Centre for Energy and Environmental Markets

REGA Forum 2005

Finding New Directions: Strategies for Continued Growth

Solving the intermittency issue(s)

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

CEEM established …

- *to formalise* growing interest + interactions between UNSW researchers in Engineering, Commerce + Economics, AGSM + more
- *through UNSW Centre* providing Australian research leadership in interdisciplinary design, analysis + assessment of energy + environmental markets, associated policy frameworks
- *in areas* of
  - Physical energy markets
  - Energy-related derivative markets
  - Environmental market-based approaches
  - Policy frameworks and instruments in energy and environment

- *'New' intermittent renewables raise interesting and important questions for both NEM and associated Aust. environmental markets – eg. MRET*
- *Wind power represents the frontier of such intermittent renewables*

Physical context for intermittent renewables - power system integration (photo courtesy AusWEA)

Shared, distributed, time-varying, non-storable energy flux

Independently owned generation

Shared electricity network & Power stations of other types

End-use equipment providing energy services

Commercial context for intermittent renewables - power system integration in NEM

Wind farms & other power stations (sellers)

National Electricity Market

Commercial activities:

- *Spot market*
- *Derivative markets*
- *Ancillary services markets*
- *Network charges*
- *REC market*

Subject to constraints:

- *Connection requirements*
- *Security requirements*
- *Regulatory requirements*

Retailers & large end-users (buyers)

Key issues for intermittent energy integration

- Physical complexity:
  - Shared, non-storable, time-varying energy flux
  - Shared, non-storable, time-varying electrical energy flow in network
- Commercial complexity:
  - Electricity industry infused with short- to long-term risks that are difficult to commercialise (correctly allocate to industry participants)
- Institutional complexity:
  - Shared issues in energy project approvals, grid connection & management of power system security

➔ ***High intermittent energy penetration tests adequacy of electricity industry restructuring:***

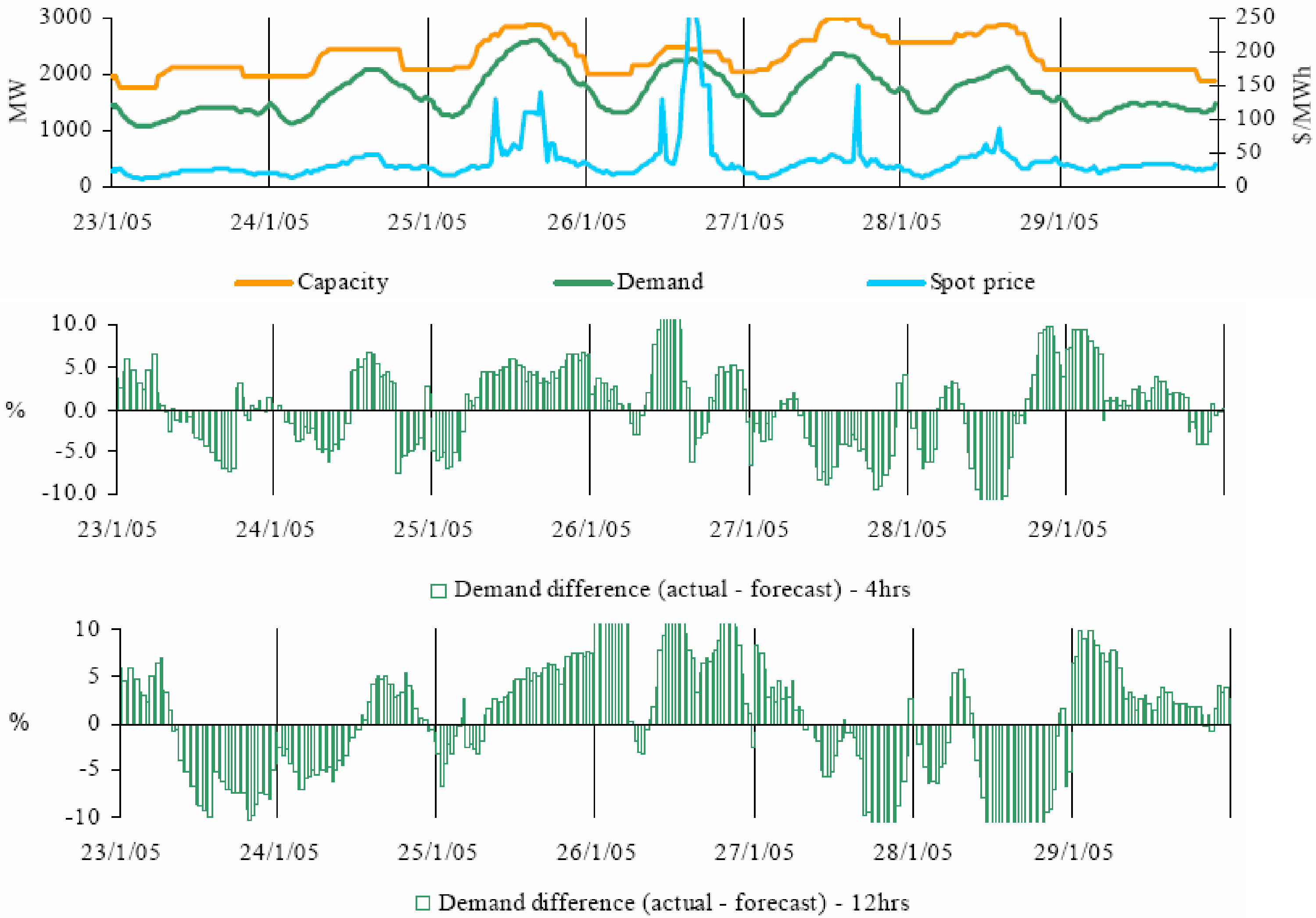
➔ ***In its technical, commercial & regulatory aspects***

Integrating significant intermittent renewables 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

Load variability and unpredictability

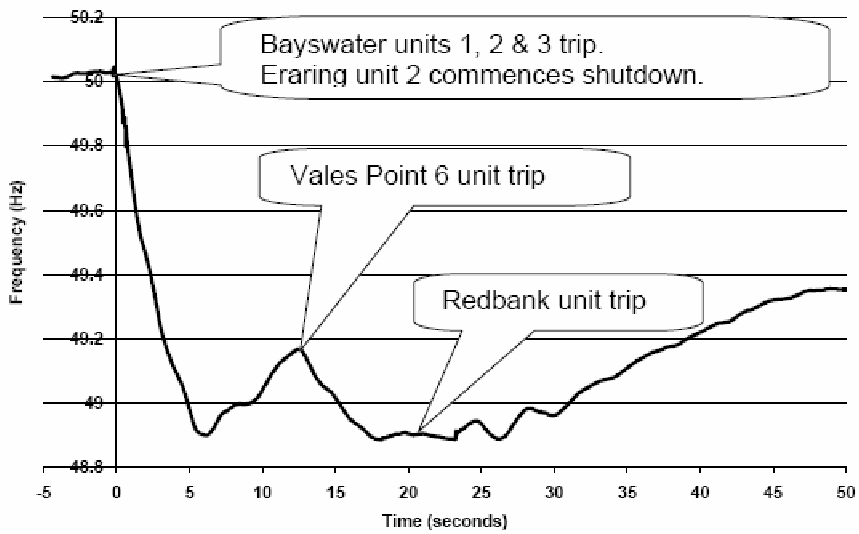
SA electricity demand cf forecasts, (NECA, Market Analysis 23-29 January, 2005)

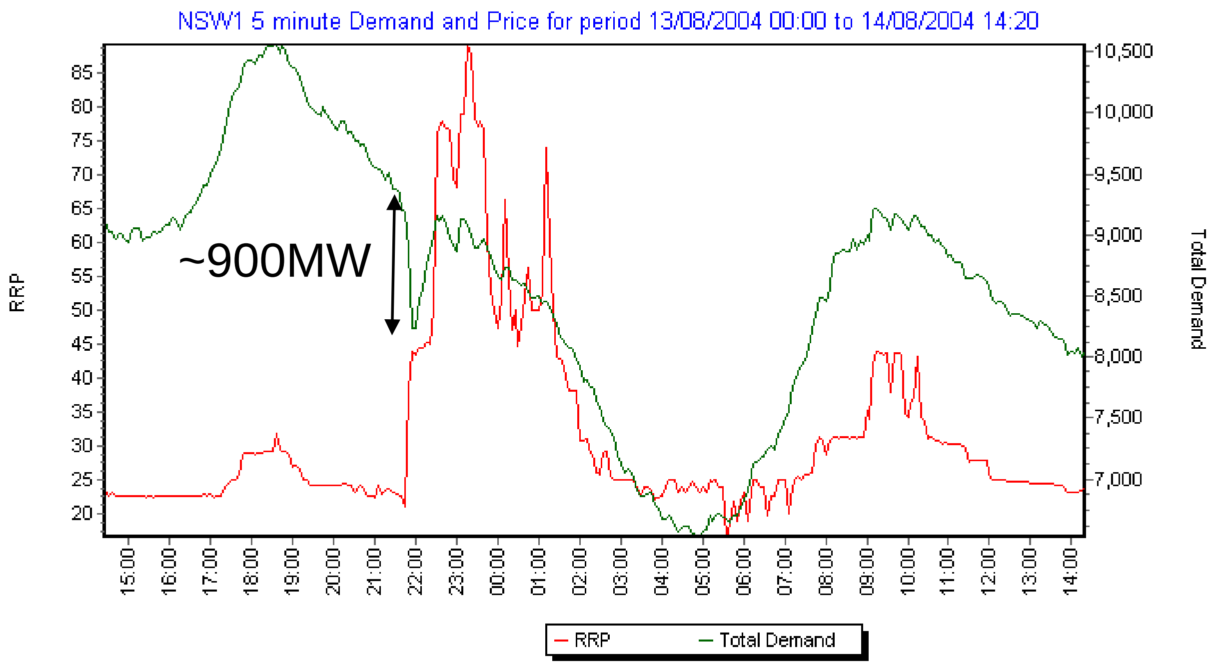


Gen variability + unpredictability

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)

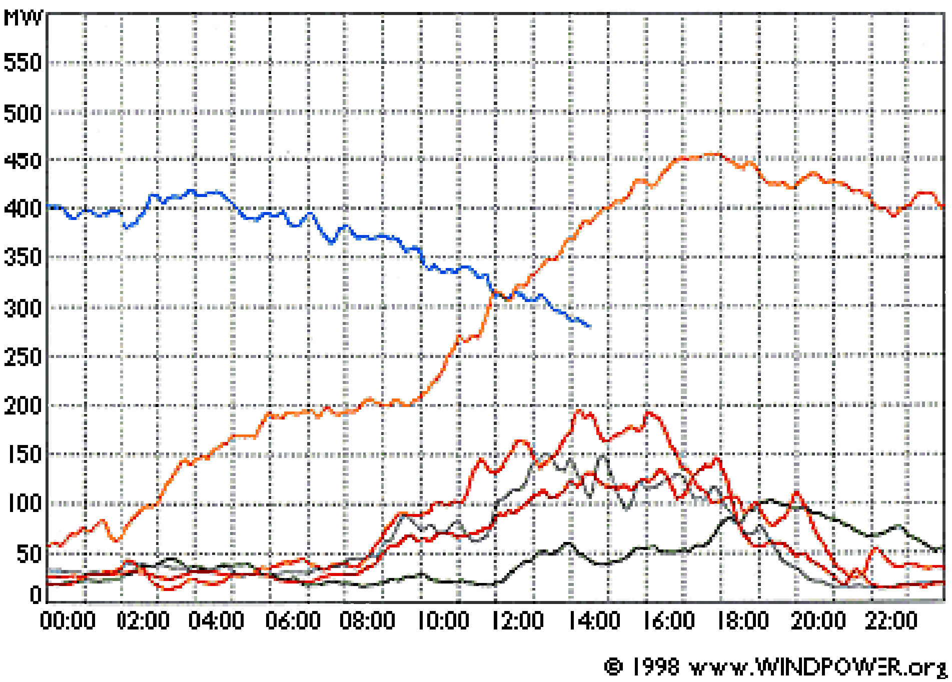
Figure 1-5: Power System Frequency

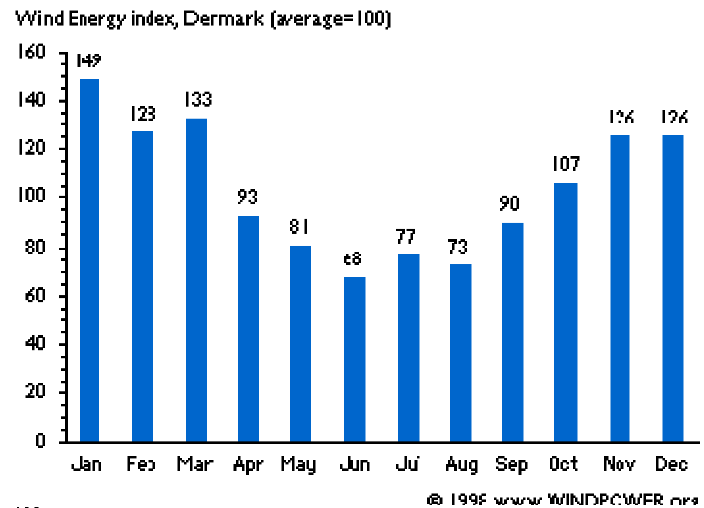


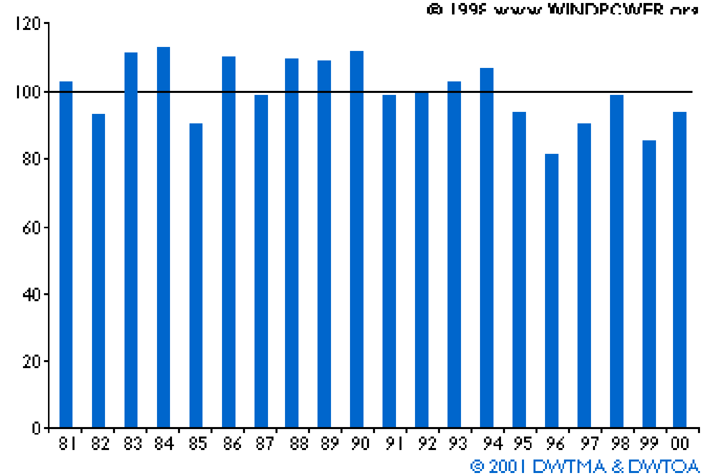


Wind power variability + unpredictability

(Danish Data, www.windpower.org)



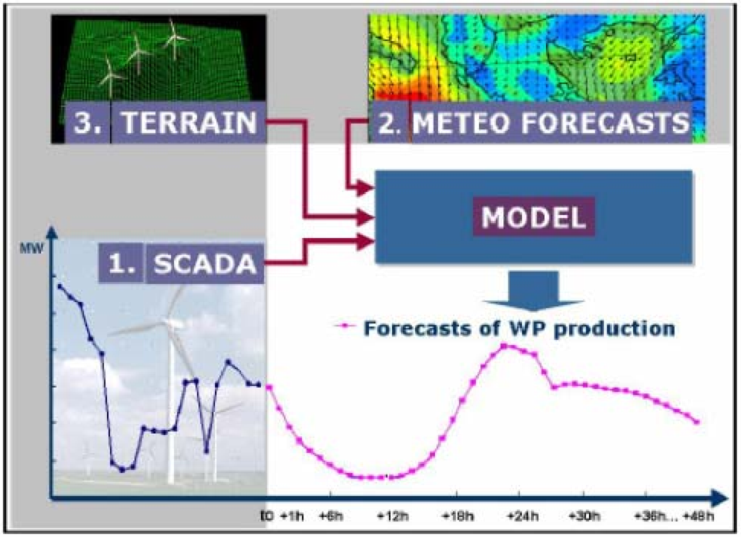




Short-term, daily, seasonal and annual variations in wind speed

Forecasting wind energy production

(CSIRO, *Report to NEMMCO*, 2004)



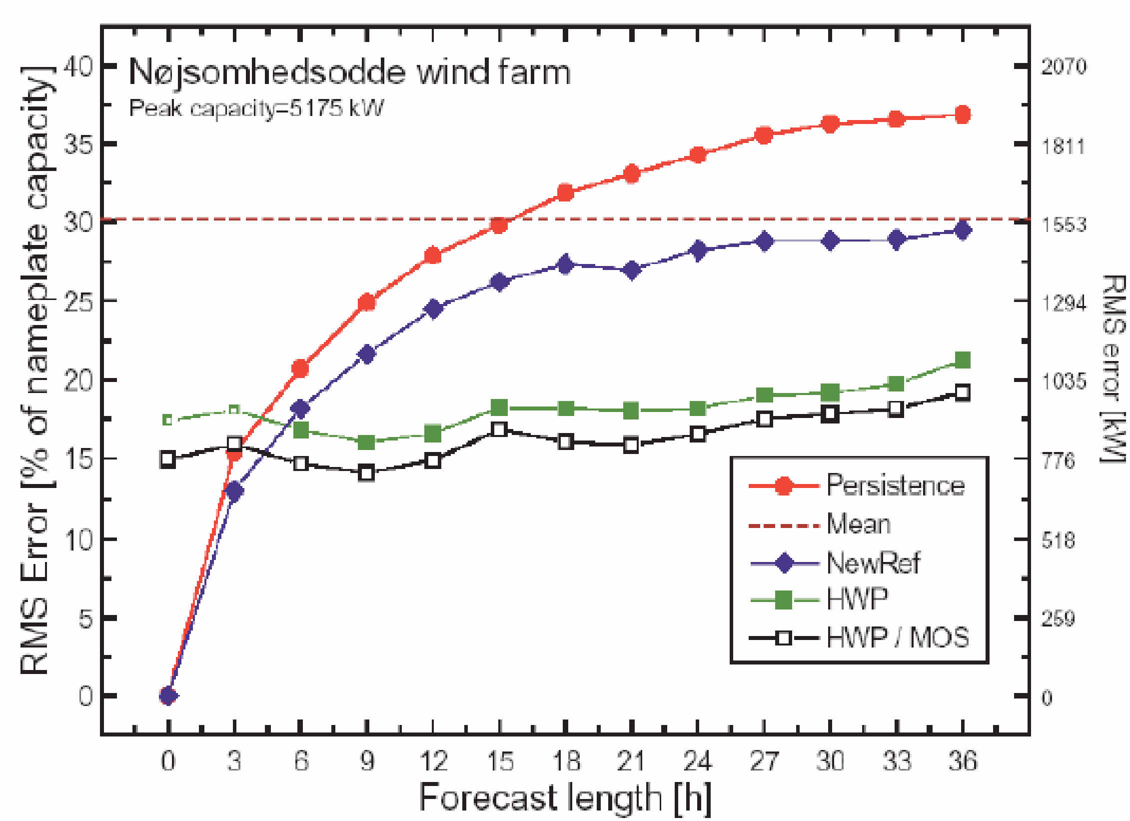


Figure 9 Root Mean Square (RMS) error for different forecast lengths and different prediction methods. Upper curves are statistically based systems, lower curves are weather forecast-based systems, from Giebel et al. (2003).

Relevant features of the NEM for managing variability and unpredictability

- System operation (& investment) managed by:
  - Price signals in ancillary, spot & derivative markets, and
  - Power system security considerations & associated system operator decisions
- High intermittent energy penetration raises challenging questions for each management technique:
  - Uncertain but correlated behaviour of intermittent power output
  - “use it or lose it” nature of such renewable energy fluxes
  - Distributed nature of intermittent generation & potential location in weak parts of network
  - Present arrangements shielding intermittent renewables from some price signals and potential operator decisions

Understanding and responding to intermittent renewables issues for NEM is 'work in progress'

- NEMMCO (2003)
  - Network management – V regulation, power quality + stability
  - Frequency control ancillary services – increased use => costs
  - Forecasting – increased errors in price + reserve forecasts
- Tas. Large-Scale Wind Integration Working Grp (2004)
  - Focus on security issues - managing freq. for contingencies under expected system operation with Basslink + light Tas. Load
- SA ESIPC (2005)
  - Reliability, security and price issues
  - Installing > 500MW of wind without structural changes to NEM + improved safeguards means unacceptable risk to reliability

‘Work in progress’ (cont.) - WETAG (2005)

- Management of network flows
- Short term variability of wind farm output
- Modelling of power system operational implications
- Network connection of large scale wind generation
- Contribution of wind generation to reserves
- Technical standards
- Contingency FCAS services & cost recovery
- Information disclosure
- Forecasting wind generation

Some international experience

- Germany (DENA, 2005)
  - 20% renewables target for 2020
  - Technical solutions for integration of up to 12.5% wind in 2015 at moderate cost and Tx expansion
- UK (Sustainable Development Commission, 2005)
  - Most of Renewables Obligation (7% new renewables by 2010) will be met by wind
  - Wind availability can be forecast to reasonable accuracy in the timeframe relevant to the electricity market
  - As penetration of wind output increases, additional balancing services required – a cost issue rather than technical constraint
  - When wind energy accounts for 6% of total electricity generation, it displaces conventional plant at around 35% of installed capacity,
  - No technical limit to the amount of wind capacity that can be added to an electricity system – the only constraint is economics
- NZ (EECA, 2005)
  - Preliminary estimates - potential for appox. 20% market share wrt technical + operational issues with modern turbines, geographical dispersion + forecasting

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 – especially regulation
  - 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)

Some possible take-home messages

- Community
  - New intermittent renewables likely essential part of any meaningful response to GW
  - Coherent + consistent policy support required – *expanded MRET can play vital role*
- Project developers
  - Community must be satisfied new renewables not just renewable, but sustainable
  - Significant intermittent gen. penetrations can raise important challenges for NEM at local, regional + 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