COAG
Energy Council
Senior Committee
of Officials

Mr John Pierce
Chairman
Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

Dear Mr Pierce

The COAG Energy Council has agreed to submit a rule change request to you about establishing a register of distributed energy resources (DER).

AEMO's January 2017 *Visibility of Distributed Energy Resources in the National Electricity Market* report noted gaps in the collection of DER data under current mechanisms. A DER register also supports a Finkel Review recommendation to develop a data collection framework for all forms of DER to support system management. A cost-benefit analysis commissioned by the Energy Council found there would be a net benefit from establishing a DER register.

The proposed approach focuses on placing an obligation on AEMO to establish a register and collect information from DNSPs. This in turn places an obligation on DNSPs to collect this information and share it with AEMO.

The rule change request and a copy of the cost-benefit analysis prepared for the Energy Council are attached for your consideration.

Sincerely

Mr Rob Heferen
COAG Energy Council Senior Committee of Officials

5 October 2017

RULE CHANGE REQUEST TO ESTABLISH A REGISTER OF DISTRIBUTED ENERGY RESOURCES

1. Name and address of rule change proponent

COAG Energy Council
Energy Council Secretariat
Department of the Environment and Energy
GPO Box 787
CANBERRA ACT 2601

2. Description of the proposed rule change

The proposed rule change seeks to improve the collection and sharing of information about small-scale[1] behind-the-meter (BTM) distributed energy resources (DER) in the National Electricity Market (NEM). The proposal seeks to achieve this by:

- requiring the Australian Energy Market Operator (AEMO) to administer a register of DER
- establishing principles in the National Electricity Rules (NER) to determine the types and capacity of DER that should be included in the register
- allowing AEMO to develop guidelines, in consultation with stakeholders, to specify the types of DER that meet the principles and the data that should be collected
- allowing AEMO to share information in the register with appropriate parties, subject to privacy laws. This would primarily include certain Registered Participants, but may extend to certain non-Registered Participants (i.e. emergency services). Some provisions for sharing data already exist in the National Electricity Law and Rules, but additional provisions may be needed, particularly for sharing data with non-Registered Participants
- requiring distribution network service providers (DNSPs) to collect information about DER connected to their network, and provide this information to AEMO.
- if necessary, amending the Rules around connection agreements and customer obligations to their DNSP, to clarify the situations when customers and their agents need to inform their DNSP about changes at their sites, including DER installations.

The primary objectives of a register are to improve power system and network security and operation, through the provision of better information on BTM DER. At first, this will be most relevant to small-scale batteries installed at the premises of small retail customers such as households and small businesses. However, a register will need to evolve to include other technologies over time. Most notably, this could involve the collection of information about small-scale photovoltaic (PV) systems. This information is currently captured under the Small-

[1] AEMO currently exempts generators of 5MW and less, including batteries, from registration. However, this Rule change proposal uses the term 'small-scale batteries' in order to capture a range of DER under this 5 MW threshold but leaves it open for the AEMC and AEMO to consider how the size range of BTM DER to be captured by a separate register should be determined.

scale Renewable Energy Scheme (SRES) but incentives to participate in this scheme will decline over time and end in 2030.

Secondary objectives of a register include:

- helping protect the safety of consumers, workers and first responders in the event of emergencies involving DER affected by fire, floods or other extreme conditions

- improving policy and market outcomes by providing access to aggregated information on DER to certain Registered Participants and non-Registered Participants (for example policy makers, and energy industry participants) in accordance with the Australian Privacy Principles and the NEL.[2]

The type of information envisaged to be collected could include a DER system's location, installation and decommissioning data, the system's capacity and technical characteristics (such as manufacturer, make, model number and inverter settings such as frequency and voltage trip settings). Other information about contractual arrangements regarding how a DER participates in the NEM would already be covered under a separate framework, as outlined in the Demand Side Participation Guidelines. Any personal information collected would be handled in accordance with privacy laws.

Some of this information is already collected by DNSPs (through network connection notices), but not all and not in every instance. Nor is it collected on a co-ordinated basis. Other information (in particular, in relation to PV systems) is collected by the Clean Energy Regulator (CER), but this is expected to decline over time as incentives decline under the SRES. Further, the Demand Side Participation (DSP) Guidelines also collect details on demand side participation from registered participants in the National Electricity Market (NEM). Collectively these processes do not gather the necessary suite of information required. The DER Register will fill in these information gaps that are not accessible under the current rules and will work in association with the CER and DSP Guideline processes to minimise duplication.

The COAG Energy Council (Council) requests that the Australian Energy Market Commission (AEMC) make necessary changes to the relevant provisions of the National Electricity Rules (NER) and the National Energy Retail Rules (NERR) to achieve these goals. The Council does not propose specific rule changes. Instead, the Council highlights a range of issues within the rules which may require changes, and proposes a range of potential solutions.

3. Subject matter is within AEMC's powers

The rule change request seeks to create obligations on AEMO to administer a register of DER, and DNSPs to collect information about DER and share it with AEMO. This will provide benefits including improved operation and efficiency of the electricity market.

This falls within AEMC's rule making powers. Section 34(1) of the NEL empowers the AEMC to make rules to regulate the operation of the national electricity system for the purposes of the

[2] This may be achievable under existing provisions in the NEL (possibly under section 54FA).

safety, security and reliability of that system ((a)(ii)) and the provision of connection services to retail customers ((a)(iv)).

Section 34(3) allows the AEMC to confer functions or powers on, or leave any matter or thing to be decided or determined by AEMO, including (c) conferring rights or imposing obligations on any person or a class of person (other than the AER, the AEMC or a jurisdictional regulator).

Schedule 1 to the NEL further elaborates on the specific subject matter for the rules. This covers procedures and related systems for the electronic exchange or transfer of information that relates to consumers of electricity, the provision of metering services and connection to the national electricity system, and requiring compliance with such procedures and use of such related systems (clause 32).

Schedule 1 also covers the establishment and maintenance of databases of information relevant to planning the development of the national grid and the provision of public access to the database (clause 30I). This is particularly relevant as the purpose of this Rule change proposal is to support the establishment and maintenance of a database or register on DER, to support operations and planning and development in the NEM, and to establish a framework for public access to this data.

In order to support obligations on DNSPs to collect information on DER and share this with AEMO, the customers who are the owners of DER systems (or their agent) should also be obliged to provide this information to their local DNSP. Relevant rule-making powers exist under the National Energy Retail Law (NERL). Section 237(1) of the NERL empowers the AEMC to make Rules with respect to regulating the provision of energy services to customers, including customer retail services and customer connection services.

Other measures may need to be used to support compliance with these obligations. These measures may include the raising of awareness by industry and updates to electrician and installer training units of competency. However, these issues fall outside the rule making powers of the AEMC and will need to be considered separately in related work streams being considered by governments.

4. Background to the rule change request

<u>Changes in technology and market conditions</u>

Small-scale batteries are being installed in homes and businesses now, and deployments are expected to accelerate as costs fall. Bloomberg New Energy Finance (BNEF) projects that 100 000 batteries could be installed by 2020, and one million by 2030. By 2040, 4.9 million BTM PV systems could be installed, with 2.7 million of them combined with storage.[3]

[3] Bloomberg New Energy Finance, February 2017.

As AEMO outlined in its *Visibility of Distributed Energy Resources in the NEM* report, these systems have the ability to change load profiles and provide opportunities to manage the power system in new ways to increase reliability and security. However, in aggregate, DER could have a material and unpredictable impact on the power system unless information about deployments is available.[4]

The report noted a number of issues that could result from a lack of visibility of large amounts of BTM DER. The report noted this would progressively hinder AEMO's ability to:

- Quantify how the power system is likely to behave and manage operations within the boundaries of the technical envelope.
- Manage the power system with the usual operational levers, because DER is managed by consumers or their agents.
- Develop, calibrate and validate its modelling, meaning AEMO needs to assume how future trends will deviate from past trends.
- Predict variability in load due to DER, increasing regulation frequency control ancillary services (FCAS) requirements and costs.
- Predict load and its response to disturbances as accurately as in the past.
- Have certainty in the effectiveness of emergency control schemes to manage power system frequency, for example if DER affected the volume of load available to be shed.[5]

AEMO noted a number of technical methods for collecting data on DER, such as using smart meter data to infer the presence of DER, and specifying data requirements in Australian Standards for devices interfaced with the network (such as AS 4777 for inverters). The report noted, however that Australian Standards can take a long time to develop and/or revise[6], so this is likely to be a longer term solution.

The report noted that using smart meter data would not be as effective as upfront direct data collection.[7] Even if appropriate metering was installed, AEMO would only see the net demand from the consumer, and not have any understanding of how DER devices are operating.[8]

The report also noted that while the CER currently collects information about installations of solar PV BTM data via an incentive under the SRES, the data collected is limited in that:

- the data collected is basic and does not meet all the technical needs of AEMO;

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[4] http://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf

[5] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf page 1

[6] Ibid.

[7] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf page 22

[8] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf page 20

- only installations that meet the criteria for a small-scale energy certificate (STC) are captured through the scheme, which excludes batteries;
- solar PV upgrades or retrofits are not captured by this system, and;
- the financial incentive for systems to register with the scheme winds back further each year, and will cease altogether by 2030.

While DNSPs currently collect some data on BTM DER via connection agreements, there is currently no obligation under the NER for DNSPs to collect and share specific technical data about DER systems required for the purposes of system security.

While information about DER can be visible to DNSPs through its connection to the network, currently any data collected by DNSPs is based on DNSP needs at the distribution level, not the needs at the transmission level at which AEMO operates. DNSPs vary as to the level and type of data collected on DER, and how it is stored and used, creating inconsistencies across the NEM.[9]

Overall, AEMO noted that under the current mechanisms, there are clear gaps in the collection of BTM DER data, and a lack of nationally consistent requirements on DNSPs in terms of what information they collect and store via connection agreements. The lack of visibility of DER, and the legacy issues created by frameworks not being established prior to market uptake of new technologies, are important for both day-to-day system operation and future planning.

AEMO argued for a national framework for technology-agnostic DER data collection, management and accessibility to be established as soon as possible.[10]

COAG Energy Council National Battery Storage Register Consultation Process and Cost-benefit Analysis

At its December 2015 meeting, the Council endorsed a work program to ensure a successful transition of the electricity market. This aims to ensure regulatory frameworks are fit for purpose to cope with the effects of emerging technologies, such as batteries, as well as to enable consumers to benefit from innovative services while mitigating any risks. Part of this work program was to launch a consultation process on the merits of a national battery storage register.

In August 2016, the Council began a consultation process on the merits of establishing a national register of small-scale battery storage systems. Stakeholders were generally supportive of a register, however, some competitive sector stakeholders held concerns about

[9] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf page 21
[10] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf page 23

potential added costs for industry. At the 14 December 2016 Council meeting, Ministers agreed in principle to develop a national battery storage register subject to a cost-benefit analysis (CBA). In March 2017, the Council's Energy Market Transformation Project Team commissioned the consultants Jacobs to develop a CBA of the proposed register. This analysis compared a register hosted by AEMO or the CER with a 'business-as-usual' base case scenario. A draft CBA report was released for public consultation in May 2017, and the Council endorsed the final report for public release in July 2017.

The results of the CBA are discussed in detail in the Explanation of Benefits and Costs in Section 7, and a copy of the final CBA report is provided at Attachment A. As a result of the 28 September 2016 'black system event' that occurred in South Australia, the Council held an extraordinary meeting on 7 October 2016. At this meeting, the Council agreed to commission the Chief Scientist, Dr Alan Finkel AO, to lead an independent review into the current state of the security and reliability of the NEM. COAG leaders welcomed the public release of Dr Finkel's report on 9 June 2017, and agreed to implement t49 of the 50 recommendations agreed by the Council at its meeting of 14 July 2017. One of these recommendations was for improved information on all forms of DER. Ministers agreed to initiate the development of a national register for DER (including solar generation and batteries), acknowledging the first step would be the drafting of a Rule change proposal.

5. Statement of issues

As installations of BTM batteries and other DERs are set to increase greatly in the coming years, system management challenges and safety risks could also increase if information gaps about these installations are not addressed.

Jacobs, in its June 2017 CBA, identified three main problems if current information gaps relating to small-scale batteries were to continue:

- Overstated or understated demand forecasts ignoring impact of BTM battery storage may lead to **inefficient market and network investment**, which can result in higher prices for consumers.
- Market operators and distributors may not be able to develop reasonable estimates of short-term demand, making system control more difficult and expensive, **leading to inefficient market and network operation**.
- **Safety risks to workers, installers and the general public,** through emergency services and line workers or electricians not having adequate information to respond effectively to emergency events on a site with a battery or other DER, such as fire, floods or other extreme conditions.

DNSP and AEMO information gaps on DER

The biggest barrier to data collection for a register is the limited recording of small-scale DER, including batteries, under the current Rules. Some information is captured through DNSP connection processes (NER Chapter 5A) and voluntary reporting to the CER, but this is not comprehensive.[11] The connection notice data, as collected by networks, enables them to obtain information about inverters at a minimum (and in some cases PV and storage), but might not cover all situations where a battery or other forms of DER are installed.

In Jacobs' consultations, the DNSP, Energy Queensland (formerly Energex and Ergon Energy), estimated that only 30% of battery systems in their networks are being detected through the existing process. Jacobs noted that this value can range from 5% to 50% between DNSPs and within the network of individual DNSPs. The Jacobs' report noted that information about these installations might not be collected because of:

- Installations undertaken by non-electricians (<2.5 kW)[12]
- Installations of batteries pairing with existing solar PV systems where no new inverter or meter is needed
- Installation of batteries in instances where electricians don't view these as a form of generation.[13]

In addition to the critical information gaps that currently exist for BTM energy storage devices, information collected on solar PV systems is expected to become less comprehensive over time as incentives from the Small-scale Renewable Energy Target (SRET)[14] are reduced.

Currently, each DNSP has a process to connect embedded generation to its network. Under the framework of Chapter 5A of the NER, electricians or installers, on behalf of customers, are required to fill in network connection notices in order to carry out these connection services.[15] These notices are completed if the installer/electrician (or household) requires a service from the network, such as a new meter or repositioning of a meter, or permission to connect a DER.

However, as DNSPs have reported, connection notices are being completed at a low rate, or many connections of DER are not being picked up through this process. Despite the

[11] Jacobs, Battery Storage Register Cost-benefit Analysis report, June 2017, http://www.coagenergycouncil.gov.au/publications/%E2%80%A2-energy-market-transformation-bulletin-no-04-%E2%80%93-national-battery-storage-register

[12] According to the Jacobs' report, South Australia advised that the *Plumbers, Gasfitters and Electricians Act 1995* (SA) contains a definition of 'electrical installation' that may allow non-licensed electricians to install batteries.

[13] Jacobs, June 2017, http://www.coagenergycouncil.gov.au/publications/%E2%80%A2-energy-market-transformation-bulletin-no-04-%E2%80%93-national-battery-storage-register page 20

[14] The SRET provides an incentive for consumers to have their PV systems registered by a Clean Energy Council (CEC) accredited electrician in the CER database by making the value of Small-scale Trading Certificates (STCs) available to offset the cost of systems. At present the deemed life of a PV system under the SRET is 14 years and this value will reduce by 1 year in each of the next 13 years to 2030. With STCs valued at around $40 per MWh and a capacity factor of around 15%, this means that consumers purchasing a 3kW PV system would receive STC value of around $1,473 now, reducing to $631 in 2025 and $421 in 2027 and diminishing to around $105 in 2030. If incentives need to be above a given threshold (which may be different for each consumer), the database maintained by the CER is likely to begin to lose relevance from around 2024. (Jacobs, National Battery Storage Register Cost-benefit analysis, June 2017)

[15] These processes differ across jurisdictions.

requirements of Chapter 5A of the NER, the data is not getting through to the DNSPs on a consistent and reliable basis.

Stakeholder feedback gathered by Jacobs through the CBA consultation process suggested that different stakeholders may require different types of information.

AEMO, for example, outlined that they may need the following types of information to be collected in a register:

- NMI identifier;
- Address (as verification check on NMI);
- Postcode;
- Capacity (continuous kW, and storage kWh and (kVA of inverter) and short-term peak output (if applicable);
- Demand response modes;
- Trip settings
- Power quality response modes;
- Power factor(pf)/Voltage-ampere-reactive (VAR) range;
- Installation date;
- Decommissioning date;
- Manufacturer, make and model number.

DNSPs have indicated that they would find location data, trip settings, capacity and peak output, power factor, power quality and demand response modes most useful for network operation and planning.

If access to register data is to be extended to certain non-Registered Participants such as emergency service providers, location and battery type may be the most important fields in responding to emergencies involving a DER in order to identify, for example, any hazardous chemicals to adjust their response accordingly.

More aggregated information relating to location, DER type and capacity could support market and policy development (e.g. other market participants, some energy service businesses, policy makers, researchers) to support the development of services that improve market and operational efficiency.

Specifying data requirements will require a balancing of costs and benefits to ensure the data collected provides value relative to the compliance costs that are imposed. This information may also change over time, so any data collection framework would need to be flexible and be able to be updated as required. Developing these data requirements will therefore require consultation with industry, to ensure the data collected and DER systems included in the register are fit for purpose and obligations on parties are appropriate.

More information on the benefits for different parties using the above types of data can be found in section 7: Explanation of expected benefits and costs.

Collection, sharing and access of data by AEMO and other parties

Another aspect of the register is to consider how the data is collected and shared to support more efficient system operation, and deliver benefits to consumers.

Access needs of a register will vary. As discussed in the previous section, some parties may need access to site specific information (e.g. AEMO, networks, emergency service providers) while others could have access to more aggregated information (e.g. other market participants, policy makers, researchers) which can support market and policy development.

This rule change will need to consider whether access and usage rights to information in the DER register need to be defined within the rules, or whether existing frameworks are sufficient in managing these issues.

There are existing provisions in the NEL that regulate AEMO's use and disclosure of 'protected information', that is, information given to AEMO in confidence or in connection with the performance of its statutory functions and classified under the NER or Regulations as confidential information.

Subsection 54(1) of the NEL provides that AEMO must take all reasonable measures to protect protected information from unauthorised use or disclosure. Unauthorised use or disclosure means use/disclosure that is contrary to, or not authorised under, the NEL, NER or Regulations: section 54(2) and (3). Accordingly, if the NER authorises particular uses or disclosures of information on the register, then it should follow that use/disclosure in accordance with those rules is not unauthorised or contrary to section 54.

Section 54FA authorises AEMO to disclose information in aggregated form given to it in confidence. This would allow for disclosure of data to bodies such as to policy-makers, researchers, consultants and other market participants or investors. Aggregated data, however, would not cover the needs of emergency services, since emergency response requires detailed information about the affected site.

However, section 54G authorises AEMO to disclose protected information if the disclosure is necessary for the safety, reliability or security of the supply of electricity or the national electricity system. While this may facilitate the achievement of the policy intention to share DER-related data with DNSPs and emergency response agencies in some circumstances, it may be more appropriate and more certain, if the sharing of this information to DNSPs and emergency response agencies were specifically addressed in the Rules. The AEMC is asked to consider this issue.

Another consideration is the collection, use and disclosure of 'personal information' in relation to the *Privacy Act 1988,* to which AEMO is also subject.[16] This means AEMO must

[16] https://www.aemo.com.au/Privacy_and_Legal_Notices/Privacy-Policy

comply with the Australian Privacy Principles (APPs) as set out in Schedule 1 to that Act.[17] The APPs set out how APP entities must deal with personal information including its collection, use and disclosure. Personal information means information or an opinion about an identified individual, or an individual who is reasonably identifiable:

a) whether the information or opinion is true or not, and;

b) whether the information or opinion is recorded in a material form or not.

Some of the information that would be collected, used and disclosed by AEMO for the purposes of the DER register may constitute personal information within the meaning of the Privacy Act, for example, a retail customer's name, address and phone number.

It is the Council's view that the APPs would not prevent the implementation of the DER register as proposed. For example, the prohibition in APP 3 against an APP entity collecting personal information does not apply if the information is reasonably necessary for one or more of the entity's functions.[18] The information collected by AEMO would fall within this category given that it would be collected in accordance with AEMO's functions, if this function is clarified in the NER.

Further, under APP 6, if an APP entity holds personal information about an individual that was collected for a particular purpose (primary purpose), the entity must not use or disclose the information for another purpose (secondary purpose) unless the individual consented or, relevantly, the use or disclosure is 'required or authorised by or under an Australian law'. Australian law is defined in section 6 of the Privacy Act to include (a) an Act of the Commonwealth or of a State or Territory; or (b) regulations, or any other instrument, made under such an Act.

To the extent that AEMO's use and disclosure of information on the DER register would be relevant to APP 6, that use and disclosure could be authorised by the NEL and/or NER. To constitute an authorised disclosure for the purposes of APP 6, a NEL provision or Rule would need to authorise either explicitly or by necessary implication the use and disclosure of personal information as defined in the Privacy Act.[19]

There are existing frameworks under the Rules that support DNSP collection of data and sharing of data to AEMO, as noted in the previous section regarding Chapter 5A of the NER and customer obligations under the NERR when connecting to a network or making changes to an existing connection. However, DNSPs have noted issues with compliance rates by installers/customers with these provisions, therefore impacting the ability of DNSPs to share data with AEMO.

To this end, this Rule change proposal seeks to ensure the NER can more explicitly provide for the transfer of data from DNSPs to AEMO and vice versa, and between AEMO and other

[17] http://www.austlii.edu.au/au/legis/cth/consol_act/pa1988108/sch1.html

[18] See APP 3.2. APP 3 also deals with sensitive information (defined in Section 6 of the Privacy Act). The DER register would not appear to involve the collection of this type of information.

[19] See for example, section 174 of the National Electricity Retail Law: http://www.austlii.edu.au/cgi-bin/sinodisp/au/legis/nsw/consol_act/nerl291/s174.html?stem=0&synonyms=0&query=174

parties (such as TNSPs if required), some of which may be Registered Participants and some of which (e.g emergency service providers) may be not.

6. Proposed solutions

To allow stakeholders and the AEMC to identify optimal solutions, the Council has not proposed specific drafting of new rules to implement the intent of this rule change proposal. However, the Council anticipates that changes could include the following:

a) Requiring AEMO to administer a register of DER.

An obligation on AEMO to administer a register of DER could be introduced through the NER and be similar to the existing obligations on AEMO to operate a B2B e-hub and establish Market Settlement and Transfer Solution Procedures.[20]

b) Establishing principles in the NER broadly defining how AEMO should determine the types and capacity of DER that should be included in the register, and allowing AEMO to use a guideline to specify the DER systems and data that should be collected.

The intent of the rule change proposal is that the register should include information about BTM DER that will materially affect patterns of electricity production and consumption at a customer's premises. This intent could be reflected in principles established in Chapter 3 of the NER or elsewhere if necessary.

c) Establishing requirements in the NER that AEMO must follow to develop, maintain publish and amend a guideline outlining the specific DER types to be included in the register and the required data sets.

These may include the requirement for AEMO to consider the principles and undertake consultation processes with stakeholders when developing and amending the guidelines.

d) AEMO's use of procedures or guidelines to specify the type of DER systems and the data to be collected from DNSPs or other market participants could be similar to the Demand Side Participation Information Guidelines also established in Chapter 3 of the National Electricity Rules. Allowing AEMO to share information in the register with appropriate parties, where there are recognised benefits for consumers in doing so.[21]

The intent of the rule change proposal is that where parties can use the data in the DER register to provide benefits to customers, such as more efficient market and network

[20] Subject to consultation, Chapter 3 of the NER may be the appropriate part of the NER to place these principles, given that the NEM Demand Side Participation Information (DSPI) framework is in Chapter 3. NER 3.7D deals with similar subject matter, so a new Rule inserted here may compliment these provisions.

[21] For information on how different parties would be expected to use data, please refer to Section 7 Explanation of Expected Benefits and Costs.

operation, or improved safety for instance, this would justify access to data at an appropriate level of aggregation and anonymity[22].

Changes to the rules could either define these parties, or establish the principles AEMO should use to make a decision on granting access to data in the register.

The AEMC should consider whether the current rules for handling confidential information will support this goal. Any rules made by the AEMC also need to be consistent with privacy legislation while achieving the policy objectives.

e) Requiring DNSPs to collect information about DER connected to their network, and provide this information to AEMO

f) This could be achieved by placing an obligation on AEMO to administer a DER register and using AEMO's information gathering powers under clause 3.7D of the Rules to put obligations on DNSPs to provide relevant data. These would likely need to be expanded, for example, to provide for the immediate provision of data after the connection agreement has been competed, as opposed to the annual collection process used for the demand side participation guidelines and to ensure it extends to all the relevant categories of information contemplated in this proposal. If necessary, amending the Rules around connection agreements to clarify the situations when customers and their agents / suppliers (such as a retailer and/or an installer/ electrician) need to inform their DNSP about changes at their sites, including DER installations.[23]

   The AEMC should consider whether changes are necessary to support the collection of information about DER at customer sites. If necessary, changes could be implemented through Chapter 5A of the NER, relating to customer connection agreements.

g) In developing these obligations consideration should include how DNSPs could apply random auditing protocols on premises / DER systems, and referral to the appropriate body for enforcement where non-compliance is identified. Changes to the NERR may also be needed, for example relating to the relationship between distributors, retailers and customers, and deemed standard connection contracts.A mechanism or obligations on other parties be considered to ensure any changes to DER post installation are captured, such as potential system changes by retailers or aggregators.

The suggested changes described above and the Rule change proposal as a whole should not preclude jurisdictions from using electricity safety, licensing and/or other methods, such as links to training and skills competencies, to support data collection by installers and electricians and the provision of this data to DNSPs. These changes may include obligations on installers to provide data to DNSPs and changes to electrician training units of competency

[22] For more detail on the types of benefits for certain parties having access to aggregated data from a DER register, please refer to section 7: Explanation of Expected Benefits and Costs.

[23] 'Changes at sites' may refer to modification, and would link to 'connection alterations' under Chapter 5A of the NER, as well as customer obligations under the NERR for customers to advise the DNSP when they connect and/or modify a connection. This would include, but not be limited such things as modification of inverters, and addition of further generation capacity.

on DER installation, in order to educate installers on requirements for data collection under the rules. While such measures fall outside the scope of the rules, and will require consideration by jurisdictional governments, the Council would welcome any recommendations the AEMC may have to support compliance with the rules.

7. Contribution to the National Electricity Objective (NEO) and the National Energy Retail Objective (NERO)

Under section 7 of the NEL, the NEO states:

"The objective of this Law is to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to

(a) price, quality, safety, reliability and security of supply of electricity; and
(b) the reliability, safety and security of the national electricity system."

Under section 13 of the NERL, the NERO states:

"The objective of this Law is to promote efficient investment in, and efficient operation and use of, energy services for the long term interests of consumers of energy with respect to price, quality, safety, reliability and security of supply of energy."

The relevant aspects of the NEO and NERO for the purposes of this rule change request are the promotion of efficient investment in and use of energy assets and services for the long term interests of consumers with respect to price, quality and reliability of supply.

8. Explanation of Expected Benefits and Costs

The changes proposed by the Council will contribute to the achievement of lower costs, improved security and safety and more reliable supply outcomes through having greater visibility of BTM DER systems. It is expected this information will contribute to:

- improved efficiency of network investments
- better medium to long term network planning
- improved ability to manage power system security
- improved ability to respond to emergencies and contingency events.

The changes will do this by allowing DNSPs and AEMO greater visibility of DER on the network in order to better manage power system security and improve efficiency of investments in network assets and services. The Council expects that this will in turn provide **benefits** to consumers in the form of lower costs, as well as additional benefits for emergency services from having timely and accurate information when responding to an emergency incident where a DER is involved.

In March 2017, the Council commissioned the consultants Jacobs to undertake a CBA of a proposed national battery storage register (including the potential for the register to expand to also cover types of DER other than batteries). Jacobs provided preliminary findings in May 2017 and delivered their final CBA report in June 2017.

The below table shows the two options for a register, in terms of host organisation, data collection organisation and data collection mechanisms. The options for AEMO and CER to host a register were based on feedback from stakeholders in the August-September 2016 consultation process, where stakeholders generally expressed a preference for the register to be managed by a government or market body and not a private sector party. There were concerns that a privately run register could be used for the commercial benefit of the owner rather than the market as a whole. There were also concerns with the sustainability of such a solution (if the private sector party chose not to maintain the register or went out of business) and the comprehensiveness of data collected under such a solution. These views were confirmed in subsequent consultations (May-June 2017) undertaken as part of developing the CBA.

Additionally, the Council's proposal for a register to be hosted and managed by an energy market body and not a private sector entity was based on the potential to capitalise on existing powers and relationships (via DNSPs, AEMO, the CER or a combination of these entities), thus reducing the potential for added costs and complexity.

Table 1: Jacobs' cost-benefit analysis battery storage register options

Design Feature	Option 1	Option 2
Database host	AEMO	CER
Collection agency	DNSPs	CER
Possible collection mechanisms	Expansion of existing DNSP connection agreements	Expansion of CER collection mechanisms
Assumed data collection tool	New fit for purpose app	Enhancing existing CER collection process
Data collector	Installers	
Technologies to be captured	Battery storage systems, PV systems and inverters. Other distributed technologies may be incorporated later.	

Table 2: Comparison of costs and benefits for the battery storage register options

	Option 1 (AEMO hosted option)	Option 2 (CER hosted option)
Establishment costs - for host	$ 1.0 m	$ 0.7 m
Non-host establishment costs (design consultation and auxiliary databases)	$ 0.6 m	$ 0.6 m
Operation and maintenance costs	$ 0.7 m	$ 0.7 m
Data collection	$ 7.0 m	$ 9.0 m

	Option 1 (AEMO hosted option)	Option 2 (CER hosted option)
Data validation an auditing	$ 1.4 m	$ 1.4 m
Total Cost	**$ 10.7 m**	**$ 12.4 m**
Avoided expenditure – wholesale	$ 14.1 m	$ 14.1 m
Avoided expenditure - networks	$ 11.6 m	$ 11.6 m
Total benefits	**$ 25.7 m**	**$ 25.7 m**
Net Present Value (NPV)	**$ 15.0 m**	**$ 13.3 m**
Benefit-Cost Ratio (BCR)	**2.4**	**2.1**

The CBA showed that there is a positive benefit-cost ratio for a battery storage register hosted by either AEMO or the CER and using the DNSPs as the primary point of data collection:

- over a 14 year assessment period a battery storage register would provide a NPV of $15.0 million for a register hosted by AEMO using data collected by either AEMO or DNSPs and $13.3 million for a register hosted by the CER using data collected by the CER.
- Both the AEMO-hosted and the CER-hosted options were close in terms of quantifiable costs and benefits, with a BCR of 2.4 and 2.1 respectively and both options expected to deliver a positive NPV.
- The benefits of one option over the other are subject to legislative and regulatory amendment costs which Jacobs were only able to consider qualitatively.

These benefits are considered to be conservative estimates, given Jacobs could not quantify a range of benefits which the CBA only considered qualitatively:

- **Innovation benefits:** better information can lead to new business opportunities and market development opportunities that provide value to consumers and support more efficient system management.
- **Safety benefits:** a secondary objective of the register is to reduce safety risks to network staff, installers and the general public. Line workers need to be able to isolate generation systems to avoid the risk of electrocution. Insufficient knowledge about the presence of batteries at a given site has been raised as a potential safety risk that may be addressed through better information. These include benefits for fire risk management and recall benefits for businesses and regulators to deal quickly with faulty electrical products.
- **End of life disposal benefits:** Illegal dumping of lithium-ion batteries could become a safety and environmental issue as these devices reach the end of their life. A register can provide more accountability for responsible disposal, and create opportunities for new policies or private investment in recycling schemes.

- **Policy benefits:** more reliable and complete information about the uptake of battery storage in Australia, and the capacity of storage can lead to more informed policy decisions in this sector.

A copy of the final CBA report is provided at Attachment A.

9. Potential impacts on different stakeholders

AEMO

AEMO is required to operate the electricity system within a given technical envelope. To do this, AEMO must ensure that power flows remain within technical limits by constraining generation in the market, and coordinates the voltage profile across the transmission grid to remain within technical limits. In this role, AEMO would benefit from improved DER information by:

- Having more information to better manage the system within the technical envelope, including scheduling generation, and managing voltage and contingency events.
- Having the necessary information to identify and respond to non-credible contingency and protected events, such as DER unexpectedly disconnecting at a certain frequency, and expected but rare events such as extreme weather incidents and solar eclipses.
- Reducing the cost of FCAS, by improving forecasting and dispatch of FCAS, and improvement of load forecasts at all levels from 5 mins to 40 hours leads to more efficient unit commitment and dispatch.

AEMO will be required to invest in the appropriate systems to develop and maintain a DER register, but the CBA suggests these costs will be more than offset by benefits generated through improved system management.

DNSPs

In the September 2016 Energy Council consultation and May-June 2017 draft CBA report consultations, network businesses consulted supported a register. They believe that information about installed equipment is needed in addition to information about energy flows. They indicated that details of installed equipment provides a better understanding of underlying demand, and information about inverter settings helps modelling of performance during events like frequency and voltage deviations. Improved understanding of distributed energy resources will also enhance ability to forecast peak demand and draw on demand response to manage constraints, delaying or avoiding unnecessary network investments.

Energy Networks Australia (ENA) and most individual businesses supported a collection and hosting model using existing connection processes, DNSP databases and data sharing with AEMO. This will minimise any additional costs for DNSPs, which in any event, should be offset by greater network efficiencies.

The ENA has expressed concerns however, that putting obligations on networks to collect and share data on DER with AEMO will need to be combined with similar obligations on installers or DER owners. The ENA discussed the potential of updates to electrician and installer licensing and/or existing accreditation schemes.

The Council acknowledges ENA's concerns, but notes that such measures will need to be considered through separate jurisdictional processes which sit outside the rules, but could be informed by feedback received during the rule change process.

End-use customers

Electricity end-use customers would:

- Receive flow-on benefits from more efficient operation of the electricity system through reductions in supply charges
- See improved safety outcomes through information being available for emergency response, fire risk management, product safety recalls and proper disposal at end-of-life.

Customers who have invested in DER are also more likely to receive benefits from the market opportunities an improvement in DER information will generate, such as an increase in demand response programs which support market efficiency and grid management.

Public and private sector stakeholders Public sector stakeholders (such as policy makers and emergency services) and private sector stakeholders, including energy service business (such as aggregators developing competitive services) would be able to benefit from access to aggregated data from a register in different ways.

Access to data on DER systems available from a register would enable emergency services to more accurately target a response knowing the location and type of DER involved in an emergency incident. The Jacobs CBA of a battery storage register cited a German study of solar PV installations in that country, and found a rate of 0.025% of the systems catching fire, most of which were due to faulty cabling and connections.[24]

Note that this rate only relates to systems themselves catching fire, and does not include incidents where the solar PV system was affected by fires caused by something else on the premises, nor does it cover other types of emergency incidents. It also refers to solar PV installations only and does not cover other types of DER.

While the CBA was unable to quantify the full benefits of a DER register to emergency services, given the lack of available data, it did quantify a conservative estimation of $2.2 million in present value terms based on a discount rate of 7%. This was based on the advantages of early response reducing severity of a fire incident by 10%. [25]

[24]Dr Harry Wirth, "Recent Facts about Photovoltaics in Germany", February 2017, Fraunhofer ISE, p 72: https://www.ise.fraunhofer.de/content/dam/ise/en/documents/publications/studies/recent-facts-about-photovoltaics-in-germany.pdf
[25] Jacobs, Battery Storage Register Cost-benefit Analysis report, June 2017, p 65

The CBA also recognised but was not able to quantify possible benefits to the public sector through the availability of more reliable and complete information about the uptake of DER in Australia, which could lead to more informed policy decisions by governments to improve market and network efficiency. Aggregated data from a register could be made available on the Australian Renewable Energy Mapping Infrastructure (AREMI), in a similar way to how aggregated SRES data is currently fed into available datasets under AREMI.[26]

The CBA also recognised but was not able to quantify possible benefits a register could provide for private sector entities such as energy service businesses. These could be realised through the availability of information to:

- promote innovation which improves market and network efficiency;
- promote business opportunities, such as recycling services for management at end-of-life;
- conduct DER product recalls, which could provide additional safety benefits to consumers.[27]

In the consultation on the draft CBA conducted in May-June 2017 some electricity retailers and competitive service providers questioned the need for a register. The Australian Energy Council considered that information about electricity flows would give enough information about changing patterns of supply and demand, and would be available from smart meters. Some aggregators and information providers felt a register operated by AEMO may minimise their own business opportunities to provide services to the market.28

On balance, the COAG Energy Council believes an AEMO operated register will offer broader benefits to consumers and the market, and support development of energy services that improve market and network efficiency.

There would be some costs for the public sector (governments and emergency services) in terms of further consultation required with all affected parties, as well as other establishment costs such as establishing IT requirements and legal advice. The public sector would seek to reduce these costs as much as possible through using existing processes and responsibilities and sharing resources across jurisdictions, where applicable.[29]

There are also potential costs from these reforms for business. These include developing new apps and introducing a new process for data collection by installers. As outlined above, it is envisaged that existing processes, leveraging off methods used to collect data on solar PV, and consultation processes used by AEMO to determine data requirements will be used to reduce compliance costs for business.

10. AEMO Declared Network Functions

[26] http://nationalmap.gov.au/renewables/
[27] Jacobs, Battery Storage Register Cost-benefit Analysis report, June 2017, p 65
[28] Ibid, p 32
[29] Jacobs, Battery Storage Register Cost-benefit Analysis report, June 2017, p 63

The proposed Rule change is expected to provide more information to AEMO about DER in the NEM. By enhancing the information available to AEMO, it is expected that the proposed Rule change will align with the following of AEMO's Declared Network Functions under section 50C of the NEL:

- to plan, authorise, contract for, and direct, augmentation of the declared shared network;
- to provide information about the planning processes for augmentation of the declared shared network, and;
- to provide information and other services to facilitate decisions for investment and the use of resources in the adoptive jurisdiction's electricity industry.

The proposed Rule change will not affect AEMO's declared network functions in any materially adverse way.

Cost Benefit Analysis of options to collect and share information about small scale battery storage

Energy Market Transformation Project Team

Final CBA report

2 | 4

30 June 2017

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Cost Benefit Analysis of options to collect and share information about small scale battery storage

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Jacobs Group (Australia) Pty Ltd
Floor 11, 452 Flinders Street
Melbourne VIC 3000
PO Box 312, Flinders Lane
Melbourne VIC 8009 Australia
T +61 3 8668 3000
F +61 3 8668 3001
www.jacobs.com

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1	16/5/2017	Draft CBA report	LP/MF/SH	LP	LP
2	22/5/2017	Second draft CBA report	LP/MF/SH	MS	LP
3	26/6/2017	Third draft CBA report	LP/MF	MS	LP
4	30/6/2017	Final report	LP/MF	LP	LP

Contents

Glossary

Abbreviation	Meaning or definition
AC	Alternating current
ABS	Australian Bureau of statistics
AEMO	Australian Energy Market Operator
AFAC	Australian Fire and Emergency Services Authorities Council
ARENA	Australian Renewable Energy Agency
BCR	Benefit Cost Ratio – a value greater than 1 implies a net benefit and a value less than 1 implies a net cost
CBA	Cost Benefit Analysis
CEC	Clean Energy Council
CER	Clean Energy Regulator
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAPR	Distribution Annual Planning Report
DC	Direct current
DER	Distributed Energy Resources. These include storage, solar PV, wind and other potential new technologies
DG	Distributed Generation
DNSP	Distribution Network Service Provider
DOGMMA	Distributed Generation Market Model Australia, a small scale generation projection tool developed in-house by Jacobs
EMTPT	Energy Market Transformation Project Team
ESOO	Electricity Statement of Opportunities
FCAS	Frequency control and ancillary services. These are usually provided by standby generation reserves that inject power to maintain system stability.
HV	High voltage
IMO	Independent Market Operator
IPSS	Integrated Photovoltaic Solar and Storage system
kVA	Kilovolt-Ampere
kWh	Kilowatt-hours
LGC	Large scale generation certificate, traded under the large scale Renewable Energy Target
LV	Low voltage
MT PASA	Medium Term Projected Assessment of System Adequacy
MVA	Megavolt ampere

Abbreviation	Meaning or definition
MW	Megawatt
NEFR	National Electricity Forecasting Report, a publication released annually by AEMO
NEL	National Electricity Law
NEM	National Electricity Market (covers SA, Tasmania, Victoria, NSW, ACT and Queensland)
NER	National Electricity Rules
NMI	National Meter Identifier
NSP or network operator	Network Service Provider (Transmission or Distribution)
pf/VAR	Power factor/ voltage-ampere reactive
PV	Photovoltaic solar generation system
REMMA	Renewable Energy Market Model Australia, a large scale generation projection tool developed in-house by Jacobs
RET	Renewable Energy Target
SRET	Small-scale Renewable Energy Target
ST	Sub-transmission station
ST PASA	Short Term Projected Assessment of System Adequacy
STC	Small-scale Technology Certificate (traded under the RET)
SWIS	South Western Integrated System, the electricity grid operated in the south west of Western Australia
TNSP	Transmission Network Service Provider
TS	Terminal substation
VCR	Value of Customer Reliability
VoLL	Value of Lost Load
WEM	Wholesale Electricity Market, Western Australia
ZSS	Zone substation

Disclaimer

The primary purpose of this report is to set out the scope, methodology and results for a Cost Benefit Analysis of a potential Energy Storage Register.

During the preparation of the draft report, Jacobs collected data and advice from stakeholders through interviews, submissions to the Energy Market Transformation Project Team (EMTPT) discussion paper and through advice and collaboration. The draft was submitted to a public stakeholder consultation and this report incorporates feedback from that consultation as received through stakeholder submissions. Information received from stakeholders has been relied upon and presumed accurate for the purposes of preparing this report. Furthermore, many of the assumptions used to estimate the benefits of a potential database have been derived from publically available sources (described where relevant), and have similarly been relied upon and presumed accurate. Over time manifestation of latent conditions may cause changes in assumptions that may require the report to be re-evaluated. Jacobs does not provide a warranty/guarantee (expressed or implied) to the data, observations and findings in the report to the extent permitted by law.

The report is to be read in full with no excerpts to be representative of the findings. The report has been prepared exclusively for the EMTPT and no liability is accepted for any use or reliance on the report by third parties.

Executive summary

Jacobs Group (Australia) Pty Ltd (Jacobs) has been commissioned by the Energy Market Transformation Project Team (EMTPT) to undertake a cost benefit analysis (CBA) of options to collect and share information about small-scale battery storage.

The objectives for developing a register include the primary objective of improving the power system and network security, and to protect the safety of consumers, line workers and installers, as well as the secondary objective of supporting emergency services, for example when responding to a fire or another incident at premises where a battery is installed.

The purpose of the CBA is to ascertain whether there will be an economic net benefit associated with the register and if this is the case, to provide clear direction and guidance to the EMTPT on appropriate development approaches.

The CBA includes a high level assessment of the costs and benefits of the options being considered. It is assumed that following the completion of the CBA, and once the preferred option has been selected, that more detailed scoping and design will be used to provide a more comprehensive cost estimate. The assessment excludes consideration and assessment of funding options for collection of data, development and operation of the database, and consideration of cost recovery options (e.g. options for membership fees). It is understood that the distribution of costs and benefits will inform future consideration of cost sharing or funding approaches.

The national database options considered in the CBA are based on the host of the database, but they also vary in the assumed collection agency, mechanism and tools. These options include:

The options considered include:

- Option 1: A national register administered by AEMO with DNSPs as the collection agency
- Option 2: A national register administered by CER with CER as the collection agency

The design components assumed for Option 1 and Option 2 are summarised in Table 1. For Option 1 (AEMO host) is assumed that DNSPs are the collection agency and that data is collected using a new fit for purpose app that can be used to streamline existing DNSP processes. For Option 2 (CER host), it is assumed that CER is the collection agency and that an enhanced CER data collection process is implemented.

Table 1 : Summary of CBA Option 1 and Option 2

Design Feature	Option 1	Option 2
Database host	AEMO	CER
Collection agency	DNSPs	CER
Possible collection mechanisms	Expansion of existing DNSP connection agreements	Expansion of CER collection mechanisms
Assumed data collection tool	New fit for purpose app	Enhancing existing CER collection process
Data collector	Installers	
Data granularity	As outlined in Section 4.2	
Technologies to be captured	Battery storage systems, PV systems and inverters. Other distr buted technologies may be incorporated later.	

The collection agencies and data collection tools assumed for each option enable a comparison of the relative costs and benefits of different design options. Although a less likely scenario, DNSPs could act as the collection agency for a CER hosted database and/ or the CER collection process could be applied to an AEMO hosted database. The preference between these design options will depend on further consultation with all affected parties and a more detailed assessment of the cost and deliverability of the underpinning regulatory or rule changes (i.e. possible collection mechanisms).

The base case is included in the assessment for comparison purposes. The costs and benefits associated with all the options are assessed as being incremental to those that would otherwise be incurred in the base case. Under the base case it is assumed that:

- There would be no further investment in a national register
- AEMO would continue purchasing and eventually installing a separate real time database, but this would not be complemented by complete and reliable static information
- Distributors would continue to enhance and develop their own databases, but because of data collection issues would only collect around 30% of new storage installations, consistently understating available storage capacity in their projections and operations

Table 2 summarises all the costs and benefits relevant to the assessment and outlines whether they are quantified in the CBA or discussed qualitatively.

Table 2: Summary of costs and benefits

Cost/ Benefit	Quantitative	Qualitative
Cost		
Project establishment costs	✓	
Ancillary database adjustment costs	✓	
Operation and maintenance costs	✓	
Competition costs		✓
Benefits		
Market benefits		
Medium to longer term planning – wholesale market generation capacity	✓	
Medium to longer term planning – network capacity	✓	
System reliability assessments		✓
Power system security monitoring and contingency planning		✓
Central dispatch process		✓
Safety benefits		✓
Other benefits		✓

The CBA results are presented in Table 3. Both options considered are economically viable, with NPVs ranging from $13.3 million to $15.0 million over a period of 14 years. The difference between the two options is predominantly due to the collection costs being lower for Option 1 which assumes that data is collected using a new app which allows streamlining of some of the existing processes (i.e. connection notices for networks). If the same data collection process was applied to both models, Option 2 would have the higher NPV. These issues will be resolved as part of the more detailed design process.

The study was developed using a conservative approach. A number of costs and benefits could not be captured quantitatively, and the unquantified benefits are expected to be more significant than the unquantified costs. The NPV is expected to increase once factoring in some of these unquantified impacts, particularly the benefits associated with safety, policy development and innovation. Furthermore, the CBA results currently capture all the costs associated with implementing the national database in Western Australia without being able to capture the full benefits associated with deferred infrastructure investment (due to data limitations). These impacts would further increase the NPV.

Table 3: CBA results

	Option 1 (PV)	Option 2 (PV)
Establishment costs - for host	$ 1.0 m	$ 0.7 m
Non-host establishment costs (design consultation and auxiliary databases)	$ 0.6 m	$ 0.6 m
O&M	$ 0.7 m	$ 0.7 m
Data collection	$ 7.0 m	$ 9.0 m
Data validation an auditing	$ 1.4 m	$ 1.4 m
Total Cost	**$ 10.7 m**	**$ 12.4 m**
Avoided expenditure – wholesale	$ 14.1 m	$ 14.1 m
Avoided expenditure - networks	$ 11.6 m	$ 11.6 m
Total benefits	**$ 25.7 m**	**$ 25.7 m**
NPV	**$ 15.0 m**	**$ 13.3 m**
BCR	**2.4**	**2.1**

From the modelled results, it appears that the choice between the two database hosting options (AEMO or CER) is equally viable with little separating them. A decision on the appropriate host may therefore not be purely driven by economic factors.

A significant factor in the NPV results is the data collection approach adopted. It is not practical to change safety regulations so this leaves two choices – collection of data through DNSP connection notices and collection of data through the industry apps enabled by the CER. The choice surrounding the collection agency, mechanism and tool will have a significant impact on the data collection cost, and most importantly, acceptance by installers and consumers, which is critical to the success of the register. A detailed design stage will be imperative to choose an approach that streamlines costs and reduces the burden on installers, but also encourages use through inclusion of soft incentives or other approaches.

Whilst the CBA assumes a given collection approach for each of the host options, there is flexibility to amend these as part of the final design of the register. Any of the collection mechanisms could be matched to any of the host options considered. The most appropriate collection process will depend on further consultation with all stakeholders and a more detailed assessment of the cost and implementation constraints associated of the underpinning regulatory or rule changes (i.e. possible collection mechanisms).

Importantly, it will be necessary to consider which collection mechanism offers the most viable options to streamline data collection needs by the national register, CER and DNSPs. The need to reduce and streamline data requirements is likely to be highly relevant. Data reduction opportunities exist by using references to CEC and other databases to complete missing information fields. For Option 1 modelled, it is assumed that streamlining opportunities exist. However, if the CER expands on its current serial number validation project, and if it could be linked to providing information for connection notices, the total burden on installers could be significantly reduced under Option 2. In fact, the total collection time for a new national storage database, CER data requirements, and DNSP connection notices could be lower than the current data collection requirements by CER and DNSPs right now. This, in itself, coupled with an appropriate education effort, could create the best incentive to installers to provide data.

As part of the more detailed design process, it is also recommended that further consideration be given to the treatment of PV system data while the REC database is still relatively reliable. To avoid duplication costs, it may be appropriate to consider:

- Whether the existing STC database managed by CER could share data collection with the national energy storage database rather than through its own separate data collection process

- Whether the storage register would rely on the STC database maintained by the CER for information about PV systems during the period prior to 2024; the two databases could operate in parallel until the incentive under the RET is considered to be too low to ensure sufficient data collection is maintained.

With benefits from a national register extending beyond those that could be quantified, and expected opportunities to further reduce the implementation and collection costs through the design process, the economic benefits of a national storage database appear to outweigh the economic costs.

1. Introduction

Jacobs Group (Australia) Pty Ltd (Jacobs) has been commissioned by the Energy Market Transformation Project Team (EMTPT) to undertake a cost benefit analysis (CBA) of options to collect and share information about small-scale battery storage.

The objectives for developing a register include the primary objective of improving the power system and network security, and to protect the safety of consumers, line workers and installers, as well as the secondary objective of supporting emergency services, for example when responding to a fire or another incident at premises where a battery is installed.

The purpose of the CBA is to ascertain whether there will be an economic net benefit associated with the register and if this is the case, to provide clear direction and guidance to the EMTPT on appropriate development approaches.

1.1 Consultation and data sources

The EMTPT released a discussion paper on 19 August 2017 to test stakeholders' views on the need for a national register. While most stakeholders indicated broad approval for the stated objectives for a register, there were concerns about whether the costs of developing and maintaining the register (including those which may ultimately be imposed on system owners, tax payers or electricity customers), will outweigh the benefits. In particular, electricity retailers were concerned that requiring battery systems to be registered would add costs and complexity to an emerging industry.

These issues were considered further in the draft CBA report. In developing the options to be considered and the assumptions underpinning the costs and benefits related to the primary and secondary objectives listed in the discussion paper, Jacobs sought stakeholders' input through:

- Targeted stakeholder interviews
- Written responses to the initial discussion paper released on 19 August 2017.

Desktop research and analysis was undertaken to supplement stakeholder input and develop the CBA.

The draft CBA report and a consultation paper were released publically on 22 May 2017. The current report incorporates feedback following this secondary consultation phase. This feedback is summarised in Appendix F.

1.2 Study limitations and exclusions

The CBA includes a high level assessment of the costs and benefits of the options being considered. It is assumed that following the completion of the CBA, and once the preferred option has been selected, that more detailed scoping and design will be used to provide a more comprehensive cost estimate. Some of the issues that would need to be considered further as part of more detailed design consideration are discussed in this report.

The assessment also excludes:

- Consideration and assessment of funding options for collection of data, development of the database and operation of the database
- Consideration of cost recovery options (e.g. options for membership fees). It is understood that the distribution of costs and benefits will inform future consideration of cost sharing or funding approaches.

1.3 Purpose of this document

This paper outlines the methodology applied to the CBA and the results for the options considered. It also features analysis of possible development paths for a battery storage register should the Energy Council decide to move forward with it.

1.4 Primary objectives

The existing information gaps of battery storage installations, if left unaddressed, is expected to lead to increasing inefficiencies and safety risks as the battery storage market matures. For example, inadequate information about the location, capacity, and technology of storage devices is expected to:

- **Result in inefficient market and network investment**. Storage can reasonably be expected to offset peak demand, the key driver of investment in both generation capacity and network infrastructure. If demand forecasts continue to be overstated through ignoring or underestimating the impact of storage, market proponents are likely to receive incorrect market signals and overinvest. Overinvestment in the energy market can consequently result in higher prices to consumers.
- **Lead to inefficient market and network operation**. Storage can materially change the shape of electricity demand over any given day, depending on how storage is deployed. If the level of available storage is not known, market operators and distributors may not be able to adequately develop a reasonable estimate of demand in the next five hours or even in the next five minutes, making the system control task more difficult and more expensive to manage. This could also lead to higher costs for consumers.
- **Expose network staff, installers and the general public to safety risks.** There are concerns that line workers may not have the information needed to efficiently isolate generation systems to avoid the risk of electrocution. Energy Queensland's response to the consultation paper stated that 'Most batteries are installed with multi-mode inverters that have the ability to supply circuits when the battery loses grid supply and still meet anti-islanding requirements. It is unknown whether the house circuits are still live after the grid has been shut off. This is particularly important in disaster response activities (e.g. cyclones).' Potentially live household circuits following a disaster of this nature may present a risk to the public.

In addition to the critical information gaps that currently exist for storage devices, information collected on solar photovoltaic (PV) systems is expected to become less reliable over time. In particular, it is expected that the existing Clean Energy Regulator (CER) database will lose relevance once the incentives from the Small-scale Renewable Energy Target (SRET)[1] are reduced. When this happens, networks and market operators will find it too difficult to guess which generation technologies customers have and be left unable to strategically respond to market trends and changes. This is why any future database should be scalable to accommodate future technologies as they arise as well as PV as existing data sources become less relevant.

The primary objectives of a register are to improve the power system and network security through the provision of better information which is currently not being collected or required to be collected. It is also to protect the safety of consumers, line workers and installers. This objective is most material to the Australian Energy Market Operator (AEMO) as well as to network operators, including transmission and distribution operators.

Impact on study: DNSPs, Transmission Network Service Providers (TNSPs), market operators and planners are seeking better quality and more detailed information around distributed resources to do their job efficiently and safely.

These requirements may be met through a combination of measures, including regulatory changes, a new technology platform for information collection, storage and dissemination, and/or the adoption of more standardised and consistent processes across jurisdictions.

These measures would enable the right amount and quality of information to be supplied in a timely fashion to the holder of a national storage register. In addition to rule changes, it may require greater consideration of incentives to provide data and/or compliance measures needed to ensure that data is provided.

[1] The SRET provides an incentive for consumers to have their PV systems registered by a Clean Energy Council (CEC) accredited electrician in the CER database by making the value of Small-scale Trading Certificates (STCs) available to offset the cost of systems. At present the deemed life of a PV system under the SRET is 14 years and this value will reduce by 1 year in each of the next 13 years to 2030. With STCs valued at around $40 per MWh and a capacity factor of around 15%, this means that consumers purchasing a 3kW PV system would receive STC value of around $1,473 now, reducing to $631 in 2025 and $421 in 2027 and diminishing to around $105 in 2030. If incentives need to be above a given threshold (which may be different for each consumer), the database maintained by the CER is l kely to begin to lose relevance from around 2024.

1.5 Secondary objectives

Secondary objectives of the study are about safety emergency services such as first responders (and potentially general public) during emergency events including fire, floods or other extreme conditions. Two types of risk related to batteries are of main concern:

- Fire risk
- Electrocution risk.

Batteries present a very low fire risk in that they rarely initiate a fire[2]; however they could become engaged in a fire that was ignited from a different source such as a bushfire. Should this happen, the energy released by the battery would complicate the management of that fire and the impact would be analogous to storing two litres of petrol inside the home. There is therefore merit in emergency services teams and consumers understanding the types of risks that exist when responding to a fire emergency at premises that might have a battery installed. However suitable preparation and precautions may not be possible if the existence of batteries is not registered, and the location of these batteries within a given property is not known.

The increasing uptake of distributed generation resources is likely to make fire risk an ever increasing one for first responders, and an increasing amount of training and emergency response management material is likely to be required regardless of whether a register is developed. New Australian Standards for battery installations are presently undergoing development (not yet released), and it is envisaged that the new standards will require signage in prominently placed areas of the property in which the energy storage resides. While improved signage has been identified as a potential solution, visual access to signage (e.g. if situated in a meter box) in some emergency situations such as cyclones may be difficult.

Appropriate enclosures of batteries to prevent external fires from reaching them have been touted as another solution that would negate the need for a register, and suitable standards that would require manufacturers to incorporate sophisticated fire suppression systems at the cell level may also appropriately negate the need for a register. Whether a register would have any benefit from fire related incidents may depend on consistent adoption of standards across jurisdictions.

A register is expected to offer incremental benefits beyond those provided by on-site signage. For example, If the address, location, technology and size of a battery is known at the time the 000 call is made, first responders and their support teams have time to prepare for the specific risks prior to leaving for the property under threat. Further, a register provides back-up information in the event that signage is not visible or destroyed during an emergency event. Access to a battery storage register may also provide additional confidence around electrical safety to avoid electrocution risk in flood situations and may assist emergency response teams in the planning and preparation around significant events such as bushfire.

The Australian Fire and Emergency Services Authorities Council (AFAC), whilst acknowledging the potential for a national register to be useful, was not in a position to confirm the likely benefits that could be delivered without more detailed information about the likely scope and usage of the register. However, it was noted that the potential uses and benefits would likely extend to all emergency responders, including the police, ambulance, and firefighters.

A discussion with Dr Penelope Crossley from The University of Sydney provided more detail on how an energy storage database could provide significant safety benefits for emergency services. This is discussed in Section 9.1.

Impact on study: The scope, costs and benefits of a national register will consider the merit of providing first responders access to relevant information.

[2] See S and C electrical company submission

2. Stakeholder summary

A list of stakeholders is provided in Table 4. One or more interviews were set up with each stakeholder to establish the impact that a register would have on each, and for the purpose of collecting appropriate operational and cost data to advise a CBA. This information was used to supplement the existing set of stakeholder submissions provided to the EMTPT.

The discussions undertaken with stakeholders are not reported in detail through the CBA. Some of the information provided is confidential and has been aggregated to inform assumptions. Where appropriate and approved by stakeholders, inputs have been summarised and captured in the report.

The following table summarises the key stakeholders, and provides details of their roles and interest in the battery storage register. It is also indicated whether each stakeholder provided a written submission to the discussion paper (SD), was interviewed (I) and/or provided a written submission to the consultation paper (SC).

Table 4 Description of stakeholder roles and interest in a battery storage register

Market participant	Role	Nature of interest	Form of engagement - interview (I), written submission to discussion paper (SD) or consultation paper (SC)
AEMO	AEMO manages the National Electricity Market (NEM) in Eastern and South Australia and the South West Interconnected System (SWIS) in Western Australia (WA). AEMO is respons ble for national electricity transmission planning and security of the national electricity grid. Network connections in the NEM and the SWIS are the shared responsibility of AEMO, statutory authorities, and electricity generation, transmission and distribution companies. The roles of these entities, including AEMO, vary between the states.	• ***Improved operation of the grid.*** A national energy storage database would provide improved wholesale market and transmission network monitoring, planning and control capability. • ***Potential host.*** AEMO already aggregates data on distributed generation uptake by utilising available information from networks and the CER. AEMO is keen to improve the quality of the data resulting from weak reporting requirements, and would also be well placed to host the system.	I, SD, SC
CER	CER administers schemes legislated by the Australian Government for measuring, managing, reducing or offsetting Australia's carbon emissions. Their role is determined by climate change law and they have respons bility for monitoring the Renewable Energy Target (RET) under the Renewable Energy (Electricity) Act 2000, in addition to other government programs such as the National Greenhouse and Energy Reporting Scheme, the Emissions Reduction Fund and the Australian National Registry of Emissions Units. As an economic regulator, CER does not have any direct role or powers under legislation to enforce work health and safety, environmental protection, or planning laws. However, they share information with relevant	• ***Improved compliance and control capability.*** CER undertakes checks to avoid fraudulent behaviour relating to issue of small scale trading certificates. Having another database available for cross checking purposes may improve this process. • ***Potential host.*** CER's existing database of PV uptake may provide initial cost savings compared to developing a new database. The database would require extension to incorporate new technologies and additional fields if they were to become the host. If another party were to undertake hosting of a system that would include PV, CER would continue to maintain existing systems side by side because it does	I

Market participant	Role	Nature of interest	Form of engagement - interview (I), written submission to discussion paper (SD) or consultation paper (SC)
	regulators in appropriate circumstances.	not identify any opportunities to streamline processes.	
CEC	The CEC is a not for profit peak body for the clean energy industry in Australia. It represents and works with hundreds of leading businesses operating in solar, wind, energy efficiency, hydro, bio-energy, energy storage, geothermal and marine technologies along with more than 4000 solar installers. The CEC works with local, state and federal governments to solve the technical, political and financial challenges faced by the clean energy industry.	• Improved health and safety for installers, customers and line workers. • Improved management of technical and political issues associated with clean energy • Improved compliance and control capability • Improved ability to provide education to consumers and installers	I, SD, SC
Networks	Transmission and distr bution networks arrange for safe and efficient delivery of power from generation source to customer site. This is done by engaging in capital investment and maintenance of the necessary poles and wires and other grid elements needed to ensure safe and efficient delivery of power.	• ***Improved operation of the grid.*** A national database (supported by regulatory requirement to collect information) would improve the quality and type of information received in network databases. This would provide improved network monitoring, planning and control capability. • ***Health and safety benefits.*** A more complete database for determining health and safety risk when undertaking works requiring isolation of electrical currents may improve the networks ability to manage occupational and consumer health and safety management. • ***Potential risk to data integrity.*** If a new data collection process is managed by a third party and is streamlined with existing network processes (such as connection notices), the networks have some concerns that this may reduce data integrity. If not managed properly, this could impose additional costs to the networks.	I, SD, SC
Retailers	• The primary role of retailers is to buy and sell electricity in wholesale markets and package these with electricity transportation services and other costs to sell to end use customers. • The secondary role adopted by some retailers includes provision of additional market services to arrange for supply and installation of distributed generation technologies and energy management	• New regulatory requirements may increase cost of installation of new distr buted generation technologies, putting a fledgling industry at risk • In the event that the cost of a new national database is recovered from consumers, retailers may incur additional costs in the form of system changes, increased information requests, complaints or questions from customers.	I, SD, SC

Market participant	Role	Nature of interest	Form of engagement - interview (I), written submission to discussion paper (SD) or consultation paper (SC)
	services.	This has potential to harm retailer relationship with clients. *Note: Given that cost recovery is outside the scope of this assessment, these costs have not been considered in more detail*	
Manufacturers and distributors of distributed generation technologies	Battery manufacturers and manufacturers of other forms of distributed generation technologies create the products eventually installed in homes and businesses.	• ***Improved safety and system verification compliance.*** Presently manufacturers do not have a means to undertake product recalls. A national battery storage register would enable this and would enable manufacturers to understand how their equipment is being used.	No direct feedback obtained other than through CEC
Emerging market players (e.g. Wattwatchers, Reposit power, Greensync)	Creators of data driven and metering solutions to enable consumers to get better control of their energy costs	• Recognises the value of data • Want to facilitate evolving DER markets	I (Wattwatchers), SD (Reposit), SC (Greensync)
S & C Electric (battery supplier and network support services)	S&C Electric Company has been actively engaged in deploying Battery Energy Storage Systems since 2006 providing a full range of services and using a range of battery technologies and currently has 76 MW/189 MWh in operation, including the Ergon Grid Utility Support System in Queensland, which reduces peak loads and provides voltage support on rural lines.	• Recognises the value of a battery register to network and system security • Recognises the value of a battery register for improved safety	SC
Data61/CSIRO	Creators of AREMI, a spatial data platform for the Australian energy industry. Information is provided to developers, financiers, and policy makers free of charge. The program is funded by the Australian Renewable Energy Agency (ARENA) in partnership with Geoscience Australia and the CEC. The AREMI website provides access to renewable energy and general information which has been provided by various third party data custodians.	Desire to include aggregated national data on their website for use by businesses and policy developers. A national energy storage database could be used for this purpose.	I
ARENA	Public authority established to make renewable energy solutions more affordable and increase the supply of renewable energy in Australia.	Possible source of funding for a national energy storage database.	I
Australian Energy Storage Alliance (AESA)	AESA was founded in 2014 with the mission of advancing the role of safe, clean and cost-effective energy storage in Australia and New Zealand and is governed by a volunteer	• Have commissioned a database already; presently populated using commercial vendor data • Interested in providing a role in	I, SD

Market participant	Role	Nature of interest	Form of engagement - interview (I), written submission to discussion paper (SD) or consultation paper (SC)
	Steering Committee. The committee guides the direction of the AESA, including its flagship project, the Australian Energy Storage Database, and also assists with various submissions to advance the energy storage industry in the Australian marketplace.	information dissemination to interested parties • Membership interest to improve the uptake of storage technologies • Interested in potential complementary role that their database could play with a national storage database	
Energy Storage Council	The Australian Energy Storage Council seeks to advance the uptake and development of energy storage solutions in Australia. The Australian Energy Storage Council provides an independent forum comprising representatives of the energy storage industry for networking and information sharing. The Australian Energy Storage Council has a critical role in creating industry standards and encouraging industry best practice for the energy storage sector. The Energy Storage Council has commissioned Global Roam to develop a database and is in the processes of developing its user customer base, business model and data collection methods. Access to data would be on a subscription/ membership basis to recover the costs and reflect the benefits of the potential users. Potential users include industry (AEMO, distributers, retailers, etc.), government, researchers, academics, emergency first responders and the private sector. The database includes a supply chain based model that undertakes validation across different datasets.	• **Competition risk**. A national database developed by government would be in direct competition with their business • Have identified a gap in the market and have invested time and money to address this gap • Have already consulted widely across the industry and invested in product and business development	I, SD, SC
Australian Fire Authorities council (AFAC)	AFAC is the Australian and New Zealand National Council for fire, emergency services and land management, creating synergies across the emergency management sector.	Improved health and safety of first responders, consumers and the general public.	I
Jurisdictional bodies including regulators	These include WorkSafe and regulatory bodies within government departments.	• Continued ability to operate within existing regulatory remit • Opportunities to deliver benefits without significant increases on regulatory burden/costs to industry • Improved and streamlined installation and compliance practices • Improved health and safety of first responders, consumers and line workers	I (direct feedback from some jurisdictions), SC (Energy Safe Victoria, NSW Energy and Water Ombudsman)

Market participant	Role	Nature of interest	Form of engagement - interview (I), written submission to discussion paper (SD) or consultation paper (SC)
Policy makers, researchers, academics and market investors	This includes government departments (national and jurisdictional), COAG, universities, potential suppliers/advisers to the above and to market intermediaries, other research bodies (private sector)	• Interest in aggregated data to inform future policy and investment decision making	I (EMTPT has been consulted as a representative policy group across jurisdictions. Feedback has not been sought outside this group as the group is too diverse)
DER customers and electricity consumers	These include households and businesses installing the DERs and therefore directly affected by any new information collection requirement, as well as other electricity consumers that will be impacted how these DERs affect market performance, projections, and ultimately electricity prices,	• Desires secure, safe and efficient delivery of power and services • Preference for service delivery at least cost and avoidance of unnecessary regulatory burdens.	SC (Submission from the customer advocate)

3. Current situation

3.1 Data collection, gaps and access to data

Currently, Distribution Network Service Providers (DNSPs) require installers to fill in network connection notices[3]. These notices are completed if the installer (or household) requires a service from the network, such as a new meter or repositioning of a meter. AEMO is able to receive information collected by networks for use in its own planning and operations under existing market rules.

The connection notice data, as collected by networks, enables them to obtain information about inverters at a minimum (and in some cases PV and storage), but might not cover all situations where a battery or other forms of Distributed Energy Resources (DER) are installed; Energy Queensland (formerly Energex and Ergon Energy) have estimated that only 30% of battery systems are being detected through the existing process. The second consultation revealed that this value can range from 5% to 50% depending on DNSP. Those that are not being detected include the following:

- Installations undertaken by non-electricians (<2.5 kW)
- Installations of batteries pairing with existing solar photovoltaic (solar PV) systems where no new inverter or meter is needed
- Installation of batteries in instances where electricians don't view these as a form of generation.

The level of advancement for each network in improving their data collection processes varies. Energy Queensland has been operating a database for around 18 months, and collects limited information on batteries, PV systems and inverters. SA Power Networks data collection processes are less advanced and collect information on the inverter only. A number of network operators have moved from paper based systems to electronic systems, and estimate that the time required for installers or other parties to fill in forms has reduced from around 20 minutes to less than five minutes per installation. Once basic information is collected, it is also possible to retrieve additional data about the system by linking to newly developed Clean Energy Council (CEC) databases and possibly by remotely accessing the relevant equipment where this facility is available.

The ACT has had more success in collecting data on battery storage through its current grant program – NextGen. Under this program, the ACT Government is currently subsidising the rollout of battery storage to approximately 5000 Canberra homes and small businesses over five years. Eligible installers have been accredited by the program and must comply with the installation requirements and data provision requirements to obtain the subsidy. As such, this financial incentive has been critical for the integrity of the data collection process. However this incentive is only available in the ACT and will only exist for a short period (currently to 2020).

Impact on study: If a national storage database is to utilise the DNSP collection process, it would need to introduce consistency across the DNSP collection process across jurisdictions, including measures to improving the completeness and reliability of information collection.

CER data collection process

CER has an online Renewable Energy Certificate (REC) Registry which is used to create, view or transfer certificates of large-scale generation certificates (LGCs) and small-scale technology certificates (STCs). The register also maintains various public registers as required by the Renewable Energy (Electricity) Act 2000 (the REE Act).

All transactions performed through the REC Registry are recorded and this information is used to manage, audit and report on certificates and the Australian renewable energy market.

[3] These processes differ across jurisdiction.

The registered installers or registered agents that submit the application for STCs must complete a number of written compliance statements and a certificate assignment form. Applications can be submitted individually or in bulk by registered installers or agents.

For STC eligibility, installations must:

- Be installed no more than 12 months prior to the creation of certificates, and have its panels and inverter, listed on the Clean Energy Council list of approved components
- Use a Clean Energy Council accredited designer and installer and meet the Clean Energy Council design and installation guidelines
- Comply with all local, state, territory and federal requirements, including electrical safety
- Be classified as small scale.

CER has also introduced a Serial Number Validating Project which is a voluntary mechanism that allows businesses in the supply chain to validate the authenticity of solar panels.

Participants in the pilot are designing and building a new app which would be used by installers to verify solar panel details and provide a digitally signed confirmation that products used in an installation are genuine. This verification process involves scanning and checking solar panel serial numbers against the manufacturer's validation database. The validation package created is provided to customers and agents and would form part of the STC application material uploaded to the REC Registry.

If the pilot is successful, CER will look to establish a voluntary serial number validation mechanism in the second half of 2017.

CER has advised that electricians currently use a range of apps and tools to meet a range of needs, including warranty information, scheduling regulatory requirements and so on. Providing another app may not result in the expected time savings if it is used as an 'additional' tool rather than replacing existing processes. CER has found that industry is more receptive to adapting their own processes and apps to meet new information requirements. This has been the approach adopted for the STC database.

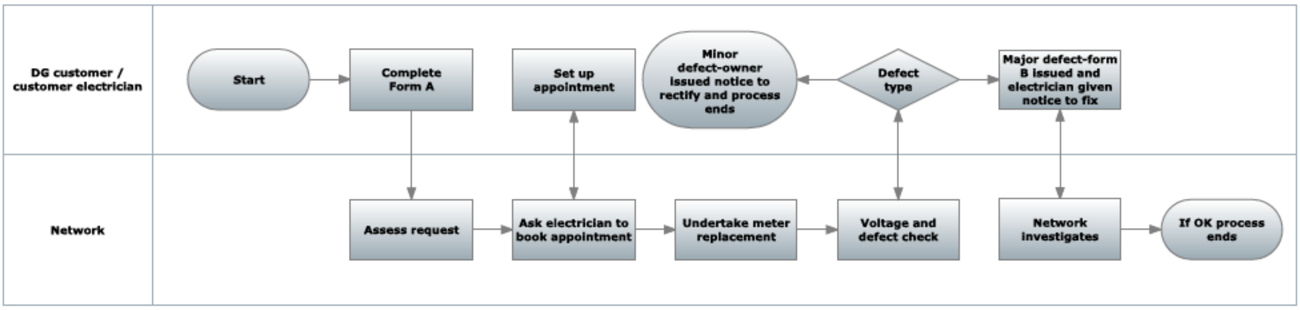
Impact on study:

- A national storage database could expand the existing CER data collection process, complement it or replace it.
- Utilising and adapting the existing data collection requirements to include other DERs has the advantage of installers already being familiar with the process and requirements. The serial number validation system developed for PV could also be extended relatively easily to include battery storage devices, with the technology and processes already in place. The other advantage is that interfaces with the existing STC database already exists which would result in some cost savings.
- The CER data collection process could be streamlined with other network data collection processes
- Replacing the existing process with a new data collection app may result in more streamlining opportunities and time savings, but would be more expensive to design and implement and may replace apps that have already been developed by the private sector for electricians. Introducing a parallel data collection process is unlikely to be efficient.
- The CER data collection process would include off-grid installations of DER.

Existing network data collection processes

The source of data collection in all DNSPs begins through installers' completion of a connection notice (also known as 'Form A' or an electrical work request). A visual depiction of the process is provided in Figure 1. The process typically involves a meter replacement, as would be the case when a PV is first introduced to a residence. If the meter replacement is not needed, as might be the case when PV is upgraded or in some cases of a battery being added to existing PV at the premises, it is possible that the network could be bypassed and the installation would occur without network knowledge. If this occurs, the only people with access to any information about the installation are the system owner and the installer.

Figure 1 PV installation process – interactions between installers and networks



Some networks do not explicitly collect data about batteries, but rather about inverters, as is the case in SA. Others collect more detailed information. As an example, data presently collected through South Australia's electrical work request includes:

- Installation details (Address, Retailer, National Meter Identifier (NMI))
- Customer details (Name, ABN, contact details)
- Customer acceptance (date, signature)
- Electrician details (license number, name, contact details)
- List of fixed appliances with demand capacity of 2.5kW or greater (tick box for off-peak hot water, space heating, under floor heating, other)
- Maximum demand for installation
- Service details (New/upgraded service tick box, service phasing, service type tick boxes)
- Metering details (New/upgraded meters tick box, existing meter tick box, meter phasing, meter category, meter subtype, meter provider, meter alteration, whether consumer mains are being replaced)

Noting the above, there is no actual information about a new battery unless an installer enters details in the list of fixed appliances[4]. Even if this occurs, there is no information about battery capacity etc. as would be required if and when the distributor develops their own database and as would be required by AEMO (noting that AEMO is entitled to ask for such information).

Impact on study:

- The connection notice process could be used to enable data collection for the register if it could be sufficiently expanded to provide the correct information on a nationally consistent basis and if installers could be compelled to use it in a wider variety of situations.
- This method would exclude off-grid applications and the trade-offs of this limitation would need to be considered.

Examples of other forms of existing data collection processes

Electrical contractors must also provide safety certificates for wired in installation work undertaken. In Queensland, this is a requirement under the *Electrical Safety Regulation 2013* (ES Regulation). There are two provisions; Section 26 relates to work on electrical equipment and section 227 relates to work on electrical installation.

[4] Installers might not consider a battery to be a fixed appliance. They also might not provide the data if the transaction cost is too high.

Section 26 of the ES Regulation requires the electrical contractor to provide a certificate of testing and safety, as soon as practicable after testing the electrical work, to the person for whom the electrical work was performed. The certificate must certify that the electrical equipment, to the extent it is affected by the electrical work, is electrically safe. A licensed electrical contractor must keep a copy of a certificate given under this section for at least five years after the certificate is given.

Section 227 of the ES Regulation requires an electrical contractor to provide a certificate of testing and compliance after connecting an electrical installation on which electrical work has been performed to a source of electricity, to the person for whom the work has been performed. The certificate must certify that the electrical installation, to the extent it is affected by the electrical work, has been tested to ensure it is electrically safe and complies with the requirements of the wiring rules and any other standard applying under this regulation to the electrical installation. In addition, a licensed electrical contractor must keep a copy of a certificate given under this section for at least five years after the certificate is given.

Impact on study:

- It may be possible to expand on any of the above processes to enable data collection for a national energy storage register.
- One advantage of doing this is that data collection is not tied to requirements for new meters or other network based modifications required from networks, and will therefore include retrofits to existing PV installations which forms a significant gap in existing network data collection processes. The process would also cover off-grid applications.
- A significant disadvantage is that the process will not be uniform across all jurisdictions and that standardisation of the process may be needed across all jurisdictions in the form of adjustment to existing regulations, training and compliance checking. This would be a complex regulatory change that would potentially take longer to implement and also be more expensive.

3.2 Storage safety issues

The CEC runs an accreditation process for installers of PV systems. However, a recent study[5] written by CSIRO, commissioned by the CEC and funded by ARENA states that there is insufficient accreditation and training to support and provide qualifications for designers and installers of energy storage systems. In addition, stationary energy storage installations and related safety incidents are insufficiently reported. The report recommended:

i. Establishment of a set of best practices specific to the battery storage industry, including development and upkeep of an installation, maintenance and incident reporting database for energy storage systems in Australia.

ii. Develop training and nationally recognised accreditation pathways for designers and installers specific to energy storage in domestic and small commercial scales.

Given the information above, CEC accreditation may significantly benefit the industry, and would likely help to keep consumers, first responders, installers, line workers and the general public safe. Presently, accreditation for PV installation is incentivised by small scale tradeable certificates under the RET, which also requires that installation is undertaken by an accredited installer.

Impact on study: Requirement for accreditation is considered to be a separate issue outside the scope of the CBA given that accreditation of installers is not essential to the development of an energy storage register.

[5] "Energy Storage Safety: Responsible installation, use and disposal of domestic and small commercial systems", Task 1B, written by CSIRO and commissioned by CEC, funded through ARENA, November 2015

3.3 Development of new Australian standards for electrical installations

Standards Australia is developing national standards for small-scale commercial and residential energy storage Standards Australia. Currently being developed is the new draft Australian Standard AS/NZS 5139, Electrical Installations – Safety of battery systems for use in inverter energy systems will enable the safe installation of battery energy storage systems. The draft document is expected to contain provisions for:

- Installation requirements for all battery systems connected to inverter energy systems, covering all battery types of greater than 1 kWh and less than 200 kWh
- Product standards
- Grid integration.

The standards have not yet been released, but are expected to include requirements for labelling and signage of battery storage devices.

Impact on study: Safety benefits from a national register only relate to those that are incremental to benefits expected to be achieved from adoption of incoming national standards.

3.4 AEMO's likely investment in real time data management

A peculiarity particular to storage is that its output in kWh is not easily modelled using other available data. PV generation for example, can be modelled against solar insolation levels to provide a reasonable proxy for output, though this method ignores impact of cloud cover or other shading or orientation issues.

AEMO has indicated that real time shape data will be collected as a separate exercise through a sampling approach, regardless of whether the energy storage register goes ahead. This means that it is feasible to assume that the shape of generation output for storage can be reasonably approximated using the data from the register assuming it becomes available.

Impact on study: Given that AEMO is already looking at measures to collect and analyse real time data through a separate process, options considered for a national database will only consider the needs for static data. Further, assessment of benefits will only capture the incremental benefits that static data will provide in addition to the benefits that real time data will provide, noting that the combination of real time and static data is likely to be more effective than either considered alone.

4. Design considerations for a national register

The implementation of a national register requires consideration of:

- **Technologies to be captured.** This relates to the types of DERs captured in the database and is expected to be consistent across all options considered
- **Granularity of data and access arrangement**: The information requirements by different user groups and the access arrangement in place to enable information sharing. This is expected to be consistent across all options being considered
- **The host**: A suitable host that develops, operates and maintains the database
- **Collection agency and mechanism:** The agency responsible for issuing a requirement to collect the data, and the rules, regulation or legislation supporting this requirement
- **Source of information**: The person charged with the responsibility to collect the data

These considerations are discussed in the following sections.

4.1 Technologies to be captured

Through discussions with stakeholders, it is understood that for continued relevance in a changing market, it is essential that the register is sufficiently flexible and scalable over time to capture emerging technologies and trends. Initially, it is proposed that for all options being considered, the register will initially capture information about the following, and be adapted to include further technologies as the need arises:

- Battery storage systems – the lack of visibility of battery storage devices that over time will lead to significant inefficiencies in prediction and load response and management
- PV systems – Whilst there is some information on PV systems being collected by CER, the information available is incomplete for AEMO's operational purposes because it does not include information on retrofits which may begin to become more prevalent. More importantly, data will no longer be collected or maintained once the SRES scheme ends and may be partially collected once the SRES scheme incentives reduce to a point that no longer encourages registration of systems. CER estimates that PV data will be less reliable from 2024
- Inverters used to convert current from DC to AC in either or both of the above systems.

For managing network issues, networks would prefer not to impose a lower size limit as it is too difficult to know what will be important later on. Rather, if a limitation was required to exclude batteries or equipment that is not likely to affect grid operation, networks prefer to exclude systems that are not able to export power to the grid[6]; this would equivalently exclude systems without an AS 4777 inverter. This would also effectively include charging stations for electric vehicles where batteries from these vehicles are able to export to the grid. Plug and play technologies[7] are unlikely to be able to be captured as these might not require installation by electrical contractors. Ideally it would be optimal to include systems that don't export as well as 'Plug and play' technologies in the list of system types requiring information.

4.2 Granularity of data and access arrangement

AEMO and DNSP requirements are considered to be the minimum requirements to be captured in all options considered. All other information needs for other user groups will include subsets of the above, and often in aggregated forms.

[6] Noting that facilities that do not export power may still impact on demand if these residences also import power, and that safety risks may also be present with systems that do not export power.

[7] Plug and play technologies include solutions where entire distributed energy solutions are pre-assembled and can be installed in homes without requiring an electrician. These approaches offer reductions in 'balance of system' costs. See http://pv.energytrend.com/knowledge/PV_20120625.html. When these solutions are installed, it would be ideal if the database host were to be advised; however, the practicality of this requirement may depend on regulations, if any, accompanying the technology.

For all database options to be considered, it is assumed that access to some of the data will be required by a number of users. The granularity of the data provided to different user groups depends on how the information will be used as well as any privacy laws. At this stage, it is expected that all options considered will allow for four interfaces (i.e. portals). These are detailed in Table 5. It is expected that the granularity of data needed will be refined through the detailed design, but that the information contained in Table 5 will form the basis of discussions with relevant stakeholders and the designers.

Table 5: Portal characteristics

Portal users	Granularity of data needed	Purpose of access
AEMO	• NMI identifier • Installation date • Decommissioning date • Manufacturer make and model number • Capacity • Performance derating (desirable but not critical) • Device part of aggregated control • Trip setting (inverters) • Enabled mode of operations (inverters)	• Dispatch power system security monitoring • Contingency planning • Forecasting and planning • Short term planning and operation • Management of load balancing including load shedding and potential system shutdowns resulting from large withdrawals of capacity
DNSPs	• NMI identifier or postcode • Installation date • Decommissioning date • Manufacturer, make and model number • Capacity (continuous kW and storage kWh) • Performance derating (desirable but not critical) • Device part of aggregated control • Trip settings (frequency and voltage) • Enabled mode of operations (inverters) • Demand side participation contract • Customer details - customer name, phone number, mobile phone number and an email address (preferred)	• System islanding to allow works on local networks and improve occupational health and safety risks • Assist networks with development of proactive rather than reactive planning • Enable a strategic approach to upgrading the network • Reduce capacity upgrades • Build up heat maps to enable reduced forecast spend • Improve understanding of demand behaviour • Improve ratio of spending against quality of supply rather than quantity of supply
Emergency response agencies	• NMI • Address • Contact details • Existence of battery • Battery type and make • Chemical composition • Capacity	• To identify and prepare for potential risks prior to arriving at an emergency (unconfirmed)
Policy makers, researchers, consultants and market investors	Aggregated data only (by postcode, statistical area or zone substation): • Technology • Capacity	• Undertaking strategic policy studies to enable market transitions to low carbon technologies, undertake impact analysis of existing or potential policies or review existing market programs • Assess stranded asset risk for new market asset acquisitions, development or power purchase agreements

A key objection raised by some stakeholders in response to the consultation paper is that the requested data is too extensive and will create a burden for installers. 'The Customer Advocate' stated that 'the dataset required should be critically reviewed and minimised for absolute necessity'. This is a practical suggestion, particularly as the entire data collection process will be heavily impacted by the amount of buy-in that can be obtained from consumers and installers. If the register goes ahead, these issues should be discussed in greater detail through the design phase. In particular, 'need to have' versus 'nice to have' must be addressed, and removal of information available through other sources is advised. Further recommendations on how the list should change are provided in Table 6.

Table 6: Suggested amendments to data requirements raised by stakeholders response to consultation paper

Stakeholder	Data suggestion
AGL	Duplication and inefficiencies if require the collection of 'device part of aggregated control'. This data may change over time and is collected by AEMO through other process (AEMO's Demand Side Participation Information Guidelines)
Ausgrid	Suggest data collected should be cross checked against DNSP connection notice data. Minimum level of information required by DNSPs includes: • NMI and address • Installation and decommissioning date • Manufacturer, make and model number • Capacity (continuous kW and storage kWh) • Aggregator (if applicable) Other information can be derived from manufacturer/technology list.
Citipower and Powercor	Recommended changes: • 'NMI identifier (or postcode)' to be changed to 'NMI identifier and postcode'. • To add 'short term peak output (if applicable)' to 'Capacity (continuous kW, and storage kWh)'.
Energy Networks Australia	'NMI identifier (or postcode)' should be changed to 'NMI identifier and postcode'. Add 'short-term peak output (if applicable)' to 'Capacity (continuous kW, and storage kWh)' Other useful data includes: • NMI identifier delete "(or postcode)" • Capacity (kVA of inverter) • Demand response modes • Power quality response modes • pf/VAR range Register could be expanded to include information on load switching and demand response services.
Ergon and Energex	This system will need to capture changes over time as systems are replaced, updated or increased in capacity. In general the residential battery range will be from 24-48V DC. Due to a higher safety risk, a separate category could be established for larger battery systems (e.g. 600V DC). DNSPs may also collect other associated data (e.g. length of consumer mains, conductor type, and number of phases to grid connected inverter) to identify network impacts as part of network connection process.
Red and Lumo Energy	Question the granularity of data requested by the networks in particular Have provided specific comments on all data requirements listed in our reports (including unobtainable data, publicly available data, variable data and data that are unrelated to the objective). Specifically: • Battery performance derating cannot be specified at time of installation • Decommissioning date is unlikely to be updated • Trip settings are regulated through Australian Standards • Inverter enabled mode of operations can be adjusted post installation • Demand side participation contract can similarly change post installation • Monopoly businesses should not have access to individual customer details • Storage kWh may provide commercially sensitive information to monopoly businesses

Stakeholder	Data suggestion
	• Manufacturer, make and model number should not be needed for network security purposes

4.3 Database host alternatives

Three database host options have been considered. These include a national database developed, operated and maintained by:

- AEMO
- CER
- DNSPs.

Other feasible options were not identified through our scoping process, noting that stakeholders were not receptive to a private sector administrator or to a subscription based service.

To identify the host options that should be scoped and assessed in more detail, we identified the enablers, challenges, advantages and disadvantages of each option. In particular, we considered:

- Willingness of potential register hosts to take on new responsibilities
- Market support or opposition for a given approach
- Ability to utilise existing systems, processes and/or resources to reduce cost
- Whether the approach creates or reduces duplication across market or jurisdictions
- Impact on quality and reliability of data, if any (as this may affect the benefits).

The broad concepts of these options, and the relative advantages and challenges are outlined below.

Host alternative 1: A national register hosted by AEMO

This alternative would involve AEMO establishing a new national register for DERs that would consolidate all information already available from DNSPs and CER into one consistent register.

AEMO has advised that if it is identified as the most cost effective option, it would be willing and able to host and manage the database. AEMO's main concern is that it did not have the regulatory remit to collect the data and would likely still require the DNSPs to collect the data (through its connection agreements). Alternatively, new regulation and data collection processes would need to be introduced, which would be less cost effective. This is discussed further in Section 4.4.

Based on consultation with CER, it is understood that if AEMO hosted a national database, CER would still need to maintain its own STC database and most likely, to also continue collecting its own data for the purpose of STC accreditation.

Table 7 summarises the advantages and challenges associated with this option which would need to be considered further.

Table 7: Summary of advantages and challenges of AEMO hosting the database

Advantages	Challenges
• AEMO has the skills and experience to manage and host the database • AEMO has an existing register to collate, aggregate and analyse data that is accessed from the DNSPs. This database could be used as a platform for the new database (though noting that the significant amendments and expansion will be required) • AEMO is an independent market body who has already	• DNSPs would still require their own databases for their operational needs and its own data collection process, leading to potential duplication costs • AEMO does not currently have the power to collect information, only the power to access information. Without a change in powers, AEMO would still be required to rely on DNSPs to collect the data on its behalf. This change in powers would require regulatory change

Advantages	Challenges
addressed privacy concerns in their existing database platforms • AEMO's existence is not subject to government funding or policy position • AEMO, as the host of the register requires the greatest granularity of data. This reduces the risk of privacy issues being compromised; noting that access by other users will be limited through use of specified portals. • AEMO would be the primary user of the data being collected. This would help ensure that data is stored and managed in a format that is most beneficial for its key purpose. It would also allow for the database to be updated and refined over time if AEMOs needs changed over time • AEMO already has database interfaces with DNSPs, which would reduce the cost of transferring data to them (i.e. reduce costs of harmonisation)	• AEMO does not currently have the regulatory remit to supply detailed data to non-market players. It is, however, possible to provide a portal for aggregated data which is more appropriate in any case • CER believed it would still need to maintain its existing STC database and potentially its data collection processes, leading to inefficiency costs for installers as well as CER. (As discussed above, there are ways in which these costs could potentially be reduced and options to do this should be investigated in the design phase). • AEMO would need to expand[8] its database to possibly include off-grid and/or minor grid applications[9]. • Some stakeholders raised the issue that AEMO may not operate as a monopoly in the future with respect to distribution system or transmission operation and therefore it would not be appropriate for them to host the database as they would have a competitive advantage. We do not agree with this premise on the grounds that the operation of the database could always be ring-fenced under such an eventuality.

Host alternative 2: A national register hosted by CER

This option would involve CER expanding its existing STC database to include other DERs, and to capture a more extensive dataset than what is currently being collected.

Through the preliminary consultation process with CER, it appears that CER's database already has established links with AEMO but no established links to the networks. It is expected that under this option, existing links would be used (and potentially updated) to transfer relevant information to AEMO. AEMO would then utilise its existing information sharing channels with DNSPs to transfer relevant data to them. This would reduce the cost of establishing new database interfaces, establishing new privacy settings, and potentially creating new regulation which would be needed to enable CER to share data with the networks.

The key challenge lies in CER's ability to collect the data. Under current legislation, the CER's ability to collect data needs to be linked to clean energy and the overarching climate change objective. The battery storage database would need to collect data on various devices with no direct relationship to the climate change agenda. This would require a change under Commonwealth law.

DNSPs noted that the CER has links to the regulatory bodies which could assist in facilitating compliant connection processes, and discussions undertaken with the CER indicated that their serial number app and/or other industry apps could be adapted to assist with distributor connection notice requirements.

Based on consultation with DNSPs, it is expected that they will continue to maintain their own registers for their own operational purposes, and where distributors are behind in the development of a standard, they are likely to invest more in the development of an internal database in the near future. Some coordination of information collection processes may be required between the register host and DNSPs to reduce administrative costs; however this would be relevant to both options.

Table 8 summarises the advantages and challenges associated with this option which would need to be considered further.

[8] System planning is not relevant to off-grid applications, but health and safety issues or regulatory compliance requirements may require information to be held for off-grid applications.

[9] AEMO only monitors major grids including the NEM (the national energy market located in the eastern states of Australia) and the SWIS (the south west interconnected system located in the south of Western Australia). Horizon Power in the north of Western Australia has advised Jacobs that they already collect and collate PV and storage data so a register is unlikely to be needed for this region. Jacobs' are unaware of collection and collation ability in other minor grids such as the Darwin-Katherine interconnected system or Mt Isa.

Table 8: Summary of advantages and challenges of CER hosting the database

Advantages	Challenges
• CER has the skills and experience to manage and host the database, based on their current STC register experience • CER has an existing register which could be amended and expanded to include other forms of distributed generation other than PV as well as more comprehensive data on PV systems. This may reduce the development costs and speed up the availability of the register for general use. • CER has an existing PV data collection process that is understood and used by installers. It has also invested in new processes to improve the efficiency and integrity of data collection (e.g. the Serial Number Validating Project) • CER has invested significant time and effort in establishing relationships with installers and agents and establishing processes that are well integrated with other industry processes and jurisdictional requirements • CER is more easily able to supply aggregated data on PV systems to non-market players than AEMO • CER has established processes for dealing with jurisdictional regulatory and safety bodies to ensure compliant connection processes are in place. • CER's database has an established channel with AEMO that has been developed over two years. Currently, information is updated on this channel every three hours. • CER is an independent government body with appropriate protocols in place to address any privacy concerns	• CER does not have the regulatory remit or the processes to collect data for non PV systems. Additional regulatory changes would be required to address this • CER does not have established processes to share battery data with DNSPs • CER's ongoing role and existence is not guaranteed. It was established on 2 April 2012 as an independent statutory authority by the *Clean Energy Regulator Act 2011* and presently collects information on PV connections under the SRET. Its continued existence and ongoing role beyond the RET scheme is subject to future government policies and funding decisions. • CER's capacity to efficiently manage data or technology amendments to meet AEMO's or DNSP's requirements may be more challenging given their distance from operational market management issues • If the CER process were to duplicate the DNSP connection process, inefficiencies would be introduced • The current approach by CER for managing PV may results in overestimation of the total installed capacity of solar PV as it also records panel array upgrades or replacements. It is l kely that this will also occur for batteries. This may be due to CER not linking data to a NMI.

Host alternative 3: Battery storage databases administered by DNSPs

This option involves enhancing existing information gathering systems, so that relevant details from distribution network service provider connection agreements, and demand side response reporting requirements are placed in a central repository collected by DNSPs and passed on to AEMO for collation into a central database to be shared with other market participants.

Under this option:

- DNSPs would hold their own registers which collect the data in the granularity they need for operational purposes as well as the granularity needed by AEMO
- There would be 14 separate databases that transfer data to AEMO who would then transfer data to CER who could then pass on the information to non-market groups (e.g. government and academics).
- AEMO would therefore still need to expand its existing database
- Storage of data would need to be consistent across DNSPs, requiring harmonisation of connection forms, systems and possibly regulatory processes. Data collection would need to be extended beyond existing connection notice requirements to include batteries that are not presently being reported (this is discussed more in Section 4.4)

A key limitation of this option is the higher implementation costs for the same benefits that could be achieved under the other host alternatives. Under this option, 14[10] DNSPs would need to invest in new or updated registers and data collection processes. While estimated costs for these amendments were not provided in the

[10] NEM and SWIS only; Excludes minor grids

DNSPs' responses to questionnaires (refer to Appendix D.2 and Appendix E), it was suggested that this investment could be significant.

Assuming approximately $150,000 per DNSP as an average estimate[11], the total hardware investment would be more than $2 million. These costs are more than double the development costs estimated by AEMO for Option 1 and CER Option 2 (discussed further in Section 7.1). Some responses to the consultation paper, particularly from Ergon Energy Corporation Limited (Ergon Energy) and Energex Limited (Energex) questioned whether this development cost would be lower given that some DNSPs would have progressed development of their systems to more advanced stages. However, it is still expected that the overall costs would be higher than host alternative 1 and 2, with no additional benefits. Further, having 14 different data storage and management databases presents other challenges in maintaining consistency of data format, quality and timing.

Other additional costs include the duplication of data management and dissemination data across 14 different organisations and the need for AEMO to still need to invest in its own database to consolidate the data from DNSPs prior to using and enabling access to other users.

Table 9 summarises the advantages and challenges associated with this option which would need to be considered further.

Table 9: Advantages and challenges associated with DNSP as database host

Advantages	Challenges
• DNSPs and AEMO already share information, with many DNSPs already having databases that are used to store this data and share relevant data with AEMO • DNSPs are expected to take on a number of new respons bilities over the next decade, some of which are outlined in the Electricity Network Transformation Network. Hosting the databases may act as a platform for some of these changes.	• It is understood that some DNSPs have not sufficiently developed their databases to transfer the information to AEMO. This would require duplication in hardware costs as well as data management and administration costs • DNSPs with existing databases would still need to invest in IT development to expand these databases to collect and store the necessary data. This would be a significant cost across 14 DNSPs (as outlined above, more than double that expected for Option 1 and Option 2) • Additional investment would still be required by AEMO to develop a database that stores information and can share information with other users. This cost would be similar to the costs in Option 1 and would be in addition to the costs imposed on DNSPs • CER would still need to maintain its own separate database so no streamlined cost savings would be available from this option • Having 14 separate data storage and management systems could mean inconsistency in format of information, quality of information and timeliness of information provided across jurisdictions • All DNSPs who responded to the consultation paper appear to prefer a centrally run national register.

Based on the above discussion, it is apparent that host alternative 3 will incur a higher cost than alternative 1 and 2 for the same benefits. As such, the alternative to have DNSPs as hosts of the databases is not considered further in the analysis.

4.3.1 Stakeholder preferences

The majority of stakeholders indicated a strong preference for a national database which would be possible under either host alternative 1 and 2.

[11] Whilst no respondents provided an estimate, some indicated that it would be over $100,000 in IT costs.

DNSPs had some concerns about relying on a third party for data, especially whether this would reduce the quality of the data collected and impose higher auditing and data validation costs. Generally DNSPs had a preference for AEMO as the host. Six DNSPs provided written responses to a questionnaire distributed through the Energy Networks Association (refer to Appendix D.2). From these responses (summarised in Appendix E):

- There were some concerns that relying on a third party for data would reduce the quality of the data collected, imposing costs on DNSPs for more auditing and data validation
- Most of the respondents preferred to continue collecting the data using existing processes and provide this information to AEMO. This relates to the collection mechanism rather than the host option and is discussed further in Section 4.4.

In the response to the consultation paper, Energy Networks Australia was particularly concerned about the uncertainty around the CER's long term ongoing existence and CER's lower capacity (relative to AEMO) to manage technology based or other market based changes that might be required for AEMO or DNSPs on an ongoing basis.

Retailers questioned the need for a register including the need for such specific data by AEMO. If a register is to be implemented, retailers generally indicated a preference for CER being the host rather than AEMO. This preference was driven by CER's ability to build on its existing STC database and processes and a concern that AEMO may one day gain a competitive advantage with other potential market operators in the future.

The CEC also preferred CER to AEMO as the host. In particular, it highlighted that AEMO's long term role in the market may be influenced by future policy changes to the regulated market and therefore challenged the assertion that "AEMO's existence is not subject to government funding or policy position" and that "AEMO would be the primary user of the data being collected".

Some stakeholders questioned why the DNSP host alternative (host alternative 3) was not assessed in more detail. Whilst it was generally agreed that the upfront costs may be higher there was some interest in more detailed analysis to confirm this. For example, Ergon Energy Corporation Limited noted that DNSPs already do and will continue to collect a large amount of the required data and would therefore consider these costs to be incurred regardless of which option is chosen. This comment seems to relate more to the collection mechanism (discussed in Section 4.4.) than the hosting option. Energy Networks Australia also suggested that DNSPs are likely to undertake a number of important actions identified in the Electricity Network Transformation Roadmap which may require some of their systems to be upgraded in any case.

GreenSync suggested that the higher upfront costs faced by DNSPs as potential database hosts could be offset by other potential benefits that may become available to DNSPs if they host the database – e.g. innovation benefits. Whilst this may be true, there is no reason why these benefits wouldn't also exist under different host options as they are attributable to data access rather than management.

Impact on study: It is believed that all concerns about the host alternatives 1 (AEMO) and 2 (CER) can be managed if necessary and that both options should be considered further in the CBA.

Although some stakeholders requested that the DNSP host options be considered in more detail, most of the benefits relate to DNSPs collecting the data for a national database rather than hosting it. A single host (e.g. AEMO or CER) is a lower cost option than having 14 separate DNSP databases. Using DNSPs as the collection agency for either of these host alternatives would utilise existing processes and therefore may be easier to implement over a short timeframe.

Issues relating to the collection mechanisms are considered in more detail below in Section 4.4.

4.4 Data collection agency and mechanism

There are a number of data collection mechanisms that could be utilised as part of a national battery storage database. These include:

- New registration with AEMO

- Expansion of existing DNSP connection agreements
- Expansion of electrical safety licence conditions
- Expansion of CER collection mechanisms.

Each collection mechanism is discussed in more detail in the following sections.

Collection mechanism option 1: New registration with AEMO

This collection mechanism would impose an obligation on homeowners to ensure that relevant data is passed on to AEMO when batteries or PV panels are installed or refurbished. For this collection mechanism to be effective, AEMO would need to adjust its current exemptions of non-market generating systems below 5 MW from being registered in the NEM.

This collection mechanism imposes new administrative costs on AEMO and places an additional burden on DER customers which are predominantly households. These issues would need to be assessed and considered in more detail as part of the detailed design.

This process would be impractical and is not considered further.

Expansion of existing DNSP connection agreements

This collection mechanism involves expanding existing DNSP connection agreements to require more complete DER data to be collected. The data collected could either be held by DERs prior to transfer to AEMO (host alternative 1) or be transferred directly to a central database (host alternatives 1 and 2).

Currently, there are some limitations on the DER data that is collected. Based on responses to questionnaires sent to DNSPs, connection notices may not currently capture batteries installed under the following scenarios:

- Customer does not need a service from the network in the form of some service on the meter, street connection or inverter (e.g. retrofit on existing PV system)
- Customer is on extra low voltage system
- Customer has not used a licensed electrician because the installation is below 2.5 kW
- The potential loss of existing feed in tariff arrangements might provide a strong disincentive for customers not to notify where their installations are changing to include additional DER
- Customer has installed DER through a changeover switch arrangement and the network is only used for back-up
- In the scenario where a customer is connected to the network and has a DER installed, the addition of a battery may not require a supply/metering service order to be generated. Without connection agreement being enforced the distributor could be blind to the battery connection.

Approaches to reach customers and installers in the above situations can include soft incentives and penalties for non-compliance. If this collection mechanism is pursued further, it will also be necessary to consider whether a more consistent and streamlined processes will be implemented. Currently some DNSPs use electronic forms and others paper forms. This data collection mechanism therefore provides an opportunity to improve consistency and efficiency of data collection requirements across DNSPs. It may also be possible to use the industry apps currently being used by the CER to facilitate collection.

Based on advice from the Australian Government solicitor, this data collection approach would require change to the NEL. Currently, the NEL requires installers to supply information about significant energy generation equipment installation on a site, but it does not happen unless a service from the DNSP is needed. As such, this collection approach would likely need an amendment to Chapter 5A of the National Electricity Rules to create a clear obligation to provide the relevant information via the DNSP connection agreement process and to enable the host to access that information. The National Electricity (South Australia) regulations and law in Western Australia (WA) may also require modification because the NEL does not yet apply in WA. Applying this collection approach would need to introduce mechanisms that incentivise information provision or otherwise penalise installers who do not provide information.

Expansion of electrical safety licence conditions

Under this collection mechanism, electrician licence conditions would need to impose an obligation for electricians to collect and pass on relevant data to a national database.

State/Territory electrical safety regulations require installers to provide a certificate of completion of their electrical work at a property. To enable this collection mechanism, licence conditions would need to be enhanced to facilitate data collection for a DER register. AEMO has also advised that changes would also be required to the NER to create a data collection schedule that would enable timely updates of important information.

This collection mechanism has the benefit of not being tied to requirements for new meters or other network based modifications required from networks, and will therefore include retrofits to existing PV installations which contribute to a key gap in existing network data collection processes. However, a key disadvantage is the complexity in implementation. Regulatory changes would be required across all jurisdictions, and some form of standardisation will be essential. This could lead to higher implementation costs and significantly longer implementation periods (estimated to be in excess of two years). Further, given that safety is not the main driver for the development of a database, using safety licence conditions as the collection mechanisms may not have the necessary industry support to deliver the required regulatory changes.

Jurisdictions were asked if amendment to some regulations may be needed to achieve the following:

- ***Require that installers be qualified electricians.*** South Australia advised that the Plumbers, Gasfitters and Electricians Act, 1995 (PGE Act) contains a definition of "electrical installation" that may allow non licensed electricians to install batteries in off-grid/standalone installations. NSW advised that electricians are not required to undertake installations at extra low voltage, and it may be costly to require electricians to undertake all installations at extra low voltage. However Tasmania and Western Australia advised that no change to Acts or regulation would be needed.
- ***Require that installers provide requested data to a host of a battery storage register.*** Suggested amendments may be required for the following regulations:
  - The Electricity (General) Regulations 2012 made under the Electricity Act 1996 (South Australia)
  - The Occupational Licensing Act 2005 (Tasmania)
  - Electricity (Licensing) Regulations 1991 made under the Electricity Act 1945 (Western Australia)
  - Electricity (Consumer Safety) Electricity Act 2004, Electricity (Consumer Safety) Regulation 2015 and Electricity (Consumer Safety) Regulation 2015 (NSW)
  - Electricity Safety (Installation) regulations 2009 made under Electricity Safety Act 1998 (Victoria)
- ***Extend the requirements of existing rules so that a wider range of installations and/or equipment is covered by data collection.*** Western Australia advised that no changes to existing electrical safety regulations would be needed but critical national standards would need amending, especially AS/NZS 3000 (Wiring Rules) which are called up in WA's regulations. South Australia concurred that standards may require review.

The above is not a complete list of the regulatory changes required, but demonstrates the complexity of the required changes. The complexity of these changes poses significant risks to the effectiveness of a national database. In addition to imposing higher administrative costs, aligning a number of regulatory changes across jurisdictions could mean that a consistent and agreed approach is not implemented for a number of years after allowing for the necessary consultation. A delayed implementation period will also reduce the host and other participants' abilities to refine the register (i.e. address any minor glitches during rollout) and reduce the host and other participants' ability to educate the sector to achieve the necessary buy-in from installers. By the time the register is fully rolled up and embraced by the sector, there is a high risk that the battery storage market would be mature by the time the database is in place. This would be a missed opportunity to realise the intended benefits and the host would not be able to sufficiently capture retrospective data.

Given the complexities discussed above, this collection process is not considered further in the CBA.

Expansion of CER collection mechanisms

Under this collection mechanism, CER would expand its current rules and process used by the CER for its REC database. This would require the adjustment of information requirements for PV systems and adding information requirements for batteries and inverters. This approach has some limitations in the ability to streamline other data collection needs for DNSPs, but these functionalities could be considered and introduced over time.

It may also be challenging to capture data changes over the life cycle of the battery, for example when a storage system or component is replaced due to a failure or upgrade. These issues could be considered and options to address them could be introduced over time.

Voluntary (including incentive based approaches) are presently the only practical options to require installers to provide information to the CER. As such, applying this collection approach would need to introduce mechanisms to incentivise information provision or otherwise penalise installers who do not provide information.

4.5 Mechanism for enabling data collection

The data collection processes discussed in this report would each depend on change to National Electricity Law (NEL) or changes to state and territory law, and sometimes a combination of both. Based on advice from the Australian Government solicitor, the three data collection approaches would require change as specified in Table 10. Review of the outcomes in the table shows that the only practical options for regulating data collection are to strengthen approaches for installers to provide information through DNSP connection notices and/or through the CER industry based apps. Using the safety regulation is fraught with difficulty and would be too expensive and time consuming. Neither form of data collection precludes AEMO from hosting the register.

Table 10 Changes required to NEL and/or jurisdictional laws

Collection approach	Rule changes to compel installers to provide information	Most efficient approach to enable the information to be supplied to AEMO	Comments
CER app	Change to Commonwealth law would be required to confer hosting responsibility to the CER. Voluntary (including incentive based approaches) are the only practical options to require installers to provide information to the CER.	No changes needed	An approach is needed to incentivise information provision or otherwise penalise installers who do not provide information.
DNSP connection notices	The NEL already requires installers to supply information about significant energy generation equipment installation on a site, but it does not happen unless a service from the DNSP is needed.	Amending Chapter 5A of the NER to create a clear obligation to provide the relevant information via the DNSP connection agreement process and to enable the host to access that information. The National Electricity (South Australia) regulations and law in Western Australia (WA) may also require modification because the NEL does not apply in WA.	An approach is needed to incentivise information provision or otherwise penalise installers who do not provide information.

Collection approach	Rule changes to compel installers to provide information	Most efficient approach to enable the information to be supplied to AEMO	Comments
Safety certificates	Each jurisdiction would need to amend safety regulation		Expensive, time consuming and difficult.

Impact on study:

- Amendment of safety regulation will not be part of the process recommended by the CBA. Instead, the CBA considers only the CER app and DNSP connection notice alternatives.

Comparison of viable collection mechanisms

The following table provides a brief summary of the two feasible data collection mechanisms and indicates its compatibility with the host options considered in Section 4.3.

Table 11: Summary of collection mechanisms

Collection mechanism	Compatibility with host options	Advantages	Disadvantages
Expansion of existing DNSP connection agreements	✓ AEMO (host alternative 1) ✓ CER (host alternative 2)	• Utilises existing collection processes systems as much as possible and therefore jurisdictions can manage their data collection processes within their existing regulation. • DNSPs have the processes in place through their connection agreements which can be strengthened to collect the necessary data. • Using NMI as the identifier avoids double counting of assets • There would be opportunities to streamline DNSP processes and data collections and to introduce shared processes that are more efficient.	• DNSPs do not have consistent databases or data collection processes, therefore potentially increasing the administration cost for the host unless these can be unified • Soft incentives or punitive measures may be required to capture connection notices not presently being filled in
Expansion of CER collection mechanisms	✓ CER (host alternative 2)	• Utilises existing processes that installers are already familiar with • Can build on existing efficiencies and apps developed for PV systems (e.g. Serial Number Validating Project) • Can be combined with soft incentives such as warranty/validation of genuine product, customer management systems and scheduling applications	• Duplication with DNSP data collection processes, unless able to streamline • Not clear how data can be collected for refurbishments and replacements of PV systems.

The different collection mechanisms should be considered in further detail. It may be appropriate that existing processes (e.g. DNSP as the collection agency) are utilised in the short term until other mechanisms are available. Combination of some of the above options may also be appropriate. For example:

- To reduce duplication of effort, while the STC applications continue, the CER process could be used for the collection of PV system data, and DNSP processes could be used to collect battery data. Once STCs are no longer created, the PV data collection process could merge with the battery data collection process

- Collecting data through DNSP processes may be more appropriate within the NEM and the WEM, with an alternative mechanism used in off-grid areas or in minor grids
- Industry apps could be adjusted to collect the same data for both DNSP connection notices and STC applications

4.6 Data collection tool

The tool used to collect and transfer data to a national database may involve:

- **A new fit for purpose app.** This involves developing a new fit for purpose mobile app or web service that combines the needs of the national energy storage database and DNSP requirements (i.e. connection notices).
- **Enhancing existing CER collection process** – This involves enhancing the existing process used by the CER for its STC database and would require the adjustment of information requirements for PV and adding information requirements for batteries. This approach has some limitations in the ability to streamline other data collection needs for DNSP, but these functionalities could be considered and introduced over time.

Developing a fit for purpose app has the benefits of streamlining a range of requirements (e.g. connection notices) and guaranteeing that efficiencies such as bar code scans, manufacturer lists, and NMI identifiers are built in to the collection. It also offers other potential benefits, such as:

- Improved reliability of data quality. Applications can have built in data validation functions that prevent a form from being submitted unless completed in its entirety. This also reduces data validation efforts by the database host
- Reduced data transfer time. An on-site app would mean that data is transferred directly to the database on the day of installation
- Improved flexibility to adjust the data requirements, and the covered DERs. This is important at the early stages when the requirements are being tested and refined and as new technologies emerge.
- Improved consistency across jurisdictions. In particular, one application would ensure that any updates to data requirements could be rolled out to jurisdictions simultaneously, rather than relying on paper forms to be replaced.

Despite the above benefits, CER has cautioned against introducing an app that must be used by installers. Based on its experience with the STC database, electricians currently use a range of apps and tools to meet a range of needs, including warranty information, scheduling regulatory requirements etc. Providing another app may not result in the expected time savings if it is used as an 'additional' tool rather than replacing existing processes. Further, if the use of a new app is regulated, it would be in direct competition with ones currently available on the market (i.e. ones that have been developed in response to requirements imposed by CER).

Through consultation with the industry for its STC database, CER has determined that the industry prefers to adapt their existing apps to meet the needs of new regulatory requirements. This would involve providing the necessary forms to installers and their agents which have the new information requirements. Over time it is expected that that existing apps used by electricians (privately developed) would be adjusted to capture these new requirements and to sync them to the national database.

Whilst the CBA captures both of these data collection tools in the analysis, it is expected that the most efficient and viable approach will be considered in more detail as part of the detailed design process.

4.7 Role of the installer

For all options, irrespective of host, collection agency and mechanism, the data will be collected by an electrician at the time of installation.

To ensure that data is collected for all new DERs, either incentives or regulations are required. Incentives are not currently available for battery storage devices apart from the ACT which has recently implemented its Next

Generation Energy Storage Grants. Without a commitment for a long term incentives program that will be extended over time to cover different technologies, it is proposed that a national storage database is accompanied by regulation:

- That an electrician is always required to install DERs:
  - At any voltage level
  - With capability to export to the grid[12]
- That the electrician installing the DER is required to collect and transfer data for inclusion in a national database.

The mechanism to enforce this data collection may vary by option as discussed in Section 4.4 above.

Some suggestions for incentives provided by stakeholders include:

- Fast track assessments
- More generous export benefits
- Enable apps to also provide Enterprise Resource Planning (ERP); i.e. scheduling services
- Enable apps to provide Customer Relations Management services

Some stakeholders also suggested tougher non-compliance penalties.

[12] These may include charging stations for electric vehicle batteries.

5. CBA Options for a national database

The national database options considered in the CBA are named based on the host of the database, but they also vary in the assumed collection agency, mechanism and tools. These options include:

- Option 1: A national register administered by AEMO with DNSPs as the collection agency
- Option 2: A national register administered by CER with CER as the collection agency
- Option 3: Base Case (status quo) option. Option 3 is not considered in its own right, but the impacts of Option 1 and 2 are considered relative to the base case – i.e. only the incremental costs and benefits of Option 1 and 2 relative to the base case are captured.

The design components assumed for Option 1 and Option 2 are summarised in Table 12. For Option 1 (AEMO host), it is assumed that DNSPs are the collection agency and that data is collected using a new fit for purpose app that can be used to streamline existing DNSP processes. For Option 2 (CER host), it is assumed that CER is the collection agency and that an enhanced CER data collection process is implemented.

The collection agencies and data collection tools assumed for each option enable a comparison of the relative costs and benefits of different design options. Although a less likely scenario, DNSPs could act as the collection agency for a CER hosted database and/ or the CER collection process could be applied to an AEMO hosted database. The preference between these design options will depend on further consultation with all affected parties and a more detailed assessment of the cost and deliverability of the underpinning regulatory or rule changes (i.e. possible collection mechanisms).

Table 12 : Summary of CBA Option 1 and Option 2

Design Feature	Option 1	Option 2
Database host	AEMO	CER
Collection agency	DNSPs	CER
Possible collection mechanisms	Expansion of existing DNSP connection agreements	Expansion of CER collection mechanisms
Assumed data collection tool	New fit for purpose app	Enhancing existing CER collection process
Data collector	Installers	
Data granularity	As outlined in Section 4.2	
Technologies to be captured	Battery storage systems, PV systems and inverters	

The base case is included in the assessment for comparison purposes. The costs and benefits associated with all the options are assessed incrementally to those that would otherwise be incurred in the base case.

Under the base case it is assumed that:

- There would be no further investment in a national register
- AEMO would continue purchasing and eventually installing a separate real time database, but this would not be complemented by complete and reliable static information
- Distributors would continue to enhance and develop their own databases, but because of data collection issues would only collect around 30% of new storage installations, consistently understating available storage capacity in their projections and operations

In 2016 the Energy Storage Council and Global-Roam Pty Ltd partnered to develop a privately run and managed national storage register[13]. The register is presently in early stages of development and is based on developing information gathering partnerships with selected industry stakeholders (such as manufacturers and

[13] http://www.batterystorage.info/whythissite/

installers for example) in order to provide this information to other stakeholders on a subscription basis. Based on the present risk around the timing and depth of information available from the available data sources, we have assumed that this database will not be developed to a level exceeding present arrangements undertaken by network operators who use connection notices to gather the required data.

6. Cost benefit analysis approach

Cost benefit analysis (CBA) is a quantitative tool for assessing the economic viability of a project or policy. In order to assess the economic viability, the CBA attempts to value all costs and benefits relative to the base case (i.e. 'business as usual' scenario), in monetary terms. This includes valuing all market and non-market economic costs and benefits. Where it is not possible to quantify an impact in monetary terms, there is scope to discuss it qualitatively.

The key outputs from a CBA include:

- **Benefit cost ratio (BCR)** – a ratio of all the quantified direct benefits and costs (relative to the base case) associated with each option. A ratio greater than one indicates that the benefits are greater than the costs and that the project is economically viable
- **Net present value (NPV)** – the present value of the net benefits associated with a project (i.e. present value of the benefits less the present value of the costs). The option with the highest NPV delivers the greatest benefit, and subject to financial constraints is generally the preferred option

In a CBA, the totality of the costs and benefits are used in the analysis. This type of analysis is commonly presented in terms of costs and benefits to 'society' or the 'community'. The impact on a defined group is provided in the distributional assessment.

6.1 CBA methodology

A summary of the CBA methodology is provided in Figure 2.

Figure 2: CBA methodology

Establish base case	Define the '***without project scenario***' which defines what the outcomes would be in the absence of further investment
Identify / quantify the costs and benefits of the project	Quantify ***incremental*** costs and benefits of the project relative to the base case in monetary terms. This includes quantifying any, economic, financial, social and environmental (where relevant) impacts over the economic life of the project
Discounting costs and benefits	Discount whole of life costs and benefits over the life of the project. A real discount rate of 7% is used over the assessment period
Quantitative economic appraisal results	Determine the net present value (NPV) and the benefit cost ratio (BCR) of the project relative to the base case. These metrics only consider the quantified costs and benefits
Sensitivity analysis	Test the sensitivity of results to changes in key assumptions underpinning the NPV
Qualitative assessment	Where costs or benefits could not be assessed quantitatively as part of the NPV or BCR, they are considered qualitatively

6.2 Summary of costs and benefits considered

Table 13 summarises all the costs and benefits relevant to the assessment and outlines whether they are quantified in the CBA or discussed qualitatively. Some of these costs are aggregated in their estimates, but have been listed separately for the purpose of demonstrating that they have been considered.

Table 13: Summary of costs and benefits

Cost/ Benefit	Quantitative	Qualitative
Cost		
Project establishment costs		
Initial hardware development or adjustment costs	✓	
Data collection systems development	✓	
Ancillary database adjustment costs	✓	
Policy and design consultation	✓	
Legislative and regulatory amendment costs		✓
Training costs	✓	
Operation and maintenance costs		
Operation costs and maintenance (data management, data access)	✓	
Data collection costs	✓	
Data validation costs	✓	
Compliance costs (auditing)	✓	
Competition costs		
Market barriers to private sector developing competing databases		✓
Benefits		
Market benefits		
Medium to longer term planning – wholesale market generation capacity	✓	
Medium to longer term planning – network capacity	✓	
System reliability assessments		✓
Power system security monitoring and contingency planning		✓
Central dispatch process		✓
Safety benefits		
Safety benefits to industry workers		✓
Safety benefits to emergency service workers and the general public[14]		✓
Improved fire risk management (e.g. training and resource location)		✓
Other benefits		
Innovation benefits (new market players from improved information)		✓
More informed policy decisions		✓

[14] There is presently insufficient information available to assess all of these benefits quantitatively, as risks include fire and electrocution from flooding. A high level indicative assessment of fire risk is provided

6.3 Treatment of beneficiaries

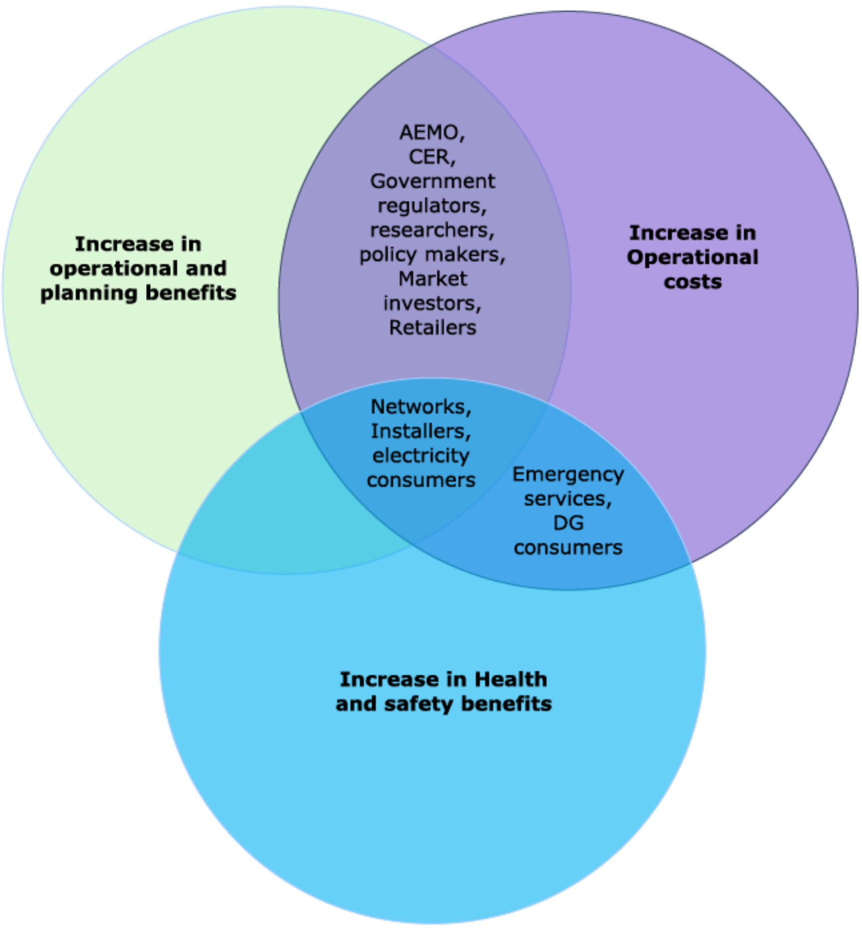
A CBA captures the costs and benefits from the perspective of society as a whole (i.e. aggregated costs and benefits) as opposed to the costs and benefits from the perspective of different interest groups.

From an operational perspective, immediate beneficiaries of a potential database include market and network operators and planners, and so ultimately could benefit consumers and investors through reduced tariffs and lower investment risk.

Network based lines workers, system installers and the general public also stand to benefit from improved health and safety as a result of a register, while government regulators, policy makers, researchers, and market investors may experience reduced planning, operating and investment costs. Emergency services and consumers of distributed generation will have improved health and safety and possibly increased cost burden, depending on the funding recovery model chosen. See Figure 3.

Interactions between costs and benefits to different beneficiaries are treated carefully within the CBA to avoid double counting. For example, wholesale market cost savings could lead to reduced retail prices; if we counted benefits from both reduced retail prices and reduced wholesale market costs this would be double counting. This means that we must evaluate costs and benefits at the wholesale rather than the retail level (or equivalently at the primary cost source). Similarly the cost of measures taken to avoid a blackout should not be counted with the expected cost of the blackout.

Figure 3 Overview of potential impacts by stakeholder type[15]



[15] Note that planning benefits include capital investment savings

6.4 General assumptions

Table 14 lists the general economic assumptions used in the CBA model.

Table 14: General assumptions

Assumption	Definition
Geographical scope	The study is intended to cover grid operations in the SWIS and the NEM
Study period	The study will evaluate costs and benefits to 2030. This allows for one year of implementation (2017/8) and 12 years of operation. This assessment period is considered to be reasonable given that technology usually has an economic life of 10-15 years.
Discount rate	Net benefits will be evaluated using a discount rate of 7%, based on the Infrastructure Australia guidelines. We will also test the sensitivity of the results to a change in discount rate (4% and 10%). All costs will be discounted to 2016/17 dollars, year 1 of the assessment period.
Database implementation period	12 months – commencing in July 2017
Design life	The design life of PV systems is assumed to be 30 years. The design life of batteries is shorter and assumed to be 10 years. In estimating timing of retrofits, it is assumed that main uptake of PV systems occurred from 2005, meaning that any retrofits would be outside the assessment period. For batteries, uptake is assumed to commence in 2007, with retrofits commencing in 2027.
Data capture on national register	The national register is assumed to capture 100% of new PV systems and batteries as well as any retrofits.
Assumed end date for STCs and therefore the reliability of the STC register	It is estimated that PV data will be less reliable from 2024 when incentives are much lower than at present. It is assumed that under the base case, the STC database and associated PV data collection continues to 2024. Whilst it is reasonable to assume that from 2024 the reliability of the register will gradually decrease, as a conservative estimate, a simplifying assumption was made that the data stops being collected under the base case from 2024 onwards. This is a conservative assumption that suggests that any collection costs incurred beyond 2024 (under option 1 and option 2) are incremental relative to the base case.
Combined installation of batteries with PV systems.	Projections of battery uptake were developed using Jacobs' proprietary modelling tools (refer to Appendix B). Our modelling approach presently assumes that batteries will be installed at sites where PV already exists, based on the economics of uptake.
Base case data capture	It is assumed that with current processes: • 100% of new PV system installations are captured in the STC database and on DNSP databases up until 2024. After 2024 only 30% are captured on DNSP databases. • 30% of new battery installations are captured[16] • Retrofits of batteries and PV systems are assumed to not be captured on existing databases.
DER uptake	Refer to Appendix B

[16] During stakeholder discussions Energy Queensland (which combines the networks formerly known as Ergon Energy and Energex) estimated they thought they were only capturing data for 30% of installations using the connection notice approach. As the Queensland network operators are considered to be relatively advanced in their data collection processes compared with other states, it was thought that this would be a relatively conservative estimate if applied to the whole of Australia.

7. Quantified costs of a National Storage Database

The costs quantified as part of the CBA were based on inputs provided through the consultation process and desktop research. In some cases, data requirements were incomplete, and an indicative estimate was developed, with the aim of testing underpinning assumptions when the CBA is released for public consultation.

In this section, all costs provided are incremental to the base case unless otherwise stated.

7.1 Project establishment costs

The project establishment costs quantified in the CBA include the following:

- **Initial hardware development or adjustment costs.** This refers to the cost of developing the national database or in the case of AEMO and CER, adapting their existing database to include the necessary information fields and access portals to the user groups defined in Section 4.2
- **Data collection systems development.** This refers to the costs associated with designing and implementing the new or adapted data collection process.
- **Ancillary database adjustment costs.** This refers to the costs borne by parties accessing the national register (predominantly DNSPs).
- **Policy and design consultation.** In designing the database and establishing the data collection needs and processes, it is expected that further consultation will be required with all affected parties. This includes government departments across jurisdictions, AEMO, CER, the DNSPs, regulators and emergency services. It is important that the cost of this consultation is captured in the analysis.

The key difference between the establishment costs of the two options relates to the assumed data collection process. Option 1 costs, developed by AEMO, assume that a new data collection mobile app or web service is developed for installers to use. This app could also be used to complete connection processes, thereby streamlining processes where possible. CER's establishment costs developed for Option 2 assume that the data collection process used for the STC database is maintained and expanded to include collection for battery storage and retrofits (upgrades to existing PV and/or replacement of aged PV installations).

The assumptions underpinning project establishment costs are summarised in Table 15.

Table 15: Assumptions for project establishment costs

Cost	Option 1 assumptions (AEMO host)	Option 2 assumptions (CER host)
Initial hardware development or adjustment costs	$790,000 AEMO estimated that to update its existing database would cost between $640,000 and $940,000. The average was applied in the analysis with the upper and lower ranges tested as part of the sensitivity analysis. The cost estimates includes training costs associated with introducing a new process for electricians.	$700,000 Provided by CER based on the estimated cost of adapting its existing STC database to capture more extensive datasets and to provide access to emergency services. The cost estimate assumes that that data is accessed by AEMO through existing channels, and that AEMO then provides the data to DNSPs.
Data collection systems development	$260,000 AEMO estimated the development cost of a new app that would be used by installers, ranging from $190,000 to $330,000. The app development allows for • Interface for installers	NA It is assumed that the CER data collection process is maintained, and that no new apps are developed. Some additional forms may be developed but costs associated with these are considered to be neglig ble.

Cost	Option 1 assumptions (AEMO host)	Option 2 assumptions (CER host)
	• Interface for suppliers/ manufacturers	In this option, it is expected that industry will respond by incorporating new functionalities into existing apps used by electricians to incorporate these new information requirements. The incremental costs of doing this are assumed to be negligible as the industry would regularly update these apps under the base case.
Ancillary database adjustment costs	NA It is assumed that under both options, DNSPs would access data from AEMO. DNSPs already existing channels to communicate data with AEMO, and therefore additional investment is not considered necessary. In responses to questionnaires sent to DNSPs, all respondents generally planned to expand their databases in the next three years to include a greater amount of detail. Given that the CBA only considers the incremental costs relative to the base case, any additional hardware and software costs for the DNSPs relative to base case investment could therefore be assumed to be negligible.	
Policy and design consultation	$610,000 This is based on the following contr bution over a 12 month period: • One month of FTE ($165,000 per annum) for AEMO, CER and each DNSP • $300,000 allowance for jurisdictions. This is approximately 0.2 FTE per jurisdiction) • 1 FTE ($100,000 per annum) for emergency services This estimate only captures the consultation costs associated with the design costs. It does not include the costs associated with changing regulations. These costs are captured qualitatively in Section 10.1.	

The establishment costs associated with Option 1 and Option 2 are summarised below.

Table 16: Establishment cost summary (present value)

Cost	Option 1 assumptions (AEMO host)		Option 2 assumptions (CER host)	
	Real $	Discounted	Real $	Discounted
Initial hardware development or adjustment costs	$ 0.79 m	$ 0.74 m	$ 0.70 m	$ 0.65 m
Data collection systems development	$ 0.26 m	$ 0.24 m	-	-
Ancillary database adjustment costs	-	-	-	-
Policy and design consultation	$ 0.61 m	$ 0.57 m	$ 0.61 m	$ 0.57 m
Total	$ 1.66 m	$ 1.55 m	$ 1.31 m	$ 1.22 m

7.2 Operation and maintenance costs

These cost assumptions have been provided by AEMO for Option 1 and CER for Option 2. Both estimated similar costs at $100,000 per annum. AEMO provided a range of between $80,000 and $100,000 per annum.

The costs associated with Option 1 and Option 2 are summarised in Table 17.

Table 17: Operation and maintenance cost summary

Cost	Option 1 assumptions (AEMO host)		Option 2 assumptions (CER host)	
	Real $ per annum	Discounted total	Real $ per annum	Discounted total
Operation and maintenance costs	$ 0.10 m	$ 0.74 m	$ 0.10 m	$ 0.74 m

7.3 Data collection costs

Data collection costs have been estimated based on the additional time it takes an installer or agent to complete the information requirements of a national register relative to the base case.

It is therefore necessary to consider data collection processes under the base case, the likely streamlining of new requirements with existing requirements, and the additional time to collect new information.

The relevant assumptions are summarised in Table 18.

Table 18: Assumptions for data collection costs

Assumption	Detail
Electrician hourly rate	• $75/hour
Base case data collection – time and cost assumptions	• **Time to complete connection notices**: 9 minutes. This is a weighted average assuming 25% of connection notices are paper format (20 minutes) and 75% are electronic (5 minutes) for the duration of the assessment period. These assumptions are based on feedback (verbal and written) from DNSPs. • **CER data collection time:** 10 minutes for PV systems until 2024 (Applicable while the REC database is assumed to exist. Battery data is not collected under the base case, so collection time is 0 minutes). • **% of new PV systems needing connection notices:** 100%.
Option 1 data collection costs	• **Time to complete connection notices: 5 minutes.** This option assumes that all connection notices will be electronic (i.e. linked to a streamlined data collection process). • **Time to collect data for STC database:** No change to base case. CER has advised that under this option, its database and current data collection process would remain in place. • **Time to collect PV data on new app**: 5 minutes while REC database still exists (until 2024), increasing to 8 minutes after 2024. This assumes that there may be some data supplemented from the REC database to reduce duplication while the two systems exist in parallel. • **Time to collect battery data:** 2 minutes if collected with PV data and 5 minutes if collected separately. • **% of batteries installed with PV system:** 80%. Although it is expected that most new batteries (i.e. excluding retrofits) will be installed at the same time as a new PV system, as a conservative estimate, it is assumed that 20% of batteries will installed separately. This is a conservative assumption to ensure that the costs of data collection are not underestimated. • **% of new batteries needing connection notices**: 30%. This is consistent with the assumption in Section 6.4 that 30% of batteries are currently captured in the network databases.
Option 2 data collection assumptions	• **Time to complete connection notices: 9 minute.** There is no streamlining of processes under this option, and this estimate is consistent with the base case estimate which accounts for the current split between paper and electronic applications. • **Time to collect PV data:** 10 minutes while the REC database is in place; reducing to 8 minutes from 2025 onwards (assuming requirements are less onerous). • **Additional time to collect data for REC database:** 0 minutes. The two systems are

Assumption	Detail
	streamlined. • **Time to collect battery data:** 2 minutes if collected with PV data and 5 minutes if collected separately (Same as Option 1). • **% of batteries installed with PV system:** 80% (Same as Option 1). • **% of new batteries needing connection notices**: 30% (Same as Option 1) .

The data collection costs associated with Option 1 and Option 2 are summarised below.

Table 19: Data collection cost summary (present value)

Cost (present value)	Option 1 assumptions (AEMO host)	Option 2 assumptions (CER host)
PV system data collection costs	$ 5.83 m	$ 7.24 m
Battery storage data collection costs	$ 1.14 m	$ 1.81 m
Total	$ 6.97 m	$ 9.04 m

As can be seen from the above results, Option 2 has slightly higher data collection costs relative to Option 1. Although Option 1 has lower costs in collecting data specifically for the national database, it does not introduce more streamlined processes for connection notices which results in higher costs over the assessment period. These time savings in Option 1 are partially offset by the remaining duplication between the collection process for the new national database and the STC database that will be maintained in parallel (to 2024).

7.4 Data validation and auditing costs

Data validation and auditing costs considered in the assessment include those that are incremental to validation and auditing that would occur under the base case. The relevant assumptions are summarised in Table 20. Note that auditing proportions are assumptions and may vary according to CER or jurisdictional regulation policy.

Table 20: Assumptions for data collection costs

Assumption	Detail
Base case data validation and auditing	• **Cost per audited installation**: $14.10. This allows for desktop analysis, which includes approximately 15 minutes per installation at an FTE rate of $100,000 per annum. • **% of installations audited:** STC database is operational. While a percentage of solar PV installations are subject to auditing, no auditing for battery installations occurs under the base case.
Data validation and auditing costs for Option 1 and 2	• The costs are the same for Option 1 and Option 2: • **Cost per audited installation:** $14.10. These are consistent with base case assumptions. • **% of PV systems validated and audited**: The percentage of solar PV installations that are subject to auditing are expected to reduce after 2024 as the value of the commonwealth incentive decreases and not all installations may be subject to a claim. • **% of battery systems audited**: In some cases PV and battery audits will be undertaken simultaneously but this conservative assumption recognises that while CER focuses on PV audits in the short term (mainly to avoid fraud with respect to issue of STCs), some separate audits for batteries are l kely to be required.

The data validation and auditing costs associated with Option 1 and Option 2 are summarised in Table 21.

Table 21: Data validation and auditing cost summary (present value)

Cost (present value)	Option 1 assumptions (AEMO host)	Option 2 assumptions (CER host)
PV system data validation and auditing	$ 1.02 m	$ 1.02 m
Battery storage data validation and auditing	$ 0.39 m	$ 0.39 m
Total	$ 1.41 m	$ 1.41 m

7.5 Total quantified summary

The total costs for Option 1 and Option 2 are summarised in Table 22.

Table 22: Total cost summary (present value)

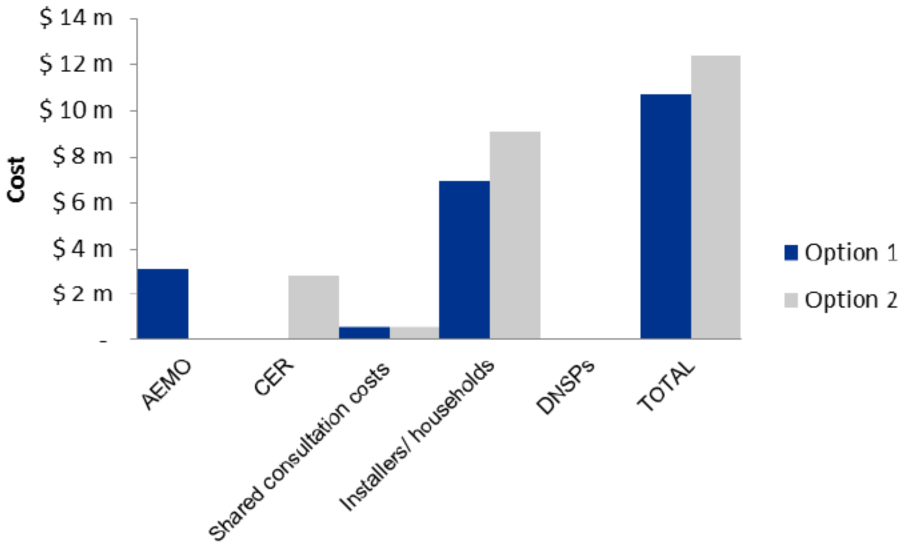
Cost (present value)	Option 1 assumptions (AEMO host)	Option 2 assumptions (CER host)
Initial hardware development or adjustment costs	$ 0.74 m	$ 0.65 m
Data collection systems development	$ 0.24 m	-
Ancillary database adjustment costs	-	-
Policy and design consultation	$ 0.57 m	$ 0.57 m
Operation and maintenance	$ 0.74 m	$ 0.74 m
Data collection costs	$ 6.97 m	$ 9.04 m
Data validation and auditing	$ 1.41 m	$ 1.41 m
Total cost	**$ 10.67 m**	**$ 12.42 m**

From the table above we can interpret the following results:

- Option 1 is less costly to implement. This is largely due to the lower data collection costs due to the efforts to streamline the connection notices process.
- Option 2 has lower development costs and if development of an app in Option 1 is not considered to be viable, Option 2 will likely become the more cost effective option.

Figure 4 illustrates the distribution of costs among the different interest groups. The majority of costs from both options fall to installers/households.

Figure 4 Summary of cost distribution (present value)



8. Benefits

8.1 Benefits considered

AEMO has prepared a detailed description of market benefits from their perspective, in their report entitled 'Visibility of Distributed Energy Resources' for the Future Power System Security Program (published January 2017). Much of the detail in this chapter is based on the existing work undertaken by AEMO, and where relevant, is supplemented by network and wholesale market system knowledge of Jacobs' team members.

As described in Section 3.4, the CBA assumes that AEMO will invest in a sampling approach to estimate the real time profile of battery storage, regardless of whether a register goes ahead or not. The benefits shown in Table 23 may include benefits associated with having real time data as well as the static data associated with a battery storage register. Note that the benefits from the real time data are only realised when static data is available. Table 25 displays non market benefits attributable to a battery storage register. For these benefits real time data is irrelevant.

Table 23 Market benefits attributable to a battery storage register

Benefit	Description	Quantitative or qualitative assessment
Medium to longer term planning	Investment in large scale generation and network infrastructure typically require 2 to 4 years of planning (and sometimes longer, depending on the asset). If planners are unaware of the scale of batteries in the market it is significantly more difficult to estimate requirements for peak and baseload demand, and this is l kely to result in overinvestment in generation or network assets.	*Quantitative*, using Jacobs' market models to assess market impacts of better quality information as well as a high level approach to estimating network planning benefits
Short to medium term market operation	AEMO regularly provide projected assessments of short to medium term system adequacy covering periods 1 to 2 years ahead (ST PASA and MT PASA). These assessments provide market signals that affect the scheduling of maintenance, fuel contracts and unit commitment. AEMO co-ordinates a 5-minute dispatch model in which they create 5-minute ahead load and power flow projections that are converted into week ahead load and power flow projections to enable market participants to plan generation and bidding strategies. The ability to access data from a battery storage database increases the accuracy of short term forecasts leading to: • Lower imbalances in forecast supply and demand, resulting in lower levels of FCAS, decreasing costs. • Impacts on power system security and monitoring, as described above. • Higher cost dispatch occurring when higher cost generation may be called upon based on unit ramp up time and/or location rather than bid value. *Impact:* A register may improve the cost and quality of power system security. AEMO needs to ensure that power flows and the voltage profile through the network remain within technical limits and sometimes may need to constrain generation in the market to ensure that these technical limits are maintained. This process creates a load shedding situation which	*Qualitative assessment;* see Section 8.3

Benefit	Description	Quantitative or qualitative assessment
	impacts on the systems overall reliability standard. This requires that a maximum of 0.002% of required energy is not delivered to consumers in any year. *Impact:* A register may also increase AEMO's ability to predict load in the presence of batteries so that the likelihood and volume of load shedding incidents will be reduced.	

Table 24 Market benefits attributable to a battery storage register

Fire safety	Different chemical compositions of batteries may require alternative approaches to emergency response. Generally, a hazardous materials team will need to be called in so the following elements may be beneficial from a register: • Advanced warning of the chemical composition of the battery to inform the requirement of the hazardous materials team, choice of supplementary fire extinguishing equipment and fire-fighting protocols • Warnings regarding noxious fumes and likely burn time that may be released from a burning battery of a given size. A register may reduce the probability and loss of property and/or life with respect to emergency incidents.	*Qualitative; see Section 10.3*

8.2 Medium to longer term planning

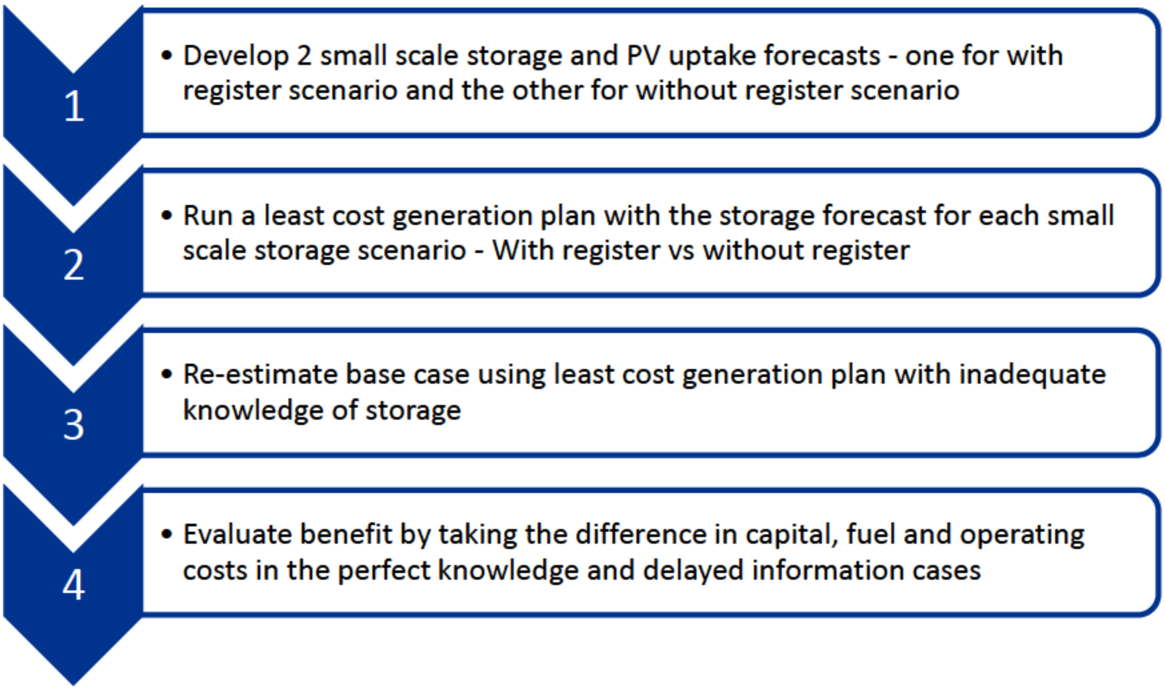
8.2.1 Medium to long term planning benefits to wholesale generation market

Jacobs has assessed the long term benefits of the battery storage register using our suite of market models. Small-scale Battery Energy Storage Systems (batteries) have the potential to affect long term investment decisions, particularly the need for peaking generation to meet reliability standards. This is because the charging and discharging profiles of batteries can add to, or subtract from, system peak demand. Better knowledge of the response characteristics of batteries may therefore lead to more efficient and timely investment decisions for new generation plant. Less than optimal plant investment decisions will have a range of flow on effects in energy markets, not only through inefficient timing of capital investment, but also in the market costs imposed by that plant, such as fuel costs and wholesale price impacts.

In the absence of a register, the impacts on load might still be able to be inferred by the market operator by analysing how observed load responds to price signals, solar insolation, and other factors. This is likely to be undertaken with considerable difficulty, cost and uncertainty as other newer technologies relating to consumption will almost certainly enter the market in the future as well. The timeliness of information will make it very difficult to ascertain whether inferred results are at all accurate, reducing any evidence base available to support research and analysis.

The long term market benefits reflect the ability to optimise investment decisions on new plant, and the flow-on effects of this on energy markets. The approach used to estimate this benefit is summarised in Figure 5.

Figure 5 Approach use to estimate long term market benefits



The above approach provides a proxy for estimating market benefits for longer term planning. The 'with register scenario' assumes perfect information and the without register scenario assumes a delay in understanding of how battery storages impact the market.

Even though demand on a year to year basis readjusts as new metering information is received (that incorporates uptake of batteries), planning for large scale plant such as combined cycle gas turbines and coal plant will need to occur at least 4 years ahead. This takes into account the construction period and the period required gaining developmental approval and project funding. The forecasting approach incorporates a moving developmental assessment of investment by considering available information at:

- The four year planning stage (i.e. using a four year lag) before placement of high utilisation plant such as combined cycle gas turbines and coal plant
- The three year planning stage before placement of gas turbines
- The two year planning stage before placement of renewable energy plant.

Our approach for estimating medium to longer term planning is outlined in greater detail in Appendix A.

Market modelling assumptions

The model assumes energy demand consistent with 50% POE peak demand and medium economic growth forecasts from the AEMO 2016 National Electricity Forecasting Report (NEFR), and consistent carbon policy to accord with the Paris agreement. It also incorporates technology and fuel cost assumptions as well as operational assumptions based on desktop research. The market outputs for the 'from each of 'With Register' and 'Without Register (or base case)' are compared to reveal an incremental benefit that is captured in the CBA. The same incremental benefit is assumed to be realised for both Option 1 and Option 2.

Projections of battery uptake used for the analysis are provided in Appendix A

Market modelling results

A comparison of cash flows from the modelling indicated that a storage register would provide overall net benefits of $15.0 million in present value terms relative to without a storage register.

8.2.2 Medium to long term planning benefits to Networks

Networks rely on forecasts for a number of things, including assessing the need for system upgrades and augmentation. Forecasts are needed because demand for energy may grow and because the time required designing, building, and planning for new infrastructure may take time. Lack of knowledge about batteries is likely to lead to higher forecasts of peak demand which will have the flow on effect of increasing network capital expenditure (capex) budgets.

Historically there has been overinvestment in distribution infrastructure in some jurisdictions that was caused by a combination of inadequate forecasting approaches as well as significant reduction in industrial load as a result of the global financial crisis. The forecasting approaches were not adequate because the utilities were unaware of significant uptake of energy efficiency and solar PV technologies that created a significant behind the meter reduction in energy use; As a result, it was not possible to develop regression models with unbiased regression coefficients because the relationship between underlying (behind the meter) energy demand and the independent variables used in the regression was not well understood. The modellers missed important clues about changing demand and models were developed that did not reflect a realistic growth path. Excessive investment in infrastructure then led to higher network tariffs to consumers and some networks now face increased risk related to stranded assets and tighter operating budgets.

The presence of existing overinvestment means that there is likely to be a lesser requirement for investment in the future. In addition, the increase in local generation and energy storage technologies may reduce that requirement further. Nevertheless there remain parts of the network that will continue to grow and good forecasts will still be very important.

A storage/distributed generation register is likely to provide networks an improved ability to forecast peak demand, which will consequently lead to greater efficiencies in timing of network augmentation expenditure. The presence of batteries within the distribution network downstream of a substation is likely to suppress peak demand served, as well as the sub-transmission network and terminal stations upstream of it, as the expected discharge profile of energy storage systems is generally well correlated with peak demand.

Network operators make augmentation decisions based on peak demand forecasts on specific network assets. When the peak demand on a substation exceeds the N-1 rating[17] of the substation, 'energy at risk' is created. That is, there is a risk that customer load will not be served. Energy at risk is valued using a metric called the Value of Customer Reliability (VCR); the VCR is calculated annually by AEMO utilising a customer survey approach to determine a defensible and robust estimate of the market value of unserved energy. The total value of energy at risk is estimated by applying the VCR to the probability of failure of network assets and the length of time demand exceeds the N-1 rating. The result is denoted as the Value of Lost Load (VoLL).

Typically, the timing of a network augmentation is based on the expected VoLL as well as the annualized cost of augmentation. When the annual expected VoLL exceeds the annualized cost of augmenting, an augmentation should be committed to. An accurate forecast of the energy at risk is based on accurate forecasting of peak demand at the substation, so if a distributed energy register can improve these forecasts this timing can be delayed leading to benefits in avoided capex.

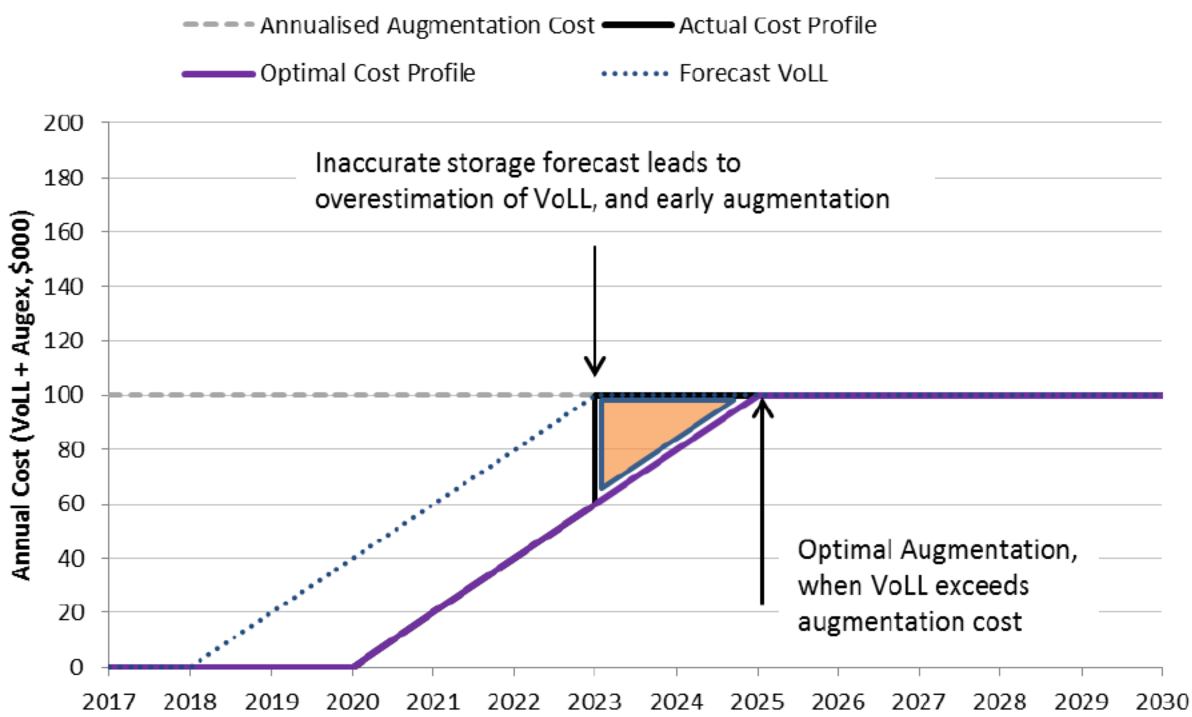
Figure 6[18] illustrates how an inaccurate forecast of VoLL could lead to sub-optimal augmentation timing. The chart should be interpreted so that the purple line represents the sum of VoLL and actual capex, corresponding with the optimal augmentation expenditure timing. Due to load growth at the substation, there is some load at risk from 2020, the value of which grows over time. Initially, the value of this lost load is less than the cost of augmenting the substation. However, by 2025 the VoLL exceeds the augmentation cost, so an augmentation occurs.

However, if the DNSPs' demand forecast is overstated under the base case (due to imperfect information) the forecast VoLL is higher than the actual value. In this example, the forecast VoLL exceeds the cost of augmentation in 2023 (dotted line) and causes the DNSP to augment, despite the actual risk of lost load being

[17] The N-1 rating refers to the required asset performance when the largest asset in a grid is not in use.
[18] Figure 7 is provided to illustrate a conceptual methodology and does not represent any given substations cost profile

lower than expected. The black line shows the cost to the DNSP in this scenario. The orange shaded area is the difference between the two cost profiles, and represents the benefit of having a more accurate demand forecast.

Figure 6 Representation of network system augmentation benefits



Importantly, the information provided by the improved forecasts does not generally allow a DNSP to avoid upgrading a substation, and does not change the value of distributed energy in reducing actual load at risk, but instead defers the capital expenditure on augmentation to a more optimal time, hence reducing the cost of capital.

Assessment Methodology

Jacobs has developed a methodology to assess the network benefits of a distributed energy register. This analysis only assesses the benefits of augmentation timing – we did not assess other benefits (such as improved ability to manage voltage, or improved power flow model benefits) as part of this quantitative exercise.

Our method builds on work we have done previously in assessing the network benefits of existing distributed technologies in Victorian networks – while a full replication of the study methodology to all Australian networks was beyond the scope of this analysis given the timeframe, we have developed an assessment of the benefits of a storage register in Victorian networks, then scaled the analysis to the remaining networks based on substation data gathered from the Distribution Annual Planning Reports (DAPR's) of all networks in the NEM[19]. Existing demand growth projections in each zone substation (ZSS) area, sub-transmission (ST) area and each terminal station (TS) was assessed. Distribution HV and LV feeders and low voltage substations cannot practically be modelled due to data limitations. One result of this previous work is that network benefits of controllable energy sources like batteries are of much more value to networks than solar, as peak demand at substations is increasingly seen in the evening when solar systems stop generating, and network elements must generally be sized to meet peak loads. As a result, we have focussed on the network economic benefits of a register for energy storage systems in this work.

[19] No equivalent available in Western Australia

The Victorian analysis of the network economic benefits was developed using a counterfactual 'With Register' and 'Without Register' case for each zone substation in Victoria. Using publically available load profiles, demand growth and capacity data for substations, as well as information on planned augmentation costs extracted from the Victorian DAPRs, we are able to calculate how an incremental amount of dispatchable generation (such as a battery storage system) or a solar system impacts on the load at risk at any given substation, which is a key variable in making network augmentation decisions.

An important element of this analysis is the fact that the knowledge provided by a distributed energy register does not impact the actual batteries installed behind any network element, nor does it affect the actual load at risk. Instead, it enables a more accurate assessment of the load at risk, which leads to better augmentation timing. Another key point is that the penetration of batteries downstream of a zone substation or other network element will not be completely unknown to network operators. The effect of battery systems on the load profile of a substation provides information about their presence, and we assume that DNSPs are able to infer the penetrations at various levels of their networks statistically over time. We have therefore assumed that information about battery uptake within a substation area is discoverable in time, even without the battery register. The advantage that the register brings is having timely information about the presence of batteries at a given network element ahead of peak demand periods. Given the fact that this is a statistical process, and subject to uncertainty, as well as the fact that a register will provide exact uptake information ahead of critical demand periods, we have assumed that networks have access to a 2-year delayed time-series of storage uptake at the substation level if a register were not available, and timely, up to date information if the register were created.

Furthermore, we assume that DNSP's take a prudent approach to augmentation planning, and when preparing demand forecasts for network planning purposes do not make predictions about storage system uptake at a ZSS level – both because the storage penetration at a ZSS is only inferred as a statistical outcome, and because without actual installation data it will be difficult to establish rates of uptake. As the consequences of overestimating storage forecasts (and underestimating peak loads) are generally more severe (load at risk) than the consequences of underestimating forecasts (deferred augex expenditure) we assume that networks will not assume that there is more storage present than their statistical analysis of existing load shapes suggests. The benefit of the register is the benefit of making augmentation decisions on the actual penetrations, rather than the 2 year delayed series of storage system uptake.

For example, if the storage uptake capacity at a particular substation in 2020 was 1.0MW, and in 2022 was 1.4MW, the benefit of the register in 2022 would be the benefit of considering an additional 0.4MW of storage at that substation when developing load at risk forecasts and making augmentation decisions.

A key outcome of our work assessing the network economic benefits of distributed energy was that the benefits are highly locational, and depend on a wide variety of factors. Many substations have sufficient spare capacity, or a large enough load, that even a rapid uptake of battery storage will not have a material impact on augmentation decisions. Benefits are more likely to accrue in substations where capacity is tight but demand growth is low, or where other locational constraints apply - where uncertainty in the contribution of batteries to peak demand could advance or delay a planned augmentation project. However, in any network there will be a wide range of substation conditions, and some more constrained than others.

The benefits at any given network element will be related to the amount, and speed of uptake, of distributed energy. Is it difficult to forecast how concentrated the actual uptakes of systems will be downstream of a particular network element, so we have developed our analysis on the basis of an average storage uptake per substation, which was developed by allocating our regional forecasts of uptake to zone substations in the NEM based on their non-coincident peak loads, then examining the average uptake per substation. We then used this average uptake to develop our estimate of network benefits per substation in Victoria using our distributed energy network model. The average uncertainty in storage uptake as a result of not having a battery register varied by state and over time but was typically between 0.2MW and 0.5MW per zone substation. Given the inherent uncertainty in developing forecasts based on this type of averaging, and given that we were scaling the benefits from VIC only to NEM wide, we have elected to use the lower end of this range – 0.2MW per substation - as the basis of our benefits calculation. While this is a relatively immaterial number for the majority of substations, our analysis indicates that for a portion of substations this level of uncertainty may mean a year's difference in the timing of some augmentations.

We have performed an explicit calculation of the discounted benefits of improved forecasting information on each zone substation in our Victorian dataset. There are also benefits at the sub-transmission and terminal station level. Our previous work on the benefits of dispatchable distributed generation indicated that benefits at the sub-transmission level are roughly 30% of the ZSS benefits, while benefits at the terminal station level are double the ZSS benefits due to the impact of greater aggregations of storage at terminal station level. We have used these ratios to assess the whole of distribution network economic benefits of a battery storage register in Victoria. We have then scaled these benefits to the rest of the NEM based on the total non-coincident loads of all ZSS for which there are public data. On the basis of this analysis we calculated the benefits across the whole of the NEM to be of the order of 3.5 times larger than the benefits in Victoria alone.

Based on the above conservative approach, Jacobs estimated net present value deferral benefits of $11.6 million.

8.3 Short to medium term market operation

Short and medium term system reliability assessments provide market signals to participants with respect to maintenance, fuel contracting, line switching and more which help the market operate efficiently, reduce the likelihood of shortfalls in delivery of electricity to customers and keep extreme price periods to a minimum. These benefits cover periods of 7 days to around 2 years.

An incorrect projection of battery and PV storage will create an incorrect reserve assessment, potentially leading to incorrect signals being sent to market participants.

Maintenance periods for most plant are typically set a year in advance; traditionally maintenance periods occur at the same time each year, usually in lower demand periods such as early or late winter, well outside of warm seasonal weather patterns. Incorrect reserve assessments for plant in areas with low levels of DERs are probably more dangerous than incorrect reserve assessments for plant located in areas with high levels of DERs, simply because the former may create undue confidence about undertaking maintenance and possibly cause high price spike events of loss of load (VoLL) events.

Similarly, some infrequently used plant are more likely to be operational in periods of high prices because their fuel contract costs are high and they may be less efficient than other, newer, plant. Providing signals to such plant that they may need to be available (when they are actually not required at all) may inadvertently increase planning and financing costs for plant operators, and similarly letting plant in areas of low DERs know there is a genuine need for them to provide standby load may be invaluable in terms of providing appropriate lead times for ramping up of generation and of alerting fuel suppliers that there will be a requirement for supply.

The consequences of inaccurate system reliability assessments are that electricity supply efficiency is lowered, potentially increasing dispatch costs to consumers. However, benefits of avoiding these consequences are difficult to assess because benefits may depend on unit locations and ramp up time rather than cost profile, and the costs of preparation associated with fuel contracting and maintenance are also difficult to quantify.

8.4 Short term market operation

AEMO is required to monitor and support system operation within a given technical envelope. To do this, they must ensure that power flows remain within technical limits by constraining generation in the market, and coordinates the voltage profile across the transmission grid to remain within technical limits.

AEMO undertakes this activity by engaging in power system studies. Load profiles from DERs may affect network flows including the flows that AEMO is expected to control, as might high levels of DER penetration and the presence of more non-synchronous generation. Additional non-synchronous generation may also reduce system strength, reducing the ability of the market operator to predict and manage system behaviour.

Some of the specific short term benefits include:

- Avoiding the costs of a more conservative operating envelope
- More efficient management of the system within the technical envelope

- Lower cost management of contingency events.

These are discussed in more detail below. These were all considered qualitatively because the timing for the CBA did not allow for a location based assessment.

8.4.1 Avoiding the cost of a more conservative operating envelope

The benefit of an energy storage register is that AEMO will know the location and size of battery installations and avoid adopting a more conservative operating envelope. Effectively, this is about how having conservative power flow constraints could affect dispatch order. If less expensive participants are constrained off, then there is a market cost of that constraint. Batteries may create unexpected load flows appearing around the network, and this is inherently difficult to quantify. Below is a case study that illustrates the potential impact of a storage register.

Case Study - Redcliff and Victoria's northwest transmission corridors

The capacities of the lines into Victoria are around 800 MVA, while midday generation from solar PV is around 1000MW. This is a section of the network that is therefore often operating near limits. Imagine now that there are 100MW of batteries along these corridors.

Without a register in place, load flows appear and disappear on the lines. AEMO can see this, and are probably aware that batteries are involved in the behaviour. They won't be sure though – it could be something else. Even if they conclude that it is batteries causing the behaviour, they don't know exactly how many there are, or the relationship between the power and capacity of them, because there may be diversity in the battery profile and there might be more than 100MW of batteries that could switch on or off suddenly depending on their manufacturer or operating settings. AEMO makes a guess as to the battery volume of 150MW. Batteries charge during the day, when solar output is high, soaking up some of the solar output. The remainder is dispatched to the point of network saturation. When they finish charging they switch off, and the energy they were storing starts flowing elsewhere on the network. AEMO has to ensure system security, and may have to consider their estimate of 150MW of batteries as a contingency to be managed. They either have to add headroom to the transmission flow limits permanently (which would lead to low cost solar in the area being curtailed during its peak output) or design a protection mechanism around an estimate of the battery penetration that will have to be conservatively high. In this circumstance we could consider the cost of not having a register to be the lesser of the value of curtailed generation or the value of monitoring equipment that may be needed to manage such a scenario.

With a register in place, AEMO are still required to manage the flows, but can design protection based around the actual maximum impact of the batteries instead of an estimate. Without control AEMO cannot manage the batteries to relieve congestion of the solar resource in the area, but the register (or collection of info by a virtual power producer or VPP) is a necessary precursor to engaging with customers with a battery, unlocking this as a potential alternative to network augmentation.

8.4.2 Power System Security – Efficient management of system within a technical envelope

In the absence of a reliable and complete register, AEMO will face increased difficulty in undertaking its role of managing the system within the technical envelope. The end result will be higher transmission and distribution costs to consumers as a result of higher operating costs. Jacobs are unable to quantify this value.

Benefits include:

- The response of batteries to contingencies and perhaps even system normal conditions can affect voltages in the electricity system, which must be kept within specified limits by AEMO
- Involves locational benefits, reactive power flows, and contingency events
- Better ability to manage contingency events
- Better ability to schedule generation and network outages.

During contingency events power flows on the network can change drastically. Voltage is not a system-wide parameter – it has to be managed on a locational basis. Batteries may produce or absorb reactive power during system contingencies and affect the power flows during these events. AEMO is obligated to operate the network to manage contingencies

Accurate power flow analysis is required to manage contingency responses. Understanding the behaviour and location of batteries to input them into load flow models is essential, and this information cannot be inferred from system normal conditions.

Power flow analyses are important for planning future expansion of power systems as well as in determining the best operation of the existing system. Power flow studies are usually accompanied by studies that seek to optimise power flow to deliver the lowest cost per kilowatt hour delivered. When the relevant information is known, networks and market operators can optimise voltage levels at relatively low cost, perhaps by adjusting transformer settings and real and reactive injections from generation equipment[20]. When systems operate outside prescribed bounds, it is possible that delivery of power is not being achieved at least cost, and may be incurring greater line losses than would otherwise be the case. However, we are not aware of any studies that provide indicative line losses or cost increases due to operation of the system outside the technical envelope. Furthermore, understanding the degree of DER penetration that would cause increases in network operating costs is not well understood.

8.4.3 Power System Security – Disconnection in non-credible contingencies

Benefits:

- If a non-credible contingency occurs that involves batteries/PV/other DER disconnecting, knowing the location and characteristics of the systems may assist in managing the risk.
- Non credible contingencies can be identified and reacted to with this information, but not as easily without

Non-credible contingencies are things like all the batteries systems disconnecting at a certain frequency unbeknownst to AEMO. They can also include situations that are identified ahead of time, but extremely rare or one-off events. For example, NSW will expect a solar eclipse in 2028 that will cause a significant drop in PV output for a short period of time.

Uncertainty in the location and solar/battery pairing relationship of distributed energy could add to the costs of managing significant power systems events, like such solar eclipses. The California ISO recently released an analysis modelling the operational response required to manage a total solar eclipse that is due to shade parts of the continental United States in August 2017 during the morning and midday period. This event provides a useful case study for the estimation of impacts of a solar eclipse in Australia, as, like Australia, the state has a large penetration of rooftop solar as well as a system load on a similar scale to the National Electricity Market. During the eclipse the California ISO expects net load of between 18,000 and 24,000MW which is comparable to the NEM – in August 2016 aggregate load in NEM states is around 26,000MW during the daytime. California also has around 6,000MW of rooftop PV. The Australian 2028 solar eclipse will shade Victoria, New South Wales and Queensland over a period of about three hours in 2028 during the middle of the day – by this stage we forecast rooftop solar penetration across these three areas to exceed 12,000MW.

When a solar eclipse cuts PV output during the middle of the day, a residential household that also has a battery storage system may not need to begin importing from the grid, as the battery will be able to service the some portion or all load. If this is the case, the net system load supplied from the grid – which the system operator must manage – will change more slowly than if significant levels of battery system were not present. Knowledge of system location from a distributed energy register would enable the system operator to be aware of which locations may be at greater risk and also estimate the batteries' response to the drop-off in PV during the eclipse.

[20] "Optimising Voltage profile of distribution networks with distr buted generation", December 2012, Kigen et al, International Journal of Emerging Technology and Advanced engineering.

Due to the uncertainty with which residential solar output will change during the Californian August event (as geographically diverse solar systems are shaded in turn), the California ISO has estimated that it will need to procure an additional 150MW of regulation frequency control services to manage the change in system load. While the Australian and Californian systems have diverse characteristics, the similarities in total load and PV penetration allow us to draw conclusions that the amount of additional FCAS that AEMO would have to procure may be a similar order of magnitude. Note that we expect PV uptake in Australia during the 2028 eclipse to be more than twice as high as current California levels and this may increase the need for FCAS; however the geographic area of Australia is much larger so the impact of the eclipse may have greater spread over a longer time period.

The potential benefit of a battery register during an eclipse event is the ability of the market operator to predict whether the rate of change of system load causes by PV systems dropping off will be offset by battery systems picking up the demand. Having high confidence in this response may mean the AEMO does not need to procure as much additional FCAS. We have assessed the maximum potential benefit of avoided FCAS that a distributed energy register might provide during the Australian eclipse using our PLEXOS market model which is able to assess the costs of various ancillary services on a time series basis. By assessing the full cost of an additional 150MW of regulation FCAS this analysis provided an estimated upper bound to the benefit the register may provide.

The minimum ‘regulation raise’ FCAS requirement in the NEM is 130MW. We have used our PLEXOS model to assess the total system costs of providing an additional 150MW of regulation raise FCAS for the duration of three hours from midday to 3pm – which is roughly the length of time for which the 2028 solar eclipse will be passing over the NEM. Historically, the price of ‘regulation lower’ services in the NEM have been 60% of the cost of ‘regulation raise’ services, so we have escalated the cost of providing an additional 150MW of regulation raise FCAS by 160% to estimate the total additional cost of the regulation reserve provision.

This analysis suggests that the maximum benefit of avoided FCAS during an eclipse brought about by a storage register is in the order of $87,000 in 2028 real terms. This includes not only the cost of the FCAS itself, but the additional generation costs that are incurred by generators operating at less efficient heat rates, starting at less than optimal times etc.

Potentially other extreme weather or other events could also occur in the assessment timeframe that may duplicate the previously described solar eclipse benefit at various times. However it is difficult to place a probability assessment of such events occurring, and even if they did, it would be unlikely that AEMO would have sufficient time to secure sufficient FCAS to manage the situation in the same way.

Nevertheless, knowledge of the location and technical characteristics of storage could provide the following benefits:

- Improvement in load forecasting accuracy at the 5min level leads to less of a need for regulation FCAS
- Improvement of load forecasts at all levels from 5mins to 40hours leads to more efficient unit commitment and dispatch.

8.5 Summary of quantified market benefits

Table 25 displays the estimated net benefit from deferring wholesale and network infrastructure upgrades and investments. Note that the CBA combined results for the NEM and the WEM.

Table 25: Deferred wholesale and network infrastructure benefit summary (present value)

Cost	Option 1 and 2 (NEM only)	Option 1 and 2 (WEM only)	Option 1 and 2 (NEM and WEM)
Wholesale market investment deferrals	$ 14.0 m	$ 1.0 m	$ 15.0 m
Network infrastructure deferrals	$ 11.6 m	N/A	N/A
Total	**$ 25.6 m**		

9. CBA results

The CBA results are presented in the following table.

Table 26: CBA results

	Option 1 (PV)	Option 2 (PV)
Establishment costs - for host	$ 1.0 m	$ 0.7 m
Non-host establishment costs (design consultation and auxiliary databases)	$ 0.6 m	$ 0.6 m
O&M	$ 0.7 m	$ 0.7 m
Data collection	$ 7.0 m	$ 9.0 m
Data validation an auditing	$ 1.4 m	$ 1.4 m
Total Cost	**$ 10.7 m**	**$ 12.4 m**
Avoided expenditure – wholesale	$ 14.1 m	$ 14.1 m
Avoided expenditure - networks	$ 11.6 m	$ 11.6 m
Total benefits	**$ 25.7 m**	**$ 25.7 m**
NPV	**$ 15.0 m**	**$ 13.3 m**
BCR	**2.4**	**2.1**

As can be seen, both options considered are economically viable, with NPVs ranging from $13.3 million to $15.0 million. The difference between the two options is predominantly due to the collection costs being lower for Option 1 which assumes that data is collected using a new app which allows streamlining of some of the existing processes (i.e. connection notices for networks). If the same data collection process was applied to both models, Option 2 would have the higher NPV. As discussed in more detail in Section 11, these issues will be resolved as part of the more detailed design process.

9.1 Sensitivity analysis

A sensitivity analysis is used to test the impact on the BCR and NPV from changes to key assumptions. This is an opportunity to test the impact of assumptions with significant uncertainty.

The key variables tested include:

- Change in discount rate – this is testing a change in discount rate form 7% to 4% and 10%
- Change in assumed percentage of connection notices completed in paper format across the assessment period under the base case. The base case assumes 25% of the connection forms are paper based across the assessment period. Even though 25% of the DNSPs had no plans to introduce electronic forms, these plans may change over the assessment period (i.e. by 2030). As such, a reduced rate of paper based forms is tested – including 0% and 15%
- Change in percentage of batteries installed. The baseline results assume that 80% of batteries are installed at the same time as PV systems. A change in this assumption is directly linked to the collection time and cost. As such, a 50% assumption is also tested
- Establishment costs. Given that the cost estimates are high level assumptions, a 20% increase has been tested
- Collection time. A doubling of collection time across both options has been tested
- Reduced collection time under Option 2 and the current CER data collection process to reflect that the new Serial Number Validation project may lead to significant time savings for installers.

The NPV and BCR results for each sensitivity test are provided in Table 27. As can be seen, the results are most sensitive to the discount rate used and the data collection time. The data collection time can be managed through the design process (and the associated design specifications) to ensure that it does not increase significantly more than the baseline assumptions.

It should be noted that under most sensitivity tests, Option 1 remains the better performing option. This is not the case for:

- **Test 3 where it is assumed that none of the connection notices are paper based in the base case.** This demonstrates that Option 1 only performs better given the assumed streamlining benefits with the DNSPs connection notices. If options to streamline are not viable under Option 1, Option 2 would have the higher NPV. Similarly if the CER collection mechanism provides streamlining opportunities the DNSP process (e.g. by linking the serial number validation apps to connection notice applications), Option 2 would become the preferred option.
- **Test 8 where it is assumed that the current serial validation project reduces the collection time under the base case and Option 2.** This demonstrates that if efficiencies currently being introduced into the CER data collection process are embraced by the industry, there could be significant time savings for installers that could also benefit a DER register. If this is the case, a CER collection mechanism, as is assumed for Option 2, would be favourable.

Table 27: Sensitivity test results

Sensitivity test	Variable	Option 1		Option 2	
		NPV	BCR	NPV	BCR
-	Baseline results	$ 15.0 m	2.4	$ 13.3 m	2.1
1	Discount rate is 4%	-$ 46.6 m	(2.5)	-$ 49.4 m	(2.1)
2	Discount rate is 10%	$ 47.0 m	6.3	$ 46.0 m	5.7
3	% of connection notices in paper format in base case is 0%	$ 5.1 m	1.2	$ 13.3 m	2.1
4	% of connection notices in paper format in base case is 15%	$ 15.1 m	2.4	$ 13.3 m	2.1
5	% of batteries installed with PV s reduced to 50%	$ 14.5 m	2.3	$ 12.7 m	2.0
6	Establishment costs increase by 20%	$ 13.5 m	2.1	$ 12.1 m	1.9
7	Data collection time doubles	$ 8.1 m	1.5	$ 4.3 m	1.2
8	CER data collection time for PV systems is reduced to 5 minutes under the base case and Option 2	$ 15.0 m	2.4	$ 16.1 m	2.7

10. External energy market costs and benefits

This section discusses some of the costs and benefits that could not be quantified as part of the CBA results and the potential impact they would have on the economic viability of the national register.

10.1 Legislative and regulatory amendment costs

In establishing the national database, regulatory changes will be required to mandate data provision for new and retrofitted PV systems and battery systems (and potentially other DERs as they become more relevant). Regulatory changes may also be required to enable the necessary data collection and data sharing by AEMO and the CER. The nature and extent of these changes will depend on the final collection process applied.

Changing legislation can be a significant time and cost burden, particularly when this needs to be done across a number of jurisdictions. It is important that in designing the final database and collection method, measures are taken to reduce the need for, and cost of, legislative or regulatory change as much as possible. This may involve:

- Utilising existing processes and responsibilities as much as possible
- Trying to time changes with other changes that are already planned
- Sharing resources across jurisdictions where possible (e.g. for any external advice)

10.2 Market barriers to private sector businesses developing competing databases

One impact that is relevant but could not be quantified is the impact a national database may have on businesses that have already invested, or are planning to invest in addressing the existing information gap in the market. As discussed in Section 2, one such example is the Australian Energy Storage Council's partnership with Global-Roam to develop a national storage database. They have already invested in initiating the development of its user customer base, business model and data collection methods and are awaiting the outcome of this analysis and EMTPT's decision to determine the impact that a government funded database would have on their business.

Access to data would be on a subscription/membership basis to recover the costs and reflect the benefits of the potential users. Potential users include industry (AEMO, distributors, retailers, etc.), government, researchers, academics, emergency first responders and the private sector.

Businesses that we know about and others that we may not know about have taken the initiative to respond to a gap in the market, and have invested time and money to do this. A national database, if free and/or regulated will most likely eliminate demand for their product and result in reduced earning potential. In some cases, where money has already been invested, this will limit the start-ups' ability to recover their costs.

Impact on CBA results: Including these costs will reduce the NPV and BCR. The relative economic viability of Option 1 and Option 2 will not change.

10.3 Safety benefits

Many of the benefits associated with a register, particularly those that relate to the secondary objective of a register cannot be considered quantitatively using available information.

The secondary objective of a register is to improve the safety emergency services including fire, floods or other extreme conditions. To assess these quantitatively, it would be necessary to have data or evidence on the likelihood of a safety incident occurring and the average consequence (e.g. cost of injury or fatality) of the average incident.

From stakeholder discussions and desktop research undertaken to date, this data does not appear to be publicly available. Despite this limitation, the potential safety benefits are considered to be significant. Some of the benefits from a national battery register that contribute to fire safety include:

- **Early risk identification and management**. In the absence of a national register, emergency responders approach a fire without prior knowledge about whether a battery storage device is on-site. Lithium-ion batteries when placed under conditions of extreme heat and/or high pressure can combust explode or release hazardous substances. Sometimes, this information could be collected by the 000 operator, but emergency service workers, particularly volunteers operate under changing conditions, and are not always directly responding to 000 calls (e.g. bushfires). Early warning would enable first responders to approach an emergency area with the correct equipment (e.g. breathing apparatus) and extinguishers, noting that different extinguishers are needed for different chemical compositions.
- **Improved fire risk management.** Knowing the location, prevalence, and types of batteries in different locations will enable better resource allocation (skills, training and equipment) and response times.
- **Recall benefits.** There have been a number of international battery recalls in recent years, and if ignored, these could lead to increased fire risk. From a recent recall[21], only 30% of the batteries were returned. A storage register could ensure that recall information is accurately and efficiently communicated to the correct households, and provide an opportunity to follow up if there is no response.

The above benefits will only increase over time as the uptake of batteries increases. If a national register is proven to be economically viable based on the energy security benefits (primary objective), the additional benefits to emergency service workers could be delivered at negligible additional costs.

Because of the sparsity of data, Jacobs has not included this benefit in the CBA. However, Jacobs did undertake some review of international incidents related to PV systems, to get an idea of the potential for fire risk issues.

A recent German study[22] by Fraunhofer ISE stated that Germany has more than 1.4 million PV plants, and that over the past 20 years, 350 solar systems have caught fire. If we assume a similar rate for batteries, this implies a risk of approximately 0.025% for each battery installation. The Alternative Technology Association (ATA) in Australia have quoted higher fire rates[23], but it would seem that these rates might not be applicable to the future because it would be likely that certain recommendations to mitigate fire risk would be implemented in coming years.

Having a probability of fire, it might be possible to apply this to an indicative cost of fire per incident. However, the potential impacts of battery related fires may be quite different to those from PV. The Fraunhofer study indicated that 75 of the 350 house fires resulted in severe damage, and 10 of the 350 house fires resulted in the building burning to the ground. None of the fires resulted in death, but the location of PV may be less likely to cause death because first responders will naturally maintain a safe distance as a result of PV being located on rooftops. In the case of batteries, the probability of death may be different because they may be installed in enclosed places such as garages.

Taking a conservative (and indicative) approach, and ignoring the likelihood of death, Jacobs has assumed an average cost per fire incident of $100,000[24] and that early response reduces severity of the incident by 10%. This would result in an average benefit of $2.2 million in present value terms based on a discount rate of 7%.

[21] Information provided by stakeholder during consultation phase
[22] Dr Harry Wirth, "Recent Facts about Photovoltaics in Germany", February 2017, Fraunhofer ISE
[23] "Fire Safety of Solar Photovoltaic Systems in Australia", ATA, May 4 2016
[24] Based on an assumption that minor incidents cost $40,000, severe incidents cost $100,000 and complete rebuilds cost $1,000,000

10.3.1 Consideration of potential benefits to network staff, installers and the general public

One of the objectives for a national storage database was also to reduce safety risks to network staff, installers and the general public. Line workers need to be able to isolate generation systems to avoid the risk of electrocution. Insufficient knowledge about the presence of batteries at a given site has been raised as a potential safety risk that may be addressed through better information.

In the initial scope of work it was considered that this group would require access to a complete and reliable database of battery storage devices because they would not know if they are working in areas near homes with battery installations which are in effect unknown sources of electrical current. However Jacobs understands that there are existing network protocols to manage this risk (e.g. disconnecting all connected properties as a precaution). There would be significant risks in changing these protocols if the register is not accurate or is not up to date. As such, it is considered unlikely that a register would have any material impact on line-worker safety or the time taken to manage safety from unknown DERs.

Similarly, members of the public who may be carrying out minor electrical works and installers need to be able to isolate generation systems to avoid the risk of electrocution. In all instances it is expected that a homeowner or installer would be aware of a battery storage device except perhaps where alternative works are being undertaken within a residence that does not involve the battery. A complete and reliable database of battery storage devices might help such people to isolate sources of electrical current from batteries; however it is questionable whether such a system would actually be used in these instances. As such, these benefits are considered to be negligible and unlikely to impact the outcome of the economic assessment.

10.4 End of life disposal benefits

Lithium-ion batteries are hazardous materials. Illegal dumping could become a safety issue as these devices reach the end of their life. In Australia, one is paid for the recycling of lead-acid batteries but not for lithium ion batteries. There have been incidents where lithium-ion batteries have been grouped with lead-acid batteries for recycling. When these chemicals are crushed together they can ignite, leading to fire and/or injury.

A storage register can provide more accountability for responsible disposal, and create opportunities for new policies or private investment for recycling. These benefits have not been quantified due to inadequate data on likelihood and consequence of these events occurring.

10.5 Policy benefits

More reliable and complete information about the uptake of battery storage in Australia, and the capacity of storage can lead to more informed policy decisions in this sector. The benefits that are realised from this will depend on the types of policies that are introduced.

10.6 Innovation benefits

Better information can lead to new business opportunities for some businesses. As mentioned above, there may be opportunities from recycling businesses or even aggregators. The potential for these benefits will depend on the privacy and access laws that are introduced.

10.7 Fraud prevention and improved consumer protection

In combination with the serial number app implemented by the CER, the register may assist with fraud prevention[25] and therefore improved consumer protection.

Impact on CBA results: Including these benefits will improve the NPV and BCR. The relative economic viability of Option 1 and Option 2 will not change.

[25] Fraud may exist in the form of claims for STCs where an installation wasn't appropriately undertaken.

11. Conclusion

The CBA is indicative that a battery storage register is economically viable, with an NPV of between $13.3 million and $15.0 million over a 14 year assessment period. The study was developed using a conservative approach. A number of costs and benefits could not be captured quantitatively, with the impact of the unquantified benefits (expected to be more significant than the unquantified costs).

The NPV is expected to increase once factoring in some of these unquantified impacts, particularly the benefits associated with safety, policy development and innovation. Furthermore, the CBA results currently capture all the costs associated with implementing the national database in Western Australia without being able to capture the full benefits associated with deferred infrastructure benefits due to data limitations. These impacts would further increase the NPV.

From the modelled results, it appears that the choice between the two database hosting options (AEMO or CER) is equally viable with little separating them. A decision on the appropriate host may therefore not be purely driven by economic factors.

A significant factor in the NPV results is the data collection approach adopted. It is not practical to change safety regulations so this leaves two choices – collection of data through DNSP connection notices and collection of data through the industry apps enabled by the CER. The choice surrounding the collection agency, mechanism and tool will have a significant impact on the data collection cost, and most importantly, acceptance by installers and consumers, which is critical to the success of the register. A detailed design stage will be imperative to choose an approach that streamlines costs and reduces the burden on installers, but also encourages use through inclusion of soft incentives or other approaches.

Whilst the CBA assumes a given collection approach for each of the host options, there is flexibility to amend these as part of the final design of the register. Any of the collection mechanisms could be matched to any of the host options considered. The most appropriate collection process will depend on further consultation with all stakeholders and a more detailed assessment of the cost and implementation constraints associated of the underpinning regulatory or rule changes (i.e. possible collection mechanisms).

Importantly, it will be necessary to consider which collection mechanism offers the most viable options to streamline data collection needs by CER, the national register and DNSPs. The need to reduce and streamline data requirements is likely to be highly relevant. Data reduction opportunities exist by using references to CEC and other databases to complete missing information fields. For Option 1 modelled, it is assumed that streamlining opportunities exist. However, if the CER expands on its current serial number validation project to link it to connection notices, the total burden on installers could be significantly reduced under Option 2. In fact, the total collection time for a new national storage register, the CER database, and DNSP connection notices could be lower than the current data collection requirements by CER and DNSPs now. This in itself, coupled with an appropriate education effort, could create the best incentive to installers to provide data.

As part of the more detailed design process, it is also recommended that further consideration be given to the treatment of PV system data while the STC database is still relatively reliable. To avoid duplication costs, it may be more appropriate to consider:

- Whether the existing STC database could share data collection with the national energy storage database rather than through its own separate data collection process
- Whether the storage database would rely on the STC database maintained by the CER for information about PV systems during the period prior to 2024; the two databases could operate in parallel until the incentive under the STC is considered to be too low to ensure sufficient data collection is maintained.

With benefits from a national register extending beyond those that could be quantified, and expected opportunities to further reduce the implementation and collection costs through the design process, the economic benefits of a national storage database appear to outweigh the economic costs.

11.1 Next steps – detailed design

The purpose of the CBA was to assess whether a National Storage Register is economically viable. The more detailed design and of the register and the implementation method are still subject to refinement and are expected to be based on further consultation between the key interest groups – particularly the relevant government departments, AEMO, CER, and DNSPs. A summary of the key design issues to be addressed through this process includes:

- The database host once a register is fully established
- The collection mechanism and whether this will be consistent across all jurisdictions
- The changes in regulation needed to underpin the collection and hosting options and the approval process needed
- Whether there will be a transitional phase between existing databases and a national database and/or existing data collection mechanisms and new collection mechanisms
- Whether it is more efficient to use existing data collection tools and processes (e.g. CER processes or DNSP processes) or to develop new fit for purpose data collection apps. This would also depend on market appetite for new tools
- The granularity of data needed for each user group, and opportunities to streamline these to reduce data collection costs
- The relative effectiveness and costs of enforcement and incentive measures to collect the data.

Appendix A. Long term planning assumptions

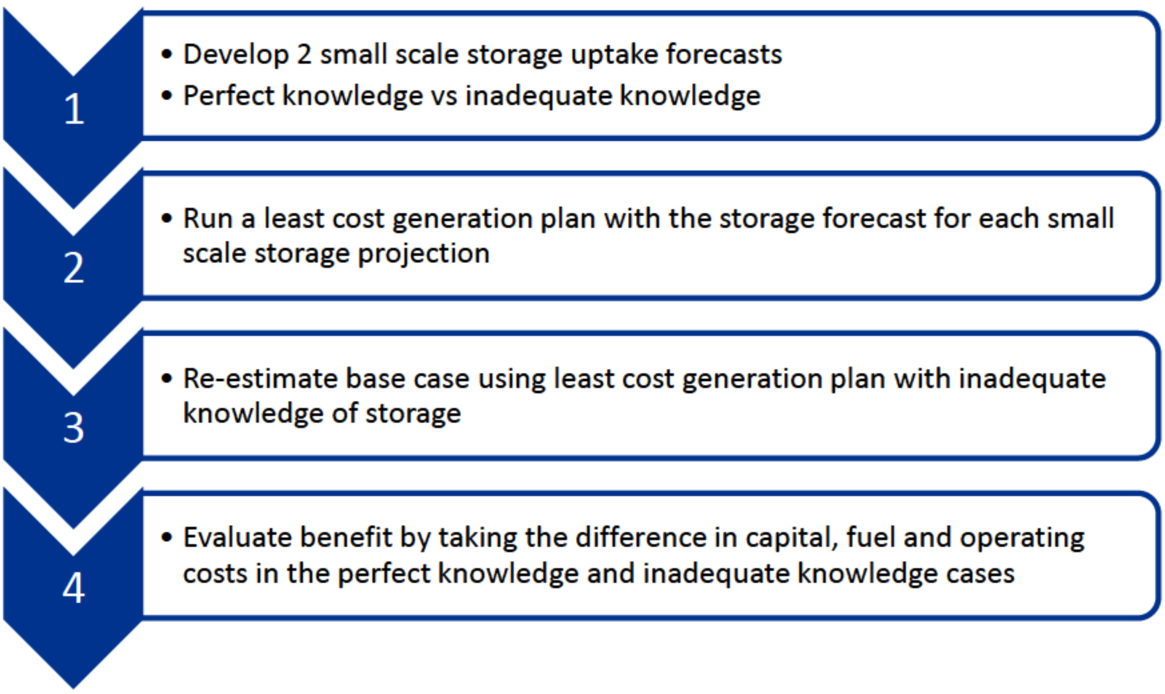
This appendix outlines the assumptions and methodology that underlie Jacobs' electricity market modelling suite, which will be used to assess knowledge benefits associated with long term planning. All modelling will be conducted in December 2016 dollars, and years referenced will refer to financial years ending in June, unless otherwise stated. For example, 2017 refers to the period from 1 July 2016 to 30 June 2017. We will assess the market benefits over the period from 2018 to 2030.

A.1 Modelling Approach

Jacobs will assess the long term benefits of the battery storage register using our suite of market models. Small-scale Battery Energy Storage Systems (batteries) have the potential to affect long term investment decisions, particularly the need for peaking generation to meet reliability standards. This is because the charging and discharging profiles of batteries can add to, or subtract from, system peak demand. Better knowledge of the response characteristics of batteries may therefore lead to more efficient and timely investment decisions for new generation plant. Less than optimal plant investment decisions will have a range of flow on effects in energy markets, not only through inefficient timing of capital investment, but also in the market costs imposed by that plant, such as fuel costs and wholesale price impacts.

In the absence of a register, the impacts on load might still be able to be inferred by the market operator by analysing how observed load responds to price signals, solar insolation, and other factors, although this may be undertaken with considerable difficulty, cost and uncertainty as other newer technologies relating to consumption will almost certainly enter the market in the future as well, and the timeliness of information will make it very difficult to ascertain whether inferred results are at all accurate, reducing any evidence base available to support research and analysis.

The long term market benefits can be assessed by how not having timely information on storage will distort optimum investment decisions on new plant, and the flow on effects of this on energy markets. We will assess this by developing an energy storage uptake forecast, then preparing two scenarios of least cost generation mix: a 'perfect information' scenario, and a 'delayed information' scenario. This analysis has four steps:



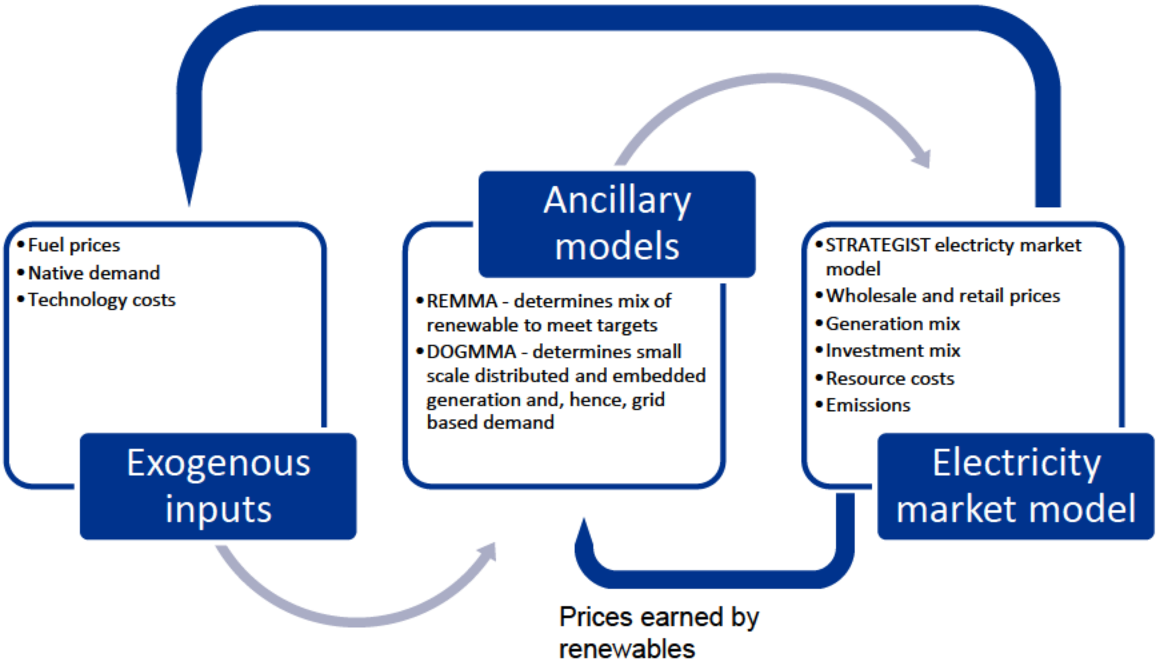
A.2 Software tools and method

Jacobs will use a suite of three models to determine the least cost generation mix in the electricity sector - that is, the electricity sector investments required to satisfy demand at least cost for society as a whole given input prices and policies. This requires iterations between the three models to determine both the direct impacts and interactions between the electricity market and the various ancillary markets used as instruments to meet an emissions constraint.

The three models are:

- Strategist - the electricity sector dispatch and investment model;
- REMMA - the renewable energy market model; and
- DOGMMA - a model that projects the uptake of small-scale embedded generation and storage technologies. Figure 7 shows the interactions between the models.

Figure 7: Modelling approach



Source: Jacobs

The approach to modelling the electricity market impacts, associated fuel combustion and emissions is to utilise externally derived electricity demand forecasts (adjusted for the embedded generation component) in our Strategist model of the NEM. Strategist accounts for the economic relationships between generating plants in the system. In particular, Strategist calculates production of each power station given the availability of the station, the availability of other power stations and the relative costs of each generating plant in the system to match the demand profile, assuming a sufficient level of competition to drive efficient dispatch.

The iterative approach is as follows:

- An initial estimate of total electricity demand and retail price projections are used to work out the level of embedded generation each year and the level and timing of new large-scale renewable generation.
- The level of embedded generation determines the net demand for electricity faced by the electricity grid, which is input into the electricity market models.
- The level and location of new large-scale renewable generation (from REMMA) is also input into Strategist.

- Strategist then simulates the response of the thermal generation sector to produce a new set of wholesale and ultimately retail price projections.
- The whole process is repeated until a stable set of wholesale prices and renewable energy mix by region is achieved.

A.3 Strategist

Jacobs uses its market simulation model of the NEM to estimate the impacts on the electricity market. Electricity market modelling was conducted using Jacobs' energy market database and modelling tools in conjunction with use of probabilistic market modelling software called Strategist. Strategist represents the major thermal, renewable, hydro and pumped storage resources as well as the interconnections between different regions. Average hourly pool prices are determined within Strategist based on plant bids derived from marginal costs or entered directly.

Market impacts are essentially driven by the behavioural responses of the generators to the incentives and/or regulatory requirements of the policy options being examined and the change in the mix of investment due to the incentives provided by the policy options. Wholesale prices are affected by the supply and demand balance and long-term prices being effectively capped near the long run marginal cost of new entry on the premise that prices above this level provide economic signals for new generation to enter the market. Generation mix and other impacts are also influenced by the incentives or regulations provided by the policy option being examined. Other factors affecting the timing and magnitude of the impacts include projected fuel costs, unit efficiencies and capital costs of new plant.

The market impacts take into account regional and temporal demand forecasts, generating plant performance, timing of new generation including renewable projects, existing interconnection limits and potential for interconnection development.

The primary tool used for modelling the wholesale electricity market is Strategist, proprietary software licensed from Ventyx that is used extensively internationally for electricity supply planning and analysis of market dynamics. Strategist simulates the most economically efficient unit dispatch in each market while accounting for physical constraints that apply to the running of each generating unit, the interconnection system and fuel sources. Strategist incorporates chronological hourly loads (including demand side programs such as interruptible loads and energy efficiency programs) and market reflective dispatch of electricity from thermal, renewable, hydro and pumped storage resources.

The Strategist model is a multi-area probabilistic dispatch algorithm that determines dispatch of plant within each year and the optimal choice of new plant over the period to 2050. The model accounts for the economic relationships between generating plant in the system. In particular, the model calculates production of each power station given the availability of the station, the availability of other power stations and the relative costs of each generating plant in the system. The timing of new thermal generation plant and interconnection upgrades is determined by a dynamic programming algorithm that seeks to minimise total system production and new capital costs.

The model incorporates:

- Chronological hourly loads representing a typical week in each month of the year. The hourly load for the typical week is consistent with the hourly pattern of demand and the load duration curve over the corresponding month.
- Chronological dispatches of hydro and pumped storage resources either within regions or across selected regions (hydro plant is assumed to shadow bid to maximise revenue at times of peak demand).
- A range of bidding options for thermal plant (fixed prices, shadow bidding, average price bidding).
- Chronological dispatch of demand side programs, including interruptible loads.
- Estimated inter-regional trading based on average hourly market prices derived from bids and the merit order and performance of thermal plant, and quadratic inter-regional loss functions.

- Scheduled and forced outage characteristics of thermal plant.

The model projects electricity market impacts for expected levels of generation for each generating unit in the system. The level of utilisation depends on plant availability, their cost structure relative to other plant in the system and bidding strategies of the generators. Bids are typically formulated as multiples of marginal cost and are varied above unity to represent the impact of contract positions and price support provided by dominant market participants. Contract positions are typically assumed to apply on an N-1 basis for a portfolio of base load generation. The principles used to represent price support in the market are for moderate bids (multiples of 2 or less) on the coal-fired generating units that provide the support and more aggressive multiples on peaking generating units. These bidding behaviours are benchmarked to actual market outcomes and projected forward in the short term. In the longer term, as the market returns to supply-demand balance, strategic bidding is moderated.

New plant, whether to meet load growth or to replace uneconomic plant, are chosen on a least cost basis subject to meeting two criteria:

To ensure electricity reliability are met under most contingencies. The parameters for quality of supply are determined in the model through the loss of load, energy not served and reserve margin. We have used a maximum energy not served of 0.002% on a regional basis, which is in line with planning criteria used by system operators.

Revenues earned by the new plant equal or exceed the long run average cost of the new generator.

Each power plant is considered separately in the model. The plants are divided into generating units, with each unit defined by minimum and maximum operating capacity, heat rates, planned and unplanned outages, fuel costs and operating and maintenance costs. Minimum operating capacities are enforced under all policy scenarios.

Strategist also accounts for inter-regional trading, scheduled and forced outage characteristics of thermal plant (using a probabilistic mechanism), and the implementation of government policies such as the Renewable Energy Target (RET) schemes.

Timing of new generation is determined by a generation expansion plan that defines the additional generation capacity that is needed to meet future load or cover plant retirements by maintaining minimum reserve and reliability standards. As such by comparing a reference case to a policy scenario, we can quantify any deferred generation benefits. The expansion plan has a sustainable wholesale market price path, applying market power where it is evident, a consistent set of renewable and thermal new entry plant and a requirement to meet reserve constraints in each region. Every expansion plan for the reference and policy scenarios in this study has been checked and reviewed to ensure that these criteria are met.

Strategist represents the major thermal, hydro and pumped storage resources as well as the interconnections between the NEM regions. In addition, Jacobs partitions Queensland into three zones to better model the impact of transmission constraints and the trends in marginal losses and generation patterns change in Queensland. These constraints and marginal losses are projected into the future based on past trends.

Average hourly pool prices are determined within Strategist based on thermal plant bids derived from marginal costs or entered directly. The internal Strategist methodology is represented in Figure 8 and the Jacobs modelling procedures for determining the timing of new generation and transmission resources, and bid gaming factors are presented in Figure 9.

The PROVIEW module of Strategist is used to develop the expansion plan with a view to minimising the total costs of the generation system plus interconnection augmentation. This is similar to the outcome afforded by a competitive market. However due to computational burden and structural limitations of the Strategist package, in one simulation it was not feasible to complete:

The establishment of an optimal expansion plan (multiplicity of options and development sequences means that run time is the main limitation), and

We therefore, conducted a number of iterations of PROVIEW to develop a workable expansion plan and then refined the expansion plan to achieve a sustainable price path applying market power where it was apparent and to obtain a consistent mix of new entry plant.

Strategist generates average hourly marginal prices for each hour of a typical week for each month of the year at each of the regional reference nodes, having regard to thermal plant failure states and their probabilities. The prices are solved across the regions of the NEM having regard to inter-regional loss functions and capacity constraints. Interregional capacity is increased in line with capacity needed to avoid prolonged substantial price separation between interconnected regions, with price separation not being greater than typical line losses.

Figure 8: Strategist Analysis Flowchart

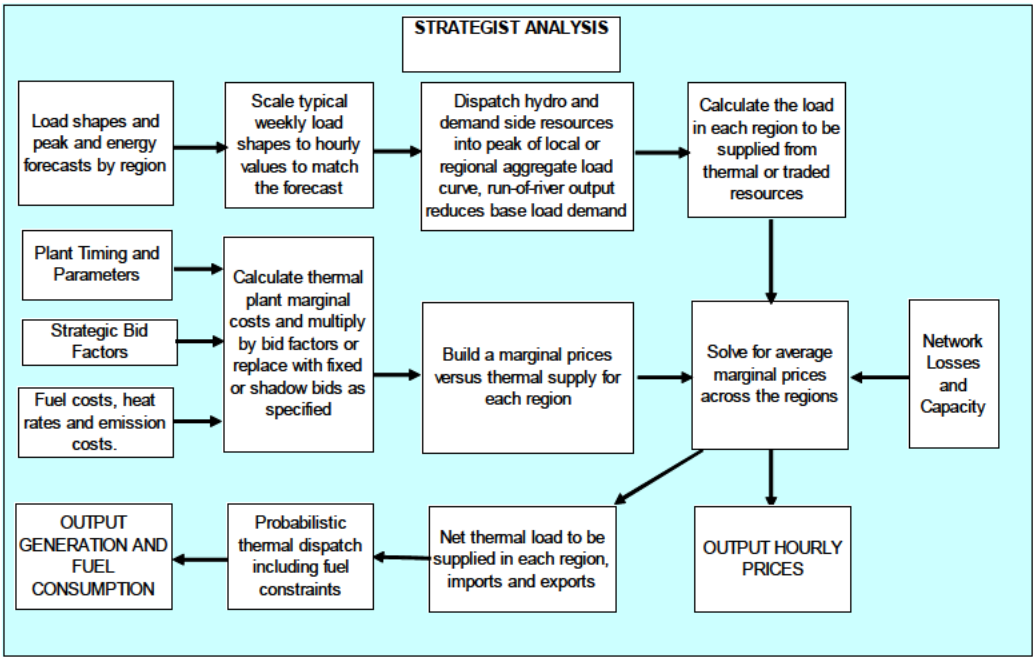
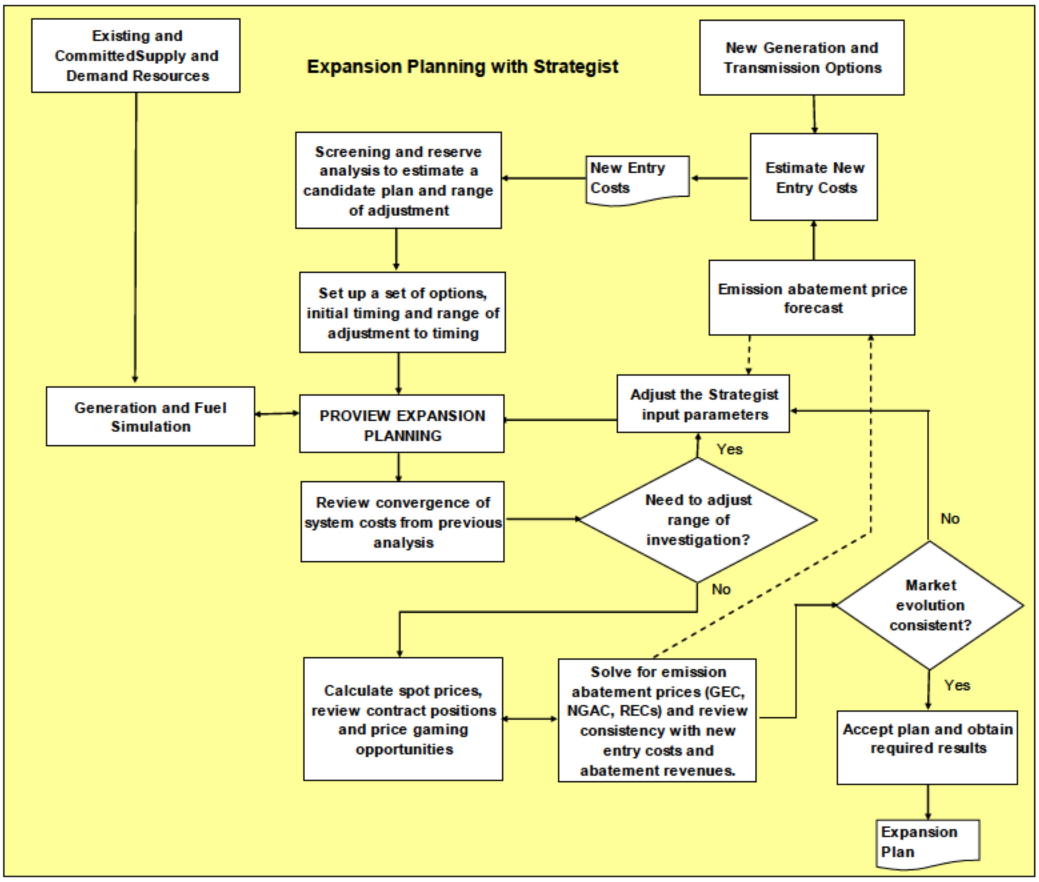


Figure 9: Jacobs Strategist Modelling Procedures



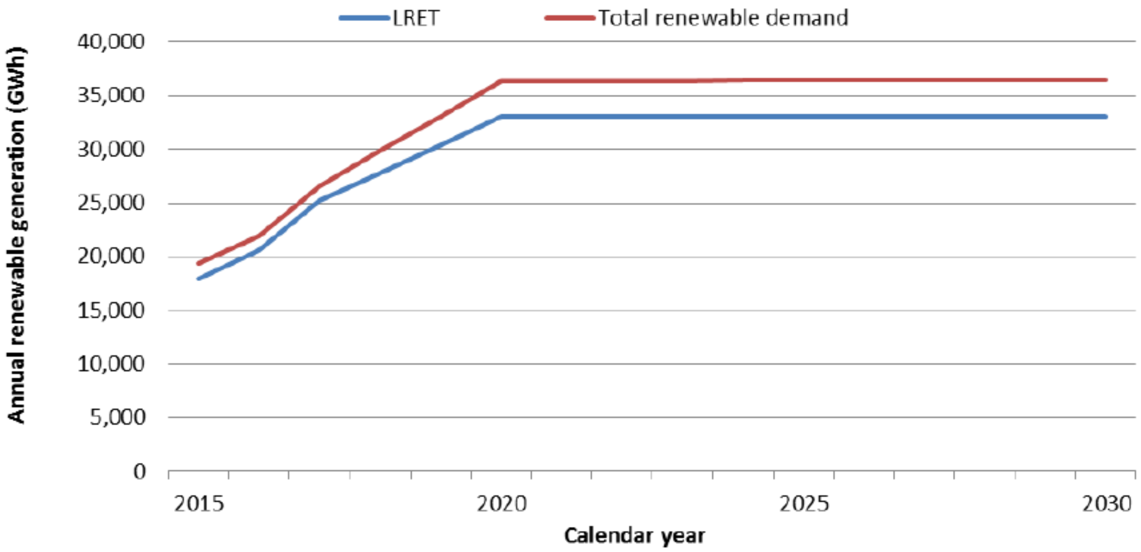
A.4 Modelling uptake of large scale renewable generation

The large scale renewable energy target (LRET) is shown in Figure 10 by calendar year, and includes estimates of GreenPower, estimated demand from water desalination and the ACT renewable energy target. REMMA operates by determining a least cost renewable generation plan to meet this target. LGC demand will no longer be a significant driver for new investment in renewable energy post 2020. It is reasoned that long term demand for renewable electricity will be based on continuing development in government policy, with a view to long-term emission abatement.

The renewable energy market under any renewable energy target scheme was modelled in REMMA. REMMA is a tool that estimates a least cost renewable energy expansion plan, and solves the supply and demand for LGCs having regard to the underlying energy value of the production for each type of resource (base load, wind, solar, biomass with seasonality).

Strategist is run in conjunction with the renewable energy market model to determine the wholesale market solution that is also compatible and most efficient with regard to renewable energy markets. Additional renewable generation has the effect of reducing wholesale prices while reduced wholesale prices typically have the effect of reducing investment in renewable generation. Iteration of these models typically allows the overall solution to converge to a stable model of consistent wholesale and renewable energy markets.

Figure 10: Current profile of the Renewable Energy Target



Source: Jacobs' analysis

The REMMA model the impact of policies affecting an expanded target or through external price incentives to be simulated. Uptake of renewable generation, both its timing and location, is affected both by mandated targets and the impacts of other policies designed to reduce emissions of greenhouse gases.

Projecting certificate prices with the REMMA model is based on the assumption that the price of the certificate will be the difference between the cost of the marginal renewable generator and the price of electricity achieved for that generation. The basic premise behind the method is that the certificate provides the subsidy, in addition to the electricity price, that is required to make the last installed (marginal) renewable energy generator to meet the mandatory target economic without further subsidisation. The REMMA uses a linear programming algorithm to determine least cost uptake of renewable technologies to meet the target, subject to constraints in resource availability and regulatory limits on uptake, whilst also taking into account the penalty price for any shortfall in meeting the target. The optimisation requires that the interim targets are met in each year (by current generation and banked certificates) and generation covers the total number of certificates required over the period to 2030 when the program is scheduled to terminate. The model has an explicit variable that measures non-compliance with the target (i.e. a shortfall of renewable energy generation), which can be set to a positive value if doing so minimises the total cost of the scheme (i.e. it is cheaper to violate the target by paying the penalty price). Therefore the ability for the RET to be met economically is an output of the model.

The certificate price path is set by the net cost of the marginal generators, which enable the above conditions to be met and result in positive returns to the investments in each of the projects. Jacobs has a detailed database of renewable energy projects (existing, committed and proposed) that supports our modelling of the renewable uptake. The database includes estimation of capital costs, likely reductions in capital costs over time, operating and fuel costs, connection costs, and other variable costs for over 900 individual projects.

The model can be readily extended to include other forms of low emission generation. The model already includes waste coal mine gas as an option to meet a separate target.

A.5 Load profiles for battery owners

It is not likely to be known how owners of batteries will operate their systems. How users choose to charge and discharge their batteries will depend on the benefits they ascribe to these systems and the degree of exposure they have to wholesale price volatility. At present, the majority of residential households adding energy storage to their homes also have solar PV systems – for these users, the charge/discharge profiles are likely to reflect an objective to maximise self-consumption. Charging and discharging profiles are therefore likely to be fixed, and tied to household usage. We will model this type of behaviour as essentially a fixed load, that isn't responsive to wholesale market conditions.

A.6 New generation

The dynamic programming method in Strategist selects new capacity on a least-cost basis. The model is generally accurate in the prediction of the future generation mix, with the main deviations from predicted investment the result of:

- Economies of scale, for example, Pelican Point was sized at twice the optimal capacity as indicated in early expansion studies
- Pre-emptive new entry: new coal plant in Queensland at Callide and Millmerran in 2000 was commissioned two years prior to the optimal timing indicated by system expansion studies
- Fuel supply arrangements: the recent mothballing at Tarong instead of other Queensland power plants would seem to be based upon flexibility of fuel supply at Tarong versus take-or-pay arrangements at other power stations that have higher average costs, but lower avoidable costs, (the details of these arrangements, and therefore implications for the avoidable cost structure, are not always ascertainable to independent third parties)

Our analysis typically shows that wind, solar and open cycle gas turbines are the favoured new entrants in the period to 2020 with some combined cycle plant thereafter.

A.7 Retirements

Plant retirements are analysed manually after the expansion plan and pricing is developed in the Strategist model. Plant is retired if its avoidable operating cost exceeds its pool revenue, allowing for some contracting premium on the pool revenue. The current commitments to reduced generation plant available at Swanbank in Queensland, Northern in South Australia[26] and Smithfield in New South Wales have been included in the modelling.

A.8 Interconnection development

Interconnection upgrades are included in the Strategist modelling as development options in competition with new generation capacity.

A.9 Demand

The NEM market model that will be used in this study is based on 50% POE [27](median) peak demand and the medium economic growth demand forecasts available in the 2016 NEFR. The use of the 50% POE peak demand is intended to represent typical peak demand conditions and thereby provide an approximate basis for median price levels and generation dispatch. For the SWIS, the demand projections that will be used are based on the median peak demand and medium economic growth scenarios developed by the IMO in the 2014-15 ESOO.

[26] AGL announced that it will defer the proposed 2017 mothballing of Torrens Island A power station. See https://www.agl.com.au/about-agl/media-centre/article-list/2016/june/agl-to-defer-mothballing-of-south-australian-generating-units We have therefore kept Torrens Island A in the model.

[27] The 50% POE (probability of exceedance) for peak demand implies that there is a 50% probability the actual peak demand will not exceed the forecasted value.

Appendix B. Battery and PV uptake projection method

Uptake of small-scale renewable distributed generation is being forecast using Jacobs' structural model of distributed and embedded generation called DOGMMA (Distributed On-site Generation Market Model Australia). The model determines the uptake of small-scale renewable technologies based on comparing the net cost of generation against the net cost of grid delivered power. The model operates on a spatial and market basis, separately providing projections by region and customer class.

The factors considered are as follows:

- Eligible system STC creation for previous years, showing the historical trend in small-scale technology uptake
- Change in cost of small-scale PV systems and Integrated PV and Storage Systems (IPSS) due to new technological and manufacturing improvements and changes in the cost of system components
- State and Commonwealth incentive schemes and any expected changes to these schemes over the timeframe, including the impact of potential changes to the state-based feed-in tariffs
- Changes to avoidable electricity retail prices, potential re-introduction of a carbon price mechanism, network regulatory reform (e.g. a number of networks are re-adjusting their tariffs to provide a higher revenue share from capacity based charges rather than variable charges)
- The forecast number of new dwellings
- PV and IPSS system output and exports
- Relevant legislative changes to the eligibility rules and criteria for small-scale PV systems
- Global financial conditions, such as changes in currency values, and changes to the cost of raw materials
- Changes in financial innovation, e.g. CEFC loans, and business models
- STC price
- Limiting factors for PV and IPSS uptake for households and businesses.

B.1 DOGMMA

DOGMMA determines the uptake of renewable technologies with and without storage based on net cost of generation (after FiT[28] revenue and other subsidies are deducted from costs) versus net cost of grid delivered power.

Revenues from small-scale generation will vary by location because of differing insolation levels which will affect the capacity factor of the units, as well as differing retail charges based on the network area of operation. The model is loaded with estimates of location specific insolation and tariff data enabling it to estimate generation and revenue from newly installed system.

The cost of small scale renewable energy technologies is treated as an annualised cost so that the capital and installation cost of each component of a small scale generation system is annualised over the assumed lifespan of each component, discounted using an appropriate weighted average cost of capital calibrated to match typical payback periods expected by customer groups (7 years for residential customers and 5 years for commercial customers).

[28] Feed-in-tariff

Revenues include sales of electricity to the grid using time weighted electricity prices on the wholesale and retail market (as affected by any emissions reduction policy), avoidance of network costs under any type of tariff structure, including upgrade costs if these can be captured, and the cost of avoided purchases from the grid.

The net cost is determined by deducting revenues from annualised costs. If the net cost is negative, uptake occurs subject to limiting factors.

B.1.1 Optimisation approach

The model selects the level of small-scale generation that minimises electricity supply costs to each region (as defined by ABS Statistical Areas).

The level of uptake of small scale systems increases to the point where any further uptake leads to higher costs of electricity supply than the PV and IPSS systems costs plus a premium for roof-top systems willing to be paid by consumers[29].

The optimisation matches the cost of small scale systems (capital costs and any operating costs) to the avoided grid supplied electricity costs (as would have been experienced by the customer in the absence of the system). The costs of small-scale systems may be reduced by being eligible for a subsidy (for example, the sale of certificates generated under the SRES scheme), or the ability to earn revenue either through sale of surplus electricity generation (surplus to the needs of the householder or commercial business) or from enacted feed-in tariffs.

The optimisation is affected by a number of constraints[30], which are as follows:

- There is a limit to the maximum number of householders and commercial businesses that can install a system:
    - The maximum proportion of residential households that can purchase the system is currently the same for each region and it is set at 55% of all households in the region[31]. This limit was determined by the number of separate dwellings (on the assumption that only separate dwellings would install systems) that are privately owned (on the assumptions that only privately owned dwellings would install systems), and allowing for some limits on installations for heritage or aesthetic reasons. For this modelling exercise, we propose to relax this limit over time to account for the potential use of leasing arrangements in rented dwellings. It is proposed the limit is gradually relaxed to 65% over a 20 year period commencing 2016.
    - The maximum proportion of commercial businesses that can install a system is 65% of electricity demand. Commercial customers are those in the wholesale and retail trade, schools, hospitals and government offices.
- There are limits on the rate of uptake of each technology in each region. This constraint is designed to ensure there is not a sudden step up in installation rates once a flip point is reached (the point at which the cost of PV and IPSS becomes cheaper than grid supplied electricity) and to account for any logistic constraints. Once the initial simulation is performed, these constraints are progressively relaxed if it appears the constraint is binding uptake unreasonably.

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[29] The model allows a premium above grid supply costs for PV systems to account for the purchase behaviour of customers who are willing to pay more for their systems. The premium diminishes to zero as uptake increases on the assumption that only a portion of customers are willing to pay this premium.

[30] In previous modelling studies we were assuming that each household or business can invest either to a solar water heater or a PV system due to space scarcity. This constraint is no longer used.

[31] According to the ABS (see ABS (2013), *Household Energy Consumption Survey, Australia: Summary of results, 2012*, Catalogue No. 4670.0, Canberra, September), there are 8.7 million households in 2012 in Australia. Around 89% of these households were either separate dwellings or semi-detached dwellings (townhouses, flats). Around 67% of dwellings are privately owned. Assuming that this number is applied to separate dwellings, then 59.2% of households could install PV systems under our assumptions. We allowed an extra 4% to cater for other constraints on installation.

- There are limits on the number of homes and business premises that can accommodate the large sized systems of above 5 kW. We do not have data on the distribution of size of household roof space by region, so this constraint is enforced to limit uptake to around 20% of total households in most regions.

The technology costs are also adjusted with premiums so that uptake predicted by the model matches historical uptake more closely. The premium reflects the willingness of some consumers to purchase PV systems even if the cost is above grid supply costs. We calculate the premium based on market survey data and other published market data. The premium is assumed to decrease as the rate of uptake increases (reflecting the fact that the willingness to pay will vary among customers).

The costs avoided by small-scale PV systems with or without battery storage comprise wholesale electricity purchase costs (including losses during transmission and distribution), market and other fees, variable network costs, and retail margins.

B.1.2 Model Structure

DOGMMA is characterised by:

- A regional breakdown, where each region is defined by ABS Statistical Areas Level 4. Transmission connection points have been grouped geographically by Statistical Area and their demand forecasts aggregated. Currently the model comprises 87 regions (see Table 28).
- The handling of different technologies of differing standard sizes. The sizes depend on typical sized units observed to be purchased in the market. For this study the technologies and systems used include:
  - For the residential sector: solar water heater, 1.0 kW PV system, 1.5 kW PV system, 3 kW PV system, 5 kW PV system, and 3 kW or 5 kW IPSS systems.
  - For the commercial sector: 5, 10, 30 and 100 kW PV systems; 10, 30 and 100 kW IPSS systems.
- Differentiation between the commercial and residential sectors where each sector is characterised by standard system sizes, levels of net exports to the grid, tariffs avoided, funding approaches and payback periods. The assumptions on these used for this study are shown in Table 29.
- The ability to test implications of changing network tariff structures and changes to Government support programs including the proportion of network tariffs that are not 'volume based' (that is, that are independent of average energy use). In practice such tariffs could be fixed supply charges, or linked to peak demand ('capacity charges'). These are not differentiated within Jacobs' model, which assumes that all Victorian customers move away from volume-based network tariffs over the period to 2023 [32]so that by 2023 50% of network tariff charges are derived from capacity charges and the remaining 50% of network tariff charges are derived from a variable component (on average, there are variations across network service providers).

  Other states and territories move away from volume-based network tariffs in the period to 2027. Capacity and supply charges are assumed to make up 50% of network tariffs by:
  - 2025 in states with higher penetration of rooftop PV (i.e. Queensland, WA and SA), and
  - 2027 in rest of Australia (i.e. NSW, ACT, Tasmania and NT).

Table 28: Number of regions modelled in DOGMMA

State	No of regions
Queensland	19
NSW (including ACT)	29
Victoria	17
South Australia	7

[32] According to published data most electricity distr butors will have 50% variable charges by 2020 with the exception of CitiPower (20%) and Jemena (80%).

State	No of regions
Tasmania	4
Western Australia	9
Northern Territory	2

Source: Jacobs' analysis based on data provided by AEMO, IMO and ABS

Table 29: System characteristics by customer sector

Sector	% of output exported	Funding approaches	Payback period
Residential	0% for smaller systems (1 and 1.5 kW) 40% for larger systems (2 kW and higher)	Upfront purchase either by debt financing or outright purchase	10 years
Commercial	40% for up to 10 kW 25% for 30 kW 20% for 100 kW	10 year leases	10 years

B.2 Cost assumptions

Capital cost assumptions for small-scale are based on the January and February 2017 *Solar PV price check* article on the Solar Choice website[33], which is based on price data from over 100 solar installation companies across Australia. The battery storage costs are sourced from CSIRO's "Future energy storage trends" report prepared for the Australian Energy Market Commission in September 2015, as modified with the latest market data[34]. The population projections are based on the latest Australian Bureau of Statistics data. The modelling environment assumes a Neutral economic growth scenario.

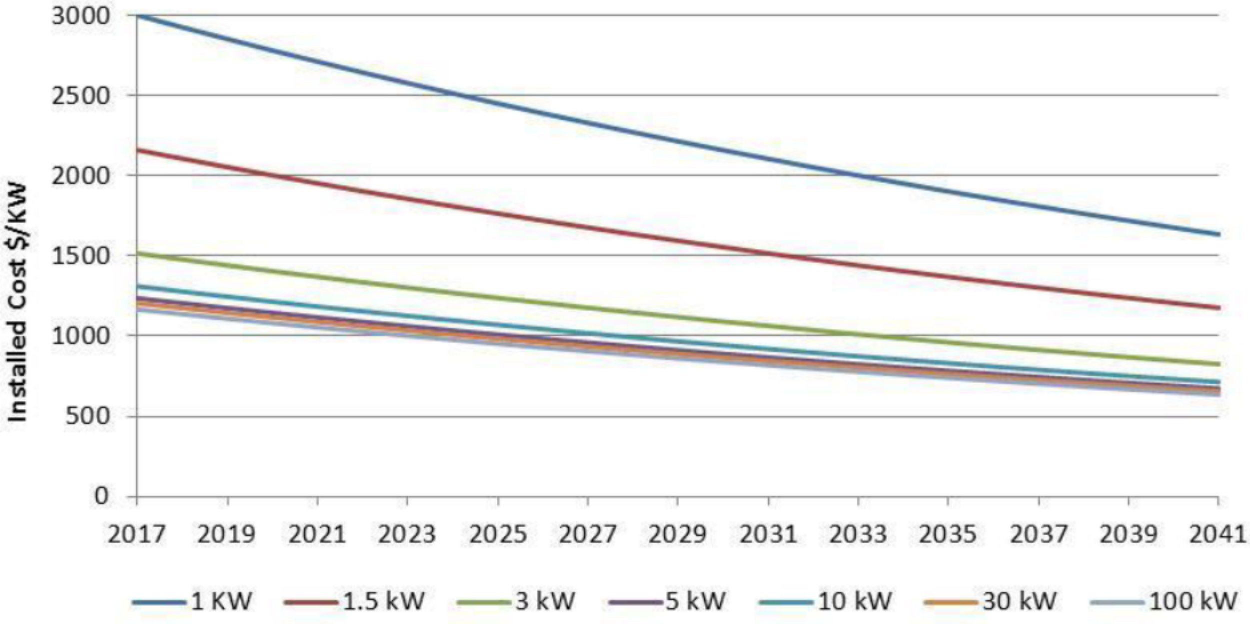
B.2.1 PV systems costs

PV systems cost assumptions are shown in Figure 11. The costs in 2017 are sourced from trade data and include balance of system and installation costs while they exclude the STCs rebates. The costs are lower for larger system sizes reflecting economies associated with installing larger systems. The capital costs are projected to decline by 1.5% per annum in real terms based on international and Australian related studies.

[33] http://www.solarchoice.net.au/blog/residential-solar-pv-system-prices-february-2017; http://www.solarchoice.net.au/blog/news/commercial-solar-system-prices-jan-2017

[34] Such as for the Tesla Powerwall 2. See https://www.tesla.com/en_AU/powerwall

Figure 11: Neutral scenario Installed total cost assumptions for PV small scale systems



Source: Jacobs analysis based on 2017 data on installed cost supplied in Solar Choice (2017), "Solar PV Power System Prices", January and February 2017 edition. Published total system installation cost data are net of the rebate obtained from Small-scale Technology Certificates.

B.2.2 PV capacity factors

Previously the DOGMMA model has used state wide capacity factors for the selected technology options due to a lack of regional data. The model has now been updated to use solar capacity installation data (by postcode) from the Clean Energy Regulator and insolation data (by coordinates) from the Bureau of Meteorology from 2009 to 2015 to calculate a unique load factor parameter for each of the 87 regions in the model.

The average capacity factor for each technology in each state diminishes as the level of capacity increases in each region. This is based on the notion that as more systems are installed, they are progressively in less favourable roof spaces (for example, roof spaces facing other than north or due to shading. The initial capacity factors applying in each state are shown in Table 30. PV systems with storage are assumed to have lower initial capacity factors due to energy losses occurring during charging and discharging cycles.

Table 30: Initial load factors for small-scale PV systems by region

	VIC	NSW and ACT	TAS	SA	QLD	WA	NT
PV	10.7-12.7%	11.2-12.3%	10.2-11.2%	12.2-13.4%	12.1-14.6%	12.1-15.4%	14.6%
IPSS	9.9-11.8%	10.4-12.3%	9.5-10.4%	11.3-12.4%	11.2-13.5%	11.2-14.2%	13.5%

Source: Jacobs' analysis based on data provided by CER and BoM.

B.2.3 Battery costs

The future of cost of batteries is subject to considerable uncertainty and it is the main driver on the future uptake of PV systems with storage. Jacobs has adopted the base Li-ion battery cost trajectories from CSIRO's "Future energy storage trends" report that was prepared for the AEMC in September 2015, as modified by more recent market data. Excluding inverter and installation costs, costs are expected to decline to around $200/kWh in 2030, compared to present levels of around $460/kWh.

The inverters for battery storage can both transmit and receive electricity (inverter-chargers) and are therefore more complex than the most common PV inverters. In the DOGMMA model, when an already installed PV system adds a battery system (retrofitting) it is assumed that a new inverter will also need to be installed to accommodate the new system[35]. More recent battery storage options, however, include a bidirectional inverter and the costs of battery will reflect this option. Inverter costs are expected to decline to around $530/kWh in 2030 compared to present levels of nearly $800/kWh.

B.2.4 Feed in tariffs

Feed-in tariffs are equivalent to payments for exported electricity. Feed-in tariff schemes have been scaled back in most jurisdictions so that the value of exported energy does not provide a significant incentive to increase uptake of solar PV systems.

Between 2008 and 2012, state governments in most states mandated feed-in tariff payments to be made by distributors to owners of generation systems (usually solar PV). A list of such schemes is provided in Table 31. Following a commitment by the Council of Australian Governments in 2012 to phase out feed-in tariffs that are in excess of the fair and reasonable value of exported electricity, most of these schemes are now discontinued and have been replaced with feed-in tariff schemes with much lower rates.

However, the costs of paying feed-in tariffs from those schemes to customers must still be recouped as eligible systems continue to receive payments over a period that could be as long as twenty years. Network service providers provide credits to customers who are eligible to receive feed-in payments, and recover the cost through a jurisdictional scheme component of network tariffs. Networks are able to estimate the required payments each year and include these amounts in their tariff determinations adjusting estimated future tariffs for over and underpayments annually as needed. Where this has occurred, it would be reasonable to assume that cost recovery components are included in the distribution tariffs under 'jurisdictional' charges, so no additional amounts are included in the Jacobs' estimates of retail price. In all cases where distributors are responsible for providing feed-in tariff payments, the distributors would have been aware of the feed-in tariffs prior to the latest tariff determination, so it is reasonably safe to assume inclusion.

Retailers offer market feed-in tariffs, and the amount is set and paid by retailers or jurisdictional regulators. Where such an amount has been mandated, the value has been set to represent the benefit the retailer receives from avoided wholesale costs including losses, so theoretically no subsidy is required from government or other electricity customers. Going forward, the tariff rates are set using Jacobs' wholesale price projections for typical PV weighted generation profiles – this should enable the capture the potential impact of high penetration rates on daytime electricity prices.

Table 31 Summary of mandated feed-in tariff arrangements since 2008

State or territory	Feed-in tariff	Cost recovery
Queensland	<u>*Queensland solar bonus scheme (legacy)*</u> The Queensland solar bonus scheme provides a 44 c/kWh feed-in tariff for customers who applied before 10 July 2012 and maintain their eligibility. The scheme was replaced with an 8 c/kWh feed-in tariff which applied to 30 June 2014. The scheme is now closed to new solar customers. The tariff provided to existing solar customers is recovered through an impost in the network tariffs of Ergon Energy, Energex and Essential Energy. These networks must apply annually to the AER for a pass through of these costs which are expected to diminish over time.	Network tariffs include provision for legacy payments
	<u>*Regional mandated feed-in tariffs*</u> From 1 July 2014, retailers in regional Queensland are mandated to offer market feed-in tariffs that represent the benefit the retailer receives from exporting solar energy, ensuring that no	Assume 7.447 c/kWh over projection period.

[35] CSIRO (September 2015), "*Future energy storage trends*", Report prepared for the Australian Energy market Commission

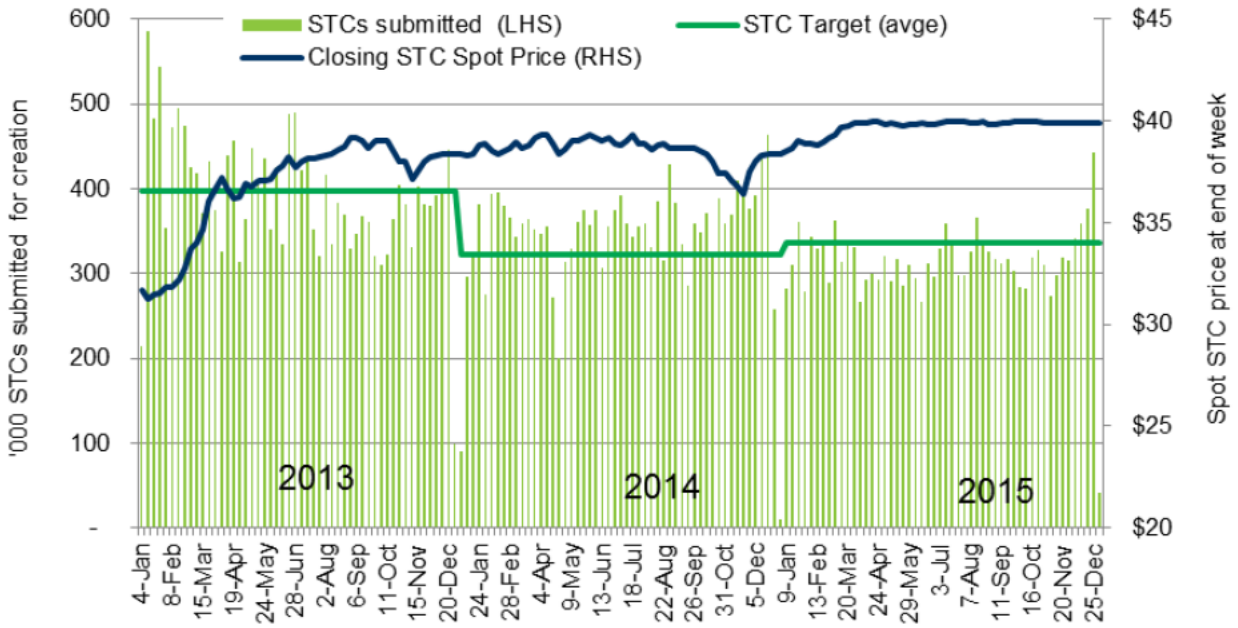
State or territory	Feed-in tariff	Cost recovery
	subsidy is required from government or other electricity customers. The feed-in tariff is paid by Ergon Energy and Origin Energy for customers in the Essential Energy network in south west Queensland. The amount set in 2016/17 is 7.447 c/kWh.	
NSW	*NSW Solar Bonus scheme* This scheme began in 2009 offering payment of 60 c/kWh on a gross basis, reduced to 20 c/kWh after October 2010. The scheme closed in December 2016 when legacy payments made by distributors and are recovered through network tariffs ended. IPART now regulates a fair and reasonable rate range for new customers who are not part of the SBS, where the minimum rates in 2011/12 were 5.2 c/kWh, 6.6 c/kWh for 2013/14, 5.1 c/kWh for 2014/15, and 4.7 c/kWh from 2015/16, and 5.5 c/kWh for 2016/17. However offering the minimum rate is optional.	Network tariffs include some provision for legacy payments which is topped up by retailer contribution. Assume 5.5 c/kWh over projection period to cover retailer benefit.
ACT	*ACT feed-in tariff (large scale)* ACT feed-in tariff (large scale) supports the development of up to 210 MW of large-scale renewable energy generation capacity for the ACT. This scheme has been declared to be a jurisdictional scheme under the National Electricity Rules, and is therefore recovered in network charges. *ACT feed-in tariff (small scale, legacy)* ACT feed-in tariff (small scale), is already declared to be a jurisdictional scheme under the National Electricity Rules, and is therefore recovered in network charges. In July 2008 the feed-in tariff was 50.05 c/kWh for systems up to 10 kW in capacity for 20 years, and 45.7 c/kWh for systems up to 30 kW in capacity for 20 years. The feed-in tariff scheme closed on 13 July 2011.	Network tariffs include provision for feed-in tariffs. Assume 5.5 c/kWh over projection period to cover retailer benefit (based on NSW estimates)
Victoria	*Premium and transitional feed-in tariff scheme (legacy)* The Victorian Government introduced the premium feed-in tariff of 60 c/kWh in 2009 and closed it to new applicants in 2011. Consumers elig ble for the premium rate are able to continue benefiting from the rates until 2024 if they remain eligible to do so. The Transitional Feed-in Tariff was then introduced with a feed-in rate of 25 c/kWh. The transitional and premium feed-in tariffs are cost recovered through distr bution network tariffs.	Network tariffs include provision for feed-in tariffs
	Minimum feed-in tariffs The Essential Services Commission (ESC) in Victoria is required to determine the minimum electricity feed-in tariff that is paid to small renewable energy generators for electricity they produce and feed back into the grid. The minimum feed-in tariff is determined by considering wholesale electricity market prices, distribution and transmission losses avoided through the supply of distributed energy, avoided market fees and charges, and avoided social cost of carbon. These payments are made by retailers and have shifted to a financial year basis. The ESC has determined that the minimum energy value of feed-in electricity for 2017/18 is 11.3 c/kWh, compared with a January 2016 to July 2017 value of 5 c/kWh, a 2015 value of 6.2 c/kWh and a 2014 and 2013 value of 8 c/kWh.	Assume a feed-in tariff of 11.3 c/kWh, to recover likely retailer rates
South Australia	*Premium feed-in tariff scheme (legacy)* In July 2008 the South Australian government introduced a feed-in tariff scheme providing 44 c/kWh for 20 years until 2028. In 2011, this amount was reduced to 16 c/kWh for 5 years until 2016. This scheme was closed to new customers in September 2013.	Network tariffs include provision for feed-in tariffs
	Retail feed-in tariff / Premium feed-in tariff bonus A retailer contr bution is also available, as set by the SA regulator (Essential Service Commission of South Australia or ESCOSA), where the minimum tariff is set to 6.8 c/kWh in 2016. For 2017, ESCOSA has not set a minimum amount for the retailer feed-in tariff (R-FiT) scheme. Each retailer will determine their own R-FiT amount and structures, and will publicly	Assume a feed-in tariff of 6.8 c/kWh over the projection period

State or territory	Feed-in tariff	Cost recovery
	demonstrate the benefits to solar customers. ESCOSA is monitoring R-FiT prices and will re-set a minimum price if in the best interest of consumers.	
Tasmania	*Metering buyback scheme (legacy)* In Tasmania, Aurora (TasNetworks) offered a feed-in tariff which offered customers a one-for-one feed-in tariff at the regulated light and power tariff for residential customers or general supply tariff for small business customers for their net exported electricity. This program was closed to new customers in August 2013 and replaced with a transitional feed-in tariff of 20 c/kWh for residential customers and a similar blocked feed-in tariff for commercial customers.	Network tariffs include provision for feed-in tariffs
	Post reform The Tasmanian regulator has now stipulated smaller rates which are now 6.67 c/kWh for 2016/17, compared with 5.5 c/kWh for 2015/16, 5.55 c/kWh in 2014/15 and 8.28 c/kWh for the first half of 2014. These rates are now a component of standing offer tariffs provided by retailers.	Assume a retailer tariff of 6.67 c/kWh to recover retailer costs

B.2.5 Small-scale Technology Certificates (STCs)

The price of STCs has been stable over the last three years with a spot price plateauing just below $40.

Figure 12 STC value



Source: Green Energy Markets

The assumed STC price in DOGMMA is $40 in 2017 and remains stable in nominal terms until 2030. Between 2017 and 2030 the SRES will follow a declining deeming rate by one year in each year. That means that systems installed in 2017 will create certificates for 14 years of output while systems created in 2030 are deemed to create certificates for only one year of output.

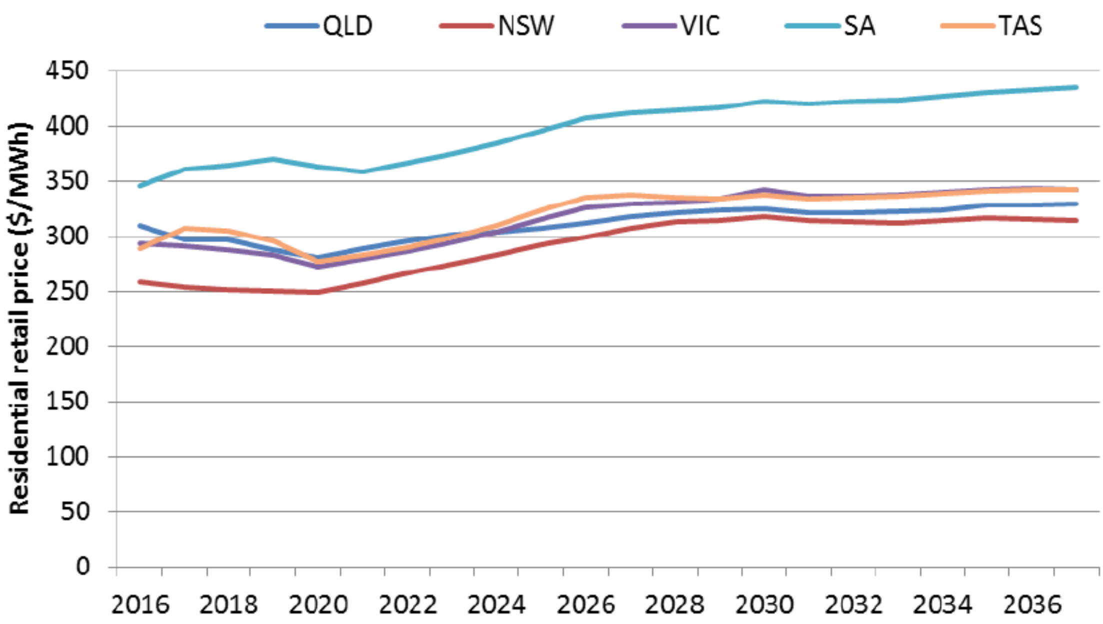
B.2.6 Retail electricity prices

The retail electricity prices are an important component to the calculations in DOGMMA since every kWh of output from a PV system that is consumed by the owner is an avoided cost. The electricity retail prices adopted for this study are the price outcomes from Jacobs' "Retail electricity price history and projections" report for AEMO, since the scenarios and the underlying assumptions have remained unchanged in both studies. For the estimation of these retail prices two policy measures were used so as to achieve the % reduction in emissions at the wholesale market level:

i. The introduction of a carbon price in 2020 commencing at \$25/t CO_2-e and escalating in a linear manner to \$50/t CO_2-e by 2030, remaining flat thereafter; and

ii. Assumed coal-fired retirements, where coal-fired power stations are assumed to be mandated to retire their capacity in a given year with the objective of achieving the 2030 emission reduction target.

Figure 13 Average annual residential retail prices in the Neutral scenario



Source: Jacobs' analysis

B.2.7 Net cost

The net cost of the PV systems is a key variable in explaining the uptake of these systems in the DOGMMA model, which is a forward looking optimisation model that seeks to minimise total energy supply costs from the consumer's viewpoint

The net cost is defined as follows:

- Sum of capital cost including installation
- Less
  - Value of any available government rebates
  - Revenue from the sale of RECs and/or STCs
  - Net present value of future feed-in tariff payments and/or retailer payments for export to the grid
  - Net present value of the avoided cost of electricity

Costs avoided by customers are in one of two ways:

- Avoided retail tariffs on electricity produced by the PV system and used in the premise.

- Revenue earned from exports of electricity that is not used on the premises. This price for exported electricity is equal to the wholesale price weighted to the hourly profile of PV generation plus network losses. This revenue acts a negative cost in the model.

B.3 Behavioural change due to solar PV generation and uptake of battery storage

There are two behavioural assumptions modelled:

- A willingness to pay premium which represent the amount above avoided grid supply costs that consumers are prepared to tolerate in choosing a PV system. This premium reduces to zero with increasing uptake levels. For standalone PV systems, the premium is now assumed to be zero, and choice is purely based on the comparison of economic cost of PV systems versus supply from the grid.

- For PV systems with storage it is assumed PV generation excess to internal load is not exported but instead charges up the battery (to its capacity limit). This stored electricity is used to displace internal energy use in the peak evening period.

B.4 Modelling uncertainties, limitations and exclusions

Some of the main uncertainties regarding this modelling are:

- There is a great uncertainty regarding the trajectory of PV installation costs. While there is a general consensus that internationally the costs will continue to decline, Australia's differentiating dynamics (high wages, low barriers to entry, high amount of Tier 2 or Tier 3 products) is making it more difficult to forecast this cost trajectory.

- The future financial incentives for PV systems such as the FiTs and its terms of payment are considered uncertain.

- In the commercial sector there are a lot of uncertainties regarding the potential size of the market. Among the factors that are difficult to determine is the number of businesses that own the commercial facilities and also the roof space that they have to install a large (>10 kW) system. Furthermore, there is a great uncertainty regarding the number of businesses that consume enough electricity during daylight hours so as to make it financially attractive to invest to PV system.

- Battery storage is an emerging technology in its infancy with no existing patterns and no recording mechanism at the moment. The future of energy storage technologies is subject to considerable uncertainty although it is generally expected to have a sharp decline of costs over the next five years.

- The financial attractiveness of PV systems and IPSS systems is heavily dependent on the future tariff structure in the NEM that is still undetermined. As part of a general drive towards cost-reflective pricing it is expected that the structure will move to time-of-use pricing over time.

- Future policies impacting the uptake of PVs and storage are still uncertain. The historical rapid uptake of rooftop PV during the implementation of generous financial incentives set by the Federal and State governments is a good example of how significant these are for determining the future uptake of the systems.

Furthermore, there are some further issues that will affect the future of PV uptake and battery storage that have not been considered in this study. Some of them are:

- The upgrades, expansions and replacement of residential PVs. Many existing rooftop PV owners have small systems (less than 3 kW) and some of them will consider expanding these systems in response to higher electricity costs and lower PV installation costs. Furthermore, there is the possibility that the transition to a time-of use tariff structure will incentivise the installation of west-facing panels so as to cut peak demand.

- No change in battery performance over time has been considered.
- Behavioural drivers have not been modelled (i.e. early adopters, business preference to invest in core activities instead of PVs etc.)
- No system optimisation based on individual customers' load profiles has been explored. Especially in the commercial sector, it is expected that the systems will be optimised increasing the financial attractiveness of PVs with and without battery storage.

Appendix C. Projections of uptake of small scale storage and PV

Jacobs has undertaken projections of small scale solar PV and battery uptake using our proprietary models. These projections have been based on existing data provided by AEMO and the CER, and were developed on a regional basis taking social and demographic factors into account. A brief description of the methodology used to create the projections is provided in Appendix B. The projections include estimates of PV only units as well as integrated PV and battery systems. For this project we have assumed that no new PV systems are captured beyond 2024, and that any battery systems that are captured, are only 30% of the total in the entire market. This results in the levels of captured and uncaptured battery systems as depicted in Figure 14.

Figure 14 Battery projections

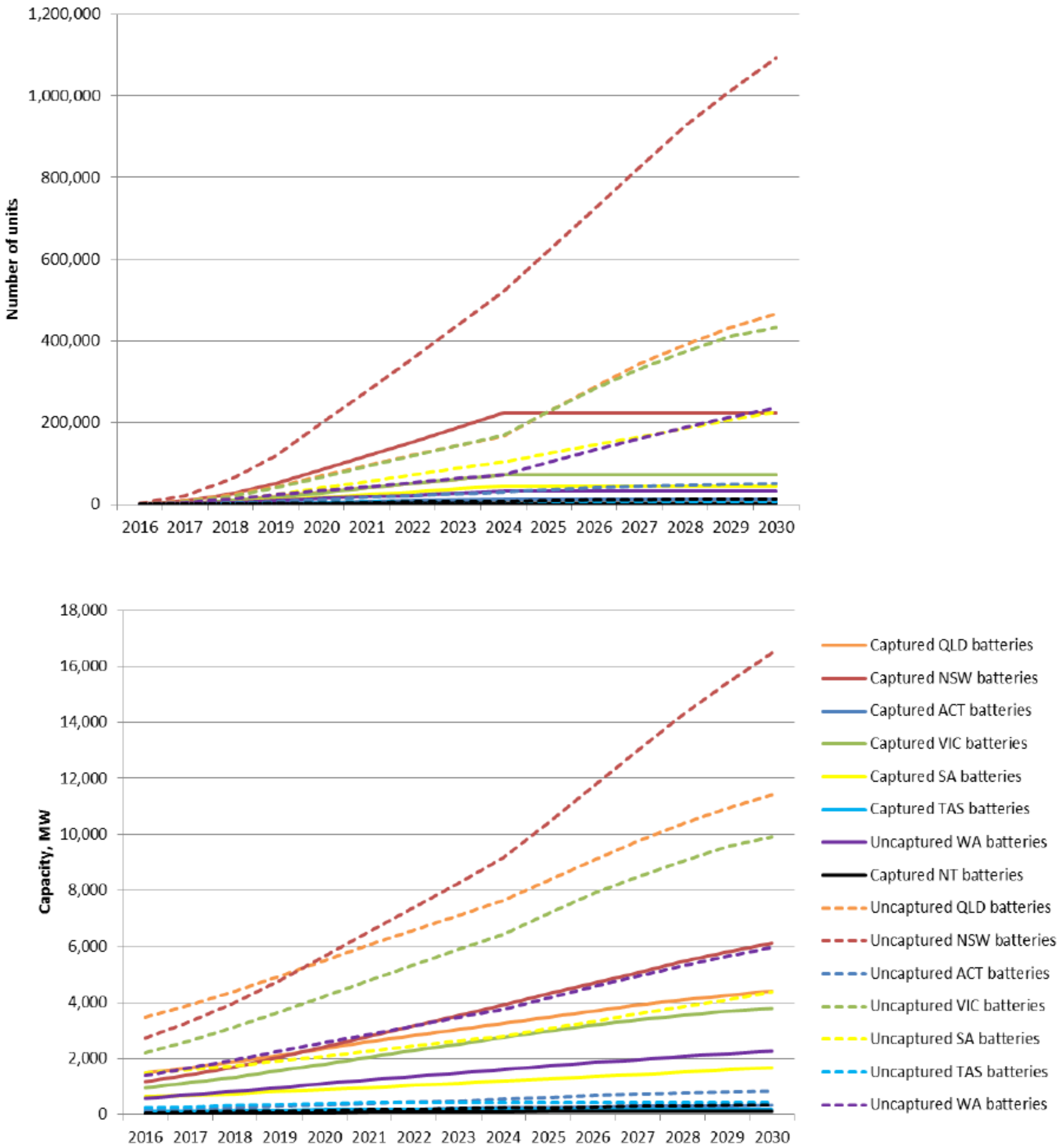
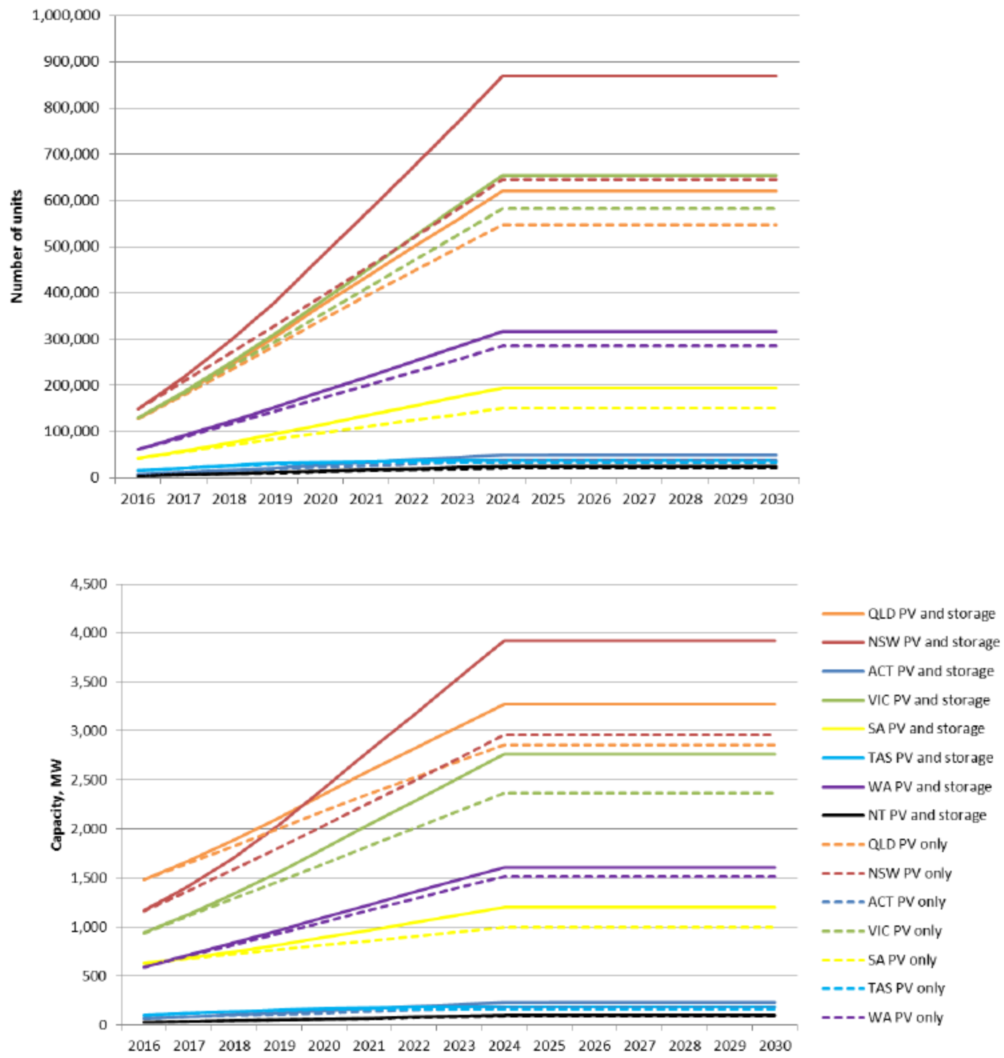


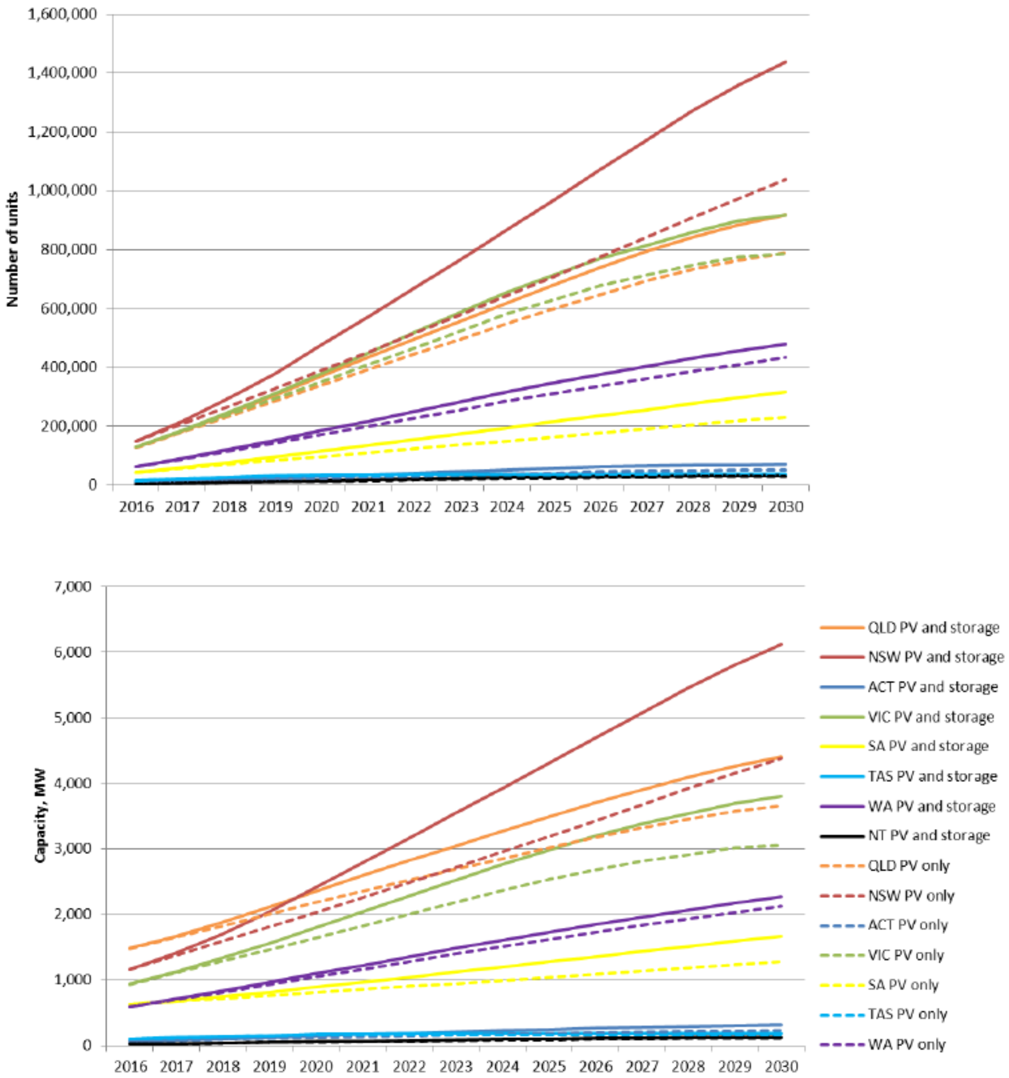
Figure 15 PV projections – Without register



When undertaking the CBA, we assumed that full knowledge of PV (i.e. a 'with register' scenario) and battery uptake data is available for forecasting purposes in each of the alternative scenarios, improving planning outcomes. In the reference case scenario, we assume that only the visible data is available and that forecasts are overstated by the amount of unknown DER capacity.

The results of the study indicated that a present value benefit of $14.1 million dollars would be achieved by having a register in place. The benefits came from delay in investment in large scale renewable generation.

Figure 16 PV projections – With register



Appendix D. Data collection questionnaires

D.1 Questions sent to jurisdictions

Dear Jurisdictional Colleagues

Thank you to all of you who have assisted Jacobs with their stakeholder consultations for the cost-benefit analysis of a proposed national battery storage register. Jacobs is exploring the extent and cost of regulatory changes (where appropriate) that may be needed to require that electricians collect battery storage data across the different jurisdictions. They would appreciate your consideration of the following questions to inform their cost-benefit analysis. If possible, a response by Friday 21 April would be of great assistance.

1) What is the name of the regulations covering information collection around safety certificates, connection notices etc.

2) How is information collected? Are there any requirements for paper forms as opposed to electronic submissions?

3) Can the jurisdiction clarify whether there are any existing loopholes or exclusions where an electrician is not required to install a battery and/or not fill in the existing paper or electronic notice requirements for installers?

4) What amendments are needed (if any) to existing legislation/regulation to:

a) always require an electrician to install DERs

b) Require electricians to always provide the requested data

c) Extend requirements to cover a wider range of installations and/ or equipment (e.g. to include new technologies, retrofits of existing devices, etc.)

5) Cost to change regulation/legislation referred to in (4) above – this should include administration costs for departments, any advisory costs etc.

6) Can the jurisdiction propose a compliance/enforcement approach for ensuring requested data is provided at installation (including for new installations, upgrades, and renewals) e.g. based on existing successful approaches.

7) Rationale for selected compliance and enforcement approach - e.g. demonstrated effectiveness or success rate

8) Cost of proposed compliance/enforcement approach (in response to question 5). Ideally this should be based on a cost per installation stating assumptions of percentage of installations audited etc.

9) How long would it take to change the regulations, as this pertains to timing of register benefits?

Thanks you again for all your contributions to this project.

D.2 Questions sent to networks

D.2.1 Background

On 7 April 2017, Jacobs held a teleconference with DNSP representative to discuss the potential role, costs and benefits of a national battery storage register. The battery storage register is intended to be expanded to include other forms of DERs as the need arises.

The options that Jacobs has been asked to consider include the following:

- Option 1: A national register administered by AEMO with system data collected from installers
- Option 2: A national register administered by CER with system data collected from installers
- Option 3: Enhancing existing systems where DNSPs continue to collect data and transfer this information to AEMO who would then host a central database
- Option 4: Base Case (status quo) option

Following on from discussions on Friday, we have listed some additional targeted questions to address some remaining information gaps for our assessment. As our time frames are very short, we would greatly appreciate if you could review these and respond by next Friday 21 April.

D.2.2 Questions for clarification for DNSPs

D.2.2.1 Existing processes

We understand that DNSPs currently collect information information through connection agreements and that this process follows the requirements of privacy law. We also understand that there are existing channels between DNSPs and AEMO where information can be shared, and that some DNSPs are already establishing databases on the location and characteristics of network-connected DER (batteries/PV).

On behalf of your organisation can you please respond to the questions regarding this topic in Table 32?

D.2.2.2 Data requirements

Based on the Energy Networks Association response to the COAG Energy Council's discussion paper, we understand that DNSPs support or require the following information to be collected:

☐Postcode or NMI (definite)
☐Demand side participation contract (definite)
☐Capacity (continuous kW and storage kWh) (definite)
☐Manufacturer (definite)
☐Make (definitive)
☐Model number (definite)
☐Whether the inverter is in addition to solar inverter capacity at site (definite)
☐Trip settings (frequency and voltage) (definite)
☐Installation date
☐Technology (optional)
☐Customer details - customer name, phone number, mobile phone number and an email address (preferred)

Please check information above already being collected.

Please include any additional information requirements in the box below.

(Please adjust the box size as needed)

Additional data requirements:

D.2.2.3 Operations framework

Jacobs has been asked to make the assessment on the assumption that data would be collected through standard compliance based arrangements, rather than through an incentive arrangement.

Based on existing information, it is also reasonable to assume that data may have to be collected for a wider array of installations than is presently being collected from installers via the network connection notice approach, principally to enable capture of retrofits and very low voltage installations.

Networks presently work in state based regulatory environments with varying operating and safety requirements and we request that the nature of these arrangements be considered when answering the questions below.

(Please feel free to adjust the row sizes to include further information you think is relevant. We would also welcome any supplementary information that you wish to attach to the completed form)

Table 32 Existing processes

#	Question		Further information (if any)
1	Is there an existing database in your region that stores information on battery storage devices and/or other DER?	Y/N	
2	If the answer to question 1 is no, is it reasonable to assume that you will develop a database within the next three years to the level of detail described above?	Y/N	
3	If the answer to question 1 is yes, is it reasonable to assume that you will expand your database within the next three years to include a greater amount of detail?	Y/N	
4	Will you still need to develop a new database or expand an existing one if AEMO or CER administers a national register?	Y/N	
5	How might operating and maintenance costs change if AEMO or CER administered a national register, assuming that no incentive was in place to enable data capture?		
6	Would you experience any cost savings if AEMO or CER administers a national register? Can you quantify this in terms of $/installation?	Y/N	
7	Are there any concerns about retrieving information in a timely manner from AEMO or the CER?		
8	Would any rules or regulations need to be changed to provide information to CER?	Y/N	
9	If the answer to question 1 is yes, will you need to expand your existing database under option 3 to provide data to AEMO?		
	Would you have done this anyway?		
	How much is this likely to cost in upfront and ongoing terms?		
10	How might operating and maintenance costs change under option 3,		

#	Question		Further information (if any)
	assuming that no incentive was in place to enable data capture?		
11	Most DNSPs collect some form of information through connection notices, even if it doesn't end up in a database just yet; is the information collected through a paper form or is there some form of automation (e.g. app, online system)?	Paper / automated	
12	What circumstances would lead to the distributor not getting information about a new battery (or other DER)? Underline or circle applicable answers to right and please add your own if we haven't covered the full set of circumstances.	a) Customer does not need a service from the network in the form of some service on the meter, street connection or inverter (e.g. retrofit on existing PV system) b) Customer is on extra low voltage system c) Customer has not used a licensed electrician because below 2.5 kW d) Others?	
13	How do you check that the data on the connection form is adequate? Who is responsible?		
14	What is the cost of checking information ($ per connection notice OR minutes per connection notice – please specify)?		
15	Is there any auditing undertaken to ensure that installers provide connection notices in all required circumstances?		
	If so, what is the frequency of audit?		
	Can the cost of this be quantified in a meaningful way (e.g. cost per installer or cost per connection notice)?		
16	Are there any consequences of an installer not providing a connection notice?		
17	Would the DNSP have a preference for AEMO collecting the data centrally or the DNSP continuing to provide the data to AEMO?		

Appendix E. Key findings from questionnaire sent to the DNSPs

Responses to questionnaires sent to the 14 DSNPs were received from:

- Energy Queensland
- Jemena Electricity Networks
- Ausgrid
- Essential Energy
- United Energy
- Horizon Power
- SA Power Networks

A summary of key findings from these responses and the impact on the scope of options considered and/or the CBA are summarised in the following table.

Key findings and conclusions from questionnaire sent to the networks:	Impact of responses on database scope and CBA assumptions
All six respondents had an existing database that stores information on battery storage devices and/or other DG. The information is generally collected on connection forms	The scope has been developed, assuming that data collection for a national database can also automate the connection notice process to save time for the electrician and for the networks.
The respondents generally planned to expand their databases in the next three years to include a greater amount of detail.	A CBA only considers the incremental costs relative to the base case. Under the base case, it would appear that over time, the networks would expand or enhance their database to capture more information. Any additional hardware and software costs for the DNSPs relative to base case investment could therefore be assumed to be negligible.
There were some concerns that relying on a third party for data would reduce the quality of the data collected, imposing costs on DNSP's for more auditing and data validation It was noted by SA Power Networks that if existing communication batches between participants and AEMO were utilised, then timely access would be less of a concern.	Data integrity is a valid concern and as such, the proposed scope under either an AEMO or CER hosted database would involve close consultation with the DNSPs to ensure that the data collection app has the necessary data and validation checks built in to the software. Under both options being considered, it is assumed that current communicating paths between AEMO and DNSPs are utilised.
It was recognised that exporting data to standard format required by the DNSPs would result in some development costs	The development costs for AEMO, CER and the data collection app would need to enable a certain level of sophistication to allow streamlining of processes formats of the information transmitted to DNSPs. Frequency, granularity and format of data capture would need to be agreed to by a working party during the design process that would include representatives from government and all parties accessing the data – irrespective of who is the host of the database. These consultation costs are captured in CBA
The DNSPs did not identify any potential cost	No specific savings (operational or maintenance) were

Key findings and conclusions from questionnaire sent to the networks:	Impact of responses on database scope and CBA assumptions
savings if AEMO or CER hosted a national database for battery collection storage	captured in the CBA
It was noted that regulatory changes may be needed as well as changes to privacy laws may be required if DNSPs were to host a database and provide information to some of the interest groups (e.g. CER)	NA – this is not an option that has been pursued further in the CBA
All DNSPs indicated that they would need to expand their existing database to provide data to AEMO (under Option 3) and that this investment would have not occurred otherwise. Cost estimates were not provided, but several respondents indicated that this investment would be significant (i.e. would require in some instances full system redesign and result in a new solution being implemented).	This high cost impact (i.e. need to adjust databases across all DNSPs as well as to expand AEMO's database to transfer information to other users) was the reason that Option 3 was not considered further.
Two of the seven DNSPs that responded collect connection notices in paper format, with no plans to transition to electronic collection processes. The others have either transitions to electronic connection notices or are have plans to transition.	These responses informed the assumption that 30% of base case connection forms are paper based. These impacts the assumed time it takes to collect information under the base case. It is assumed that with a national database, 100% of the data will be collected electronically, therefore providing some time savings for electricians completing connection notices that were previously in paper format.
There are varying circumstances across the jurisdictions and networks where information about a new battery is not being captured. (E.g. low voltage systems, not using licenced electrician, customer does not need a service form the network, lack of regulatory obligation etc.)	These responses are aligned with our overall assumptions that small share of battery storage devices are captured on a database currently (we have assumed 30% based on previous advice provided by Energy Queensland.
Validating of data on connection notices in inconsistent across the networks. Some undertake audits and others do not. Consequences of an installer not providing a connection notice vary across DNSPs.	Given this inconsistency, the CBA does not factor in any change (positive or negative) in auditing requirements by the distributors. All auditing activities for the national database are treated as additional to those that would otherwise be undertaken by the networks.
Most of the respondents preferred to continue collecting the data using existing processes and provide this information to AEMO	This option was not considered further in the CBA given the higher implementation costs (duplication of databases) and the potential inconsistencies in the format approach to data collection

Appendix F. Summary of consultation paper feedback

Response	Data	Scope	Cost	Benefit	Preferred option	Other
AEMO		Agrees a register is needed		Methodology robust but only partially addresses benefits which should be much higher than the CBA suggests. Many of the benefits were not quantified; In particular regulation frequency control costs and benefits related to high impact, low probability events. The solar eclipse benefit in 2028 is understated.	AEMO's primary imperative is to have access to the data and having a host role is a secondary consideration. They have no issue with either themselves or CER being the host of the database, as long as the host is independent and has no commercial incentives related to the data. However they would prefer that the collection process using DNSPs is reconsidered, mainly because it will be quicker to implement the required legal and regulatory changes and because the rules are already present requiring customers to inform networks.	If consumers were to register with AEMO, this would impose an onerous requirement on consumers and would also increase the administrative burden on AEMO in addition to the network connection process. Changes to electrician licence conditions would require update to eight state and territory electrical safety regulations. This process will be complicated and time consuming, requiring a long lead time. A network connection agreement approach suffers from the disadvantage that it does not apply to off-grid installations.
Jacobs' response				*It was not possible to quantify all the benefits in the time available. The solar eclipse benefit is only one small part of operational benefits and reporting this benefit in isolation may lead to misinterpretation of the results so it has been*	*Rather than testing an option where DNSPs host separate databases, we have instead considered the DNSP roles in data collection with either CER or AEMO as the central host. This appears to address the concerns raised and maintains the benefit of*	*Additional explanations of possible collection approaches have been added to the report and captured in the options assessed in the CBA.* *The chosen collection approach for the two options under consideration has*

Response	Data	Scope	Cost	Benefit	Preferred option	Other
				removed.	*a central database.*	*been redefined.*
Australian Energy Council	Should a registry go ahead, it should be nationally consistent.	AEC does not believe a robust case has been made for a registry when compared against other alternatives.		Benefit of real time information may not be appropriate against costs of a static register.	Preferable to have CER extend its existing database to include battery options, mainly to reduce cost impacts on stakeholders.	Retailers and wholesale market participants should be included as potential beneficiaries of a register. Rule change allowing AEMO to schedule load would be preferable to creation and use of a register.
Jacobs' response		*Jacobs' scope was to assess the relative costs and benefits of a national registry, relative to the base case (status quo). The scope of the CBA did not include additional non-registry options*		*AEMO has advised that it will undertake a sampling approach to estimate real time impact of distributed generation, regardless of whether the register goes ahead. This means that the collection of static data can be used to add value to the real time information collected.*		*The list of stakeholders has been extended.* *Jacobs was not asked to assess rule changes around scheduling of load.*
AGL	Duplication and inefficiencies if require the collection of 'device part of aggregated control'. This data may change over time and is collected by AEMO through other process (AEMO's Demand Side Participation Information Guidelines)			Agree that secondary objectives are negligible	Believe a register should be delayed In the short term avoid the creation of a new register, processes and governance frameworks On this basis prefer CER option	Cost recovery should be aligned with beneficiaries
Jacobs' response	*Stakeholder suggestions around reduction/extension of data to be collected will be included in the report and used*				*A number of stakeholders are concerned that delay of the register would result in lost system operation and*	*Cost recovery is not being assessed in this work.*

Response	Data	Scope	Cost	Benefit	Preferred option	Other
	in the design phase should the register go ahead.				*safety benefits. Delay of the register would increase the risk of those benefits not being fully realised.*	
Ausgrid	Suggest data collected should be cross checked against DNSP connection notice data. Minimum level of information required by DNSPs includes: • NMI and address • Installation and decommissioning date • Manufacturer, make and model number • Capacity (continuous kW and storage kWh) • Aggregator (if applicable) Other information can be derived from above list.	• Supports a central register for improved consistency • Supports collection of information at the point of installation	Suggest manufacturers could include a greater amount of information on their equipment bar codes to reduce impact of data collection on installers.	Insufficient detail to assess quantitative or qualitative benefits in CBA	Prefers AEMO as register host because they are better placed to enable integration into business to business processes on behalf of DNSPs and the market	Use of safety regulations may not be appropriate to incorporate changes for data collection purposes unrelated to furthering safety outcomes.
Jacobs' response	*Stakeholder suggestions around reduction/extension of data to be collected will be included in the report and used in the design phase should the register go ahead.* *Jacobs will incorporate advice that requests for extensive amounts of information may reduce the effectiveness of the data collection process supporting the register.*		*This suggestion will be added to the report.*			*Agreed. A DNSP connection notice based data collection approach has been substituted for the regulation based approach in the CBA.*

Response	Data	Scope	Cost	Benefit	Preferred option	Other
CitiPower and Powercor	Recommended changes: • 'NMI identifier (or postcode)' to be changed to 'NMI identifier and postcode'. • To add 'short term peak output (if applicable)' to 'Capacity (continuous kW, and storage kWh)'.	General support for a single register host (reasons are consistency and reduced cost for distributors)				Proposed single register will save Citipower money in investing in its own system – no plans to do so.
Jacobs' response	*Data requirements list adjusted in CBA.*					*Agreed. A DNSP connection notice based data collection approach has been substituted for the regulation based approach in the CBA.*

Response	Data	Scope	Cost	Benefit	Preferred option	Other
Clean Energy Council		Supportive of a battery register, and suggest that a privately owned register would struggle with issues of privacy and commercial confidentiality. Furthermore, a private register would not be able to compel the reporting of battery installation and resulting datasets would be incomplete.	• The key to encouraging installers to provide additional information will be to make that process as simple and streamlined as possible. • Assumptions behind paper form collection for CER option are unclear (Table 6) • The collection costs for the CER option should capture the efficiencies that will be realised from the serial number project if that is rolled out to batteries. • Installers will have a very strong preference for using a single app. • It would be a retrograde step to require installers and retailers to use an AEMO app in addition to the apps that are being developed in conjunction with the CER's serial number validation pilot program.	• The estimate of $11.6 million (net present value) for avoided network augmentation costs seems very modest. • The description of the anticipated qualitative benefits seems reasonable. • The economic benefits of fraud prevention and improved consumer protection could also be considered in the benefits of a battery register that is integrated with the CER's other data collection activities.	The CEC supports the proposal for the Clean Energy Regulator (CER) to host the national battery register. Reasons include: • Installers have established processes for providing information to the CER under the RET, and supplying information to the CER will reduce transaction cost • The CER would still be required to collect data if a register were approved with AEMO as host, duplicating processes. • The CEC and CER, as well as industry, has developed a serial number validation system for PV modules which could be utilised for the purposes of the register • CER already has customer facing infrastructure such as call centres • AEMO would not collect off-grid data • There may exist competition policy issues in the future as other parties may compete with or complement AEMO's role in management of transmission and distribution grids	Dispute the assertion that "AEMO's existence is not subject to government funding or policy position". State governments, COAG Energy Council or the AEMC could in future take a very different approach to the regulation of market operators and the framework for deciding which aspects of market operation are regulated monopolies and which are opened to competition. Also challenge the assumption that "AEMO would be the primary user of the data being collected". Would be more likely that installers will report installation details if the app used to register installations also includes features that provide additional benefits to the installer and retailer. In the future there may be an issue with integrated systems incorporating small batteries. It may be infeasible in the future to capture these. The attachment of specific collection processes to database hosts is inadequate.

Response	Data	Scope	Cost	Benefit	Preferred option	Other
Jacobs' response			*The serial number application is relatively new and its adoption and impact are not known. Rather than building these efficiencies into the options considered, we have included a sensitivity test that assesses the impact of shorter data collection time associated with this app (test 8).* *We have noted electricians' preferences for using a single app and this will be a key consideration in the final design.*	*It was not feasible to estimate every possible benefit quantitatively in the time frame for the project. The focus was on the key benefits that also had the strongest links to the investment objectives.*	*The above issues have generally already been included in the report and issues that would impact the final design, The purpose of the CBA is to demonstrate the economic viability (or otherwise) of a register based on a broad option definition, with the final details to be considered at a later stage. The report mentions that CER could introduce more efficient apps, with several references to the serial number app.*	*It was never intended to attach specific collection processes to each data host, but rather illustrate the impact the various collection processes may have on the results and that a collaborative or hybrid approach is likely to realise optimal results. The CBA has been adjusted to make these distinctions clearer.*
Energy Networks Australia	'NMI identifier (or postcode)' should be changed to 'NMI identifier and postcode'. Add 'short-term peak output (if applicable)' to 'Capacity (continuous kW, and storage kWh)' Other useful data includes: • NMI identifier delete "(or postcode)" • Capacity (kVA of inverter) • Demand response modes • Power quality response modes • pf/VAR range Register could be expanded to include information on load	Supports Stage 2 of the CBA including undertaking more detailed analysis to establish the costs of developing and implementing uniform enforcement mechanisms for current jurisdictional connection agreement arrangements. This should include a review of the compliance framework, including strengthened obligations at the time of installation (e.g. appropriate penalties for non-compliance, compulsory accreditation, and regulatory	The updated CBA should also list the applications (apps) which are currently in use by solar PV installers and provide some estimated costs of updating these apps to include all the fields which would be required for the new battery storage register (irrespective of whether it is hosted by AEMO or the CER). The provision of more detailed quotes on the development of a new app would also be of value, perhaps by undertaking an indicative tender process with appropriate app developers.		Energy Networks Australia members concur that AEMO is the preferred storage register host. However, before a final decision is taken, network businesses consider that a more thorough appraisal of Option 3 should be undertaken and provided. Also keen for further analysis of Option 1. ENA agrees with the disadvantages listed for CER host option and is particularly concerned about the uncertainty around the CER's long term ongoing	The current distribution connections agreement process is only capturing approximately 30 per cent of battery installations. Member companies report that this rate can vary between 5 and 50 per cent for different distribution network service providers (DNSPs).

Response	Data	Scope	Cost	Benefit	Preferred option	Other
	switching and demand response services.	changes to relevant jurisdictional energy safety or energy licensing legislation or Amendments to the National Electricity Law, National Electricity Rules, the National Energy Retail Law or the National Energy Retail Rules. Penalty provisions for failure to follow the mandated connections agreement process should apply.	Cost estimates and assumptions seem to be reasonable.		existence and CER's lower capacity (relative to AEMO) to manage technology based or other market based changes that might be required for AEMO or DNSPs on an ongoing basis.	
Jacobs' response	*Data requirements list adjusted in CBA.*	*We suggest that a detailed design phase will be required, regardless of the CBA results for option 1 relative to option 2.*	*Industry app developers in this area have historically adjusted their apps to conform to evolving requirements without charging consumers directly for this service. Presumably industry retains a benefit in the form of being able to provide after sales care to customers or similar.* *Should industry app developers seek a fee for this service as a result of the register, the cost would be unlikely to exceed the estimate for app development provided by AEMO.*		*Through review of DNSP responses on this matter, Jacobs recognises that most DNSPs still prefer a centralised register, however with facilitation of data collection through DNSP connection notices. We have adapted option 1 and option 2 to provide this outlook.*	

Response	Data	Scope	Cost	Benefit	Preferred option	Other
Ergon Energy Corporation Limited (Ergon Energy) and Energex Limited (Energex)	This system will need to capture changes over time as systems are replaced, updated or increased in capacity. In general the residential battery range will be from 24-48V DC. Due to a higher safety risk, a separate category could be established for larger battery systems (e.g. 600V DC). DNSPs may also collect other associated data (e.g. length of consumer mains, conductor type, and number of phases to grid connected inverter) to identify network impacts as part of network connection process.		Consider that hardware development and data collection system development costs appear to be on the low side. No alternatives have been provided. Option 3 should be reconsidered. Question the continued use of paper based connection notices under the base case and Option 2. Ergon Energy and Energex support industry developed apps as a tool which all DNSPs should be using for residential and small – medium enterprise connections. The app would be of greater value if it was integrated with the online connection portals of the individual DNSPs. One unified data catchment process would give the greatest economies of scale. Notwithstanding, is it l kely that each DNSP would require an individual process given the differences in each businesses' system and the need for the app to work alongside the online option.	Consider that the power system security values appear very low. Other qualitative benefits to academia. Specifically, having this data (collated at a suburb level) is of significant benefit to economic, social and engineering researchers. This has been demonstrated from other datasets such as the CER PV list; the PVOutput.org site; or appliance data reports from Smart Grid Smart City. Do not agree with the minimal benefit included for improved safety of line workers. Most batteries are installed with multi-mode inverters that have the ability to supply circuits when the battery loses grid supply and still meet anti-islanding requirements. It is unknown whether the house circuits are still live after the grid has been shut off. This is particularly important in disaster response activities (e.g. cyclones).	Do not support the position that option 3 is prohibitive in cost and recommend that this option is quantified further. In particular, we note that DNSPs already do and will continue to collect a large amount of the required data and would therefore consider these cost to be incurred regardless of which option is chosen. Prefers a central registry with AEMO as host. A further advantage of option 1 is that it doesn't introduce an additional party when AEMO already require the information themselves. Ergon Energy and Energex have identified the following additional challenges with option 2: The CER collection process duplicates the DSNP process of collecting the data as part of the connection process. The CER will require a means to transmit battery data to a DSNP so they are aware of the installation in case they haven't received a valid application for it. The current approach by CER for managing solar photovoltaics (PV) often results in overestimation of	Identified additional limitations of the CER hosting option. Ergon Energy and Energex suggest that the length of time required to modify and approve legislation is an impediment as these devices are being installed now. However, we recognise that subordinate legislation such as a regulation may be amended more easily and expeditiously than an Act. Therefore, as noted above, we consider that an amendment to the *Queensland Electrical Safety Regulation 2013* would be most appropriate for this purpose.

Response	Data	Scope	Cost	Benefit	Preferred option	Other
Jacobs' response	*The final data collection process to be determined during the design phase will need to consider means for which ongoing changes to distributed generation installations will be recorded. These means may be in the form of soft incentives such as registering equipment warranties or similar as would be the case under installation of a new system.* *Additional information requirements are recorded in the CBA.*	*We suggest that a detailed design phase will be required, regardless of the CBA results for option 1 relative to option 2.*	*Hardware development costs were provided by AEMO and CER.* *Data collection approaches using connection notices and apps have been discussed in more detail in the report.*	*Line worker safety issues will be noted in the CBA.* *Academia will be added as a beneficiary.*	*Through review of DNSP responses on this matter, Jacobs recognises that most DNSPs still prefer a centralised register, however with facilitation of data collection through DNSP connection notices. We have adapted option 1 and option 2 to provide this outlook.*	*The CBA no longer considers jurisdictional regulation to be the appropriate approach for enforcing data collection.*
Energy Safe Victoria		Not opposed to a register.	The cost of changing the Certificate of Electrical Safety (COES) system and the Electricity Safety Act and regulations would be in excess of $600,000 and risks placing impediments to uptake of new technologies.	Agrees with Jacobs' assessment of line worker safety benefits, noting that 'existing design requirements for inverters and controllers ensure that any energy generation system that connects to the grid automatically disconnects from the electricity grid in the event of a grid failure thus protecting line workers' For emergency workers, reforms under Australian Standards will address safety issues.	CBA should consider DNSP or supplier held databases.	ESV is reluctant to change legislation to make a non-safety related function the responsibility of the installer (electrician). The cost of changing the COES system and the Electricity Safety Act and regulations would be in excess of $600,000 and risks placing impediments to uptake of new technologies.

Response	Data	Scope	Cost	Benefit	Preferred option	Other
Jacobs' response			*CBA no longer suggests that a regulatory jurisdictional approach would be appropriate.*	*Above argument to be added to the report.*	*Through review of DNSP responses on this matter, Jacobs recognises that most DNSPs still prefer a centralised register, however with facilitation of data collection through DNSP connection notices. We have adapted option 1 and option 2 to incorporate collection of data through DNSP connection notices.*	*The CBA no longer considers jurisdictional regulation to be the appropriate approach for enforcing data collection.*
Energy Storage Council		The Energy Storage Council, together with its partner Global-Roam, is well advanced in developing an industry-led national battery storage register with work underway so far for a period of two years. Any delay in the development of a national storage register could result in missing 75,000 systems across Australia by 2019.	The CBA appears to have overestimated the cost of utilising the infrastructure already put in place by the Clean Energy Regulator in establishing its Small-scale Renewable Energy Scheme Register. Jacobs has underestimated the number and types of portal users.	Disagrees that support of emergency services is a secondary objective and should be a primary objective.		Energy Storage Council is ready to work with the COAG Energy Council to develop and implement a national battery storage register and is confident that they could put a system in place in a much timelier manner than the current COAG process is likely to produce.
Jacobs' response			*Jacobs consulted the CER in the estimation of costs*	*Jacobs was asked to assess emergency services safety as a secondary objective.*		
NSW Energy and Water Ombudsman (EWON)	Agrees that a wider collection of information should be enabled.			A register will provide the following safety benefits: • Improved ability of emergency teams to select appropriate	No preference. Noted that access to information by all relevant parties is a key requirement in determining	

Response	Data	Scope	Cost	Benefit	Preferred option	Other
				equipment. • More effective disaster management planning. • Planning a disposal strategy as batteries come to the end of their life span • Product recall When combined with the quantitative benefits established in the cost benefit analysis then the case for proceeding with the national register is fully made. The establishment of a national register that contributes to increasing consumer safety, and promotes a framework for a more reliable energy system, provides a further significant reputational benefit. This is another qualitative benefit that adds to the overall case for the cost effectiveness of a national register for small scale battery storage.	where the register should be hosted.	
Jacobs' response	*Noted.*					
GreenSync		Provision in the register needs to be made to allow for information needs to be adjusted over the life of the asset		The level of uncertainty surrounding future costs and benefits of the register, in combination with the small difference in cost between	Not clear why a DNSP hosting option was not considered. Higher upfront costs could be offset by potential benefits of registers	Data collection applications are likely to be appropriate to both streamline and incentivise data collection. Industry developed apps

Response	Data	Scope	Cost	Benefit	Preferred option	Other
		Administrative burden for installers could be reduced if the registration process is integrated into installers other systems – e.g. enterprise resource planning and customer relations management systems. This could be done through third party apps for installers integrated into their existing systems The register needs to be extensible and the register host needs retain close links with users to ensure functionality develops as DER market evolves		the two options, implies that a CBA may not be the best approach for choosing a host.	being managed and further developed by DNSPs (e.g. innovation benefits as the role of DNSPs evolve).	integrated into existing or future ERP and CRM systems and communicating with an open API developed for the register are likely to allow the register to evolve with DER markets and retain the register's relevance as an authoritative and trusted source of information about storage assets.
Jacobs' response		*Comments provide appropriate soft incentives to encourage consumers and installers to provide information.*		*Agree that non-economic factors should also be considered when choosing the most appropriate host.*	*DNSPs are each at varying stages of development of DER database management, largely as a result of differing levels of penetration of DER in each of their regions. It is not practical to require all DNSPs to develop databases at the same time even though we recognise that they are all likely to require some form of market intelligence in this area eventually.*	*CBA incorporates streamlining approaches in data collection options provided.*

Response	Data	Scope	Cost	Benefit	Preferred option	Other
Red/Lumo Energy	Question the granularity of data requested by the networks in particular Have provided specific comments on all data requirements listed in our reports (including unobtainable data, publicly available data, variable data and data that are unrelated to the objective). Specifically: • Battery performance derating cannot be specified at time of installation • Decommissioning date is unlikely to be updated • Trip settings are regulated through Australian Standards • Inverter enabled mode of operations can be adjusted post installation • Demand side participation contract can similarly change post installation • Monopoly businesses should not have access to individual customer details • Storage kWh may provide commercially sensitive information to monopoly businesses • Manufacturer, make and model number should not be needed for network security purposes	Agree that information regarding small scale battery storage will result in improved system and network security, but question the extent of information required.		Agree that prevalence and location of batteries in the NEM could enable AEMO to better forecast for future generation and uphold grid reliability. Agree that network businesses may benefit from the data and it may help them to avoid or defer capital expenditure. Expect that most small scale batteries will not export to the grid.	Clean Energy Regulator would be best placed to host the database, given the efficiencies that can be obtained through the existing REC register.	Any battery storage register developed must not be used as a vehicle for regulated businesses to gain commercially sensitive information under the guise of network planning and security.

JACOBS

Response	Data	Scope	Cost	Benefit	Preferred option	Other
Jacobs' response	*Will note the above in the CBA, highlighting the risk that excessive data requirements may cause a lower response data collection rate.*					
S&C Electric Company	Batteries providing system services will have a much shorter life. Agrees that listed level of information is needed by stakeholders. Engaging stakeholders, particularly those that will have to provide the data will be critical to ensure compliance and the success of any register.	Supports development of a register It will be necessary to incorporate smaller domestic-scale battery installations		The approach does not include the newly proposed Fast Frequency Response service, nor the requirement for newly connecting non-synchronous generation to provide support to system security targets (AEMC, System Security Market Frameworks Review, March 2017).	Longevity of AEMO versus CER makes AEMO the preferred option. AEMO also currently has access to data and the ability to manage that data. It already has well-established (regulated) pathways to access data from the networks, and it is both the networks and AEMO who will benefit most from any battery register.	Provided international examples of where high energy/demand assets that could be connected to the network are deemed to be "notifiable" and installers are required to notify the DNSP if they connect a notifiable technology. In the UK, incentives are employed for small scale equipment because one of the following occurred: (a) deployment occurred prior to notification being established; (b) there is no incentive to do so (there is currently no equivalent to the FiT for batteries); (c) it's extra work and (d) many domestic-scale developers consider the imposition of the G83 connection requirements to be unnecessary "red tape" that hinders the rapid expansion of their business.
Jacobs' response				*This was not part of Jacobs' brief.*		

Response	Data	Scope	Cost	Benefit	Preferred option	Other
The customer advocate	The dataset required should be critically reviewed and minimised for absolute necessity.	Title of report should make it clearer that the intent is to cover all forms of distributed generation The CBA should recognise the cost to use the app as a means of populating the DB databases; however the issue is that the DBs seek the data largely as an approval process before installation proceeds. The proposal should show how the data capture would practically align with the field process. Again, installers should be consulted as part of the CBA.	CBA seems to understate cost of collection of data because it is I kely that information will also come from customers (or other sources) as well as installers. The transaction cost associated with data provision will imply a significant risk to timeliness, accuracy and completeness. Update of data as customers change usage parameters, move residence or change tariffs will cost more than set out in the CBA.	Jacobs' proprietary forecasting analysis is not clear. The way the benefits have been arrived at is not clear. The nature of the benefits, particularly in the wholesale market, do not reinforce the requirement for individual, NMI based, near-real time data as proposed. It appears that the capital infrastructure costs could be realised with better forecasting of the uptake of DER, not with the register, and data aggregated by region or node. The network benefits are an incentive for the networks themselves to improve their data collection, with benefits reflected in EBSS and CESS. The approach to storage as a DM function for contingencies, planning and investment through mechanisms such as tariff design, DM incentives and local DM agreements are related to this benefit, and it is hard to see just where the 11.6M comes from as a result of the register alone. Do the 'without register' benefits assume no knowledge of DER implementation? If so, then the results are questionable, because we do actually know a fair bit about the DER, perhaps not to the level of accuracy and precision suggested in this project, but a fair bit about where, how much and how it performs all the same. Regulatory change is slow, expensive and not guaranteed of success. The benefit of market operation does not support the detailed, granular database. AEMO could get by with lesser regional granularity and could ask DNSPs to provide weekly data. Would a database administered by a central body be of sufficient quality to use for safety purposes? Similarly recall benefits should sit with the manufacturer.		CBA should recognise consumers, owners of DER and installers of systems as key stakeholders and take their point of view in assessing many of the benefits. Concerned about potential for multiple forms of data collection to occur. The application of the database is likely to expand as the market evolves and this additional cost should be reflected in the CBA. The CBA should incorporate a risk analysis on data quality and cost variations. Possible 'carrots' for installers providing data include the offer of standardised connection and approval processes, fast track assessments and more generous export benefits.
Jacobs' response	*Noted in CBA*	*A number of industry bodies covering installers were consulted.*	*Proponents do not seek to follow customer changes of tariff or home movements, but may*	*Agree that forecasting benefits do not depend on localised data; however they are built up from localised data and are therefore still a valid basis of assessment. The project*		*Consumers will be included in the list of beneficiaries* *Installers are front of mind*

Response	Data	Scope	Cost	Benefit	Preferred option	Other
			seek to follow usage change parameters. *The data collection costs have been estimated based on the need. If the data is provided by households rather than installers (which is not the recommendation), the time to do this should not differ substantially.*	*timeframe does not allow for adequate assessment of localised benefits but that does not mean that these do not exist.* *Networks are not able to improve their ability to collect and record storage data in an efficient way at present.* *As explained in the CBA, the 'without register' scenario assumes lagged/incomplete knowledge of DER uptake, not zero knowledge.* *Regulatory change has been removed as an approach to enable data collection.* *AEMO cannot rely on DNSPs for operational data because the DNSPs are not able to realise a complete set of data themselves under present arrangements.*		*with respect to streamlining approaches that are likely to minimise cost and inconvenience to this group. This group is a critical stakeholder; without this groups support the register would not succeed.* *If the purposes of the CBA expand then the cost of doing so should be justified at the time. It is not possible to construct a CBA with every known possibility of market evolution in mind.* *Possible 'carrots' have been listed in the CBA.*