I Network Support and Control Services

Network Support and Control Services (NSCS) are those services procured and delivered by either Transmission Network Service Providers (TNSPs) or NEMMCO for the purpose of managing network flows to ensure the secure and reliable operation of the power system. This Appendix describes the historical development of the framework for NSCS procurement and delivery and notes that these arrangements have been subject to repeated reviews since 1997. This Appendix also provides a comprehensive definition of existing NSCS and the current rationale for the various forms of service provision.

I.1 Network Support & Control Service History

This section traces the development of services characterised herein as Network Support and Control Services (NSCS), providing context for the evolution of how key services have been defined and how various reviews through the history of the NEM have impacted on responsibilities for the procurement and delivery of NSCS.

I.1.1 Ancillary services pre-market start

I.1.1.1 The National Grid Management Council

In the early history of the development of the NEM – when the National Grid Management Council (NGMC) was the driving force – service categories were not clearly or consistently defined among the vertically integrated (State-owned) electricity entities. Consequently, approaches and definitions adopted by the NGMC were likely to be the first attempt to classify services and suggest responsibilities for service procurement and delivery within a national electricity market.

An NGMC paper from November 1994 [302] sets out the earliest available thinking on the subject of ancillary services in a national electricity market. The philosophy adopted by the NGMC in that 1994 paper on the provision of ancillary services was that the system operator would, wherever possible, operate markets in ancillary services, stating:

> "The objective of the electricity market is to increase economic efficiency through competition. In keeping with this objective, the level of services required to support the operation of the power system and their sourcing should be determined through market forces wherever possible. However it is recognised that some aspects of these services can make this difficult to achieve. These include:
>
> - shared benefits can lead to free rider problems;

[302] *National Grid Management Council, National Electricity Market Project, Ancillary Services & Reserves*, Market Trading Working Group, (draft for comment) version 0.1, 15 November 1994.

- provision of services may be difficult to quantify and monitor;

- the service may be achievable by different mechanisms which are not directly comparable;

- the requirement may be localised, with a local monopoly [in] its provision; and

- fully market based provision of the service may be complex and not cost effective.

As a result, pragmatic and less ideal arrangements may have to be considered in the interim and the level of service may have to be determined centrally rather than via market forces. The cost of each service provided may be determined by market forces or as a result of commercial negotiations between the service providers and the System Operator. In any commercial negotiations, the System Operator will examine the opportunity costs of various alternatives. The costs of providing these services should be shared on an equitable basis between all participants."[303]

Definitions of service categories inevitably evolved as the structure of a national market and its rules for operation were developed. The NGMC proposed the following as one possible categorisation of ancillary services:

<u>System Security</u>

- system security control schemes (e.g. islanding, generator reduction control schemes); and

- black start and restart capability.

<u>Frequency Control</u>

- generator governor action;

- automatic generation control (AGC);

- automatic load shedding schemes (underfrequency tripping); and

- demand reduction schemes.

<u>Voltage Control</u>

- generator reactive capability; and

- automatic load shedding schemes; and

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[303] Ibid., pp.2-3.

- generator network support.[304]

Although the NGMC work probably set the scene for future development of NSCS, no mechanisms for procurement and delivery were formalised at that stage.

I.1.1.2 NEM1 Phase 2, Ancillary Services Project

Following the initial efforts of the NGMC, the next significant step in the development and consolidation of ancillary services after the early draft stages of the NGMC Code of Conduct, was in a 1997 report for the NEM1 Phase 2, Ancillary Services Project.[305] This report established arrangements for the procurement of ancillary services prior to market start, the intention being for VPX and TransGrid to enter into ancillary service contracts that would be novated to NEMMCO on the commencement of the NEM. An extract from the report outlining the definition of services and project objective is repeated in Box 1.

Box 1: Extract from Ancillary Services Project Working Group report: definition of services and project objective

Definition of Ancillary Services in the context of NEM1 Phase 2

"Ancillary Services are those services performed by generation, transmission and control equipment which are necessary to support the transmission of electric power from producer to purchaser given the responsibilities of the operating authorities to maintain safe, secure and reliable operation of the interconnected power system.

The services include both mandatory services and services subject to competition."

Project Objective

The objective of the NEM1 Ancillary Services project is:

"To achieve a consistent set of arrangements for the procurement of and payment for the required Ancillary Services in line with the above definition which (in priority order):

1. *will be practical to implement by July 199;*
2. *do not require significant investment in new monitoring hardware and/or IT facilities to administer;*
3. *provide adequate short and long term price signals to users and providers of the services; and*
4. *are capable of operating until NEMMCO has completed its review of the ancillary services arrangements in accordance with Clause 3.13.1 of the draft National Electricity Code."*

With respect to support and control services, the report established sub-categories of ancillary services as follows:

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304 Op. cit., p.7.

305 *NEM1 Phase 2 Ancillary Services Project Report, Recommendations for the procurement of ancillary services and for reimbursement by the market*, VPX and TransGrid, May 1997.

Voltage control – which includes services from:

- Generator unit reactive;
- Transmission plant reactive;
- Other reactive plant (e.g. hydro machines as SynCons, distributors and EHV customers);
- Emergency load shedding schemes; and
- On load tap changers on transformers.

Stability control – which includes services from:

- Excitation systems;
- Power system stabilisers; and
- Rapid generating unit unloading.

Network loading control – which includes services from:

- Automatic generation control (AGC);
- Rapid generator unloading; and
- Interruptible load shedding.

The recommendations that emerged from the Ancillary Services Project Working Group report formed the basis of Schedule 9G of the Code.[306] Schedule 9G articulated arrangements for procurement and cost recovery of all ancillary services:

- Frequency control,
- Voltage control,
- Stability control,
- Network loading control, and
- System restart.

Schedule 9G was deemed to be a more practical arrangement (than those in Chapter 3 of the Code) for the start of the NEM and remained in place until the completion of the first ancillary services review.

[306] A derogation of clause 3.11 in relation to acquisition, delivery and settlement of ancillary services. Schedule 9G was a Jurisdictional derogation that, in essence, sought to extend VPX / TransGrid pre-market arrangements, but also included some specific arrangements for Queensland.

I.1.2 Evolution of ancillary services post market start

I.1.2.1 The first ancillary services review

The (first) ancillary services review was a requirement of the Code as it existed at NEM-start.[307] The Code indicated [at clause 3.11.1]:

> (c) In conjunction with its obligations under clause 3.8.9(d), NEMMCO must investigate, consult with Code Participants in accordance with the Code consultation procedures and report to NECA within 2 years of market commencement on the possible development of market-based arrangements for the provision of ancillary services, including a short term market in which Market Participants which are not parties to ancillary services agreements may submit offers for the provision of regulating capability or contingency capacity reserve.

The review referred to in the above clause was completed in August 1999[308]. As a general comment on the ancillary services arrangements that prevailed in the first two years of the NEM, the report of the review stated:

> "None of the parties most involved in the current arrangements finds them satisfactory. Contract negotiations for the initial round were protracted and difficult both for NEMMCO and the parties that responded to NEMMCO's invitation to tender. Generators feel they are unfairly and unreasonably required to provide too many services for free under the mandatory requirements of the Code and connection agreements. Retailers feel they are unfairly and unreasonably required to pay for all services, when they consider that they are not the cause of the requirement (although their customers may be). Many of these real or perceived problems are inherent to the central procurement of ancillary services overlaying a competitive energy market. "[309]

With respect to recommendations for future arrangements for network control ancillary services (NCAS) – that is, all ancillary services other than frequency control and system restart – the report of the review stated:

> "Initial arrangements for voltage control (contingency and continuous) services are proposed as follows:
>
> - NEMMCO would remain responsible for the dispatch of voltage control services and for ensuring that there are sufficient voltage control services from a power system security perspective.

[307] The review clause (with minor modifications regarding timetables) was included in the Code until version 5.6 was replaced by version 5.7 (Gazetted 9/8/01).

[308] *Evaluation of options for an ancillary services market for the Australian electricity industry, A project commissioned by the NEMMCO Ancillary Services Reference Group, Final Report*, Intelligent Energy Systems, August 1999.

[309] Ibid. p.vii.

- Contracts (for hedging/procurement) would be written between generators and TNSPs / NEMMCO depending on the clarification of responsibilities for reactive reserve.

- For reactive generation that is required due to the connection of a generator and that is consequently specified in a connection agreement, no cost associated with reactive reserve. For reactive above this level, negotiated contracts that specify availability and enablement components. Compensation to be payable if generating plant needs to be backed off to provide the reactive service.

- Although testing of an AC load flow nodal pricing model that would price reactive energy in the context of energy spot trading is proposed, the co-dispatch of generator reactive capability with the energy spot market may not be warranted or feasible in the transitional phase.

Initial arrangements for Stability and Network Offloading [or network loading control] services are proposed as follows:

- Negotiated contracts are recommended as the most appropriate arrangement for procuring stability and network loading services for the foreseeable future.

- The arrangements would require NEMMCO to provide information on potential schemes and the service that they would provide. This would need to be included in the Statement of Opportunities.

- Further consideration of markets in NCAS should be preceded by a review of the basis for and structure of the currently defined generic (security) constraints applied in the SPD."[310]

The recommendations of this first review were (largely) implemented as proposed.[311] Reflecting the final dot point immediately above, Code changes requiring further review of non-market ancillary services (the NCAS review) were made, inserting a requirement in clause 3.1.4 of the Code[312] as follows:

(a1) *NEMMCO* must review, prepare and *publish* a report on:

…

[310] Ibid. p.xiv.

[311] NCAS continued to be procured on the basis of long-term contracts (per Schedule 9G of the Code) until a new NCAS tendering process [supported by new clause 3.11 in Version 5.7 of the Code (Gazetted 9/8/01) was implemented for NCAS contracts commencing 1 July 2002 and SRAS contracts commencing 1 July 2003.

[312] Version 5.7 of the Code (Gazetted 9/8/01).

(4) the provision of *network control ancillary services* including:

(i) a review of the responsibilities of *NEMMCO* and *Transmission Network Service Providers* for the provision of *reactive power support*;

(ii) a review of the formulation of those generic *network constraints* within *central dispatch* that are dependant on the provision of *network control ancillary services*; and

(iii) a program to assess the potential implementation of market mechanisms for the recruitment and *dispatch* of *NCAS*.

(a2) In conducting the reviews under clause 3.1.4(a1) …

(2) elements of the reviews set out under clauses … 3.1.4(a1)(4)(iii) must take into consideration the results of the [*NECA* report that analyses the outcome of trade in *market ancillary services* through the *spot market*.]

The ACCC's authorisation of the Code changes incorporating the NCAS review indicated:

" … the Commission notes a number of reviews may impact upon the future provision of NCAS, including:

- the review of the integration of network services and energy markets [aka NECA's review of the integration of energy markets and network services (RIEMNS)][313];

- the market and system operator review [aka the Market and System Operator Review Committee (MSORC) process][314];

- the Code change process arising from the network pricing review [aka NECA's transmission and distribution pricing review]; and

- the review of the treatment of constraints in the market.

… in relation to NCAS the ancillary services review will need to encompass the outcomes of the other reviews listed above, and in particular the outcomes of the MSORC.

[313] See Section I.1.2.2.

[314] See Section I.1.2.3.

> The MSORC is considering the most appropriate allocation of roles between NEMMCO, as the system operator, and TNSPs as service providers. The outcome of this review will determine which agency should be responsible for procuring NCAS, dispatching NCAS, recovering the costs of NCAS and determining the most appropriate methodology for recovering the costs.
>
> … in terms of timing, any review considering possible market arrangements of future development for NCAS will have to commence after the outcomes of other relevant reviews are known."

The RIEMNS and MSORC process are discussed further in following sections.

The reference to "the review of the treatment of constraints in the market" was likely to be a reference to either or both of: the NEMMCO review on formulation of intra-regional constraints;[315] or the IES review on optimising combined secure and economic dispatch, conducted on behalf of the Reliability Panel.[316] Each of these reviews was scheduled for around that time. The outcomes of neither review had any apparent impact on fulfilment of TNSP / NEMMCO responsibilities for NSCS.

The requirement to conduct an NCAS review per Clause 3.1.4(a1)(4) remains in the current version of the National Electricity Rules although the review referred to has yet to commence for the following reasons:

- the review of network control ancillary services alluded to in clause 3.1.4(a1)(4) had to take account of the NECA report alluded to in clause 3.1.4(a2)(2) – a final version of this NECA report was not released prior to NECA being disbanded;[317] and
- given the possibility of NEMMCO's NCAS review overlapping with the considerations of the Commission's congestion management review (CMR), NEMMCO sought and received the Commission's agreement to delay the commencement of the NCAS review until such time as the CMR is able to provide some guidance as to appropriate direction.

I.1.2.2 The RIEMNS process

The review of the integration of energy markets and network services (RIEMNS) resulted in a report[318] that did not impact in any substantial way on the

[315] See NEMMCO (Network Constraints Reference Group), *Formulation of intra-regional constraints, Issues and options paper*, Version No. 2 (January 2002) available at: http://www.ksg.harvard.edu/hepg/Papers/Nemmco%201-02%20trans%20price%20148-0061.pdf.

[316] Intelligent Energy Systems (IES), *Optimising combined secure and economic dispatch, Report to the Reliability Panel* (February 2003).

[317] This report on frequency control ancillary services has subsequently been made available – see NECA, *Review of market ancillary services*, Final report (June 2004), available at: http://www.nemmco.com.au/ancillary_services/160-0287.pdf.

[318] NECA, *The scope for integrating the energy markets and network services, Stage 1 final report*, August 2001. No subsequent stages of the RIEMNS process were undertaken.

development of network support and control services, although RIEMNS did touch on a couple of issues relating to the management of network congestion:

- provision of network outage information to the market by TNSPs; and
- a proposal for NECA to develop a network performance framework.

Code changes requiring TNSPs to provide network outage information were authorised. However, the ACCC considered that NECA's proposed network performance framework duplicated powers already vested in the ACCC.[319] Consequently, the ACCC did not authorise NECA's proposed Rule changes on the development of a network performance framework.

I.1.2.3 The MSORC process

The report of the Market and System Operation Review Committee (MSORC) was expected to be a key element of the evolution of responsibilities for ancillary services. The NEM Governance and Liability Steering Committee, comprising the NEM jurisdictions and the Commonwealth, established MSORC in late-1999 / early-2000 to assist the Steering Committee to, *inter alia*:

> "address governance issues, including … the allocation of responsibilities for MSO System Security and System Operation functions between NEMMCO and the TNSPs."[320]

With respect to allocation of responsibilities for network control, the members of MSORC were unable to reach agreement, with the report noting:

> "Although it is not a core issue for the MSORC review, the MSORC has given some consideration to the allocation of responsibilities between NEMMCO and the TNSPs regarding the procurement, scheduling, dispatch and funding of NCAS in the NEM.
>
> The MSORC finally resolved to put this issue to one side because a final decision on it would not change any other MSORC recommendations. The MSORC notes that current code change proposals before the ACCC call for NEMMCO to undertake a further review of this issue during 2001. It is suggested however that before NEMMCO can reasonably be expected to find a satisfactory resolution to this issue, it will need some policy decisions in the form of much clearer regulatory principles and guidelines from the

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319 See ACCC, *Determination: Stage 1 of integrating the energy market and network services* (October 2002), available at: http://www.accc.gov.au/content/trimFile.phtml?trimFileName=D03+15425.pdf&trimFileTitle=D03+15425.pdf&trimFileFromVersionId=756520.
The recently commenced reporting of total constraint cost measures by the AER is a second generation manifestation of the "powers already vested in the ACCC".

320 From the MSORC terms of reference, *System Security & System Operation Review Report 1 (Final Draft) System Operator Functions & Responsibilities*, December 2000, Appendix 1.

jurisdictions and/or the ACCC concerning the future scope of TNSPs' regulated network services."[321]

The recommendations of the MSORC report were never implemented.

I.1.2.4 NECA report on generator rebidding

The next change in the network control ancillary services environment came with a requirement for NEMMCO to use NCAS to increase in benefits of trade from the spot market. The requirement arose in the context of Code changes designed to address concerns regarding generator rebidding behaviour.

NECA's inquiry into rebidding resulted in a 2001 report[322] that included some proposals for tackling short-term price spikes and to remove opportunities for generators to exploit inefficiencies arising from: transfer limits across interconnectors; short-term loading constraints; dispatch processes; and network services. With respect to these inefficiencies the report indicated:

> " Our evidence to the South Australian electricity taskforce[323] drew attention to four specific examples of these sorts of inefficiencies and to the need to take urgent action to improve the operation of the market in order to remove the opportunities they create for generators to exploit those inefficiencies:
>
> **efficiency of despatch**. The draft report of our review of the scope for integrating the energy market and network services pointed to the tendency for constraint equations to be written relatively to favour local generation. This is the case, for example, in relation to Ladbroke Grove in South Australia and generators in south-east Queensland. This arguably breaches one of the fundamental objectives of the market, set out in the Code, that intrastate trading should not be treated more or less favourably than interstate trading. It can, and does, lead to relatively more expensive plant being despatched even where cheaper electricity would have been available for import across an interconnector. NEMMCO recently established a reference group to address these issues. That group should report urgently. Its focus should be on ensuring the essential integrity of the fundamental anti-discriminatory objective of the Code and the objective of maximising the benefits of trade. To the extent that meeting any second-order technical obligations imposed by the Code conflicts with fulfilling that overriding objective, those technical obligations should be rewritten. A common complaint from participants is the perceived complexity of the constraint equations, in part as a result of inconsistent formulation. Work is required to increase the quality of constraints to enhance the usability of this critical information; and

321 Ibid, p.11.

322 NECA, *Generators' bidding and rebidding strategies and their effect on prices*, Report, July 2001.

323 The SA Government established the South Australian National Electricity Market Taskforce in March 2001 to assess the impact of the National Electricity Market (NEM) on business and domestic customers in South Australia.

network services. We believe there is scope within the existing arrangements for NEMMCO to make more use of, for example, load shedding, real and reactive support and scheduling, and unit commitment contracts. Network services, including pre-emptive unit commitment contracts and real-time ancillary services, could be developed to help to cope with the consequences of interconnector constraints. The recently-established gatekeeper project is working towards possible solutions to some of these issues. The extent of NEMMCO's current power to enter into such contracts is, however, uncertain. We therefore recommend a change to the Code to give NEMMCO clearer and wider powers to enter into such contracts.

NEMMCO should take the most urgent possible action to address these inefficiencies. The changes we recommend to the Code will help facilitate that action."[324]

As a consequence of the NECA report and subsequent application to amend the Code, the ACCC authorised a change to clause 3.11.3(b) of the Code as follows [insertions from version 7.5 underlined]:

NEMMCO must develop and *publish* a procedure for determining the quantity of each kind of *non-market ancillary service* required for *NEMMCO*:

(1) to achieve the *power system security and reliability standards*; and

(2) where practicable to enhance *network* transfer capability whilst still maintaining a *secure operating state* when, in *NEMMCO's* reasonable opinion, the resultant expected increase in *non-market ancillary service* costs will not exceed the resultant expected increase in benefits of trade from the *spot market*.[325]

This revised clause is retained in the current Rules [now renumbered as 3.11.4].

I.1.3 Current Arrangement for the management of interconnector transfer capability

At present, where interconnector capability is managed, it is done by NEMMCO, but this only applies to two out of five the interconnectors in the NEM — Snowy to New South Wales and Victoria-Snowy. Arguably, these cases represent a "legacy assignment" of responsibilities, dating back to the start of the market in 1998. Transfer capability on the VIC-SA and QNI links is not actively managed by NEMMCO or the respective TNSPs.

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324 NECA, *Generators' bidding and rebidding strategies and their effect on prices*, Report, July 2001.

325 Clause 3.11.3(b)(2) first appeared in Version 7.6 of the Code (Gazetted 16/1/03) and remains in the current version of the Rules.

However, there are likely to be strong commercial incentives on Basslink's asset owner to effectively manage the transfer capability of the DC link, given it is an MNSP whose income stream depends (in part) on the available capacity of the link.

The procedure governing how NEMMCO manages transfer capability on these interconnectors is described below.

First, NEMMCO manages the transfer capability of two interconnectors — Snowy1 and VIC-Snowy — by sourcing reactive support from Snowy Hydro generators, which operate in Syncronous Condensor (SynCon) mode. When operating in SynCon mode, Snowy Hydro's generators either inject or absorb reactive power (MVArs), which is used by NEMMCO to manage the voltage level drop along the long interconnection between Melbourne and Sydney. Without this SynCon service, the interconnectors' transfer capabilities would be substantially lower unless TransGrid and VenCorp invested substantial capital in the provision of alternative, network based, sources of reactive power and voltage control.

Prior to the start of the NEM, the reactive power support for both of these interconnectors was managed by the State Electricity Commission of Victoria (SECV) via a contract with Snowy Hydro Trading Pty Ltd. The SECV is most likely to have done this as part of its management of Victoria's electricity entitlements under inter-governmental agreements on the Snowy Mountains Hydro Electric Scheme.[326] The SECV's creation of the Victorian Power Exchange (VPX), a market and system operations arm, resulted in responsibility for managing the reactive support contracts passing to VPX. At the start of the NEM in December 1998, NEMMCO took over the functions of VPX, and as a consequence responsibility for the interconnector support contracts passed to NEMMCO.[327]

There does not appear to have been any consideration of whether in the long term TNSPs or NEMMCO were the most appropriate party to manage the reactive support contracts, having regard to the incentives on TNSPs versus NEMMCO. The purpose of the report was solely to establish savings and transitional arrangements for Ancillary Services to be managed once the NEM started. These interim arrangements were to be reviewed by NEMMCO within two years of market start (as specified in Clause 3.13.1. of the draft National Electricity Code).[328] The report recommended temporary arrangements, such that NEMMCO would be the counter-party to Ancillary Service contracts entered into by TransGrid/VPX, following the novation of the contracts to NEMMCO on market start. Arguably, the increased power transfer capability through the Snowy region ultimately provides reliability of

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326 *Snowy Mountains Hydro-electric Agreements Act 1958 No.20 (NSW).*

327 See TransGrid & VPX 1997, "*National Electricity Market (NEM1, Phase 2) — Recommendations for the Procurement of Ancillary Services and for Reimbursement by the Market*", for TransGrid and Victorian Power Exchange, by NEM1 Ancillary Services Project, May 1997, p. ix, "Transition to NEMMCO Management"; Appendix C, Attachment 2, items 6 (Synchronous condensor spinning reserve); Table 4.2.2.2; and Appendix D, Sections 2.2.1 and 2.2.2.

328 NEMMCO's 1999 Ancillary Services review recommended the establishment of markets for Frequency Control Ancillary Services (FCAS) and a further review of arrangements for Network Control Ancillary Services (NCAS). To date, the basic NCAS arrangements remain unchanged from those established at market start. Two other reviews — RIEMNS and MSORC — each failed to address reforms to NCAS.

supply benefits to customers in the importing region(s), a principle recognised by market designers before market start in 1998.[329]

Second, NEMMCO procures a network loading control service for imports along the Snowy-VIC directional interconnector, which involves arming a Victorian smelter to trip. This network loading control scheme can raise the maximum secure Snowy-VIC transfer limit by 200MW (currently from 1700MW to 1900MW) and is of most value (and generally only utilised) when there are potential shortfalls in supply in VIC-SA during periods of high demand.[330] Like the reactive support service discussed above, prior to the start of the NEM, the SECV and then VPX contracted for this load tripping service, with the responsibility for the contract assigned to NEMMCO at market start, where it has remained.[331] Importantly, this smelter load tripping scheme primarily provides reliability benefits rather than security benefits. To see this, it is worth considering that in the absence of the load tripping scheme, NEMMCO could still operate the network securely at the lower Snowy-VIC transfer limit, but this could result in involuntary load shedding in Victoria and South Australia (with resulting VoLL pricing). The system would still be secure in this case, but at the cost of some lost load in VIC and SA. Arguably, it is customers in Victoria and SA who are the principal beneficiaries of the increased reliability arising from the increase in secure transfer capability of the Snowy-VIC interconnector.[332] If this is accepted, it can be argued that the Victorian and South Australian TNSPs should be responsible for procuring the smelter load tripping service, rather than NEMMCO.

I.2 Current approach to service delivery

This section focuses on the current environment, for NSCS outlining:

- The definition of relevant NSCS, the rationale for their procurement and how they work;
- The guidance provided to each of TNSPs and NEMMCO in determining what type and how much NSCS should be procured and delivered; and
- Some stylised examples of NSCS.

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329 This beneficiary pays principle appears to have been recognised both as a general principle (*ibid*, p. 5) and in the way reactive power expenses were to be recovered on a location specific basis (*ibid*, p.13). Specifically, appears that a form of Cost Reflective Network Pricing (CRNP) was used to recover the unbundled costs of providing reactive support — "MVAr demand charges to distributor based on 10 highest reactive demands at each wholesale metering point" (ibid, Table 4.2.2.2).

330 Arming the smelters for rapid off-loading enables the (higher) 5-minute thermal limits on the Victoria-Snowy interconnector to be used in dispatch. This network loading control scheme is only used under lack of reserve level 2 (LOR2) conditions, as defined in clause 4.8.4(r) of the Rules, and after NEMMCO has assessed if there is an economic benefit from enabling the service.

331 *ibid*, p. ix "Transition to NEMMCO Management" and Appendix C, Attachment 2, item 8 (Interruptibility service) deals specifically with the smelter tripping service. See also Table 4.2.2.3; and Appendix D, Section 2.2.3 of the same report.

332 This beneficiaries pay principle was explicitly acknowledged in Table 4.2.2.3 of TransGrid & VPX report, which states that the recovery costs relating to the smelter rapid unloading scheme is to be based on "CRNP to beneficiaries (charges to distributors)".

I.2.1 Service definition and rationale

Network Support and Control Services (NSCS) currently procured and delivered include:

- **Network support services** – procured by TNSPs via contracts with third parties (network support agreements or NSAs) via services in the form of:
  - generators agreeing to be constrained-on or -off;
  - loads agreeing to be constrained-on or -off;
  - generators providing reactive power capability (see Box 2), either as a condition of a network connection agreement or under a separate contract;
- **Network control services** – delivered by TNSPs from their own infrastructure as reactive power capability in the form of voltage control from:
  - capacitor banks and reactors;
  - static Var compensators (SVCs);
- **Network control ancillary services (NCAS)** – procured by NEMMCO via contracts with Market Participants (not TNSPs) as either:
  - reactive power ancillary service (RPAS) in the form of voltage control from:
    - generators operating in generation mode;
    - generators operating in synchronous condensor mode (SynCons)[333]; and
    - DC links;
  - network loading control ancillary service (NLCAS) – provided via:
    - generator control schemes – for example: rapid generator unit loading; or rapid generator unit unloading; and
    - load tripping schemes.

Box 2: A note on reactive power

Delivery of real power (MWs), and delivery of reactive power (MVars), are complementary services – the power system cannot be effectively operated without control over both MWs and MVars. Control over reactive power injection or absorption is necessary to manage voltage levels at specific locations in a network. Voltage stability is a key form of constraint on the operation of the power system.

Reactive power capability can be delivered via several different technologies.

333 Generators operating in SynCon mode do not produce MWs – they operate as a motor (with small or negligible load on the power system), but retain the ability to inject and absorb MVars.

Dynamic reactive power capability is the ability to change the level of MVar injection or absorption in response to emerging real-time power system conditions. Dynamic reactive power capability can be provided by: generators in generation mode; generators in SynCon mode; SVCs; and DC links.

Static reactive power capability is the ability to inject or absorb MVars at a given level depending on whether the relevant plant is switched on. Static reactive power capability can be provided by: capacitor banks (injecting MVars); and reactors (absorbing MVars). Static reactive plant can be configured to switch automatically in response to network voltage changes.

Voltage stability constraint equations in NEMDE reflect the availability of plant with reactive power capability. When the availability of reactive plant changes, so too will the RHS limits of relevant constraint equations in NEMDE. As RHS limits on constraint equations change, network congestion can be relieved or exacerbated.

Aside from procuring and delivering different forms of NSCS, TNSPs and NEMMCO employ differing rationales for delivering or contracting NSCS:

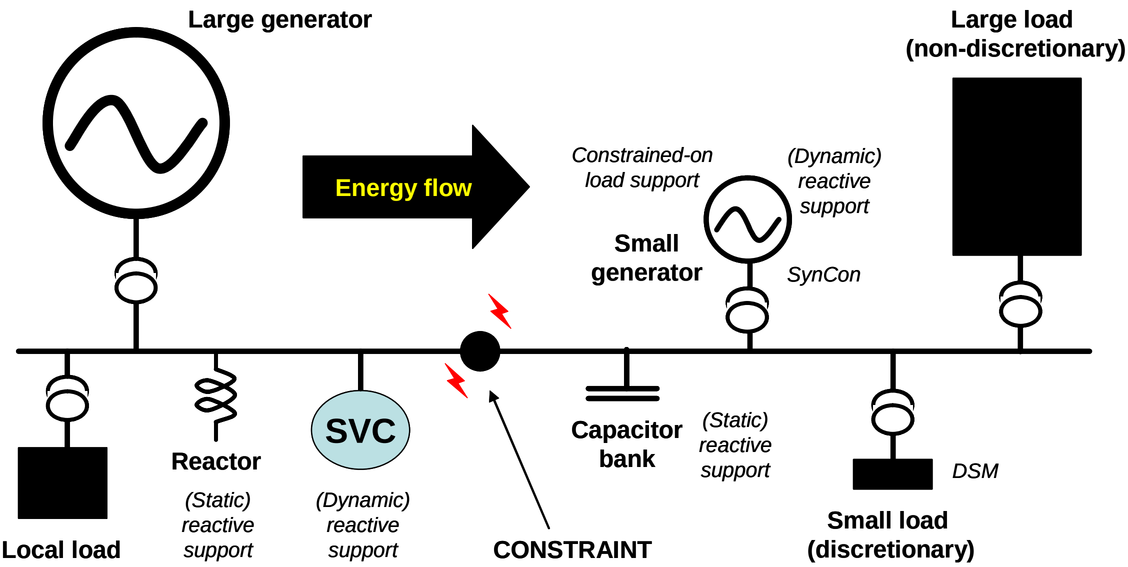
- TNSPs ensure appropriate levels of NSCS are delivered such that there is the capability to manage intra-regional network reliability at expected peak demand in an effort to meet "intra-regional reliability" obligations;
- TNSPs could procure and deliver NSCS as part of the most efficient package of measures to deliver network capability with net market benefit consistent with the market benefits limb of the regulatory test;
- NEMMCO procures appropriate levels of NCAS such that there is the capability to ensure a system-wide secure and reliable network at all times as part of meeting the power system security and reliability standards under the Rules; and
- NEMMCO may procure NCAS to assist in maximising the value of spot market trading.

As indicated previously, although various legislative instruments and obligations package TNSP and NEMMCO responsibilities in different ways, the services TNSPs and NEMMCO procure and deliver, and the outcomes they seek to achieve, are in many way indistinguishable.

I.2.2 How support & control services work

Delivery of network capability can be accomplished with a variety of technologies and combinations thereof. Most of the requirements for NSCS are highly locationally specific and, by varying the level of real or reactive power at different locations in the network or by operating load control facilities, the level of network congestion can be altered in ways that either reduce or increase the dispatch cost on the spot market for energy. Examples of network infrastructure and NSCS that can be used to facilitate network flows are depicted in Figure 1.

Figure I.1 Stylised network with infrastructure and support & control services to facilitate network flows



In the stylised network depicted in Figure 1, energy typically flows from left to right although there is a constraint in the middle of the network. Constraints are commonly of two forms:

- *thermal limit* – limitations on the amount of heating that network elements can withstand, controlled by increasing or reducing real power (MWs) loading on a specific side of the constraint; and
- *stability limit* – limitations on the ability of network infrastructure to dampen / withstand unanticipated fluctuations in the power system, controlled by injecting or absorbing reactive power (Vars) at a specific location in the network.

Depending on the constraint form ("thermal" or "stability") and network loading conditions, the constraint could be relieved in a variety of ways as noted in Table 1.

Table I.1: Use of NSCS technology by either TNSPs or NEMMCO

Technology	Under current arrangements …
Capacitor bank providing static voltage support as MVar injection.	• technology is TNSP owned and controlled – not available to be contracted by NEMMCO.
Reactor providing static voltage support as MVar absorption.	• technology is TNSP owned and controlled – not available to be contracted by NEMMCO.
Static Var compensator (SVC) providing dynamic voltage support – MVar injection or absorption.	• technology is TNSP owned and controlled – not available to be contracted by NEMMCO.
Small generator discretionally controlled to provide: • network support by being "constrained-on"; • dynamic voltage support – MVar injection or absorption – while either: o operating in generation mode; or o operating in SynCon mode.	• constrained-on network support contracted by TNSPs. • voltage support from generators in generation mode contracted by both TNSPs and NEMMCO. • voltage support from generators in SynCon mode contracted by NEMMCO.
Small load providing demand-side management (DSM) as either: • pre-contingent network support (e.g. enabling / arming the rapid unloading of a smelter); or • post-contingent network support (e.g. utilising the rapid unloading of a smelter).	• network load relief services are contracted by both TNSPs and NEMMCO.
"Build out" the constraint via upgraded transmission lines or transformers.	• option only available to TNSPs.

I.2.3 Services procured or delivered by TNSPs

I.2.3.1 Guidance to TNSPs

The mix of assets and form of NSCS an TNSP supplies with its own infrastructure, or procures via contract with third parties, will be a function of the relevant standards associated with preventing or managing congesting occurring in the network for each TNSP and the testing of available options through the Regulatory Test.

The standards to be met by each TNSP are unique to that TNSP, and may include:

- Requirements outlined in state-based legislation;
- Licence conditions imposed by jurisdictional regulators (or ministers);
- Technical requirements included in the National Electricity Rules;
- Standards agreed with connected customers;

- Formal (and informal) internal long-term planning documents;
- Formal (and informal) internal operational and maintenance planning documents;
- Standards imposed via regulatory resets conducted by the AER; or
- Standards imposed by Standards Australia or other relevant international standards.

This suite of documentation noted above will be collectively referred to here as "TNSP network capability obligations". Any combination of one or more (or even all) of the above may state (or suggest) a need to procure NSCS to ensure the appropriate "standard" is not breached.

Although Network Service Provider obligations are commonly referred to in the context of "reliability", TNSPs must also ensure that supply is robust to credible contingencies, indicating that TNSPs must also consider "security" as a factor. Hence the distinction between reliability and security does not represent a boundary of TNSP responsibility and "TNSP network capability obligations" is the preferred generic reference.

Note that the costs of the services procured by TNSPs as support and control services are recovered via their regulated revenues.

I.2.3.2 Determining the level of procurement

Setting aside (for the moment) procurement of NSCS for purely "market benefit" reasons, the appropriate level of procurement of NSCS is not always straightforward to determine.

Where TNSP network capability obligations are relevant[334], the level of NSCS procured or delivered by TNSPs will depend on the TNSP's interpretation of the applicable instrument(s); and the mix of infrastructure and services by which the TNSP meets the relevant standard. Subject to funding restrictions established via regulatory resets, there is a degree of flexibility with respect to the mode by which TNSPs will choose to deliver on network capability obligations – choices are between:

- New or augmented TNSP owned infrastructure:
  - transmission lines or transformers; or
  - reactive power capability in the form of:
    - capacitor banks or reactors; or
    - static Var compensators (SVCs);

334 That is, the "market benefits" limb of the regulatory test does not apply.

- Network control mechanisms using the TNSP's infrastructure (e.g. splitting / switching schemes that deliberately break a point of connection between network elements to increase network capability at the cost of a probabilistic loss of network reliability); or

- Network support services procured by TNSPs via contracts with third parties in the form of:

  - generators agreeing to be constrained on or off;

  - loads agreeing to be constrained on or off; or

  - generators providing reactive power capability.[335]

Where the "markets benefits" limb of the regulatory test is applied, some mix of any or all of the above modes for delivery of network capability is also likely to be appropriate – the optimal mix being that which maximises net market benefit.

I.2.4 Services procured by NEMMCO

I.2.4.1 Guidance to NEMMCO

NEMMCO's obligations with respect to procuring NCAS are most clearly expressed in clause 3.11.4(b) of the Rules, which states:

> "NEMMCO must develop and publish a procedure for determining the quantity of each kind of [network control ancillary service][336] required for NEMMCO:
>
> (1) to achieve the *power system security and reliability standards*; and
>
> (2) where practicable to enhance *network* transfer capability whilst still maintaining a *secure operating state* when, in *NEMMCO's* reasonable opinion, the resultant expected increase in *non-market ancillary service* costs will not exceed the resultant expected increase in benefits of trade from the *spot market*."

The formal descriptions of NCAS are provided in NEMMCO's Amended procedure for determining quantities of network control ancillary services.[337] The two types of NCAS identified by NEMMCO are described in those procedures as follows:

[335] Dynamic voltage support (MVar injection or absorption) either as part of the amount a generator is required to make available as a condition of its connection agreement with the NSP; or as a separately contracted amount in addition to that available via connection agreements.

[336] Clause 3.11.4(b) actually refers to "non-market ancillary services" that comprise both *system restart ancillary services* (SRAS) and *network control ancillary services* (NCAS). Procurement of SRAS is not relevant to this paper.

[337] See http://www.nemmco.com.au/ancillary_services/168-0021.pdf.

> “**Reactive power ancillary service** [RPAS] is the capability to supply reactive power to, or absorb reactive power from, the transmission network in order to maintain the transmission network within its voltage and stability limits following a credible contingency event but excluding such capability within a transmission or distribution system or as a condition of connection.
>
> and
>
> **Network loading control ancillary service** [NLCAS] is the capability of reducing an active power flow from a transmission network in order to keep the [electrical] current loading on interconnector transmission elements within their respective ratings following a credible contingency event in a transmission network.”

NEMMCO’s choices in the procurement of NCAS is limited because of:

- Clause 3.11.5(a) of the Rules that states:

> “… NEMMCO must call for offers from persons who are in a position to provide the *non-market ancillary service* so as to have the required effect at a connection to a *transmission network* in an invitation to tender.”

- Clause 3.11.5(j) of the Rules that states:

> “… NEMMCO must not acquire non-market ancillary services from any person who is not a Registered Participant.”

- the RPAS description (noted above), which is qualified as:

> “excluding such capability within a transmission or distribution system.”

thus excluding TNSPs from tendering for “residual” NCAS to NEMMCO.

Therefore, NEMMCO can only acquire NCAS from Registered Participants who are neither transmission NSPs nor distribution NSPs. The consequence being that provision of NCAS in the form of reactive power capability is effectively limited to:

- Registered generators operating in generation mode;
- Registered generators operating in SynCon mode; and
- MNSPs providing DC link voltage control.

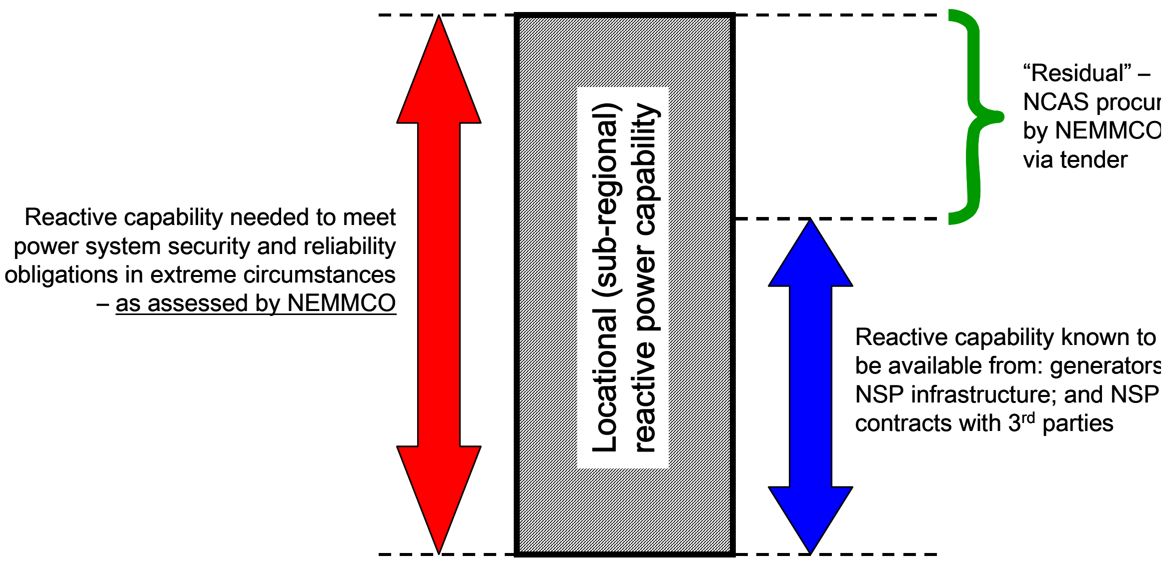
Note that the costs of the services procured by NEMMCO as NCAS are recovered via a levy on all Market Customers in proportion to their energy.

I.2.5 Determining the level of procurement

I.2.5.1 Power system security and reliability

NEMMCO's role with respect to ensuring availability of appropriate levels of network support and control service to achieve the *power system security and reliability standards* may be seen as that of a "procurer of last resort" – in the absence of NEMMCO procurement of NCAS the power system could experience either security or reliability problems.[338]

Figure I.2 Schematic representation of NEMMCO's reactive power capability procurement decision



With respect to NCAS in the form of reactive power capability, the volume procured by NEMMCO on a locational (sub-regional) basis is currently determined as the residual between (see Figure 2):

- total capability required to manage power system security and reliability in either "peak loading conditions" or "low loading conditions";[339] and
- the capability guaranteed to be available through the combination of:

[338] NEMMCO anticipates the need for support & control services into the medium term. In the past, NEMMCO has contracted for NCAS on two-year time frames.

[339] Peak loading conditions are normally associated with high summer and air-conditioning loads. Low loading conditions are those normally associated with overnight and/or weekend loads. For formal description of the reactive power requirement, see NEMMCO's *Amended procedure for determining quantities of network control ancillary services* [Section 4.3, p.5], which can be found at http://www.nemmco.com.au/ancillary_services/168-0021.pdf.

– TNSPs (own infrastructure and contracts with third parties); and

– Generators delivering on performance standards specified within connection agreements between generators and TNSPs.

In making assessments as to the nature of the residual requirement NEMMCO is therefore highly reliant on information provided to it by TNSPs.

I.2.5.2 Increasing the benefits of trade from the spot market

NEMMCO's obligations with respect to increasing the benefits of trade from the spot market are mentioned only in the (heavily qualified) Rule clause 3.11.4(b)(2) – whereby NEMMCO is required:

> "where practicable to enhance *network* transfer capability whilst still maintaining a *secure operating state* when, in *NEMMCO's* reasonable opinion, the resultant expected increase in *non-market ancillary service* costs will not exceed the resultant expected increase in benefits of trade from the *spot market*.

The degree of qualification in this clause (underlined) gives a large amount of discretion to NEMMCO as to how the requirements of the clause are to be met.

NEMMCO has not yet conducted tenders for NCAS with the specific intent to procure services to increase the benefits of trade from the spot market. However, where NEMMCO has procured NCAS for the purpose of achieving the *power system security and reliability standards*, and those services can be deployed to increase the (net) benefits of trade from the spot market, NEMMCO will deploy NCAS for the (net) benefit of the market.

NEMMCO gives effect to clause 3.11.4(b)(2) through deployment of both NLCAS and RPAS. Each of these services increases the secure (post-contingent) network capability of interconnectors and thus increases the ability for the dispatch process to replace high cost generation in one region with low cost generation from an adjoining region.

I.2.6 Stylised examples

The following examples outline the types of services that can be procured by either TNSPs or NEMMCO in fulfilling their respective NSCS obligations.

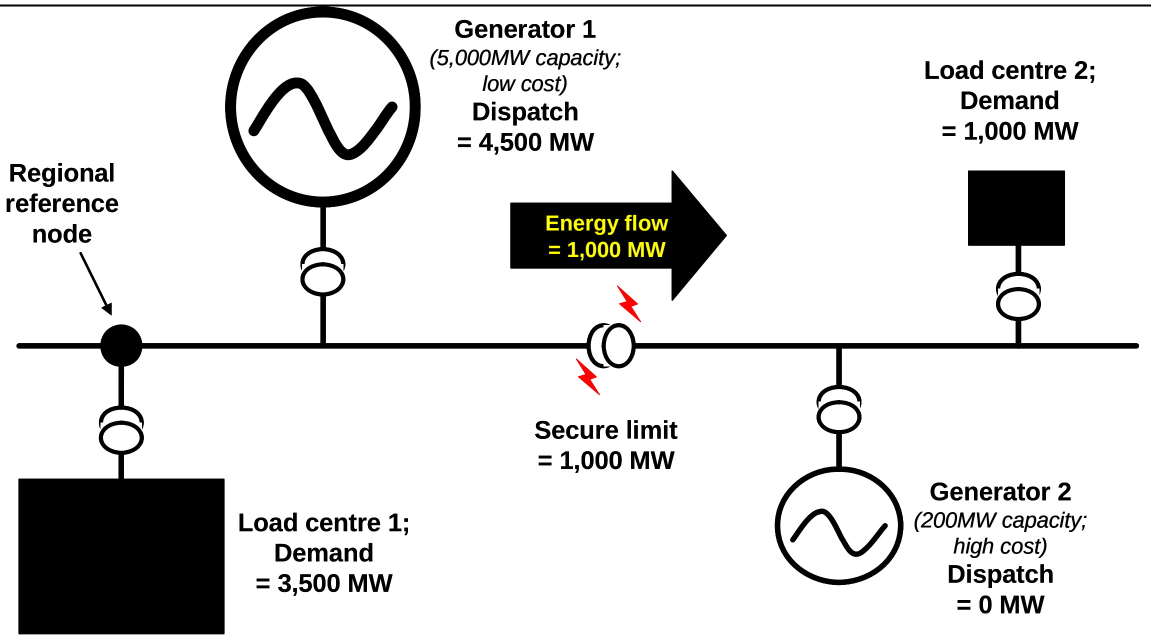
I.2.6.1 Constrained-on generation

This example demonstrates the use of constrained generation as mechanism to relive loading on a critical transmission element.

- Power flow within the region depicted in Figure 3 is constrained by a thermal limit on a transformer, such that flow is restricted to ≤ 1,000MW from left to right. Demand and generation patterns within a region are initially such that low cost generator 1 is able to service all load within the region without network loading constraints being breached.

- Total regional load is 4,500MW [3,500MW at Load centre 1; and 1,000MW at Load Centre 2].
- Low cost Generator 1 is dispatched at 4,500MW and high cost Generator 2 is not dispatched.
- Loading on the transformer subject to the constraint is at its secure limit of 1,000 MW.

Figure I.3 Initial network loading patterns – generation not constrained



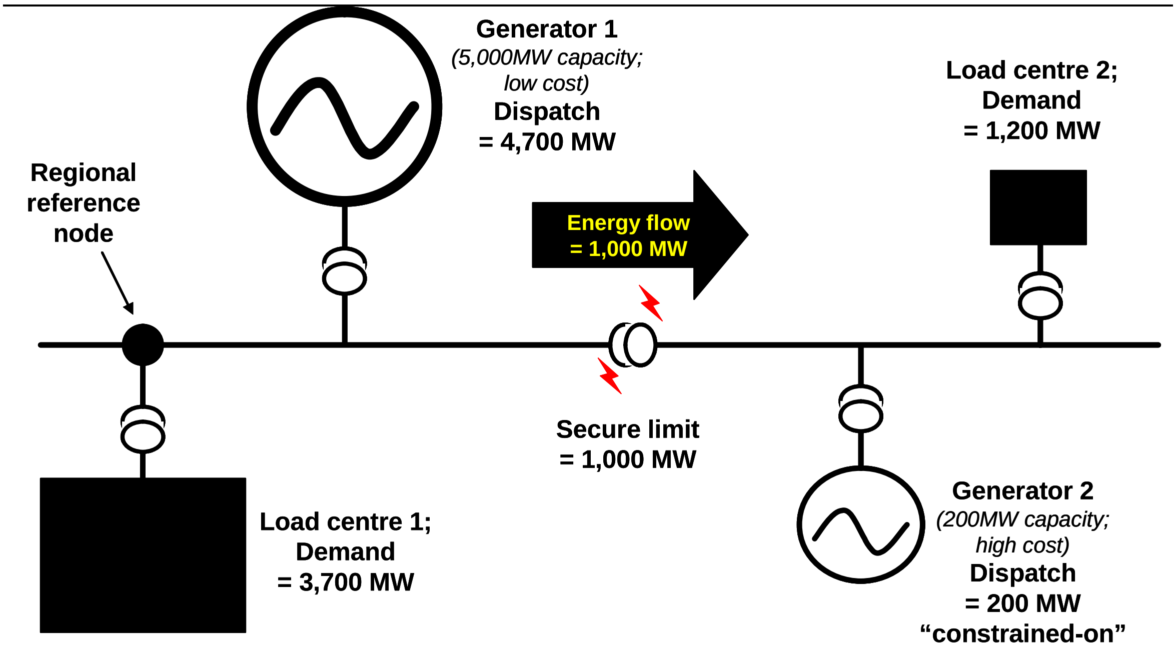
- System conditions change, with a 200MW increase in demand at each of Load centre 1 and Load centre 2 – total demand rises to 4,900MW.
- In the absence of network constraints, total network loading is within the capability of low cost Generator 1, but dispatch of 4,900MW from Generator 1 (with no support from Generator 2) would breach the constraint on power flow through the transformer in the middle of the network by 200MW. The choices are to either reduce demand (shed load) at Load centre 2, or dispatch Generator 2 to relieve the constraint on the transformer in the middle of the network.
- With network support available from Generator 2 (see Figure 4):
  - Total regional load is 4,900MW [3,700MW at Load centre 1; and 1,200 MW at Load Centre 2].

– Low cost Generator 1 is dispatched at 4,700MW and high cost Generator 2 is dispatched at 200MW.

– Loading on the transformer subject to the constraint is at its secure limit of 1,000MW.

As the regional reference price is established by the cost of meeting an increment of load at the regional reference node, the Generator 1 (low marginal cost) offer will set the price. If all generators are offering their output at marginal cost, Generator 2 (high marginal cost) will need to be constrained on. In the absence of some constrained-on payment (via a network support agreement or other mechanism), Generator 2 is likely to bid at or near VoLL or bid itself unavailable.

Figure I.4 Subsequent network loading patterns – generation constrained-on



I.2.6.2 Deployment of reactive power support (SynCons)

Figure 5 demonstrates the use of voltage support to increase power transfer capability. Although the example makes reference to transfers across region boundaries, the example is equally applicable to circumstances where no region boundary is involved.

- In the absence of dynamic reactive power support, interconnector flow from Region A to Region B is limited to only 500MW by voltage stability considerations. With reactive power support from G_{B3} operating in SynCon mode, interconnector flow from Region A to Region B can rise to 1,000MW (see Figure 5).

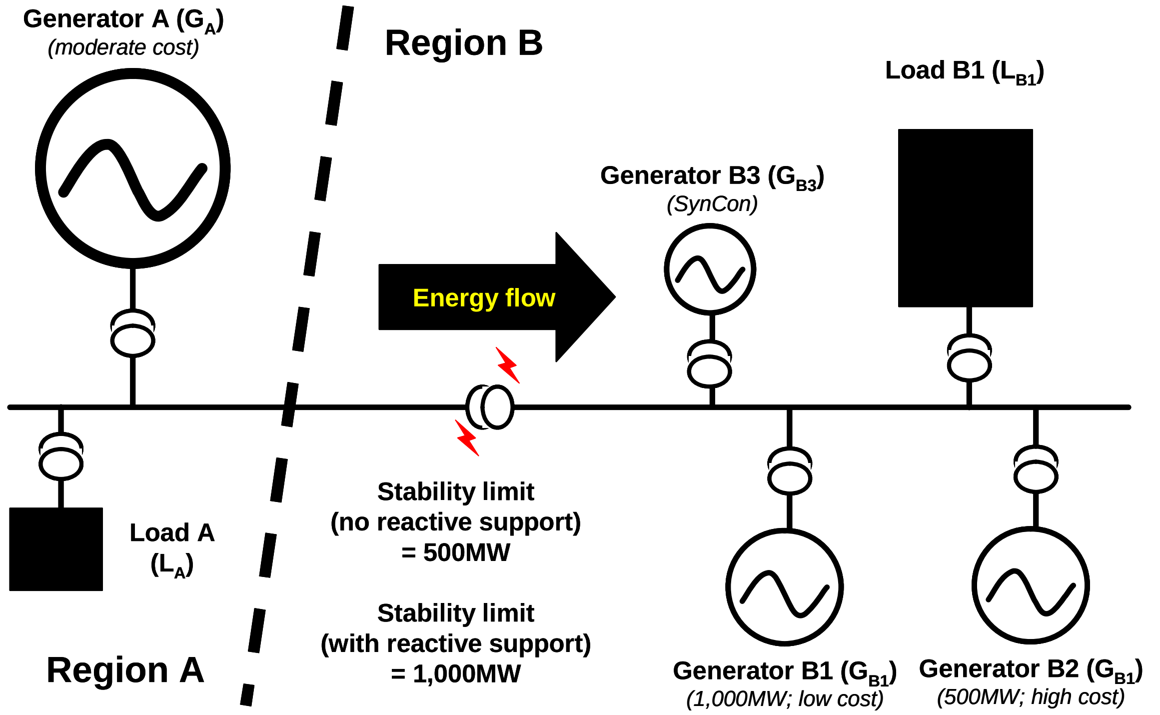
- If Region B load is 1,450MW, optimal dispatch is 1,000MW from (low cost) G_{B1} and 450 MW across the interconnector from Region A – there is no need to deploy reactive power support from G_{B3}.

- If Region B load rises beyond 1,500MW, G_{B1} will be dispatched to its 1,000 limit and either:

  – in the absence of reactive power support from G_{B3}, interconnector flow will be limited to 500MW, with high cost generation G_{B2} being dispatched to pick up the remaining supply deficit; or

  – with reactive power support from G_{B3}, interconnector flow will be increased to (up to) 1,000MW, with high cost generation G_{B2} only being dispatched if Region B load rises beyond 2,000MW. (Assuming generation from G_{B3} is high cost, but operating G_{B3} in SynCon mode is very low cost).

Figure I.5 Deploying SynCons to manage voltage stability limit



I.2.6.3 Deployment of load tripping scheme

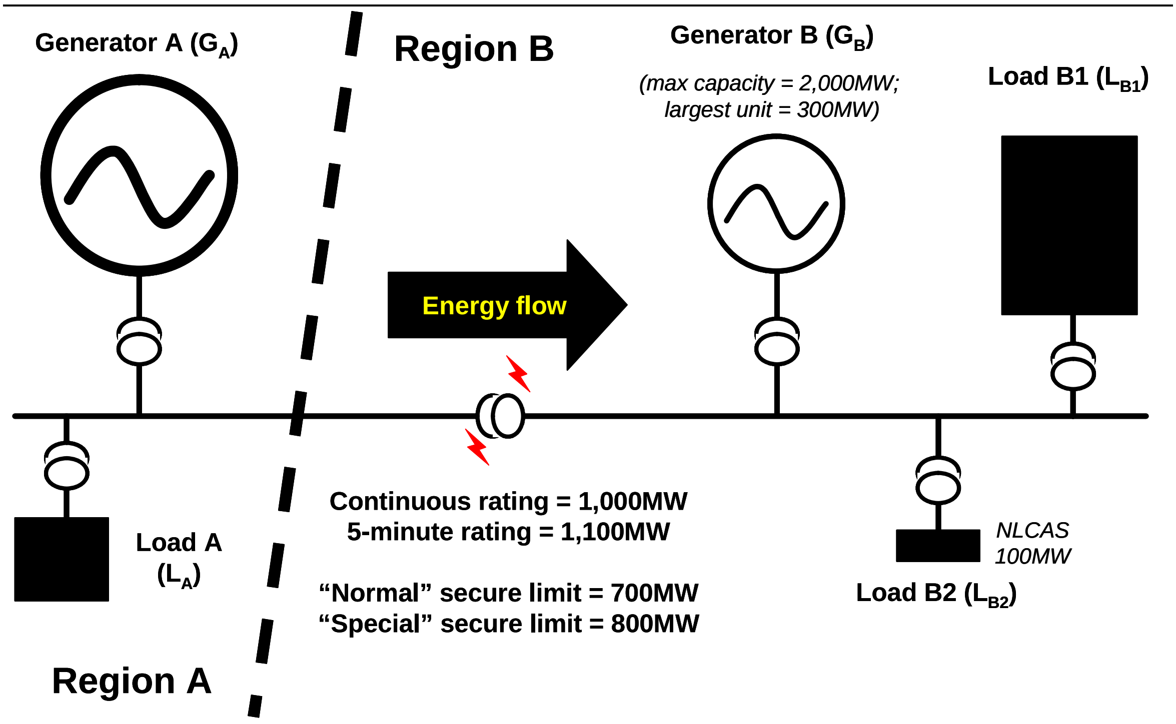
Figure 6 demonstrates the use of a load tripping scheme, although the principles outlined may also be translated to rapid response generators.

- Under "normal" conditions local load (in Region B) of up to 2,700MW can be securely and reliably managed – local generation GB of 2,000MW plus interconnector transfer of up to 700MW (see Figure 6). The continuous rating of the interconnector flow from Region A to Region B is 1,000MW (a thermal limit) but, in the absence of a suitable control scheme, it must be operated at a level such that the largest credible contingency (in this case, loss of 300MW of Region B generation) does not push the transfer beyond its continuous rating – that is:

secure limit (700 MW) = continuous rating (1,000MW)
– largest credible contingency (300 MW)

- If 100 MW load L_{B2} (e.g. a smelter) is associated with a control scheme that would trip it within 5 minutes of the post-contingent line flow reaching its 5 minute limit, and this scheme is procured by NEMMCO as network loading control ancillary service (NLCAS), arming[340] the scheme enables the interconnector to securely operate at 800MW, and thus (securely) service Region B load of up to 2,800MW.

Figure I.6 Deploying load tripping scheme to access 5-minute thermal ratings



If Region B load approaches 2,800 MW and the NLCAS at L_{B2} is armed, the higher "special" secure limit on interconnector flows of 800MW could apply. This is because the occurrence of the largest single credible contingency (loss of a 300MW generation unit) would result in the interconnector flow increasing up to 1,100MW (its 5-minute rating) until such time as the control scheme operated by tripping the

[340] "Arming" the NLCAS involves preparing the load to trip in the event that flows on critical network elements move beyond their continuous rating – the design of the scheme is such that the load should remain "on" unless the relevant contingency occurs.

100MW of load at L_{B2} (sometime within 5 minutes). Tripping the 100 MW of load at L_{B2} would reduce Region B load back to 2,700MW and interconnector flow to 1,000 W (its continuous rating).[341]

Note that generator control schemes – rapid unit loading or unloading – can be used to achieve similar outcomes to load tripping schemes.

I.2.7 NEMMCO applications of support & control services

NEMMCO procures a network loading control service in the form of a smelter tripping scheme to access additional interconnector capability and also procures reactive power capability in the form of Snowy generators operating in SynCon mode to manage voltage stability limits through the Snowy Region.

Under existing Rules, these services could be used to either:

- Manage power system security or reliability [in accordance with clause 3.11.4(b)(1)]; or
- Increase the benefits of trade from the spot market [in accordance with clause 3.11.4(b)(2)].

The latter usage – to increase the benefits of trade from the spot market – depends on the cost of deploying the service being less than the reduction in the total cost of generation dispatched throughout the market during the period in which the RPAS is deployed.

I.2.8 Summary

The current environment in which NSCS is delivered to the market is quite complex and contributes to a lack of clarity regarding the objectives for deploying NSCS. The environment can be described at a high level by matrixes that canvass several dimensions:

- **Responsibility:** "TNSPs" or "NEMMCO";
- **Purpose:** "security & reliability" or "benefits of trade";
- **Location:** "intra-regional" or "inter-regional";
- **Application:** "voltage control" or "network loading control"; and
- **Technology:** capacitor banks, SVCs, reactive power from generators in SynCon mode, reactive power from generators in generation mode, pre-contingent DSM, post-contingent DSM.

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341 If a contingency occurs and network elements exceed their secure operating limits, but stay within short term ratings, the power system is declared to be in a satisfactory operating state and NEMMCO would have 30 minutes in which to return the power system to a secure operating state.

Tables 2 and 3 outline the relationships between these dimensions.

Table I.2: Service responsibility by purpose and location

	Intra-regional	Inter-regional
Security & reliability	Both TNSPs and NEMMCO have responsibility for procuring / supplying NSCS.	No clear responsibilities formally assigned. Both TNSPs and NEMMCO procure / deliver services that have effect in this space.
Benefits of trade	Both TNSPs and NEMMCO have responsibility for procuring / supplying NSCS.	No services specifically procured for this purpose. Where practicable, NEMMCO deploys services procured for other reasons that have effect in this space.

Table I.3: Service technology by responsibility and application

	Reactive power capability	Network loading control
NEMMCO	Procured from generators in either SynCon or generation mode to: • manage power system stability in credible circumstances; and • increase secure transfer capability of selected network elements.	Procured in the form of load tripping schemes to increase the secure power transfer capability of selected network elements.
TNSPs	• Provided in the form of SVCs, capacitor banks and reactors to manage intra-regional reliability. • Secured from generators in generation mode as part of connection agreement.	Procured from generators and loads as network support to manage intra-regional reliability.