Business case: Mobile Substation Replacement

2025-2030 Regulatory Proposal

Supporting document 5.3.11

January 2024

SA Power Networks

Empowering South Australia

Contents

Glossary

Acronym / term	Definition
AER	Australian Energy Regulator
Capex	Capital expenditure
DER	Distributed Energy Resources
ICT	Information and Communication Technology
LV	Low Voltage
NPV	Net Present Value
Opex	Operating expenditure
PoE	Probability of Exceedance
RCP	Regulatory Control Period
TEAM	Transport Engineering and Management

1 About this document

1.1 Purpose

This business case is driven by the need to address significant reliability risks associated with SA Power Networks' ageing and poor condition mobile substations and mobile switchboard.

This document describes the need, identifies and evaluates options to address the need, and selects a preferred option for investment which is proposed to be delivered as part of our replacement program for the 2025-30 Regulatory Control Period (**RCP**).

1.2 Expenditure category

- Network capex: Replacement expenditure (repex)

1.3 Related documents

Table 1: Related documents

Ref	Title
5.3.1	Network asset replacement expenditure business case
5.2.5	Resourcing Plan for Delivering the Network Program

2 Executive summary

This business case recommends capital expenditure (**capex**) of $9.5 million ($June 2022 exclusive of overheads) to replace two 10MVA mobile substations, one 11kV mobile switchboard and ongoing management as per historic expenditure of the mobile bypass equipment fleet, in 2025-30.

Mobile substations and switchboards allow rapid restoration of supply after network asset failures when no alternative supply is available. We own two 66-33/11kV 10MVA Mobile Substations commissioned in 2000, and one 11kV mobile switchboard commissioned in 2012 which has been deployed at Port Pirie substation since 2013 following an unrecoverable asset failure.

Mobile bypass equipment is a very cost-effective way to increase asset utilisation. The South Australian distribution network is designed such that for a single substation transformer fault, there may be no alternative supply for up to 3MVA of load. For a switchboard failure, equivalent to the loss of two or three transformers, the potential unserved load is significantly greater. These asset failure events require mobile bypass equipment to restore supply. To reinforce these substations such that an alternative supply is always available (i.e. N-1) would be orders of magnitude more cost than managing a small number of mobile substations.

Mobile substations also support planned upgrades and maintenance of substations, with a historical average of eight weeks deployment per year. The alternatives of generation or lengthy planned interruptions are far more costly to both SA Power Networks and the community.

In 2023, both mobile substation trailers were inspected by Transport Engineering and Management Pty Ltd (**TEAM**), an expert firm for the condition assessment of trucks and trailers. TEAM identified levels of corrosion which could potentially fail a vehicle roadworthy inspection. Furthermore, both trailers are already 8 years

past business and industry standard practice of 15-year asset life and have travelled thousands of kilometers in harsh conditions across South Australia. TEAM state that to complete a full repair and assessment of the trailers, the substation plant would require complete disassembly and reassembly from the trailer. The cost to do so is estimated at 42% of the total capex to replace and would only increase the life of the mobile substation by an estimated seven years.

The existing mobile switchboard is unavailable owing to its permanent deployment at Port Pirie substation since 2013. This substation services a single large industrial plant with plans since 2013 to upgrade such that a switchboard is no longer required. However, with the mobile switchboard condition significantly deteriorating in the harsh environment and an enduring service requirement, the mobile switchboard is now considered the permanent supply and itself a failure risk.

The **recommended option** is to replace the two large mobile substations for $3.2 million each and the mobile switchboard for $2.2 million in the 2025-30 RCP for a total of $9.5 million. This total includes $0.9 million of historical expenditure for management of the whole mobile bypass fleet including replacing failed cables and protection relays. This option is efficient with quantified benefits outweighing costs, a **positive net present value (NPV) of $17.6 million** and addresses all reliability and operational issues identified with the mobile bypass equipment.

Other options have been considered and evaluated, including different combinations of replacement and refurbishment of the mobile bypass fleet. All these alternatives were found to have a lower NPV than the recommend option.

3 Background

3.1 The scope of this business case

This business case seeks investment in the 2025-30 RCP to address the increasing reliability risk due to ageing, poor condition and unavailability of the mobile substations and switchboard. The two mobile substation trailers have reached the end of their life expectancy and are due for replacement. The existing mobile switchboard is permanently deployed at Port Pirie and as such unavailable as a mobile switchboard.

3.2 Our performance to date

We own two 66-33/11kV 10MVA mobile substations procured in 2000. These mobile substations have allowed us to significantly increase utilisation of substation assets by providing emergency restoration capability for asset failures when no alternative supply is available. There are 150 substations with up to 3MVA of load with no alternative supply should a single substation transformer fail. Without mobile substation plant, far more investment would be required to provide the necessary redundancy in Substations to avoid long term outages.

Figure 1: A Mobile Substation enroute

We procured one 11kV mobile switchboard in 2012 which was deployed as an emergency bypass of a failing 6.6kV switchboard at Port Pirie Substation in 2013. This installation currently provides the sole point of 6.6kV supply for the single industrial customer, has recently been assessed as significantly deteriorated, and is now considered the permanent replacement for the switchboard that failed in 2013.

Figure 2: Mobile Switchboard deployed at Port Pirie

3.3 Drivers for change

Both mobile substation trailers are in poor condition and are past their replacement period of 15 years. Travelling across the state over the last 23 years has also significantly shortened the substation plant asset life. They have travelled a combined distance of approximately 14,900km across 46 deployments. Due to the harsh and forever changing environmental conditions and the mechanical impact of distance travelled, the condition of the assets has significantly deteriorated compared with an equivalent fixed asset.

TEAM are considered experts in their field of condition assessment of trucks and trailers. An assessment performed by TEAM in 2023 concluded that both trailers are in poor condition and could potentially fail a vehicle roadworthy inspection. If one or both Mobile Substations were defected, there would be a very high reliability risk across South Australia. That is, a single substation asset failure could result in unserved energy over many weeks until a permanent replacement is commissioned. This risk increases as the condition of the trailers deteriorates.

Figure 3: Visible corrosion between chassis top flange and floor on Mobile Substation

TEAM state that to complete a full repair and assessment of the trailers, the substation plant would require complete disassembly and reassembly from the trailer. The cost to do so is estimated at 42% of the total capex to replace and would only increase the life of the mobile substation by an estimated 7 years.

The mobile switchboard was deployed at Port Pirie substation in 2013 to address the risk of immanent failure of the existing 6.6kV switchboard and the expectation of a short-term service need. Enduring service requirements at Port Pirie now leaves the network exposed to escalating risk of extended supply outages as condition of the switchboard population deteriorates (refer to document 5.3.1 repex business case- section on Circuit Breakers). The mobile switchboard was not designed for long term deployment in a harsh environment, and after ten years is itself a failure risk due to deteriorated condition. A replacement mobile switchboard also serves to mitigate the reliability risk of the switchboard at Port Pirie failing.

3.4 Industry practice

Mobile substations and other bypass equipment are common industry practice, particularly for Distribution Network Service Providers (**DNSPs**) where less redundancy exists in the HV distribution network.

The industry standard asset life for trucks and trailers is approximately 15 years. This is applied to all SA Power Networks' trailers. At 23 years old, the mobile substation trailers are already significantly passed their expected service life.

4 The identified need

We own two mobile substation trailers, both of which require replacement due to their age and significantly deteriorated condition. The risk of the trailers failing a vehicle inspection and thus unavailable for deployment due to their condition becomes very high in the 2025-30 RCP.

The mobile switchboard is permanently deployed at Port Pirie and as such unavailable as a mobile switchboard. Enduring service requirements at Port Pirie requires a new mobile switchboard be purchased as soon as possible.

Without the mobile substations and mobile switchboard there is an escalating risk of extended supply outages as the condition of substation assets deteriorates, and a significant increase in the cost of delivery of some substation maintenance and upgrades.

5 Comparison of options

5.1 The options considered

Three options were considered in addition to the base case of recurrent expenditure. Capex is $2022 exclusive of overheads.

Table 1: Summary of options considered

Option	Description
The base case Minor refurbishment only on existing mobile substations	This option involves minimal refurbishment and regular maintenance on the existing fleet of mobile substations. The risk of one or both trailers being defected unroadworthy increases annually along with the risk of unserved energy. Without a mobile switchboard available today, this risk is constant. Capex: $0.9M over 5 years
Alternative options	
Option 1 – Procure two new mobile substations and one new mobile switchboard	Option 1 is to procure two new mobile substations at a cost of $3.2M each and one new mobile switchboard at a cost of $2.2M. The mobile switchboard will be purchased as soon as possible with specification and design underway in the current RCP. The two new mobile substations would be purchased in approximately 2027. Minimal ongoing refurbishment at $0.9M over the 5 years continues for all other mobile bypass equipment. Capex: $9.5M over 5 years

Option 2 – Procure one new mobile substation and one new mobile switchboard	Option 2 is to procure one new mobile substation at $3.2M and one new mobile switchboard at $2.2M. Minimal ongoing refurbishment at $0.9M over the 5 years continues for all other mobile bypass equipment. Capex: $6.3M over 5 years
Option 3 – Refurbish existing mobile substations and procure one new mobile switchboard	Option 3 is to undertake major refurbishment on both existing mobile substations as soon as possible. Some of the substation plant, in particular the transformers, would be reused. However, by 2035 this substation plant is forecast to be at end of life requiring replacement of the mobile substations again. The cost to refurbish a mobile substation is $2.0M. A mobile switchboard will be procured as soon as possible for $2.2M. Minimal ongoing refurbishment at $0.9M over the 5 years continues for all other mobile bypass equipment. Capex: $7.1M over 5 years

5.2 Calculation of unserved energy from unavailability of mobile plant

When a substation transformer or switchboard fails, there may be an interruption to supply if there's insufficient redundancy. In this case, supply restoration is undertaken by transferring the load to adjacent substations or feeders. However, in many cases after load transfers there remains a portion of the load which cannot be restored, up to a maximum of 3MVA. This could be all the load for a small substation where the peak is less than 3MVA, or a portion of the load up to 3MVA for a larger substation.

Different regions around South Australia are subject to different load at risk. Where no available feeder transfers exist, the load at risk is much greater. To accommodate for these differences, the State aggregate of load at risk was calculated. This was determined by summing the load at risk after available feeder transfers for all 11kV substations.

We have two mobile substations for planned and emergency use, primarily located at our Angle Park depot. If one or both are defective, they are no longer available for deployment. A mobile substation may be unavailable due to:

- planned work – Mobile substation is deployed for a substation bypass to maintain supply during upgrade or maintenance – 8 weeks total per year (historical average);
- unplanned work – Mobile substation is deployed for a transformer failure to supply the unserved energy - 8 weeks to replace a failed transformer (historical average); and
- maintenance – Mobile substation is being maintained - 2 weeks per year total (historical average)

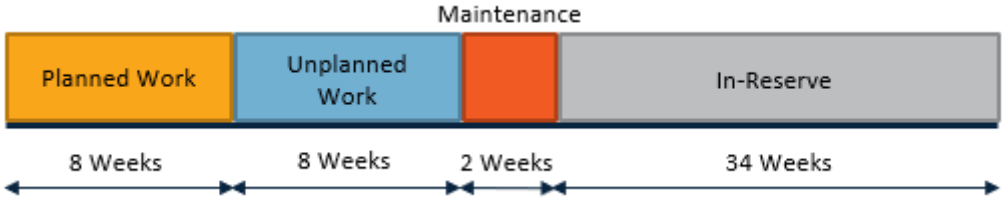

Figure 4: Annual Mobile Substation Utilisation.

The figure above describes a mobile substation's utilisation within 52 weeks. For 34 weeks of the year, the mobile substation is in-reserve. Travel time for the mobile substations is dependent on the location of need but total unplanned deployment time is generally 24 hours.

5.2.1 Unserved energy without a mobile substation or switchboard

When a transformer fails and it's not possible to transfer all the load to an alternative supply, a mobile substation is deployed. However, if a mobile substation is unavailable the unrestored load will be become unserved energy for a long time until a replacement can be commissioned. Across the whole substation population, this unserved energy is calculated using the following:

$$Energy\ (MWh/year) = \left(Energy\ at\ Risk\ Across\ the\ Network\ \left(\frac{MWh}{year}\right) \times Peak\ Load\ Duration(\%) \times Failure\ Rate\right) \times Probability\ Mobile\ Substation\ Unavailable$$

Where:

Energy at Risk Across the Network

The Load at Risk across the network is calculated by adding the available feeder transfers, N-1 capacity (where N is a transformer or bus section), standby transformer capacity and subtracting the 50 PoE Non-Coincident Reconciled Load Forecast. This difference is the load at risk per annum.

The Energy at Risk across the network is dependent on the time taken to replace the asset. Our historical average of 8 weeks for a transformer replacement and 11 months for a switchboard replacement have been used, the availability of a mobile switchboard reduces the energy at risk due to the reduction in restoration time.

Peak Load Duration (% of year)

For many substations, the load at risk is only for a small portion of the year. This can be seen from a load duration curve for the substation. However, for other smaller substations the load at risk can be all year as there's no redundancy or transfer capacity. For the whole SAPN population of substations, the Peak Load Duration as a percent of the year was found to be 5%.

Failure Rate (of a transformer or switchboard)

The historical failure rate for substation transformers is 3.5 per year from a population of 529. Refer to Figure 5 below and the Repex Justification Document – Power Transformers. The failure of a switchboard is a less likely but higher consequence event, with an expected failure rate of 0.01 from a population of 400.

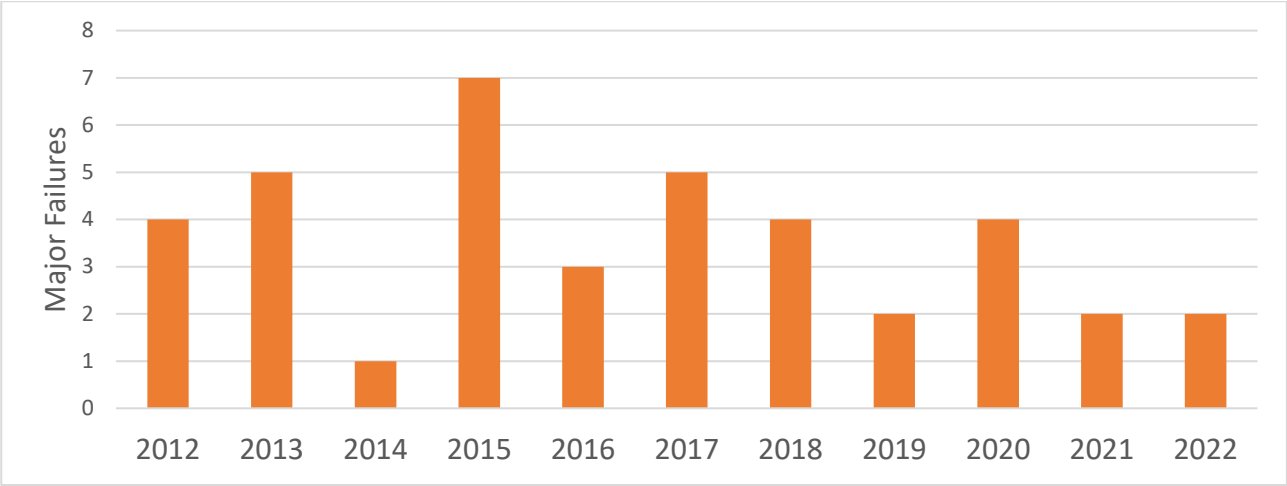

Figure 5: Historical Power Transformer Major Failures.

Probability a mobile substation is unavailable

Considering a mobile substation can be unavailable due to the trailer being defected, maintenance or planned or unplanned deployment, the probability a mobile substation is unavailable is given by:

$$\begin{aligned} &Probability\ of\ Mobile\ Substation\ Unavailable \\ &\quad = (Probability\ of\ Trailer\ Defected)^2 \\ &\quad + \{(1 - (Probability\ of\ Trailer\ Defected)^2) \\ &\quad \times ((Probability\ of\ Trailer\ Defected) \times (\%\ Planned\ Deployment\ or\ Maintenance)) \\ &\quad + ((Probability\ of\ Trailer\ Defetced) \times (TF\ Failure\ Rate) \\ &\quad \times (Unplanned\ Deployment\ Duration))\} \end{aligned}$$

Where:

Probability of a trailer being defected

The probability a mobile substation trailer will be defected is modelled with a mean failure year of 2028. Each Mobile substation is modelled with the same defective or failure rate.

% Planned deployment or maintenance

The portion of the year when the mobile substation is deployed for planned work or out for maintenance. i.e., (8 + 2)/52

Unplanned deployment duration

If a transformer fails requiring the mobile substation be deployed, the portion of the year when the mobile substation is deployed for this failure. i.e., 8/52

The unserved energy when a switchboard fails is calculated using the same logic.

5.2.2 Unserved energy with one new mobile substation

If just one of the mobile substations is replaced with a new unit, there remains a significant residual risk of unserved energy. This unserved energy can be found in much the same way as before. Assuming the probability of the new mobile substation failing is effectively zero, the probability a mobile substation is unavailable now becomes:

$$Probability\ of\ Mobile\ Substation\ Unavailable = \{((Probability\ of\ Trailer\ Defected) \times (\%\ Planned\ Deployment\ or\ Maintenance)) + ((Probability\ of\ Trailer\ Defetced) \times (TF\ Failure\ Rate) \times (Unplanned\ Deployment\ Duration))\}$$

5.3 Cost of unserved energy

The cost of unserved energy from unavailability of mobile substation plant to restore load at risk from a transformer or switchboard failure uses the AER's VCR method published in December 2022.

As mobile substation plant can be deployed to any substation in South Australia, the State-wide VCR rate of $34,460/MWh is used.

5.4 Unquantified Benefits

The mobile substations support planned upgrades and maintenance of substations, with a historical average of 8 weeks deployment per year. If the mobile substations are deemed unroadworthy or otherwise fail and are not replaced, they will not be available to support planned work. In many cases the only alternative to a mobile substation is a lengthy interruption to supply or generation, which are not viable options due to excessive costs associated with generation. The support of planned substation work is an unquantified benefit.

5.5 Analysis summary and recommended option

5.5.1 Options assessment results

The costs, quantified benefits and risks of alternative options relative to the base case over a 20-year period, $M June 2022 exclusive of overheads. The Option 0 (Base Case) costs have been subtracted from all options. A central case of input parameters is presented which we consider the most reasonable and produces the proposed recommendation. A low benefits, high benefits, and weighted benefits case is presented, which does not change the recommended option. Refer to the Sensitivity Analysis for discussion.

Central case

Option	Costs		Benefits	NPV	Risk Level	Ranking
	Capex (PV)	Capex 25-30 ($2022)	(PV)			
Option 0 (Base Case)	-	-	-	-	High	Not Credible
Option 1 -	5.3	8.6	22.9	17.6	Minimal	1
Option 2 -	3.4	5.4	17.3	13.9	Low	2
Option 3 -	14.9	6.2	22.8	7.9	Low	3

Low benefits case

Option	Costs		Benefits	NPV	Risk Level	Ranking
	Capex (PV)	Capex 25-30 ($2022)	(PV)			
Option 0 (Base Case)	-	-	-	-	High	Not Credible
Option 1 -	6.7	8.6	2.8	-3.8	Minimal	2
Option 2 -	4.3	5.4	1.8	-2.5	Low	1

Option 3 -	17.8	6.2	2.8	-15.1	Low	3

High benefits case

Option	Costs		Benefits	NPV	Risk Level	Ranking
	Capex (PV)	Capex 25-30 ($2022)	(PV)			
Option 0 (Base Case)		-			High	Not Credible
Option 1 -	3.9	8.6	83.6	79.7	Minimal	1
Option 2 -	2.5	5.4	60.5	58.0	Low	2
Option 3 -	11.9	6.2	90.2	78.4	Low	3

Weighted benefits case

Option	Costs		Benefits	NPV	Risk Level	Ranking
	Capex (PV)	Capex 25-30 ($2022)	(PV)			
Option 0 (Base Case)	-	-	-	-	High	Not Credible
Option 1 -	5.3	8.6	33.1	27.8	Minimal	1
Option 2 -	3.4	5.4	24.2	20.8	Low	2
Option 3 -	14.9	6.2	34.7	19.8	Low	3

5.5.2 Sensitivity Analysis

Sensitivity analysis was undertaken on the NPV calculation. The key sensitivities were found to be the failure rate for a transformer and the probability of the current trailers being defected unroadworthy. The key sensitivity for the mobile switchboard is the failure rate of a switchboard bus section. Other parameters varied include the VCR and Discount Rate.

The Central case uses historical averages of variables across our network. Two additional cases to the Central were considered in the sensitivity analysis: a Low Benefits case and a High Benefits case. For each, the parameters were adjusted as per the table below considering what a practical extreme case would be. The weighted NPV considers both the Central, Low and High Benefits case with the weights provided below.

Table 3: Variables applied for NPV Sensitivity analysis

	Sensitivity Variable	Low	Central	High
1x Mobile Substation	TF Failure Rate	0.001890359	0.006616257	0.011342155
	Mean year Trailer Defected	2030	2028	2026
2x Mobile Substations	TF Failure Rate	0.000652562	0.002283968	0.003915374
	Mean year Trailer Defected	2030	2028	2026
Mobile Switchboard	Switchboard Failure Rate	1.87032E-05	2.49377E-05	7.4813E-05
All	Commercial Discount Rate	4.50%	4.05%	3.50%
	VCR ($/MWh)	24,122	34,460	44,798
All	Weights for Weighted NPV	25%	50%	25%

5.5.3 Recommended option

The recommended option is to procure two new mobile substations and one new mobile switchboard; **Option 1.** This option has the highest NPV with the most reasonable set of values, the Central scenario and after a weighted sensitivity analysis. Under this option, the procurement of a new mobile switchboard will be as soon as possible with specification and design underway in the current RCP. Two new mobile substations will be procured in approximately 2027. **The total expenditure will be $9.5 million ($2022 exclusive of overheads), with a NPV of $17.6 million.**

5.6 How the recommended option aligns to our consumer and stakeholder engagement

The sum total of our proposed forecast network asset replacement and renewal expenditure, of which this recommended option is a component of, aims to achieve outcomes that were directly supported by our customers, as ultimately reflected in the recommendations of the People's Panel. This is noting that:

- the topic of service reliability and safety has been a key focus of our consumer and stakeholder engagement program. One of the four key themes that have framed our engagement under a desire to 'focus on what matters' to our customers has been the theme of 'a reliable, resilient, and safe electricity network';
- in engaging on this theme, and under the specific topic of 'reliability and bushfire safety' we undertook a series of deep-dive workshops called 'Focused Conversations' with a broad range of consumer, industry, and government and regulatory body representatives. In these Focused Conversations we sought recommendations on the service outcomes that customers prefer and expect;[1]
- while the specific circumstances of the mobile substation assets were not directly discussed, we engaged in a more aggregate way across all of our potential network asset replacement, by engaging on service outcomes for customers in relation to managing reliability and safety through network asset replacement. We engaged on the overall identified need for repex by outlining:
    1. information on what impacts on the safety and reliability of our network and how these drivers have been evolving over time and how this can be managed through either asset replacement or asset upgrades;
    2. our service outcomes and expenditure performance over time in asset replacement;
    3. information on the ageing and deteriorating condition of our network assets;
    4. our approach to forecasting service performance risks for customers; and
    5. our assessment of current risk versus forecast risk for service performance outcomes to customers;
- in the focused conversations we then posed three scenarios of how we could respond to the needs, and expected outcomes for customers in relation to service, expenditure and price, these included:
    1. 'basic' – which was a base-case counterfactual of Business-As-Usual, whereby we do nothing materially different and maintain to our current level replacement expenditure, showing the

[1] This was covered in workshops (1) scene setting / rationale – providing stakeholders with an overview of the factors impacting service outcomes including ageing assets, (2) delivering service outcomes through asset replacement – providing stakeholders with an understanding of the challenges and drivers associated with managing ageing infrastructure and what this means for customers in terms of service levels), (4) optimising asset investment – summary of focused conversations outcomes and discuss proposed investment levels) for the 'Reliability and bushfire safety' Focused Conversation. Materials presented at the Focused Conversations are available on our TalkingPower website under the page titled 'focused conversations'. [https://www.talkingpower.com.au].

decline in service performance outcomes for customers (in dollar terms) arising from forecast asset failures

2. ‘maintain’ – a scenario in which we undertake expenditure to maintain the current level of reliability and safety in the network in aggregate
3. ‘new value’ – a scenario in which we undertake expenditure to maintain the current level of reliability and safety in the network by geographic region

- as the focused conversations progressed, these three scenarios evolved, as we sought to integrate choices for customers on outcomes through network upgrades and network replacements;
- while our customers and stakeholders were consistently mindful of energy affordability concerns, the Focused Conversations arrived at a clear consensus recommendation to the People’s Panel, as the next stage in our engagement program, that we should invest sufficiently in network asset replacement in order to maintain reliability by geographic region – highlighting the importance of considering equity between regions and customers when investing in the reliability of the network; and
- ultimately, the People’s Panel deliberated on and affirmed the results of the Focused Conversations in their formal recommendation, and we have committed to taking this recommendation forward as reflected in the overall recommendation reflected in this justification document for forecast asset replacement and renewal expenditure.

6 Deliverability of recommended option

We have developed a plan to ensure that we can deliver the recommended option in this business case, together with the increased volume of work reflected in the programs that comprise our total network expenditure forecast in our Regulatory Proposal. This plan considers the detailed implications of our proposed overall uplift in total network expenditure for our required workforce and supporting internal services of information technology, fleet, property and human resources.

We consider that our plan is realistic and achievable over the 2025-30 RCP. The details of our approach are set out in our accompanying document*, ‘5.2.5: Resourcing Plan for Delivering the Network Program’.*