Jemena Electricity Networks (Vic) Ltd

2021-26 Electricity Distribution Price Review - Revised Proposal

Attachment 04-02

Future Grid Investment Proposal (Addendum)

Table of Contents

Glossary

initial proposal	JEN's proposal to the Australian Energy Regulator setting our revenue and pricing requirements over the next regulatory period
next regulatory period	The regulatory control period covering 1 July 2021 to 30 June 2026
VaDER report	Koerner M, Graham P, Spak B, Walton F, Kerin R (2020), *Value of Distributed Energy Resources: Methodology Study: Final Report*. CutlerMerz, CSIRO, Australia

Abbreviations

AER	Australian Energy Regulator
DER	Distribution Energy Resources
DERMS	Distributed Energy Resource Management System
DSS	Distribution Substations
JEN	Jemena Electricity Network
OLTC	On-load Tap Changer
VaDER	Value of Distribution Energy Resources

1. Future Grid – Summary of program

Jemena Electricity Network's (**JEN**'s) initial regulatory proposal (**initial proposal**) for the 2021-2026 regulatory control period (**next regulatory period**) included $28.5 million ($2021) of capital expenditure and $3.75 million of operating expenditure step changes to deliver on the outcomes of our Future Grid Program. We detailed this program in *Attachment 05-04 – Future Grid investment proposal – 31 January 2020*.

Regarding the draft decision on JEN's Future Grid Program outlined in our initial proposal, the Australian Energy Regulator (**AER**):

- accepted our proposed Future Grid capital expenditure overall, however, did note concerns from some stakeholders about the assumed value of distributed energy resources (**DER**) – discussed in section 2 of this document
- did not accept our proposed operating expenditure step change.

JEN's revised proposal for the next regulatory period has amended its capital expenditure forecast to include two of the three initiatives originally included in our opex step change forecast. These initiatives are:

1. preparatory work packages to investigate how best to implement design changes to JEN's systems
2. the development of processes and the collection of data for low voltage network assets.

This change in approach has meant JEN's Future Grid capital expenditure is increasing from $28.5 to $30.4 million ($2021). This revised proposal amount also incorporates minor cost escalation adjustments.

JEN's revised proposal does not include any operating expenditure step changes for our Future Grid program, as we have removed the third limb of our original operating expenditure step change—namely an incentive for customers to modify the settings of their DER inverters to enable voltage regulation. Removal of this customer incentive may result in these systems tripping-off when their connection point voltage exceeds 253V rather than using the inverter capabilities to reduce the amount of energy being exported to the grid but continuing to operate.

Our proposed capital expenditure can broadly be split into two categories:

- Investments in systems to help us better understand how DER is impacting the network, and provide JEN with the capability to define operating envelopes for DER customers and to assess existing and forecast network constraints to DER export (which can then be used to analyse and determine the prudent levels of investment to increase total hosting capacity)
- Investments that are necessary to increase the hosting capacity of the distribution network to receive additional DER exports from customers. This includes both system-wide investments for voltage regulation and dynamic exports limits for commercial customers as well as network upgrades to low-voltage and distribution transformer assets.

JEN's revised proposal includes the capital expenditure shown in Table 1-1.

Table 1-1: Future Grid revised capital expenditure forecast (5 years, $2021)

	FY22	FY23	FY24	FY25	FY26	Total
Foundation investments (tools & systems)	4.4	2.1	3.6	3.8	2.0	**15.9**
Investments to increase network hosting capacity	1.2	1.9	4.9	3.3	3.2	**14.5**
Network wide control systems	*-*	*0.5*	*3.2*	*1.3*	*1.1*	***6.1***
Spatial hosting capacity network upgrades	*1.2*	*1.4*	*1.7*	*2.0*	*2.1*	***8.4***
TOTAL	**5.6**	**4.0**	**8.5**	**7.1**	**5.2**	**30.4**

JEN has already commenced work in developing an action plan for these foundation investments. The challenges the network faces due to increased levels of DER, the outcomes we are aiming to achieve and the first steps on the journey to future proof our network are shown in Figure 1–1. The challenges and outcomes are grouped across five key streams identified as part of Energy Networks Australia's Electricity Network Transformation Roadmap.[1]

[1] https://www.energynetworks.com.au/resources/reports/electricity-network-transformation-roadmap-final-report/

Figure 1–2 details JEN's proposed DER Integration Roadmap. This roadmap will evolve as the long term industry technical, regulatory and economic direction becomes clearer. For now, the proposed plan represents the minimum preparation work required to set our Future Grid vision up for success.

Figure 1–1: JEN Future Grid – Initial Action Plan

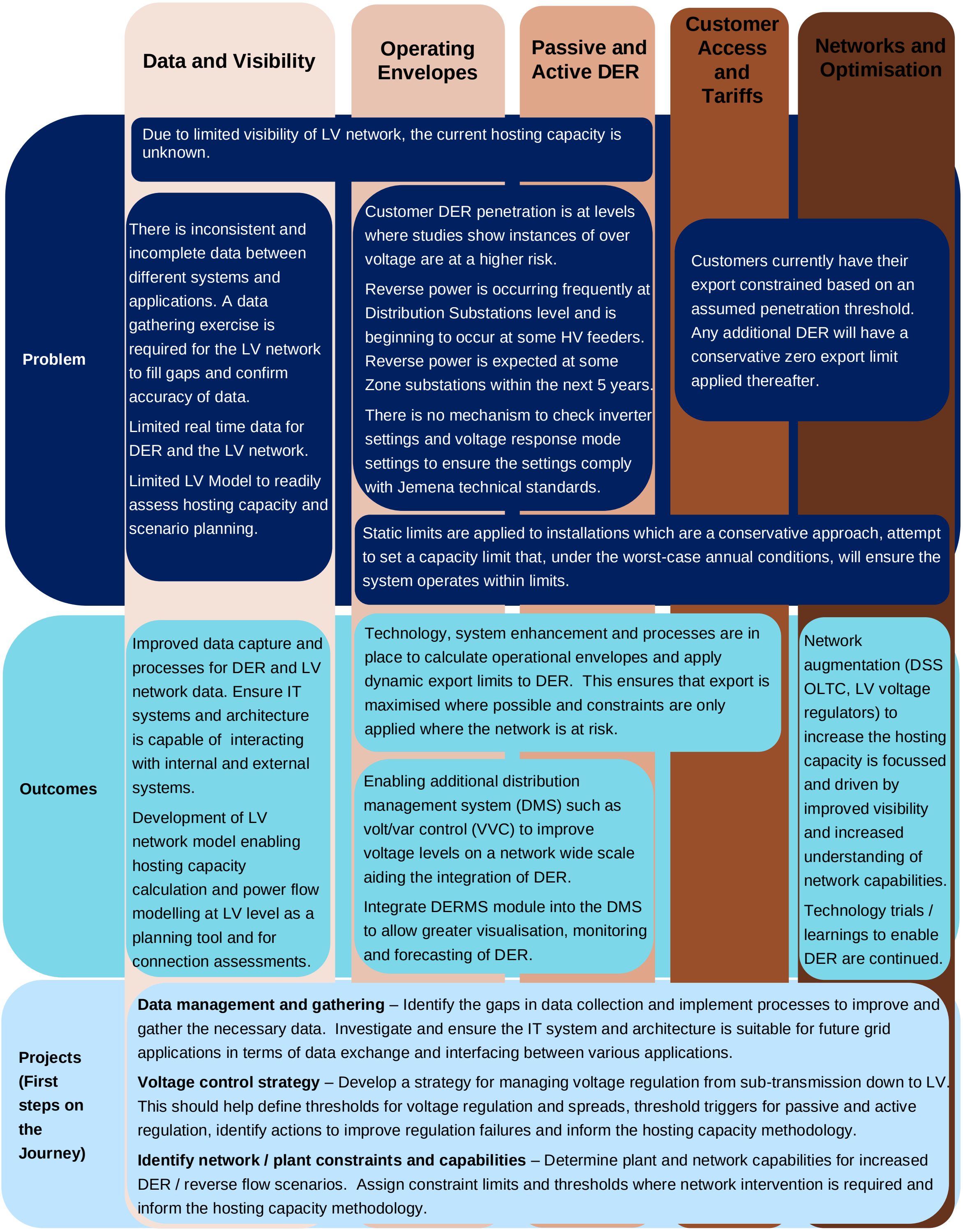
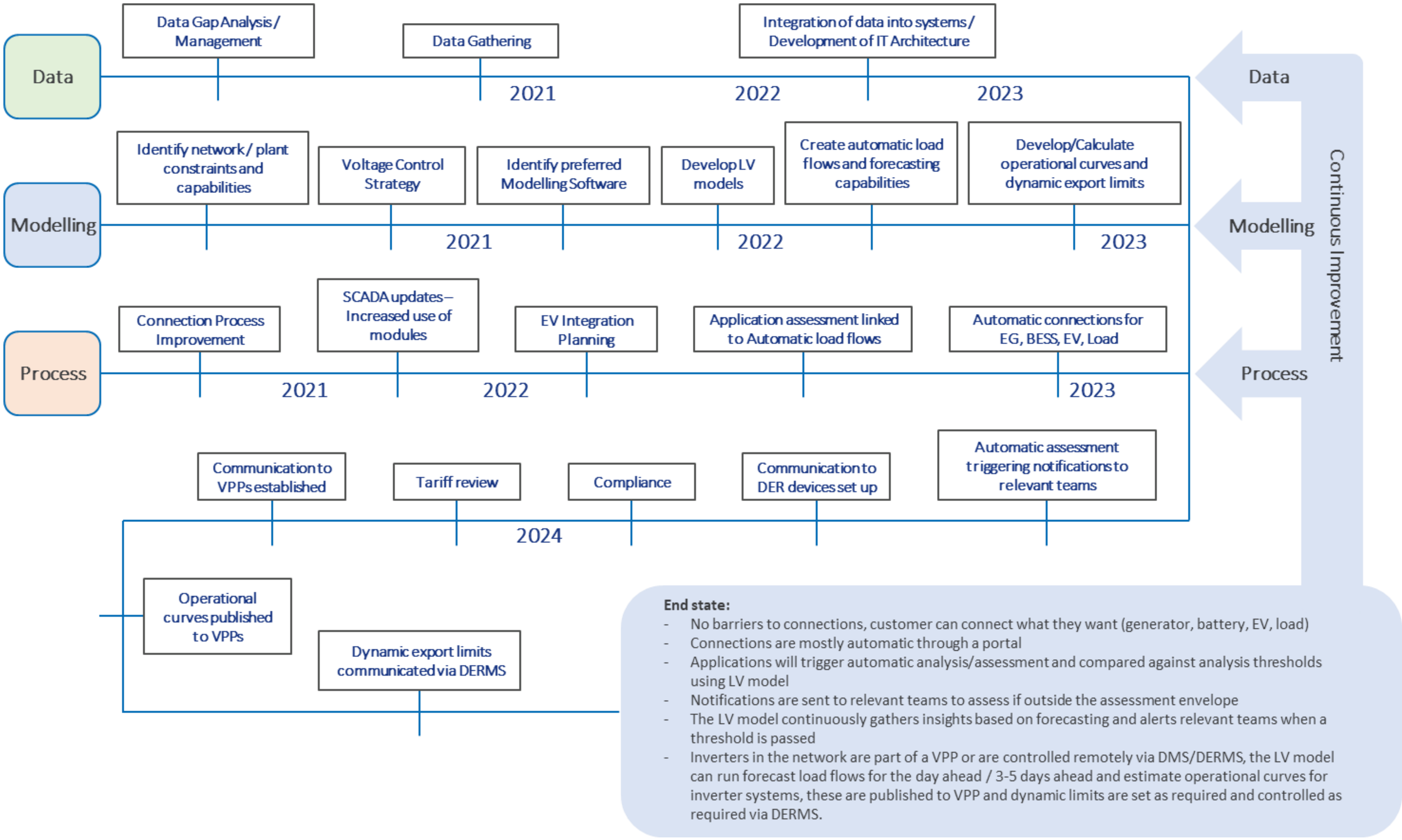


Figure 1–2: DER Integration Roadmap



2. Value of DER – Justification Sensitivity Analysis

In recent years, numerous industry forums have discussed and debated the value of DER benefits to be used in assessing the efficiency of investments by network service providers to enable DER. In acknowledgement of this, the AER commenced work in this area in November 2019 (‘Assessing Distributed Energy Resources Integration Expenditure’), with the objective of publishing a guideline to outline how it would assess such expenditure proposed by networks. As part of this work, the AER commissioned CSIRO and CutlerMerz to conduct a study into potential methodologies for determining the value/s of DER, which should be used in cost-benefit analysis.

The final VaDER report[2] was published in November 2020 (**VaDER report**). The approaches to value DER outlined by the VaDER report have some differences to the approach we used to value DER when assessing our Future Grid program. Due to the uncertainty around how (or whether) the VaDER report’s recommended methodologies might be incorporated into the AER’s future DER expenditure assessment guideline, and given the outstanding questions around the practical application of the VaDER methodologies, we have not sought to apply these to our Future Grid program.

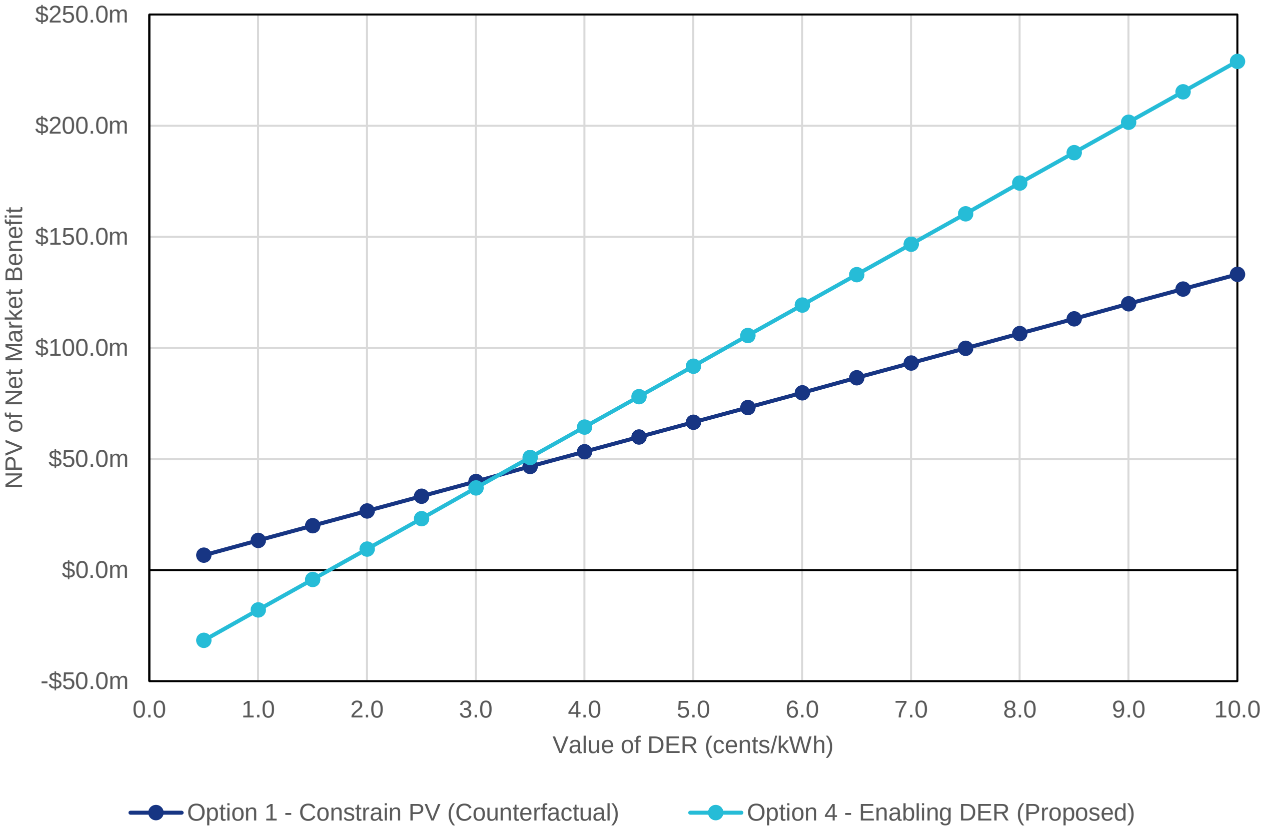
However, acknowledging concerns and uncertainty around the valuation of DER benefits, JEN has undertaken a sensitivity analysis on the value of DER assumed in our Future Grid investment proposal. This analysis demonstrates that our proposed capital expenditure is prudent and efficient as the ‘break-even point’ for DER benefit values is materially lower than the values of DER applied by all other Victorian Network Service Providers in their initial regulatory proposals.

The CSIRO and CutlerMerz VaDER report focuses on assessing the efficiency of network investments which increase the hosting capacity of the network (i.e. remove or address DER constraints). As shown in Table 1-1, JEN is proposing $14.5 million ($2021) of capital expenditure to increase network hosting capacity during the next regulatory period.

Undertaking the same VaDER sensitivity analysis, as described above, but focused only on investments which increased DER hosting capacity produces the NPV sensitivity results shown in Figure 2–1. This demonstrates that our Option 4 (‘Build Smart’), which is reflected in our forecast capital expenditure, remains the preferred option where the value of DER benefits is greater than 3.2 cents per kilowatt-hour.

[2] Koerner M, Graham P, Spak B, Walton F, Kerin R (2020) *Value of Distributed Energy Resources: Methodology Study: Final Report*. CutlerMerz, CSIRO, Australia.

Figure 2–1: Hosting capacity increase NPV sensitivity to DER values



3. Current state of DER in JEN

Two key factors used as input in the economic analysis of our Future Grid investment proposal are the:

- forecast penetration of DER on our network, and
- assumed penetration rate at which DER constraints eventuate.

The analysis presented in this section demonstrates that:

- DER penetration is already tracking above the forecast levels presented in our initial regulatory proposal
- network issues resulting in DER congestion or constraints are beginning to emerge earlier than previously forecast
- at a distribution substation level, JEN has 2,120 distribution substations (34% of JEN's distribution substations) where DER penetration is at a level requiring active management
- at a HV feeder level, 17 feeders are starting to experience reverse power flows—this phenomenon has emerged recently, and as DER continues to be installed, more of our feeders are likely to experience reverse power
- at a zone substation level, there are no instances of reverse power, however, forecasts indicate that reverse power is likely to occur at three of our zone substations from 2021/22.

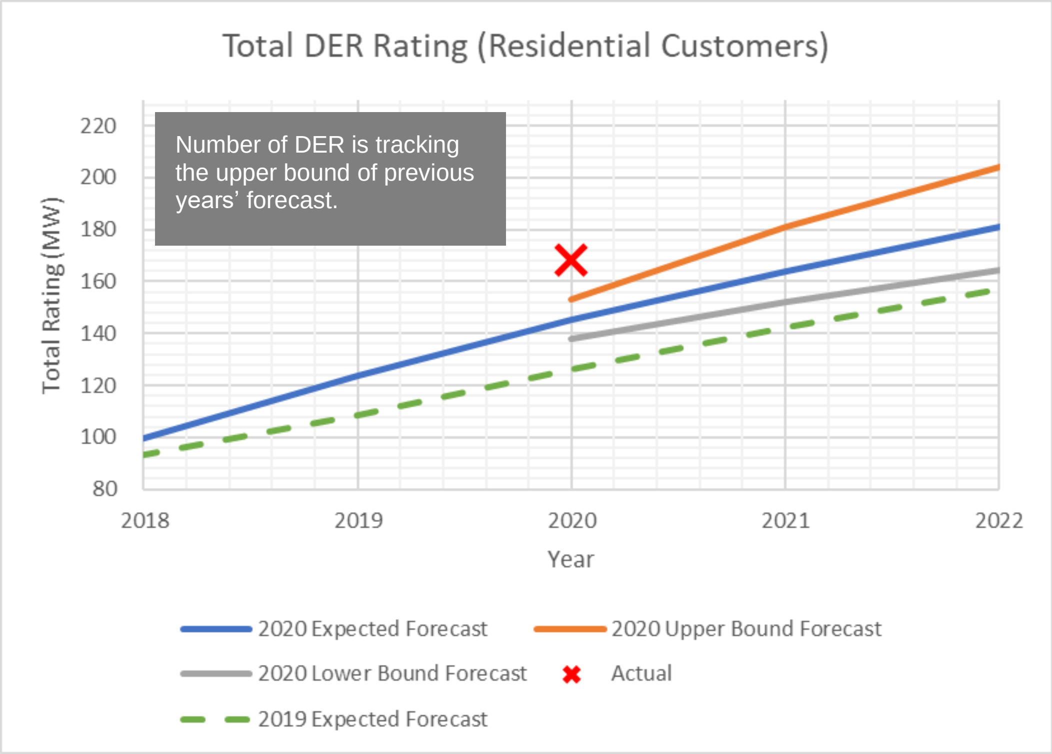
3.1 DER Forecast

The total number of DER installed in JEN's distribution area exceeds 45,000, which is equivalent to 12.5% of our customers. In 2020, the actual number of DER installations has exceeded our 2020 expected forecast. Also, the average size of DER installations has also exceeded our 2020 expected forecast.

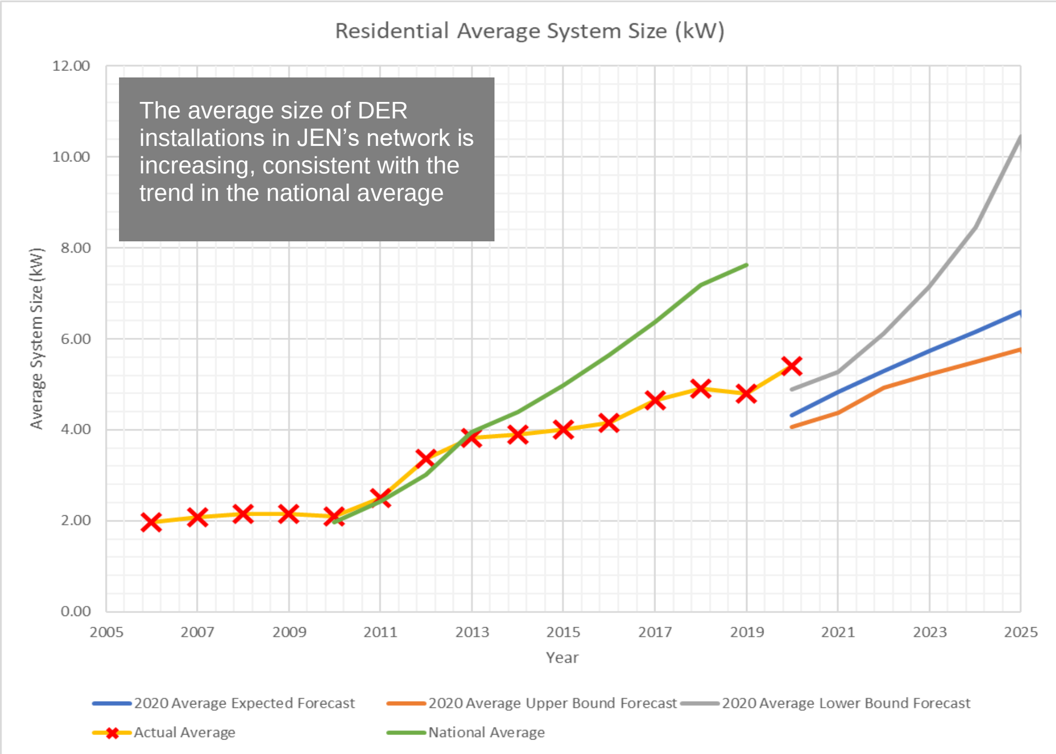
Key data—shown in the table and figures below—outlines the total number of DER installed.

	Number of DER installations	DER rating (MW)	% of customers
Residential customers	43,309	168	13.1%
Commercial/industrial customers	1,660	79	5.4%
All customers	**45,003**	**247**	**12.5%**

[3] Data/figures are taken as at 5 October 2020


Total DER Rating (Residential Customers)
Number of DER is tracking the upper bound of previous years' forecast.
Total Rating (MW)
220
200
180
160
140
120
100
80
2018
2019
2020
2021
2022
Year
2020 Expected Forecast
2020 Upper Bound Forecast
2020 Lower Bound Forecast
Actual
2019 Expected Forecast


Residential Customers
Total rating of installed DER is tracking the upper bound forecast of previous years'
Customer Numbers
60,000
55,000
50,000
45,000
40,000
35,000
30,000
2018
2019
2020
2021
2022
Year
2020 Expected Forecast
2020 Upper Bound Forecast
2020 Lower Bound Forecast
Actual
2019 Expected Forecast



3.2 DER penetration analysis at Distribution Substations (DSS)

In the absence of being able to perform detailed network analysis and constraint modelling of low voltage network and distribution substations (**DSS**), JEN assumed the network would reach its hosting limit when 30 per cent of customers supplied by a DSS install DER (i.e. customer DER penetration) when developing our Future Grid program.

We consider the 30% hosting limit is a relatively conservative assumption, as the following analysis demonstrates that:

- network hosting capacity limits can occur at 20% of customer DER penetration
- the various methods of approximating DER penetration limits highlight that for one-third of JEN's DSS, DER customers are at risk of experiencing some form of DER export constraint.

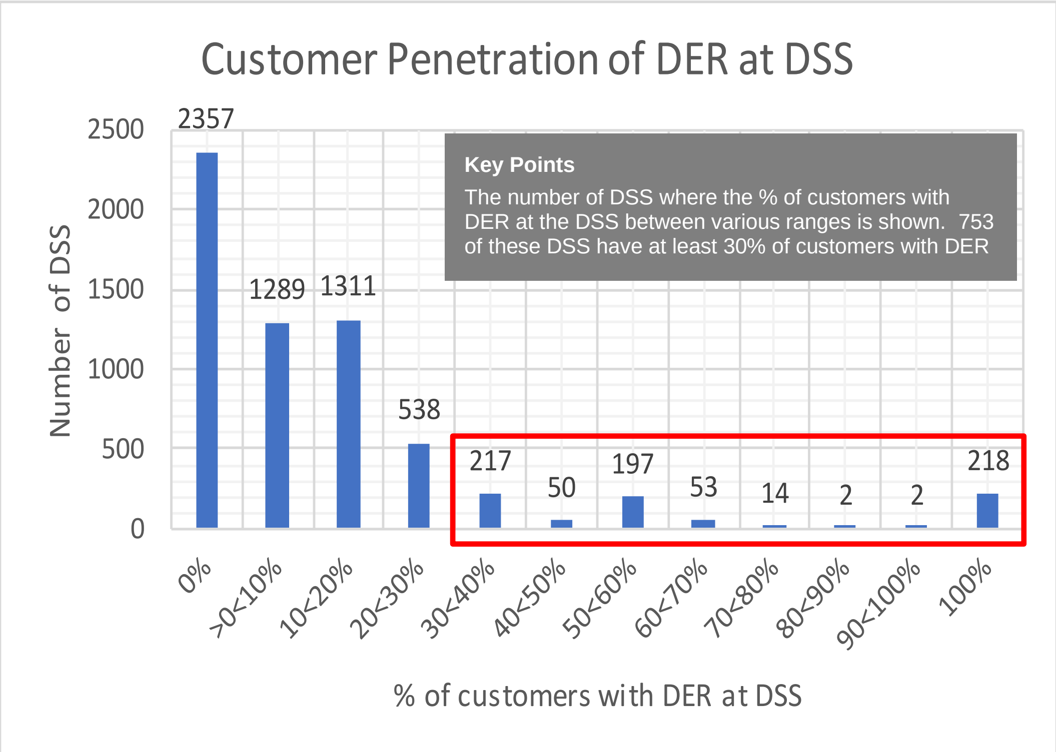
We have considered three indicators to approximate DER penetration limits at each DSS. These indicators are outlined in the table below, alongside the summary results of our analysis. These results are discussed further in the sections below.

Overall, there are 2,120 (34 per cent) of JEN's DSS where at least one of these three indicators has been met. Customers connected to these substations who wish to connect (or upgrade the size of) DER are at risk of being constrained. This accounts for 115,844 customers or 32 per cent of JEN's customer base.

Indicator	Notes	Summary of JEN results
1. The number of customers with DER connecting to DSS (Customer % DER Penetration Analysis)	A recent study by Melbourne University on behalf of Ausnet Services[4] identified that instances of high voltage can be observed when the customer penetration is at 20%. JEN's Future Grid Investment Proposal uses a 30% penetration level threshold.	753 (~12%) of JEN's DSS already have at least 30% customer DER penetration
2. The total rating of the DER connecting to the DSS (DER Rating Analysis)	Traditional planning methods will typically allow DER connections up to 30% of the transformer rating and then constrain all other DER export at the DSS.	724 (~12%) of JEN's DSS have an aggregate total DER rating at least 30% of the DSS transformer rating
3. DSS in reverse power (DSS in Reverse Power Analysis)	Increasing the transformer rating, DSS tap changes and on-load tap changers (**OLTC**) at the zone substation will not address reverse power in the network and a greater understanding of the plant capabilities is required to allow DER to be connected safely.	2007 (~32%) of JEN's DSS are experiencing reverse power

3.2.1 Customer % DER Penetration Analysis

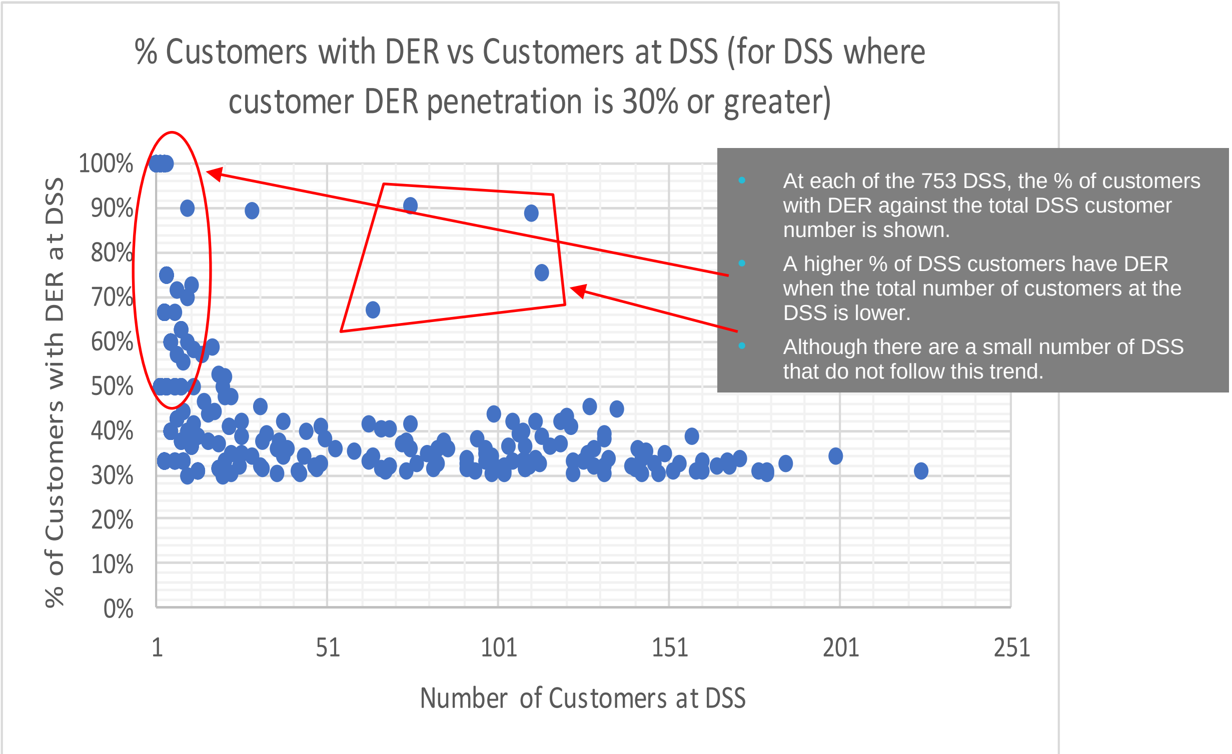
This indicator considers the number of customers with DER who are connected to a DSS.



4 A.T. Procopiou, K. Petrou and L. Ochoa – The University of Melbourne, *Advanced Planning of PV-Rich Distribution Networks – Deliverable 3: Traditional Solutions*, 25 February 2020, https://arena.gov.au/assets/2019/02/advanced-planning-of-pv-rich-distribution-networks-deliverable-3-traditional-solutions.pdf

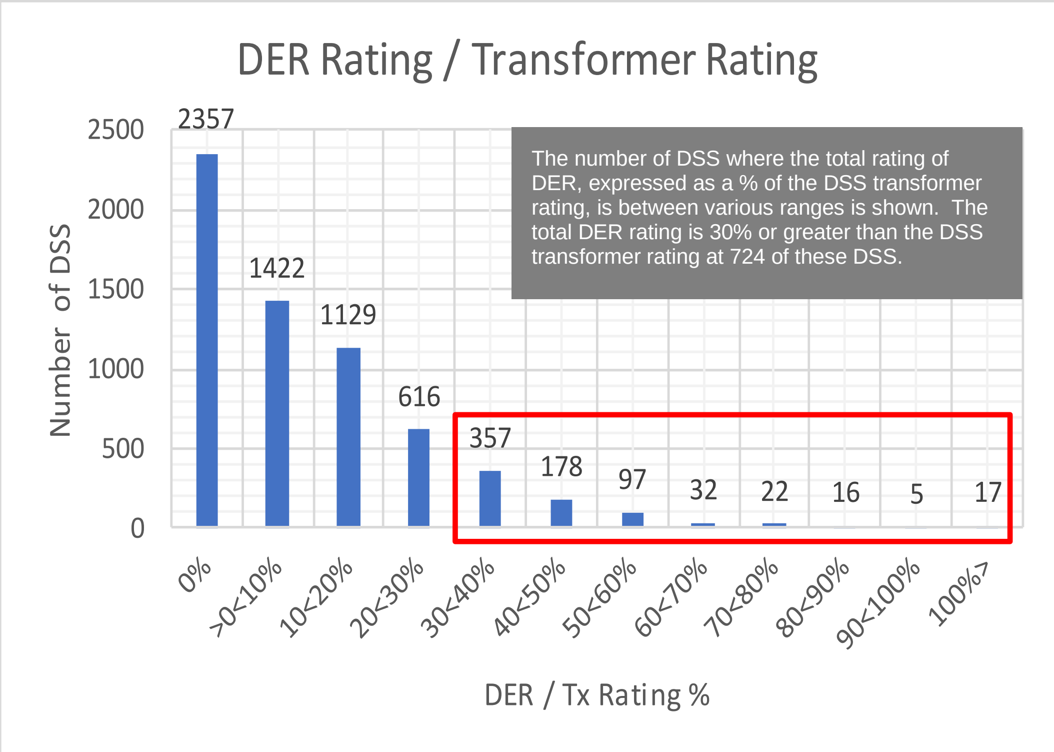
The table below shows the break-down of customers supplied by the 753 DSS (12% of DSS population) where customer DER penetration exceeds 30%. This highlights that 9,272 customers are at risk of being constrained if they sought to connect DER.

At 753 DSS where customer DER penetration ≥30%	
Total DSS Customers	15,032
Total Customers with DER	5,760
Total Customers without DER	9,272



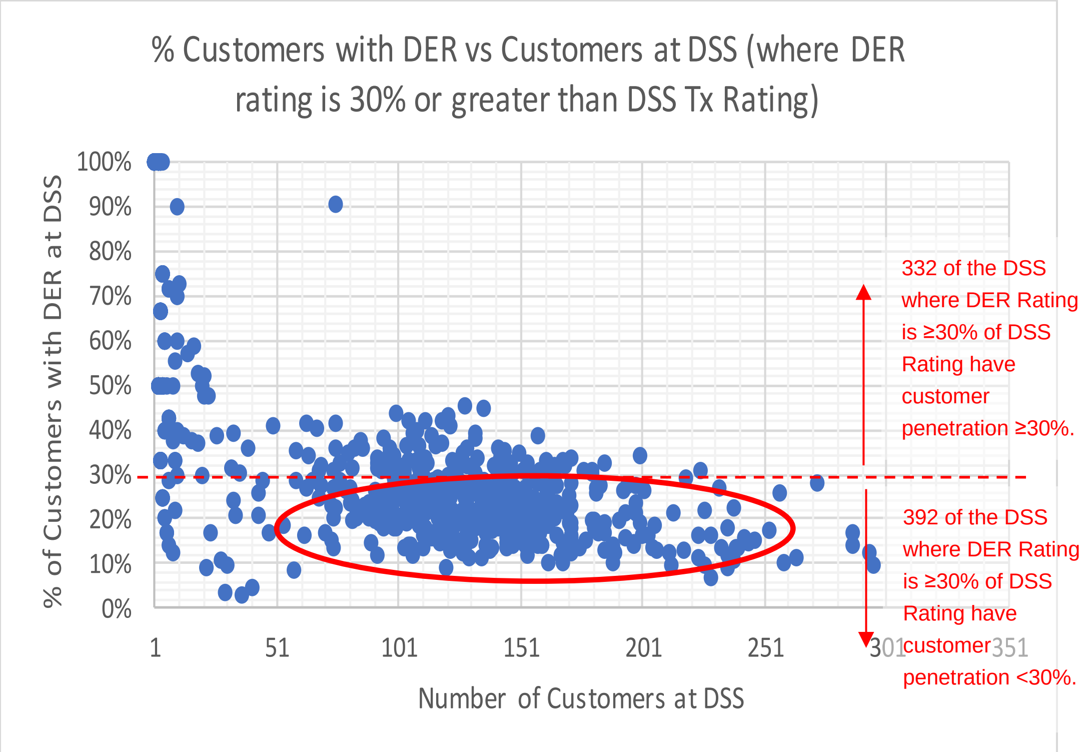
3.2.2 DER Rating Analysis

This indicator considers the total *rating* of the DER connected to a DSS.



The table below shows the details of customers supplied by the 724 DSS (approximately 12% of JEN's DSS) where the connected DER rating is equal to or greater than 30% of the DSS transformer rating. This highlights that 49,720 customers are at risk of being constrained if they sought to connect DER.

At 724 DSS where DER rating is ≥30% of DSS transformer rating	
Total DSS Customers	64,650
Total Customers with DER	14,930
Total Customers without DER	49,720



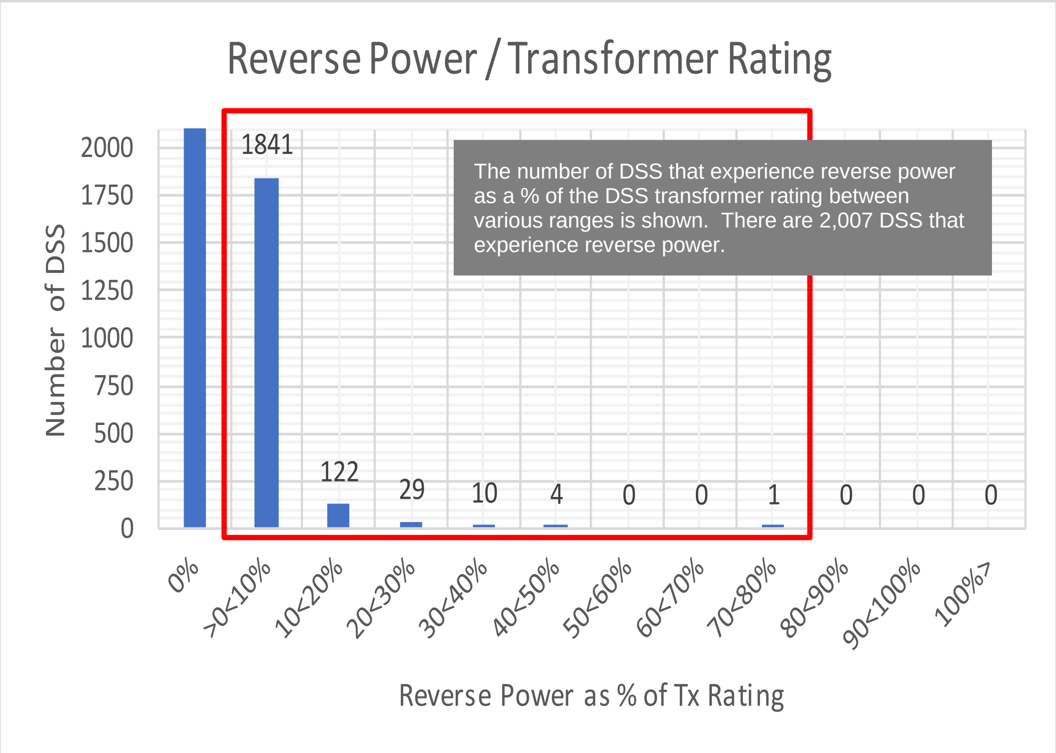
The chart below shows the proportion of customers with DER at a DSS against the total number of customers connected to that DSS, for the 724 DSS where the DER rating is ≥30% of the transformer rating.

The DSS where the DER rating is ≥30% of the transformer rating tend to be at DSS with a higher total customer number. This explains why, for a similar DSS number, the affected customer number is much higher compared to the customer number DER penetration indicator shown in section 3.2.1.

Over half of these 724 DSS currently have a customer % DER penetration less than 30%. Should the circled DSS cluster reach a 30% customer DER penetration level, it is likely that the total DER rating will greatly exceed 30% of the DSS transformer rating.

3.2.3 DSS in Reverse Power Analysis

This indicator considers the presence of reverse power flows due to DER.

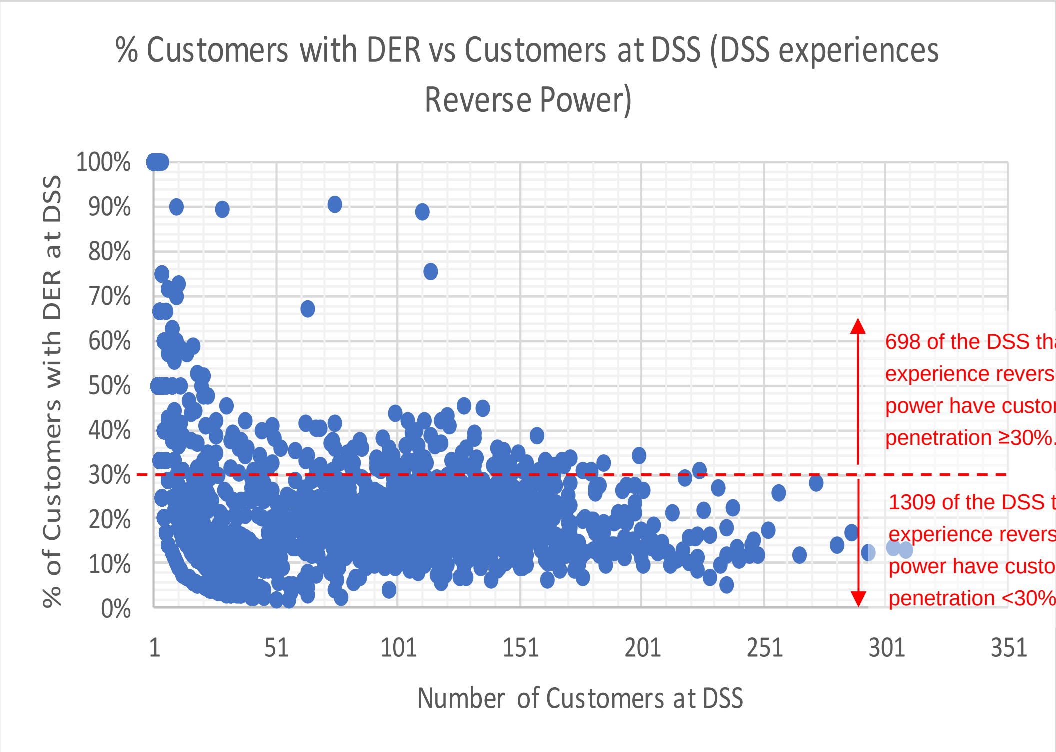


The table below shows the break-down of customers connected to the DSS experiencing reverse power. For these 2,007 DSS (approximately 32% of JEN's total DSS), approximately 20% of the customers have DER. This shows that 108,247 customers are at risk of being constrained if they sought to connect DER.

At 2,007 DSS with reverse power

Total DSS Customers	135,167
Total Customers with DER	26,920
Total Customers without DER	108,247

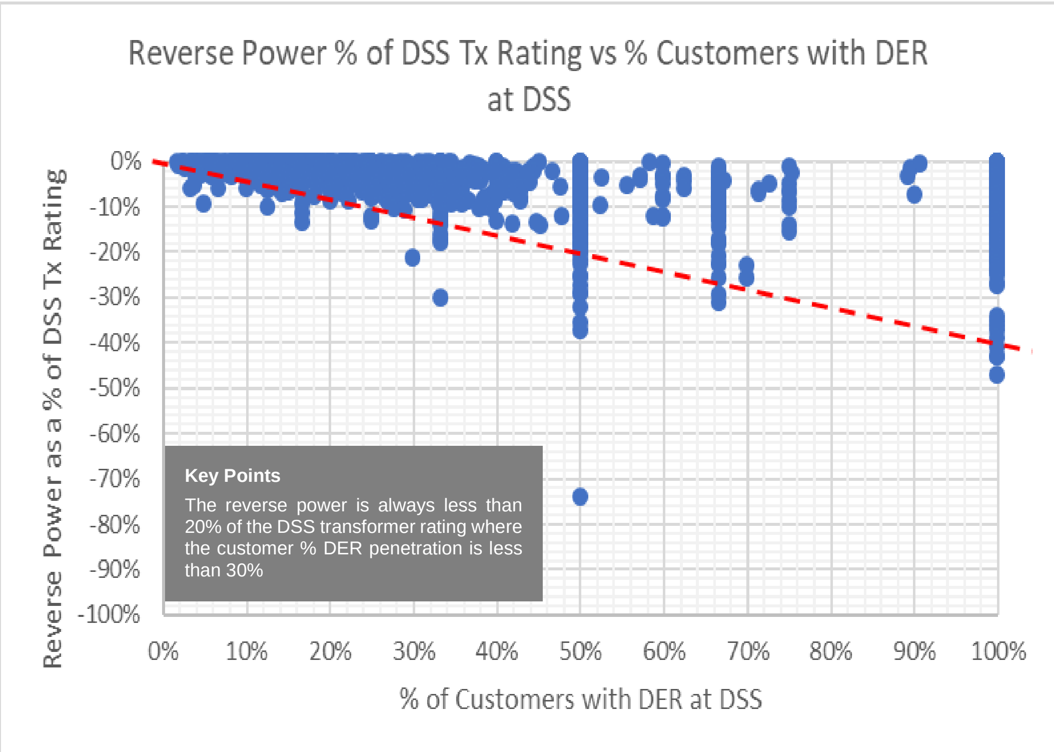
Of these 2,007 DSS, 1,841 have reverse power less than 10% of the DSS transformer rating, with these accounting for 99% of the customers connecting to these DSS.

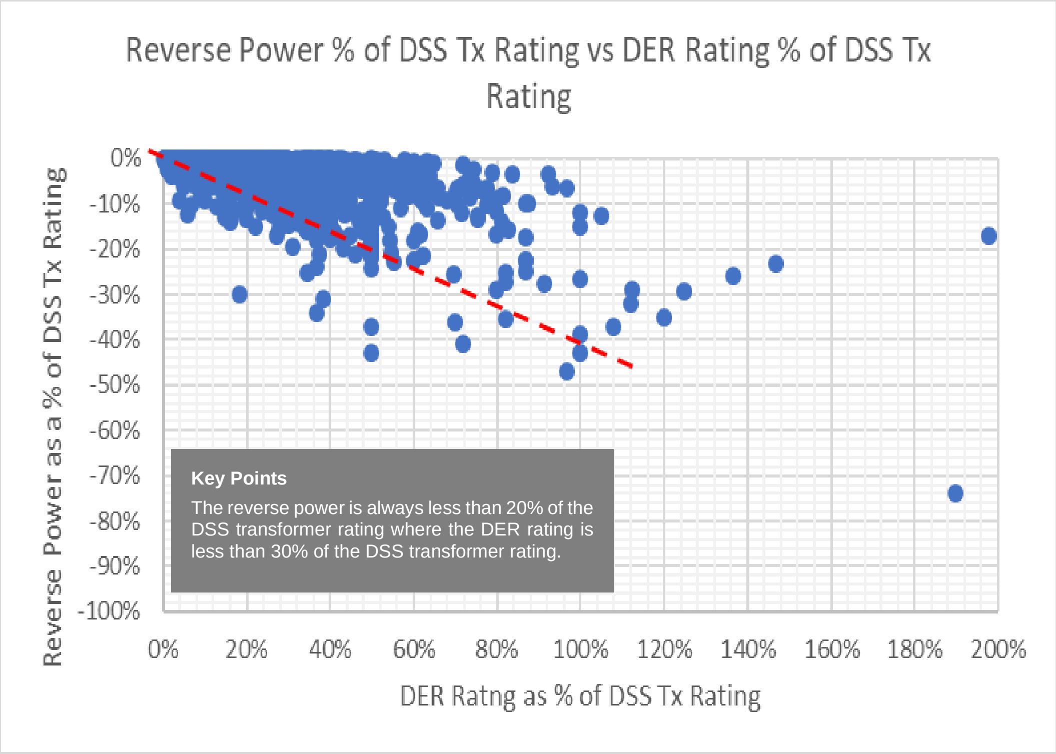


The chart above shows the proportion of customers with DER against the total number of customers supplied by each DSS, for the 2,007 DSS which experience reverse power. This shows that reverse power frequently occurs when the customer DER penetration is less than 30%.

Additionally, reverse power is experienced at:

- 93% of DSS where customer DER penetration ≥30%
- 90% of DSS where DER rating is ≥30% of the transformer rating.





3.2.4 Key findings

The analysis of the indicators outlined above can be applied in combination to estimate the current customers at **risk of curtailment**. The table below presents the results of applying the following criteria using these indicators:

- Criteria 1: Customer DER % penetration at the DSS is 30% or greater
- Criteria 2: The total DER rating connecting to the DSS is 30% or greater
- Criteria 3: Reverse power is experienced at the DSS.

Without increased visibility and obtaining a greater understanding of equipment capabilities (to ensure the system operates within operation limits), it is likely customers connecting to these DSS which meet the above thresholds will have their exports constrained.

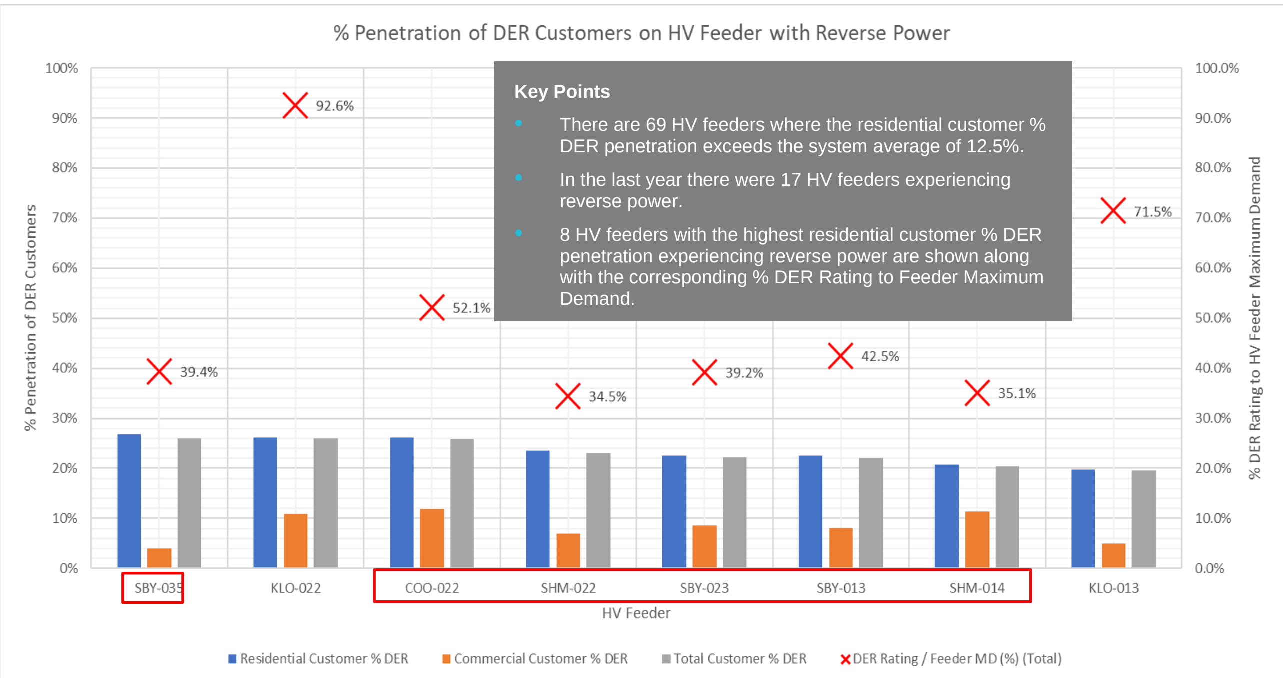
Criteria	Number of DSS impacted	Customers with DER at DSS	Total customers at DSS	Customers without DER at DSS (constrained)	% of JEN customers at risk of curtailment
Criteria 1	753	5,760	15,032	9,272	2.57%
Criteria 2	724	14,930	64,650	49,720	13.80%
Criteria 3	2007	26,920	135,167	108,247	30.05%
Criteria 1 OR Criteria 2	1145	16,328	67,707	51,379	14.26%
Criteria 1 OR Criteria 3	2062	27,001	135,334	108,333	30.07%
Criteria 2 OR Criteria 3	2077	28,213	143,977	115,764	32.14%
Criteria 1 OR Criteria 2 OR Criteria 3	2120	28,279	144,123	115,844	32.16%

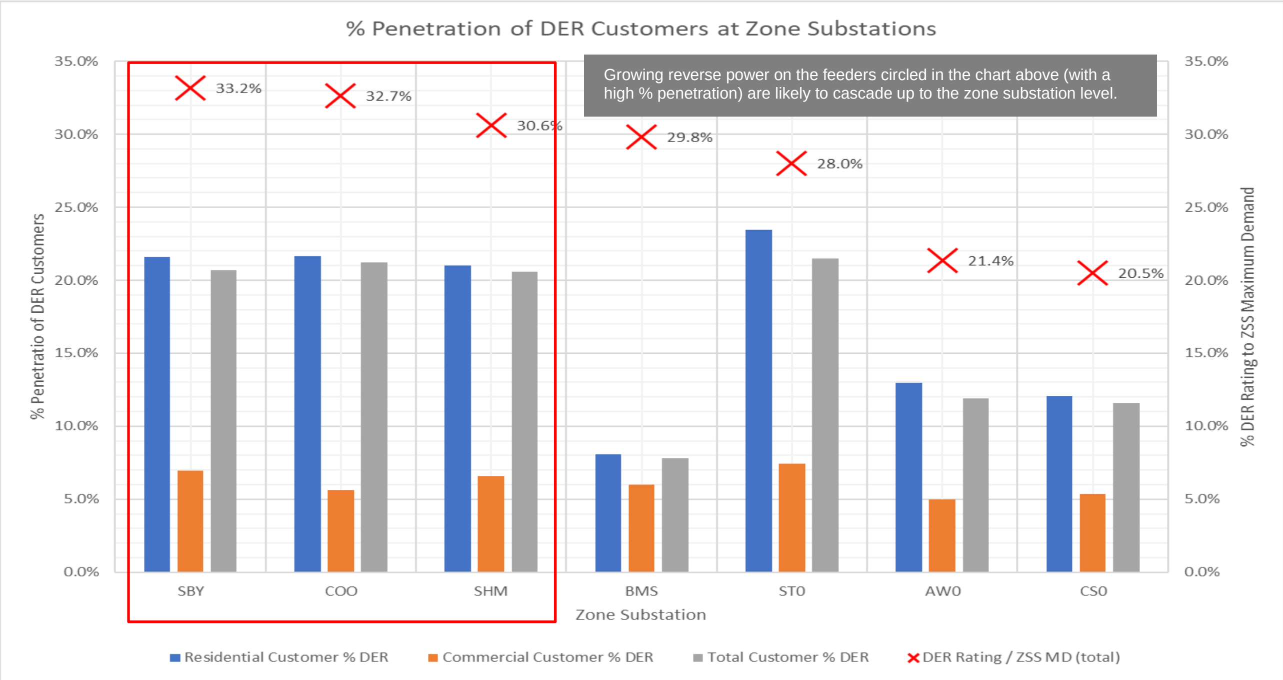
3.3 Reverse Power Flow on HV Feeders and at Zone Substations

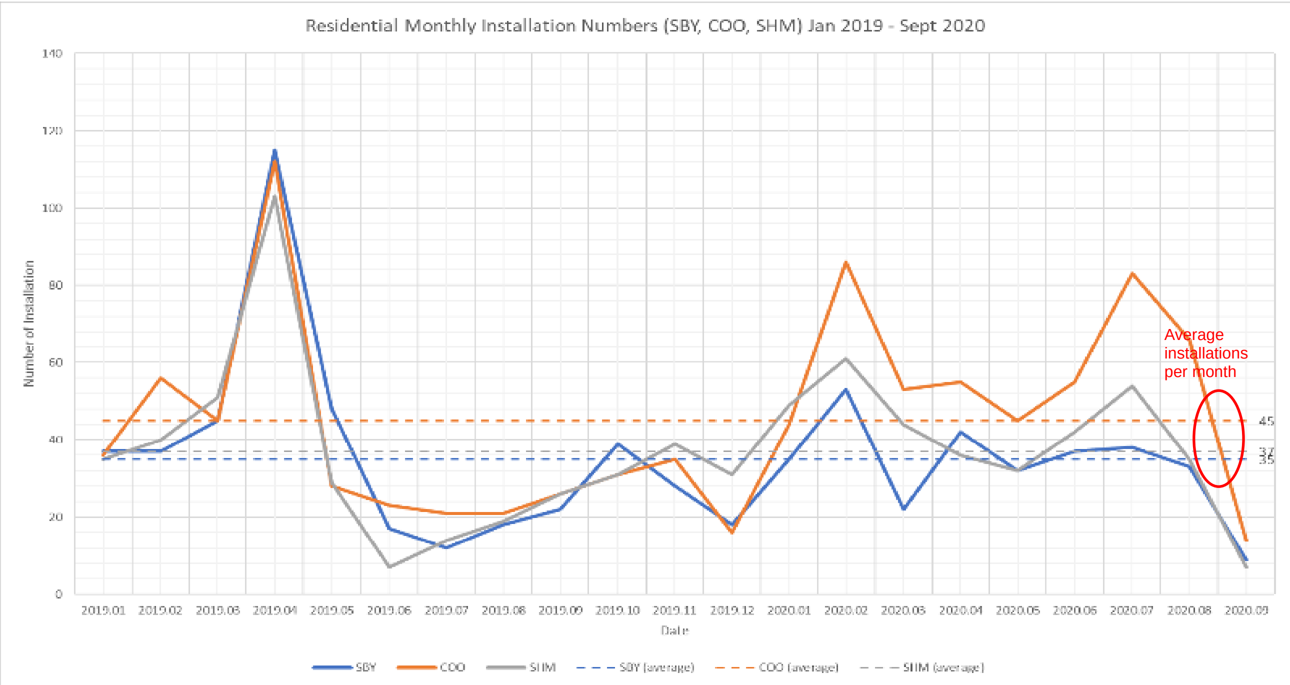
DER will become a network issue at various locations in the distribution network, with the initial stage being constraints and reverse power starting to occur at the distribution substation level (as examined in in section 3.2.3). However, as the amount of DER connected to the network continues to grow, these impacts will move upstream to impact multiple network components:

- the second stage is where constraints and reverse power occur on HV feeders back to the zone substation
- the final stage is when reverse power occurs at the zone substation level into the sub-transmission network.

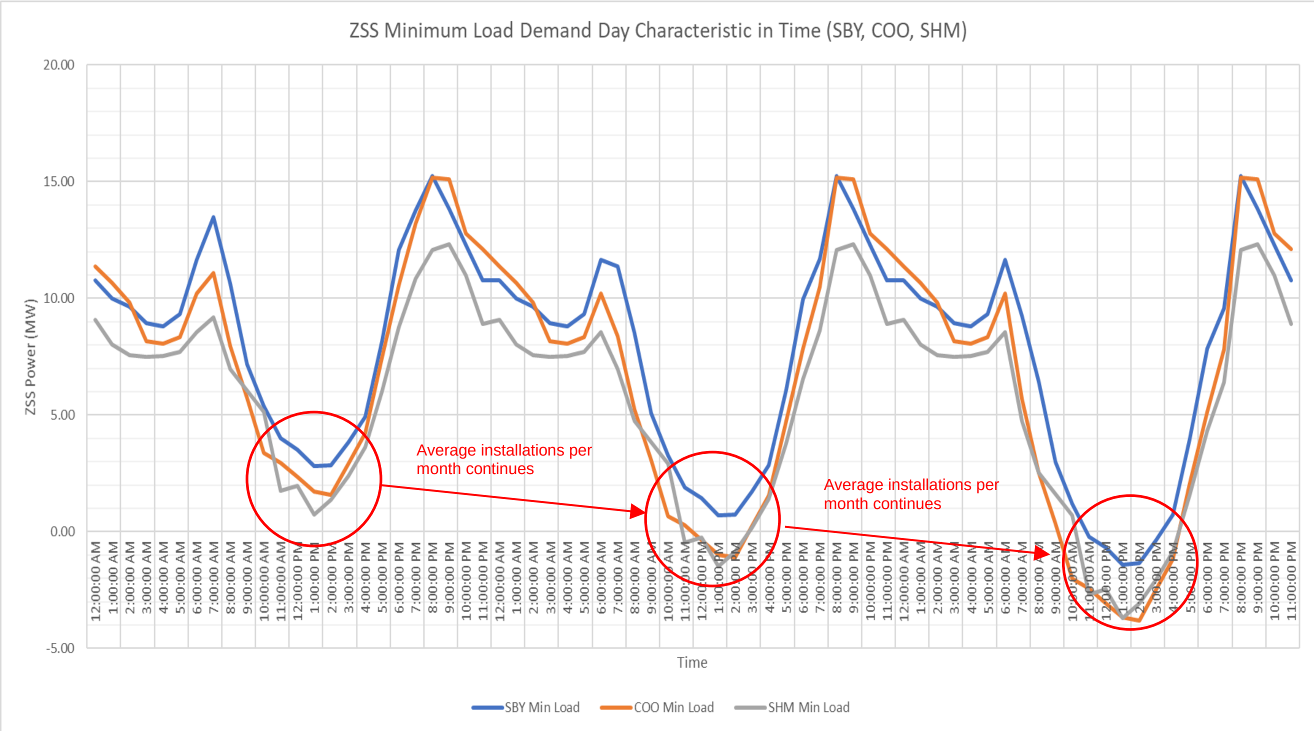
The issue occurring at a DSS level is now expanding further up into the network, and as a consequence is beginning to result in HV feeders showing instances of reverse power. As installations of DER continue to track (or exceed) our forecasts, this will become more acute and start to affect a larger number of HV feeders, and over time will expand further up the network to the zone substation level. JEN has not yet experienced reverse power at its zone substations, however, based on existing DER forecasts, we expect that reverse power will occur at some JEN zone substations within the next two years.







Based on existing DER forecasts, JEN expects two of our zone substations—Coolaroo and Sydenham—to experience reverse power flow in 2021, and a third—Sunbury—in 2022.


ZSS Minimum Load Demand Day Characteristic in Time (SBY, COO, SHM)
ZSS Power (MW)
Time
Average installations per month continues
Average installations per month continues
SBY Min Load
COO Min Load
SHM Min Load