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High renewable energy penetrations in the Australian National Electricity Market: key challenges and opportunities

Iain MacGill

Associate Professor, School of Electrical Engineering and Telecommunications
Joint Director (Engineering), CEEM

Electricity Markets with a High Share of Renewables

Joint ZAWT / CEEM Workshop

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The renewables integration challenge

- Maximise the contribution of our renewable energy options towards overall energy, environmental + social values

- For high penetrations, maximising energy value can get harder
  - *network connection* + *management*; match to existing assets, investment
  - *security*; particularly wrt possible large + unexpected swings in generation
  - *economic operation* + *investment*; implications for other generation of highly variable + somewhat unpredictable low-operating cost renewables

- Key electricity industry issues
  - How well do industry arrangements mesh underlying economic energy value with commercial signals to market participants?
  - *…and in particular, wrt new technology + participants*
  - Interactions with specific renewable policy support measures

Outline

- **Current industry status**; level of RE penetrations, mix of technologies, geographical spread
- **Current market status**; impacts of RE on market operation and regulatory frameworks to date
- **Emerging issues** – challenges for current market and regulatory arrangements
- **Market and wider efforts underway** to address these challenges

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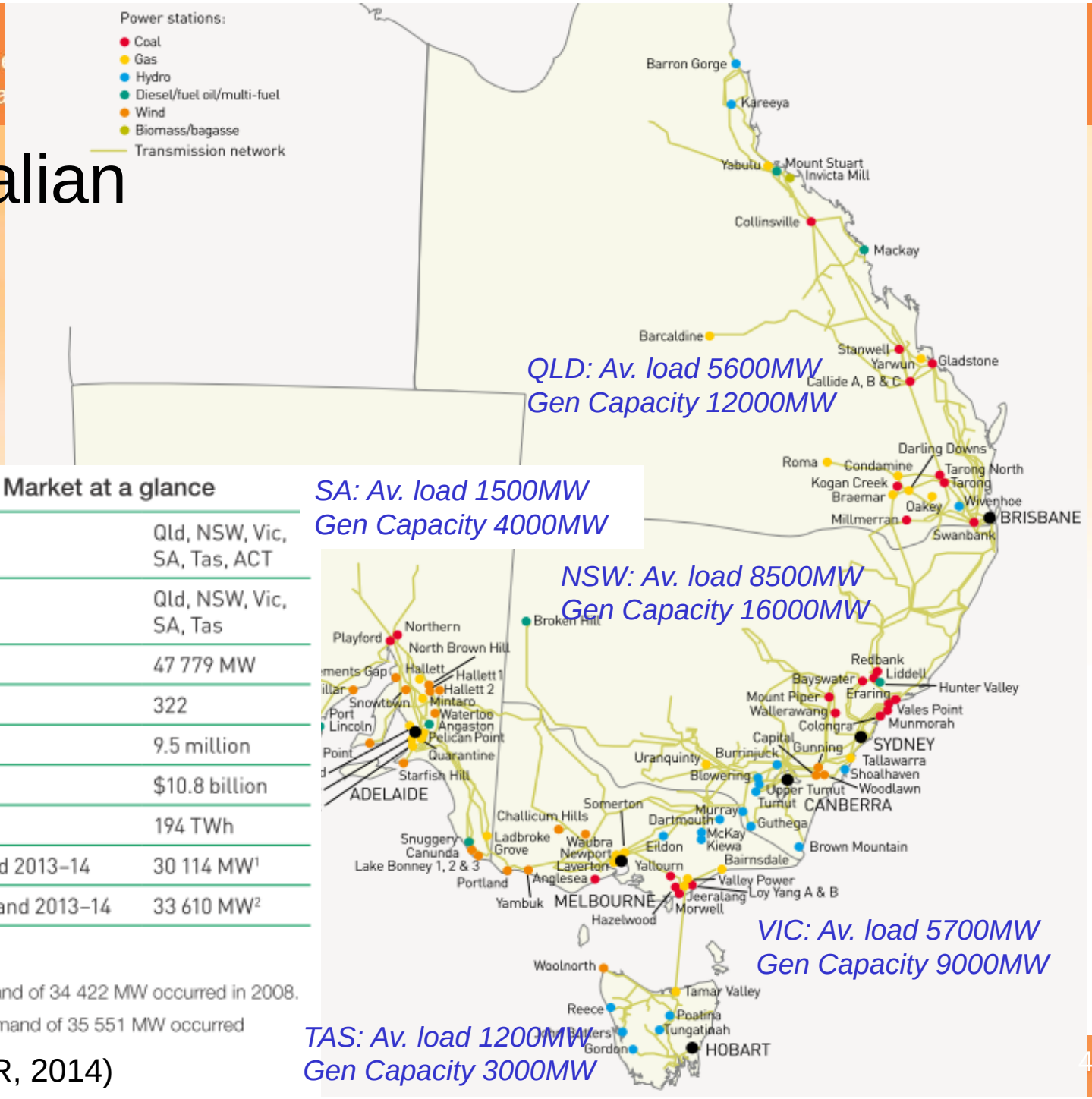
The Australian National Electricity Market



QLD: Av. load 5600MW
Gen Capacity 12000MW

SA: Av. load 1500MW
Gen Capacity 4000MW

NSW: Av. load 8500MW
Gen Capacity 16000MW

VIC: Av. load 5700MW
Gen Capacity 9000MW

TAS: Av. load 1200MW
Gen Capacity 3000MW

Table 1.1 National Electricity Market at a glance

Participating jurisdictions	Qld, NSW, Vic, SA, Tas, ACT
NEM regions	Qld, NSW, Vic, SA, Tas
Installed capacity	47 779 MW
Number of registered generators	322
Number of customers	9.5 million
NEM turnover 2013–14	$10.8 billion
Total energy generated 2013–14	194 TWh
National maximum winter demand 2013–14	30 114 MW[1]
National maximum summer demand 2013–14	33 610 MW[2]

MW, megawatts; TWh, terawatt hours.

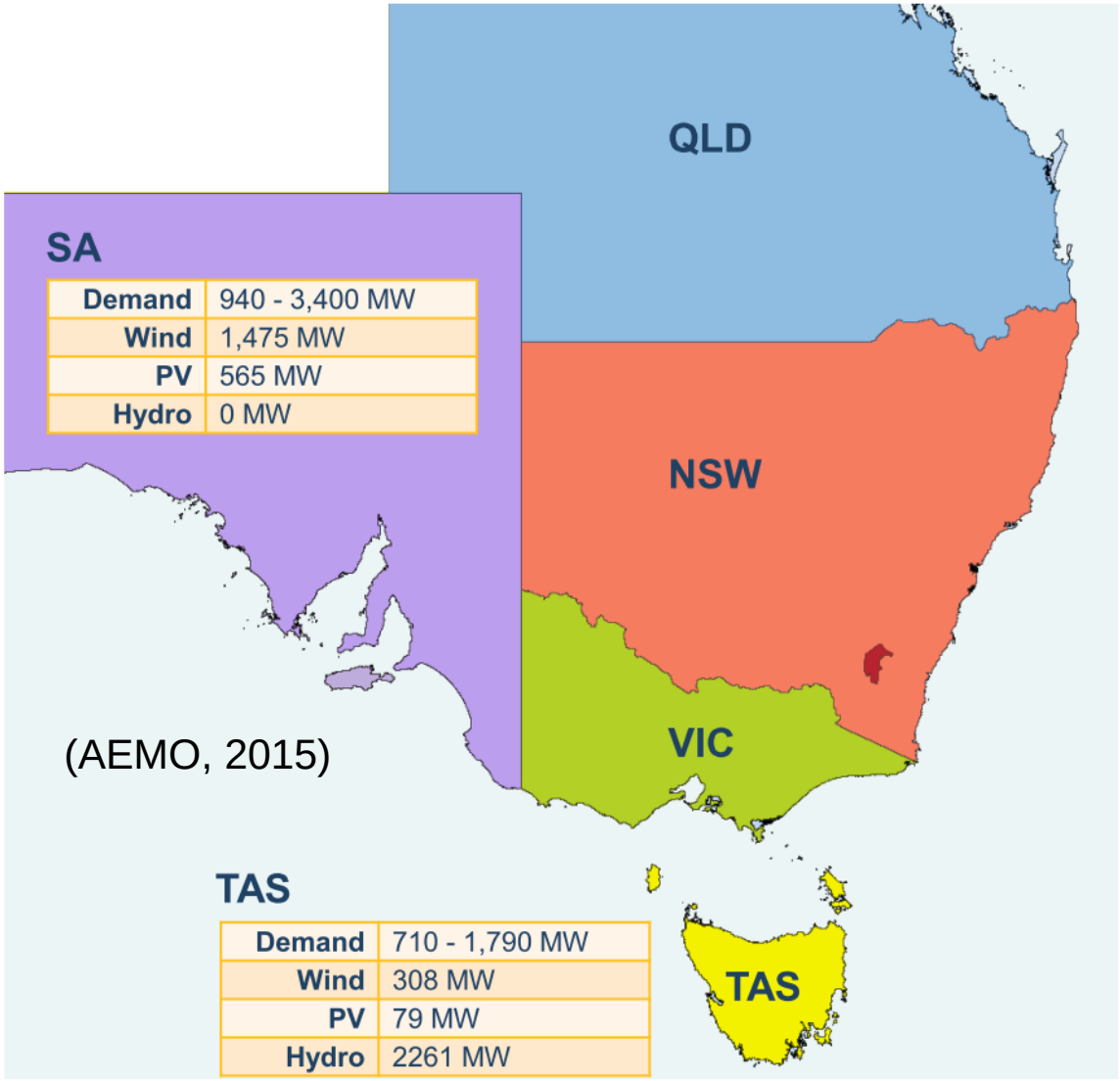
1 The maximum historical winter demand of 34 422 MW occurred in 2008.

2 The maximum historical summer demand of 35 551 MW occurred in 2009.

Sources: AEMO; AER.

(AER, 2014)

Current renewables deployment



(AEMO, 2015)

SA

Demand	940 - 3,400 MW
Wind	1,475 MW
PV	565 MW
Hydro	0 MW

TAS

Demand	710 - 1,790 MW
Wind	308 MW
PV	79 MW
Hydro	2261 MW

QLD

Demand	3,940 - 8,900 MW
Wind	0 MW
PV	1,250 MW
Hydro	652 MW

NSW

Demand	5,160 - 14,740 MW
Wind	649 MW
PV	851 MW
Hydro	2650 MW

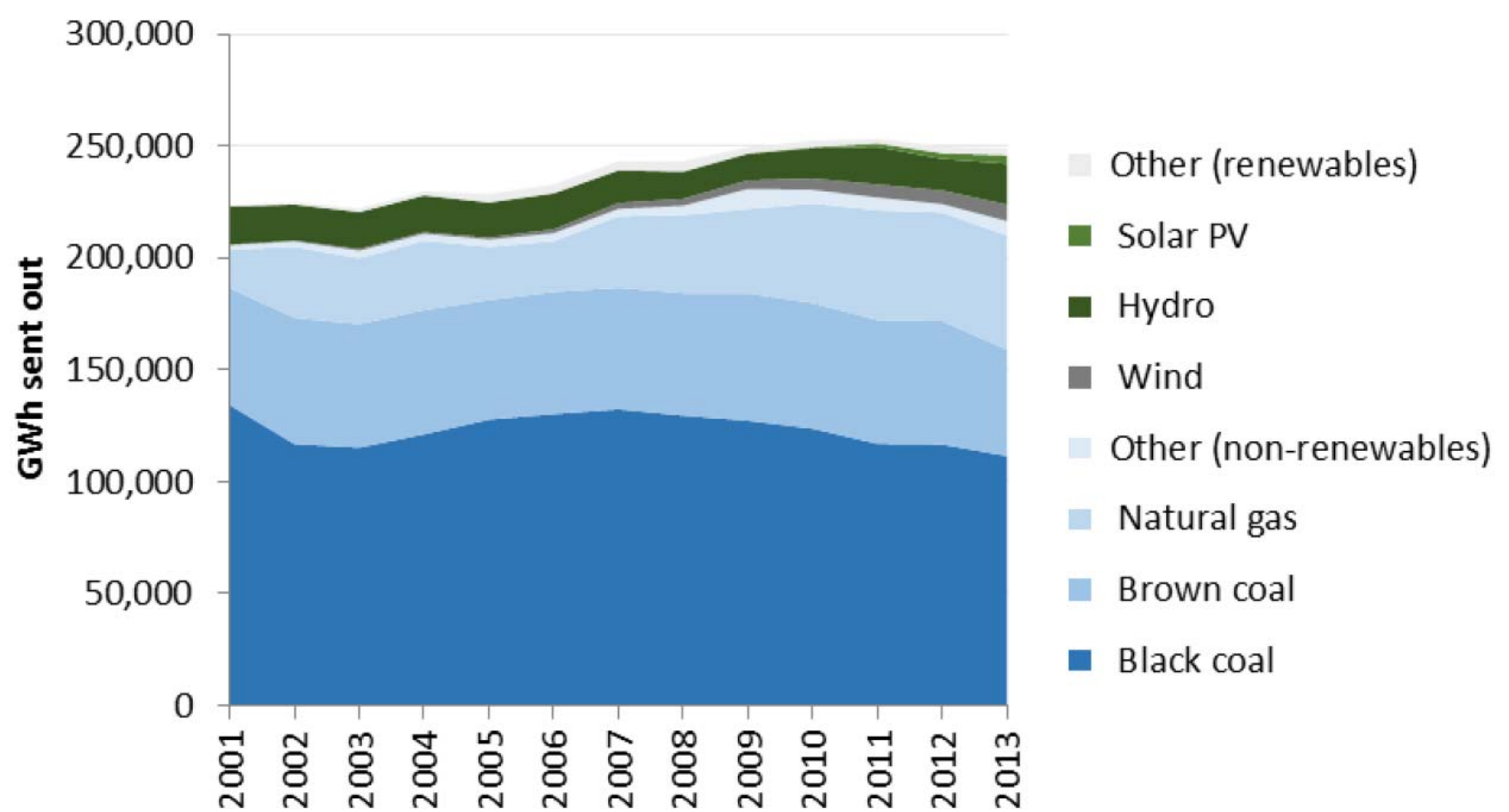
VIC

Demand	3,820 - 10,580 MW
Wind	1,168 MW
PV	693 MW
Hydro	2237 MW

NEM total

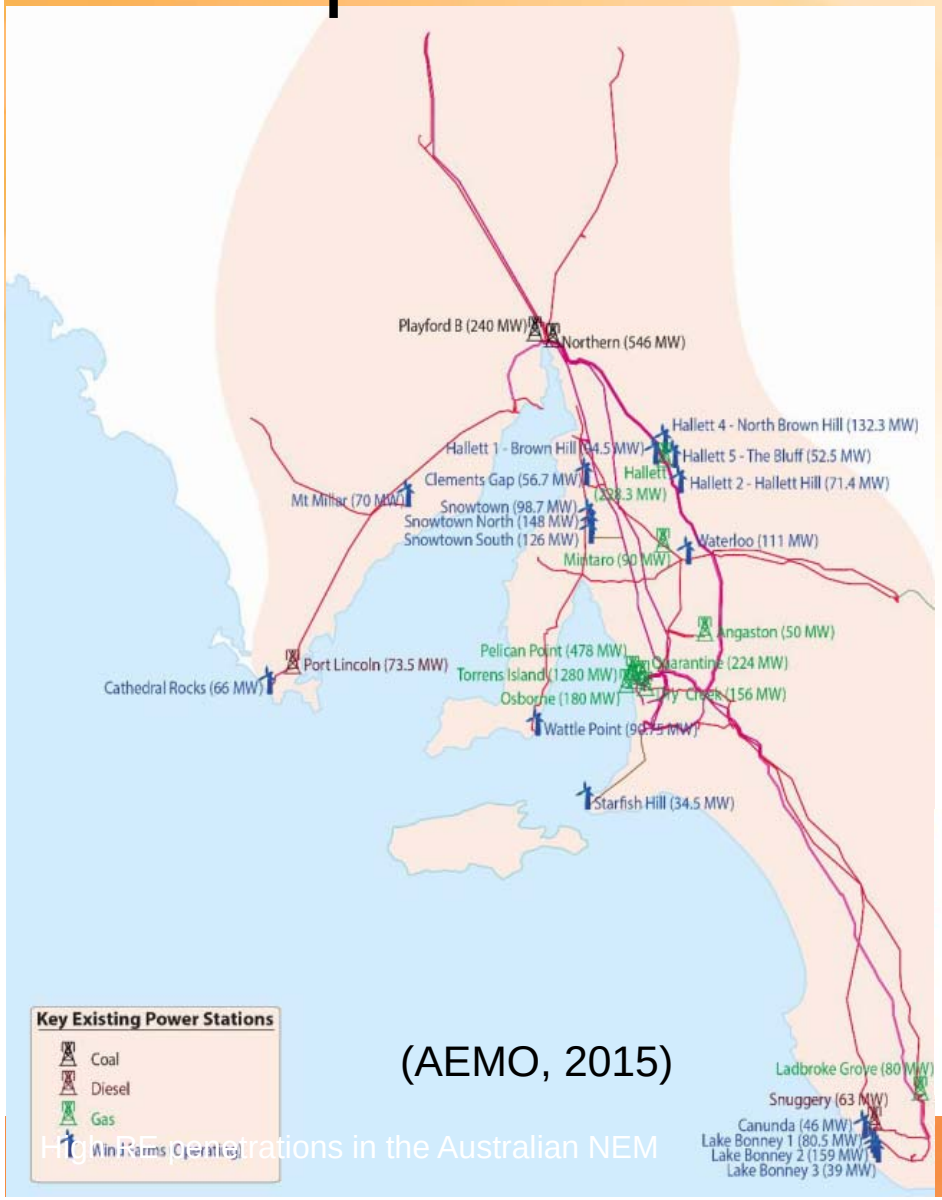
Demand	15 GW – 35 GW
Wind	3,600 MW
PV	3,438 MW
Hydro	7,800 MW

RE penetrations remain modest

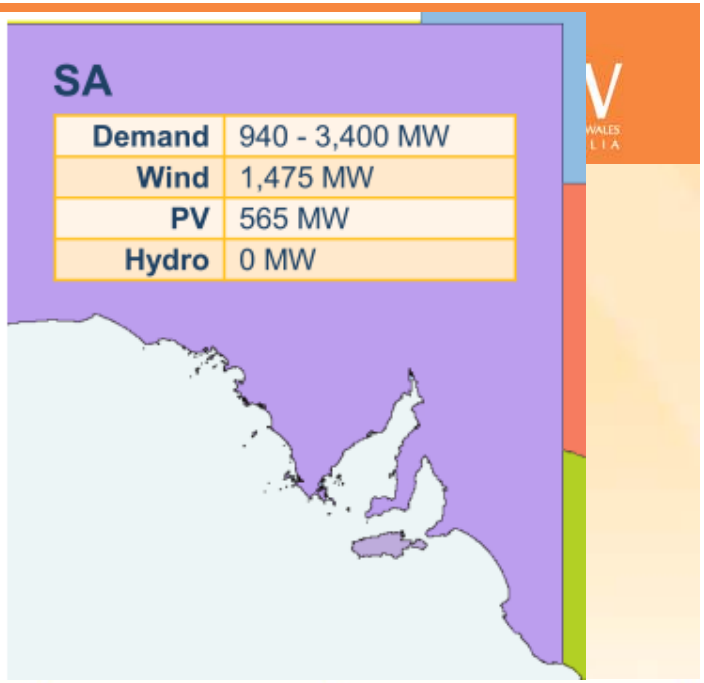


(CER, 2014)

…except in South Australia



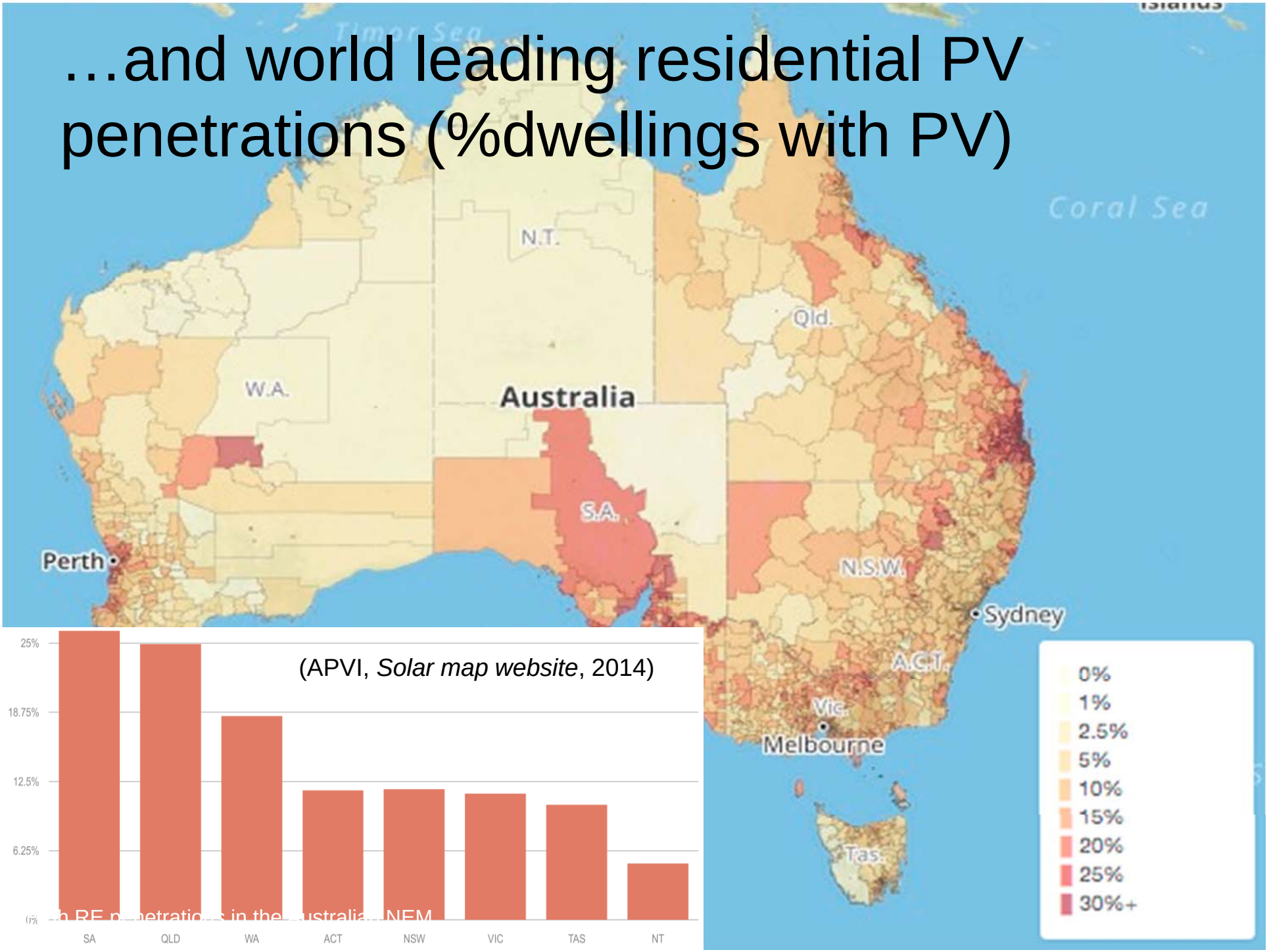
(AEMO, 2015)



Balancing Area	Annual energy from wind	Peak Instantaneous Wind
Ireland (all island)	16.3% (5.8 TWh)	50%
Texas	10.6% (36.1 TWh)	29 %
NEM	4.4% (8.5 TWh)	16 %
South Australia	31% (4.1 TWh)	> 100%

Balancing Area	Annual energy from PV (est.)	Peak Instantaneous PV (est.)
Hawaii (Oahu)	4.0% (0.29 TWh)	>15%
NEM	2.3% (4.6 TWh)	9 %
South Australia	5.6% (0.78 TWh)	> 30%

…and world leading residential PV penetrations (%dwellings with PV)



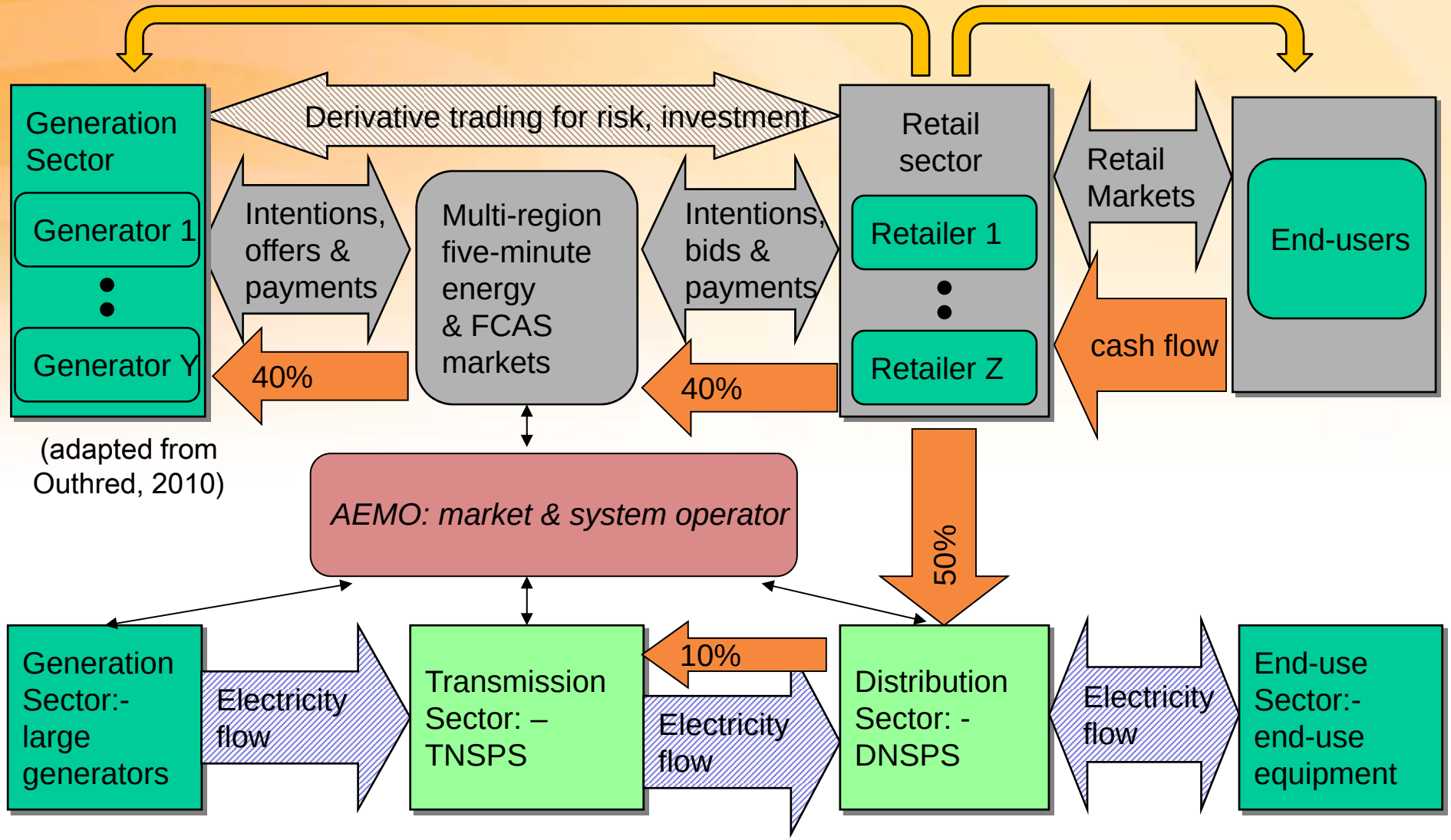
(APVI, *Solar map website*, 2014)

…h PE p…netratio…s in the …ustralia… NEM

Outline

- Current industry status
- **Current market status**; impacts of RE on market operation and regulatory frameworks to date
- Emerging issues – challenges for current market and regulatory arrangements
- Market and wider efforts underway to address these challenges

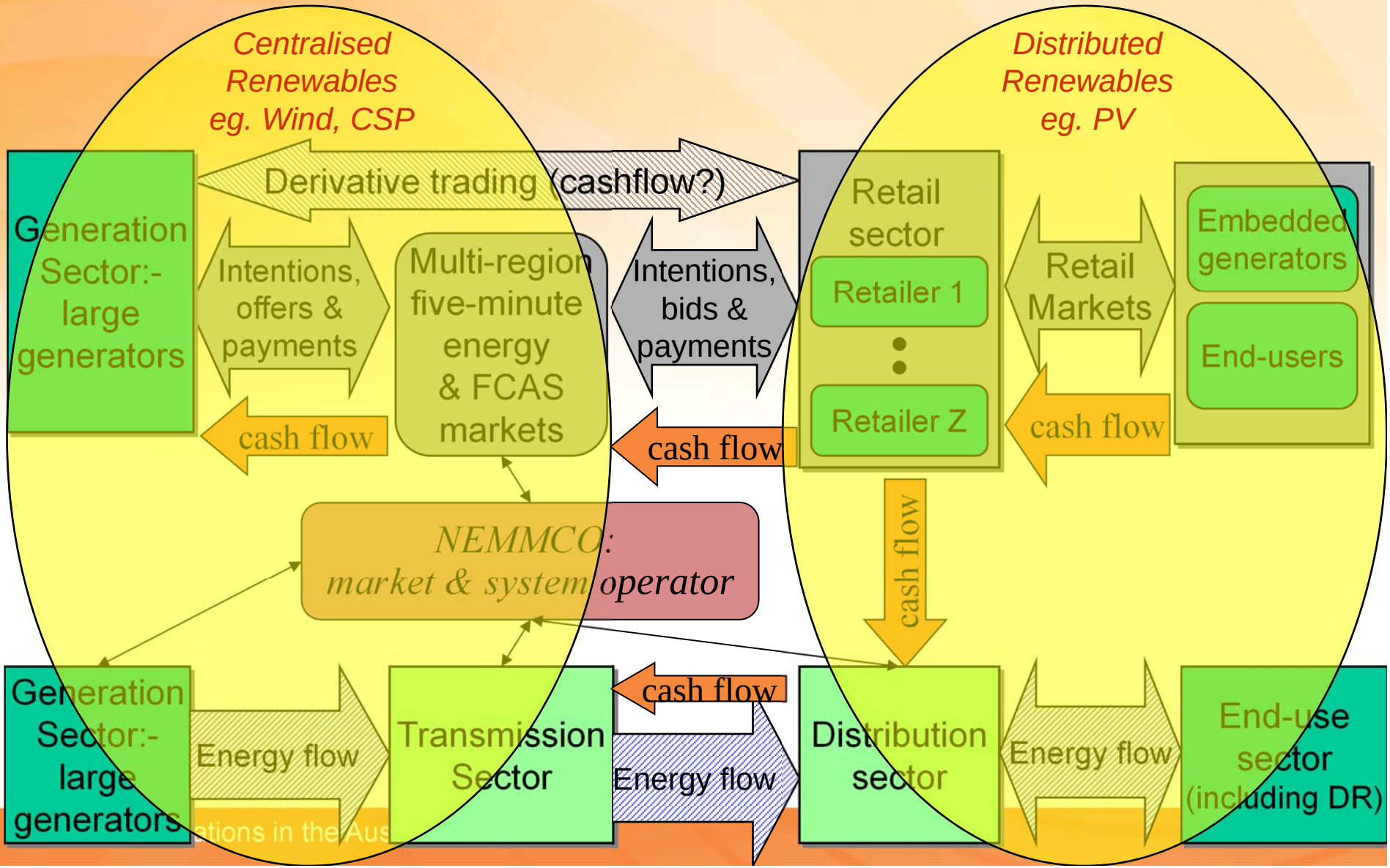
The Australian NEM – commercial regime



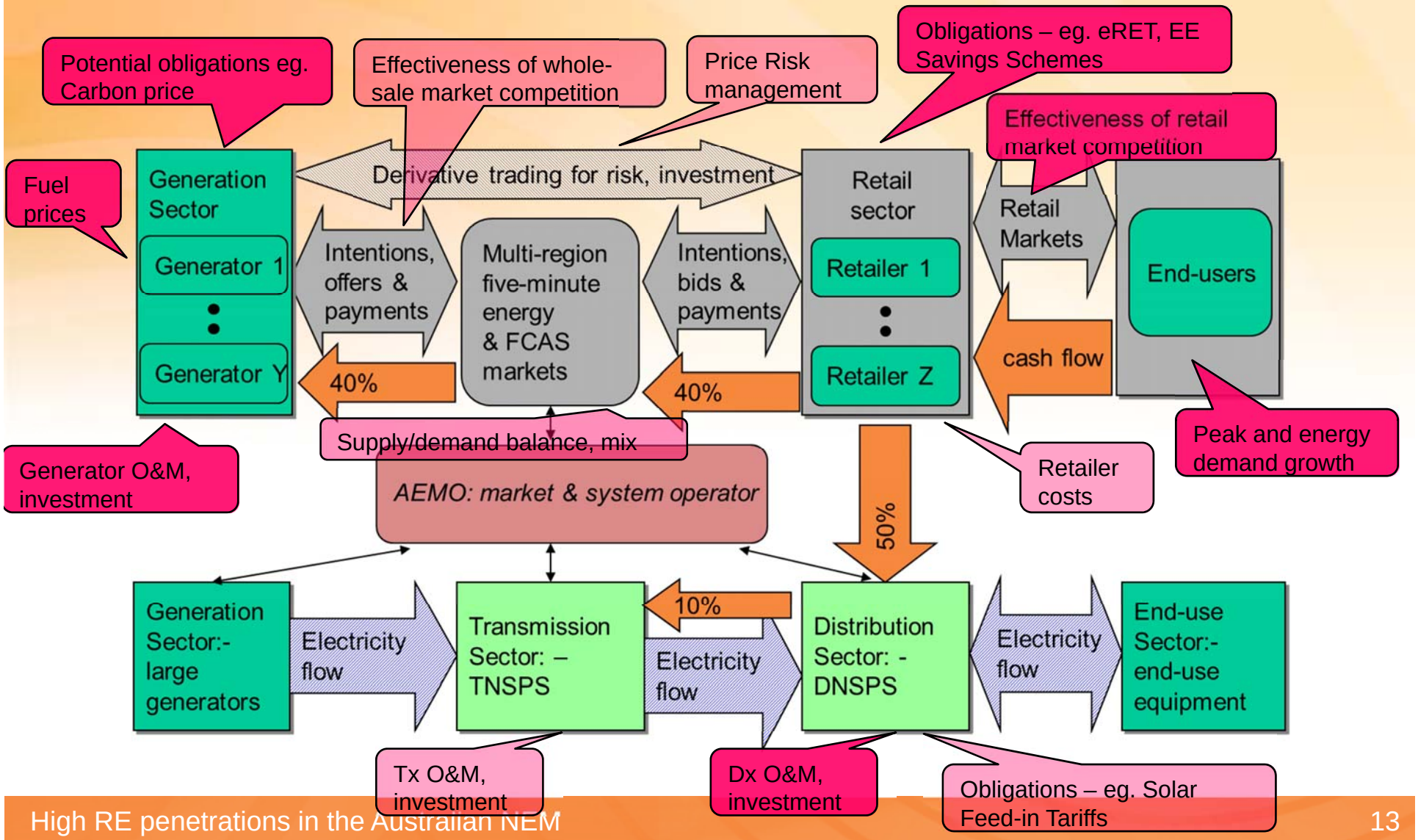
Features of National Electricity Rules (NER)

- NEM covers all participating states: operated by AEMO
  - A multi-region gross wholesale electricity spot market with dynamic intra-regional loss factors (separate prices for each region)
  - Generators bid price/quantity a day ahead, load 'bid' in at $12,500/MWh – hybrid 5/30 minute dispatch to max. benefits-costs
  - 8 FCAS markets for maintaining supply/demand balance over < 5min
  - No capacity market or equivalent; participants determine unit commitment through energy spot market bidding strategy
- Compulsory participants in NEM:
  - All dispatchable generators & links > 30 MW (unless intermittent)
  - Network service providers & retailers
- Networks
  - Regulated monopoly NSPs obliged to provide non-discriminatory access; technical connection standards, 'shallow' connection costs
- Outside formal NEM rules + arrangements…
  - Range of derivative markets to manage risk + underpin investment
  - Other key markets – coal, gas, **Renewable Energy Target, CPRS?**

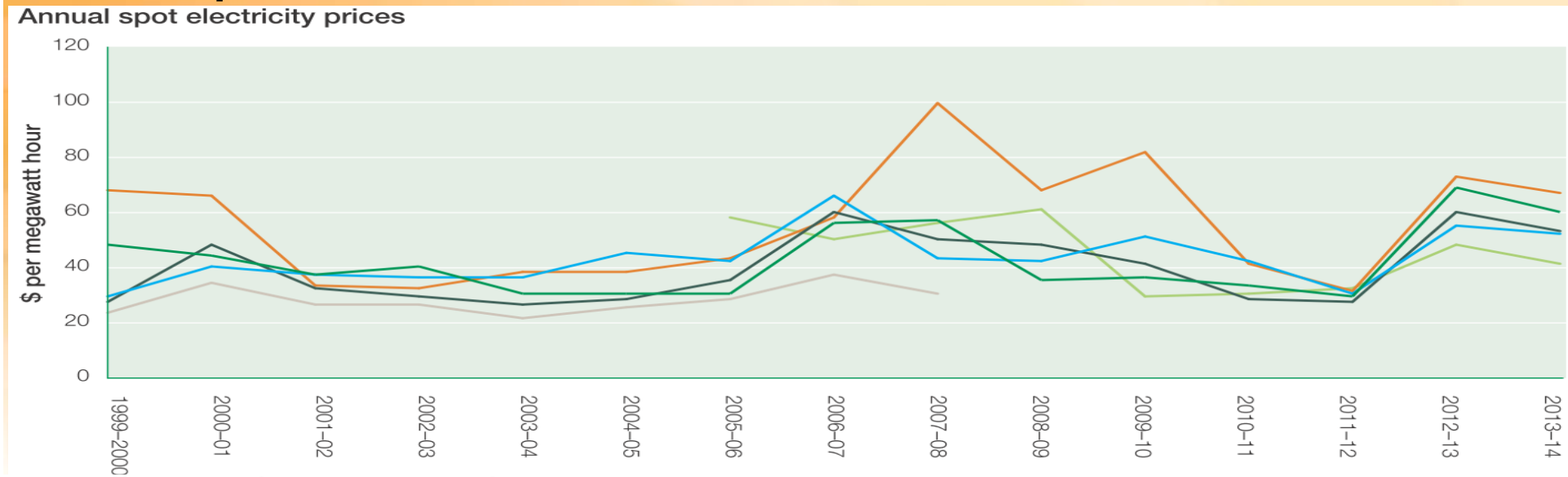
Two 'worlds' for renewables integration in NEM

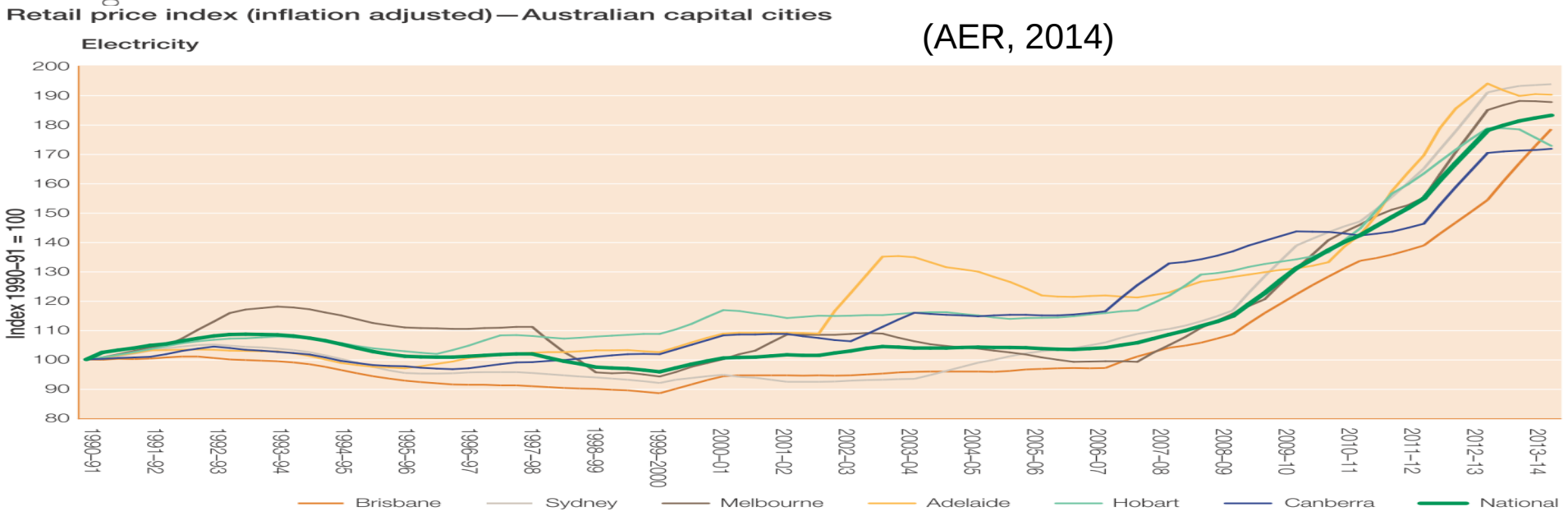


.. many drivers of cost, price outcomes



NEM prices – wholesale and retail





(AER, 2014)

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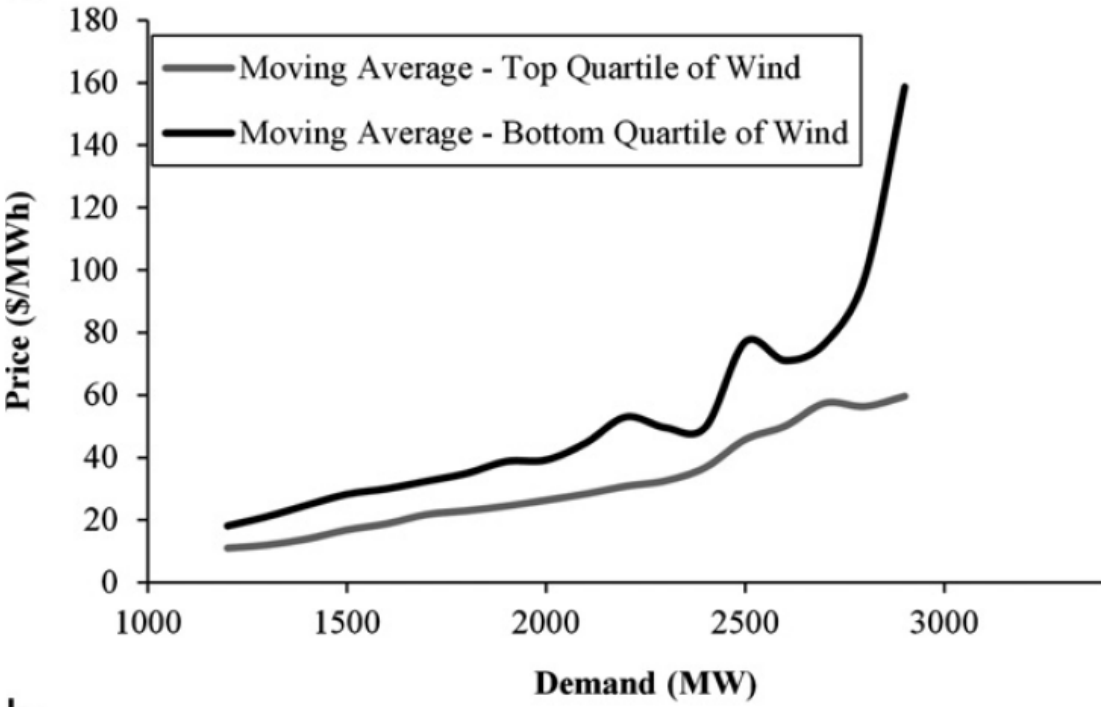
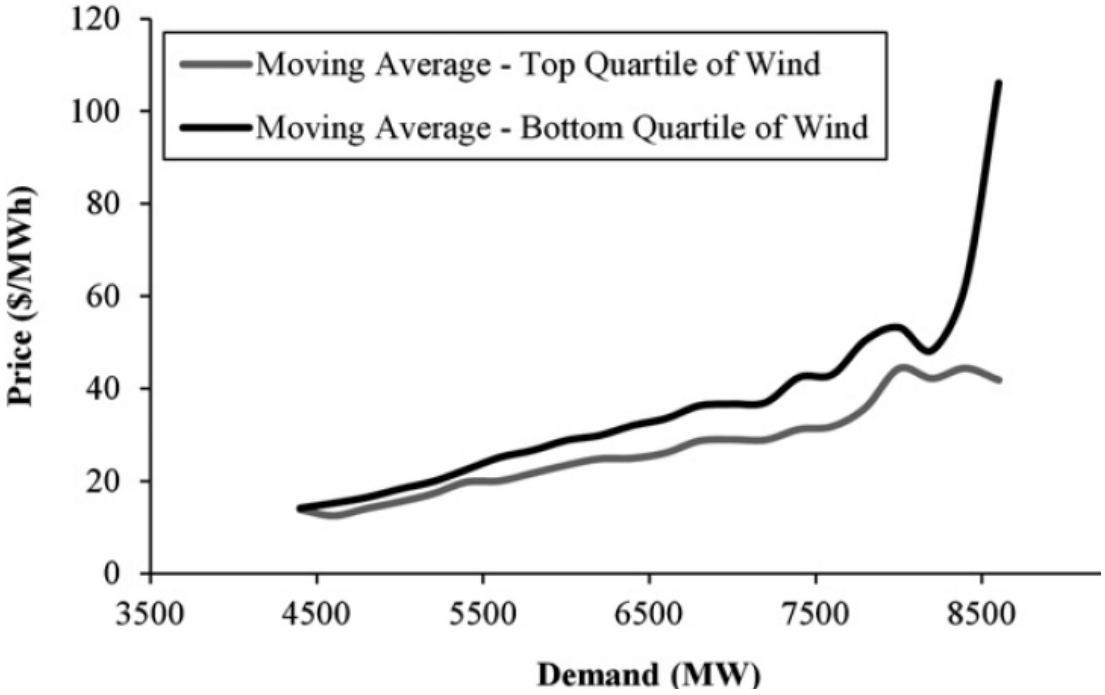
Wind appears to be reducing prices in both South Australia and Victoria

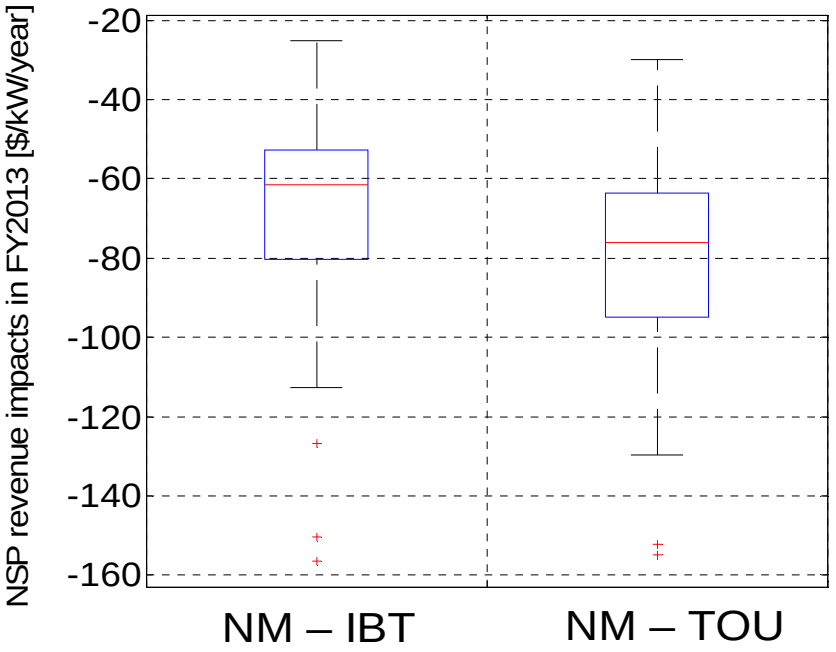


b *(Forrest and MacGill, 2014)*

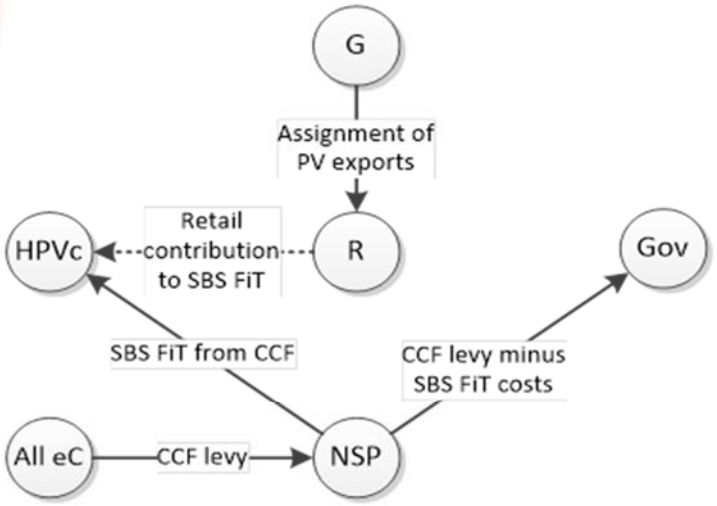


Residential PV now net-metered and definitely reducing network and retailer revenues

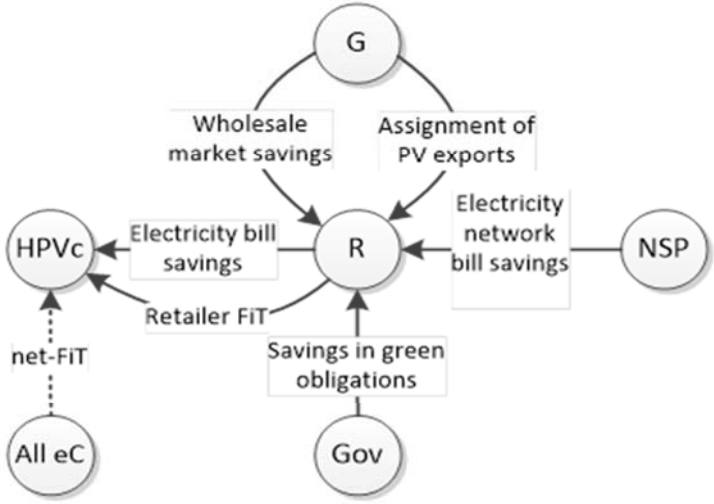
(Oliva, 2014)



Cash flows due to addition of PV under GM



Cash flows due to addition of PV under NM



HPVc: Household PV customers
R: Electricity retailers
NSP: Network service providers

G: Generators
Gov: NSW government
All eC: All electricity customers

Outline

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The evolving status of wind in the NEM

- Non-scheduled
  - *Original category for intermittent gen – wind treated as negative demand*
  - Can only be curtailed for system security or key network issues
  - Don't pay for FCAS
  - Technical connection standards relevant to wind generators

    Historical windfarm outputs published

    Centralised wind forecasting system (AWEFS)
- Scheduled
  - *All major generation SA formerly required new wind farms to register as scheduled*
  - Submission of dispatch offers
  - Compliance with targets
  - Causer-pay for ancillary services
  - Ability to offer ancillary services
  - Publication of individual outputs:- forecast, offered & actual
- Semi-Scheduled
  - *Specifically intended for intermittent gen >30MW + compulsory* from *March 2009*
  - Submission of dispatch offers
  - Causer-pay for ancillary services
  - Ability to offer ancillary services
  - Are treated as positive supply
- If involved in a constraint
  - Compliance with targets if less than forecast

Potential advantages of NEM for RE integration

Identical wholesale mkt price signals as other generators (additional support via Green certificates)

Renewables fully participate in market

Single platform (no day ahead), gross pool

Wholesale dispatch of all generation co-optimised together in real-time

Major Incentives for flexibility

Strong price signals

Ceiling $13,500
Floor -$1,000

Unit commitment self-managed

Incentives for flexibility? NEM RE forecasting

Single balancing area

Whole NEM dispatched together (minimise balancing reserves)

Competition for provision of services, causer pays provisions

Sophisticated frequency ancillary services market

Fast

5 minute dispatch interval with rebidding

Short delay from gate closure to dispatch

Facilitating RE integration

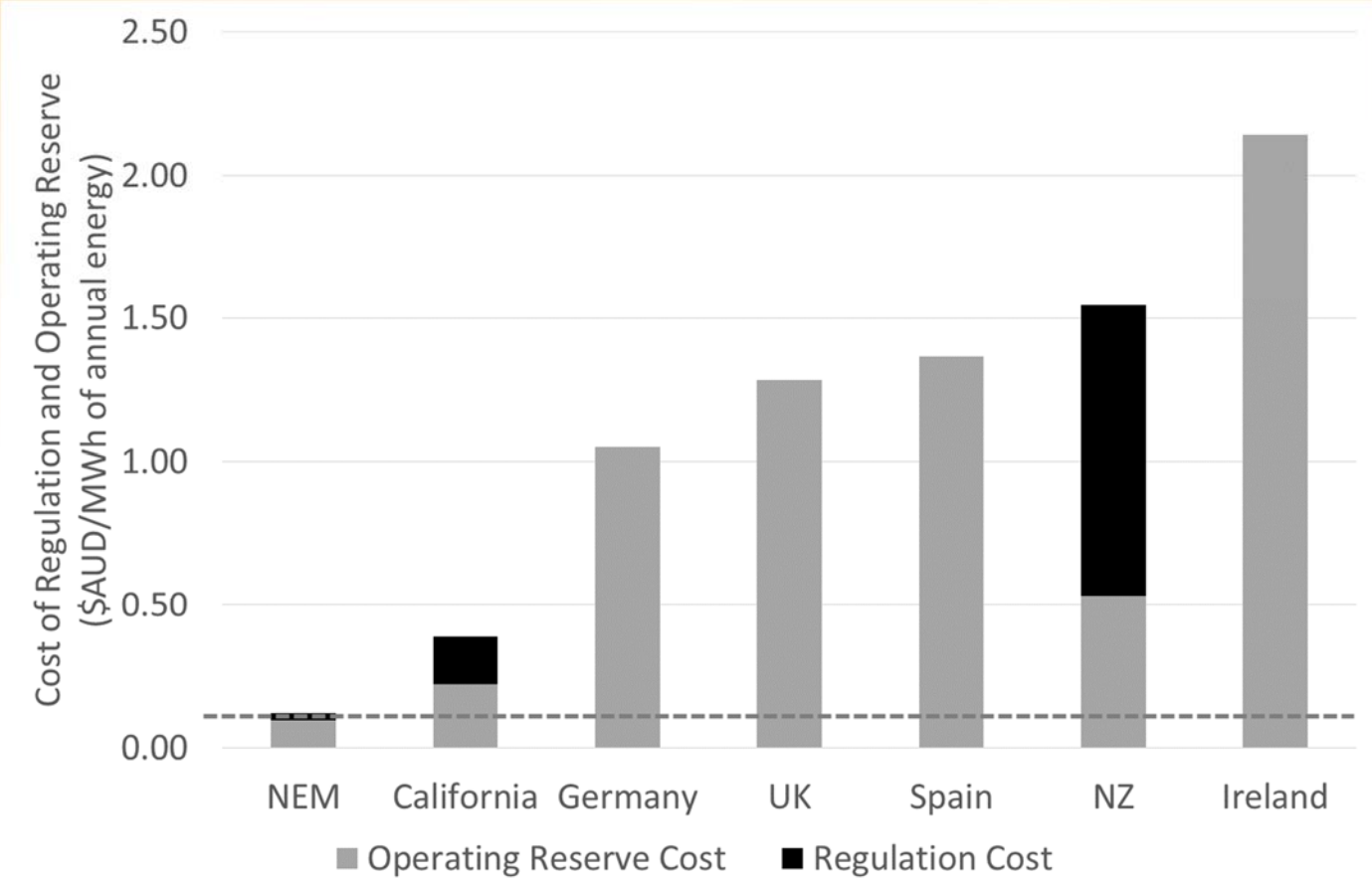
Pays for capacity via very high prices when actually required

Energy-only mkt

(Riesz, 2015)

- Australian NEM FCAS market can serve as a model for others seeking to integrate more renewables?

1. Dynamic regulation reserve setting
2. Causer pays cost recovery
3. Fast primary frequency response service



J. Riesz, J. Gilmore, I. MacGill (2015) "***Frequency Control Ancillary Service Market Design – Insights from the Australian National Electricity Market***', *The Electricity Journal (in press)*

Key large-scale renewable integration challenges

- Forecasting
  - to inform & assist decision making by NEM participants: Security implications for AEMO, commercial implications for all participants
  - Centralised forecasting AWEFS now deployed
- Formal RE participation in NEM scheduling + cost allocation
  - 'Semi-scheduled' generation category for intermittent renewables now being connected to the NEM *A necessary price for success*
  - *RE has high operational flexibility within constraint of resource availability*
- Transmission investment
  - Transmission investment and costs rising due to underlying NEM factors
  - Current NEM arrangements may not facilitate timely and efficient Tx investment to support renewable generation through new lines & congestion management
- Appropriate participation in derivative markets
  - Particularly given spot price impacts…. *but risks wrt contract volume*

Given present over-capacity from falling load and increasing renewables

ClimateSpectator

Origin moves to optimism on RET while AGL won't invest unless coal shut down

TRISTAN EDIS | 26 MAY, 5:04 PM |
CLIMATE | ENERGY MARKETS | RENEWABLE ENERGY | SOLAR ENERGY | WIND POWER

Distributed generation

- Resides in largely disfunctional retail markets that don't provide appropriate pricing signals for DG… or other demand-side activities (eg. cross-subsidies to air-conditioning
- Current network business efforts may target PV rather than these underlying challenges – eg. fixed charges
  Is this an appropriate incentive structure for an industry in desperate need of clean energy transition?

SA network wants solar homes to pay $100/year more for grid

By Giles Parkinson on 27 May 2015

SA Power Networks, the monopoly network operator in South Australia, has caused a furore in the solar industry by proposing a $100 a year network surcharge on solar households.

The proposal was revealed in a submission to the Australian Energy Regulator earlier this week, and follows decisions by both the Queensland and West Australian governments – the owners of their respective networks – to back away from similar moves.

Outline

- Current industry status
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Key AEMO directions (AER, 2014)

- Respond to low inertia conditions in South Australia by limiting interconnector flows.
- Implement rate of change of frequency constraints
- Introduce over frequency generation shedding of non-synchronous generation

- Longer-term
  - Arrangements to ensure minimum levels of synchronous generation remain online in SA
  - Development of new ancillary service markets, such as localised provision of inertia, frequency regulation.
  - Network augmentation options
  - New ‘protected events’ category for security management

Broader policy, market and regulatory framework for action still lacking….

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Thank you, questions and discussion

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