Powercor AUSTRALIA

AUGMENTATION

CUSTOMER-DRIVEN ELECTRIFICATION

PAL BUS 3.01 – PUBLIC
2026–31 REGULATORY PROPOSAL

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1. Executive summary

Customers are driving the electrification of gas and transport through the use of innovative new technologies to lower bills and reduce their emissions. Governments are supporting customers to electrify through net-zero targets, legislating bans on new gas connection applications and implementing subsidies to support adoption of electrified technologies.

This electrification of gas and transport stands to increase consumption and peak demand across our network as customers adopt new technologies. Growing peak demand and increasing consumption will place downward pressure on voltage levels for our customers. Lower voltage levels can cause unstable power quality, impact appliance function, lower appliance lifespan and reduce customers' ability to charge EVs.

Customer feedback

Our customers have consistently demonstrated concern with the impact that electrification will have on the stability and power quality of the network, impacting their customer experience. Customers were also apprehensive of the network's capability to cope with increasing electricity use, particularly to facilitate electrification and net-zero technologies.

Our customers prioritised developing better infrastructure to prevent outages, while expressing clear preferences for maintaining a reliable electricity supply even during times of high demand. To our customers, reliability was perceived as a consistent and uninterrupted supply of electricity, where customers did not delineate between reliability, power quality or capacity.

More than three-quarters of customers participating in our collaborative Future Home Demand study with Monash University preferred to charge electric vehicles at home, highlighting the importance of stable power quality at a customer level.

To limit the impact that lower voltage levels can have on customers, we are obligated under jurisdictional regulatory instruments to maintain voltage levels between 216 and 253 volts at least 99 per cent of the time.[1] Functional compliance is met if these limits are maintained across at least 95 per cent of our customers.[2] Our jurisdictional voltage compliance obligations are subject to tier 1 civil penalties as of October 2022.

When customers receiving non-compliant voltage outcomes complain to us, we are further obligated under jurisdictional instruments to resolve their voltage supply issues as soon as practicable. We expect non-compliant customer complaints to increase over time as more customers electrify and the capability of existing assets is exhausted.

Our proposed response

We have developed new LV power flow forecasting capabilities and can now forecast thermal and voltage impacts over time down to a customer level. This forecasting capability is beyond any other distributor in the National Electricity Market today.

1 The Electricity distribution code of practice is a jurisdictional instrument administered by the Essential Services Commission that regulates our activities to ensure they are undertaken in a safe, efficient and reliable manner

2 Electricity distribution code of practice clause 20.4.2

Without intervention, these forecasts show that voltage compliance will continue to decline — 46,052 customers will consume 31.4 GWh of load delivered at non-compliant voltages by FY31, with 1,373 non-compliant customers complaining over the period.

To address the reliability needs of our customers and facilitate customer preferences to electrify, we are proposing to instead maintain current voltage performance service levels through our customer-driven electrification program. Our proposed investment will ensure that an additional 17,739 customers will receive compliant voltage levels, enabling an additional 12.4 GWh of compliant load. In total over 81,000 customers will receive improved power quality.

The majority of our investment program will be proactive in targeting sites with high customer numbers, improving service levels, enhancing customer experiences and avoiding complaints. Proactive investments are more efficient than reactive investment because we can plan works in advance, target high-value sites, utilise efficiencies in service delivery and implement long-term efficient solutions such as tendering the constraint on our non-network platform.

A smaller part of our investment program will still be required to reactively remediate voltage performance issues following customer complaints to meet our jurisdictional regulatory obligations.

Our proposed investment comprises distribution substation upgrades, distribution substation offloads and low voltage network reconductoring. In forming this program, we have ensured that the portfolio of projects is efficient by targeting sites with the highest number of non-compliant customers and identifying the most efficient intervention at each site. We have also optimised our portfolio of investments by considering where HV augmentation would be more efficient than several LV augmentations, avoiding overlap with our replacement program and avoiding augmentation through increasing successful tenders for non-network solutions.

A summary of our investment program to maintain current voltage performance is below in table 1.

TABLE 1 EXPENDITURE FORECAST FOR PREFERRED OPTION ($M 2026)

DESCRIPTION	FY27	FY28	FY29	FY30	FY31	TOTAL
Proactive LV augmentation	3.0	14.7	8.0	18.4	18.8	**63.0**
Reactive augmentation	4.9	4.9	5.4	5.6	5.9	**26.6**
HV augmentation	1.4	1.4	1.6	0.8	3.8	**8.9**
Avoided augmentation from non-network solutions	-	-0.1	-	-0.6	-0.7	**-1.4**
Total	**9.3**	**20.8**	**15.0**	**24.3**	**27.8**	**97.1**

These investment levels were supported by our customers throughout our engagement program:

- at our trade-off forums, 30 per cent of customers supported $80m of investment (with residential bill impacts of $0.97 p.a) and an additional 43 per cent supported $120m of investment (with residential bill impacts of $1.46 p.a) to facilitate increased EV charging and reduce EV-related outages.
- customers at our test and validate forums supported our proposed investment, primarily to support energy reliability and acknowledging growing demand and infrastructure challenges.

2. Background

Our CER integration and electrification strategy sets out our approach to accommodating electrification through the 2026-31 regulatory period. This business case is a core component of our CER integration and electrification strategy, covering the electrification needs of our customers on low voltage assets. Separate business cases cover the needs of our HV assets.

The electrification needs of regional and rural customers are considered in this business case except for customers supplied by single wire earth return (SWER) assets. Our regional and rural SWER upgrades business case considers the needs of customers serviced by SWER lines due to the different nature of the investment drivers.

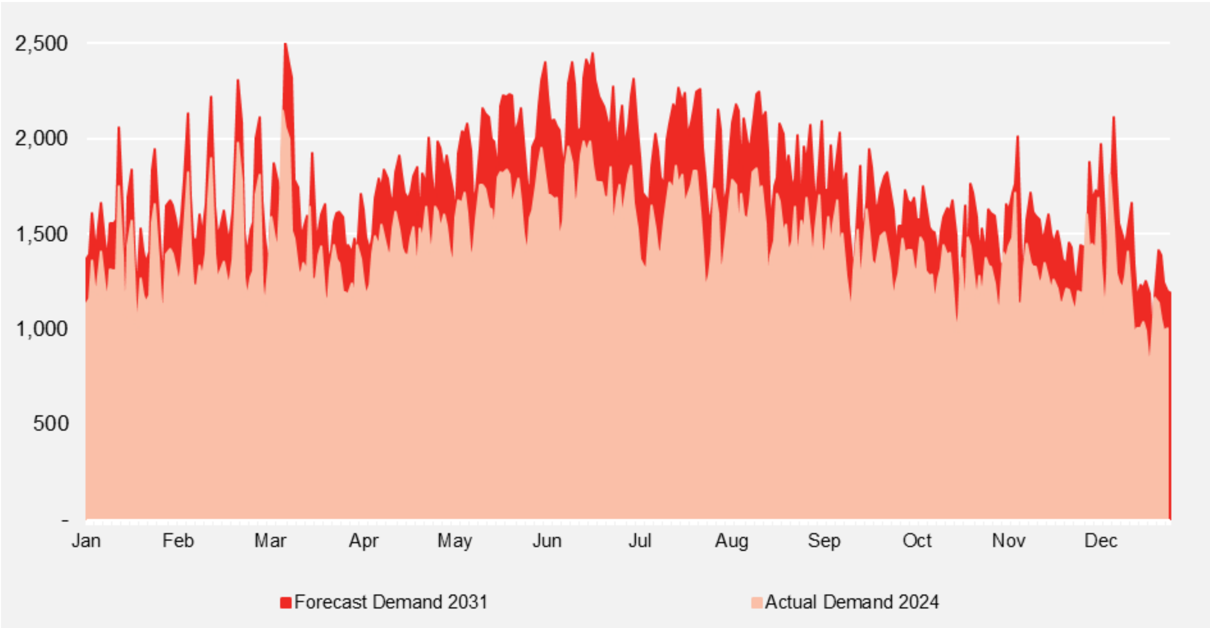
2.1 Customers are increasingly electrifying and investing in CER

Customers are increasingly driving the energy transformation through investments in CER, such as the electrification of gas appliances, solar photovoltaic (PV), battery technologies, residential electric vehicles (EV) and commercial vehicles such as those for farming or transport.

Changing consumer preferences are producing daily, intra-day and seasonal shifts in how and when electricity is consumed. Electrified homes and transport will drive a significant increase in peak demand and annual consumption by 2031. Growing demand from electrified heating will drive an increase in the frequency and duration of winter peak demand periods.

Figure 1 below shows a comparison of our actual demand in winter 2024 compared to winter demand in 2031. Winter peak demand is expected to grow 600 MW and result in more frequent peak demand periods compared to summer.

FIGURE 1 CONSISTENCY AND INTENSITY OF WINTER PEAK DEMAND (MW)



2.1.1 Electrification of gas

Customer electrification of gas load is expected to add 2,600 GWh of annual Victorian electricity consumption by 2031. Victorians are more dependent on gas than any other jurisdiction, with 80 per cent of Victorian homes using gas for space heating, hot water and cooking. This leads Victorians to consume triple the amount of gas that New South Wales and South Australia customers, and over 40 per cent more than ACT and Tasmania customers, who live in similar cool climate zones.[3]

Electrification of gas heating will increase winter consumption and peak demand, shifting 10 per cent of our zone substations from summer-peaking to winter-peaking in the next regulatory period. Heating loads are more sustained than cooling loads and will occur when solar production is lowest.

Uncertainty in forecast gas supply conditions could accelerate gas electrification beyond forecasts. The Victorian Government and AEMO anticipate a 600 petajoule (PJ) gas supply shortfall between 2028 and 2035.[4] Victorians are unwilling to pay more for gas, and record uptake of electrified water heating in response to gas supply concerns was observed in Europe in 2022.[5]

The Victorian Government is investing significant resources into the electrification of gas. Under the government's Gas Substitution Roadmap, all new Victorian homes requiring a planning permit will be all-electric, which the government expects will reduce gas consumption from 200 petajoules (PJ) in 2026 to 150 PJ in 2031.[6] In alignment with this objective, AEMO forecasts electrification to reduce gas consumption by 44 PJ between 2024 and 2031.[7] To support the delivery of the roadmap, the Victorian Government has invested:

- $10 million in a Residential Electrification Grant to subsidise electrified appliances in residential developments[8]
- $11.8 million in the Victorian Energy Upgrades program, including a review to ensure the program is fit for purpose to electrify homes and businesses[9]
- $1.5 million in feasibility studies for large gas users to electrify.[10]

2.1.2 Electrification of transport

To achieve its legislated emission reduction targets, the Victorian Government has target of a 45–50 per cent fall in emissions below 2005 levels by 2030. To support this target, the government intends for half of all light vehicle sales to be zero emissions vehicles by 2030.

Electric vehicles will transform our electricity grid, for both EV and non-EV owners, with increased consumption from wide-spread adoption having the ability to lower per-unit energy charges for all customers.

The Australian Energy Market Operator (AEMO) forecasts rapid growth in EV uptake, with 880,000 EVs across Victoria by 2031, accounting for 22 per cent of all cars in Victoria by 2031. That represents more than 18 times the number of EVs on the road than today. Over 250,000 of these EVs are expected to call our network home.

Figure 2 shows AEMO's forecast for projected consumption from electrification of vehicles and transport in Victoria between 2024 and 2031.

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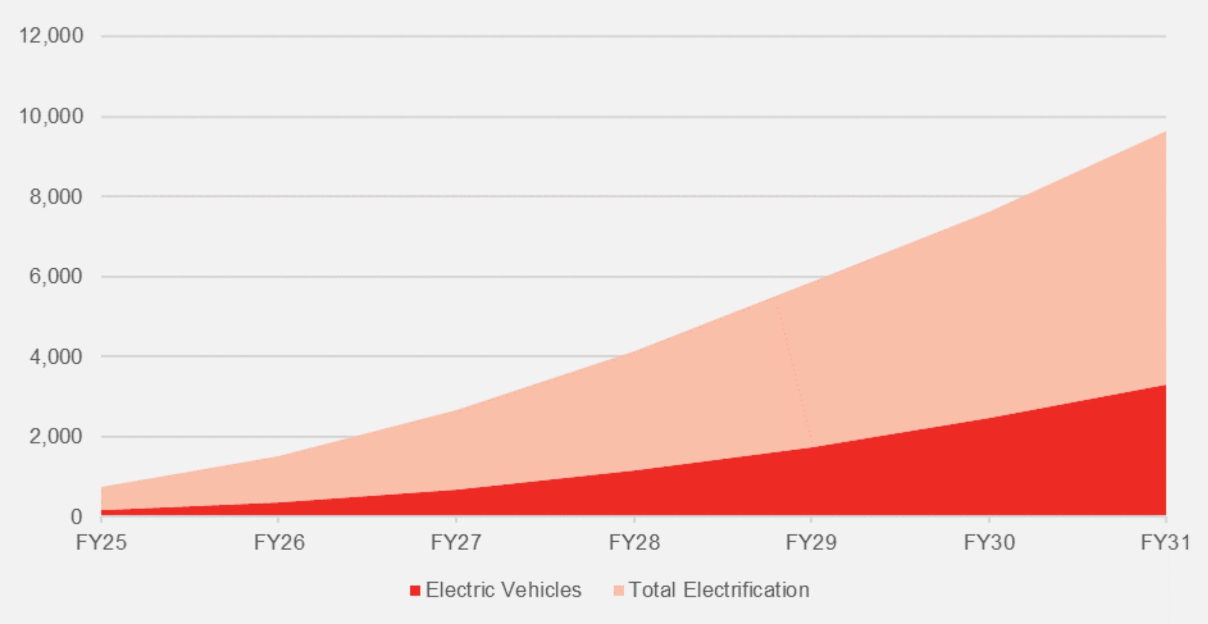
3 Frontier Economics, *Residential energy consumption benchmarks*, prepared for the AER, 2020, p. 26.
4 Victorian Government, *Gas Substitution Roadmap update 2024*, 2024, figure 1, p.7.
5 European Heat Pump Association, *European Heat Pump Market and Statistics Report 2023*, 2022
6 Victorian Government, *Victoria's Gas Substitution Roadmap*, 2024
7 Australian Energy Market Operator, *Gas forecasting data portal, GSOO, 2024, electrification, Victoria*, *Step Change*, 2024.
8 Victorian Government, *Delivering solar and hot water at scale for new homes,* media release, 2024.
9 Victorian Government, *Helping Victorian business cut their energy bills*, media release, 2024.
10 Victorian Government, *Helping Victorian business cut their energy bills,* media release, 2024.

FIGURE 2 ADDITIONAL VICTORIAN CONSUMPTION FROM ELECTRIFICATION (GWH)



2.1.3 Electrification will benefit all customers, not just those that electrify

Our customers stand to benefit substantially from Victoria's energy transition to net zero emissions by 2045. The Australian Energy Market Commission forecasts electrification to place downward pressure on energy costs, resulting in a nine per cent electricity price reduction.[11] CSIRO modelling for Energy Consumers Australia (ECA) forecasts more efficient network utilisation from EV charging to save non-EV customers $230 annually by 2030, which aligns with evidence in California.[12]

For customers that do electrify, ECA forecasts that electrification of gas and the adoption of EVs will save Victorians $1,730 by 2030.[13] For fully electrified homes, the Victorian Government's State Electricity Commission forecasts annual household savings of $780 for electrified heating and cooling, $250 for hot water, and $375 for cooking.[14]

2.2 We have voltage compliance obligations that are subject to civil penalties

In Victoria, the standard nominal voltage for the supply of electricity to customers is 230 volts. This is a requirement of Australian Standard AS 61000.3.100, with which electricity distributors must comply.[15]

As voltage is highly variable, it is not possible to maintain supply voltages at 230 volts at all times and on all locations in the network. To account for variability, the Australian Standards and the Electricity Distribution Code of Practice (EDCoP) allow for voltage range, within which distribution network service providers (DNSPs) safely manage voltage.

Under the EDCoP, we are obligated to maintain voltage levels between 216 and 253 volts at least 99 per cent of the time, as figure 3 shows. Functional compliance is met if these limits are maintained for

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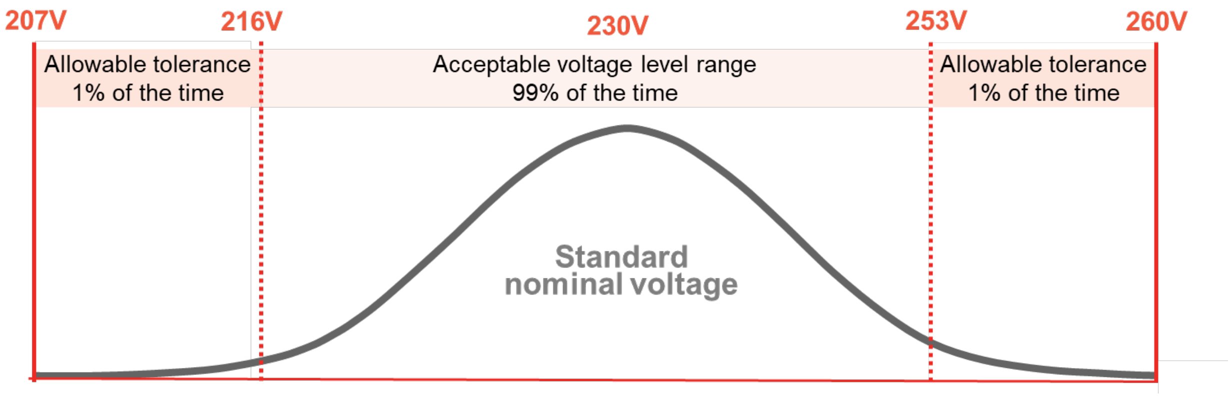
11 Australian Energy Market Commission, *Residential electricity price trends* 2024, p. 32
12 Energy Consumers Australia, *Stepping Up, CSIRO Chart Data, 2023, figure 3-17 and Stepping Up: NRDC, EV Impacts October 2022,* 2022
13 Energy Consumers Australia, *Stepping Up, CSIRO Chart Data, 2023*, figure 3-17
14 State Electricity Commission, *Save money on your energy bills*, 2024
15 Victorian Essential Services Commission, Electricity distribution code of practice clause 20.4.1

at least 95 per cent of our customers. If over five per cent of our customers receive less than 216 volts more than one per cent of the time, we are non-compliant.

Voltage compliance is measured by the Essential Services Commission (ESC) as our worst performing week in a financial year.

FIGURE 3 VOLTAGE COMPLIANCE OPERATING RANGES



Voltage breaches are considered a tier one EDCoP breach, which carry civil penalties of up to $11,855,400 for periods in which we are non-compliant.

We are held to account for compliance through monitoring of our Advanced Metering Infrastructure (AMI) smart meters, which we are required to report quarterly to the ESC under the EDCoP.

2.2.1 We have optimised voltage levels within stable, compliant ranges

Innovative solutions, such as our Dynamic Voltage Management System (DVMS), alongside low-cost solutions such as transformer tap changes and phase balancing, have sufficiently remediated voltage non-compliance and optimised voltage levels to maximise voltage compliance across our network in line with our obligations.

DVMS, tap changes and phase balancing work by shifting voltage set points across our network, meaning they are limited in what they can accomplish in an electrified future. These solutions do not add any additional capacity to the network, nor do they support voltage further at electrified customer connections. The efficient use of these solutions will be limited going forward due to the increasing need to address both under and overvoltage.

We are receiving more customer complaints that can only be addressed through network capacity-based solutions and expect this trend to continue as more customers electrify.

2.2.2 We are obligated to reactively address poor voltage service levels if customers with non-compliant voltage levels complain

Our voltage compliance obligations require us to maintain 95 per cent voltage compliance. This means at any time there can be up to 5 per cent of customers receiving non-compliant, poor quality service levels. Specifically, compliance or service levels are measured as the lowest number of compliant customer connections as a percentage of total customer connections in one week in a financial year.

If non-compliant customers complain to us, we are obligated to reactively remediate voltage levels to within compliant ranges for the complaining customer as soon as practicable.[16]

[16] Victorian Essential Services Commission, Electricity Distribution Code of Practice, clause 15.2.1

A reactive approach has functioned appropriately in an operating environment in which we receive a low number of complaints annually. This model ensures we only invest when required. Expenditure to date with low levels of electrification and EV adoption has been minor, and we have been able to maintain adequate service levels for customers.

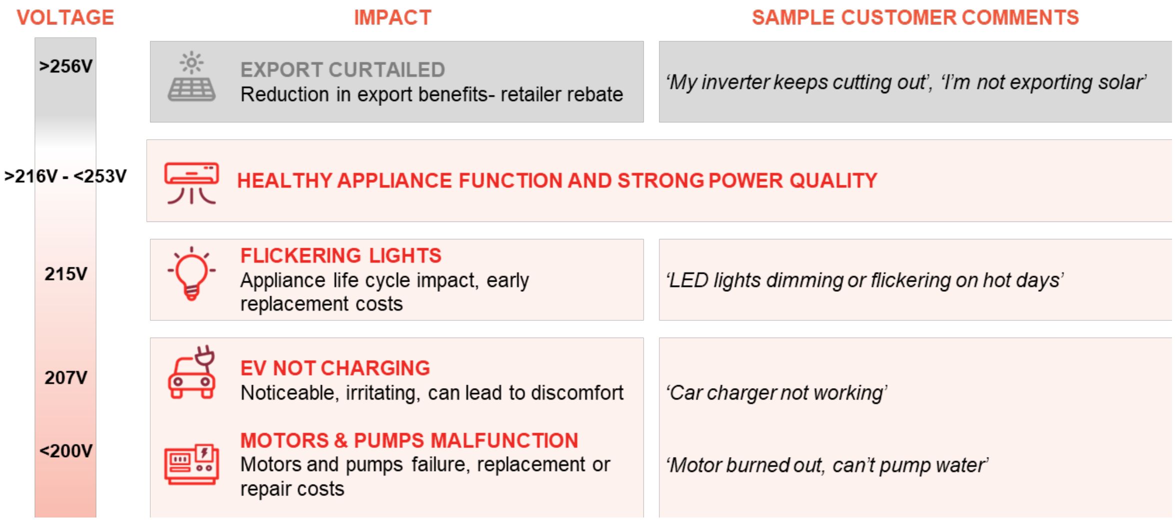
3. Identified need

The extent of electrification forecast in the 2026–31 regulatory period will challenge our existing network. In particular, the ongoing customer-driven electrification of homes and transport will drive more undervoltage issues on our network today than ever before.

Receiving non-compliant voltages can have tangible and disruptive impacts for our customers. Commonly reported consequences of undervoltage constraints on our network include malfunctioning appliances, increase energy costs as appliances run inefficiently, and reductions in the lifespan of electrical equipment.

Customers may also experience the impacts of undervoltage differently, influenced by the severity of undervoltage. Figure 4 demonstrates how appliances may be impacted at different voltages, and how customers report experiencing impacts to us.

FIGURE 4 IMPACT OF VOLTAGE NON-COMPLIANCE



In this context, and for the reasons expanded on below, the identified need is to maintain existing service levels and ensure efficient compliance with our obligations under the EDCoP.

3.1 Our customers expect us to maintain existing performance levels

Our customer engagement program spanned across three years and sought input from over 9,000 customers. During this period, our customers were asked about their expectations relating to energy, what they expected from us and whether customers supported our investments.

From our broad and wide engagement—the earliest phase of our program—it was clear that customers had clear expectations around our role in supporting a fair and just energy transition, including how we support EV charging (for both EV and non-EV owners).

Summaries of several key engagements are discussed below.

Monash University: Future Home Demand report

In 2023, we partnered with Monash University to better understand longer term behavioural trends to inform electricity sector planning. This involved research inside our customers' homes, with questions about their lifestyles, energy use practices and how they expected these to change in the future. The study was a multi-staged research project with 36 households, supported by a survey of 477 of our customers.

More than one quarter of surveyed customers intended to purchase an EV or plug-in hybrid vehicle in the next five years. Customers also shared positive sentiment to electrifying household appliances such as induction cooktops, air purifiers and reverse cycle air conditioners, primarily due to the cost of gas and environmental concerns.

Monash's found that working and studying from home will be a permanent feature. They also identified increasing trends towards greater in-home care, recreation and home automation. These trends add to the increasing dependency on a reliable supply from our energy system.

Additionally, more than 80 per cent of customers participating in our collaborative Future Home Demand study with Monash University preferred to charge electric vehicles at home, highlighting the importance of stable power quality at a customer level.

Monash University identified that of customers who preferred to charge EVs at home, 30 per cent prefer slow charging (level-one) and 70 per cent prefer fast charging (level-two).

Energy transition summit and Future energy network forum

Recognising the fundamental changes that are occurring as part of the energy transition, we released an options paper and facilitated two separate forums that focused on rooftop solar, EVs and electrification of gas.[17] We sought preferences on service levels and investment options to better identify customer value propositions.

Participants supported a measured approach to EV charging enablement and recognised that forecasts for electrification of gas were too conservative to achieve net zero by 2050 but the logistics of electrifying gas were challenging.

Regional and rural forums

Regional and rural customers make up over 60 per cent of our network. We held two regional and rural summits in Creswick (2023) and Bendigo (2024) to better understand regional and rural customer expectations of our network in an electrified future.

Regional and rural customers expressed concern about the inequity gap between the service levels of urban and regional and rural customers. While our customers and stakeholders understand that parity in service levels is not realistic, they have repeatedly highlighted that without action, the gap in service levels will continue to widen.

Customers also emphasised that a more equitable investment approach was needed, pointing out that while regional and rural areas bear the burden of hosting significant renewable energy generation, there was no plan or cohesive strategy to support regional and rural customers to achieve net-zero emissions.

Recognising the long-term and systemic nature of this problem, regional and rural customers urged us to shift our planning beyond the immediate regulatory period.

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[17] CitiPower, Powercor and United Energy, Customer energy futures: service level options paper, 2023

3.1.1 Customers repeatedly expressed preferences to maintain reliability and deliver strong power quality

Our customers prioritised developing better infrastructure to prevent outages, while expressing clear preferences for maintaining a reliable electricity supply even during times of high demand. To our customers, reliability was perceived as a consistent and uninterrupted supply of electricity, where customers did not delineate between reliability, power quality or capacity.

Customers prioritised proactively mitigating the impact of outages with forward-thinking, and regional and rural customers believed that addressing reliability, power quality, and capacity issues was essential for their communities to participate in the clean energy transition.[18]

> *"Prevention is better than cure. Powercor are great if something goes wrong, but they could play a more proactive role"*

Customers are increasingly concerned about power quality and highlight that any disruption or issue can significantly impact their way of life. Poor power quality was noted consistently by customers as an issue because it leads to appliance malfunction and premature failures, resulting in inconvenience and additional expenses.

Commercial and industrial customers in particular prioritised strong and stable power quality as their top priority for improvement to avoid costly operational suspensions. Commercial and industrial customers felt that power quality would increasingly become a concern through the energy transition, and that access to available capacity is a primary requirement.[19]

> *"Even a few seconds can cost $25,000"*

3.1.2 Customers support investment through the energy transition

Our customers view a quality power supply as an enabler for their participation in Victoria's energy transition. As they have continued to electrify their homes, transport and businesses, power quality has increased as a priority for our customers to become the fourth most important issue, out of 14 issues surveyed. For customers in our regional cities and towns, improved power quality is crucial to the survival and growth of their communities.

There is widespread support for further infrastructure and investment to support greater EV adoption. However, customers questioned whether their local network was going to provide the quality of power necessary to sustain local fleets of electric vehicles. Customers are particularly concerned that our network will experience challenges maintaining stability as peak demand increases in total consumption and duration during winter. For many customers, this concern reflects the tangible, disruptive impact that poor power quality can have on daily life, which includes malfunctioning or degrading appliances.

Doubt is also driving apprehension among our customers who are considering electrification of gas heating, cooling and cooking. Customers are concerned that electrification of gas will result in grid stability challenges and grid capacity issues that limit their ability to access the benefits of electrification.

As our customers consider options to electrify, they have expressed concern regarding our network's capacity to provide a quality power supply that supports the use of their appliances and vehicles as they intended. Before our customers engage with electrification at the pace necessary to support

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18 Forethought, *Regional and Rural Summit Report*, October 2024, p. 29

19 Forethought, *Economic Growth Engagement,* CitiPower, Powercor and United Energy Commercial and Industrial Customers, 2023, p. 11.

Victoria's energy transition, they have communicated that they want the network future-proofed against disruptions from increased renewables usage. They expect assurances that the network can endure these challenges and provide continuous supply.

3.1.3 Our consumer sentiment findings are supported by independent research

What we heard from our customers reflects what CSIRO and Energy Consumers Australia (ECA) observed when engaging Australians for similar research.

56 per cent of those surveyed by CSIRO disagreed or strongly disagreed with the prospect of risking more electricity blackouts to enable a faster energy transition. CSIRO identified that design and regulation of renewable energy projects must not negatively impact the reliability of electricity supply if the energy transition is to gain public trust and support community wellbeing.[20]

Energy Consumers Australia found that 75 per cent of consumers listed reliability, defined as having energy available when they need it, as one of the values that are most important to them when they think about the future of energy, selected from 15 options.[21]

3.2 Undervoltage constraints and customer impacts are forecast to increase

As discussed in section 2.1.3, we have optimised voltage levels within stable, compliant ranges.

We achieved functional compliance with our overvoltage performance obligations in 2022 primarily through the use of low-cost solutions such as tap changes and our DVMS. This has enabled our customers to export more solar and avoid appliance damage or malfunction caused by overvoltage.

Our network also delivers strong undervoltage performance of 97 per cent for our customers, ensuring that they can maintain stable and reliable use of their appliances and continued charging of EVs.

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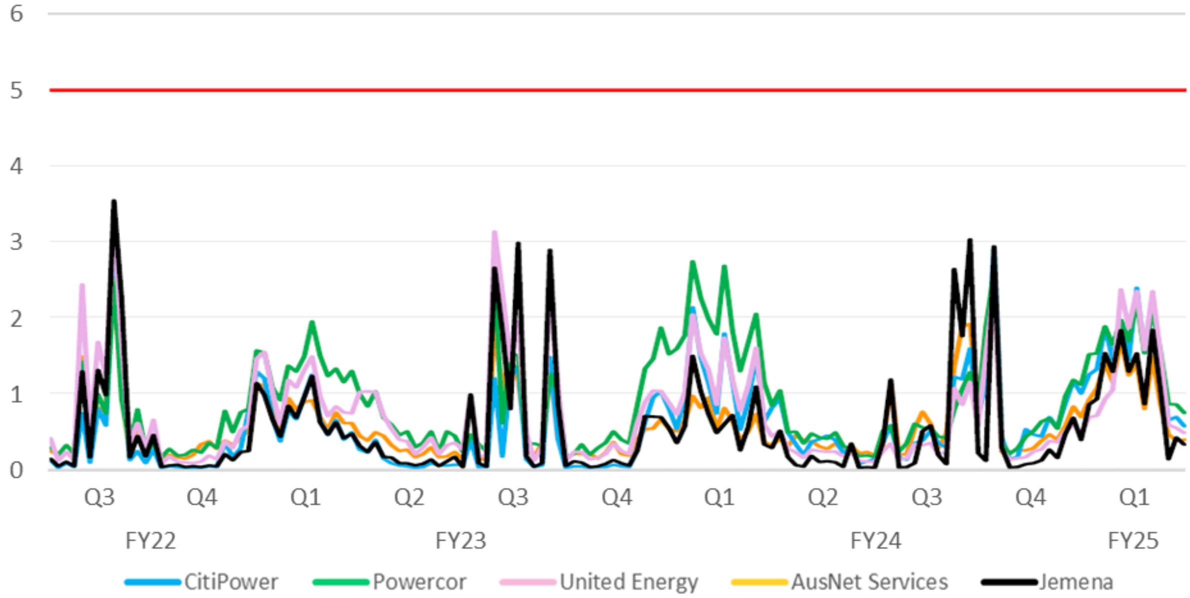
[20] CSIRO, Australian attitudes toward the renewable energy transition (2024)
[21] Energy Consumers Australia, PowerUp: Consumer Voices in the Energy Transition (2023)

FIGURE 5 UNDERVOLTAGE NON-COMPLIANCE OF VICTORIAN DISTRIBUTORS (%)

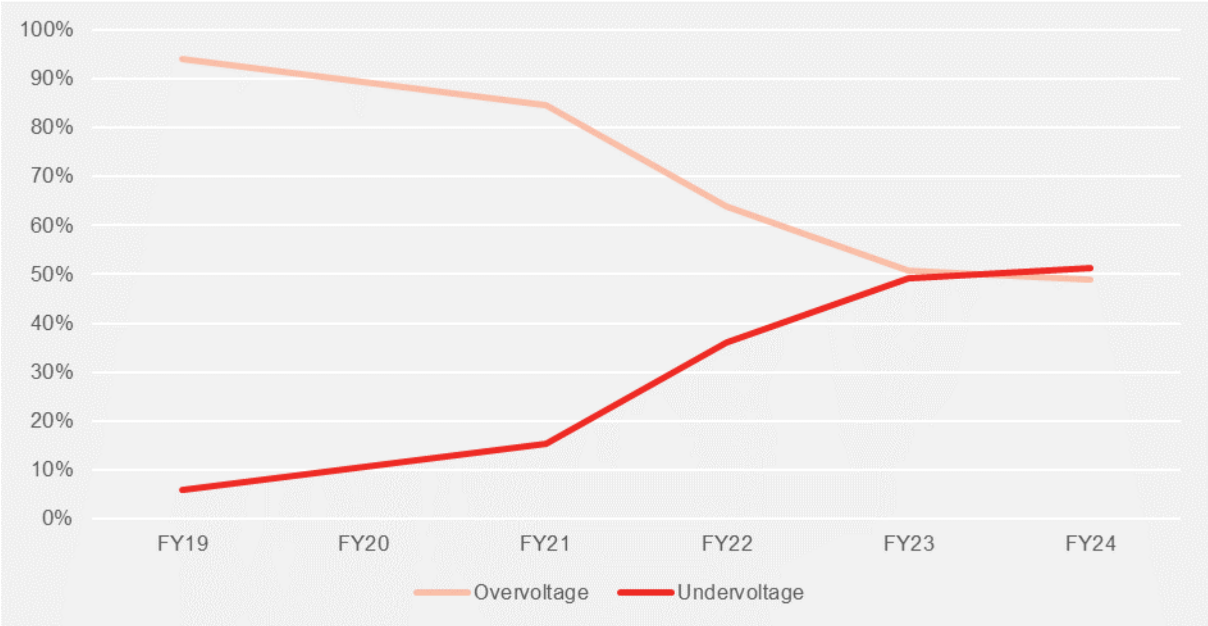


Source: Essential Services Commission, Voltage Performance data

However, increasing electrification is already placing downward pressure on our undervoltage performance, leading to more customer complaints relating to undervoltage over the last few years.

Since 2019, the number of customer undervoltage complaints has risen to become the most common form of voltage complaint we receive. Figure 6 shows the change in proportion of historical undervoltage and overvoltage complaints over time.

FIGURE 6 SHIFT TOWARDS UNDERVOLTAGE AS THE PRIMARY TYPE OF CUSTOMER COMPLAINT (%)



3.2.1 We have found through network analytics that five per cent of EV customers are already curtailed at least once a month

United Energy has been analysing AMI data across its network for over a year now. This analysis has found that approximately five per cent of EV customers experienced charging curtailment at least once a month between June 2023 and July 2024. Overall, approximately one per cent of EV charging sessions were curtailed over the period. We are finding similar trends in early analysis of our own AMI data.

EV charging curtailment typically occurs due to sustained undervoltage driven by high demand or when voltage reduces by more than 12 per cent in a short period of time when an EV charger turns on, known as a 'high impedance' issue. Manufacturers mandate these curtailment settings to protect their equipment. Further information on manufacturer curtailment settings and an example of our analytics detecting EV charging curtailment can be found in appendix 40B.

We have found using our network analytics that customers who charge their EV during peak periods experience the most curtailment, followed by customers who charge overnight.

Our 'Future Home Demand' collaboration with Monash University found that 55 per cent of surveyed customers across our networks who have an EV or intentions of purchasing an EV in the next five years intend to charge their EV at home utilising a wall charging box. This customer sentiment indicates that EV charging curtailment will be a persistent and increasingly prevalent issue.

Low tolerance to voltage fluctuations have already contributed to several EV undervoltage complaints across our networks in 2024, with increasing issues expected as customers adopt more EVs.

3.2.2 Voltage service levels will deteriorate and undervoltage complaints will increase through 2026–31

Today, 97 per cent of our customers have received compliant voltage 99 per cent of the time. Under business-as-usual conditions, we expect that electrification will drive reductions in voltage performance and increases in undervoltage compliance.

New forecast models provide visibility around the location, severity and duration of customer voltage issues

Traditionally, our approach to modelling customer demand across our network has relied on taxonomic representations of network topologies and point-in-time power flow simulations that approximate the expected performance of the network. Economic assessments typically interpolated customers synthetically to determine investment opportunities across our network.

These methods have been considered best practice, but they are limited in addressing the dynamic interplay between energy import and export, the diversity of our network topology, and customer demographics and behaviour. Additionally, evolutions in price and demand dynamics necessitate constraint assessments that analyse intraday demand patterns and export behaviour.

Comprehensive HV to LV power flow model

To address these limitations, we have developed a next-generation modelling approach that utilises AMI data to simulate power flows at each individual customer connection on our network every 30 minutes, over 10 years. We capture the full extent of the network, from the zone substation bus, through the high voltage network, to individual customer connection points on our low voltage network.

We engaged Zepben to develop a comprehensive high-voltage (HV) to low-voltage (LV) simulation of our network through their Energy Work Bench (EWB) platform. The model uses our network topography and AMI data to achieve unmatched power flow accuracy of ±2 per cent for 90 per cent of customer connection points, making it the most precise and reliable model Zepben has developed to date.

Our approach generates 800 billion data points, which has required a novel approach to data management. We have used distributed computing on Amazon Web Services to execute the power flow output workflow (alleviations, service levels and economics), which utilises 240 CPUs, 960 gigabytes of memory and over 5,000 lines of code to compute the electrical to economic assessment.

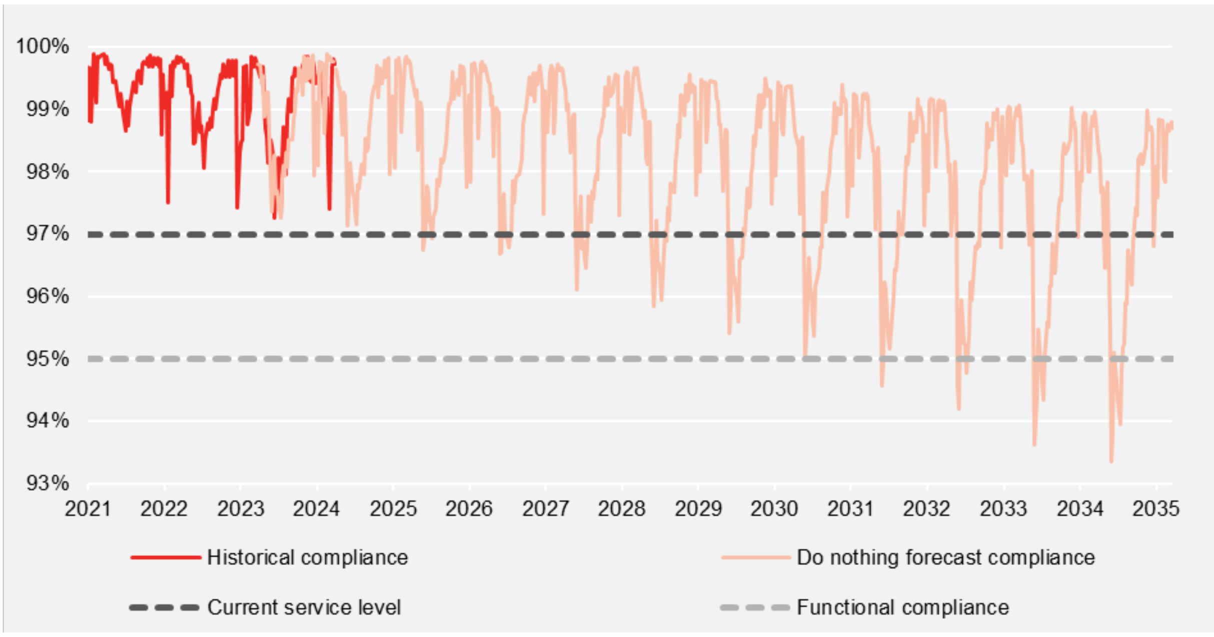
Our approach is summarised in figure 7, and a complete description of our methodology is attached.[22]

FIGURE 7 CUSTOMER-LEVEL FORECASTING TOOLS TO BETTER UNDERSTAND CUSTOMER IMPACTS

Using our new forecasting tools, we have assessed that without intervention, voltage compliance over the next regulatory period will fall from 96.7 per cent in FY27 to 95 per cent in FY31, as shown in figure 8.

[22] PAL ATT 2.04 – Zepben – Detailed customer electrification forecasting methodology – Jan2025 – Public

FIGURE 8 DO NOTHING VOLTAGE COMPLIANCE (%)



This reduction in voltage compliance will lead to more customers receiving non-compliant voltage levels, and consequently more customer complaints across our network. The changes in voltage compliance and complaints are described in table 2.

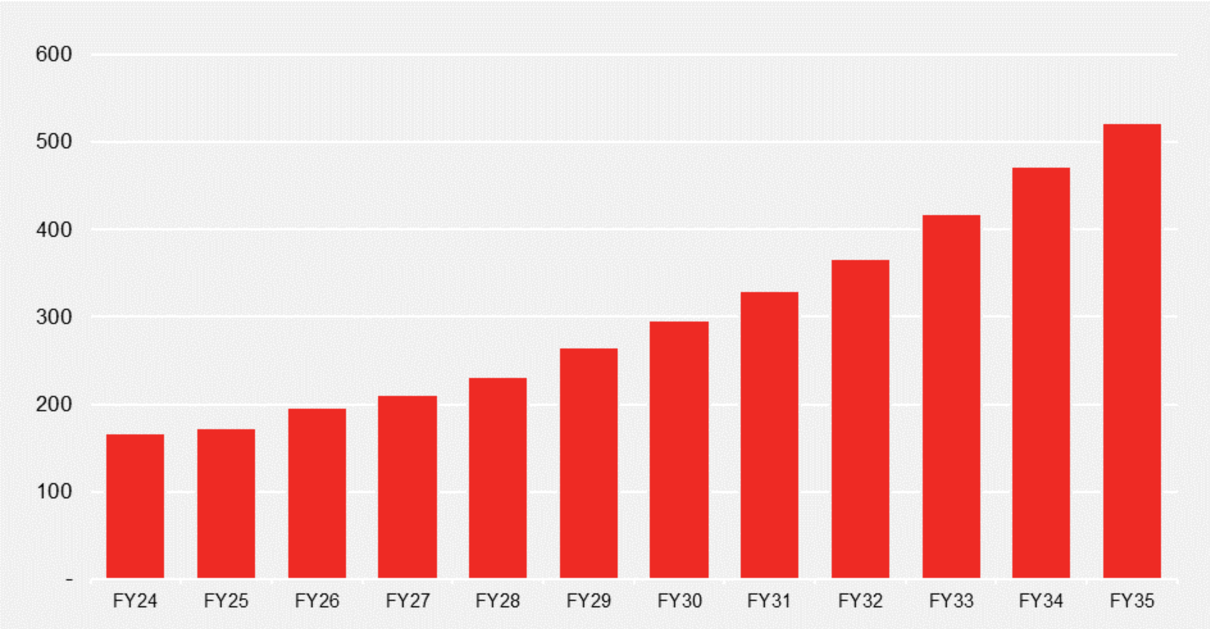
TABLE 2 DO NOTHING CUSTOMER EXPERIENCE IN 2031

FACTOR	FY24	FY31
Service level	97%	95.0%
Non-compliant customers	25,255	46,218
Annual complaints	167	330

By FY31, we expect 46,218 non-compliant sites across our network, a 20,963 increase from today. We expect this will result in 1,332 customers reporting undervoltage complaints in the next regulatory period. This is a sharp increase on the five-year period December 2019 to December 2024, in which we received a total of 766 undervoltage complaints.

9 shows expected growth in complaints under the do nothing scenario, which will continue increasing beyond the 2026-31 regulatory period as load from electrification continues to drive undervoltage constraints.

FIGURE 9 ANNUAL CUSTOMER UNDERVOLTAGE COMPLAINTS IF WE DO NOTHING



We use our experiences with the relationship between overvoltage service levels and overvoltage complaints to inform future undervoltage complaint levels. Our forecast likely under-estimates the number of complaints we will receive because the impacts of undervoltage, for example the inability to charge EVs, will be more noticeable and impactful than the impacts of overvoltage (i.e. inability to export).

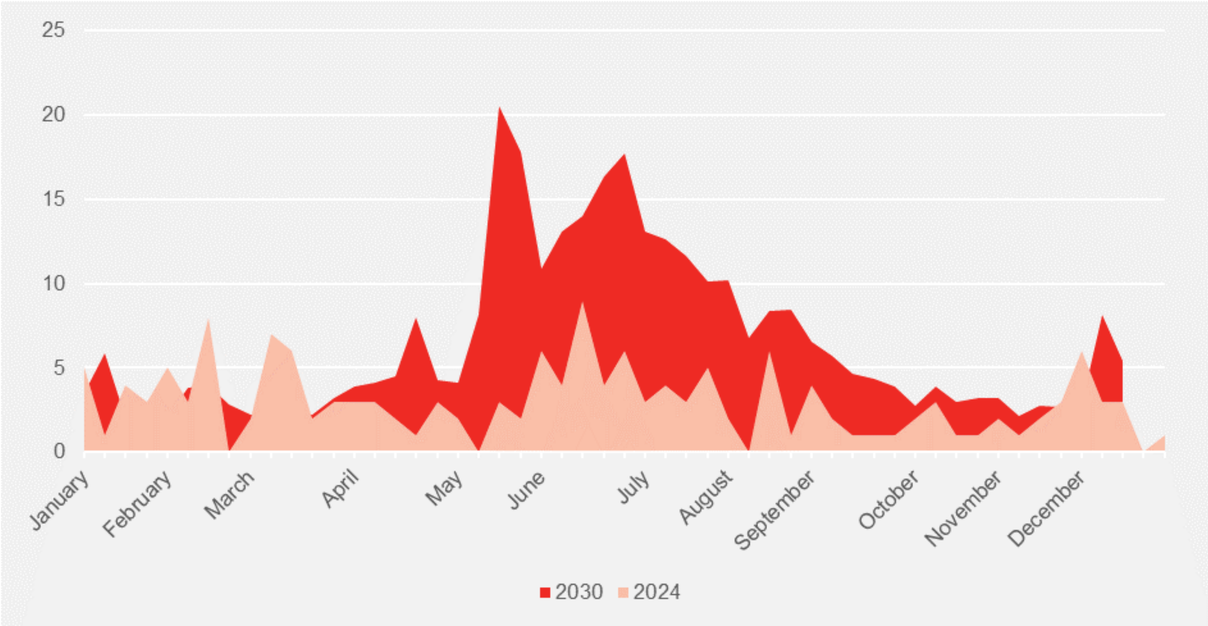
3.2.3 Undervoltage will be most prominent in winter

Electrification is expected to contribute significantly to winter peak demand, leading to further undervoltage constraints and an increase in complaints.

We typically receive more complaints in winter because of the consistent need to use heating over long periods of time, whereas there may only be a few very hot summer peak days per year. Notably, winter undervoltage constraints will last longer than summer constraints and will therefore be more impactful to customers than undervoltage constraints in summer.

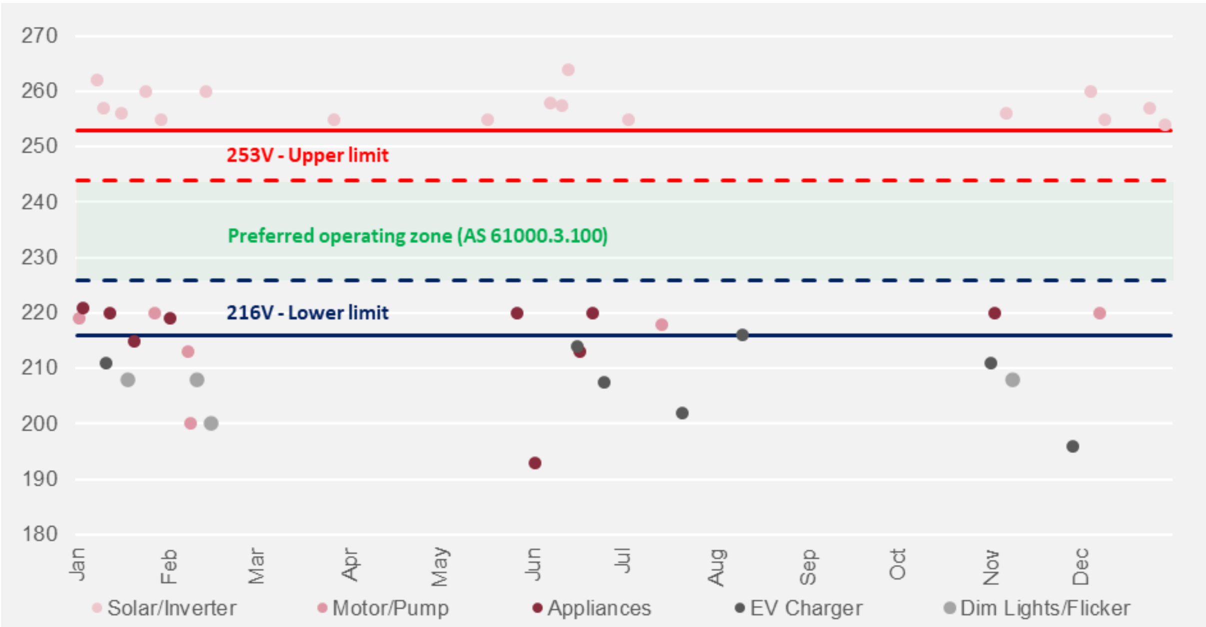
This seasonal spread of complaints, based on historical relationships between weekly compliance levels and complaints, is shown in figure 10.

FIGURE 10 SEASONAL SPREAD OF COMPLAINTS (COMPLAINTS PER WEEK)



The driver of complaints is also subject to variation. Figure 11 shows a sample spread of when we received complaints from customers over a 12-month period and what impact customers were complaining about. As our network continues to shift to winter peaking, we expect the number of complaints we receive between June and August to increase.

FIGURE 11 THE CUSTOMER IMPACTS OF UNDERVOLTAGE CAN VARY (V)

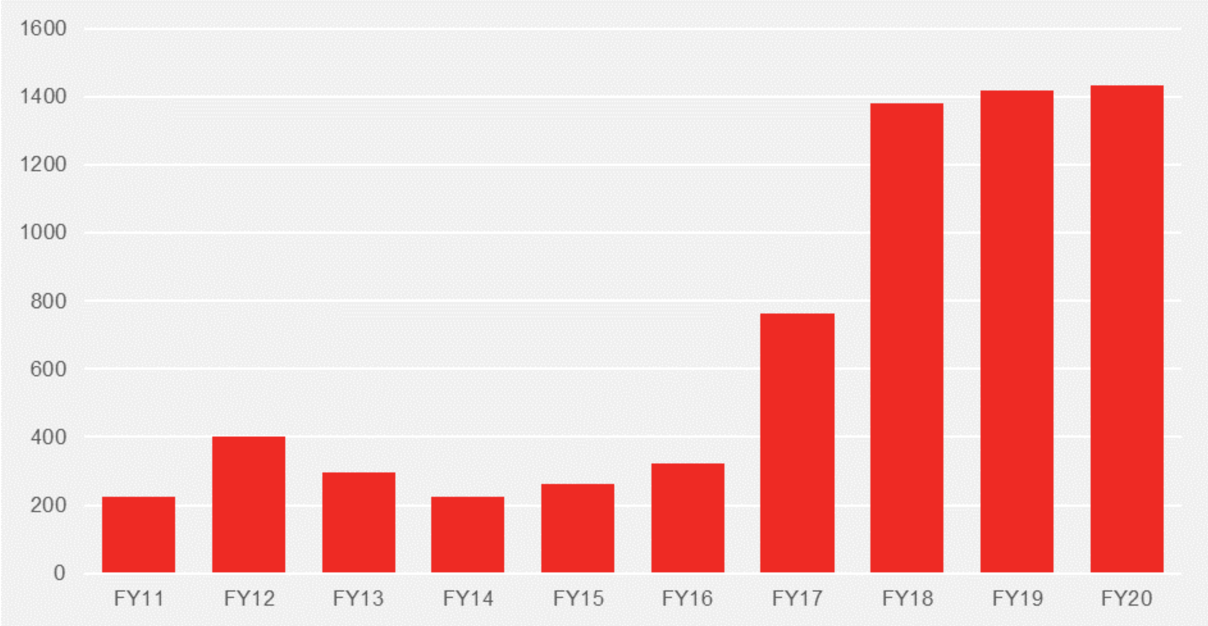


3.2.4 Similar early trends were seen with solar adoption and overvoltage

The correlation between voltage compliance levels and customer complaints is well established through our experiences with rooftop solar adoption.

Between 2017 and 2021, the capacity of rooftop solar PV on our network increased from 329 MW to 755 MW. Exports from rooftop solar caused an increase in voltage on sections of our network as export outstripped our network's capacity to maintain a stable range. The increase in voltage resulted in a rapid increase in overvoltage complaints as customers reported their solar inverters malfunctioning or shutting off, shown in figure 12.

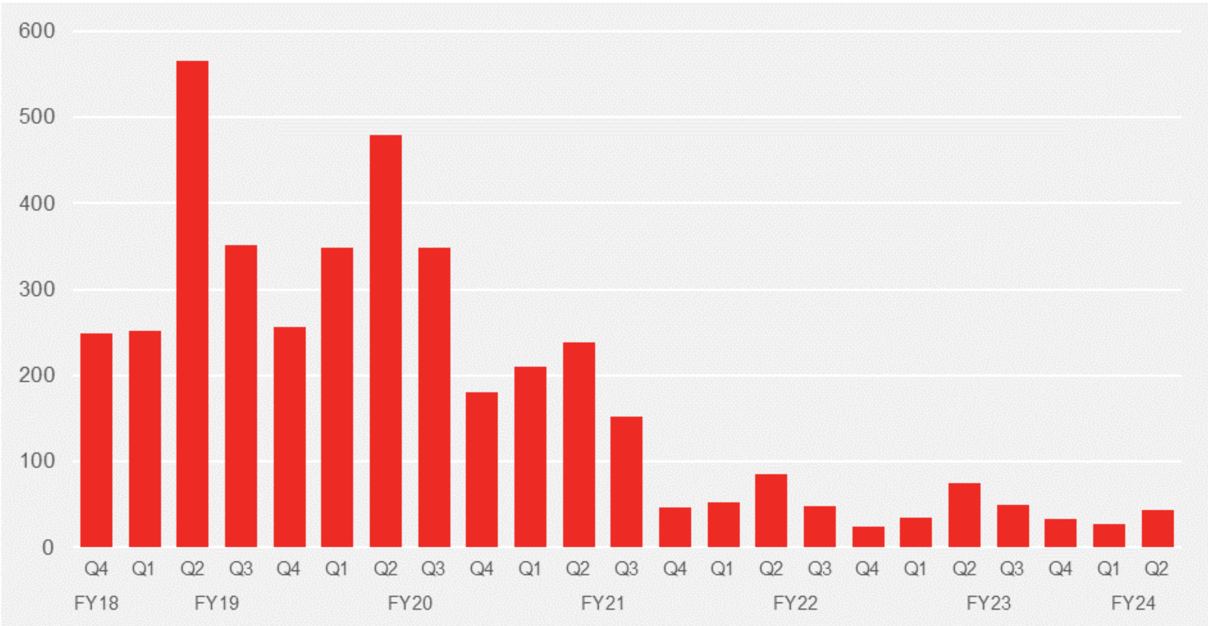
FIGURE 12 OVERVOLTAGE COMPLAINTS



In response, we implemented a series of minor augmentation projects such as transformer tap changes and phase balancing to optimise our network. These solutions optimised our performance on over and under-voltage simultaneously to maximise voltage performance within compliant ranges.

We deployed our Solar Hot Spots program to improve overvoltage compliance using low-cost augmentations in Q4 FY20. We implemented our Dynamic Voltage Management System (DVMS) in Q4 FY21. Figure 13 shows the immediate impact of these projects on reducing overvoltage complaints.

FIGURE 13 OVERVOLTAGE COMPLAINTS REDUCED OVER TIME USING LOW-COST SOLUTIONS



Managing the impact of overvoltage is a material and ongoing issue. National standards and inverter compliance requirements mandate that solar exports are ramped down or shut off as voltage levels rise to protect customer equipment and the network. While inverter compliance is improving over time to manage overvoltage, we were too slow to address overvoltage increases because we did not recognise the early warning signs in time.

Similar trends are emerging for load-based equipment such as EV chargers, which will curtail electricity usage as voltage levels lower or the local network is not strong enough to sustain high power quality. It is clear that undervoltage issues are on a similar trajectory as overvoltage issues were.

3.2.5 Undervoltage is more tangible and impactful to customers than overvoltage

Customers have typically experienced voltage non-compliance through curtailed solar exports, creating a financial impact through foregone feed in tariff revenue. However, the impacts of overvoltage rarely replicate the impacts of undervoltage, which, as case studies below demonstrate, customers are telling us can cause significant disruption to daily life.

We anticipate that the impacts of undervoltage will intensify as customers incorporate electrification into various aspects of their daily lives. As customers electrify, undervoltage will extend from flickering lights to heating, cooling and cooking appliance malfunction, appliance lifespan degradation and inability to travel if EVs don't charge as expected. For the 39 per cent of Victorians that usually work from home, these disruptions may impact their ability to run their business or work as desired.[23]

We expect to support charging for almost 200,000 additional electric vehicles across our network between January 2025 and January 2031. We know from our engagement on electrification that our customers who already own or are considering purchasing an EV will become more engaged in considering energy efficiency improvements and utilising smart home technologies to manage their energy than non-EV customers. We consider these changes in consumer behaviour likely to result in more undervoltage complaints than we received for overvoltage.

[23] Australian Bureau of Statistics, *6336.0 Working Arrangements, Data downloads: Job Flexibility and Security*, 2024

FIGURE 14 CASE STUDY – EV CHARGING IMPACTED BY UNDERVOLTAGE

A customer in Ocean Grove complained to us that their EV was not being charged overnight when they expected it to be. They found that their car was not charged when they wanted to go to work in the morning, impacting their ability to get to work.

The customer was notified via their phone application that their charging was interrupted early in its charging cycle. Undervoltage was found to be the cause of the issue, requiring network upgrades to remediate.

> *"…the interruption occurred multiple time in the night, sometimes I didn't realise until I was ready to* ***go to work the next day*** *in Melbourne* ***and the car didn't have enough charge****."*

Quote from customer in Ocean Grove, 9 August 2023

FIGURE 15 CASE STUDY – ELECTRIC HEATING IMPACTED BY UNDERVOLTAGE

A customer in Buninyong complained to us that their heater was not operating. The **customer and their young family were left without heating during cold winter months where mean temperatures in the area are less than 4 degrees**.

We found that undervoltage was the cause of the customers' heater not functioning. The voltage levels experienced by this customer were repeatedly below 180V.

Electrification of this customers' property would not be possible with the voltage levels that were being supplied to them.

We upgraded the conductor supplying the customers' property to resolve the issue.

VOLTAGE	IMPACT
>253V	EXPORT CURTAILED
>216V - <253V	HEALTHY LIGHTING AND APPLIANCE OPERATION
215V	POOR LIGHTING AND APPLIANCE OPERATION
207V <200V	LIGHTING AND APPLIANCE MALFUNCTION/ DEGRADATION

3.2.6 Customer trust in our network increased as we improved service levels

5,728 customers lodged an overvoltage complaint between 2017 and the operationalisation of Solar Hot Spots and DVMS becoming operational in 2022. Widespread overvoltage had a significant, negative impact on how we were perceived by our customers. As shown in table 3, we have been able to build trust as our service levels have improved to 2024.

TABLE 3 CUSTOMER TRUST IN POWERCOR

POWERCOR IS TRUSTED TO:	Q2 2020	Q3 2024
Act in customer best interests	17%	26%
Enable solar connections	17%	24%
Provide a reliable supply of electricity	27%	36%
Keep customers informed	27%	34%
Help manage customer usage	13%	23%

Source: Powercor internal brand tracker

While we have managed to strengthen our relationship with customers in the last four years, our customers have told us that trust in our ability to drive the energy transition hinges on reliability and our ability to facilitate consumer energy resource adoption.

In considering key risks for delivery of the 2024 Integrated Systems Plan, the Australian Energy Market Operator (AEMO) states that energy institutions must earn the social license to invest in the energy transition by 'working hard to build relationships on trust'.

4. Options analysis

To address increasing voltage non-compliance and deteriorating services levels for customers, we investigated several credible investment options over the 2026–31 regulatory period. Consistent with our CER and electrification strategy, these options are informed by our enhanced forecasting capabilities and follow the exhaustion of low-cost solutions.

4.1 Enhanced forecasting tools and optimisation

The integration of consumer energy resources is driving an unprecedented shift in the profile and location of load on our low voltage network. The uncertainty of when and where load will originate is necessitating a shift in how we model and forecast voltage on our network.

4.1.1 Our forecasting model optimises network voltages with low-cost solutions

As discussed in section 2.2.1, we have used low-cost solutions such as transformer tap changes, phase balancing and our DVMS platform to optimise our network and resolve customer complaints. This approach has helped us achieve voltage compliance to ensure that our network is optimised and that costs are minimised.

One of the benefits of our time-series modelling, described previously in section 3.2.2, is that it produces holistic time-series voltage forecasts over a 10-year period. We can assess the forecast voltage profile of our assets and optimise each augmented asset to maximise undervoltage and overvoltage compliance. We only augment sites where the forecast voltage spread does not allow for tap optimisation to be realised. This ensures that any augmentation projects are efficient and cannot be otherwise resolved by low-cost solutions.

For example, a customer that has undervoltage growing to >37 V cannot have voltages optimised and as such only augmentation is the economic option to address the customer non-compliance. This process ensures that unnecessary capacity upgrade investments are avoided.

Any costs associated with further network optimisations using low-cost solutions have been conservatively excluded from our expenditure proposal.

Going forward, we expect that low-cost solutions will be less effective because our network is becoming fully optimised to achieve both over and under-voltage compliance simultaneously. Capacity upgrades are required when low-cost solutions can no longer address undervoltage issues.

4.2 Costing alternative site-specific options for alleviation

We modelled the cost and impact of a range of site-specific options to proactively resolve forecast undervoltage impacts for our customers, including non-network options, low-cost options and network upgrades.

The cost of each type of network upgrade has been derived from historical actuals, including cost differences between urban and rural upgrades.

The benefits of each upgrade have been assessed based on the forecast voltage profile and the expected impact of each upgrade. These impacts are based on engineering characteristics and historical performance.

We modelled the cost and impact of implementing our own non-network options in the form of a battery that we owned. However, batteries were not cost competitive because voltage compliance steadily declined and outstripped the capabilities that a battery could provide.

The availability and effectiveness of local third-party non-network solutions is not certain, and we have assumed that some proactive investments are deferred in options that include proactive investments. Further information on our assessment of the impact of third-party non-network solutions is available in our flexible services business case.[24]

A summary of the credible options we have modelled are shown below in table 4, with further detail on all options considered provided in appendix C.

TABLE 4 CREDIBLE SITE-SPECIFIC ALLEVIATION OPTIONS CONSIDERED

ALLEVIATION OPTION	ALLEVIATION COST	DESCRIPTION	IMPACT OF INVESTMENT
Tap change	$0	Tap change to adjust voltage set point at the distribution substation (DSS)	Optimise overvoltage and undervoltage compliance simultaneously
Distribution substation offload	$100,000	Install new DSS to offload parts of existing circuits which will redistribute load to relieve capacity and voltage constraints on existing substations	An additional DSS halves the voltage spread and load on the circuit it is installed on
LV reconductoring	$80,000	Enhance voltage stability of conductors through upgrading low voltage conductors to higher capacity types, such as 19/3.25 aluminium	Improves conductor voltage spread by 18V through a 9V reduction in max voltage and a 9V increase in min voltage
Rural substation upgrades	$60,000	Install substations in low density areas to offload long rural LV servicing to alleviate voltage constraints	An additional DSS halves the voltage spread and load on the circuit it is installed on

4.2.1 Proactively addressing voltage non-compliances will deliver better service levels for customers and is more efficient over the long-term

Proactive investment to remediate voltage non-compliance is more efficient over the long term because it delivers several additional benefits relative to reactive investment. These benefits include:

- better service levels due to improving voltage performance in advance of materially poor performance
- fewer complaints because negative customer experiences such as appliance malfunction and EV curtailment that drive complaints are avoided
- additional service delivery efficiencies through the ability to schedule projects

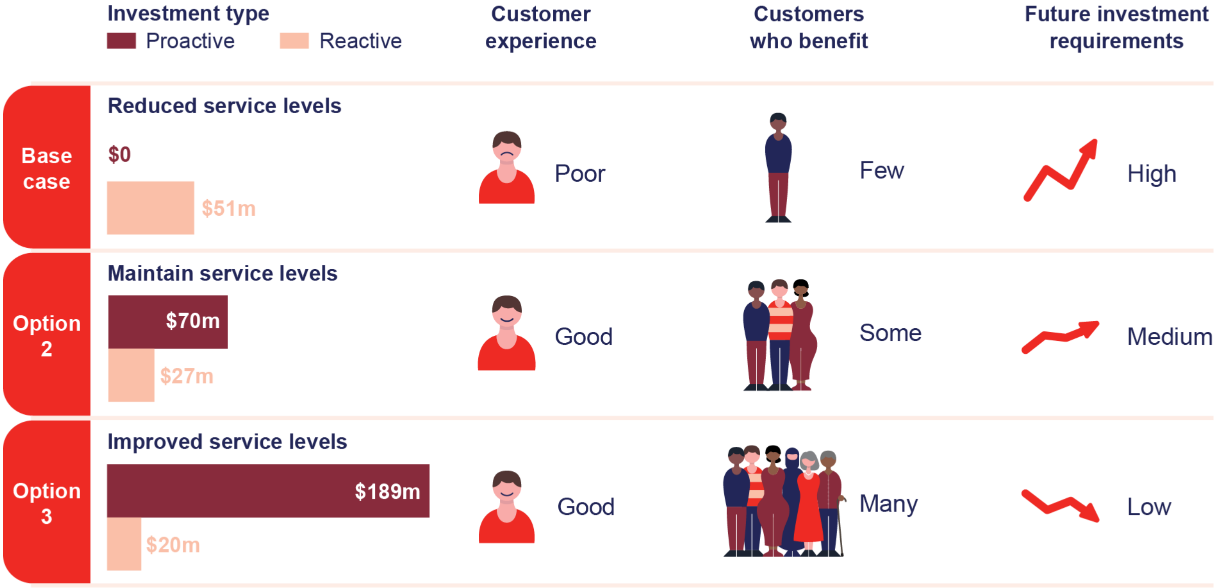
[24] PAL BUS 2.01 – Flexible services – Jan2025 – Public

- implementation of better long-term solutions through designing to maximise long-term performance than least cost solutions
- higher value network investments through targeting sites with the highest number of customers that will lead to the greatest benefits
- Improved social licence and customer trust in the energy transition, fostering buy-in for flexible products in the future and reducing long-term prices.

4.3 Balancing proactive and reactive approaches

Our options assessment, as set out in the following sections, consider three alternatives—reducing, maintaining and improving service levels. A summary of the cost, investment type, customer outcomes and future investment requirements under three alternative options are shown in figure 16.

FIGURE 16 SUMMARY OF OPTIONS CONSIDERED



Broadly, each option varies through different levels of proactive and reactive expenditure based on varying obligations, targets or economic assessments. Each option results in different customer experiences, voltage compliance levels, costs, long-term efficiency and required future investment.

Investing less in proactive upgrades will ultimately lead to lower service levels, poorer customer experiences, more customers 'eligible' to complain, and therefore more customer complaints. This has been our historical approach because we have not had granular low voltage forecasts to guide future efficient investment.

Investing more in proactive upgrades will ultimately lead to maintaining or improving service levels and customer experiences, and with fewer customers eligible to complain, therefore fewer customer complaints. New granular forecast capabilities have enabled proactive upgrades.

Proactive upgrades are also expected to be more efficient over the long-term because we can optimise investment location and timing, and deliver higher long-term service levels for a given cost, as further described in section 4.2.1.

However, proactive investments are more expensive in the short term because we would be upgrading some sites ahead of customers complaining (despite these customers receiving poor and/or non-compliant service levels).

While coding software has been used to derive options for our customer electrification program, we have replicated the chain of logic to determine our proactive upgrades program under each option in our attached customer-driven electrification excel model.[25] The model is intended to demonstrate the link between the outputs of our LV power flow modelling and development of our proactive upgrade program options.

4.4 Base case: reduced service levels

Under the base case option, we would restrict investment to only what is necessary to meet our compliance requirements under the EDCoP, including:

- proactive investments strictly to maintain functional compliance
- remediating incidents of voltage non-compliance following a complaint from non-compliant customers.

In effect, this base case represents a degradation in service levels for customers. Without investment, increasing demand on our network will create voltage constraints that reduce voltage compliance from 97 per cent today to 95 per cent by FY31.

Degrading voltage compliance will also drive a corresponding rise in complaints through the 2026–31 regulatory period.

Table 5 summarises the impact of degrading to functional compliance on customers.

TABLE 5 CUSTOMER OUTCOMES UNDER THE BASE CASE

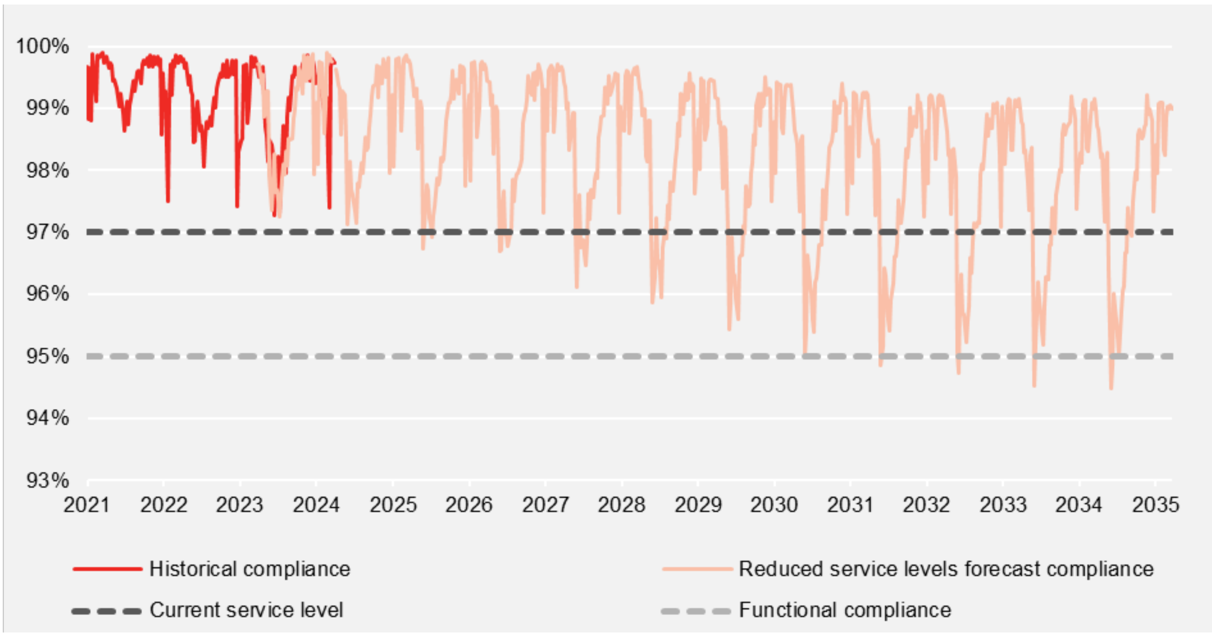
OUTCOME	FY27	FY28	FY29	FY30	FY31	TOTAL
Annual service level compliance	96.7%	96.1%	95.9%	95.4%	95.0%	-
Annual non-compliant sites	30,429	35,668	38,098	42,103	46,052	-
Customer complaints	220	240	273	303	337	**1,373**
Undervoltage energy at risk (MWh)	4,643	5,362	6,346	6,960	8,046	**31,357**

Figure 17 summarises forecast voltage service level compliance under the base case. Forecast compliance is lowest in winter, driven by increasing electrification of gas.

The base case assumes that proactive works commence in FY31 to avoid non-compliance. Without these proactive works, voltage performance in FY31 would fall to non-compliant levels of 95 per cent and in FY34 would fall further to 93.6 per cent.

[25] PAL MOD 3.31 - Customer-driven electrification - Jan2025 - Public

FIGURE 17 FORECAST UNDERVOLTAGE COMPLIANCE UNDER THE BASE CASE (%)



4.4.1 Forecast costs under the base case

Under the base case option, we would proactively target sites to upgrade based on the highest number of customers that would become compliant following an augmentation investment. This ensures that our proactive investments are efficient, and we invest no more than necessary.

We would only utilise proactive investments to achieve functional compliance and will invest as late as possible to optimise our capex portfolio. Minimal proactive investment is required to maintain functional compliance to 2031.

In addition to proactive investments, under the EDCoP we must remediate non-compliant customers as soon as practicable when we become aware of non-compliance. Investments prioritise timely resolutions to reported non-compliance at the lowest cost, rather than highest possible value capture. These reactive costs form the largest component under the base case option.

A summary of expenditure required under the base case option over the 2026-31 regulatory period is shown in table 6.

TABLE 6 BASE CASE EXPENDITURE ($M, 2026)

AUGMENTATION TYPE	FY27	FY28	FY29	FY30	FY31	TOTAL
Proactive LV augmentation	-	-	-	-	0.1	**0.1**
Reactive LV augmentation	6.2	7.7	9.8	12.1	14.9	**50.8**
Avoided augmentation from non-network solutions	-	-	-	-	-	**-**
Annual total	**6.2**	**7.6**	**9.8**	**11.6**	**14.3**	**49.5**

4.4.2 Assessment of the base case option

The primary benefit of the base case option, relative to other alternatives, is that it requires the lowest amount of capital expenditure over the 2026–31 regulatory period. Investing only to maintain functional compliance reduces the amount of proactive expenditure required, which allows us to minimise bill impact for customers over the 2026–31 regulatory period.

The base case option, however, carries several risks and is not consistent with stakeholder expectations that we maintain today's service levels for customers. For example:

- **increased likelihood of breaching functional compliance**: operating marginally above functional compliance risks breaching functional compliance in the event that demand is higher than expected. This risk is heightened given our voltage forecasts are based off a 50 per cent probability of exceedance scenario. No distributor has ever operated below 96 per cent undervoltage compliance. Degrading to functional compliance is unprecedented.
- **customer experience will deteriorate as Victoria's energy transition needs electrification to accelerate**: operating at functional compliance means at least 17,739 more customers will experience appliance malfunctioning, faster appliance degradation, inability to charge EVs and more prevalent power quality issues, than other options. Degradations in reliability or power quality were repeatedly rejected by our customers during our engagement program as they considered options to electrify. Under the base case, these expectations will not be met for a number of customers during a period where the Victorian Government has targeted half of all light vehicle sales to be zero emissions by 2030
- **the impacts of undervoltage are sustained until a resolution is provided:** remediating undervoltage may require complex augmentation projects that can have lead times of up to one year. Customers will experience the sustained impacts of undervoltage until the constraint is alleviated. For many customers, this could result in malfunctioning heating over two winter periods, or consistent inability to charge their EV
- **degradation of social licence, reducing uptake of flexible products in the future:** Victoria's energy transition requires our customers to electrify their homes, transport and businesses at a rapid pace and great scale. Our industry is the second least trusted source of information regarding the energy transition, and customers must trust that networks operate in their best interest to accept flexible offerings that facilitate orchestration in the future.[26] Poor experiences can lead to negative sentiment within communities that may slow the uptake of electrification and reduce the uptake of flexible products in the future
- **higher amounts of less efficient reactive expenditure:** this option only invests to maintain functional compliance, resulting in lower service levels and more reactive expenditure. Reactive expenditure is less efficient over the long term, as described in section 4.2.1
- **higher investment requirement to maintain functional compliance over 2031–36:** allowing voltage compliance to deteriorate leads to a lower level of voltage compliance in 2031. Relatively more expenditure would be required to maintain functional compliance over the 2031-36 regulatory period
- **inability to take advantage of non-network solutions**: works planned in advance can be tendered to market to test for the presence of efficient non-network solutions that could defer augmentation. However, reactive works do not allow us to tender for non-network solutions because they must be addressed as soon as possible.

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26 CSIRO, *Attitudes Towards the Energy Transition: Energy Transition Survey,* Trusted Information sources, 2024

4.5 Option two: maintain current service levels

Under option two, we would maintain the power quality and reliability of supply that our customers experience today. Proactive investments would resolve forecast constraints from additional load on our network through the 2026–31 regulatory period to maintain current service levels.

Voltage compliance of 97 per cent will be maintained in line with the service level we offer customers today. Maintaining voltage compliance in line with current service levels will ensure that complaints through the 2026–31 regulatory period remain stable.

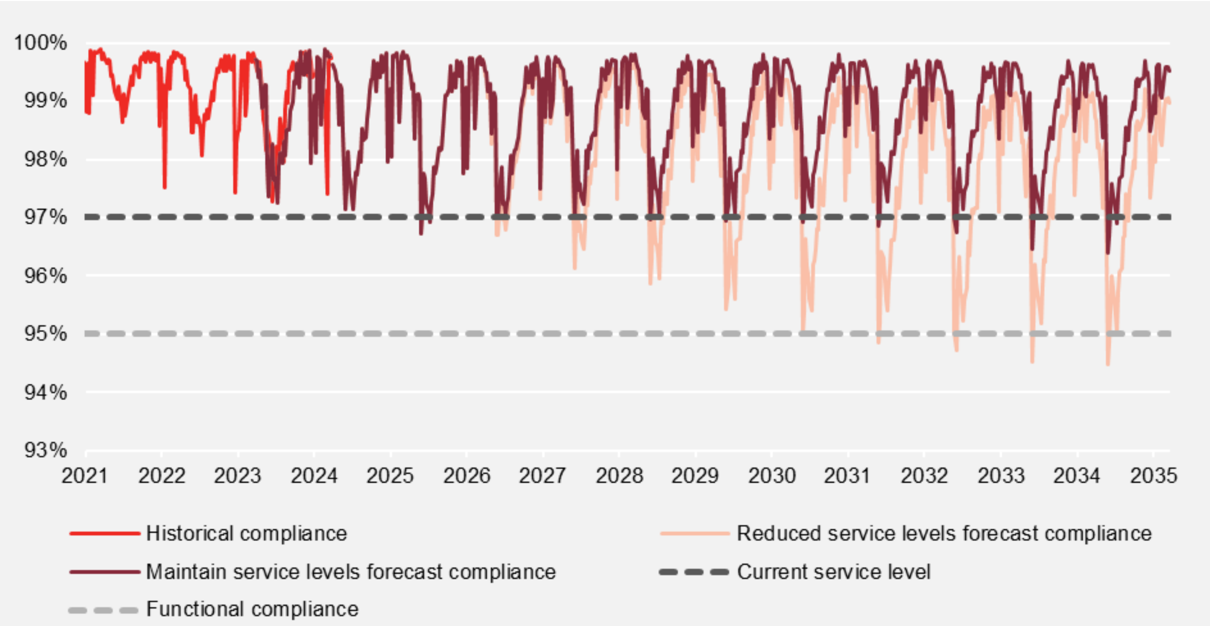
Table 7 summarises the impact of maintaining functional compliance for our customers.

TABLE 7 MAINTAIN SERVICE LEVELS CUSTOMER OUTCOMES

OUTCOME	FY27	FY28	FY29	FY30	FY31	TOTAL
Annual service level compliance	97%	97%	97%	97%	97%	-
Annual non-compliant sites	27,656	27,749	27,854	28,071	28,312	-
Customer complaints	198	182	190	185	182	**938**
Undervoltage energy at risk (MWh)	3,985	3,664	3,781	3,643	3,907	**18,980**

Figure 18 summarises the forecast voltage service level if we maintain compliance at our current compliance level of 97 per cent through the 2026-31 regulatory period. Forecast compliance is lowest in winter, driven by increasing electrification of gas.

FIGURE 18 FORECAST UNDERVOLTAGE COMPLIANCE IF WE MAINTAIN CURRENT SERVICE LEVELS (%)



4.5.1 Forecast costs of maintaining compliance

To maintain current service levels, we would proactively target sites to upgrade based on the highest number of customers that would become compliant following an augmentation investment. This ensures that our proactive investments are efficient, and we invest no more than necessary.

We would utilise proactive investments to maintain current service levels of 97 per cent and will invest as late as possible to optimise our capex portfolio. Our proactive investment program includes DSS offloads and reconductoring. Proactive investments form the largest component of our investment program to maintain compliance.

In addition to proactive investments, under the EDCoP we must remediate non-compliant customers as soon as practicable when we become aware of non-compliance. Investments prioritise timely resolutions to reported non-compliance at the lowest cost, rather than highest possible value capture. The amount of reactive upgrades required to maintain compliance is lower relative to the base case.

A summary of expenditure required to maintain current service levels is shown in table 8.

TABLE 8 SUMMARY OF EXPENDITURE TO MAINTAIN SERVICE LEVELS ($M 2026)

AUGMENTATION TYPE	FY27	FY28	FY29	FY30	FY31	TOTAL
Proactive LV augmentation	3.0	14.7	8.0	18.4	18.8	**63.0**
Reactive augmentation	4.9	4.9	5.4	5.6	5.9	**26.6**
High voltage cluster augmentation	1.4	1.4	1.6	0.8	3.8	**8.9**
Avoided augmentation from non-network solutions	-	-0.1	-	-0.6	-0.7	**-1.4**
Annual total	**9.3**	**20.8**	**15.0**	**24.3**	**27.8**	**97.1**

4.5.2 High voltage clustering

We have investigated the use of HV upgrades to address issues on LV networks. HV feeders supply several downstream LV circuits, and upgrading the HV feeder can address the voltage constraints of all downstream LV circuits at once.

HV upgrades are more expensive than a single LV upgrade, however they can still be more efficient when the HV upgrade resolves a large enough number of LV voltage constraints that are supplied by the same HV feeder.

HV feeders are identified for upgrade if the total upgrade cost is less than the sum of individual LV augmentation costs. More information on our methodology to assess high voltage clustering can be found in our attached methodology document.[27]

In total, we found seven high voltage projects that would deliver comparatively more value, displayed in table 9.

[27] PAL ATT 2.01 - Customer electrification forecasting methodology - Jan2025 - Public

TABLE 9 SUMMARY OF HIGH VOLAGE AUGMENTATION ($M 2026)

FEEDER	TOWN	SPAN (KM)	CUSTOMERS	LV COST ($M 2026)	HV COST ($M 2026)	COST SAVING
SHP014	Rushworth	5	766	1.7	1.4	0.3
WND013	Lancefield	1.8	117	0.6	0.5	0.1
PLD001	Heywood	3.2	250	1.1	0.9	0.2
STL005	Pomonal	2	191	0.6	0.5	0.1
BAN003	Mount Egerton	4	105	1.5	1.1	0.4
CLC013	Apollo Bay	3.8	1,613	2.0	0.8	1.2
SHP012	Rochester	13.8	455	5.5	3.8	1.7
Total		**33.6**	**3,497**	**12.9**	**8.9**	**4.0**

4.5.3 Avoided augmentations from non-network solutions

Our flexibility services business case involves further investments in our third-party non-network procurement platform to incentivise market development of non-network solutions. Sufficient uptake of non-network solutions in the future can deliver efficiencies for customers.

We expect that some proactive investments could be deferred as the market scales up over the 2026-31 regulatory period and beyond, and we receive increasing amounts of successful tenders to defer LV constraints. Further information on our assessment of the impact of third-party non-network solutions is available in our flexible services business case.[28]

4.5.4 Assessment of maintaining current service levels

The primary benefit of maintaining current service levels is improved customer experiences, with 17,739 additional customers receiving compliant voltage levels, leading to improved appliance function, longer appliance lifespan, enhanced local power quality and better ability to charge EVs.

There are several other benefits of maintaining current service levels relative to the base case option, which include:

- **435 fewer reactive complaints:** better customer experiences will lead to fewer reactive complaints that we are obligated to resolve and less reactive expenditure to resolve them than

[28] PAL BUS 2.01 – Flexible services – Jan2025 – Public

under the base case. Reactive expenditure is less efficient than proactive expenditure, as described in section 4.2.1

- **reduced undervoltage energy at risk**: there will be a total of 19.0 GWh of non-compliant undervoltage energy delivered to customers over the 2026–31 regulatory period, 12.4 GWh lower than the base case. This will result in fewer appliance malfunctions and degradations, with more customers able to charge EVs
- **improved ability to manage changes in demand:** operating above functional compliance creates headroom to offer higher service levels, or maintain functional compliance, if peak demand is higher than forecast through the 2026–31 period. Maintaining our service levels will put us in a strong position to facilitate increasing electrification in following regulatory periods, potentially driven by Victoria's forecast 600 PJ gas supply shortfall between 2028 and 2035
- **support from our customers for maintaining current service levels**: customers consistently emphasised their expectation that we maintain current reliability and service levels through the energy transition. In addition, 43 per cent of customers supported an investment of $120 million, and an additional 30 per cent supported an investment of $80 million. Our proposal to maintain service levels was supported by stakeholders at our customer roundtable
- **continued customer social licence:** maintaining similar service levels for customers will maintain the trust and social licence we have built with customers. Customer trust in us to act in their best interests, provide a reliable supply, and help manage customer usage has each improved between 9 to 10 percentage points over the last 4 years, which aligns with the reduction in overvoltage complaints we have received over the same period. Positive social licence will lead to greater uptake of efficient flexible products and facilitate the system orchestration required through the energy transition, which customers are willing to engage with, but have told us that they require reliable power to do so [29]
- **lower investment requirements over the 2031-36 regulatory period**: improving service levels ensures that customers receive higher quality services through the 2026–31 regulatory period, putting us in a stronger position heading into the 2031-36 regulatory period than the base case option. Starting from a better service level creates optionality to set higher or lower future performance targets and it would require relatively less investment to reach any 2031-36 performance target compared to the base case
- **ability to tender for non-network solutions**: works planned in advance can be tendered to market to test for the presence of efficient non-network solutions that could defer augmentation. Substantive proactive works to maintain compliance present opportunities to seek non-network solution opportunities and defer augmentation to deliver more efficient services for customers.

Maintaining current service levels does however require more investment relative to the base case option because we would be investing proactively to maintain current service levels rather than simply responding reactively to customer complaints.

While maintaining current service levels delivers improved outcomes relative to the base case, there would still be over 28,000 customers receiving non-compliant voltage levels in FY34.

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[29] CSIRO, *Attitudes Towards the Energy Transition: Energy Transition Survey,* Trusted Information sources, 2024

4.6 Option three: improve service levels

Under option three, we would improve our voltage performance above the service levels we deliver to customers today. Proactive investments would resolve forecast undervoltage constraints from additional load on our network through the 2026–31 regulatory period.

This option economically values the undervoltage energy supplied to each customer and compares the value of resolving an undervoltage constraint against the cost to resolve it. The methodology to value undervoltage is based on voltage levels supplied to customers and the AER's value of customer reliability. Our methodology is discussed further in section 4.6.2.

Voltage compliance under option three improves from 97 per cent today to 97.9 per cent in 2026-27 before reducing to 97.2 per cent by FY31. The frequency and peak number of complaints will fall substantially in alignment with an increase in the service levels we offer to customers, before gradually increasing to 2031 as our service degrades from the peak.

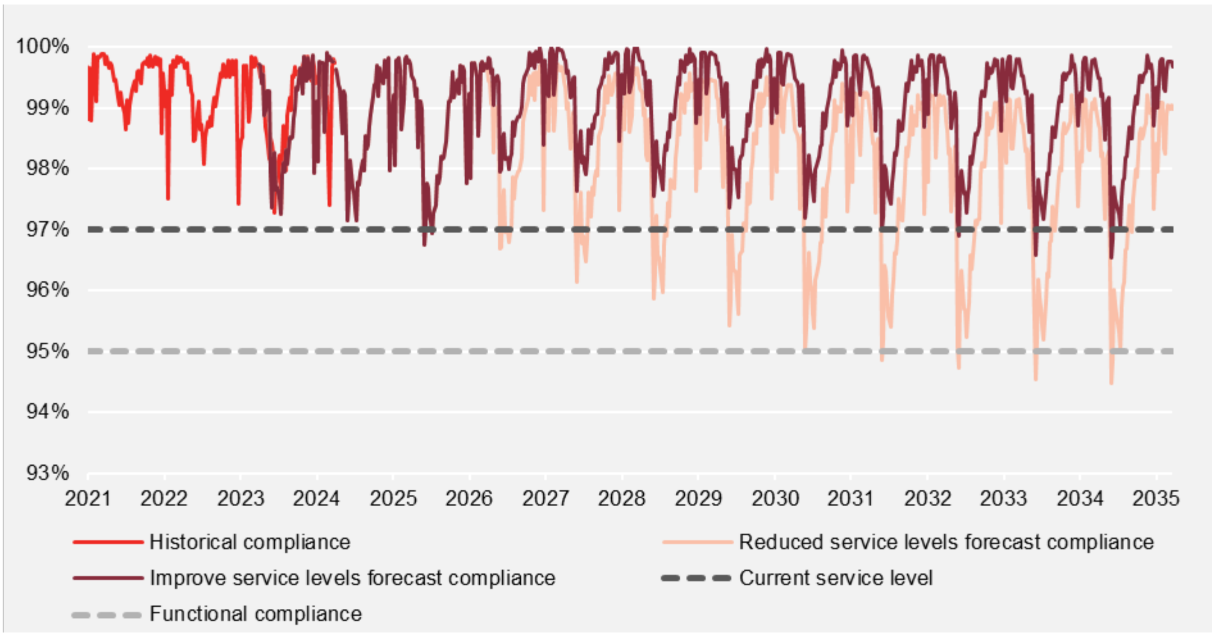
Table 10 summarises the impact of improving service levels for our customers.

TABLE 10 IMPROVE SERVICE LEVELS CUSTOMER OUTCOMES

OUTCOME	FY27	FY28	FY29	FY30	FY31	TOTAL
Annual service level compliance	97.9%	97.6%	97.6%	97.4%	97.2%	-
Annual non-compliant sites	19,005	21,716	22,549	24,332	25,894	-
Customer complaints	130	135	144	151	157	**717**
Undervoltage energy at risk (MWh)	210	271	295	331	342	**1,449**

Figure 19 summarises the forecast voltage service level if we improve service levels beyond our current compliance level of 97 per cent through the 2026-31 regulatory period. Forecast compliance is lowest in winter, driven by increasing electrification of gas.

FIGURE 19 IMPROVE SERVICE LEVELS COMPLIANCE AND COMPLAINTS (%)



4.6.1 Forecast costs of improving service levels

We would utilise proactive investments to improve service levels beyond 97 per cent and will invest as late as possible to optimise our capex portfolio. Our proactive investment program includes DSS offloads and reconductoring. Proactive investments form the largest component of our investment program to improve compliance.

In addition to proactive investments, under the EDCoP we must remediate non-compliant customers as soon as practicable when we become aware of non-compliance. Reactive investments prioritise timely resolutions to reported non-compliance at the lowest cost, rather than highest possible value capture. The number of reactive upgrades required to improve compliance is lower relative to both the base case and maintain current service levels.

A summary of expenditure required to improve service levels is shown in table 11.

TABLE 11 SUMMARY OF EXPENDITURE TO IMPROVE SERVICE LEVELS ($M 2026)

AUGMENTATION TYPE	FY27	FY28	FY29	FY30	FY31	TOTAL
Proactive LV augmentation	119.1	14.2	22.4	11.7	22.7	**190.1**
Reactive augmentation	3.2	3.6	4.1	4.6	5.0	**20.5**
High voltage cluster augmentation	-	-0.1	-	-0.6	-0.7	**-1.4**
Avoided augmentation from non-network solutions	122.3	17.6	26.4	15.7	27.0	**209.2**
Annual total	**119.1**	**14.2**	**22.4**	**11.7**	**22.7**	**190.1**

4.6.2 Proactive approach to targeting sites

Under the improve service levels option, we would proactively target sites based on an economic assessment of the value of energy enabled by an augmentation compared to the project cost. This differs to our approach under the base case and maintaining compliance, which targeted sites with the highest number of non-compliant customers.

Our voltage compliance obligations require us to not supply voltage levels below 216V more than one per cent of the time for each customer, and not below 207V for more than 10 seconds.[30] We use our voltage compliance obligations to value the undervoltage energy supplied to customers using the AER's Value of Customer Reliability (VCR).

We apply the VCR to all energy supplied to customers below 207V as 207V is our 'hard' compliance limit. We then linearly weight application of the VCR between 100% of the VCR at 207V and 0% of the VCR at 216V, consistent with our 'soft' compliance limit. For example, energy supplied at 211.5V, halfway between 216 and 207 would be valued at 50 per cent of the VCR. We use this methodology to reasonably value all undervoltage energy supplied to customers.

We first assess the value of the energy at risk below voltage compliance levels without any investment using our valuation methodology. We then model the impact of our augmentation options at each site and re-assess the value of energy at risk below voltage compliance levels. The difference between these two assessments is the customer benefit from an upgrade.

Under this option, we would pursue all proactive investments where the customer benefit from an upgrade exceeds the augmentation cost. The preferred investment year is chosen based on when the annualised benefits exceed the annualised cost.

More information on how we value the net economic benefit of projects is available in our attached methodology document.[31]

4.6.3 Assessment of improving service levels

The primary benefit of improving current service levels is improved customer experiences, with 20,157 additional customers receiving compliant voltage levels, leading to improved appliance function, longer appliance lifespan, enhanced local power quality and better ability to charge EVs. This is 2,418 more customers than maintaining current service levels.

There are several other benefits of improving current service levels relative to the base case option, which include:

- **656 fewer reactive customer complaints**: better customer experiences will lead to fewer reactive complaints that we are obligated to resolve and less reactive expenditure to resolve them than under the base case. This is also 221 fewer complaints than maintaining customer service levels. Reactive expenditure is less efficient than proactive expenditure, as described in section 4.2.1
- **reduced undervoltage energy at risk**: there will be a total of 1,449 MWh of non-compliant undervoltage energy delivered to customers over the 2026–31 regulatory period, 29,909 MWh lower than the base case. This will result in fewer appliance malfunctions and degradations, with more customers able to charge EVs
- **improved ability to manage changes in demand**: operating above functional compliance creates headroom to offer higher service levels, or maintain functional compliance, if peak

30 We are liable to pay compensation to customers if damage occurs due to voltage levels supplied below 207V
31 PAL ATT 2.03 – Blunomy – Detailed demand forecasting methodology – Jan2025 – Confidential

demand is higher than forecast through the 2026–31 period. Maintaining our service levels will put us in a strong position to facilitate increasing electrification in following regulatory periods, potentially driven by Victoria's forecast 600 PJ gas supply shortfall between 2028 and 2035

- **improved customer social licence**: delivering better services for customers will improve the trust and social licence we have built with customers. Customer trust in us to act in customer's best interests, provide a reliable supply, and help manage customer usage has each improved between 9 and 10 percentage points over the last 4 years, which aligns with the reducing number of overvoltage complaints we have received over the same period. Positive social licence will lead to greater uptake of efficient flexible products and facilitate the system orchestration required through the energy transition, which customers hare willing to engage with[32], but have told us that they require reliable, quality power to do so
- **lower investment requirements over the 2031-36 regulatory period**: improving service levels ensures that customers receive higher quality services through the 2026–31 regulatory period, putting us in a stronger position heading into the 2031-36 regulatory period than the base case option. Starting from a better service level creates optionality to set higher or lower future performance targets and it would require relatively less investment to reach any 2031-36 performance target compared to the base case
- **ability to tender for non-network solutions**: works planned in advance can be tendered to market to test for the presence of efficient non-network solutions that could defer augmentation. Substantive proactive works to improve compliance present opportunities to seek non-network solution opportunities and defer augmentation to deliver more efficient services for customers.

Improving customer service levels does however require more investment relative to the base case and maintaining compliance options because we would be investing proactively to maintain current service levels rather than simply responding reactively to customer complaints.

Customers did not provide direct support for improving service levels. While customers held strong views about ensuring the network was prepared for the energy transition and sought confidence that their service quality did not deteriorate, customers held mixed preferences for improving service levels. Affordability was raised as a key concern for customers and was often prioritised above reliability improvements.

While proactive investments are efficient over the long term, proactive investment in voltage constraint alleviation produces diminishing short-term returns as overall voltage compliance increases. Prioritising investing in the highest value projects naturally means that subsequent investments deliver relatively fewer benefits than prior projects, while unit costs remain constant.

[32] CSIRO, *Attitudes Towards the Energy Transition: Energy Transition Survey*, Trusted Information sources, 2024

5. Preferred option

Option two, maintaining our current service levels is preferred because it addresses the identified need, balances competing energy transition and affordability priorities and is supported by our customers.

Maintaining current service levels includes portfolio efficiencies relating to avoiding overlap with our replacement program and delivering more efficient HV solutions that address several LV constraints.

We consider that option two on balance would lead to the most efficient outcomes for customers because the option:

- balances delivery of high-quality services to remediate voltage constraints for a material number of at-risk customer connections, with affordability considerations that customers have raised. Customers have supported the level of expenditure consistent with maintaining service levels at our trade-off forums and our direct program of investment during test and validate roundtables
- is consistent with customer expectations to maintain service levels
- defers some efficient augmentation opportunities to meet affordability expectations while only investing in the highest value projects
- provides more equitable outcomes in ensuring that an additional 17,739 customer connections are compliant by 2030–31 relative to the base case
- avoids 435 more customer complaints over the period relative to the base case.
- applies a future-focus by placing the network in a strong position in 2031 to be responsive to an uncertain but accelerating energy transition
- operating with headroom to maintain functional compliance if the uptake of electrification leads to more non-compliant connections than forecast
- ensures that we are accountable for the delivery of a network that maintains current customer service levels through the 2026-31 regulatory period
- facilitates non-network service provision to deliver efficient customer outcomes.

Our proposed capital expenditure profile over the 2026–31 regulatory period is shown in table 12:

TABLE 12 EXPENDITURE FORECAST FOR PREFERRED OPTION ($M 2026)

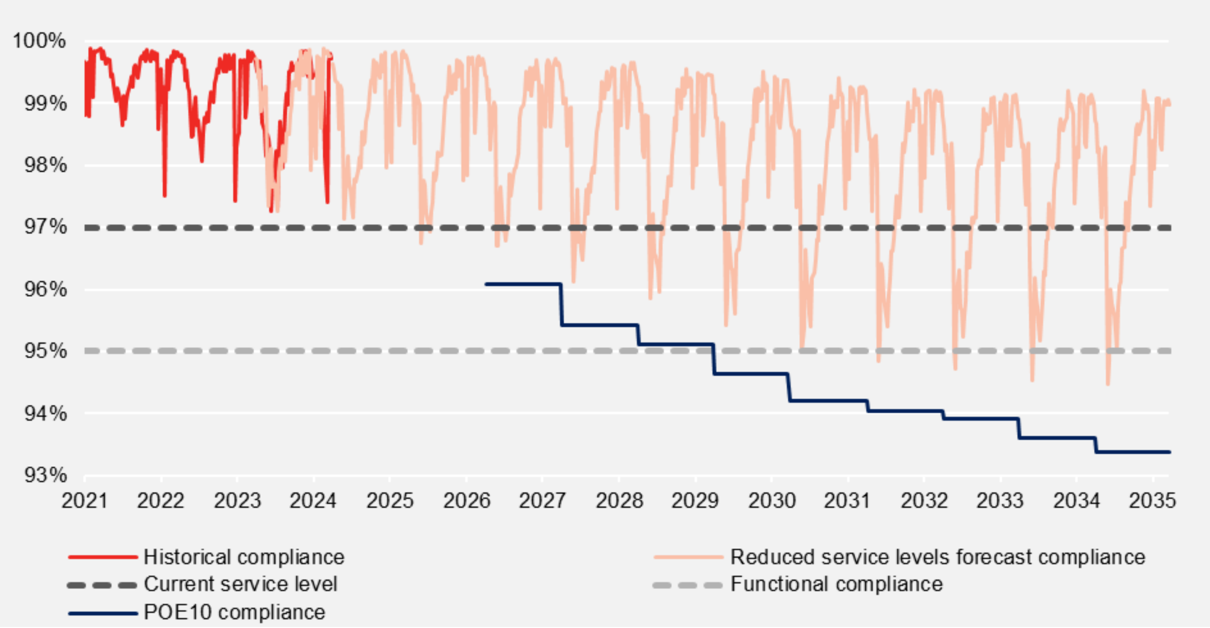
AUGMENTATION TYPE	FY27	FY28	FY29	FY30	FY31	TOTAL
Proactive LV augmentation	3.0	14.7	8.0	18.4	18.8	**63.0**
Reactive augmentation	4.9	4.9	5.4	5.6	5.9	**26.6**
High voltage cluster augmentation	1.4	1.4	1.6	0.8	3.8	**8.9**
Avoided augmentation from non-network solutions	-	-0.1	-	-0.6	-0.7	**-1.4**
Annual total	**9.3**	**20.8**	**15.0**	**24.3**	**27.8**	**97.1**

A One in 10-year risk assessment

The pace and ambition of Victoria's energy transition is unprecedented, which creates significant uncertainty when forecasting uptake rates of customer load that will drive undervoltage. Given we have an obligation to maintain functional compliance, we have assessed the impacts that a 10 per cent probability of exceedance (PoE) forecast being realised would have on our voltage performance.

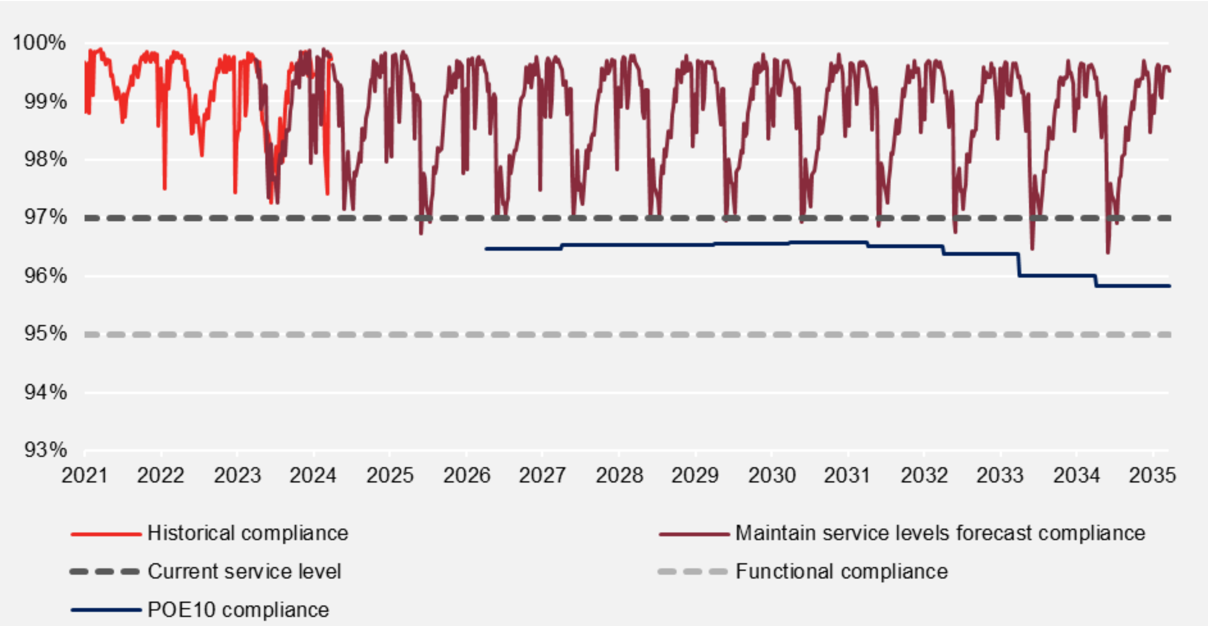
Under a one in 10-year peak demand period, we would breach functional compliance during the 2026-31 regulatory period under the base case, shown in figure 20.

FIGURE 20 BASE CASE 10 PER CENT POE VOLTAGE COMPLIANCE (%)



Under the preferred option to maintain current service levels, we are not forecast to breach functional compliance under a one in 10-year peak demand period. Instead, we will maintain a service level of above 96 per cent through the 2026-31 regulatory period, shown in figure 21.

FIGURE 21 MAINTAIN SERVICE LEVELS 10 PER CENT POE VOLTAGE COMPLIANCE (%)



B EV supply equipment protection

has been prepared from discussions with manufacturers, observed performance in network operation and from equipment manuals available online. This table is not complete and as new manufacturers enter the market the diversity of protection elements is expected to grow and likely increase the potential for customer complaints to rise.

Some manufacturers mandate that their equipment curtails under certain conditions to protect their equipment. We have developed analytics to detect curtailment and an example of curtailment is shown below in table 13. Curtailment can result in incomplete charging and longer charge durations.

Uni-direction EV supply equipment is outside of the scope of AS/NZS 4777.2:2020 and there is therefore no mandatory standard to regulate the operation of the EV chargers with respect to grid voltage levels.

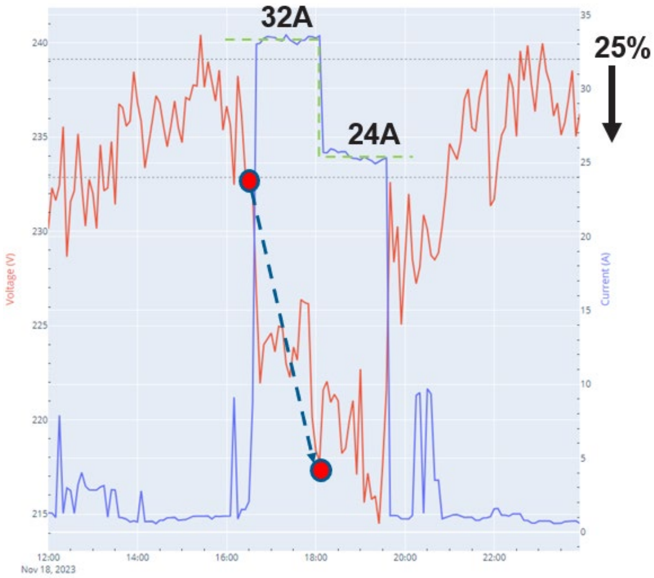
TABLE 13 MANUFACTURER SETTINGS FOR EV CHARGERS

Type/Model	Over voltage	Under voltage	Curtailment	Phase unbalance	PEN	Auto Reset
Tesla 	264V	180V	12% V_{drop} → 75% Charging 14% V_{drop} → 0% Charging (TRIP)	Unknown	No	No
BMW Charger 	Unknown	100V	Unknown	*Suspected* ≥ 5% voltage unbalance	Unknown	Unknown
Wall box Charger 	Trips at ≥ 248V	Trips at ≤ 212V	Unknown	Unknown	Yes (Not applicable in Aus)	No
Zappi Charger 	Trips at ≥ 257V	Trips at ≤ 202V	Unknown	Unknown	Yes (Not applicable in Aus)	Yes

B.1.1 Example of detected EV charging curtailment

Figure 10 shows the curtailment of one of our customers' EVs due to the impact of voltage drop in 2023. This customers' voltage level before charging was 235V and the charger curtailed charging fully when voltage levels fell sufficiently during the charging cycle.

FIGURE 10 EXAMPLE OF DETECTED EV CHARGING CURTAILMENT



Note: these values are taken at the Smart Meter and additional voltage performance is lost through the customer circuits to the vehicle.

C Alleviation options considered

SOLUTION	CAPEX	IMPACT	FEASIBILITY
Distribution Substation Offload	$100,000	Halve voltage spread	Feasible
Reconductoring	$80,000	+/- 9 volts Set thermal rating to 315a	Feasible
Rural Substation Upgrades	$60,000	Halve voltage spread	Feasible
Single Wire Earth Return line Upgrades	Considered elsewhere	Considered elsewhere	Considered in our regional and rural upgrades business case
Battery Energy Storage System	$300,000	+/- 6 volts increase thermal rating by 50kVA	Not economic due to steadily increasing constraints year on year, where the capabilities of non-network solutions are outstripped.
Flexible Exports	Considered elsewhere	Enable newly connected generation within limits on voltage constrained circuits	Preferred option to reduce overvoltage, and considered specifically in our flexible services business case
High Voltage Network Augmentation	Variable	The HV network can be upgraded in some instances to resolve a cluster of low voltage constraints	Per section 4.5.2, $8.5 m of high voltage line upgrades to efficiently resolve LV clustered non-compliance
Flexible load		Non-network solution capabilities are assumed to match increasing market maturity over time	Feasible, and considered specifically in our flexible services business case

D HV clustering case studies

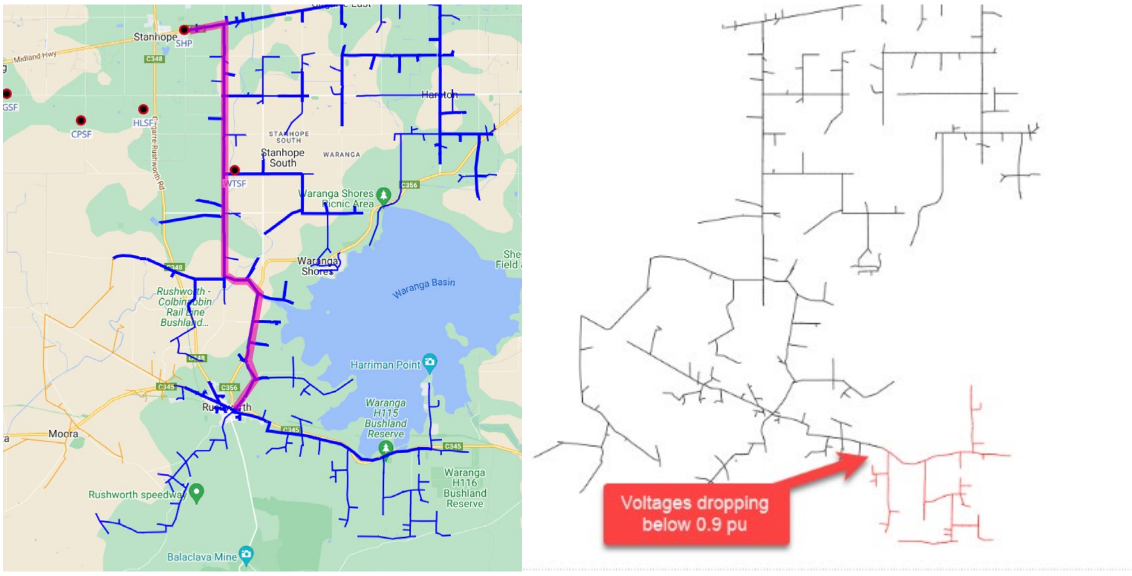
D.1 HV clustering case study: Rochester

Rushworth is a town in our network serving approximately 1,500 customers. The town's maximum demand is currently 4.6 MVA, occurring during the summer period. Over the next decade, this demand is projected to exceed 5 MVA, driven by growth in the area.

D.1.1 Network Configuration

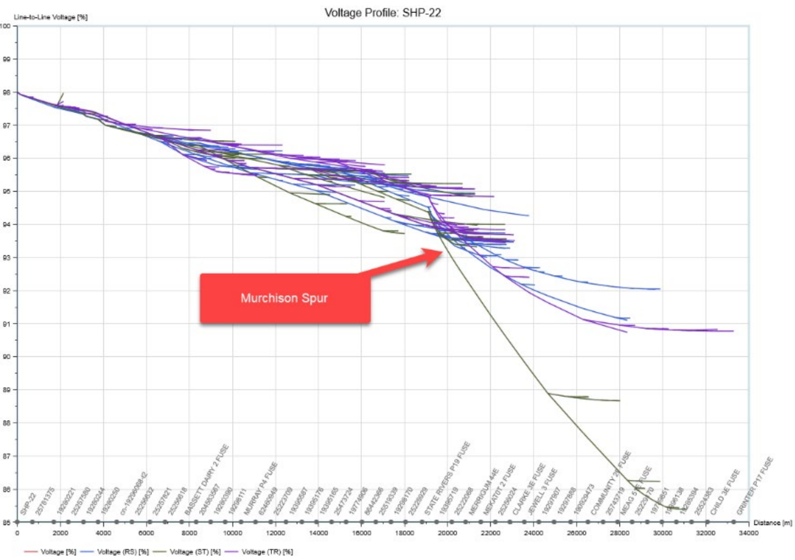
Rushworth is supplied via the SHP014 feeder from Shepparton. Most of the high-voltage network in the township comprises Steel SC/GZ 3/2.75 conductor backbone. Poor voltage performance of these conductors is increasingly insufficient to meet the growing demand of the town.

FIGURE 22 OVERVIEW OF THE SHP014 FEEDER SUPPLYING RUSHWORTH TOWNSHIP



The Murchison Spur, a critical section of the network, relies on the SC/GZ 3/2.75 conductor as its backbone. Due to its poor performance and limited capacity, this conductor has become a major constraint, particularly as it forms the main east-west supply path. HV modelling of the Rushworth network highlights this limitation, emphasising the need for reinforcement to ensure reliable service and accommodate future growth.

FIGURE 23 VOLTAGE PROFILE OF SHP014 SHOWING POOR ELECTRICAL PERFORMANCE TO RUSHWORTH TOWNSHIP



Upgrading the spur by replacing the obsolete steel conductor with a low-impedance conductor will significantly enhance the voltage performance of the HV network, restoring it to compliant levels.

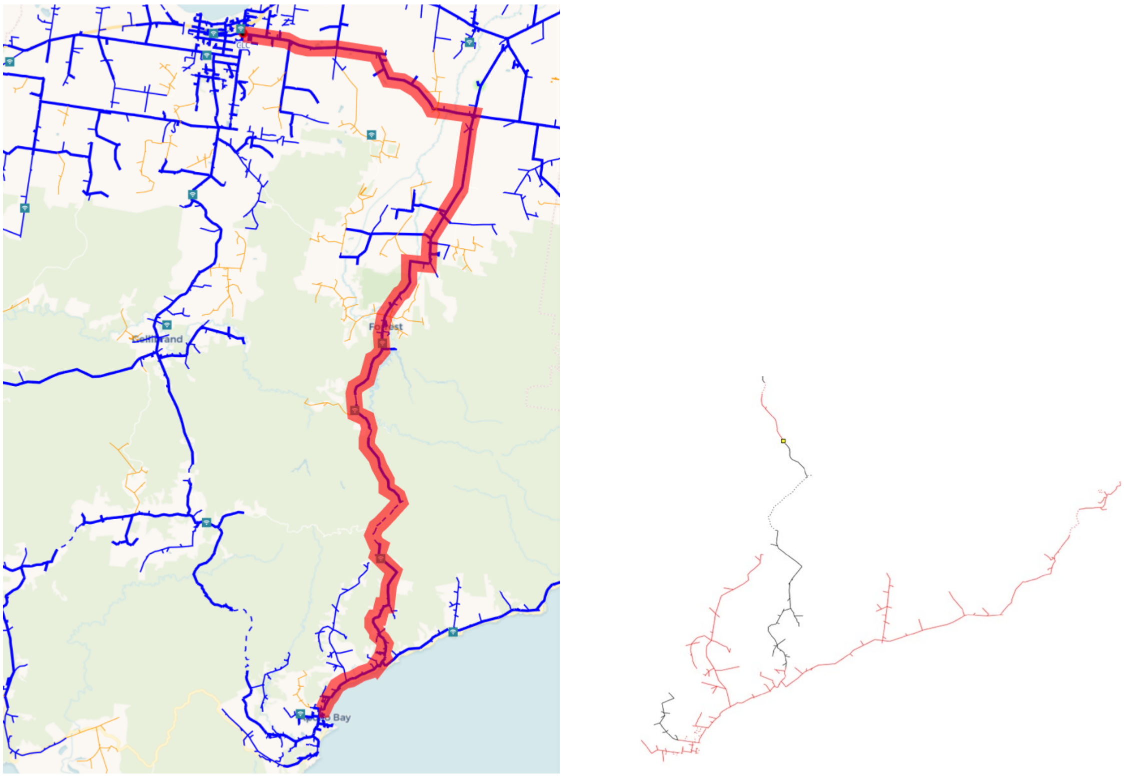
Without this augmentation, persistent customer complaints due to voltage issues will necessitate costly upgrades to the network.

D.2 HV clustering case study: Apollo Bay

Apollo Bay, a coastal town in Victoria, Australia, has a population of around 1,900. Just a three-hour drive from Melbourne, it's a popular holiday destination with hundreds of Airbnbs and hotels. The town's maximum demand is currently at 5.8MVA, occurring during the summer period. Over the next decade, this demand is projected to exceed 8 MVA, driven by growth and tourism in the area.

D.2.1 Network Configuration

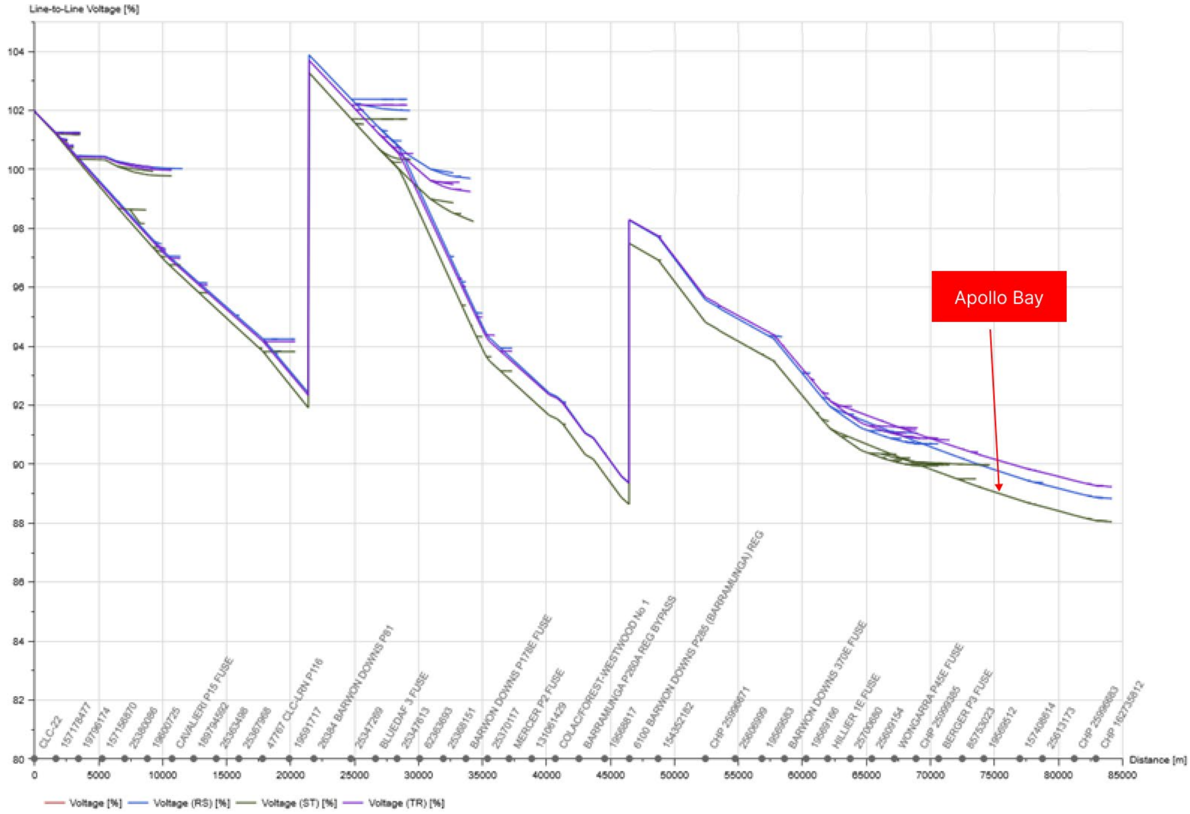
FIGURE 24 OVERVIEW OF THE CLC013 FEEDER SUPPLYING APOLLO BAY TOWNSHIP



Apollo Bay is supplied via the 70km CLC013 feeder from Colac. A large section of the feeder leading up to the township comprising of Cu 7/.104 conductors makes up the network backbone.

Poor voltage performance of these conductors is increasingly insufficient to meet the growing demand of the town. This is especially true during the summer periods when the town will attract more visitors from Melbourne and Geelong.

FIGURE 25 VOLTAGE PROFILE OF CLC013 SHOWING POOR ELECTRICAL PERFORMANCE TO APOLLO BAY TOWNSHIP



Upgrading the spur by replacing the old copper with a low-impedance conductor will significantly enhance the voltage performance of the HV network, restoring it to compliant levels.

Without this augmentation, persistent customer complaints due to voltage issues will necessitate costly upgrades to the network.

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