic objectives and the Technical ones. Establishing control over distributed generation sources is the top priority (45% of the projects). Cost-efficiency of renewable integration (22% of the projects) is equally important with a number of other objectives; the commercial focus on creating new business models (33% of the projects) is clearly evident, especially in South Korea.

Countries like China, Japan and South Korea all have different priorities based on their domestic energy situation.

Japan is dedicated in integrating solar PV, wind power and distributed energy into the grid and promoting the development of electric vehicles and micro-grids. The concept of "Community Energy Management" is a common theme as seen in various regional projects.

The Chinese government has included renewable and smart grid construction into its "National Science and Technology Development Plan". The goal is to meet the increasing energy demand while reducing the proportion of fossil-fuel generation, to lower its environmental impact. To achieve this goal, in China's 13th Five-Year Plan, attention is given to a wide range of key smart grid technologies areas such as large capacity and long distance transmission of wind power, ramping up of roof-top solar PV and its integration to the network, large-capacity energy storage, electric vehicles, intelligent deployment of distributed energy, and gradually modernizing China's power grid.

South Korea is more economically and commercially oriented. Through the construction of Jeju Island Smart Grid Test-Bed, the Korean government aims to develop its long-term energy independence goal through the integration of renewables and EV, reducing reliance on fossil fuel resource imports, creating employment opportunities, and encouraging the export of its renewable integration know-how, equipment and technologies to harness the export opportunity presented by renewable integration initiatives going on around the world.

4.2.3 Americas

It is extremely difficult to define generic trends and themes in the Americas.

South America has relatively few projects; further, the breadth of climatic and other environmental conditions within which the projects are implemented is so great that solutions are naturally diverse.

Regarding South America, there has been seen a good deal of influx of models and experience from Europe and elsewhere. We expect South America to display more of this trend in coming years as European and other utilities flow in to make up for their own business model weaknesses in their markets closer to home. Of course European models cannot be simply applied to South America but South America's trends, will, in our opinion to a significant extent reflect or run parallel to those elsewhere.

Project types are extremely varied in North America, and innovative (in part at least a function of the U.S.'s devolved and highly varied market structures and regulatory regimes). The use of IT and ICT has been ground-breaking in many instances, for example the utilisation of demand side effectively capability.

Comparing North America and Europe, it can be argued that Europe is focusing more on facilitating long term robust national and inter-state solutions for renewable integration, including the physical and IT/ ICT infrastructure, whereas the USA appears to be following a trend more focused on integrating renewables with minimal impact on network upgrade and operational costs. The consequence of this could be that the solutions in the USA are more appropriate in the shorter term, whereas the European solutions may be more costly but more capable in the longer term. Only time will tell.

4.2.4 Key Global Trends

4.2.4.1 Moving beyond Technology Integration to Convergence of Technology, Energy and Consumer Activation (Consumer Engagement)

The growth in electricity network modernization is driving an important change in the way utilities deploy smarter equipment and automation. Today, utilities' control centres are designed for a different set of assumptions about electricity generation and consumption. Power system environments are becoming more complex as new sources of generation are added into the distribution and transmission network.

This modernization is characterized by the continuous growth in operational technology (OT) deployment, the implementation of information technology (IT) to manage a utility's distribution network and, as a result, the integration of a utility's IT and OT networks is continuing to gain traction.

However, the path towards a new energy era is not limited to IT/OT integration. A bigger wave is about to arrive, which is the convergence of telecommunication, IT technology, energy network, and consumer engagement to integrate the fluctuating energy input from renewables, such as wind and solar power with stable and affordable energy services. The current electricity infrastructure is not designed to cope with the future increasing levels of electricity produced from fluctuating renewable energy sources. As a result a revised network infrastructure is required. Although the fundamental challenge remains the same, "the power must be available when energy consumers need it", the approach is becoming different.

In the new energy era, to ensure failure-free grid operation, the combined output of all power-generating sources should only equal the amount that consumers actually need. It is evident in numerous projects around the world that the increased integration of renewable energies requires the increased use of monitoring and control, and solar and wind forecasting systems at the network level: this will allow fine level balancing of supply to meet end consumer demand. To balance supply and demand, new approaches must be developed in order to store energy in the most cost-effective way and to adapt consumption to the availability of renewables.

The energy network of the future will have to deal with these challenges, with the focus on the necessary expansion of renewables, the integration of distributed energy resources, and the active participation of end consumers among other factors. The analysis has confirmed that information and communication technologies (ICT) are a significant enabler for this energy revolution. The increasing requirements for metering and regulating the generation, transmission, storage and consumption of electricity can only be met by means of intelligent convergence of ICT and energy systems, as demonstrated in projects across different continents, from Germany's E-Energy initiative to South Korea's Jeju Island Smart Grid Test-Bed. A great number of projects around the globe have been investing effort in this area, especially in EU and Japan.

4.2.4.2 Customer engagement and active participation

The expected revolution of electricity infrastructure presents huge challenges to the energy industry, technology development, policy making and society as a whole. Research confirms that consumers and communities cannot simply be viewed as passengers on the journey towards the energy supply of the future, but must be involved actively in these processes from an early stage.

In this way, it will be demonstrated how technology can help to reduce energy consumption without compromising the quality of services provided to the end consumer. The consumption characteristics will also change in the future as the international projects show. Electric mobility, heating / cooling pumps and other consumer appliances will create a new dynamic in the network and will be integrated into the smart grid. As the shift to renewable energy sources progresses around the world, it should be anticipated that distributed generation will be used increasingly to provide heating and power mobility.

The core message is that there are no major obstacles to the integration of distributed energy resources into the smart grids. However, if it is not possible to implement an integrated overall strategy in which energy, ICT and consumers' active participation are matched with each other, the energy revolution may be hindered.

4.2.4.3 Regulatory Flexibility

We see the evidence in our stocktake that international projects tend to more often include engagement with the regulator, and not to only to purely inform them: the regulator is often actively consulted about the project.

- Example: Project 162: NETFLEX – Network-enhanced flexibility
- Example: Project 174: Reforming the Energy Vision
- Example: Project 216: PNM Prosperity

Some regulatory mandates found overseas can be quite activist and progressive (e.g. OFGEM in the UK), as compared to Australia. However, this is not always the case. Flexibility and progressiveness in project design and execution varies greatly between each jurisdiction, between different authorities and over time.

These attributes are, however, helped by:

- **Clear time specific targets**. Europe for instance has the "20-20-20" targets[10] which are binding and mean that regardless of short term political change, the EU's climate and energy objectives have to be met.
- A sense of both **collaboration and competition** in European projects. The cross-fertilisation between different markets leads to a lot of variety in solutions.
- The **tendering process** for EU projects favours **originality**. Projects with a more innovative approach, even if the outcome is therefore more risky, are more likely to win funding.
- In the US, projects tend to be relatively more ROI driven. Where innovativeness and practicality via an iterative approach can lead to greater cost-effectiveness, they are likely to be chosen as the way forward.

4.3 Top Australian Projects

The projects in this section were selected on the basis of scoring the most highly against our stocktake's defined areas of relevance, in total.

4.3.1 Project 196: King Island Renewable Energy Integration Project (Hydro Tasmania)[11]

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

[10] A summary of these targets can be found at http://ec.europa.eu/clima/policies/package/index_en.htm

[11] This project was part funded by ARENA

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.

4.3.2 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.

4.3.3 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. 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.

4.3.4 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.

4.3.5 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.

4.4 Top International Projects

eTelligence

4.4.1 Project 325: The eTelligence Project (EWE AG)

The eTelligence project provides important tools for the future by intelligently linking the fields of telecommunication, IT and energy.

Germany's aim to obtain 50% of its energy from renewables by the year 2030 was already realized in Cuxhaven region in 2008, where the urgency to look for new solutions is already evident. EWE has set the course for the future with its eTelligence project in Cuxhaven by linking large and small-scale consumers and producers via ICT technologies into an intelligent system. The Cuxhaven model demonstrates how the regional balance between generation and consumption can contribute to security of supply and how ICT, in combination with existing energy structures can enable the optimisation of distributed energy supply. As a result, the foundations have been laid for the energy supply system of the future, by creating an efficient system that integrates distributed energy resources intelligently into the energy system.

It is worth noting that the eTelligence project addresses most of the renewable integration objectives defined in this stocktake, ranging from Commercial, Economic to Technical aspects, with a number of innovative concepts.

What makes it special?

The fundamental elements of the project include the Regional Marketplace, the Virtual Power Plant and the Intelligent Distribution Network.

The eTelligence Marketplace

The digital energy marketplace enabled small and medium-sized power-generating systems, as well as medium to large electricity consumers, to trade energy products in a fully automated way. Plant operators did not need any extra knowhow or extra time to participate in the electricity market and they were still able to achieve excellent prices when generation and consumption by the power plants, and renewable energy supply followed the requirements of the overall energy system. EWE TRADING also offered a link with the wholesale market to ensure sufficient liquidity on the marketplace. Some of the market participants included EWE NETZ GmbH, various cogeneration plants and a virtual power plant consisting of a PV system, a wind farm and two refrigerated warehouses.

Active Distribution Network

In order to understand the network behaviour, network measurement data (active and reactive power, voltages, currents, frequency) was collected from 100 substations in the distribution network, saved and exported on request. The data was recorded for the participation of the network in the regional marketplace. The installation of sensor and feedback technologies is the key in order to overcome infrastructural challenges related to the successful integration of renewable energy resources. It is an innovative approach which helps to avoid the expansion of the electricity network, helps to support the integration of renewable resources and offers a major economic advantage.

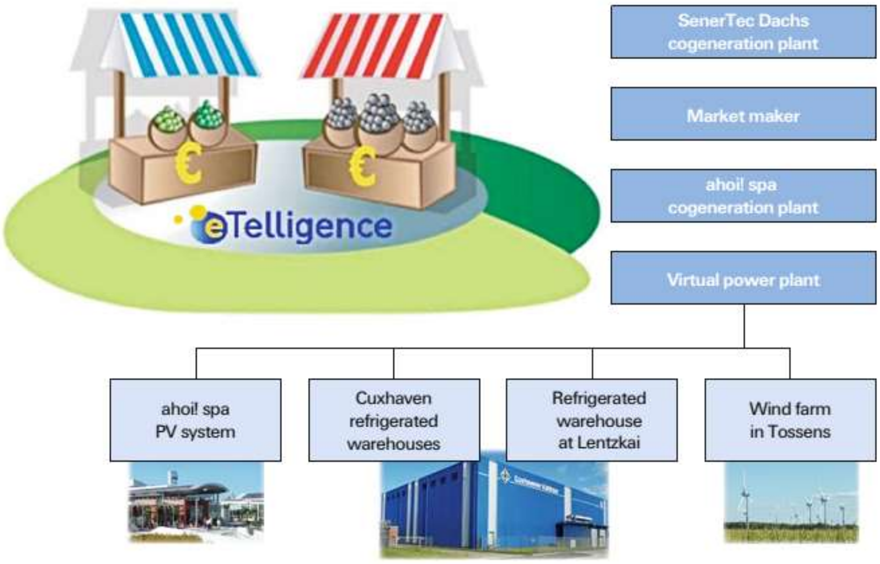


Figure 22. Participants in the eTelligence marketplace (eTelligence)

The savings and load shift potential of the energy consumers were also evaluated in 650 households. The most important instruments for this were customer specific tariff incentives and the use of intelligent metering technology (smart meters), as well as the feedback of electricity consumption in real time. On average, electricity consumption was reduced by 11% with the real-time visualisation, which leads to higher energy savings and lower CO2 emissions.

Jeju JEJU SMART GRID TEST-BED

4.4.2 Project 175: Jeju Island Smart Renewable Project (KEPKO, HYUNDAI Heavy industries, POSCO)

To achieve South Korea's national greenhouse gas emission reduction goal, establishing Low-Carbon Green Growth Infrastructure is an urgent task for the Korean energy industry.

To promote the use of renewable energy, distributed energies and electric vehicles, which cannot be accommodated with its existing network infrastructure, establishing a smart renewable system is the key in this project:

- South Korea needs to foster the smart grid industry as a new growth engine that surpasses semiconductors and IT products: they expect exponential growth in the world smart grid market.
- A great ripple effect in the economy is expected not only in the power and heavy electric industries but also in the related key industries of South Korea, including telecommunication, smart home appliances, construction, electric vehicles, and energy.

- South Korea aims to create more jobs in the highly value-added renewable energy industry, as well as creating various new business models.

What makes it special?

South Korea's renewable integration and technology development are the result of its national strategic planning. Commercial, economic, and environmental benefits are among the key drivers. The Korean government also seeks to create the synergy between renewable development and other key national industries that are already playing an important role in world market, especially the home appliance and automobile industries.

The Korean National Road Map committee, which is composed of approximately 130 experts from industry, academia, and R&D, collects expert opinions through interviews and workshops. It also holds hearings to solicit the opinions of experts and citizens who do not participate in the committee, with a view to developing a National Road Map for the smart grid and renewable integration to lead the low carbon green growth in Korea.

The Jeju Island project embodies the Korean government's long-term holistic vision. It is estimated that the establishment of the smart grid will not only solve Korea's future energy problems and improve the quality of life, but will also bring other benefits such creating new jobs, reducing greenhouse gas emissions, lowering dependence on energy imports, increasing exports, creating domestic consumption, and avoiding the need to build new power plants.

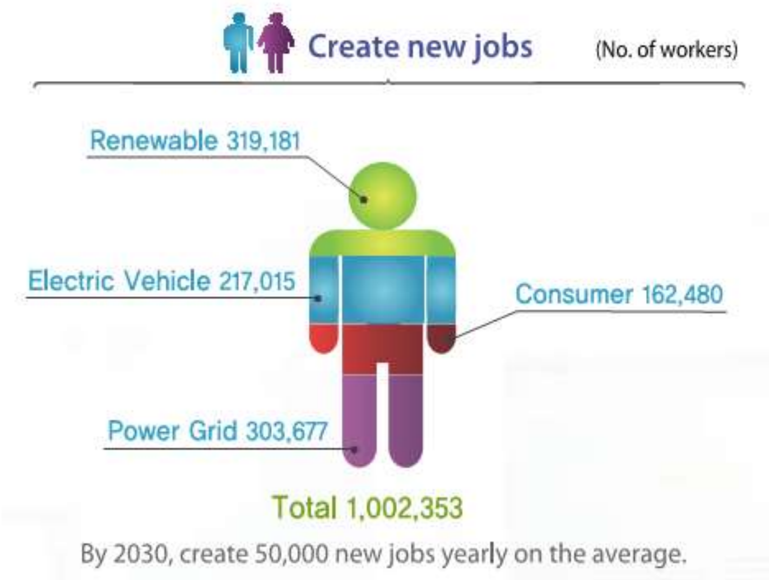


Figure 23. Estimated job creation of renewable and smart grid development in South Korea (KSGI)

Figure 24. Estimated export contribution from renewable and smart grid development in South Korea (KSGI)

4.4.3 Project 324: Renewables-based Fair Neighbor Comparison (Opower)

As a leading cloud-based software service provider for the utilities, Opower has built a business model around the analysis of metering data and other data sources. Its software provides utilities ways to communicate potential energy savings to customers and compare electricity use with that of peers. Communications channels include web portals, mobile applications and SMS but also paper-based "energy-use" reports that complement electricity bills.

Opower currently counts eight of the 10 biggest U.S. electric utilities as clients, reaching over 22 million utility customers worldwide. Their approach has saved 3.7 billion kWh overall and lowered carbon emissions by 2.6 million tonnes.

According to preliminary research, use of the data analysis software can achieve sustained systemic energy consumption reductions of around 3% across a utilities' network, which can be sufficient to avoid the need to further increase installed capacity for meeting peak demand (Allcott, 2009; Ayres et.al., 2009). Opower combines a cloud-based platform, big data, and behavioural science to provide its innovative customer engagement approach.

What makes it special?

One of the components found most engaging for energy consumers and prosumers is comparing their energy use with that of similar homes in their neighbourhood, so that they can see how their home is performing. Distributed self-generation through renewables presents an interesting element as well as challenge for this comparison, since it is unfair and not useful to compare the net usage of customers with self-generation to those without.

Opower's Renewables-based "Fair Neighbor Comparison" project is able to intelligently compare customers with self-generation to other customers with self-generation. The platform can also ensure that customers without renewables are compared to each other.

By ensuring more accurate neighbour comparisons, it helps educate customers about their energy more effectively by providing as much context as possible for evaluating usage. Therefore, it is an innovative approach by addressing renewable integration from the consumer and prosumer engagement side.

Figure 25. Opower's Compare, Save and Share portal (Opower)

4.4.4 Project 328: Smart City Búzios (Ampla Energia e Serviços)

Búzios was chosen as the first technology showcase of Enel Group in South America, because it has the necessary requirements to ensure a successful outcome to the project, including:

- It is a compact tourist centre, but with a good visibility abroad
- There are already automated facilities in the medium voltage network
- Solar energy and wind have a great development potential
- There are a significant number of people to experience the introduction of smart meters and active demand management.

Approximately 10,000 electronic meters are being installed, 2 electric stations trickle chargers, and 130 points of LED lighting, plus 48 KW distributed generation, 17 points of network automation, and intelligent buildings and other technologies, which will cover about 10,363 consumers in the residential, commercial and industrial sectors. The project has already been widely recognized by the media and scientific community as a relevant and high impact technological initiative. For example, recently the project was considered one of the 100 most important infrastructure initiatives in world cities by KPMG.

What makes it special?

Apart from being one of the top renewable integration and smart city initiatives in Brazil, the project is divided into blocks defined for the initiative. A broad range of stakeholders, such as the government, local society, new technology providers and academia, are engaged in research, development, dissemination and implementation of the project.

The project is aimed at developing knowledge to enable the interconnection of new generation sources to a highly automated and fully integrated network as a result of deploying a monitoring centre which facilitates the possibility of diagnosing problems and repairs that can be performed efficiently and rapidly due to investment in the distribution network.

The project is also established as a "living laboratory" for testing and evaluation of a technological concept, including renewable integration under smart city context, which is being done in Brazil.

4.4.5 NREL Projects

The National Renewable Energy Laboratory (NREL)'s projects feature in this stocktake:

- Project 230: High Penetration Photovoltaic Case Study Report
- Project 231: Photovoltaic Systems Interconnected onto Secondary Network Distribution Systems – Success Stories
- Project 232: Maximum Photovoltaic Penetration Levels on Typical Distribution Feeders
- Project 233: Deployment of High Resolution Real-Time Distribution Level Metering in Maui
- Project 234: Analysis of High-Penetration Levels of PV into the Distribution Grid in California (NREL/SCE High-Penetration PV Grid Integration Project)
- Project 235: An advanced platform for development and evaluation of grid interconnection systems using hardware-in-the-loop

They are designed and established to tackle a wide range of specific technical issues faced by the U.S. utilities when integrating renewables into the network. The researched technical areas include:

- Examining the technical problems arising from four large solar generation facilities
- Testing the interconnection of PV systems onto Secondary Network Distribution Systems without impairing the reliability of the networks in which they are interconnected

- Assessing a Grid Interconnection System Evaluator (GISE) that leverages hardware-in-the-loop (HIL) simulation techniques to rapidly evaluate the grid interconnection standard conformance of an ICS according to the procedures in IEEE Std 1547.1™
- Modelling the effects of various PV penetrations across the wide spectrum of U.S. distribution feeder architectures
  - Quantifying the impacts of interconnected PV systems on the distribution system

What makes them special?

NREL's projects focus on identifying creative answers to address the technical challenges of renewable energy integration. NREL's projects develop renewables and energy efficiency technologies and practices through highly disciplined science and engineering practices, aiming to transfer knowledge and innovations to address the renewable energy and environmental goals of the U.S.

The core concept that guides NREL projects' research efforts is "Energy Systems Integration", which is concentrated in the areas of network configuration, resource assessment and forecasting for renewable integration. Another major characteristic of NREL's renewable integration projects is the collaboration of a diverse set of stakeholders to design the projects and tackle the problems on a very large scale.

5 Recommendations

5.1 Recommended Priorities for Knowledge Sharing

5.1.1 Emerging Technologies

New forms of renewable energy generation technologies will become essential to define the future of this industry. In Australia, we have found a few projects focusing on such technologies as controllable energy storage, and owing to their importance to the sector we believe they would benefit from proactive efforts to share successful approaches between industry participants.

- Example: Project 54: Development of high temperature phase change storage systems and a test facility by the Barbara Hardy Instititute

5.1.2 Facilitated knowledge exchange forums between retailers, networks, and large energy users

Energy retailers (and large energy users who participate directly in the energy market, effectively as retailers to themselves) were notably reluctant to submit their work to this stocktake, and this is understandable given that their commercial imperative is to sell energy in volume, rather than experiment with technology.

However, just like networks, they will need to find an effective transition path toward the new decentralised model of energy, and transitioning to this new model will, in our view, require retailers and networks to act as allies. Both will need to

- develop aligned cost-reflective pricing plans that recognise the needs of both the energy market and energy networks at particular times and locations
- develop an aligned approach for pricing and selling demand management products and distributed energy solutions that recognise these same needs, and are attractive to customers
- develop a joint plan for optimally managing Storage / EVs, again for the ultimate benefit of customers

For this reason, we strongly believe that facilitated knowledge sharing between retailers and networks will be vital.

5.1.3 Uncommon but Easily Transferable Projects

Several Objective categories were found to be highly relevant to other entities, easily transferable, and under-represented (by volume) in our stocktake. These were

- Supporting the transition to an alternative electricity pricing approach (#2)
  - Example: Project 305: Modelling the impact of various tariff structures on distributed energy resource take-up and electricity pricing project by SA Power Network

- Storing and organise information on customer renewable energy deployments (#13)
  - Example: Project 270: Solar Resource Mapping for High Prospectivity Regions by Geoscience Australia
- Improving techniques for forecasting renewable energy output (#14)
  - Example: Project 263: Machine learning based forecasting of distributed solar energy production by The Australian National University
- Informing the regulatory environment for renewable energy (#4)
  - Example: Project 265: Planning Future Energy Grids: Renewables by QUT

Their reliance on quantifiable and context-independent data makes work in these areas perfect for knowledge sharing, and we recommend that this be targeted.

5.1.4 Overcoming perceived barriers to knowledge sharing on Cost-Benefit Analysis and Internal Practices

In section 3.4, we noted two Objective categories where participants nominated many barriers to transferability.

- Measuring or quantifying the benefits and costs of renewable energy (#1)
- Improving internal practices and processes relating to the acceptance of distributed energy resources on the network (#7)

However, we see few reasons why an understanding of the benefits and costs of renewable energy should not transfer from one context to the next, or why better internal practices relating to renewable energy integration can't be widely learned from. We believe that lessons from those projects with identified transferability limitations may well in fact be applicable in other environments.

We also believe that work in these areas may benefit from facilitated knowledge-sharing to test whether these barriers are real. These economic objectives are, it should be remembered, some of the most important when it comes to enabling greater uptake of renewables.

5.1.5 Industry Collaboration on Knowledge Gaps

Finally, we would suggest that any plan to promote knowledge sharing in the industry should consider the gaps in knowledge noted in section 4.1.2:

- Supporting the transition to an alternative electricity pricing approach (#2)
- Informing the regulatory environment for Renewable Energy (#4)
- Improving internal practices and processes relating to the acceptance of Renewable Energy on the network (#7)

Few projects addressed or informed these objectives thoroughly. Given the difficulty that has been encountered to date in designing projects to adequately address them, we believe that they may benefit from focused industry workshops to design joint or partnered approaches to these areas of work. Such an approach should, importantly, win credibility with the regulators and policy makers who will be critical in transitioning to new pricing approaches.

> Note: the recommendations above align most closely to Recommendation 19 from the recently released *Smart Grid, Smart City* national cost benefit assessment: *Industry peak bodies and Smart Grid Australia should consider the most effective ways to improve information sharing and knowledge transfer pertaining to smart grid technologies and their application in the Australian context.*

5.2 Projects that ARENA might sponsor

Note: this section features only in the confidential report ("Report A")

6 Appendices

6.1 How the stocktake was undertaken

6.1.1 Approach to Information Gathering

The following describes how MHC 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 our 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.

6.1.2 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.
- Undertake a relevance assessment for each project objective (see section 1.4.5)
- 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 our 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

6.1.3 Approach to sensitive information

Stakeholders were usually keen to share selected headline lessons from their renewable energy integration trials that were uncontroversial, put the business in a favourable light, and do not compromise their regulatory strategy. For this stocktake to be valuable, however, it will especially need to capture lessons from trials that are commercially sensitive, or unsuccessful. Stakeholders may be understandably reluctant to share this information.

In our experience, stakeholders *will* share commercial-in-confidence information, if they believe it will be used properly.

Our approach was be to:

1. Clearly present the purpose of the stocktake and the reasons we need this data in our 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 our 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 our 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 our synthesis of lessons and barriers of renewable energy integration.

6.2 Extra Analysis

Note on interpretation: the cells in these tables show the average number of times a project that addressed objective x also adopted approach y. Since projects can take multiple approaches of the same type, it is possible for these numbers to exceed 1 in some cases.

6.2.1 Approach Type by Objective Addressed: Australian Projects

	Analysis	Commercial	Demand-Side	Engagement	Installation	Technical
1. Measure or quantify the benefits and costs of renewable energy	0.70	0.09	0.09	0.15	0.17	0.07
2. Support the transition to an alternative electricity pricing approach	0.44	0.06	0.56	0.44	0.13	0.06
3. Create new business models to cater to the shift to a network with high levels of distributed energy resources	0.47	0.20	0.17	0.20	0.17	0.03
4. Inform the regulatory environment for renewable energy	0.79	0.04	0.29	0.36	0.18	0.11
5. Engage customers to build their and the industry's understanding of distributed energy resources	0.28	0.10	0.62	0.31	0.17	0.03
6. Make the process of integrating renewable energy into the grid more cost-efficient	0.64	0.08	0.08	0.15	0.28	0.10
7. Improve internal practices and processes relating to the acceptance of distributed energy resources on the network	0.55	0.23	0.18	0.18	0.09	0.05
8. Establish control over, or otherwise influence, intermittent generation sources	0.58	0.15	0.12	0.19	0.19	0.12
9. Strengthen the network to manage higher renewable energy penetration	0.78	0.05	0.08	0.18	0.18	0.43
10. Smooth out intermittent generation output	0.57	0.09	0.13	0.17	0.35	0.17
11. Alter local load profile to match a desired level	0.46	0.12	0.27	0.15	0.19	0.04
12. Use distributed energy solutions to address network and system constraints	0.44	0.09	0.22	0.16	0.22	0.22
13. Store and organise information on customer renewable energy deployments	0.46	0.00	0.08	0.31	0.08	0.08
14. Improve techniques for forecasting renewable energy output	1.15	0.05	0.00	0.10	0.15	0.00

6.2.2 Approach Type by Objective Addressed: International Projects

	Analysis	Commercial	Demand-Side	Engagement	Installation	Technical
1. Measure or quantify the benefits and costs of renewable energy	0.15	0.00	0.31	0.00	0.54	0.08
2. Support the transition to an alternative electricity pricing approach	0.28	0.11	0.78	0.00	0.39	0.17
3. Create new business models to cater to the shift to a network with high levels of distributed energy resources	0.48	0.10	0.52	0.00	0.55	0.14
4. Inform the regulatory environment for renewable energy	0.47	0.20	0.47	0.07	0.60	0.07
5. Engage customers to build their and the industry's understanding of distributed energy resources	0.41	0.09	0.68	0.00	0.64	0.18
6. Make the process of integrating renewable energy into the grid more cost-efficient	0.38	0.03	0.38	0.00	0.72	0.31
7. Improve internal practices and processes relating to the acceptance of distributed energy resources on the network	0.43	0.14	0.21	0.07	0.36	0.43
8. Establish control over, or otherwise influence, intermittent generation sources	0.50	0.08	0.27	0.04	0.81	0.19
9. Strengthen the network to manage higher renewable energy penetration	0.47	0.05	0.32	0.00	1.00	0.53
10. Smooth out intermittent generation output	0.33	0.06	0.22	0.00	0.89	0.22
11. Alter local load profile to match a desired level	0.40	0.00	1.00	0.00	0.50	0.20
12. Use distributed energy solutions to address network and system constraints	0.56	0.06	0.28	0.06	0.78	0.33
13. Store and organise information on customer renewable energy deployments	0.14	0.00	0.71	0.14	0.43	0.00
14. Improve techniques for forecasting renewable energy output	0.45	0.00	0.18	0.09	0.55	0.45

6.2.3 Approach Type by Objective Addressed: Projects Scoring HIGH

	Analysis	Commercial	Demand-Side	Engagement	Installation	Technical
1. Measure or quantify the benefits and costs of renewable energy	0.69	0.08	0.08	0.23	0.31	0.08
2. Support the transition to an alternative electricity pricing approach	1.00	0.00	0.00	0.00	0.00	0.00
3. Create new business models to cater to the shift to a network with high levels of distributed energy resources	0.45	0.09	0.18	0.09	0.73	0.27
4. Inform the regulatory environment for renewable energy	0.83	0.00	0.00	0.17	0.00	0.00
5. Engage customers to build their and the industry's understanding of distributed energy resources	0.21	0.07	1.07	0.29	0.50	0.07
6. Make the process of integrating renewable energy into the grid more cost-efficient	0.50	0.00	0.25	0.00	0.50	0.17
7. Improve internal practices and processes relating to the acceptance of distributed energy resources on the network	0.33	0.50	0.00	0.50	0.00	0.00
8. Establish control over, or otherwise influence, intermittent generation sources	0.83	0.00	0.17	0.00	0.83	0.33
9. Strengthen the network to manage higher renewable energy penetration	0.33	0.00	0.33	0.17	0.83	0.17
10. Smooth out intermittent generation output	2.00	0.00	0.00	0.50	0.00	0.00
11. Alter local load profile to match a desired level	0.86	0.00	0.29	0.00	0.43	0.29
12. Use distributed energy solutions to address network and system constraints	0.75	0.13	0.25	0.13	0.50	0.38
13. Store and organise information on customer renewable energy deployments	0.60	0.00	0.00	0.40	0.00	0.00
14. Improve techniques for forecasting renewable energy output	1.14	0.00	0.14	0.00	0.29	0.14

About MHC

Marchment Hill Consulting is a management consulting firm dedicated to serving the needs of the utilities, infrastructure, and transport sectors in Australia.

Our quarterly journal, QSI Online, shares our insights with the industries we serve and empowers businesses with high quality, content-rich and contemporary information relevant to their industry.

Read it at www.marchmenthill.com/qsi-online

Our Philosophy

The Marchment Hill philosophy, validated and reinforced by our work for clients around the world, holds that the value (V) of a consulting intervention rests on three cornerstones:

$$V = Q \times S \times I$$

Value of Engagement | *Quality of Insight* | *Support for Change* | *Implementation with Integrity*

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About VaasaETT

VaasaETT is a World leading Global Energy Think-Tank focusing on all issues relating to customer behaviour and psychology in energy and utilities markets, including loyalty & switching, pricing, smart energy demand (including also demand response & smart grid) and the broader issues of marketing, competition and market efficiency.

VaasaETT, through its massive breadth of expertise and collaborative business model, has become an internationally leading source of a wide variety of specialist expertise, for instance VaasaETT is: the World's leading source of data for global utility customer switching trends and dynamics; Europe's best source of retail energy price data and analysis; arguably the world's best source of benchmark information on effective demand response and smart grid programmes; and a founding member of the Smart Energy Demand Coalition (SEDC). We collaborate with an enormous network of thousands of experts and specialists in six continents whom we collect data from, work with and disseminate publicisable data and reports to.

VaasaETT provides three categories of services to its network and clients: Research and Consulting; Data and Analysis; and Collaboration (networking, associations and events).

What makes us unique, apart from our world-class expertise and collaborative business model, is our intense specialisation, our experience & track record, our commitment to independence and our unrivaled collection of global data which is soon to be available to our our network through our exciting new online EnergyDataStore.

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