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Workshop Session 2: Wind farm planning & network-related issues

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Outline

- Wind farm planning in Australia:
  - Trends in wind farm installation in Australia
  - Concepts of sustainability & European experience
  - Wind farm planning in Australia & possible enhancements
- Network-related issues in the NEM:
  - Potential disturbances & their management
  - Network connection requirements & costs

Wind turbine installations in Australia: history & forecast

Summary of wind farm projects at February 2004.
Approximate, based on www.auswea.com.au

Completed	200 MW
Under Construction	140 MW
Tendering	540 MW
Approved	920 MW
Planning	1100 MW
Total	**2900 MW**

Sustainability concepts for wind energy projects

- Important aspects of sustainability:
  - Environmental (ecosystem) sustainability
  - Economic (ability to progress) sustainability
  - Technical (physical) sustainability
  - Institutional (social) sustainability

- Sustainability has a broader context than a particular project – *cumulative impacts matter*
- Perfect sustainability not a practical goal – *trade-offs required*

Trade-offs in sustainability - wind energy:
Coastline at Woolnorth Tasmania looking north

Trade-offs in sustainability - wind energy:

Coastline at Woolnorth Tasmania looking south

Are renewables sustainable?

- Australia's Federal Treasury view
  "Even though renewable energy is renewable, it does not necessarily mean it is environmentally benign. Like fossil fuels, renewable energy can also impose external costs on the community… the large-scale use of wind turbines may adversely affect landscapes, migrating bird species, and pristine wilderness areas. Additionally, it may result in noise and aesthetic pollution…"
  Treasury (2002) "Renewable energy – a clean alternative?" *Economic Roundup Spring 2002*
- => renewable technologies aren't inherently sustainable (eg. Gordon below Franklin Hydro), but appropriate renewable energy systems can be

Externalities + stakeholders

- Externalities
  - Positive or negative effects of activity that don’t appear as direct costs or benefits to party undertaking activity (ie. don’t automatically influence project decision making)
  - Wind farms have very important externalities
  - People affected by externalities are ‘stakeholders’
- Important stakeholders in wind projects:
  - Governments (federal, state, local)
  - Citizens (local, remote) & NGO’s
  - Businesses & employees (direct & indirect)
  - Electricity industry

The role of governments

- Hard to internalise all externalities at project level
  - potential for poor outcomes + social discord
  - May be ‘internalised’ after great expense and effort has already been undertaken
  - May engender generalised resistance to future projects

- Govts should provide appropriate frameworks where externalities and stakeholders identified, and project developers + stakeholders can negotiate solutions

European experience with public support for wind farms

- Danish experience (1980s & 1990s):
  - Mostly uncontentious sites
  - Strong local community participation & support
- German experience (1990s):
  - Strong government, industry & community support; some organised opposition
- British experience (1990s):
  - Contentious sites & few approvals
  - Organised resistance & limited support
  - Concerns about cumulative impact

Analysis of European resistance to wind farms (Wolsink, 2000)

- Resistance type A:
  - Positive to wind farms but not here (NIMBY)
- Resistance type B:
  - General opposition to wind energy (NIABY)
- Resistance type C:
  - Initially positive but put off by a bad experience
- Resistance type D:
  - Approval subject to meeting certain criteria

Australian wind farm planning

- National developments
  - AusWEA best practice guidelines:
    - www.auswea.com.au
    - Partnership with Aust. Council of Natl. Trusts to develop landscape assessment protocols
  - Fed. Govt has few 'planning' powers but EPBC Act
  - Some other stakeholder interest – eg. Aust Heritage Comm.
- State Governments
  - VIC: Govt vision "facilitate appropriate development of up to 1000MW by 2006", State-wide policy + planning provisions for local Govt, Minister for planning if >30MW, Wind Atlas
  - NSW: PlanningNSW guidance + State Govt responsibility for >30MW, some local govts have DCPs for wind, SEDA
  - SA: Local Council relevant authority (state-wide planning provisions) unless classified major development (Minister feels it will have significant social, env. or economic impacts

Australian wind farm planning experience to date

- Limited experience to date:
  - Some strong support, some strong opposition
- Mixed federal, state & local government approvals process lacks coherence:
  - Project based - may not manage cumulative issues & interactions well
- Other industries have a comprehensive planning framework, eg:
  - Strong, state-based planning framework for the minerals industry

Planning summary

- Wind farms have many stakeholders:
  - Governments, developers, citizens & NGO's, businesses & employees, electricity industry
- Wind farms have important externalities:
  - Environmental, social, mutual impacts
- Wind farms are not independent projects:
  - Economies of scale in network connection
  - Interference between shared wind resources
  - Shared social & environmental impacts

Planning recommendations

- Develop a comprehensive wind farm planning framework - federal, state, local:
  - – Staged regional development process:
    - Resource evaluation; regional wind development & grid connection strategy; wind farm siting
  - – On-going monitoring & evaluation
  - – Integrated forecasting process
- Adapt other models, such as:
  - – Existing mineral industry
  - – Emerging water catchment management

Example of state role in planning

Queensland Government
Natural Resources and Mines

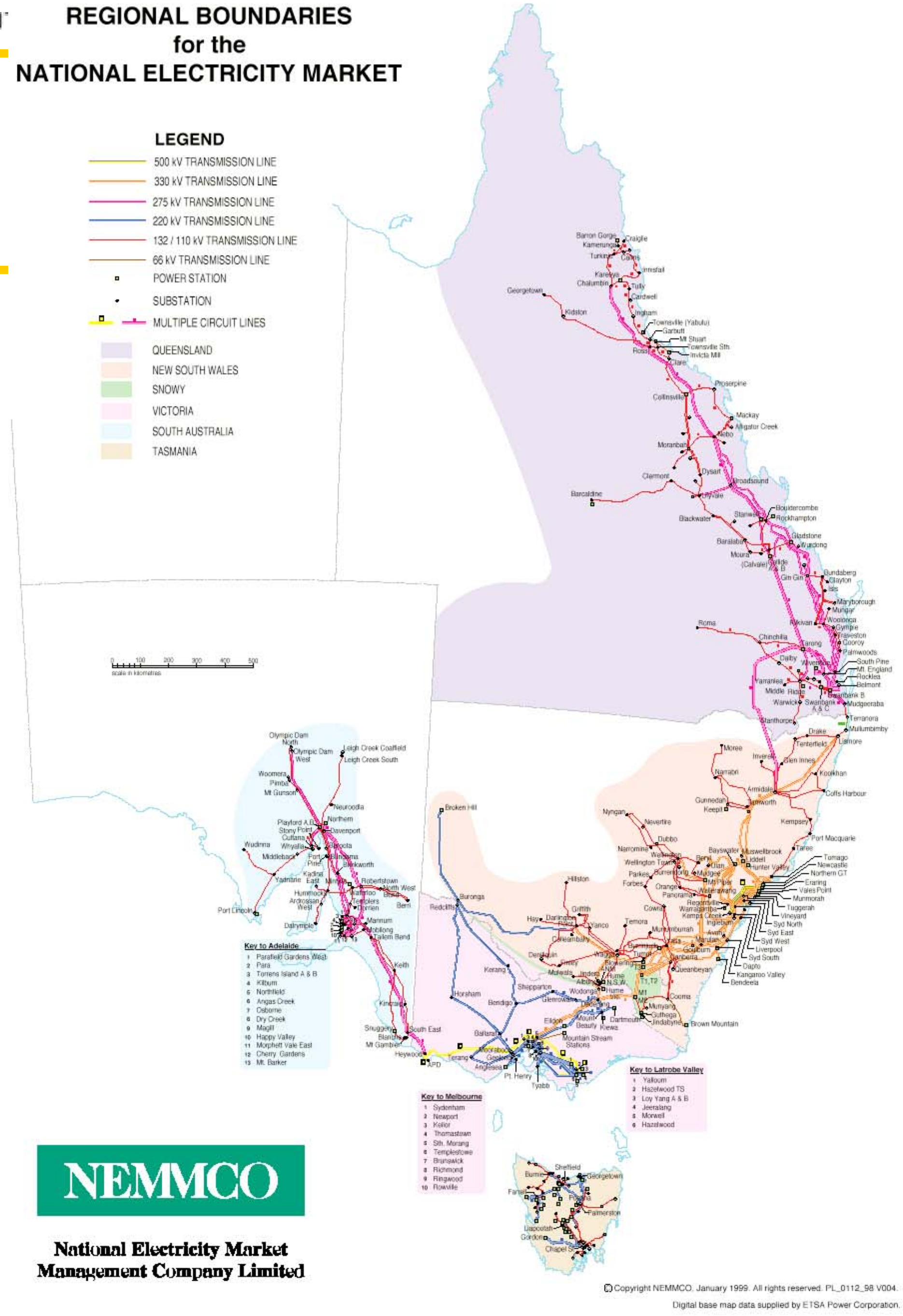
- Queensland Coal Seam Gas Regime (2002)
  "The regime provides greater certainty for explorers and developers to invest in coal seam gas projects as well as provide clear rules, rights and obligations for the coal and gas industries to work cooperatively in developing the resource."

States participating in the National Electricity Market (NEM)

- Queensland
- New South Wales & ACT
- Victoria
- South Australia
- Tasmania (on connection to the mainland)

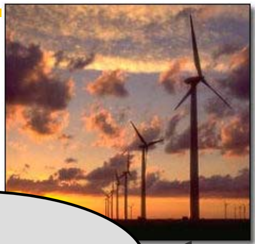
NEM regions are indicated, and their boundaries need not be on state borders (e.g. two regions in NSW)

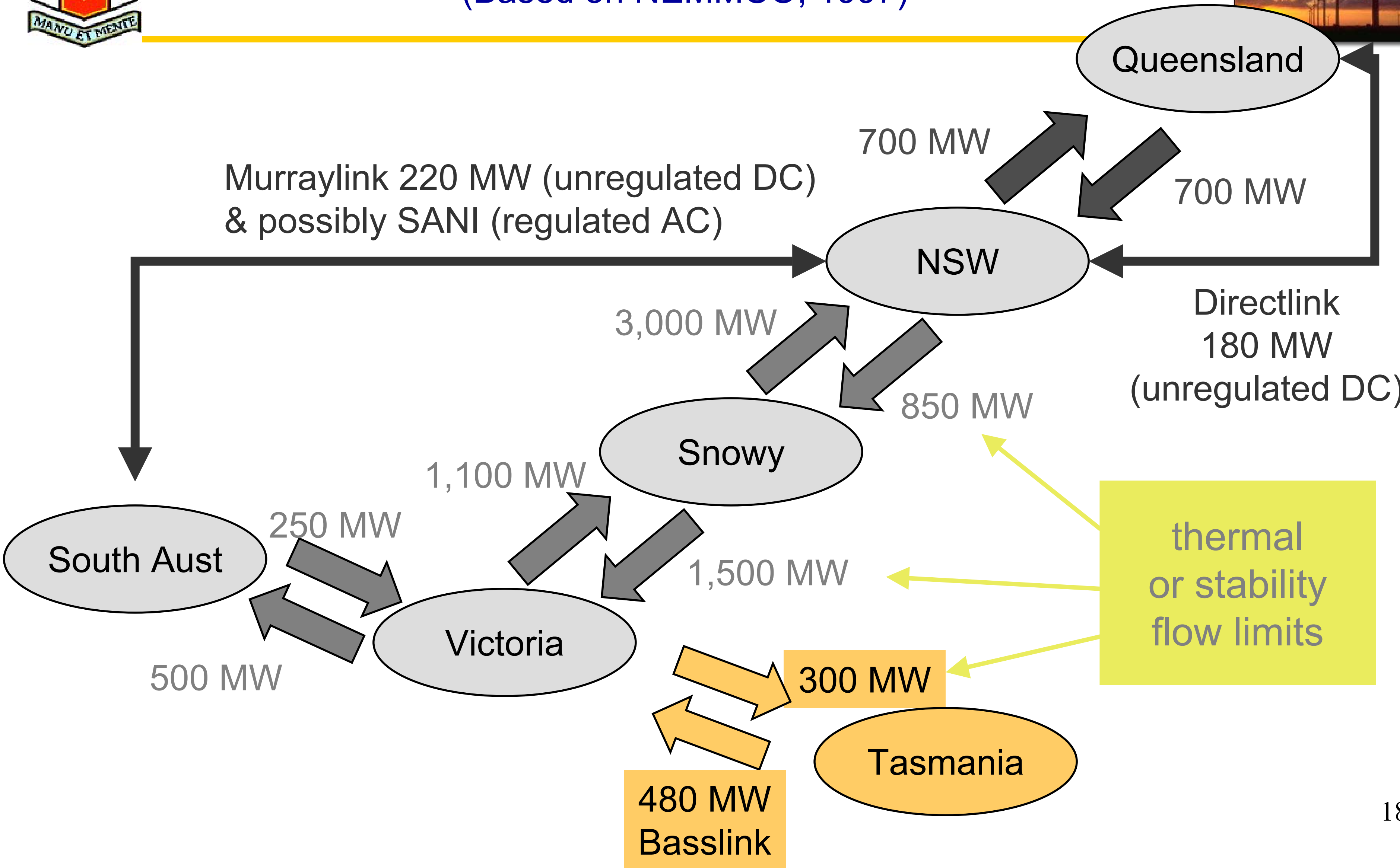
Queensland was expected to have 3 NEM regions, but transmission augmentation is removing the associated flow constraints



NEM Model

(Based on NEMMCO, 1997)





Network issues for wind farms #1

- Networks are shared, centrally planned resources:
  - Must limit disturbances caused by wind farms
  - Windfarms must survive disturbances from the network
- Renewable resources are often distributed differently from fossil fuel resources:
  - Weak network conditions likely to be more common in Australia than Europe or North America
- Network must be built to carry peak flows:
  - Want good estimates of aggregation & seasonal effects
- Benefits of staged development of wind resources:
  - Network savings; reduced voltage & frequency impacts

Network issues for wind farms #2

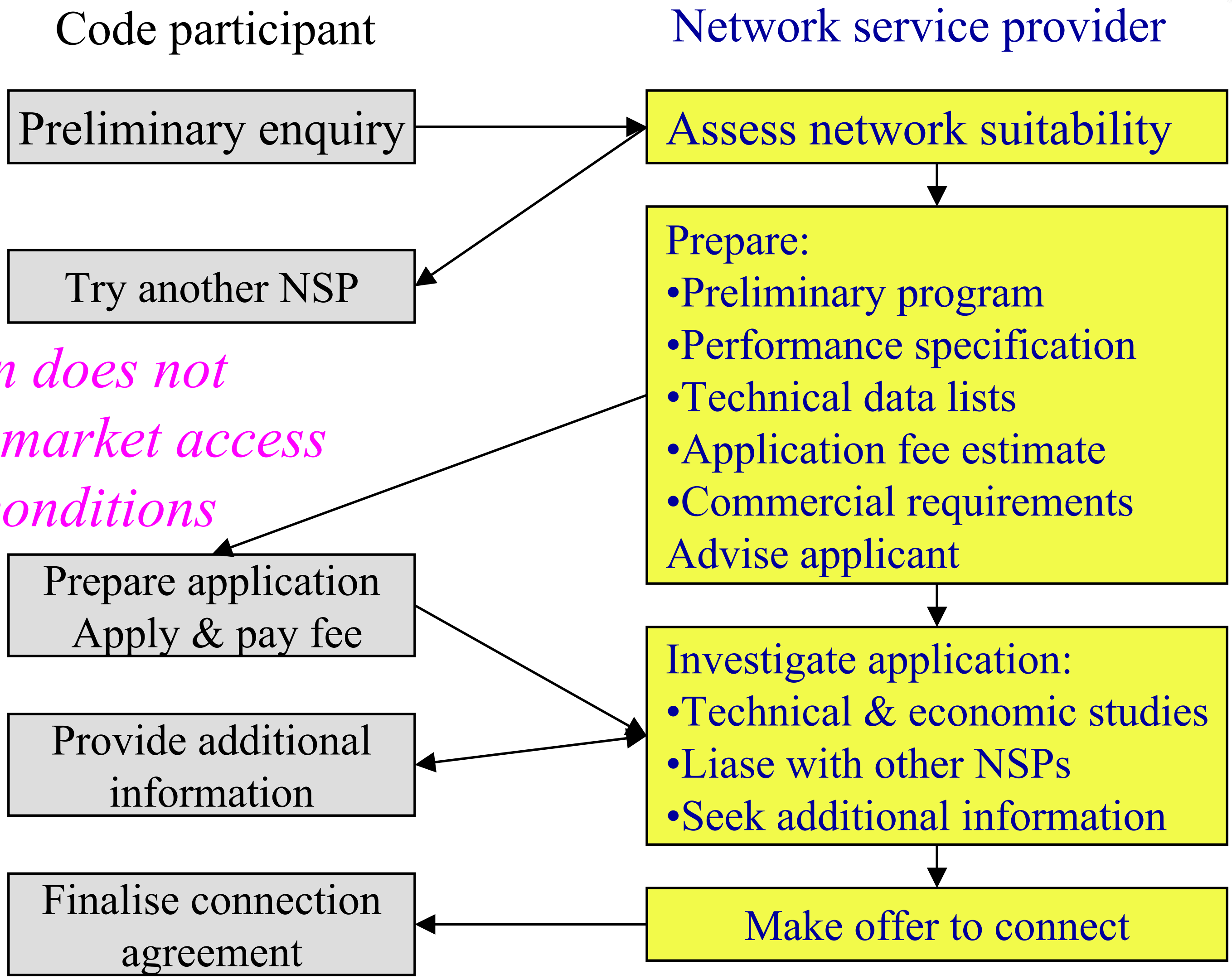
- Wind turbine starting & stopping transients:
  - Severity can be alleviated by soft-start & high wind-speed power-management
- Some wind turbine designs:
  - May cause voltage distortions:
    - Harmonics &/or transients
  - May have poor power factor, eg:
    - Uncompensated induction generator
  - May not ride-through system disturbances
    - Temporary voltage or frequency excursions

National Electricity Code

- Objectives
  - Market should be competitive
  - Customers should be able to choose with which supplier they trade
  - Any person wishing to do so should be able to gain access to the interconnected T&D network
  - A person wishing to enter the market should not be treated more or less favouruably than incumbents
  - A particular energy source or technology should not be treated more or less favourably than another energy source or technology
- However, hard to achieve in practice

NEC Grid connection process

(NEC, Chapter 5, p 9)



Connection does not guarantee market access under all conditions

National Electricity Code (NEC) requirements for generators

- Reactive power & voltage control capability
- Quality of electricity injected into network
- Protection requirements
- Remote control arrangements
- Excitation system requirements
- Loading rates
- Ride-through to avoid cascading outages:
  - Loss of largest generator; 175ms network fault

NEC categories of generators

- Market, non-market or exempt
  - Market implies sell to NEM
    - Can then also sell ancillary services
  - Non-market or exempt implies sell to retailer
- Scheduled or non scheduled:
  - Scheduled implies centrally dispatched:
    - Must then participate in the NEM processes of bidding, pre-dispatch & PASA
    - Default category for generation projects > 30 MW
    - Not appropriate for "intermittent" generation, eg wind

Effect of turbine type on network interaction

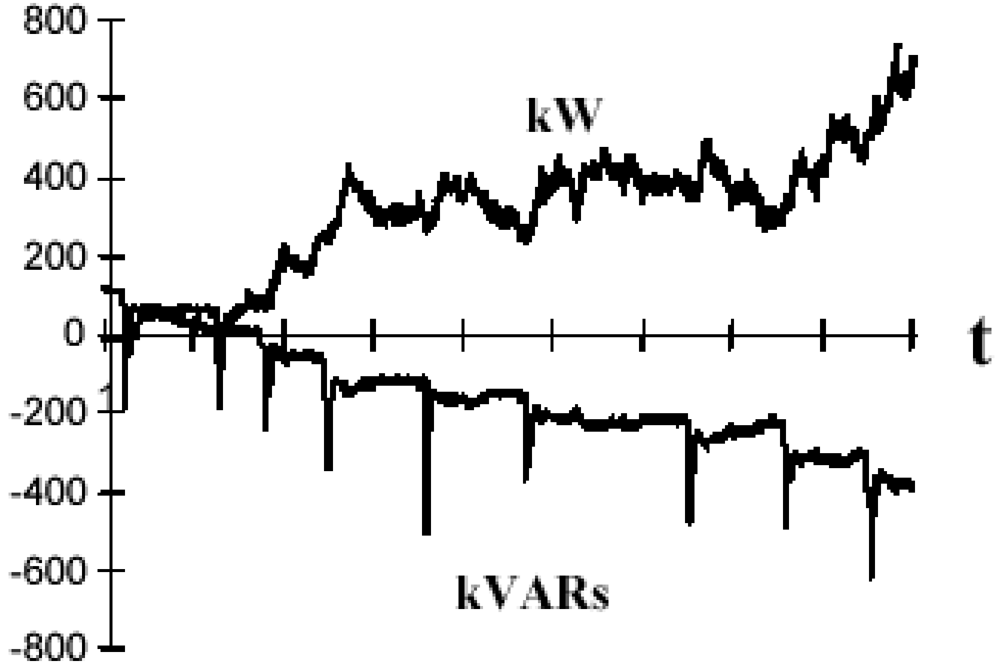
Aspect of grid interaction	Constant speed	Doubly Fed	Direct Drive
Voltage control	Only possible with additional equipment, e.g. capacitor banks, SVC's or STATCOM's	Theoretically possible, but dependent on converter rating	Theoretically possible, but dependent on converter rating
Harmonics	Hardly of interest	Theoretically of interest, but should not be a problem	Theoretically of interest, but should not be a problem
'Flicker'	Important, particularly in weak grids	Unimportant due to functioning of rotor as energy buffer	Unimportant due to functioning of rotor as energy buffer
Contribution to fault currents	Yes	Yes: but turbine is normally quickly disconnected	No: converter not capable of carrying fault current, turbine is quickly disconnected

(Slootweg & Kling, TU Delft, 2003, http://local.iee.org/ireland/Senior/Wind%20Event.htm)

Wind turbine starting transients for Esperance 2 MW wind farm

- 9 x 225 kW turbines with squirrel cage IG
- Magnetisation inrush current may cause a voltage dip - starts should be spaced out

(Rosser, 1995)



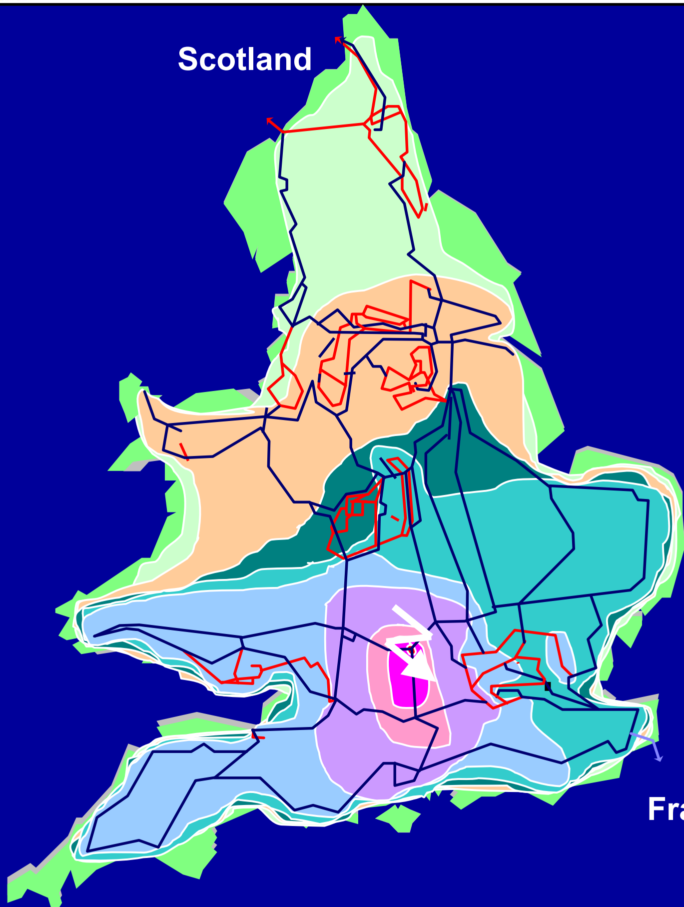
Hampton Wind Farm, NSW

(2x660 kW Vestas, connected to different 11 kV feeders)

Turbulence probably fairly high at this site

Induction generators may not ride through voltage dips well.

Voltage dip during a 3 phase fault on a UK 400 kV substation



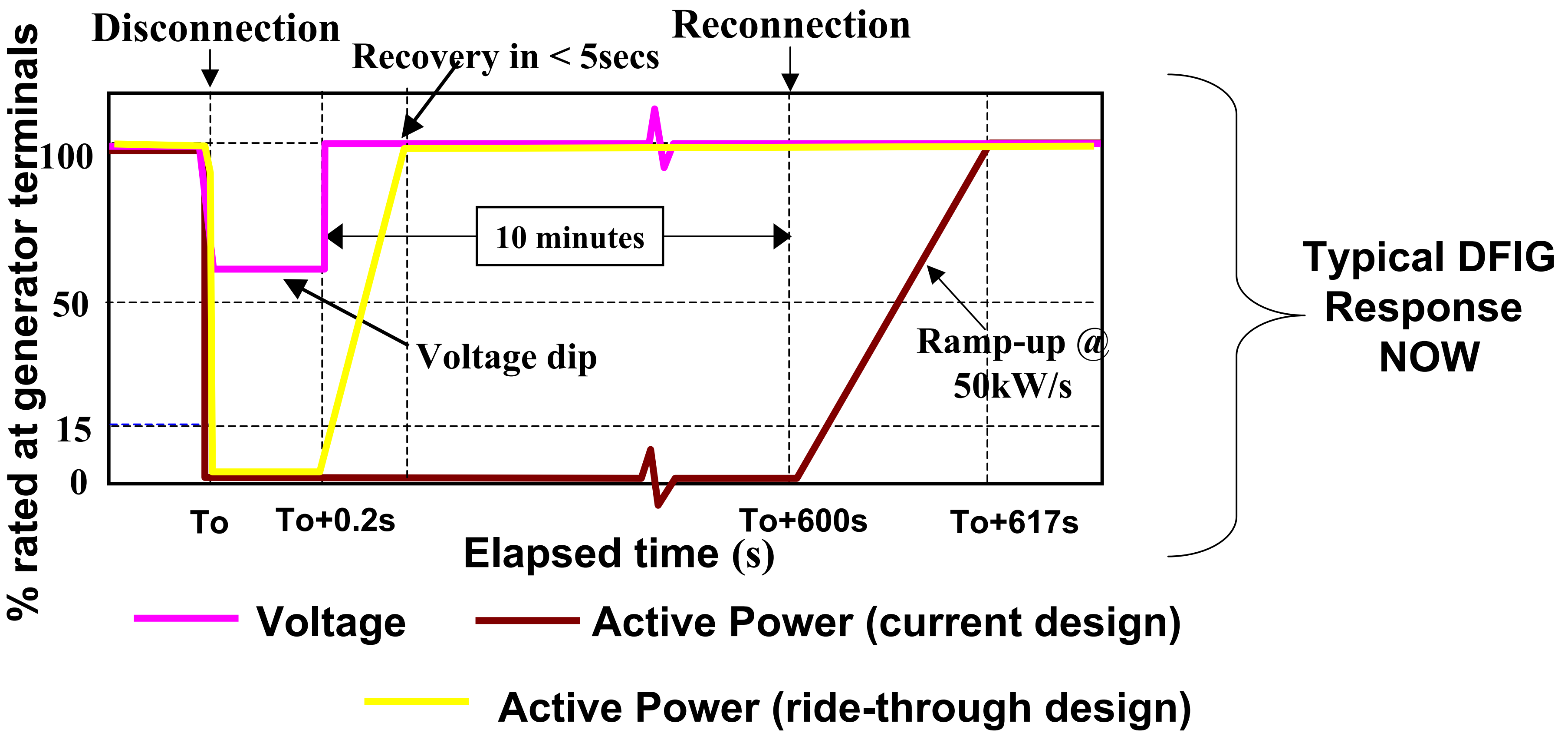
3 Phase Fault applied at Cowley 400 KV Substation

- Fault Location 0 % Volts
- 0 - 10 % Volts
- 10 - 30 % Volts
- 30 - 40 % Volts
- 40 -50 % Volts
- 50 - 60 % Volts
- 60 - 70 % Volts
- 70 - 80 % Volts
- 80 -90 % Volts

(Johnson, 2003, http://local.iee.org/ireland/Senior/Wind%20Event.htm)

Wind farm recovery following voltage dip

(Johnson, 2003, http://local.iee.org/ireland/Senior/Wind%20Event.htm)

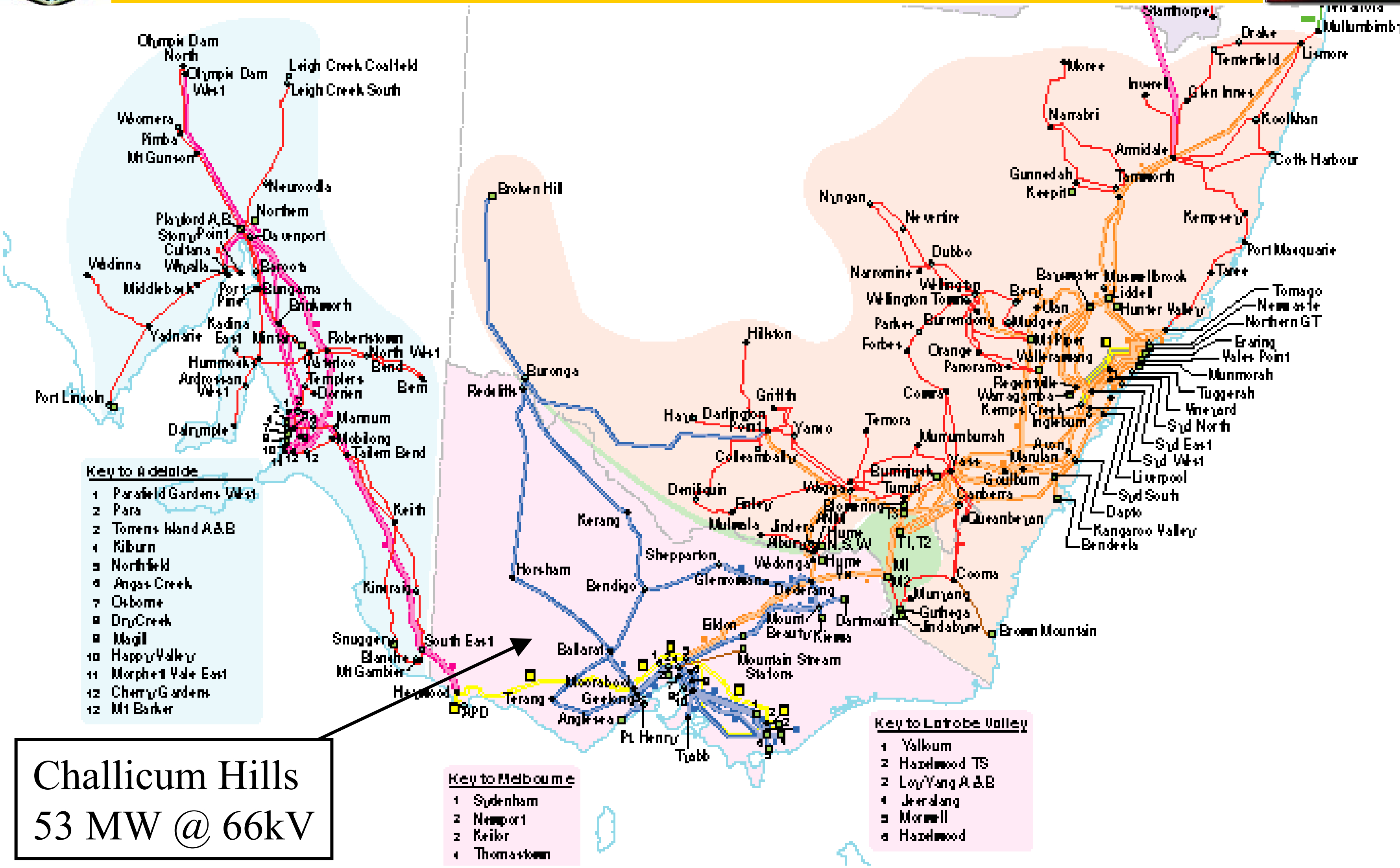


- DFIG wind turbines may take 10 minutes to re-start
- NEC ride-through requirements:
  175ms @ 0 V; 10 sec @ 80-110%V; 3 minutes @ 90-110% V

Network connection issues & examples

- Approximate ability of a transmission line to accept a wind farm:
  - 66kV ≤ 20MVA
  - 132kV ≤ 100MVA
  - 330kV ≤ 200MVA
  - Constraints may be determined by several factors:
    - Thermal, voltage, fault clearance, quality of supply
    - Thermal ratings depend on line temperature & wind speed
- Relevant wind farm rating is its maximum output, not the sum of turbine rated powers:
  - Coincident output of the connected wind turbines

NSW, Snowy, Victorian & SA regions of the NEM (NEMMCO, 1999)



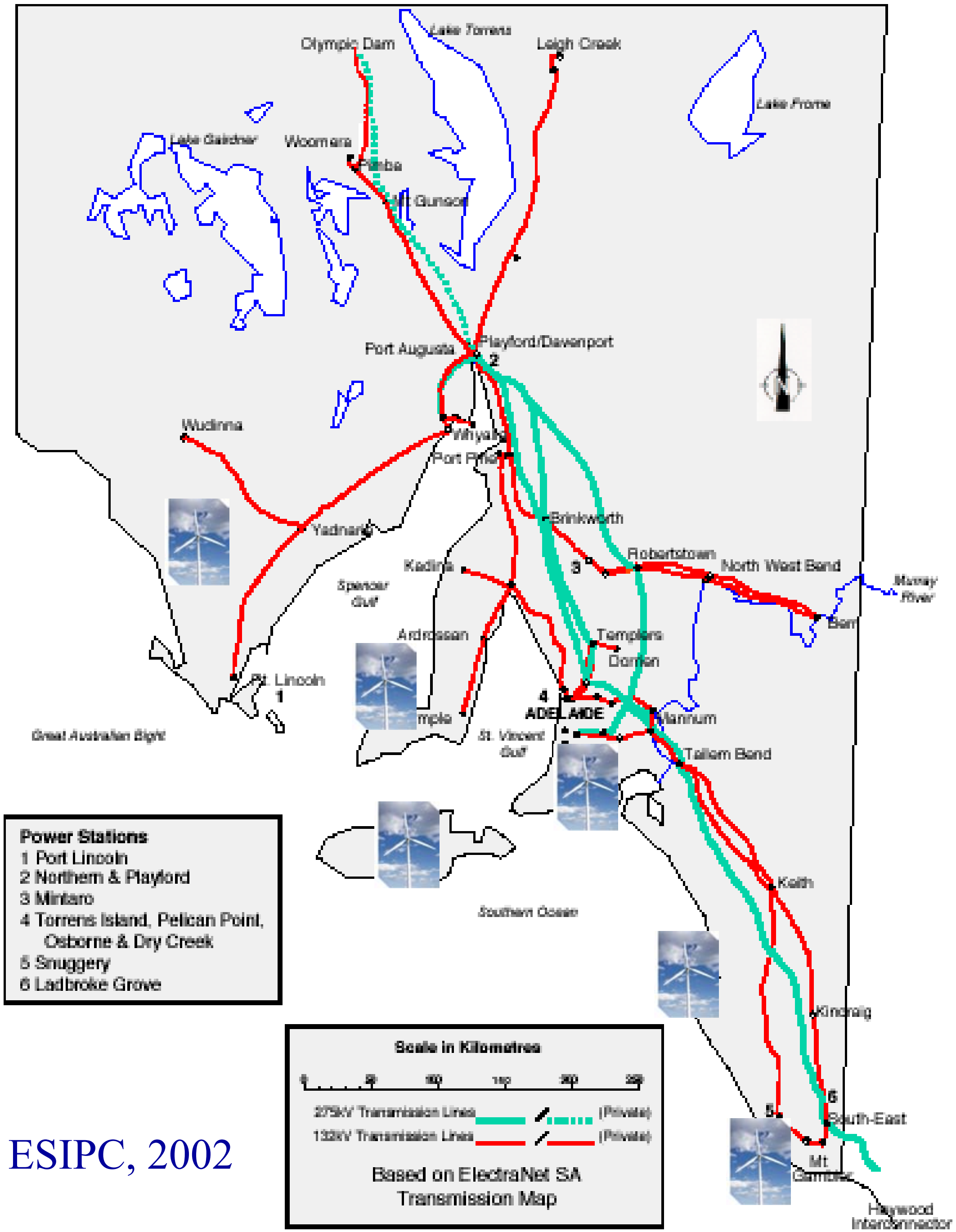
Challicum Hills
53 MW @ 66kV

Wind resource & network issues in South Australia

Good wind resources along entire coastline including:

- Eyre Peninsula
- Yorke Peninsula
- Fleurieu Peninsula
- Kangaroo Island
- South-East

Currently 35MW of wind farms installed in SA & 1200 MW proposed. Suitable sites for at least 2000MW

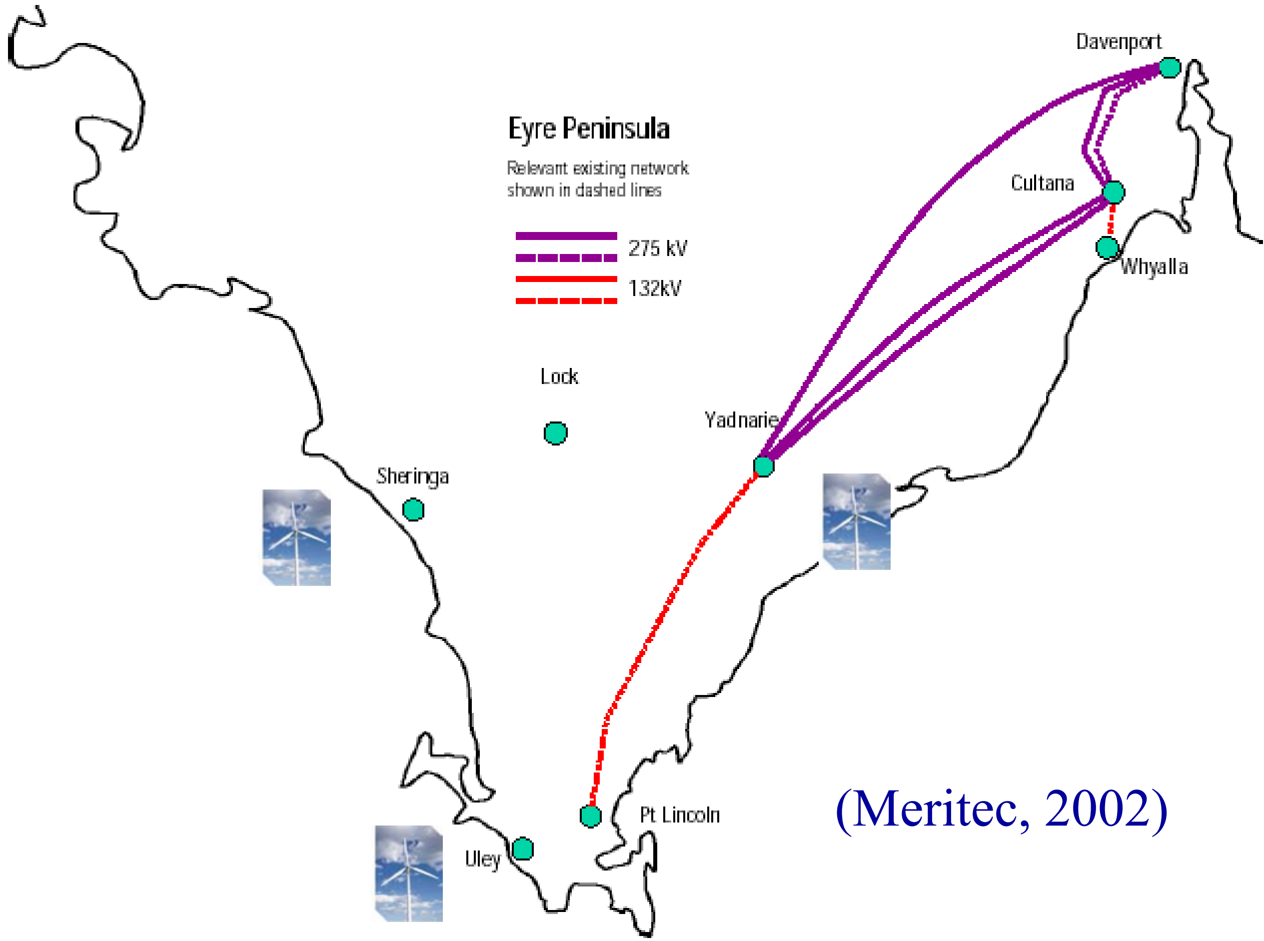


Map: ESIPC, 2002

Eyre Peninsula Backbone network upgrade to support 500MW wind

Estimated cost of 275kV backbone upgrade: $140M or $280/MW assuming equally shared by 500MW of wind.

Wind may not have to pay full cost of backbone upgrade.



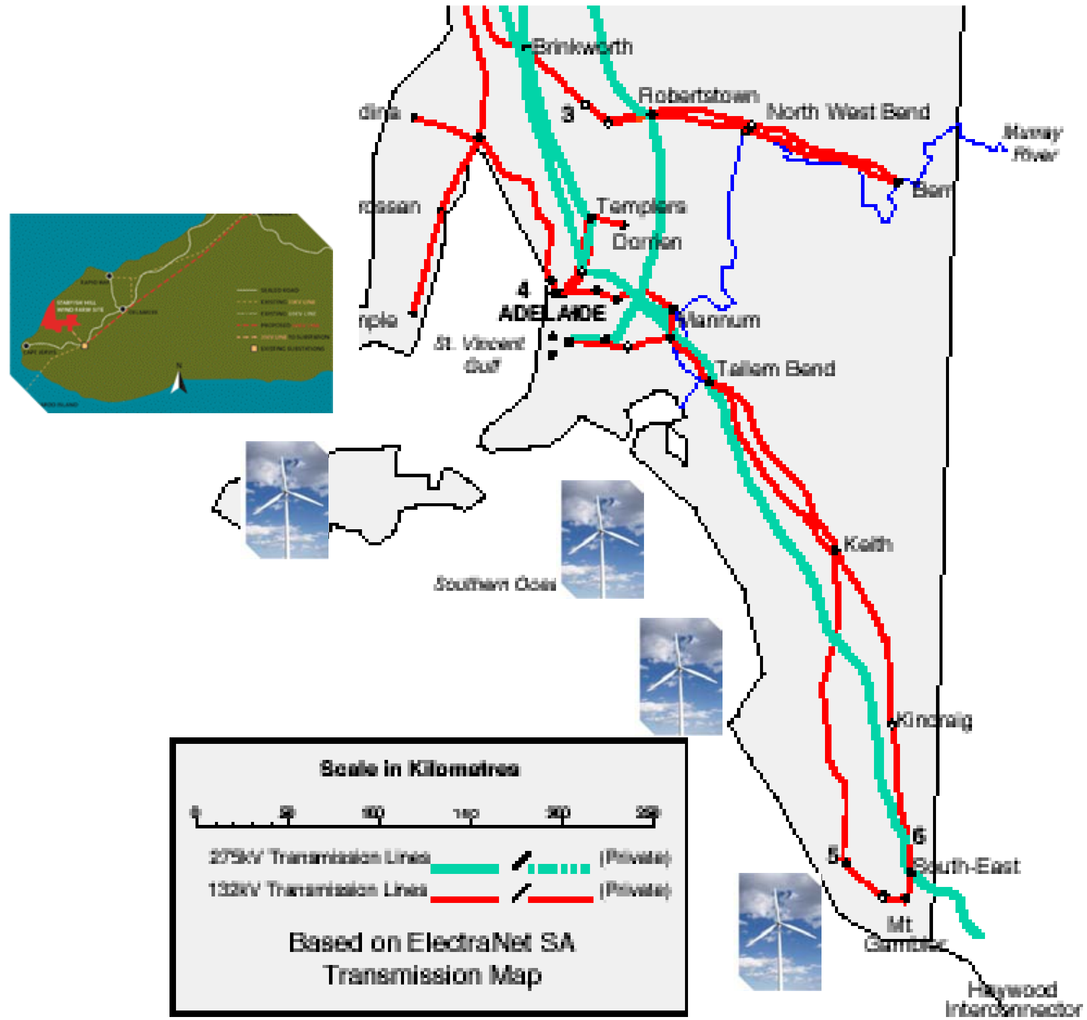
(Meritec, 2002)

South-east South Australia

Some scope for limited wind farm development without transmission upgrade.

Likely future upgrade of 275kV backbone with conversion of 132 kV network to radial operation

Unlikely that wind farms would have to pay for the backbone upgrade

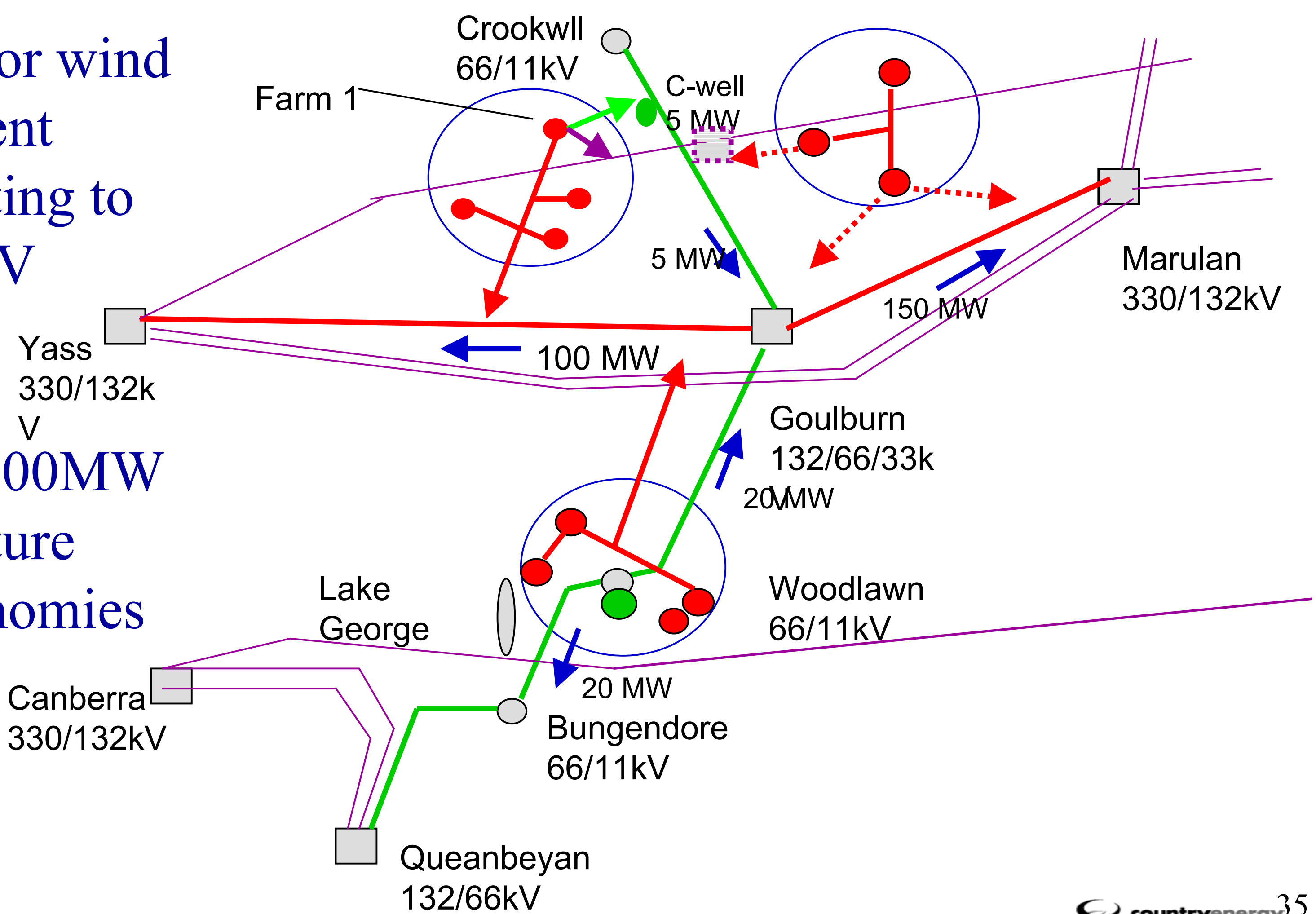


Goulburn region of NSW

(Country Energy, 2002)

Limited scope for wind farm development without connecting to 132kV or 330KV

Then group to 100MW or above to capture connection economies of scale



Connection costs to 330kV

(Transgrid, 2002)

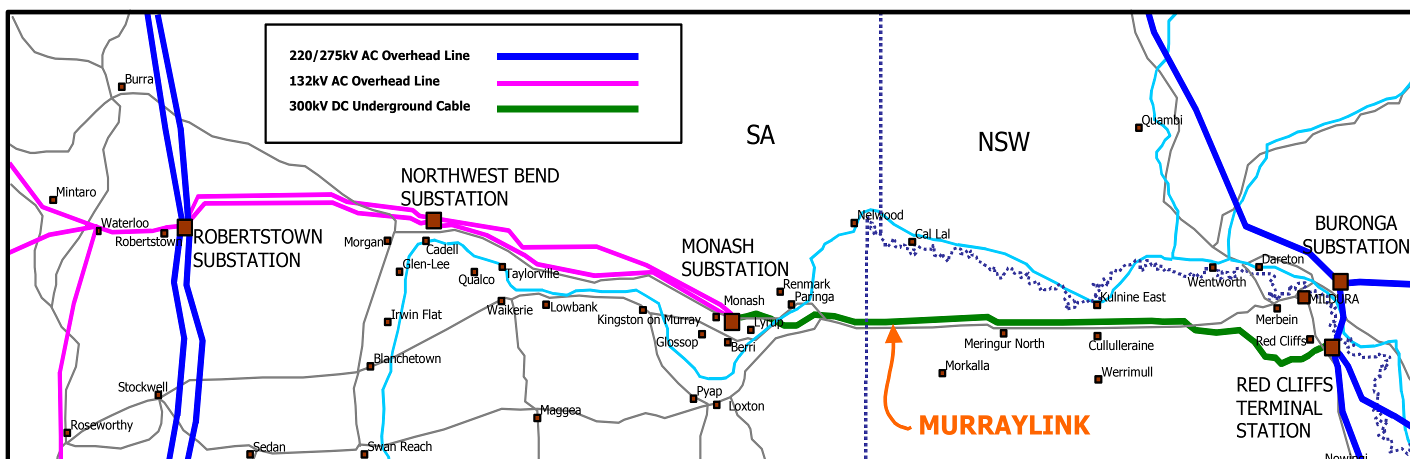
Wind farm number	Total wind MW	Conn. cost $M	Conn.cost $/kW
1	5	12.7	2,500
1	20	12.9	650
2	100	17.7	180
4	200	28.3	150

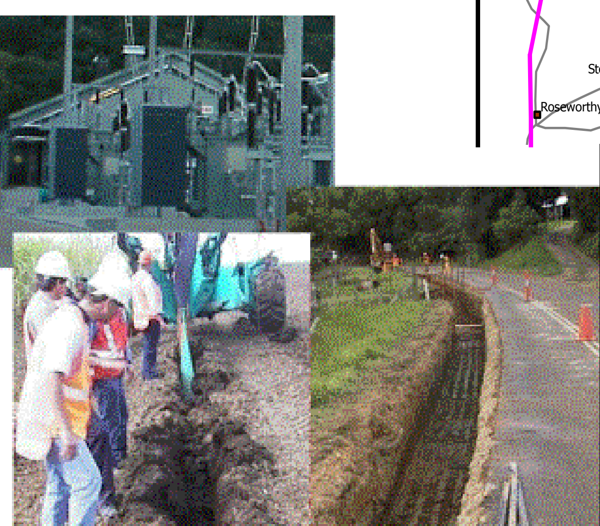
Important to capture economies of scale of grid connection

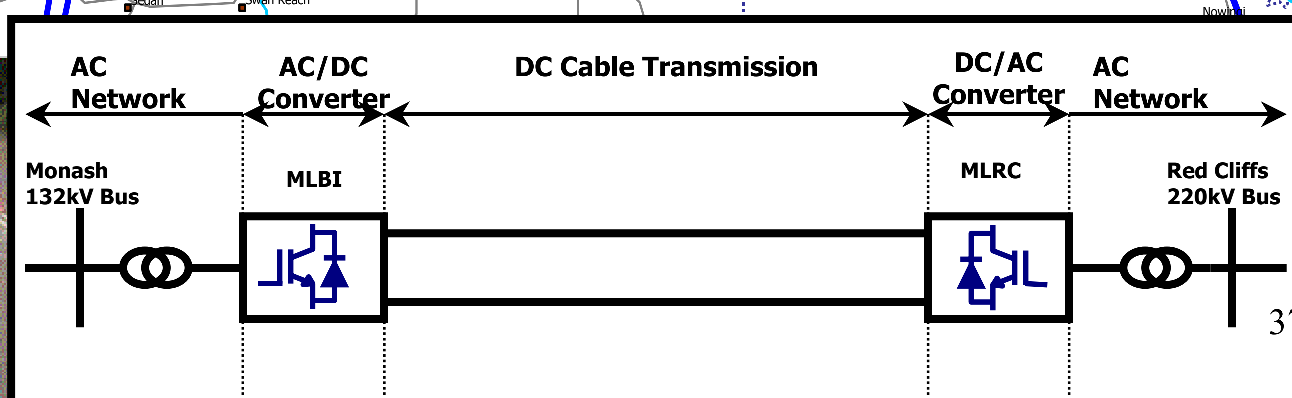
DC link option for grid connection

(www.transergie.com.au)

- AC: cheap but easements and interference to other users
- DC: Expensive but easement easier to get
- Example: Murraylink; 220MW, 180km







Conclusions

- Important opportunities for collaboration between wind farm developers & government:
  - Staged development of wind resources
  - Capturing economies of scale in grid-connection
- Wind farm technology should be chosen to give adequate performance:
  - Turbines & wind farm control system
  - Network connection arrangements