D Background on the Snowy region

This Appendix provides background to the three Rule change proposals by explaining the background to the National Electricity Market (NEM) regional structure, describing the network in the Snowy region, discussing the Snowy region network loop, and the way in which this has been managed and considering the potential for investment to address the issues arising from congestion in the Snowy region.

Appendices E and F contain additional background on the 1997 decision on the current Snowy region boundary and the historical incidence of constraints, respectively.

D.1 NEM regional structure and Rules on region boundaries

The NEM spot market is priced on a region basis. In 1997, the NEM was established with five regions, and expanded to six regions when Tasmania joined on 29 May 2005. The decision on the appropriate region boundaries was based on technical criteria in the National Electricity Code (NEC or Code) regarding the design of regions (clause 3.5) and modelling of losses (clause 3.6).[454]

The purpose of the region division was to allow market prices to reflect the real-time cost of transmission congestion, where "cost" is based on market participants' bids and offers.[455] Region boundaries were initially established at the points across the NEM where transmission network connection was weak and hence congestion was greatest and/or most likely. This enabled the region boundary structure to facilitate price signalling when generation and demand patterns created network congestion. Generation investors would be encouraged to develop new capacity in regions experiencing high prices and load investors would be encouraged to locate their operations in regions experiencing low prices.

The original version of the Code envisaged that region boundaries would be reviewed annually, and changed as required to reflect and price new points of "material" congestion. Materiality was to be assessed according to a number of technical criteria, including whether network constraints were likely to affect optimal dispatch (taking bids and offers as given) for more than 50 hours over a financial year. Various other technical criteria were also relevant, relating to matters such as the ease of defining transfer limits and the accuracy of static intra-regional loss factors.

---

454 NEMMCO – TIRC 1997, *Report on Marginal Loss Factors and Regional Boundaries for Victoria, South Australia and New South Wales in the National Electricity* Market, NEMMCO, Melbourne, September 1997 (including Recommendation on NEM Regions & MLF, dated 14/08/1998).

455 Cost based on bids and offers received may diverge from the economic cost of dispatch, which is based on underlying resource costs, particularly where generators behave strategically.

Appendix E provides further information on the 1997 Determination of Region Boundaries, but in summary, a separate, generation only, Snowy region was decided upon at NEM start for a number of reasons including:[456]

1. Tidal flows (i.e. power switching direction) in and out of Snowy area, which meant that variance (as measured by the standard deviation of the static marginal loss factor (MLF) under a range of load and generation patterns) was large enough under the Code's criteria to warrant a separate region being created, with dynamic loss equations being used on the interconnectors;

2. Dispatch inefficiencies arising from the use of static loss factors. It was considered that use of a single static MLF at either Murray or Tumut would result in significant dispatch inefficiencies at those times when the actual, dynamic, loss factor diverged substantially from the static MLF; and

3. A generation only region was allowed for in the Code.

Since the start of the NEM, there have been a number of reviews considering the criteria to apply when reviewing the current region boundary structure. These reviews were accompanied by a moratorium on region boundary changes by the NEM Ministers Forum in 2002, pending the development of an appropriate long term framework for making region boundary changes.

The most recent review was initiated by the Ministerial Council on Energy (MCE) submitting a Rule change proposal to the Commission on 5 October 2005 regarding the process and criteria to assess region boundary changes in the NEM. The Rule changes that may result from this proposal would supersede the current moratorium on region boundary changes contained in the Rules.[457] The MCE Rule change proposal on the reform of region boundaries is informed by a report prepared by consultants Charles River Associates (CRA), who were commissioned by the MCE to develop criteria and processes for boundary changes and initial boundary options.[458] The Commission will soon publish its draft Rule determination on the MCE's proposed process for region change.

D.2 Description of the network in the Snowy region

The Snowy region provides a crucial transmission link in the middle of the NEM. The transmission grid within the Snowy region and between NSW and Victoria was designed to deliver energy from the Snowy Mountains to major load centres and to connect the state-based power systems in NSW and Victoria. Figure D.1 shows the network configuration in the Snowy region.

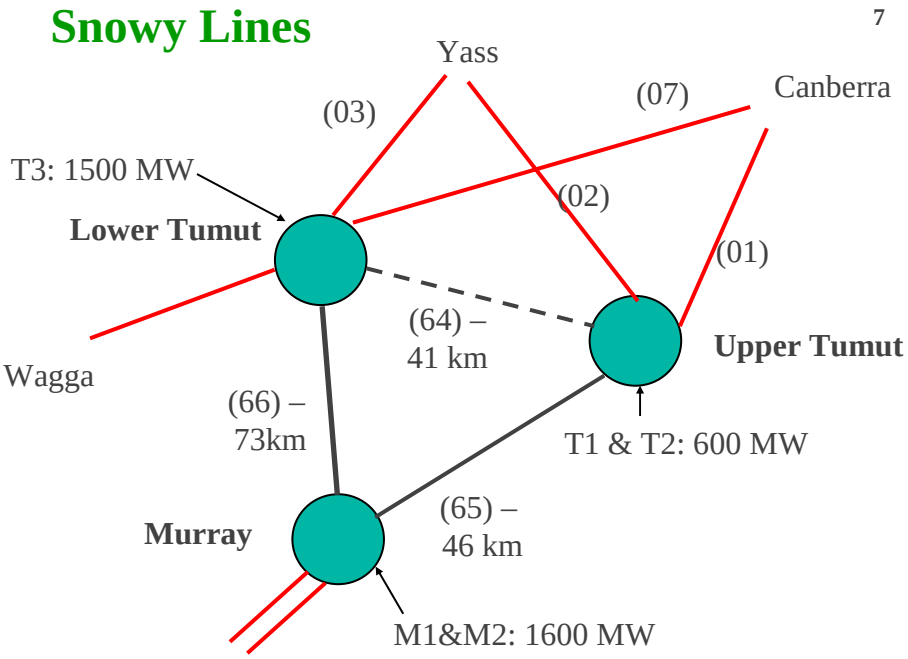
---

456 NEMMCO – TIRC 1997 Report.

457 Clause 3.5.4 of the Rules.

458 Charles River Associates, *NEM – Transmission Region Boundary Structure, Final Report*, submitted to Ministerial Council on Energy, Melbourne, September 2004.

Figure D.1 Transmission lines in Snowy Mountains & connections into NSW & VIC



Note: Transmission line numbers are in brackets. The lines between Murray, Lower Tumut, and Upper Tumut are 330kV lines. M1 and M2 represent the Murray power stations and T1, T2, and T3 represent the Tumut power stations.

Data source: TransGrid

A key feature of the Snowy Region is that it only contains generation and very little demand. Hence, virtually all the electricity generated by the Snowy generators is exported to other NEM regions. Snowy Hydro is the major provider of peaking generation during periods of high Victoria and NSW demand.

The critical transmission elements between Murray and Tumut are the 65 and 66 lines (see Figure D.1). Thermal limits on these lines mean that loading of one line has to be protected against the potential loss of the other. These thermal limits largely determine the typical 1,350MW transfer limit across the Murray–Tumut cutset of lines.[459]

There are multiple lines from the Snowy region into NSW and Victoria, with a substantially higher transfer capacity from Snowy to NSW (commonly 3,100MW) than from Snowy to Victoria (in extreme circumstances up 1,900MW). The differing transfer capabilities are, in part, a legacy of water and power entitlements set out in

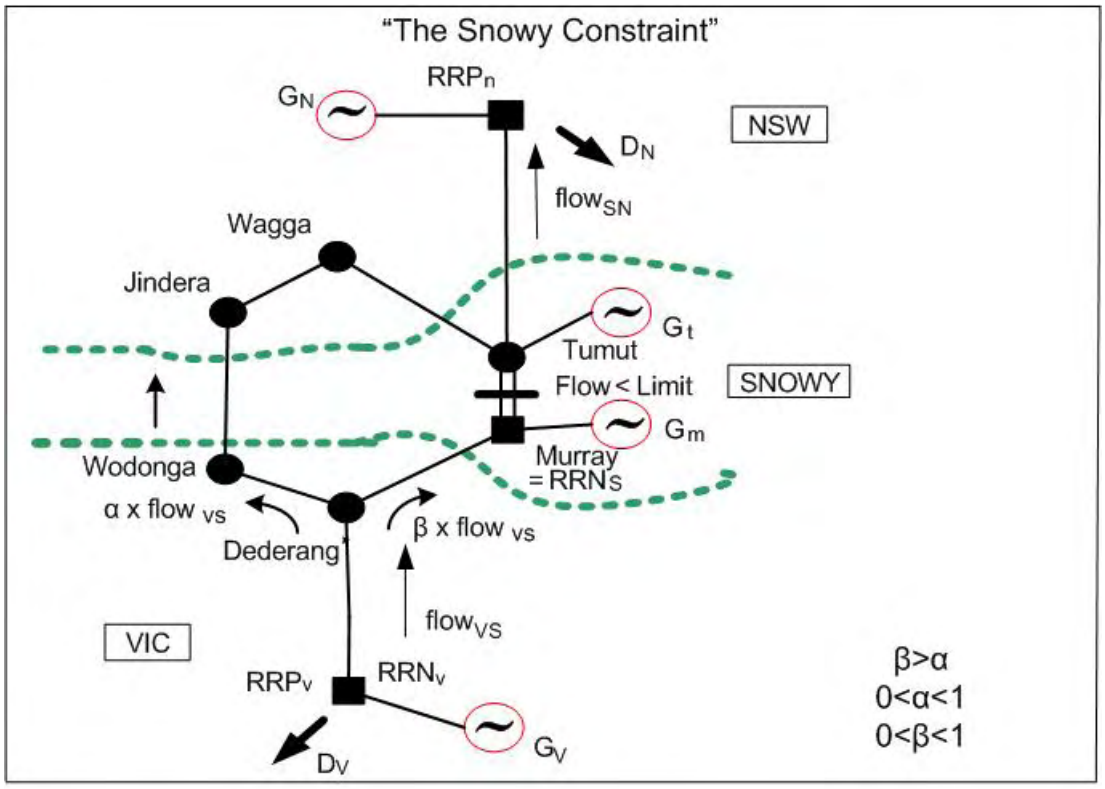
[459] The Murray-Tumut cutset comprises: a) the 64, 65 and 66 lines between Murray, Lower Tumut and Upper Tumut; and b) the 60, 62 and 51 lines between Wodonga, Jindera, Wagga and Tumut. The first group of lines pass over steep alpine terrain in the Kosciuszko National Park.

the 1957 Commonwealth-States Agreement (the Agreement) on entitlements to power and water from the Scheme.[460]

D.3 Loop flows in the Snowy region

Figure D.2 shows the looped network in and around the Snowy Region. Power flows around the loop are determined by the relative impedance of the different paths around the loop and it is common for flow across the Snowy network to alternate from northwards (i.e. Victoria-to-NSW) to southwards on a daily basis. Electricity can also flow both north and south from the Snowy region simultaneously.

Figure D.2 Snowy region network topology



The limit on the Murray to Upper and Lower Tumut transmission lines ranges between 1,250MW and 1,350MW under normal network conditions. The congestion on these lines has increased since NEM start, especially since 2002, and the point of congestion is referred to as the Murray-Tumut constraint. This is a cutset constraint in the sense that it limits flows across a cutset of lines which also include the lines

[460] The Agreement was ratified by the NSW and Victorian parliaments in 1958 — e.g. *Snowy Mountains Hydro-electric Agreements Act 1958 No.20 (NSW)* — and was a schedule added to the *Snowy Mountains Hydro-electric Power Act 1949*.

between Wagga and Wodonga. Appendix F present information on the incidence of binding for the Murray Tumut constraint from 2003/04 to 2006/07

D.3.1 Implications of the Snowy network loop

The current location of the Snowy region boundary, combined with the network configuration and limitations within the region, may have a number of implications for the economic efficiency of dispatch and longer term investment incentives. This is because the regional reference price (RRP) for the Snowy region is set at Murray, and lies on a physical transmission loop that straddles three regions. Congestion on this loop can result in the marginal value of electricity (as measured by the "shadow price") around the loop varying when a constraint binds between Murray and Tumut.[461] Describing the network loop as going from Murray to Dederang to Tumut, if the constraint binds in a northward direction, the shadow price of electricity rises through the loop.[462] If the constraint binds in a southward direction, the shadow price falls through the loop.[463]

This means that given that the Snowy regional reference node (RRN) is at Murray, and in the absence of constraints between Dederang and Melbourne, the Dederang shadow price will be similar to the Victorian RRN price. The consequences of a constraint between Murray and Tumut are that:

- The Victorian RRN price will exceed the Snowy RRN at times of northward flows – implying counter-price flows from Victoria to Snowy in the absence of intervention; and

- The Snowy RRN price will exceed the Victorian RRN at times of southward flows – implying counter-price flows from Snowy to Victoria in the absence of intervention.

These pricing outcomes may, in turn, have several important implications for dispatch and risk management.

First, Snowy Hydro and other generators may face incentives to bid their plant in a way that does not reflect their underlying costs. As discussed in more detail in Appendix A, this may result in inefficient dispatch.

---

[461] The "shadow price" of electricity is equal to the marginal value of electricity at the relevant location on the transmission network. At the regional reference node (RRN), the shadow price of electricity sets the price for the region. However, at all other nodes within a region, the shadow price can be above or below the RRN price, depending on whether the marginal value of electricity at that location is greater or less, respectively, than at the RRN. For example, if an injection of electricity at a particular location would help alleviate a constraint that affects the price at the RRN, the marginal value of electricity (and hence the shadow price) at that location would typically be greater than the price at the RRN. On the other hand, if an injection of electricity at a particular location would exacerbate a constraint that affects the price at the RRN, the shadow price at that location would typically be less than the price at the RRN.

[462] In other words, the shadow price of electricity at Tumut would exceed the shadow price at Dederang (i.e. Victoria), which in turn would exceed the shadow price at Murray.

[463] In other words, the shadow price of electricity at Murray would exceed the shadow price at Dederang (i.e. Victoria), which in turn would exceed the shadow price at Tumut.

Second, counter-price flows (i.e. when power flows from a higher priced to a lower price region) result in negative settlement residues. This can affect the usefulness of inter-regional settlement residue (IRSR) units (sold through Settlement Residue Auctions (SRAs)) as a hedging mechanism for participants to manage the risk of entering inter-regional financial contracts, as discussed in Appendix A. The occurrence of negative residues has also historically been a trigger for intervention by the National Electricity Market Management Company (NEMMCO) (in the form of "clamping" flows or "re-orientating" constraints under the derogation in Part 8 of Chapter 8A of the Rules), which can distort economic dispatch.[464]

D.3.2 Interim congestion management measures

A number of interim measures have been introduced to the Snowy region to address some of the issues arising from counter-price flows and the associated generator incentives. The introduction of the Tumut Constraint Support Pricing /Constraint Support Contract Trial (Tumut CSP/ CSC Trial) on 1 October 2005 changed the settlement outcomes (and hence bidding incentives) for generators located at Tumut at times when the Murray–Tumut constraints bound. At times of northward flows and constraint between Murray and Tumut, generators located at Tumut now receive the Tumut nodal shadow price. This is similar to the NSW RRN price in the absence of binding constraints between Tumut and Sydney. The NSW RRN price tends to be higher than the Snowy RRN price set at Murray at these times. At times of southward flows and constraints between Murray and Tumut, the trial leads to Tumut receiving the Victorian RRN price on most of its output instead of the (typically lower) NSW RRN price.

The Commission's final Rule determination to make the Southern Generators Rule on 14 September 2006[465] introduced a new mechanism for managing negative settlement residues arising on the Victoria-Snowy interconnector. The Rule requires positive settlement residues on the Snowy to NSW interconnector to be used to offset negative settlement residues accruing on the Victoria to Snowy interconnector (in both directions). This was intended to enhance the usefulness of Victoria to Snowy IRSRs, particularly for participants in Victoria seeking to hedge contracts referenced to the NSW RRN, and to overcome the imperative for NEMMCO to intervene in dispatch or pricing.

These interim measures were deemed necessary pending introduction of a longer term solution to address the congestion and associated issues.

D.4 Investment options

Investment to increase the transmission capacity between Murray and Tumut could address some of the issues associated with the Snowy region. The 2005 and 2006

---

[464] A detailed explanation of the occurrence of counter price flows caused by the Snowy region is contained in the Commission's Final Rule Determination on the Management of Negative Settlement Residues in the Snowy Region, 14 September 2006, Section 2.3, p.7-8.

[465] AEMC 2006, *Management of negative settlement residues in the Snowy region*, Final Rule Determination, 14 September 2006, Sydney. Available on AEMC website.

Annual National Transmission Statement (ANTS) highlighted that there are potential benefits to upgrading the Victoria to Snowy and Snowy to NSW interconnectors, but that preliminary investigations concluded that such upgrades are, at best, marginal and unlikely to pass the Regulatory Test.[466]

TransGrid, who owns the transmission network in the Snowy region, has (in conjunction with VENCorp) investigated a range of longer term options to upgrade the interconnectors. Two of the options (NEWVIC Stage 1 and NEWVIC Stage 2) involve upgrading the capacity of the Murray-Tumut cutset, while the remaining two options (NEWVIC 2500 and 3500) entail the construction of new transmission lines to the west of the existing Murray-Tumut cutset.[467] None are presently deemed to be worth pursuing because they are unlikely to pass the reliability limb of the Regulatory Test. However, TransGrid considers that upgrading the NSW network that supplies the Newcastle-Sydney-Wollongong area ("western ring") from 330KV to 500KV as a pre-requisite for any upgrading of the network between NSW and Victoria.[468] The 500kV upgrade has passed the Regulatory Test and TransGrid intends completing the work by 2009/10.[469]

Environmental considerations also influence the possibility of investment in the Snowy region transmission network. Some of the current lines between Murray and Tumut are on some of the steepest terrain in Australia, which would make investment expensive.[470] Further, engineering works on the steep slopes have the potential to cause soil erosion, which would be a factor in the decision to grant an environmental permit for the works. In addition, the lines are primarily located within the Kosciuszko National Park, which raises a range of environmental issues.[471]

The Commission has sought advice from TransGrid on the potential for a transmission upgrade to the Murray-Tumut cutset to relieve congestion on the interconnector. In October 2006, TranGrid advised the Commission that:[472]

---

466 NEMMCO, *Annual National Transmission Statement*, 2005 and 2006.

467 For details of these four options, see TransGrid, *Annual Planning Report 2006*, pp.88.

468 TranGrid consider the most pressing transmission capacity upgrade to its network involves improving voltage support into the Newcastle-Sydney-Wollongong area, so that reliability and security of supply can be increased. TransGrid believe that the best means of improving voltage support entails finishing the construction of a 500kV transmission ring around Sydney, which will allow voltage to be better controlled.

469 TransGrid, *2006 Annual Planning Report*, and TransGrid, *Final Report on Proposed New large transmission network asset development to the Newcastle-Sydney-Wollongong Area*, October 2006.

470 For example, the number 65 line running between Murray and Upper Tumut Switching Stations rises from 300 metres at Murray 2 to around 1200 metres near Upper Tumut.

471 Environmental regulations and permits relating to the operations of the Snowy Mountains Scheme in the Kosciuszko National Park are set out in a range of documents, including: *Snowy Hydro Act 1997*; Snowy Park Lease; Kosciuszko National Park Plan of Management; Road Maintenance Agreement; Schedule of Existing Developments; Snowy Management Plan; and *Snowy Mountains Cloud Seeding Trial Act 2004*. For details, see: NSW National Parks and Wildlife Service, *2006 Plan of Management Kosciuszko National Park*, NSWPWS, Sydney. Available: http://www.nationalparks.nsw.gov.au/npws.nsf/Content/k_np_mgmtplan

472 TranGrid, Submission on Investment Options in the Snowy Region, 30 October 2006.

1. TransGrid's 2006 Annual Planning Report (APR) contains the latest information on options to upgrade the NSW to VIC (particularly Sections 7.3.12 and 7.3.13).

2. Initial assessments of an Aerial Laser Survey (ALS) of the 64, 65 and 66 lines between Murray, Upper Tumut and Lower Tumut indicate:

   (a) that any remedial works to the Murray-Tumut lines is "unlikely to result in any material increase in the capability of these lines. Any substantial increase of this capacity would require a major reconstruction of these lines that are wholly within the Kosciuszko National Park. That work would be subject to passing the "Regulatory Test" and extensive Environmental Approval processes";

   (b) that "uprating the lines…may not substantially change the occurrence of binding constraints in other parts of the NSW to Victoria link" which also limit interconnector flows.

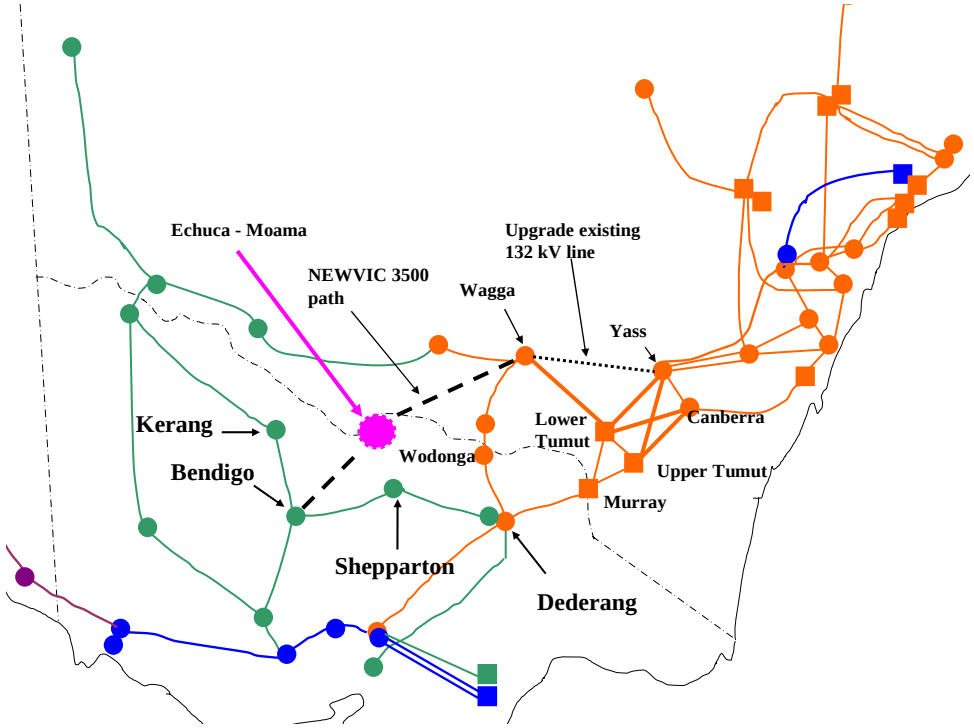
3. "As highlighted in Chapter 7 of the TransGrid's 2006 APR, a number of alternative arrangements to increase NSW-Victoria interconnection have been assessed. It is unlikely that these could be implemented in less than say the next three years. The 2006 Statement of Opportunities (SOO) and the ANTS indicate that this project could have at best marginal market benefits [i.e. with a Net Present Value (NPV) of $10–$100 million]. TransGrid will continue to investigate this upgrade."

The Commission understands that two of the four longer term (5-15 years ahead) options for upgrading transmission capacity between Sydney and Melbourne involve transmission lines south west of Wagga, to the west of the Murray-Tumut cutset. These two options, NEWVIC 2500 and NEWVIC 3500, appear to offer the greatest potential for increased transfers between the Victoria and NSW regional reference nodes in the longer term. The geography of the area west of Wagga is flat, open farmland, which is likely to mean that upgrades to transmission capacity there will be relatively cheaper than if the same upgrades were carried out in steep alpine terrain.

Further, the Commission is aware that there is significant load growth in the area to south-west of Wagga (in the Euchuca-Moama area) that may necessitate increased transmission capacity being built 5 to 15 years into the future (Figure D.3).[473] Any such transmission upgrades could eventually form part of a new, 500kV branch of the NEWVIC 3500 interconnector between Sydney and Melbourne. Should that potential augmentation prove to be economic in future, it could relieve the loading of lines on the Murray-Tumut cutset by providing an alternative, higher voltage, parallel path to the existing 330kV lines.

[473] TransGrid, *Annual Planning Report 2006*, pp.86-87.

Figure D.3 Possible route for the NEWVIC 3500 option



Note. 500kV lines (blue), 330kV lines (orange), 220kV lines (green), 275kV lines (purple),

Source: TransGrid

The Commission notes that building out the congestion across the Murray-Tumut cutset does not appear to be a viable alternative to a boundary change in the next three to five years, based on current assessments under reliability limb of the Regulatory Test. The Commission also understands that upgrades to the Murray-Tumut lines that involve raising the height of transmission towers are likely to require extensive outages over many months. Such outages would likely lead to physical separation of the southern and northern regions of the NEM for extended periods of time, causing considerable market disruption.

In its 2007 Annual Planning Report, TransGrid confirmed that works to rehabilitate the transmission lines between Lower Tumut and Upper Tumut, Murray and Upper Tumut and Murray and Lower Tumut in the Snowy area were underway. However, there is no new information on either the NEWVIC 2500 or NEWVIC 3500 projects.

This page has been intentionally left blank