NEMMCO

Wind Energy and the Power Network

NEMMCO Perspectives

Ross Gillett - Market Development

EESA Seminar - 14 May 2008

Session Overview

NEMMCO

- Who is NEMMCO?
- Energy Market Reform Framework
- How Much Wind Is Coming?
- Wind Energy Issues & the “Semi-Dispatch” solution
- Stability Issues in South Australia
- Overview of Technical Standards for Connection
- Questions?

Energy Market Reform Framework

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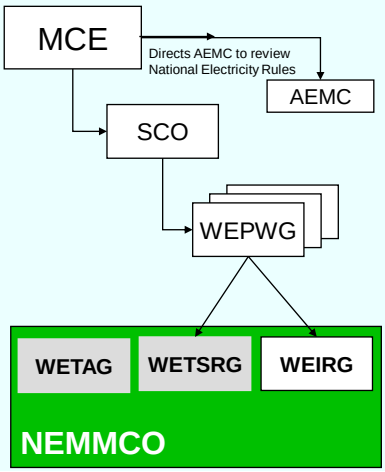
- **Hierarchy**



← **Ministerial Council on Energy**
First Ministers

← **Standing Committee of Officials**
Jurisdiction Energy Departments

← **Reform umbrella working groups**
Wind Energy Policy Working Group

← **NEMMCO working groups formed by request**

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Who is NEMMCO ?

NEMMCO

- **National Electricity Market Management Company Limited (NEMMCO)**

- **Key Responsibilities**
  - **Operation of physical power system**
    - Power system security
    - Generation/Transmission Planning Statements (SOO/ANTS)
    - Technical assessment of new & existing connected plant
  - **Operation of National Electricity Market (NEM)**
    - Generation dispatch (targets from NEMMCO every 5 minutes)
    - Setting prices
    - Settling the market ($)
    - Management of prudential arrangements
    - Registration of Market Participants
    - Development of the NEM

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How Much Wind Is Coming ?

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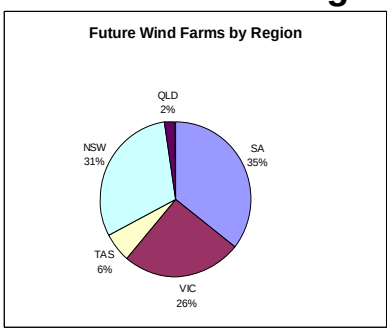
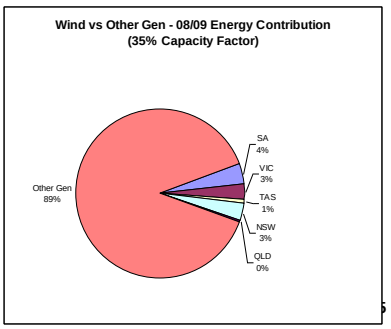
- **MRET → starts early 2009**
  - **By 2020, 60 GWh pa (20%) of all electricity must come from renewable generation = 16 to 20 GW installed**
  - **~50% likely to be wind = 8 to 10 GW installed (1 GW now)**

  PLUS
- **Emissions Trading Scheme → starts 2010**





Significant Wind Generation in NEM

South Australia

- ~**740MW** operating (350MW scheduled)
- Further 60MW is committed
- ~**1,900MW** on drawing board

Victoria

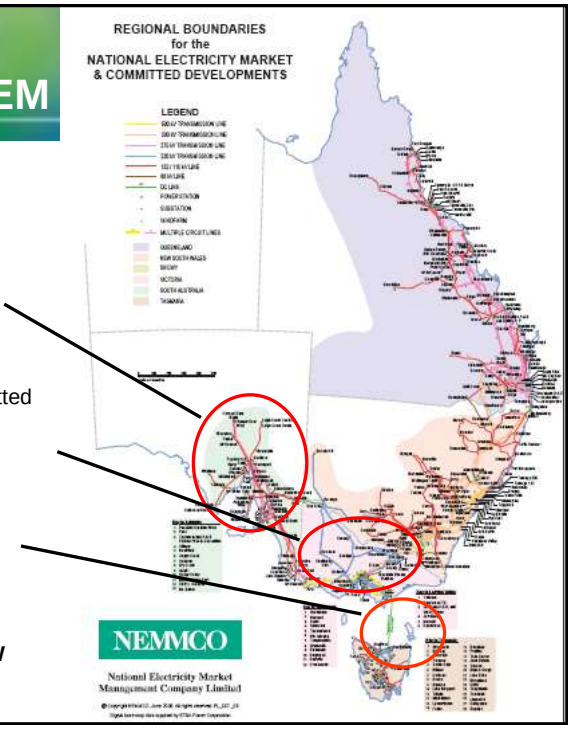
- **80MW** operating + 360MW committed
- ~**1,600MW** on drawing board

Tasmania

- **140MW** operating
- ~320MW on drawing board

Rest of NEM **(NSW, QLD)**

- **< 30MW** operating, but ~**2,450MW** (mainly NSW) on drawing board



Wind Generation in SA over past year

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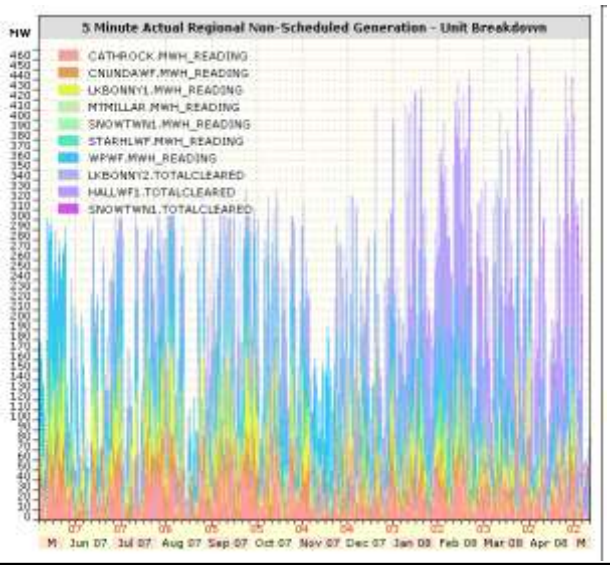

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Technical Limitations of Wind

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- **Unable to increase wind "on demand"**
  - **No material wind energy storage**
- **High wind energy variability**
  - **worse if not geographically dispersed**
- **Typically asynchronous generators**
  - **Little reactive power support (some import reactive power)**
  - **May require auxiliary reactive plant for fault ride-through capability**
- **Relative Lack of Inertia**
  - **Less Post-fault stability**
  - **Lower the system inertia, shorter the critical fault clearing time**

Regulatory Approach to Date

NEMMCO

- Wind generation automatically registered in NEM as non-scheduled as it is *intermittent* (assumed "uncontrollable")
- Exempt from central dispatch control
- Has dispatch & network priority over scheduled
- Excluded from demand forecasting
  - -ve forecast offset, based on "persistence" (no change)

Wind Generation Issues for NEMMCO

NEMMCO

WETAG 2005 Report

1. Network Security Management
2. Network Security - Sub-5 Minute Variability
3. Power System Stability Implications
4. Islanding
5. Contribution to System Reserves
6. Optimising Shared Network Assets at Design Stage
7. Network Connection Process
8. Network Connection Access Standards
9. Provision of Dynamic Generating Plant Models
10. Contingency FCAS & Cost Recovery
11. Regulation FCAS & Cost Recovery
12. Information Disclosure
13. Wind Generation Forecasting

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Wind Generation Issues for NEMMCO (1)

NEMMCO

Issue	Implications	Proposed Solution	Status
Network Security Management	Non-scheduled (wind) plant has dispatch & network priority over scheduled plant & may generate what they like, except if no other choice (eg: scheduled plant cannot be constrained further as at their technical limits & affected network constraint violated) Non-scheduled plant can impact secure network limits, but (unlike scheduled plant) their output cannot be optimised against network limits Non-scheduled dispatch control is not centrally co-ordinated with scheduled dispatch control Routine use of directions on non-scheduled plant challenges orderly & transparent operation of NEM	Semi-Dispatch Rule From May 2008 all significant (≥ 30 MW) intermittent generation must meet revised active power control standard & must register as Semi-Scheduled Generators From March 2009 all Semi-Scheduled Generators must participate in central dispatch & cap its output when involved in a binding network constraint	Done
Network Security - Sub 5-Minute Variability	Sub 5-minute output variations may result in violation of secure network limits unless operational safety margins increased	Semi-Dispatch Rule: From March 2009 the recovery of Regulation FCAS costs from Semi-Scheduled Generators based on deviations around NEMDE dispatch trajectories	Done
Power System Stability Implications	Displacement of conventional large scheduled plant with relatively low inertia wind plant may reduce ongoing power system stability. Need to be aware of operational implications well before plant designs are committed & operational incidents occur	More power system security modelling required with focus on impact on power system stability. NEMMCO has already engaged consultant DigSilent to conduct stability studies. ESIPC has also conducted studies. Results from studies may inform future generation licensing & connection negotiations, & may result in further network constraints	**WIP** **11**

Wind Generation Issues for NEMMCO (2)

NEMMCO

Issue	Implications	Proposed Solution	Status
Islanding	Wind generators is typically not able to control power system frequency. If an island forms with mainly wind generation, frequency may drift until frequency protection settings are exceeded & load interrupted	NEMMCO may need to consider policy on managing such islanding contingencies if they become credible. Issue may need to be managed during negotiation of network connection.	WIP
Contribution to System Reserves	Reserve contributions need to take into account of a number of factors including: - Individual wind farm patterns - Impact of geographic diversity - Impact on network transfer limits Justification of reliability-based network augmentations may need to account for wind generator contributions at local peak demand.	NEMMCO, through the Inter-regional Planning Committee, is progressing work to improve techniques used by network planners for better estimates of supply reliability contributions from significant levels of wind generation in the NEM. Note that the Semi-Dispatch Rule deems that wind generators are ineligible for reserve contracting by NEMMCO	WIP
Optimising Shared Network Assets at Design Stage	Current arrangements consider each connection in isolation, worsened by desire for confidentiality between connecting parties & sequential nature of network connection. Sub-optimal connection of multiple developments can result in increased cost, increased environmental impact, stranded assets from earlier connections, & reduced viability of later connections	Better coordination of multiple connection applications may be required. Optimal design of new connection assets should Ideally account for ultimate amount of wind generation likely to connect in the area. There are policy issues relating to: - who should fund shared connection assets (shallow versus deep network funding & "free-riders") - allocation of firm access rights for proponents that fund deep network augmentation	WIP **12**

Wind Generation Issues for NEMMCO (3)

NEMMCO

Issue	Implications	Proposed Solution	Status
Network Connection Process	Rule arrangements for negotiating network connection unclear NSPs may be reluctant to conduct analysis of alternate connection options if uncertain that they can recover associated costs	Technical Standards Rule changes (March 2007) substantially resolved the issues There may be further merit in clarifying the enquiry, application & funding arrangements to allow NSP to investigate connection options prior to a formal application Note that AEMC have commenced a review of Technical Standards in the Rules	**WIP**
Network Connection Access Standards	Technical Standards for network connection could not be directly applied to wind generation as typically asynchronous, hence Standard was (NOT technologically neutral Some Standards also lacked flexibility, resulting in excessively onerous requirements. Application of Standards to supply reliability issues is unclear in some instances.	Technical Standards Rule changes (March 2007) substantially resolved the issues, by introducing: -Tighter tech standards for network connection -Greater information disclosure -More accurate generator performance models However Rule also removed third party access to confidential data	Done Issue to be resolved
Provision of Dynamic Generating Plant Models	If NEMMCO & NSPs cannot access verified, accurate Generator dynamic models then: - Power system security is at risk, as NEMMCO uses models for on-line security assessment & planning - Plant or network security is at risk, as NSPs use models for operational planning (eg protection settings) - Design of new connections & processing of new connection applications is more problematic	Technical Standards Rule changes (March 2007) substantially resolved the issues	Done

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Wind Generation Issues for NEMMCO (4)

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Issue	Implications	Proposed Solution	Status
Contingency FCAS & Cost Recovery	The relatively high variability & low inertia of wind generation could result in increased contingency FCAS requirements. Do the current funding arrangements apply appropriately to wind farms?	The modelling of Contingency requirements are the subject of ongoing NEMMCO review NEMMCO's recent FCAS Review ratified the current funding arrangements	WIP
Regulation FCAS & Cost Recovery	The relatively high variability & low inertia of wind generation could result in increased regulation FCAS requirements Do the current Causer Pays funding arrangements apply appropriately to wind farms?	The modelling of Regulation requirements are the subject to ongoing NEMMCO review NEMMCO's recent FCAS Review ratified the current funding arrangements	WIP
Information Disclosure	The current generation information disclosure provisions in the Rules relate primarily to scheduled plant. May be merit in disclosure of additional wind & non-scheduled plant information to facilitate market	"Publication of Information for Non-Scheduled Generation" Rule Change (Jul 2006) addressed this issue.	Done
Wind Generation Forecasting	Better wind generation forecasts will improve Dispatch, Predispatch, STPASA & MTPASA outcomes	NEMMCO already has an interim wind forecasting process (WEPROG) in place covering Pre-dispatch & PASA Interim system to be replaced by AWEFS, which will also cover 5-Min Dispatch. AWEFS to go-live from Sep 2008, & used for Semi-Dispatch from Mar 2009	Done

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Network Violation Issue (1)

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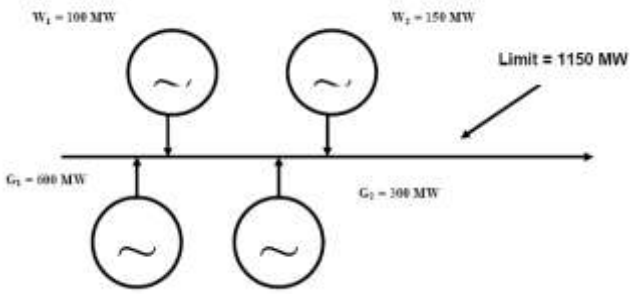

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Network Violation Issue (2)

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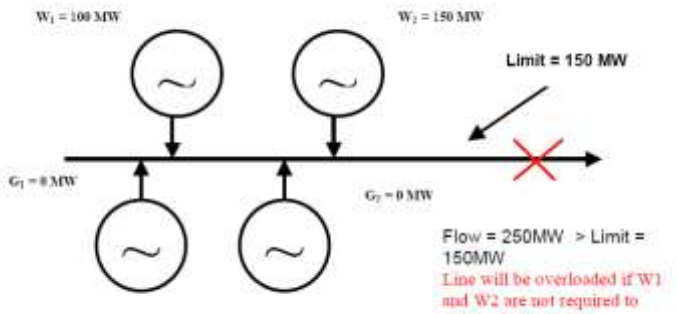
- **(Rule 4.3.1) NEMMCO must maintain power system in a secure operating state, & efficiently control network flows within their secure operating limits**



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South Australia Power System

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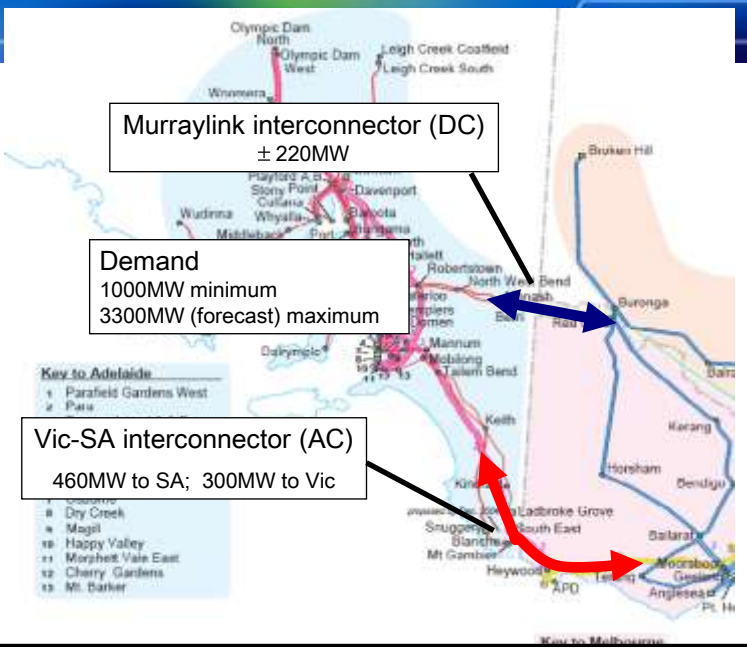

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V-SA Interconnector Flow Variability & Operating Margin

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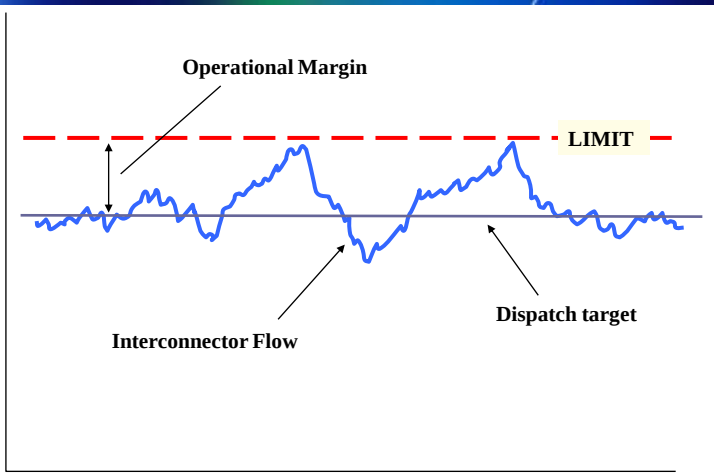

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V-SA Interconnector – Increased Flow Variability

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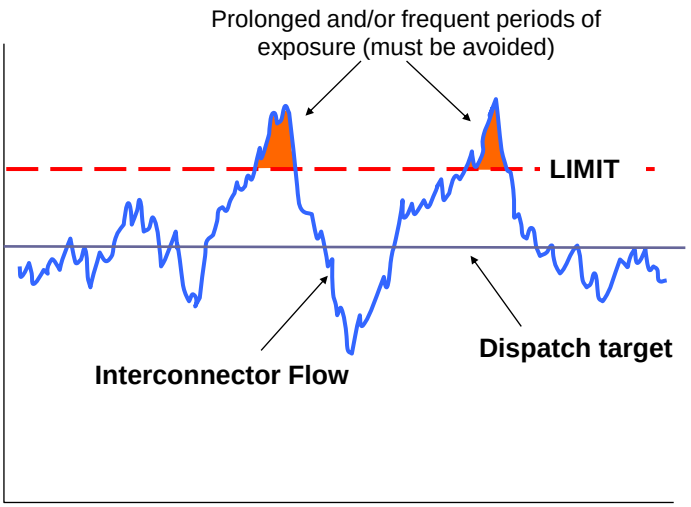
Higher Operating Margin, due to combo of Demand & Wind Variability…



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Current Approaches to Network Violation Issues

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- **Special licence conditions in SA**
  - Scheduled wind farms cannot comply → frequent rebids
  - Increased Compliance costs
  - Greater investment uncertainty
- **Local NSP generation control schemes**
  - Less market transparency
  - Crude control → disconnects wind farm if not complying
- **Increased network constraint operating margins**
  - Cheaper scheduled plant constrained-off before non-scheduled → Higher market costs
  - Under-utilisation of available network capacity
- **Market intervention**
  - Less market transparency & higher market costs

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New Semi-Dispatch Rules

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- Semi-Dispatch Rules will improve competition for limited network capability
- Significant intermittent generators must register as Semi-Scheduled from 1 May 08
- From 31 Mar 09 all Semi-Scheduled Generators:
  - Must submit dispatch offers & plant availability
  - Must participate in central dispatch & PASA
  - Must limit generator output at times when it would otherwise violate secure network limits

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Triggering of Semi-Dispatch

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Unit is "Semi-Dispatched"

Rules → a *semi-dispatch interval*
MMS → Semi Dispatch Cap flag status = "True"

IF:

Unit Dispatch affected by a binding or violated network constraint (Unit on constraint LHS)

MMS → constraint's marginal value ≠ $ zero

OR

Unit Dispatch < Wind Generation Forecast (UIGF)

…may also be due to its offer price

ELSE Rules → a *non semi-dispatch interval*

Semi-Dispatch Compliance with Dispatch Instructions (1)

NEMMCO

- IF Unit is "semi-dispatched"
  THEN

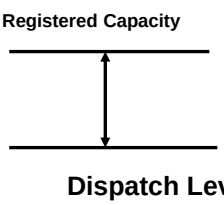
  Generator must reduce output to at or below the Dispatch Level in the dispatch instruction

- ELSE.. Unit is "non-semi-dispatched"

  → Generator free to generate to any level, subject to NEMMCO's powers to direct

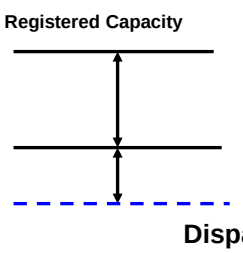
Semi-Dispatch Compliance with Dispatch Instructions (2)

NEMMCO



No binding network constraint
AND
Dispatch Level = UIGF

The wind farm IS NOT required to control its output!



Binding network constraint
OR
Dispatch Level < UIGF

The wind farm IS required to control its output!

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SA Example: Rapid Wind Change event on 9 Feb 2006

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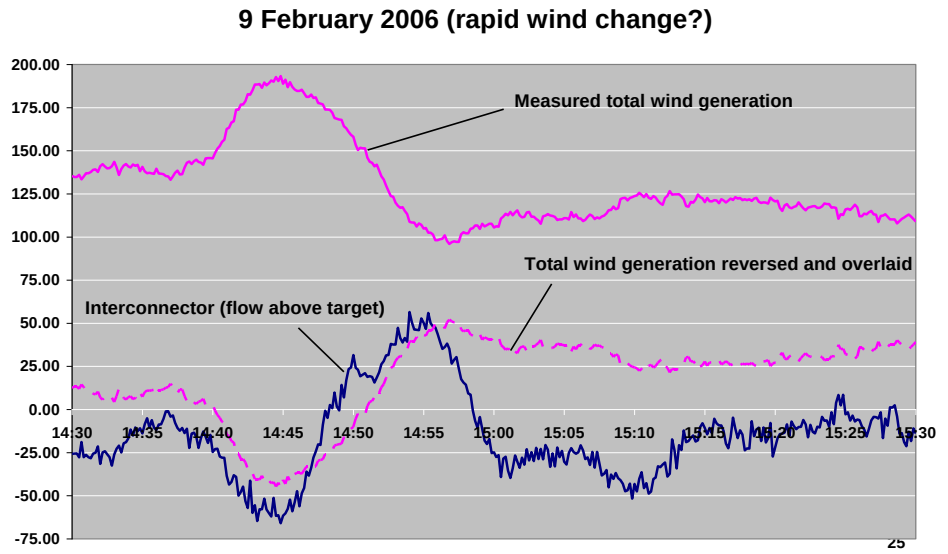

SA Example: Rapid Wind Change event on 12 Dec 2005

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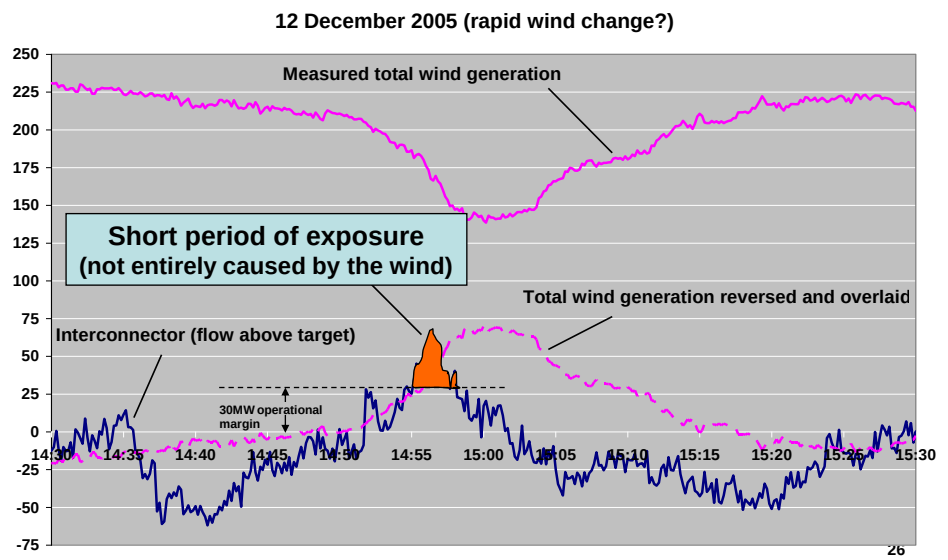

SA System Stability issues & DIgSILENT Studies

NEMMCO

- Previous two examples were worst cases in 2005/2006
- Some periods significantly above target - to be expected
  - Rapid load variations
  - Generator trips
  - Do something if periods of exposure become excessive
- DigSilent studies aimed at answering:
  - **Main technical issues that could arise in future?**
  - **In broad terms, the extent of any impacts?**
  - **Is there a stability issue that could limit total amount of installed wind capacity in SA?**
- Stability studies were from system perspective
  - **Transient Stability**
  - **Short Term Voltage Collapse**
  - **Long Term Voltage Collapse**
  - **Oscillatory (small signal) Stability**

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DIgSILENT Stability Studies (1)

NEMMCO

- Determine technical envelope – worst case combinations of:
  - **SA Demand: highest to lowest**
  - **V-SA interconnector flow: Max Export to Max Import**
  - **2005 Study → Installed wind: Base Case 0 MW; 400MW / 800MW / 1,200MW**
  - **2007 Study → Installed wind: Base Case 0 MW; 300MW / 900MW**
- Assumptions:
  - **Assume all wind generation operating at full capacity**
  - **Wind generation displaces synchronous generation in NEM**
- DIgSILENT dynamic models
  - **Used in-house knowledge & models for wind**
  - **Obtained model information directly from manufacturer**
  - **Other (synchronous generator) models benchmarked with existing PSSE models**

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DIgSILENT Stability Studies (2)

NEMMCO

Key results from DIgSILENT studies in 2005…

- 800MW of installed SA wind capacity could be managed, with
  - Some reduction in V-SA interconnector capability (around 140MW) under peak demand (high load) conditions
  - With no impacts at other conditions
- Voltage control:
  - A combination of placement of wind farms at remote locations & displacement of synchronous generation significantly reduces voltage control capability on SA 275kV system
  - This occurred under maximum demand conditions with 1,200MW of installed wind capacity
- Transient Stability & Oscillatory Stability was no problem under any of assessed conditions
- 2007 Studies roughly confirmed the above

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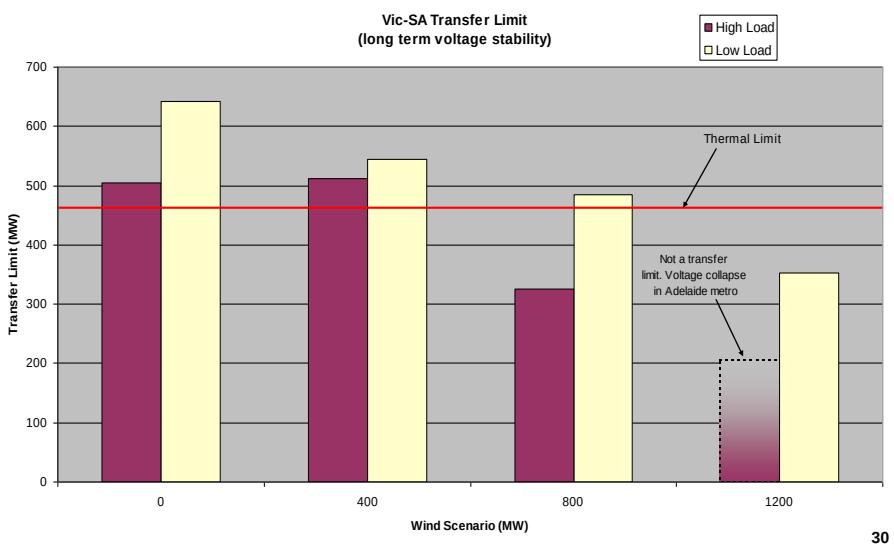
DIgSILENT Stability Studies (2005)

NEMMCO



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DIgSILENT Stability Studies (2007)

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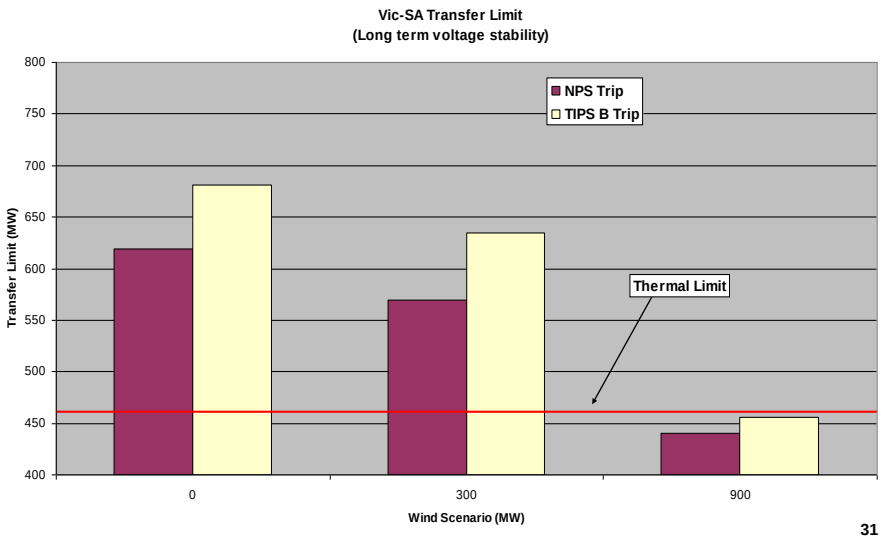

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Network Access Technical Standards in the Rules (1)

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- S5.2.5.1 Reactive power capability
- S5.2.5.2 Quality of electricity generated
- S5.2.5.3 Generating unit response to frequency disturbances
- S5.2.5.4 Generating system response to voltage disturbances
- S5.2.5.5 Generating system response to disturbances following contingency events
- S5.2.5.6 Quality of electricity generated and continuous uninterrupted operation
- S5.2.5.7 Partial load rejection
- S5.2.5.8 Protection of generating systems from power system disturbances
- S5.2.5.9 Protection systems that impact on power system security
- S5.2.5.10 Protection to trip plant for unstable operation
- S5.2.5.11 Frequency control
- S5.2.5.12 Impact on network capability
- S5.2.5.13 Voltage and reactive power control
- S5.2.5.14 Active power control

- S5.2.6.1 Remote Monitoring
- S5.2.6.2 Communications equipment

- S5.2.8 Fault current

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Network Access Technical Standards in the Rules (2)

NEMMCO

- Network Connection Agreement
  - Commercial contract between NSP & Generator
- Automatic Access Standard
  - NSP & NEMMCO cannot require a higher standard
  - Anything below this must be negotiated
- Negotiated Access Standard
  - Some technical assessments must involve NEMMCO
- Minimum Access Standard
  - "do no harm" to other network users (no impact on System Standard)
- Registered as Performance Standards with NEMMCO
- General Technical Requirements
  - All control system settings must be approved in writing by the NSP & NEMMCO (S5.2.2)
  - Data Provision
    - Design & Setting data
    - Dynamic Models

Questions.....?

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