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DER could provide $19 billion economic boost by 2040

Urgent action needed to capitalise on consumer-owned energy assets

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Key Findings

Distributed energy resources (DER) such as rooftop solar, electric vehicles and smart appliances could deliver economic benefits for Australia of at least $19 billion by 2040.

IEEFA conducted a meta-analysis of nine studies of DER identifying these significant economic benefits, along with a further potential consumer benefit of $10 billion in reduced generator super-profits.

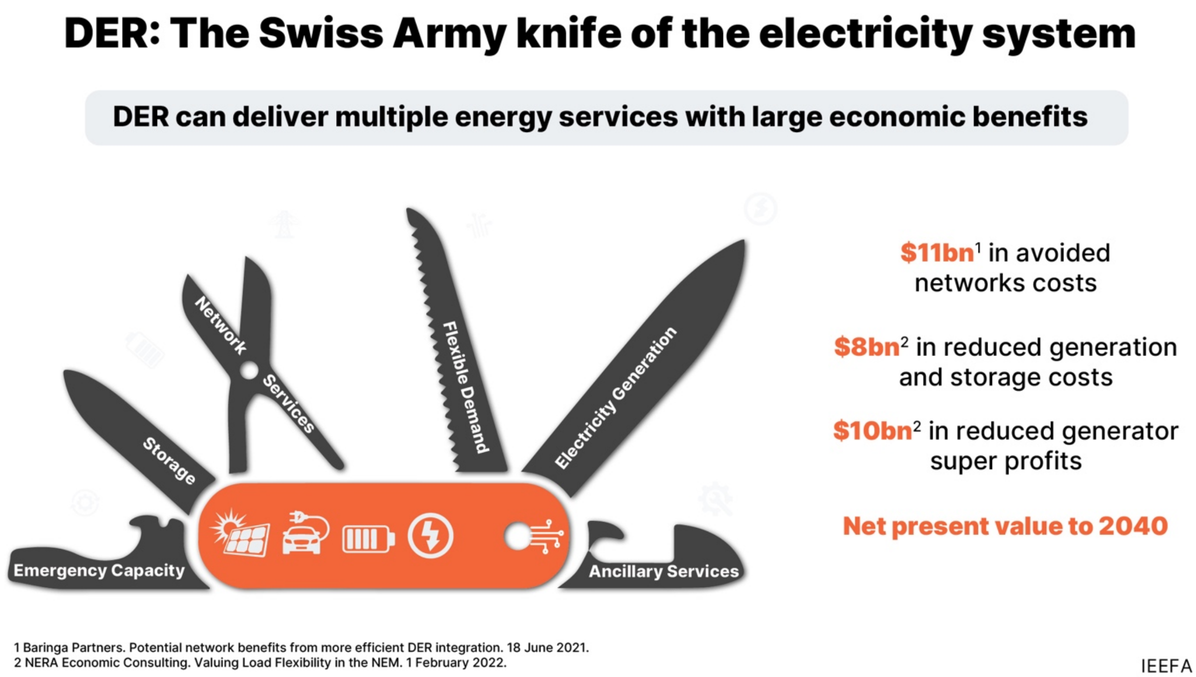
Further research is required to fully understand the economic value of rooftop solar, battery storage and flexible demand.

Action is urgently needed for Australia to realise the potential of DER and ensure our economic prosperity. DER must be treated on equal terms as large-scale generation and storage in terms of policy, planning and regulation.

Executive Summary

Collectively households and businesses are driving the installation and operation of a huge number of devices that are supporting the decarbonisation of the National Electricity Market (NEM).

These distributed energy resources (DER) can reduce the amount of large-scale renewable generation needed, reduce the amount of transmission and distribution network build, provide Frequency Control Ancillary Services (FCAS), emergency power supplies (individually and through the Reliability and Emergency Reserve Trader (RERT) scheme), as well as flexible demand, including demand response. Offering such an array of possibilities, DER can be seen as the Swiss Army knife of the electricity system.



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Including the likes of rooftop solar combined with stationary batteries, batteries on wheels (in other words, electric vehicles), and flexible demand (such as hot water systems), DER can respond quickly to signals to export, import or store electricity, and so can provide almost any service the grid needs. With this will come a range of economic benefits including reducing electricity system costs.

The question is: what economic contribution could DER make to the energy transition? And therefore, what value is being left on the table by not maximising the rollout and effective integration of DER? IEEFA has sought to answer these questions by conducting a meta-analysis of the available studies on the topic.

Only a handful of studies in Australia have assessed the potential economic benefits of effectively integrating DER into the electricity system, and none of them have been comprehensive. This report examines the economic modelling of both individual technologies and multiple forms of DER to understand the range of benefits and the further modelling needed to fully appreciate a DER-based electricity system.

This meta-analysis finds that, based on the results of studies by Baringa Partners and NERA Economic Consulting, DER integration could deliver a **combined net present value (NPV) of more than $19 billion by 2040.** The Baringa study found $11 billion in distribution and transmission network avoided costs and benefits of DER integration. Meanwhile the NERA study found $8 billion in generation and storage cost reductions resulting from high levels of DER with high flexibility. **In addition, there is $10 billion in wholesale market super profit reductions which would benefit consumers**, according to the NERA study.

The Baringa and NERA studies had no overlap in their modelled value streams. Summing two separate studies like this is not without risk, especially as the Baringa study is based on 2020 forecasts and does not include flexible demand more broadly or from electrification. Nonetheless, **the $19 billion figure gives a sense of the magnitude of the economic benefits that could be unlocked if the energy transformation supports DER investment and integration.**

Further research is needed to fully understand the economic value of rooftop solar, battery storage and flexible demand. However, despite the limited number of economic studies available, our meta-analysis reveals significant insights about the potential of DER:

1. Changes to the wholesale market are likely to be highly significant. Indeed, it is likely that the “duck curve” will be put to sleep and that the 4pm-8pm evening peak will effectively disappear, transferring generators’ ‘supernormal’ profits into wholesale bill savings for consumers ($10 billion NPV by 2040 according to the NERA study) if the market operates efficiently.
2. Dynamic operating envelopes (DOEs or flexible exports) are essential to realise the value of DER. In fact, the cost-benefit analysis for one trial, Project Edge, showed that $5 billion of the $6 billion in benefits (NPV to 2042) were related to the value unlocked by increasing DER exports through implementation of DOEs.
3. Ensuring flexibility is vital to unlock value from electrification and to minimise the costs of the energy transition. Flexible demand is the necessary partner to variable renewable energy and as much DER as possible needs to be flexible or made flexible in the process of electrification. Policy and programs need to optimise flexibility at every possible opportunity.
4. DER is not only capable of providing network services, but could save consumers at least $11 billion in NPV by 2040 according to Baringa. However, capex-bias in the existing revenue regulation is likely to prevent optimal outcomes. There is an urgent need for a first-principles review of distribution network revenue regulation. The distribution networks have a completely different role in a high-DER world to that of 20 years ago, and how they are remunerated needs to reflect this.

Our meta-analysis concludes that we need significant, courageous action on DER integration as soon as possible if we want to underpin Australia's future economic prosperity with lower electricity and transport costs, and electrification to eliminate dependency on gas. **DER must not come second in policy, planning and regulation to transmission and large-scale generation.** DER must be considered on equal terms, with more thoughtful recognition of the multiple benefits outlined in this report.

Below is a table outlining some of the benefits that can be gained from the various services DER can provide, as well as the actions required to realise benefits. A table providing a more detailed summary of this report's findings can be found towards the end of this report.

Benefit / Service	Avoided networks costs	Avoided centralised generation and storage costs	Avoided system management costs	Actions required
Electricity generation	☑	☑		• DOEs implemented across the National National Electricity Market (NEM) and the Wholesale Electricity Market (WEM) • Ideally, time and location varying feed-in tariffs
Storage	☑	☑	☑	• Subsidies and loans to support battery purchases, enabling scale-up of DER storage. • Allow aggregated household storage to participate in the Capacity Investment Mechanism. • Aggregated batteries to participate in all FCAS markets
Flexible demand	☑	☑	☑	• Policy and programs need to optimise flexibility at every possible opportunity. • Rewards for flexible demand including through the wholesale demand response mechanism (DRM) • Allow consumers to have multiple trading relationships to realise value from multiple sources including RERT and flexible demand
Distribution network services	☑		☑	• Reform the economic regulation of networks – there is an urgent need for a first-principles review of distribution network revenue regulation
FCAS			☑	• Consider DER participation in Regulation FCAS and other future Essential System Services
RERT		☑	☑	• Allow consumers to have multiple trading relationships contracts with multiple retailers or aggregators – to realise value from RERT and flexible demand
Economic benefits (NPV by 2040)	**$11bn**	**$8bn**		

Introduction

As Paul Kelly and Kev Carmody sing, "From little things, big things grow." We know that rooftop solar systems are now collectively the largest generation capacity by type in the National Electricity Market (NEM), and that if we were to electrify our domestic hot water systems, we could create around 22 gigawatts (GW) of flexible demand.[1,2]

It is now appreciated by the industry and energy market institutions that aggregated distributed energy resources (DER), operating as 'Virtual Power Plants' (VPPs), can provide the following services:

- Generation.
- Demand flexibility – both increasing (e.g. electric vehicle (EV) charging) and decreasing demand for wholesale price arbitrage and risk management (especially during high price periods greater than $300 per megawatt-hour (MWh), to avoid negative price periods, and potentially to charge batteries in negative price periods).
- Reliability and Emergency Reserve Trader (RERT) – including through behavioural demand response and aggregated behind-the-meter (BTM) batteries.
- Contingency Frequency Control Ancillary Services (FCAS) – Analysis by Grids suggests DER has provided 10%-20% of contingency FCAS in the NEM since 2018.[3] Notably, this now includes the new Fast Frequency Response FCAS service.
- Wholesale Demand Response (WDR) – though only 67 megawatts (MW) is currently registered.
- Network services – though, so far only some services in trials such as Projects Converge, Edge, Symphony and Edith.
- Capacity – as in the Federal Government's Capacity Investment Mechanism, where Enel X recently succeeded in securing payments for 95MW of demand response.[4]

Possible future sources of revenue include:

- Regulation FCAS.
- Other future Essential System Services – Although these have yet to be defined, they might include inertia or voltage management.

There is also potential to 'value stack' several of these sources of revenue, especially if the DER can respond quickly to signals. For example, Reposit receives revenues from 15 different electricity markets, including trading on the wholesale market and providing frequency response to eight ancillary services markets.[5]

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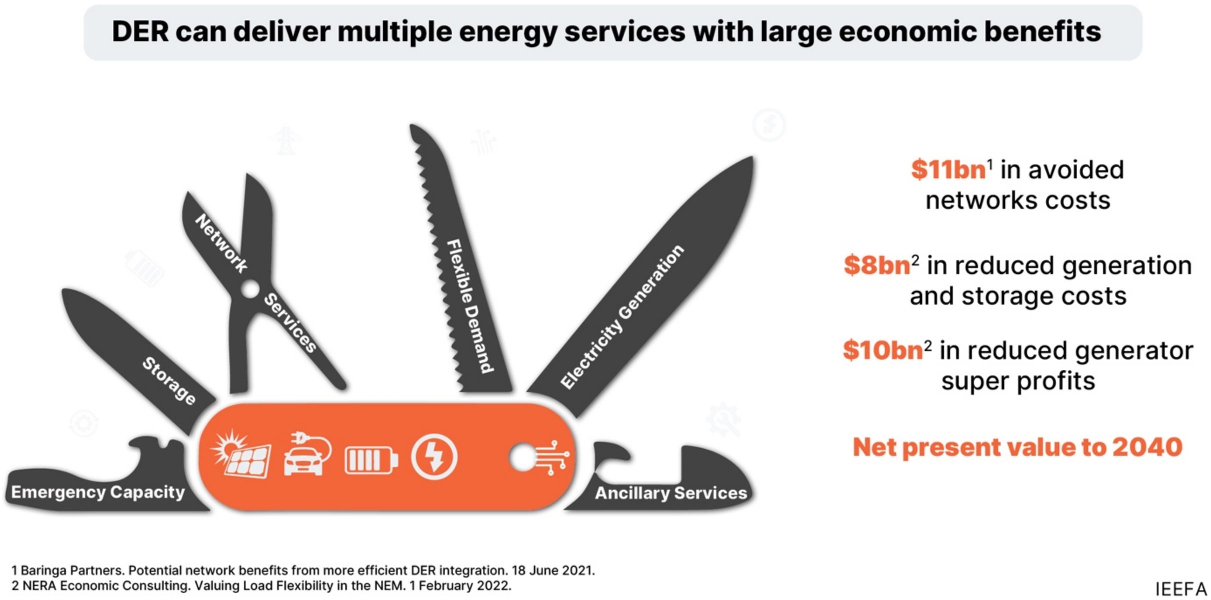
[1] IEEFA analysis of data from the Australian PV Institute and the Clean Energy Regulator. Details of calculations provided in the full report.
[2] UTS Institute for Sustainable Futures. Domestic Hot Water and Flexibility. 5 June 2023.
[3] Grids. 2023 DER in Energy Markets.
[4] NSW Government. Capacity Investment Scheme supports NSW to deliver 1 GW of cleaner, cheaper, more reliable energy. 22 November 2023.
[5] Consumers International. Designing a one-stop-shop for consumer renewable energy systems. 8 December 2023.

Figure 1: DER is the Swiss Army knife of the electricity system



Source: IEEFA

In addition, there is potential value to gentailers (electricity retailers with combined generation businesses) from DER in terms of:

- Reduced customer churn, and therefore reduced customer retention costs, if customers stay with a retailer because of its DER offerings such as cheap EV charging or demand response payments.
- A margin on solar and/or battery systems where these are sold by the gentailer.
- Financing of solar-plus-battery systems.

Opportunities such as these are why IEEFA suggested in a report on the state of VPPs in 2021, that the future of energy retail lay in 'VPP-tailing' and that "Retailers without VPP capabilities will struggle to be profitable into the future."[6]

Given all these current and potential value streams, what do we know about the forecast economic benefits of DER in the NEM?

[6] IEEFA. What Is the State of Virtual Power Plants in Australia? From Thin Margins to a Future of VPP-tailers. March 2022.

Economic analyses of the benefits of individual types of DER

There are now several studies examining the possible future costs and benefits for consumers and/or the NEM resulting from DER integration. All these studies are partial; they only examine some forms of DER or only examine some of the possible costs and benefits. Some of the studies used data that is already out of date, such as earlier Integrated System Plan (ISP) forecasts with lower levels of DER uptake. In addition, modelling of the economic benefits of EVs is challenging because EV integration is at formative stages, especially given that vehicle-to-grid (V2G) is an emerging technology for which there has only been one trial in Australia.[7] It remains uncertain which markets or regulated schemes (such as the NSW Peak Demand Reduction Scheme (PDRS)) EVs will be able to participate in, either now or in the future; what the revenue from those value streams might be; what proportion of EV battery capacity would be made available to participate; what proportion of customers might be able to participate in these markets and through which aggregators; and so on.

Nevertheless, this small collection of studies is worthy of a meta-analysis to understand the current estimates of the economic benefits of integrating different individual types of DER, and in some cases multiple forms of DER. By drawing these comparisons, we can see the scope of analysis that has been undertaken, and what further research is needed. All economic forecasts will be unreliable, but by furthering our understanding of the costs and benefits of DER integration, we can understand what actions will unlock the greatest benefits, and therefore give these policy and regulatory changes the appropriate priority.

The studies reviewed are for this meta-analysis are:

For individual types of DER:

- ***Rooftop solar:*** Victoria Energy Policy Centre. *Rooftop PV and electricity distributors: who wins and who loses?* June 2020. By Mountain, B; Percy, S; and Burns, K.[8]
- ***Hot water:*** UTS Institute for Sustainable Futures. *Domestic Hot Water and Flexibility*. 5 June 2023. Prepared for the Australian Renewable Energy Agency (ARENA). By Roche, D; Dwyer, S; Rispler, J; Chatterjee, A; Fane, S; and White, S.[9]
- ***Load flexibility:*** RACE for 2030 CRC. *Flexible demand and demand control*. October 2021. Final report of opportunity assessment for research theme B4. By Brinsmead, TS; White, S; Bransden, C; Stanley, C; Hasan, K; Alexander, D; Sprague, M; Northey, J; Walgenwitz, G; Nagrath, K; Briggs, C; Leak, J; Harkins-Small, L; Murray-Leach, R; and Jennings, K.[10]

[7] ANU Battery Storage and Grid Integration Program. Realising Electric Vehicle-to-grid Services.
[8] Victoria Energy Policy Centre. Rooftop PV and electricity distributors: who wins and who loses? June 2020.
[9] UTS Institute for Sustainable Futures. Domestic Hot Water and Flexibility. June 2023.
[10] RACE for 2030 CRC. Flexible demand and demand control. October 2021.

- ***Household electrification:*** CSIRO. *Consumer impacts of the energy transition: modelling report*. 1 July 2023. Prepared for Energy Consumers Australia. By Graham, Paul; Meher-Homji, Zubin; Havas, Lisa; and Foster, James.[11]

For multiple forms of DER:

1. CSIRO and Energy Networks Australia (ENA). *Electricity Network Transformation Roadmap: Final Report*. April 2017.[12]
5. Baringa Partners. *Potential network benefits from more efficient DER integration*. 18 June 2021. Prepared for the Energy Security Board (ESB).[13]
6. NERA Economic Consulting. *Valuing Load Flexibility in the NEM*. 1 February 2022. Prepared for ARENA.[14]
7. Deloitte Access Economics. *Project EDGE Cost Benefit Analysis*. October 2023. Prepared for ARENA.[15]
8. ITP Renewables. Saturation DER modelling. 2021. Confidential commission and not publicly available.

The economic value of rooftop solar installed to date

An analysis by Professor Bruce Mountain and colleagues estimated that electricity generated by rooftop solar reduced average annual prices in the NEM by $3.1/MWh in 2017, $4.7/MWh in 2018, and $6.4/MWh in 2019 from what they otherwise would have been.[16] This is significant to contemplate, but sadly it is the only study of rooftop solar's value to the NEM that has been completed, and it only estimated wholesale price reductions.

The economic value of flexible demand and distributed storage installed to date

The value of demand flexibility or battery storage, let alone coordinated DER, currently in operation in the grid has not been estimated. There are some financial values that could be estimated for DER that are contracted under the RERT or that are participating in FCAS markets or the WDR Mechanism. For example, a 2021 RACE for 2030 report found 1,422MW of flexible demand was contracted over 2019-21, delivering 5,223MWh of flexible demand at $1,296.86/MWh, and a benefit-to-cost ratio of almost 2:1.[17] However, there is no analysis of the overall economic value of the flexible demand currently available. This is a major shortcoming in the available information for energy market planning,

[11] CSIRO. Consumer impacts of the energy transition: modelling report. 1 July 2023.
[12] CSIRO and ENA. Electricity Network Transformation Roadmap: Final Report. April 2017.
[13] Baringa Partners. Potential network benefits from more efficient DER integration. 18 June 2021.
[14] NERA Economic Consulting. Valuing Load Flexibility in the NEM. 1 February 2022.
[15] Deloitte Access Economics. Project EDGE Cost Benefit Analysis. October 2023.
[16] Victoria Energy Policy Centre. Rooftop PV and electricity distributors: who wins and who loses? June 2020.
[17] RACE for 2030 CRC. Flexible demand and demand control. October 2021.

especially as the value of flexible demand will only increase as the proportion of variable renewables in the system increases.

Future potential for specific types of DER

There have been a handful of studies that have examined system benefits of particular types of DER.

UTS research on the electrification of domestic hot water lists the following savings across its four scenarios:

1. **Highly flexible** – Savings of $6.7 billion (from reduced gas and electricity use) by 2040; plus $14.3 billion in avoided grid storage costs.
9. **Highly efficient** – Savings of $4.7 billion (from reduced gas and electricity use) by 2040; plus $10.1 billion in avoided grid storage costs.
10. **Rapid electrification** – Savings of $4.7 billion (from reduced gas and electricity use) by 2040; plus $13.1 billion in avoided grid storage costs.
11. **BAU** – No savings in energy use; $5.4 billion in avoided grid storage costs.[18]

The UTS report acknowledged these savings are partial, without accounting for additional system benefits resulting from increasing minimum demand that are difficult to quantify, such as "increased ease of managing voltage, increased efficacy of emergency frequency control schemes, and higher likelihood of having a stable load for system restart services to successfully enable grid operation after a system outage".[19]

The recently commenced NSW PDRS is the first certificate scheme for demand flexibility in Australia. The NSW PDRS is designed to reduce peak demand by 1,029MW (7.5% on 2019 peak) by 2030, and is projected to result in $388m of total benefits and $154m in net benefits by 2030.[20] This, in turn, is anticipated to lower average wholesale prices by $4.30/MWh over 2022-30, in addition to network investment benefits (see **Table 1**). This net benefit unfortunately cannot be used as the basis for any other estimate of peak demand reductions because of the significant costs in running the certificate scheme and its NSW-specific valuations of avoided wholesale and network costs.

[18] UTS Institute for Sustainable Futures. Domestic Hot Water and Flexibility. June 2023.
[19] Ibid.
[20] UTS Institute for Sustainable Futures. ARENA Knowledge Sharing Demand Flexibility Portfolio Retrospective Analysis Report. July 2023. Report prepared for ARENA. By Briggs, C; Hasan, K; Dwyer, S; Bashir, U; Niklas, S; Alexander, D; and Chatterjee, A.

Table 1: Summary of NSW PDRS cost-benefit analysis

Present value of incremental costs and benefits to 2040	ESS	PDRS
Scheme costs		
Government costs ($m)	–$50	–$42
Regulatory costs ($m)	–$377	–$192
Total costs ($m)	**–$427**	**–$234**
Scheme benefits		
Reduced wholesale purchase costs ($m)	$1,089	$130
Avoided network investment ($m)	$122	$235
Avoided cost of greenhouse gas emissions ($m)	$258	$21
Avoided cost of air pollution ($m)	$21	$2
Total benefits ($m)	**$1,490**	**$388**
Net economic benefit ($m)	**$1,063**	**$154**
Benefit–cost ratio	**3.5**	**1.7**

Source: NSW Government[21]

The 2021 RACE for 2030 report estimated the value of 1,000MW of relatively expensive sources of flexible demand (costing about $155 kilovolt-amperes per year) to be around $455 million per year in bill reductions for consumers across the NEM through value stacking wholesale, network services, RERT and FCAS (see table below).[22] The fact that in this case the wholesale value is three times larger than the network augmentation cost savings, which is almost the opposite of the PDRS cost-benefit analysis, shows how dependent DER benefit modelling is on the assumptions made.

Table 2: 1GW of flexible demand, estimated market value

Source of value	Value ($m/year)
Wholesale market	290
Network augmentation	100
RERT	35
FCAS	30
Total	**455**

Source: RACE for 2030 CRC

[21] NSW Government. Energy Security Safeguard: Overview of the position paper. September 2021.
[22] RACE for 2030 CRC. Flexible demand and demand control. October 2021.

A report prepared by Chris Briggs and colleagues at the UTS Institute for Sustainable Futures summarised the outcome of demand flexibility projects funded by ARENA.[23] The report noted the challenges of estimating and valuing demand flexibility: "Valuation of demand flexibility revenue streams is very difficult: there is high uncertainty about the volume of earnings from different revenue streams making it very difficult to make a compelling business case. The value can vary depending on energy market circumstances, barriers to accessing the opportunity, the pricing model, baselines and resource availability at the time it is required which can also be unpredictable.

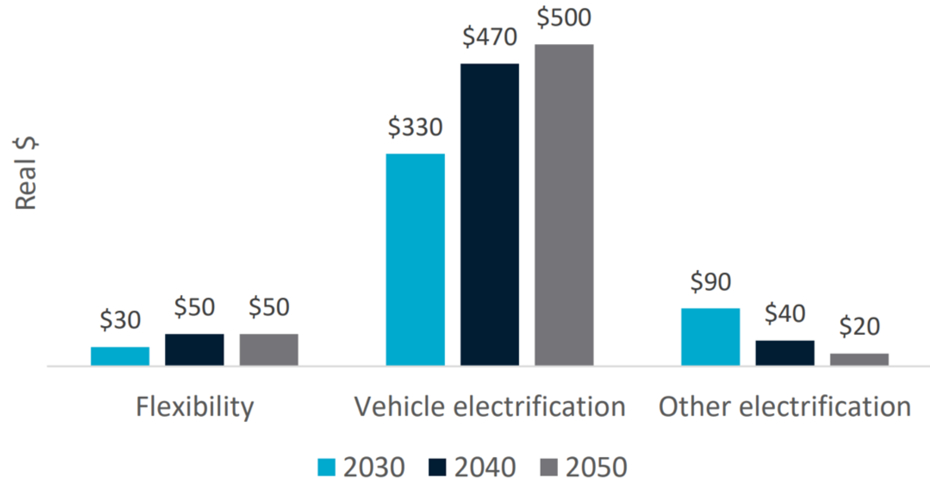
"Pathway to accessing value-streams is sometimes unclear: Whilst minimum demand has emerged as a major priority in several jurisdictions as rooftop solar erodes demand in the middle of the day, there is limited information on the value of the opportunity, for example, what's the value of the curtailed solar that could be unlocked? What is the value of the network service and how can it be accessed?"

From another perspective, Energy Consumers Australia commissioned CSIRO and Dynamic Analysis to determine the customer impacts and benefits of electrification, both for households that electrify and for all consumers.[24] The greatest benefit is from EVs, which increase electricity network utilisation and therefore decrease unit distribution network charges by $500/year by 2050 for the average customer. Flexibility due to peak demand growth curtailment was valued at $50/year from 2040 for the average NEM consumer. [25] Total savings in 2050 are modelled to be $570/customer – assuming there are roughly 11 million customers by then, this represents a $6.3 billion collective benefit.

However, using the Australian Energy Market Operator (AEMO)'s Step Change scenario for the input assumptions, the CSIRO analysis has significant limitations: it doesn't appear to examine the full benefits of electrification; it appears to underestimate the value of demand flexibility (as it only finds very small values compared with other studies detailed below); and it is highly conservative about the potential for EV managed charging and V2G (at only 5% by 2030 in the 'Well-coordinated' sensitivity). AEMO has several other scenarios and sensitivities with higher levels of electrification uptake than the Step Change scenario.

[23] UTS Institute for Sustainable Futures. ARENA Knowledge Sharing Demand Flexibility Portfolio Retrospective Analysis Report. July 2023. Page 20.
[24] CSIRO. Consumer impacts of the energy transition: modelling report. 1 July 2023.
[25] Ibid

Figure 2: Bill savings over time from electrification for the average NEM customer



Source: CSIRO

Economic analyses of the benefits of multiple forms of DER

There are five studies that have attempted to calculate the combined savings from DER for the NEM as a whole, all of which have their strengths and weaknesses.

CSIRO and ENA 'Electricity Network Transformation Roadmap' (2017)

In 2017, ENA commenced an intensive and lengthy process with CSIRO to develop an Electricity Network Transformation Roadmap.[26] The process included the development of more than 19 reports covering expert analyses, scenario analyses and quantitative modelling to 2050. An integrated set of 'no regrets' actions was identified to enable balanced, long-term outcomes for customers, enable the maximum value of customer DER, and position Australia's networks for resilience in 'uncertain and divergent futures'. The result was a **reduction in forecast cumulative total expenditure in the electricity sector of $101 billion by 2050 compared with business as usual (BAU)** – see figure 3.

Specific savings include:

- $40 billion in reduced distribution costs across the NEM.
- $16 billion of network infrastructure investment is avoided via orchestration of DER. (In this modelling, distribution networks pay DER customers more than $2.5 billion per annum for grid

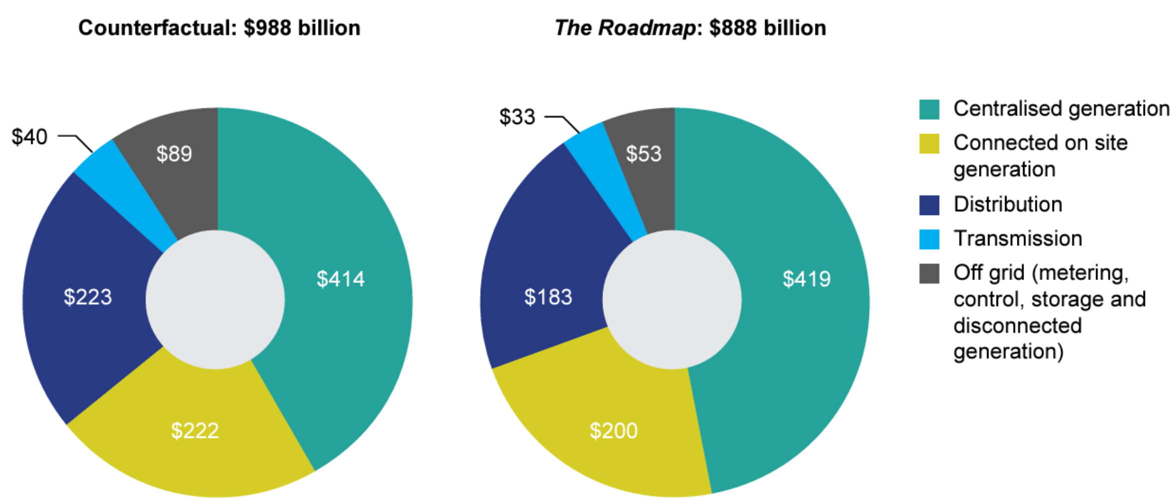
[26] CSIRO and ENA. Electricity Network Transformation Roadmap: Final Report. April 2017.

support services by 2050. The report projects that by 2027, network orchestration using DER on a dynamic locational basis will result in one third of customers selling DER services to networks, directly or through their agents.)

- A $5 billion increase in centralised generation due to more customers staying on grid.
- $36 billion in reduced off-grid costs across the NEM (paying consumers for their DER-services encourages them to stay on the grid).
- $22 billion in reduced on-site generation.
- $7 billion in reduced transmission build.

This Roadmap envisaged more consumers staying on the grid with reduced distribution costs, including from consumers with DER providing distribution network services in return for significant collective payments.

Figure 3: Whole-of-system NEM costs under BAU compared with ENA Roadmap

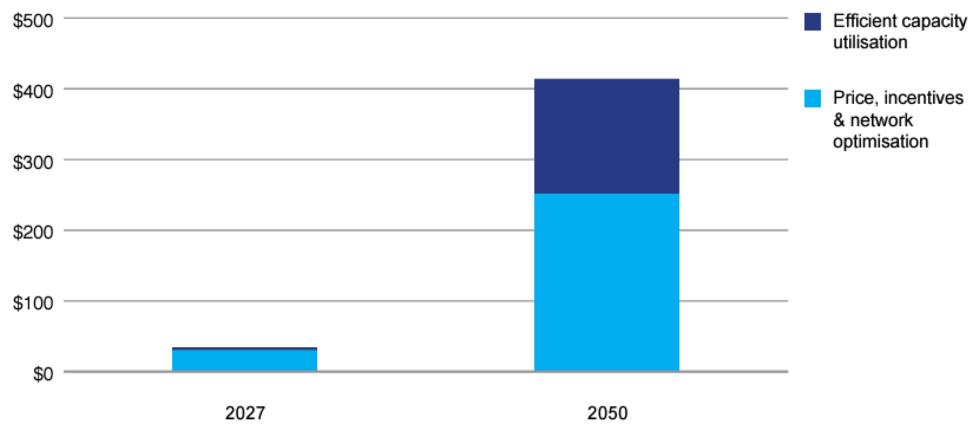


Source: CSIRO and ENA. Cumulative electricity system total expenditure to 2050 (in real terms) under the Roadmap and counterfactual scenarios

This results in a $414 annual saving in average household electricity bills by 2050 when compared with a 'counterfactual' BAU pathway. A medium family that cannot take up DER was found to be more than $600 per annum better off (in real terms) through removal of cross subsidies – see figures below. In addition, the electricity sector achieves zero net emissions by 2050.[27]

[27] CSIRO and ENA. Electricity Network Transformation Roadmap: Final Report. April 2017.

Figure 4: Household bill savings under ENA Roadmap scenario compared with BAU



Source: CSIRO and ENA

Figure 5: Household bill savings by type in 2050 under the ENA Roadmap

	Counterfactual			*The Roadmap*		
	Active $	Passive $	The Gap $	Active $	Passive $	The Gap $
Working Couple	$1,346	$1,811	**$465**	$1,123	$1,422	**$299**
Medium Family	$1,816	$2,601	**$785**	$1,428	$1,988	**$560**
Large Family	$2,794	$3,950	**$1,156**	$2,346	$2,734	**$288**
Single, Retired	$1,058	$1,730	**$672**	$883	$1,355	**$472**

Source: CSIRO and ENA

Baringa Partners for the ESB 'Potential network benefits from more efficient DER integration' (2021)

In 2021, the ESB commissioned Baringa Partners to evaluate the potential benefits of an efficient integration of DER into the NEM, building on its previous study for the Open Energy Networks (OpEN) project, and using updated DER (solar photovoltaic (PV), batteries and EV) forecasts from AEMO's 2020 Electricity Statement of Opportunities (2020 ESOO).[28]

Baringa's modelling covered the potential benefits of avoided investment and avoided curtailment costs at both the distribution and transmission levels for AEMO's Central and Step Change scenarios. Combined, the distribution network benefits amount to $2.3 billion in the Central scenario, and $9.9 billion in the Step Change scenario. Baringa's estimates of combined distribution and transmission network benefits from DER integration are **$2.3 billion under the Central scenario, and $11.3 billion under the Step Change scenario.**

Table 3: Network benefits from DER to 2040

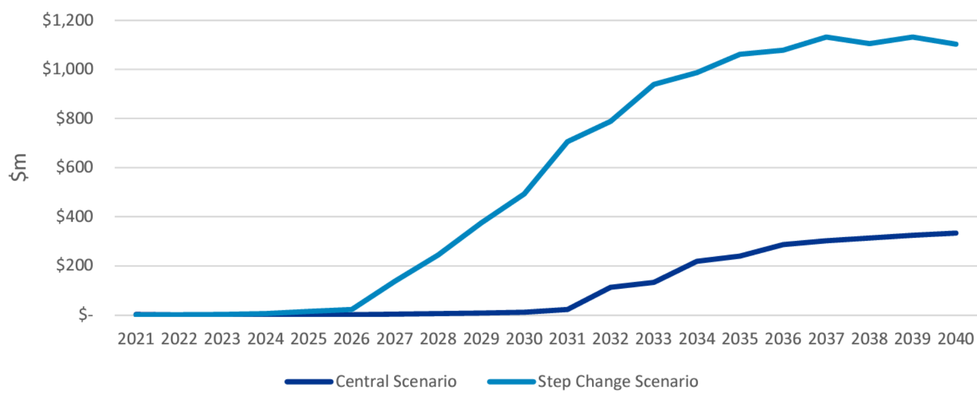
Benefit category	Benefit sub-category	ESOO Scenario	NPV potential benefits (ESOO 2020) ($m)
Avoided distribution investment / reduced curtailment costs	Avoided curtailment costs (generation driven)	Central	367
		Step Change	1,514
	Avoided distribution investment (demand driven)	Central	1,918
		Step Change	8,389
Avoided transmission investment / reduced curtailment costs	Avoided curtailment costs (generation driven)	Central	18
		Step Change	104
	Avoided transmission investment (demand driven)	Central	20
		Step Change	1,315
Total network benefits		**Central**	**2,323**
		Step Change	**11,321**

Source: Baringa Partners.

It is vital to note this analysis did not include calculation of reduced wholesale ancillary service costs or reduced wholesale energy costs, which could be significant as the NERA and "sleeping duck" curve modelling (explored below) show. It also did not include the broader spectrum of flexible demand technologies, only including batteries and EVs. The network benefits do not begin to be realised until after 2026 due to the lock in of network costs under the five-yearly reset process (see figure 6).

[28] Baringa Partners. Potential network benefits from more efficient DER integration. 18 June 2021.

Figure 6: Network benefits from DER to 2040



Source: Baringa

Baringa issues a strong warning in the report: "We estimate that current arrangements, without further reform, are likely to realise less than half of these potential benefits. Further reforms across network tariffs, direct procurement and other non-tariff DER integration measures will take time to implement. Any significant delays in the commencement of further reforms would reduce the potential 'size of the prize' of network benefits that could be captured, meaning some benefits would become permanently unrealised, particularly if actual DER penetration outcomes develop along the step change scenario trajectory. This is because after certain expenditure on network upgrades are incurred, or after certain solar PV is curtailed in a particular year, these impacts cannot be reversed even if they were avoidable if reforms to more efficiently integrate DER had taken place earlier."[29]

NERA Economic Consulting for ARENA 'Valuing Load Flexibility in the NEM' (2022)

ARENA commissioned NERA Economic Consulting to study the potential value of load flexibility in the NEM over the next 20 years.[30] The definition of 'demand flexibility' considered all the following sources of flexibility:

1. Orchestrated consumer devices (air conditioning, hot water, pool pumps).
2. Behind-the-meter solar and battery storage.
3. Smart commercial buildings.
4. Electrification of process heat in industry (metals, minerals, food and beverage).
5. EVs.
6. Green/renewable hydrogen.

[29] Baringa Partners. Potential network benefits from more efficient DER integration. 18 June 2021. Page 13.
[30] NERA Economic Consulting. Valuing Load Flexibility in the NEM. 1 February 2022.

Essentially three of NERA's four 'state of the world' (SoW) non-baseline scenarios are DER scenarios focused respectively on high EV uptake (SoW 2), electrification leading to flexible demand (SoW 3), and high uptake of rooftop PV and BTM batteries, as well as high large-scale variable renewable energy (VRE) (SoW 4) – see **Figure 7**.

Benefits assessed included:

- Avoided need to invest in new physical generating or storage capacity.
- Avoided need to dispatch expensive generation or curtail load.
- Lower end-user prices to consumers, due to reductions in power prices at peak times.
- Lower carbon emissions due to reduced fossil-fuel based thermal generation.
- More efficient use of the transmission grid through reduction in the system peak demand.
- More efficiently utilised transmission-connected generation (though NERA did not quantify the consumer savings associated with this).

The cost savings were modelled in terms of NPV to 2040 for both 'new build costs savings' (the reduction in future capital and operating costs of large-scale generation and storage) and 'consumer cost savings' (which includes both new build cost savings), and 'inframarginal rent' that generators capture during peak pricing events, as a better proxy for wholesale market prices.

Figure 7: State of the World scenarios in NERA's flexibility modelling

SoW 1: Baseline Case ISP Central Case set up with additional flexibility from enabling smart residential and commercial sources that are already electrified (e.g. heating and cooling, hot water systems and pool pumps), as per the Energy Synapse Base Case[3].	
Low flexibility scenario Demand-side participation levels as assumed in the ISP Central Case	High flexibility scenario Additional residential & commercial demand flexibility
SoW 2: High EV Uptake SoW 1: High flexibility scenario **plus** the additional demand from high EV uptake[3]. Additional flexibility from managed charging and V2G services.	
Low flexibility scenario As above	High flexibility scenario SoW 1 High Flexibility scenario + Additional flexibility from EVs (deferred charging and V2G services)
SoW 3: Electrification SoW 2: High flexibility scenario **plus** the electrification of residential, C&I sources and processes[3]. Additional flexibility from high electrification of residential and C&I sources (e.g. HVAC, metals and minerals production, and food and beverage industries).	
Low flexibility scenario As above	High flexibility scenario As above + High electrification of residential and C&I sources
SoW 4: High DER Uptake SoW 3: High flexibility scenario **plus** the faster uptake of DER sources[3]. Additional flexibility from high BTM PV and battery uptake, large-scale PV at ISP Step Change prices, and ISP Step Change renewable targets.	
Low flexibility scenario As above	High flexibility scenario As above + high BTM PV and battery uptake + large-scale PV + ISP Step Change renewable targets
SoW 5: Hydrogen SoW 4: High flexibility scenario **plus** the uptake of hydrogen electrolysers[3]. Load flexibility in SoW 5 was measured at two levels - 85% and 60% load factor.	
Higher flexibility scenario (as above) + electrolysers operating with an 85% load factor	High flexibility scenario (as above) + electrolysers operating with a 60% load factor

Source: NERA

NERA notes that the High DER Uptake scenario (SoW 4), which has the highest benefits for flexibility of $8 billion (new build only) or $18 billion (consumer cost savings) "presents the most instructive scenario, given it most closely matches current investment trends in large-scale and distributed renewable energy resources. It also provides the best indication of the total potential value of flexible demand."

The $10 billion difference between the NPV of new-build and consumer cost savings represents the reduction in inframarginal rent received by generators: this means there is a potential $10 billion consumer saving on offer (in a high DER uptake world) due to reduced incidents of high peak pricing events – what NERA calls generator "supernormal" profits (in other words, profits that are not required to pay off investment costs).

Other points to note from the NERA modelling:

- BTM storage and EVs constitute the highest single contribution to flexible capacity reflecting their low marginal cost. While not visible in these charts, industrial flexibility starts to grow rapidly towards the end of the modelling period.
- Emissions decrease on average by 3 million tonnes (Mt) per year from 2035 to 2040, as the high flexibility scenario consistently deploys less coal generation.
- Flexibility reduces NEM peak demand by around 8GW from 2035 to 2040 and transmission load factor is improved by around 6% [6GW] overall.[31]

Table 4: Flexible demand benefits by 2040 across four scenarios

	NPV System Costs ($ bn)			NPV Costs to Consumers ($ bn)			Avg Annual Emissions (Mt)			Avg. Peak Load on Transmission Grid (GW)		
	HF	LF	Diff.	HF	LF	Diff.	HF	LF	Diff.	HF	LF	Diff.
SoW1 Baseline	87	89	-1	184	189	-6	93	93	0	34	35	-0
SoW2 EV uptake	103	106	-3	202	207	-5	97	97	0	40	41	-1
SoW3 Electrification	110	114	-4	212	217	-5	99	99	0	41	43	-2
SoW4 High VRE	92	100	-8	141	159	-18	82	85	-3	35	41	-6

Source: NERA. Note HF refers to high flexibility scenario and LF refers to low flexibility scenario. High VRE scenario in above table is also referred to as High DER Uptake scenario. Differences may include rounding errors.

The transmission peak load reduction of 6GW is likely to be a major system cost benefit, but this was not calculated. Instead, the report pointed to Baringa's figure of avoided or deferred distribution and transmission network capital expenditure worth up to $11.3 billion under the Step Change scenario from AEMO's 2020 ISP.

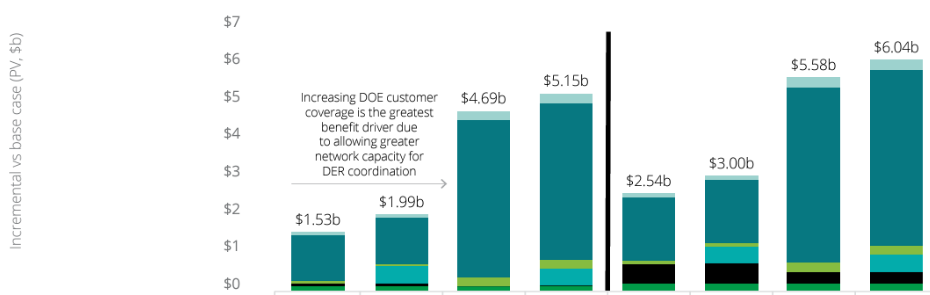
[31] NERA Economic Consulting. Valuing Load Flexibility in the NEM. 1 February 2022.

Deloitte Access Economics for ARENA 'Project EDGE Cost-Benefit Analysis' (2023)

The fourth and most recent economic analysis of the benefits of DER is the Cost-Benefit Analysis (CBA) that was completed for Project EDGE, "a collaboration between AEMO, Ausnet Services and Mondo, with support from ARENA, to demonstrate how to facilitate efficient and scalable trade of electricity services from coordinated DER".[32] More than 320 residential and commercial/industrial customers took part in an 11-month trial providing 3.5MW of flexible capacity from more than 400 DER devices that were coordinated in real time by three different VPPs.

The CBA considered two scenario sets, the first of which reflects DER uptake assumptions based on AEMO ISP 2022 forecasts (Scenarios 1-5), and the second of which represents a more rapid rate of DER uptake (Scenarios 6-10).

Figure 8: Project EDGE CBA by driver of value by scenario over 20 years



Key drivers of value across the CBA Scenarios	Scenario 2 (Simple DOE, Moderate Coverage)	Scenario 3 (Simple DOE, Moderate Coverage with Data Hub)	Scenario 4 (Advanced DOE, High Coverage)	Scenario 5 (Advanced DOE, High Coverage with Data Hub)	Scenario 7 (Simple DOE, Moderate Coverage)	Scenario 8 (Simple DOE, Moderate Coverage with Data Hub)	Scenario 9 (Advanced DOE, High Coverage)	Scenario 10 (Advanced DOE, High Coverage with Data Hub)
DOE Constraint Optimisation Frequency (more total network capacity unlocked for DER coordination)	$0.06	$0.06	$0.22	$0.22	$0.08	$0.08	$0.24	$0.24
DOE Customer Coverage (more total network capacity unlocked for DER coordination)	$1.21	$1.21	$4.12	$4.12	$1.67	$1.67	$4.60	$4.60
DOE Objective Function (more network capacity allocated to DER)	$0.06	$0.06	$0.22	$0.22	$0.08	$0.08	$0.24	$0.24
Data Hub (reduced costs and enables additional DER services)	$-	$0.45	$-	$0.45	$-	$0.45	$-	$0.45
LSE (reduced DER curtailment)	$0.07	$0.08	$0.00	$0.01	$0.50	$0.51	$0.29	$0.30
Visibility of DER (enhanced power system operations) [55]	$0.12	$0.12	$0.12	$0.12	$0.20	$0.20	$0.20	$0.20

Source: Deloitte Access Economics. Note: CBA findings – key drivers of value incremental to the base cases (20-year time horizon, $FY23, 4.83% discount rate)

[32] Deloitte Access Economics. Project EDGE Cost Benefit Analysis. October 2023.

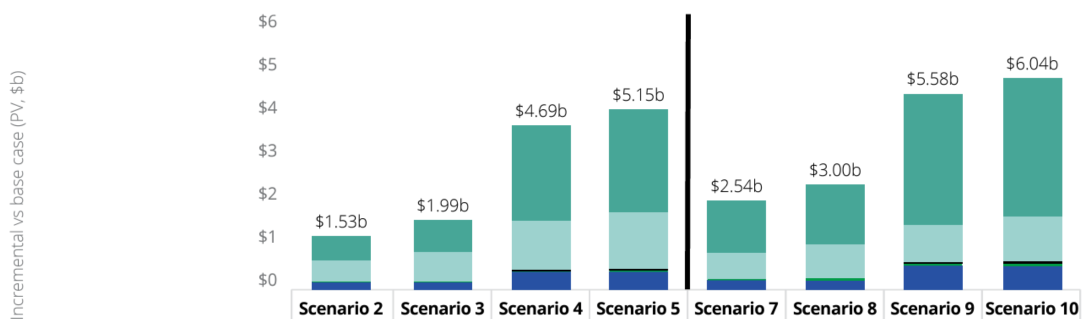
Scenario 10, which includes advanced dynamic operating envelopes (DOEs), high coverage of DER and a data hub, creates $6.04 billion in benefits. The vast majority ($5.08b) of this is in DOEs unlocking more network capacity for DER. This unlocked DER capacity is used to partially displace large generators in wholesale supply (the majority of the benefit), to provide local network support services and contingency FCAS.

Deloitte admits the CBA is a conservative estimate of the benefits as it does not include the benefits of:

- V2G.
- Any compounding effect of market configurations on DER uptake.
- Additional DER services such as retailers requesting DER aggregators manage DER exports and hedge their exposure during periods of negative prices.

The benefits allocated to distribution and transmission savings also seem small in comparison to other modelling (see table below).

Figure 9: Project EDGE cost benefit analysis by market participant by scenario over 20 years



Key drivers of value across the CBA Scenarios	Scenario 2 (Simple DOE, Moderate Coverage)	Scenario 3 (Simple DOE, Moderate Coverage with Data Hub)	Scenario 4 (Advanced DOE, High Coverage)	Scenario 5 (Advanced DOE, High Coverage with Data Hub)	Scenario 7 (Simple DOE, Moderate Coverage)	Scenario 8 (Simple DOE, Moderate Coverage with Data Hub)	Scenario 9 (Advanced DOE, High Coverage)	Scenario 10 (Advanced DOE, High Coverage with Data Hub)
DER Aggregators (includes Retailer VPPs) and DER Customer	$0.68	$0.90	$2.70	$2.93	$1.48	$1.71	$3.73	$3.95
DNSPs	$0.62	$0.84	$1.41	$1.62	$0.74	$0.96	$1.07	$1.28
TNSPs	$0.00	$0.00	$0.06	$0.06	$0.00	$0.00	$0.06	$0.06
Market Operator	$0.02	$0.04	$0.02	$0.04	$0.05	$0.07	$0.05	$0.07
Other (FCAS and Visibility of DER)	$0.20	$0.20	$0.50	$0.50	$0.26	$0.26	$0.68	$0.68

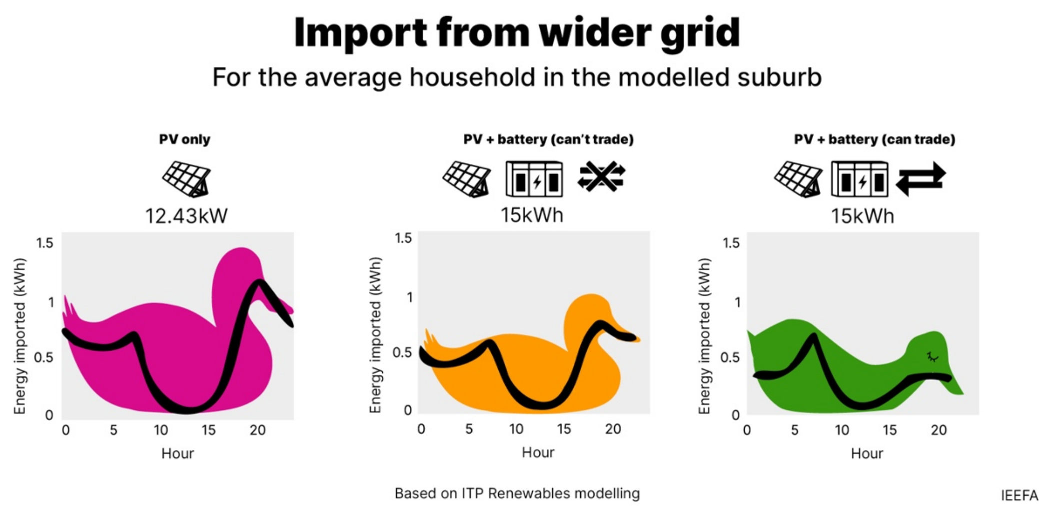
Source: Deloitte Access Economics. Note: CBA findings across key market participants (20-year time horizon, $FY23, 4.83% discount rate)

ITP Renewables for anonymous client 'Saturation DER modelling' (2022)

ITP Renewables modelled a range of scenarios for 'saturation' levels of DER. It first modelled a scenario where 70% of households had solar systems (i.e. every rooftop that can have solar, has solar and assuming that apartments and shaded homes will not have solar). It then added flexible demand (e.g. all hot water systems), battery storage to match ever solar system, batteries that can trade, and so on, and examined the consequences at different sizes. The modelling was done for a theoretical suburb in one state and climate zone across multiple scenarios, with majority households and some commercial and industrial demand.[33]

As in a previous IEEFA analysis, the modelling showed a reduction of up to 92% in the 4pm-8pm wholesale market evening peak (the green "sleeping duck" in **Figure 10**), consistent in the nature of outcome with the $10 billion of 'consumer cost savings' due to reduction in wholesale peak periods in the NERA modelling.[34]

Figure 10: The "sleeping duck" modelling under saturation levels of DER



In the ITP modelling, rooftop solar with household batteries that can trade easily reduced the average summer network peak by 64%. This is consistent with the $9.9 billion in avoided distribution investment and reduced curtailment costs found in the Baringa modelling, as distribution networks generally build to meet summer peaks.

This ITP modelling is the most comprehensive of all the modelling outlined in this report in that it tests multiple scenarios and examines the impacts of saturation DER on wholesale demand and network

[33] IEEFA. Saturation DER modelling shows distributed energy and storage could lower costs for all consumers if we get the regulation right. 27 April 2023.
[34] Ibid.

demand, including under different tariffs, and therefore the implications for consumers bills. Unfortunately, it is only for one jurisdiction and climate zone and is not publicly available.

The following table summarises the five economic studies of collective DER benefits by type and size of benefit modelled.

Economic analyses of the benefits of aggregated DER

Name of study	Total benefit value	Wholesale/generation cost reductions, including at peak times	Avoided/ reduced transmission costs	Avoided/ reduced distribution costs	Other cost reductions e.g. carbon emissions	Commentary
CSIRO and ENA. *Electricity Network Transformation Roadmap: Final Report.* (2017)	**$101bn saving to 2050** in cumulative electricity system total expenditure (in real terms) under the Roadmap compared with the Counterfactual.	**$5bn *more*** in centralised generation due to more customers staying on-grid **$22bn in reduced** on-site generation **Therefore, a net $17bn in reduced generation costs**	**$7bn** in reduced transmission costs	**$40bn** in reduced distribution costs **$16bn in network infrastructure investment is avoided through DER providing network services**	**$36 bn in avoided off-grid systems** (i.e. avoided death spiral)	Half of the savings in this analysis are in reduced distribution network service provider (DNSP) costs through networks paying consumers more than $2.5bn per annum for DER services.
Baringa Partners. *Potential network benefits from more efficient DER integration*. (2021)	Baringa's estimates of distribution and transmission network benefits, combined, are $2.3bn under AEMO's Central scenario, and **$11.3bn under the Step Change scenario in NPV by 2040.**	**None included**	$38m under the Central scenario, and **$1.4bn under the Step Change scenario**	$2.3bn in the Central scenario, and **$9.9bn in the Step Change scenario**	**None**	This analysis did not include reduced wholesale ancillary service costs or reduced wholesale energy costs (which could be significant as the "sleeping duck" curve modelling shows). It also does not include the broader spectrum of flexible demand either (other than rooftop solar, batteries or EVs).
NERA Economic Consulting. *Valuing Load Flexibility in the NEM*. (2022)	State of the World 4 (high DER) has the largest benefits of **$8bn (new build generation and storage savings only) or $18bn (consumer cost savings, including wholesale peak pricing reductions) NPV by 2040.**	**$8bn (new build generation and storage savings only) or $18bn (consumer cost savings, including wholesale peak pricing reductions) NPV by 2040**	**Not included**	**Not included**	**3Mt for SoW 4 (not priced)** Only the CO_2 emissions coming from fossil fuel-based thermal generators connected to the NEM, so it understates the emissions reductions from electrification	This analysis did not include network benefits so can be seen as the counterpart to Baringa's analysis, but the DER scenarios are not the same. The NERA analysis is more sophisticated in the sense it makes greater use of EVs and electrification than the Baringa analysis, which relies on the 2020 ISP scenarios.

Name of study	Total benefit value	Wholesale/generation cost reductions, including at peak times	Avoided/ reduced transmission costs	Avoided/ reduced distribution costs	Other cost reductions e.g. carbon emissions	Commentary
Deloitte Access Economics. *Project EDGE Cost Benefit Analysis*. (2023)	Scenario 10 produces a present value of **$6.04bn over 20 years** compared with the base case. (Note that in terms of drivers of value, **$5bn** of this is due to the introduction of DOEs)	**$3.95bn over 20 years** to DER Aggregators	**$0.06bn** in reduced transmission costs	**$1.3bn** in reduced distribution costs	**$0.68bn in FCAS and visibility of DER** **$0.07 in reduced system operator costs** The total emissions avoided can be up to 18,859,157 tonnes of carbon dioxide-equivalent (tCO2e) (**$1.54bn**) under the AEMO ISP Step Change DER uptake assumptions and up to 32,871,522tCO2e (**$2.60b**) under the High DER uptake assumptions.	The Project EDGE arrangement was found to avoid 50.1 Terawatt-hours (TWh) of customer rooftop solar curtailment to 2030 and up to 257.1TWh across the 20-year time horizon to 2042. The CBA also found that greater DER export capacity and VPP uptake can lower electricity sector emissions in the NEM (up to $2.60bn).
ITP Renewables. *Saturation DER modelling.* (2022)	Not available as modelling was only done for one NEM region	**4pm-8pm wholesale market evening peak reduces by 67%-92%**	Not available as modelling was only done for one NEM region	rooftop solar alone reduces the average summer network peak in the region modelled **by 28% and shifts it 2.5 hours later in the day.** In scenarios where household batteries can trade easily, **the average summer network peak is reduced by 64%.**		This modelling has the potential to create the clearest picture of DER benefits under multiple scenarios but needs to be conducted for the whole NEM and made publicly available.

Summary of the economic modelling of the collective benefits of DER

A comprehensive analysis of the economic benefits of DER for the NEM has not been undertaken. All of the five studies listed above have more than one of the following shortcomings:

- Underestimating revenue potential by not covering all possible sources of DER income/service provision and not including value stacking.
- Underestimating rooftop solar and battery storage (stationary and EVs) by failing to consider increases in power density (when based on AEMO projections, to be discussing in a forthcoming IEEFA report).
- Not considering the potential of EVs to discharge to homes or the grid (V2G or V2H) (this is however covered in the NERA report).
- Underestimating flexible demand capacity through not accounting for electrification (covered by the NERA report but no other).
- Underestimating DER exports by not including increases due to the adoption of DOEs (only covered by the Project Edge CBA).
- Not examining the impacts of different tariffs on DER utilisation and therefore household electricity prices (only the ITP modelling did this, but only for one suburb located in one climate zone/NEM region, and not publicly available).
- Not examining the reduced transmission expenditure using the latest cost estimates under the ISP (the draft 2024 ISP was released in December 2023).
- Not including estimates of greenhouse gas (GHG) emissions reductions bought forward by greater DER deployment and not estimating the benefits of these GHG reductions via a 'cost of carbon' or 'value of emission reductions'.

In terms of the strengths and weaknesses of the combined DER economic analyses, the ENA/CSIRO work was the most comprehensive, but is now five years out-of-date which means it underestimated DER's potential, especially the role of EVs with V2H and V2G which was only emerging technology at the time. It under-estimated the potential of DER to replace centralised generation and was done prior to the first ISP so will have underestimated the costs of future transmission build.

The NERA analysis is the next most comprehensive. It is insightful about the value that could be unlocked through consumers paying for BTM generation, storage and flexibility that reduces the cost of large-scale generation and storage, and the large reductions in generator supernormal profits due to reductions in peak demand. However, it does not include calculation of the network benefits, instead referring to the Baringa modelling.

The Baringa modelling only analysed the reduced transmission and distribution networks costs. It therefore missed all the other potential benefits of DER and is out of date given it is based on 2020 ISP scenarios.

The Project Edge CBA focuses on wholesale value of DER due to increased exports through the deployment of DOEs and seems to underestimate the potential role of DER in providing distribution network services, at only about 15% of the value of that calculated by the Baringa analysis.

The ITP Renewables analysis is more robust and comprehensive than any of the other economic analyses, but it only evaluates the impacts for one climate zone with household bill savings for that region, not NEM-wide cost savings. Moreover, the report is not publicly available.

Despite these shortcomings, these studies combined offer helpful insights into a rich-DER future.

Insights from the meta-analysis of the economic benefits of DER

Changes to the wholesale market are likely to be highly significant

The Saturation DER modelling shows that there could be highly significant reductions in wholesale prices if sufficient storage is installed with rooftop solar. Flexible demand could also have a similar impact by soaking up abundant solar generation during the middle of the day and not using it during the 4pm-8pm evening peak. Hot water is the largest potential near-term capacity here, but the role, for example, of air conditioning or of pre-heating commercial office buildings could also be significant.[35] **Both flexible demand and storage will be needed to optimise the value of DER.** After hot water, managed charging of EVs and EVs providing vehicle-to-home (V2H) or V2G (i.e. battery storage discharges) is the second biggest opportunity here, and will likely end up providing more capacity than hot water over the longer term.[36]

NERA's economic analysis states, "Due to the move in dispatch patterns away from system peak, electricity prices tend to decrease by more on average than just the forward-looking costs. This means that the savings to consumers from flexibility is usually greater than the savings in forward-looking costs. In other words, there is a reduction in generator profits, beyond the reduction in true system costs."[37] This suggests a fundamental change in the wholesale market, the "sleeping of the duck", or as Western Power has put it, the supply/demand curve evolving to resemble a platypus.[38]

With fewer incidences of high prices and lower extreme prices, overall costs for consumers should decrease significantly, if the market works as designed.

[35] GBCA and Buildings Alive. From net zero to zero: A discussion paper on grid-interactive efficient buildings. 22 June 2023.
[36] enX. V2X.au Summary Report – Opportunities and Challenges for Bidirectional Charging in Australia . 30 June 2023. Prepared for ARENA.
[37] NERA Economic Consulting. Valuing Load Flexibility in the NEM. 1 February 2022. Page 112.
[38] Renew Economy. From solar duck to platypus: Ground-breaking energy shift changes demand curve. 5 November 2021

DOEs are essential to realise the value of DER

The Project EDGE cost-benefit analysis shows for the value of DER to be unlocked, the implementation of DOEs is vital. Roughly 80% of the $6 billion benefit identified in the Deloitte analysis for Project Edge is related to DOEs.

South Australia Power Networks (SA Power networks) commissioned a cost-benefit analysis from KPMG for implementing dynamic operating envelopes, which estimated an NPV of $39.68 million to 2035.[39] This was based on neutral DER growth assumptions when compared to a 'do nothing' option.

The Deloitte analysis for Project Edge would suggest this level of benefit is highly conservative and that distribution network service providers (DNSPs) across the NEM should fast-track the implementation of DOEs to reduce bills for all consumers. This also suggests DOEs should be the default offer for consumers, with flat export rates as opt-in.

Flexibility is vital to unlock value in electrification

The NERA analysis shows installing DER has benefits, but it is DER with high degrees of flexibility that is vital to unlock the greatest benefits, and that the value of load flexibility increases as DER capacity increases.

NERA states that "more ambitious states of the world will be more expensive in the absence of load flexibility, and hence the value of load flexibility increases in more ambitious states of the world. The uptake of greater demand side participation reduces costs in a way that may support electrification and the electrification of some sectors of production or consumption may not materialise in absence of demand response, as it would be very expensive to both the system and consumers to build and maintain capacity to meet the increased demand. The availability of demand response technologies could therefore enable policymakers to work towards greater electrification in pursuit of economic or emission reduction objectives." [40]

In other words, flexibility with electrification provides a virtuous circle that unlocks greater VRE to match the increased demand of electrification. It is not sufficient to deploy DER or VRE, we need to optimise flexible demand in the system to minimise the costs of the energy transition.

> **It is not sufficient to deploy DER or VRE, we need to optimise flexible demand in the system to minimise the costs of the energy transition.**

Several policies and regulations are needed to ensure electrification supports flexibility. In particular,

[39] SA Power Networks. LV Management Business Case, Supporting document 5.18. 25 January 2019.
[40] NERA Economic Consulting. Valuing Load Flexibility in the NEM. 1 February 2022. Page ix.

we need to put in place standards to ensure major household appliances have 'flexible demand' capacity, as detailed in the IEEFA report *Growing the Sharing Energy Economy*.

To provide network services, DER must have a level playing field with capital expenditure

While the wholesale benefits of DER will be significant, it is likely that there is also just as much, if not more value to be unlocked in the reduced cost of network services, as illustrated in the CSIRO/ENA Electricity Transformation Roadmap modelling and the Baringa modelling for the ESB. The largest component of this is avoided distribution and transmission investment ($9.6 billion of the $11.3 billion to 2040), which will likely require changes to network revenue regulation to be realised.

Baringa warns that changes are needed soon "because after certain expenditure on network upgrades are incurred, or after certain solar PV is curtailed in a particular year, these impacts cannot be reversed even if they were avoidable if reforms to more efficiently integrate DER had taken place earlier." [41] The timing of the next round of DNSP regulatory resets due to lock in capital expenditure are shown by jurisdiction in the map below.

Figure 11: Timings for the next round of DNSP regulatory resets

Source: Australian Energy Regulator (AER)

There is an enormous risk that the size of the Regulated Asset Bases (RABs) of the distribution businesses will continue to grow, locking out the use of DER for the provision of network services because of the capex-bias in the existing revenue regulation.[42] It is urgent that we consider afresh how to remunerate distribution networks in an era of high and growing DER. For further information on the need for a first principles review of distribution network revenue regulation, see the 2023 IEEFA report *Growing the Sharing Energy Economy*.[43]

[41] Baringa Partners. Potential network benefits from more efficient DER integration. 18 June 2021. Page 13.
[42] KPMG. Optimising Network Incentives Report. 2018.
[43] IEEFA. Growing the Sharing Energy Economy. 13 October 2023.

If DER is well integrated, the economic benefit will be at least $19 billion by 2040

There are multiple potential economic benefits from DER as outlined at the beginning of this report. No study has examined all of them in one economic analysis. However, if we combine Baringa's $11 billion in distribution and transmission network cost reductions and NERA's $8 billion in generation and storage cost reductions there is a combined NPV of more than $19 billion by 2040.

While it could be argued that this combined total is misleading as the studies were not equivalent, there is no overlap in the benefits assessed and, if anything, the resulting value is likely to be conservative given the Baringa study is based on the 2020 ESOO and does not include all possible sources of demand flexibility. Ideally, a comprehensive analysis of the economic value of rooftop solar, battery storage and flexible demand would be conducted for the NEM using the ITP saturation DER model.

There is a fundamental logic to why a high DER energy transition will be cheaper:

- Consumers pay more of the capital cost of the generation and storage directly, and what they purchase is co-located with load, reducing network and retail costs.
- The smart on-site use of DER reduces the use of the network and reduces network peaks (as the "sleeping duck" modelling shows), so it should reduce the cost of networks. Obviously, if EV charging is badly managed, it could increase peak demands on distribution networks, especially in winter, but there is considerable headroom available in the distribution networks given the falling utilisation. This issue requires further analysis, taking into account the potential for V2H and V2G.
- There is large capacity available in distribution networks most of the time due to declining utilisation over the 15 years, as shown by the fact that South Australia Power Networks' DOEs are only expected to bind below the 10kW limit 2% of the year.[44,45]
- The time efficiencies compared with large-scale generation and transmission construction are significant.
- The social licence issues are minimal compared with large-scale generation and transmission.

[44] Australian Energy Regulator (AER). Electricity performance report 2023. July 2023. Page 26.
[45] SA Power Networks. Flexible Exports FAQs.

Summary of findings

Benefit / Service	Avoided networks costs	Avoided centralised generation and storage costs	Avoided system management costs	Best current understanding of scale of benefits	Further research required	Ability to capture benefits through existing mechanisms	Actions required to realise benefits
Electricity generation	☑	☑		Rooftop solar reduced the average annual prices in the NEM by an estimated $3.1/MWh in 2017, $4.7/MWh in 2018 and $6.4/MWh in 2019[46]	Benefits with DOEs in place	Presently, most solar PV exports are limited to 5kW in most distribution networks[47] Feed-in tariffs vary across the grid, but are not based on time or specific location	• DOEs implemented across the NEM and WEM • Ideally, time and location varying feed-in tariffs

[46] Victoria Energy Policy Centre. Rooftop PV and electricity distributors: who wins and who loses? June 2020.
[47] IEEFA. Growing the Sharing Energy Economy. 13 October 2023.

Benefit / Service	Avoided networks costs	Avoided centralised generation and storage costs	Avoided system management costs	Best current understanding of scale of benefits	Further research required	Ability to capture benefits through existing mechanisms	Actions required to realise benefits
Storage	☑	☑	☑	Storage will reduce evening price peaks, "putting the duck curve to sleep". Analysis shows that the 4am-8pm evening peak will effectively disappear[48,49]	Understanding of V2G potential at early stages[50]	Storage can receive payment for its services through the wholesale market and some FCAS markets, but not yet network services (beyond pilots). Storage may be included in the NSW PDRS.	• Subsidies and loans to support battery purchases, enabling scale up of DER storage. • Allow aggregated household storage to participate in the Capacity Investment Mechanism. • Aggregated batteries to participate in all FCAS markets

[48] NERA Economic Consulting. Valuing Load Flexibility in the NEM. 1 February 2022.
[49] IEEFA. Saturation DER modelling shows distributed energy and storage could lower costs for all consumers if we get the regulation right. 27 April 2023.
[50] IEEFA. Distributed storage will be the majority of storage. 8 November 2023.

Benefit / Service	Avoided networks costs	Avoided centralised generation and storage costs	Avoided system management costs	Best current understanding of scale of benefits	Further research required	Ability to capture benefits through existing mechanisms	Actions required to realise benefits
Flexible demand	☑	☑	☑	Reasonable understanding of the benefits of flexibility through NERA's scenarios.[51] Rapid electrification of hot water has been well explored by UTS, finding $4.7bn in savings (from reduced gas and electricity use) by 2040.[52]	Further work to break down savings from different types of flexibility – and better bottom-up analysis of electrification	Only households with Amber or Origin Spike or households falling under the NSW PDRS can benefit from financial rewards for flexing their demand	• Policy and programs need to optimise flexibility at every possible opportunity. • Rewards for flexible demand including through the wholesale DRM • Allow consumers to have multiple trading relationships to realise value from RERT and flexible demand
Distribution network services	☑		☑	Some understanding of the potential for DER to provide network services, as in the CSIRO/ENA report, though this needs to be updated.	Investigation of the scale of network services DER could provide under revised economic regulation.	Economic regulation of distribution networks is capex-biased and DER cannot compete with networks on a level-playing field	• Reform the economic regulation of networks – urgent need for a first-principles review of distribution network revenue regulation

[51] NERA Economic Consulting. Valuing Load Flexibility in the NEM. 1 February 2022.
[52] UTS Institute for Sustainable Futures. Domestic Hot Water and Flexibility. 5 June 2023.

Benefit / Service	Avoided networks costs	Avoided centralised generation and storage costs	Avoided system management costs	Best current understanding of scale of benefits	Further research required	Ability to capture benefits through existing mechanisms	Actions required to realise benefits
FCAS			☑	Grids analysis suggests DER has provided 10-20% of contingency FCAS in the NEM since 2018[53]	Publicly available analysis of the potential for DER to provide FCAS	DER can only participate in contingency FCAS, not yet regulation FCAS	• Consider DER participation in regulation FCAS and other future Essential System Services
RERT		☑	☑	1,422 MW of flexible demand was contracted over 2019-21, delivering 5,223 MWh of flexible demand at $1296.86/MWh and a benefit-to-cost ratio of almost 2:1[54]	None	No barriers to DER providing RERT following Demand Response Short Notice Reliability and Emergency Reserve Trader Trial from 2017 to 2020[55]	• Allow consumers to have multiple trading relationships contracts with multiple retailers or aggregators - to realise value from RERT and flexible demand

[53] Grids. 2023 DER in Energy Markets.
[54] RACE for 2030 CRC. Flexible demand and demand control. October 2021.
[55] ARENA. Demand Response Short Notice Trial RERT Trial Year 3 Report. October 2021.

Benefit / Service	Avoided networks costs	Avoided centralised generation and storage costs	Avoided system management costs	Best current understanding of scale of benefits	Further research required	Ability to capture benefits through existing mechanisms	Actions required to realise benefits
Economic benefits (NPV by 2040)	**$11bn** of avoided distribution network investment/reduced curtailment costs[56] • $9.9bn in avoided transmission network investment • $1.4bn in reduced curtailment costs	$8bn			Full value stack modelling, preferably Saturation DER modelling for the NEM. Further analysis of the value of the transmission peak load reduction is required. Analysis of value of avoided GHG emissions for all potential revenue streams.		

[56] Baringa Partners. Potential network benefits from more efficient DER integration. 18 June 2021.

Conclusion

This meta-analysis shows the economic value of DER integration could be highly significant – of the order of $19 billion by 2040 for only the generation and network benefits. Consumers could also benefit through another $10 billion reduction in wholesale super profits. Further value could be unlocked through, for example, the fast-tracking of DOEs. Despite the world-leading uptake of household rooftop solar in Australia, we are only at the formative stages of recognising how the integration of DER could support a lower-cost, smoother energy transition. Both NERA and Baringa warn that delays in DER integration will reduce the economic benefits that could be realised by 2040.

There are only five studies that have investigated the economic benefits of DER collectively for the Australian electricity system. While none are comprehensive, they collectively show there are major benefits that can be unlocked in terms of the following value streams:

- Wholesale costs/reducing the need for centralised generation.
- Reduced generator supernormal profits in the wholesale market.
- Reduced/avoided transmission costs.
- Reduced/avoided distribution costs.
- GHG emissions reductions.

Missing from these analyses are estimates of the value DER could provide in terms of:

- Wholesale Demand Response (WDR).
- Frequency Control Ancillary Services (FCAS).
- Reliability and Emergency Reserve Trader (RERT).
- Capacity – under the Federal Government's Capacity Investment Mechanism.

Also missing, but next to impossible to calculate in terms of economic value, is the resilience that DER can provide, such as providing power when distribution networks are offline due to extreme weather events.

As the AER's State of the Energy Market 2023 stated, "The effective integration of consumer energy resources into the electricity system presents a significant opportunity to lower electricity costs for all electricity consumers. … Harnessing CER assets and the new energy services that they enable is critical for an orderly and cost-effective energy transition."[57]

If we want to underpin Australia's future economic prosperity with lower electricity and transport costs and electrification to eliminate gas prices, we need courageous action on DER integration. DER must not come second in policy, planning and regulation to transmission and large-scale generation. DER must be considered on equal terms with more thoughtful recognition of its multiple benefits.

[57] AER. State of the Energy Market 2023. October 2023. Page 59.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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Dr Gabrielle Kuiper is an energy, sustainability and climate change professional with over 20 years' experience in the corporate world, government and non-government organisations and academia. Dr Kuiper has held senior executive or senior advisory energy-related positions at the Energy Security Board, in the Office of the Prime Minister, at the Public Interest Advocacy Centre (PIAC) and in the NSW Government. Dr Kuiper currently works internationally on oil and gas strategy and in Australia on policy and regulation to support Distributed Energy Resources (DER), including as a guest contributor with IEEFA.

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