



Renewable energy integration into the Australian NEM: Characterising the energy value of wind and solar generation

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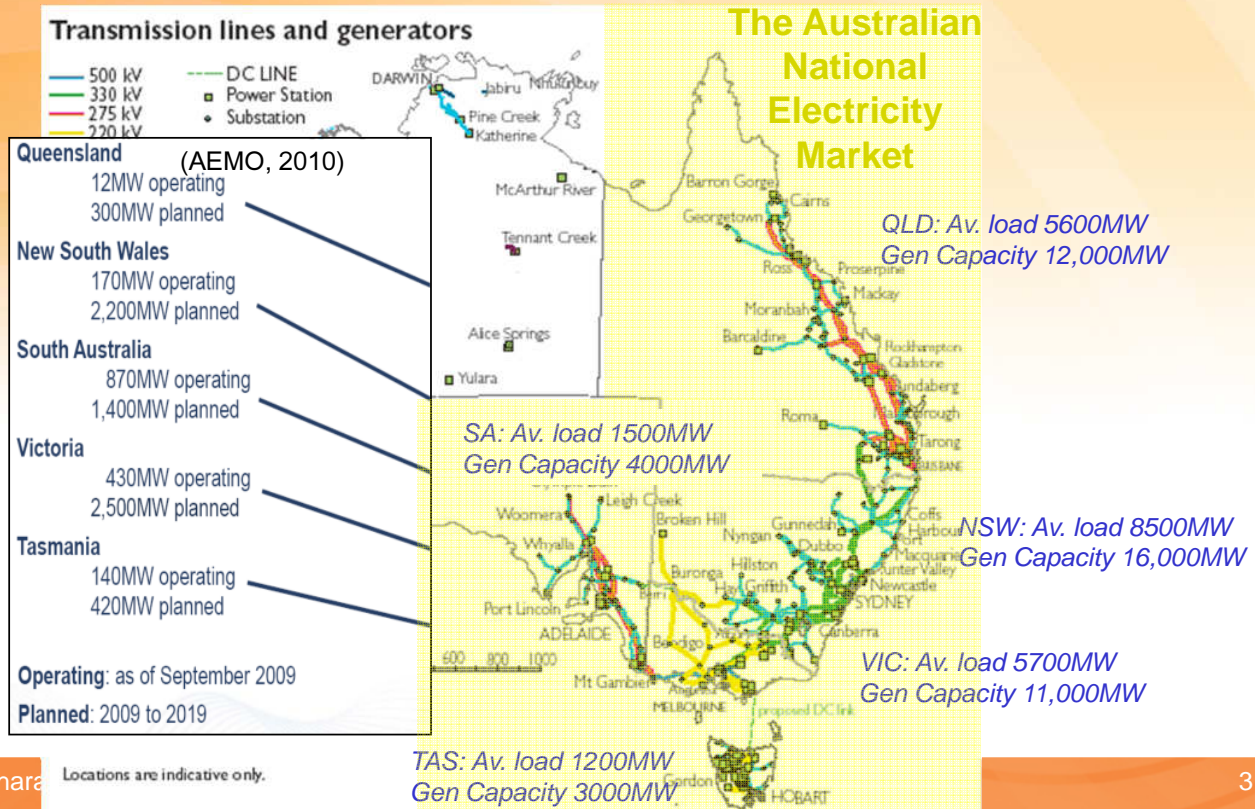


Renewable energy's diverse values

- **Energy** (and network) costs and benefits
 - depends on other supply options, and value of providing energy services; varies by time, location and uncertainties
 - *Particularly challenging to estimate for highly variable and somewhat unpredictable wind and solar*
- **Environmental** costs and benefits
 - greenhouse emission reductions – depends on other gen options
Industry development provides future option for energy transformation
 - regional air + water benefits, possible amenity costs
- **Social** costs and benefits
 - possible investment + job outcomes with industry development
 - Major deployment will require social consensus
- *In the Australian context, NEM has a key role in determining renewable's energy and environmental costs and benefits*

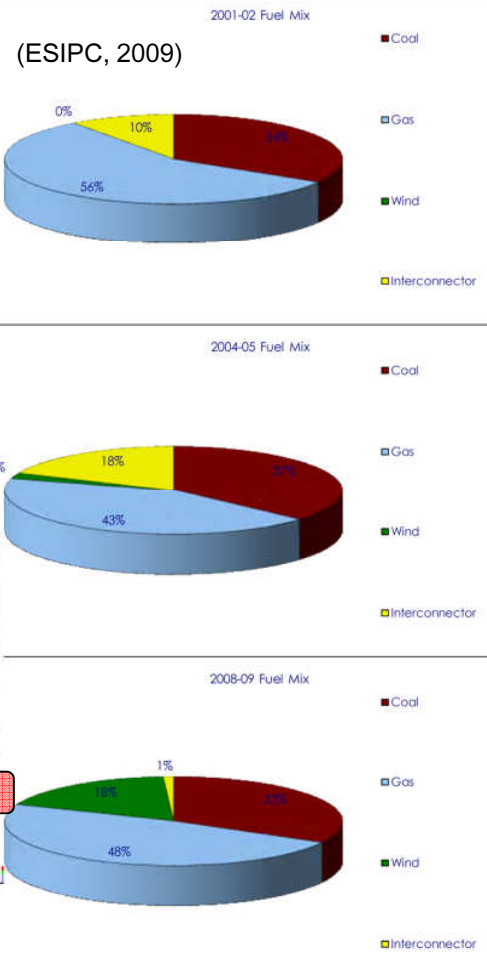
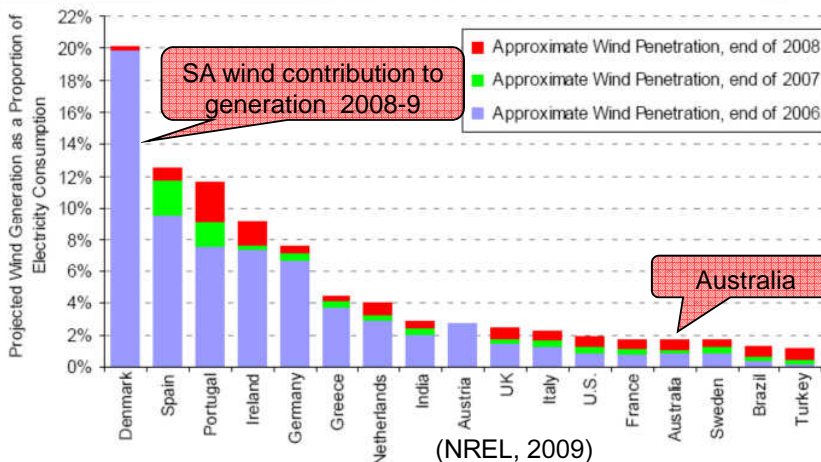


The NEM... & current/planned large-scale wind



South Australia

- A world leading jurisdiction for assessing the potential energy value of intermittent renewables
 - A large and rapid deployment of wind with a world leading penetration
 - Excellent solar resource
 - High wholesale spot/ancillary service market transparency

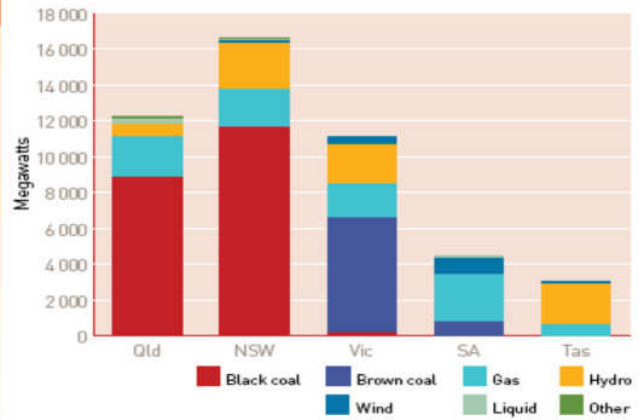




NEM energy markets

- Largely the same rules but different regional contexts... and dynamics
- Three key markets
 - Regional wholesale spot markets
 - Regional wholesale frequency control ancillary services (FCAS) markets
 - Regional wholesale derivative mkt
- High wholesale spot/ancillary service market transparency
- Spot market revenue typically 100X greater than ancillary service mkt

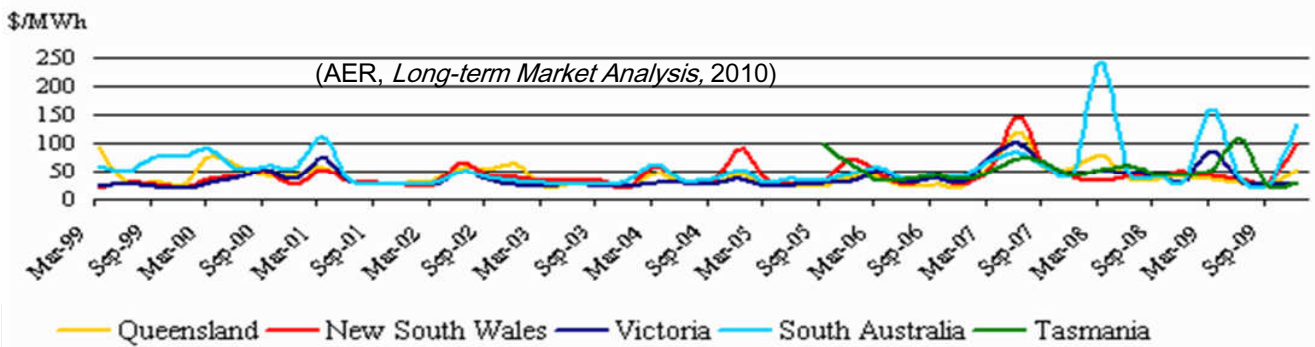
Figure 1.6 Registered generation capacity, by fuel source—regional, 2009



Note: New South Wales and Victoria include Snowy Hydro capacity allocated to those regions.

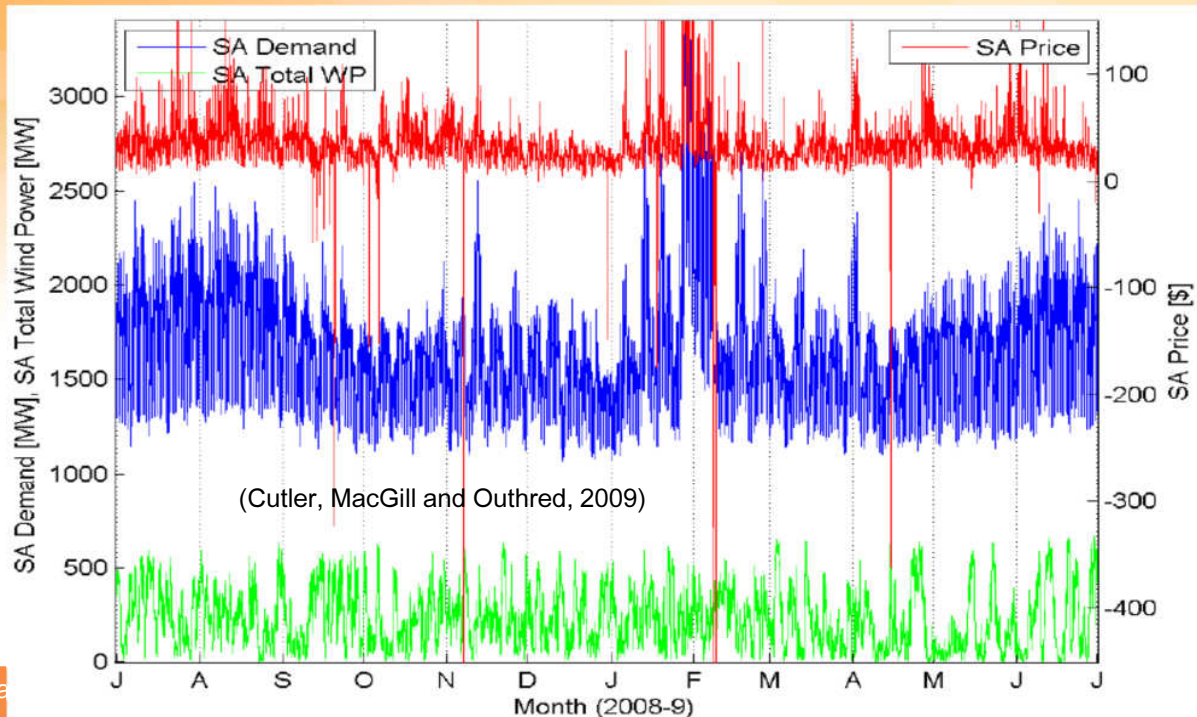
Sources: AEMO/AER.

(AER, State of the Energy Market 2009)



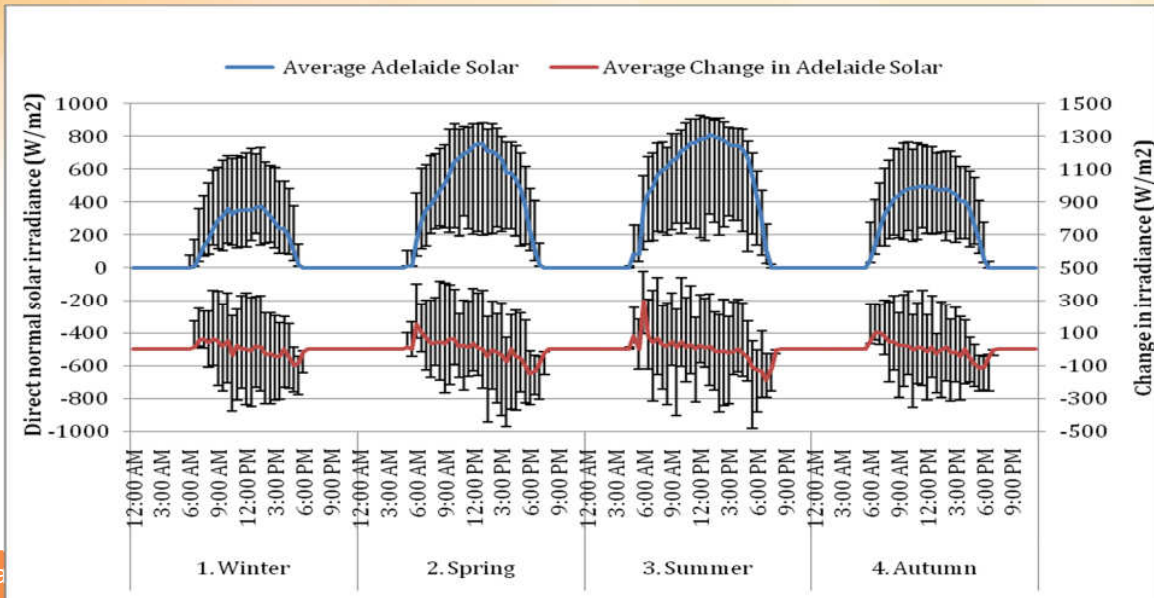
Demand, wind & spot price dynamics in SA (2008-9)

Wind has very high relative variability cf. demand although overall impact currently less ... note different dynamics and different predictability



Simulating potential large-scale solar in SA

- Av. & 95% CI daily direct solar irradiance and ½ hr changes each season in Adelaide highlight high variability of the resource.
- Site diversity reduces relative variability – average of six sites across Australia has half maximum irradiance variability of just Adelaide site

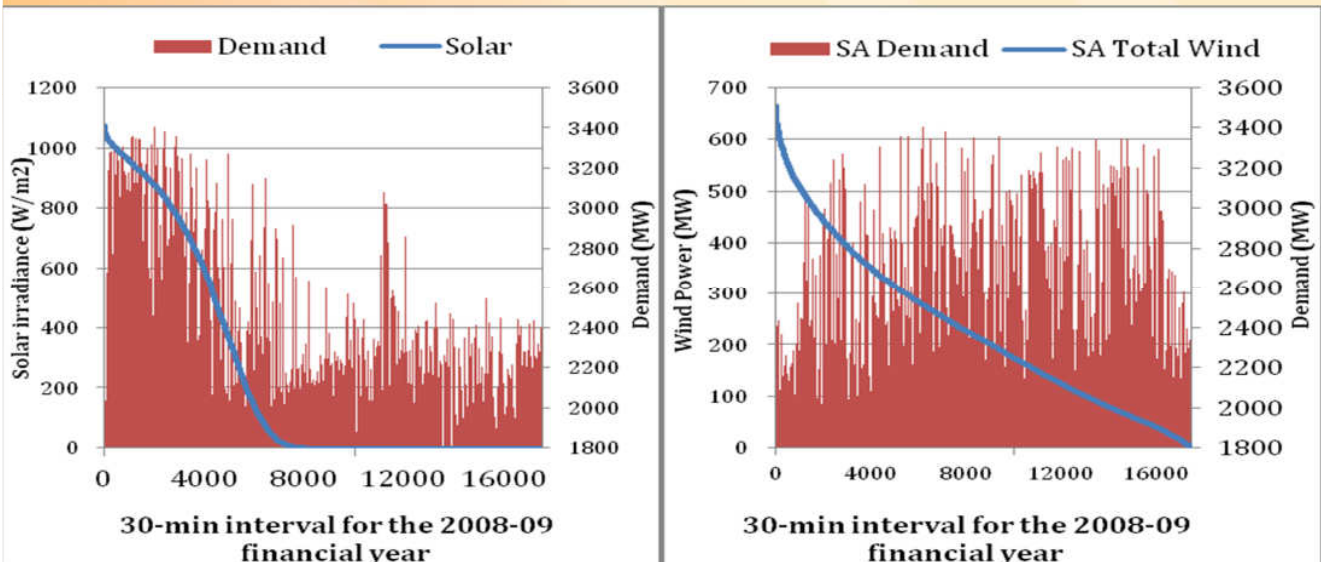


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Renewable generation & SA demand

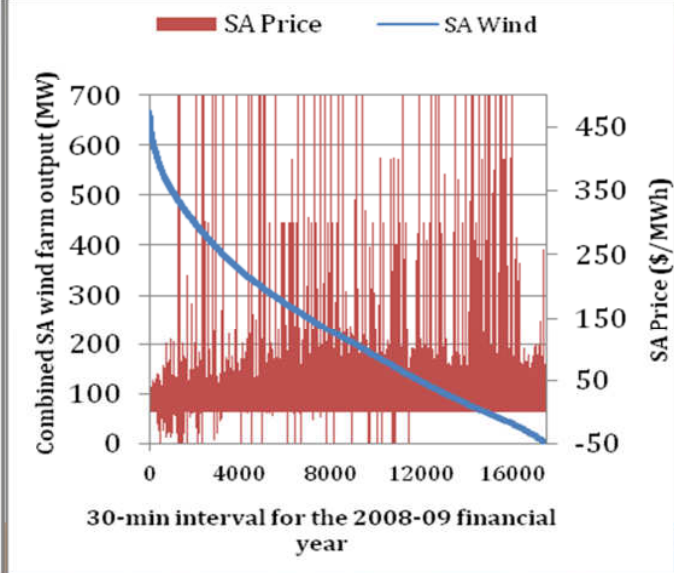
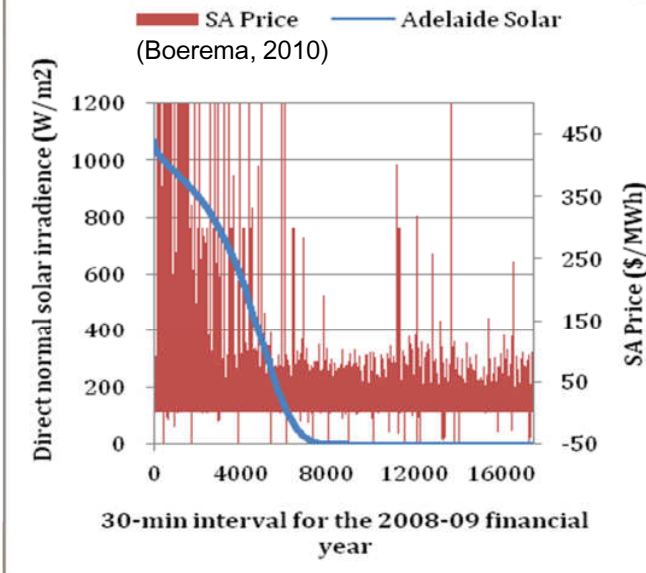
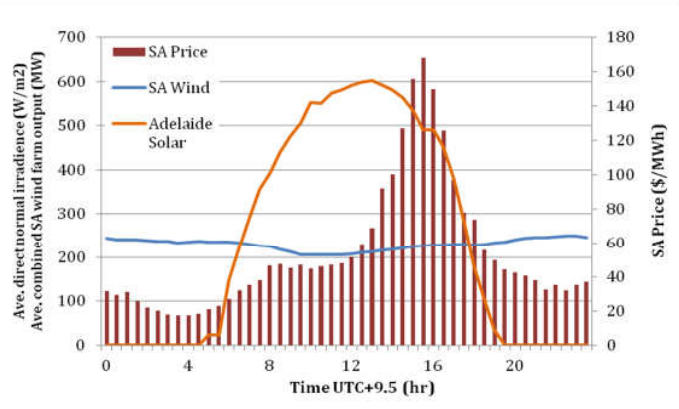
- Direct irradiance (reasonable proxy for CSP and concentrating/tracking PV output) has, unsurprisingly given daily demand profile, a significantly better correlation with demand than wind





Renew gen. and price

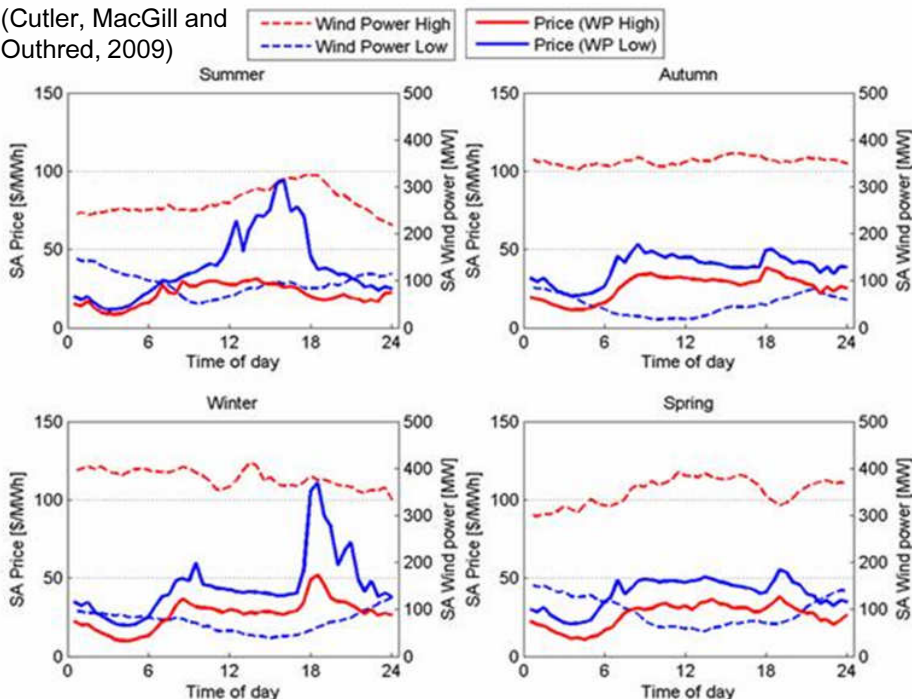
- In 2008-9, large tracking PV plant may have earned spot revenue >\$100/MWh or 2X Wind \$/MWh
- Key driver is correlation with demand (key price determinant)



However, wind gen in SA now a price driver itself

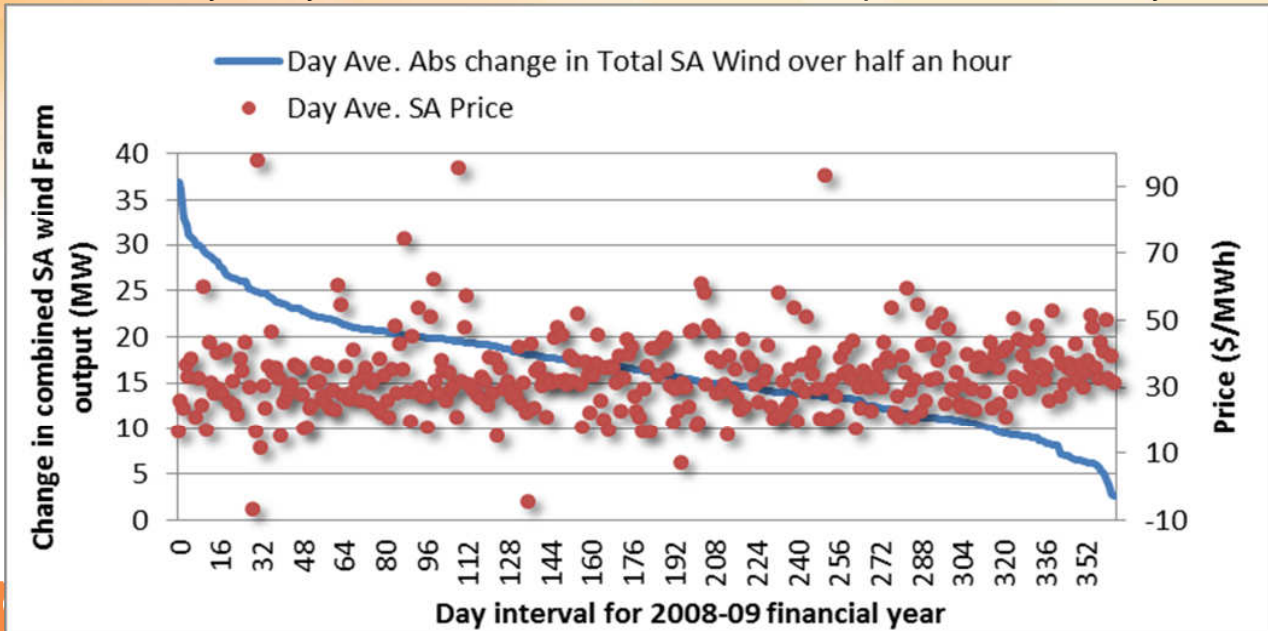
- Top quartile and bottom quartile average wind gen. for week-days and associated SA prices (note that prices capped at \$415/MWh to avoid infrequent high price events dominating results)

(Cutler, MacGill and Outhred, 2009)



Impact of renew gen variability on prices

- Significant wind variability might drive conventional generation shortfalls but also excess (coal plants have minimum operating levels & ramp rates)
Hence, might drive both very high but also low (negative) prices
- Preliminary analysis doesn't show clear relationship on ½ hour or day basis



- **In conclusion**, Australian NEM and renewable 'energy' value
 - Relatively sound design provides reasonable commercial signals on the time & location varying, uncertain value of energy across NEM states
 - Wind generation in SE Australia doesn't appear particularly correlated with demand (the most significant price driver); solar far better correlated
 - Significant wind gen in SA appears to be having price impacts – the lowest operating cost gen in the NEM so when the wind blows, prices fall
 - Wind gen offers less 'energy value' than more dispatchable generation
lacks energy storage in industry that must maintain supply = demand
 - Large-scale solar likely to have significantly higher energy value than wind due to far better correlation with demand and hence price
 - More work on variability, forecasting and derivative markets required
- NEM externality costs
 - Likely far higher than direct energy costs. IEA suggests carbon price of \$50=>\$175/tCO₂ from now to 2050 required to halve 2050 emissions
 - *Would increase costs of current Aust. coal generation more than 2-5 X*
 - *The most important value for renewables yet still mainly 'missing' in NEM*

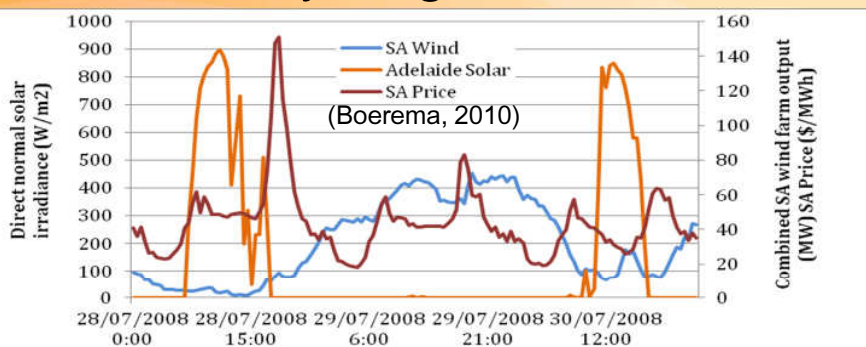


Thank you... and questions

Comments, suggestions and corrections regarding this presentation are all welcome. Please contact Iain at i.macgill@unsw.edu.au



Potential synergies between solar and wind



- Possibly only a limited complementarity between wind and solar generation in SA over 2008-9

