

Challenges and opportunities for integrating clean energy technologies into the Australian NEM

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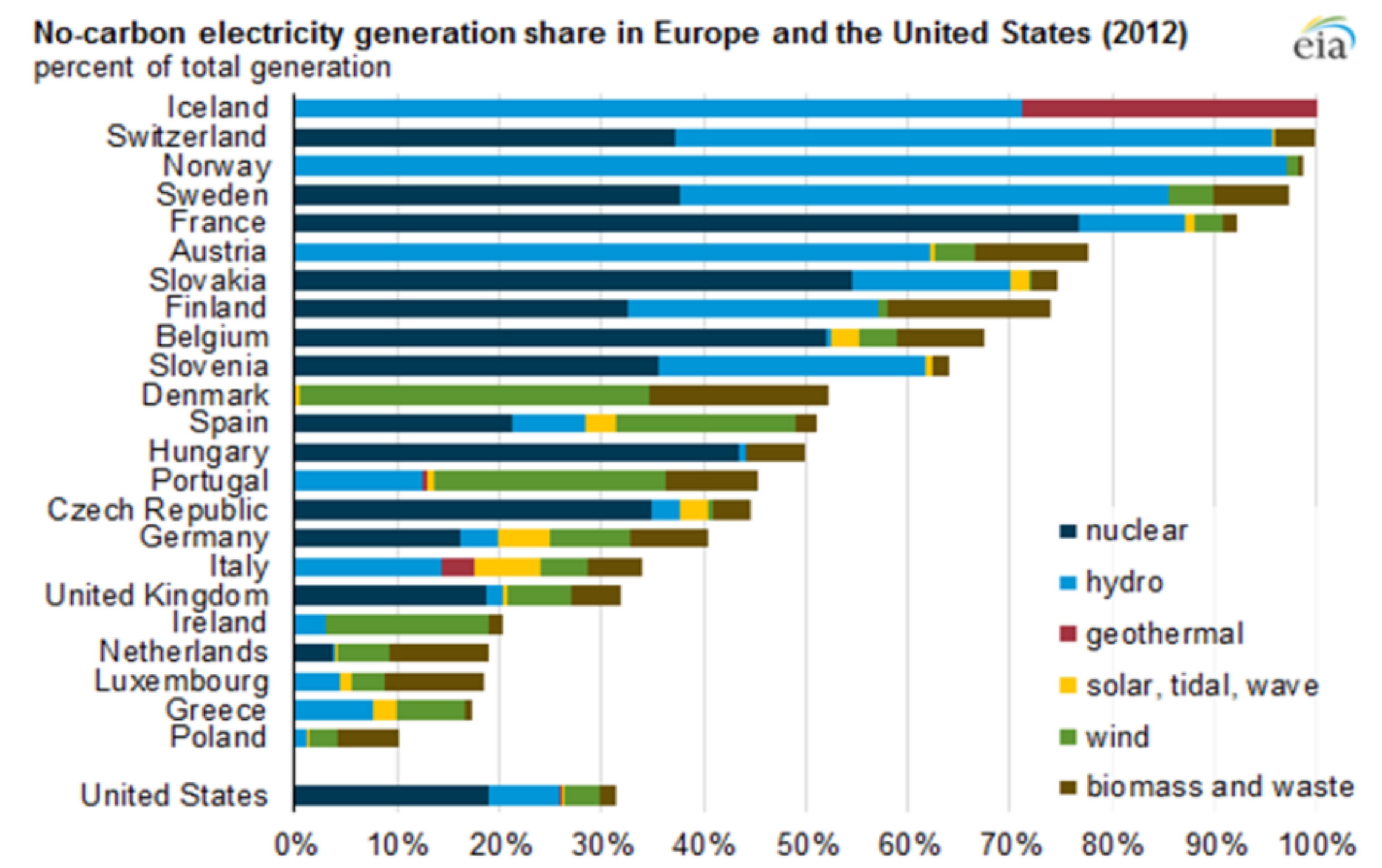
Interest in future clean energy electricity sector

- Many drivers including
  - climate change and other environmental impacts
  - energy security (most countries see fossil fuel $ as economic liabilities)
  - falling costs for some key renewable technologies, deployment success, although poor progress with some of the ‘alternatives’

- Some key questions
  - *Technical feasibility?* – can high (even 100%) clean energy mixes, particularly utilizing highly variable and somewhat unpredictable solar and wind reliably meet demand at all times and locations
  - **If yes,** *Economic feasibility?* – is clean energy economically worth doing given likely costs vs costs of inaction, other options
  - **If yes, how to get there** *including commercial feasibility for new technologies and industry transition*

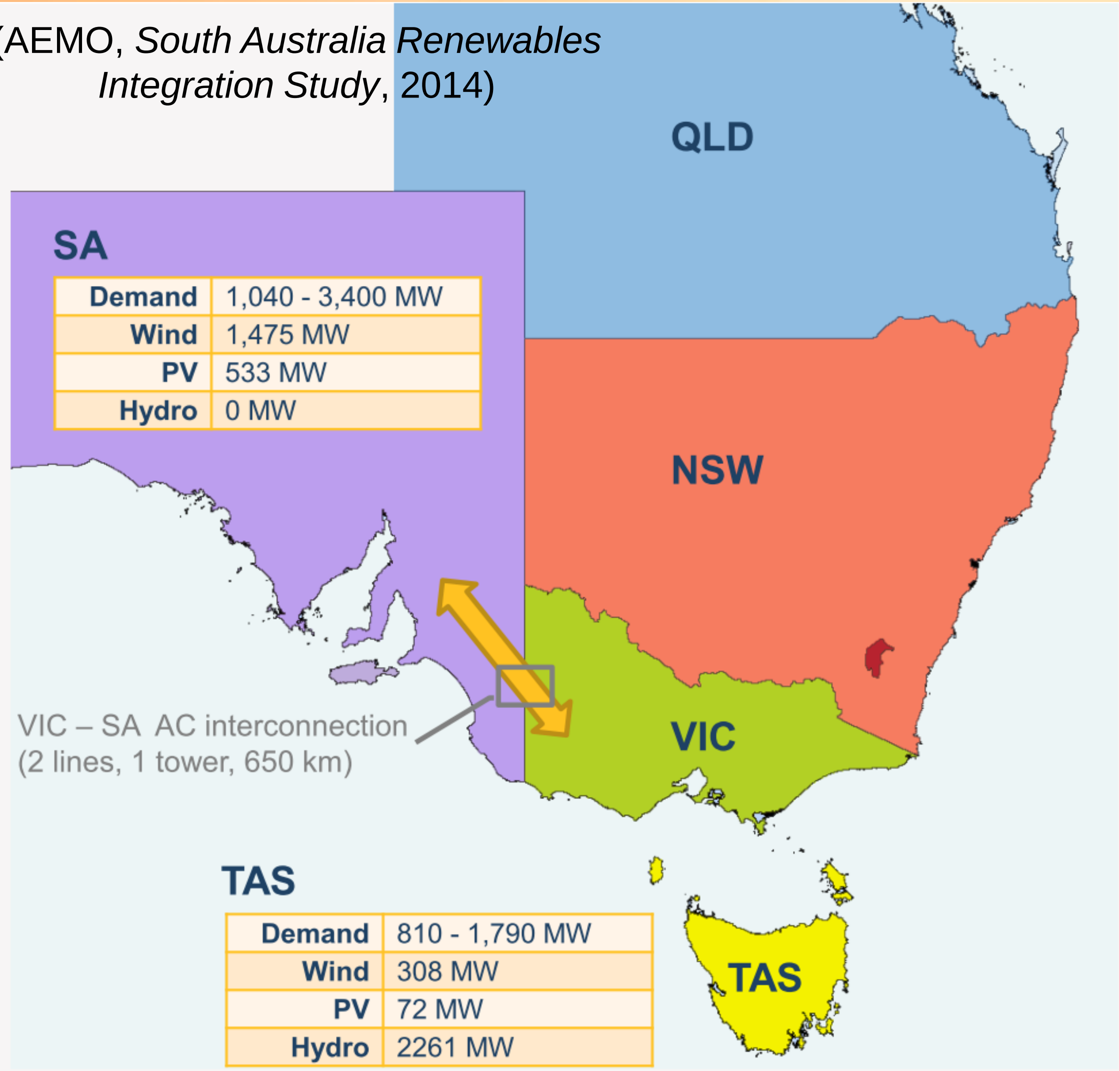
Technical feasibility – what exists is possible



Source: Energy Information Administration, International energy statistics

SA a world leading example for wind + solar

(AEMO, *South Australia Renewables Integration Study*, 2014)



SA

Demand	1,040 - 3,400 MW
Wind	1,475 MW
PV	533 MW
Hydro	0 MW

TAS

Demand	810 - 1,790 MW
Wind	308 MW
PV	72 MW
Hydro	2261 MW

QLD

Demand	4,100 - 8,900 MW
Wind	0 MW
PV	1,151 MW
Hydro	652 MW

NSW

Demand	5,120 - 14,740 MW
Wind	431 MW
PV	775 MW
Hydro	2650 MW

VIC

Demand	3,780 - 10,490 MW
Wind	1,015 MW
PV	625 MW
Hydro	2237 MW

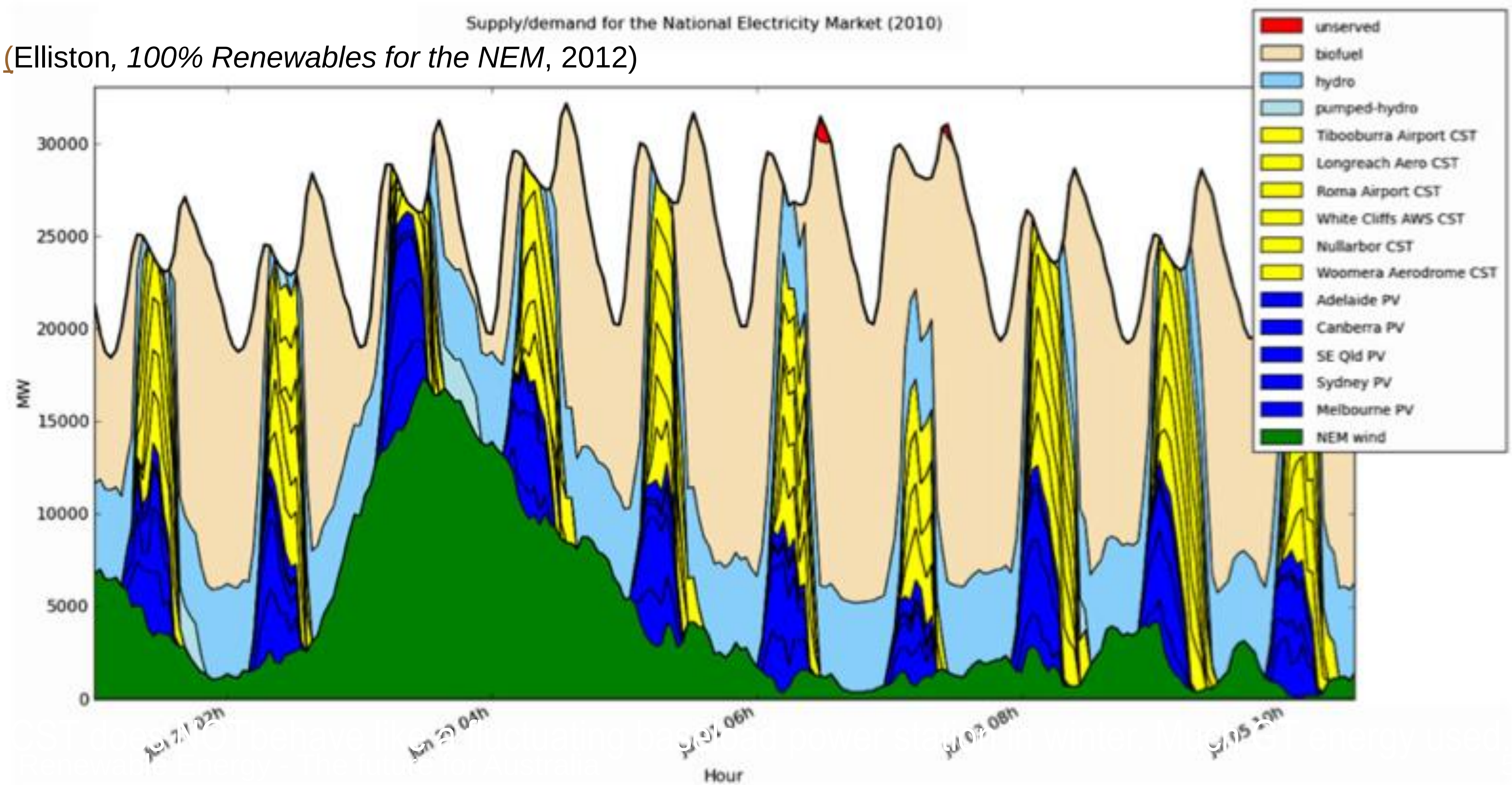
NEM total

Demand	15 GW – 30 GW
Wind	3,334 MW
PV	3,156 MW
Hydro	7,800 MW

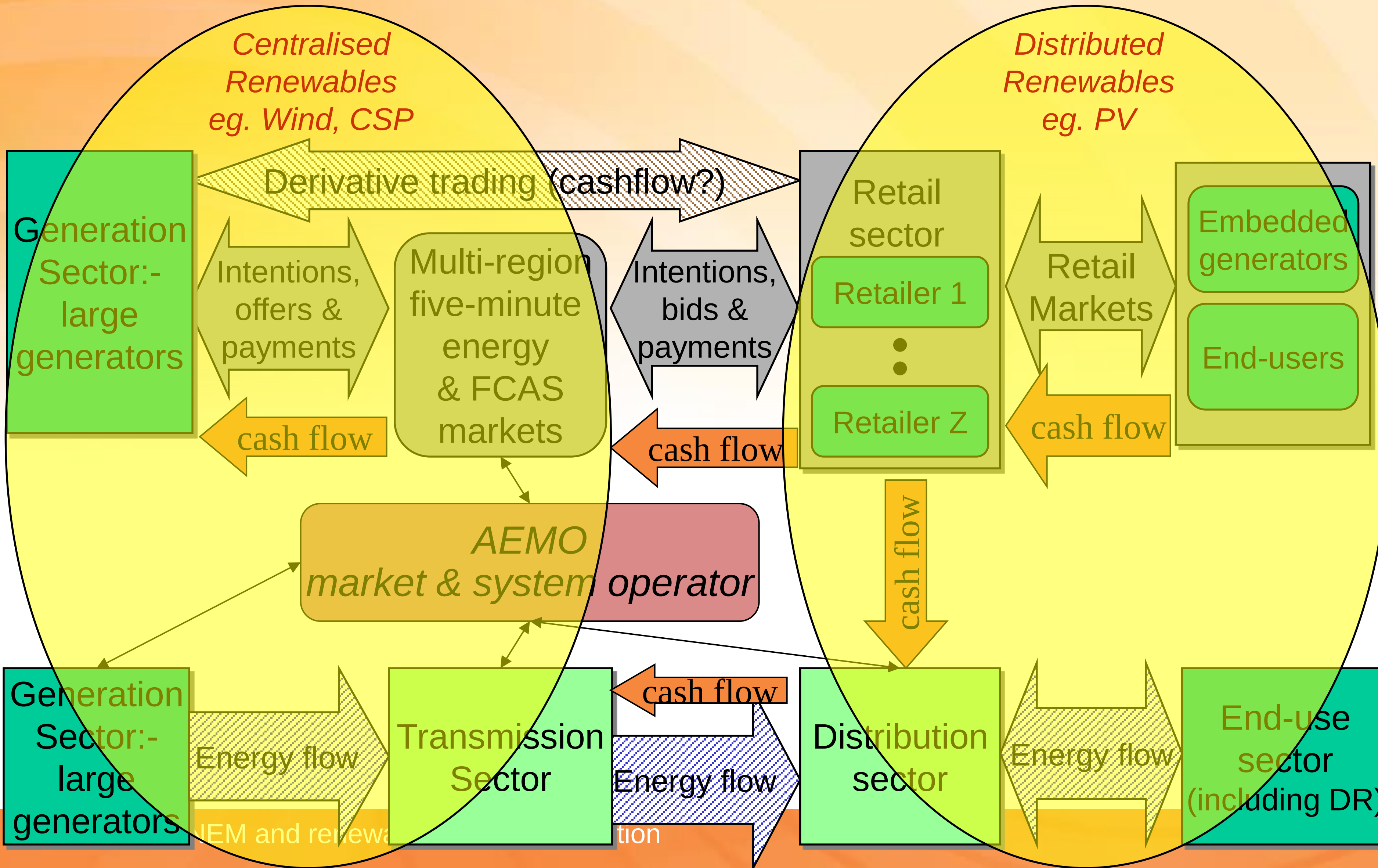
Technical feasibility – how high RE can we go?:

Simulations based on hourly estimates of RE availability across the NEM versus demand – *eg. a challenging Week in Winter 2010*

(Elliston, *100% Renewables for the NEM*, 2012)



Two ‘worlds’ for renewables integration in NEM

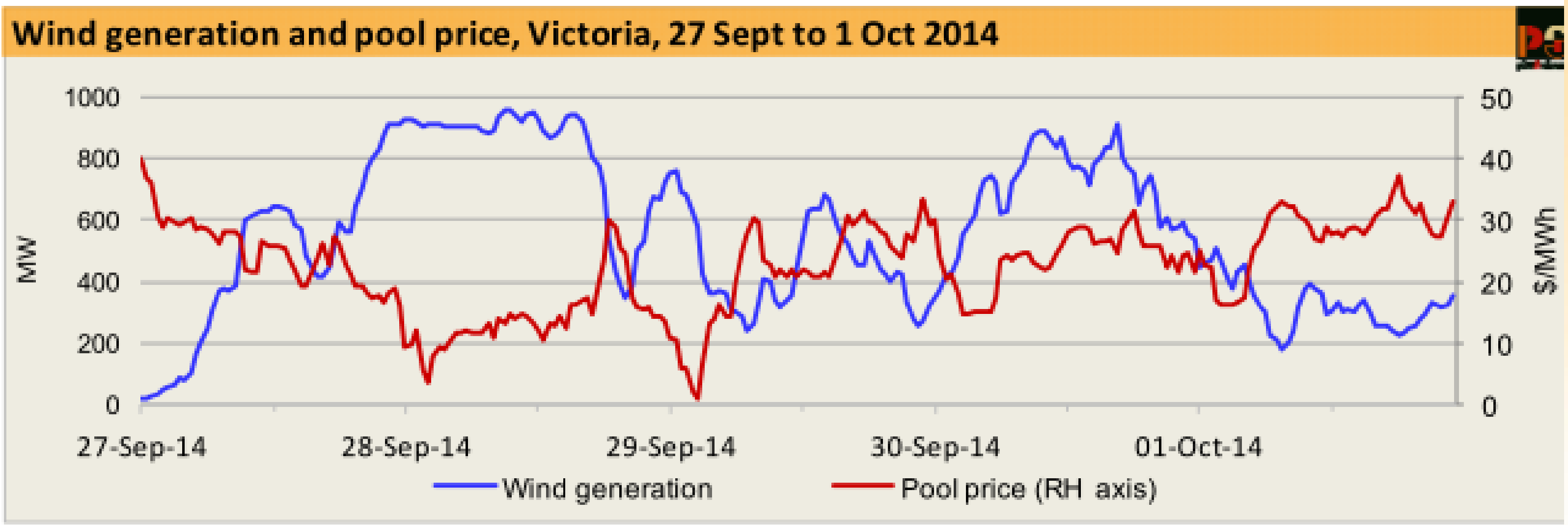


Managing security + reliability

Maintaining NEM security has priority over commercial arrangements – widespread industry failure is not an option.

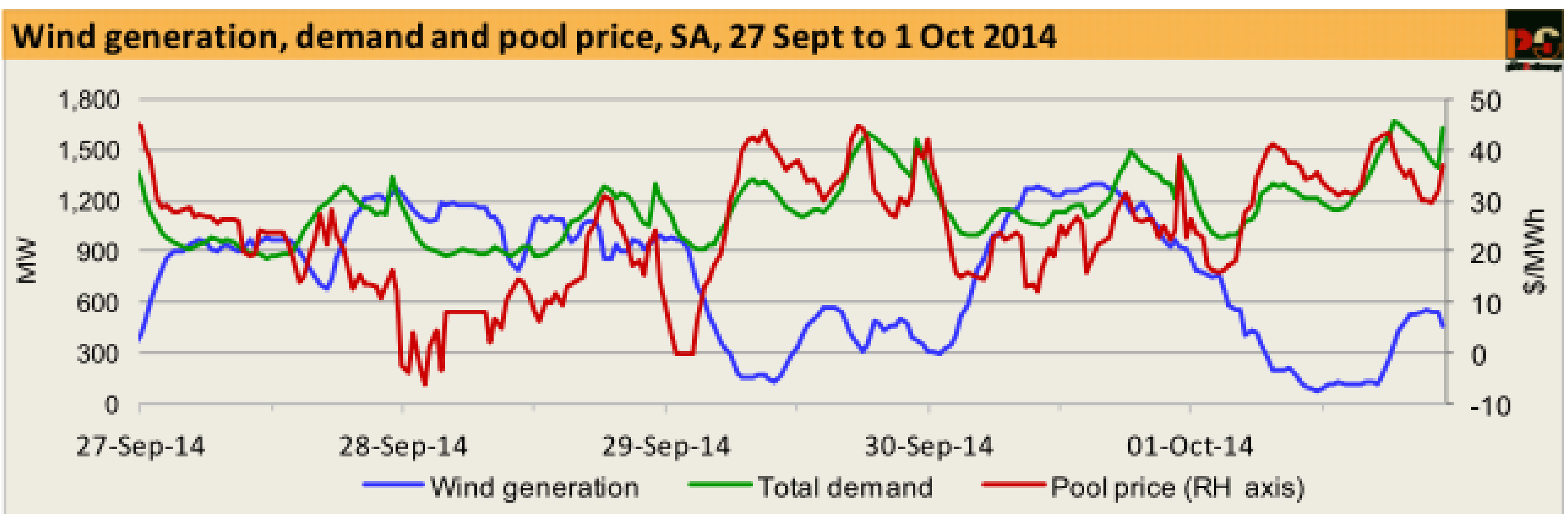
- At wholesale level, carefully designed interface between market and centralised security regimes
  - Price can range from -$1000 to $13,500 / MWh (for brief periods)
  - If system security or reliability of supply threatened, AEMO has authority to use Security and Reliability Directions, Load Shedding and Reserve Trading
- At distribution level
  - Largely based around reliability and security oriented performance standards on distribution network service providers
  - Less clarity on managing high distributed energy penetrations including poor interface between retail market and security regime

NEM appears to be managing to date

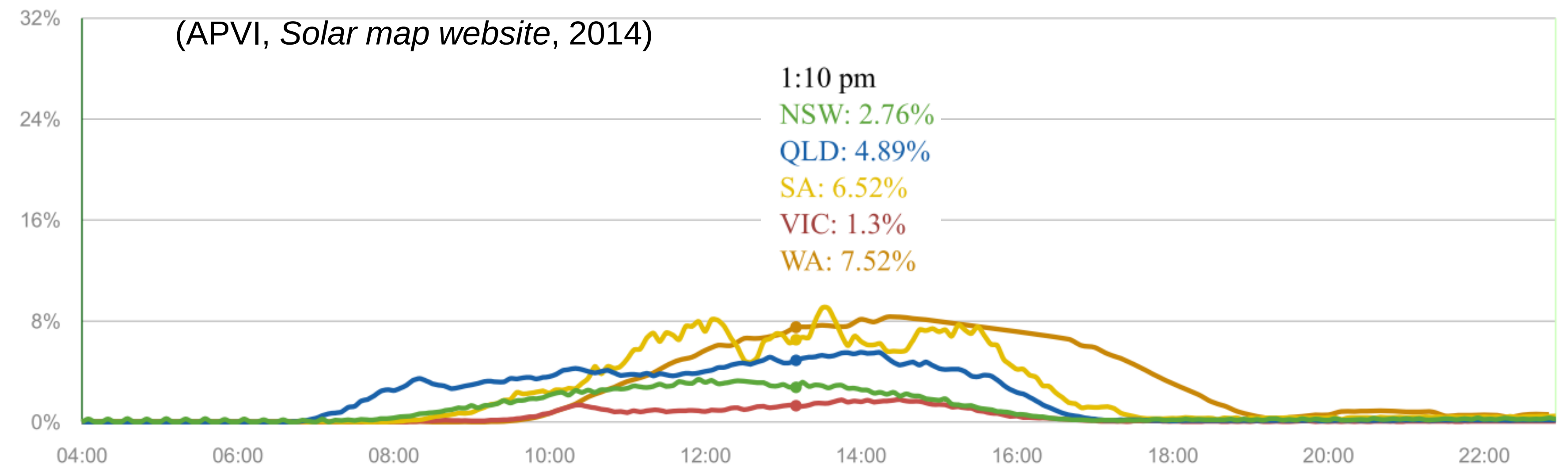


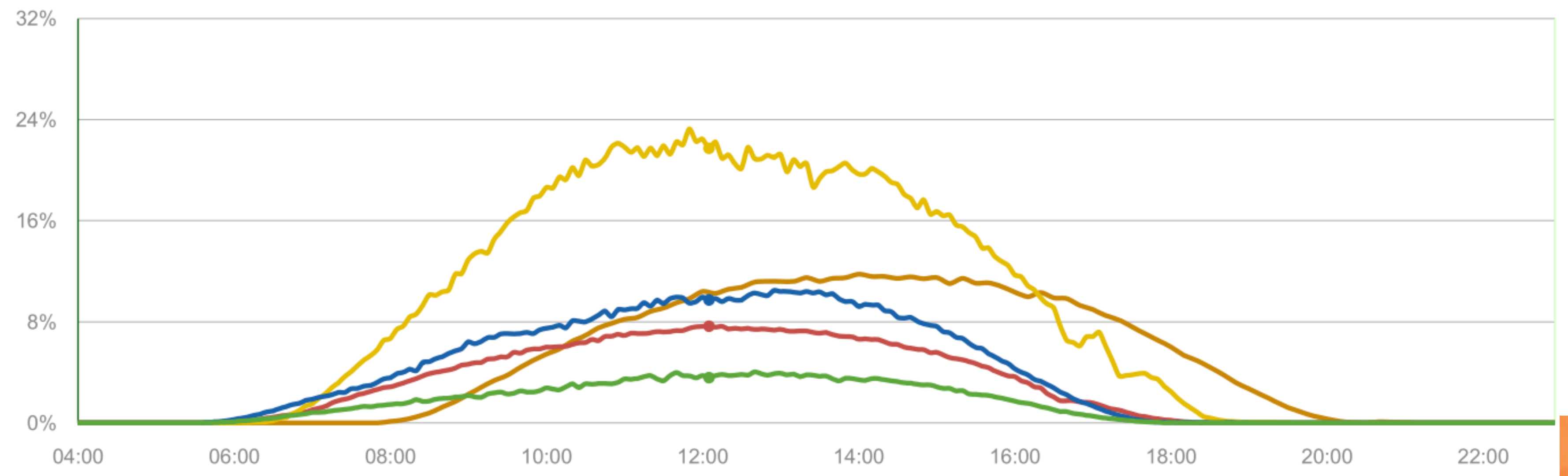
(Pitt and Sherry, *CEDEX*, 2014)

FIGURE 5



Distributed PV penetrations also becoming significant
(24 June 2014 and 5 October 2014)





Q: Does wind generation occur at times of high demand when most needed?

Figure 2-1 — Wind generation contribution to summer peak demand

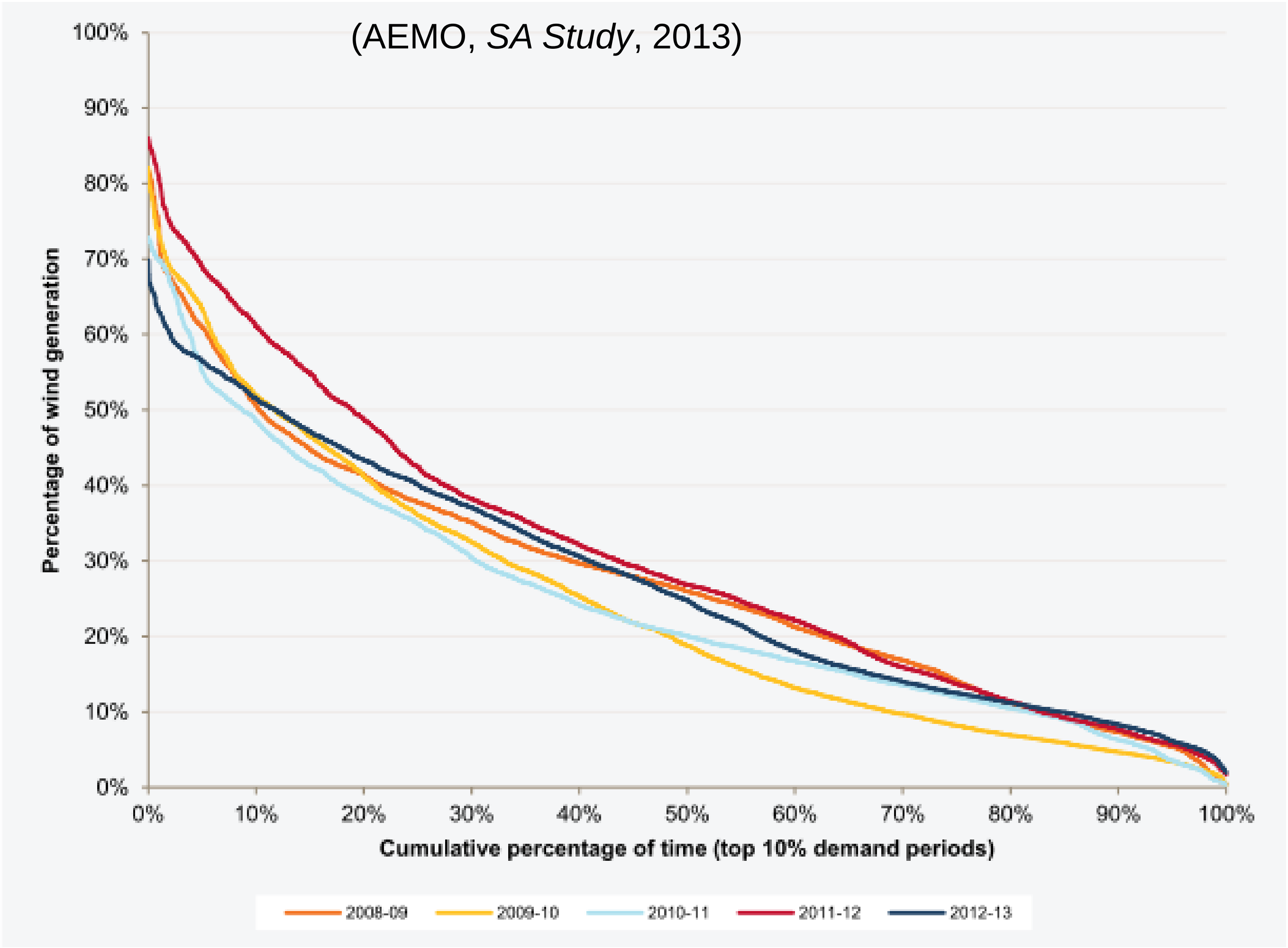
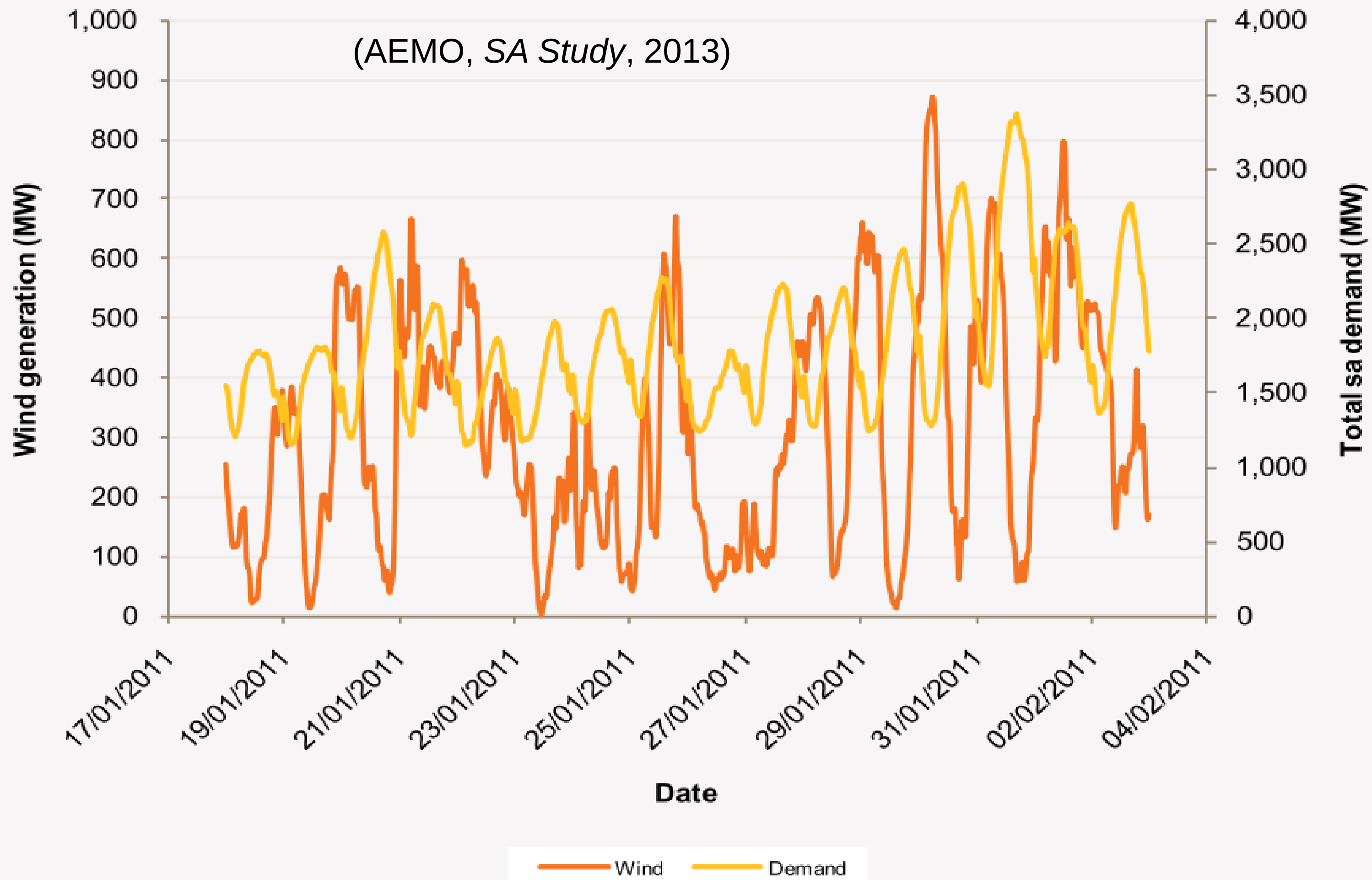


Figure 5-9 — Wind generation and total South Australian demand from 20 January 2011 to 2 February 2011



Q: does wind require conventional (typically fossil-fuel) backup generation to be running?

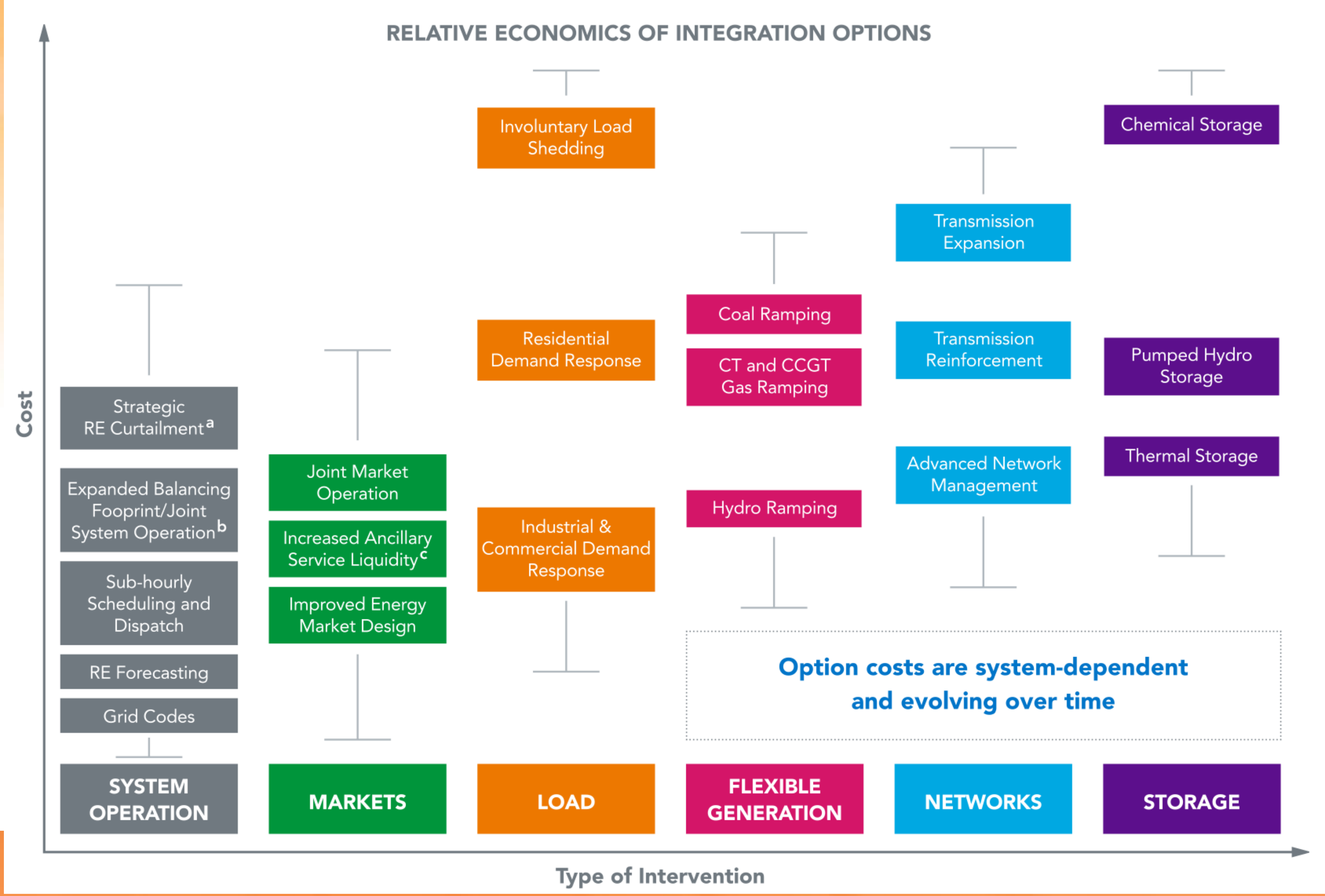
- All generating plant (and network links) are subject to possible failure / forced outage
- Secure operation of a power system requires that it be able to operate:
  - Despite potentially significant and only partially predictable demand variation (regulation) – *significant wind will impact on requirements*
  - Despite worst-case ‘credible’ contingencies – typically failure of largest power plant or network link (coal-fired generation in the NEM
- In the NEM
  - regulation and contingency services are provided by competitive market with participants including controllable loads, hydro and partially dispatched coal and gas plant

Q: Do we need to install storage systems with wind farms or PV systems?

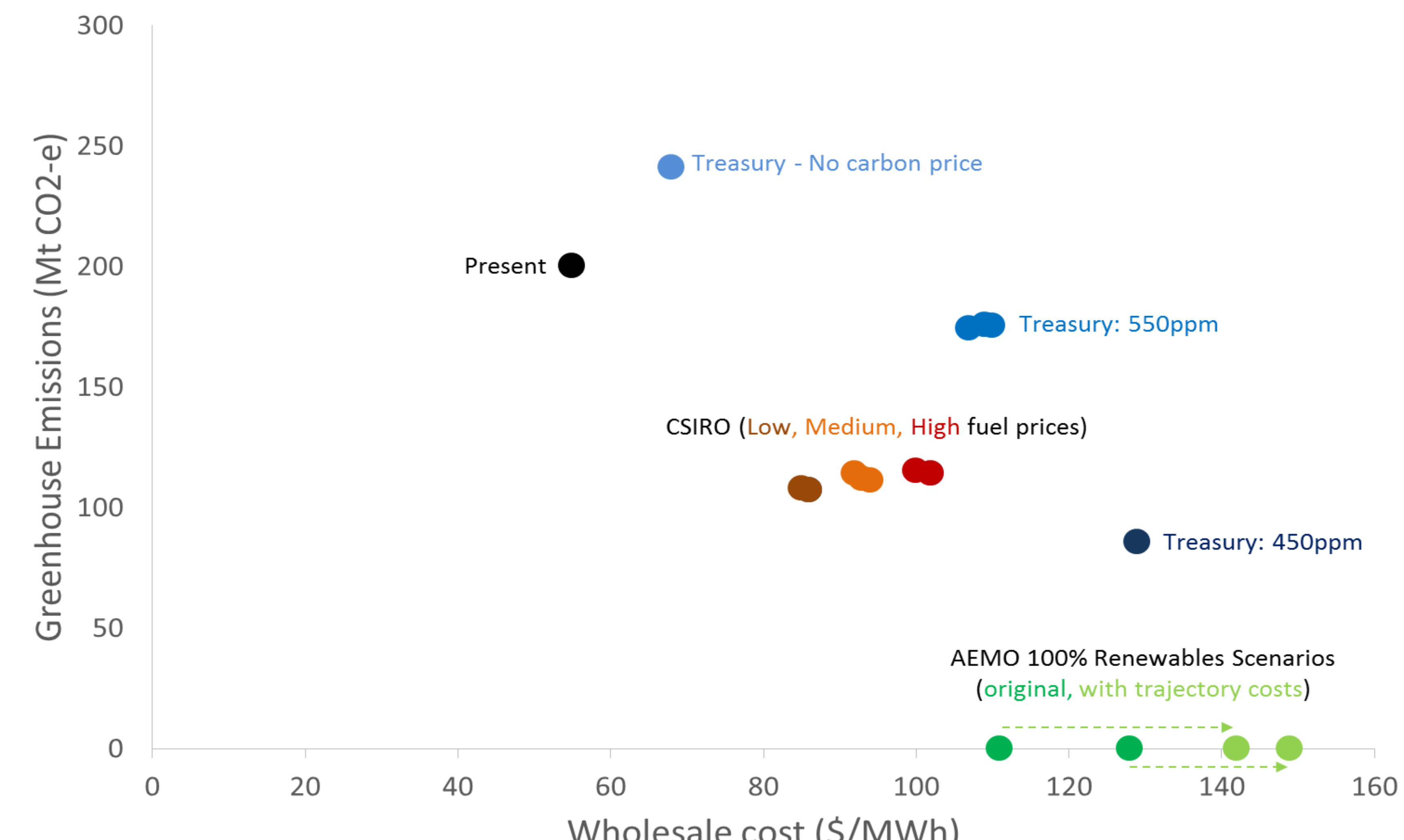
- Not at current or envisaged penetration levels
  - There may be some highly regional circumstances where such storage adds overall value due to network limitations
  - Wind variability and unpredictability generally best managed at the power system level in the same way that demand variability and unpredictability, and unexpected failure of large coal and gas plant are

Many options for facilitating RE integration

(21st Century Power Partnership, *Flexibility in 21st Century Power Systems*, 2014)



Economic feasibility? Affordable so far, but as clean energy penetrations climb…. *only modelling to guide us*



(Riesz, 2013)

The renewables integration challenge

- Maximise the contribution of our clean energy energy options towards overall energy, environmental + social values
- For high penetrations, maximising energy value can get harder
  - More challenging sites, increasingly significant integration costs
    - *network connection* + *management*; match of renews with existing Tx + Dx assets, yet also potential network value for larger deployments
    - *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*
    - *For example, Wind the first significant intermittent generation: now testing the adequacy of industry arrangements & governance around the world while PV is testing retail market arrangements – finding them wanting*

Concept: Renewables Integration costs

- Conceptually simple and potentially useful:
  - estimation of costs imposed on power system by accommodating wind *or other renewables with highly variable, non-storable primary resource*
  - Policy makers can then be better informed of system-wide costs, benefits of introducing supporting policy and regulations for that technology

- Generally considered to include a range of potential aspects
  - Costs of additional operational/flexibility reserves to manage variability and uncertainty of wind generation.
  - Costs of additional transmission and connection assets.
  - **'back-up' capacity** costs of matching variable capacity wind with some quantity of firm capacity (eg. OCGTs) when it is introduced into power system (eg. for making appropriate LCOE comparisons)

However in practice

- complex and very context specific to calculate
  - industry-wide costs, benefits of any particular generation technology depend upon integrated operation of all generation sources
  - Clean energy integration costs, benefits depends on rest of generation mix, nature of demand
- not applied equally to other generation technologies
  - Eg. adding wind causes other units to cycle more, increasing their costs.. but so does nuclear, coal baseload by shifting merit order
  - *Where is discussion on integration costs of these technologies?*
- even more challenging to allocate fairly
  - Wind + PV 'causes' cycling costs only b/c inflexible thermal plant have high costs associated with cycling process; RE itself highly flexible
  - Instead, can argue that inflexible existing plant with high cycling costs are responsible for imposing these additional costs on system

A better framework

- Costs caused by system *as a whole*, shouldn't arbitrarily be attributed to any particular participant. Instead, **ideally**
  - variable generators and loads that add net fluctuations to system would internalise (pay) costs associated with that increased variability, encouraging smoother operation if economically efficient.
  - inflexible generators with high cycling costs would pay those costs, encouraging upgrades, operational changes if economically efficient.
- Designing, implementing market that achieves this non-trivial
  - Requires prices that reflect all industry-wide costs, benefits that different participants bring to market, incentivizes them to invest and operate their generation, loads to maximize net system benefit.
  - *In practice, fidelity of commercial arrangements varies greatly; efforts to improve internalization of relevant costs useful, but mustn't discriminate between technologies, or between existing, new participants*

(LBL, 2013)

How to get there? *Better understand how markets are responding to renewables already present*

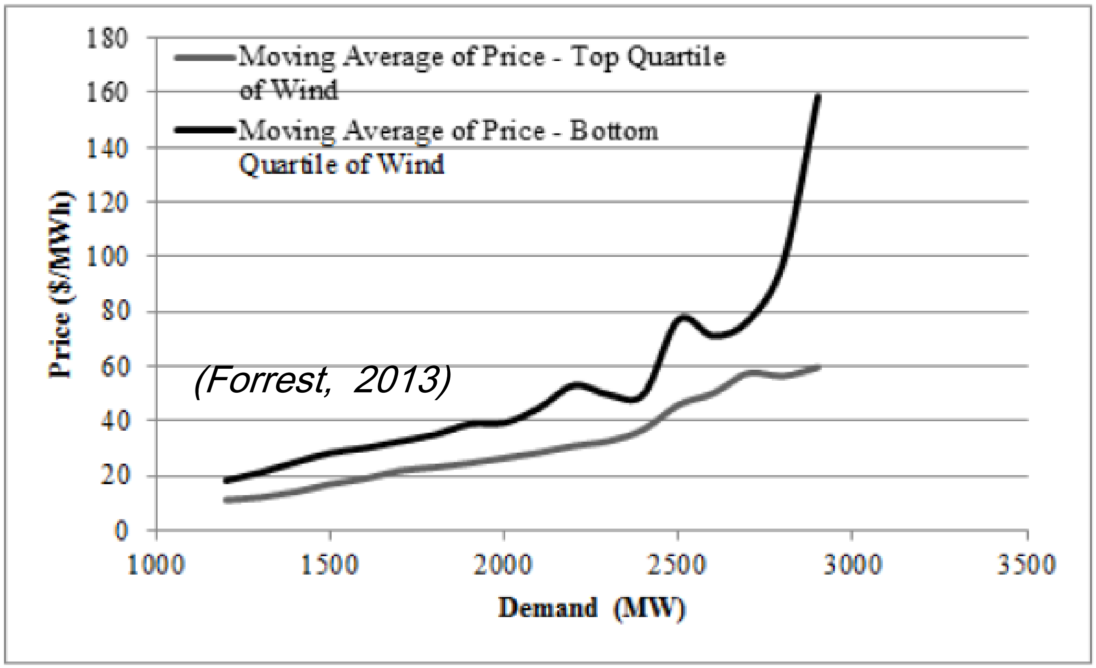


Figure 4 Indicative RET costs for residential and small business consumers for different assumptions on pass-through of merit order effects

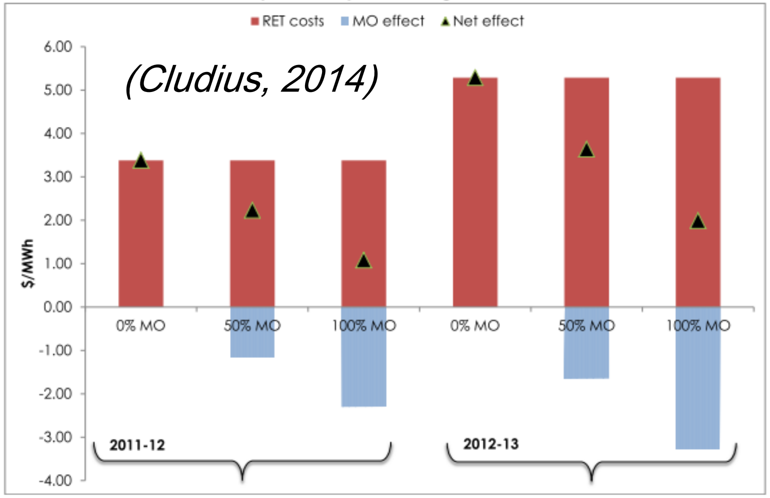
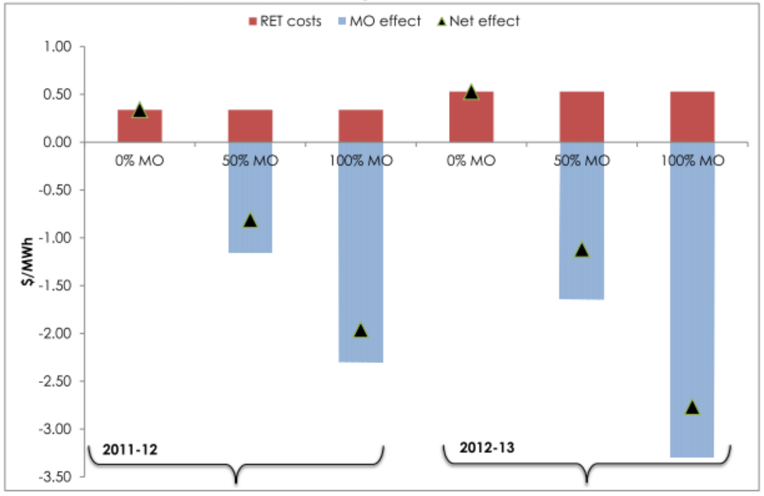


Figure 5 Indicative RET costs for industry with 90% RET exemptions for different assumptions on pass-through of merit order effects



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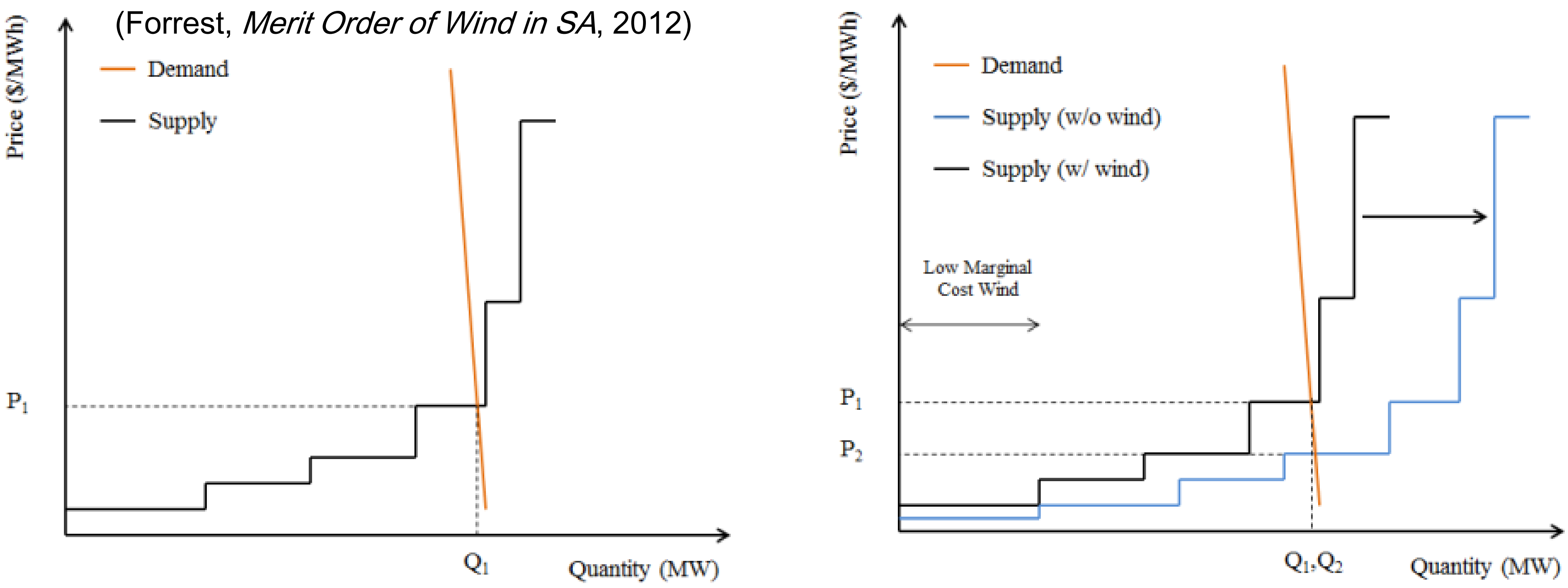
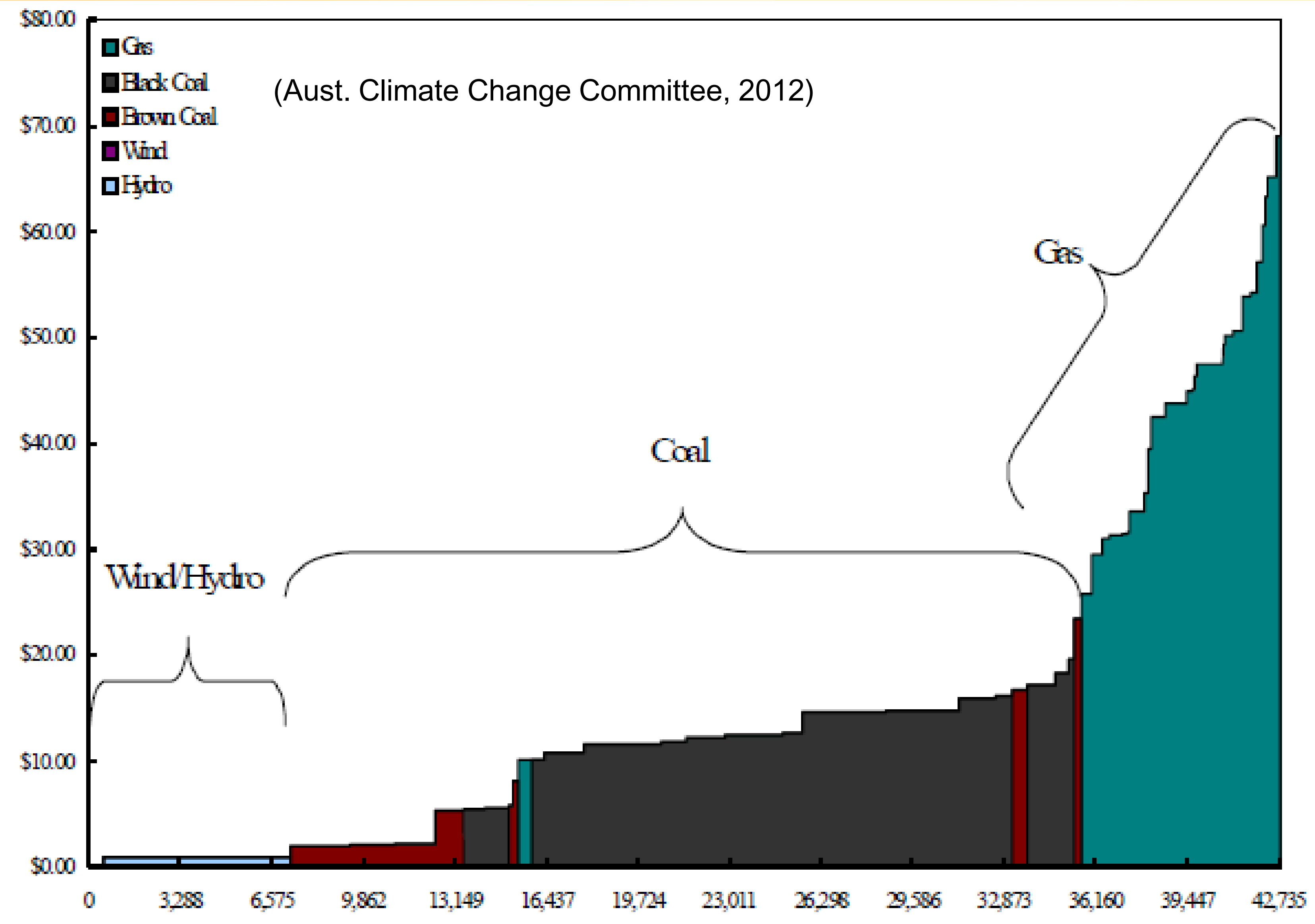
The Merit Order Effect

- Generation incentivised to offer generation at operating cost
- Any change in availability of low-cost generation (or demand) may change wholesale dispatch price, perhaps volume
- Overall industry operational *economic* saving from change in total operating costs of dispatched generation.
- Surplus (profit) transfer between buyers and generators from price change

(Forrest, *Merit Order of Wind in SA*, 2012)



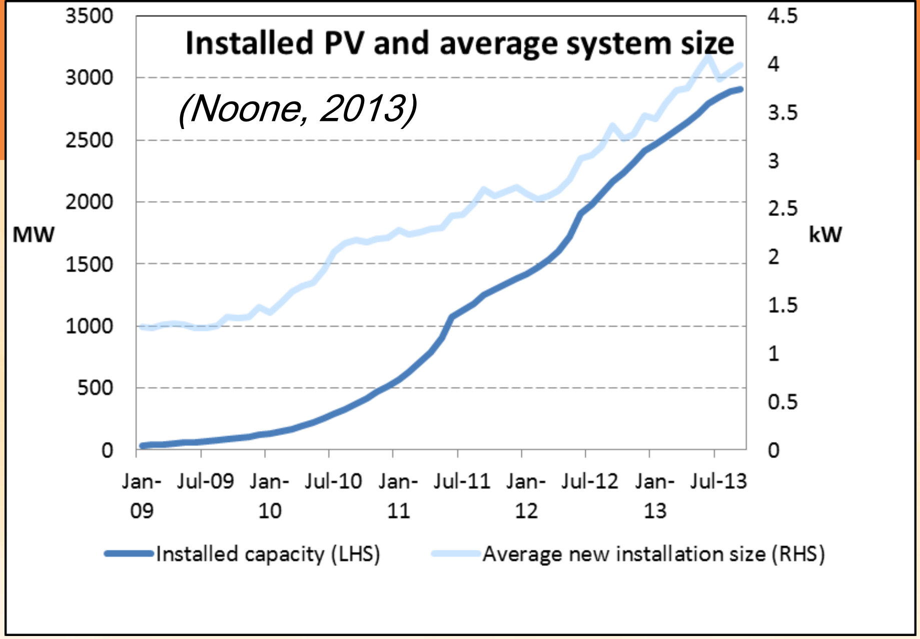
Current NEM Supply Curve



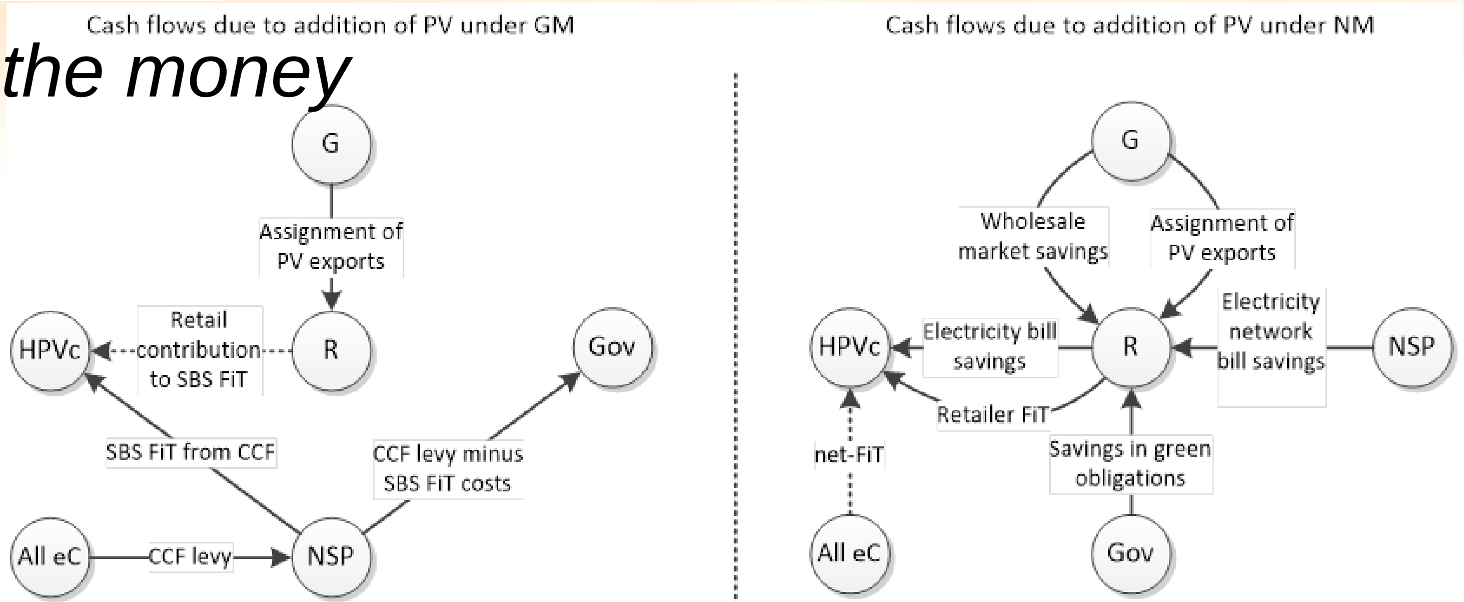
Now, some real retail competition with PV

State	#systems	Capacity (MW)	Proportion of dwellings with Solar Power
ACT	14,000	38	10%
NSW	252,000	633	10%
NT	3,000	11	4%
QLD	360,000	986	22%
SA	160,000	450	25%
TAS	18,000	55	9%
VIC	201,000	532	10%
WA	149,000	334	18%
National	1,157,000	3,039	14%

(from www.renew-economy.com.au)



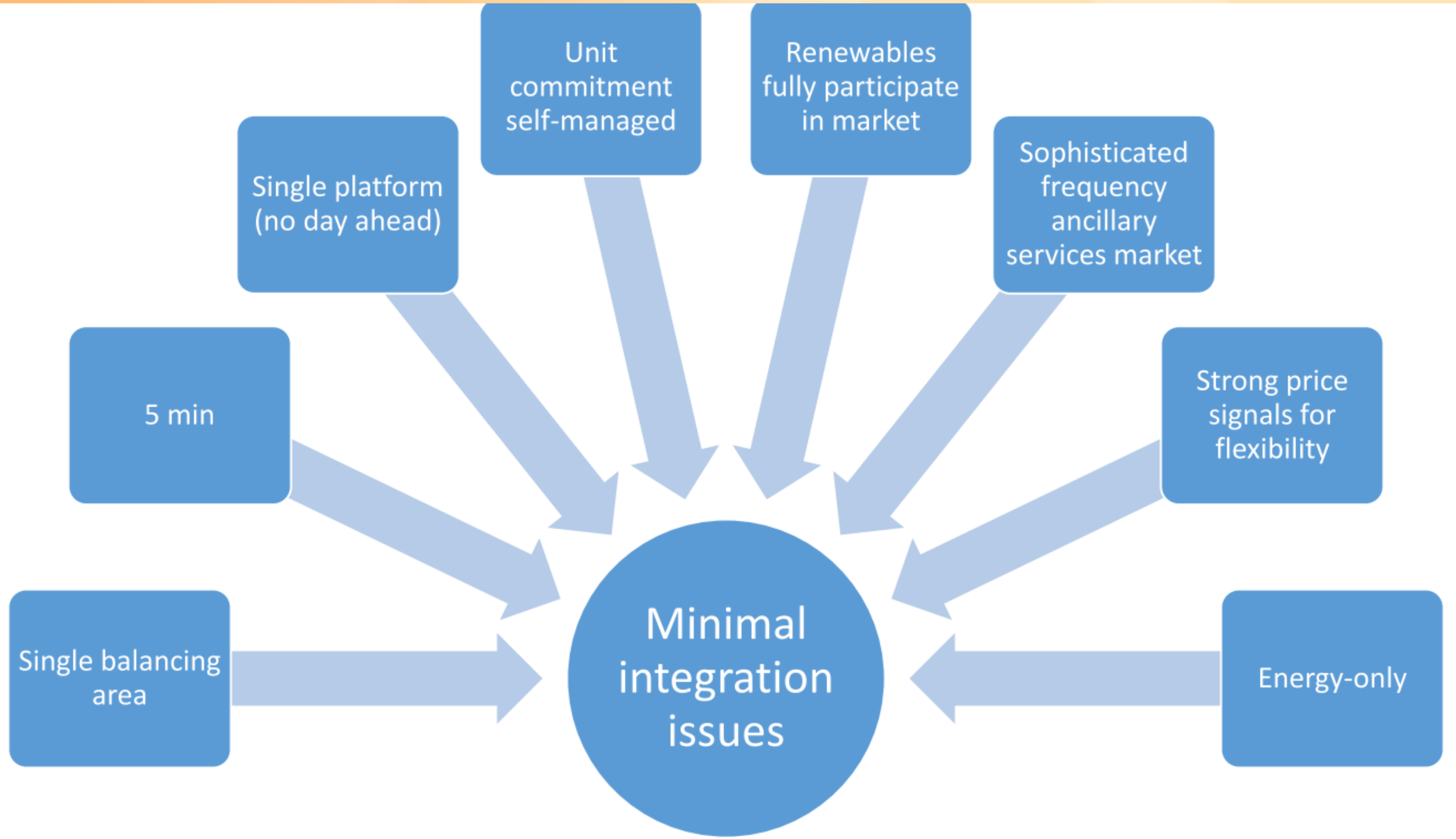
Follow the money



(Oliva, 2014)

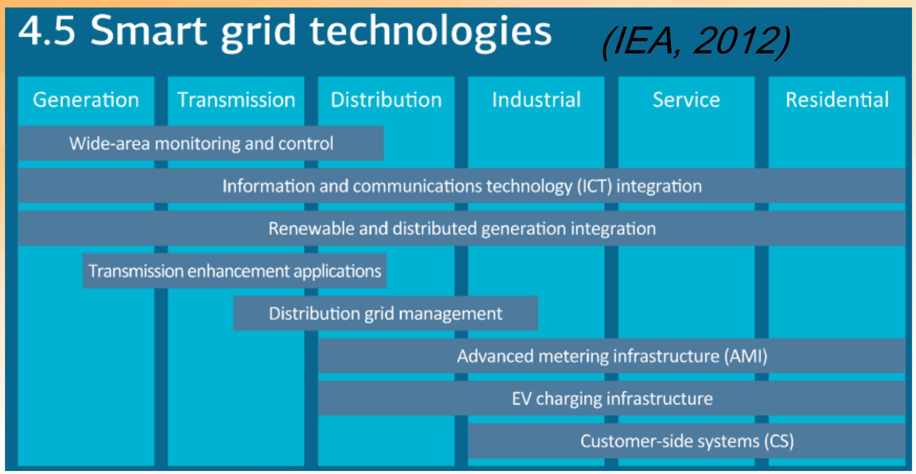
HPVc: Household PV customers
R: Electricity retailers
NSP: Network service providers
G: Generators
Gov: NSW government
All eC: All electricity customers

Questions of future market design for high RE



(Riesz, 2013)

Smart grids can improve our options for high RE



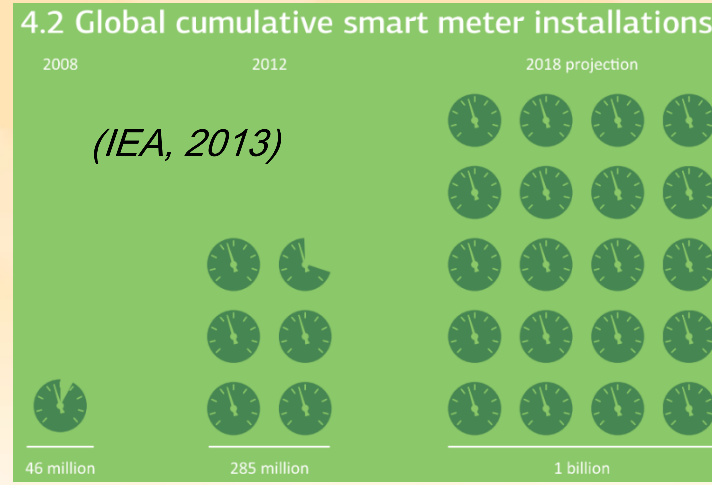
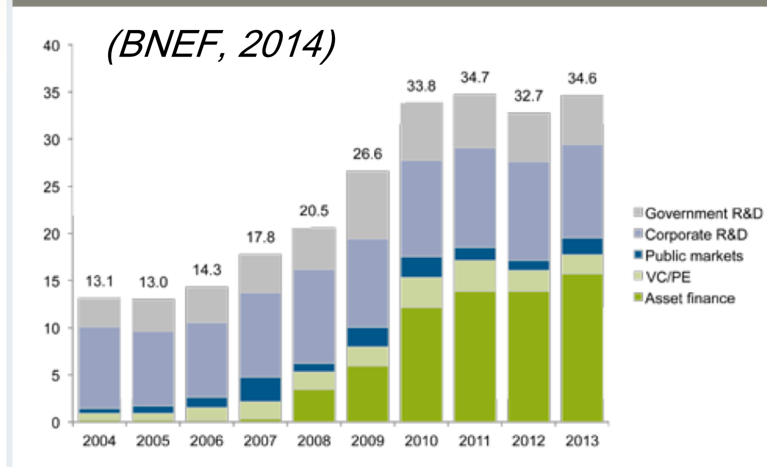


Table 15.1 Emissions reductions and investment needs in the 2DS, by technology

Sector *(IEA, 2012)*	CO_2 savings (Gt) 2050	Cumulative CO_2 savings (Gt) 2010 to 2050	Investment needs (USD trillion) 2010 to 2050
Power generation			
Bioenergy for heat and power	1.7	20.4	0.5
CCS in power generation	3.3	57.0	2.6
Concentrating solar power	1.7	22.5	2.6
Geothermal for heat and power	0.5	7.1	1.3
High efficiency, low emissions coal	n.a.	n.a.	1.9
Hydropower	0.9	19.4	3.0
Nuclear	3.2	59.6	4.0
Smart grids	1.7	36.4	5.0 to 6.0
Solar photovoltaic (PV)	1.7	27.7	3.9
Wind	3.0	61.0	5.9

FIGURE 27. NEW INVESTMENT IN ENERGY-SMART TECHNOLOGIES, 2004-2013, $BN



Asset finance includes smart grid and power storage only, excludes roll-out of efficiency and advanced transportation products

Source: Bloomberg New Energy Finance

Possible conclusions

- The current NEM
  - Relatively sound wholesale market design
  - Formal objectives of equal treatment… although difficult in practice
  - Clean energy integration just one of a number of NEM challenges
  - A reasonable environment for integrating large-scale renewables –
    - significant wind penetrations challenging but appear to be manageable given appropriate regulatory and commercial arrangements
    - Transmission investment likely to become more problematic
    - *A question whether NEM 'fit for purpose' for major decarbonisation*

  - RE bringing very welcome greater competition to the industry – new technologies and participants – the 'incumbents' are responding
  - Wider environmental, social + industry development value of RE needs to be recognised with effective 'external' policy support

Conclusions (cont.)

- However, for distributed renewables in the NEM
  - Arrangements remain supply-side focussed; DE a disruptive set of technologies for these arrangements
  - Significant asymmetries between resources, knowledge and motivation of centralised vs DE participants
  - Insufficient attention to complex realities of end-user decision making
  - Difficult for DE to receive the potential benefits it can bring to reduced network investment
  - Immature gas market arrangements, DE equipment markets and more…
- More widely…
  - Poor governance in design, implementation and long-term prospects of related environmental markets – *RET's future particularly problematic*
  - Many relevant institutional and regulatory arrangements not supportive of DE – eg. planning laws, solar access, regional air quality and more.
  - Institutional capacity in key supporting areas such as the building industry is limited, and likely inadequate for major deployment

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Thank you, questions and discussion

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