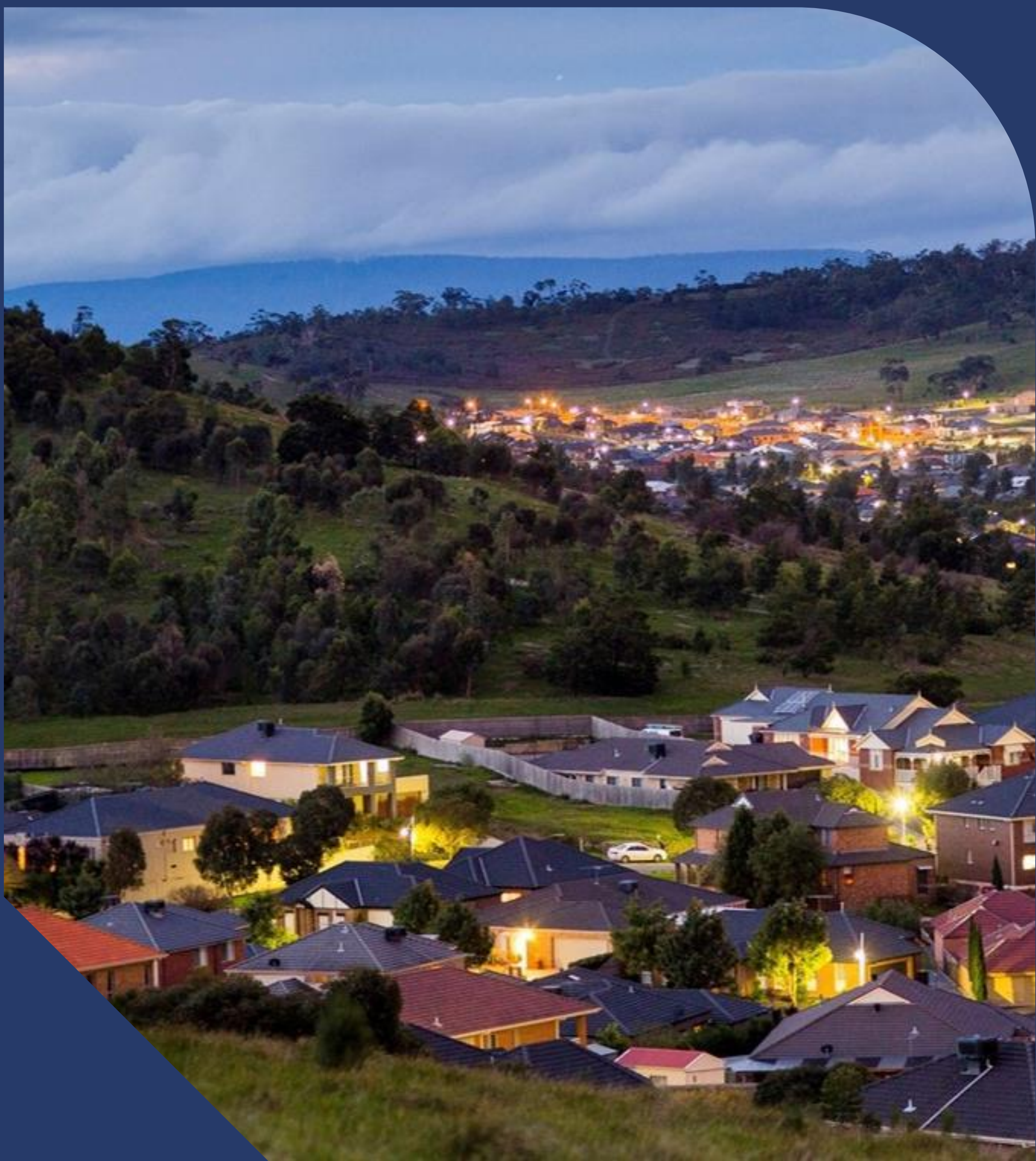
Large Renewables Enablement Program

Addressing sub-transmission network constraints proactively to enable more renewables and benefit customers

Friday, 31 January 2025



AusNet

Table of contents

1.	**Executive summary**	**3**
2.	**Key drivers of change and stakeholder feedback**	**5**
2.1.	Key drivers for change	5
2.2.	Network limitations	7
2.3.	Customer and stakeholder feedback	8
2.4.	Relationship to Chapter 5 of the National Electricity Rules	10
2.5.	Relationship to transmission investment	10
3.	**Delivering customer benefits**	**11**
4.	**Market modelling approach**	**12**
4.1.	Hosting capacity	12
4.2.	Overview of market modelling	13
4.3.	Illustrative example of energy market analysis	14
5.	**Proposed investments**	**16**
5.1.	Wodonga – Barnawartha in North-Eastern Victoria	16
5.2.	Morwell East Area – Stages 1 and 2	18
5.3.	Morwell South area	20
5.4.	Forecast expenditure and net economic benefits	21

1. Executive summary

The purpose of this document is to outline AusNet's Large Renewable Enablement Program, which will be reflected in our capital expenditure proposal for our 2026-2031 Electricity Distribution Price Review (**EDPR**) submission.

Australia's ageing coal-fired power stations are closing down, which is driving an unprecedented energy transition to net zero carbon emissions. The Federal and Victorian governments both have ambitious renewables targets, including:

- Victorian government legislated targets:
  - Emissions targets: 45-50% reduction by 2030 and net zero emissions by 2045
  - Renewable energy targets: 65% by 2030 and 95% renewables by 2035
- Federal government legislated targets:
  - Emissions targets: 43% reduction by 2030 and net zero emissions by 2050
  - Renewable energy targets: 85% by 2030.

In 2023, the National Electricity Objectives (NEO)—an overarching set of objectives that guide energy sector investment—were updated to include the objective of meeting emissions reduction targets. This is a significant positive step towards unlocking more investment in renewable generation and grid capacity to ensure Australia's emissions targets are achieved.

AusNet's role as a distribution network is to undertake network and non-network investments that are consistent with the NEO, which from 2023 includes assessment of the benefit of the emission reduction in assessing the efficiency of investment. AusNet does this by assessing the efficiency of investment to unlock capacity for the growth of renewable generation and storage, including from smaller Consumer Energy Resources (**CER**) as well as utility scale renewable generation and storage more recently.

Utility scale or large renewable generation in the distribution network is mostly concentrated in the sub-transmission (66kV) component of our network. This is the highest voltage part of the network closest to the transmission network, which attracts larger generators and storage. We are already seeing a lot of demand for renewable generation in specific parts of our network that have strong renewable resources, including solar and wind. We summarise existing enquiries in appendix A.

To unlock value from large renewable generation, including emissions reduction and generation cost reductions, we have conducted sophisticated modelling to identify areas in our 66kV network where additional capacity can be unlocked while still delivering net benefit that is consistent with the updated NEO. Our modelling has identified several projects that are expected to deliver significant net market benefits, and we have commenced regulatory investment tests (**RIT**) for in relation to these projects[1], which are:

- options to address constraints in the Wodonga Terminal Station sub-transmission system to enable more renewable generation to the sub-transmission and distribution networks in North-eastern Victoria (Wodonga – Barnawartha area)
- options to address constraints in the Morwell Terminal Station East sub-transmission network which are restricting new renewable generation
- options to address the constraints in the Morwell Terminal Station South sub-transmission network which are restricting new renewable generation.

As explained in section 5.2, we have identified a two-stage process for Morwell Terminal Station East, which means that four projects will be progressed in total. The stage 2 project will be subject to a separate RIT process, which has not yet commenced.

The large renewable enablement program is a new expenditure category which responds to the challenges arising from the energy transition in a way that is consistent with the updated NEO. Our program delivers a range of customer benefits, including emissions reductions, cost of generation reductions and reliability improvements, at efficient cost. The inclusion of the Large Renewable Enablement Program in our electricity distribution price review has the support of our customers, who recognise that integrated planning will deliver more needed renewable generation while lowering total energy costs.

[1] For further information, please refer to: https://www.ausnetservices.com.au/projects-and-innovation/regulatory-investment-test

The table below provides a summary of objectives and customer benefits from our Large Renewable Enablement Program.

Table 1: Program objectives and benefits

<table>
<tr><th></th><th></th></tr>
<tr><td>Key objectives</td><td>To enable efficient large-scale renewable generation (5MW or above) in AusNet's sub-transmission network by undertaking targeted network augmentations that will deliver emissions reductions, lower electricity costs for our customers and reliability improvements, consistent with the updated NEO.</td></tr>
<tr><td>Key benefits to customers</td><td>Reduces cost of energy by enabling additional low cost renewable generation in the market.
Reduces emissions principally by offsetting thermal generation with zero emissions generation.
Contributes to maintaining network reliability by increasing thermal capacity and redundancy at a lower total cost.</td></tr>
<tr><td>Program timings</td><td>Each year 2026-2031</td></tr>
<tr><td>Expenditure forecast[2]</td><td><table><tr><th></th><th>2026-27</th><th>2027-28</th><th>2028-29</th><th>2029-30</th><th>2030-31</th><th>Total</th></tr><tr><td>Capex</td><td>$17.7m</td><td>$44.5m</td><td>$25.8m</td><td>$29m</td><td>$39.1m</td><td>$156m</td></tr></table></td></tr>
<tr><td>Customer Engagement</td><td>We engaged with our EDPR Future Networks Panel, who agreed that sub-transmission investments to integrate large renewables should be part of AusNet's planning process and that there is value in enabling all renewable energy where efficient. The panel also expressed the view that the Large Renewable Enablement Program made good sense conceptually, however there is a need to ensure the small-scale and larger scale generation are coordinated well.</td></tr>
</table>

Source: AusNet analysis

While each of the four projects (including Stage 2 for Morwell East) will be subject to further detailed cost-benefit analysis and stakeholder consultation through the RIT process, we set out below our expected net economic benefits for each of the projects, expressed in present value terms.

Table 2: Expected net economic benefits in present value terms ($M, real 2024)

	Total costs	Total gross benefits	Net economic benefit
Wodonga – Barnawartha	$38.88m	$99.7m	$60.8m
Morwell East – Stage 1	$5.38m	$98.72m	$93.34m
Morwell East – Stage 2	$11.24m	$63.02m	$51.78m
Morwell South	$70.71m	$120.59m	$49.79m
Total	$126.21m	$382.03m	$255.71m

Source: AusNet

The conclusion from the cost-benefit analysis shown above is that each project is expected to deliver significant net economic benefits compared to the 'Business as Usual/Do nothing' option. While provisional in nature, it provides strong support for the proposed projects and the Large Renewable Enablement Program.

All generator connections in AusNet's network are subject to Chapter 5 of the National Electricity Rules. However, we anticipate the direct cost to some generators may be lower as a result of the proposed investment. This has the anticipated benefit of accelerating large renewable generation on our network, in Victoria and in the NEM, and delivering the calculated benefits to our customers and across the NEM.

[2] It should be noted that expenditure has already been incurred in relation to these projects in the current regulatory period.

2. Key drivers of change and stakeholder feedback

AusNet considers that the sub-transmission network (66kV network) has a critical role to play in accommodating the growth in large-scale renewables that is required if Australia is to meet its emission reduction targets; manage the closure of coal power plants; and deliver the lowest cost outcome for electricity customers. The purpose of this Large Renewable Enablement Program is to identify network augmentations to facilitate the growth in large renewable generation efficiently and prudently for the benefit of our customers.

The investments described in this document have been developed through a modelling process that is consistent with the requirements of the regulatory investment tests. Our modelling approach will ensure that our customers will benefit from the proposed augmentations by enabling their energy needs to be met at the lowest total cost.

2.1. Key drivers for change

The Large Renewable Enablement Program is a new category of investment. As such, it is important to understand why we are introducing this program now, i.e., what are the drivers for change. This section explains the three key drivers for the introducing the Large Renewable Enablement Program:

- The Victorian government's legislated targets for renewable generation and emissions reductions, consistent with the emissions objective in the NEO.
- The changing role of distribution networks in unlocking more renewable generation.
- Strong demand for renewable generation in our sub-transmission network, as illustrated by the growth in large generator enquiries on our network and the broader national drivers for increased renewable generation, as outlined in AEMO's Integrated System Plan.

We discuss each of these drivers below.

2.1.1. Legislated renewable energy and emissions targets

The NEO has been amended to recognise that the long-term interests of consumers include contributing to the achievement of government targets for reducing Australia's greenhouse gas emissions. Through the connection of additional renewable generation, fossil fuel powered generation is displaced. As such, the Large Renewable Enablement Program will promote the long term interests of consumers in accordance with the NEO.

The Victorian Government's legislated emissions reductions and renewable energy targets provide further context and impetus for the Large Renewable Enablement Program. The targets are set out below:

- Legislated emissions targets
  - 45-50% reduction by 2030
  - Net zero emissions by 2045
- Legislated renewable energy targets
  - 65% by 2030
  - 95% renewables by 2035.

The transition to renewable energy and electrification will be an important factor in achieving these emissions targets. Enabling greater renewables on the sub-transmission network will support meeting these targets by unlocking the potential for increased renewable generation capacity to connect in less time compared to reliance on only the transmission network to deliver the decarbonisation goals for Victoria.

2.1.2. Changing role of distribution networks

As indicated by AEMO's 2024 ISP, it is expected that distribution networks across the NEM will play an important role in accommodating the projected growth in renewable generation.[3] From a network perspective, it should be noted that promoting renewable generation at the sub-transmission level has several advantages compared to transmission including:

[3] AEMO, 2024 Integrated System Plan, June 2024, page 30.

- **Social licence**—distribution upgrades are a lot less intrusive compared to transmission towers that require easements, and therefore entail less community impact.
- **Faster project delivery**—distribution upgrades can be delivered faster than major transmission infrastructure due to less complex planning, community/stakeholder engagement and construction processes.
- **More streamlined network planning & delivery**—because AusNet is the planner as well as owner and operator of the sub-transmission and distribution network in its region, planning and delivery of upgrades is more streamlined than transmission upgrades that typically involve multiple parties.
- **Supply reliability risk mitigation**—augmentation at the sub-transmission level helps to mitigate supply reliability risks that may be caused by delays in progressing major transmission projects. These advantages represent a significant opportunity to overcome the current barriers of transmission investment and accelerate the deployment of renewables to support Vicotria in meeting its targets.

In short, AusNet can unlock capacity for renewable generation efficiently and in a way that meets government targets at least cost, without the project delivery risks that are typically associated with transmission network growth.

2.1.3. Growth in renewable generation

We are experiencing significant growth in distribution-level enquiries from large renewable generators. In particular, the magnitude of the total capacity that is being sought is several multiples of the existing large renewable generation capacity and the available capacity on these portions of the network.

Table 3: Existing generation compared to enquires per location

	Existing large-scale generation	Large-scale generation enquires[4]
Morwell East network	123.1 MW	1360 MW
Morwell South network	141.4 MW	860 MW
Wodonga – Barnawartha in North-Eastern Victoria	60 MW	390 MW
Cranbourne network	Nil	505 MW
East Rowville network	12.6 MW	40 MW
Glenrowan and Mt Beauty network	141.25 MW	550 MW
Morwell West network	10.75 MW	85 MW
Ringwood network	6.2 MW	5 MW
South Morang network	86.86 MW	485 MW
Templestowe network	4.3 MW	10 MW
Thomastown network	6.8 MW	Nil

Source: AusNet

AEMO's 2024 Integrated System Plan (**ISP**) observed that investment in both utility-scale and consumer-owned renewable generation is needed to meet growing demand for electricity as coal generation retires. In particular, AEMO explained that:

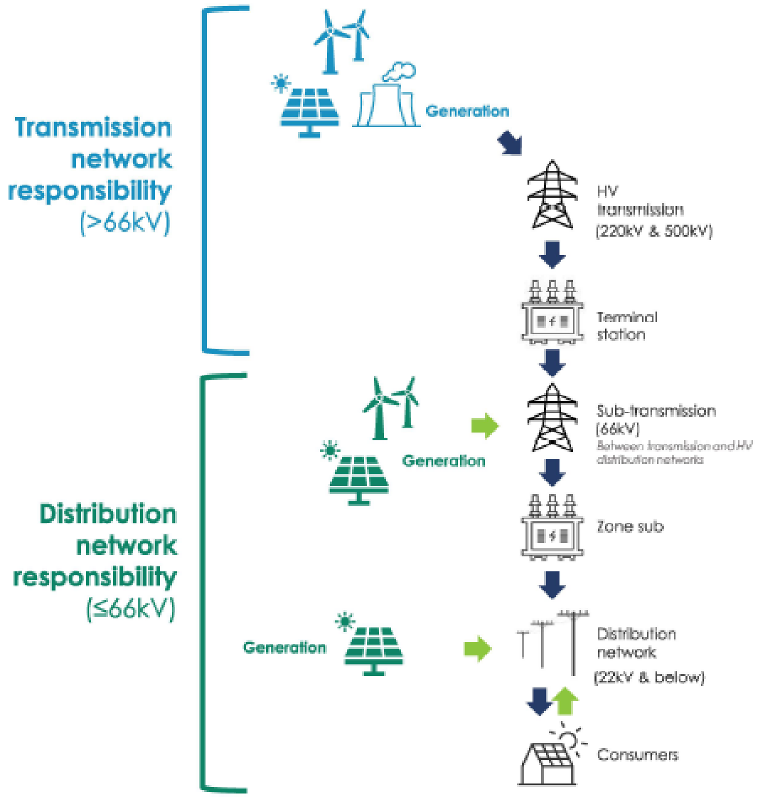
- Coal is retiring faster than previously announced.
- Rooftop solar and other consumer-owned energy resources are forecast to grow five-fold by 2049-50.
- Utility-scale solar and wind are forecast to grow six-fold by 2049-50.
- Renewable Energy Zones (REZs) are being planned to house most of the utility-scale assets.[5]

With most coal plant expected to withdraw by 2034-35, AEMO forecasts that approximately 82 GW of utility-scale wind and solar will be required by that date. A further increase in capacity to 126 GW is forecast by 2049-50. To put these capacity requirements into context, the current utility-scale renewable generation capacity in the NEM is only 19 GW, with a further 5 GW of capacity planned to be operational before the end of 2024. The projected growth in renewable generation connection across the NEM is therefore extremely challenging for transmission and distribution network service providers.

[4] See Appendix for details
[5] AEMO, 2024 Integrated System Plan, June 2024, page 49.

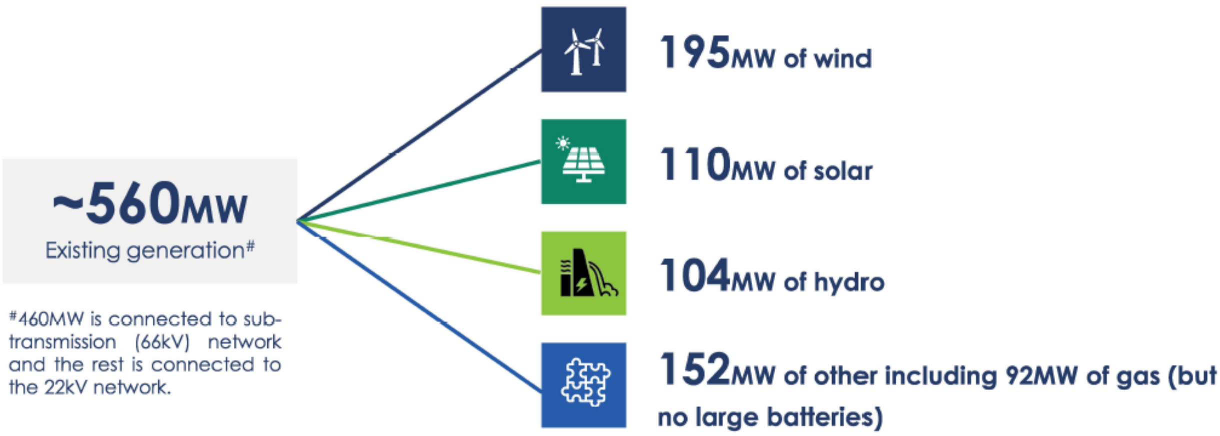
Error! Reference source not found. below illustrates the transmission and distribution network service providers' different roles and responsibilities for connecting renewable generation.

Figure 1: Roles and responsibilities for transmission and distribution networks



For our distribution network, **Error! Reference source not found.** shows the mix of generation sources and the existing capacity of renewable generation, which is relatively modest at 560 MW. It shows that more than 80% of this total capacity is connected to the sub-transmission network, with the remaining 100 MW connected to the 22 kV network.

Figure 2: Existing mix of renewable generation connections



These observations, together with the analysis presented in the 2024 ISP, help to explain why we are experiencing a rapid growth in renewable generation enquiries in the 66kV network and, more importantly, why this growth is likely to continue into the 2026-2031 regulatory period and beyond.

2.2. Network limitations

Our 66kV sub-transmission network was planned, built, and maintained to deliver energy to load customers, and is typically not strong enough to connect significant additional renewable generation. The distribution network below 66kV is vast and covers a wide geographical area. It is currently experiencing many new challenges, including the integration of CER with increasing latent demand as electrification grows. In contrast to the 66kV sub-transmission network, this portion of the distribution network is even less equipped to accommodate large-scale renewable generation.

The ability of the distribution network to accommodate renewable generators may be limited by a number of technical considerations including:

- thermal limits
- voltage levels including voltage dips / rise and voltage fluctuations at the connection point, considering both normal and single contingency scenarios
- voltage harmonics and flicker emissions
- network fault levels
- reverse power flows
- system strength
- the availability of fibre optic capacity to provide communications services.

Depending on the nature of the constraint, it may be addressed by augmentation of the shared network, installing equipment at the connection point, or modifying the design and operation of the embedded generator. Based on renewable generation enquiries, we can anticipate the need for network augmentation that is likely to arise from the projected growth in renewable generation capacity over the planning horizon. As already noted, our modelling approach to address these issues is discussed in section 4.

For sub-transmission connected renewables, depending upon the protection, remote monitoring, constraint and runback requirements, communications services may be required between the customer substation, the contestable switching station, multiple terminal stations/zone substations and AusNet's control centre, as well as AEMO. This communication requires duplicated digital communication channels, which is best provided by optical fibre-based communication links.

2.3. Customer and stakeholder feedback

The previous section explained the strong drivers for introducing the Large Renewable Enablement Program in the 2026-31 EDPR. In addition to considering those drivers, we regard stakeholder feedback as an important component of our investment planning. Accordingly, we sought stakeholder feedback on the rationale for this program noting that AusNet has not previously developed a specific program for augmentation of the sub-transmission network.

With this objective in mind, in September 2023, we sought stakeholder feedback on the initial formulation of the investment program from our EDPR Future Networks Panel. The Future Networks Panel agreed that sub-transmission network augmentations to integrate large renewables should be part of AusNet's planning process for the 2026-31 EDPR. Stakeholders raised the question of the charging arrangements between transmission and distribution users, noting that further work was required to address that issue, but regarded it as secondary to efficient network planning. Stakeholders also commented that AusNet should advocate for a more integrated planning approach across transmission, sub-transmission and distribution.

The key discussion points on sub-transmission augmentation are summarised below:

- There was a broad consensus that the approach makes good sense conceptually.
- Panel members agreed that integrated planning across networks makes a lot of sense. There was broad agreement that AEMO should include DNSP-planned sub-transmission investments as inputs to its ISP and that AusNet should advocate for them to do this.
- A panel member said they think regional communities would be pleased to see investment in more medium-sized infrastructure. The panel member noted that there is a lot of talk about large infrastructure, but it is good to see a mix so that medium-sized developers do not get 'squeezed out of the network'.
- Sub-transmission could be an important location for connecting new battery capacity to support the grid.
- Discussion on who should pay included:
  - A panel member raised questions about how the charges would be passed through—via Distribution Use of System (DUoS) charges, meaning the costs are borne by AusNet customers alone, or by Transmission Use of System (TUoS) charges, where the costs are borne by all Victorians, and how transmission easement costs might be reflected. If developers are using the sub-transmission network instead of the transmission network, the panel member queried whether the sub-transmission costs should be socialised through TUoS.

- Whether the costs could be kept with the generator but recovered through a pioneer scheme/other cost-sharing mechanism. AusNet said it is considering pioneer schemes for network extensions but not for upstream augmentations to remove constraints due to large costs associated with upstream augmentations which may discourage developers.

- Discussion on risk of overbuilding, noting that customers are effectively underwriting the risk. However, overbuilding was considered to be a very low risk, given the strong and rapidly growing enquiries pipeline, and would be addressed through appropriate modelling. It was also suggested that AusNet should speak to government about underwriting this risk, including through the involvement of VicGrid.

Additionally, we sought stakeholder feedback on our draft plans including this program from all our panels at our EDPR offsite workshop in March 2024, where we did not receive much additional feedback. Although we did not receive much feedback at our EDPR Offsite in March 2024, no opposition to including a program to enable utility-scale renewables was raised by panel members. We heard some positive sentiment towards the use of the existing network to enable renewables.

Finally, in August 2024 we engaged with our EDPR stakeholders on two options for this program, as part of a service and cost trade-off engagement. We presented two options to customers for trade-offs, presented in Figure 3. During the offsite, stakeholders

Figure 3: Two investment options presented to EDPR stakeholders for trade-offs discussion, August 2024

	Committed projects only Portion to be incl. in EDPR 2026-31	**Doing more to efficiently connect renewables** Committed projects + additional efficient investment
Renewable capacity unlocked	650MW	950MW
CO_2 reduced	2.18Mt	2.71Mt
NEM wholesale market cost reduction	-$79M	-$85M
Per customer wholesale price reduction in NEM	Wodonga - 1 line Morwell - 2 lines	-$1.89 p.a. for >9m customers
Locations	-$1.75 p.a. for >9m customers	Wodonga - 1 line Morwell - 3 lines
Total cost	$108m capex	$121 capex
Alternative cost to customers to unlock the same MW of renewables on the transmission network	$216m-$1b in transmission costs	$242m-$1.2b in transmission costs

Source: AusNet.

During the engagement at the offsite, the Future Networks Panel was unable to agree unanimously on an outcome. The broader group opted to "do more" to efficiently connect renewables, selecting the option at $121m. This decision was made on the basis that it would lower overall costs of the system compared to deferring large renewables to the transmission system or connecting generators paying the whole cost of connecting without coordinated planning. The fact that upgrading the sub-transmission network uses existing easements and may defer the need for new easements and power lines, was also very attractive to some.

We further tested support for investments in sub-transmission to enable larger generators where efficient through our customer workshops and draft proposal where customers indicated support for proactive investment where it would lead to clear benefits. Our draft proposal's alignment with sustainability, government policy and net-zero goals was generally well-received including in relation to connecting large generators. A caveat over support for the large renewable connections enablement proposal is that customers and stakeholders want AusNet to provide more evidence that customers would be better-off-overall. While customers in the workshop were generally comfortable with others benefitting (even if they were not directly paying), they did want confidence that AusNet customers would benefit.

In addition, we conduct an annual survey of large embedded generators looking to connect to AusNet's distribution network. In our 2023 survey, we heard the upfront cost of connecting and lack of network capacity were the main obstacles applicants cited for connections at the sub-transmission level. Developers suggested the costs of upgrades should be shared where the upgrade will benefit other parties beyond the connection applicant. Our proposal is aligned with this feedback by sharing costs to alleviate constraints with AusNet, where our customers will benefit from the upgrades at locations with high demand for connection applicants.

2.4. Relationship to Chapter 5 of the National Electricity Rules

All generator connections in AusNet's network are subject to Chapter 5 of the National Electricity Rules. However, we anticipate the direct cost to some generators may be lower as a result of the proposed investment. This has the anticipated benefit of accelerating large renewable generation on our network, in Victoria and in the NEM, and delivering the calculated benefits to our customers and across the NEM.

2.5. Relationship to transmission investment

Our program takes into account any expected transmission constraints upstream from the sub transmission network that is being augmented. That means that when we model the benefits from our program, we model the level of constraint the generators may experience due to the transmission network congestion.

3. Delivering customer benefits

As highlighted, there is a significant opportunity to unlock more customer benefits through investment that enables large renewable generation in AusNet's sub transmission network. Our planned investment demonstrably delivers net benefits to our distribution customers whilst also providing benefits to the broader NEM. This approach ensures that the Large Renewable Enablement Program is consistent with the updated NEO and capital expenditure objectives of the National Electricity Rules. It also addresses stakeholder feedback regarding 'who pays' for the augmentation, by ensuring that distribution customers are net beneficiaries from any proposed augmentation of the sub-transmission network.

While our analysis has identified several areas of our network where renewable generation enquiries are limited by current network constraints that could be relieved through augmentation, our proposed program only targets the areas which can be economically justified by quantifying the customer benefits below. Our approach is therefore consistent with the NEO and stakeholder feedback.

In broad terms, the types of customer benefits that may be delivered through investments in this program are:

- **Market benefits that lower energy costs for consumers**

  Electricity from renewables is cheaper than fossil fuels. Therefore, enabling additional renewable generation in the network will put downward pressure on wholesale electricity prices. This is calculated in our model as a reduction in wholesale generation costs.

- **Lower emissions by offsetting thermal generation with zero emissions generation**

  The benefit in emissions reductions is achieved by enabling renewable generation to displace thermal generation. AusNet quantified the benefits from reductions in carbon emissions using the cost of carbon as given in the draft guidance published by the AER[6].

- **Maintaining network reliability at lower cost**

  The additional thermal capacity and redundancy provided by sub-transmission network augmentations such as additional/upgraded 66kV lines, transformers and other components will assist in ensuring that we maintain network reliability in accordance with our customers' expectations. Furthermore, the additional network capacity created would benefit load customers through future electrification requirements such as adaptation of EVs, replacement of gas appliances with electric appliances etc.

From the four proposed projects, our program can unlock 950 MW of renewables which will lead to wholesale market price reductions and reduced emissions by 2.7 Mt CO_2.

[6] Valuing emissions reduction AER guidance and explanatory statement – May 2024

4. Market modelling approach

The purpose of this section is to explain our modelling approach, which is focused on identifying network augmentations that will facilitate large renewable generation in our sub-transmission network which are expected to deliver a net benefit to our customers.

The remainder of this section is structured as follows:

- Section 4.1 explains the concept of hosting capacity, including how it is assessed and its impact on the economic viability of prospective generators.
- Section 4.2 provides an overview of our modelling approach, concluding with a reminder that investment must deliver benefits to consumers in order to be included in this Large Renewable Enablement Program.
- Section 4.3 highlights key aspect of the energy market modelling, which is an important component of the cost-benefit analysis.

4.1. Hosting capacity

Hosting capacity refers to the amount of new generation in a specific location in the electricity sub-transmission system. Locations may be existing zone substations or new connection points established on existing sub-transmission lines. In most cases a new line will be required between the existing connection point and the generation asset.

At terminal stations in Victoria, high voltage transmission at 220 kV is transformed down to 66kV for sub-transmission, or 22kV for distribution. The transmission capability declines with the voltage level. Broadly speaking, 220 kV transmission lines are typically capable of transmitting approximately 600 MW of load or generation, which reduces to approximately around 100 MW for 66 kV sub-transmission lines.

Historical design choices sometimes lead to 66kV sub-transmission assets having much lower transmission capacity, such as transformers capable of transmitting a maximum of 75 MW or sub-transmission lines that transmit a maximum as low as 40 MW. Assets were also designed to transmit energy in one direction: energy was expected to arrive at the terminal station from the 220kV network, transformed down to 66kV, and transmitted to zone substations at load centres. When new generation is connected downstream of the terminal station, energy flows can be reversed. Transmission lines are agnostic to forward or reverse flow, but transformers can be optimised for one direction over another and as a result the reverse-flow capacity of transformers can be lower than their forward-flow capacity.

Moreover, reverse power flows associated with substantial renewable generation output may result in significantly increased variability of transformer loadings, increased transformer utilisation, and reduced time for transformers to cool down between periods of high loading in either direction. In these circumstances, existing cyclic ratings may no longer apply to these transformers because they no longer exhibit a predictable cyclic loading pattern. Instead, it may be necessary to adopt the transformer's name plate rating (rather than the higher cyclic rating) for planning and operational purposes.

For generation connected to sub-transmission assets at 66 kV, limitations at the 220 kV side of terminal stations and the 220 kV, 330 kV or 500 kV networks do not typically introduce constraints, due to their much higher carrying capacity. However, 66kV-connected generation will be constrained by the reverse-flow capacity of 220/66kV transformers at the terminal station, or the capacity of 66 kV lines that carry energy from the generator to the terminal station.

Assessments of the hosting capacity of 66 kV assets can be made by measuring the summer and winter rating of sub-transmission lines and transformers between the new generator and the 220 kV side of the terminal station. For example: a generator is connected to a 105 MVA sub-transmission line operating at 66 kV. That transmission line connects to the 220 kV transmission system via two 150 MVA transformers. The hosting capacity of the connection point is the minimum rating of the two intervening assets, which is 105 MW.

In practice, hosting capacity is not a measure of whether a generator will be constrained by transmission limitations, but how often and how much. A generator that has its output reduced (curtailed) due to a transmission constraint for one hour per year will still be a viable option. A generator that is curtailed due to transmission constraint for one thousand hours per year may not be a viable option. It may still be a viable option if the amount of constraint is only a small portion of the generator's total capacity – it may be acceptable, for example, for a 100 MW generator to be constrained to 99 MW for one thousand hours per year, but not if that generator is constrained to 90MW for one thousand hours per year.

Hosting capacity, particularly for renewable generators which are not subject to fuel costs, is a question of energy (MWh) even though capacity values – particularly for the transmission assets they are connected to – are usually expressed in terms of power (MW).

Our Large Renewable Enablement Program also assesses communication capability, as this capability, in addition to increasing network capacity, is essential to enable generation. To maximise the net economic benefit arising from our communications expenditure, we have focused on the specific communications requirements for each identified project. By taking a project-specific approach, we are able to target investment in communications capability in a way that maximises net benefits to our customers.

4.2. Overview of market modelling

This section provides an overview of our market modelling approach in assessing the potential benefits of network augmentations to facilitate an increase in renewable generation in our sub-transmission network. As a general observation, market models provide a comprehensive assessment of hosting capacity by calculating the instantaneous (power) dispatch of generation over thousands of dispatch intervals, subject to thousands of variations in external factors such as demand and availability of the renewable wind or solar resource. Market modelling also enables us to examine the impact on the total cost of meeting customers' energy needs if increased renewable generation capacity is facilitated through network augmentation.

Market models produce three key values for assessing net benefits:

- savings in total generation costs when new low-cost generation is introduced
- curtailment of new low-cost generation
- savings in total generation costs when a sub-transmission augmentation is introduced to reduce curtailment.

To determine whether new generation in a specific location is beneficial to electricity consumers as a whole, compared to the case without new generation:

- the sum of capital expenditure for the new generation and NEM-wide generation operating costs must be lower
- curtailment of existing and new generation must be within bounds that are reasonably acceptable for generation proponents
- the capital cost of network augmentation must be lower than the savings developed by introducing the new generation.

Adhering to these three determinants leads to a future generation and sub-transmission mix that reduces total costs to consumers. AusNet undertakes market modelling to assess hosting capacity of 66kV-connected locations for new wind and solar generation, with and without 66kV augmentation. The assessment is performed using time-sequential modelling that takes account of:

- Projected changes in demand, with specific components that track potential growth in rooftop solar systems, electric vehicle penetration and charging habits, domestic and commercial battery installations, demand-side participation, and virtual power plant schemes utilizing aggregated batteries and vehicle-to-grid technologies.
- Addition of new transmission-connected generators and retirement of existing ageing generators according to AEMO's latest-available Integrated System Plan (ISP) projections.
- Addition of new interconnector projects according to AEMO's ISP projections.
- Projected changes in fuel costs for coal and gas-fired generators.
- Projected changes in fixed and variable generator operating costs, maintenance cycles and unplanned outages.
- National Electricity Market Dispatch Engine (NEMDE) constraint equations for regions outside Victoria.
- NEMDE constraint equations for electricity system stability in Victoria.
- Secure thermal operation under N-1 contingency conditions within Victoria, with reference to future changes in power flow.
- Multiple macroeconomic growth scenarios according to AEMO's latest-available Input Assumptions and Scenarios Report (IASR).
- Federal and State-based targets for renewable energy and emissions reduction.

Modelling is performed using hourly time intervals over multiple years to develop a long-term view that aligns with the operational lifetime of generation and transmission assets.

To assess hosting capacity, new wind or solar generation is added in 50 MW increments to an existing 66kV connection point (zone substation) in AusNet's distribution network. A new dispatch solution is developed for each case. Higher curtailment due to network constraints will occur as more generation is added. The economic case for network augmentation to relieve the constraint depends on the costs and benefits of that investment, where the benefits are the reduced energy costs as a result of lower curtailment.

As described in section 3, customer benefits may include:

- lower energy costs for consumers
- contributing to the achievement of emission reduction targets
- maintaining network reliability at a lower cost.

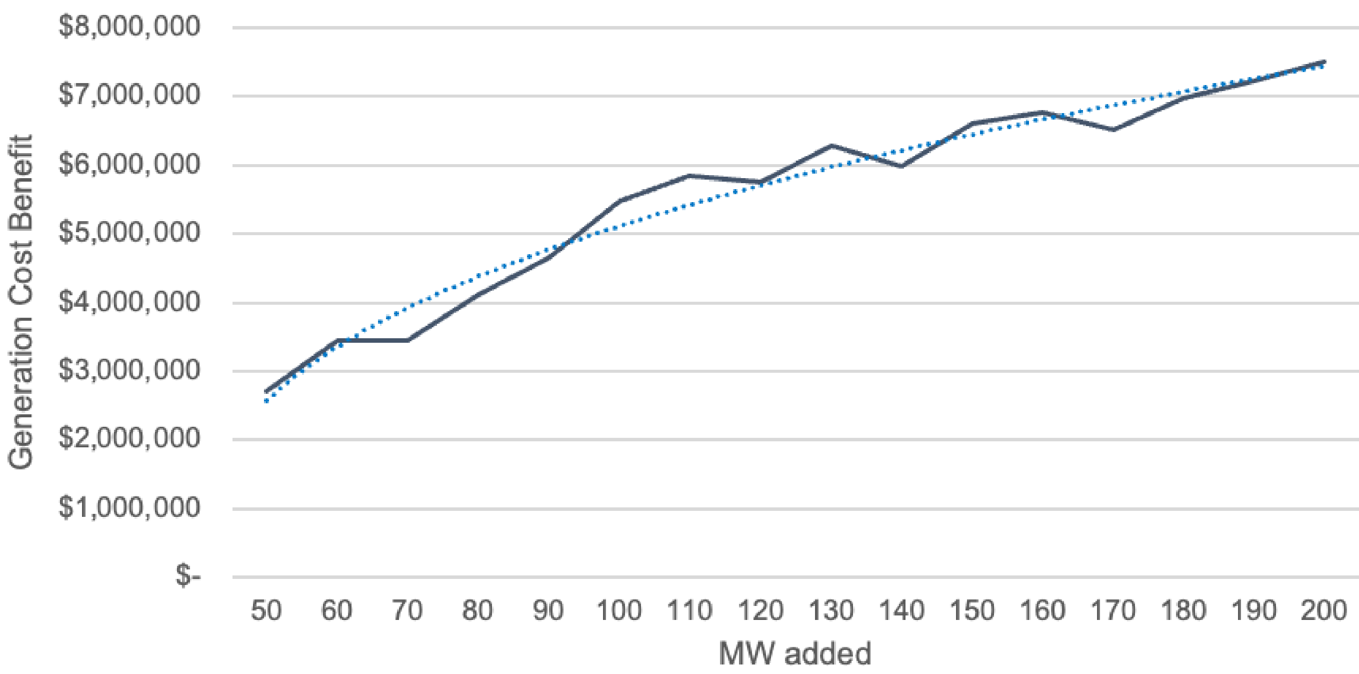
Network augmentation will only be included in this Large Renewable Enablement Program if customers are expected to obtain a net benefit from that investment.

4.3. Illustrative example of energy market analysis

This section provides an illustrative example of the market modelling analysis that is a key input to the cost-benefit analysis. As already noted, the purpose of the cost-benefit analysis is to assess whether increasing large renewable generation in our sub-transmission network may reduce energy costs for our distribution customers.

4 shows the change in generation cost in an example case, where new solar generation is added at the end of a low capacity 66kV line. This example shows that the new entry solar generation reduces total energy costs, but as larger amounts are installed, smaller benefits accrue for every additional megawatt.

Figure 4: Benefits accrued by reduction in total generation cost by MW of new entry solar generation installed



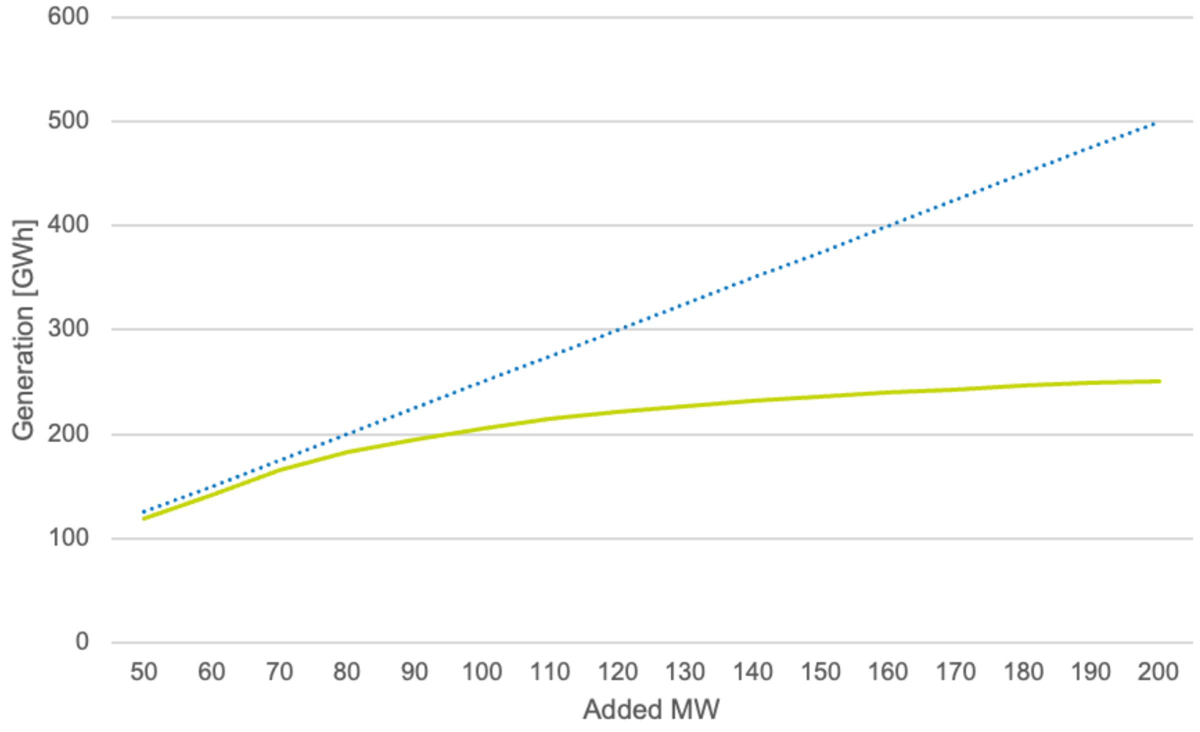
Source: AusNet

Figure 5 below shows how the output of the new entry generation changes (yellow line), compared to the hypothetical case where there are no network constraints (dotted blue line). This shows that the two lines diverge at approximately 70MW, indicating that network augmentation may be attractive above this value.

Figure 6 shows how generation changes across the NEM in response to the addition of 140MW of new entry solar generation as a result of network augmentation. Solar generation exhibits very low variable costs, which means that every unit of solar energy that enters the transmission system will displace generation elsewhere in the NEM. The nature of the displaced generation will determine the value of increased solar generation. For example, gas generation incurs high fuel costs, whereas wind generation, like solar generation, has very low variable operating cost. Therefore, if the new entry solar generation displaces gas generation, the value accrued will be high. If it displaces wind generation, the value accrued will be low.

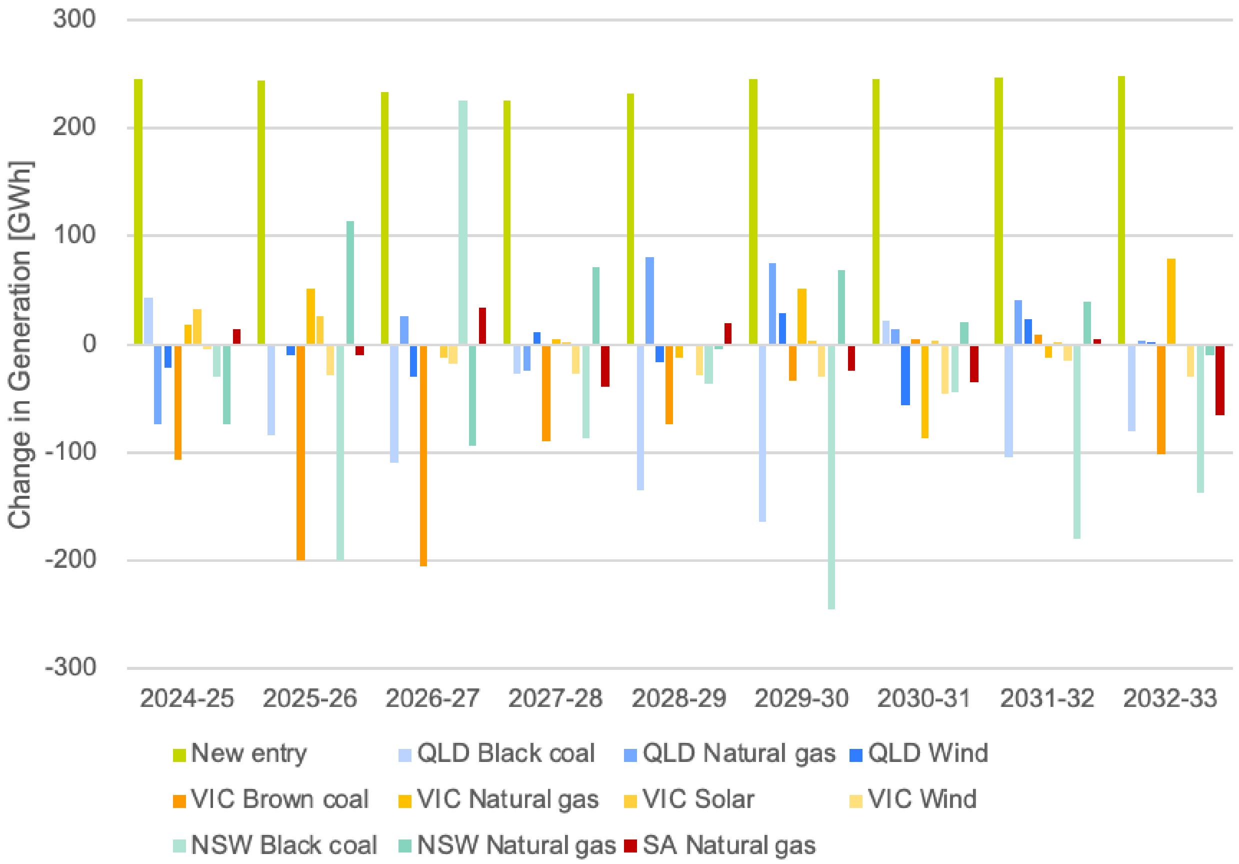
Simulations studies are undertaken to determine the expected value of the different forms of generation that are displaced by the entry of new solar generation. Where the avoided cost of the energy displaced by the new renewable source exceeds the cost of the augmentation required to accommodate that new source, our modelling indicates that augmentation provides a net benefit and is therefore economically justified.

Figure 5: New entry generation output without network augmentation



Source: AusNet

Figure 6: Change in generation in response to 140MW of new entry solar generation



Source: AusNet

5. Proposed investments

This section sets out the proposed network augmentations that are included in the Large Renewable Enablement Program for the 2026-31 EDPR. We have commenced the regulatory investment test process for each of these projects and we expect the cost-benefit analysis to show that customers will benefit from the proposed expenditure. The four projects are:

- Wodonga – Barnawartha in North-Eastern Victoria
- Morwell East Area – stages 1 and 2
- Morwell South area.

We discuss each in turn below. We conclude this section with our forecast capital expenditure for the Large Renewable Enablement Program, noting that this program will continue in future regulatory periods given the on-going drivers for increased renewable generation capacity connecting to the sub-transmission network.

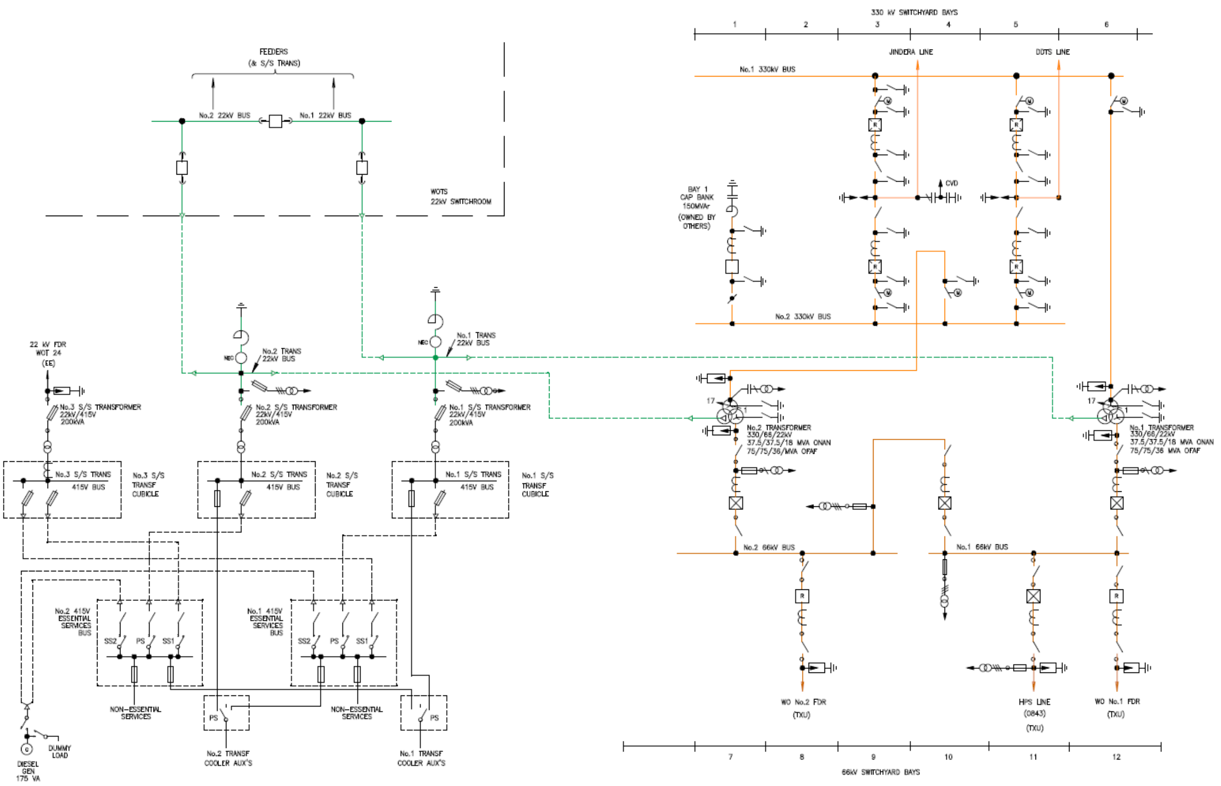
5.1. Wodonga – Barnawartha in North-Eastern Victoria

Wodonga Terminal Station (WOTS) is the main source of supply for a significant part of north-eastern Victoria. The supply is via two 330/66/22 kV three-winding transformers with a nominal rating of 75 MVA each. These transformers are unique and due to the condition of the transformers, AusNet purchased a spare transformer with the same voltage ratio and capacity recently. This spare transformer is now stored at the WOTS as a cold spare (not energised or connected to the network).

AusNet is responsible for planning the transmission connection facilities and distribution network for this region.

WOTS consists of three switchyards operating at voltages of 330 kV, 66 kV and 22 kV as shown below. The 330 kV switchyard interconnects a transmission line from Dederang Terminal Station (DDTS) and a transmission line from Jindera Substation in New South Wales.

Figure 7: Network diagram showing Wodonga and Dederang Terminal Stations



Most of the time, total station demand (66 kV and 22 kV demand) at WOTS is below the N-1 station summer rating of 81 MVA. The maximum demand on the station reached 107.4 MVA in summer 2008/09. Since then, maximum demand has declined slowly each year before recently flattening. The recorded maximum demand in summer 2022/23 was 80.6 MW (81.9 MVA).

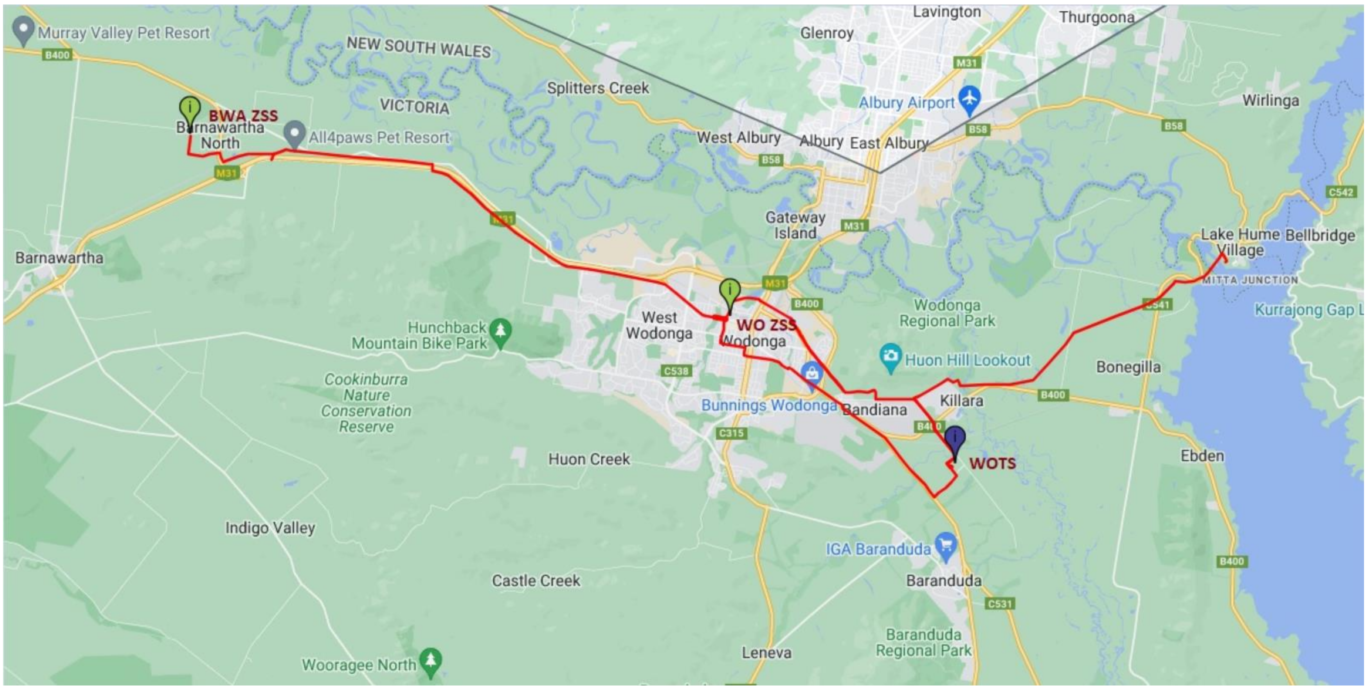
A total of 115.3 MW of embedded generation capacity is installed on the AusNet sub-transmission and distribution systems connected to WOTS. It consists of:

- 60 MW of large-scale embedded generation
- 55.3 MW of rooftop solar PV, including all the residential and small-scale commercial rooftop PV systems that are smaller than 1 MW.

Hume Power Station (HPS) is connected to the WOTS 66 kV bus 1 via a 66 kV line from HPS. HPS generation can also be connected to the TransGrid 132 kV network in New South Wales. The nameplate capacity of the HPS is 58 MW.

WOTS supplies Wodonga as well as the area from Rutherglen in the west to Corryong in the east. Wodonga zone substation (WO ZSS) is connected to the WOTS via two 66 kV feeders connected to 66 kV bus 1 and 2 of WOTS for improved reliability.

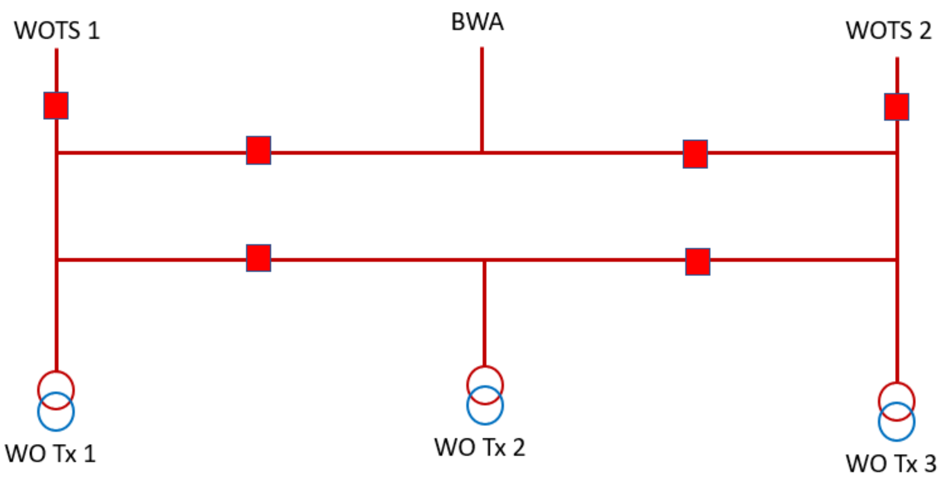
Figure 8: Map showing the Wodonga - Barnawartha sub-transmission network



As shown in the map above, the Barnawartha zone substation (BWA ZSS) is connected to WO ZSS 66 kV bus via a single 66 kV feeder (66 kV feeders are shown in red lines). The length of this feeder is 16.6 km.

The following diagram shows the 66 kV bus connection arrangement of WO ZSS with the 66 kV feeder connection to BWA ZSS (red boxes demonstrate 66 kV circuit breakers). The three WO ZSS transformers are 66/22 kV transformers.

Figure 9: Wodonga - Barnawartha sub-transmission network



As noted above, there is already 60 MW of large-scale embedded generation connected to WOTS. AusNet has received a number of enquiries for a total of 390 MW of renewable generation to WOTS sub-transmission (66 kV) system. Of this, 370 MW is to connect into BWA ZSS and another 10 MW to WO – BWA 66 kV feeder.

The WO – BWA 66 kV feeder was originally planned to supply the small rural load connected to BWA ZSS. The summer rating of the existing line is limited to 64 MVA and the existing line cannot accommodate this additional generation. Further, WOTS would experience a significant reverse power flow with this proposed generation and the existing two transformers are not capable of handling this reverse power flow.

Through preliminary studies AusNet has found that only a portion of this proposed generation can be accommodated by the existing assets, and the output of the connected generation would have to be curtailed during peak generation due to the existing network constraints. The Large Renewable Enablement Program will, therefore, address the identified need in accordance with the regulatory investment test, which is to address the existing constraints on the sub-transmission and distribution network in north-eastern Victoria (Wodonga - Barnawartha area) to enable more renewable generation to connect to this part of AusNet's network.

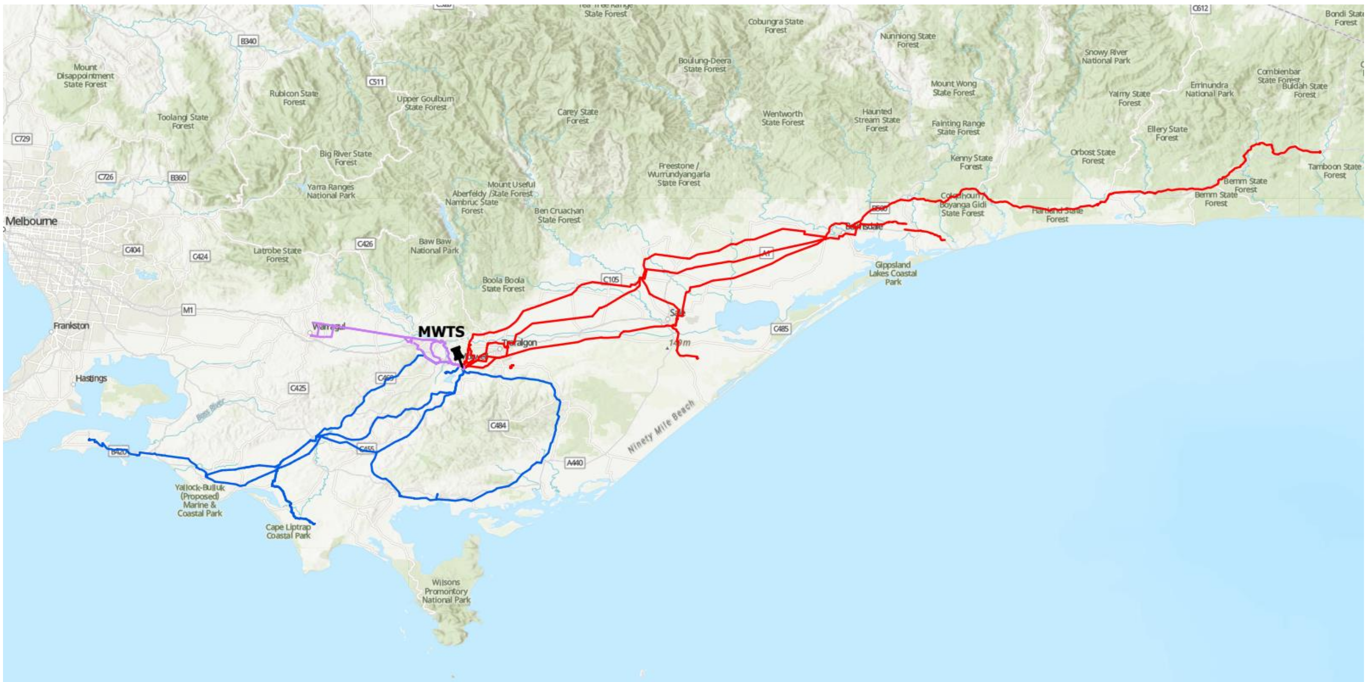
The commissioning of the third transformer at WOTS would be a transmission augmentation project whereas augmenting the sub transmission network would be a distribution project. As per the NER 5.10.2 RIT-T Project (b)(1), a RIT-T was initiated to address network augmentation needs of both transmission and distribution networks for this project. Note that only the sub transmission augmentation capex component would be included in this program as commissioning of the WOTS third transformer would be a transmission augmentation project.

5.2. Morwell East Area – Stages 1 and 2

Morwell Terminal Station (MWTS) 66 kV is the main source of supply for a major part of south-eastern Victoria including Gippsland. AusNet is responsible for planning the transmission connection and distribution network for this region.

MWTS 66 kV is supplied by two 150 MVA 220/66 kV transformers and one 165 MVA 220/66 kV transformer. Maximum demand at MWTS 66 kV typically occurs in summer. The station recorded a maximum demand of 452 MW (464 MVA) in early January 2013. The maximum demand on the station reached 422.3 MW (425 MVA) in winter 2022. The maximum demand period is usually quite short and coincides with a few weeks of peak tourism from Christmas to early January along the east coast of Victoria – however driven by unusually cool 2022/2023 summer conditions the maximum demand occurred in winter 2022. The maximum demand at MWTS 66 kV is forecast to increase over the ten-year planning horizon.

Figure 10: Map showing Morwell Terminal Station and the Morwell sub-transmission network



Morwell East network (shown in red) supplies Omeo in the north and Bairnsdale and Mallacoota in the east. Morwell South (shown in blue) supplies Phillip Island, Wonthaggi and Leongatha.

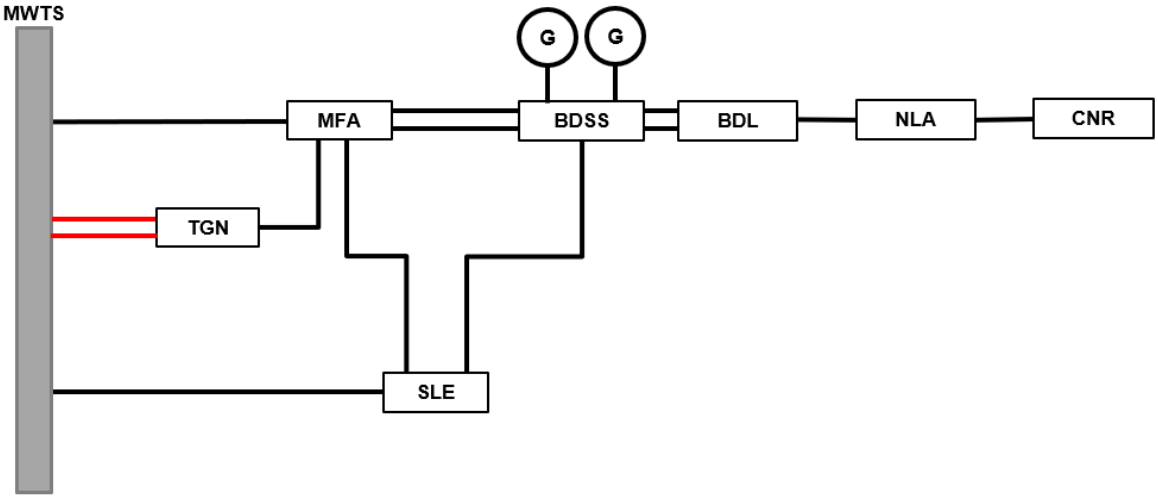
A total of 523.7 MW of embedded generation capacity is installed on the AusNet sub-transmission and distribution networks connected to MWTS[7]. It consists of:

- 277.4 MW of large-scale embedded generation
- 246.3 MW of rooftop solar PV, including all the residential and small-scale commercial rooftop PV systems that are smaller than 1 MW.

Of this generation connected to MWTS, Morwell East network has 123.1 MW of large-scale connected generation. AusNet has received enquiries for a total of 1360 MW of renewable generation to Morwell East sub-transmission (66 kV) system, including a 77 MW solar farm which is at the committed stage between MWTS - MFA and an 80 MW solar farm in advanced stage between MWTS – SLE.[8]

The East Gippsland 66 kV network, which emanates from Morwell Terminal Station (MWTS), supplies over 71,200 customers via six AusNet zone substations, including Traralgon (TGN), Sale (SLE), Maffra (MFA), Bairnsdale (BDL), Newmerella (NLA) and Cann River (CNR)[9]. The following diagram sourced from the Distribution Annual Planning Report (DAPR) – 2024-2028 shows the Morwell East sub-transmission network (constrained line segments under single order contingency are coloured in red). This is stage 1 of the proposed augmentation at Morwell East.

Figure 11: Morwell East sub-transmission network – Stage 1



As shown above, two 66 kV lines between MWTS and TGN are vital as a significant portion of the Morwell East is connected to MWTS through these two lines along with MWTS-MFA and MWTS-SLE lines. The MWTS-TGN No.1 line has a lower summer rating (39.44 MVA) constraining the No.2 line (with summer rating 91.45 MVA) operating in parallel. It is evident that the constraint of this portion is a major bottleneck for connecting new generation to the Morwell East network. The summer ratings of MWTS-MFA and MWTS-SLE lines are 73.73 MVA and 90.31 MVA respectively.

Through preliminary studies AusNet found that only a portion of the proposed generation could be accommodated by the existing assets, and the output of the connected generation would have to be curtailed during peak generation due to the existing constraints of the network. The Large Renewable Enablement Program will, therefore, address the identified need in accordance with the regulatory investment test, which is to address the constraints between MWTS - TGN sub-transmission section (approximately 19 km) to enable more renewable generation in AusNet's sub-transmission and distribution network in Morwell East network.

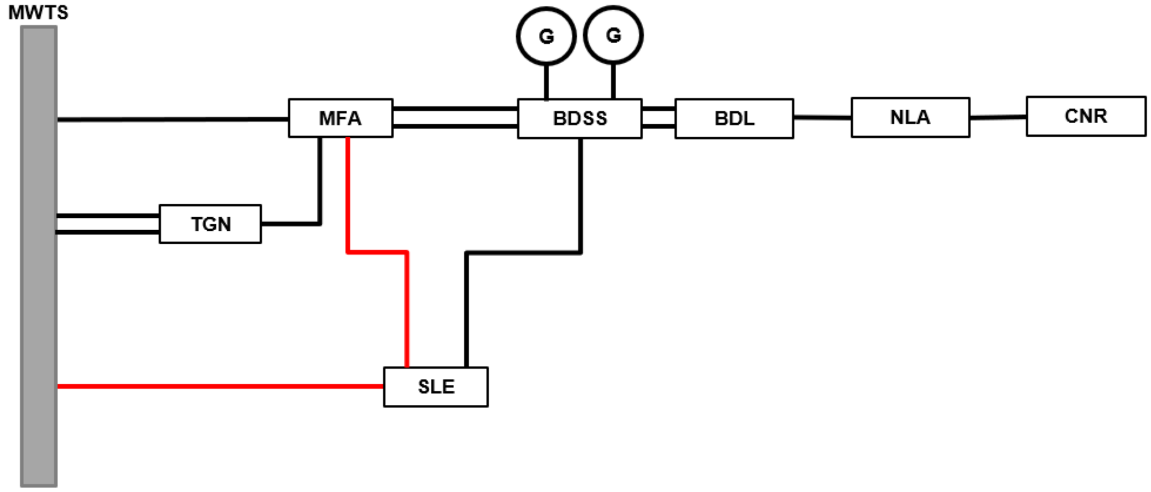
The MWTS East Stage 2 plans are to augment SLE-MFA section to accommodate more renewable generation at SLE. At present the summer rating of this line is limited to 49.73 MVA and the line length is 19.6 kms. We are investigating the following network options to augment this section of the line:

- augment existing line with 19/4.75 (increasing the summer rating to 105 MVA)
- augment existing line with 37/3.75 (increasing the summer rating to 118 MVA)
- add a new 19/4.75 line in parallel to the existing (increasing the summer rating to 99 MVA).

We are also considering the possibility of further improving the capacity of the MWTS-MFA and MWTS-SLE sections by removing bottlenecks. Any additional expenditure that is warranted to further improve the line capacity will be included in the stage 2 works. The figure below shows the planned augmentation for MWTS East Stage 2, noting that this is a separate project which will be progressed through its own RIT process.

[7] 2023 Transmission Connection Planning Report (TCPR)
[8] Latest information is available at Subtransmission Ratings and Connections dashboard
[9] AusNet Distribution Annual Planning Report (DAPR) – 2024-2028

Figure 12: Morwell East sub-transmission network – Stage 2



5.3. Morwell South area

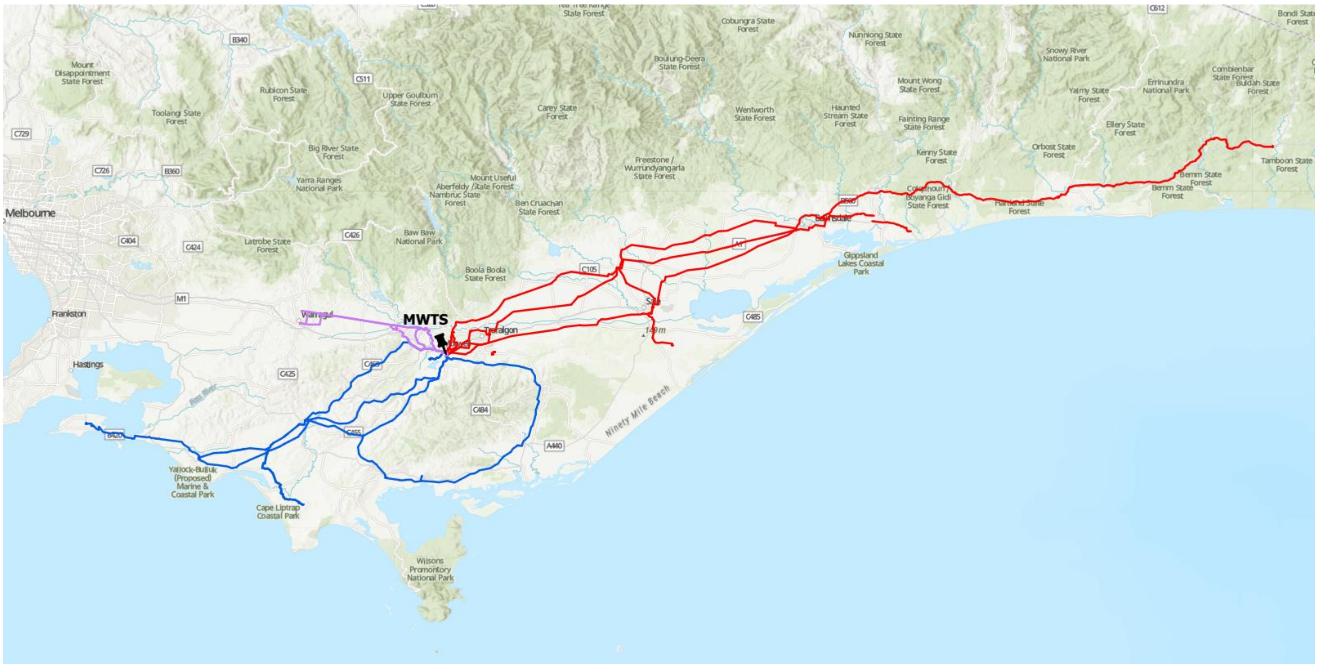
As already noted, Morwell Terminal Station (MWTS) 66 kV is the main source of supply for a major part of south-eastern Victoria including Gippsland. A total of 523.7 MW of embedded generation capacity is installed on the AusNet sub-transmission and distribution networks connected to MWTS[10]. It consists of:

- 277.4 MW of large-scale embedded generation
- 246.3 MW of rooftop solar PV, including all the residential and small-scale commercial rooftop PV systems that are smaller than 1 MW.

Of this generation connected to MWTS, Morwell South network has 141.36 MW (more than half) of the large-scale connected generation. In addition, AusNet has received another 860 MW of large-scale generation enquiries to connect to the Morwell South network[11].

Morwell South (in blue colour) supplies Phillip Island, Wonthaggi and Leongatha as shown below. Morwell East network (in red colour) supplies Omeo in the north and Bairnsdale and Mallacoota in the east.

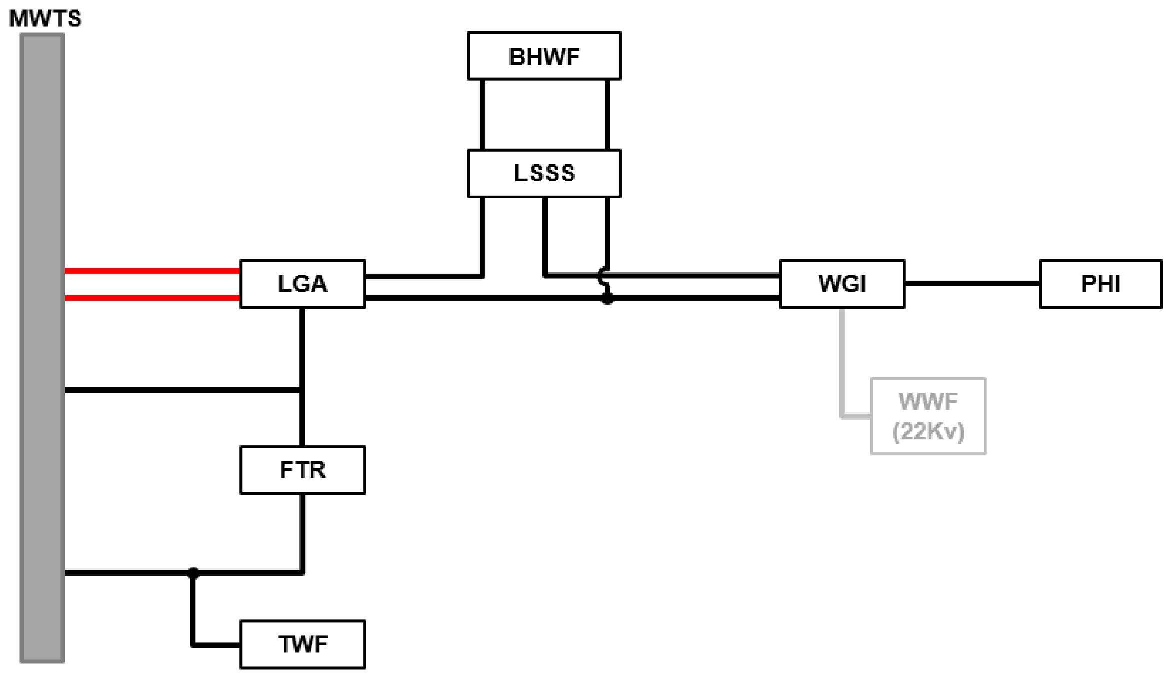
Figure 13: Map showing Morwell Terminal Station and the Morwell sub-transmission network



[10] 2023 Transmission Connection Planning Report (TCPR)
[11] UpToDate information is available at External dashboard

The Morwell Terminal Station (MWTS) to Leongatha (LGA) to Foster (FTR) to Wonthaggi (WGI) to Phillip Island (PHI) 66 kV network supplies over 54,700 customers via the four zone substations at Leongatha, Foster, Wonthaggi and Phillip Island[12]. The following diagram sourced from the Distribution Annual Planning Report (DAPR) – 2024-2028 shows the Morwell South sub-transmission network (note that MWTS-LGA No.2 line is marked in red due to summer load constraint with the line above this being the No.3 line).

Figure 14: Morwell South sub-transmission network



As shown above a significant portion of the Morwell South (LGA, WGI, PHI substations, Bold Hills wind farm, Wonthaggi Wind farm etc) is connected to MWTS through two 66 kV lines between MWTS and LGA. One of these lines (No.2 line) has a lower summer rating (39.44 MVA) constraining the other line (No.3 line with summer rating 64.59 MVA) operating in parallel. It is evident that this configuration is a major constraint to connecting new generation to the Morwell South network.

Through preliminary studies AusNet has found that only a portion of the proposed generation could be connected by the existing assets, and the output of the connected generation would have to be curtailed during peak generation due to the existing constraints of the network. The Large Renewable Enablement Program will, therefore, address the identified need in accordance with the regulatory investment test, which is to address the sub-transmission constraints between MWTS - LGA zone substation (approximately 59 km) to enable more renewable generation to connect to AusNet's sub-transmission and distribution network in Morwell South network.

5.4. Forecast expenditure and net economic benefits

At this stage, each of the projects that comprise the Large Renewable Enablement Program will be subject to a cost-benefit assessment in accordance with the regulatory investment test, which will include the modelling approach described in section 4. As explained in section 3, our approach is to ensure that projects only proceed if it can be shown that our customers will be net beneficiaries of the proposed expenditure. In broad terms, this means that the total costs of meeting customers' energy needs will be demonstrably lower with the proposed augmentation of the sub-transmission network compared to the 'without' case.

While the preferred options to address the identified need for each project will be subject to further extensive analysis and stakeholder consultation through the regulatory investment test process, it is useful for the purpose of this Large Renewable Enablement Program to set out our forecast capital expenditure and estimated net economic benefits for each project.

[12] AusNet Distribution Annual Planning Report (DAPR) – 2024-2028

Table 4 below shows:

- our estimated total costs for each of the four identified projects, and capital expenditure already incurred in the current regulatory period, expressed in present value terms
- our estimated total gross benefit for each option, which is the sum of the estimated benefits as described in section 3, compared to the Business as Usual/Do nothing option:
  - market benefits that lower energy costs for consumers
  - emission reduction benefits by displacing thermal generation
  - maintaining network reliability at lower costs.

The net economic benefit is the total gross benefit minus the total cost, expressed in present value terms.

Table 4: Expected net economic benefits in present value terms ($M, real 2024)

	Total costs	Total gross benefits	Net economic benefit
Wodonga – Barnawartha	$38.88m	$99.7m	$60.8m
Morwell East – Stage 1	$5.38m	$98.72m	$93.34m
Morwell East – Stage 2	$11.24m	$63.02m	$51.78m
Morwell South	$70.71m	$120.59m	$49.79m
Total	$126.21m	$382.03m	$255.71m

Source: AusNet

The conclusion from the cost-benefit analysis shown above is that each project is expected to deliver significant net economic benefits compared to the 'Business as Usual/Do nothing' option.

Table 5 provides a summary of the forecast capital expenditure for each of the projects. The annual data shown here is expressed in nominal terms,and therefore differs from the total costs shown in Table , but is consistent with the information presented in the cost-benefit analysis above.

Table 5: Forecast capital expenditure for the Large Renewable Enablement Program ($M)

	2026-27	2027-28	2028-29	2029-30	2030-31	Total
Wodonga – Barnawartha	7.632	23.031				30.663
Morwell East – Stage 1	1.504					1.504
Morwell East – Stage 2	0.164	1,690	5,078	3,083	3,055	13,070
Morwell South	8.365	19.821	20.705	25.883	36.000	110.774
Total	17.665	44.542	25.783	28.966	39.055	156.011

Source: AusNet

It should be noted that some expenditure has already been incurred during the current regulatory period in relation to these projects. While we have included this expenditure in the cost-benefit analysis shown in Table , our forecast expenditure only shows the expenditure proposed in the forthcoming EDPR.

A. Appendix – Enquiry details

Table A1: Large – scale generation connection enquiry details – area wise (MW)

Area	Preliminary Enquiry	Detailed Enquiry	Feasibility Assessment	Connection Application	Delivery	Total in Progress
Morwell East	800	220	25	310	5	**1360**
Morwell South	760	100	-	-	-	**860**
Wodonga - Barnawartha	220	65	20	80	5	**390**
Cranbourne	495	-	10	-	-	**505**
East Rowville	20	10	5	5	-	**40**
Glenrowan and Mt. Beauty	350	50	35	5	110	**550**
Morwell West	20	60	-	-	5	**85**
Ringwood	-	3	2	-	-	**5**
South Morang	445	-	10	20	10	**485**
Templestowe	-	-	-	-	10	**10**
Thomastown	-	-	-	-	-	**-**
Total	**3115**	**508**	**107**	**420**	**145**	**4295**

Source: AusNet

Table A3: Large – scale generation connection enquiry details – technology wise (MW)

Technology	Preliminary Enquiry	Detailed Enquiry	Feasibility Assessment	Connection Application	Delivery	Total in Progress
Solar	1625	398	90	305	125	**2538**
Battery	890	100	5	50	5	**1050**
Hydrogen	40	-	-	-	-	**40**
Wind	325	-	-	-	-	**325**
Other	235	10	12	70	15	**342**
Total	**3115**	**508**	**107**	**420**	**145**	**4295**

Source: AusNet