



Wind 2005 – *Australian Wind Energy Conference*

23-24 February 2005, Adelaide

Facilitating Wind Power Development in Australia

Dr Iain MacGill

Research coordinator - Engineering

Centre for Energy and Environmental Markets

Senior Lecturer

School of Electrical Engineering and Telecommunications

The University of New South Wales

i.macgill@unsw.edu.au

www.ceem.unsw.edu.au

Outline

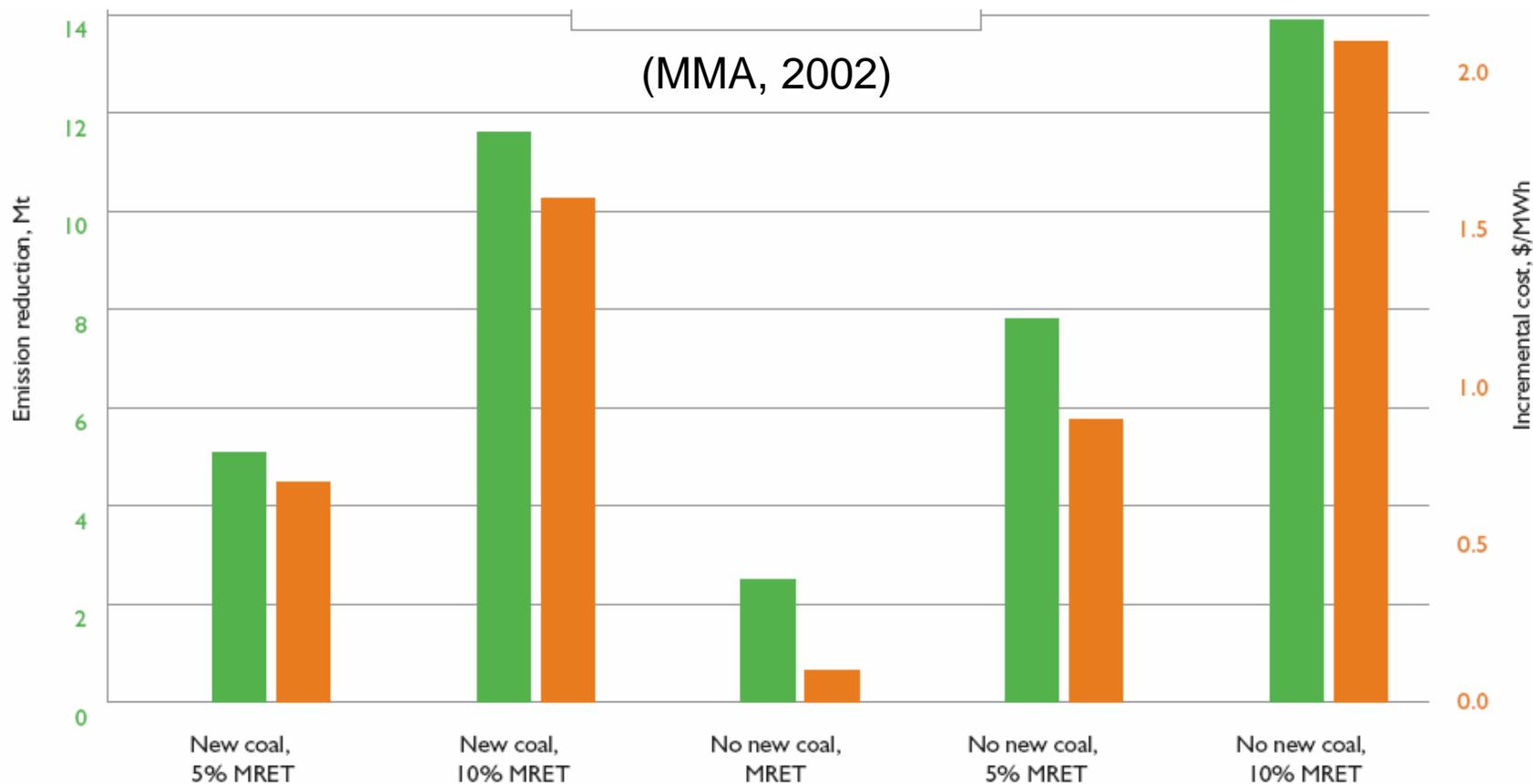
- The Australian energy policy context + wind power
 - Role of economic, energy security + environmental drivers
- Australia's energy options in a greenhouse world
 - how does wind rate?
- The sustainability of wind
 - Its social, economic and environmental context
- Successfully integrating wind into the NEM

Australia's electricity industry policy drivers

- Economic
 - Energy's role in economic development
 - Continuing market-based industry restructuring
- Energy security
 - Short-term: keeping the lights on now
 - Longer-term: ensuring the lights continue to stay on
- Environmental
 - The Australian electricity industry is responsible for about one third of greenhouse emissions, and has high emissions growth

Electricity industry economics + wind

- Wind one of our lowest cost 'new renewables'
- Significant expansion of Australian renewable generation appears possible at relatively low cost



Electricity industry restructuring + wind

- Drivers for EI restructuring include efficiency objectives
 - Technical or productive: reduce costs of production
 - Allocative: most appropriate choices b/n supply + demand options
 - Dynamic: support innovation + response to change
 - new technologies, social expectations, environmental impacts
 - **This is the most important for longer-term**
- Good market design
 - Allocate costs + benefits to participants as possible according to contribution
 - **internalise externalities as feasible**
 - Foster competition via a level playing field
 - don't favour incumbent technologies + participants against 'new entrants'
 - Support appropriate innovation to meet emerging challenges + change
- Wind an emerging technology + industry that
 - can help us meet emerging greenhouse challenges
 - has very different characteristics from conventional resources (the first serious intermittent power)
 - Poses challenges to existing power system operation + investment

Energy security + wind

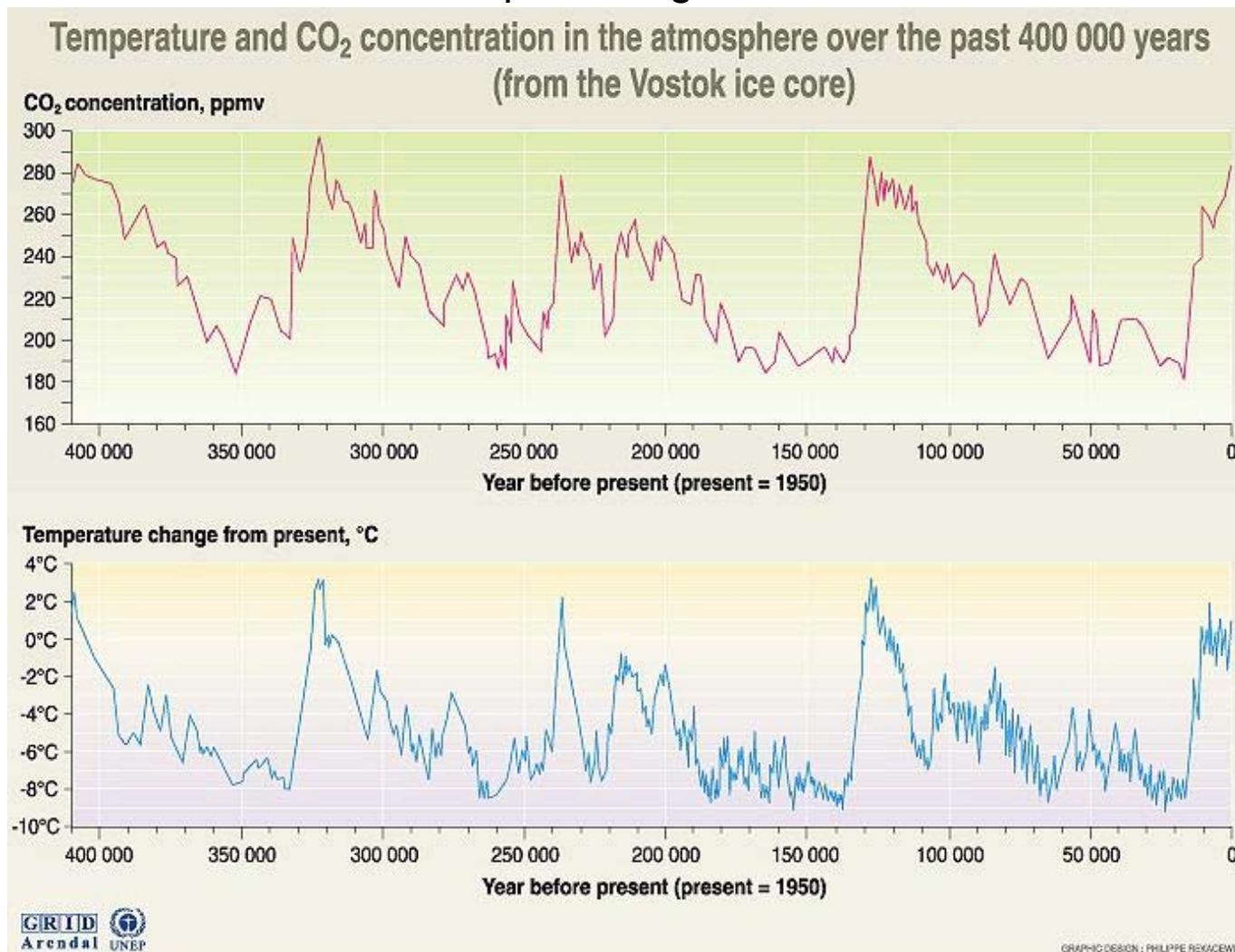
- All PS resources (loads + generation) electrical flows are
 - Variable over time
 - Never more than partially controllable
 - Somewhat unpredictable
- ⇒ Short-term power system security
 - ⇒ operate PS to maintain supply/demand balance at all points in network under normal conditions yet also contingencies
- ⇒ Longer-term electricity industry security
 - ⇒ Ensure appropriate supply/demand side investment given possible trends, resource constraints
 - eg. gas reserves, possible future coal constraints?
- Wind
 - Intermittency (variable, partially controllable + somewhat unpredictable output) with different characteristics of conventional gen
 - A 'free', locally sourced energy resource

EI environmental impacts + wind

- Wind one of our lowest cost zero-emission technologies
- Actual emissions reductions in electricity industry depends on context
 - Amount of wind, generation mix, load profile, losses
- **Nevertheless**, wind farms into PS with largely thermal gen will
 - Reduce operational emissions
 - Can, in the longer term, influence nature of investment in other generation sources
- eg. ESIPC wind study – SA wind generation can reduce CO₂ by approx. 0.52Mt/MW

The link between climate change and CO₂

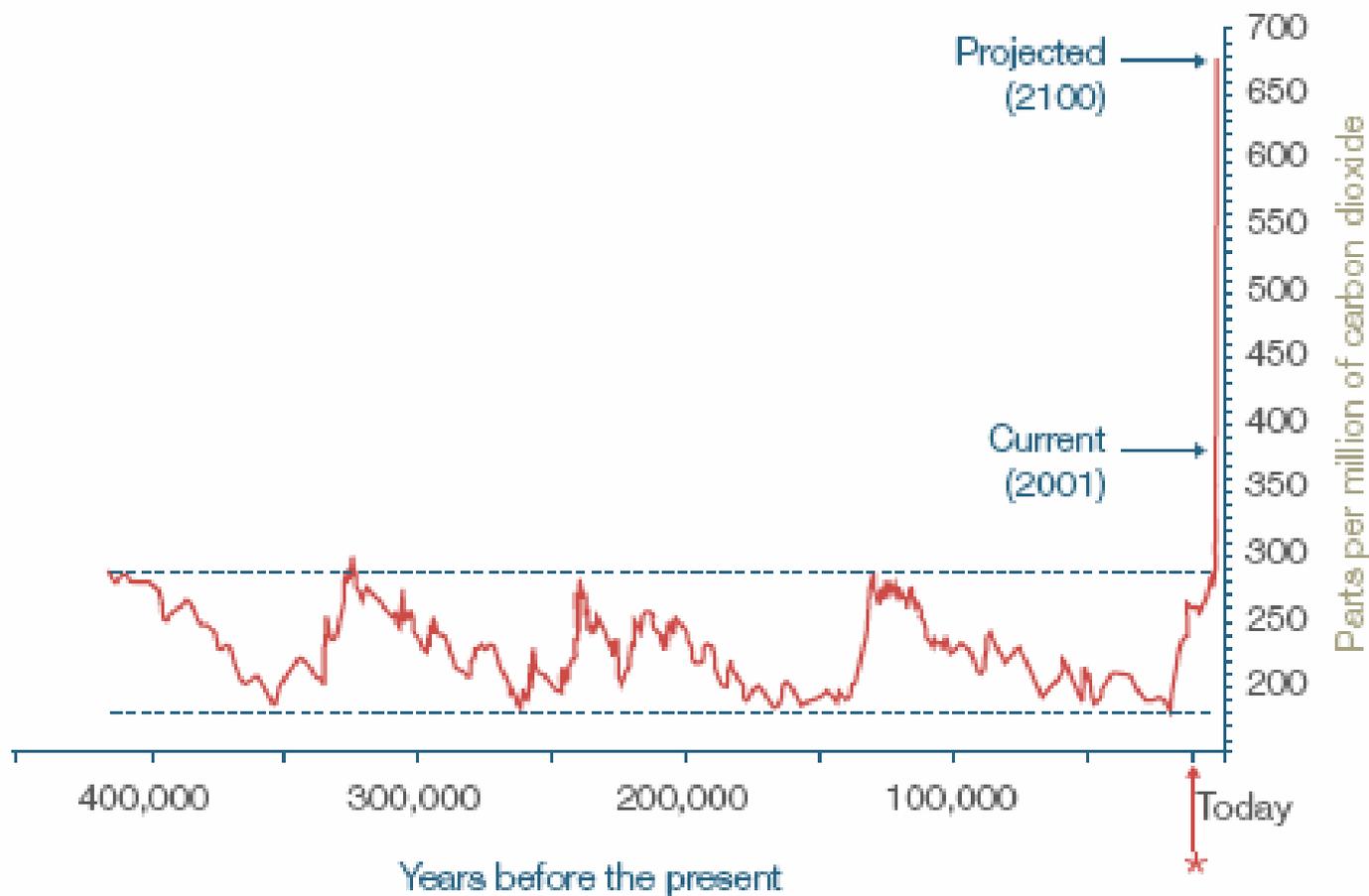
Source: <http://www.grida.no/climate/vital/>



CO₂ concentration in the atmosphere

(Climate Action Group, 2004)

Source: Co-operative Research Centre for Greenhouse Accounting, 2001



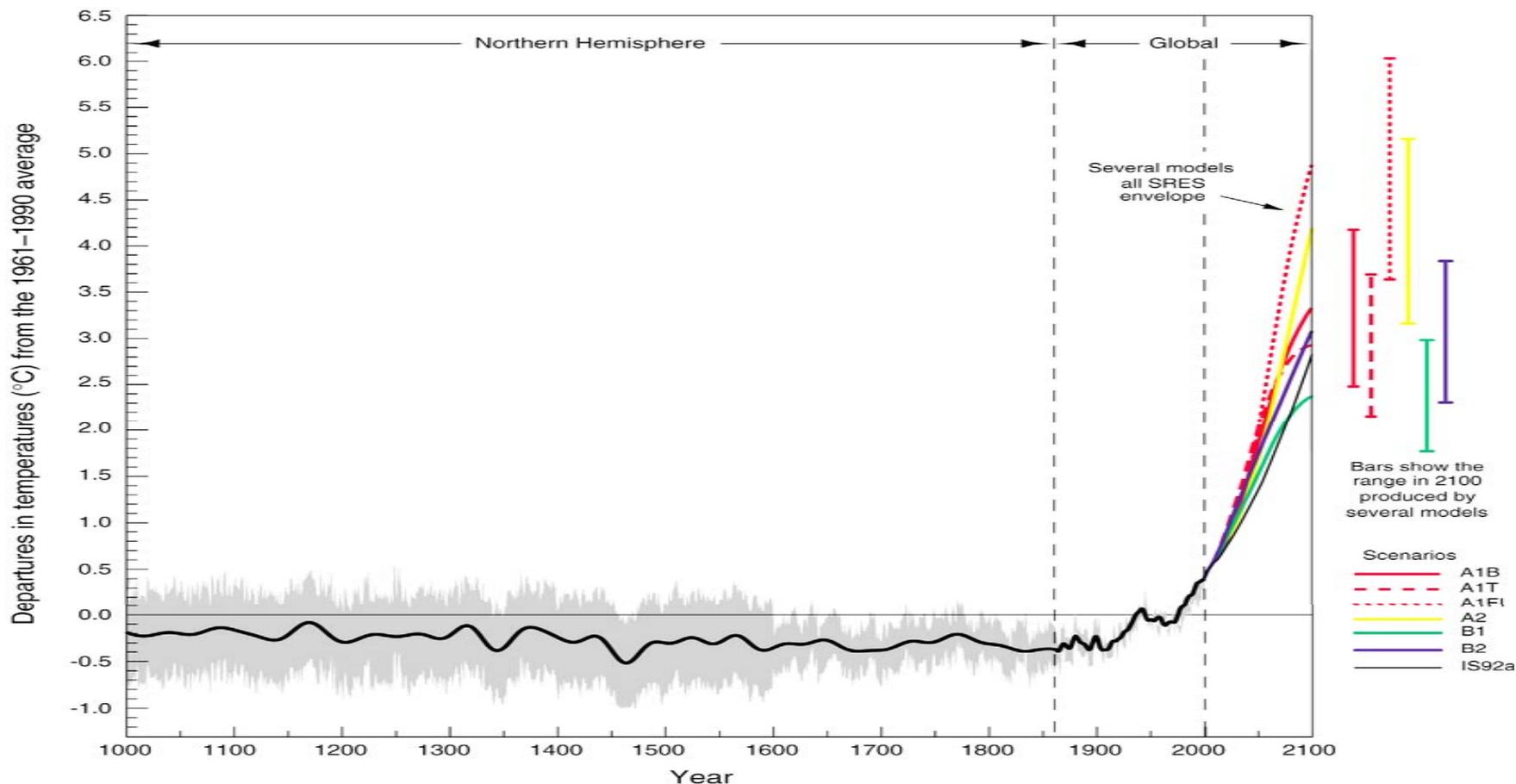
*Note: Civilisation began 7,000-10,000 years ago

It all suggests major warming if emissions continue

(www.ipcc.ch)

Variations of the Earth's surface temperature: 1000 to 2100.

1000 to 1861, N.Hemisphere, proxy data; 1861 to 2000 Global, Instrumental;
2000 to 2100, SRES projections



Global warming concerns grow..

Climate change may lead to war

Sunday 22 February 2004 7:12 PM GMT

Guardian
Unlimited

A secret report prepared by the Pentagon warns climate change may lead to a global catastrophe costing millions of lives and is a far greater risk than "terrorism".

The report was ordered by an influential US Pentagon adviser, but was covered up by US defence chiefs for four months, until it was obtained by a British newspaper.

...and grow

The Independent

Global warming approaching point of no return, warns leading climate expert

January 24, 2005

Global warming has already hit the danger point that international attempts to curb it are designed to avoid, according to the world's top climate watchdog.

Dr Rajendra Pachauri, the chairman of the official Intergovernmental Panel on Climate Change (IPCC), told an international conference attended by 114 governments in Mauritius this month that he personally believes that the world has "already reached the level of dangerous concentrations of carbon dioxide in the atmosphere" and called for immediate and "very deep" cuts in the pollution if humanity is to "survive".

...He told delegates: "Climate change is for real. We have just a small window of opportunity and it is closing rather rapidly. There is not a moment to lose."

...He also cited alarming measurements, first reported in The Independent on Sunday, showing that levels of carbon dioxide (the main cause of global warming) have leapt abruptly over the past two years, suggesting that climate change may be accelerating out of control.

...He added that, because of inertia built into the Earth's natural systems, the world was now only experiencing the result of pollution emitted in the 1960s, and much greater effects would occur as the increased pollution of later decades worked its way through. He concluded: "We are risking the ability of the human race to survive."

and grow...



THE AUSTRALIAN

[Print this page](#)

'Scary' science finds Earth heating up twice as fast as thought

Leigh Dayton, Science writer
27jan05

THE largest ever climate-change experiment reveals that scientists may have dramatically underestimated the threat of global warming.

The study by British scientists, which is published today, found the planet's global temperature could climb by between 2C and 11C because of skyrocketing levels of greenhouse gases such as carbon dioxide.

That more than doubles the current prediction of a 1.4C to 4.5C rise this century.

"When we started out we didn't expect anything like this," said Oxford University's David Stainforth, chief scientist for climateprediction.net.

The project is a collaboration of experts at Oxford and Reading universities, The Open University, London School of Economics, Hadley Centre for Climate Prediction and Research, and Rutherford Appleton Laboratory.

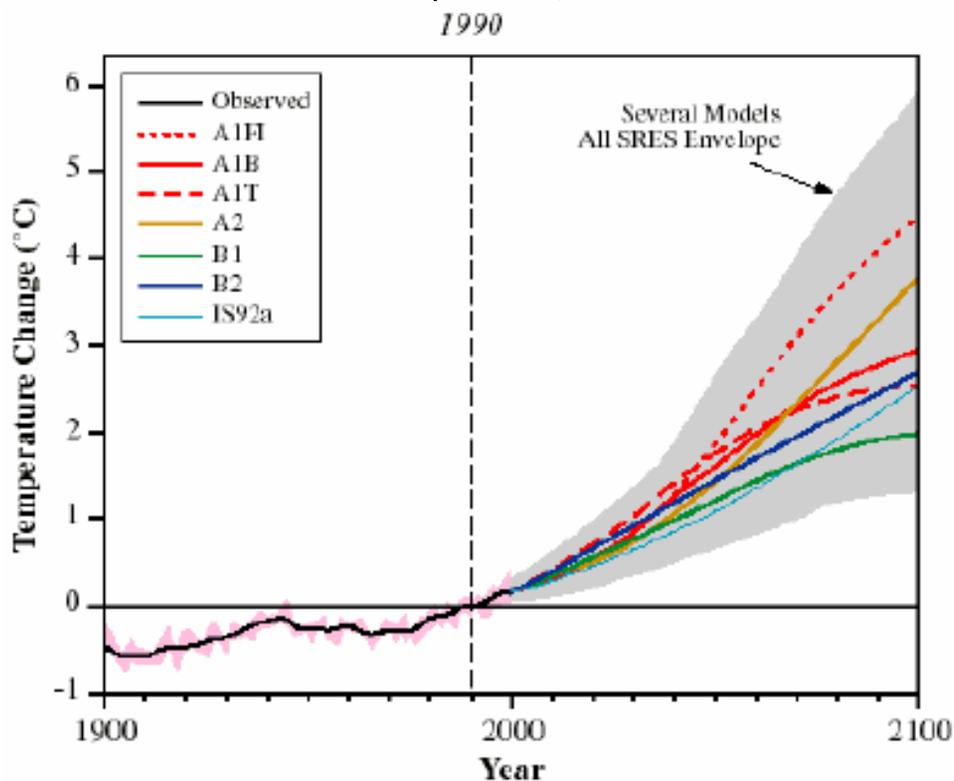
The findings are published in the journal Nature.

"If this is the case, it's very dramatic and very scary," Mr Stainforth said.

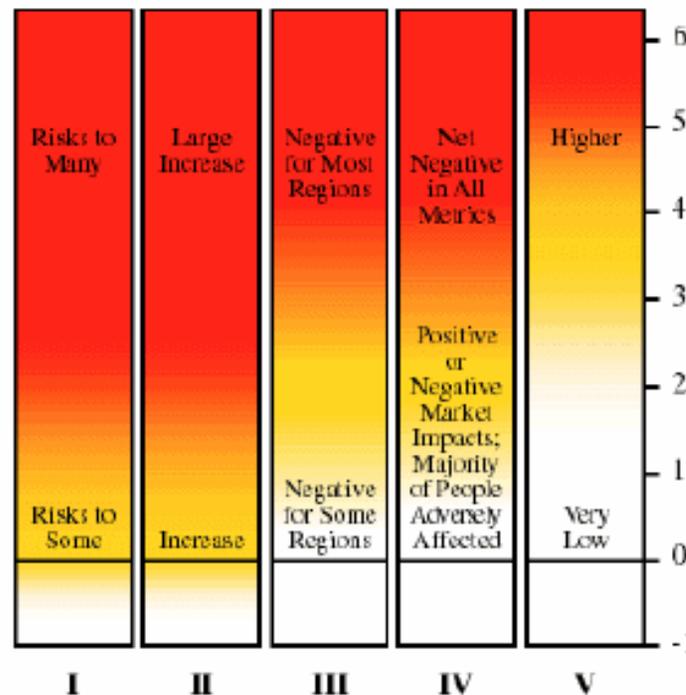
Even rises that are more modest are expected to trigger disastrous changes, including melting glaciers, sea-level rises, shut-down of the Gulf Stream, and increases in droughts, cyclones and other extreme weather events. The new results follow two reports in last week's edition of Science, showing that global warming probably caused the "Great Dying".

Avoiding dangerous climate change – stay <2 deg.C

(IPCC, Third Assessment Report, 2001)

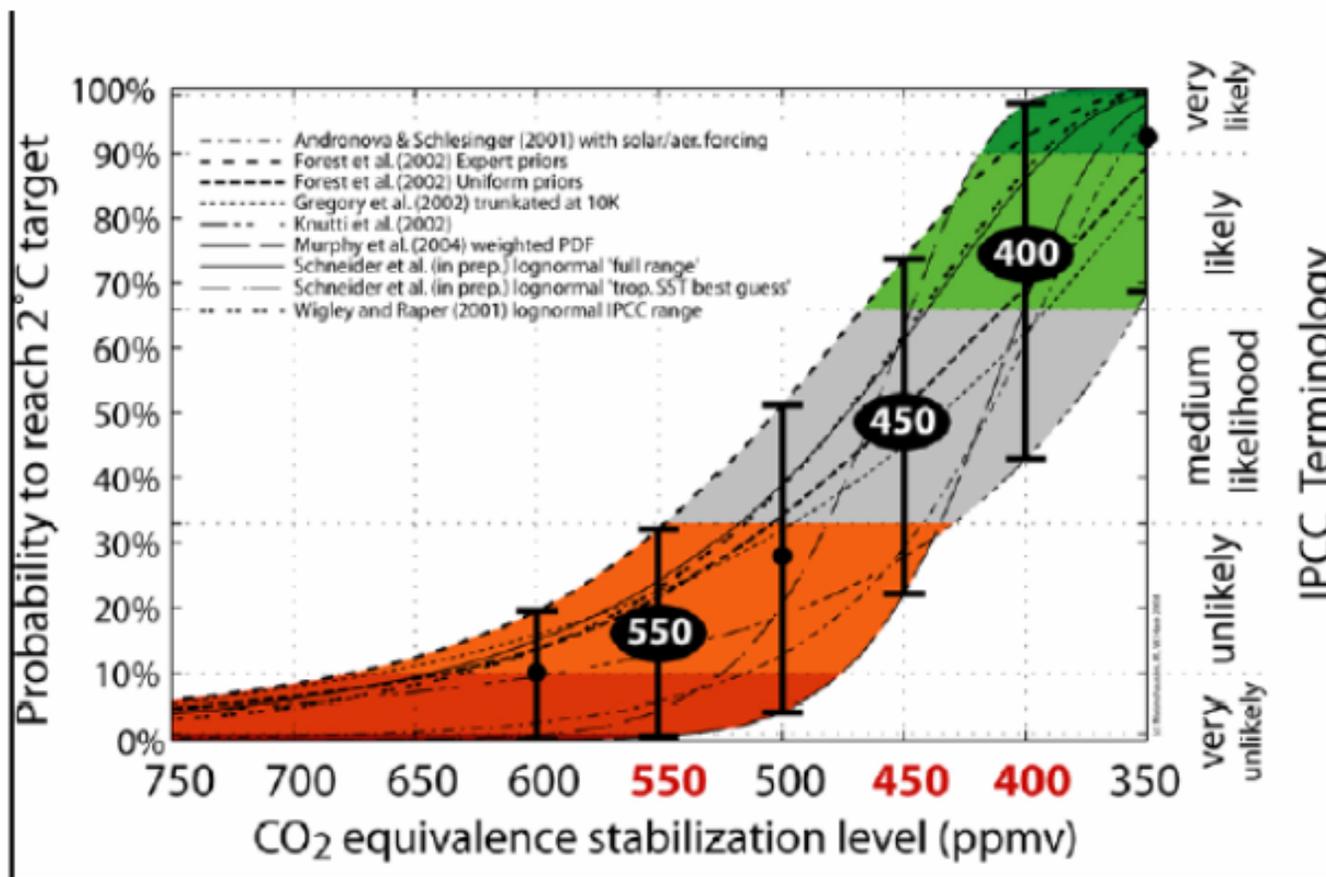


Reasons for Concern

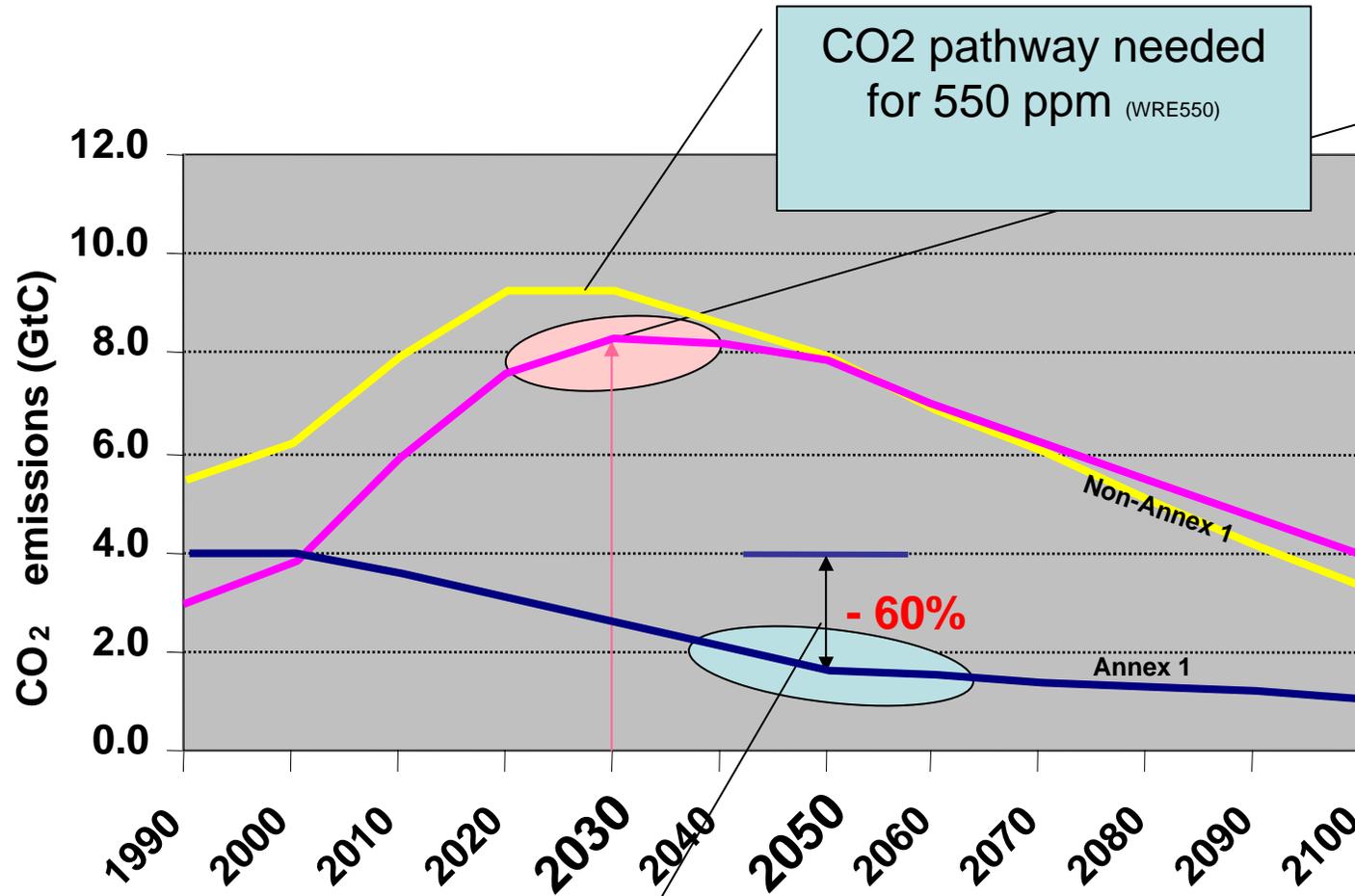


- I Risks to Unique and Threatened Systems
- II Risks from Extreme Climate Events
- III Distribution of Impacts
- IV Aggregate Impacts
- V Risks from Future Large-Scale Discontinuities

What stabilisation target might then be required? (EEAC, 2004)



Possible emissions scenario for stabilisation (Bourne, 2004)



Developing world emissions grow as they “catch up” then need to diminish from ~2030

Developed and developing worlds converge on some combination of emissions/capita and emissions/GDP while contracting their emissions

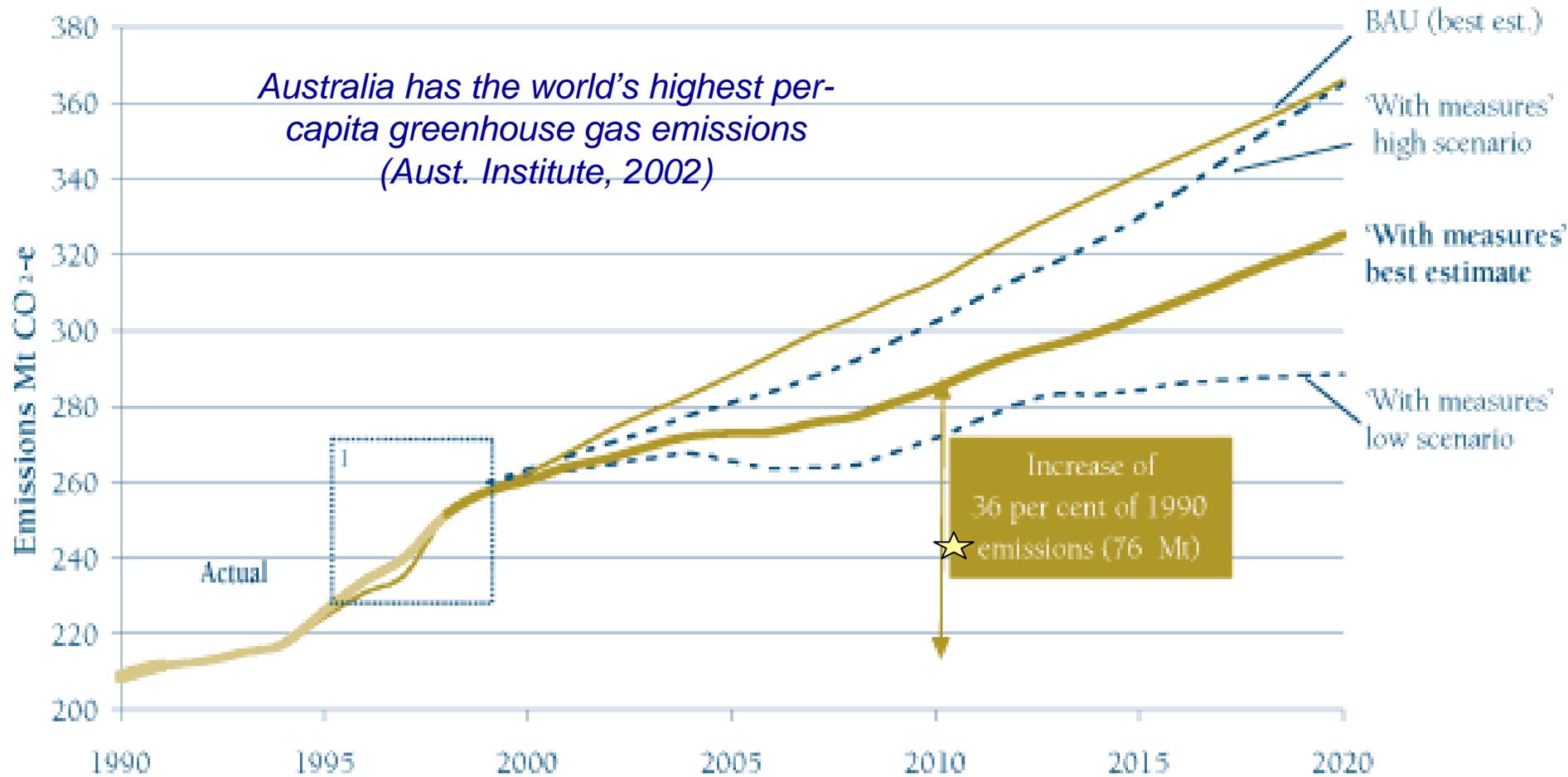
Developed world needs to reduce emissions ~60% by ~2050 starting now!

Starting Wind Power Development in Australia

Thoughts on Australian GHG abatement policy

- **Little evidence of coherent abatement + innovation strategy**
 - Challenge is not to meet our modest Kyoto greenhouse target by stopping land clearing, but to begin the major emissions reductions required to avoid dangerous climate change
 - *Energy White Paper* focuses largely on technological push (eg. innovation fund), rather than market pull (eg. enhanced MRET, strong EE regulation) *this is very unlikely to be optimal policy approach*
- For our different abatement options
 - **Renewables** – needs R&D but, critically, deployment support eg. **Expanded MRET. Emerging techs like HDR need R&D&Demo support**
 - *Energy efficiency* – has been woefully neglected, needs R&D yet, critically, targeted (mainly regulatory) deployment support
 - *Gas generation* – present immature Aust. gas market needs to be strengthened (CoAG, 2002), policy support for base-load NGCC, also CHP
 - *Carbon Capture & Storage* – an important area for R&D + demonstration that should focus on key question of storage uncertainty + site specificity.
- **We need EE, renewables + gas now to buy us time to develop CCS**

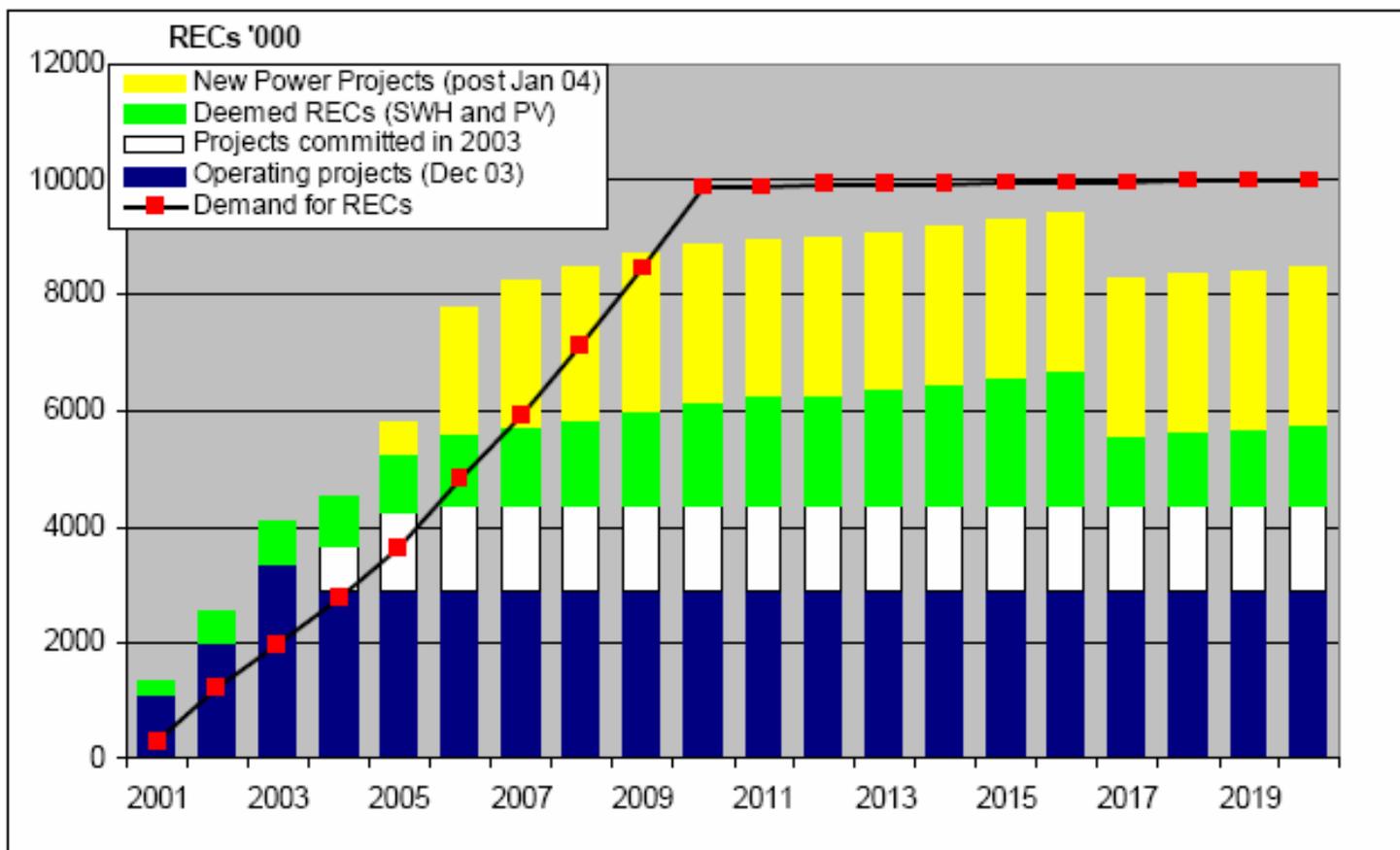
Projected emissions from Stationary Energy sector, 1990-2020



Source: Australian Greenhouse Office (2002)

Present MRET is just about finished

- The Federal Govt. has rejected key review finding of a higher target to 2020
- BCSE estimates only approx. 700-800MW of new (post Jan04) projects required to meet existing target, and...
- ...project commitments > 500MW in 2004 leaves < 300MW new projects reqd



However, are renewables even 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*, 2002

⇒ renewable technologies aren't inherently sustainable but *appropriate* renewable energy systems can be

⇒ Key decisions are in the planning phase

The planning process for wind farms

- Wind farms have important externalities:
 - Costs + benefits of activity that fall on parties other than those undertaking activity => don't *necessarily* influence decision making
 - Costs + benefits can be economic, environmental or social
 - Those effected by externalities are 'stakeholders' so wind farms have many: - project developers *but also* governments, other developers, local communities, the electricity industry, NGOs...
- Wind farms are not independent projects:
 - Economies of scale in network connection
 - Possible interference between shared wind resources
 - **Shared social & environmental impacts, particularly at the regional level**

A government role for wind farm planning

- Hard to internalise all externalities at project level
 - Many externalities depend on cumulative wind projects
 - Potential for poor outcomes + social discord
 - May be ‘internalised’ only after great expense + effort already undertaken
 - May engender generalised resistance to future projects
- ⇒ Govts required to provide appropriate frameworks
- externalities and stakeholders identified
 - project developers + stakeholders can negotiate solutions

Australian wind farm planning

- National developments
 - AusWEA best practice guidelines (www.auswea.com.au)
 - Also partnerships with other stakeholders (eg. Landscape assessment protocols with Aust. National Trust)
 - **However**, limits to what wind industry can do alone
- Fed. Govt has few ‘planning’ powers but EPBC Act
- State Govts have most important planning role
 - Some provide state-wide guidelines, provisions for local Govt.
 - Some local Govts can have own Development Control Plans
 - Can retain option of declaring particular project a ‘state significant development’ and taking over consent process
 - **However**,
 - Largely project-based approach may still fail to handle cumulative issues well
 - Possible risks (eg. Politicisation) if no clear planning framework

Analysing European public resistance to wind farms

(Wolsink, 2000)

- 4 general categories of resistance
 - A: Positive to wind farms but not here (NIMBY)
 - B: General opposition to wind energy (NIABY)
 - C: Initially positive but put off by a bad experience
 - D: Approval subject to meeting certain criteria
- Some possible lessons
 - Generally strong public support for wind farms
 - **However**, this doesn't necessarily translate to local support
 - Poor planning processes can create local opposition, erode general support and increase general opposition

A recent example in Australia



People power beats wind power

By Melissa Marino, February 16, 2005

For Debbie Martin, news that renewable energy company Wind Power was shelving plans for a wind farm overlooking her property was still sinking in yesterday.

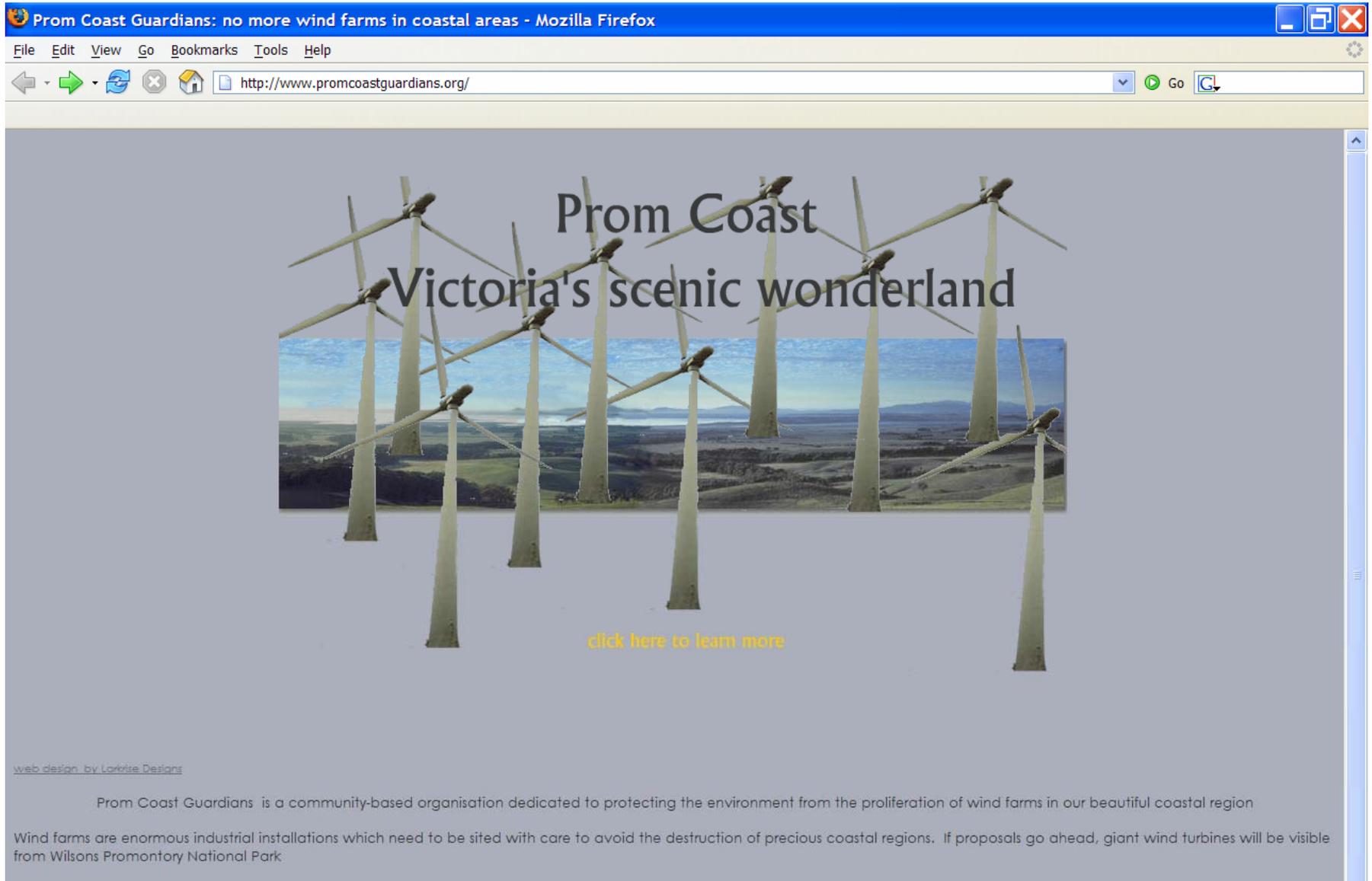


"I've never been involved in a campaign like this," said the playwright who was among dozens of community members who rallied against the proposal at Clarke's Hill. ...

The proposal, she said, was inappropriate, with 100 houses, including her own, within one kilometre, and 300 houses within three kilometres of 20 proposed turbines standing 110 metres tall. It was also on a main tourist route, between Daylesford and Ballarat, and a corridor for native birds.

"We're not anti-renewable energy or anti-wind energy (but) we think there needs to be more thought into the appropriate placing of wind turbines," she said, **"not around people's houses."**

And another example....



The screenshot shows a Mozilla Firefox browser window with the title "Prom Coast Guardians: no more wind farms in coastal areas - Mozilla Firefox". The address bar contains the URL "http://www.promcoastguardians.org/". The main content area features a large image of several wind turbines in a coastal landscape. Overlaid on the image is the text "Prom Coast" and "Victoria's scenic wonderland". Below the image is a yellow link that says "click here to learn more". At the bottom left, there is a small text credit: "web design by Lakrize Designs". At the bottom of the page, there is a paragraph of text: "Prom Coast Guardians is a community-based organisation dedicated to protecting the environment from the proliferation of wind farms in our beautiful coastal region. Wind farms are enormous industrial installations which need to be sited with care to avoid the destruction of precious coastal regions. If proposals go ahead, giant wind turbines will be visible from Wilsons Promontory National Park."

Possible ways forward for planning

- Develop a comprehensive + coherent wind farm planning framework - federal, state, local:
 - Staged regional development process via stakeholder consultation:
 - Resource evaluation
 - Regional wind development & grid connection strategy with integrated forecasting processes
 - On-going monitoring & evaluation
- Opportunities to adapt other models –eg. minerals industry



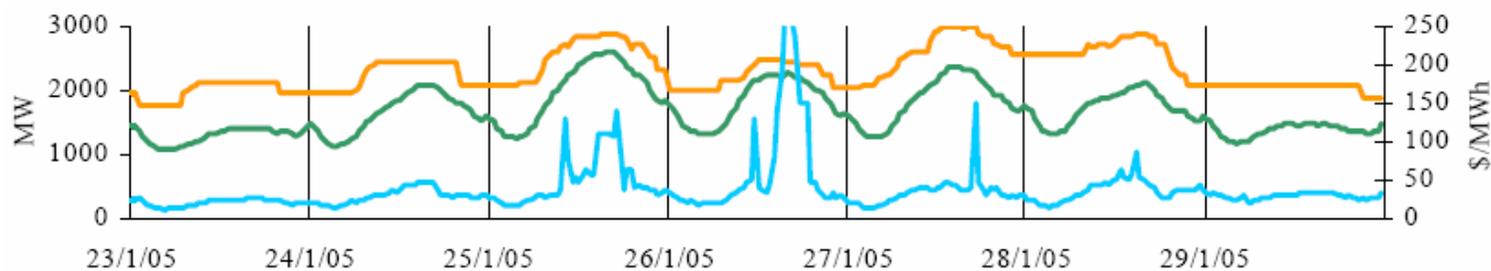
Queensland Coal Seam Gas Regime (2002)
"The regime provides greater certainty for explorers and developers to invest in coal seam gas projects as well as provide clear rules, rights and obligations for the coal and gas industries to work cooperatively in developing the resource."

Integrating significant wind into power systems

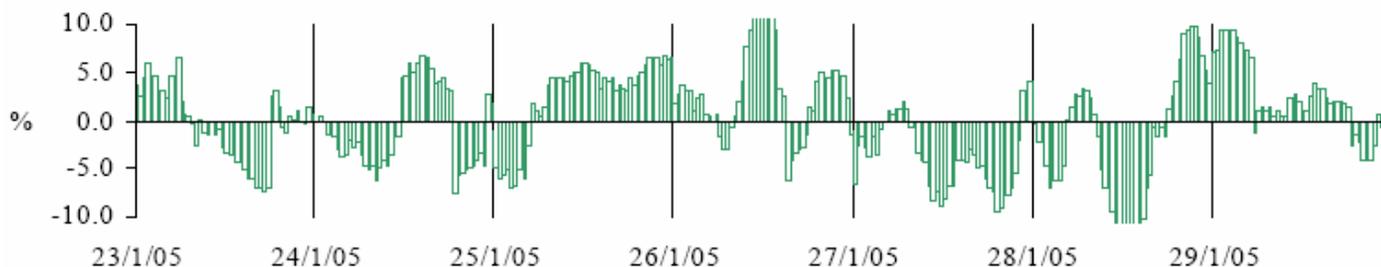
- All loads and generators have electrical flows that are
 - Variable over time
 - Never more than partially controllable
 - Somewhat unpredictable
- Major part of network value arises b/c enables diversification
 - help manage variability and stochasticity of all power system resources (load, generation and network elements)
- **Wind**
 - A **very reliable** but highly variable and somewhat unpredictable generation resource with limited control options
 - The first such type of generation to achieve significant grid penetrations
 - => represents the frontier of managing such types of intermittent resources in the electricity industry

Load variability and unpredictability

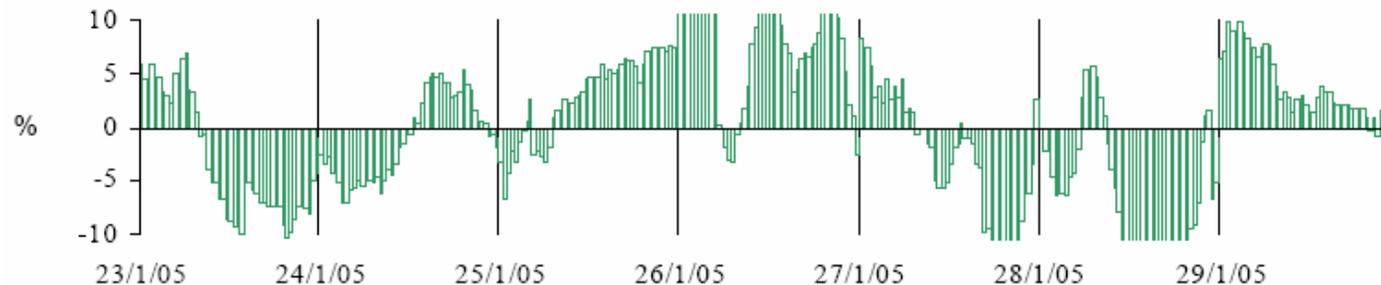
SA electricity demand of forecasts, (NECA, Market Analysis 23-29 January, 2005)



— Capacity — Demand — Spot price



□ Demand difference (actual - forecast) - 4hrs



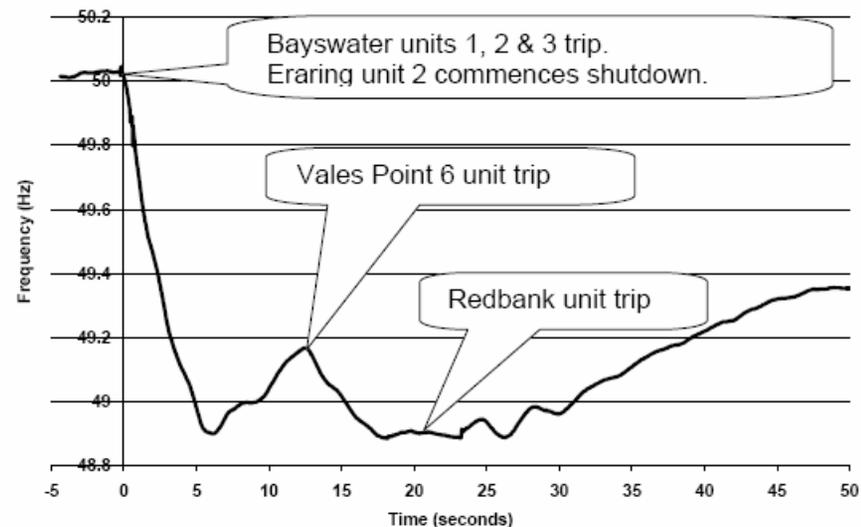
□ Demand difference (actual - forecast) - 12hrs

Gen variability + unpredictability

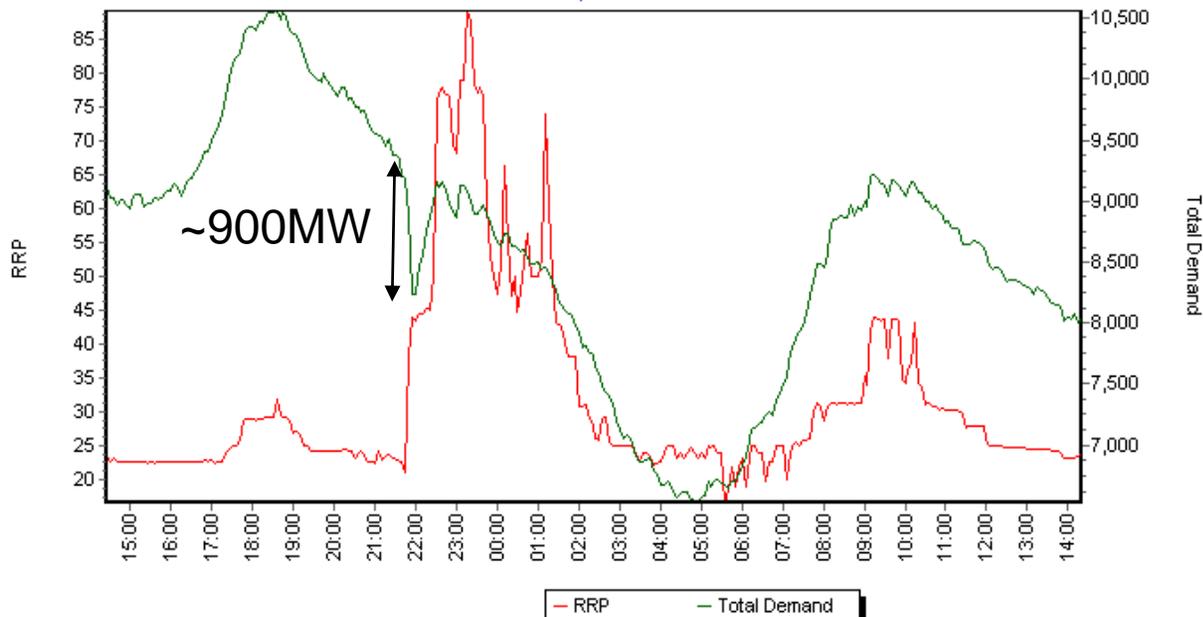
Transformer failure on Friday 13/8/04 causes 6 coal-fired NSW generators to trip totalling 3100MW:

Approx. 2100 MW load shed in NSW, Qld & Vic (also some in SA)
(www.nemmco.com.au)

Figure 1-5: Power System Frequency

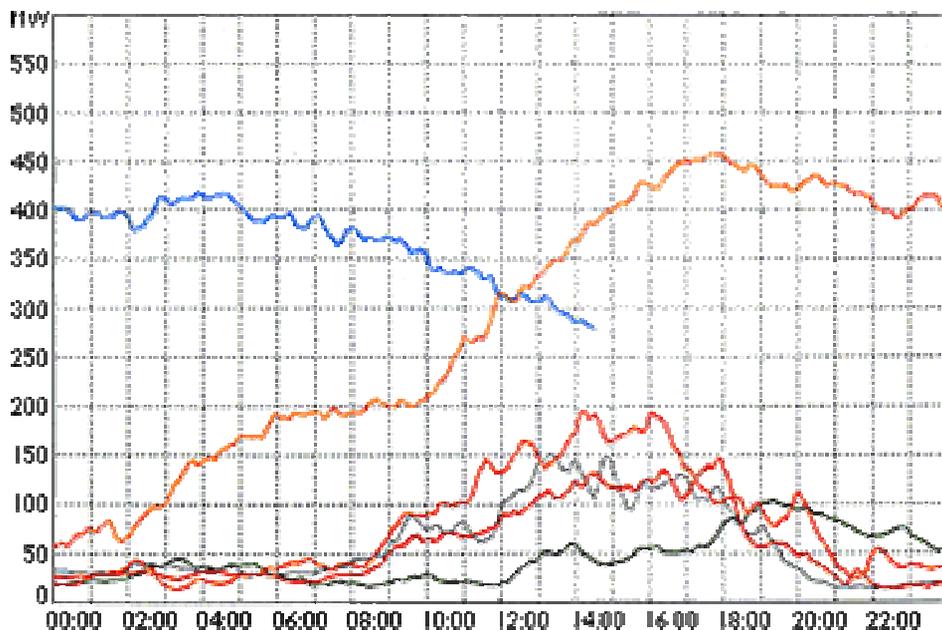


NSW1 5 minute Demand and Price for period 13/08/2004 00:00 to 14/08/2004 14:20



Wind power variability + unpredictability

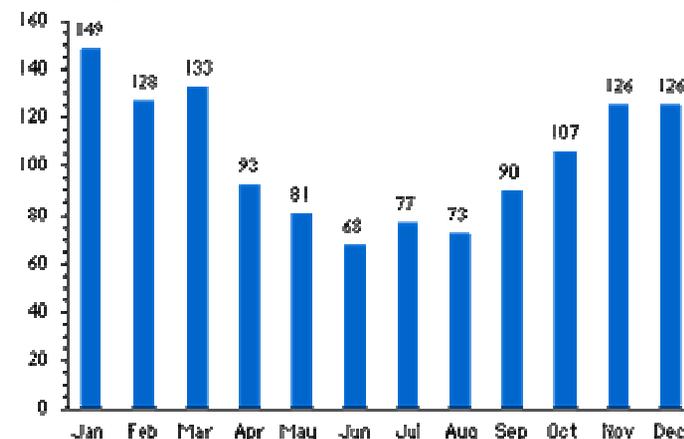
(Danish Data, www.windpower.org)



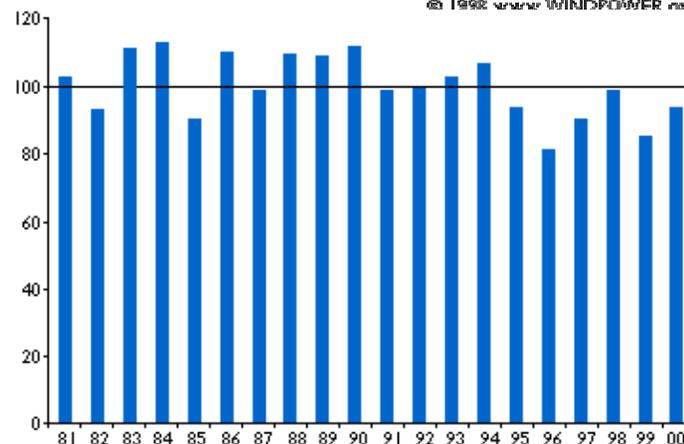
© 1998 www.WINDPOWER.org

Short-term, daily, seasonal and annual variations in wind speed

Wind Energy index, Denmark (average=100)



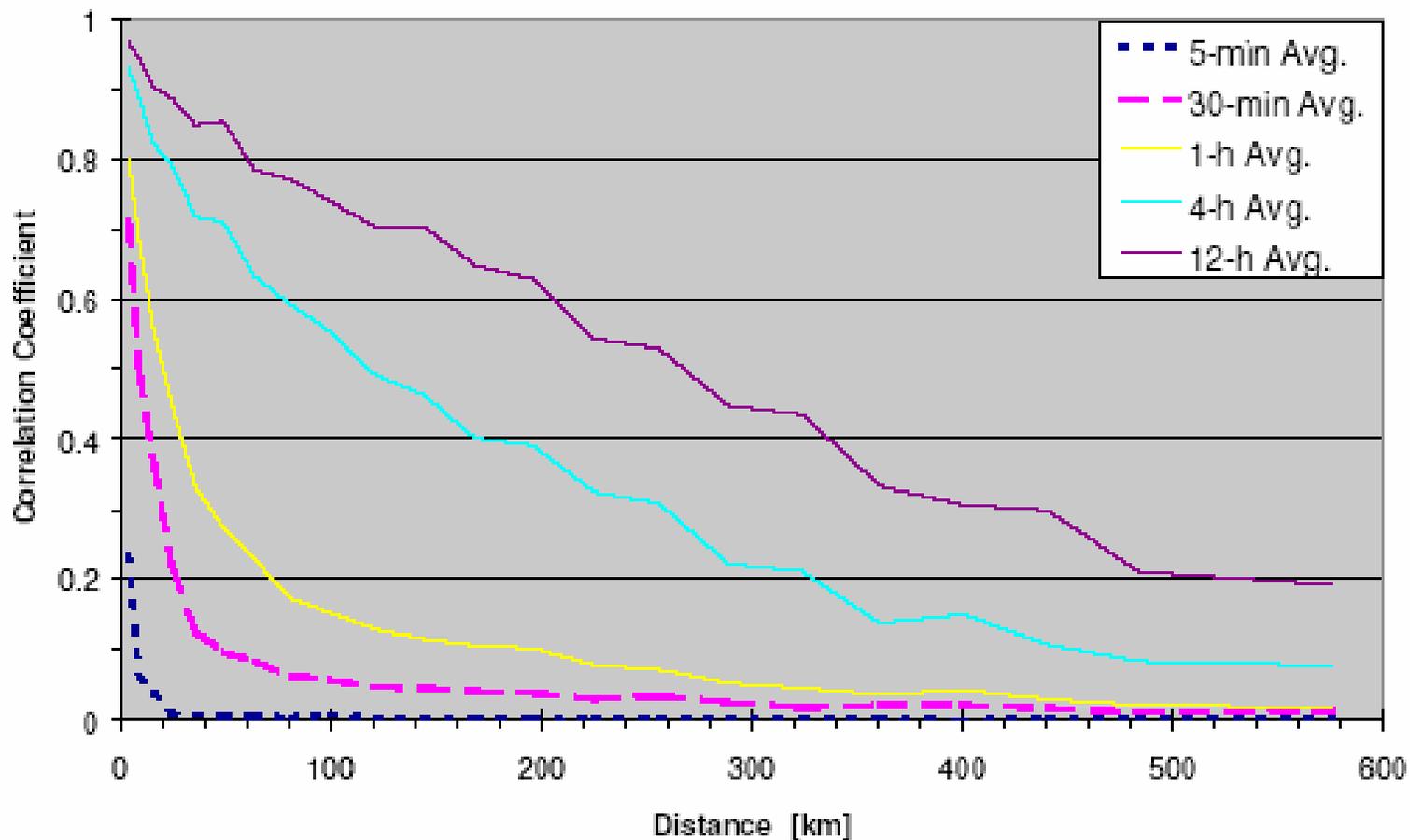
© 1998 www.WINDPOWER.org



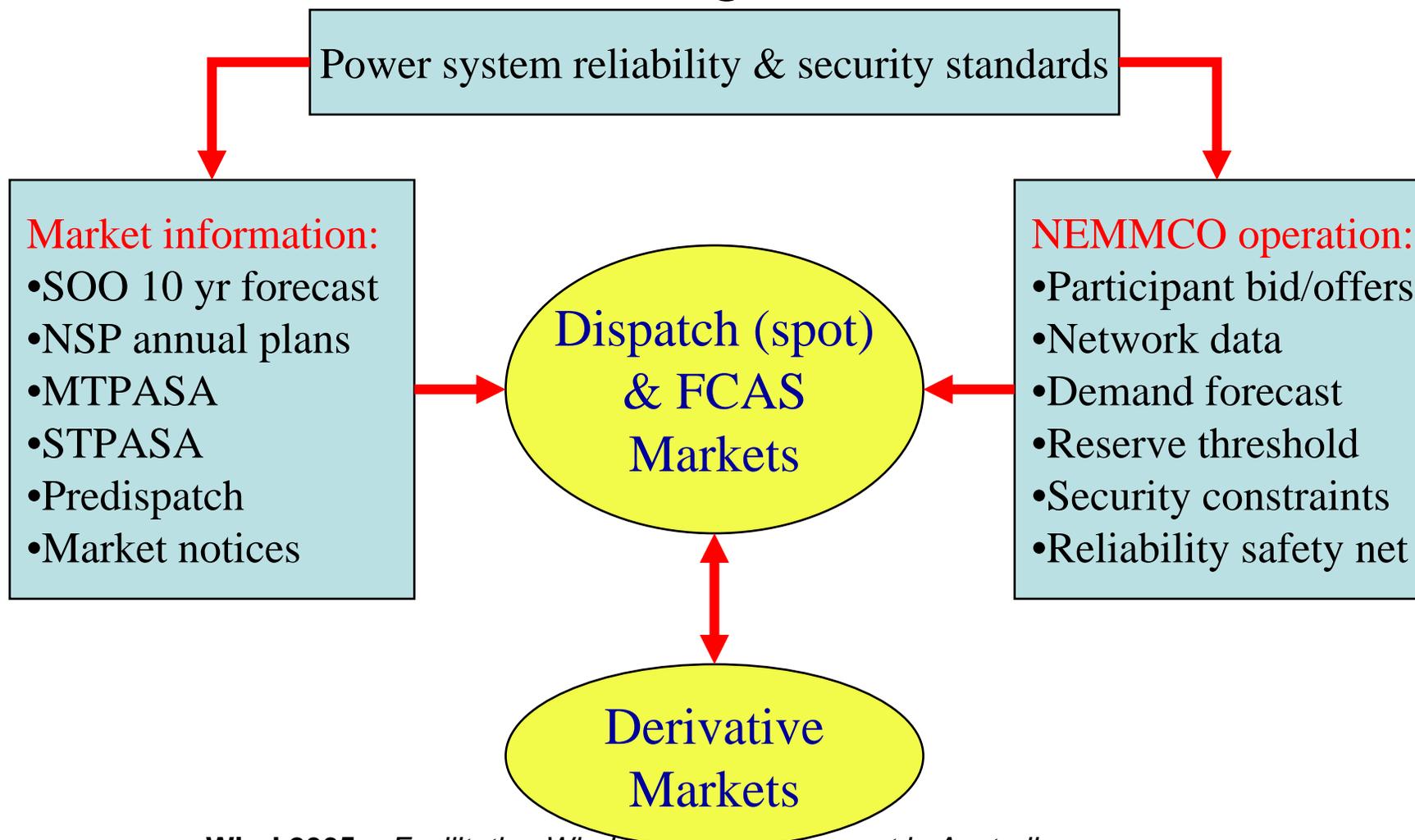
© 2001 DWTMA & DWTOA

Overall variability depends on distribution of wind farms

Cross-correlations between measured power outputs of German wind farms (Giebel, 2000)



NEM processes for managing supply-demand balance short to long term (secs to decades)

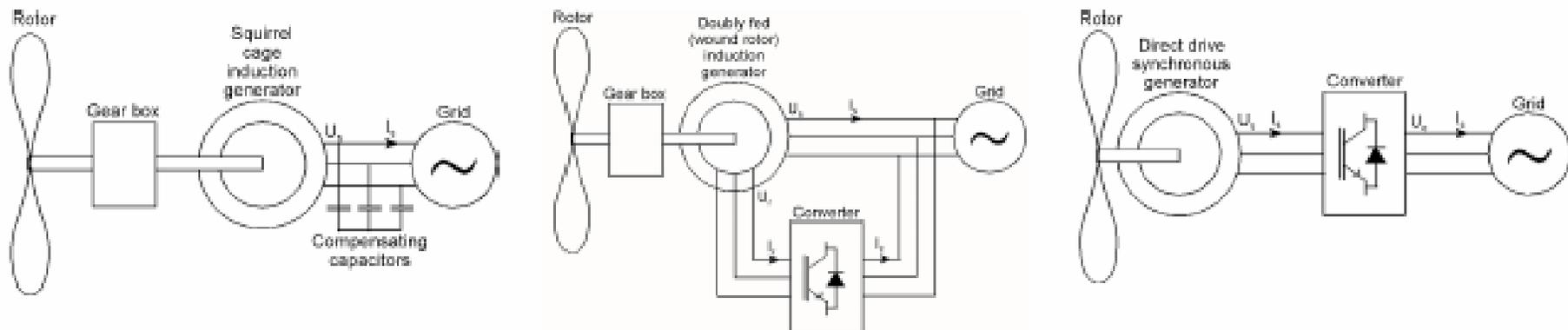


NEMMCO

- *Intermittent Generation in the NEM (2003) 'issues'*
 - Network management
 - impacts on V regulation, sub 5min flows on network may cause power quality + stability issues
 - => Proponents should be aware of conditions for permission to connect to network Currently under review - changes could impact on plant design
 - Frequency control ancillary services
 - increase in usage + cost of these
 - => proponents need to know that 'causer pays' – stay 'tuned'
 - Forecasting
 - Increased errors in price + reserve forecasts
 - => 2004 proposal on managing this – NEMMCO short-term forecasting using real-time wind farm data, longer term forecasting to be provided by project developers

Turbine technology can assist in N/W management

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

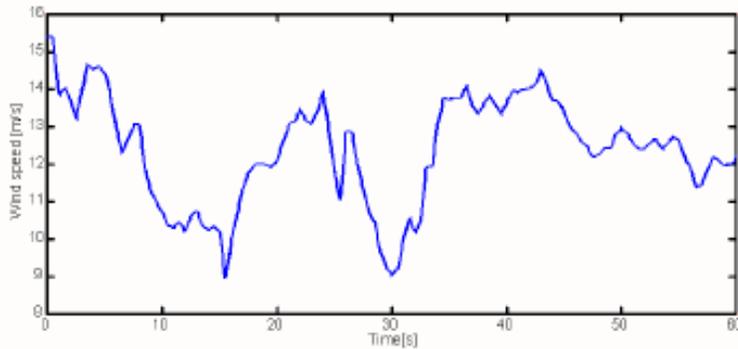


Aspect of grid interaction	Constant speed	Doubly Fed	Direct Drive
Voltage control	Only possible with additional equipment, e.g. capacitor banks, SVC's or STATCOM's	Theoretically possible, but dependent on converter rating	Theoretically possible, but dependent on converter rating
Harmonics	Hardly of interest	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

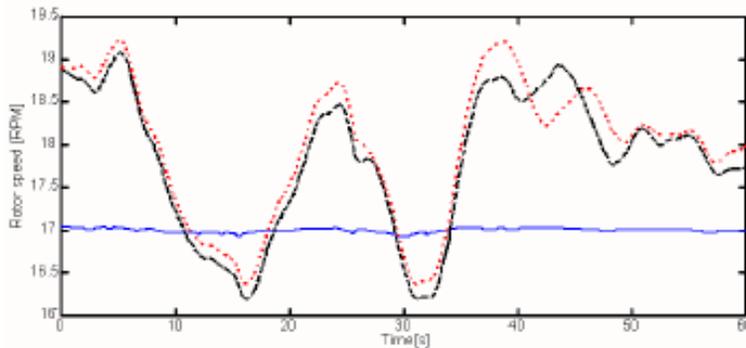
Dynamic behaviour of different turbines

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

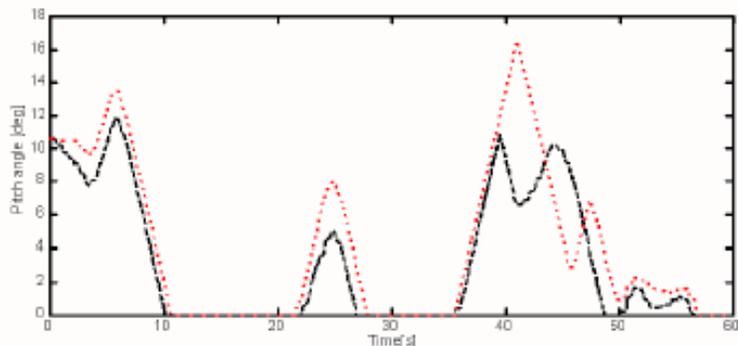
Wind speed



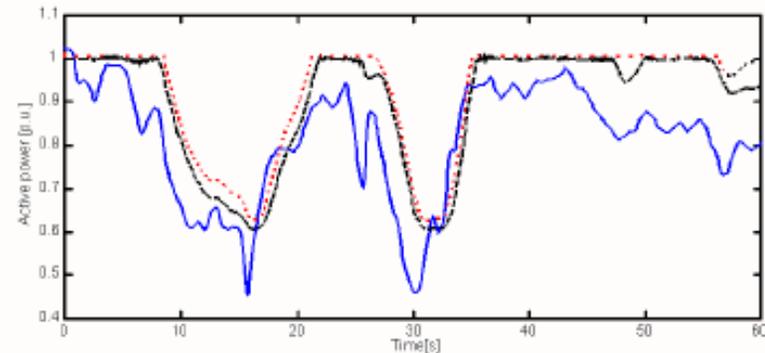
Rotor speed



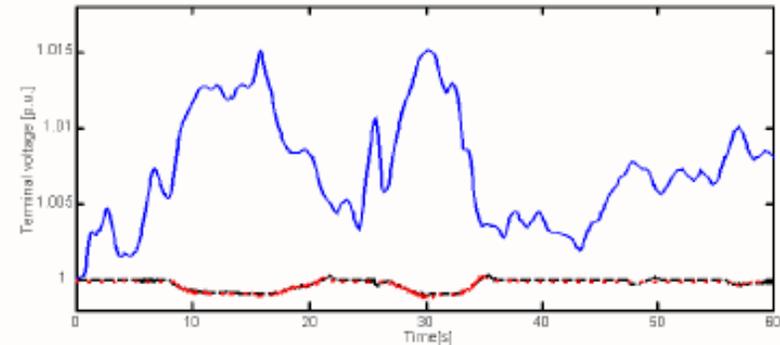
Blade angle



Output power



Output voltage



Constant speed



DFIG



Direct Drive



Forecasting wind energy production

(CSIRO, *Report to NEMMCO, 2004*)

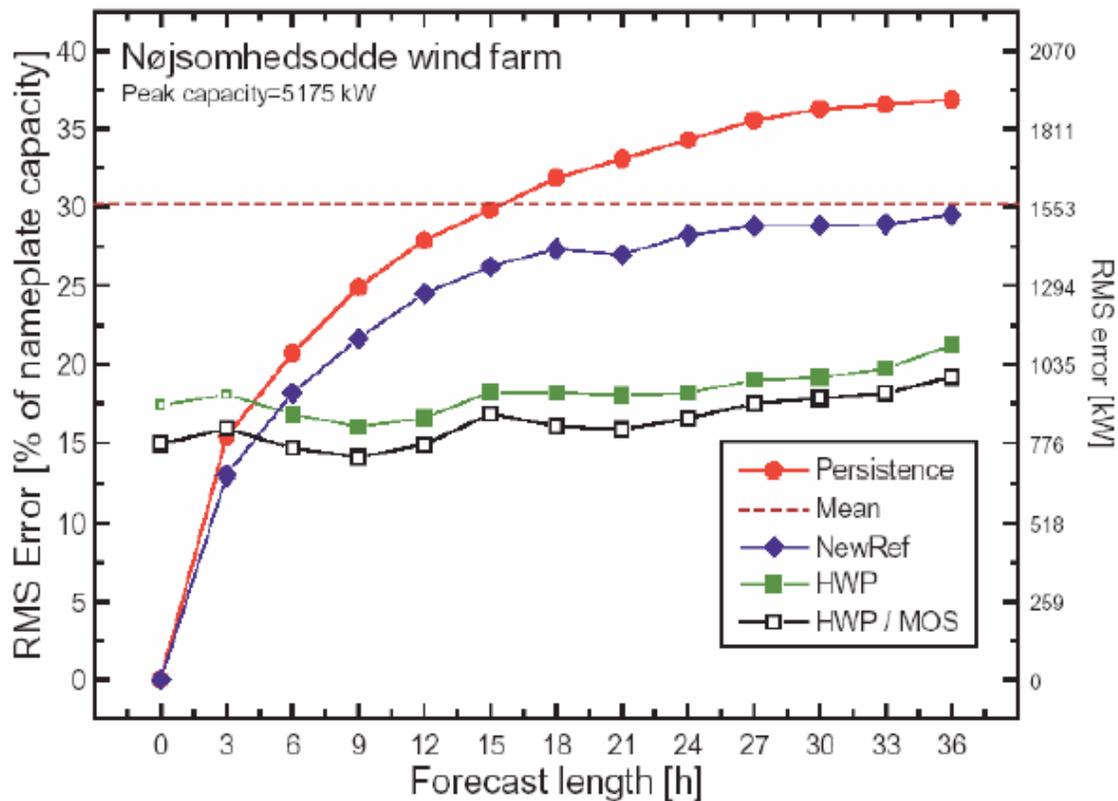
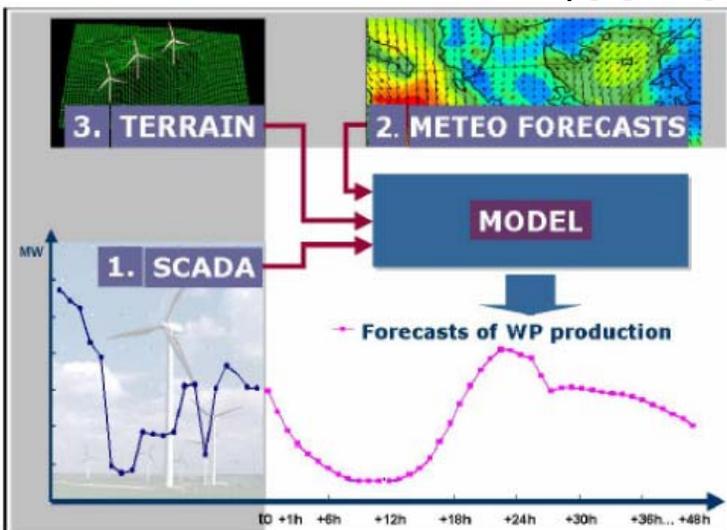


Figure 9 Root Mean Square (RMS) error for different forecast lengths and different prediction methods. Upper curves are statistically based systems, lower curves are weather forecast-based systems, from Giebel et al. (2003).

Wind interconnection - possible ways forward

- Network management
 - Improved turbine technologies + control strategies can help
 - High penetrations can still have significant local/regional impacts
 - Technical standards, pricing signals can play a useful role, strategic investments by Govts may also be required
- Frequency control ancillary services
 - Short-term reserve requirements set by N-1 contingency (typically sudden loss of largest generator or interconnector flow)
 - Wind may, however, add to the use of FCAS
 - Seems reasonable to have at least some ‘causer pays’
- Longer-term variability
 - Forecasting key – requires real-time data from wind farms, longer-term modelling using NWP probably best done centrally (AGO, NEMMCO and CSIRO collaboration)
 - Wind’s longer-term unpredictability already reflected in part through lower forward contract prices

‘Readily acceptable’ wind penetrations

- Readily acceptable – there are technical solutions to any associated problems that are not prohibitively expensive
- NEM might be able to readily accept up to 8000MW *if*
 - Wind installed in progressive manner
 - Wind farms widely + evenly dispersed within NEM
 - Wind farms used advanced turbine technology + control systems with remote monitoring + control
 - Advanced wind forecasting techniques developed for regional projections up to 2 days ahead(Outhred, 2004)

Current wind farms and forecasts (www.auswea.com.au, February 2005) vs estimates of readily acceptable wind capacity

	QLD	NSW	VIC	SA	TAS	WA	AUS
Installed /under construction	12	17	122	395	67	121	734
Under tender	0	0	177	160	0	26	363
Planning approved	0	62	0	608	214	41	925
Feasibility	52	1021	1427	1252	350	99	4200
Total proposed	64	1100	1726	2415	631	287	6223
<i>Readily acceptable</i>	<i>2100</i>	<i>3100</i>	<i>2200</i>	<i>500</i>	<i>500</i>	<i>500</i>	<i>8900</i>

Some possible take-home messages

- Wind an essential part of any meaningful response to climate change
- Coherent and consistent policy support will be required – *expanded MRET can play vital role: a possible role for State Governments*

- Wind farm developers
 - Community must be satisfied that wind is not just renewable, but sustainable
 - Significant wind penetrations can raise important challenges for NEM at local, regional and potentially, *at very high penetrations*, national scale
 - It is reasonable to assign at least some of these associated costs to them

- Network service providers and power system operators
 - These challenges should be readily manageable as long as

- Policy makers take action to ensure
 - Regional planning frameworks
 - Regional wind forecasting
 - Markets are fair to new technologies and participants
 - Market signals drive appropriate project development – location, machines, control strategies etc.
 - Possible that strategic investments required