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Some Recent 'High PV Penetration' Developments in Australia

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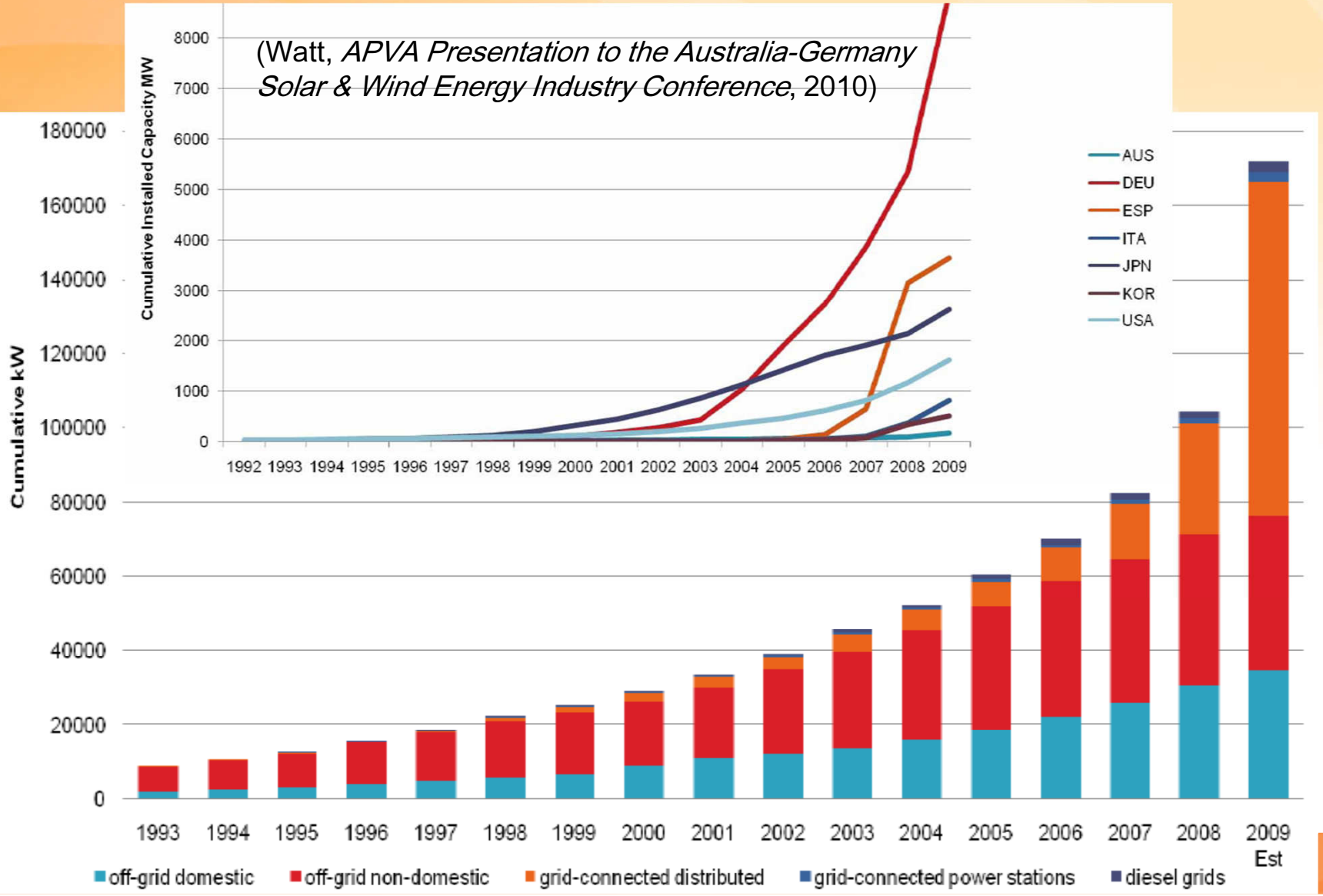
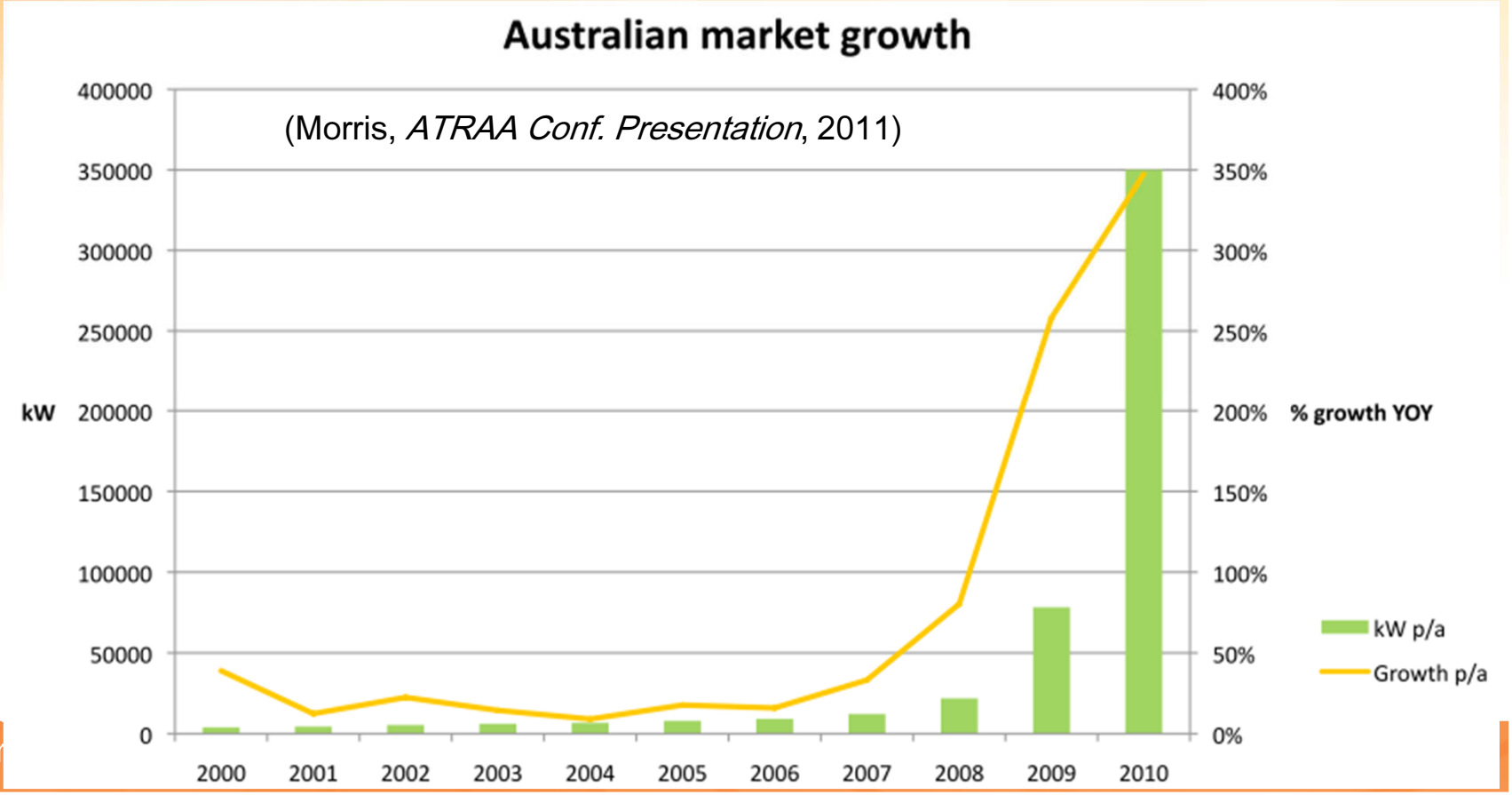
PV uptake in Australia has been growing

(Watt, *APVA Presentation to the Australia-Germany Solar & Wind Energy Industry Conference*, 2010)



…and recently accelerated

- High recent growth in PV deployment – almost all residential systems
- Penetration levels in some regions of the Dx network becoming significant – solar cities, demographics, developer strategies



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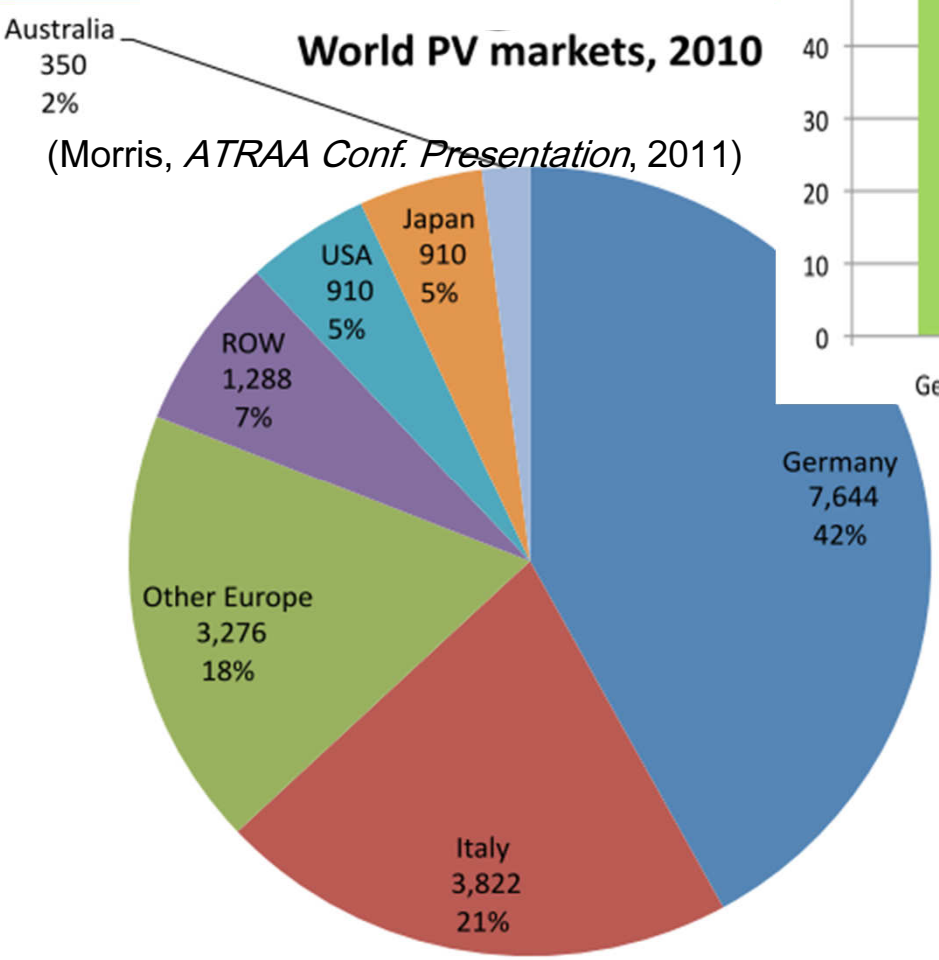
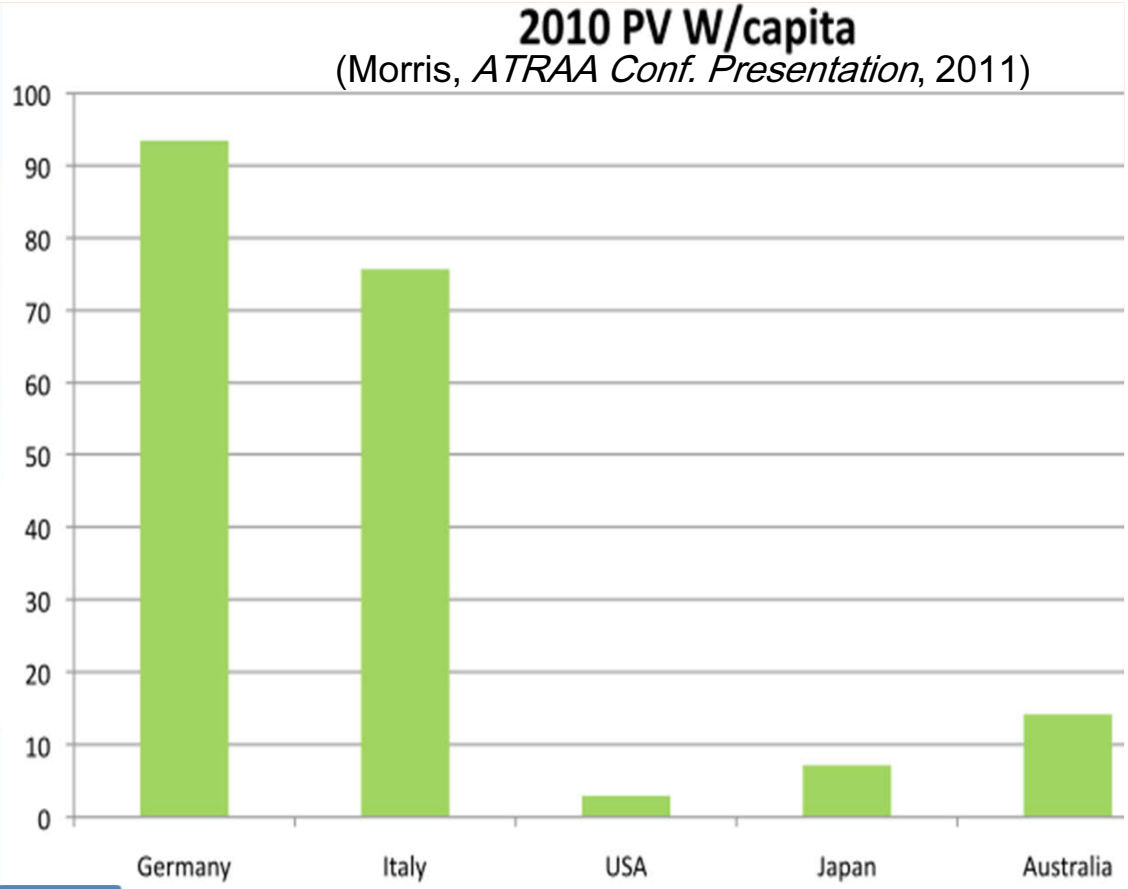
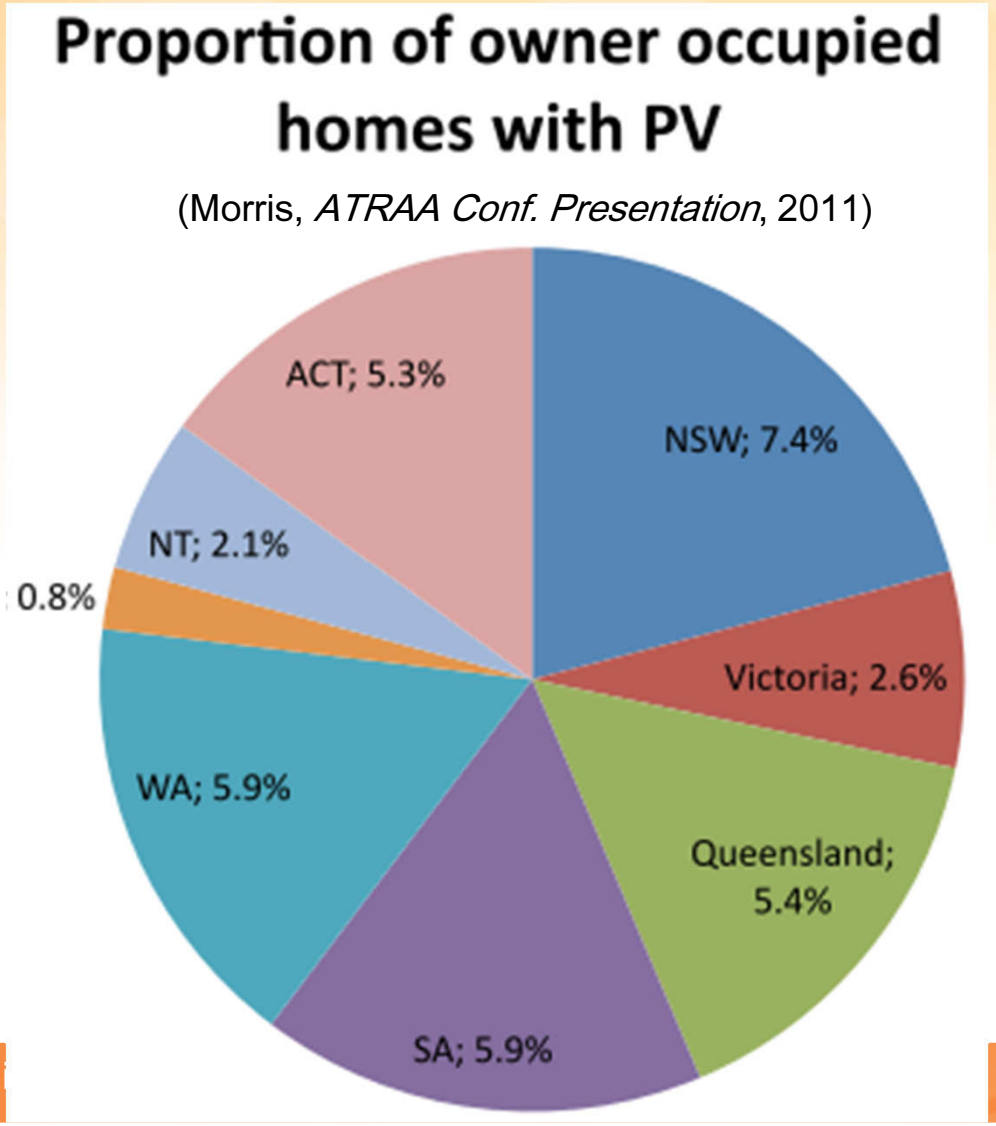
A significant recent player with growing penetrations





… nearly all small-scale domestic systems

- Almost all <5kW, hence connected to LV Dx System
- Regional distribution a factor of climate but, particularly, also jurisdictional policy support
  (note: some policies now being substantially wound back)



Under a range of policy drivers

- Federal 'deemed' Renewable Energy Certificates with a (declining) multiplier for small-scale including PV
- Range of State feed-in tariffs
- Other programs including *Solar Flagships* for large scale solar
  - 100MW+ PV and CSP by 2013
  - Second round to follow
- *Solar Cities*

State	Max installation size	Rate $/MWh (gross or net payment)	Duration	Comment (AECOM, *NSW Feed-in Tariffs*, 2010)
Vic	5kW	$600 (net)	15 years	Commenced in 2009 – FiT can be credited on account or paid cash.
SA	30kW	$540 (net)	20 years	The rate is capacity-determined with reduced rates for larger capacity increments.
NSW	10kW	$600 (gross)	7 years	A 2010 review reduced the rate to $0.20. Subsequent announcement that new installations would not receive the rate in 2011.
QLD	30kW	$440 (net)	20 years	The rate is capacity-determined with reduced rates for larger capacity increments.
ACT	30kW	$450 (gross)	20 years	The rate was reduced after review by the independent regulator concluded a payback period of 7 years was acceptable

Source: AGL Energy Ltd.

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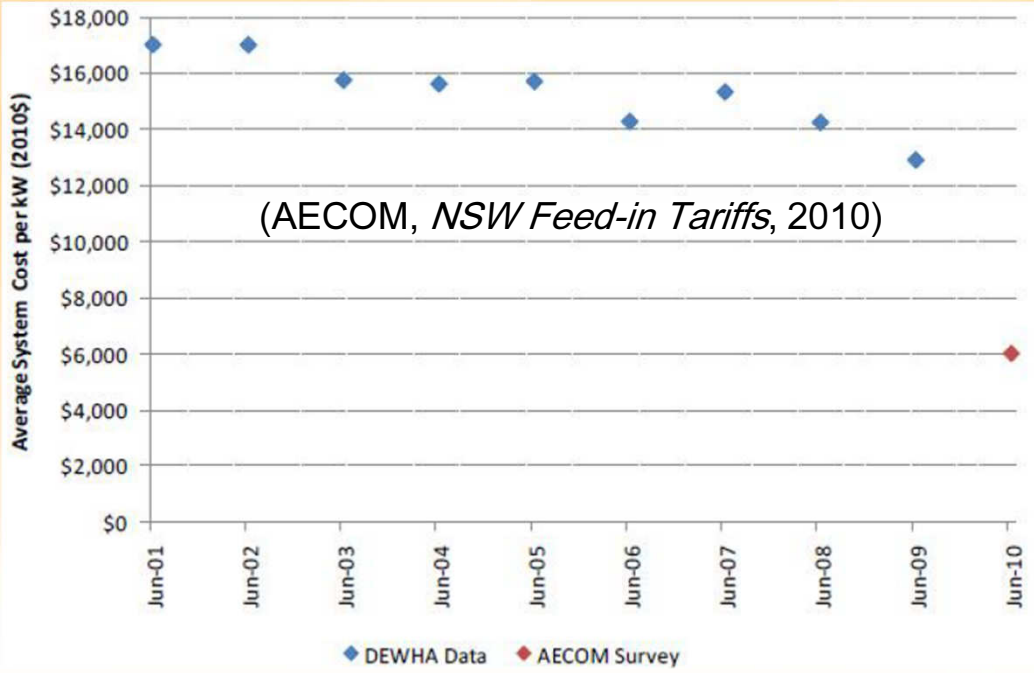
.. and falling PV prices rising electricity prices

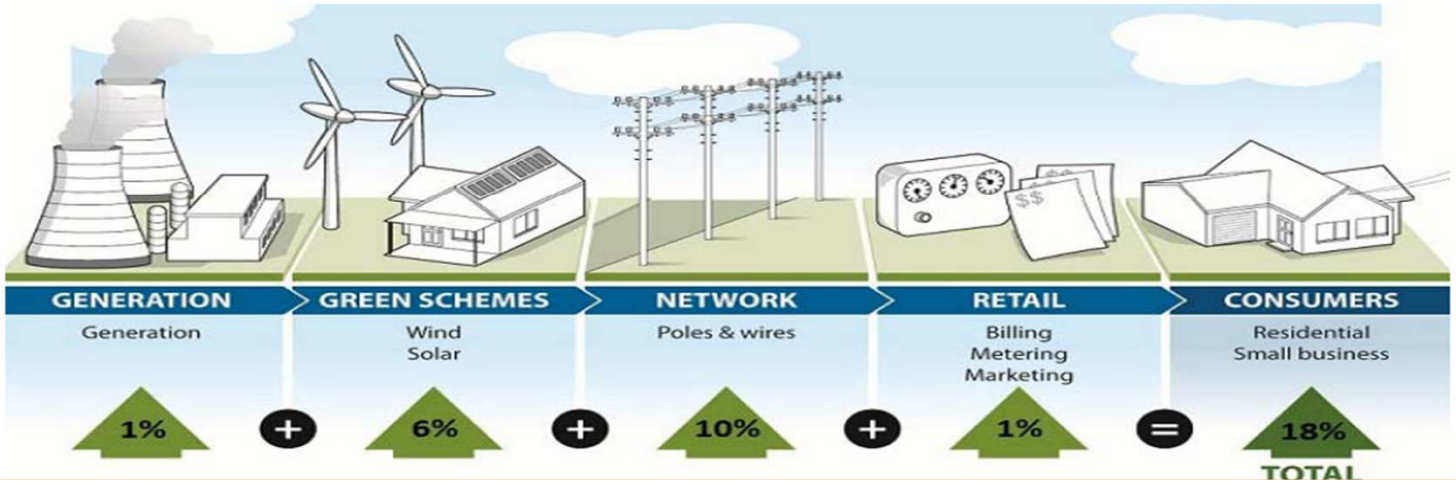
not unrelated – PV is a moderate, but not the major, cost-driver in some regions



(AECOM, *NSW Feed-in Tariffs*, 2010)

Figure 1.1 Contributions from the supply chain to overall price increases on 1 July 2011

(IPART, *Draft Determination on Regulated Electricity Prices*, 2011)

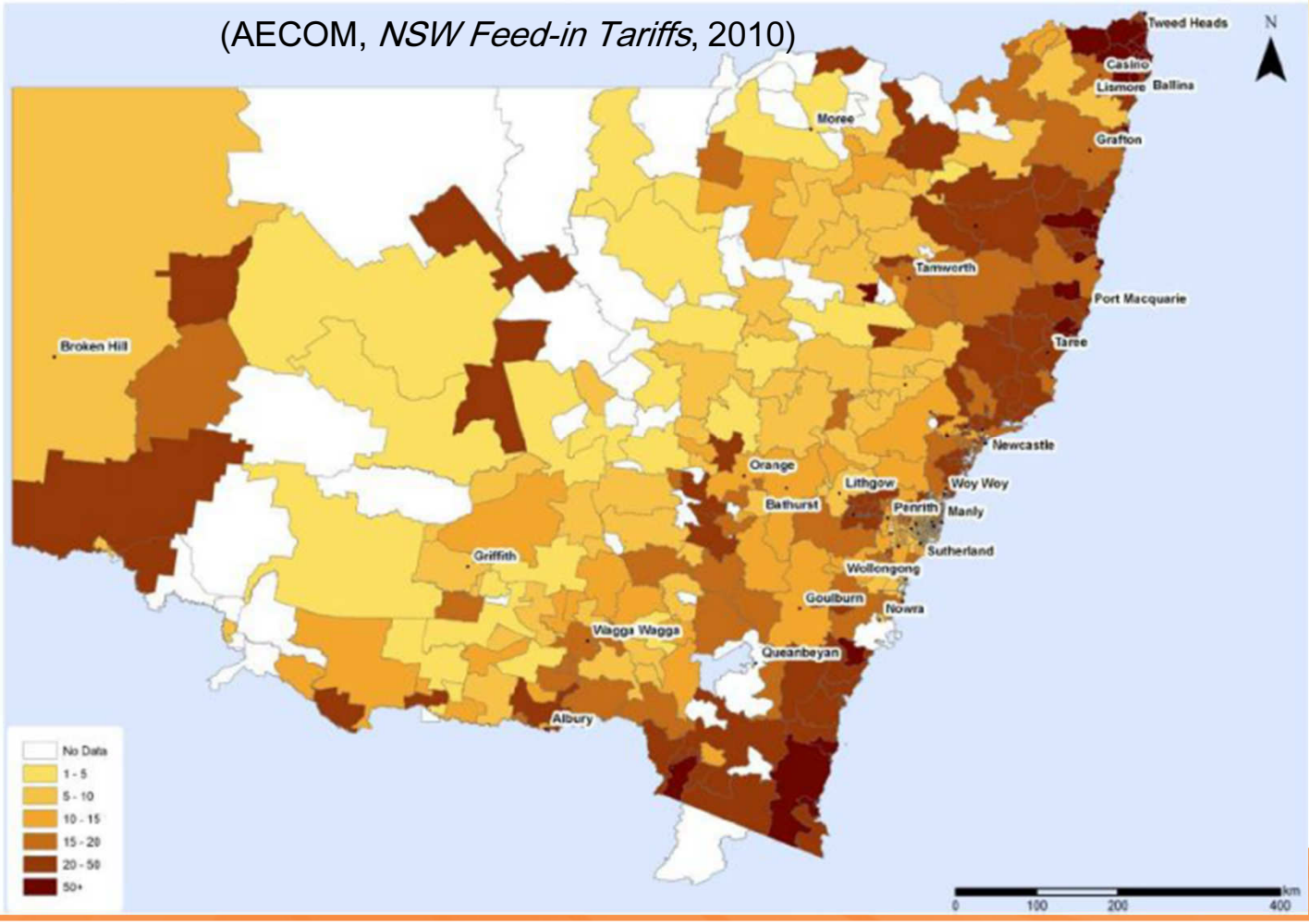


Some ‘high PV’ penetrations now emerging

Mini-grid systems with PV, some regions of Dx network now seeing signifcant PV penetrations – jurisdictional policy efforts, demographics, mkt strategies

Figure 5: Systems per 1,000 “suitable” dwellings by postcode, NSW (data as at end June 2010)

(AECOM, *NSW Feed-in Tariffs*, 2010)



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Some Dx NSPs particularly impacted

(AECOM, *NSW Feed-in Tariffs*, 2010)

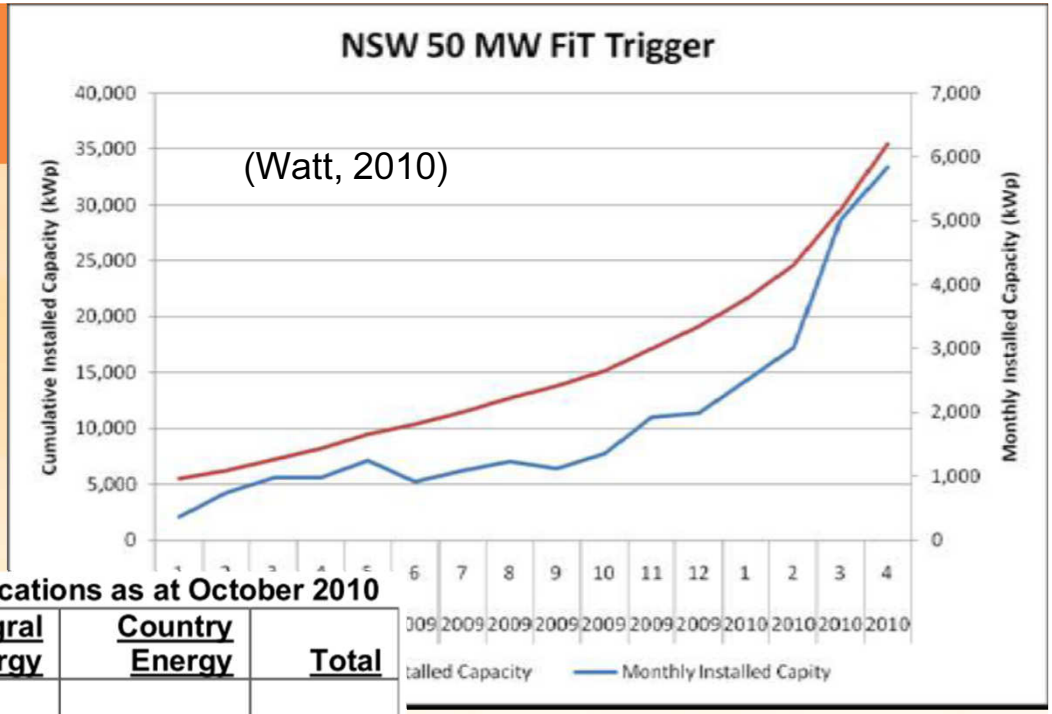
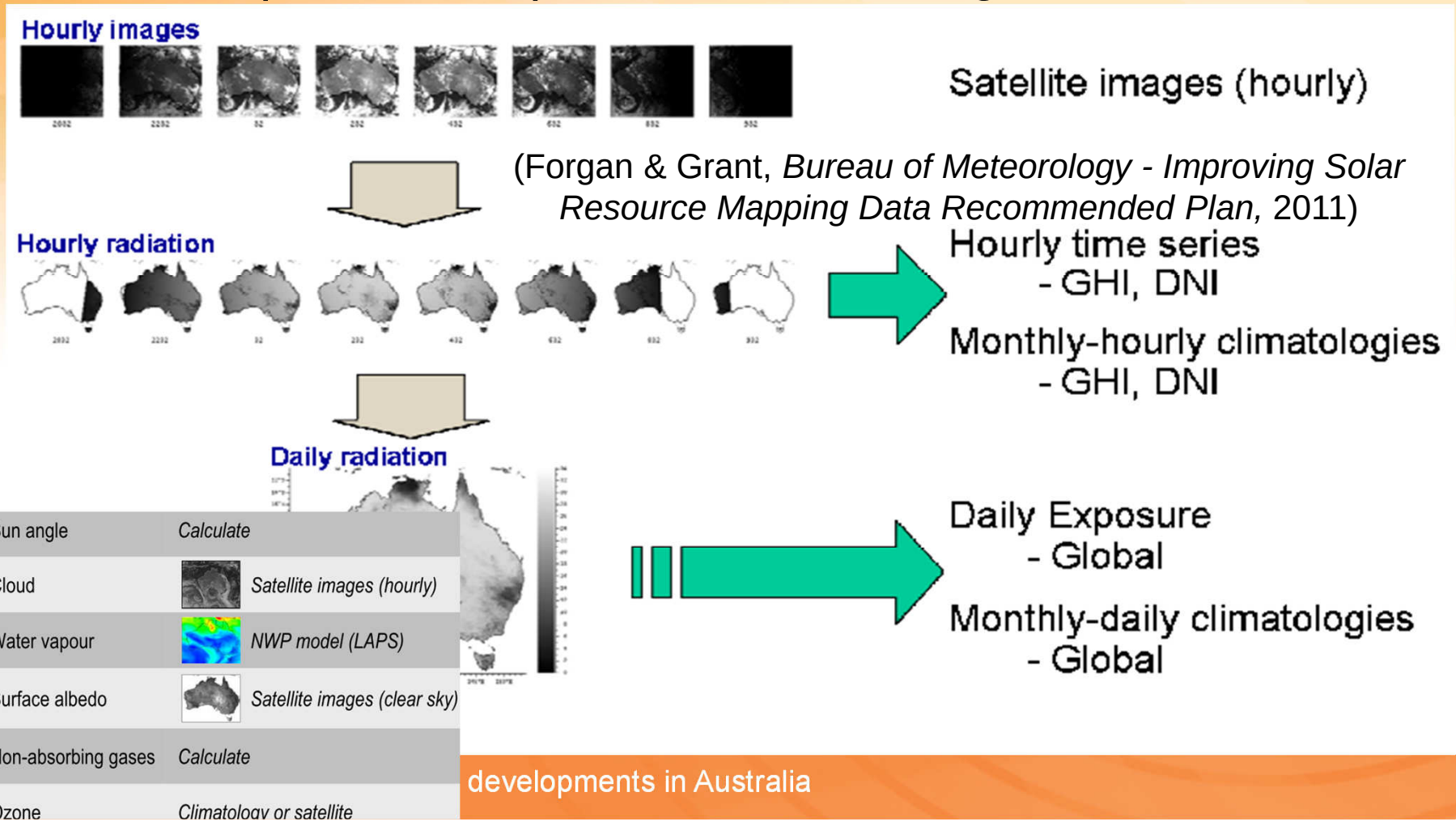


Table 1: NSW total connections, installed capacity and applications as at October 2010

Date/Network	Energy Australia	Integral Energy	Country Energy	Total
Prior 1 January 2010*				
Connections				
Number of Connections	6,554	3,346	5,179	15,079
Capacity (MW)	9.8	5.5	9.4	24.7
Average System Size	1.5	1.6	1.8	1.6
30 June 2010				
Connections				
Number of Connections	10,520	8,557	9,436	28,513
Capacity (MW)	16.5	15.9	20.0	52.3
Average System Size	1.6	1.9	2.1	1.8
Early October 2010				
Connections				
Number of Connections	17,456	15,388	17,448	50,292
Capacity (MW)	29.5	30.9	40.4	100.8
Average System Size	1.7	2.0	2.3	2.0
Applications (includes connections)**				
Number of applications	28,242	21,900	33,138	83,280
Capacity (MW)	53.2	47.0	92.7	193.0
Average System Size	1.9	2.1	2.8	2.3

Responses – Solar Resource Characterisation

- Very limited ground stations for DNI – developing satellite derived spatial + temporal estimates for generation simulation

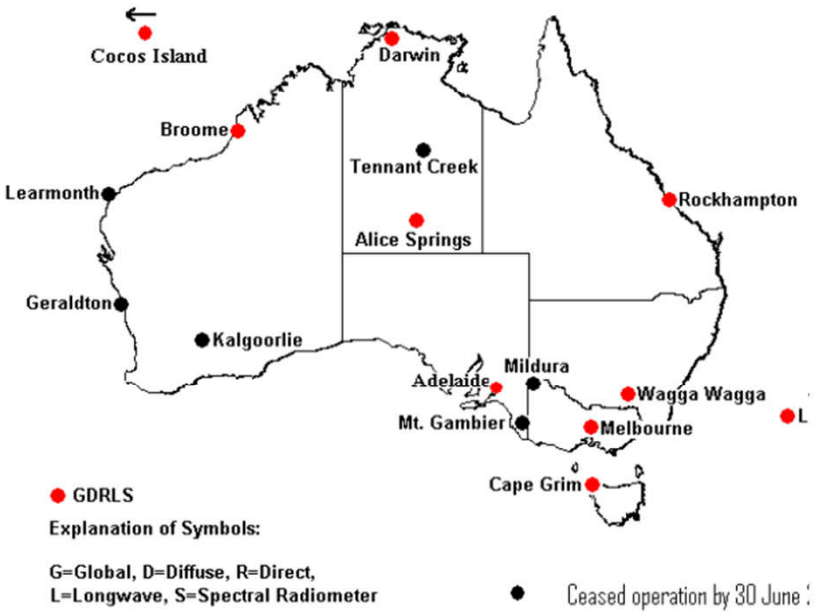


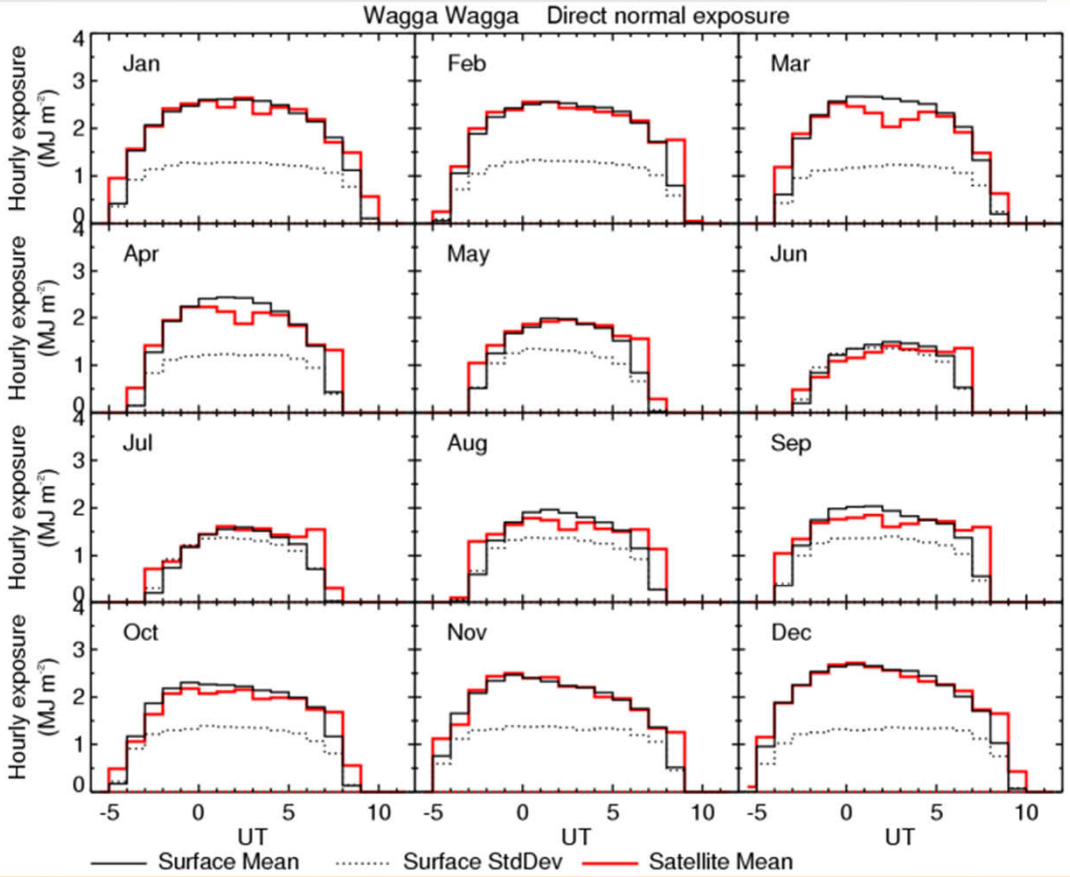
Responses – Solar Resource Characterisation

Work underway to increase ground station coverage + improve satellite estimates

(Forgan & Grant, *Bureau of Meteorology - Improving Solar Resource Mapping Data Recommended Plan,* 2011)

The Department of Resources, Energy and Tourism (RET) has tasked Geoscience Australia (GA) to develop an authoritative solar mapping resource to assist the solar community to make more informed decisions through the provision of pre-competitive solar resource prospectively data and analysis.





Some recent "high PV penetration" developments

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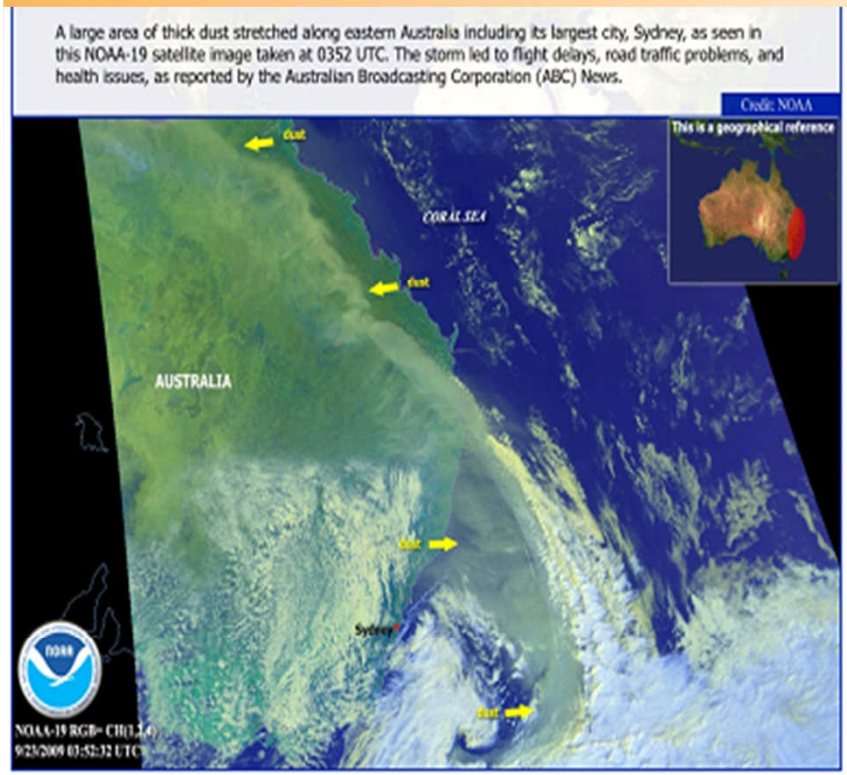
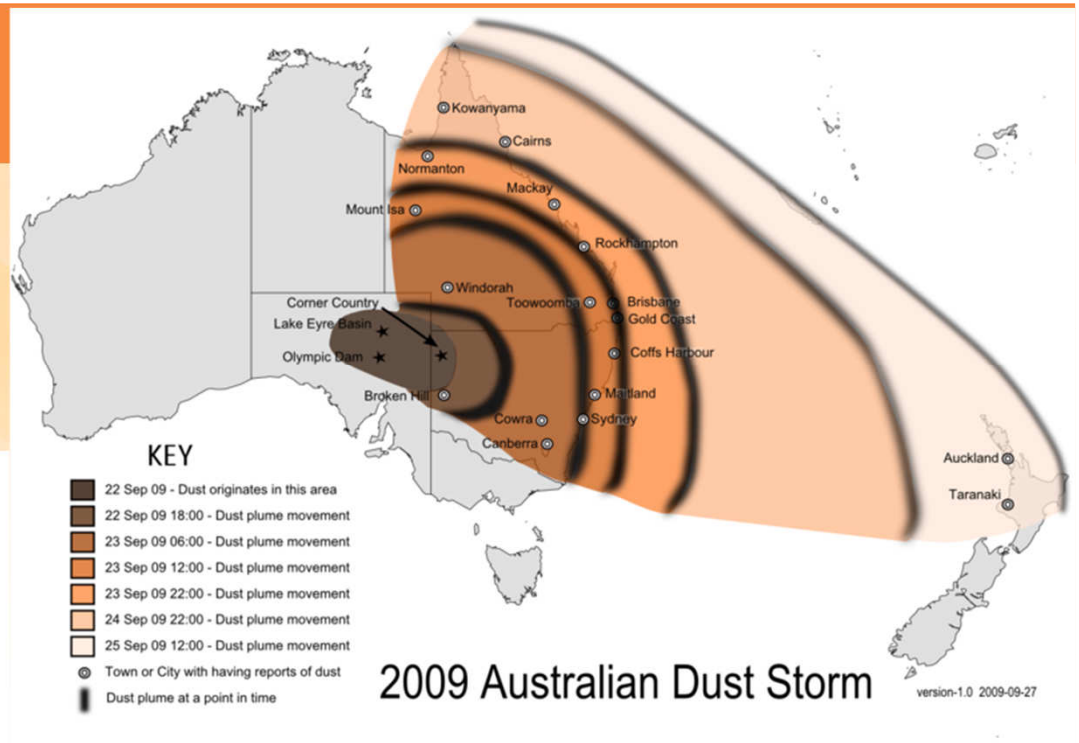
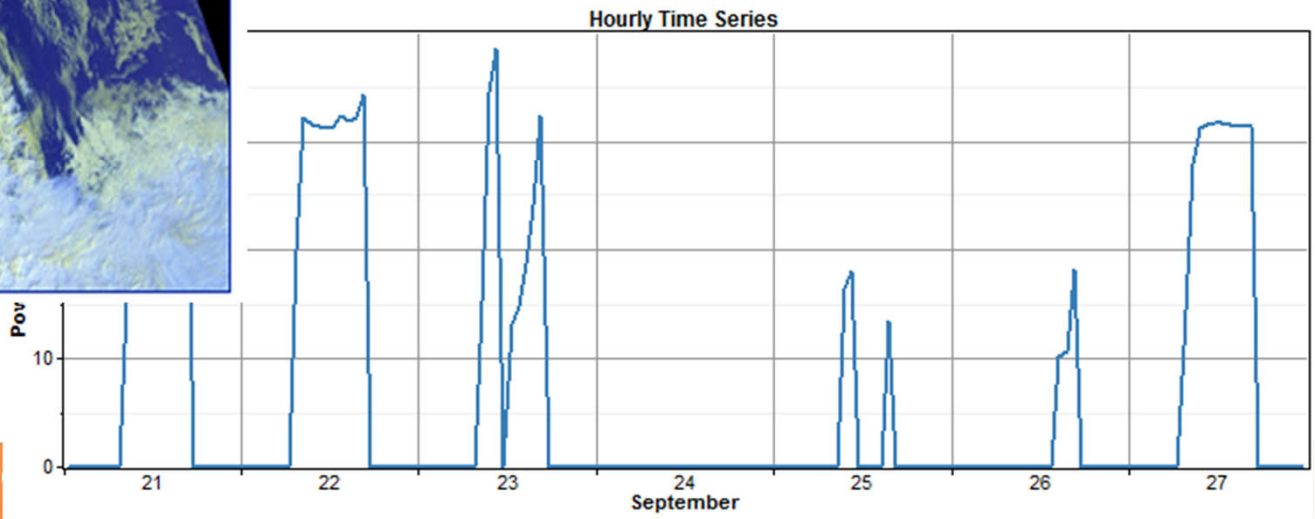
Operational simulations







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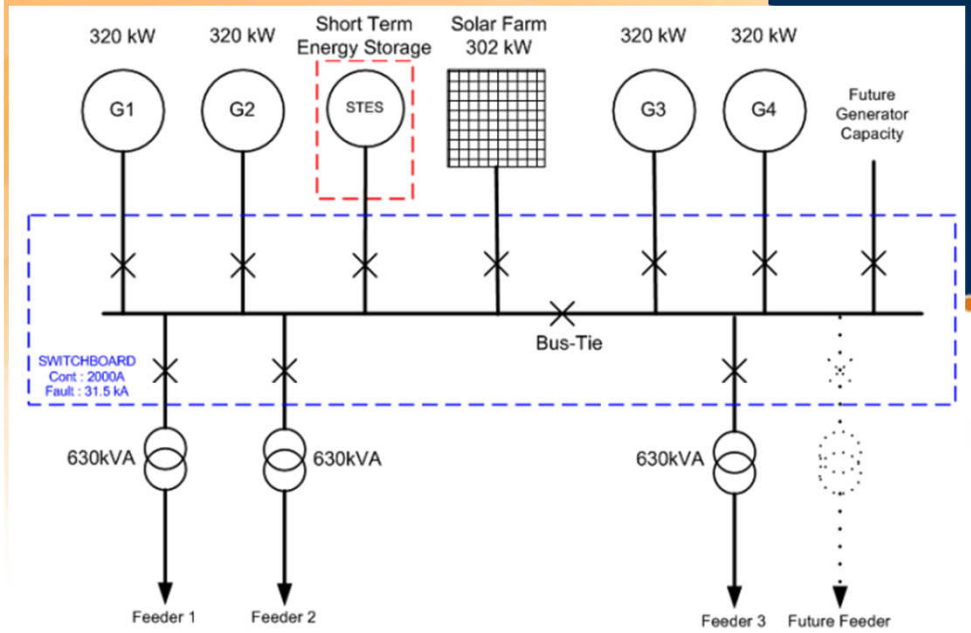
High PV mini-grids

(Darbyshire J., *Horizon Power Presentation to Aust. Energy Storage Academy*, Adelaide, 2011)



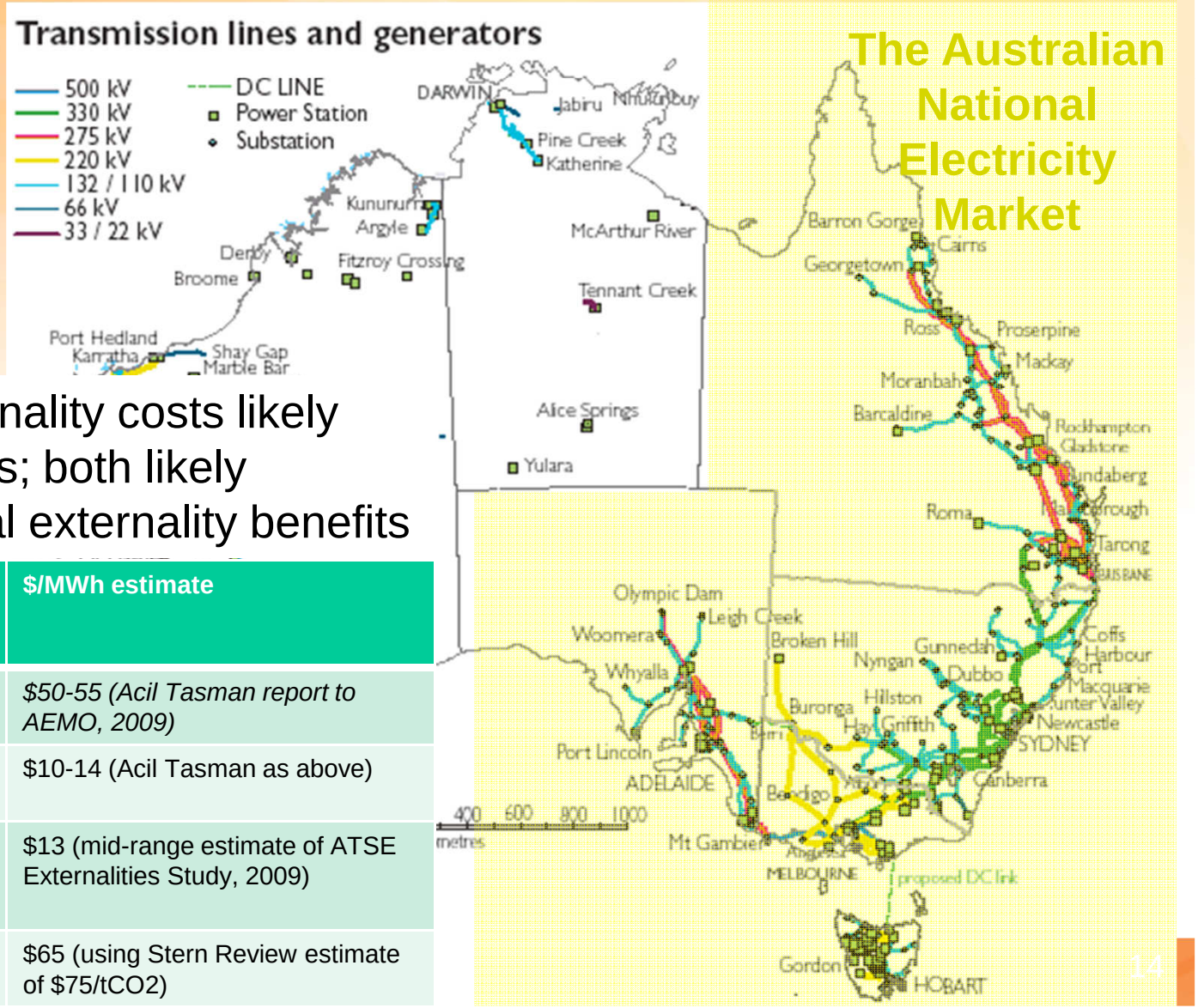
Marble Bar	
Diesel Generation	4 x 400 kW Detroit 60 engines
PV Modules	1350 x SunPower 225 (303.5 kW)
PV Mounting System	135 x T20 Single -Axis Tracker
PV Inverters	45 – SMC 7000HV
Short Term Energy Inverter	ABB PCS100 ESS
Short Term Energy Storage	Pillar Flywheel

Worlds first high penetration solar/diesel hybrid stations

- Largest single axis tracking arrays in Australia
- 80% day time load from solar energy
- 30% annual load from solar energy

Some recent 'high PV penetration' developments in A

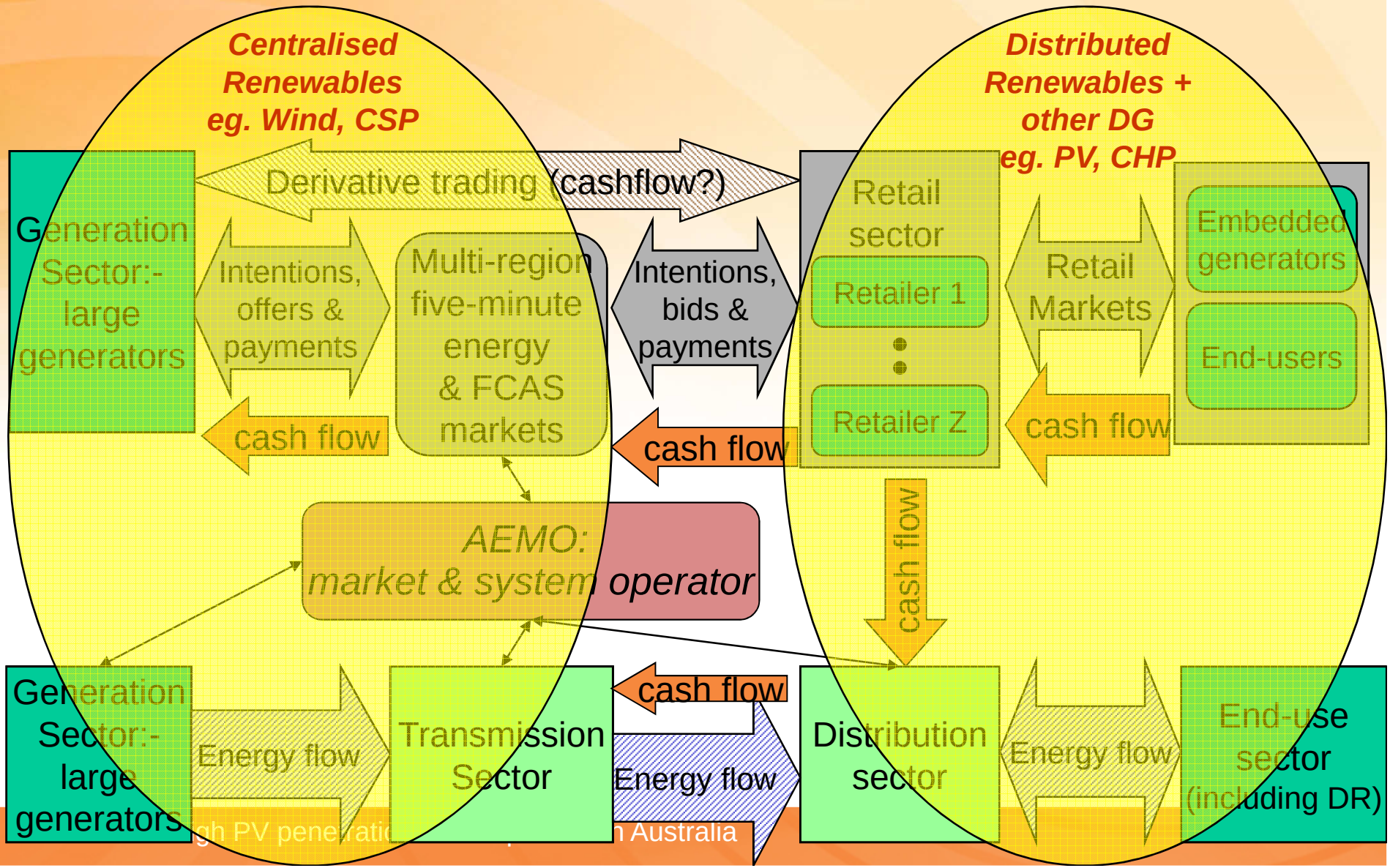
NEM: Aust's largest environmental (externalities) market



Environmental externality costs likely outweigh direct costs; both likely outweighed by social externality benefits

Coal-fired generation in NSW (2009-10) Note: supplying >90% of state electricity	$/MWh estimate
Direct Long Run Marginal Cost (new SC plant)	*$50-55 (Acil Tasman report to AEMO, 2009)*
Direct Short Run Marginal Cost (fuel, variable O&M)	$10-14 (Acil Tasman as above)
External Health damage costs (PM10, SOx, NOx)	$13 (mid-range estimate of ATSE Externalities Study, 2009)
External Climate Change damage cost	$65 (using Stern Review estimate of $75/tCO2)

Two 'worlds' for renewables and DE integration



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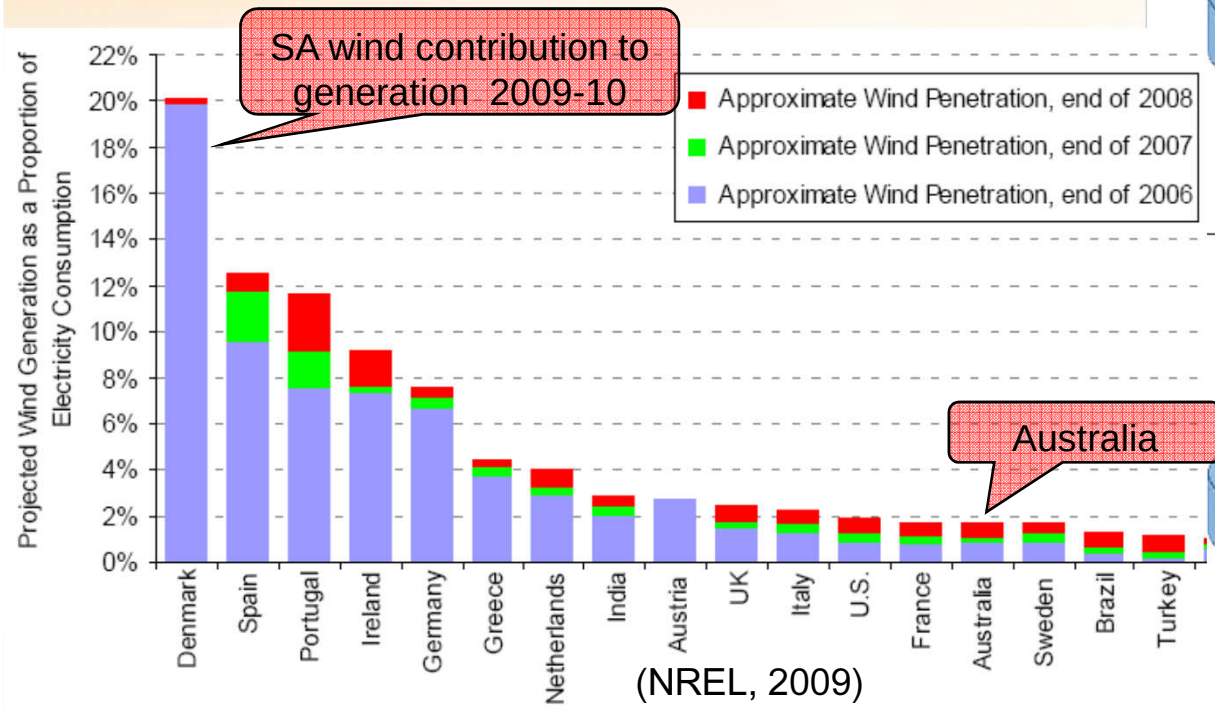
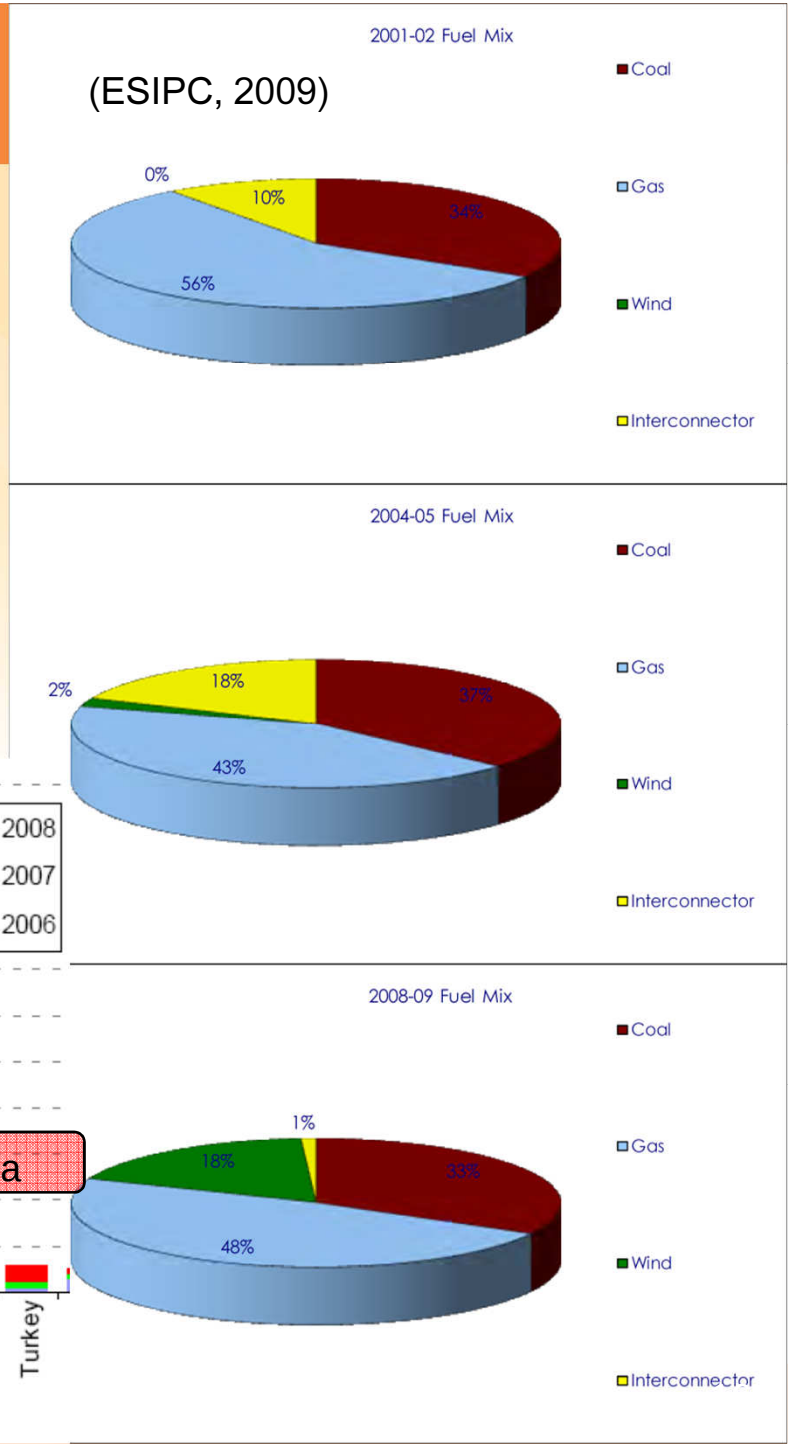
Wind in South Australia

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



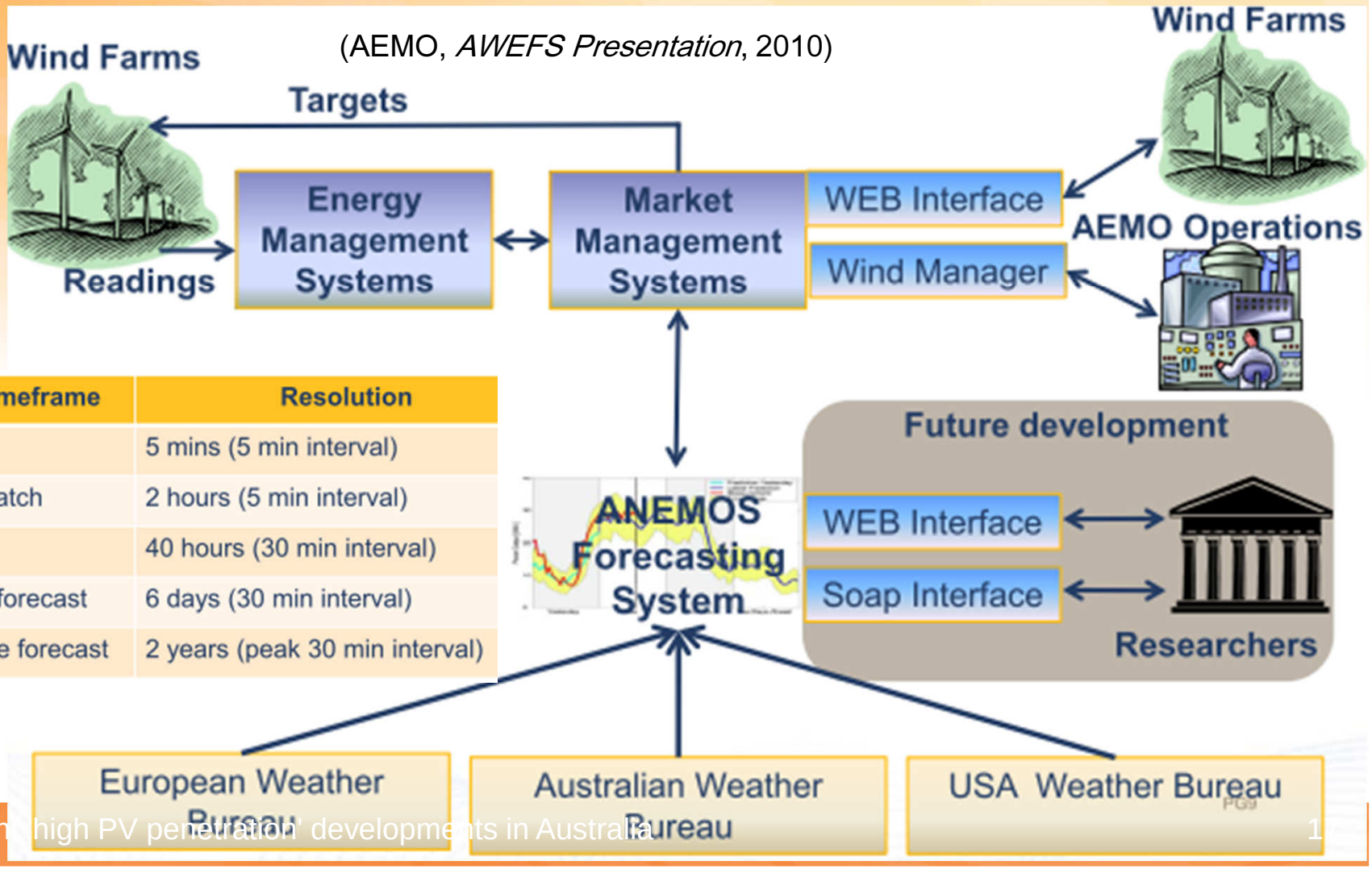
(NREL, 2009)



Renewable energy forecasting

- Centralised forecasting for Wind, solar under development

(AEMO, *AWEFS Presentation*, 2010)



Forecast timeframe	Resolution
Dispatch	5 mins (5 min interval)
5min Pre Dispatch	2 hours (5 min interval)
Pre Dispatch	40 hours (30 min interval)
6 day reserve forecast	6 days (30 min interval)
2 years reserve forecast	2 years (peak 30 min interval)

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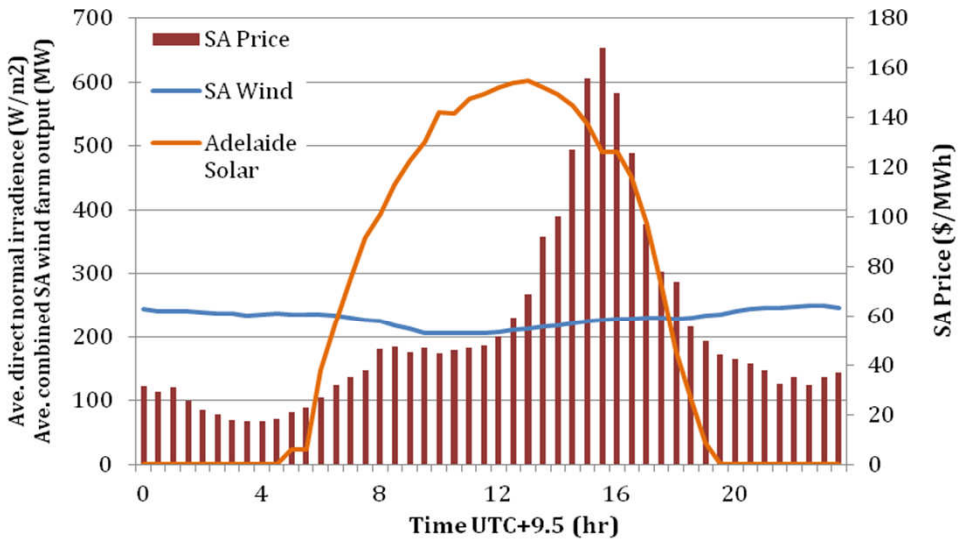
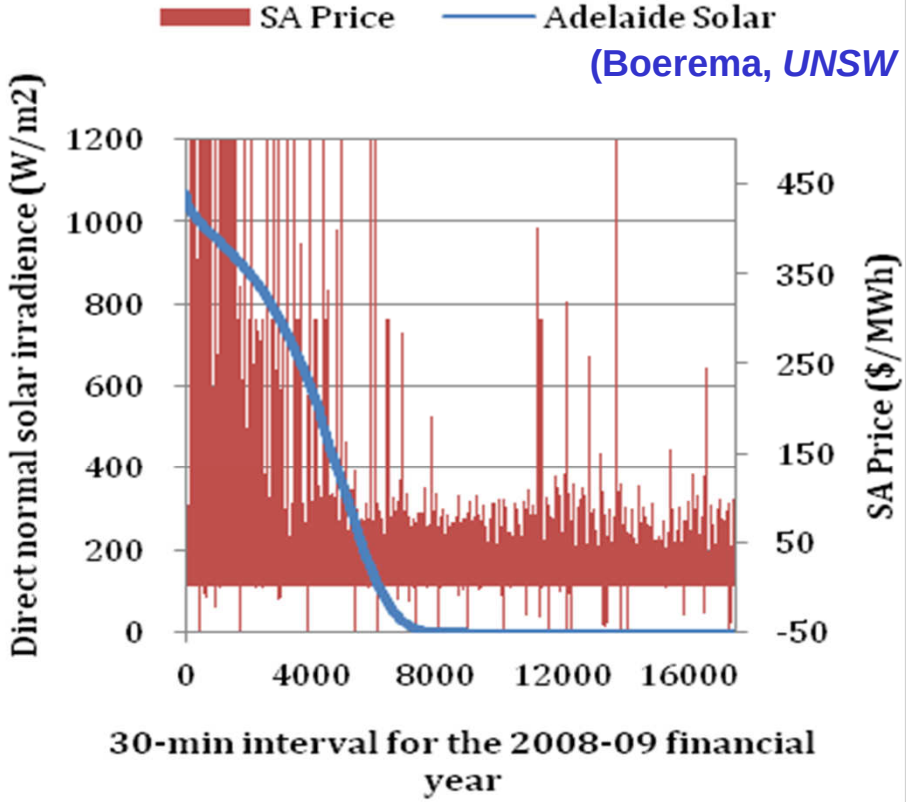
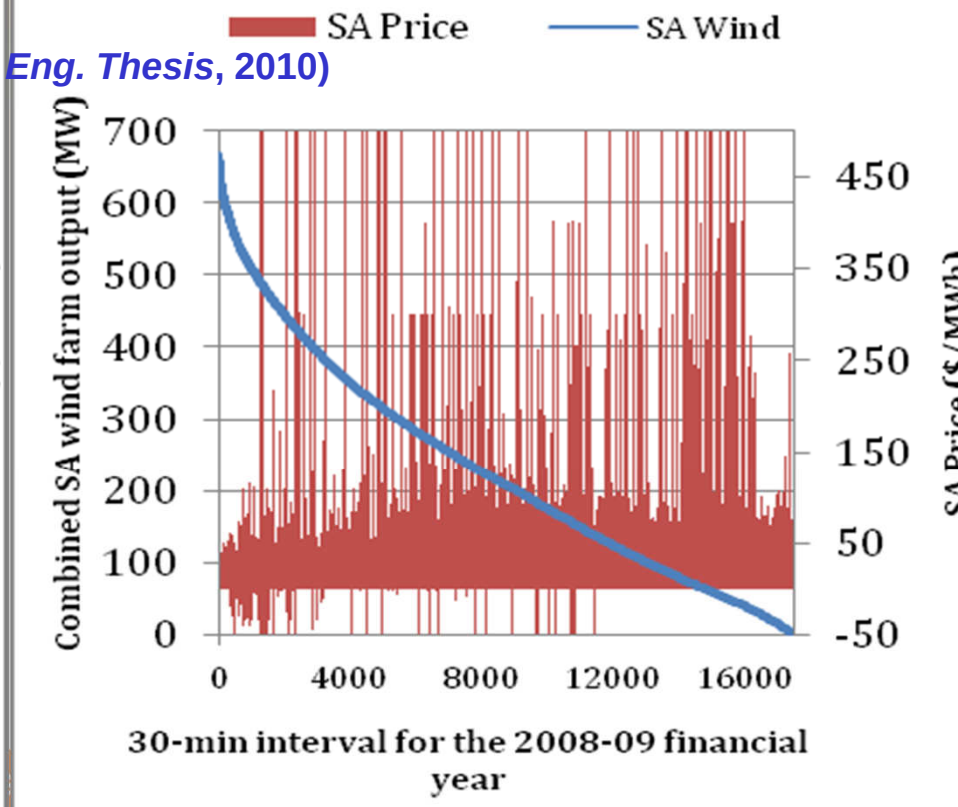
Renew gen. and price

- 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)



(Boerema, *UNSW Eng. Thesis*, 2010)

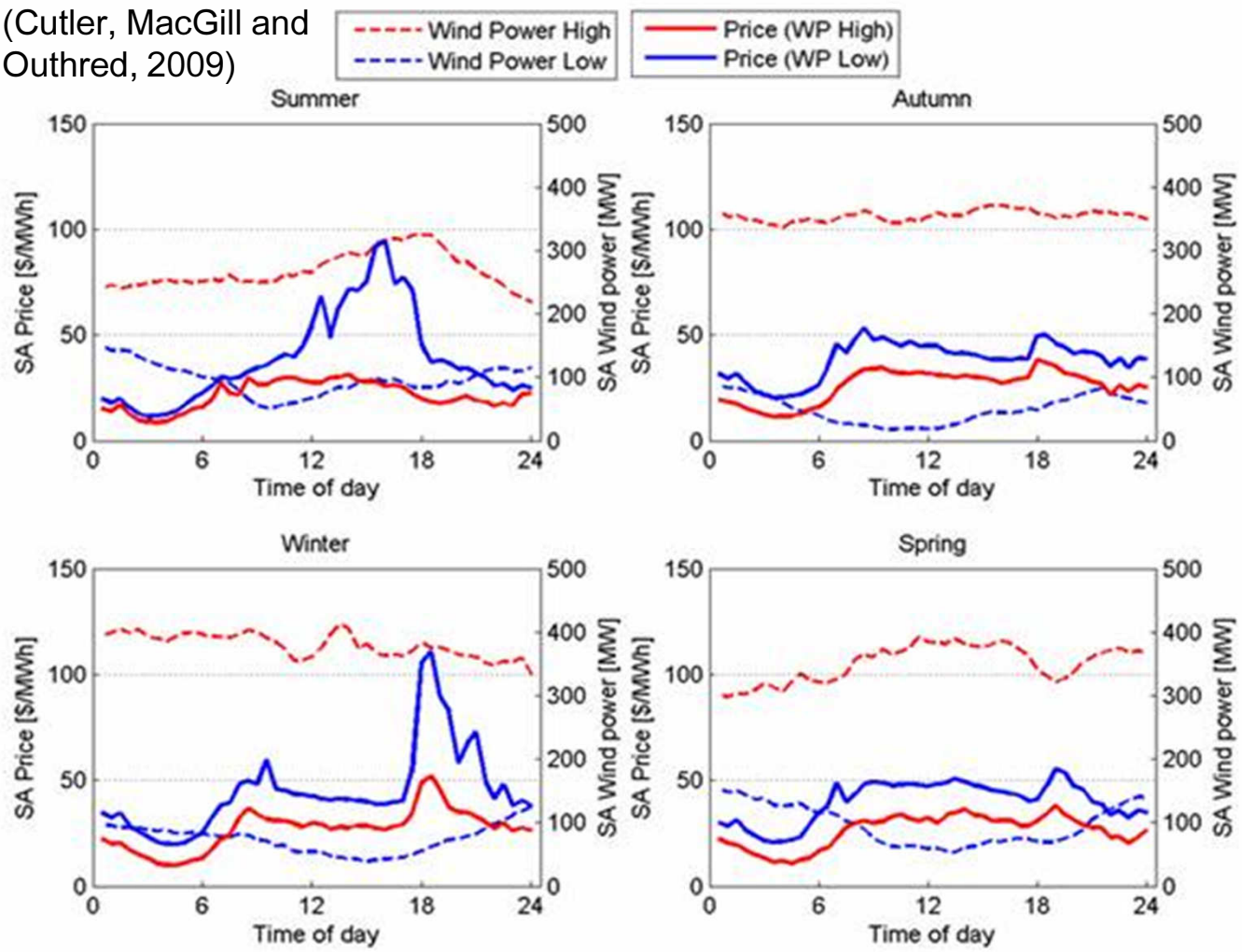




However, wind gen in SA now a price driver itself

- 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)



Wind's energy value

- Energy value of wind declines as penetrations increase
  - An 'efficient' market signal – generation without inherent energy storage has lower value than conventional generation with storable primary energy sources (coal, gas, hydro, diesel)
- Wind in SA currently being managed by conventional generation in SA (and NEM more widely)
  - Significant 'storage' competition in the wholesale space

Period (Cutler, et al, 2011)	All wind farms ($/MWh)	All other generators ($/MWh)
Financial year 2008-9	46.6	73.5
Financial year 2009-10	47.4	90.1

Tx investment

Options for Tx to support wind, solar and geothermal transfer to major load centres

New investment arrangements under development

SOUTH AUSTRALIAN INTERCONNECTOR FEASIBILITY STUDY

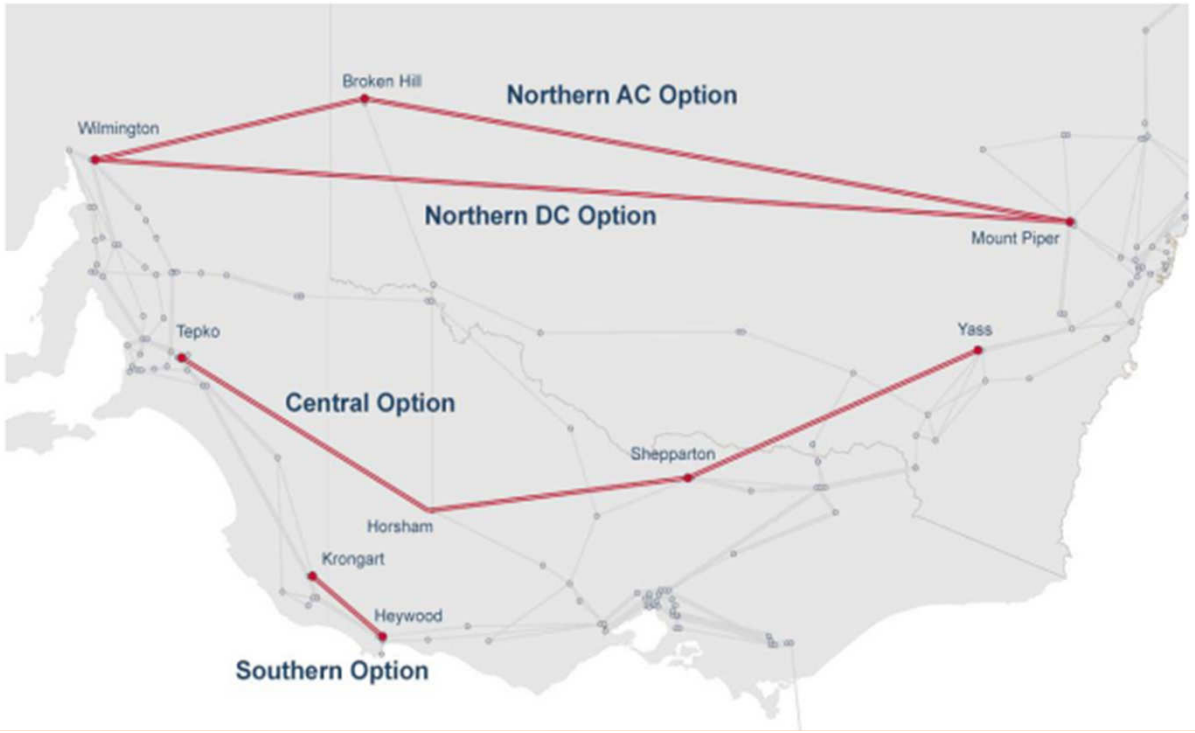
ElectraNet AEMO

Table 1 Interconnector augmentation options

Option	Description	Distance (km)	Cost estimate ($ million[2])
Incremental (Heywood)	Add a third 500/275 kV transformer at Heywood in Victoria plus associated minor works in South Australia, increasing the interconnector transfer limit to 650 MW[3]	N/A	38
Northern AC	Wilmington to Mount Piper 2000 MW 500 kV AC double circuit routed via Broken Hill	1,100	3,750
Northern DC	Wilmington to Mount Piper 2000 MW 500 kV HVDC bi-pole	1,100	3,000
Southern	Krongart to Heywood 2000 MW 500 kV AC double circuit	125	530
Central	Tepko to Yass 2000 MW 500 kV double circuit routed via Horsham and Shepparton	1,050	3,500

(AEMO, *SA Interconnector Feasibilty Study*, 2011)

Figure 1 New high-capacity augmentation options



Some recent 'high PV penetration'

High grid-connected Dx PV penetrations

- A range of potential case studies
  - Alice Springs Solar City *(case study near completed)*
    - Regional (50MW) grid with gas-fired generation
  - Townsville Solar City (Magnetic Island)
    - PV with major demand management initiative (network constraint)
  - Blacktown Solar City, Newington Olympic Village
    - Sydney region
  - High PV penetration diesel mini-grids
- Relatively low penetrations by some international comparisons, but particular contexts to investigate

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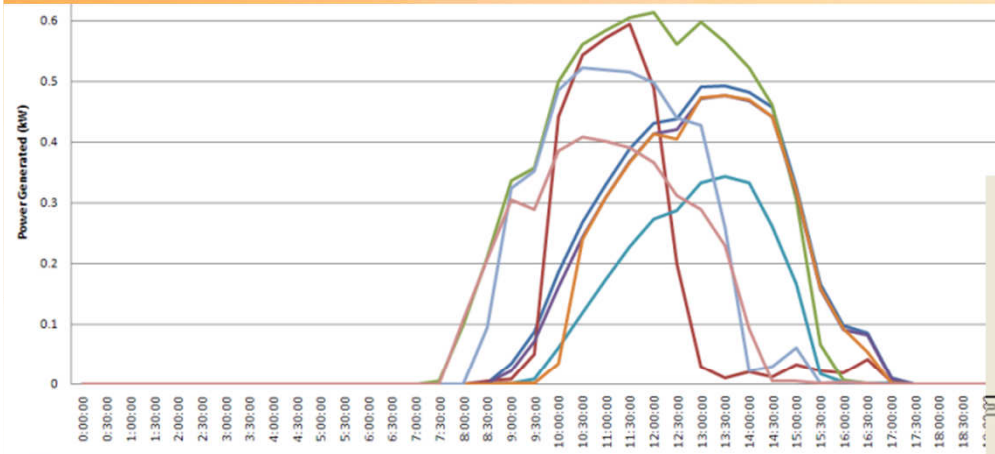
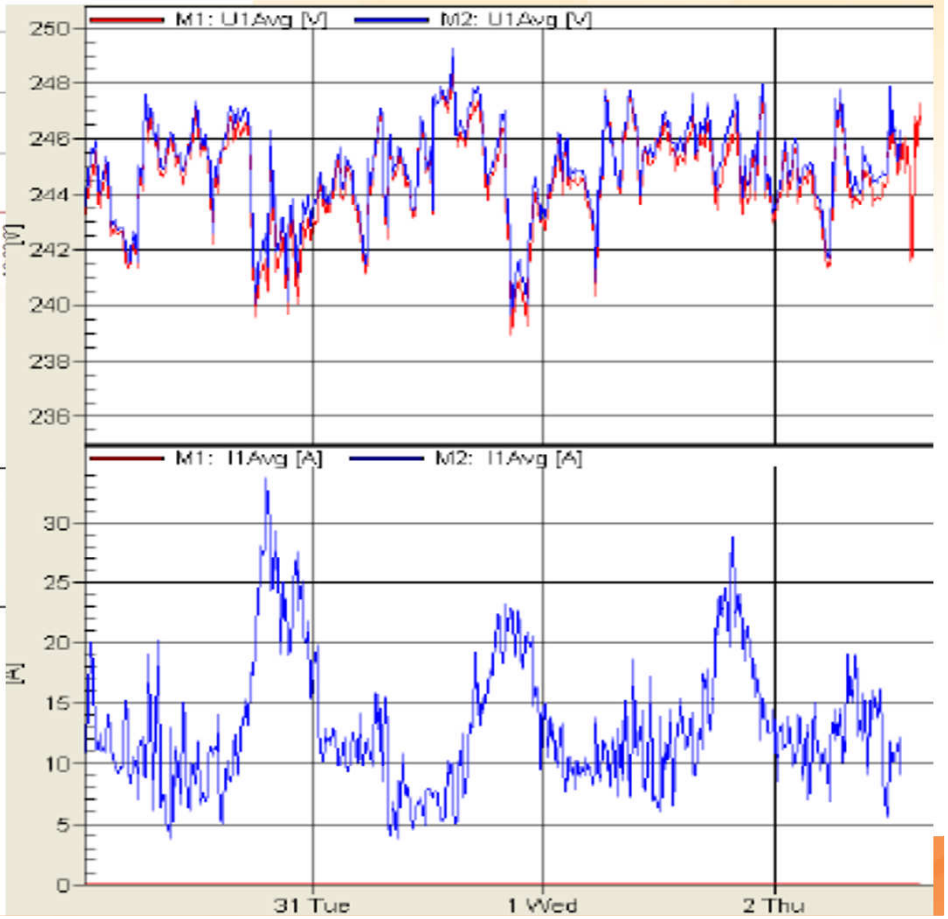
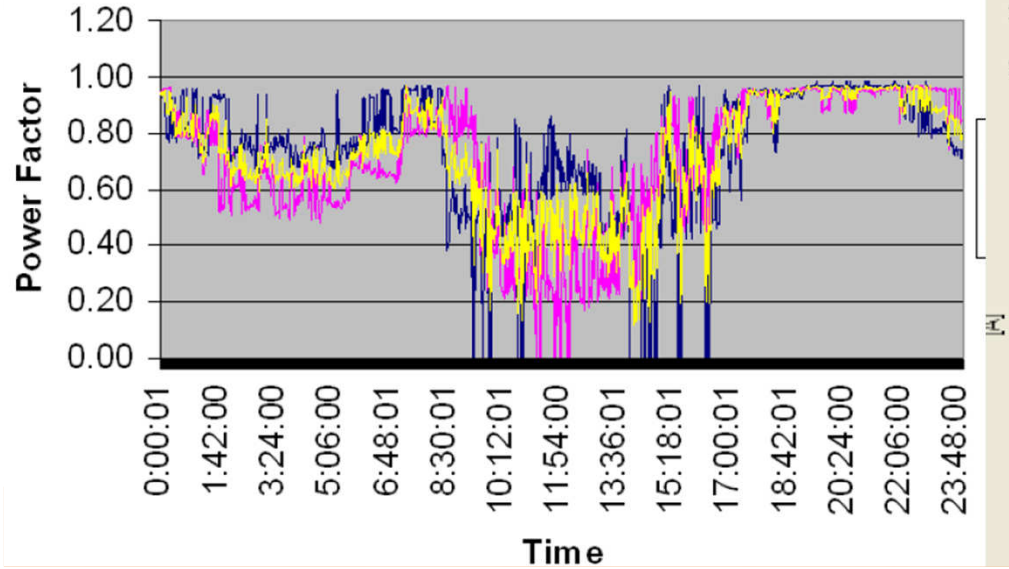
Dx PV Case studies

(Lewis, UNSW B.E. Thesis, 2010)







Conclusions

- PV penetrations growing significantly in Australia at present from a small base
- Arrangements for large-scale systems seem relatively sound
  - Relatively sound wholesale market design
  - Formal objectives of equal treatment… although difficult in practice
  - Renewable integration just one of a number of NEM challenges
  - A reasonable environment for integrating large-scale renewables –
  - Wider environmental, social + industry development value of RE needs to be recognised with effective ‘external’ policy support
- Arrangements for distributed renewables far less developed
  - Immature retail market design
  - inadequate technical interface
  - Limited institutional capacities for major deployment

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