TransGrid

# TransGrid's Submission to the Australian Competition & Consumer Commission

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## Revised Transmission Capital Investment Program 2004-2009

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## Attachment 7A

## Interconnector Capability and Development Options

*November 2004*

# ATTACHMENT 7A


## INTERCONNECTOR CAPABILITY AND DEVELOPMENT OPTIONS

## REVENUE RESET

**Transmission Development**
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# INTERCONNECTOR CAPABILITY AND DEVELOPMENT OPTIONS REVENUE RESET

**CONTENTS**

# INTERCONNECTOR CAPABILITY AND DEVELOPMENT OPTIONS REVENUE RESET

## 1. PURPOSE OF THE DOCUMENT

This document describes the power transfer capability of the interconnections between NSW and the other states and the potential reinforcement options.

## 2. HISTORICAL DEVELOPMENT OF THE INTERCONNECTIONS

The south east Australian interconnected system comprises the power systems of Queensland, New South Wales, Victoria and South Australia. It is expected that Tasmania will be connected via Basslink in 2005.

The main transmission voltages on the mainland are 500 kV, 330 kV, 275 kV and 220 kV.

In the late 1950's the NSW and Victorian systems were interconnected using 330 kV transmission in association with the development of the Snowy Mountains Hydro-Electric Scheme. The output of the Snowy scheme was then shared between NSW and Victoria.

The interconnection was reinforced in 1979 via a Wagga – Jindera – Wodonga – Dederang 330 kV connection. This latter interconnection also provided support to the developing loads at Albury and Wodonga, astride the border between the two states.

The development of the Broken Hill load was the catalyst for interconnection at 220 kV between Darlington Pt, Buronga and Red Cliffs in 1988.

The NSW – Victoria interconnection has provided benefits to both states through the sharing of Snowy generation, the sharing of generation overall, supply to intermediate loads and the close control of frequency typical of large interconnected systems.

Interconnection to South Australia was developed in 1989 via a 500 kV and 275 kV transmission system between Heywood in western Victoria and the Mt Gambier area in south eastern South Australia. The overall route length from Port Augusta in South Australia to northern New South Wales is about 2800km.

In 1999 the entrepreneurial Directlink HVDC project was completed linking the far north coast of NSW to the Queensland Gold Coast System.

In 2000 Queensland was connected to NSW via a 330 kV and 275 kV HVAC system that extended from the Hunter Valley in NSW to the Tarong Power Station in Queensland. The overall route length of the interconnected system from South Australia to northern Queensland was extended to about 4400km.

QNI has provided benefits in sharing of generation between Queensland and the southern states, the connection of the Millmerran Power Station and close control of system frequency.

In 2002 the entrepreneurial Murraylink HVDC project was completed linking the far north west of Victoria to the Riverland of South Australia.

## 3. COMPONENTS OF THE NSW INTERCONNECTIONS

In this document the interconnections are viewed as forming the electrical connections between the states and between the NSW main system and the Snowy generators. Also included are the critical intra-regional parts of the network that may determine the interconnector capability. Hence the interconnectors in this document don't directly align with the interconnectors between the Regions of the NEM.

### 3.1 NSW – Queensland

The connection between NSW and Queensland is comprised of QNI and Directlink.

Directlink is connected within the far north NSW 132 kV system supplied from Lismore 330/132 kV Substation.

For export from NSW the power transfer capability is determined by the capability of the 330 kV and 132 kV system supplying the Lismore area and the three 132 kV lines from Lismore 330/132 kV Substation to Lismore 132/66 kV Substation.

For export from Queensland the power transfer capability is determined by the capability of the Gold Coast system.

QNI connects Armidale and Dumaresq 330 kV switchyards in NSW to Bulli Ck in Queensland. This interconnection is supported by the 330 kV system extending from Liddell in NSW and the 330/275 kV system extending from Bulli Ck to Tarong. The NSW mid north coast 132 kV system also operates in parallel with the northern NSW 330 kV system. The power transfer capability of QNI is partly determined by the capability of these supporting systems and loads connected in these systems.

A 330 kV line is being constructed from Millmerran to Middle Ridge in Queensland and this augmentation will also affect the power transfer capability of QNI.

### 3.2 NSW - Snowy

The Snowy region to NSW system comprises the system between switching stations in the Snowy NEM region and the Yass / Canberra area and thence to the south coast of NSW. The south west area of NSW, comprising the load centres of Wagga, Jindera, Darlington Pt and Broken Hill is also supplied from the Snowy area.

The interconnection between Snowy and NSW comprises the following 330 kV lines:

- Upper Tumut Switching Station to Yass
- Upper Tumut Switching Station to Canberra
- Lower Tumut Switching Station to Wagga

- Lower Tumut Switching Station to Yass
- Lower Tumut Switching Station to Canberra
- Yass to Canberra
- Yass to Marulan (two lines)
- Yass to Sydney
- Canberra to Dapto via Kangaroo Valley
- Lower Tumut to Wagga
- Marulan to Avon and Dapto

### 3.3 NSW – Victoria

The interconnection is formed by the following lines:

- Murray – Dederang 330 kV (2 lines)
- Jindera – Wodonga 330 kV
- Buronga – Red Cliffs 220 kV.

The capability of the Murray – Dederang and Jindera – Wodonga system is governed by the generation conditions at Snowy and the loading in the NSW south west area. The capability of the 220 kV interconnection is dependent on the integrity of the supporting Wagga – Darlington Pt 330 kV and 132 kV systems and the 220 kV line from Darlington Pt to Buronga.

The capability for power transfer between NSW and Victoria is also governed by overall stability considerations.

## 4. FACTORS GOVERNING THE POWER TRANSFER CAPABILITY OF THE INTERCONNECTIONS

The power transfer capability of the interconnectors is governed by considerations of:

- Line thermal ratings;
- Voltage control capability;
- Transient stability; and
- System oscillatory damping.

Any one or all four of these factors may limit the power transfer over any interconnector at any time, the power transfer capability being determined by the most restrictive of the capabilities.

The oscillatory damping performance of the system has been managed through the design of power oscillation dampers on SVC's and power system stabilisers on generators. The interconnected four state system has been tested and shown to have adequate damping capability such that damping is not expected to impose an overriding limitation for the current interconnector capabilities. The tuning of the system is continuing and further testing is required on QNI to release its full capability, this is expected to be completed by 2005 [1].

The capabilities of the interconnectors are generally described by multi-term limit equations with variables that include load levels, generation dispatch and voltage profiles. The power transfer capability is not a fixed quantity but varies as conditions in the supporting systems vary. The capabilities presented in this document are indicative capabilities for the purpose of illustration.

The capabilities are given for system normal conditions, ie with the network intact. The capability is the secure power transfer capability in anticipation of the next credible contingency.

The capabilities presented in the document exclude any necessary safety margins that may be implemented by NEMMCO as part of the NEM dispatch process.

## 5. CAPABILITY - QNI AND DIRECTLINK

The quantification of the capability for NSW export to Queensland and NSW import from Queensland applies to the combined power transfers over QNI and Directlink. The capabilities of QNI and Directlink may be separated under some conditions such as when specifying the capability for Queensland export determined by transient stability.

Indicative power transfer capabilities are shown in the summary below. The recent history of constraints is set out in the Appendix.

Summary of Capability

Line Rating Limitations

| | **Capability** | **Trend With Time** |
|---|---|---|
| NSW Export | At peak load in summer: 390 MW, capability increases as northern load reduces below peak.<br><br>At peak load in winter: 470 MW, capability increasing as northern load reduces below peak. | Summer - declining about 15 MW per annum<br><br>Winter - declining about 10 MW per annum |
| NSW Import | Maximum of 1500 MW in summer due to the rating of the Tamworth – Armidale 330 kV lines<br><br>Total QNI and Directlink limits due to No. 965 rating:<br>2004/5: 980 MW<br>2005/6: 880 MW<br>2006/7: 830 MW | Summer increasing about 15 MW per annum<br><br>Declining capability – subject to local 132 kV network reinforcements |

Voltage Control Limitations

| | **Capability** | **Trend With Time** |
|---|---|---|
| NSW Export | At peak load in summer: 460 MW, capability increases as northern load reduces below peak. | Declining about 20 MW per annum<br><br>Kogan Ck development reduces capability by about 300 MW. |

Transient Stability Limitations

| | **Capability** | **Trend With Time** |
|---|---|---|
| NSW Export | Ranges from 0 to about 700 MW but dependent on loading of Queensland generators | Kogan Ck development reduces capability |
| NSW Import | Up to about 1150 MW expected as QNI testing is progressed. | Trend of marginally increased capability through new line development in Queensland. |

### 5.1 Capability - NSW Export

Line Rating Limits [2]

The rating of the Tamworth – Armidale 330 kV lines is critical. On outage of one of the lines the remaining line carries the loads at Armidale and Lismore 330 kV Substations and export over QNI (and Directlink).

At the time of the 2005 winter peak the minimum export capability is expected to be about 470 MW. As the NSW northern load reduces below peak load the capability increases.

At the time of the 2004/5 summer peak the minimum export capability is expected to be about 390 MW.

Voltage Control Limits [3]

The power transfer capability is determined by the system response to the trip of either a transmission line or heavily loaded generator in Queensland.

The development of the 750 MW Kogan Ck power station is expected to reduce the voltage control capability by about 300 MW.

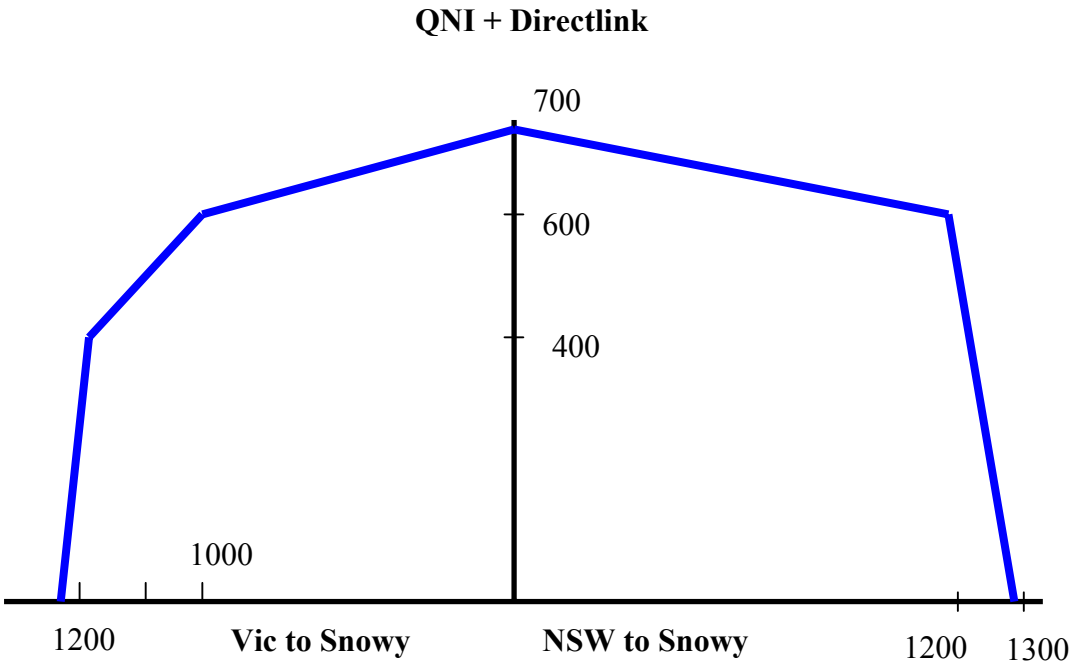
Transient Stability Limits [4]

At any particular system operating condition the transient stability capability is generally determined by either of the following factors:

- The response of the system to a fault on a line, with the fault cleared in primary protection time with all intertrips available; or
- The response of the system to the trip of a heavily loaded generator in Queensland.

The transient stability NSW export capability applies to the total export to Queensland, ie QNI and Directlink combined.

The transient stability capability of the four-state system forms an envelope of the form shown below.




When there is a high power transfer between NSW and Victoria the power transfer capability between NSW and Queensland approaches zero, and vice versa.

For example the transient stability limited power transfer capability is given below under two different conditions:

| System Conditions | NSW export capability | Determining contingency |
|---|---|---|
| Low NSW demand<br>Snowy to NSW 600 MW<br>Vic to Snowy 1000 MW<br>SA to Vic 250 MW<br>Major NSW units in service<br>Pumping at Snowy and Wivenhoe<br>One Millmerran unit in service | 360 | Line fault |
| High NSW demand<br>Snowy to NSW 1100 MW<br>Snowy to Vic 1000 MW<br>Vic to SA 500 MW<br>Major NSW units in service<br>One Millmerran unit in service | 500 | Trip of a Callide C unit |

The most significant future impact on NSW export capability will be the development of a Kogan Ck generator. Under conditions where the capability is determined by the trip of a heavily loaded unit in Queensland it will generally result in the NSW export capability being reduced by about 280 MW.

### 5.2 Capability - NSW Import

Tamworth – Armidale – No. 86 330 kV Line Rating Limits

The rating of a Tamworth – Armidale 330 kV line is critical. One outage of one of the lines the remaining line carries the import over QNI and Directlink minus the loads at Armidale and Lismore 330 kV Substations

At the time of the 2004/5 summer peak the minimum import capability is expected to be about 1500 MW - maximum.

Armidale – Kempsey No. 965 132 kV Line Rating Limits

The Armidale – Kempsey 132 kV No. 965 line was uprated in 2003.

The following import limitations are expected at time of peak NSW load [2]:

| **Peak of summer:** | **Total QNI and Directlink capability** |
|---|---|
| 2004/5 | 980 |
| 2005/6 | 880 |
| 2006/7 | 830 |

In 2006/7 the establishment of Coffs Harbour 330/132 kV Substation partially relieves the loading of No. 965 line.

Transient Stability

The capability is determined by the performance of the system in response to one of the following events:

- Line faults in Queensland; or
- Line faults in NSW; or
- Trip of the largest load in Queensland.

The capability over QNI alone is expected to be up to about 1150 MW once the present 950 MW damping limit is relieved through system testing.

## 6. CAPABILITY - DIRECTLINK

The recent history of constraints is set out in the Appendix.

Summary of Capability

| | **Capability** | **Trend With Time** |
|---|---|---|
| NSW Export | 100 MW at summer peak<br>90 MW at winter peak | Decline by 4-6 MW per year |
| NSW Import | Up to 180 MW governed by Gold Coast conditions | Affected by reinforcement of Gold Coast system |

### 6.1 Capability - NSW Export

The northerly power transfer on Directlink is limited to approximately:

- 100 MW at time of summer peak
- 90 MW at time of winter peak

due to the thermal rating of the 132 kV connections between Lismore 330/132 kV Substation and Lismore 132/66 kV Substation

### 6.2 Capability - NSW Import

The southerly power transfer limit is up to 180 MW determined by the loading on the Gold Coast system.

### 6.3 Future Trend of Capability

The northerly transfer capability will decline due to local load growth of the order of 4 to 6 MW per year.

## 7. CAPABILITY - SNOWY – NSW

The capability is specified in four categories:

- NSW export - Marulan – Yass / Canberra network limitation
- NSW import – limitations due to the four 330 kV lines north of Snowy
- NSW import – limitations north of Yass / Canberra
- NSW import – limitations between Marulan and the coast

The recent history of constraints is set out in the Appendix.

Summary of Capability

| | **Capability** | **Trend With Time** |
|---|---|---|
| NSW Export | About 300 MW at time of peak load. Higher capability at times of reduced load | Decline about 40 – 50 MW per year |
| NSW Import - Lines North of Snowy | 3340 – 3480 MW in winter<br><br>3185 – 3220 MW in summer | Increase about 15 MW per year |
| NSW Import – lines north of Yass / Canberra | Approximately 3440 MW in summer | Increase as loads from Yass to the south increase. |
| NSW Import – Marulan - coast | Limits arise at time of high western generation and high Snowy to NSW transfers | |

**NSW Import – Limitation North of Snowy** [5]

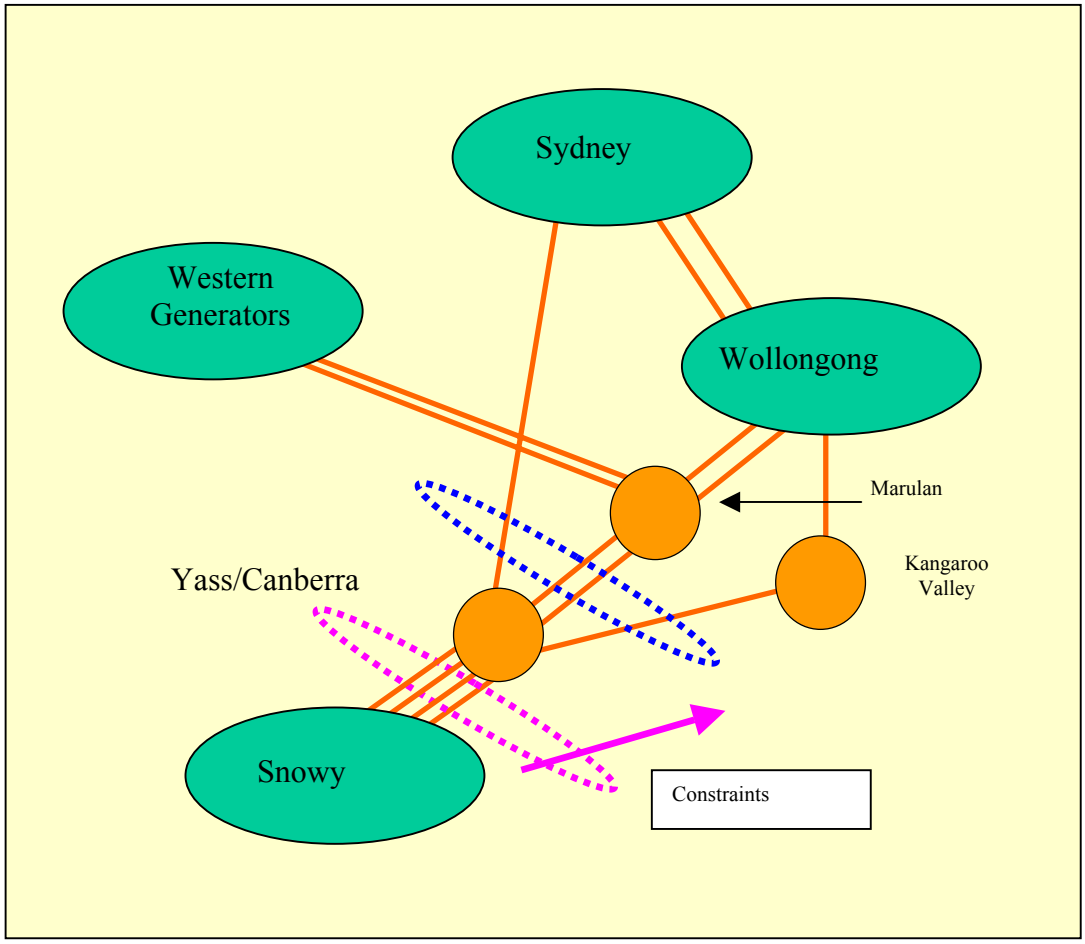
The system limitation north of Snowy is shown in the Figure below.

The ratings of the four 330 kV lines north of Snowy to Yass and Canberra determines the capability for power transfer from Snowy to NSW.

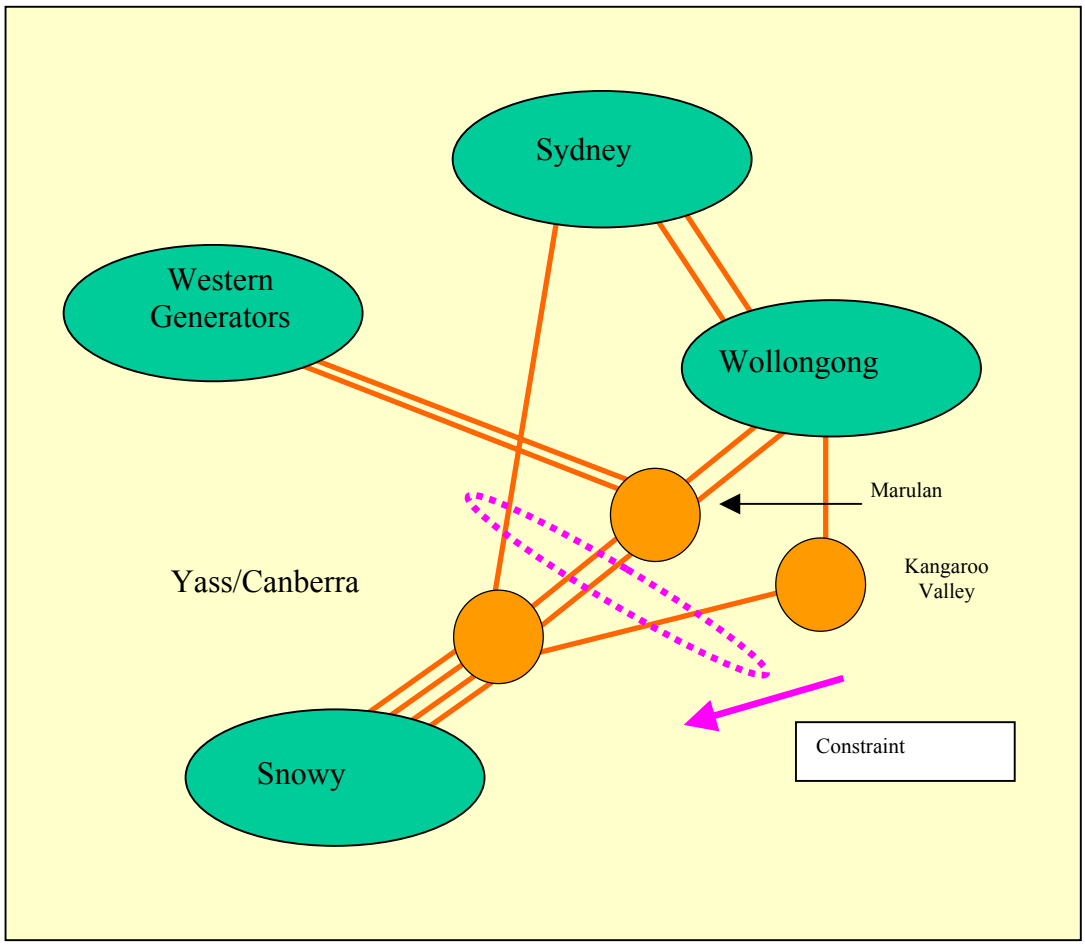
The limitation ranges from 3340 – 3480 MW in winter and 3185 – 3220 MW in summer depending on system conditions. The higher end of the range occurs when the Upper Tumut – Lower Tumut line is opened under system normal conditions.

The rating of lines within the Snowy system can further govern the feasible dispatch of generation within Snowy.

The network between Yass and Marulan does not presently impose an overriding limitation at time of peak load.


Sydney
Western Generators
Wollongong
Marulan
Kangaroo Valley
Yass/Canberra
Snowy
Constraints

**Marulan – Yass / Canberra**



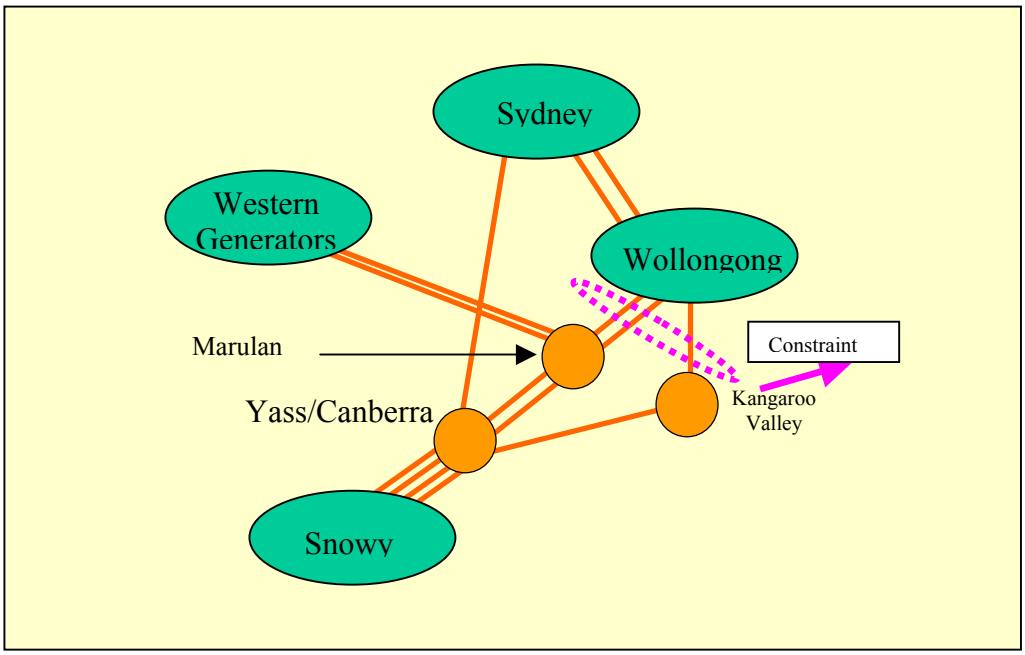

Four 330 kV lines presently extend from Sydney and the south coast to the south west of NSW and the Snowy region as shown in the Figure. The capability of this system immediately south of Marulan to transfer power from Snowy to the north or from the Sydney area into the southwest area of NSW is limited by line thermal ratings.

Power transfer north from Snowy is dictated by the dispatch of Snowy Hydro generation and Victorian export into NSW. Power transfer to the south is governed by load levels in the southwest area, the operation of the Snowy region in the National Electricity Market and power transfer from NSW to Victoria.

The capability has a minimum of about 300 MW at time of peak summer load and increases as the NSW load falls below peak.

The capability is declining at about 40-50 MW per annum as the NSW south west area load grows.

**Marulan - Coast**




Marulan connects to the south coast system via two 330 kV lines. The south coast is further supported by a 330 kV line from Canberra via Kangaroo Valley and two 330 kV lines from Sydney.

When NSW is importing heavily from Snowy and Victoria there can be relatively high power flows between Marulan and the south coast substations. The flow is exacerbated by high generation levels in the western power stations.

A constraint emerges on the lines between Marulan and the south coast due to the limited rating of the lines[1].

[1] Refer to the analysis associated with market "Backgrounds"

## 8. CAPABILITY - NSW – VICTORIA

The capability for transfer between the states is determined by transient stability considerations. Victorian import capability is determined by line rating and voltage considerations.

Summary of Capability

| | **Capability** | **Trend With Time** |
|---|---|---|
| NSW Export | Transient stability – up to about 1000 MW at time of low load<br><br>Falls to near zero at time of high NSW load<br><br>Interaction with QNI capability should be noted | Dependent on generation development. |
| NSW Import | About 1100 MW with a dependence on Vic to SA power flows | |
| Victorian Import | 1900 MW | Reducing by about 15 MW per year |

### 8. 1 Transient Stability

The overall power transfer capability between the states is determined by transient stability considerations.

At times of low to medium demand in NSW the capability for NSW export is up to about 1000 MW.

The capability declines as NSW load increases.

The capability for NSW import from Victoria is about 1100 MW[2].

### 8.2 Victorian Import – Line Rating and Voltage Limitations

The capability is up to about 1900 MW at time of peak NSW load.

The capability is declining with NSW load growth, due to the influence of the NSW south west load [6].

[2] Refer VENCorp website for limit equations for Victorian export

## 9. NSW – QUEENSLAND – REINFORCEMENT OPTIONS

Network reinforcement is required to maintain the existing power transfer capability in response to load growth and generation development. Options are available for increasing NSW import capability without the need for new line development. Large scale interconnection development is feasible.

Various options for short term and long term reinforcement have been assessed by TransGrid and Powerlink [7].

### 9.1 Maintaining Existing Capability

#### 9.1.1 NSW Export

To maintain the existing NSW export capability up to the time that Kogan Ck Power Station is completed would require that the following factors be addressed:

- The impact of increasing northern NSW load on the loading in the Tamworth – Armidale 330 kV line
- The impact of increasing northern NSW load on overall voltage control limitations.

The Armidale – Tamworth lines were upgraded as part of the QNI development works. It is expected that there is no further scope for upgrading the most critical No. 86 line.

One reinforcement option is the replacement of the No. 86 line with a higher rated line or development of a new parallel line.

Voltage control limitations would require additional capacitor support.

At this stage the thermal rating of the Tamworth – Armidale 330 kV line No. 86 limits any other potential gains.

Impact of Kogan Ck Power Station

In order to offset the impact of Kogan Ck Power Station the following works are expected to be required [4] :

- Line series compensation (to 70%) of the Armidale – Dumaresq double circuit 330 kV line and the Dumaresq - Bulli Ck 330 kV double circuit line; and

- Shunt capacitor support

The lead-time for this development is expected to be about 4 years.

#### 9.1.2 NSW Import

The rating limitation of the No. 965 line will need to be overcome to maintain the existing NSW import capability at time of peak NSW northern load. There are two main options:

- Installation of power flow control on No. 965 line. This may be accomplished by summer 2007/8 [8]

- Upgrading of the Coffs Harbour – Kempsey 66 kV line to 132 kV operation. This requires works in the Country Energy system.

The capability for NSW import will be dependent on the network developments in the mid north coast area. These are set out in the APR.

The lead-time for the power flow control facility is about 3 years.

### 9.2 Increased NSW Import

There is potential for improving the NSW import capability by about 150 MW. The options include line series compensation (to 70%) of the Armidale – Dumaresq double circuit 330 kV line and the Dumaresq - Bulli Ck 330 kV double circuit line.

The above options for addressing the rating limitation on No. 965 line are also required.

The lead-time for this development is expected to be about 4 years.

### 9.3 Significant Increase in Capability

Significant upgrading of the interconnector capability would require new line developments and probably power system control developments to overcome stability constraints.

A recent joint study by TransGrid and Powerlink has indicated that a major uprating of QNI is unlikely to be justified under the ACCC's regulatory test. This analysis was undertaken before announcement of the Kogan Ck Power Station development and the study is being repeated with the change in base case assumptions.

The development of power stations in Queensland, such as the recently announced 750 MW generator at Kogan Creek, is expected to increase the frequency of high power transfers towards the south over QNI. The development of such large unit generators will reduce the northwards capability, which at times is defined by the need to allow for an unsheduled trip of the largest generating unit in Queensland.

#### 9.3.1 Additional NSW – Queensland HVAC Interconnector

This concept involves an additional AC interconnection between New South Wales and Queensland, operating in parallel with QNI. It could provide a capability of about 800 MW for southward and northward power flows.

This concept is not developed in relation to the feasibility of obtaining easements and full assessment of transient stability and damping implications. It is likely to require the development of a back-to-back HVDC link at a convenient point in the interconnection.

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The concept would require a number of preceding, but as yet uncommitted 330 kV and 275 kV developments within New South Wales and Queensland, some of which

could be driven by intra-regional reliability requirements. For example, reinforcement of supply on the Darling Downs in Queensland and reinforcement of supply to the Lismore area in New South Wales. The NSW system south of the Hunter Valley would also require reinforcement.

Works in Queensland

- 330 kV line from the New South Wales border to an as yet undetermined point in south east Queensland
- Substation works at the Queensland terminal, and possibly other points in south Queensland

Works in New South Wales

- 330 kV line from the Hunter Valley in NSW to the Queensland border
- Substation works at a number of NSW substations

The power transfer capabilities of the New South Wales – Queensland, New South Wales – Snowy – Victoria and Victoria – South Australia interconnection, governed by transient stability considerations, are inter-related. Increased export from Queensland to the south will impact on the New South Wales export capability to Snowy – Victoria.

The lead-time for such a development is expected to be of the order of 7 years.

### 9.3.2 Additional NSW – Queensland HVDC Interconnector

This conceptual proposal would involve a high capacity point-to-point HVDC link between Queensland and New South Wales, integrating with the present QNI network.

It would comprise a bipolar ± 500 kV line between the Hunter Valley in New South Wales and the Tarong area in Queensland together with converter stations at each terminal.

The HVDC interconnection would be rated at approximately 2000 MW northward and southward.

The concept assumes the significant ongoing augmentation of the intra-regional networks and reinforcement to support a capability of 2000 MW in either direction.

The works would include a 800 km ± 500 kV HVDC line, terminal converter station and substation works. Intra-regional developments in NSW, particularly south of the Hunter Valley, would be required.

The power transfer capabilities of the New South Wales – Queensland, New South Wales – Snowy – Victoria and Victoria – South Australia interconnection, governed by transient stability considerations, are inter-related. Increased export from Queensland to the south will impact on the New South Wales export capability to Snowy – Victoria. The HVDC link controls could be arranged to optimise the capability of the combined HVDC and AC systems.

The lead-time for such a development is expected to be of the order of 7 years.

### 9.4 Directlink Reinforcement Options

For NSW export there is potential for application of a Special Protection Scheme that would initiate a run-back of Directlink following a critical contingency to relieve the system limitations close to Lismore 330/132 kV Substation. Other limitations may apply within the Country Energy system.

The lead-time for this development is expected to be 1 year.

## 10. SNOWY – NSW REINFORCEMENT OPTIONS

### 10.1 Snowy 330 kV Lines

The ownership of 330 kV assets within the Snowy region was transferred from Snowy Hydro to TransGrid in mid 2002. Since taking ownership TransGrid has not changed the rating of the 330 kV transmission lines. Constraints can occur within this region due to the thermal rating of these lines. TransGrid is presently reviewing the condition of these lines and associated terminal equipment with the aim to maximise their thermal rating.

It may be feasible to increase the line rating to 85 degrees C. This would improve the power transfer capability of the system within the Snowy area north of Murray Switching Station by the order of 100 MW.

### 10.2 Snowy to Yass / Canberra

It is not considered feasible to develop and new transmission lines in this part of the network due to environmental constraints.

Some uprating may be possible to improve the NSW import capability.

### 10.3 Yass – Wagga 330 kV Line Development

The development of a single circuit 330 kV line between Yass and Wagga is expected to increase the NSW import capability from Victoria / Snowy by approximately [5]:

Winter: 250 MW
Summer: 275 MW

The development of a double circuit line is expected to provide an additional 120 MW capacity.

In both cases attention will be required to address the limits to power transfer north of Yass.

Such a development may be required to enable any generation development south of Yass to be transmitted to the NSW load a s a whole.

### 10.4 Marulan – Yass / Canberra Area

The transmission system will need to be supported to supply the growing southwest area load with power flow in a southerly direction. Reinforcement by transmission development would also increase the capability for the export of power from NSW to Victoria and possibly from Victoria to NSW.

TransGrid has undertaken uprating of the existing lines between Marulan and Yass in recent times. Further upgrading is planned in the future as required to relieve the system limitations due to ongoing load growth.

TransGrid has considered a number of options for further relieving the supply constraints, including:

- Additional uprating of the Yass to Marulan lines
- Diversion of the existing Sydney West to Yass 330 kV line into Marulan;
- Establishing a substation at the intersection of the Mt Piper – Marulan lines and the Yass – Sydney West line at a site nominally referred to as Bannaby;
- Installation of power flow control equipment on the 330 kV lines; and
- Construction of new transmission lines between Marulan and Yass, which may include 500 kV line development options.

At this stage one indicative network option that will achieve a low level upgrade of the system capability is either the establishment of a new substation at Bannaby or the diversion of the Sydney West - Yass 330 kV line into Marulan. This may be achievable late in this decade. The staging of further upgrading works is under consideration.

The Bannaby site may also be utilised to connect potential wind farms in the southern tablelands area.

### 10.5 Marulan – Coast

TransGrid has considered a number of options for further relieving the supply constraints, including:

- Diversion of the existing Sydney West to Yass 330 kV line into Marulan, in common with the possible network solution set out in 10.4;
- Establishing a substation at Bannaby as described in 10.4;
- Installation of power flow control equipment on the 330 kV lines;
- Development of new 330 kV lines; and
- Uprating of the Marulan – Avon and Marulan – Dapto 330 kV lines.

At this stage line uprating is being investigated and may provide an adequate solution in combination with the diversion of the Sydney West – Yass line to Marulan or establishment of a substation at Bannaby.

### 10.6 Likely Pattern of Reinforcement – NSW Import

The likely pattern of network development to achieve increased power transfer capability from the south, including access to southern generation:

| **Import requirement** | **Works** |
|---|---|
| Up to about 250 MW | Yass – Wagga 330 kV single circuit line development<br><br>Uprating Marulan – Yass 330 kV lines<br><br>Uprating Marulan – Dapto line |
| Above about 250 MW | Yass – Wagga 330 kV double circuit line<br><br>Reconstruction of Marulan – Yass line and/or establishment of Bannaby |

## 11. NSW – VICTORIA – OPTIONS FOR REINFORCEMENT

In summary the options for upgrading the capability for Victorian import include:

- Substation works to maintain a capability of about 1900 MW;
- Line series compensation works to increase the capability by about 180 MW;
- Increased interconnection capability by about 600 MW involving development of a Yass – Wagga 330 kV line;
- Longer-term interconnector development.

The far south-western sector of NSW is supplied via a 330kV line from Wagga to Darlington Point, three 132kV lines from Wagga to Yanco and Finley, as well as a 132kV line from Albury to Mulwala. This network is heavily loaded and it is expected that additional augmentation, most likely by the construction of a further 330kV line to the region, would be required within the next 5 years or so. In addition to that, Country Energy's 66kV network, especially to the Moama area from Deniliquin is reaching its capacity. In conjunction with Powercor and SPI PowerNet, TransGrid and Country Energy have been considering the need to reinforce supply to the load areas along the Murray River.

One option given for augmenting this network is the construction of the second 330kV line to Darlington Point, and lower voltage lines to the Deniliquin / Moama area. A second option is to construct a 330kV line from Wagga to Finley, and then on to the Moama / Echuca area to augment not only the main transmission supplies, but also to avoid proliferation of the new 66kV or 132kV lines to the Murray River region. This option could be further extended to connect to the 220kV network in Victoria and, consequently, to increase inter-regional NSW to Victoria power flow capability.

## REFERENCES

1. Reports by the Interconnector Testing Working Group to the IRPC – latest report 6th October 2004.

2. TransGrid File “Power Systems – Planning – QNI – Thermal Rating Limits” 2003/3426.

3. TransGrid File “Power Systems – Planning – QNI – Voltage Control Limits” 2003/3427.

4. TransGrid File “Power Systems – Planning – QNI – Transient Stability Limits” 2003/3425.

5. TransGrid File “Power Systems – Planning – NSW Import – Victoria – Snowy – Analysis” 2004/2239.

6. N/A

7. “Benefits of Upgrading the Capacity of QNI – A Preliminary Assessment”, Report by TransGrid and Powerlink, 19/3/2004.

8. “The Investigation of the Phase Shift Transformer for the 965 Armidale – Kempsey 132 kV Line” Report January 2004, File ND/P/89

9. “Impact of Series Compensation in Armidale – Dumaresq – Bulli Ck Transmission Lines on Transfer Limit From Queensland to NSW”. Report September 2004, File 2003/3460.

## APPENDIX – RECENT HISTORY OF CONSTRAINTS

The number of hours of constraint on each of the interconnectors for the past year (1/10/2003 to 30/9/2004) is summarised below. Values are indicative.

In some cases discretionary limits are imposed to cover particular system conditions. These have grouped as "limited transfer".

### A1: Directlink

Directlink – NSW Export

| **Constraint** | **Number of hours of constraint** |
|---|---|
| 132 kV line loading Lismore area | 6:40 |
| 132 kV line loading (966 on trip of 96C) | 8:50 |
| Limited transfer to 0 MW | 3:35 |
| Limited transfer to 50 MW | 0:40 |
| Rate of change limit | 21:30 |
| **Total** | **41:15** |

Directlink – Qld export / NSW Import

| **Constraint** | **Number of hours of constraint (hours: minutes)** |
|---|---|
| Total Gold Coast related constraints | **928:40** |

## A2 : QNI and Directlink

QNI and Directlink – NSW Export

| **Constraint** | **Number of hours of constraint (hours:minutes)** |
|---|---|
| 86 line – line rating | 3:45 |
| Limited transfer 100 MW | 0:05 |
| Transient stability | 1:40 |
| Voltage control – loss of largest unit in Qld | 3:50 |
| **Total** | **8:20** |

QNI – NSW Import

| **Constraint** | **Number of hours of constraint (hours:minutes)** |
|---|---|
| Limited transfer | 183:20 |
| 965 capability | 6:00 |
| Transient stability | 416:30 |
| Voltage control – loss of largest unit in Qld | 3:50 |
| **Total** | **609:40** |

## A3 – Snowy – Victoria

Snowy to Victoria

| **Constraint** | **Number of hours of constraint (hours:minutes)** |
|---|---|
| Limited transfer <800 MW | 111:15 |
| Limited transfer up to 1300 MW | 14:20 |
| Dederang transformers | 9:45 |
| Trip of largest Vic generator | 1:25 |
| Murray– Dederang lines | 1:45 |
| Other limits | 25:10 |
| Total | **163:40** |

Victoria to NSW / Snowy

| **Constraint** | **Number of hours of constraint (hours:minutes)** |
|---|---|
| Limited transfer <800 MW | 111:15 |
| Limited transfer up to 1300 MW | 14:20 |
| Dederang transformers | 9:45 |
| Trip of largest Vic generator | 1:25 |
| Murray– Dederang lines | 1:45 |
| Transient stability | 1083:40 |
| Other limits | 25:10 |
| Total | **1247:20** |

## A4 – Snowy – NSW

Due to Intra - Snowy lines

| **Constraint** | **Number of hours of constraint (hours:minutes)** |
|---|---|
| Line ratings | 12:35 |

Snowy to NSW

| **Constraint** | **Number of hours of constraint (hours:minutes)** |
|---|---|
| Limited transfer <3000 MW | 115 |

NSW to Snowy

| **Constraint** | **Number of hours of constraint (hours:minutes)** |
|---|---|
| Limited transfer <400 MW | 0:05 |
| Limited transfer <500 | 0:45 |
| Transient stabilty | 1:30 |
| Total | **2:20** |

### A5 NSW Intra-Regional

| Constraint | Number of hours of constraint (hours:minutes) |
|---|---|
| Bayswater – Liddell lines | 0:55 |
| Yass – Marulan (NSW export) | 2:25 |
| Marulan – Avon / Dapto lines | 7:20 |
| Vales Pt – Munmorah | 0:35 |
| Liddell – Newcastle / Tomago | 2:50 |
| Total | **14:05** |

### A6 Murraylink – Vic to SA

| Constraint | Number of hours of constraint (hours:minutes) |
|---|---|
| Due to NSW south west system constraints | 89:00 |