PROJECT SPECIFICATION CONSULTATION REPORT

DEVELOPMENT OF THE QUEENSLAND - NSW INTERCONNECTOR

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Executive Summary

The existing Queensland - NSW interconnector has been operating since 2001. Its original maximum transfer capacity was 300 to 350 MW in both directions. This has been increased progressively through a series of incremental augmentations and additional extensive testing to a present maximum transfer capacity of 700 MW from NSW to Queensland and 1078 MW from Queensland to NSW.

QNI is nonetheless constrained on occasions for both northwards and southward flows, and the number of hours of constraint in both directions is increasing. TransGrid and Powerlink have been conducting studies for a number of years to assess market benefits from uprating the interconnector or reducing the constraints on its operation by other means. Preliminary market modelling studies indicate that there are market benefits associated with relieving constraints on the interconnector and that consultation on potential options should be initiated.

This Project Specification Consultation Report has been prepared to provide a basis for TransGrid and Powerlink to consult with AEMO, registered participants and interested parties to identify options for the development of QNI that will be included in an application of the Australian Energy Regulator's Regulatory Investment Test for Transmission.

This report is the first stage of the consultation process, and:

- Describes the identified need. The identified need is an increase in the sum of consumer and producer surplus in the National Electricity Market. The market benefits of relieving the interconnector constraints would need to outweigh the cost of doing so.
- Describes the credible options being proposed for analysis that may overcome the constraint. One option considered is consistent with and forms part of the NEMLink project covered in AEMO's 2010 NTNDP.
- Describes the requirements for non-network options.

The Project Specification Consultation Report was derived using AEMO's 2010 NTNDP scenarios and other latest information at the time of preliminary study. Further extensive market modelling using AEMO's 2012 NTNDP and other latest information due to change in key assumptions on load and generation outlook will be undertaken. A Project Assessment Draft Report will be developed using results from this extensive study which will include full option analysis, and a preliminary decision on the preferred option is envisaged to be published in the period mid to late 2013. It is proposed to invite registered participants and interested parties to make submissions and provide other feedback in the period to 30th November 2012. Section 6 provides contact details for provision of written submissions on this Report.

1. Introduction

1.1. Background

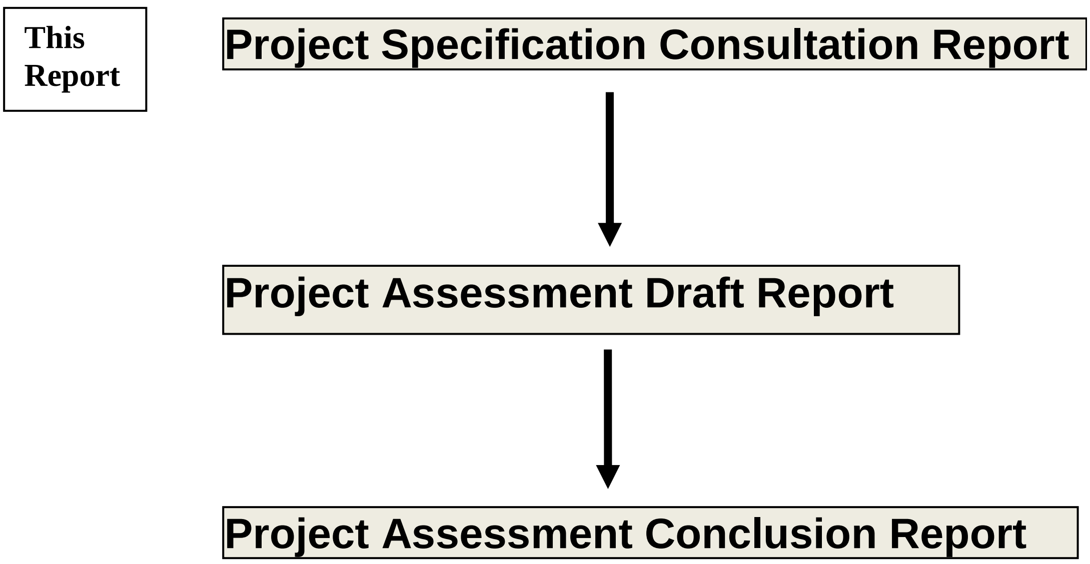
This Project Specification Consultation Report (Report) has been prepared by TransGrid and Powerlink in accordance with the requirements of clause 5.6.6 of the National Electricity Rules (NER) and the Australian Energy Regulator's (AER) guidelines for application of the Regulatory Investment Test for Transmission (RIT-T). These requirements are designed to ensure that the network is augmented only if the costs of development are economically justified.

This Report represents the first stage of the consultation process in relation to the application of the RIT-T to the further development of Queensland-NSW Interconnector (QNI) capacity, via an increase in the existing transfer capacity of QNI or the reduction of constraints in its operation by various means. These developments are referred to as the 'QNI upgrade' in this Report.

TransGrid and Powerlink are required to apply the RIT-T to this investment, in accordance with NER clause 5.6.5C (a).

Figure 1.1 shows the consultation documents required under the RIT-T process.

Figure 1.1 Consultation Documents under the RIT-T Process



A brief outline of this Report is as follows:-

Section 1 provides the context of this Report within the regulatory consultation process. It is proposed to invite registered participants and interested parties to make submissions and provide other feedback in the period to 30th November 2012. A Project Assessment Draft Report which will include a preliminary decision on the preferred option is envisaged to be published in mid to late 2013.

Section 2 describes the identified need, the existing supply arrangements, the limitations on the network and the nature of the interconnector loading.

In Section 3 credible options, some with sub options, are described. A number of other network developments that were considered but not put forward as credible options are also described.

Section 4 discusses which market benefits are, or may be, material to the assessment of the credible options under the RIT-T and the market benefits that are not likely to be material.

Section 5 describes the performance which would be required of non-network or market network service options.

Section 6 provides contact details for provision of written submissions on this Report.

1.2. Purpose and Scope

TransGrid and Powerlink are Transmission Network Service Providers (TNSPs) in NSW and Queensland respectively. They are each responsible inter alia for planning and developing their networks to meet the requirements of customers within each state and to facilitate operation of the National Electricity Market (NEM). As part of their planning responsibilities and in accordance with the requirements of the NER TransGrid and Powerlink consult with NEM registered participants, AEMO and interested parties on existing and emerging transmission limitations and on opportunities to achieve net market benefits within their respective transmission network.

Essential Energy, ENERGEX and Ergon Energy are Distribution Network Service Providers (DNSPs) in the relevant areas of NSW and Queensland and are each responsible for planning and developing those networks. In addition, there is an area in southern Queensland adjoining the NSW border which is an Essential Energy Authorised Supply Area and Essential Energy has those above mentioned supply functions in that area.

TransGrid and Powerlink are required under NER Clause 5.6.2 (b) to carry out joint planning to facilitate the development of the transmission and distribution networks within the area of interconnection and also to consult with the appropriate distribution company as required.

This Report has been prepared in accordance with Clause 5.6.6 (c) of the NER. It relates to a proposal for a new transmission asset, non-network service or market network service to increase the capacity of the interconnection between the NSW and Queensland transmission networks or the reduction of constraints in its operation by various means, resulting in an overall net market benefit. The identified need for the investment is an increase in net market benefit.

In accordance with the requirements in NER clause 5.6.6 (c) this Report:

- Describes the identified need which TransGrid and Powerlink are seeking to address, together with the assumptions used in identifying that need, including:
    - A summary of the loading on the interconnection;
    - A description of the constraints on current interconnection capacity, which TransGrid and Powerlink have identified would result in market benefits, if relieved.
- Describes the known credible options that TransGrid and Powerlink currently consider may address the identified need, including for each:
    - Its technical characteristics;
    - Whether it is likely to have a material inter-regional impact[1];
    - The construction timetable and, to the extent possible, indicative costs;
- Discusses specific categories of market benefit which in the case of this specific RIT-T assessment are unlikely to be material, in line with the requirement of NER 5.6.6(c)(6)(iii); and
- Sets out the technical characteristics that a non-network or market network service option would be required to deliver in order to address the identified need; and
- An invitation to NEM registered participants, AEMO and interested parties to make submissions on this Report.

In addition, these requirements are consistent with TNSPs' long standing joint planning practice to facilitate optimal development of inter-regional transfer capability. The AEMC found in November 2011 that TransGrid and Powerlink were acting as expected having "commenced an investigation of the economic viability and optimum timing of various upgrade options to the QNI interconnector based on the methodology of the RIT-T[2]."

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[1] The term "material *inter-regional impact*" is not defined in the NER. TransGrid and Powerlink take this to be "*material inter-network impact*".

[2] AEMC, *Last Resort Planning Power Review: 2011 Decision Report*, 3 November 2011, p.7.

1.3. History of Previous Investigations and Upgrades

In the years since QNI was commissioned in 2001, there have been a number of studies to assess the technical and economic viability of increasing the power transfer capability in both directions.

In 2003, TransGrid and Powerlink undertook a pre-feasibility investigation of the market benefits of various upgrade options under the Australian Competition and Consumer Commission (ACCC) Regulatory Test (later replaced by the RIT-T). The results of this study were published in March 2004. A copy of the report is available on TransGrid's and Powerlink's websites. The main conclusion from this study was that no major upgrade of QNI could be justified under the regulatory framework at the time. The study showed that only a very low cost intra-regional augmentation to enhance the NSW import capability was economic.

In February 2007 TransGrid published a Final Report on the regulatory consultation with respect to a proposal for relieving a limitation on the southward flow of power on QNI due to the thermal rating of the Armidale – Kempsey 132 kV No. 965 line. A copy of the Final Report is available on TransGrid's website. The Final Report concluded that the proposal for the installation of a phase shifting transformer at Armidale to control power flows on the No. 965 line satisfied the market benefits limb of the Regulatory Test. The works have now been completed.

Following significant market developments, including the then proposed Kogan Creek coal fired generator in Queensland and Tallawarra, Uranquinty and Colongara gas fired generators in NSW, Powerlink and TransGrid undertook further detailed investigations, leading to the publication of an Interim Report for Market Consultation in March 2008. The Final Report for the information of Registered Participants and interested parties on the results of this investigation, including responses to submissions, was published in October 2008. A copy of the Final Report is available on TransGrid's and Powerlink's websites. This report concluded that an augmentation to the interconnector capacity of up to nominally 300-400 MW in about 2015/16 in the absence of any large changes in forecast load growth and generation developments it would be premature for TransGrid and Powerlink to recommend any augmentation option at that time.

Since the commissioning of QNI, TransGrid, Powerlink and AEMO (NEMMCO) have undertaken testing work and the refinement of control systems to gradually improve its capability. The original maximum transfer capacity was 300 to 350 MW in both directions. This has been progressively increased following additional extensive testing and limit equation revisions to the present maximum transfer capacity of 700 MW north from NSW to Queensland and 1,078 MW south from Queensland to NSW.

Since the 2008 Powerlink/TransGrid report, there have been a number of network, generation and load developments that might drive findings and conclusions of a study which supports an increase in QNI's transfer capacity. In general, these changes are:

- Switched capacitors to be installed at Armidale, controlled by the Armidale SVC, to improve the voltage control constraint on QNI;
- Routine revision of the limit equations describing the NSW to Queensland transient stability power transfer capability; and
- Various generation and large load developments in NSW and Queensland.

In the addition, there have been changes to the NER which have introduced the Regulatory Investment Test for Transmission (RIT-T) to replace the Regulatory Test.

As a result TransGrid and Powerlink commenced the re-evaluation of the potential to upgrade the transfer capacity of QNI by applying the RIT-T methodology, taking into account the changes to the network, generation and load that have occurred since the 2008 investigation.

1.4. Outline of the Consultation Process

TransGrid and Powerlink have each published a description of limitations affecting the capacity of QNI in their Annual Planning Reports (APRs). Reports have been published from 2002 onwards for TransGrid and from 2005 onwards for Powerlink.

AEMO's National Transmission Network Development Plan (NTNDP) for 2010, National Transmission Statement (NTS) in 2009 and their Annual National Transmission Statement (ANTS) in 2008 also contained descriptions of these limitations. These reports have shown potential market benefits from upgrading QNI under some market development scenarios.

This Report is the first stage of the formal RIT-T consultation process.

A summary of this Report has been published on AEMO's website. In accordance with Clause 5.6.6 of the NER it is intended to proceed with further consultation in relation to this RIT-T assessment as follows:

- Registered participants, AEMO and interested parties have until 30th November 2012 to provide written submissions in respect of this proposal - refer to Section 6 for contact details.
- The NER provides for a further period for the consideration of submissions and the preparation and publication of a Project Assessment Draft Report which is to, inter alia, identify the preferred option. The preferred option is the credible option that maximises the net economic benefit to all those who produce, consume and transport electricity in the market compared to all other credible options.
- The Project Assessment Draft Report for this consultation is envisaged to be published in mid to late 2013 depending on the number and the nature of the submissions received in response to the Project Specification Consultation Report.
- Following a further consultation period of at least six weeks a Project Assessment Conclusions Report is to be published.

2. Identified Need

2.1. Description of Identified Need

The transfer capacity of QNI is frequently fully utilised, leading to network constraints between NSW and Queensland. Currently, the transfer capability across QNI is limited by voltage control, transient stability, oscillatory stability and line thermal rating considerations. These constraints are discussed in more detail in Section 2.4.

The line thermal rating limitations across the majority of the interconnection are generally higher than the voltage control or stability limits. This means that investments to relieve the voltage control and stability limits can increase the effective capacity of the interconnection.

TransGrid and Powerlink have conducted joint planning investigations in order to develop a clearer understanding of the technical and economic issues which need to be considered in order to alleviate the power transfer constraints, as well as the likely timing and nature of any upgrade.

TransGrid and Powerlink have identified that the upgrading of the power transfer capability across QNI would result in an increase in market benefits. In particular expected increases in the two following classes of market benefits have been identified:

- A reduction in the overall cost of fuel consumption (and other variable operating costs) by allowing the increased dispatch of lower cost generating plant in each region to meet the overall energy needs of the NEM; and
- Facilitation of increased sharing of generation sources between regions across the interconnector, thereby reducing the overall need for new generation investment in the NEM.

These market benefits arise primarily as a result of peak demand in the NSW and Queensland region not being co-incident (as described in Section 2.4). This means that generation capacity in one region can be dispatched to meet peak demand in the other region, provided that there is sufficient interconnection capacity. Investments which reduce the present constraints on the interconnector will therefore facilitate greater sharing of generation resources between regions and the realisation of the market benefits described above.

The identified need for this investment is therefore an increase in the sum of consumer and producer surplus in the NEM or an expected increase in net economic benefit compared to the base case (do nothing).

The market benefits of augmenting the interconnector, or of implementing a non-network option to influence generator and load behaviour on either side of the interconnector, would need to outweigh the cost of doing so. To be cost effective the investment option pursued would need to have a positive net market benefit, in order to satisfy the RIT-T.

TransGrid and Powerlink note that both the 2010 and 2011 NTNDPs indicated the possibility of achieving net market benefits from increasing the capacity of QNI. The particular options considered by AEMO are discussed in Section 3, in relation to the credible options identified to date for this RIT-T assessment.

The remainder of this section sets out the assumptions used in defining the identified need, as required under NER 5.6.6(c) (2). In particular, in finding that the expansion of QNI could be expected to lead to increases in the two classes of market benefit identified, TransGrid and Powerlink have considered:

- the present network supply arrangements;
- the difference in the profiles of demand in NSW and Queensland;
- the present nature of the interconnector loading and the historic flows over the interconnector; and
- the nature of the present limitations on the transfer capacity of QNI, and the extent of the constraints experienced.

TransGrid and Powerlink have also undertaken preliminary market modelling which indicates that relieving the constraints on QNI would result in an increase in market benefits, given projections of future demand and market development. This preliminary market modelling has been based on published load forecasts for NSW and Queensland and the 2010 NTNDP scenarios.

2.1.1. Material Market Benefits Relating to the Upgrade of the Interconnection

From the analysis that has been carried out to date, TransGrid and Powerlink have identified a range of classes of market benefit most likely to change materially as a result of increasing the capacity of QNI and these are set out below in this section of the Report. These benefits will be captured in the market modelling used in the assessment of the options but will not be necessarily separately identified. The market benefits which are not expected to be material are covered in Section 4.

Changes in generator fuel consumption arising through different patterns of generation dispatch

Increased power flow capacity between NSW and Queensland is expected to improve the sharing of generation between Queensland and the rest of the NEM. As discussed in Section 2.4, peak demand in Queensland and NSW are not coincident. Sharing of generation is expected to reduce the overall cost of dispatch by reducing fuel costs and variable operation and maintenance costs.

Changes in costs for parties other than TransGrid and Powerlink, due to differences in the timing of new plant, capital and operation and maintenance costs

Increased power flow capacity between NSW and Queensland is expected to affect the pattern of future generation development in the NEM.

Increased interconnector capability is expected to defer the need for investment in new generating plant in Queensland to meet the peak Queensland demand and also to defer the need for new generating plant in NSW to meet the NSW peak demand. Given the non-coincidence of peak demand in Queensland and NSW, an expansion of the interconnector capacity is therefore expected to improve the utilisation of existing plant across the NEM to meet peak demand requirements.

A reduced need for new investment in generating plant, or a deferral of generation investment, would represent a market benefit.

Changes in Network Losses

Any change in network losses may be material in the assessment of the upgrade options. Changes in network losses will be captured in the market modelling used in the assessment of the options as part of the overall change in generation production costs.

Increasing the effective capacity of the existing interconnection is expected to increase the power flows across the interconnector and hence would increase the network losses on the interconnector itself. The development of new HVAC lines between NSW and Queensland (i.e., options 4a, 4b and 4c) may reduce overall losses across the interconnection.

Power flows in the supporting networks in NSW and Queensland will also change, depending on the particular option adopted, which will have a further impact on losses. Losses may increase or decrease in these supporting networks depending on the pattern of generation dispatch and the level of load. Any overall increase in network losses would represent a *negative* market benefit.

Competition Benefits

Increased capacity of QNI has the potential to increase competition between generators across the NEM at times where currently the existing interconnection capacity is constrained.

Increased competition may affect the pattern of generation dispatch over and above the change associated with the displacement of higher cost generation with lower cost generation as a result of the increased capacity of the interconnector. An increase in competition between generators may represent a further market benefit associated with the interconnection augmentation. This benefit will be captured by the market modelling used in the RIT-T assessment but will not be quantified separately.

Changes in involuntary load shedding

An increase in interconnection capacity between NSW and Queensland will enhance the ability to meet high loads across the NEM, increasing supply reliability and reducing the potential for supply shortages. This will reduce the risk of involuntary load shedding.

Changes in voluntary load shedding

The interconnector upgrade may have a material impact on pool prices and hence there may be changes to voluntary load curtailment. AEMO provides information on voluntary load curtailment and this has been incorporated in the market modelling.

2.2. Jurisdictional Requirements

Powerlink and TransGrid have reliability and quality of supply obligations under the NER and jurisdictional requirements.

TransGrid is required to comply with the *Transmission Network Design and Reliability Standard for NSW* promulgated by the former NSW Department of Industry and Investment. Included in this document are the following requirements with respect to market benefits which are consistent with TransGrid's obligations under the RIT-T and the NER.

- "A TNSP shall plan their transmission network to achieve supply at least overall community cost, without being constrained by State borders or ownership considerations."
- "The network planning process will be undertaken at five levels (one of which is):-

  Inter-regional Planning

  The development of interconnectors between regions and of augmentations within regions that have a material effect on inter-regional power transfer capability shall be coordinated with network owners in other states in accordance with the NER. The inter-regional developments will be consistent with the National Transmission Network Development Plan (NTNDP)."

Powerlink is required to comply with the planning standard set in its Transmission Authority under the *Electricity Act 1994*, and connection agreements with customers.

TransGrid and Powerlink must plan and develop the transmission system in accordance with good electricity industry practice, such that the network must be able to meet forecast electricity demand during an outage of the most critical single network element (known as the N-1 criterion), unless otherwise agreed with affected parties.

TransGrid and Powerlink jointly assess the future capability of the network and take action to ensure it continues to meet these performance requirements. New developments of network, including interconnectors, may be proposed that deliver a net market benefit when measured in accordance with the RIT-T. In line with this obligation, development and assessment of new or augmented interconnections between Queensland and New South Wales (or other States) is the responsibility of the respective TNSPs, i.e. Powerlink and TransGrid (or other relevant TNSPs).

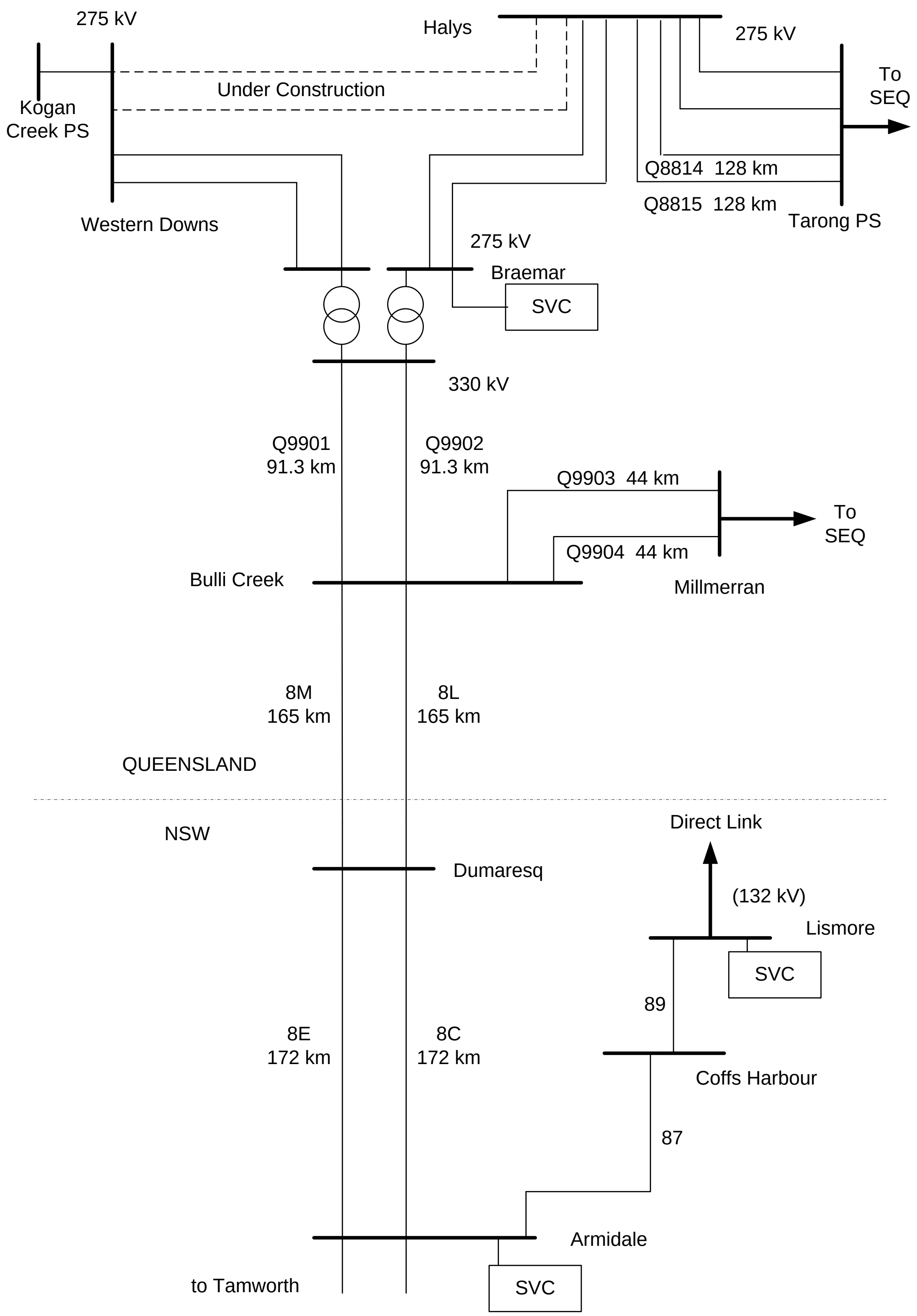
2.3. Present Network Supply Arrangements

QNI was commissioned in February 2001, and has been operated under a joint operating agreement between TransGrid and Powerlink to date. It comprises a double-circuit 330 kV line from Armidale to Dumaresq in NSW, to Bulli Creek in Queensland, to Braemar in Queensland and a double-circuit 275 kV line from Braemar to Tarong Power Station as shown in Figure 2.1. The length of the QNI connection from Armidale to Tarong is around 560 km.

QNI is supported by a 330kV transmission system in NSW between Armidale and the Hunter Valley. Underlying 132kV systems operate in parallel with various sections of the 330kV network.

In Queensland QNI is supported by a 275kV system from Tarong to south east Queensland and a 330 kV and 275 kV system from Bulli Creek to south east Queensland.

Figure 2.1 Transmission System Comprising the Queensland to NSW Interconnector



2.4. Assumptions Made in Defining the Identified Need

2.4.1. The Nature of Demand in NSW and Queensland

Diversity of peak demand across geographically diverse areas, such as the eastern seaboard of Australia, occurs primarily due to differing weather conditions.

Generally, there has been diversity between peak demands in NSW and Queensland (that is peak demands have generally not been coincident). This provides an opportunity for generator capacity sharing between the two regions for economic trade of electricity.

Market benefits across QNI can arise as a result of peak demand between the Queensland and NSW regions (and other interconnected regions) occurring at different times which enables generation capacity to be shared across the interconnected system.

The following tables show the NSW and Queensland summer and winter peak demands[3] for recent years. Tables 2.1and 2.2 show each State's summer peak demand and the other State's coincident demand. Table 2.3 shows the overall NSW plus Queensland summer peak demands and the contribution of each State to that demand. Tables 2.4, 2.5 and 2.6 show this information for winter peak demands.

The times referred to in the tables are all expressed as Eastern Standard Time.

Historically higher levels of demand diversity occur during the summer seasons compared to winter. This suggests that benefits of generator reserve sharing are more likely to occur during summer than winter. It should also be noted that peak power consumption within both Queensland and NSW is forecast to occur during summer (ie peak demand during summer is higher than the corresponding winter season for both States), which may make the sharing of generation capacity more critical during hot summer periods.

Summer

Table 2.1 NSW Summer Peak Demand with Coincident Qld Demand

Year	Date and Time	NSW Peak Demand MW	Coincident Qld Demand MW	Coincident Qld Demand % of Qld Peak
2004/05	8/02/2005, 15:30	12,630	8,148	100%
2005/06	2/02/2006, 13:30	13,292	7,944	96%
2006/07	30/01/2007, 16:00	12,876	8,141	95%
2007/08	30/01/2008, 15:00	12,940	7,306	90%
2008/09	6/02/2009, 16:00	14,101	7,827	90%
2009/10	22/01/2010, 15:30	13,766	7,928	89%
2010/11	1/02/2011, 16:30	14,595	7,798	88%
2011/12	30/01/2012, 16:30	11,916	7,313	84%
Average				92%

[3] These maximum demands are "scheduled demands" (as generated by scheduled generators). The data are sourced from AEMO's SCADA system.

Table 2.2 Qld Summer Peak Demand with Coincident NSW Demand

Year	Date and Time	Qld Peak Demand MW	Coincident NSW Demand MW	Coincident NSW Demand % of NSW Peak
2004/05	8/02/2005, 14:00	8,176	12,318	98%
2005/06	14/02/2006, 16:30	8,280	9,892	74%
2006/07	12/03/2007, 16:00	8,611	10,087	78%
2007/08	22/02/2008, 16:30	8,086	11,220	87%
2008/09	9/02/2009 17:00	8,707	10,517	75%
2009/10	18/01/2010, 15:30	8,897	9,703	70%
2010/11	21/02/2011, 14:00	8,826	10,479	72%
2011/12	9/01/2012 15:30	8,714	10,226	86%
Average				80%

Table 2.3 Total NSW and Qld Summer Peak Demand

Year	Date and Time	Total Peak Demand MW	NSW Demand MW	NSW Demand % of NSW Peak	Qld Demand MW	Qld Demand % of Qld Peak
2004/05	8/02/2005 15:30	20,778	12,630	100%	8,148	100%
2005/06	2/02/2006 14:00	21,280	13,288	100%	7,992	97%
2006/07	30/01/2007 16:00	21,017	12,876	100%	8,141	95%
2007/08	29/01/2008, 14:30	20,345	12,727	98%	7,618	94%
2008/09	6/02/2009 16:00	21,928	14,101	100%	7,827	90%
2009/10	22/01/2010 15:00	21,751	13,763	100%	7,988	90%
2010/11	1/02/2011, 16:30	22,393	14,595	100%	7,798	88%
2011/12	30/01/2012 16:30	19,229	11,916	100%	7,313	84%
Average				100%		92%

Winter

Table 2.4 NSW Winter Peak Demand with Coincident Qld Demand

Year	Date and Time	NSW Peak Demand MW	Coincident Qld Demand MW	Coincident Qld Demand % of Qld Peak
2004	19/07/2004, 18:30	13,032	6,876	97%
2005	23/06/2005, 18:30	13,126	7,222	98%
2006	20/07/2006, 18:30	13,076	7,036	92%

Year	Date and Time	NSW Peak Demand MW	Coincident Qld Demand MW	Coincident Qld Demand % of Qld Peak
2007	17/07/2007, 19:00	13,871	7,366	94%
2008	28/07/2008, 18:30	14,289	8,154	99%
2009	10/06/2009 18:30	12,971	7,096	92%
2010	29/06/2010, 18:30	13,219	7,335	100%
2011	19/07/2011, 18:30	12,885	7,054	92%
Average				96%

Table 2.5 Qld Winter Peak Demand with Coincident NSW Demand

Year	Date and Time	Qld Peak Demand MW	Coincident NSW Demand MW	Coincident NSW Demand % of NSW Peak
2004	21/06/2004, 19:00	7,092	11,730	90%
2005	12/08/2005, 17:30	7,354	10,860	83%
2006	20/06/2006, 18:30	7,628	12,138	93%
2007	20/06/2007, 18:00	7,862	12,819	92%
2008	28/07/2008, 19:00	8,212	14,105	99%
2009	11/06/2009, 20:30	7,694	12,379	95%
2010	29/06/2010, 18:30	7,335	13,219	100%
2011	9/06/2011, 18:00	7,632	12,271	95%
Average				93%

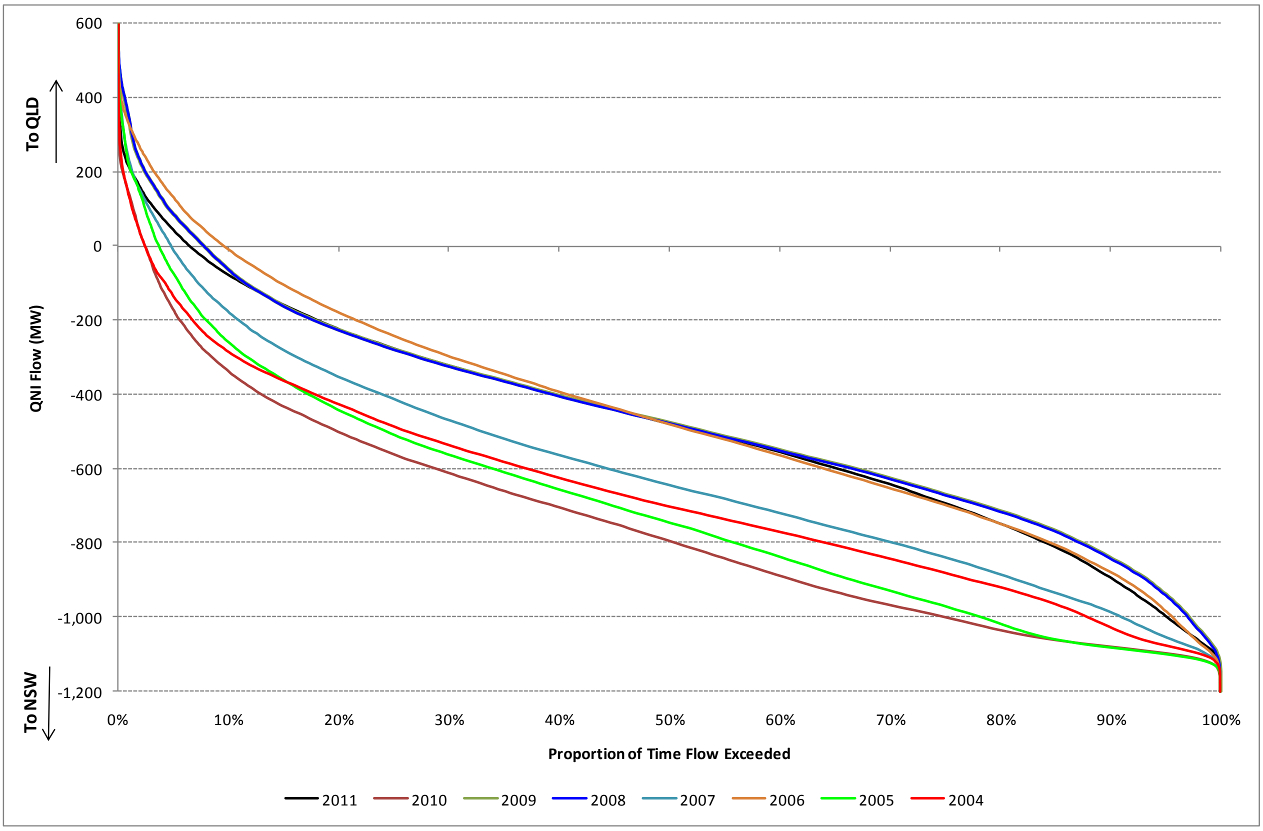
Table 2.6 Total NSW and Qld Winter Peak Demand

Year	Date and Time	Total Peak Demand	NSW Demand MW	NSW Demand % of NSW Peak	Qld Demand MW	Qld Demand % of Qld Peak
2004	19/07/2004, 18:30	19,908	13,032	100%	6,876	97%
2005	23/06/2005, 18:30	20,348	13,126	100%	7,222	98%
2006	26/07/2006, 18:30	20,112	13,076	100%	7,036	92%
2007	16/07/2007, 18:30	21,280	13,825	100%	7,455	95%
2008	28/07/2008, 18:30	22,443	14,289	100%	8,154	99%
2009	11/06/2009, 19:00	20,462	12,898	99%	7,564	98%
2010	29/06/2010, 18:30	20,554	13,219	100%	7,335	100%
2011	9/06/2011, 18:30	19,995	12,367	96%	7,628	100%
Average				99%		97%

2.4.1. Interconnector Loading and Energy Transfer

Since it commenced operation in February 2001, the interconnector has been widely recognised as a valuable infrastructure investment. The transfer capacity of QNI is well utilised. Over the last eight years, power transfers across QNI have been predominantly in the southerly direction. The flow duration curves across QNI since 2004 are shown in Figure 2.2. (This figure excludes the power transfer over Directlink).

Figure 2.2 – QNI Power Flow Duration Curves



The above duration curves indicate that the power flow on QNI has been in the southerly direction for about 90% of the time since 2004, and at least 95% in 2005, 2006, 2008 and 2010 calendar years.

The energy transfer between the regions is shown in Table 2.7 with data extracted from AEMO's ESOO 2011. This table shows that energy flow in a southerly direction is significantly higher than for the northerly direction for the periods shown.

Table 2.7 – Historical QNI Energy Transfer between the regions (GWh)

Direction	2006-07	2007-08	2008-09	2009-10	2010-11
Northerly Direction NSW to Qld	44	105	122	54	47
Southerly Direction Qld to NSW	5,759	4,798	4,321	4,974	5,660

2.4.2. The Nature of Limitations on the Network

The actual capacity of QNI is dynamic and is determined by a range of parameters including line thermal ratings, transformer ratings, transient stability, voltage control considerations and oscillatory stability considerations. The capability is defined by a technical envelope which is represented in the NEM by multi-term limit equations which include terms that describe the critical factors affecting the power transfer capability. The capability at any time is dependent on a number of power system conditions, including substation loads and generation patterns.

Whilst the 330kV interconnecting lines may have a relatively high thermal rating, the power transfer capability of QNI is governed by the capability of the supporting transmission systems in NSW and Queensland, as well as power system conditions across the whole interconnected NEM grid. These supporting systems can, and do, at times limit the capability for overall power transfer between the States.

Due to the dependency of QNI transfer limits on system wide conditions, development of the network, generation and loads in Queensland and NSW since the commissioning of QNI has gradually changed the power transfer capability. For example, connection of new large merchant generating units in southern Queensland have had a detrimental impact on the NSW export capability.

The number of hours that a constraint has bound for transfers over QNI by year since 2004 is shown in Table 2.8. It should be noted that these include periods with planned network outages which are generally required for maintenance activities.

Table 2.8 – Historical QNI Constraint Times (Hours)

Direction	2004	2005	2006	2007	2008	2009	2010	2011
Northerly Direction (hrs)	33	23	34	389	262	352	365	296
Southerly Direction (hrs)	346	1,084	2,063	513	881	577	2,135	900

The data in Table 2.8 highlights that from 2004 southerly binding constraints have been more prevalent than northerly binding constraints.

At present the QNI transfer capability in the southerly direction is most likely to be limited by the following constraints:

- Transient stability associated with transmission faults in Queensland;
- Transient stability associated with transmission faults in the Hunter Valley (New South Wales);
- Transient stability associated with a fault on the Hazelwood to South Morang 500 kV transmission line in Victoria;
- Thermal capacity of the 330 kV transmission network between Armidale and Liddell in New South Wales; and the
- Oscillatory stability upper limit of 1,078 MW.

In the northerly direction, the QNI transfer capability is limited by the following constraints:-

- Transient stability associated with transmission line faults in the Hunter Valley (New South Wales);
- Transient stability and voltage stability associated with loss of the largest generating unit in Queensland;
- Transient stability associated with transmission faults in New South Wales;
- Thermal capacity of the 330 kV and 132 kV transmission network within northern New South Wales; and the
- Oscillatory stability upper limit of 700 MW.

Table 2.9 identifies the dominant constraints for power flows in the southerly direction for the 2011 calendar year.

Table 2.9 Schedule of Dominant Constraints for Southerly Power Flow over QNI (2011 Calendar year)

Dominant Constraints	Limited by (hours)	Constraint bound (hours)
Transient Stability	7,431	527
Oscillatory Stability	433	17
Thermal Limits	187	25
Voltage Control	3	0
Frequency Control Ancillary Service (FCAS)	641	274
Other Constraints	64	58
Total	8,759	901

The “Limited by (hours)” column in Table 2.9 is a measure of the number of hours during which the particular classes of constraint were limiting irrespective of whether the constraint actually bound. When actual transfer levels were close to the limit there may have been an impact on generator bidding behaviour.

Table 2.10 identifies the dominant constraints for power flows in the northerly direction for the 2011 calendar year.

Table 2.10 Schedule of Dominant Constraints for Northerly Power Flow over QNI (2011 Calendar year)

Dominant constraint	Limited by (hours)	Constraint bound (hours)
Transient Stability	36	1
Oscillatory Stability	0	0
Thermal Limits	852	194
Voltage Control	7,641	75
Frequency Control Ancillary Service (FCAS)	223	20
Other Constraints	8	6
Total	8,760	296

2.4.3. State Load Forecasts and NTNDP Scenarios

TransGrid and Powerlink have undertaken preliminary market modelling in order to identify whether relieving the constraints on QNI is expected to result in an increase in market benefits going forward, given projections of future demand and market development. This preliminary market modelling has been based on published load forecasts for NSW and Queensland and the 2010 NTNDP scenarios

Appendix 1 shows the 2010 NTNDP scenarios which have been used for the preliminary market modelling referred to in this Report. These scenarios have not been changed in the 2011 NTNDP.

The NSW and Queensland load forecasts to be used for the market modelling for the preparation of the Project Assessment Draft Report will be those that are the most up to date available at the time. Whilst it is important to use the most up to date data available at the time, TransGrid and Powerlink recognise that during the period over which the RIT-T is conducted the data will change and TransGrid and Powerlink wish to avoid inefficient re-working of the analysis with relatively small changes to forecasts or other input data. At this stage it is expected that market modelling for the Project Assessment Draft Report will be based on the scenarios in AEMO's 2012 NTNDP, which has yet to be published.

2.5. Joint Planning

TransGrid and Powerlink periodically reviewed whether upgrading the capacity of QNI might be cost effective by delivering net market benefits. Earlier sections of this Report including in particular Section 1.3, describe that co-operation and the previous work conducted on this interconnector. This Report summarises the most recent assessment on the feasible options for upgrading of QNI, in line with the formal RIT-T process.

Section 1.4 has outlined the extent to which information on this interconnector has been published in APRs by each organisation and by AEMO in their planning documents such as the NTNDP.

TransGrid and Powerlink have carried out joint annual planning reviews as required by Clause 5.6.2 (b) of the NER. As required by Clause 5.6.2(c) they have identified that the limitations described in Section 2.1 give rise to a need for augmentations of network capacity and have carried out joint planning to determine options for these augmentations.

Section 2.2 has outlined requirements for TNSPs in planning the transmission network to achieve least overall community cost irrespective of the State borders or ownership considerations and to co-ordinate with network owners in other states to achieve this.

3. Credible Options

Clause 5.6.6 (c)(5) of the Rules requires the Project Specification Consultation Report to include "… a description of all credible options of which the Transmission Network Service Provider is aware that address the identified need…".

Credible options must be commercially and technically feasible. Clause 5.6.5D(b) requires TransGrid and Powerlink in applying the RIT-T to consider all options that could reasonably be classified as credible options, including network options, non-network options and market network service developments. The absence of a proponent does not exclude an investment from being considered a credible option.

This section covers the credible options which have been identified by TransGrid and Powerlink to date. These options include network options (for which TransGrid and/or Powerlink would be the proponent). The technical characteristics that non-network options or market network service provider options provided by others would need to meet are set out in Section 5.

In addition this section discusses options which TransGrid and Powerlink considered but have decided not to pursue, for the reasons given.

3.1. Corporate Objectives and Other Legislative Requirements

In addition to the requirements of the NER, TransGrid is also subject to obligations under its enabling legislation, the Energy Services Corporation Act 1995. Section 6B of the Act sets out the five principal objectives which in summary are:

1. To be a successful business. This includes:
    a. To operate at least as efficiently as any comparable business;
    b. To maximise the net worth of the State's investment in it;
    c. To exhibit a sense of social responsibility by having regard to the interest of the community in which it operates;
2. To protect the environment by conducting its operations in compliance with the principles of ecologically sustainable development;
3. To exhibit a sense of responsibility to regional development;
4. To operate efficient, safe and reliable facilities; and
5. To promote effective access.

It is important to note that the Act explicitly identifies that each of these objectives is of equal value, and thus a balanced approach must be taken in decision making to reflect this obligation. In particular it is worth noting that efficiency is not superior to the environment or the community.

Powerlink is established under the Government Owned Corporations Act 1993 (Queensland) that requires it to operate commercially in the expectation of delivering financial results commensurate with the risk of the business. Powerlink's 2010/11 Statement of Corporate Intent under that Act explains that Powerlink's field of business is to deliver a reliable transmission service to electricity market participants via open, non-discriminatory access to the Queensland transmission grid, which connects power stations with customer and distribution network connection points. This involves planning, designing, constructing, operating and maintaining transmission assets to meet present and future needs for the transmission of electricity in its designated area in Queensland. These activities are regulated in accordance with the Rules and the Electricity Act 1994.

Powerlink is also subject to other state based legislative requirements in particular to the Sustainable Planning Act 2009 when constructing new projects which are in addition to the requirements of the NER.

This Act provides a framework to integrate planning and development assessment so that development and its effects are managed in a way that is ecologically sustainable.

In relation to the Sustainable Planning Act, ecological sustainability is defined as achievement of a balance that integrates:

- protection of ecological processes and natural systems;
- economic development; and
- maintenance of the cultural, economic, physical and social wellbeing of people and communities.

Selection of feasible credible network options will need to be cognisant of the requirements of this Sustainable Planning Act and other applicable environmental legislation.

In considering options to expand the effective capacity of QNI TransGrid and Powerlink have assessed possible options to see whether they are technically and commercially feasible, taking into account the above requirements. TransGrid and Powerlink will apply the RIT-T to options which are found to be technically and commercially feasible.

Possible options which were considered but not pursued are described in Section 3.5.

3.2. Material Inter-network Impact

TransGrid and Powerlink are required to assess whether credible options have a material inter-network impact with respect to the main transmission systems of NSW and Queensland.

All the options being considered would increase the power transfer capability between NSW and Queensland. As the anticipated increase for each option is greater than 50 MW, TransGrid and Powerlink believe that each option would be likely to have a material inter-network impact as defined by AEMO. TransGrid and Powerlink will carry out assessment of inter-network impact and consult with relevant parties. Additionally, options including series compensation will entail a detailed investigation to ensure that the impact of sub-synchronous resonance (SSR) is either mitigated or managed. SSR risks are being addressed to ensure no material impact on market participants.

3.3. Known Credible Options

Credible options must, inter alia, address the identified need. In this case that entails that all options result in an increase in market benefit from facilitating more cost efficient dispatch to meet demand in NSW and Queensland, and deferring the need for further generation investment in those jurisdictions. The credible options described below all achieve this through relieving the constraints across the QNI interconnector.

Six credible options relating to the upgrading of QNI have been identified. Some of these have sub options that represent a variation on the development.

3.3.1. Option 1a - Series Compensation

This option involves the installation of thyristor controlled series capacitors across the Bulli Creek to Dumaresq and the Dumaresq to Armidale 330 kV circuits and provision of additional 275/330 kV transformer capacity at Braemar.

TransGrid and Powerlink would be the proponents of this option, which is shown in diagrammatic form in Figure 3.1.

The series capacitors reduce the effective reactance across the transmission lines which subsequently bring the two systems electrically closer together, thereby improving both transient and voltage stability. The transfer capability of QNI would increase, however series compensation would not increase the thermal ratings of the circuits.

It is evident from analysis undertaken by TransGrid and Powerlink that the stability limit increase in the northerly direction at high compensation levels would not encroach on the thermal ratings of QNI. In the southerly direction however, the stability limit would reach the thermal ratings for high compensation levels. This has implications for the percentage of transmission line compensation selected under this option.

System analyses have identified the potential for subsynchronous resonance to occur with some generators as a result of series capacitors being installed at any location along the QNI interconnector. In order to counteract sub-synchronous resonance, the system studies have determined that the series compensation scheme must have a component of the series capacitance controlled by thyristors in series with a fixed capacitor component. This is known as Thyristor Controlled Series Compensation (TCSC).

An indicative series compensation scheme using TCSCs is shown in Figure 3.2.

At this stage, neither the percentage of the transmission line compensation nor the component of thyristor controlled series capacitance have been selected. The optimal design will be identified as part of the analysis process prior to the issue of the Project Assessment Draft Report.

For the purposes of preparing the preliminary costing for Report, 50% of transmission line compensation and equal proportions of fixed and thyristor controlled series capacitance has been used. These proportions may change once the final technical analysis has been completed.

Although the location of the TCSC installations is presently shown to be at Dumaresq in Figure 3.1, further work on identifying the optimal site selection would form part of the analysis process prior to the issue of the Project Assessment Draft Report.

Figure 3.1 Option 1a - Series Compensation

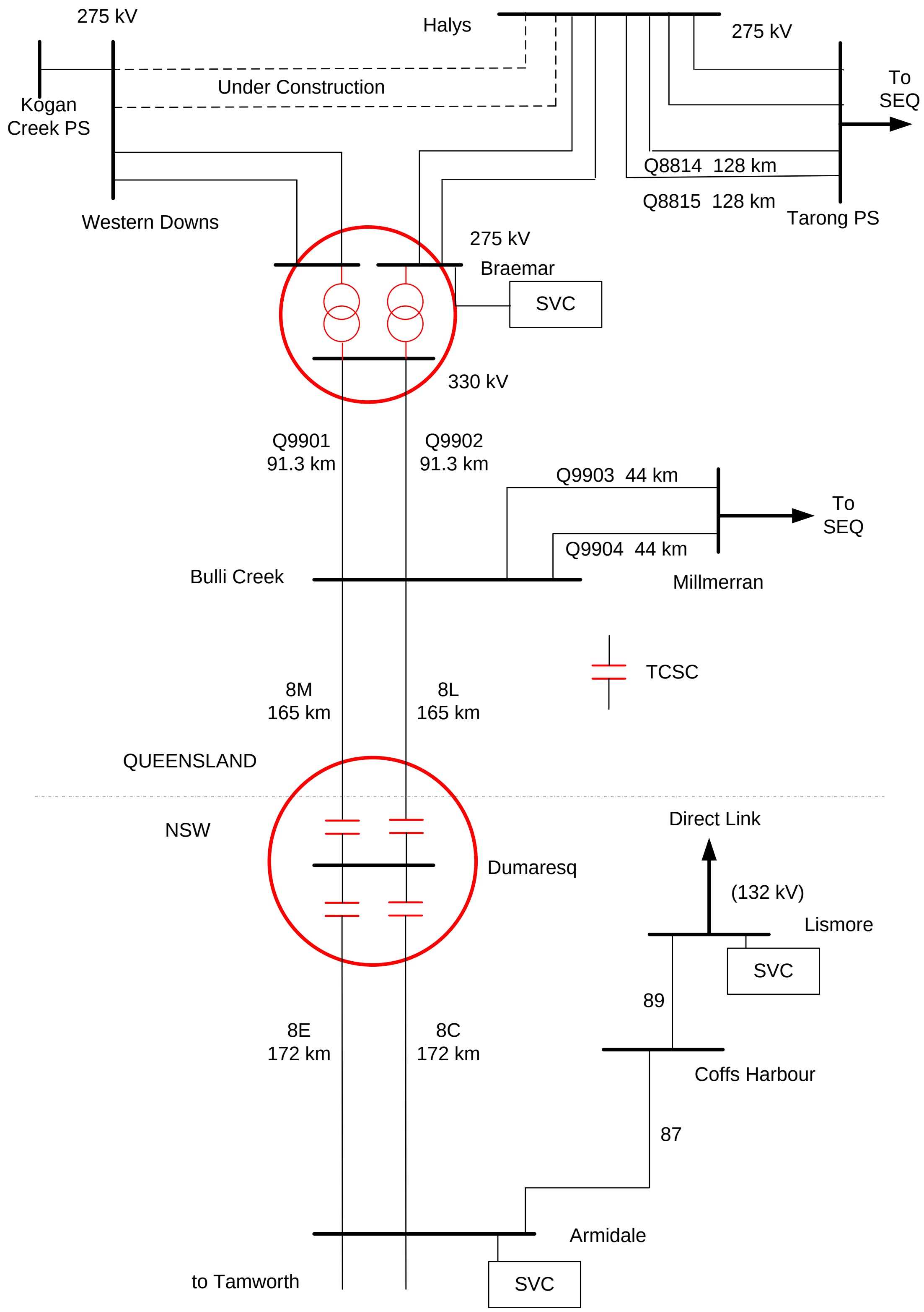
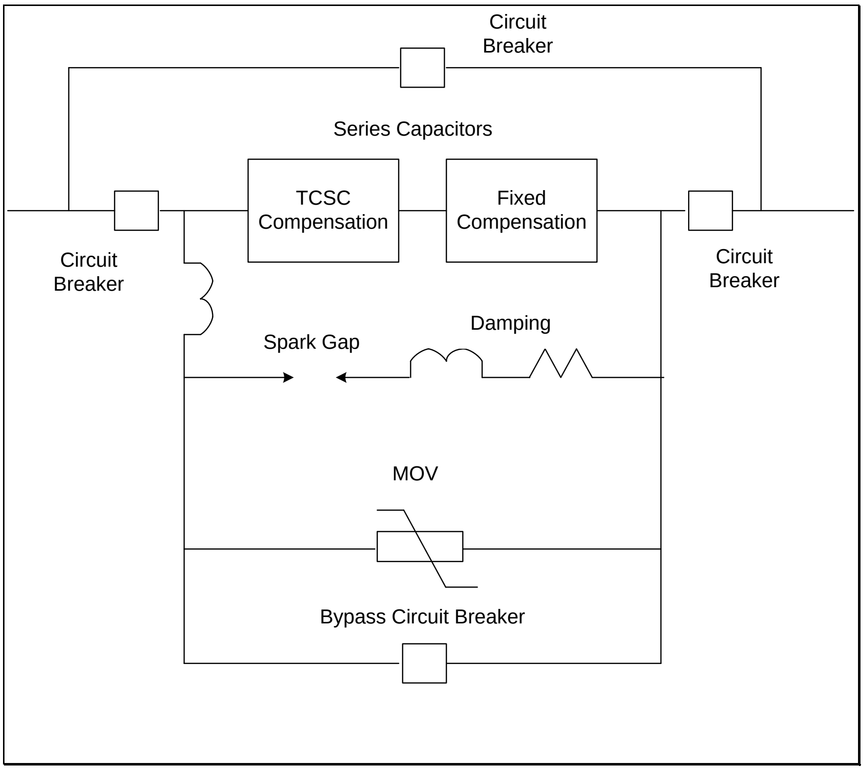


Figure 3.2 Indicative Arrangement of a TCSC



<u>Technical Characteristics</u>

This scope of works for this option would include:

- The installation of four thyristor controlled series capacitors, one in each of the Dumaresq to Bulli Creek 330 kV transmissions lines (8L and 8M) and the Dumaresq to Armidale 330 kV transmission lines (8E and 8C);
- The installation of four new 330 kV line bays to connect to the existing 8L, 8M, 8C and 8E transmission lines;
- Erection of new busbar sections to connect the new TCSC's to the existing plant at Dumaresq;
- Extension of the existing switchyard bench to accommodate the four TCSC units and new 330 kV line bays;
- Diverting the existing transmission lines to allow connection to the TCSC units; and
- Upgrade of the existing 330/275 kV transformers with 1500MVA units at Braemar Substation.

The broad technical details of each of the four TCSC devices are:

- System Highest Voltage (SHV) (continuous): 362 kV
- Rated load current: approximately 2.6 kA (1500 MVA) at 330 kV
- Short circuit duty: 40 kA at the Dumaresq 330 kV busbars
- Fixed series compensation component: equivalent to 25% of the line or about 250 MVAr at rated current

- Variable series compensation: equivalent to 25% of the line or about 250 MVAr at rated current
- Total series compensation: equivalent to 50% of the line or about 500 MVAr at rated current

The resulting change to the export limits under a range of generator and system operating conditions for critical contingencies are outlined in the following Tables 3.1, 3.2, 3.3 and 3.4. Preliminary modelling indicates that, the increase in transfer capacities (transient stability and voltage control) from Queensland to NSW under this option would be from 470 MW to 640 MW and from NSW to Queensland would be from 210 MW to 250 MW.

Queensland to NSW transfer[4]

Table 3.1 50% Series Compensation - 2014/15 Average Export Limit and Standard Deviation

Series Compensation	Transient Stability Export Limit (MW)		Improvement in Export Limit (MW)	
	Average	Standard Deviation	Average	Standard Deviation
50%	1,920	70	570	80

Table 3.2 50% Series Compensation - 2014/15 Queensland to NSW Export Limit

Contingency	Average Transient Stability Export Limit (MW)			Average Improvement in Export Limit (MW)		
	Low Demand	Medium Demand	High Demand	Low Demand	Medium Demand	High Demand
Bulli Creek Fault	-	1,950	1,980	-	610	640
Liddell-Tamworth Fault	1,840	1,950	-	470	610	-

NSW to Queensland transfer

Table 3.3 50% Series Compensation - 2014/15 Average Export Limit and Standard Deviation

Series Compensation	Transient Stability Export Limit (MW)		Improvement in Export Limit (MW)	
	Average	Standard Deviation	Average	Standard Deviation
50%	740	70	230	20

[4] The transient stability limit may exceed the thermal capacity of QNI

Table 3.4 50% Series Compensation - 2014/15 NSW to Queensland Export Limit

Contingency	Average Transient Stability Export Limit (MW)			Average Improvement in Export Limit (MW)		
	Low Demand	Medium Demand	High Demand	Low Demand	Medium Demand	High Demand
Trip of Kogan Creek Generator	760	790	680	230	250	210
Liddell-Tamworth Fault	-	-	660	-	-	240

Construction Timetable and Anticipated Costs

At this stage, it is expected that it would take around four years to complete this option. The preliminary cost estimate, which is subject to confirmation, is approximately $150 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital cost.

National Transmission Network Development Plan

This option is reported in AEMO's 2010 NTNDP and the AEMO market modelling indicates that this option would deliver net market benefits in five out of the ten NTNDP scenarios.

3.3.2. Option 1b - Series Compensation with Second Armidale SVC

This option involves the installation of series compensation across the Bulli Creek to Dumaresq and Dumaresq to Armidale 330 kV circuits and additional 275/330 kV transformer capacity at Braemar, as described in Option 1a together with a Static VAr Compensator (SVC).

The addition of a second SVC at Armidale would increase the level of dynamic reactive reserves within the northern NSW network. This would enable an increase in the level of both northerly and southerly QNI transfer capability, above that achieved under option 1a.

The installation of series capacitors and an SVC would not increase the line thermal rating limitations in the system.

TransGrid and Powerlink would be the proponents of this option, which is shown in diagrammatic form in Figure 3.3.

The SVC is likely to be installed at a new Armidale 330kV switchyard near to the existing Armidale 330/132kV Substation. The location of the SVC would be optimised as part of the detailed design and analysis process prior to publication of the Project Assessment Draft Report.

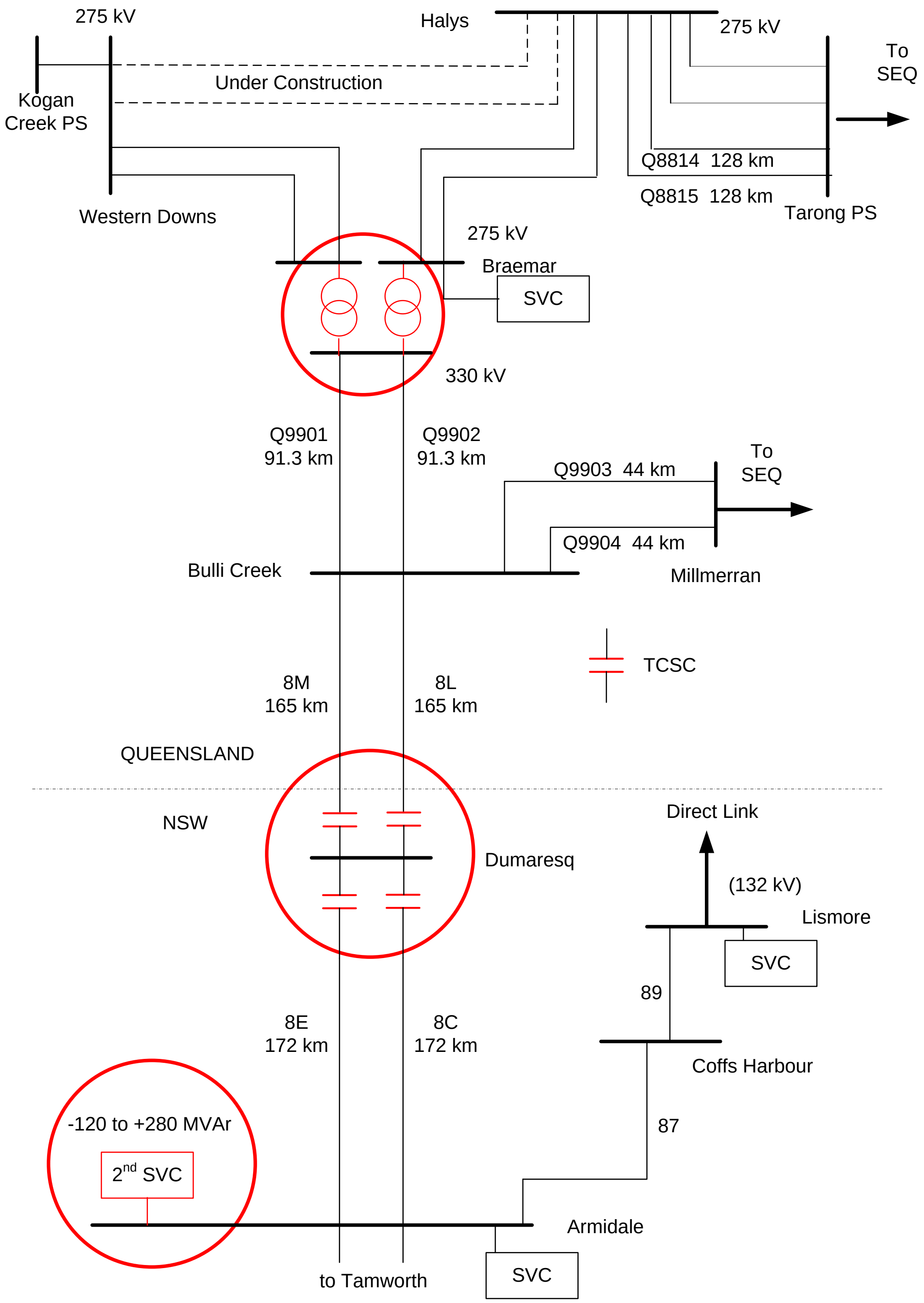
Technical Characteristics

The scope of works for this option would include:

- Works as described above for the four TCSC banks in option 1a;
- The installation of one SVC with a range of -120 MVAr inductive to +280 MVAr capacitive at nominal voltage and connected to a 330 kV busbar;
- The installation of one 330 kV switchbay (with a 50 kA short-circuit rating) for connection of the SVC to the 330 kV bus at the site; and
- Upgrade of the existing 330/275 kV transformers with 1500MVA units at Braemar Substation

The resulting change to the export limits this option would provide for a range of generator and system operating conditions for critical contingencies are outlined in Table 3.5, 3.6, 3.7 and 3.8. Preliminary modelling indicates that the increase in transfer capacity (transient stability and voltage control) from Queensland to NSW under this option would be around 590 to 800 MW, whilst transfer capacity from NSW to Queensland would increase between 230 MW to 380 MW.

Figure 3.3 Option 1b – Series Compensation with Second Armidale SVC



Queensland to NSW transfer[5]

Table 3.5 50% Series Compensation - 2014/15 Average Export Limit and Standard Deviation

Series Compensation	Transient Stability Export Limit (MW)		Improvement in Export Limit (MW)	
	Average	Standard Deviation	Average	Standard Deviation
50%	2,060	90	710	110

Table 3.6 50% Series Compensation - 2014/15 Queensland to NSW Export Limit

Contingency	Average Transient Stability Export Limit (MW)			Average Improvement in Export Limit (MW)		
	Low Demand	Medium Demand	High Demand	Low Demand	Medium Demand	High Demand
Bulli Creek Fault	-	2,100	2,140	-	760	800
Liddell-Tamworth Fault	1,950	2,080	-	590	740	-

NSW to Queensland transfer

Table 3.7 50% Series Compensation - 2014/15 Average Export Limit and Standard Deviation

Series Compensation	Transient Stability Export Limit (MW)		Improvement in Export Limit (MW)	
	Average	Standard Deviation	Average	Standard Deviation
50%	830	80	320	70

Table 3.8 50% Series Compensation - 2014/15 NSW to Queensland Export Limit

Contingency	Average Transient Stability Export Limit (MW)			Average Improvement in Export Limit (MW)		
	Low Demand	Medium Demand	High Demand	Low Demand	Medium Demand	High Demand
Trip of Kogan Creek Gen.	870	900	-	230	350	-
Liddell-Tamworth Fault	-	910	730	-	360	380

Construction Timetable and Anticipated Costs

It is expected that it would take around four years to complete. The preliminary cost estimate, which is subject to confirmation, is approximately $200 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital cost.

[5] The transient stability limit may exceed the thermal capacity of QNI

National Transmission Network Development Plan

The addition of the SVC to the series compensation option is not covered in the 2010 NTNDP.

3.3.3. Option 2 – Second Armidale SVC

This option involves the installation of a second Static VAr Compensator (SVC) nominally at Armidale 330 kV substation and provision of additional 275/330kV transformer capacity at Braemar.

The addition of the second SVC at Armidale would increase the level of dynamic reactive reserves within the northern NSW network. This would enable an increase in the level of northerly and southerly QNI transfer capability.

The installation of an SVC would not increase the line thermal rating limitations in the system.

TransGrid would be the proponent of this option, which is shown in diagrammatic form in Figure 3.4.

The SVC is likely to be installed at a new Armidale 330kV switchyard near to the existing Armidale 330/132kV Substation. The optimal location of the SVC will be identified as part of the detailed design and analysis process prior to the issue of the Project Assessment Draft Report.

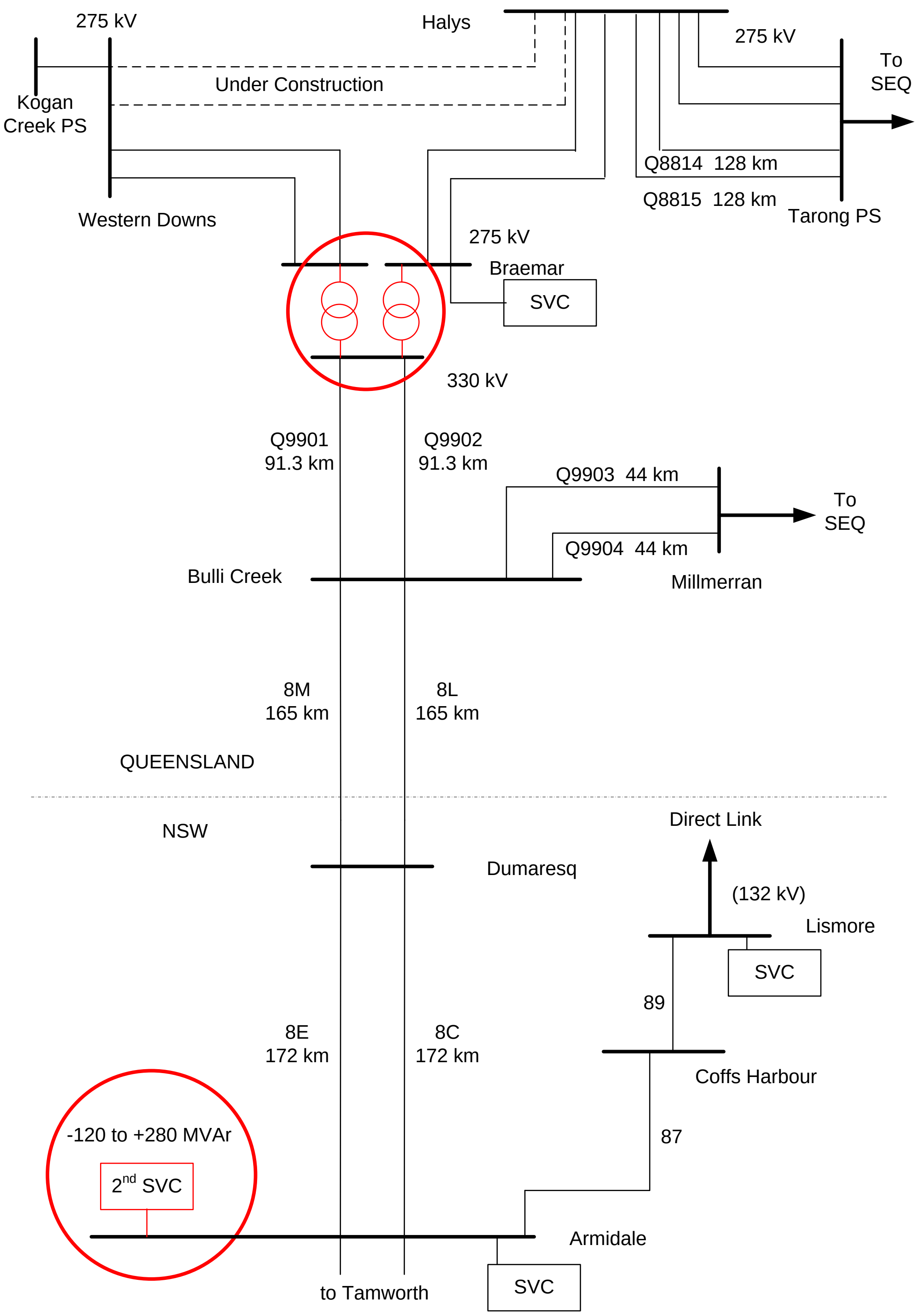
Technical Characteristics

This scope of this option would include the following:

- The installation of one SVC with a range of -120 MVAr inductive to +280 MVAr capacitive at nominal voltage and connected to a 330 kV busbar;
- The installation of one 330 kV switchbay (with a 50 kA short-circuit rating) for connection of the SVC to the 330 kV bus at any of the nominated sites; and
- Upgrade of the existing 330/275kV transformers with 1500MVA units at Braemar Substation.

The resulting change to the export limits under a range of generator and system operating conditions for critical contingencies are shown in Tables 3.9 and 3.10. Preliminary modelling indicates that the increase in transfer capacity (transient stability and voltage control) from Queensland to NSW under this option would be from 70 MW to 80 MW, whilst transfer capacity from NSW to Queensland would increase from between 100 MW to 130 MW.

Figure 3.4 Option 2 – Second Armidale SVC



Queensland to NSW transfer

Table 3.9 2014/15 Queensland to NSW Export Limit

Contingency	Average Transient Stability Export Limit (MW)			Average Improvement in Export Limit (MW)		
	Low Demand	Medium Demand	High Demand	Low Demand	Medium Demand	High Demand
Bulli Creek Fault	1,450	1,420	1,410	80	80	70

NSW to Queensland transfer

Table 3.10 2014/15 NSW to Queensland Export Limit

Contingency	Average Transient Stability Export Limit (MW)			Average Improvement in Export Limit (MW)		
	Low Demand	Medium Demand	High Demand	Low Demand	Medium Demand	High Demand
Trip of Kogan Creek Gen.	630	660	560	100	120	130

Construction Timetable and Anticipated Costs

It is expected that it would take around four years to complete this option with the establishment new Armidale 330kV switchyard. The preliminary cost estimate, which is subject to confirmation, is approximately $70 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital cost.

National Transmission Network Development Plan

This SVC option has been covered in the 2010 NTNDP.

3.3.4. Option 3 – System Protection Scheme - Fast Fault Clearing Times

This option involves the installation and implementation of high speed System Protection Schemes (SPS) at Liddell and at other sites as described below to allow higher transfer across the existing QNI.

The transfer capability across QNI is set by a series of transient stability and voltage control limitations, and thermal ratings following transmission and generator contingencies. This option involves the implementation of fast acting protection schemes to mitigate large power system disturbances following line contingency events.

The scheme requires pre-determined responses to be automatically taken following critical contingencies on transmission lines to reduce the level of disturbance on the power system. Hence, by reducing the impacts of the disturbance on the system following the contingency, the existing interconnector can operate at higher levels prior to the contingency.

TransGrid would be the proponent of this option.

Technical Characteristics

This option would involve a combination of protection relay upgrades and circuit breaker replacements to reduce the fault clearance times. These would be applied to the following lines:

- Liddell – Tamworth 330kV No.84 line;

- Liddell – Muswellbrook 330kV No.83 line; and
- Liddell – Newcastle 330kV No.81 line.

The scope of work associated with the Liddell – Newcastle 330 kV No. 81 line is:

- Replace the Newcastle Circuit Breaker 812A (NNSNEW1L2); and
- Replace the No.1 Protections at both ends of the line.

The scope of work associated with the Liddell – Muswellbrook No. 83 line is:

- Replace the Muswellbrook Circuit Breaker 832A (NNSMRK1AC);
- Replace the Muswellbrook Circuit Breaker 832B (NNSMRK1BC); and
- Protection changes.

The resulting change to the export limits under a range of generator and system operating conditions for critical contingencies are shown in Tables 3.11 and 3.12. Preliminary modelling indicates that the increase in transfer capacity from NSW to Queensland would increase by 40 MW to 90 MW.

<u>NSW to Queensland transfer</u>

Table 3.11 NSW to Queensland Export Limit Fast Fault Clearing Times Liddell - Muswellbrook

Fast Clearing Times on TL Liddell – Muswellbrook			
Regional Demand	**Transient Stability Export Limit (MW)**		**Improvement in Export Limit (MW)**
	Base Case	**Fast Clearing Times**	
Low Demand	900	950	50
Medium Demand	800	850	50
High Demand	660	700	40

Table 3.12 NSW to Queensland Export Limit Fast Fault Clearing Times Liddell - Tamworth

Fast Clearing Times on TL Liddell – Tamworth			
Regional Demand	**Transient Stability Export Limit (MW)**		**Improvement in Export Limit (MW)**
	Base Case	**Fast Clearing Times**	
Low Demand	800	890	90
Medium Demand	740	800	60
High Demand	620	670	50

<u>Construction Timetable and Anticipated Costs</u>

This option involves lower capital cost and construction lead times than some of the other options but it results in less capacity increase.

It is expected that it would take around two years to complete this option. The preliminary cost estimate, which is subject to confirmation, is approximately $3 million. Given that this option involves replacement of existing equipment, it is expected that there would be little (if any) change to annual operation and maintenance costs.

<u>National Transmission Network Development Plan</u>

This option has not been mentioned in the 2010 NTNDP.

3.3.5. Option 4a – Second High Voltage alternating current (HVAC) Interconnector at 330 kV

This option involves the construction of an additional 330 kV double circuit transmission line and intermediate switching stations between Bayswater and Western Downs substations.

TransGrid and Powerlink would be the proponents of this option, which is shown in diagrammatic form in Figure 3.5.

Technical Characteristics

The scope of work associated with the construction of a second 330kV HVAC double circuit transmission line between Bayswater and Western Downs is:

- Establish three new switching stations, one in the Narrabri/Gunnedah area, one west of Armidale and one west of Dumaresq;
- Construct four double circuit 330kV transmission lines:
  - From Bayswater to the new 330kV switching station in the Narrabri/Gunnedah area;
  - From the Narrabri/Gunnedah site to the new switching station west of Armidale;
  - From the site west of Armidale to the new switching station west of Dumaresq;
  - From the site west of Dumaresq to Bulli Creek; and
  - From Bulli Creek to Western Downs.
- Construct three single circuit 330kV transmission lines:
  - From the new Narrabri/Gunnedah site to the new Tamworth 330kV Switching Station;
  - From the new site west of Armidale to the new Armidale 330kV Switching Station;
  - From the new site west of Dumaresq to the existing Dumaresq 330kV Switching Station.
- Augment the existing substations/switching stations at Bayswater, Tamworth (New), Armidale (New), Dumaresq, Bulli Creek and Western Downs to accommodate the additional transmission line connections.

The intermediate switching stations would be located to enable connections to be made to the existing 330kV switchyards at Tamworth, Armidale and Dumaresq.

The resulting change to the export limits under a range of generator and system operating conditions for critical contingencies are outlined in Tables 3.14 and 3.15. Preliminary modelling indicates that the increase in transfer capacity from Queensland to NSW under this option would be around 1,300 MW, whilst transfer capacity from NSW to Queensland would increase by around 1,070 MW.

Figure 3.5 shows the option in diagrammatic form with a new double circuit line to the west of the existing 330 kV lines between Liddell and Armidale. It is possible that the additional transmission lines may consist of new lines largely along the routes of one or both of the existing single circuit 330 kV lines between Liddell and Tamworth and between Tamworth and Armidale. The end result would be additional 330 kV circuits between Liddell and Armidale via Tamworth. Electrically these developments would be very similar to the system south of Armidale shown in Figure 3.5.

Queensland to NSW transfer

Table 3.14 Queensland – NSW Export Limits for 2nd HVAC 330 kV Line

Description	Number of circuits	Base Case (MW)	2nd Transmission Line (MW)	Transfer Improvement (MW)
Bayswater to Western Downs 330 kV DC	2	1,200	2,500	1,300

NSW to Queensland transfer

Table 3.15 NSW to Queensland transfer Level for 2nd HVAC 330 kV Line

Description	Number of circuits	Base Case (MW)	2nd Transmission Line (MW)	Transfer Improvement (MW)
Bayswater to Western Downs 330 kV DC	2	480	1,550	1,070

Construction Timetable and Anticipated Costs

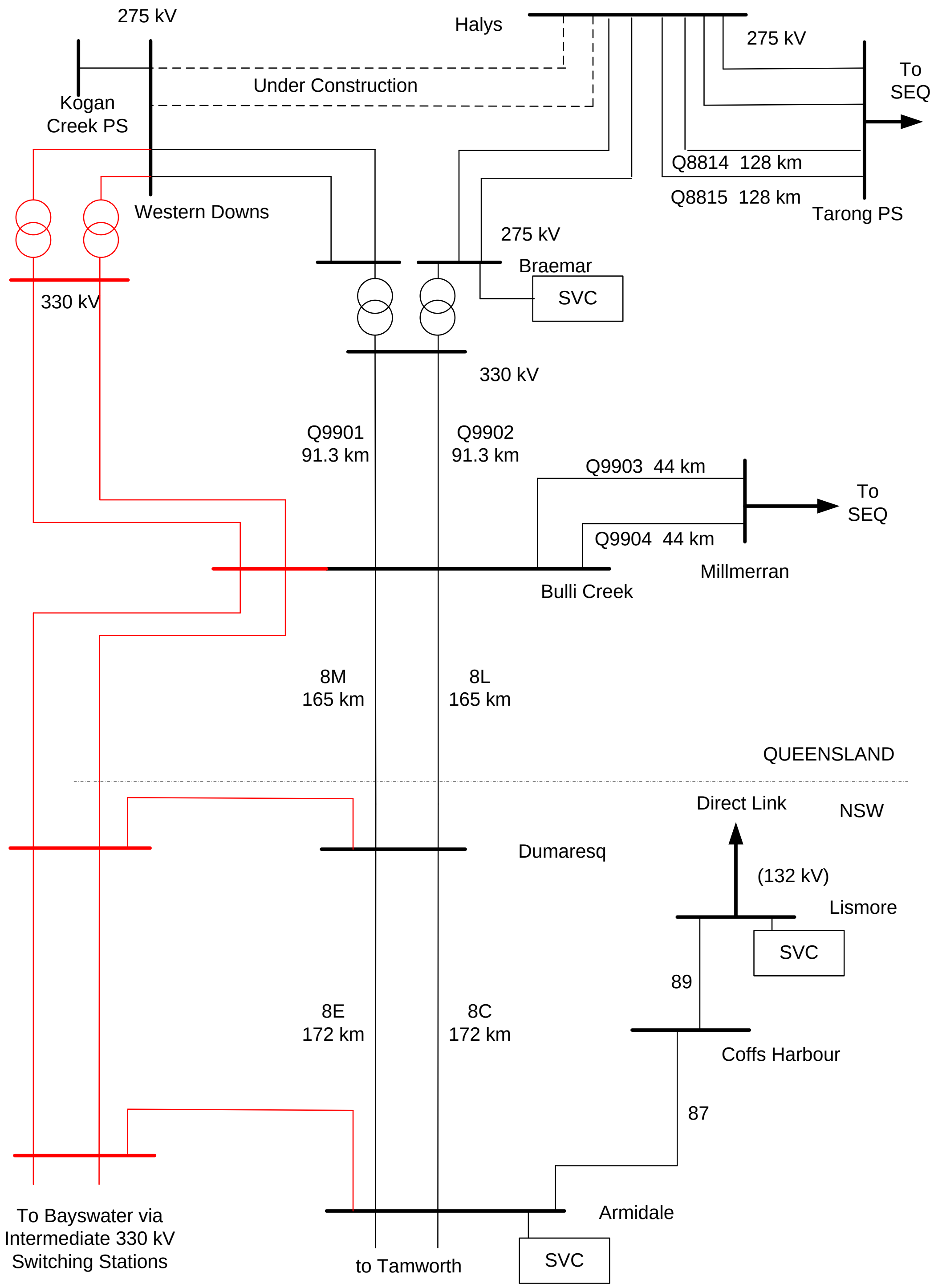
This option involves a significantly higher capital cost and longer construction lead times than some of the other options.

It is expected that it would take around seven years to complete this option. The preliminary cost estimate, which is subject to confirmation, is approximately $1300 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital cost.

National Transmission Network Development Plan

This option has been directly addressed in the 2010 NTNDP.

Figure 3.5 Option 4a – Second HVAC 330 kV Interconnector



3.3.6. Option 4b – New Armidale – Bulli Creek High Voltage alternating current (HVAC) Interconnector at 330 kV

This option involves the construction of an additional 330kV double circuit transmission line between a new Armidale 330kV switchyard and Dumaresq, and Dumaresq and Bulli Creek.

TransGrid and Powerlink would be the proponents of this option, which is shown in diagrammatic form in Figure 3.6.

Technical Characteristics

The scope of work associated with the construction of a second Armidale – Bulli Creek via Dumaresq 330 kV HVAC double circuit transmission line is:

- Construct two double circuit 330 kV transmission lines:
    - From the new Armidale to existing Dumaresq switching station;
    - From Dumaresq to Bulli Creek.
- Augment the existing substations and/or switching stations at Armidale (new), Dumaresq and Bulli Creek to accommodate the additional transmission line connections.

The resulting change to the export limits this option would provide for a range of generator and system operating conditions for critical contingencies would be less than those for the option 4a.

Queensland to NSW transfer

Description	Number of circuits	Base Case (MW)	2nd Transmission Line (MW)	Transfer Improvement (MW)
Armidale to Bulli Creek 330 kV DC	2	1,200	2,240	1,040

NSW to Queensland transfer

Description	Number of circuits	Base Case (MW)	2nd Transmission Line (MW)	Transfer Improvement (MW)
Armidale to Bulli Creek 330 kV DC	2	480	880	400

Construction Timetable and Anticipated Costs

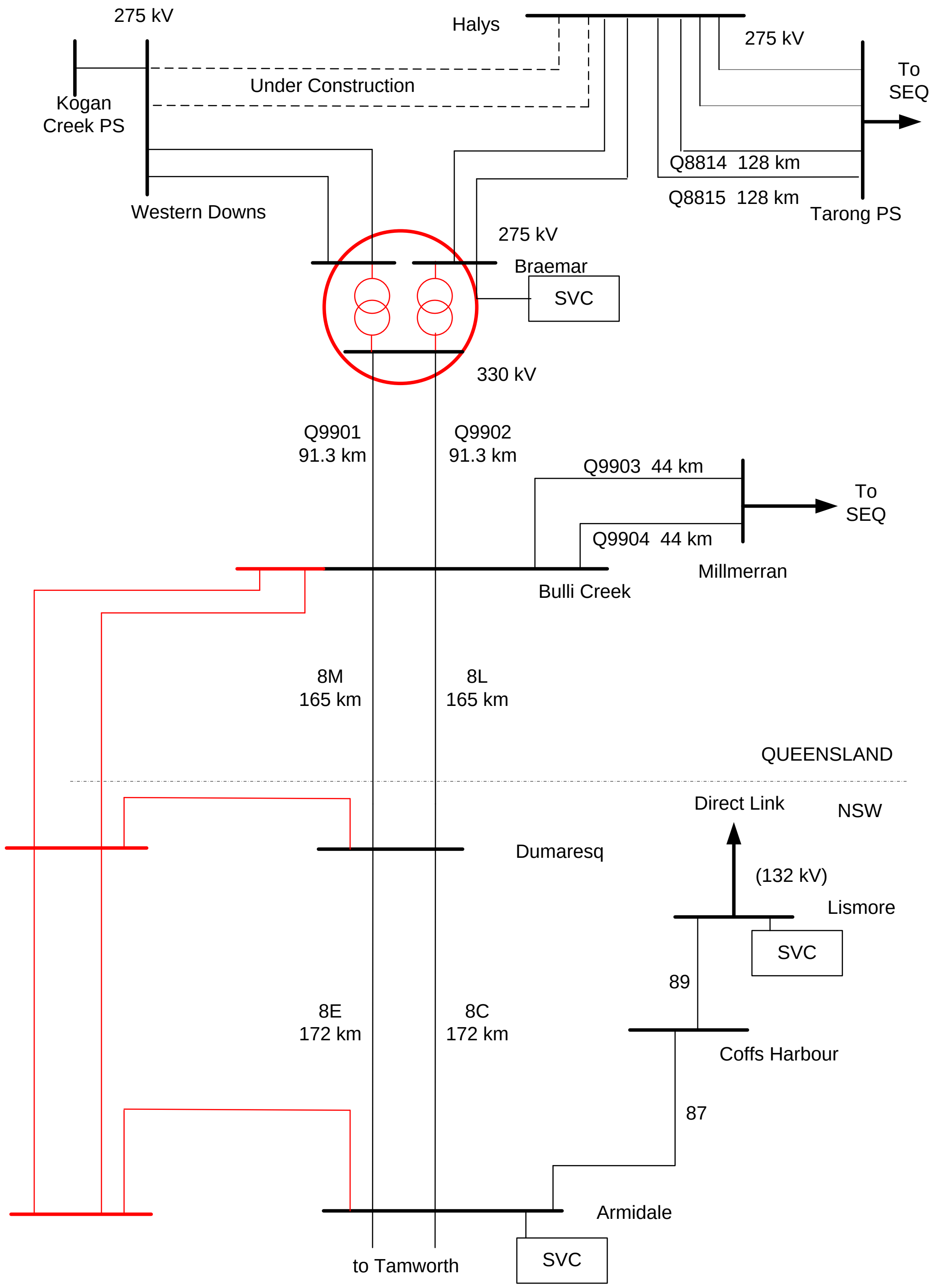
This option involves a significantly higher capital cost and longer construction lead times than some of the other options.

It is expected that it would take around seven years to complete this option. The preliminary cost estimate, which is subject to confirmation, is approximately $500 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital costs.

National Transmission Network Development Plan

This option has not been directly addressed in the 2010 NTNDP.

Figure 3.6 Option 4b – New Armidale – Bulli Creek HVAC 330 kV Interconnector



3.3.7. Option 4c – Second High Voltage alternating current (HVAC) Interconnector at 500 kV

This option involves the construction of an additional 500 kV double circuit transmission line and intermediate switching stations between Bayswater and Western Downs substation in Queensland.

TransGrid and Powerlink would be the proponents of this option, which is shown in diagrammatic form in Figure 3.6.

Technical Characteristics

The scope of work associated with the installation of the proposed 500kV interconnector includes:

- The construction of three new 500/330kV substations at:
  - A site west of Dumaresq;
  - A site west of Armidale; and
  - A site in the Gunnedah/Narrabri area.
- The construction of double circuit 500kV transmission lines with a total route length of approximately 700km;
- The construction of single circuit 330kV transmission lines with a total route length of approximately 235km;
- Augmentations to Dumaresq 330kV switching station, new Armidale 330kV switching station, and new Tamworth 330kV switching station to accommodate the 330kV single circuit transmission line connections to the new 500/330kV substations.
- Augmentations to Bulli Creek Substation to establish a 500 kV switchyard and 500/330 kV transformer.
- Augmentations to Western Downs Substation in Queensland to convert the existing 275 kV switching station to a 500/275 kV substation and connect the 500 kV transmission line.
- Augmentations to Bayswater 500/330kV substation in northern NSW to accommodate the double circuit 500kV transmission line connections.

The intermediate substations are likely to be located in the Gunnedah / /Narrabri area, Armidale area, Dumaresq area and at Bulli Creek to enable connections to be made to the existing 330kV switchyards at Tamworth, Armidale, Dumaresq and Bulli Creek.

The resulting change to the export limits under a range of generator and system operating conditions for critical contingencies are outlined in Tables 3.16 and 3.17. Preliminary modelling indicates that the increase in transfer capacity from Queensland to NSW under this option would be around 2,200 MW, whilst transfer capacity from NSW to Queensland would increase around 1,600 MW.

Queensland to NSW transfer

Table 3.16 Queensland – NSW Export Limits for 2nd HVAC 500 kV Line

Description	Number of circuits	Base Case (MW)	2nd Transmission Line (MW)	Transfer Improvement (MW)
Bayswater to Braemar 500 kV DC	2	1,200	3,400	2,200

NSW to Queensland transfer

Table 3.17 NSW to Queensland transfer Level for 2nd HVAC 500 kV Line

Description	Number of circuits	Base Case (MW)	2nd Transmission Line (MW)	Transfer Improvement (MW)
Bayswater to Braemar 500 kV DC	2	480	2,080	1,600

Construction Timetable and Anticipated Costs

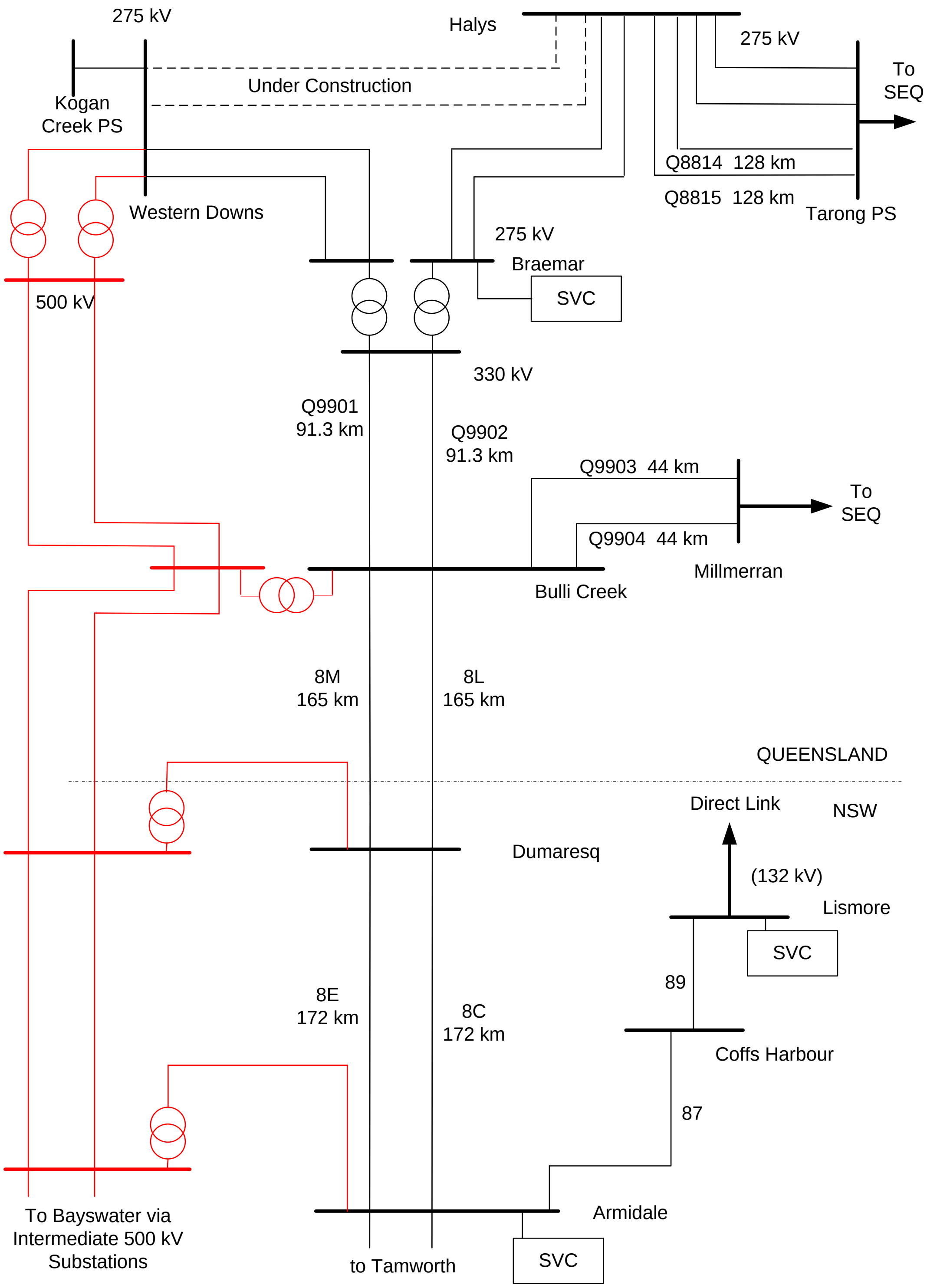
This option involves the highest capital cost and longer construction lead times of all of the options.

It is expected that it would take around seven years to complete this option. The preliminary cost estimate, which is subject to confirmation, is approximately $2,300 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital cost.

National Transmission Network Development Plan

This option forms part of the NEMLink project covered in the 2010 NTNDP.

Figure 3.6 Option 4c – Second HVAC 500 kV



3.3.8. Option 5 – High Voltage Direct Current (HVDC) Back to Back Converter Station

This option involves the installation of a 1,500 MW HVDC back to back asynchronous link located in the interconnected network between Bulli Creek Substation in Queensland and Dumaresq Substation in NSW, together with supporting works. The supporting works may include additional 275/330 kV transformation capacity at Braemar Substation. This option isolates the alternating current systems of the Queensland and the southern state transmission networks.

TransGrid and Powerlink would be the proponents of this option, which is shown in diagrammatic form in Figure 3.7.

<u>Technical Characteristics</u>

In order to ensure reliability of service and to provide a firm transfer capability around 1500MW, a scheme incorporating 5 x 350MW HVDC back-to-back converters operating in parallel would be required for this option.

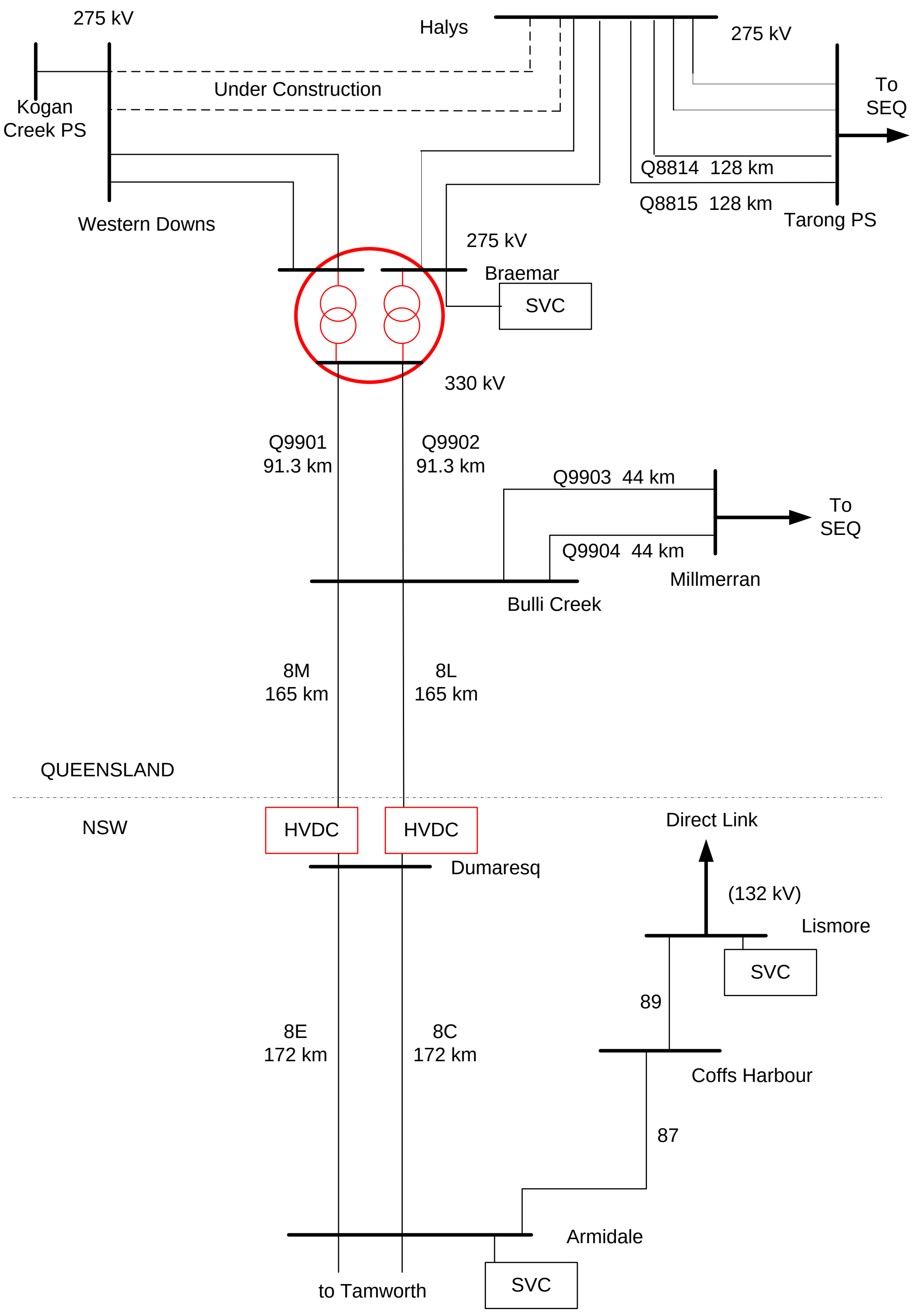
The scope of the works for this option includes the following:

- Development of a HVDC back-to-back scheme north of the existing Dumaresq 330kV switching station;
- The northern terminals of the HVDC scheme to be connected to the re-routed end of the Dumaresq to Bulli Creek lines No.8L and 8M; and
- Upgrade of the existing 330/275 kV transformers with 1500MVA units at Braemar Substation.

The HVDC back to back converter would separate the Queensland and NSW HVAC systems via a direct current connection. This scheme would remove the existing transient stability limitations to power transfer over the interconnector and improve the bidirectional transfer capacity between NSW and Queensland to 1,400 MW. There would be some improvement to the scope to which the existing line ratings could be used.

This option would necessitate additional control schemes to ensure that the interconnected system remains stable under normal operating conditions and that voltage collapse and converter blocking issues are correctly managed following a credible system contingency.

Figure 3.7 Option 5 – HVDC Link



Construction Timetable and Anticipated Costs

It is expected that it would take around five years to complete this option. The preliminary cost estimate, which is subject to confirmation, is approximately $500 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital cost.

National Transmission Network Development Plan

This option has been mentioned in the 2010 NTNDP.

3.3.9. Option 6 – Hunter Valley NSW Braking Resistor

This option involves the installation of a 500 MW braking resistor connected to either the Liddell or Bayswater Power Station 330kV busbar to improve the NSW to Queensland transfer over QNI only. The braking resistor at either of these locations would not provide any improvement to the Queensland to NSW transfer capability.

At this stage it is not certain that a braking resistor of the required size could be implemented. This will be investigated further prior to publication of the Project Assessment Draft Report. Should it prove to be feasible, TransGrid would be the proponent of this option.

Technical Characteristics

This option would involve the installation of control, communication and switching systems to control a 500 MW 330kV braking resistor.

The scope of work associated with the installation of the Braking Resistor for this option includes:

- Construction of the two circuit breaker switchbay;
- Erection, test and commissioning of the 500 MW Braking Resister; and
- Commissioning the 330kV switchbay.

The resulting change to the export limits under a range of generator and system operating conditions for each critical contingency are outlined in Table 3.18. Preliminary modelling indicates that transfer capacity from NSW to Queensland under this option would increase by around 100 MW.

NSW to Queensland transfer

Table 3.18 Improvement to the NSW to Queensland transient Stability Limitation over QNI

Transient Stability Export Limit Improvement MW			
Braking Resistor MW	Regional Demand		
	Low	Medium	High
500	50	100	100

Construction Timetable and Anticipated Costs

It is expected that it would take around three years to complete this option. The preliminary cost estimate, which is subject to confirmation, is approximately $10 million. Annual operation and maintenance costs are anticipated to be around 2% of the capital cost.

National Transmission Network Development Plan

This option has not been mentioned in the 2010 NTNDP.

3.4. Summary of Credible Options

Option	Qld to NSW Increase (MW)	NSW to Qld Increase (MW)	Preliminary Cost Estimate ($ M)	Time years
1a Series compensation	470 to 640	210 to 250	150	4
1b Series compensation with SVC	590 to 800	230 to 380	200	4
2 SVC	70 to 80	100 to 130	70	4
3 System protection scheme, FFCT	-	40 to 90	5	2
4a Second 330kV HVAC	1,300	1,070	1,300	7
4b New Armidale – Bulli Creek 330kV HVAC	1,040	400	500	7
4c 500kV HVAC	2,200	1,600	2,300	7
5 HVDC	1,400	1,400	500	5
6 Braking resistor	0	100	10	3

3.5. Options Considered but not Pursued

A number of options and sub-options were considered but not pursued for a variety of reasons.

TransGrid and Powerlink considered:

- 330 kV line development from the Lismore area to south east Queensland via the Gold Coast area.
- 330 kV or 500 kV line developments from the Lismore area to the Queensland system in the Ebenezer area.
- Tripping of a Queensland generator following a trip of a Boyne Island potline.
- New 132 kV transmission lines.

3.5.1. Additional Lines from the Lismore Area

The area around the NSW and Queensland border has a number of National Parks, nature reserves and world heritage listed areas. Areas outside the environmentally sensitive areas are relatively densely populated. Earlier work undertaken by TransGrid and Powerlink associated with securing the current QNI easements confirmed the difficulty of attempting to pursue easements in the areas generally towards the east of the current alignment. Considering the environmental and community impact of the other available options, TransGrid and Powerlink believe that it would not be possible to obtain a route for a transmission line through this environmentally sensitive area. Consequently options involving that were not pursued.

3.5.2. Generator Tripping Options

An option considered in the 2008 report was the installation of a high speed System Protection Scheme (SPS) to automatically trip a Queensland generator following the trip of a Boyne Island potline. Since that time, changes in the network topology have resulted in the associated constraint no longer binding. Consequently, this option was not pursued.

3.5.3. 132 kV Line Options

Options involving 132 kV developments were not pursued due to the low capability of 132 kV lines (particularly over long distances) compared to that of the 330 kV lines making up QNI.

3.5.4. Underground Cable Options

Options involving underground cables including HVDC cables were not pursued due to high cost for the required capacity.

4. Materiality of Market Benefits

The NER requires all market benefits to be considered to be material in the RIT-T analysis unless it can be demonstrated that:

- particular classes of market benefits are not likely to materially affect the assessment of the credible options under the RIT-T; or
- the estimated cost of undertaking the analysis to quantify the market benefit is likely to be disproportionate to the scale, size and potential benefits of each credible option being considered in the report.

This section considers each of the classes of market benefits identified in the RIT-T and highlights those which TransGrid and Powerlink do not expect to be material for this RIT-T assessment, together with the reasons why (in line with NER clause 5.6.5B(c)6).

The classes of market benefits set out in the NER and in the RIT-T itself are:

- Changes in generator fuel consumption arising through different patterns of generation dispatch.
- Changes in voluntary load curtailment (since there is a material impact on pool prices from an interconnector upgrade).
- Changes in involuntary load shedding.
- Changes in costs for parties other than TransGrid and Powerlink, due to:
  - Differences in the timing of new plant;
  - Differences in capital costs; and
  - Differences in operation and maintenance costs (since there may be a deferral of generation investment).
- Differences in the timing of transmission investment.
- Changes in network losses.
- Changes in ancillary services costs.
- Competition benefits.
- Any additional option value.
- The negative of any penalty paid or payable for not meeting the LRET.
- Any other benefits that TransGrid and Powerlink determines to be relevant for a specific RIT-T assessment and which are agreed to by the AER in writing before the PSCR is made available to other parties.

Not all of these potential benefits will be material for the interconnection upgrade. The market benefits expected to be material are covered in Section 2.1.1. The market benefits which are not expected to be material are discussed below.

4.1. Benefits Which Are Not Expected to be Material

At this stage of the consultation, TransGrid and Powerlink consider that the following classes of market benefits are not likely to be material for this RIT-T assessment:

Differences in the Timing of Network Investment

It is envisaged that the known credible options are not expected to affect the timing of other transmission investments (to meet unrelated needs). However, this matter will be reviewed as part of the detailed development of the Project Assessment Draft Report.

Changes in Ancillary Services Costs

The cost of Frequency Control Ancillary Services (FCAS) may change as a result of changed generation dispatch patterns and changed generation development following an augmentation to QNI.

FCAS costs are relatively small compared to the total market costs and the cost of FCAS is not likely to be material in the selection of the preferred option.

The inclusion of FCAS in the market modelling would require a significant modelling assessment, which would be disproportionate for this specific RIT-T assessment, as it would be unlikely to change the ranking of the credible options. TransGrid and Powerlink therefore do not propose to estimate the impact on FCAS costs for this RIT-T assessment.

There are presently no Network Control Ancillary Services arrangements provided by generators near to QNI or related to QNI. It is therefore unlikely that NSCAS costs would be affected as a result of any of the options considered. TransGrid and Powerlink therefore do not propose to estimate the impact on NSCAS costs for this RIT-T assessment.

Option Value

TransGrid and Powerlink note the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change and the credible options considered are sufficiently flexible to respond to that change.

TransGrid and Powerlink also note the AER's view that appropriate identification of credible options and reasonable scenarios captures any option value, thereby meeting the NER requirement to consider option value as a class of market benefit under the RIT-T. TransGrid and Powerlink intend to undertake scenario analysis as part of the market modelling, in order to capture the impact of key uncertainties on the assessment of credible options.

For this RIT-T assessment, the estimation of any option value benefit over and above that already captured via the scenario analysis in the RIT-T would require a significant modelling assessment, which would be disproportionate to any additional option value benefit that may be identified for this specific RIT-T assessment. TransGrid and Powerlink therefore do not propose to estimate any additional option value market benefit for this RIT-T assessment.

It should be noted that all of the credible options provide some flexibility to enable compatibility with future network developments. The development of a second HVAC interconnection at 330kV or 500kV provide links that may later form part of the NEMLink project. TransGrid and Powerlink do not believe that the additional option value relating to any of the credible options would affect the selection of the preferred option.

5. Non-Network or Market Network Service Options Performance Requirements

Clause 5.6.6(c)(3) of the NER requires the PSCR to include the technical characteristics that a non-network option would be required to deliver in order to meet the identified need.

In the case of the QNI upgrade the identified need is an increase in market benefits, and in particular the reduction in dispatch costs and deferral of future generation investment as the result of the greater sharing of generation resources between Queensland and the rest of the NEM.

To be considered as alternative options to the expansion of the capacity of QNI, non-network alternatives would also need to deliver these same categories of market benefits.

The following is a guide to the technical characteristics that a non-network option would need to deliver.

Market Benefit	**Non-network or Market Service Options**
Changes in generator fuel consumption arising through different patterns of generation dispatch and competition benefits	The option would need to be able to reduce load in Queensland or NSW at peak demand times so as to reduce the need for peaking or other generators to be dispatched, or to provide a fast response in the event of contingencies, in order to relieve the current operational constraints on the interconnector. Possible alternatives include: • Load reduction at peak load times, in either Queensland or NSW • The shifting of load to alternative time periods, in either Queensland or NSW • Energy storage that uses any surplus of low cost generation to be released at appropriate times, in either Queensland or NSW • Pre-emptive load reduction to reduce the loading on QNI at constraining times • Post-contingent load reduction and generator shedding to counteract the stability limitations on QNI. These actions would need to be very high speed (within a few cycles of a contingency.
Changes in costs for parties other than TransGrid and Powerlink, due to differences in the timing of new plant, capital and operation and maintenance costs	The option would need to defer the need for further generation development in NSW, Queensland or other regions of the NEM. Possible alternatives include: • Load reduction at peak load times, in either Queensland or NSW • The shifting of load to alternative time periods, in either Queensland or NSW • Energy storage that uses any surplus of low cost generation to be released at appropriate times, in either Queensland or NSW

Market Benefit	Non-network or Market Service Options
	• Improved utilisation of existing generating plant, in either Queensland or NSW.

TransGrid and Powerlink note that a non-network option involving an additional generator in either NSW or Queensland is unlikely to represent a non-network alternative. Such a generator would need to be lower cost than current peaking plant used, in order to result in a dispatch cost benefit. It would also represent an option in which additional generation investment occurs sooner, in order to achieve a potential deferral of later generation investment, and so would be likely to have an overall negative net benefit in terms of avoided costs for other parties.

TransGrid and Powerlink note that the magnitude of the market benefit for a non-network option may differ from that of network options. However, overall a non-network option would need to be able to deliver a higher net market benefit (ie, market benefit minus costs) than any of the credible options discussed in Section 3, in order to satisfy the RIT-T.

Proponents on non-network options are invited to make submissions as part of this consultation process.

6. Contact Details for Submissions and Enquiries

TransGrid and Powerlink invite written submissions from Registered Participants, AEMO and Interested Parties on this Report. Submissions are due on or before the 30th November 2012.

Submissions and other queries should be emailed to:

regulatory.consultation@transgrid.com.au

OR

networkassessments@powerlink.com.au

TransGrid and Powerlink have obligations under a number of Acts[6] to divulge information, including under:

- the NER to summarise submissions received; and
- the Government Information (Public Access) Act 2009.

Parties making submissions should note that their submissions may be required to be made publicly available.

Further details in relation to this project can be obtained from:

regulatory.consultation@transgrid.com.au

OR

networkassessments@powerlink.com.au

[6] Refer to www.legislation.nsw.gov.au for NSW Acts.

Appendix 1 Scenarios and Load Forecasts

The scenarios and load forecasts for the preliminary market modelling which has been used in establishing the identified need for an expansion of the effective interconnector capacity are those included in AEMO's NTNDP 2010. Figure A2.1 shows the scenarios included in the NTNDP 2010. The load forecasts are available at:-

http://www.aemo.com.au/planning/ntndp.html

Table 2-1 Scenarios and sensitivities

Scenario name		Alternative carbon price (sensitivity)	
Fast Rate of Change, high carbon price	FC-H	medium carbon price	FC-M
Uncertain World, low carbon price	UW-L	zero carbon price	UW-0
Decentralised World, medium carbon price	DW-M	high carbon price	DW-H
Oil Shock and Adaptation, medium carbon price	OS-M	low carbon price	OS-L
Slow Rate of Change, low carbon price	SC-L	zero carbon price	SC-0