New 33kV Feeder from Nudgee Bulk Supply to Nundah Zone Substation

Business Case
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energex
Part of Energy Queensland

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DOCUMENT VERSION

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1.0	Reviewed	08/12/2023	Principal Planning Engineer
2.0	Approved	08/12/2023	Manager Sub-Transmission Planning
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1 SUMMARY

Title	New 33kV Feeder from Nudgee Bulk Supply to Nundah Zone Substation
DNSP	Energex
Expenditure category	☐ Replacement ☒ Augmentation ☐ Connections ☐ Non-Network
Identified need	☐ Legislation ☒ Regulatory compliance ☐ Reliability ☐ CECV ☐ Safety ☐ Environment ☐ Financial ☐ Other Under its Distribution Authority, Energex must adhere to the Safety Net which identifies the principles that apply to the operation of network assets under network contingency conditions. It has been identified that under a N-1 contingency of feeder 622/ F623 (Nudgee Bulk supply (SSNGE BS) to Hendra Zone Substation (SSHDA)), feeder 593 (Nudgee Bulk supply (SSNGE) to Nundah Zone Substation (SSNDH)) will overload during peak period and will be unable to provide electricity to all the load at SSNDH and some of SSHDA load.
Summary of preferred option	The proposed option is to establish a 33kV feeder between SSNGE BS to SSNDH approximately 2.6kms of underground single circuit (SCCT) to address the regulatory compliance risk following an outage of F622, F623.
Expenditure	

Year	2025-26	2026-27	2027-28	2028-29	2029-30	2025-30
$m, direct 2022-23	-	0.008	0.05	0.117	6.219	**6.394**

2 BACKGROUND

2.1 Network Arrangement

Nundah (SSNDH) and Hendra (SSHDA) zone substations are connected in a 33kV ring network arrangement and are supplied by Nudgee (SSNGE) bulk supply substation via 2 x underground 33kV feeders 622-1 and 623-1 (connected to SSHDA) and 1 x underground 33kV feeder 593-1 (connected to SSNDH). SSNDH and SSHDA are connected via a single 33kV underground feeder 540-1. Besides that, Hamilton (SSHTN) zone substation is being supplied from SSHDA via 2 x radial 33kV underground feeders 674-1 and 643-1.

Nundah 33/11kV substation (SSNDH) comprises of one incoming 33kV feeder (F593 (Nudgee Bulk supply (SSNGE) to Nundah Zone Substation (SSNDH)) which supplies SSNDH and one outgoing feeder F540 (SSNDH-SSHDA) which supplies SSHDA and comprises of 1 x 15/25MVA and 1 x 15/20MVA 33/11kV transformers.

Hendra 33/11kV substation (SSHDA) comprises of three incoming 33kV feeders, F622 (SSNGE-SSHDA), F623 (SSNGE-SSHDA) and F540 (SSNDH-SSHDA) which supplies HDA, and four outgoing feeders F674 (SSHDA-SSHTN) and F643 (SSHDA-SSHTN) which supplies SSHTN, F3280 (SSHDA-SSCFD) and F636 (SSHDA-SSCFD) which supplies SSCFD. It also comprises of 2 x 15/25MVA 33/11kV transformers.

Hamilton 33/11kV substation (SSHTN) comprises of two incoming 33kV feeders, F674 (SSHDA-SSHTN) and F643 (SSHDA-SSHTN) and comprises of 2 x 15/25MVA 33/11kV transformers.

This 33kV feeder network supplying these substations has been identified as one of the critical supply to the Olympic Games 2032 infrastructure which would include new Mayne Stadium/Brisbane Indoor Sports Centre.

SSNDH, SSHDA, SSCFD and SSHTN substations customers and loads are summarised below:

- **Nundah zone substation (SSNDH)** – is a 33/11kV zone substation supplying approximately 11,090 customers. The maximum recorded load at SSNDH was 21.57MVA in Summer 2022/23.
- **Hendra zone substation (SSHDA)** – is a 33/11kV zone substation which supplies approximately 6,063 customers. The maximum recorded load at SSHDA was 17.74MVA in Summer 2022/23.
- **Clayfield zone substation (SSCFD)** – is a 33/11kV zone substation which supplies approximately 6,971 customers. The maximum recorded load at SSCFD was 18.85MVA in Summer 2022/23.
- **Hamilton zone substation (SSHTN)** – is a 33/11kV zone substation which supplies approximately 6,345 customers. The maximum recorded load at SSHTN was 20.47MVA in Summer 2022/23.

Figure 1 shows the network arrangement and Figure 2 shows the geographic layout of the network area under study.

Figure 1 – Existing network arrangement (schematic view)

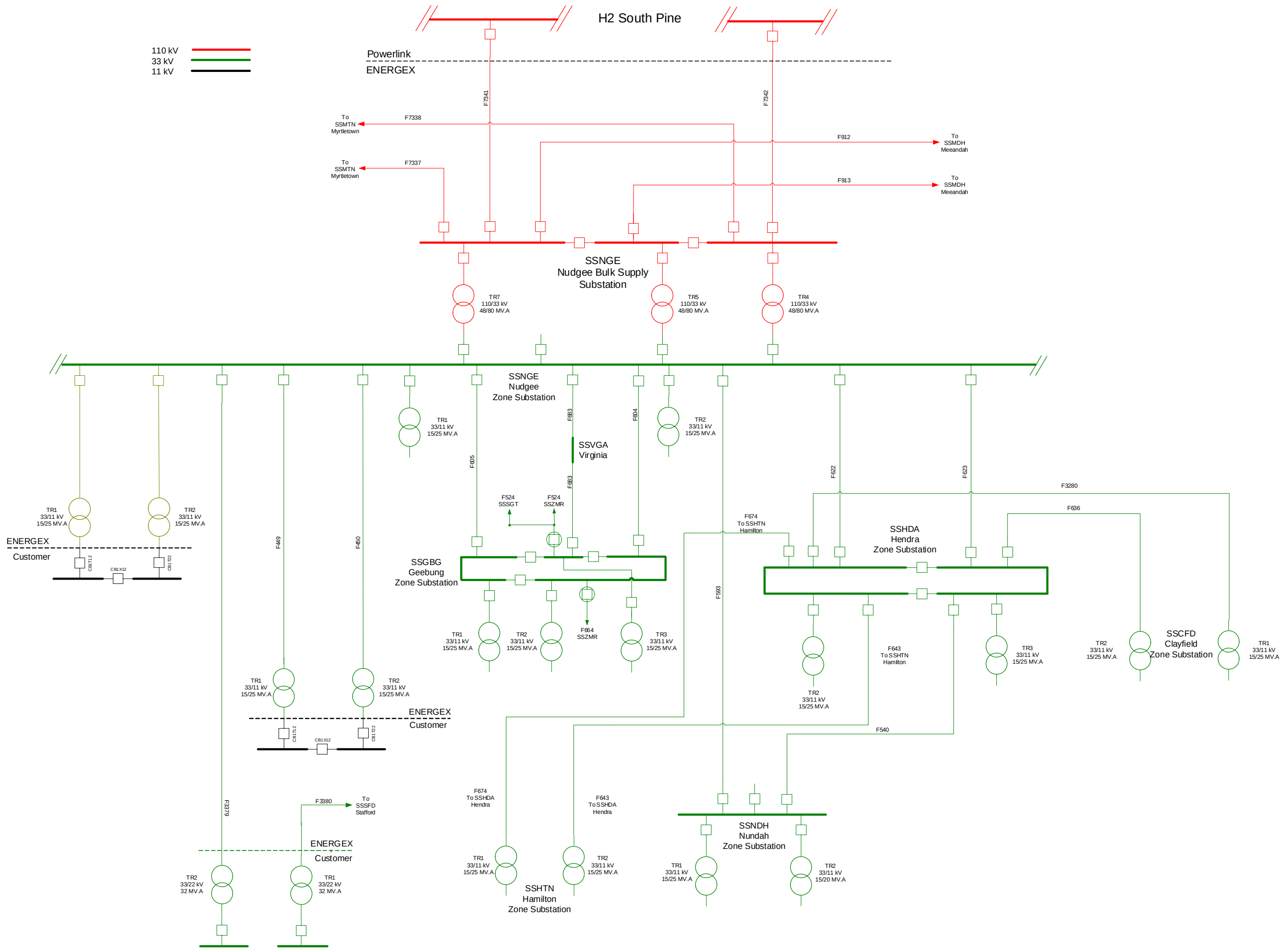
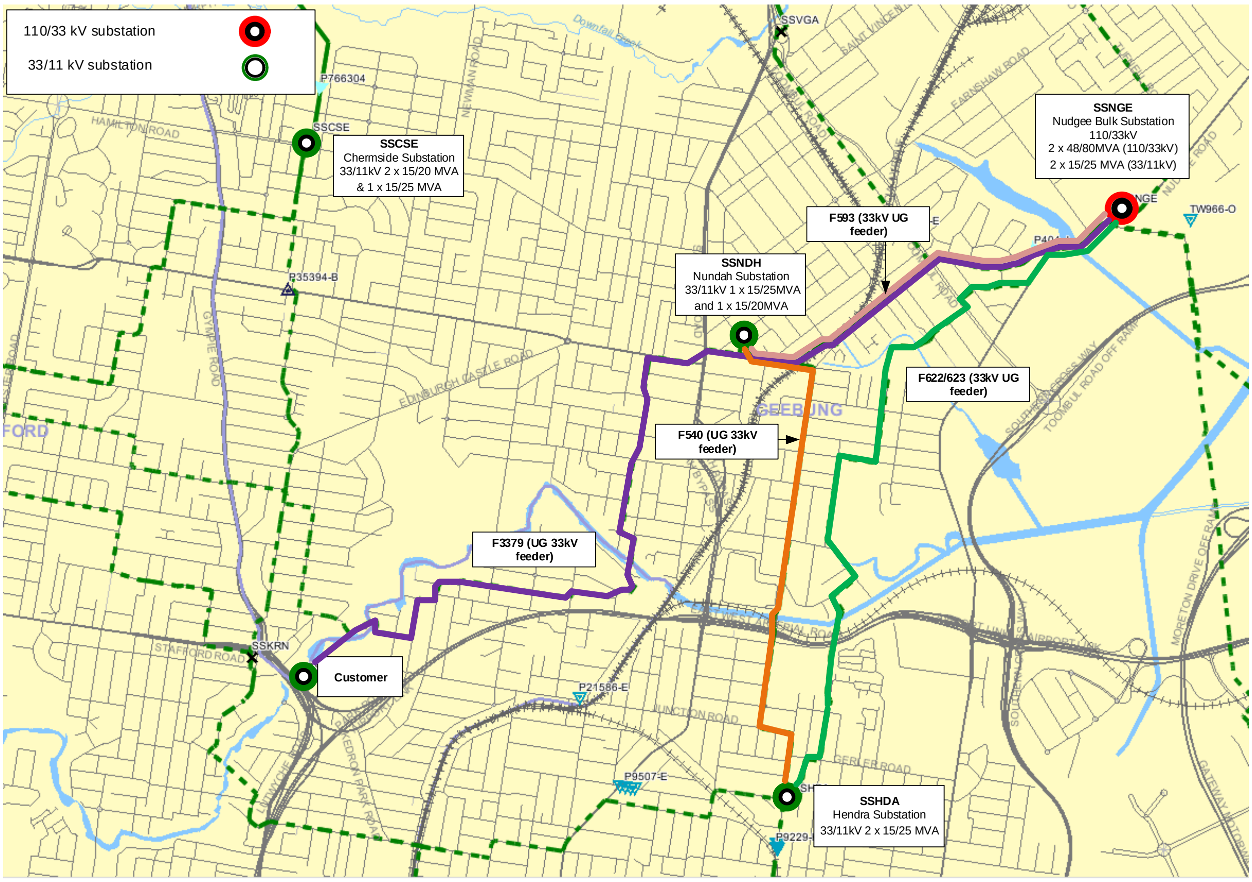


Figure 2 – Existing network arrangement (geographic view)



3 IDENTIFIED NEED

The identified need for this investment is to ensure supply in the area around Nundah and Hendra remains compliant with Safety Net requirements, which is a regulatory obligation as outlined in the Distribution Authority.

This investment is driven by insufficient capacity to restore supply within the required timeframes as stipulated in the Safety Net under the following scenarios:

- 33kV feeder F593 will overload during peak period following a N-1 contingency of F622 or F623 from 2030/2031.
- Furthermore, this 33kV feeder ring network has been identified as one of the critical supply to the Olympic Games 2032 infrastructure. It is anticipated the critical loads in the vicinity would include new Mayne Stadium/Brisbane Indoor Sports Centre

3.1 Compliance

3.1.1 Sub-transmission Network

Under its Distribution Authority, Energex must adhere to the Safety Net which identifies the principles that apply to the operation of network assets under network contingency conditions. System contingency related capability is assessed against a 50% probability of exceedance (PoE) load forecast, available load transfers, capacity ratings, non-network response, mobile plant, mobile generators, and short-term ratings of plant and equipment where available.

33kV feeders 622 and 623 are all classified as Urban, and as such, the following Safety Net criteria apply:

Urban – following an N-1 event:

- No greater than 40MVA (16,000 customers) is without supply for more than 30 minutes
- No greater than 12MVA (5,000 customers) is without supply for more than 3 hours and
- No greater than 4MVA (1,600 customers) is without supply for more than 8 hours

Further to an assessment against its Safety Net obligations, in accordance with industry practice Energex also undertake an analysis of system capacity under normal conditions such that no sub-transmission network asset should be operated above its normal cyclic capacity for a 10% probability of exceedance (PoE) load forecast.

3.1.2 Distribution network

To meet our Safety Net obligations Energex needs to maintain adequate automated, remote and manual transfer capability via its 11kV feeders without exceeding their Normal Cyclic Capacities.

3.2 Sub-transmission Network Limitations

The most important characteristic of the network to understand when considering the proposed investment is that the feeder ring has 3 incoming feeders from the bulk supply substation, following the loss of a 33kV feeder, there is still 2 incoming supplies. Therefore, in order to de-load the target amount from feeder 593, approximately twice the load has to be shed and transferred out of the ring.

3.2.1 33kV Sub-transmission Feeder 593 Limitation

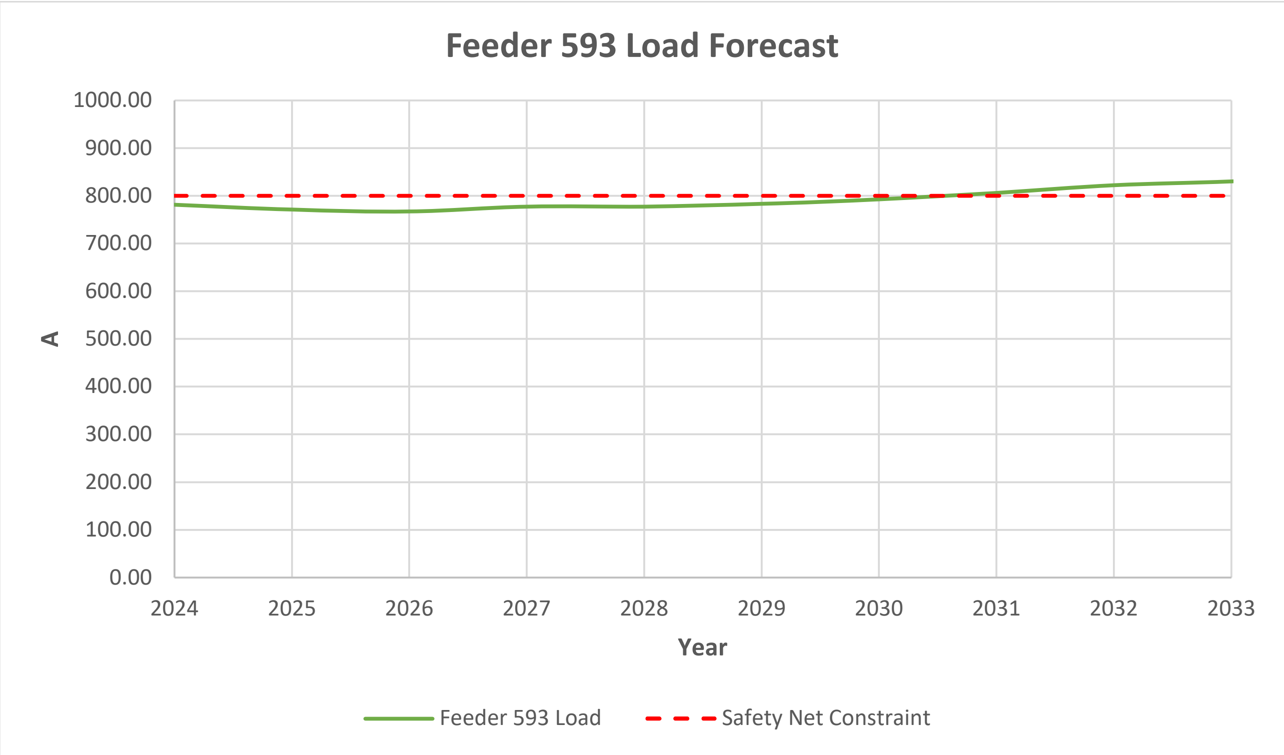
33kV feeder 593 is comprised of 33kV underground feeder F593 (2.6kms) is 630mm sq Cu 1C XLPELYHDPE and the feeder provides and NCC, ECC and 2HEC as below:

- Normal Cyclic Capacity (NCC) – 696A
- Emergency Cyclic Capacity (ECC) – 696A
- 2 Hour Emergency Capacity (2HEC) – 800A
- Safety Net Constraint – 800A

The Safety Net Constraint includes all capabilities that can be made available within the required restoration timeframe for Urban category, following the loss of 33kV feeder 622 or 623.

Figure 3 below shows the 50% POE load forecast and safety net constraint for feeder 593.

Figure 3 – Load on F593 following contingency on F622/F623 (Summer Day)



As shown in above figure, based on the 50% POE load forecast, there is a breach of Safety Net for feeder 593. For the loss of F622/F623 (SSNGE - SSHDA), all the load on SSHDA will be supplied by only two feeders (F622 or F623 and F540) instead of three feeders (F622 & F623 & F540), which will overload F593 from 2030/31 onwards. This results in a Load at Risk (LAR) of around 0.36 MVA following an outage of 33kV feeder 622 or 623 in 2030/31.

4 OPTIONS ANALYSIS

In determining the most cost-effective solution to address the identified network limitations, Energex has sought to identify a practicable range of technically feasible, alternative options that could satisfy the network requirements in a timely and efficient manner.

4.1 Option 1 - Build a new 33kV feeder from SSNGE to SSNDH

This option will help in permanently providing additional feeder capacity to address the feeder limitation which involves Safety Net breaches on F593.

The works under this option involves:

- Establish approximately 2.6km of new 33kV 630XLPE LYHDPE conductor underground SCCT construction from SSNGE to SSNDH.

<u>At SSNGE bulk supply substation:</u>

- Install a new 33kV feeder bay which includes new 33kV outdoor circuit breaker, CTs, new termination structure and bus work.
- Install new 33kV feeder protection panel in the control building.

<u>At SSNDH zone substation:</u>

- Install new 33kV feeder protection panel in the control building.

The network requirement date for the above work is 2030. Figure 4 shows the network arrangement and Figure 5 shows the geographic layout for option 1.

Figure 4 – Option 1 network diagram

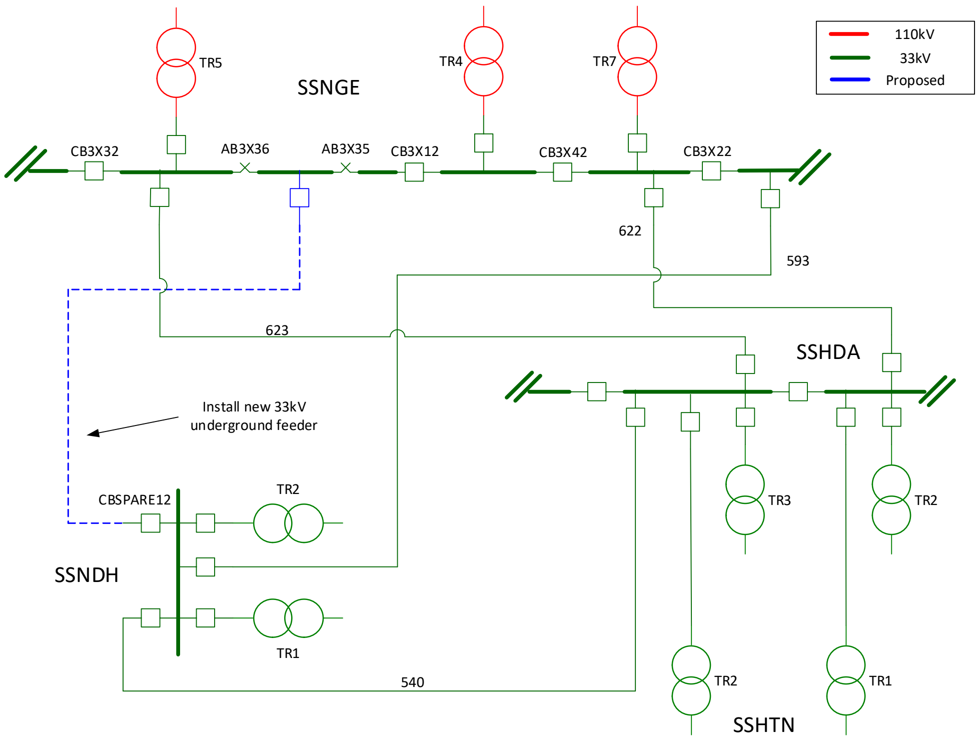
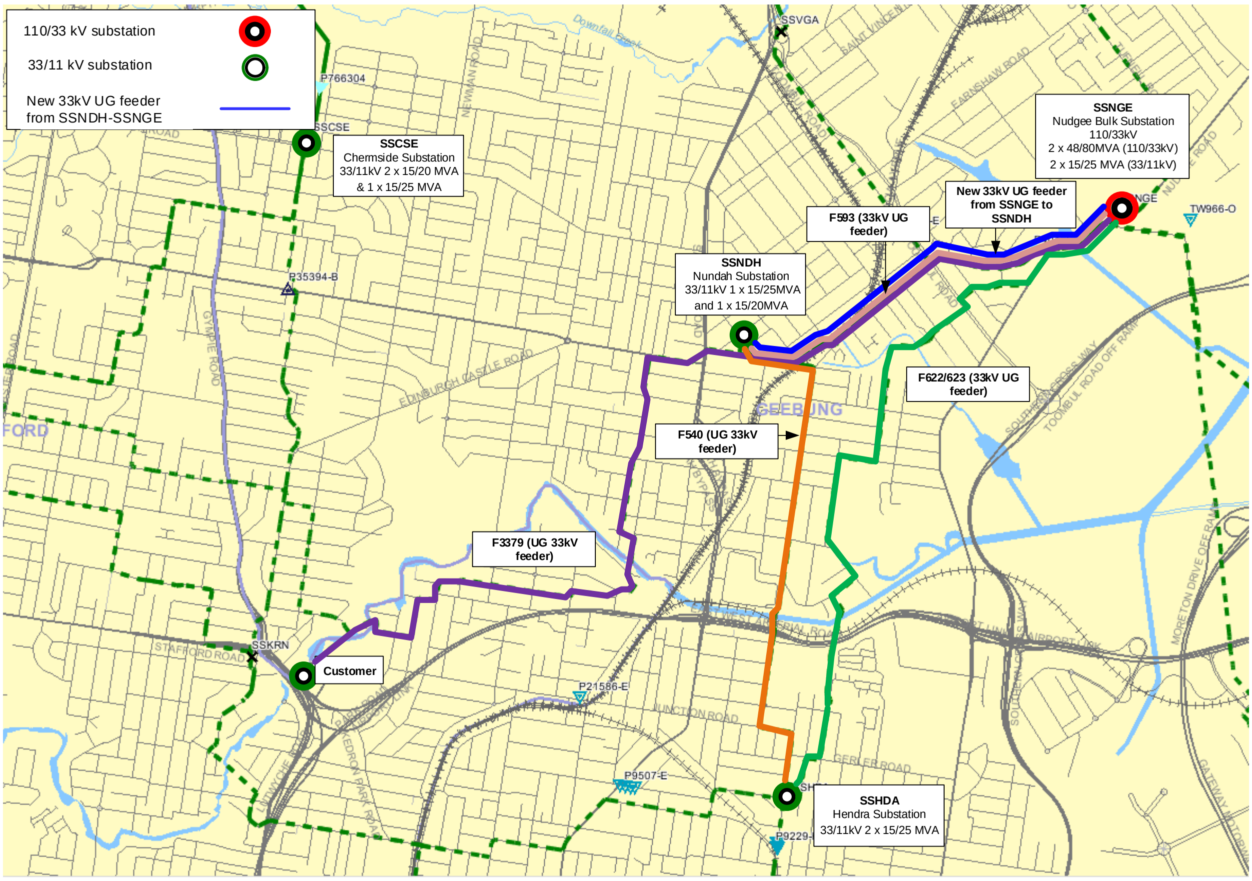


Figure 5 – Option 1 network arrangement (geographic view)



4.1.1 Costs

The establishment of the new 33kV underground feeder from SSNGE to SSNDH has been estimated at $6.394m direct cost, which has been factored into the NPV as a cost in 2030.

4.2 Option 2 - Cut into F3379 from SSNDH and rebuild SSNDH Zone Substation

This option involves replacing the 33kV switchgear at SSNDH and establishing a new 33kV connection from SSNDH by cutting into the existing 33kV feeder F3379, to help support in supplying the SSNDH and SSHDA load for the loss of F622/623.

The works under this option involve:

SSNDH zone substation:

- Install a new building to accommodate 2 bus indoor 33kV switchboard consisting of 8x33kV feeder CB, 2 x transformer CB and 1x bus section CB.
- The new building will be constructed on the vacant Energex owned land adjacent to the existing site. Building to be masonry type with brick facade to match existing heritage listed ENERGEX control building on site.

- Construct 200m of 33kV DCCT UG feeder from SSNDH to cut existing 33kV feeder F3379 (SSNGE-SSALO (Airport Link)) into new 33kV switchboard at SSNDH.
- Existing 33kV feeders will be cut over to the new 33kV switchboard.
- Recover existing outdoor 33kV switchgear at SSNDH.

Figure 6 shows the network arrangement and Figure 7 shows the geographic layout for option 2.

Figure 6 – Option 2 network diagram

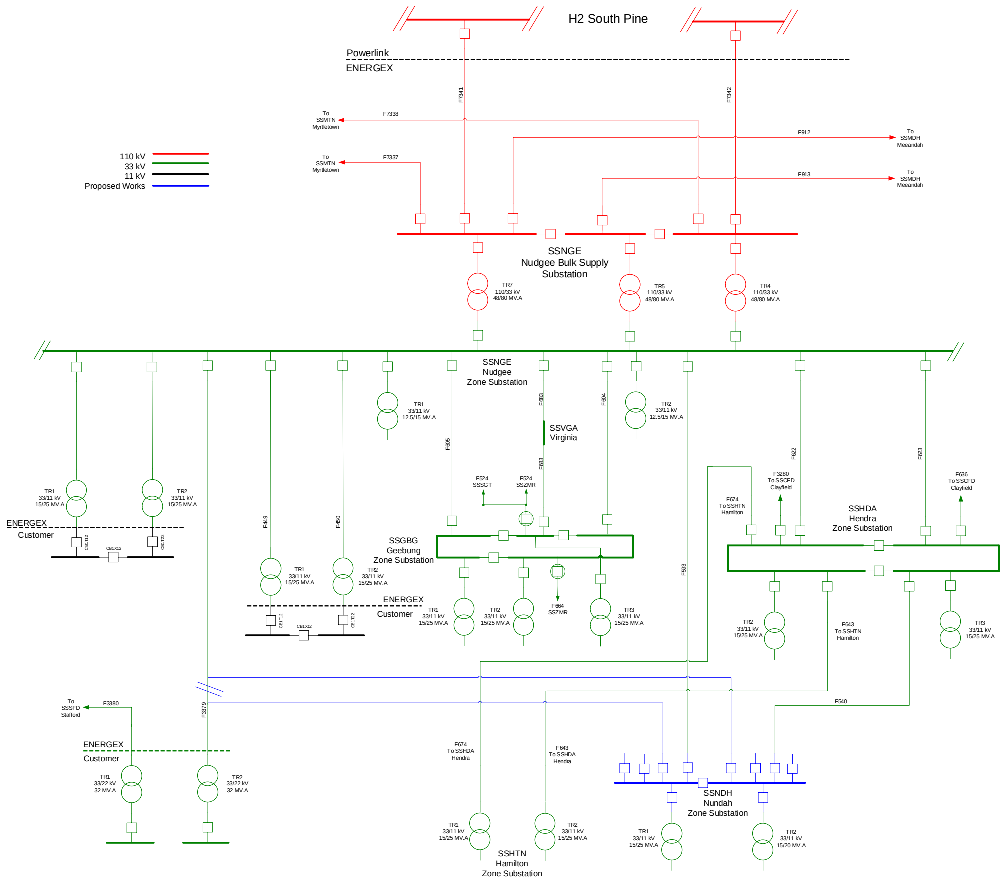
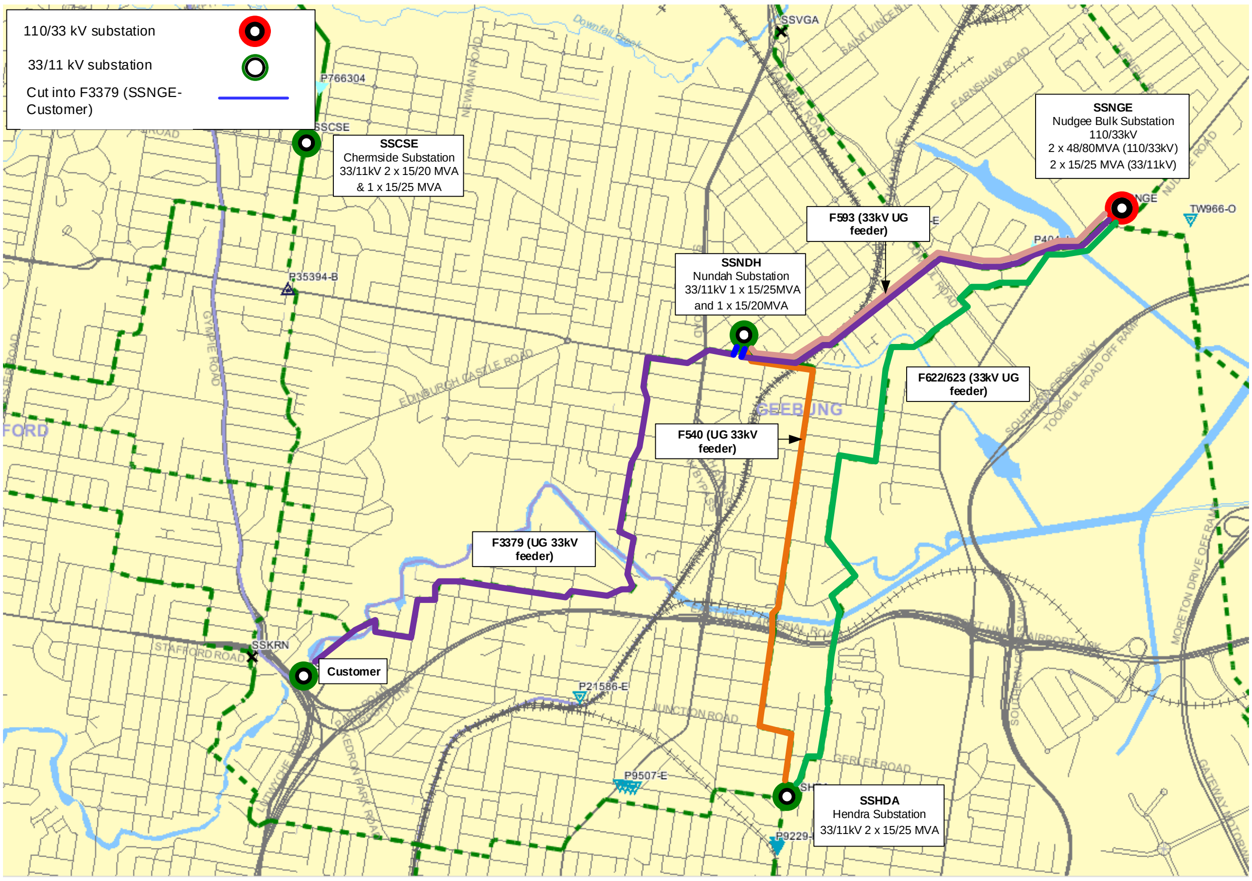


Figure 7 – Option 2 network arrangement (geographic view)



4.2.1 Costs

The cutting into F3379 from SSNDH and rebuilding SSNDH zone substation has been estimated at $7m direct cost, which has been factored into the NPV as a cost in 2030.

4.3 Option 3 - Establishing a Zone substation at Virginia (SSVGA)

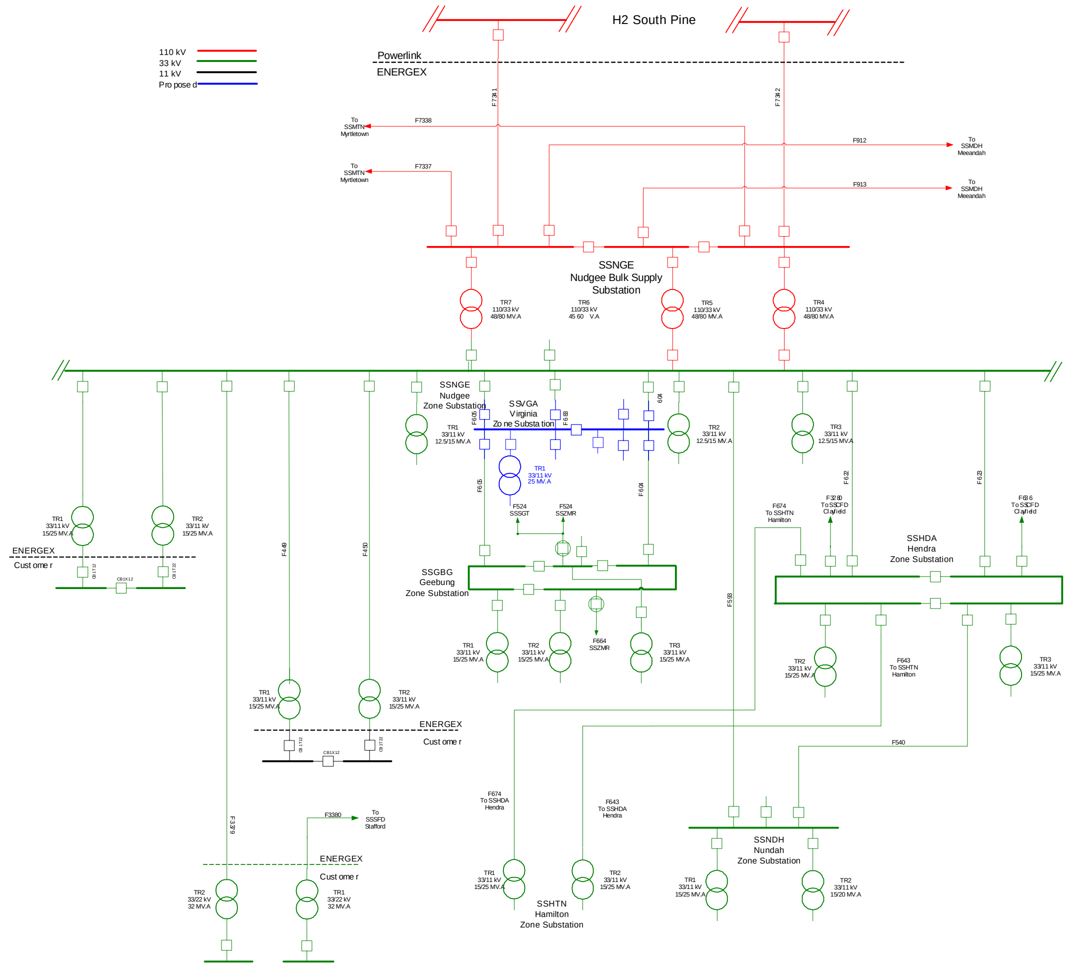
This option will permanently transfer load from SSNDH to a new 33/11kV zone substation (SSVGA) to address the identified limitations.

The works under this option involves:

- Establishing a Zone substation at Virginia (SSVGA) consisting of 1 x 25 MVA 33/11kV transformer and 2 bus indoor 33kV switchboard with provision for a second 25MVA transformer in the future.
- Permanently transfer 10 MVA of SSNDH load to SSVGA zone substation.

Figure 8 shows the network arrangement for option 3.

Figure 8 – Option 3 network diagram



4.3.1 Costs

Building a new double modular zone substation at SSVGA has been estimated at $9.33m direct cost, which has been factored into the NPV as a cost in 2030.

4.4 Option 4 – Installing an 8MWh/4MW network connected battery energy storage system (BESS) and 11kV switchgear at Virginia (SSVGA)

The BESS will be able to provide support to SSNDH during peak loads for the loss of supply of 33kV feeder 622 or 623.

The works under this option involves:

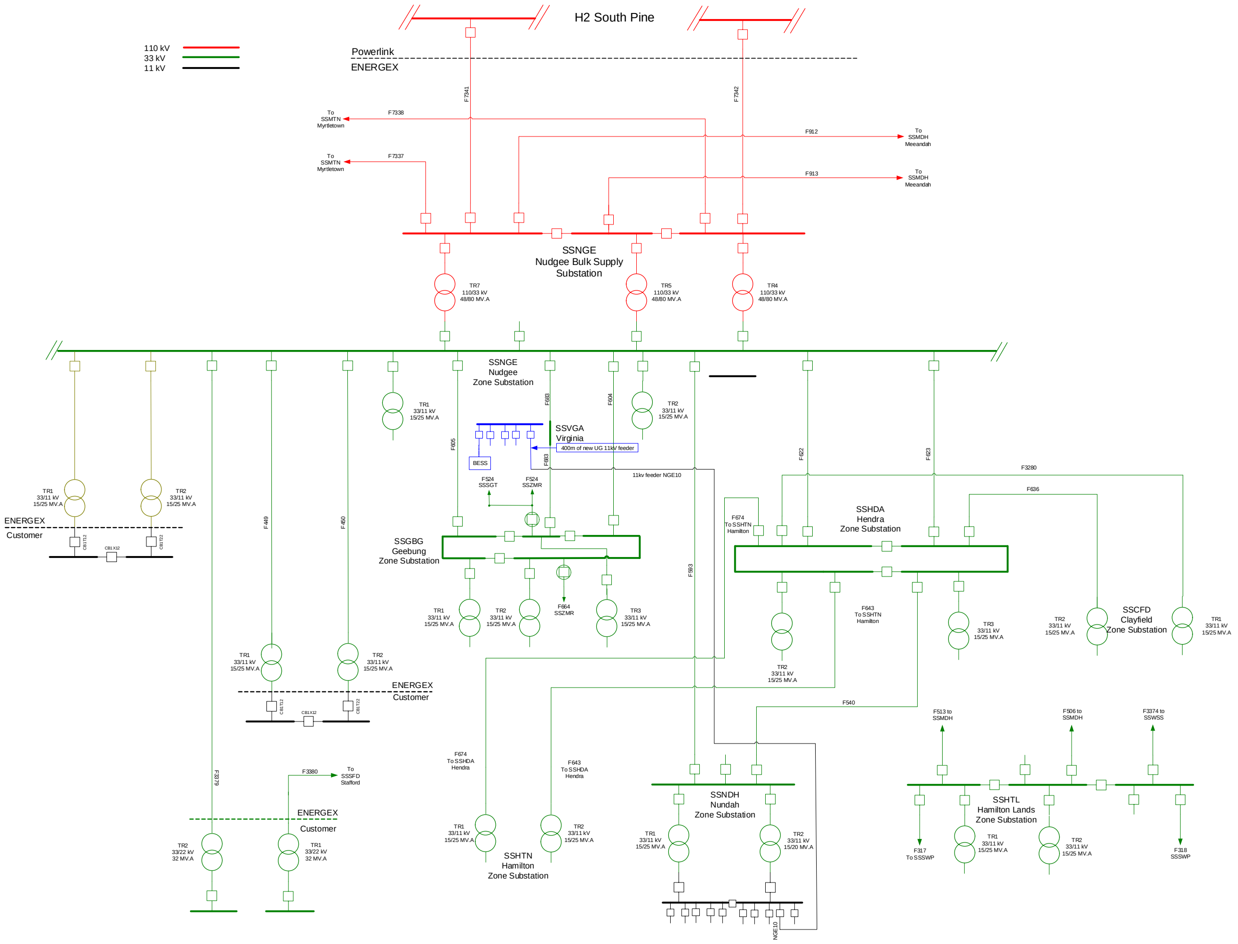
- Installing an 8MWh/4MW network connected battery energy storage system (BESS) with grid-forming capability, at SSVGA
- Building an 11kV indoor switchgear (1 bus) at SSVGA.

- Installing a new 400m 11kV underground feeder utilising existing spare conduits from a new pole in the vicinity of P22786-E to 11kV CB at SSVGA, extending NDH10 to SSVGA.

This option will defer the limitation on F593 for the loss of F622 or F623 until 2038. A new 33kV feeder from SSNGE to SSNDH will be required in 2038 to resolve the limitation.

Figure 9 shows the network arrangement for option 4.

Figure 9 – Option 4 network diagram



4.4.1 Costs

Installation of an 8MWh/4MW network connected battery energy storage system (BESS) and 11kV indoor switchgear at SSVGA has been estimated at $11m direct cost, which has been factored into the NPV as a cost in 2030. The cost to establish a new 33kV feeder from SSNGE to SSNDH has been factored into the NPV in 2038.

4.5 Economic Analysis

4.5.1 Cost summary 2025-30

The establishment of a new 33kV feeder from SSNGE to SSNDH has been estimated as $6.394m. The forecast expenditure by year is shown in Table 1.

Table 1 – Cost summary 2025-30 2022-23 $

Option	2025-26	2026-27	2027-28	2028-29	2029-30	Total 2025-30
Build a new 33kV feeder from SSNGE to SSNDH	$0.0m	$0.008m	$0.05m	$0.117m	$6.219m	$6.394m

4.5.2 NPV analysis

From the table below, Option 1 is the winning option. The NPV under the base case is -$5.479m, with the Capex, Opex and Benefits NPV shown in Table 2. Table 3 shows the results after completing a sensitivity analysis having changed various inputs in the financial model. Under all models Option 1 is the preferred option.

Table 2 – Base Case NPV analysis

Option	Rank	Net NPV	Capex NPV	Opex NPV
Build a new 33kV feeder from SSNGE to SSNDH	1	-$5.081m	-$4.931m	-$0.150m
Cut into F3379 from SSNDH and rebuild SSNDH zone substation	2	-$5.455m	-$5.398m	-$0.057m
Establishing Single Modular Zone substation at Virginia (SSVGA)	3	-$8.011m	-$7.218m	-$0.793m
Installing an 8MWh/4MW network connected battery energy storage system (BESS) and 11kV switchgear at Virginia (SSVGA)	4	-$13.108m	-$13.891m	$0.784m

Table 3 – NPV Sensitivity Analysis

Option	Discount rate	
	2.5%	4.5%
Build a new 33kV feeder from SSNGE to SSNDH	-$5.404m	-$4.764m
Cut into F3379 from SSNDH and rebuild SSNDH zone substation	-$5.777m	-$5.131m
Establishing Single Modular Zone substation at Virginia (SSVGA)	-$8.653m	-$7.426m
Installing an 8MWh/4MW network connected battery energy storage system (BESS) and 11kV switchgear at Virginia (SSVGA)	-$14.346m	-$11.958m

4.6 Optimal Timing

This is a Safety Net requirement and the optimum timing for this project is 2030. As the feeder is one of the critical supply to the Olympic Games 2032 infrastructure, deferral of this project is not recommended.

5 RECOMMENDATION

It is recommended to establish a new 2.6 km underground 33kV feeder from Nudgee (SSNGE) to Nundah (SSNDH) Substation to meet the projected load growth and enabling Energex to continue to meet the Safety Net regulatory obligation. Table 4 summarises the option under consideration.

Table 4 – Options Analysis Scorecard

Criteria	Option 1 – Build a new 33kV feeder from SSNGE to SSNDH	Option 2 – Cut into F3379 from SSNDH and rebuild SSNDH zone substation	Option 3 – Establishing Single Modular Zone substation at Virginia (SSVGA)	Option 4 – Installing an 8MWh/4MW network connected battery energy storage system (BESS) and 11kV switchgear at Virginia (SSVGA)
Net Present Value	-$5.081m	-$5.455m	-$8.011m	-13.108m
Investment cost	$6.394m	$7m	$9.36m	$11m
Investment Risk	Medium	Medium	Medium	Medium
Delivery time	4 years	5 years	5 years	5 years
Detailed analysis – Risks	Difficult to seek council approval/design/construct UG feeder along Melton Road.	Energex owns land adjacent to the existing SSNDH site. Council DA process will be required to re-zone this land for rebuilding SSNDH.		
Detailed analysis - Advantages	Better utilises available capacity on 33kV network between SSNDH, SSNGE and SSHDA	Better utilises available capacity on 33kV network between SSNDH, SSNGE and SSHDA	Provides 11kV transfer capacity and security to SSNDH and surrounding substations.	The BESS will be able to provide 4MW of support to SSNDH during peak loads for the loss of supply of 33kV feeder 622 or 623.

Appendix 1: Alignment with the National Electricity Rules

Table 5 – Recommended Option's Alignment with the National Electricity Rules

NER capital expenditure objectives	Rationale
A building block proposal must include the total forecast capital expenditure which the DNSP considers is required in order to achieve each of the following (the capital expenditure objectives):	
6.5.7 (a) (1) meet or manage the expected demand for standard control services over that period	Section 3, Section 4.1
6.5.7 (a) (2) comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;	Section 3, Section 4.1
6.5.7 (a) (3) to the extent that there is no applicable regulatory obligation or requirement in relation to: (i) the quality, reliability or security of supply of standard control services; or (ii) the reliability or security of the distribution system through the supply of standard control services, to the relevant extent: (iii) maintain the quality, reliability and security of supply of standard control services; and (iv) maintain the reliability and security of the distribution system through the supply of standard control services	Section 3, Section 4.1
6.5.7 (a) (4) maintain the safety of the distribution system through the supply of standard control services.	Section 3, Section 4.1
NER capital expenditure criteria	**Rationale**
The AER must be satisfied that the forecast capital expenditure reflects each of the following:	
6.5.7 (c) (1) (i) the efficient costs of achieving the capital expenditure objectives	Section 4.5
6.5.7 (c) (1) (ii) the costs that a prudent operator would require to achieve the capital expenditure objectives	Section 4.5
6.5.7 (c) (1) (iii) a realistic expectation of the demand forecast and cost inputs required to achieve the capital expenditure objectives	Section 3, Section 4.5

Appendix 2: Reconciliation Table

Table 6 – Reconciliation

Expenditure	2025-26	2026-27	2027-28	2028-29	2029-30	2025-30
Expenditure in business case $m, direct 2022-23	$0.0m	$0.008m	$0.05m	$0.117m	$6.219m	**$6.394m**