Renewable Hydrogen Connections to the Tasmanian Electricity Network

TasNetworks
Delivering your power

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Introduction

As the world looks to decarbonise, renewable hydrogen is emerging as a significant energy source of the future. Australia's National Hydrogen Strategy identifies Tasmania as having very high potential for the production of renewable hydrogen and the *Tasmanian Renewable Hydrogen Action Plan* sets out the State Government's vision to capitalise on the State's many advantages and become a world-leader in large-scale renewable hydrogen production.

Both the National Hydrogen Strategy and Tasmanian Renewable Hydrogen Action Plan recognise the importance of developing hydrogen production hubs to leverage existing infrastructure and develop the industry. Tasmania has a number of sites that are well suited to large-scale hydrogen production, including the Bell Bay Advanced Manufacturing Zone (**BBAMZ**) in northern Tasmania.

The Tasmanian Office of the Coordinator-General is actively working with proponents interested in developing a renewable hydrogen industry in Tasmania to supply domestic end users as well as service export markets. The Office has released the *Tasmanian Renewable Hydrogen Prospectus* highlighting Tasmania's competitive advantages for renewable hydrogen production.

The purpose of this document is to provide proponents of renewable hydrogen production with comprehensive and consistent information about the Tasmanian power system and its ability to supply the loads involved with producing hydrogen.

With the network having the capability, depending on location, to supply both small-scale (below 10 MW) and large-scale (100+ MW) hydrogen production facilities, this document discusses the:

- benefits the Tasmanian electricity network can provide for renewable hydrogen producers;
- opportunities for larger hydrogen producers to not only take their energy supply from, but also provide system services to, the Tasmanian electricity network;
- network pricing guidelines applying to both the transmission and distribution networks; and
- attributes of the Tasmanian power system, in particular the supply of bulk electricity to the BBAMZ, and the system protection schemes which are vital to the stability of the power system.

Regardless of size, location or voltage, as the operator of both the State's transmission and distribution networks, TasNetworks is ready to connect and deliver power for the production of renewable hydrogen in Tasmania.

The Hydrogen opportunity in Tasmania

The emergence of a hydrogen economy is creating an opportunity for Tasmania to use its existing and future renewable energy generation assets, in conjunction with its abundant freshwater resources, to become a global competitor in large-scale green hydrogen production. Tasmania is in an enviable position to take advantage of the international momentum and economic opportunities linked to renewable hydrogen's potential as an energy store, energy carrier and a zero-emission replacement for fossil fuels.

Tasmania has high quality industrial precincts with access to deep-water ports, bulk transmission infrastructure, plentiful freshwater resources and the road and rail services needed for such developments. The State has a number of locations that are ideal for large-scale hydrogen production facilities involving loads of 100 MW or more, including the BBAMZ, the Burnie industrial precinct and other locations in North West Tasmania. For producers that don't need access to facilities like a deep-water port or Tasmania's rail network, there are many other locations around the State where the electricity network is capable of supporting hydrogen production facilities involving loads of 5-10 MW (or lower).

Large industrial loads, like those associated with the large-scale production of renewable hydrogen, potentially have the capacity to help stabilise the power system. This is already the case in Tasmania, where a number of major industrial users of electricity make an important contribution to the stability of the power system, and support the operation of the Basslink interconnector.

As well as being a storage mechanism for low emission energy sources like wind and solar, industrial scale hydrogen production facilities may also be able to provide network support and participate in various system protection schemes. However, not all hydrogen production processes have the same capacity to support the power system.

Choices about the hydrogen production technology deployed in Tasmania and its location should, therefore, take into account the effects on power system security and stability.

In reality, large industrial users of electricity in Tasmania are rarely called upon to provide demand responses and their involvement in system protection schemes represents a commercial opportunity for those businesses.

With extensive experience in the integration of renewable energy generation in Tasmania to draw on, TasNetworks' engineers and technicians are ready to provide tailored, confidential assistance to potential investors in large-scale renewable hydrogen production. By working together, we can ensure that the processes used in Tasmania to produce hydrogen have the correct performance characteristics to support the Tasmanian power system, to the benefit of both the producer and the State as a whole.

TasNetworks

TasNetworks is a State Government owned business that owns and operates Tasmania's electricity grid. While in other parts of the country the ownership of transmission and distribution networks is generally separated, in Tasmania TasNetworks provides both transmission and distribution network services. With total assets of over $3 billion, TasNetworks provides the electricity network that ensures our customers receive a safe, reliable and affordable electricity supply of renewable energy.

The Tasmanian power system has its origins in supplying bulk power to the new industries that began arriving in the State in the early 1900s, attracted by the availability of reliable, low cost electricity. TasNetworks, therefore, has a long history of supporting and supplying energy intensive major industry with renewable energy. TasNetworks' transmission network connects more than 30 hydro-electric power stations, five wind farms and one thermal (gas-fired) power station. We also provide network capability that supports the Basslink high-voltage direct current (**HVDC**) interconnector and we deliver high voltage electricity directly from the transmission network to ten large commercial and industrial users of electricity around Tasmania.

Our distribution network delivers electricity to some 290,000 households, businesses and organisations throughout Tasmania, including a number of large commercial/industrial enterprises taking power at high voltage. We operate a largely rural overhead distribution network, with underground cables generally restricted to central business districts and newer subdivisions and commercial centres in urban and suburban areas.

TasNetworks leverages this experience as a network operator to offer tailored transmission connection solutions to major energy projects

throughout the State. This includes designing, building and operating the transmission lines and other connection assets required to connect new projects to the grid, as well as other contestable connection services.

In addition, TasNetworks is currently progressing an investigation into another Bass Strait interconnector, involving a 1,500 megawatt capacity undersea and underground electricity connection (Project Marinus) linking North West Tasmania's renewable energy generation and storage resources to Victoria and the National Electricity Market (**NEM**).

We are aware that low costs are important for our commercial and industrial customers and support the State Government's goal of delivering the lowest possible power prices that are genuinely sustainable over the longer term. Like every electricity network business in the NEM, our revenue and prices are regulated by the Australian Energy Regulator (**AER**).

The Tasmanian power system

Tasmania's power system is ideally positioned to support renewable hydrogen production. Nearly all of the State's electricity is generated using a combination of hydro-electric generation and the island's world-class wind resources – which offer significantly higher capacity factors than wind farms located in other states. While wind farms on mainland Australia typically have average capacity factors of between 30 and 35 per cent, many areas of Tasmania offer average capacity factors of 40 to 45 per cent.

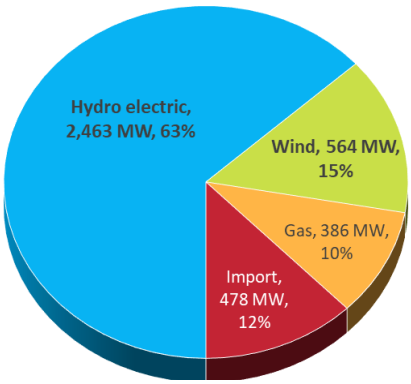
While other parts of Australia are seeing growth in the contribution made by renewable generation – particularly from wind and solar generation – the use of hydro-electric generation in Tasmania, with its ability to be switched on and off in response to variations in the output of variable renewable generation, is a key attribute of the State's renewable energy mix.

The charts on the following page provide breakdowns of the generation capacity[1] currently connected to the transmission network in Tasmania[2] (including Basslink's import capacity) and the contribution each source of generation made to towards meeting Tasmania's demand for electricity in 2019. It is anticipated that the proportion of electricity produced in Tasmania using wind generation will increase in the future as recently completed projects commence full commercial operation.

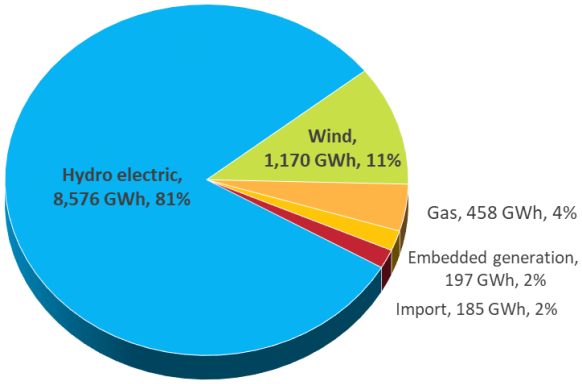
[1] Based on nameplate ratings

[2] The breakdown of Tasmania's on-island generation capacity excludes embedded generation in the distribution network, which is not directly modelled in transmission planning studies, but adds around 160 MW of solar generation capacity, based on figures obtained from the Australian Government's Clean Energy Regulator. The total generation capacity also reflects the ratings of several new wind farms which were not operational in 2019.

Figure 1 Tasmania's generation portfolio and outputs



Tasmania's generation mix



Generation output by type (2019)

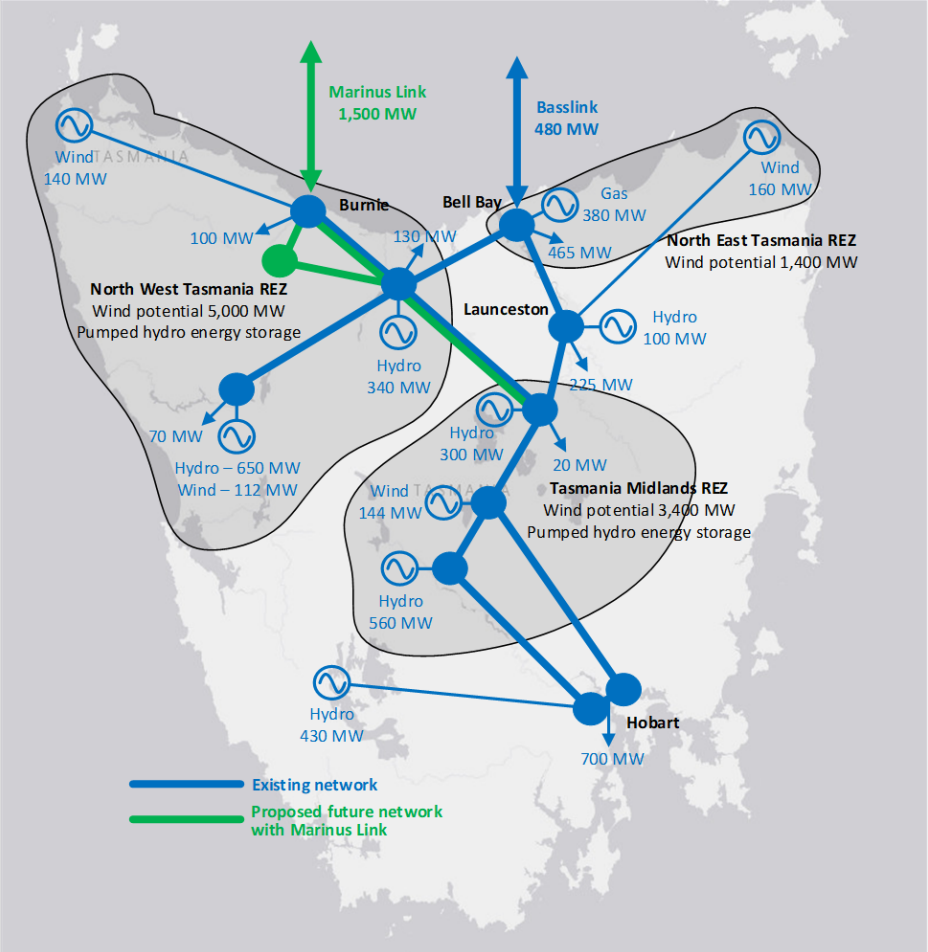
Details of the transmission connected and embedded generation sites in Tasmania can be found on the Australian Energy Market Operator (**AEMO**) generation information page[3].

Tasmania is already Australia's largest producer of renewable electricity, with 3,000 MW of installed renewable energy capacity and much more in the pipeline. The 2020 AEMO Integrated System Plan (**ISP**) has identified three Renewable Energy Zones (**REZ**s) in Tasmania with total potential additional renewable energy resources of just under 10,000 MW. The following illustration (Figure 2) shows the locations of the REZs identified in the ISP.

Pumped hydro storage developments are also under consideration as part of Hydro Tasmania's Battery of the Nation study, along with upgrades to a number of existing hydro-electric power stations that will lift their output. Together, the three most promising pumped hydro developments identified by Hydro Tasmania, in conjunction with proposed upgrades to existing power stations, have the potential to add an estimated 1,950 MW of capacity to Tasmania's renewable generation portfolio.

[3] AEMO generation information page, TAS, http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information

Figure 2 Tasmania's potential for additional renewable generation



Tasmania's transmission network

Tasmania has an islanded 50 Hz electrical power system connected to mainland Australia via a single monopolar High Voltage Direct Current (**HVDC**) submarine interconnector (**Basslink**), which is capable of importing 480 MW into Tasmania and exporting 500 MW to mainland Australia.

The backbone transmission network is made up of 220 kV infrastructure with some parallel 110 kV assets. Radial 110 kV networks are used to supply regional load centres. Tasmania's distribution network predominantly operates at 22 kV and 11 kV, with some 33 kV circuits.

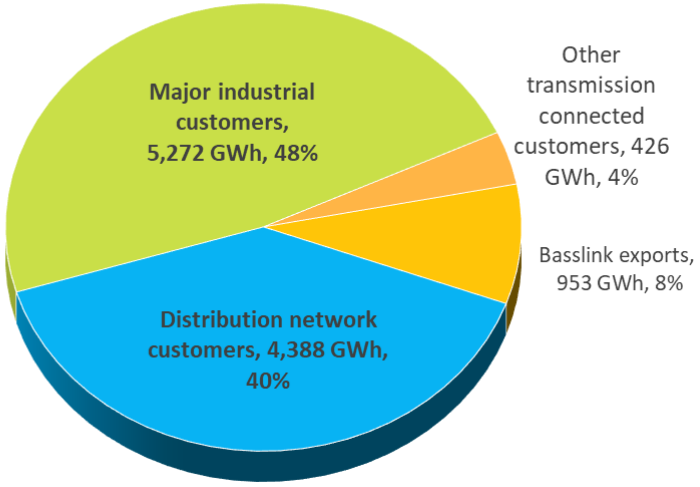
Appendix C of this document provides a diagram of the Tasmanian transmission network.

The maximum operational demand on the transmission network during 2019 to supply Tasmanian customers was 1,734 MW, with median demand of approximately 1,150 MW (over the past seven years). The total network maximum demand was 2,110 MW, which included the generation and power flows associated with Basslink. High demand periods in Tasmania occur during winter, driven principally by residential and commercial heating loads. Historically, minimum demand occurs overnight during summer and fell as low as 757 MW in 2019.

Electricity use in Tasmania

A large portion of the energy used in Tasmania is supplied to customers directly connected to the transmission network. In 2019 ten load customers directly connected to the transmission network, including four major industrial customers, collectively used approximately 52 per cent of the total energy that flowed through the transmission network and accounted for 33 per cent of total network maximum demand. This represents 55 per cent and 40 per cent, respectively, of on island energy use and demand. A breakdown of the energy supplied by Tasmania's transmission network in 2019 is presented in Figure 3 below.

Figure 3 Relative transmission network use in 2019



Supplying new load in the BBAMZ

The BBAMZ is supplied from TasNetworks' George Town Substation. George Town Substation is a major 220 kV transmission node in the Tasmanian network and provides connection to a number of industrial customers, as well as the Basslink HVDC interconnector. The Substation is supplied via four 220 kV circuits which connect to other transmission nodes located to the west and south. An overview of the existing connection arrangements is provided in Figure 4.

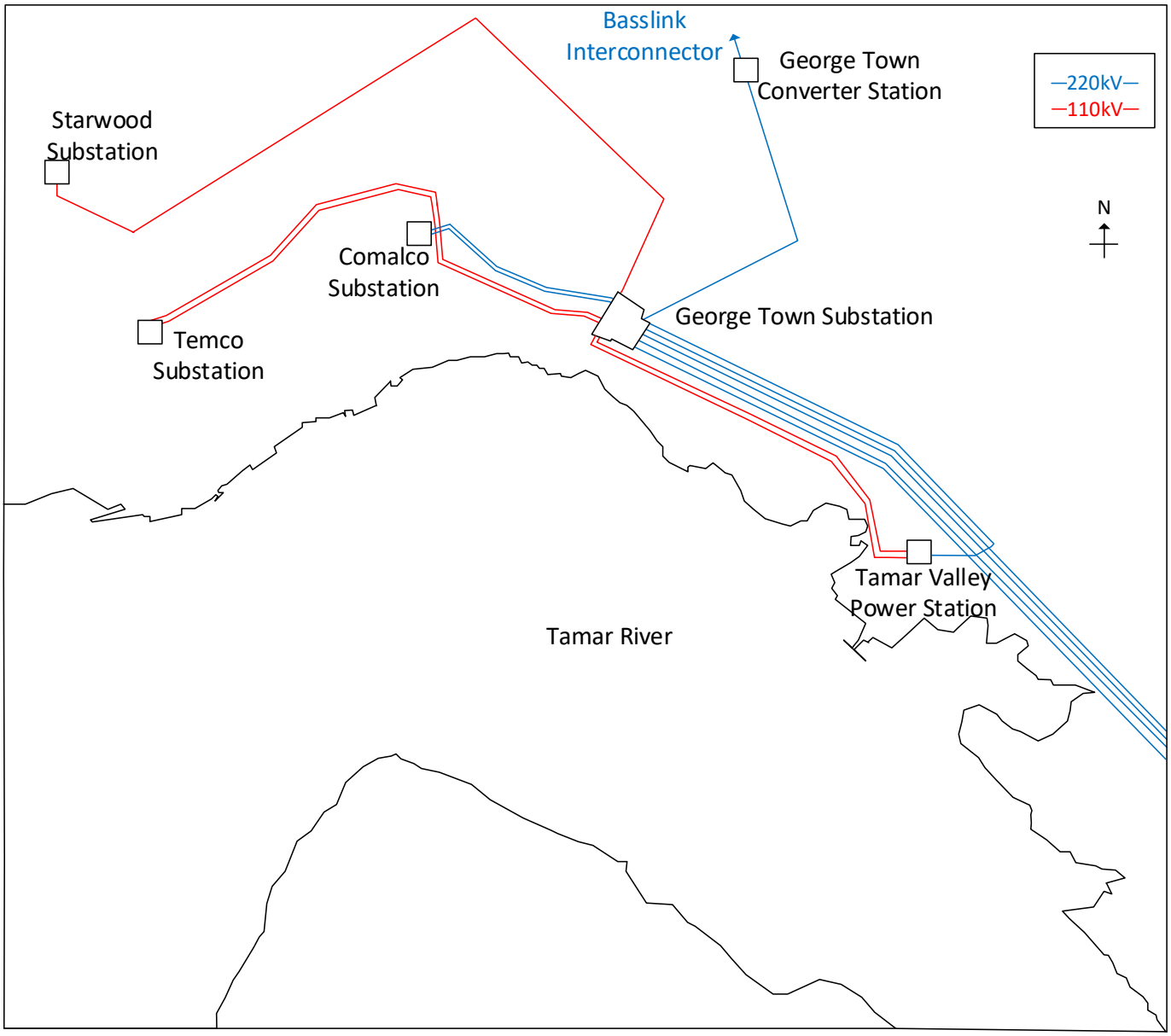
George Town Substation has the capacity to supply additional loads at 22 kV, 110 kV and 220 kV. Preliminary studies have indicated that a 300 MW load could be readily supplied within the BBAMZ at 220 kV, but would require dynamic reactive support to be installed as well as participation of the new load in relevant system protection schemes. Further studies are being undertaken to supply more than 300 MW of additional load in the BBAMZ.

Smaller loads within the BBAMZ could be connected to George Town Substation at 110 kV and 22 kV, depending on requirements.

Appendix A of this document provides an overview of a critical system protection scheme which is an important consideration for any industrial scale load development in the BBAMZ. Also discussed is how load flexibility and responsive loads can be used to support the network.

Appendix B provides additional technical details which will need to be considered by potential developers. The discussions provide information specific to George Town Substation and are intended to supplement the general technical requirements contained in Schedule 3 of the National Electricity Rules (**NER**) – Conditions for connection of customers.

Figure 4 George Town Substation and associated transmission network



System Performance

Transmission

Transmission network reliability is monitored and reported to the AER and the Office of the Tasmanian Energy Regulator (**OTTER**). Based on the historical performance of the network, the AER sets service targets in terms of the number of Loss of Supply (**LOS**) events that occur during a year, circuit outage rates, and the average LOS event duration.

LOS is measured in system minutes and is calculated by dividing the total energy (MWh) not supplied to customers during an event by the energy supplied during one minute at the time of historical Tasmanian maximum demand[4]. LOS events are split into two categories: major events (measuring > 1.0 system minute) and all events > 0.1 system minutes, including major events.

Table 5 lists the performance of Tasmania's transmission network over the past five years[5]. Performance measures are as defined by the AER in the Service Target Performance Incentive Scheme (**STPIS**), October 2015.

Continued investment in asset replacement on the Transmission network together with modern protection technology will enhance network performance.

Figure 5 Transmssion network reliability

Performance Measure	Limit	2015	2016	2017	2018	2019
Transmission network reliability performance						
Number of LOS events >0.1 system minute	10	3	1	4	2	2
Number of LOS events >1.0 system minute	3	0	1	1	0	1
Transmission circuit outage rate						
Transformer circuit fault outage rate (%)	31.17	19.60	28.30	8.45	15.9	18.79
Transmission circuit fault outage rate (%)	11.60	7.30	9.17	8.26	10.00	9.13

Distribution

Network reliability is the term that's used to describe the ability of a distribution network to deliver uninterrupted service to customers. The most common measures of network reliability are:

- System Average Interruption Frequency Index (**SAIFI**)
- System Average Interruption Duration Index (**SAIDI**)

SAIFI measures how often customers have experienced an outage while SAIDI measures the total duration of outages experienced for the year. Momentary power interruptions of less than one minute are not included in these measures, nor are Major Event Days (where the duration and scale of an outage exceeds an annually calculated threshold, generally as a result of intense storm activity across a wide area of the State). In line with industry practice, planned interruptions are also not included.

Under the distribution STPIS applying to TasNetworks, the AER sets overarching limits for the Tasmanian distribution network in terms of the frequency and duration of outages which are considered acceptable. OTTER has also set a series of scaled reliability standards which apply SAIDI and SAIFI limits to different Tasmanian communities based on the size of the customer base in each community, as well as customer and load density. This recognises that the costs of providing redundancy in rural areas of the network are generally high in relation to the loads likely to be affected by an outage.

[4] In Tasmania, an event of one system minute equates to about 31.2 MWh of unserved energy
[5] Performance reporting to the AER under STPIS can be viewed at https://www.aer.gov.au/networks-pipelines/compliance-reporting

The following table shows the performance of TasNetworks' distribution network in 2019-20 against the reliability standards set by OTTER for each of the five community categories used by OTTER to monitor network reliability.

Figure 6 Distribution network reliability

Supply reliability category	Annual frequency of supply interruptions (on average) (SAIFI)		Annual duration of supply interruption (on average) (SAIDI)	
	Limit	2019-20	Limit	2019-20
Critical infrastructure	0.2	0.25	30	26.62
High-density commercial	1	0.31	60	48.60
Urban and regional centres	2	1.28	120	148.71
High-density rural	4	2.56	480	322.97
Low-density rural	6	3.25	600	543.42

As can be seen in Figure 6, in 2019-20 TasNetworks' performance against the SAIFI standards (the frequency measure) was satisfactory for all classifications except Critical Infrastructure. For the duration of outages measure (SAIDI), the networks' performance was within the limits set by OTTER in all areas except in the Urban and Regional Centres category, which were heavily impacted by outages caused by environmental factors.

TasNetworks plans to improve network performance, with targeted asset replacement, improved network configurations, and greater remote control and monitoring.

Network pricing

As noted previously, TasNetworks provides both distribution network services and transmission network services in Tasmania. As the monopoly provider of these services, TasNetworks will be the network service provider for any hydrogen production facilities in the State, regardless of its size or location.

However, the approach to connections and the provision of network services differs between the two networks due to differences in the regulatory arrangements applying to each network (including ring-fencing requirements). Proponents of hydrogen production in Tasmania are, therefore, encouraged to contact TasNetworks to discuss their connection requirements and confirm the network to which they would connect.

The following information on the pricing of connection and network services is necessarily general in nature. More specific information, including network costs, can be provided by TasNetworks once it has been established which network a proposed hydrogen production facility would be connected to and the likely characteristics of its connection and load profile.

Transmission pricing

Transmission services are classified as one of three categories:

- Prescribed transmission services are monopoly services provided by a transmission network service provider (**TNSP**) where the revenue and standard of service are regulated through the National Electricity Rules (**the Rules**) by the AER. Typically, these services are provided by the TNSP's investment in the transmission network and associated infrastructure to get power from generators to load customers.

- Negotiated transmission services are also monopoly services provided by a TNSP but are for individual customers and the price and standard of service can be negotiated between the parties. These services are also regulated through the Rules. This category of service includes the physical connection to the transmission network.

- Non-regulated transmission services which are contestable and can be provided by the local TNSP or by other parties. This category of service includes the connection from the customer's site to the transmission network.

Importantly, transmission service charges relate to the connection and network services provided by a TNSP and do not include the cost of energy to be supplied through the network.

Prescribed transmission service pricing

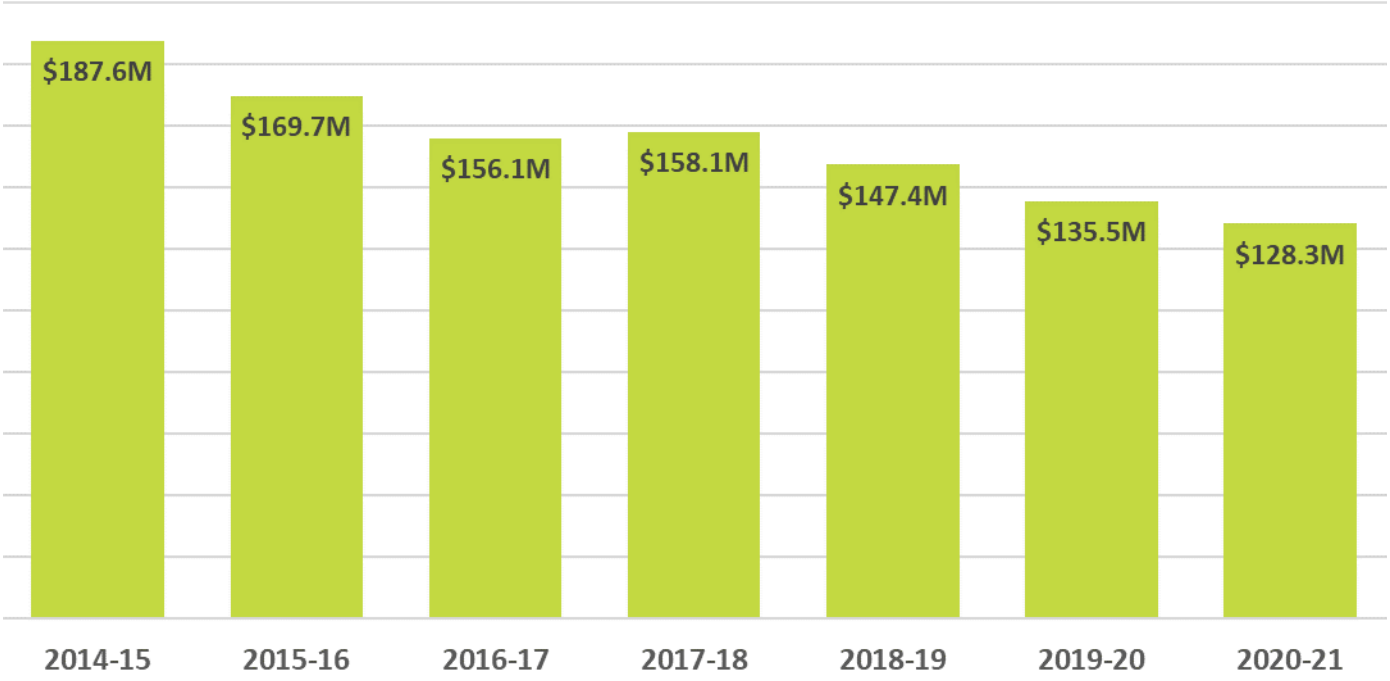
TasNetworks is a regulated business with most of our revenue set by the AER. For each year of a regulatory period (typically five years), the AER sets the maximum allowed revenue (**MAR**) for the (monopoly) prescribed transmission network services TasNetworks provides. TasNetworks prepares a Pricing Methodology that sets out how TasNetworks' revenue allowances are converted into prices, which must be approved by the AER as part of the five-yearly regulatory process. TasNetworks' Pricing Methodology does not relate to the provision of negotiated transmission services or the non-regulated transmission services provided by TasNetworks, such as connection services, which are not subject to economic regulation under the Rules.

Amongst other things, the actual connection charges to be faced by a hydrogen producer will depend on the configuration of their network connection, which is typically established as part of the connection process. The network costs faced by customers taking supply from the transmission network are also dependent on a number of factors that impact our revenue allowance, such as inflation rates, over or under-recoveries of TasNetworks' regulated revenue in preceding years, outcomes under regulatory incentive schemes like the STPIS, and the recovery of approved pass-through costs. An individual customer's share of TasNetworks' MAR is also affected by their contracted network capability, the number of other customers connected to the network, the aggregate contract capability and energy taken off the network by all connected customers, and the location and value of recent investment in the transmission network.

This complexity makes it difficult to publish accurate transmission network costs for prospective producers of hydrogen in Tasmania. Proponents of hydrogen production in Tasmania are, therefore, encouraged to make contact with TasNetworks to discuss their connection requirements and the likely characteristics of their load, in order that TasNetworks might provide a range of indicative network charges. All enquiries are dealt with commercially in confidence.

Figure 7 below shows that TasNetworks' aggregate prescribed transmission charges have been on a downward trajectory in recent years, which puts downward pressure on the delivered cost of energy for all

Figure 7 TasNetworks target transmission invoiced revenue ($nominal, million)



Negotiated transmission service pricing

As noted above, this is a monopoly service provided by TasNetworks and relates to the provision of a connection to the transmission network. Pricing for negotiated transmission services depend on a customer's connection requirements, which will be confirmed as part of the application phase of the connection process.

Charges are calculated based on the capital value and anticipated operations and maintenance (**O&M**) of the assets constructed to provide the connection to the transmission network. In addition to connection charges, transmission connected customers will also incur costs in relation to metering, communication systems and supervisory control and data acquisition (**SCADA**).

Negotiated transmission service charges are typically recovered under the terms of each customer's Connection Agreement with TasNetworks as an annual annuity payment which is indexed by inflation annually over an agreed contract term.

Non-regulated transmission service pricing

Similar to the approach for negotiated transmission services, the charges for non-regulated transmission services are typically calculated based on the capital value and anticipated O&M of the assets constructed to provide the connection. As there are a number of sites being considered by hydrogen proponents, an estimate of the non-regulated transmission charge has not been included. However, TasNetworks would be pleased to talk to proponents about their non-regulated connection requirements, considering their site, location and connection requirements.

The provision of non-regulated transmission services is contestable and TasNetworks is the leading service provider in Tasmania, with significant local experience in transmission asset construction.

Distribution pricing

A hydrogen production facility taking its supply of electricity from the distribution network will receive two types of service from TasNetworks – connection services and network services. As a result, the production facility will incur two types of charges: a one-off connection charge and ongoing network charges.

Distribution Connection Charge

The electricity rules establish a set of regulatory obligations governing the sale and supply of electricity to all customers that are connected to TasNetworks' distribution network. As a consequence, TasNetworks must:

- provide access to the distribution network to those parties that request new connections, which may:
  - involve extension and augmentation of the existing distribution network; and
  - require the party requesting the new connection to contribute towards the cost of making that connection.

Connection charges are payments made by persons intending to connect to TasNetworks' distribution network to:

- enable those persons to access network services under the standard suite of network tariffs;
- ensure, where appropriate, that costs for that particular connection are borne by the party requesting the connection, and not shared across the entire customer base;
- share the cost of works that have previously been funded by other customers; and
- reduce the likelihood of making uneconomic (inefficient) connections.

The amount of the charge for a new connection to the distribution network will depend on a number of factors and TasNetworks would be pleased to talk to prospective hydrogen producers about their connection requirements, considering their site and its proximity to the existing network.

More information about TasNetworks' approach to the charges for connecting to the distribution network can be found in our Distribution Connection Pricing Policy[6]. As part of the five-yearly regulatory approval process, this Policy has been reviewed by the AER and found to be compliant with the requisite regulatory obligations.

Distribution Network Charges

TasNetworks is a regulated business with the amount of revenue we are able to recover from our distribution network customers each year, and the prices we charge to recover that revenue, approved by the AER. Every five years the AER sets our revenue allowances in advance, and then approves each year the network prices we charge to recover that revenue in the following year.

Every year TasNetworks publishes a Network Tariff Application and Price Guide[7] that provides information for customers and retailers seeking to identify and understand the network tariff which is best suited to the circumstances of individual customers and the criteria for the application of those tariffs. The Guide sets out:

- the terms and conditions applying to the network tariffs used to recover the cost of the shared network from customers;
- the distribution use of system (**DUoS**) and transmission use of system (**TUoS**) charges, collectively referred to as Network Use of System (**NUoS**) charges, applied by TasNetworks to all customer sites connected to the distribution network;
- how TasNetworks assigns customers to tariff classes and the review process which is followed if a customer lodges an objection to a tariff assignment or reassignment; and
- the typical metering arrangements required for each network tariff.

Every household, business and organisation connected to the distribution network makes a contribution towards the cost of building, running and maintaining the network. However, rather than bill customers directly for their use of the network, TasNetworks charges their retailer, which then passes the cost of the network on to customers through the retail tariffs that appear on their power bills.

While it is possible to identify the network tariff(s) that potentially apply to an individual customer, based on the characteristics of their connection and their load profile, it is recommended that the proponents of any hydrogen production facility engage with an electricity retailer in order to identify the retail tariff(s) that best suit their requirements, as this will inform the selection of an appropriate network tariff.

[6] See https://www.tasnetworks.com.au/config/getattachment/df3e59dc-3278-47b2-b323-3501f832fa04/tn-distribution-connection-pricing-policy-r19.pdf

[7] The Network Tariff Application and Price Guide for 2020-21 (as approved by the AER) can be found at https://www.tasnetworks.com.au/config/getattachment/52534774-bb46-4fee-931d-1457d69e209e/2020-21-network-tariff-application-and-price-guide.pdf

Need to know more?

Tasmania embraced the electrification of its towns and industries ahead of most of the western world, and was an early adopter of what is still the World's most prolific source of renewable energy – hydro-electric generation. With over 100 years of investment in renewable energy generation and infrastructure in Tasmania to draw on, TasNetworks' engineers and technicians are ready to provide tailored, confidential assistance to potential investors in large-scale renewable hydrogen production. By working together, we can create a future where renewable hydrogen plays a significant role in meeting the World's need for energy. And we can ensure that the processes used in Tasmania to produce hydrogen have the right load characteristics to support the Tasmanian power system, to the benefit of both the producers and the State as a whole.

TasNetworks is committed to working with its industrial customers to find innovative ways of supplying their needs while minimising the delivered cost of energy. We've already pioneered the use of dynamic line rating in order to optimise the Tasmanian transmission network's capacity to deliver energy from renewable generation without the need for augmentation. And by better understanding our customers' operations we've enabled a number of larger customers to increase their loads without the need to upgrade the network assets supplying those customers.

TasNetworks encourages all proponents of hydrogen production in Tasmania to talk about their proposals with TasNetworks as early in the planning process as possible, using the contact details that follow. All enquiries will be dealt with in the strictest of confidence.

Contact Details

For more information regarding the Tasmanian power system and the supply of electricity to large scale hydrogen production facilities within Tasmania, please contact:

Stephen Tully
Customer Account Manager – Commercial Solutions
transmission.connections@tasnetworks.com.au

For more information about transmission connections in Tasmania, please visit our website:
www.tasnetworks.com.au/transmission-connections

For more information regarding the Tasmanian power system and the supply of electricity to a commercial hydrogen production facility within Tasmania, or to lodge a connection enquiry, please contact:
www.tasnetworks.com.au/connections-help

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PO Box 606 Moonah TAS 7009

APPENDIX A

Overview of TasNetworks' transmission system protection scheme

To maximise interconnector transfers from Tasmania to Victoria (export) without the need for additional infrastructure developments, a wide area System Protection Scheme (SPS) was developed in 2006 which enables the Tasmanian transmission network to be operated "non-firm".

Non-firm operation involves transmission lines being loaded to the extent that following a credible contingency event (such as loss of a parallel transmission circuit), the remaining circuits will be initially overloaded beyond continuous ratings. The SPS identifies the overload condition and then acts to reduce transmission line power flows in a time frame that returns equipment to within rating before thermal limits are exceeded. The SPS extends the operating range of transmission circuits across the state, not just those connecting to George Town Substation.

Importantly, this particular SPS is only active during Basslink export conditions (power flow from Tasmania to Victoria). In such circumstances, Basslink is seen as a 'load' from the perspective of the Tasmanian power system. The ability of Basslink to rapidly and automatically reduce power transfer in support of SPS activation is key to its operation and ability to maintain power system security.

To facilitate the connection of additional new load in the BBAMZ area without augmenting existing transmission lines throughout the state, similar response characteristics will be required from new loads to support SPS operation. An inability to provide this functionality will reduce the effectiveness of the existing SPS and greatly reduce the power transfer capability of the Tasmanian transmission system. This would significantly curtail the capacity of new developments that would be allowable in the BBAMZ area.

Since 2005, there have been seven events (unplanned outages) that have coincided with interconnector export which have resulted in SPS operation.

The value of responsive load

The term "responsive load" is not a defined term in the NER. In this document it is taken to mean a *load shedding* mechanism that has broader application than *interruptible load*. Interruptible load is defined in the NER as a load which is able to be disconnected "for the restoration or control of the power system frequency… to cater for contingency events or shortages of supply".

In the Tasmanian context, the primary value of responsive load is to allow "non-firm" operation of transmission assets. The concept of "firm" versus "non-firm" power transmission is well established and understood. However, the special application of non-firm operation within the Tasmanian transmission network warrants additional explanation for anyone considering the industrial scale production of hydrogen in the BBAMZ.

Firm operation of power generation and transmission systems

The concept of firm power system operation goes back to the origins of electric power systems and was developed as a means of engineering reliable and secure power systems. The principle behind firm operation is one of redundancy and can be explained by way of the example illustrated in Figure 1.

By including redundancy in both the transmission and generating systems, the supply of electricity can be guaranteed following the loss of any single asset that has a reasonable probability of failure. In the NER, such outcomes are classified as *credible contingency events*. In the example, one of the transmission lines is struck by lightning and is quickly disconnected from the power system by the operation of protection systems. Since each line has sufficient rating to supply the entire load the power system continues to operate satisfactorily with the impacted circuit out of service. The NER specifies how long such operating conditions are allowed to prevail before alterations to power system operating conditions must occur (to allow for the possibility of subsequent contingency events).

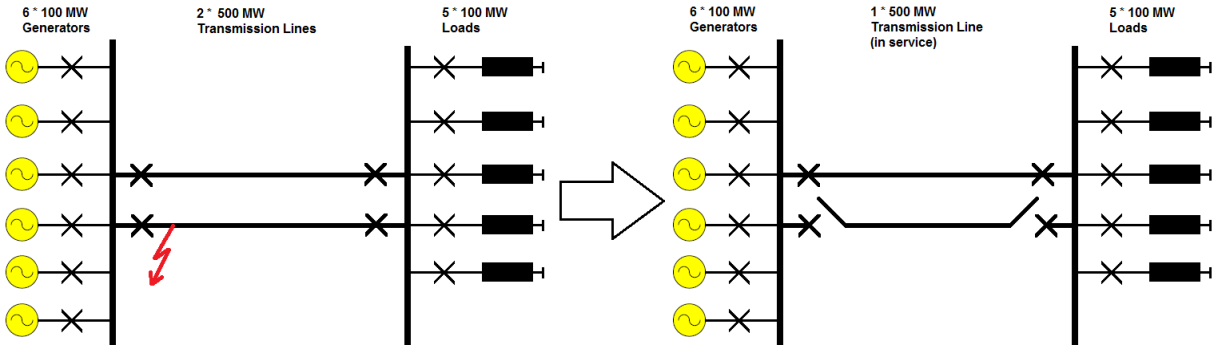

Figure 1 Example 1, concept of a firm transmission system

While firm operation is an effective means of achieving reliability and security within transmission systems, it comes at a cost. If transmission assets can only be operated up to their continuous ratings, then sufficient capacity must be continuously maintained as 'head room' to allow for the impacts of contingency events as shown in Example 1. The cost of firm transmission has sometimes been too high for transmission connected load customers and they have traded reliability of supply for lower cost by accepting radial connections arrangements comprised of multiple single circuits. Such solutions cannot be extended to the shared network, which is often meshed.

Non-firm operation of transmission systems

In recent decades some transmission system owners, including TasNetworks, have applied the principles of non-firm operation to their main transmission networks by applying wide area system protection schemes (**SPS**). The objective in doing so has been to increase asset utilisation and minimise the need for new asset builds. This has become technically feasible with increased access to fast and reliable telecommunications and advanced protection relays.

In Tasmania, non-firm operation of the transmission network was key to the development of the Basslink 500 MW HVDC interconnector which was commissioned in 2006. After its connection, the maximum 'load' at George Town approximately doubled during times of maximum exports over the interconnector to Victoria. To maintain firm operation of the surrounding transmission network would have required major augmentation and new line developments. To avoid this expenditure, interconnector export is facilitated on a non-firm basis. This means that if a transmission line trips under such conditions, then the interconnector quickly reduces its power transfer to help restore satisfactory operations.

As a result, any future loads of significance which connect to the George Town Substation can only be accommodated by either major new transmission developments or participation of the new loads in the existing SPS arrangements. It is assumed that the latter option will be pursued.

Basic requirements

To participate in the SPS, any new load will have to be 'responsive' and capable of being integrated into a centrally coordinated control scheme. The basic concept of the SPS is as shown below in Figure 2. In this example, a fault and trip of one transmission circuit initially forces the remaining circuit to operate above its continuous rating. This is subsequently controlled by reducing generation and load on either side of the overload such that the circuit loading is satisfactorily reduced. In the Tasmanian network, this response must occur within tens of seconds requiring automated and highly coordinated control action that simultaneously reduces the overload but also avoids excessive frequency disturbances.

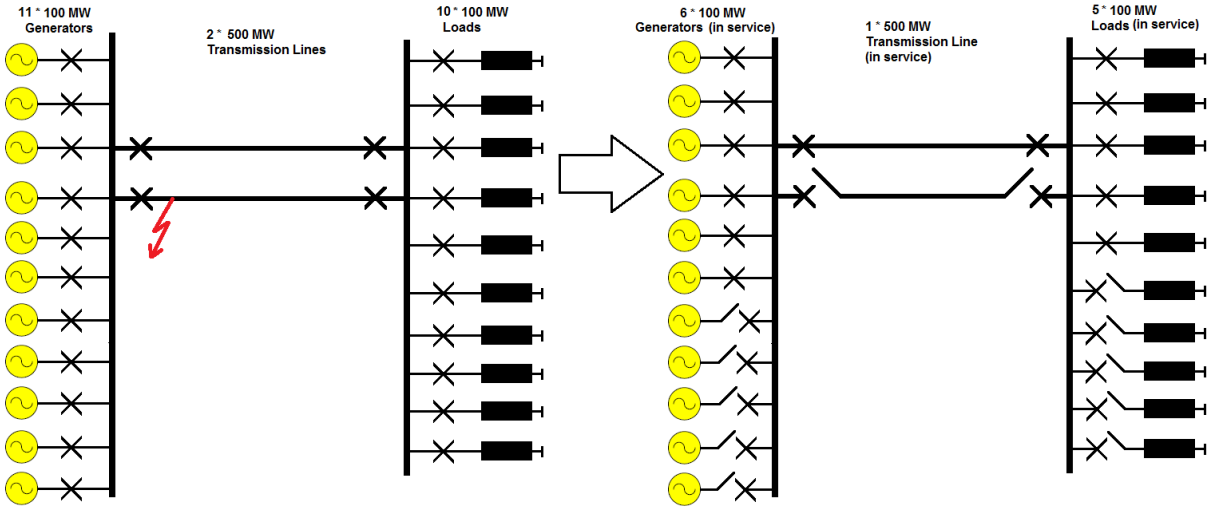

Figure 2 Example 2, non-firm operation of double circuit transmission line

In the Tasmanian context, the 'responsive load' to achieve such an outcome has been the Basslink interconnector. Through its frequency control capabilities, the interconnector is able to rapidly and automatically adjust to any generation reductions that are initiated by the SPS to alleviate transmission line overloads. The existing SPS design is therefore quite robust as it utilises a continuously acting frequency control function that regulates the interconnector's response to precisely match the requirements of the network.

Such an outcome would be significantly more difficult to achieve if load could only be interrupted, i.e. tripped, as inferred in Figure 2. Matching discrete load blocks to satisfy the requirements of the SPS would introduce another level of complication to the existing design, with corresponding time and cost implications for new load developments.

As a result, TasNetworks has an expectation that any developers of large scale hydrogen production facilities will make available sufficient 'responsive load' that can be rapidly controlled in an automated manner to deliver outcomes comparable to that of the Basslink interconnector. Fast downward ramping of load to pre-determined set points that can be dynamically varied in real time and coordinated via a centralised controller (being the SPS) is the minimum expectation for any electrolysis based process.

APPENDIX B

Technical characteristics of Tasmanian power system

This appendix provides information specific to Tasmania and is intended to supplement the general technical requirements contained in Schedule 5.3 of the NER – *Conditions for connection of customers*.

As a minimum, it is recommended that anyone considering the development of hydrogen production facilities in Tasmania familiarise themselves with both Schedule 5.3 and Schedule 5.1a (System Standards) of the NER.

The NER is available online at the following website and is administered by the Australian Energy Market Commission (**AEMC**):

https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current

System strength

In accordance with the requirements of NER Chapter 5.20C, the minimum three phase fault level that TasNetworks must maintain at George Town Substation is 1,450 MVA for an intact network (all transmission lines in service).

This will be an important consideration for any proposed large scale hydrogen production facility using power converters which may have minimum short circuit ratio (**SCR**) requirements. Furthermore, developers should be aware that there is already a significant concentration of power electronic converters connected in close proximity to George Town Substation.

While the issues related to system strength have recently focused on the negative interaction between inverter based resources (**IBR**) such as wind and solar, TasNetworks is of the view that a large converter capacity needed to support large scale hydrogen production could also cause similar issues.

Developers should be aware of this issue. The following references from the Australian Energy Market Operator (**AEMO**) are provided as recommended reading:

https://aemo.com.au/newsroom/energy-live/energy-explained-system-strength

https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/system-security-market-frameworks-review

Frequency operating standards

The Frequency Operating Standard (**FOS**) for the NEM current as of 1 January 2020 is available from the following website:

https://www.aemc.gov.au/markets-reviews-advice/review-of-the-frequency-operating-standard

Importantly, developers should be careful to note that the frequency operating bands applicable to the Tasmanian region are different to the mainland. Power system frequency in Tasmania is allowed to vary over a much wider range. Compliance with the FOS is a key compliance requirement for any new load development in Tasmania given the potential impacts on network stability and controllability.

Load block sizing

There are a number of technical issues related to load block sizing that TasNetworks recommends developers become familiar with as part of developing future plans for large scale hydrogen production facilities.

Largest credible contingency event for load

The largest block of load tripped for a credible contingency event should be limited to 144 MW consistent with the requirements for generation events in Tasmania (refer to the FOS).

As a result, the disconnection of any single transmission line, transformer, feeder, rectifier, reactive support device etc. should not result in the loss of more than 144 MW of load. In accordance with NER Chapter 4.2.3, bus faults are considered non-credible contingency events, as are simultaneous failures of multiple pieces of plant or equipment.

At present, the largest load contingency in the Tasmanian power system which determines the requirements for frequency control ancillary services (**FCAS**) is approximately 120 MW. It is considered advantageous for all Tasmanian consumers that the contingency size not be materially increased due to future load developments.

Participation in the Tasmanian Under Frequency Load Shedding (UFLS) scheme

Participation is a mandatory requirement in accordance with NER Schedule 5.3.10. Not less than 60 per cent of the rated load capacity must be available for automatic tripping at part of this emergency frequency control (**EFC**) scheme.

To assist with the coordination of UFLS protection settings, it is preferable to have access to modestly sized load blocks of between 25 MW and 75 MW. While not impossible, larger load blocks are more difficult to incorporate and can thereby complicate the design of the scheme. Wherever possible, developers should look to unitise conveniently sized load blocks such that they can be individually tripped by UFLS relays.

Individual load blocks in excess of 144 MW should be avoided.

Load Restoration

Following any event that results in the disconnection of load, TasNetworks and AEMO will implement a load restoration sequence when safe to do so. As a result of the frequency control limitations in the Tasmanian network due to relatively low levels of synchronous inertia and fast FCAS capability, the maximum load block that can be instantaneously restored is 50 MW, i.e. as a step change.

The rate of power recovery after initial switching will be a function of prevailing network capability, however this may be limited to as low as 50 MW per 5-minute dispatch interval at times.

Modelling requirements

Given the potential impacts on network stability, as well as the potential to impact the performance of existing *network users*, TasNetworks will require that detailed simulation models be provided that adequately represent the dynamic response characteristics of equipment to be installed.

The corresponding rule requirements can be referenced in NER Schedule 5.3.1.

It is proposed that major items of electrical equipment such as rectifiers, compressor plants and other equipment which can be logically grouped, be represented as individual aggregated models, i.e. one model per equipment category. Any remaining equipment can be represented by a suitable static load model which replicates the aggregate voltage and frequency dependencies of those devices.

The types of models that must be provided are as follows:

a) RMS (positive sequence) model/s suitable for use in the power system simulation package "Power System Simulator for Engineers" (**PSS/E**).

b) Electromagnetic transient (**EMT**) models suitable for use in the software package PSCAD.

EMT models will be used to assess the impacts on system strength and the risk of negative interactions with existing power electronic converters already operating in Tasmania. The same models will be used to assess fast transient phenomena including dynamic over voltages and fault ride through (**FRT**) performance, the latter being strongly linked to the design and tuning of the converter controls as well as related protection systems.

Fault ride through capability

For the avoidance of doubt, TasNetworks will apply strict requirements on FRT capability. All new loads are expected to achieve the same FRT performance as required from transmission connected generating equipment.

The implication of load being sympathetically tripped due to network faults remote from the customers' site would be significant and likely negatively impact on intra and inter-regional power transfer capabilities. This outcome would not be accepted and prevent connection of the equipment to the network.

APPENDIX C

Tasmania's Electricity Transmission Network