Benefit Analysis of Load-Flexibility from Consumer Energy Resources:
DRAFT Cost-Benefit Analysis

Prepared by Energeia for the
Australian Energy Market Commission

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ENERGEIA

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Executive Summary

Background

This study is driven by the Australian Energy Market Operator's (AEMO's) rule change requests to the Australian Energy Market Commission (AEMC) entitled Flexible Trading Arrangements (Model 2) and Minor Energy Flow Metering in the National Electricity Market (NEM) (May, 2022). The proposed rule changes seek to improve trading of consumer energy resources (CER) to further unlock value for consumers. It also aims to facilitate better integration of flexible CER into the power system to deliver a more reliable and secure energy system that would benefit all consumers.

The purpose of this report is to report on the results of Energeia's research, analysis and modelling of the impacts, costs, and benefits of the proposed rules, as well as to provide recommendations on future directions for the AEMC to consider to maximise the potential value from CER flexibility.

The analysis delivered in this study is designed to feed into the AEMC's consideration of AEMO's rule change request. Energeia's companion Methodology Report[1] detailing the proposed analytical methodology was issued by the AEMC for consultation, and a summary of the feedback received and Energeia's response to them is available in Appendix B: Feedback Received on Draft Methodology.

A forthcoming report will detail the results of work on the potential value of CER, as described in the Methodology Report.

Scope and Approach

The analysis outlined in the Methodology report alongside the AEMC's Directions Paper fell under two phases of objectives:

- **Phase A** – to determine the incremental value of the most promising CER load flexibility options in terms of benefits to the electricity system and to consumers, considering an expected sharing of benefits across supply chain participants, and
- **Phase B** – to determine the economic impacts, costs, and benefits of proposed rule changes on the system, the required threshold of incremental uptake to ensure that this rule change is viable for market participants and consumers.

This report outlines the findings of Phase B from the above scope.

Energeia worked closely with the AEMC to design a scope or work to meet the key objectives and requirements of this supporting study for the AEMC's Draft Determination, which is outlined below:

- **Define Rule Change Policy Options** – Energeia worked closely with the AEMC to develop the key rule change options to be tested,
- **Develop and Agree Upon Key Inputs, Assumptions, and Methodology** – Energeia undertook desktop research to capture additional inputs needed for the analysis,
- **Analyse Rule Change Impacts** – Energeia estimated the economic costs and benefits of each rule change option via a series of case studies, and estimated the level of uptake needed to break even on the rule changes costs at a system-wide level,
- **Develop Recommendations** – Energeia worked with the AEMC to identify and model the impact of removing additional regulatory policy and regulatory barriers in order to unlock the full potential of CER in future rule changes, and
- **Validate Reporting with Key Stakeholders** – Energeia presented the delivered analysis to key AEMC stakeholders, revised it based on feedback, and documented it in this report.

[1] Benefit Analysis of Load-Flexibility from Consumer Energy Resources: Methodology Report https://www.aemc.gov.au/sites/default/files/2023-08/CER%20Flexibility%20Modelling%20Methodology%20Paper%20-%20FINAL.pdf

While streetlighting (Workstream 3) is part of the rule change, a separate standalone analysis and accompanying report has been completed.

Value of the Rule Change (Phase B)

Phase B involved an analysis of the economic impacts, costs, and benefits of the proposed rule change on the system, including the:

- potential rule change scenarios,
- adoption required to break even on the estimated costs of the rule change, and
- the potential value of removing the key policy and regulatory barriers that would remain.

The AEMC's Key Rule Change Scenarios

Energeia modelled the following rule change scenarios for small and large customers.

Small Customers (Workstream 1)

For small customers, the proposed rule change would allow for an additional national metering identifier (NMI) to be established at a willing customer's premises for a given flexible device, thereby creating a second settlement point. It would also enable using certified device metrology to avoid the cost of additional metering.

The rule change implementation options assessed in this analysis can be described as:

- **Current Retailer Virtual Power Plant (VPP)** – the current market arrangement whereby CER is used by retailers to manage wholesale price exposure without certified device level metrology, nor a standard for accessing its data streams,
- **Current Retailer VPP Providing Network Services** – as per Current Retailer VPP, but includes provision of demand management (DM) services to the network including installation of an additional meter, which is also possible today,
- **Rule Change VPP** – a retailer VPP, where a flexible CER device is given a NMI and uses certified in-device metrology, providing standardised data access to authorised participants and enabling use of it by networks to optimise their grids, and
- **Rule Change VPP Providing Network Services** – the above Rule Change VPP where the NMI allocated CER device provides DM services to the network.

The rule change would not affect how service providers currently enable CER to provide frequency control ancillary services (FCAS), meaning that an additional market ancillary service specification (MASS) compliant meter would still need to be installed at the premises.

Large Customers (Workstream 2)

For large customers, the proposed rule change would allow additional retailers at a willing customer's premises for each given flexible device, thereby enabling discrete settlement points for CER by retailer. It would also enable using certified device metrology to avoid the cost of additional metering.

The rule change implementation options assessed in this analysis can be described as:

- **Embedded Network** – the current market arrangement whereby a CER management service provider uses separately metered CER to participate in the wholesale market through the embedded network framework,
- **Embedded Network Providing Network Services** – as per Embedded Network, but includes provision of demand management (DM) services to the network including installation of an additional meter, which is also possible today,
- **Multiple Financially Responsible Market Participations (FRMPs) VPP** – a retailer VPP, whereby a flexible CER device is given a NMI, a FRMP, and uses certified in-device metrology, providing standardised data access to authorised participants and enabling use of it by networks to optimise their grids, and

- **Multiple FRMPs Providing Network Services** – the above Multiple FRMPs VPP where the NMI allocated CER device provides DM services to the network.

Rule Change Impacts

The rule change impact analysis identified and modelled the key costs and benefits of each rule change scenario relative to a baseline. It calculated the break-even point for flexible CER uptake to make the rule change costs economic for active customers (a NMI with a flexible load), as well as any associated costs and benefits for passive customers (a NMI with an inflexible load). A final step identified the key remaining regulatory barriers and estimated the impact of their alleviation.

Costs and Benefits

Energeia worked with the AEMC to identify and estimate additional cost and benefit categories to model, which included:

- **Regional Reference Price (RRP) Benefits** – Avoided wholesale energy settlement costs for the retailer using CER flexibility
- **FCAS Benefits** – FCAS value generated for the retailer using CER flexibility
- **Network Benefits** – Avoided augmentation costs for the network to meet peak demand or additional solar PV hosting capacity using CER flexibility
- **Per Device Costs** – Additional metering and NMI allocation costs incurred by the network for using flexible CER, which are passed on to the retailer
- **Shared Costs** – System upgrade costs for AEMO and retailers to accommodate the rule change (shared), which are passed on to the retailer
- **Network Management Benefit** – Network optimisation benefits excluding thermal overload and voltage excursion mitigation, which are covered under network benefits.

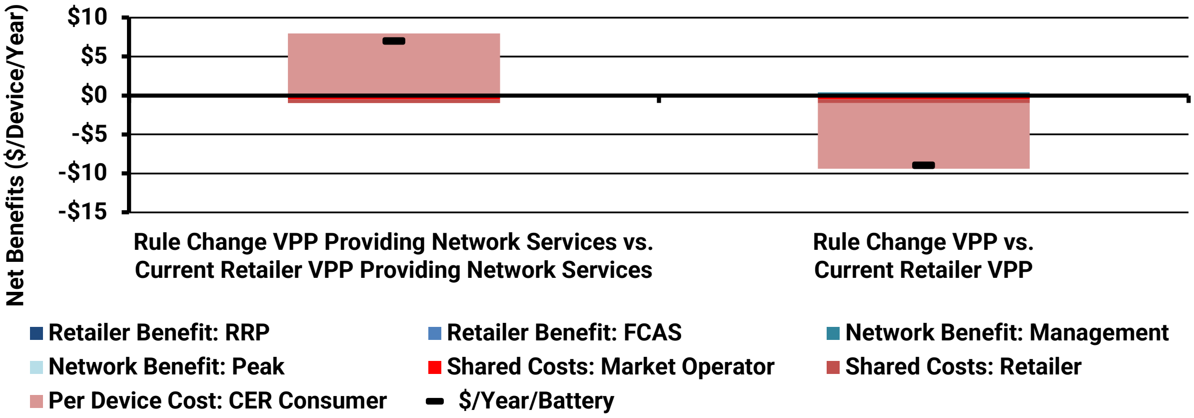
Energeia's estimate of the economic impacts of the proposed rule change for the small active customer battery case study is reported in Figure ES1.

The analysis shows that for small customers, Rule Change VPP Providing Network Services, when compared to Current Retailer VPP Providing Network Services, is estimated to generate $7.0/battery/year in estimated net benefits. These benefits are driven by avoiding a metering installation cost of $16.4/year, in exchange for a pro-rata share of shared costs, and a NMI allocation cost of $9.4/year. This outcome assumes utilisation of in-device metrology.

The Rule Change VPP, when compared to the Current Retailer VPP, results in a net negative outcome. The policy results in a net cost due to system costs incurred which are not offset by the added network management benefits generated by the rule change in this scenario. These benefits are also being provided by smart metering, and the rule change would only accelerate the timing of their realisation where CER is deployed ahead of the full smart meter deployment planned by 2030[2].

[2] Review Of The Regulatory Framework For Metering Services, AEMC. https://www.aemc.gov.au/sites/default/files/2023-08/emo0040_-_metering_review_-_final_report.pdf

Figure ES1 – Annual Net Benefits per Device Case Study (Small Customer Battery, 2023)

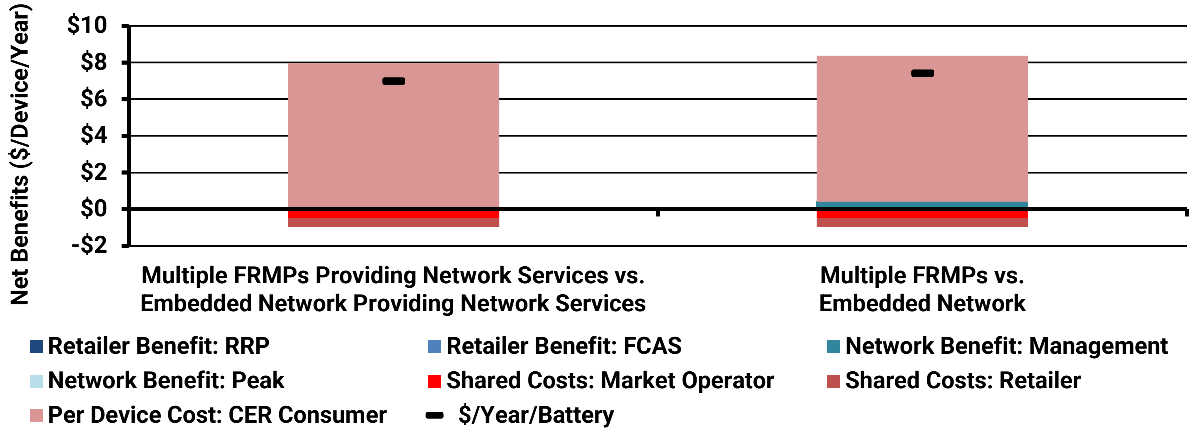


Source: Energeia

Energeia's estimate of the economic impacts of the proposed rule change for the large customer workstream is reported in Figure ES2.

The findings show the same additional net benefits available to small customers can be captured by large customers CER if used for network service provision. However, unlike for small customers, this rule change allows large customers to avoid installing a meter even when not providing network services, given the embedded network framework requires the device to be metered.

Figure ES2 – Annual Net Benefits per Device Case Study (Large Customer Battery, 2023)



Source: Energeia

A key takeaway from the above analysis is that avoiding an additional meter is the key value driver for this rule change to be economically beneficial, regardless of whether the customer is large or small. While not required by the rules, installation of an additional smart meter is assumed to occur for network services including voltage support and demand management for small customers.

Energeia considered the emissions reduction impacts of the proposed rule and found them to be negligible due to the rule changes not directly impacting the level of uptake of CER flexibility in the NEM, or how it is operated.

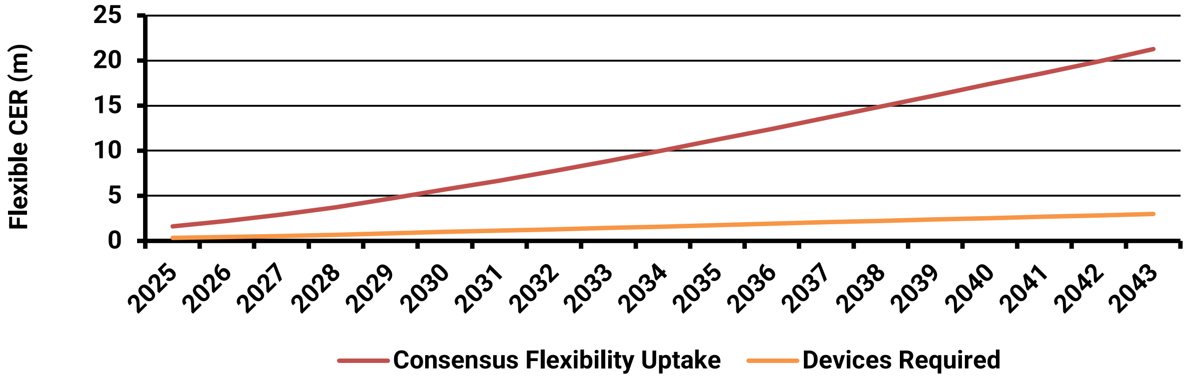
Additional expected benefits of the proposed rule changes, which were not modelled, include lower barriers to entry and associated enhancements in competition, choice and innovation. Finally, Energeia also notes the rule changes are necessary, but not sufficient, to realise their full value potential.

Break-Even Analysis

A break-even analysis was used to determine the level of flexible CER uptake that would be required for the benefits of the rule change to outweigh its costs, e.g., AEMO and retailer costs to upgrade their systems to account for the impact of this rule change. This analysis includes small and large customers, with each segment separately assessed within Section 3.2.

Figure ES3 shows the estimated level of CER device uptake required for the Rule Change VPP Providing Network Services option to break even with the Current Retailer VPP Providing Network Services option compared to the consensus[3] flexible CER uptake forecast.

Figure ES3 –Flexible CER Uptake Required vs. Consensus Uptake for Rule Change to Breakeven



Source: Energeia

The key draft finding is that for the rule change to make economic sense, there would need to be an additional 156,798 devices per year on average taking up load flexibility via a second NMI for the observed horizon. At this point, the additional shared system upgrade costs of the rule change are equal to higher per device costs that would persist without the rule change. This corresponds with 14% of the consensus forecast level of flexible CER uptake. If the uptake of load flexibility via a second NMI were to exceed these levels, the rule change would produce net benefits.

Energeia's use of the Current Retailer VPP Providing Network Services vs. Rule Change VPP Providing Network Services for the break-even analysis is a key assumption in this analysis. It presumes that current barriers to using CER for network thermal and voltage constraints are addressed via future rule changes, as per the recommendation below, unlocking this key value driver for flexible CER. In Energeia's view, 14% of forecast flexible devices being used for network services once key barriers have been removed is not unreasonable.

Energeia's also analysed the proposed rule change's impacts to active and passive customers. Passive customers can be defined as any NMI that does not have load flexibility or has it and chooses to not participate in load flexibility programs, which contrasts with active customers who are participating in load flexibility programs.

Ultimately, we found that the rule change would be expected to impact the outcomes of active and passive customers in the same way, due to retailer behaviour, which prefers to smear some costs across all customers to simplify customer decisions and other operational reasons. Key assumptions we made in reaching this conclusion include:

- All costs considered in the two scenarios are shared between all customers via their retail tariffs. This includes the shared system upgrade costs and the costs that are incurred per device for installing new meters at a premises and allocating a new NMI.
- It is common practice for retailers to not directly charge customers for a standard meter installation, but instead to smear the recovery of that cost into their tariffs.

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[3] The consensus view referred to throughout this report reflects Energeia's consolidation of respected industry publications, primarily the E3 Residential and Commercial Baseline Studies (2022), the AEMO ISP Step Change Inputs and Assumptions (2023), and the E3 'Smart' Demand Response Capabilities report (2022)

- It is therefore reasonable to assume that in the event of this rule change that retailers would smear the NMI allocation cost in the same way to reduce the direct cost to active customers, whom they want to attract to their product.

Draft Findings, Conclusions, and Recommendations

Based on the results of the analysis of the associated costs, Energeia found that the rule change would be cost effective if it leads to an additional 156,798 devices per year on average participating in load flexibility programs that provide network services at some point over the observed horizon.

This breakeven analysis excludes consideration of second-order benefits, nor does it include benefits from reduced barriers to entry, including greater choice, lower prices, and more innovation. Regardless of whether the rule change is cost-effective on its own, Energeia notes that it will be necessary, but not sufficient, to achieve the full value potential of CER.

Based on the above findings, Energeia concludes that the proposed rule change would satisfy the National Electricity Objective. Furthermore, throughout the analysis, Energeia did not identify any modifications to the proposed rule changes that could result in a more optimal outcome.

Longer-term, Energeia have identified the following key regulatory barriers for the AEMC's consideration in future rule changes:

- **Remove barriers to the use of flexible CER for network services:** Flexible CER must be of sufficient size and dependability and be lower cost than alternatives to provide network services. This is more likely to be the case over time, as more CER is deployed, but also where investment incentives are cost reflective, and there is no network capex bias.
- **Remove barriers to using devices for MASS[4] compliant metering**: FCAS was found to be a key value driver for flexible CER but currently faces significant barriers to access, mainly metering requirements. Enabling the use of devices for MASS compliance, provided they meet operational requirements, would unlock access to the significant FCAS value stream.
- **Ensure cost-reflective network and retail incentives:** Establishing cost-reflective network and retail prices may allow for more efficient CER utilisation. Current arrangements lead to conflict between retail bill savings and system savings, and result in sub-optimal CER utilisation. Cost-reflective pricing would enable 100% flexible CER utilisation and maximise system benefits.
- **Level the playing field for third parties:** Currently, retailers have an upper hand in accessing the value of CER flexibility through existing access to wholesale value. Allowing third party aggregators equal access to these benefits will increase competition amongst flexibility service providers, generating additional value to consumers.

Supporting analysis for these recommendations is provided in Section 3.3.

[4] Market Ancillary Service Specification

Table of Contents

Table of Figures

Table of Tables

1. Background

This study feeds into an Australian Energy Market Commission (AEMC) Unlocking Consumer Energy Resources (CER) Benefits Through Flexible Trading rule change. The proposed rule changes seek to improve trading of consumer energy resources (CER) to further unlock value for consumers. It also aims to facilitate better integration of flexible CER into the power system to deliver a more reliable and secure energy system that would benefit all consumers. The purpose of this report is to report on the results of Energeia's research, analysis and modelling of the impacts, costs and benefits of the proposed rules, as well as to provide recommendations on future directions for the AEMC to consider to maximise the potential value from CER flexibility.

1.1. The Rule Change

The Australian Energy Market Operator's (AEMO) rule change request to the AEMC's Flexible Trading Arrangements (Model 2) and Minor Energy Flow Metering in the National Electricity Market (May, 2022) seeks to enable end users to separate their controllable electrical resources and have them managed independently from their passive load without needing to establish a second connection point.[5] The AEMO model also allows for a consumer to contract with more than one financially responsible market participant (FRMP) if they choose to do so.[6]

This rule change is one of the many CER implementation reforms underway. Other rule changes and reviews that have an impact on this analysis include but are not limited to:

- Integrating Price-Responsive Resources into the NEM
- Review of the Regulatory Framework for Metering Services
- Review into CER Technical Standards
- Consumer Protections for Future Energy Services
- Development of Interoperability Policy
- Review of the Regulatory Framework for Flexible Export Limit Implementation
- Network Visibility for the Market

1.2. Methodology Report

The AEMC published Energeia's draft methodology report[7] alongside its Directions Paper,[8] which outlined the proposed rule change assessment methodology and work to date. The modelling in this report reflects the feedback Energeia received from the public consultation. A summary of feedback received, along with how it was addressed, is provided in Appendix B.

[5] https://www.aemc.gov.au/sites/default/files/2022-05/ERC0346%20Rule%20change%20request%20pending.pdf

[6] AEMO rule change request, Appendix B HLD p. 42.

[7] Benefit Analysis of Load-Flexibility from Consumer Energy Resources: Methodology Report https://www.aemc.gov.au/sites/default/files/2023-08/CER%20Flexibility%20Modelling%20Methodology%20Paper%20-%20FINAL.pdf

[8] Directions Paper: National Electricity Amendment (Unlocking CER Benefits Through Flexible Trading) Rule 2023 https://www.aemc.gov.au/sites/default/files/2023-08/ERC0346%20CER%20Benefits%20Directions%20paper%20-%20rule%20change.pdf

2. Scope and Approach

The AEMC engaged Energeia to develop an estimate of the economic costs and benefits of unlocking flexible CER[9] across a range of potential rule change scenarios – including rule changes not incorporated in the current rule change process – as well as to estimate the impact of associated wealth transfers between customer types, and to conduct a break-even analysis. The work was developed with the AEMC to inform the Directions Paper and Draft and Final Determinations, and future work.

2.1. Scope

The scope of this cost-benefit analysis aimed to estimate the incremental costs and benefits due to the AEMC's proposed rule changes, and the required uptake of CER to economically break even on estimated rule change costs.

The above outcome was modelled using a fit-for-purpose Microsoft Excel-based modelling tool that estimated the material costs and benefits of flexible CER for the system and for consumers, and, crucially, enabled the quantification of the benefits needed to be realised by a potential AEMC rule change to be cost effective. The modelling included the flexible load types and consumer segments outlined in Appendix A across the NEM to 2050.

> The scope of this engagement was not to forecast the impact of a potential rule change on system costs, but to estimate the quantum of system benefits that load flexibility could potentially provide and how large these benefits and the consumer allocation would need to be to justify the industry costs associated with a potential rule change.

The analysis plan outlined in the Methodology Report[10] alongside the AEMC's Directions Paper fell under two phases of objectives:

- **Phase A** – to determine the incremental value of the most promising CER load flexibility options in terms of benefits to the electricity system and to consumers, considering an expected sharing of benefits across supply chain participants, and
- **Phase B** – to determine the economic impacts, costs, and benefits of proposed rule changes on the system, the required threshold of incremental uptake to ensure that this rule change is viable for market participants and consumers.

This report outlines the Phase B of the above scope, with Phase A remaining an internal project with the AEMC. The sections below describe the approach to Phases A and B in more detail.

2.2. Approach

Energeia worked closely with the AEMC to deliver the following scope and approach to achieve the key objectives and requirements of this supporting study for the AEMC's Draft Determination.

2.2.1. Phase A

The key project steps for Phase A included:

- Develop and Agree Upon Key Inputs, Assumptions, and Methodology
- Develop CER Flexibility Optimisation Tool
- Determine Allocation of Benefits

[9] CER for the purposes of the rule change request is defined in Chapter one of the Directions Paper.

[10] Benefit Analysis of Load-Flexibility from Consumer Energy Resources: Methodology Report https://www.aemc.gov.au/sites/default/files/2023-08/CER%20Flexibility%20Modelling%20Methodology%20Paper%20-%20FINAL.pdf

- Validate Reporting with Key Stakeholders

The following sections summarise each step of Phase A.

Develop and Agree Upon Key Inputs, Assumptions, and Methodology

Energeia developed key modelling inputs and assumptions via desktop research and meetings with key subject matter experts, e.g., AEMO. Preliminary inputs and proposed methodology were documented in Energeia's Directions Paper,[11] and further developed and refined based on feedback as the project progressed.

Develop CER Flexibility Optimisation Tool

Energeia developed a CER flexibility model to estimate the impacts the first-order impacts of load flexibility on customer retail bills and system costs, including wholesale, ancillary services, transmission, distribution, and carbon emissions reduction benefits. These outcomes were then extrapolated to a NEM-wide level using CER uptake and flexibility paths consistent with the consensus view of CER flexibility uptake.[12]

The modelling was delivered via a bespoke fit-for-purpose Microsoft Excel-based tool that was developed for the AEMC.

Determine Allocation of Benefits

Energeia researched and analysed current virtual power plant (VPP) offers to estimate the average level of CER utilisation and the impact on the customer's bill of orchestration of CER to provide system benefits.

Validate Reporting with Key Stakeholders

Energeia presented the delivered research, analysis, and results to key AEMC stakeholders, and revised them based on feedback received.

2.2.2. Phase B

The key project steps for Phase B included:

- Define Rule Change Policy Options
- Develop and Agree Upon Key Inputs, Assumptions, and Methodology
- Analyse Rule Change Impacts
- Develop Recommendations
- Validate Reporting with Key Stakeholders

The following sections summarise each step.

Define Rule Change Policy Options

Energeia worked closely with the AEMC and developed several rule change implementation options based on the current and ideal interaction of flexibility of CER with the current and future state of the National Electricity Rules (NER). The options targeted improving the transparency of CER flexibility processes at a low cost to consumers.

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[11] Benefit Analysis of Load-Flexibility from Consumer Energy Resources: Methodology Report, Energeia. https://www.aemc.gov.au/sites/default/files/2023-08/CER%20Flexibility%20Modelling%20Methodology%20Paper%20-%20FINAL.pdf

[12] The consensus view referred to throughout this report considers Energeia's consolidation of respected industry publications, primarily the AEMO ISP Step Change Inputs and Assumptions (2023), the E3 Residential and Commercial Baseline Studies (2022), and the E3 'Smart' Demand Response Capabilities report (2022)

The policy options modelled within this cost-benefit analysis are contained in Section 3.1.

Develop and Agree Upon Key Inputs, Assumptions, and Methodology

Energeia undertook desktop research to capture additional inputs needed in Phase B.

The inputs and methodologies that are relevant to the Phase B modelling are detailed throughout Section 3.

Analyse Rule Change Impacts

Energeia used its configured CER Flexibility Model to estimate the economic costs and benefits of each rule change option via a series of case studies and estimated the level of uptake needed to break even on the rule changes costs. Energeia also considered the impact of removing other identified barriers to load flexibility as potential future directions.

Section 3.1 details the economic cost-benefit case study, Section 3.2 details the break-even analysis, and Section 3.3 details the future directions analysis.

Develop Recommendations

Energeia worked with the AEMC to identify and model the impact of removing additional regulatory policy barriers.

This report demonstrates the outcomes of each of the policy options, recommends future directions within the scope of the policy options, and identifies barriers to deriving increased value from CER flexibility.

Section 5 documents the recommendations we developed based on this workstream.

Validate Reporting with Key Stakeholders

Energeia presented the delivered analysis to key AEMC stakeholders, revised it based on feedback, and documented those assessments in this report.

3. Value of the Rule Change (Phase B)

Phase B analysed the economic impacts of key rule change options, the adoption required to break even on the estimated costs of the rule change, and the potential value of load flexibility unlocked by removing the key policy and regulatory barriers that would remain.

Phase B of the analysis is segmented into three workstreams:

- **Economic Cost-Benefit Case Study** – this analysis modelled the value of the proposed policy options that were conceptualised through a series of case study cost-benefit assessments, to analyse the impact of the rule change on a per customer basis,
- **Break-Even Analysis** – this analysis determined the level of the CER flexibility uptake that would be required for benefits to outweigh the costs, and
- **Future Directions** – this analysis was an extension of the economic cost-benefit analysis (CBA) case studies conducted, but with additional policy scenarios to consider the value of better enabling frequency control ancillary services (FCAS) as well as network and retail cost-reflective pricing for CER.

The following section details the first of the above workstreams.

3.1. Economic Cost-Benefit Case Study

The value of the proposed policy options was conceptualised through a series of case study cost-benefit assessments, to analyse the impact of the rule change on a per-customer basis.

3.1.1. Methodology

The methodology of this stage included:

1. **Develop policy options** – Energeia worked closely with the AEMC to develop rule change implementation options for the two workstreams: small customers (consisting of residential and small commercial) and large customers (consisting of large commercial customers).
2. **Develop further inputs** – Phase B analysis continued the development of the use of the CER flexibility optimisation model which was developed in Phase A internally with the AEMC with additional inputs.
3. **Test customer outcomes as a case study** – the scope of this work required testing the marginal impact to customers across proposed rule change implementation options for active customers. The case study analysis demonstrates the net costs and benefits for both a representative flexible unidirectional load and bidirectional CER for each customer segment – to determine if the rule change is net beneficial for each case.
    a. For Small Customers the selected case study loads were:
        i. Unidirectional load: electric vehicle (EV) charger
        ii. Bidirectional load: Battery
    b. For Large Customers the selected case study loads were:
        i. Unidirectional load: Ventilation unit[13]
        ii. Bidirectional load: Battery

    Energeia worked with the AEMC to identify and estimate additional cost and benefit categories to model, which included:

    - **Per Device System RRP Benefits –** Avoided wholesale energy cost to the retailer from CER flexibility. This value was estimated for each case study using outputs from the CER Flexibility Optimisation Tool

[13] A ventilation load (unit or fan) used for air quality purposes, separate from heating or cooling loads

- **Per Device System FCAS Benefits –** FCAS value generated for the retailer from CER flexibility. This value was estimated for each case study using outputs from the CER Flexibility Optimisation Tool
- **Per Device System Network Peak Benefits –** Avoided augmentation costs for the network to meet peak demand or additional solar PV hosting capacity using CER flexibility. This value was estimated for each case study using outputs from the CER Flexibility Optimisation Tool
- **Per Device Costs** – Additional metering and NMI allocation costs incurred by the network for using flexible CER, which are passed on to the retailer
- **Shared Costs** – System upgrade costs for AEMO and retailers to accommodate the rule change (shared), which are passed on to the retailer
- **Network Management Benefit** – Network optimisation benefits excluding thermal overload and voltage excursion mitigation, which are covered under network benefits.

3.1.2. Rule Change Scenarios

The impact of the rule change was defined for this analysis by the way it would alter the market arrangements for customers wishing to partake in CER flexibility services. The focus of this rule change is on separately identifying and measuring a consumer's CER in a cost-effective way. Improving these arrangements may allow or enable:

- consumers to have different network and retail pricing offers for their CER assets based on their individual preferences from their passive load, or to be offered direct payments for the use of their assets
- energy service providers to better participate in wholesale energy market scheduling processes
- networks to procure demand and export management services more efficiently from these resources, helping to reduce the need for network augmentation
- an aggregated resource that the market operator (AEMO) could use to deliver secure, reliable, and low-emissions energy at lower cost.

Standardising and streamlining the process for establishing load flexibility programs for service providers will in turn lower transaction and metering costs below current levels. This would improve competition in the market by reducing the barriers to entry for new providers. The specific market arrangements considered in this rule change are discussed in the sections below for small and large customers, respectively.

This rule change is not expected to impact how service providers enact load flexibility on CER. Policy that improves cost-reflective pricing arrangements from retailers and networks, coupled with the improved market accessibility enabled by this rule change, would result in more opportunities for consumer load flexibility. By better aligning customer-facing electricity pricing structures with actual system costs, the amount of time that a CER load could be controlled would increase beyond current levels. This approach is further explored in Section 3.3.

Small Customers

For small customers, current arrangements with market and network operators and regulators do not recognise a flexible CER device in the market. Network demand management programs for specific devices, while possible under existing arrangements, at the network's discretion may require the installation of an additional standard meter at a premises, such as through a controlled load arrangement.

The rule change would result in creation of an additional national metering identifier (NMI) at a customer's premises to identify a given flexible device, thereby creating a secondary settlement point. It would leverage the ability to optionally use CER flexibility without the need for additional metering installations at the premises by instead recognising the in-built metrology of CER as a metering type compliant with the NER. These new meter types would need to comply with specifications set in

AEMO's procedures and to be compliant with the National Metering Institute requirements. The rules require metering to be compliant with National Measurement Institute requirements. Only one FRMP would be allowed at a small customer's premises under this rule change, recognising the significant consumer protection costs that this revision would instigate. The rule change policy options assessed for this analysis can be described as:

- **Current Retailer VPP** – the current market arrangement whereby CER is used by retailers to manage wholesale price exposure without certified device level metrology, nor a standard for accessing it,
- **Current Retailer VPP Providing Network Services** – as per Current Retailer VPP, but includes provision of demand management (DM) services to the network including installation of an additional meter and is possible today,
- **Rule Change VPP** – a retailer VPP, where a flexible CER device is given a NMI and uses certified in-device metrology, providing standardised data access to authorised participants and enabling use of it by networks to optimise their grids, and,
- **Rule Change VPP Providing Network Services** – the above Rule Change VPP where the NMI allocated CER device provides DM services to the network.

The rule change would not affect how service providers currently enable CER to provide FCAS, meaning that an additional market ancillary service specification (MASS) compliant meter would need to be installed at the premises. It also will not directly influence how retailers or networks price devices. This analysis does however consider a series of future directions to explore to further unlock CER flexibility benefits, which can be seen in Section 3.3, but which are not the focus of this rule change.

The policy option design considered for small customers is summarised in Table 1.

Table 1 – Small Customer Rule Change Scenarios Considered

	Net Benefit Drivers			Market Arrangements				
Scenario Name	Increases Competition	Lowers Transaction Costs	Lowers Metering Costs	FRMPs	NMIs per FRMP	Std. Meter	MASS Compli-ant Meter	Device Meter
Current Retailer VPP				1	1			1*
Current Retailer VPP Providing Network Services	✓			1	1	1		
Rule Change VPP	✓	✓	✓	1	2			1
Rule Change VPP Providing Network Services	✓	✓	✓	1	2			1

Source: AEMC, Energeia
*Does not meet metrology standard

Large Customers

Current market arrangements enable the subloads of large customers to be separately metered and visible to the market operator (unlike small customers), through the embedded network framework. However, networks do not have visibility of this subload and, as with small customers, any network demand management programs for specific devices – while currently possible under existing arrangements – and at the network's discretion, may require the installation of an additional standard meter at the premises of large customers.

This rule change would provide a more appropriate and enduring framework for large customers to engage multiple FRMPs and establish secondary settlement points. Large customers could also use devices with in-built metrology for metering at secondary settlement points, effectively establishing the CER as a separate load from the premises (though still sub-metered) with a FRMP that is separate from the rest of the premises and metered using the in-built metrology of the CER (subject to compliance). As per the small customer rule change, networks would also have visibility of this load, and device metering would need to comply with National Measurement Institute requirements to allow for this. The rule change policy options assessed for this analysis can be described as:

- **Embedded Network** – the current market arrangement whereby a CER management service provider uses separately metered CER to participate in the wholesale market through the embedded network framework,
- **Embedded Network Providing Network Services** – as per Embedded Network, but includes provision of demand management (DM) services to the network including installation of an additional meter and is possible today,
- **Multiple FRMPs** – a retailer VPP, where a flexible CER device is given a NMI, a FRMP, and uses certified in-device metrology, providing standardised data access to authorised participants and enabling use of it by networks to optimise their grids, and
- **Multiple FRMPs Providing Network Services** – the above Multiple FRMPs where the NMI allocated CER device provides DM services to the network.

As per small customers, the rule change would not affect how service providers currently enable CER to provide FCAS, meaning that an additional MASS compliant meter would need to be installed at the premises. It also will not directly how devices are priced by retailers or networks price devices. This analysis does however consider a series of future directions to explore to further unlock CER flexibility benefits, which can be seen in Section 3.3. These directions are investigated but are not the focus of this rule change.

The policy option design considered for large customers is summarised in Table 2.

Table 2 – Large Customer Rule Change Scenarios Considered

	Net Benefit Drivers			Market Arrangements				
Scenario	Increases	Lowers	Lowers					
Name	Competition	Transaction Costs	Metering Costs	FRMPs	NMIs per FRMP	Std. Meter	MASS Compli-ant Meter	Device Meter
Embedded Network				2^	1	1		1*
Embedded Network Providing Network Services	✓			2^	1	1		
Multiple FRMPs	✓	✓	✓	2	1			1
Multiple FRMPs Providing Network Services	✓	✓	✓	2	1			1

Source: AEMC, Energeia
*Does not meet metrology standard
^Using embedded network functionality

3.1.3. Inputs

This section outlines the scope of inputs utilised in this modelling.

Rule Change Cost Assumptions

The input costs for small customers and large customers by policy option are shown in Table 3 and Table 4 respectively. The costs were categorised by the key stakeholder that they would affect.

Table 3 – Small Customer Cost Assumptions

Policy Option	Costs ($/Year/Device)							
	AEMO	Retailers/Metering Coordinators			Networks		OEM	
Name	System Changes	System Changes	Std. Meter	MASS Compliant Meter	System Changes	NMI Allocation	Certific-ation	System Changes
Current Retailer VPP	-	-	-	-	-	-	-	-
Current Retailer VPP Providing Network Services	-	-	$16.38	-	Negligible	-	-	-
Rule Change VPP	$0.49	$0.49	-	-	-	$8.42	Negligible	Negligible*
Rule Change VPP Providing Network Services	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*

Source: Energeia
Note: OEM = Original Equipment Manufacturer
*Assumes internet delivery, not, e.g., a dedicated 4G service

Table 4 – Large Customer Cost Assumptions

Policy Option	Costs ($/Year/Device)							
	AEMO	Retailers/Metering Coordinators			Networks		OEM	
Name	System Changes	System Changes	Std. Meter	MASS Compliant Meter	System Changes	NMI Allocation	Certific-ation	System Changes
Embedded Network	-	-	$16.38	-	-	-	-	-
Embedded Network Providing Network Services	-	-	$16.38	-	Negligible	-	-	-
Multiple FRMPs	$0.49	$0.49	-	-	-	$8.42	Negligible	Negligible*
Multiple FRMPs Providing Network Services	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*

Source: Energeia
*Assumes internet delivery, not, e.g., a dedicated 4G service

The sources of these cost assumptions are as follows:

- Costs associated with the **installation of an additional/different meter** were based on previous interviews Energeia has conducted with metering coordinators.
- Distribution network costs associated with the **establishment and management of new NMIs** are taken from an Energeia analysis for AEMC on establishing a second connection point[14], which leveraged network pricing schedules of NSW Distributed Network Service Providers (DNSPs). Note that this cost includes the site establishment fee and the connection offer service charge.
- The costs for CER original equipment manufacturers (OEMs) to **comply with metering requirements** and system changes were deemed negligible, because manufacturers can leverage existing circuits and measuring capabilities.
- **System change costs** to AEMO, retailers, and third-party aggregators are created by the need to upgrade their IT systems to account for additional streams for small and large customers that undergo market settlement, which was derived from AEMO's reported cost of facilitating the Distributed Energy Resource Integration Program[15] ($5.2m/year) and was assumed to be equal for retailers. It should be noted that the costs of these system changes were assumed

[14] Energeia, Expert Advice on the Cost of Establishing a Second Connection Point, 2020, https://esb-post2025-market-design.aemc.gov.au/32572/1608712682-enegeia-expert-advice-on-the-cost-of-establishing-a-second-connection-point.pdf

[15] AEMO, 2022-23 AEMO Budget and Fees

to be allocated per connection point and should therefore be treated as indicative based on the current number of connection points.

- DNSPs need to account for these costs, i.e., meter loads, when being used for DM benefits. These were deemed negligible because **networks already have the capability to allocate sub-metering arrangements**, such as through controlled load programs.

It should be noted that for all identified non-negligible costs, it is assumed that retailers directly incur these costs but pass them through to all consumers via their retail tariffs.

Network Management Benefits

Network management allows networks to plan for future infrastructure upgrades more accurately, such as network augmentation and the timing of replacement expenditure, through the increased visibility and granularity of existing assets from the higher number of smart meters and data flow streams for individual subloads. Energeia had previously conducted a review for the Energy Networks Association (ENA) to summarise the additional network benefits that could be realised from increased smart metering services and market penetration.[16] The review identified seven network benefits as moderately to very significant:

- Network Demand Management
- Low-Voltage (LV) Phase Balancing
- LV Dynamic Reconfiguration
- LV Automated Volt-Var Control
- LV Power Quality Investigations
- LV Vegetation Detection
- LV Incipient Asset Failure Detection

The level of network benefits that can be fully achieved varies, depending on the assumed level of smart metering penetration. Some benefits require a minimum level of smart meter penetration to operate at all. However, most benefits were found to increase at some rate as the accuracy of the information improved (i.e., as smart meter penetration increased).

The listed benefits were based on a high-level review at the time of existing information and informal interviews of subject matter experts. The materiality of each benefit varied according to the specific circumstances of each DNSP, and further work was required to develop robust estimates for national policymaking. For each potential beneficial application of smart metering technology, Energeia developed an estimate of the potential benefits to a network business through interviews with subject matter experts from DNSPs.

Much of the identified network benefits in this analysis are being captured by the ongoing rollout of smart meters to NMIs across the NEM. Some CER, including solar PV systems, require a smart meter, for other CER Energeia modelled the expected change in timing of network access to data before a smart meter is installed, and estimated the benefit value to be $0.42/year per metered device.

CER Flexibility Assumptions

The following sections contains all inputs relating to the included representative customers, and the way they are operated flexibly. They were used in the CER Flexibility Optimisation Tool to generate the per device benefits of each case study.

<u>SUBLOADS</u>

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[16] ENA, Review of the Potential Network Benefits of Smart Metering, 2014, https://www.aemc.gov.au/sites/default/files/content/996c9319-39d8-49e2-b2ba-26afb8d0ff3b/RuleChange-Submission-ERC0169-Energy-Networks-Association-140529.pdf

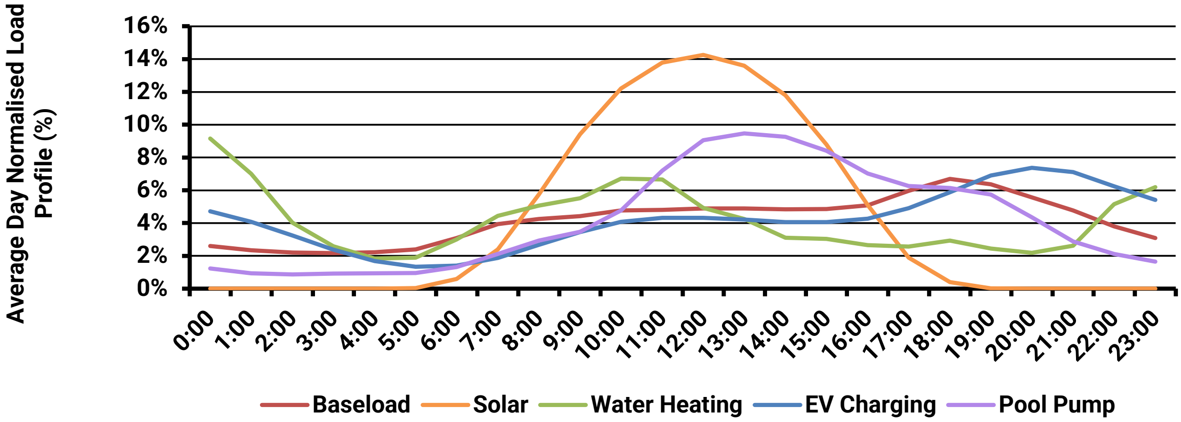
The following section covers the selection of subloads, their profiles, consumption, and capacities used as inputs to the modelling.

Subload Profiles

Appliance load shapes provide the timing of energy consumption of each CER prior to any load flexibility occurring. They provide the foundation with which load shifting and shedding is modelled in this analysis.

The residential load profiles are sourced from the Residential Baseline Study,[17] and are shown in Figure 1.

Figure 1 – Average Day Residential Normalised Load Shape



Source: Residential Baseline Study (2022)

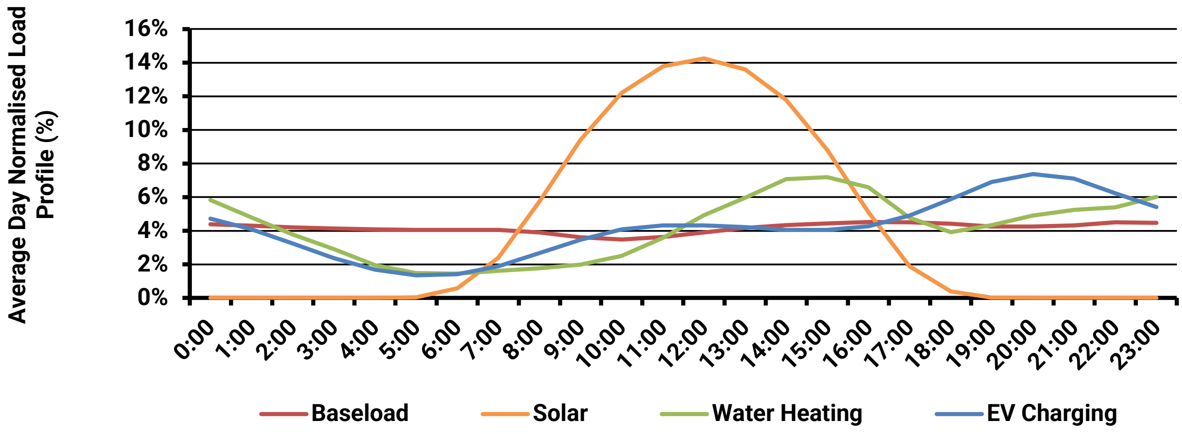
The load shapes for small and large commercial water heating, refrigeration, and ventilation were adapted from end-use load profiles for the United States (US) Building Stock (National Renewable Energy Laboratory (NREL)), mapped to 2022 capital city weather and seasonality for each NEM state considered, and are shown in Figure 2 and Figure 3.

The process of climate matching Australian cities with a US city involves comparing several different climatic and economic factors, such as average temperature differential, average humidity differential, average daylight differential, average wind differential, average rainfall differential, average income, and average energy prices. These factors were compared across major US cities, and the city that matched most closely, i.e., that had the most factors with low amounts of difference, was taken forward.

US data was used because, to the best of Energeia's knowledge, no publicly available data exists on Australian subload consumption load shapes for commercial premises.

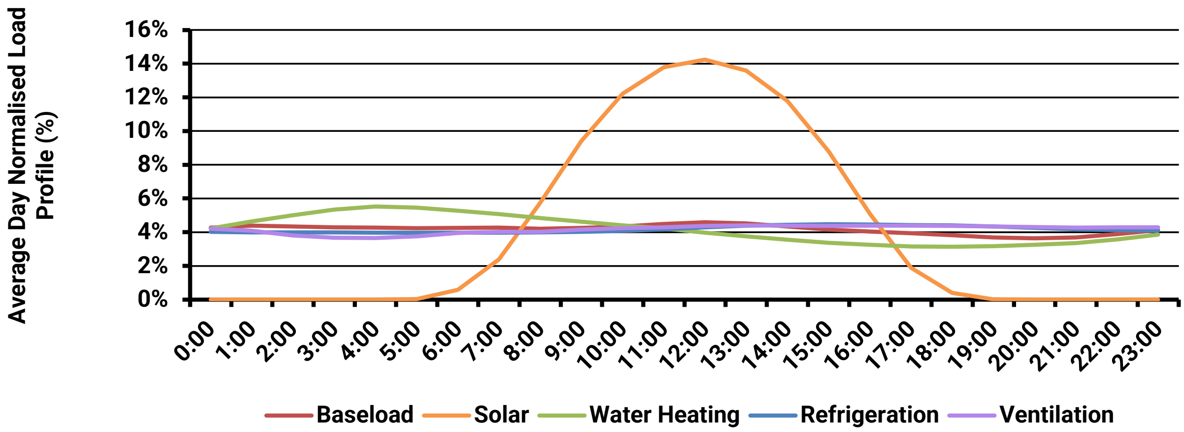
[17] Residential Baseline Study, 2022. https://www.energyrating.gov.au/industry-information/publications/report-2021-residential-baseline-study-australia-and-new-zealand-2000-2040

Figure 2 – Average Day Small Commercial Normalised Load Shape



Source: Commercial Baseline Study (2022), NREL

Figure 3 – Average Day Large Commercial Normalised Load Shape



Source: Commercial Baseline Study (2022), NREL

The solar photovoltaic (PV) load shapes were adapted from NREL's PV Watts tool for each capital city in each NEM state. The EV charging load shapes were sourced from the AEMO 2023 Inputs, Assumptions and Scenarios Report (IASR). The convenience charging load shapes were taken forward for this analysis.

Annual Consumption and Capacity

The following section demonstrates the size of the representative customers utilised in the case study modelling. The annual consumption inputs for each subload are shown in Table 5, Table 6 and Table 7, for the residential, small commercial, and large commercial segments. These consumption values are per premises and were used to scale the normalised consumer load profiles to a per premises level. In turn, the per premises profiles could then be scaled based on forecast CER and flexibility uptake by segment and state.

Table 5 – Residential Annual Consumption by Subload

Baseload (kWh)	Water Heating (kWh)	EV Charging (kWh)	Pool Pump (kWh)
4,011	996	2,240	1,099

Source: Energeia

Table 6 – Small Commercial Annual Consumption by Subload

Sub Segment	Baseload (kWh)	Water Heating (kWh)	EV Charging (kWh)
Offices	16,253	255	2,240
Retail	16,461	46	2,240
Accommodation	16,196	311	2,240
Entertainment	16,199	309	2,240
Warehouses	16,414	93	2,240
Health	16,225	322	2,240

Source: Energeia

Table 7 – Large Commercial Annual Consumption by Subload

Sub Segment	Baseload (kWh)	Water Heating (kWh)	Refrigeration (kWh)	Ventilation (kWh)
Offices	417,861	27,300	-	70,098
Retail	397,161	15,958	-	102,139
Accommodation	342,595	106,076	2,920	63,667
Entertainment	414,406	26,408	4,836	69,609
Warehouses	348,750	2,114	-	164,395
Health	375,987	64,490	1,039	73,743

Source: Energeia

For generation and storage devices, the capacities of each subload are shown by segment in Table 8. These were used to determine the generation and load shifting capabilities of these CER devices.

Table 8 – Subload Capacities by Segment

Segment	Solar PV (kW)	Battery (kW/kWh)	V2G (kW/kWh)
Residential	7.5	5/10	5/5.83
Small Commercial	30	5/10	5/5.83
Large Commercial	100	75/150	-

Source: Energeia
Note: Stationary battery and V2G capacities are dictated by export limits

VPP OPERATION HOURS

The following section outlines inputs utilised in modelling flexibility of CER by characterising current VPP provider strategies for optimising customer VPP participation. Current VPP operation is used to show the impact of rule changes on existing implemented CER operation.

To determine an operational limit (i.e., maximum days of the year of flexible device control by the VPP/FRMP) for modelling CER flexibility, Energeia researched 16 available residential battery VPP offers in Australia and narrowed them down to a selection of offers that included explicit annual operation limits or estimates. The operational limit taken forward was determined based on the average of this selection, as shown in Table 9. Note that depending on the provider, these limits were either defined in units of energy (kWh) or days of the year. The analysis assumed that the battery would cycle once per day of operation, allowing for a conversion of all operational limits to days of the year.

Table 9 – VPP Annual Operation Limits

VPP Provider	Max Annual Operation (days/year)	Source
origin	20	https://www.originenergy.com.au/solar/batteries/origin-loop-partner-battery-offer/
nectr	50	https://nectr.com.au/news-and-resources/everything-you-need-to-know-about-vpps/
ShineHub	104*	https://shinehub.com.au/virtual-power-plant/
simply energy	41	https://www.simplyenergy.com.au/residential/energy-efficiency/simply-vpp/new-solar-battery
TESLA	50	https://www.tesla.com/en_au/tep
AVERAGE	53	

Source: Solar Quotes (2023), Origin "Loop" (2023), Nectr VPP (2023), ShineHub VPP (2023), SimplyEnergy "Simply VPP" (2023), Tesla "Energy Plan" (2023), Energeia
*Based on ShineHub's estimate of two VPP events per week

The resulting average of 53 operational days per year was taken forward as an input to limit the number of days of flexible operation in the rule change scenarios. A flexible operational limit is needed to reflect a reasonable market outcome, which considers that flexible operation of CER devices competes with consumer retail bill minimisation interests.[18]

In the modelling of future policy, this operational limit is no longer applied, given the assumptions that CER flexibility is completely unlocked.

CER FLEXIBILITY ORCHESTRATION STRATEGIES

The modelling mechanisms through which CER flexibility was considered for each load type are summarised in Table 10 and Table 11, for small and large customers, respectively. They were intended as an approximation of what CER flexibility would look like in reality, rather than a complete strategy. Device types not used in the case studies are displayed in the tables for comparative purposes.

[18] Note that there are some available VPP offers which are allowed greater access to customers' batteries based on risk appetite and rewards available

Table 10 – CER Flexibility Modelling Mechanisms: Small Customers

Device Type	No Orchestration	Wholesale Price Orchestration	Tx Orchestration	Dx Orchestration	FCAS Orchestration
Storage Water Heater (100% power flexible)	Operates per base subload	Shifts all flexible consumption in highest price to lowest price, on a daily basis	Shifts all flexible consumption out of peak network period and into minimum network period, defined as top 1.4% peak/minimum demand hours on network	Shifts all flexible consumption out of peak network period and into minimum network period, defined as top 1.4% peak/minimum demand hours on network	Flexible loads and generation bid into the highest value market between 6 sec – 5 min for raise and lower, but does not change load behaviour from optimal state
Pool Pump[2] (100% power flexible)					
Level 2 EV Charger (availability varies by hour)					
Solar (100% power flexible)		Curtailed when RRP < 0 $/MWh	No solar exports during minimum period	No solar exports during minimum period	
Battery (100% power flexible)	Charges during excess solar, immediately discharges as soon as grid consumption is recorded. Does not export to the grid	Charges during lowest RRP price intervals to fully charge the battery. Discharges during highest RRP prices of the day to fully discharge the battery. Can export to the grid	Charges during network minimum period, discharges during network peak period. If neither occurs in a day, the battery performs bill minimisation behaviour. Can export to the grid	Charges during network minimum period, discharges during network peak period. If neither occurs in a day, the battery performs BaU behaviour. Can export to the grid	
Vehicle to Grid (V2G) (100% power flexible, availability varies by hour)	Same logic as battery. Available charging is factored in by the percentage of vehicles plugged-in per hour				

Source: Energeia. [1]Off-peak period assumed to have sufficient hours within which to recharge, [2]pool pumps modelled only for residential premises
Note: Tx = Transmission, Dx = Distribution, RRP = Regional Reference Price

Table 11 – CER Flexibility Modelling Mechanisms: Large Customers

<table>
<tr><th>Device Type</th><th>No Orchestration</th><th>Wholesale Price Orchestration</th><th>Tx Orchestration</th><th>Dx Orchestration</th><th>FCAS Orchestration</th></tr>
<tr><td>Storage Water Heater (100% power flexible)</td><td rowspan="4">Operates per base subload</td><td rowspan="3">Shifts all flexible consumption in highest price to lowest price, on a daily basis</td><td rowspan="3">Shifts all flexible consumption out of peak network period and into minimum network period, defined as top 1.4% peak/minimum demand hours on network</td><td rowspan="3">Shifts all flexible consumption out of peak network period and into minimum network period, defined as top as top 1.4% peak/minimum demand hours on network</td><td rowspan="5">Flexible loads and generation bid into the highest value market between 6 sec – 5 min for raise and lower, but does not change load behaviour from optimal state</td></tr>
<tr><td>Refrigeration[1] (100% power flexible)</td></tr>
<tr><td>Ventilation[2] (100% power flexible)</td></tr>
<tr><td>Solar (100% power flexible)</td><td>Curtailed when RRP < 0 $/MWh</td><td>No solar exports during minimum period</td><td>No solar exports during minimum period</td></tr>
<tr><td>Battery (100% power flexible)</td><td>Charges during excess solar, immediately discharges as soon as grid consumption is recorded
Does not export to the grid</td><td>Charges during lowest RRP price intervals to fully charge the battery. Discharges during highest RRP prices of the day to fully discharge the battery.
Can export to the grid</td><td>Charges during network minimum period, discharges during network peak period. If neither occurs in a day, the battery performs bill minimisation behaviour
Can export to the grid</td><td>Charges during network minimum period, discharges during network peak period. If neither occurs in a day, the battery performs BaU behaviour.
Can export to the grid</td></tr>
</table>

Source: Energeia. [1]Includes refrigeration units and freezers for cold storage, [2]Includes ventilation units and fans for maintaining air quality – separate from heating or cooling loads, [3]Off-peak period assumed to have sufficient hours within which to recharge.

The modelling methodology implemented by Energeia optimised across the value streams. In the policy options considered within this section, CER loads were modelled to optimise consumption and export (in the case of bi-directional loads) across:

- Minimising wholesale energy cost
- Avoiding transmission and distribution costs

All other remaining days, customers operate under non orchestration behaviour, which represents customers current convenience-driven behaviours. In the future policy options explored in Section 3.3, the FCAS revenue value stream is also considered.

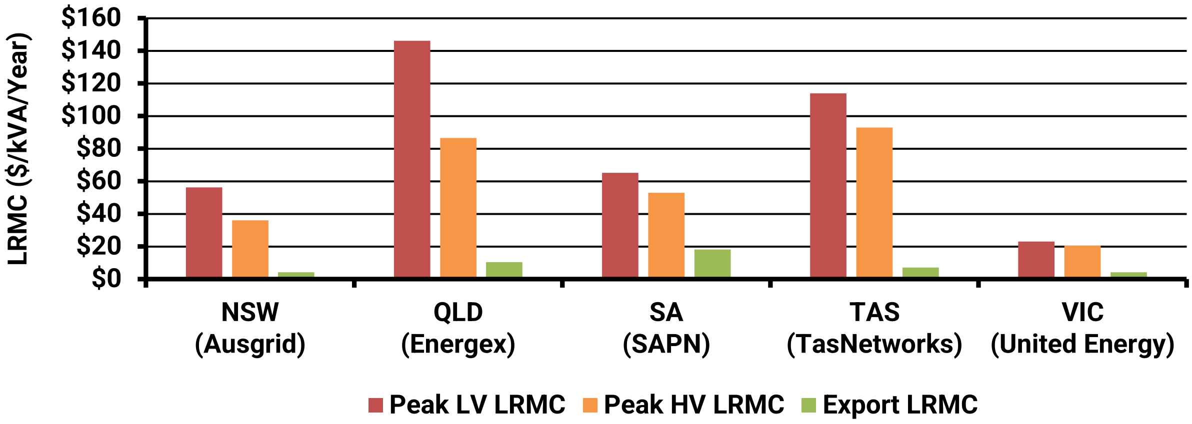
NEM Price Signals

<u>NETWORK LRMC</u>

Network long-run-marginal cost (LRMC) denotes the annualised cost for a network to host an incremental unit of demand. Network LRMC inputs were used for determining the cost impacts of flexible operation on distribution and transmission networks. For each NEM state, Energeia selected a relevant distribution network service provider (DNSP) and transmission network service provider (TNSP) to represent that state in the modelling.

Energeia sourced peak demand distribution network LRMCs directly from DNSP Tariff Structure Statements (TSS) published on the Australian Energy Regulator's (AER's) website. Export LRMCs were taken forward from a previous Energeia analysis for AEMO, which forecast a bottom-up cost estimation of the least-cost pathway to resolve voltage insufficiency caused by hosting solar PV on the distribution LV network for each DNSP in the NEM. These values are shown in Figure 4.

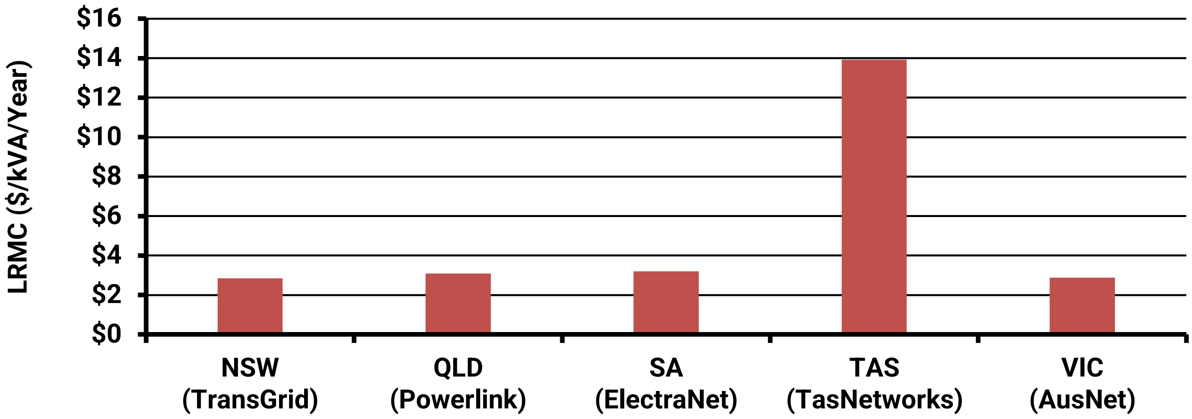
Figure 4 – Distribution Network LRMC Inputs



Source: AER (2023), Ausgrid (2019), Energex (2022), SAPN (2021), TasNetworks (2022), United Energy (2021), Energeia

Transmission network LRMCs are not directly published by TNSPs, so they needed to be estimated for this analysis. To cost the load hosting capacity-driven expenditure, Energeia observed the relationship between each TNSP's stated replacement and augmentation expenditure requirements and their stated annual peak demand to develop an LRMC estimate in $/kVA/year. These values are shown in Figure 5.

Figure 5 – Transmission Network LRMC Inputs



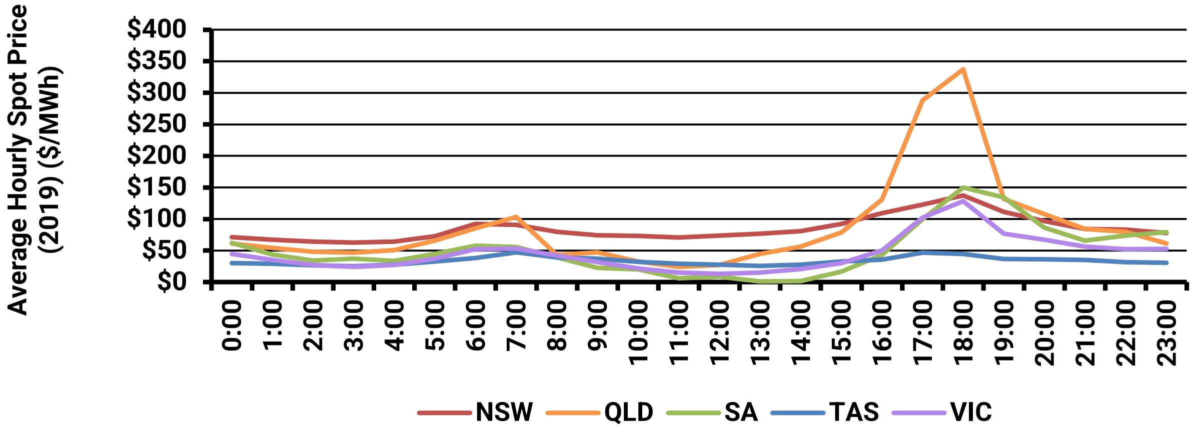
Source: AER (2023), TransGrid (2019), Powerlink (2022), ElectraNet (2021), TasNetworks (2022), AusNet (2021), Energeia

<u>WHOLESALE COSTS</u>

The electricity wholesale RRPs at hourly intervals were used in the model to value the impact of load flexibility on the wholesale market, generally by moving a load from higher-priced time intervals throughout a given day to lower-priced time intervals.

To minimise how the coronavirus pandemic (COVID-19) lockdowns and fuel price shocks due to international conflicts influenced the analysis, Energeia applied wholesale cost inputs data from 2019, projected the hourly prices over the year, and forwarded that data across the forecast period. This allows for the typical variation of prices to be incorporated, while avoiding non-typical market occurrences, such as the 2022 spot market suspension. The average annual hourly spot market price can be seen in Figure 6.

Figure 6 – Average 2019 Hourly Spot Price



Source: AEMO (2019), Gorman et al. (2018)

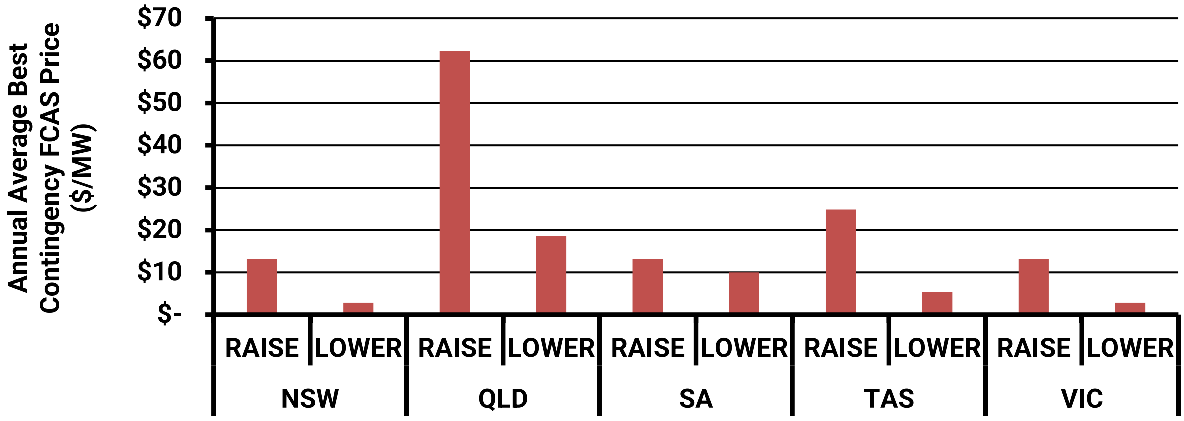
For the final report, Energeia will conduct a sensitivity analysis on wholesale prices.

<u>FCAS COSTS</u>

Contingency FCAS pricing at 30-minute intervals was used in the model to value the impact of load flexibility by using the spare capacity of a CER at a given interval to make it available to the highest-valued market.

As with wholesale costs, Energeia based its FCAS analysis on 2019 prices to minimise the impact of the coronavirus pandemic (COVID-19) lockdowns and fuel price shocks due to international conflicts. Prices were collected by state for the 6-second, 60-second, and 5-min contingency raise and lower markets. The highest raise and lower prices across these markets were calculated for each 30-minute interval by state, as the best use case option for FCAS capacity. Figure 7 shows the annual average of these best prices by state.

Figure 7 – Annual Average Best Contingency FCAS Price by State



Source: AEMO (2019), Gorman et al. (2018)

For the final report, Energeia will conduct a sensitivity analysis on FCAS prices.

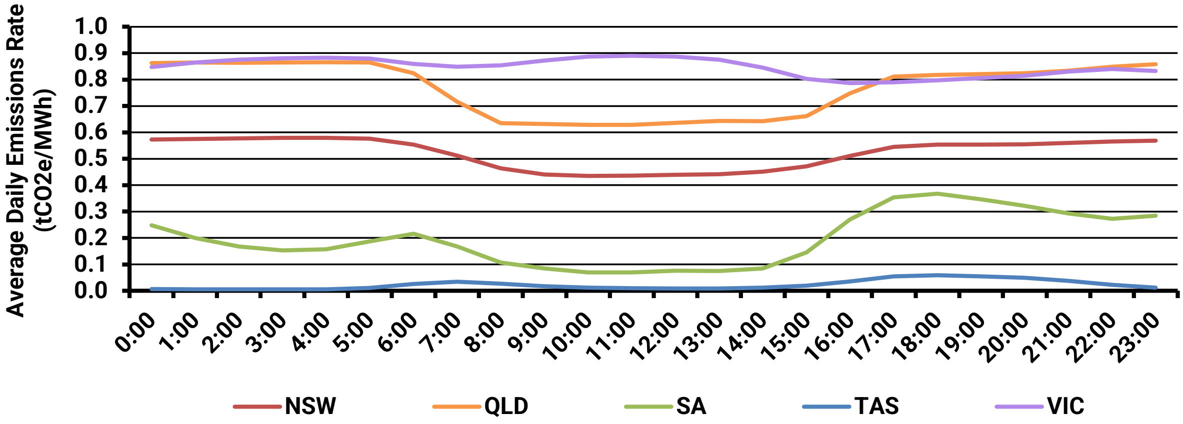
<u>EMISSIONS REDUCTION BENEFITS</u>

Whilst emissions reporting is not included in this report as part of the Draft Determination, Energeia will incorporate emissions reporting in the Final Determination results using the inputs described below.

The calculated volume of emissions in the NEM will be calculated from the change in consumption and export (incl. rooftop PV, batteries, and V2G) of consumer devices, as determined by the representative subloads and customer segments, multiplied by the grid emissions factor by hour and by year.

The charts shown in Figure 8 demonstrate the change in emissions intensity by hour and by year[19] to 2050.

Figure 8 – Average Hourly Emissions Factor



Source: Energeia
Note: CO2e = Carbon Dioxide equivalent

The NSW Treasury carbon emissions value will be used to evaluate the emissions reduction benefits by multiplying it with the estimated emissions volume reduction. The 2023 emissions value used is $130/tCO2e.

3.1.4. Draft Results

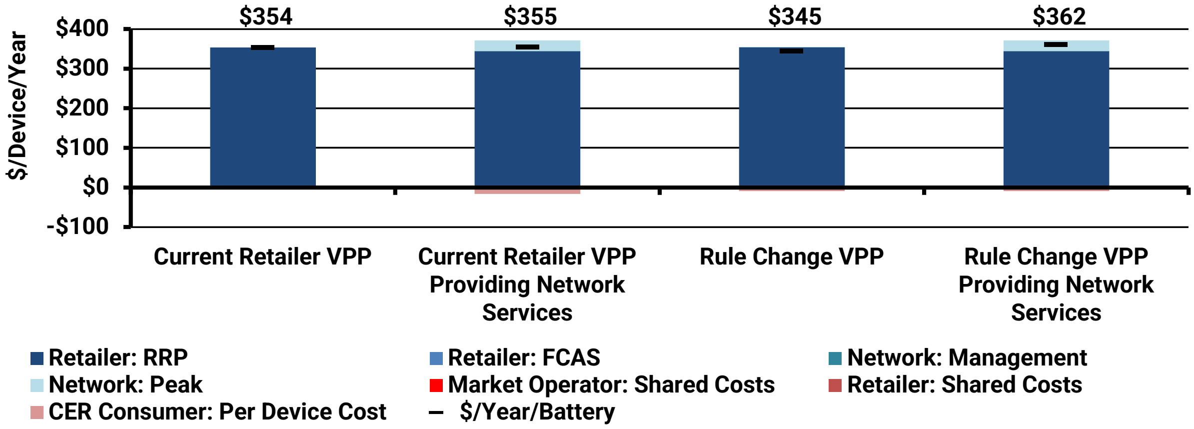
The following section details the modelled impacts of the rule change on a selection of unidirectional and bidirectional loads for the small and large customer segments. The results of this analysis quantify the costs and benefits for each device in the case study, highlighting for which cases the rule change is economical.

Small Customers

The small customer battery case study draft results in Figure 9 show that the Rule Change VPP Providing Network Services would generate an additional $7.0/battery/year in estimated net benefits compared to the Current Retailer VPP Providing Network Services. These benefits are driven by avoiding a metering installation cost onsite of $16.4/year, in exchange for the customer's share of the system upgrade costs, and the cost of allocating the NMI, which costs an additional $9.4/year. Energeia found that there was no net benefit if the device does not have in-built metering.

[19] A yearly emissions profile is used to account for seasonality of emissions.

Figure 9 – Small Customer Battery Case Study Draft Results



Source: Energeia

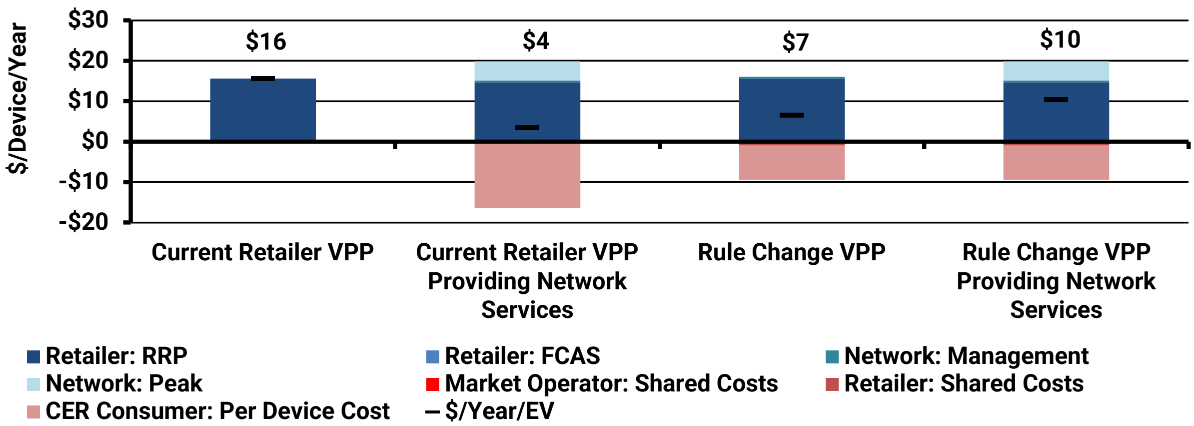
Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

Furthermore, Rule Change VPP Providing Network Services produced the highest net benefits of any option assessed, driven by the value that providing network peak demand management services deliver for a small customer battery.

Ultimately, this shows that the rule is beneficial for a small customer battery, so long as the device is being used for providing network services. This provides evidence the rule change would be beneficial for small customer bidirectional loads.

Similar findings were observed for the small customer EV charger, as shown in Figure 10, having the same $7.0/EV charger/year net benefit, if the device is used for providing network services.

Figure 10 – Small Customer EV Case Study Draft Results



Source: Energeia

Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

However, the contrast between the results for small customer battery and EV charging loads, is that the benefits of providing network services using an EV charger, with or without the rule change, do not outweigh the costs of either NMI allocation or installing a new meter. Further, the benefits of increased visibility of subloads for networks – estimated to be worth $0.42/year/device based on previous Energeia analysis for ENA, is not enough to outweigh the additional system administration costs required by the rule change. The per device benefits of network demand management and tuning do not outweigh the costs of establishing this framework. These benefits are also being provided by smart metering, and the rule change would only accelerate the timing of their realisation where CER is deployed ahead of the full smart meter deployment planned by 2030[20].

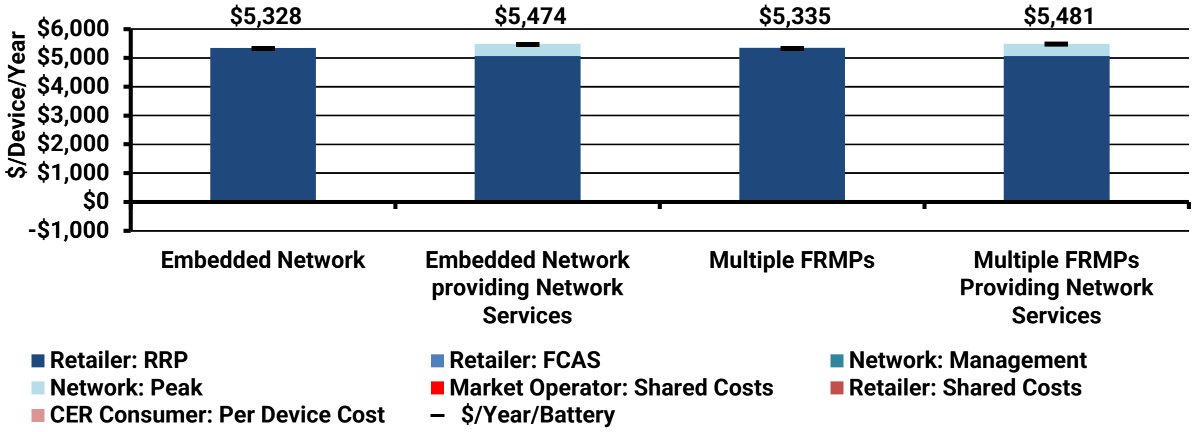
Hence, this provides evidence that the rule change is not economical for EV chargers, and other small customer unidirectional loads.

A limitation arises from using representative DNSP's LRMC values to estimate the costs of additional consumption across the network. Network wide LRMC obscure the true range of locational costs and constraints. In practice in many areas of any given network there will be many distributors and feeders where the potential benefits from network services exceed the average LRMC. We consider that in many of these areas the additional benefits will exceed the costs of NMI allocation.

Large Customers

Energeia's estimated costs and benefits for large customers revealed no changes in realised benefits from the proposed rule changes due to removal of metering costs in lieu of certified device metrology, and the addition of NMI allocation fees and system costs, as observed for small customers. The results are shown in Figure 11 and Figure 12, respectively.

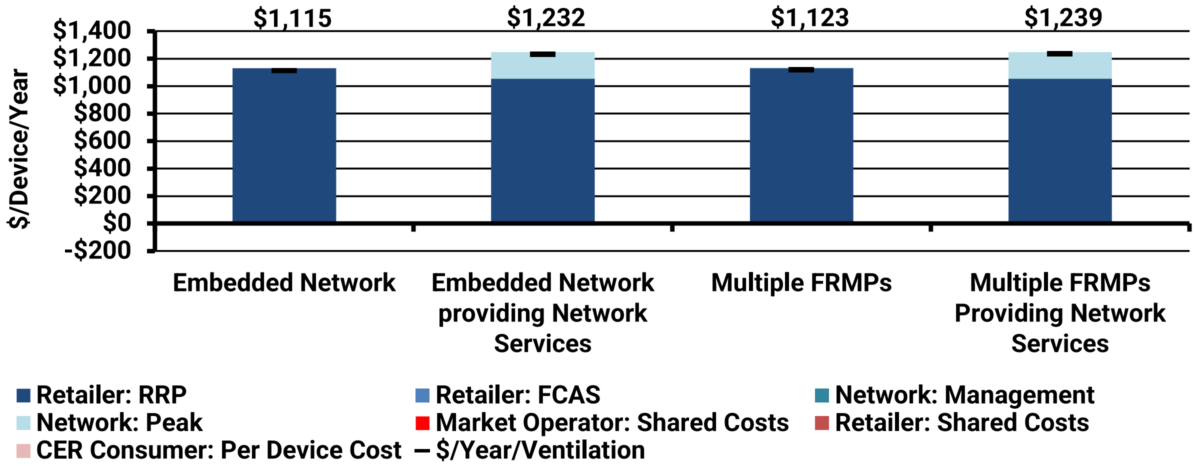
Figure 11 – Large Customer Battery Case Study Draft Results



Source: Energeia
Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

[20] Review Of The Regulatory Framework For Metering Services, AEMC. https://www.aemc.gov.au/sites/default/files/2023-08/emo0040_-_metering_review_-_final_report.pdf

Figure 12 – Large Customer Ventilation Case Study Draft Results



Source: Energeia
Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

The findings show the same $7.0/device/year of additional net benefits available to the small customer device can be captured by the large customer device when factoring in network service provision. Unlike for small customers, the rule change can allow large customers to avoid installing a meter even when not providing network services, given the embedded network framework requires the load to be metered.

For both the large customer battery and ventilation case studies assessed, Multiple FRMPs Providing Network Services produces the largest net benefits of all the considered scenarios. Given the size of these devices, the benefits they can provide to the network through demand management services outweigh the cost of enabling it, with the rule change providing the lowest cost option.

The above analysis provides evidence that the rule change is economical for both unidirectional and bidirectional CER devices for large customers.

It should be noted that the emissions reduction impacts of this rule change were deemed negligible, considering the rule change does not directly impact the level of uptake of CER flexibility in the NEM, or how it is applied.

3.2. Break-Even Analysis

The purpose of this analysis was to determine the level of the load flexibility participation that would be required for the benefits of the rule change to outweigh the shared costs of AEMO, retailers and third-party aggregators having to upgrade their systems. For this analysis, the Current Retailer VPP Providing Network Services and the Rule Change VPP Providing Network Services were the considered scenarios without and with a rule change respectively. It presumes that current barriers to using CER for network thermal and voltage constraints are addressed via future rule changes, unlocking this key value driver for flexible CER.

3.2.1. Methodology

This section outlines the methodology, inputs, and draft results of the break-even analysis. Energeia made these determinations through the following steps:

1. **Calculate the number of flexible devices in consensus view** – The aggregated load flexibility in the NEM forecast by the consensus view of uptake was converted to several devices by utilising assumptions on annual consumption and capacity per device. Note that this is the forecast of all flexible CER, not just flexible CER with its own NMI.
2. **Determine the costs and benefits of load flexibility for each device with and without a rule change using case studies** – The total costs and benefits of CER flexibility with and without the rule change were derived from the Rule Change VPP Providing Network Services and Current VPP Providing Network Services options, respectively. These options were chosen to

allow the full range of network benefits to be considered. The potential costs considered were:

a. **Shared Costs** – costs that would apply to all customers regardless of flexibility uptake and include the costs of AEMO and retailers upgrading their systems to enable the additional visibility of flexible devices. In the modelling, this was an annual fixed cost, of $5.2 million to both AEMO and retailers respectively, regardless of the level of flexibility uptake, and applies only to the rule change scenario.

b. **Per-Device Costs** – costs that would apply to each device that was registered to a load flexibility program. Without a rule change, this included the installation of a separate meter on site to conduct network demand management. With the rule change, this cost is avoided, but allocation of a NMI to each flexible CER exerts an additional cost. These costs align to those explained in Rule Change Cost Assumptions portion of Section 3.1.3.

c. **Shared Benefits** – system benefits that would be directly accrued to all customers because of networks having visibility of flexible CER loads. It was assumed these would be present with or without a rule change but do scale with CER flexibility uptake. The value of these benefits aligns to the Network Management Benefits portion of Section 3.1.3.

d. **Per-Device Benefits** – system benefits that would apply to each device that was registered to a load flexibility program. For the scope of this analysis, this was limited to wholesale RRP and network peak cost minimisation. It was assumed these benefits would be available with or without a rule change and would be scaled with CER flexibility uptake. These benefits align to the Case Study findings in Section 3.1.4.

3. **Assign and scale case study results to each flexible CER** – Each CER type considered was assigned to a case study according to the size of the customer and the nature of the subload with respect to its energy flow. The per-device benefits calculated by the case studies were scaled to each CER type on a pro-rata basis with respect to the per-device system benefits calculated with the CER Flexibility Optimisation Tool developed for Phase A.

   As shown in the small customer EV charging case study (See Figure 10), the costs associated with establishing a second NMI for an EV charger does not exceed the benefits. As a result, it was assumed that small energy-consuming devices including water heaters, pool pumps and EV charging do not utilise the rule change, and were excluded from this analysis. They are still however considered as part of consensus flexibility uptake.

4. **Determine break-even flexibility uptake levels for rule change** – The net benefits with and without the rule change were then aggregated according to the consensus view of uptake. That level of uptake was then scaled such that the net benefits were equalised across policy options. This was considered the level of CER flexibility uptake needed for the rule change to be viable. The analysis was repeated by testing the rule change applying to just small or large customer flexible CER where the rule change was deemed viable by the Case Study analysis.

3.2.2. Inputs

This analysis utilised the inputs and outcomes of the previous modelling, in addition to developing a consensus view of flexibility uptake, which is explained below.

Segments Inclusions

The selection criteria for segments included is outlined in Energeia's methodology report, with the relevant section captured in Appendix A: Inclusion of Flexible Subloads. The chosen segments for this analysis include:

- Residential
- Small Commercial

- Offices
- Retail
- Accommodation
- Warehouses
- Health

- Large Commercial
  - As above for Small Commercial

It's important to note that upon discussion with the AEMC, industrial customers were deemed out of scope, and were not included in the large commercial segment, as they are already strongly involved in the market with regards to their flexibility (registered loads etc.).

Segments are iterated by NEM state to account for jurisdictional differences between energy usage by subloads.

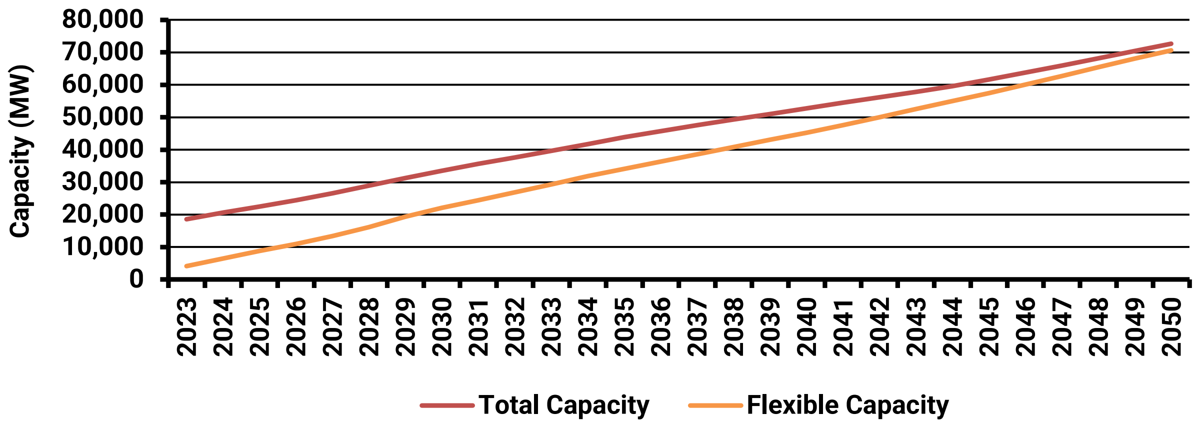
CER and Flexibility Uptake Consensus View

The consensus view uptake of CER and flexibility was used in the analysis to scale the rule change impacts to a NEM-wide level and over the forecast horizon for the included subloads, to ultimately determine the break-even level of flexibility uptake required for the rule change to be viable. Energeia developed uptake profiles for all consumer segments considered in the analysis. However, for simplicity, the following section reports an aggregation of these values.

The total consumption and flexibility uptake curves for solar and battery technology, shown in Figure 13 and Figure 14 respectively, were collected from AEMO's 2023 IASR Step Change scenario to model out flexible capacity uptake to 2050 as a percentage of total capacity. Flexible battery capacity is shown to grow to above 95% of total battery capacity by 2050 due to the number of batteries installed on the network and its inherently flexible load capability, allowing it to be quickly dispatched when called upon. Due to a lack of data on flexible solar capacity, flexible solar uptake was set to follow the flexible battery uptake rate. This assumption is reasonable as it is expected that smart inverter capabilities will be effectively standard for new and replacement inverters, due to both regulatory changes (e.g., consumer energy resources technical standards), and falling technological costs of smart implementation.

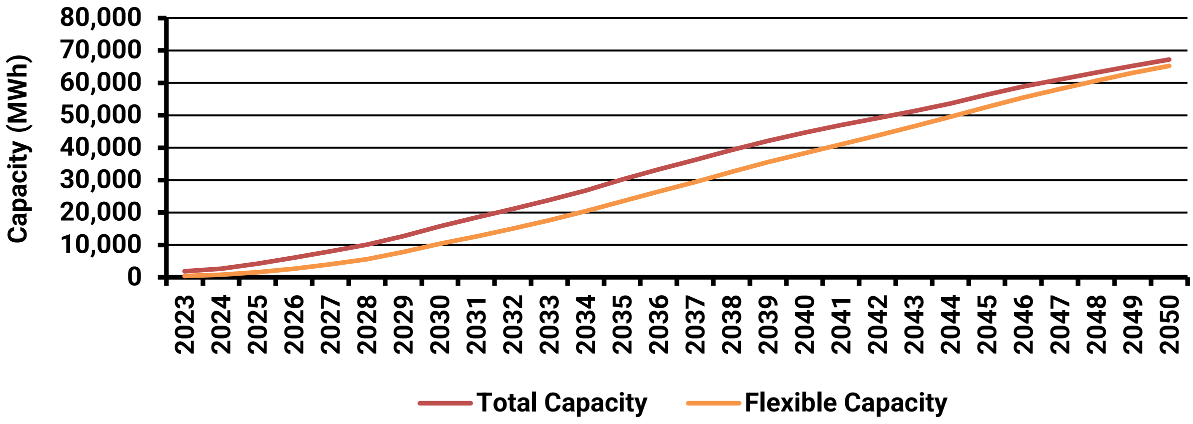
It should be noted that batteries were assumed to be paired with solar PV in the modelling, with any value of dispatched generation from the battery attributed to battery flexibility. Only solar PV curtailment is attributed to solar PV flexibility.

Figure 13 – Total Solar Capacity vs Flexible Capacity



Source: AEMO IASR (2023), Energeia

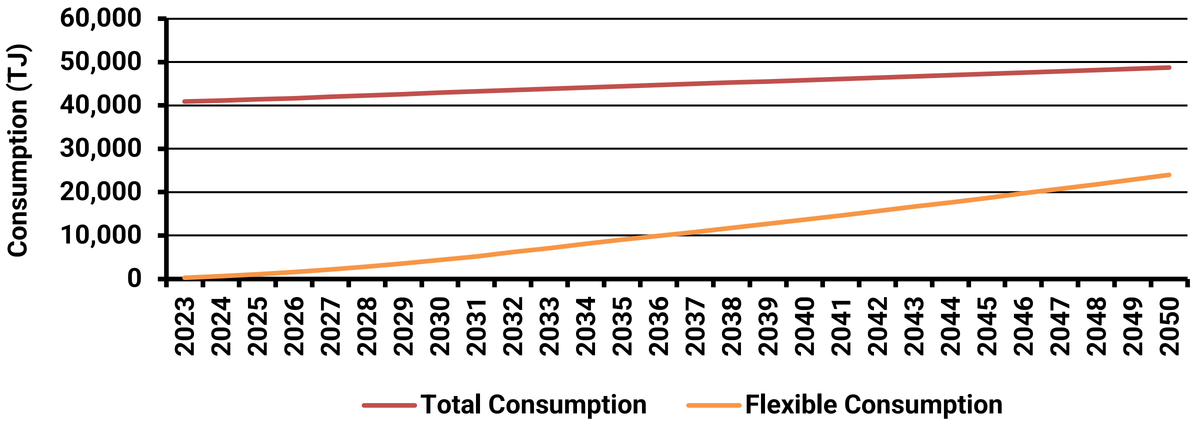
Figure 14 – Total Battery Capacity vs Flexible Capacity



Source: AEMO IASR (2023), Energeia

The total water heating consumption, shown in Figure 15, was collected for both residential and commercial premises from the Residential[21] and Commercial Baseline Study,[22] respectively, and modelled out to 2041, with the remaining years being trended to 2050. The flexible water heating uptake rate came from the E3 Demand Response Capabilities report[23] and was modelled to 2036, with the remaining years being trended to 2050.

Figure 15 – Total Water Heating Consumption vs Flexible Consumption



Source: Residential Baseline Study (2022), E3 Report (Gov Energy rating) (2019), Energeia

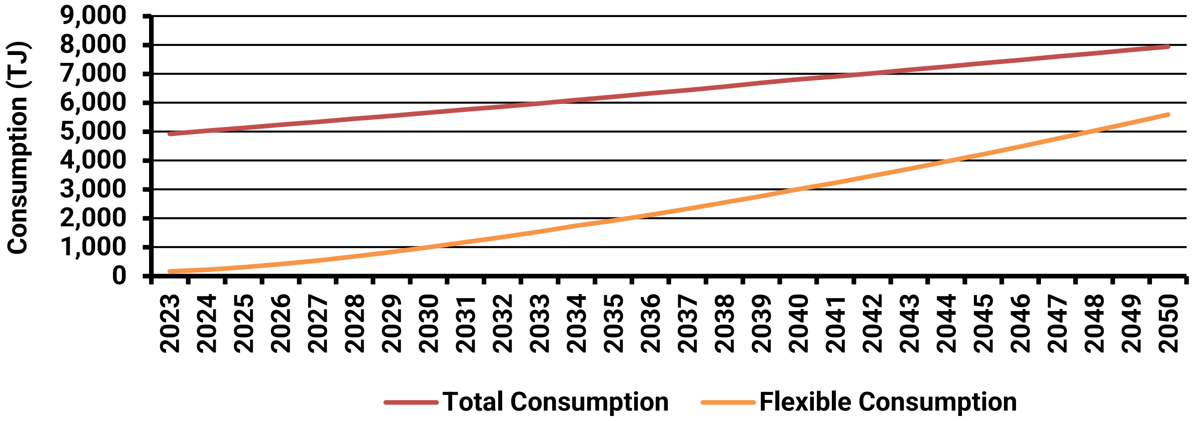
Total pool pump consumption, shown in Figure 16, was collected from the Residential Baseline Study and modelled out to 2041, with the remaining years being trended to 2050. The flexible pool pump uptake rate also came from the E3 Demand Response Capabilities report, and was modelled to 2036, with the remaining years being trended to 2050. Pool pump consumption had the highest uptake percentage of flexible load compared to all other technologies. It is one of the easiest to integrate with demand response programs due to its ability to be scheduled to run during off-peak hours. Pool pump consumption was collected only for residential premises.

[21] Residential Baseline Study, 2022. https://www.energyrating.gov.au/industry-information/publications/report-2021-residential-baseline-study-australia-and-new-zealand-2000-2040

[22] Commercial Baseline Study, 2022. https://www.dcceew.gov.au/energy/publications/commercial-building-baseline-study-2022

[23] Regulation Impact Statement for Decision: 'Smart' Demand Response Capabilities for Selected Appliances, https://www.energyrating.gov.au/sites/default/files/2022-12/smart_appliance_decision_ris.pdf

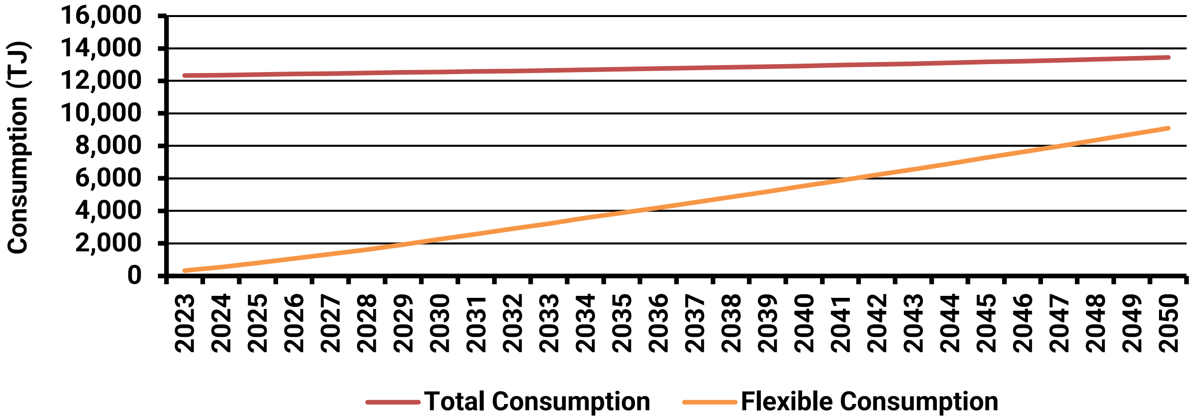
Figure 16 – Total Pool Pump Consumption vs Flexible Consumption



Source: Residential Baseline Study (2022), E3 Report (Gov Energy rating) (2019), Energeia

The CER flexibility uptake curves for refrigeration and ventilation consumption, shown in Figure 17 and Figure 18, respectively, also were collected from the E3 Demand Response Capabilities report and modelled out to 2036, with the remaining years being trended to 2050. Total commercial consumption for ventilation and refrigeration were collected from the Commercial Baseline Study[24] to 2041, with the remaining years being trended to 2050. Flexible ventilation consumption is shown to reach around 73% in 2050. Refrigeration was assumed to follow the same uptake curve as ventilation, due to its similar constraints and consumption profile, as well as a lack of publicly available data. These loads were considered only for large commercial premises.

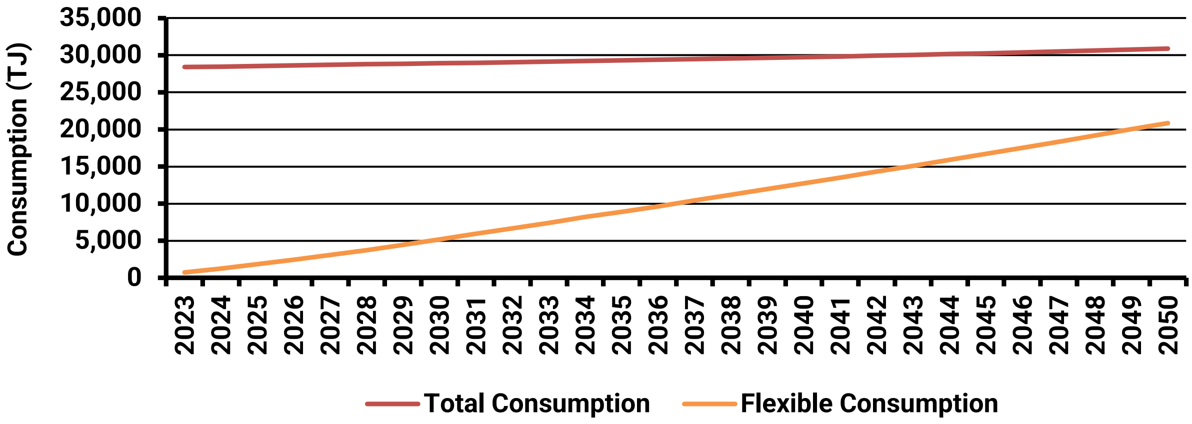
Figure 17 – Total Refrigeration Consumption vs Flexible Consumption



Source: Commercial Baseline Study (2022), E3 Report (Gov Energy rating) (2019), Energeia

[24] Commercial Baseline Study, 2022. https://www.dcceew.gov.au/energy/publications/commercial-building-baseline-study-2022

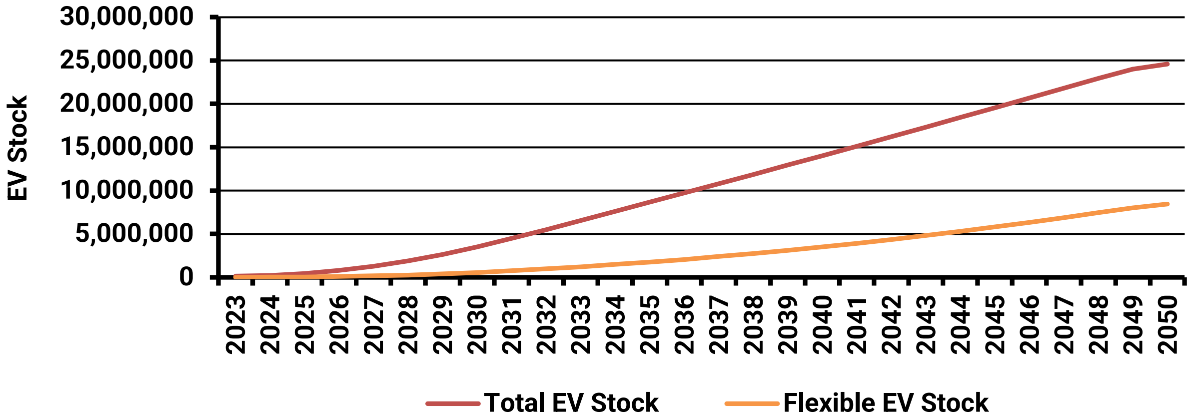
Figure 18 – Total Ventilation Consumption vs Flexible Consumption



Source: Commercial Baseline Study (2022), E3 Report (Gov Energy rating) (2019), Energeia

The vehicle stock uptake for EVs, shown in Figure 19, was gathered from AEMO's 2023 IASR Step Change scenario to model total and flexible EV stock uptake to 2050. Flexible EV stock reaches only an estimated 36%, with the assumed flexibility uptake derived from the E3 Demand Response Capabilities report. Despite this low percentage uptake in flexible EV stock, a load flexibility study published by Australian Renewable Energy Agency (ARENA)[25] determined that flexible charging of EVs, whether through deferred charging or V2G services, remained the most utilised source of load flexibility. Note that the IASR/ISP has a 'coordinated charging' cohort of EVs in its forecasts. It does not include a typical usage profile for this since it is flexible.

Figure 19 – Total EV Stock vs EV Charging Flexible Stock

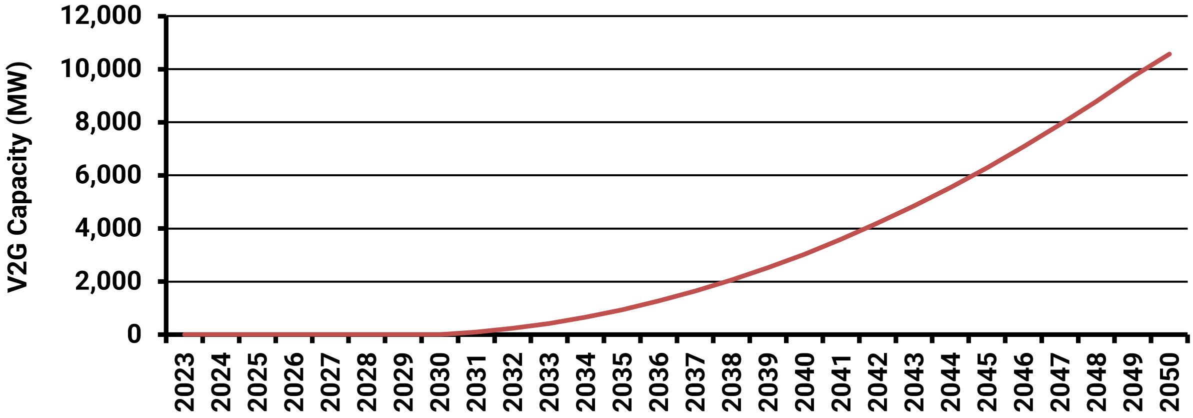


Source: AEMO IASR (2023), Energeia

Data on V2G capacity, illustrated in Figure 20 was similarly collected from AEMO's 2023 IASR Step Change scenario, and shows V2G growing from a negligible amount in 2023 to beyond 10GW by 2050. This is assumed to be flexible due to V2G's inherent properties as a dischargeable battery load. By definition, all V2G capacity was assumed to be flexible.

[25] ARENA Load Flexibility Study, https://arena.gov.au/assets/2022/02/load-flexibility-study-technical-summary.pdf

Figure 20 – V2G Total Capacity



Source: AEMO IASR (2023), Note, all V2G capacity is assumed to be flexible

3.2.3. Draft Results

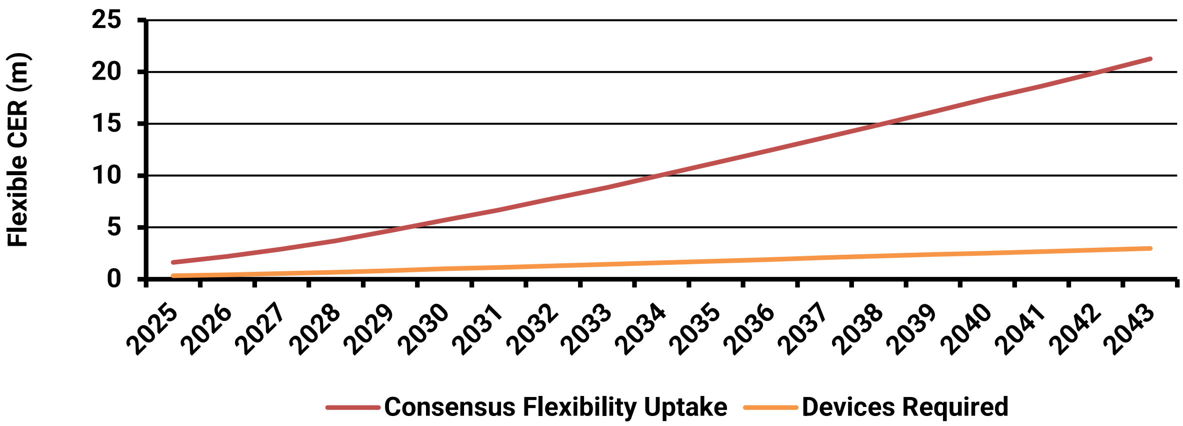
The value of this rule change can essentially be distilled into the net benefit of consumers paying an additional fixed shared cost every year to accommodate AEMO and retailers upgrading their systems to enable a second NMI using in-device metrology as a result of the rule change, in exchange for avoiding higher per device costs that would exist without the rule change from the need to install meters in order to undertake network peak management. As the fixed costs do not scale with each additional NMI created due to CER flexibility uptake, but the per device costs do, there exists a break-even point where consumers paying the additional fixed shared cost outweighs the higher per device costs.

The below analysis explores this outcome.

All Flexible Devices

Figure 21 shows the level of CER device uptake required for the Rule Change VPP Providing Network Services option to break even with the Current Retailer VPP Providing Network Services option, relative to the total consensus flexible uptake.

Figure 21 – Break-Even Flexible CER Uptake Required vs. Consensus Uptake (Current Retailer VPP Providing Network Services vs. Rule Change VPP Providing Network Services)



Source: Energeia

The key draft finding is that for the rule change to make economic sense, there would need to be an additional 156,798 devices per year on average taking up load flexibility via a second NMI for the observed horizon. At this point, the additional shared system upgrade costs of the rule change are equal to higher per device costs that would persist without the rule change.

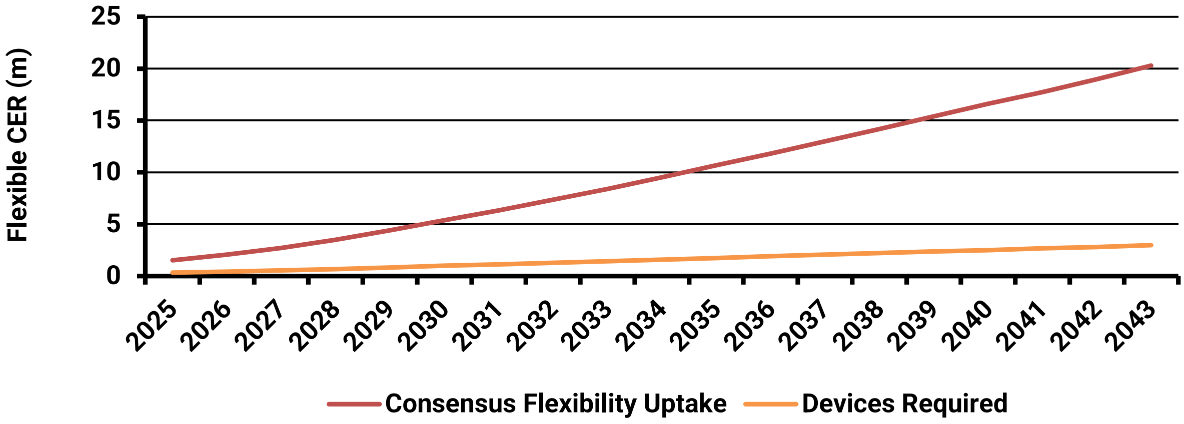
This corresponds with 14% of the consensus level of flexible CER uptake, which consists of 27% of small customer flexible solar PV, batteries and V2G as well as large customer appliances, solar PV and batteries. This excludes small customer appliances, where the rule change was deemed to be not cost effective in the cost-benefit case study. They are however still considered as part of consensus flexibility uptake.

If the uptake of load flexibility via a second NMI were to exceed these levels, the rule change could be deemed as producing net benefits.

Small vs. Large Customers

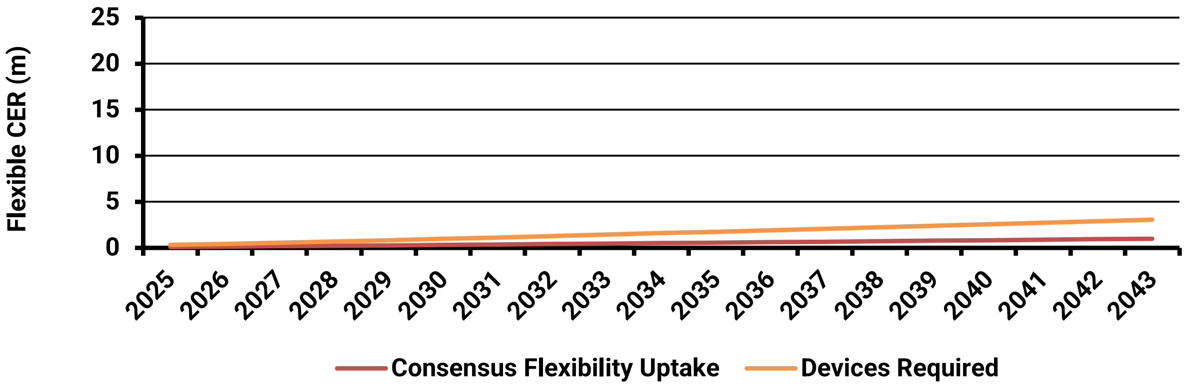
Figure 22 and Figure 23 provide the break-even CER uptake requirements for the same comparison of options but separated by small and large customers, respectively. It is effectively determining the break-even level of CER flexibility uptake if the rule change were applied to just small or large customers.

Figure 22 – Break-Even Flexible Small Customer CER Uptake Required vs. Consensus Uptake (Current Retailer VPP Providing Network Services vs. Rule Change VPP Providing Network Services)



Source: Energeia

Figure 23 – Break-Even Flexible Large Customer CER Uptake Required vs. Consensus Uptake (Current Retailer VPP Providing Network Services vs. Rule Change VPP Providing Network Services)



The draft finding illuminated by the comparison of small and large customer break-even uptake, is that the rule change would still be cost effective if only applied to small customers, but it would not be cost effective if only applied to large customers. This is because, unlike with small customers, there are too few flexible large customer devices to justify making changes to the entire system to accommodate for them.

However, the rule change is still valuable for large customers as it moves them away from the embedded network framework – a framework that is not intended to be used for enabling flexibility for large customers. Hence, the recommendation is to apply the rule change to both small and large customers together, requiring minimal device uptake to break-even whilst providing an intended framework for large customers.

Active vs. Passive Customers

Passive customers can be defined as any NMI that does not have load flexibility, which contrasts active customers who are engaged in load flexibility.

This rule change was found to impact the outcomes of active and passive customers in the same way. All costs considered in the two scenarios are shared between all customers via their retail tariffs. This includes the shared system upgrade costs and the costs that are incurred per device of installing new meters at a premises and allocating a new NMI. It is common practice for retailers to not directly charge customers for a standard meter installation, but instead to smear the recovery of that cost into their tariffs. It is therefore posited that in the event of this rule change, retailers have an incentive to smear the NMI allocation cost in the same way as it would reduce the direct cost to the active consumer, whom they want to attract to their product.

As previously stated, there are no differences in shared or per device benefits derived from this rule change, meaning that active customer benefits from load flexibility are not altered by this rule change.

3.3. Future Directions

Through the process of assessing the impact of the proposed policy options, Energeia identified barriers that impede unlocking the full potential of load flexibility in the NEM.

While this rule change does not consider changing the process to enable FCAS in behind-the-meter CER, the current process requires installing a separate MASS compliant meter at the premises. Energeia's discussions with subject matter experts revealed that this was a costly process and presents a real obstacle to enabling FCAS in consumer devices. Future rule changes could consider allowing the use of MASS-compliant in-device metrology for service providers to participate in the FCAS market.

This rule change does not directly impact the tariffs offered by networks and retailers for consumers and their flexible devices. The investigation of current battery VPP offerings outlined in Section 3.1.3 revealed that VPPs typically are operational only around 53 days of the year on average due to the need to mitigate the impact of orchestrating a customer's behaviour with their retail tariff. The main reason is that system benefits generated from orchestrating loads do not always outweigh the increase in the customer's electricity bill that result from the load being shifted.

The future directions assessment below aims to model scenarios outside of the proposed policy options that can enable CER access to a greater number of value streams, including FCAS, through MASS compliant metrology standards, as well as network and retail cost-reflective pricing.

3.3.1. Methodology

This analysis is an extension of the economic CBA case studies conducted (see Section 3.1), but with additional policy scenarios to consider. The methodology contained the following similar stages:

1. **Develop future directions scenarios** – Energeia worked closely with the AEMC to develop future direction scenarios to investigate in addition to the policy options presented in Section 3.1
2. **Develop further inputs** – the additional future directions scenarios were attributed implementation costs
4. **Test customer outcomes as a case study** – the scope of this work aligns to the assessment of the policy options through a case study analysis. The case study analysis demonstrates the net costs and benefits for both a representative flexible unidirectional load and bidirectional CER for each customer segment – to evaluate the additional benefits of addressing other barriers to unlocking CER flexibility discussed above.

a. For Small Customers the same case study loads as the CBA were selected:
   i. Unidirectional load: EV charger
   ii. Bidirectional load: Battery
b. For Large Customers the same case study loads as the CBA were selected :
   i. Unidirectional load: Ventilation unit[26]
   ii. Bidirectional load: Battery

The following section outlines the development of the future direction scenarios.

3.3.2. Scenarios

Energeia and AEMC developed a series of additional scenarios to the policy options described in Section 3.1.2 for analysis to explore the impact of further barriers to CER flexibility being alleviated. The scenarios were developed in a stepwise fashion of removing each identified barrier, to isolate the incremental impact of resolving these barriers. The future directions scenarios or small and large customers are outlined below.

Small Customers

The future direction scenarios are benchmarked against the proposed policy options. The rule change policy options are as described in Section 3.1.2:

- **Current Retailer VPP**
- **Current Retailer VPP Providing Network Services**
- **Rule Change VPP**
- **Rule Change VPP Providing Network Services**

The future directions considered within this analysis are:

- **Current Retailer VPP with FCAS** – the current market arrangement as per Current Retailer VPP, but additionally the CER participates in FCAS market through an additional MASS compliant meter
- **Future VPP with FCAS** – incorporates rule change option as per Rule Change VPP, and CER is enabled to provide FCAS metrology (assuming compliance with standards)
- **Future VPP Providing Network Services with FCAS** – incorporates rule change option as per Rule Change VPP Providing Network Services, and CER is enabled to provide FCAS metrology (assuming compliance with standards)
- **Future VPP with Network Cost-Reflective Pricing (CRP) and FCAS** – as per Future Change VPP Providing Network Services with FCAS and includes more cost-reflective network pricing for CER load, assessing impact on CER utilisation
- **Future VPP with Retail and Network CRP and FCAS** – as per Future Change VPP with Network CRP and FCAS and includes more cost-reflective retail pricing for CER load, assessing impact on CER utilisation.

The policy option design considered for small customers is summarised in Table 12.

[26] A ventilation load (unit or fan) used for air quality purposes, separate from heating or cooling loads

Table 12 – Small Customer Rule Change Scenarios Considered

	Net Benefit Drivers				Market Arrangements				
Scenario	**Increases**	**Lowers**	**Lowers**	**Lowers**					
Name	**Competition**	**Transaction Costs**	**Metering Costs**	**Deadweight Loss[27]**	**FRMPs**	**NMIs per FRMP**	**Std. Meter**	**MASS Compli-ant Meter**	**Devic e Meter**
Current Retailer VPP					1	1			1*
Current Retailer VPP Providing Network Services	✓				1	1	1		
Rule Change VPP	✓	✓	✓		1	2			1
Rule Change VPP Providing Network Services	✓	✓	✓		1	2			1
Current Retailer VPP with FCAS					1	1		1	
Future VPP with FCAS	✓	✓	✓		1	2			1**
Future VPP Providing Network Services with FCAS	✓	✓	✓		1	2			1**
Future VPP with Network CRP and FCAS	✓	✓	✓	✓	1	2			1**
Future VPP with Retail and Network CRP and FCAS	✓	✓	✓	✓	1	2			1**

Source: AEMC, Energeia
*Does not meet metrology standard
** Meets MASS requirements

Large Customers

Similarly to small customers, the key four core policy options are included in the future directions, as documented in Section 3.1.2. These are as follows:

- **Embedded Network**
- **Embedded Network Providing Network Services**
- **Multiple FRMPs**
- **Multiple FRMPs Providing Network Services**

As per small customers, the rule change would not affect how service providers enable CER to provide FCAS, meaning that an additional MASS compliant meter would need to be installed at the premises. It also will not directly influence how retailers or networks price devices.

The future directions analysis considers the following scenarios to further unlock CER flexibility benefits, which can be described as:

- **Embedded Network with FCAS** – the current market arrangement as per Embedded Network, but additionally the CER participates in FCAS market through an additional MASS compliant meter
- **Future Multiple FRMPs with FCAS** – incorporates rule change option as per Multiple FRMPs, and CER is enabled to provide FCAS metrology (assuming compliance with standards)
- **Future Multiple FRMPs Providing Network Services with FCAS** – incorporates rule change option as per Multiple FRMPs Providing Network Services, and CER is enabled to provide FCAS metrology (assuming compliance with standards)

[27] Deadweight losses refers to inefficiencies between the cost to serve a customer and the retail rate paid by the customer.

- **Future Multiple FRMPs with Network CRP and FCAS** – as per Future Multiple FRMPs Providing Network Services with FCAS, and includes more cost-reflective network pricing for CER load, assessing impact on CER utilisation
- **Future Multiple FRMPs with Retail and Network CRP and FCAS** – as per Future Multiple FRMPs with Network CRP and FCAS and includes more cost-reflective retail pricing for CER load, assessing impact on CER utilisation.

The policy option design considered for large customers is summarised in Table 13.

Table 13 – Large Customer Rule Change Scenarios Considered

	Net Benefit Drivers				Market Arrangements				
Scenario	Increases	Lowers	Lowers	Lowers					
Name	Competition	Transaction Costs	Metering Costs	Deadweight Loss	FRMPs	NMIs per FRMP	Std. Meter	MASS Compli-ant Meter	Device Meter
Embedded Network					2^	1	1		1*
Embedded Network Providing Network Services	✓				2^	1	1		
Multiple FRMPs	✓	✓	✓		2	1			1
Multiple FRMPs Providing Network Services	✓	✓	✓		2	1			1
Embedded Network with FCAS					2^	1	1	1	
Future Multiple FRMPs with FCAS	✓	✓	✓		2	1			1**
Future Multiple FRMPs Providing Network Services with FCAS	✓	✓	✓		2	1			1**
Future Multiple FRMPs with Network CRP and FCAS	✓	✓	✓	✓	2	1			1**
Future Multiple FRMPs with Retail and Network CRP and FCAS	✓	✓	✓	✓	2	1			1**

Source: AEMC, Energeia
*Does not meet metrology standard
** Meets MASS requirements
^Using embedded network functionality

3.3.3. Inputs

This section contains the additional inputs required to determine the outcomes of the future directions.

Rule Change Cost Assumptions

The input costs for small customers and large customers by policy option are shown in Table 14 and Table 15 respectively. The costs are consistent with the initial analysis for policy options from Section 3.1 and include the future directions scenarios in the tables below.

Table 14 – Small Customer Cost Assumptions Including Future Directions

Policy Option	Costs ($/Year/Device)							
	AEMO	Retailers/Metering Coordinators			Networks		OEM	
Name	System Changes	System Changes	Std. Meter	MASS Compliant Meter	System Changes	NMI Allocation	Certific-ation	System Changes
Current Retailer VPP	-	-	-	-	-	-	-	-
Current Retailer VPP Providing Network Services	-	-	$16.38	-	Negligible	-	-	-
Rule Change VPP	$0.49	$0.49	-	-	-	$8.42	Negligible	Negligible*
Rule Change VPP Providing Network Services	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Current Retailer VPP with FCAS	-	-	-	$81.88	-	-	-	-
Future VPP with FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Future VPP Providing Network Services with FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Future VPP with Network CRP and FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Future VPP with Retail and Network CRP and FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*

Source: Energeia
*Assumes internet delivery, not, e.g., a dedicated 4G service

Table 15 – Large Customer Cost Assumptions Including Future Directions

Policy Option	Costs ($/Year/Device)							
	AEMO	Retailers/Metering Coordinators			Networks		OEM	
Name	System Changes	System Changes	Std. Meter	MASS Compliant Meter	System Changes	NMI Allocation	Certific-ation	System Changes
Embedded Network	-	-	$16.38	-	-	-	-	-
Embedded Network Providing Network Services	-	-	$16.38	-	Negligible	-	-	-
Multiple FRMPs	$0.49	$0.49	-	-	-	$8.42	Negligible	Negligible*
Multiple FRMPs Providing Network Services	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Current Retailer VPP with FCAS	-	-	$16.38	$81.88	-	-	-	-
Future Multiple FRMPs with FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Future Multiple FRMPs Providing Network Services with FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Future Multiple FRMPs with Network CRP and FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*
Future Multiple FRMPs with Retail and Network CRP and FCAS	$0.49	$0.49	-	-	Negligible	$8.42	Negligible	Negligible*

Source: Energeia
*Assumes internet delivery but not, e.g., a dedicated 4G service

The MASS compliant meter required to measure FCAS for a device was assumed to be five times as expensive to install than a standard meter based on Energeia discussions with subject matter experts. It is assumed under the rule change scenarios that internal device metrology would be compliant with FCAS requirements, at a negligible cost to OEMs.

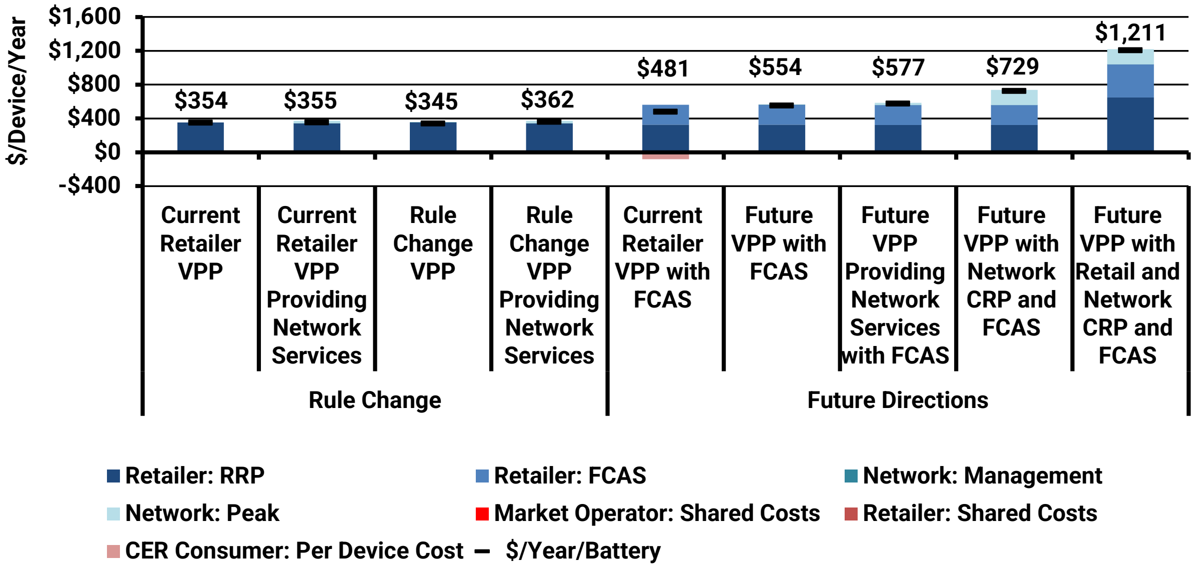
3.3.4. Draft Results

This section outlines the draft results of the future directions analysis.

Small Customers

The small customer battery case study draft results in Figure 24 – which include additional policy options separate from the rule change to further investigate key barriers to flexibility– show that Future VPP with Retail and Network CRP and FCAS would generate the greatest additional benefits: $729/battery/year in estimated net benefits compared to Current Retailer VPP with FCAS. This consists primarily of benefits from reduced metering costs and improved cost reflectivity of retail and network pricing enabling greater utilisation of load flexibility.

Figure 24 – Small Customer Battery Case Study



Source: Energeia

Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

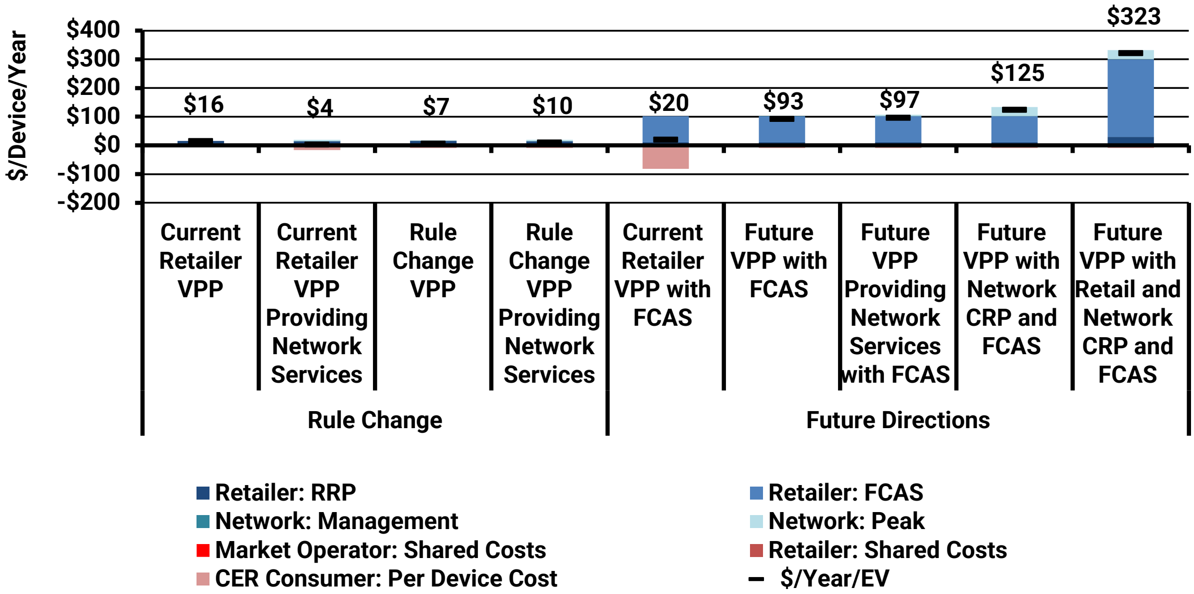
These future direction policy options primarily seek to expand CER flexibility by unlocking key barriers that remain, specifically for FCAS market participation and wider consumer choice for network and retailer tariffs.

The remaining future directions polices have decreasing benefit streams compared to Future VPP with Retail and Network CRP and FCAS because of their metering configurations and out-of-scope policy settings, which have varying levels of cost categories and flexible market arrangements. Future VPP with Network CRP and FCAS has benefit streams similar to those of Future VPP with Retail and Network CRP and FCAS, as its cost-reflective network pricing allows for greater use of load flexibility without any trade-offs from the consumer's perspective; however, exhibits lower retailer benefits due to its lack of retailer cost -reflective pricing.

Future VPP Providing Network Services with FCAS yields even lower benefits because it lacks any type of cost-reflective pricing, while Current Retailer VPP with FCAS has the least benefits due to its costly metrology requirements, despite having slightly higher retailer benefits the comparable options with the additional provision of network services and splitting the VPP usage time between a number of value streams lowers the absolute allocation to retailer benefits. The minor cost difference between Future VPP with FCAS and Future VPP with FCAS is due to the additional metering cost, as Future VPP with FCAS option does not require a separate MASS compliant meter for FCAS participation.

Similar results were observed for unidirectional loads, including small customer EV charging, as shown in Figure 25.

Figure 25 – Small Customer EV Charging Case Study



Source: Energeia
Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

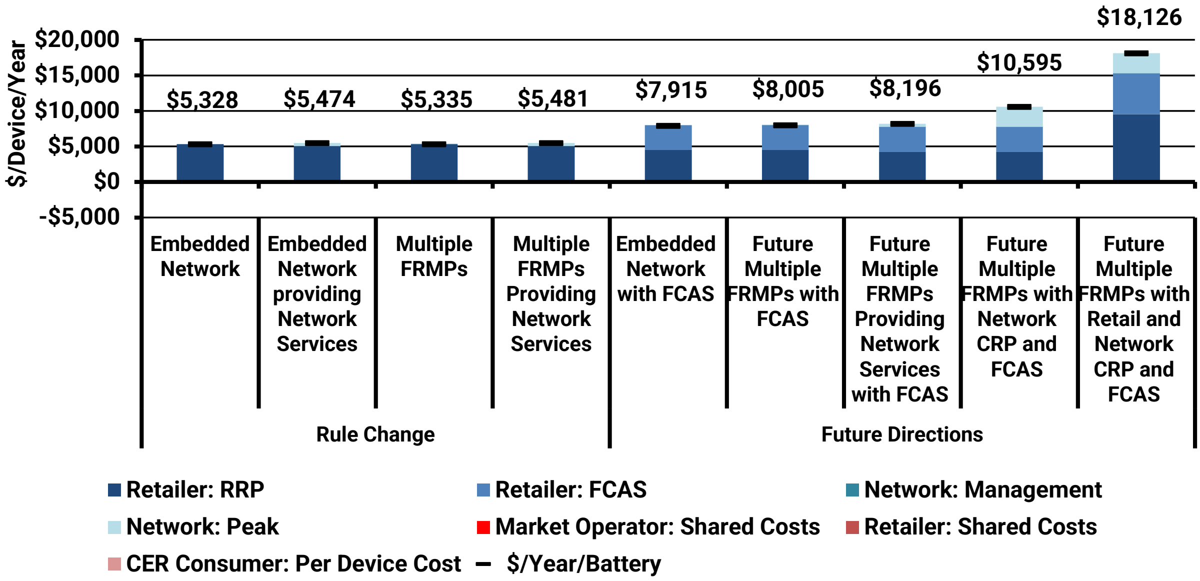
In the case of EV charging, Future VPP with Retail and Network CRP and FCAS yields an additional $302/EV/year in estimated net benefits compared to Current Retailer VPP with FCAS, again driven by reduced metering costs and improved cost reflectivity of retail and network pricing enabling greater utilisation of load flexibility.

The other options follow benefit trends similar to the battery device policy options, with Future VPP with Network CRP and FCAS exhibiting similar but lower retailer costs due to the lack of retailer cost-reflective pricing; Future VPP Providing Network Services with FCAS, Future VPP with FCAS, and Current Retailer VPP with FCAS generate decreasing levels of benefits due to the lack of both network and retailer cost-reflective pricing and increased metrology requirements.

Large Customers

The large customer battery case study draft results shown in Figure 26 generate similar benefit streams to the small customers, but on a much larger scale due to their naturally larger battery system sizes. Future Multiple FRMPs with Retail and Network CRP and FCAS yields an additional $10,194/battery/year in estimated net benefits compared to Embedded Network with FCAS. This consists primarily of benefits from reduced metering costs and improved cost reflectivity of retail and network pricing enabling greater utilisation of load flexibility.

Figure 26 – Large Customer Battery Case Study



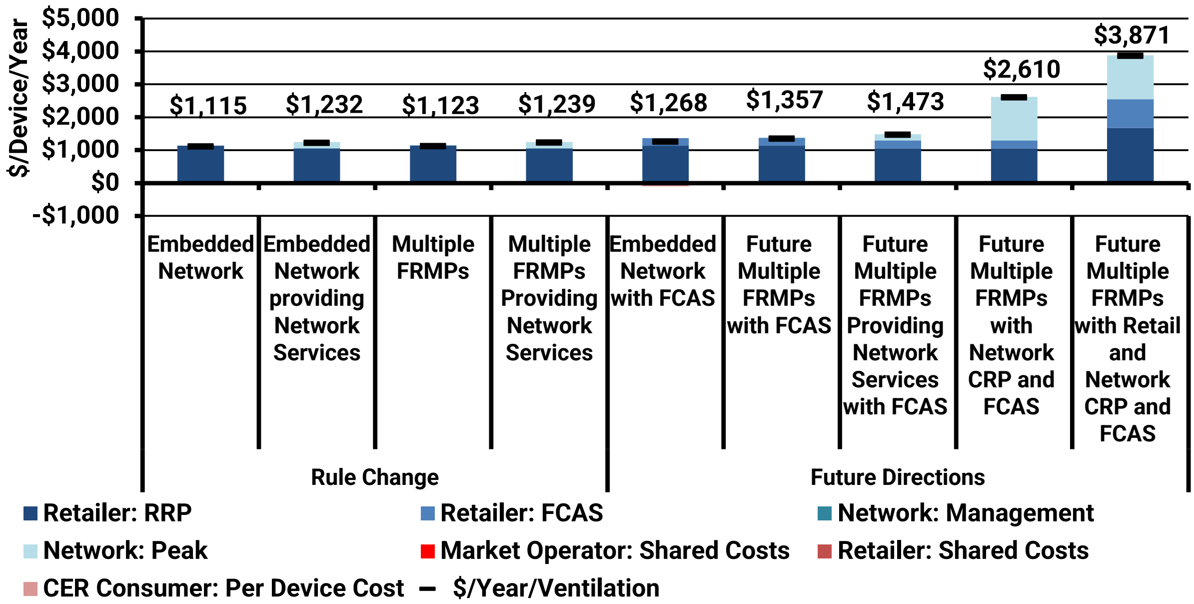
Source: Energeia
Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

These future direction policy options provide larger benefits to large customers through allowing them to participate in FCAS markets whilst also having a broader choice in their network and retailer tariffs across their individual flexible subloads.

As with small customers, large customers exhibit similar trends in benefit streams and see the most benefits under Future Multiple FRMPs with Retail and Network CRP and FCAS due to the cost-reflective pricing and lack of metrology requirements when compared to other future direction policy options.

Similar results were observed for unidirectional loads such as ventilation, shown in Figure 27.

Figure 27 – Large Customer Ventilation Case Study



Source: Energeia
Note: Red = Cost; Blue = Benefit; Network: Peak = Operation of CER to minimise peak demand impacts; Network: Management = Network usage of data enabled through CER device metrology provision to network operators

In the case of ventilation, Future Multiple FRMPs with Retail and Network CRP and FCAS has $2,587/ventilation/year in estimated net benefits compared to Embedded Network with FCAS, again driven by reduced metering costs and improved cost reflectivity of retail and network pricing enabling greater utilisation of load flexibility.

The other options follow benefit trends similar to the battery device policy options, with Future Multiple FRMPs with Network CRP and FCAS seeing similar but lower retailer costs due to the lack of retailer cost-reflective pricing, and the remaining future directions options generating decreasing levels of benefits due to the lack of both network and retailer cost-reflective pricing and increased metrology requirements.

4. Modelling Limitations

In the applied methodology, simplifications were made such that the resulting model would be parsimonious and tractable. As a result, five key limitations were identified and are detailed below.

It is Energeia's view that the modelling is fit-for-purpose given the project scope and objective to inform the AEMC regarding the indicative size of the load flexibility market and to provide an indicative estimate of the required rule change impacts needed to cover the implementation costs.

More detailed and complex modelling is recommended in the future to gain a clearer understanding of the potential benefits on a more granular basis.

Reliance on First Order Impacts

The modelling method implemented contained interactions between consumer behaviour and the wholesale and FCAS markets as well as transmission and distribution networks to determine the value of load flexibility. However, no feedback loop was modelled between electricity wholesale market outcomes and load flexibility. In reality, increased flexibility uptake likely would directly alter market outcomes (e.g., change wholesale prices) which would in turn diminish flexibility incentives. Instead, the modelling only captured first order wholesale market effects of avoided RRP cost, which are expected to be the most significant.

Use of Key Case Studies

The selected consumer case studies were limited in that they did not include an exhaustive list of customer segments and CER technologies for modelling. Instead, Energeia carried out an analysis of end-use load magnitudes by consumer segment and a review of third-party load flexibility assessments to inform the proposed scoping of flexible loads to be included, which was then validated with the AEMC team. This analysis included considerations of the probability of each technology becoming a significant source of flexibility, and the quality of information available. Energeia and the AEMC believe the resulting scope defined through this analysis captures the segments that are the most significant and representative.

Alignment to AEMO's 2023 Step Change Scenario for Adoption and Participation Rates

Another key limitation is the alignment of assumptions to AEMO's 2023 IASR[28] in developing a consensus view of load flexibility uptake upon which to base the break-even analysis. The IASR is not descriptive about its assumed levels of load flexibility uptake, particularly around the uptake of load flexibility in water heating, pool pumps, ventilation, and refrigeration. Energeia has made assumptions about the level of flexibility assumed in the modelling by utilising forecasted activation rates from a 2019 E3 paper.[29] The level of solar PV flexibility assumed in the modelling was aligned to the level of behind-the-meter battery aggregation assumed in the IASR. Energeia believes these assumptions align the consensus view of flexibility uptake defined in this analysis to the Step Change scenario in a reasonable way.

Use of Hourly Model Resolution

Hourly profiles were used in modelling despite 5-minute market settlements. Five-minute resolution is important for several reasons including greater accuracy of faster response resources, but in the view of Energeia and the AEMC it is unlikely to be justified given the indicative nature of this work. Additionally, the resolution was limited by the data and computational limits of the platform (Microsoft Excel).

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[28] https://aemo.com.au/-/media/files/major-publications/isp/2023/2023-iasr-assumptions-workbook.xlsx?la=en

[29] https://www.energyrating.gov.au/sites/default/files/2022-12/smart_appliance_decision_ris.pdf

Broad Network Impact Scope

Modelling of grid impacts was undertaken on a network-wide basis and assumed a continuous benefit from reducing peak and increasing minimum demand, based on the associated LRMC for thermal and voltage upgrades. While the impacts may vary within networks, the chosen approach gives a relatively unbiased view of network-wide benefits. The expected impact on the CBA accuracy is the potential understatement of LV and high-voltage (HV) thermal and voltage impacts.

5. Key Findings, Conclusions and Recommendations

Based on the results of the analysis of the associated costs, Energeia found that the rule change would be cost effective if it leads to an additional 156,798 devices per year on average participating in load flexibility programs that provide network services at some point over the observed horizon.

This breakeven analysis excludes consideration of second-order benefits, nor does it include benefits from reduced barriers to entry, including greater choice, lower prices, and more innovation. Regardless of whether the rule change is cost-effective on its own, Energeia notes that it will be necessary, but not sufficient, to achieve the full value potential of CER.

Based on the above findings, Energeia concludes that the proposed rule change would satisfy the National Electricity Objective. Furthermore, throughout the analysis, Energeia did not identify any modifications to the proposed rule changes that could result in a more optimal outcome.

Longer-term, Energeia have identified the following key regulatory barriers for the AEMC's consideration in future rule changes:

- **Remove barriers to the use of flexible CER for network services:** Flexible CER must be of sufficient size and dependability and be lower cost than alternatives to provide network services. This is more likely to be the case over time, as more CER is deployed, but also where investment incentives are cost reflective, and there is no network capex bias.
- **Remove barriers to using devices for MASS[30] compliant metering**: FCAS was found to be a key value driver for flexible CER but currently faces significant barriers to access, mainly metering requirements. Enabling the use of devices for MASS compliance, provided they meet operational requirements, would unlock access to the significant FCAS value stream.
- **Ensure cost-reflective network and retail incentives:** Establishing cost-reflective network and retail prices may allow for more efficient CER utilisation. Current arrangements lead to conflict between retail bill savings and system savings, and result in sub-optimal CER utilisation. Cost-reflective pricing would enable 100% flexible CER utilisation and maximise system benefits.
- **Level the playing field for third parties:** Currently, retailers have an upper hand in accessing the value of CER flexibility through existing access to wholesale value. Allowing third party aggregators equal access to these benefits will increase competition amongst flexibility service providers, generating additional value to consumers.

[30] Market ancillary service specification

Appendix A: Inclusion of Flexible Subloads

The following sections contains an excerpt of Energeia's methodology report,[31] published alongside the AEMC's Draft Determination. This Appendix summarises the justification of the subloads utilised within the analysis of the wider report.

Scope of Flexible Loads Considered

Energeia carried out an analysis of end use load magnitudes by consumer segment and a review of third-party load flexibility assessments to inform the proposed scoping of flexible loads to be included in the modelling, which was then validated with the AEMC team.

Table A1 outlines the range of flexible loads and consumer segmentations initially incorporated as part of the analysis and the resulting scope, designed to capture the most significant flexible loads.[32]

Table A1 – Initial Scope of Flexible Loads

Consumer Type	Appliances	Flexibility Options
Residential and Small Business	Water Heating	Shift Shed
	Heating, Ventilation and Air Conditioning (HVAC)	Shift Shed
	Pools / Spas	Shift Shed
	Lighting	×
	Cooking	×
	Solar PV	Shed
	Battery	Shift
	EV Charging and Discharging	Shift Shed
	Refrigeration	×
Large Business**	Water Heating	Shift Shed
	HVAC*	Shift Shed
	Pools / Spas	×
	Lighting	×
	Cooking	×
	Solar PV	Shed
	Battery	Shift
	EV Charging and Discharging	Shift Shed
	Refrigeration*	Shift Shed

Source: Energeia
* Will vary by type of consumer
** Does not include industrial consumers

Upon discussion with the AEMC, industrial consumers were deemed out-of-scope because they are already strongly involved in the market with regards to their flexibility (e.g., registered loads).

[31] Benefit Analysis of Load-Flexibility from Consumer Energy Resources: Methodology Report https://www.aemc.gov.au/sites/default/files/2023-08/CER%20Flexibility%20Modelling%20Methodology%20Paper%20-%20FINAL.pdf

[32] Load shifting refers to moving electricity consumption from one time period to another. Load shedding refers to reducing/removing electricity consumption.

Load Magnitude by End Use

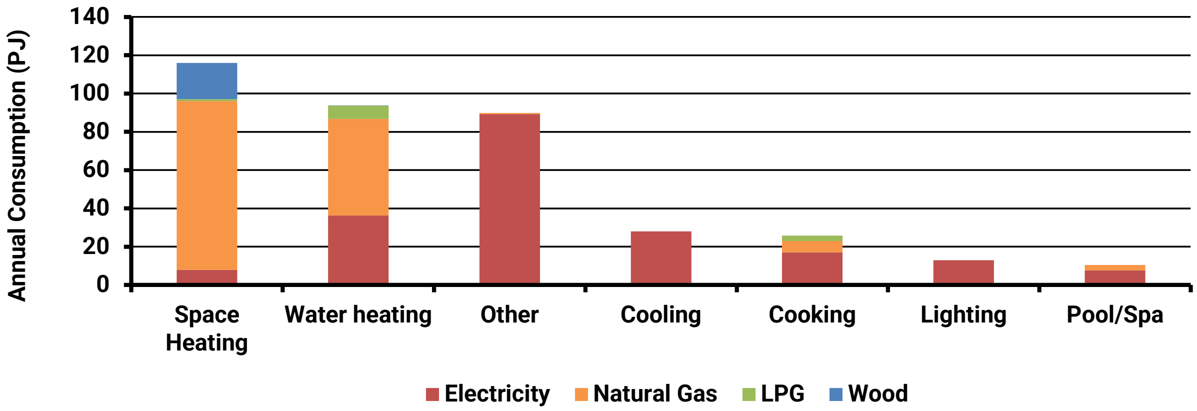
Energeia conducted a quantitative analysis of estimated building end uses by consumer segment to identify the highest consumption end uses in the NEM states. This analysis provides insight into the existing resource potential.

Residential Buildings

Energeia sourced data from the 2021 Residential Baseline Study[33] to identify the most significant residential end uses by consumption.

As shown in Figure A1, space heating and water heating are responsible for the most significant end use consumption in the NEM states, with most of this energy being provided by natural gas. "Other" end uses also constitute a significant source of load but are not further considered due to the lack of information regarding the nature of the load.

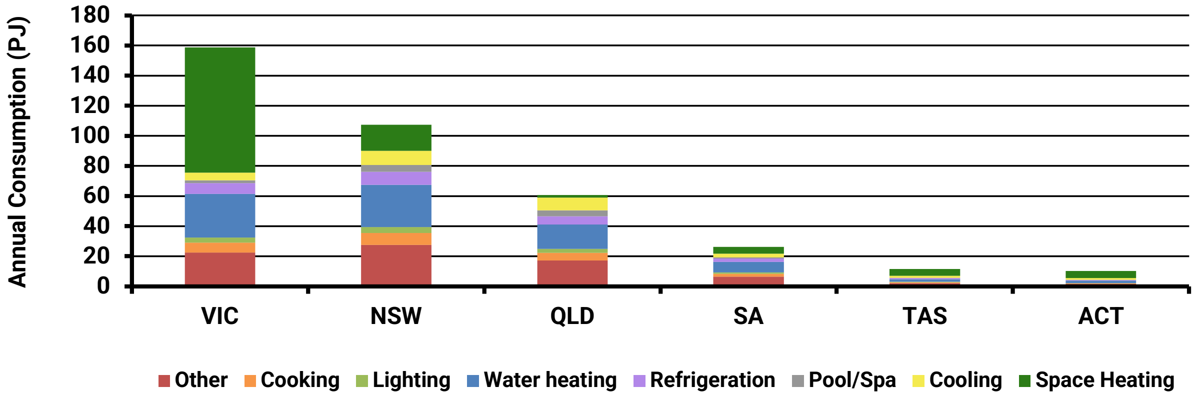
Figure A1 – NEM Residential End Use Consumption by Fuel Type



Source: EnergyConsult (2022), Energeia

Figure A2 shows consumption by NEM state and end use. Victoria leads with an extreme, predominantly gas-fuelled space heating load. The other states show expected breakdowns based on their differing climates and populations.

Figure A2 – Residential End Use Consumption by NEM State



Source: EnergyConsult (2022), Energeia

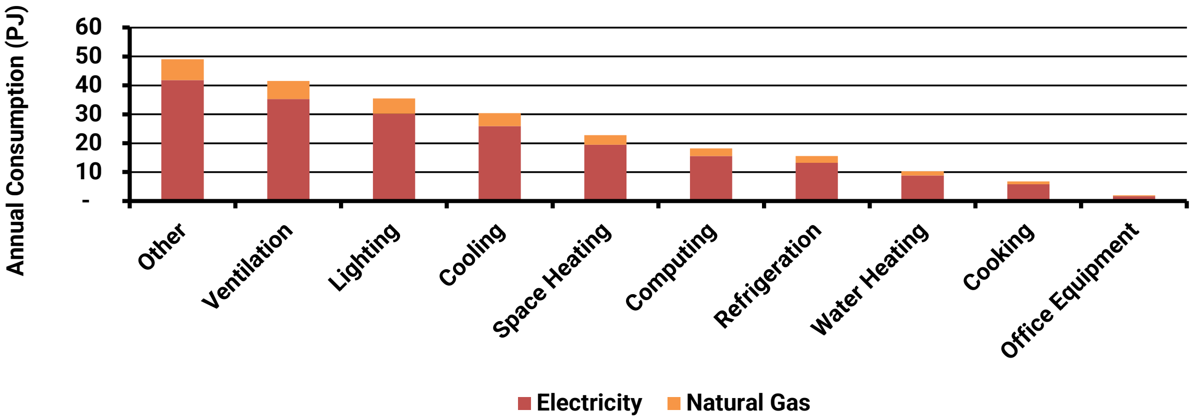
33 https://www.energyrating.gov.au/industry-information/publications/report-2021-residential-baseline-study-australia-and-new-zealand-2000-2040

Commercial Buildings

To the best of Energeia's knowledge, there is no publicly available dataset that estimates subload consumption by commercial building type in Australia. As such, Energeia estimated commercial subload energy consumption by fuel type and end use in NEM states by gathering commercial end use energy intensities, sourced from US data,[34] and applying them to Australian energy consumption by building type from the 2022 Commercial Buildings Energy Consumption Baseline Study.[35]

Figure A3 displays the total annual electricity and natural gas consumption by end use. "Other" end uses provide the greatest source of consumption but these are out of scope, as are the more minor loads of computing and office equipment. Of the remaining loads, HVAC loads (space heating, cooling, and ventilation) are the most significant, alongside lighting, which Energeia deemed as inflexible.

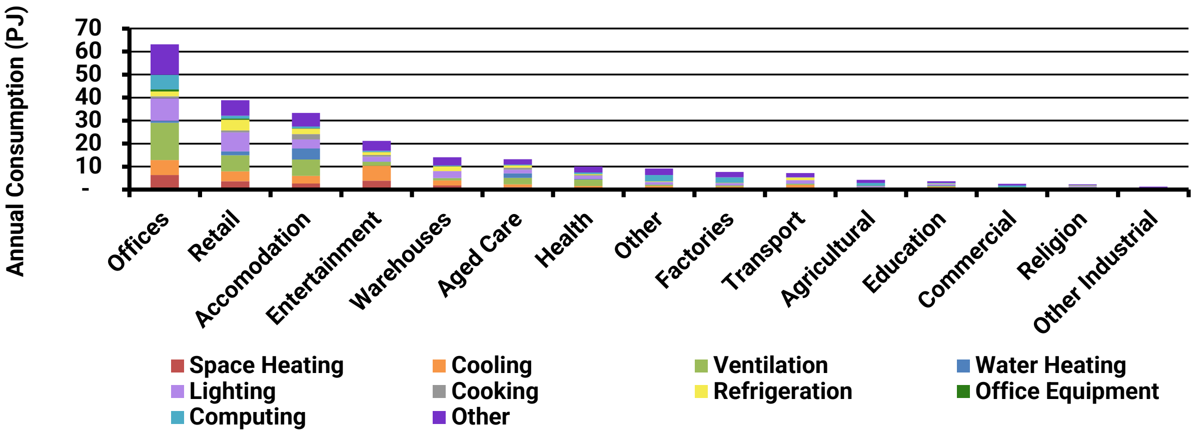
Figure A3 – NEM Commercial End Use Consumption by Fuel Type



Source: Energy Information Administration (2018), DCCEEW (2022), Energeia

Figure A4 displays the end use consumption by building type, showing that office buildings are the dominant consumption source in the NEM states, followed by retail and accommodation. Although there is some variation between building types, HVAC loads and lighting are frequently the highest sources of consumption, consistent with the results in Figure A3.

Figure A4 – NEM Commercial End Use Consumption by Building Type



Source: Energy Information Administration (2018), DCCEEW (2022), Energeia

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[34] https://www.eia.gov/consumption/commercial/data/2018/index.php?view=consumption

[35] https://www.energy.gov.au/publications/commercial-buildings-energy-consumption-baseline-study-2022

End Use Load Flexibility Potential

Energeia analysed the latest research regarding load flexibility and found two key reports relevant to this study. The first is from the Reliable Affordable Clean Energy (RACE) for 2030 initiative and the second is from the Australian Renewable Energy Agency (ARENA) assessing the flexibility potential of different loads in the Australian context to supplement discussions with the AEMC on which loads to include in the modelling scope. This research was used to inform the final scoping of which end uses and technologies were likely to be the most significant for including in the study.

RACE for 2030 – Opportunity Assessment, Flexible Demand and Demand Control

RACE for 2030[36] commissioned an assessment of the prospective potential for commercial load flexibility by end use, with the aim of identifying priority research areas to assist in advancing flexible demand growth.

Assessments were completed using a semi-qualitative HUFF Matrix, which evaluates potential load flexibility using the following criteria:

- **Homogeneity:** How replicable is the solution?
- **Ubiquity:** How scalable is the solution?
- **Feasibility (techno-economic):** How cost effective is the solution?
- **Feasibility (realistic):** How well does the solution fit with the industry?

Each type of load was given a score of 1 to 3 for each of the HUFF criterion, for which a higher score is more prospective based on a qualitative assessment. Scores were summed to produce a total ranging from 4 to 12. Each building type also was given a score of 1 to 3 for each criterion and summed. The summed load and building scores were multiplied to produce the final score in the matrix for each opportunity (hence the scores could range from 16 to 144).

The HUFF Matrix shown in Figure A5 rated HVAC and electrical storage as the most prospective forms of load flexibility in the commercial sector. Embedded generation, water heating, thermal storage, and refrigeration also were highly rated. Commercial EV flexibility was given the lowest rating.

Figure A5 – Commercial End Use HUFF Matrix

	HVAC	Heat pumps	Hot water	Thermal storage	Electric vehicles	Pool pumps	Embedded generation	Electrical storage	Refrigeration
Retail	70	56	63	63	35		63	70	
Offices	80	64	72	72	40		72	80	
Warehouses	80	64		72	40		72	80	72
Apartments	90	72	81	81	45	72	81	90	81
Public buildings	90	72	81	81	45		81	90	81
Data centres				63			63	70	
Supermarkets	90	72	81	81	45		81	90	81
Aquatic centres		72	81	81	45	72	81	90	

Source: RACE for 2030 (2021)

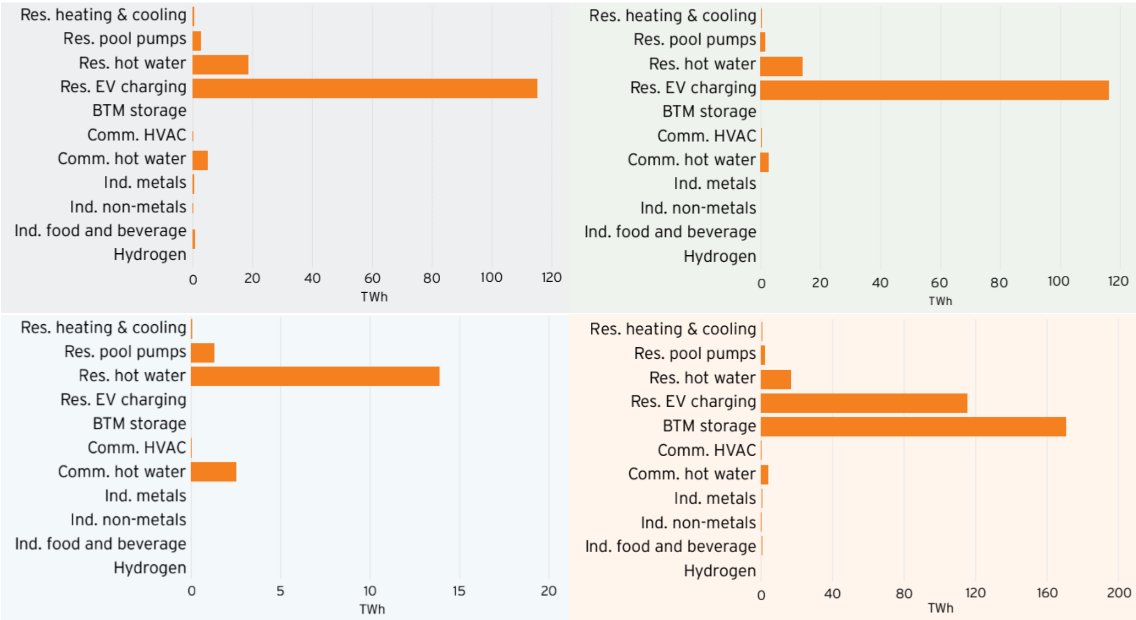
36 https://www.racefor2030.com.au/wp-content/uploads/2021/10/RACE-B4-OA-Final-report.pdf

ARENA – Load Flexibility Study

ARENA[37] identified load flexibility as a focus area in their 2021 Investment Plan, leading them to produce their Load Flexibility Study. ARENA used PLEXOS[38] to model a range of scenarios through to 2040 and reported the magnitude of load flexibility by resource.

Figure A6 shows results by scenario, each indicating the total modelled load flexibility contributions by resource. Across all the scenarios, residential EV charging, and hot water heating were significant contributors to flexible load, with minor contributions from residential pool pumps. The High DER Uptake scenario showed battery as the largest flexible load. On the commercial side, water heating provided the most flexible load. Other resources were modelled to be relatively negligible.

Figure A6 – Modelled Flexible Load by Scenario (2021-2040)



Scenarios: Baseline (top left), High EV Uptake (top right), Electrification (bottom left), High DER Uptake (bottom right)
Source: ARENA (2022)

Subload Inclusions

Table A2 outlines the resulting scope of flexible loads to be included in the modelling, which has been refined from the original scope in Table A1.

The objective of this project was not to model every flexible load option, but rather to estimate the quantum of system benefits that added load flexibility could potentially provide. How large these benefits and the consumer allocation would need to be to justify the industry costs associated with a potential Rule change? Additionally, the goal was to determine if there are any broad opportunities that may be particularly attractive for policymakers and regulators to focus on.

[37] https://arena.gov.au/assets/2022/02/load-flexibility-study-technical-summary.pdf

[38] PLEXOS is a specialised market simulation software, https://www.energyexemplar.com/plexos

Table A2 – Proposed Scope of Flexible Loads

Category	Subload	Estimated Total Energy Consumption/Generation (PJ, 2023)	Load Flexibility Ranking	Include/Exclude?	Flexibility Options
Residential and Small Business	Space Heating	121.2	Medium	×	Shift Shed
	Water Heating	96.1	High	✓	Shift Shed
	Solar PV	82.6	High	✓	Shed
	Space Cooling	34.9	Medium	×	Shift Shed
	Cooking	25.7	Low	×	×
	Refrigeration	15.5	Low	×	×
	Lighting	12.9	Low	×	×
	Pools / Spas	10.3	High	✓	Shift Shed
	Ventilation	9.5	Medium	×	Shift Shed
	Battery	8.0	High	✓	Shift
	EV Charging EV Discharging	1.0	High	✓	Shift Shed
Large Business*	Solar PV	82.6	High	✓	Shed
	Ventilation	32.0	Medium	✓	Shift Shed
	Lighting	27.3	Low	×	×
	Space Cooling	23.5	Medium	×	Shift Shed
	Space Heating	17.6	Medium	×	Shift Shed
	Refrigeration	12.0	High	✓	×
	Water Heating	7.9	High	✓	Shift Shed
	Battery	8.0	High	✓	Shift
	Cooking	5.2	Low	×	×
	EV Charging EV Discharging	1.0	Low	×	Shift Shed
	Pools / Spas	0.0	High	×	Shift Shed

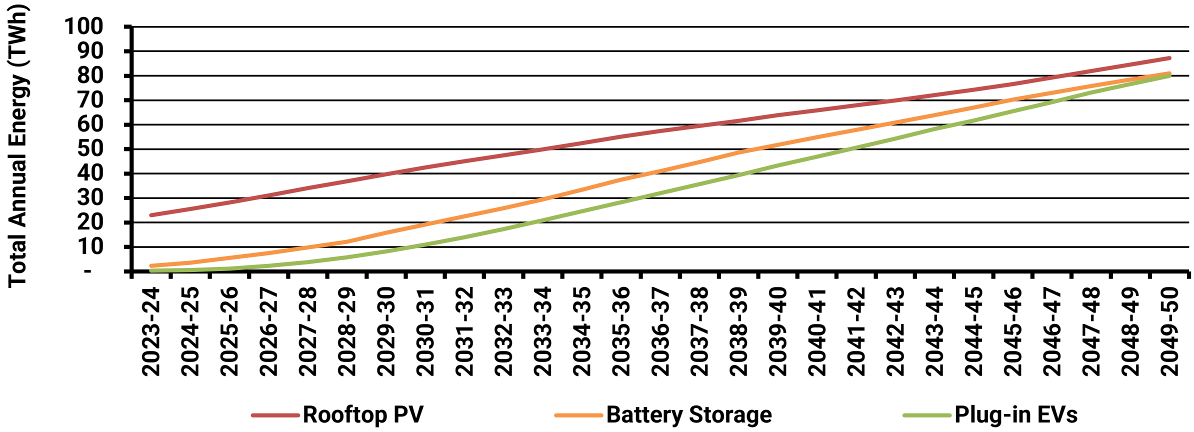
Source: Energy Information Administration (2018), DCCEEW (2022), AEMO (2023), Energeia
* Does not include industrial consumers

More detailed explanations for the notable inclusions and exclusions are as below:

- Space heating, cooling, and ventilation were excluded because they are not expected to be a practical source of flexibility due to the lack of centralised control and smart home thermostats in Australia. Electrification of heating may increase ability of control in the future, and thus in future iterations this assumption should be revisited. Additionally, ARENA did not find these loads to be significant flexibility resources in their modelling (See Figure A6).
- Refrigeration was also excluded from the residential and small business segment for similar reasons regarding lack of opportunity and materiality of flexibility. Refrigeration is included in the large business segment, because they are not expected to have the same degree of conflict and have been identified as potentially flexible loads by RACE for 2030 (See Figure A5).

- Battery and EV flexibility was included despite current uptake levels being low, as they are expected to grow in uptake in the future and are highly flexible resources. Figure A7 shows the forecast uptake from AEMO's Draft IASR 2023.[39]

Figure A7 – Total Energy by CER, 1.8°C Orchestrated Step Change



Source: AEMO Draft IASR (2023)

Another key finding of the analysis and validation with the AEMC was that modelling of small and large businesses would be represented by the following key building types:

- Offices
- Retail
- Accommodation
- Entertainment
- Warehouses
- Health

These categories were selected due to these commercial building types having the highest total consumption across the NEM (see Figure A4), therefore representing most of the system.

[39] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/2023-inputs-assumptions-and-scenarios-consultation/draft-2023-inputs-and-assumptions-workbook.xlsx?la=en

Appendix B: Feedback Received on Draft Methodology

Table B1 summarises key feedback provided to Energeia's draft methodology paper, anonymised by provider and grouped by topic.

Table B1 – Summary of Feedback by Topic

Issue #	Topic	Issue	Energeia's Response
1	Consultation	Caution against conducting analysis without data from retailers	Happy to include any data made available from retailers around load flexibility costs or uptake of load flexibility
2	Consultation	Flag the lack of consultation around input data quality in all areas, particularly around current programs	Welcome feedback from stakeholders on costs or other inputs to feed into the modelling
3	Cost / Avoided Cost Inputs	Provided a more accurate source for hot water technology splits - BIS Oxford Economics "Hot Water Systems Market in Australia Report" July 2022	Happy to utilise this report
4	Cost / Avoided Cost Inputs	Consider the difference between implementing flexible trading arrangements (FTAs) for large vs. small customers	Will be considered based on granularity of cost inputs
5	Cost / Avoided Cost Inputs	Need to consider additional costs to network of hosting dynamic operating envelopes (DOEs) and flexible pricing arrangements	Happy to include any data made available from networks around load flexibility implementation costs, will be considered in the case studies analysis
6	End-to-End Modelling Process - Phase A	Concerned Energeia's method is an overestimation of value as it does not account for diminishing returns	The AEMC have considered a more complex modelling approach and have determined that a simplified, first order-based approach to be appropriate
7	End-to-End Modelling Process - Phase A	Energeia's methodology doesn't consider opportunities and costs from a customer's perspective	Method accounts for the alternative case where consumers minimise their own bill, and also the impact of system optimisation on their bill
8	End-to-End Modelling Process - Phase A	Concerned that the method is double counting/overestimating benefits	Have accounted for the fact that addressing one system benefit has implications for other value streams, so should lower risk of double counting
9	Population Inputs	Note lack of consideration for jurisdictional differences	We are considering unique jurisdictional subloads and costs to the extent the information is in the public domain
10	Selected Case Studies	Want commentary on the difference in consumer outcomes between 'whole-of-home' optimisation and device by device optimisation	Will be addressed in the consumer case studies
11	Selection of Subloads	Suggest that Residential HVAC should be re-included as it has a large opportunity (up to 25% during system peak intervals)	The resource was excluded due to the technology's availability and ultimate level of flexibility
12	Selection of Subloads	Flexible load should only consider electric load (referring to table 3 of methodology report)	Modelling will only consider electric load. However, all load was used to determine scope of analysis since it could be electrified in the future

13	Selection of Subloads	Concerned V2G isn't likely due to car warranties	In the long run, if the benefits are great enough we expect warranty issues would be resolved; we note no warranty issues currently exist
14	System and Customer Inputs	Caution using 2022 prices, suggest taking an average or other historical year or AEMO forecast	We agree to use 2019 prices noting they are lower on average vs. today. We disagree with averaging as it would smooth hourly price spikes, which are a key driver of the value of flexible resources
15	System and Customer Inputs	Concerned that we haven't considered customer's reluctance to uptake new tariffs incentives	This will be explored in Phase B where we look deeper into the achievable uptake of flexibility
16	Other	Suggest better language regarding BaU scenario which is currently called 'No Flexibility' when currently there is some flexibility	There is no current ability to break out subloads outside of the primary NMI for settlement purposes

Source: AEMC, Various Stakeholders

Energeia's mission is to empower our clients by providing evidence-based advice using the best

Heritage

Energeia was founded in 2009 to pursue a gap foreseen in the professional services market for specialist information, skills and expertise that would be required for the industry's transformation over the coming years.

Since then the market has responded strongly to our unique philosophy and value proposition, geared towards those at the forefront and cutting edge of the energy sector.

Energeia has been working on landmark projects focused on emerging opportunities and solving complex issues transforming the industry to manage the overall impact.

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