Centre for Energy and Environmental Markets

UNSW

GLOBAL WINDPOWER'06

Adelaide, September 2006

The Commercial Context for Integrating Wind Energy into the Australian National Electricity Market

Dr Iain MacGill

Research coordinator – Engineering

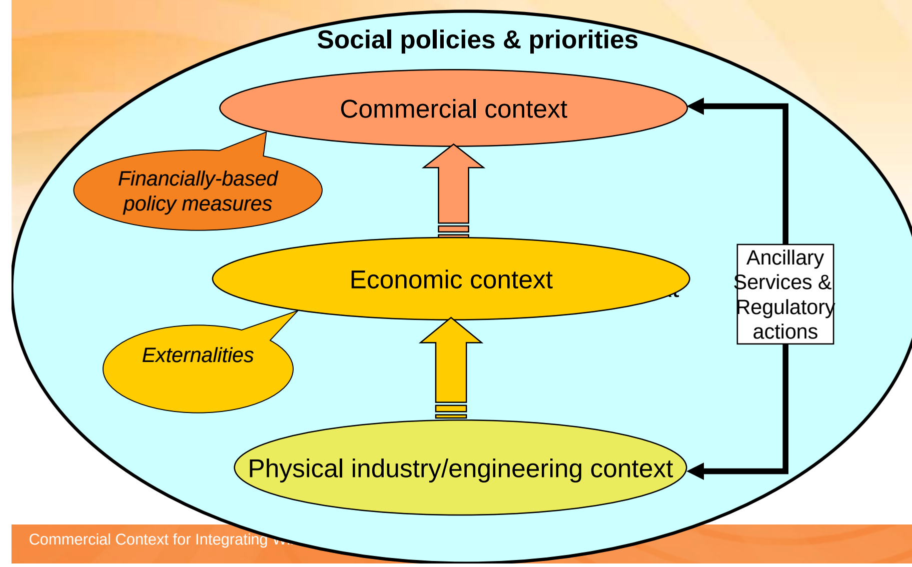
Centre for Energy and Environmental Markets

The University of New South Wales

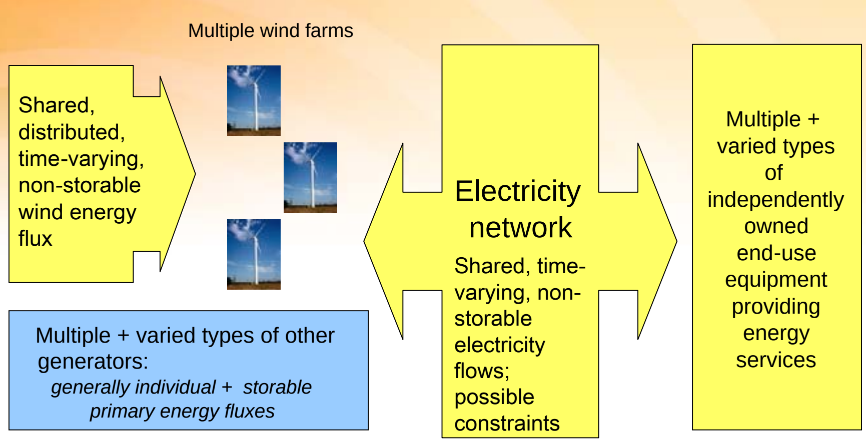
i.macgill@unsw.edu.au

www.ceem.unsw.edu.au

Various contexts of wind energy integration



Physical context for wind energy integration



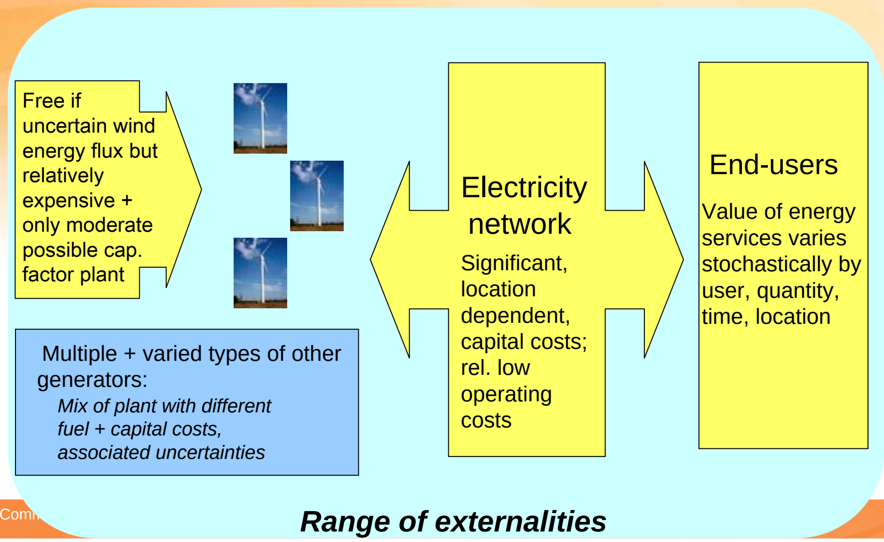
Physical integration of significant wind

- All loads, generators + network elements have electrical flows that are variable, not completely controllable + somewhat unpredictable
- **Wind:** reliable but highly variable, limited (downward) possible control + somewhat unpredictable
  - *Variability by some measures actually more predictable than base-load thermal plant where unexpected variations are forced outages*

The operational challenge for power systems

- complex and time-critical systems: no cost-effective electricity storage
- manage small disturbances well but entire system put at risk by large unexpected changes
  - failure of large centralised generation or Tx elements
  - strong correlation between behaviour of many small generators or loads; eg. air conditioners on a hot day, **wind farms upon arrival of storm front**.

Economic context for wind energy integration



Economic integration of significant wind

- Value of energy varies stochastically wrt time, location + possible contingencies s.t behaviour of all participants
  - Major part of network value comes from aggregation + diversification
- *Industry objectives*
  - Maximise Industry Benefits of Trade (IBOT)
  - Include externalities to max. social welfare
    - Economic development, energy security, environmental
- Wind energy
  - Energy value determined by overall electricity industry operation + investment
  - Also has economic development, energy security + environmental values
    - These have very different stochastic variation wrt time, location + contingencies than does energy value

Commercial context for the electricity industry

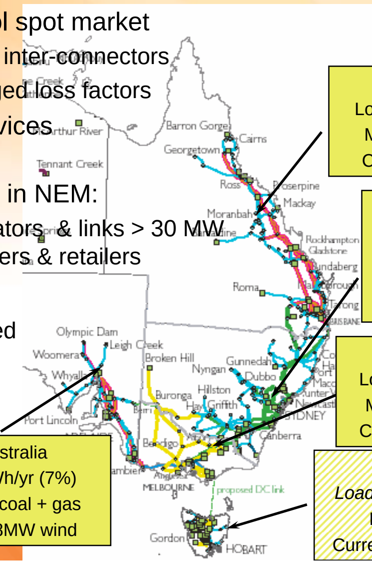
- Electricity industry operation + investment always a mix of centralised + decentralised (commercial) decision making
  - Even monopoly utilities don't own + operate their end-users
  - Can't fully commercialise short-term decision making in industry
- Last 2 decades has seen worldwide efforts in restructuring EIs
  - structural disaggregation from monopoly utilities to mix of competing firms in generation + retail markets, monopoly NSPs + system operators
- Key challenges
  - Electricity industry infused with short to long-term risks that are difficult to commercialise (correctly allocate to industry participants)
  - Wide range of choices in design + structure
    - eg. gross pool vs bilateral trading with balancing market; energy only vs energy+capacity markets
    - eg. number of market participants, government vs private ownership
  - Incorporation of externalities
    - Directly within energy market design vs external policy frameworks
  - *Outcomes to date mixed + too soon to declare success or failure*

Commercial context for wind energy integration

- Some principles of good market design:
  - focus on embracing + hence better managing inherent uncertainties within EI: *uncertainty drives competition*
  - allocation, as best possible, of costs + benefits to participants wrt costs + benefits they each provide to the industry,
  - Establish level playing field that doesn't favour incumbent technologies + participants against 'new entrants' –*key part of competition*
  - Commercialise externalities as best possible
  - Enhance transparency
  - support for innovation to meet emerging challenges + change
- High wind penetrations
  - one of the first generation technologies to emerge within restructured industry context
  - will test adequacy of electricity industry restructuring

The Australian NEM

- A multi-region gross pool spot market
  - Potentially constrained inter-connectors
  - Within a region, averaged loss factors
- Associated ancillary services + derivative markets
- Compulsory participants in NEM:
  - All dispatchable generators & links > 30 MW Network service providers & retailers
- **Wind**
  - Currently non-scheduled
  - Can be non-market (sell to local retailer) or market participant



Queensland
Load ~37 TWh/yr (21%)
Mainly black coal gen
Currently 12 MW wind

NSW & ACT
Load ~63 TWh/yr (36%)
Mainly black coal gen + Snowy Hydro
Currently 17MW wind

Victoria
Load ~38 TWh/yr (22%)
Mainly brown coal gen
Currently 134 MW Wind

South Australia
Load ~11 TWh/yr (7%)
Mix of brown coal + gas
Currently 388MW wind

Tasmania
Load ~9 TWh/yr (6%)
Mainly hydro
Currently 67MW Wind

Commercial context for wind integration in Australia's National Electricity Market

- 5-minute spatially-differentiated spot energy & associated derivatives mkts support dispatch, commitment, operation planning & investment
- 5-minute Frequency Control Ancillary Service (FCAS) market support chosen contribution to managing short-term regulation + contingencies

Wind farms + other generators *(sellers)*

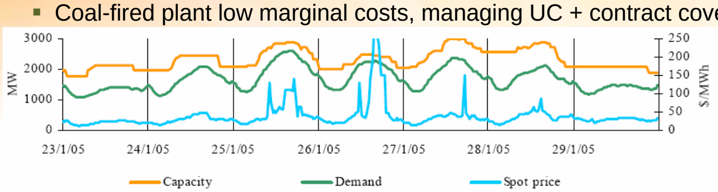
National Electricity Market
Commercial activities:
- *Spot market*
- *Derivative markets*
- *Ancillary services markets*
- *Network charges*
- *REC market*

Subject to constraints:
- *Connection requirements*
- *Security requirements*
- *Regulatory requirements*

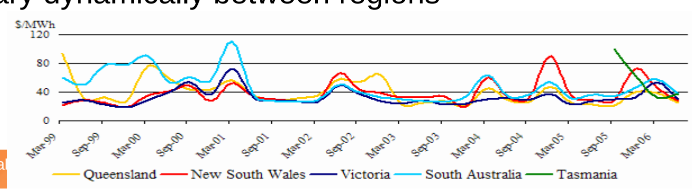
Retailers + large end-users *(buyers)*

NEM spot market prices

- Volatile with 'hockey-stick' distribution
  - high prices up to $10,000/MWh possible + not easily predicted
    - Load variability + unpredictability; other contingencies
    - gens can rebid offers 5 min before dispatch
  - Prices normally low ($20-30/MWh), can even go negative
    - Coal-fired plant low marginal costs, managing UC + contract cover



- Vary dynamically between regions

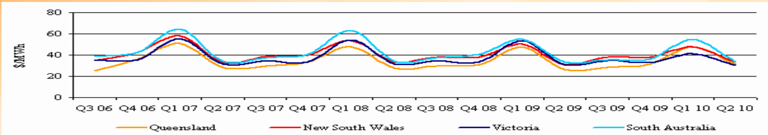


Wind in the NEM spot market

- Wind currently non-scheduled
  - Generate whenever wind is blowing (possibly s.t. to N/W constraints)
  - Wind farms (or local retailer) operate as "price takers" although high penetrations will impact spot market prices – *difficult to estimate*
  - Value of wind energy in the spot market depends on how regularly wind farms are producing when spot prices are high *can be reasonably good correlation seasonally and daily cycle*
- Wind farm developers see locational price signals
- Load will remain major source of variability + unpredictability until we see considerably higher wind penetrations (SA an exception)
  - **NEMMCO has interim + progressing major NEM wind forecasting sys**
- Considerable transparency
  - NEMMCO provide historical generation, now also non-scheduled generation forecast in pre-dispatch + PASA
- Coming changes to wind non-scheduled status
  - **Semi-dispatch:** Wind farms can be given downward dispatch targets when network constraints (NEMMCO is progressing)
  - **Scheduled generation:** Licensing requirement by ESCOSA.

Wind in derivative markets

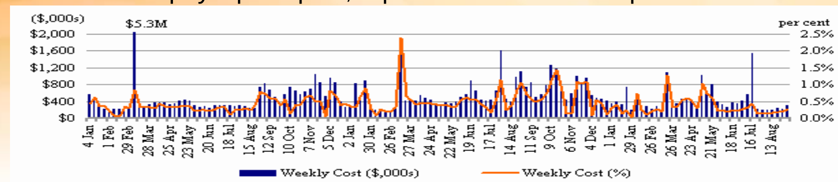
- Most generators + retailers operate with considerable contract cover – *CFDs, Calls, Puts*



- Wind farms may wish to participate in derivative markets:
  - Variable + somewhat unpredictable energy will normally have lower value that energy from other generators
  - Important to have good forecasts of average production plus seasonal & diurnal patterns
  - 'Smoothing/firming' contracts between wind + other gens possible
- All market participants will be interested in predicting future wind power at local, regional + system-wide scale:
  - Important to develop high quality forecasting techniques

Wind in ancillary services markets

- Frequency (FCAS) markets for regulation + contingencies
  - 'Causer pays' principles, represent low cost c.f. spot market turnover



- Wind currently doesn't participate
  - NEMMCO progressing non-scheduled generator contribution to FCAS costs
  - Wind farms will be buyers but could also be sellers in FCAS markets
  - Australian power systems are technically challenging:
    - Wind farm installers should be choosing Best Available Technology for both turbines & wind farm control schemes

Wind + network integration

- Existing generators
  - Currently no Use-of-System charges
  - Considerable network 'endowment' to incumbents
- New generators including wind
  - Must fund any N/W augmentation required to facilitate connection – both 'shallow' + 'deep'
    - unless augmentation can pass 'regulatory test' of mkt benefit
  - Costs therefore very location dependent
  - Some possibilities for 'sharing' N/W connection costs
    - eg. Victorian Government support for Dx level connections
  - Technical standards for connection being revised

Wind in energy-related environmental markets

- Range of markets
  - Federal MRET
    - National target obligation imposed on retailers: market trading in RECs (1 MWh of 'new' renewable generation) provides cashflow for renewable projects additional + independent of energy mkt cashflow
    - Targets to 2020 already nearly filled, will be insufficient to drive significant future investment. REC prices now falling markedly.
  - Victorian scheme (VRET) coming, SA exploring options
  - Existing wind farms
    - Typically financed via PPAs from retailers
    - Approx. half of revenue from energy market, half from RECs
    - Limited exposure to changing energy market conditions
      - Effectively worth generating in spot market at –ve REC price
  - Wind farm investment
    - Energy market signals significant wrt location; potentially significant wrt chosen turbine technology, windfarm layout, control systems

Conclusions

- NEM
  - Infused with uncertainty – *a key to driving competition*
    - Generators can rebid with 5 min notice, don't know dispatch beyond 5 min
  - Some success in commercialising costs + benefits
    - Spot/forward markets price current/future uncertainty for all generators
    - FCAS markets set frequency ancillary services costs
    - Principle of 'causer pays' although difficult in practice
  - Formal objectives of equal treatment… although difficult in practice
- Wind
  - Currently unscheduled generation + outside many NEM processes
    - NEMMCO has very limited opportunities to direct behaviour yet remains accountable for maintaining system security
  - Already 'sees' many of NEM's commercial signals; reasonable that they 'see' more of costs + benefits they bring to NEM + society
  - Wider environmental + industry development value needs to be recognised with greater 'external' policy support

Centre for Energy and Environmental Markets
UNSW

Thank you… and questions

CEEM gratefully acknowledges the support of the Australian Greenhouse Office in funding this research as part of the Australian Government's Wind Energy Forecasting Capability initiative

Many of our publications are available at:
www.ceem.unsw.edu.au