Centre for Energy and Environmental Markets

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA



Some Australian insights into sustainable energy technology innovation in the electricity industry

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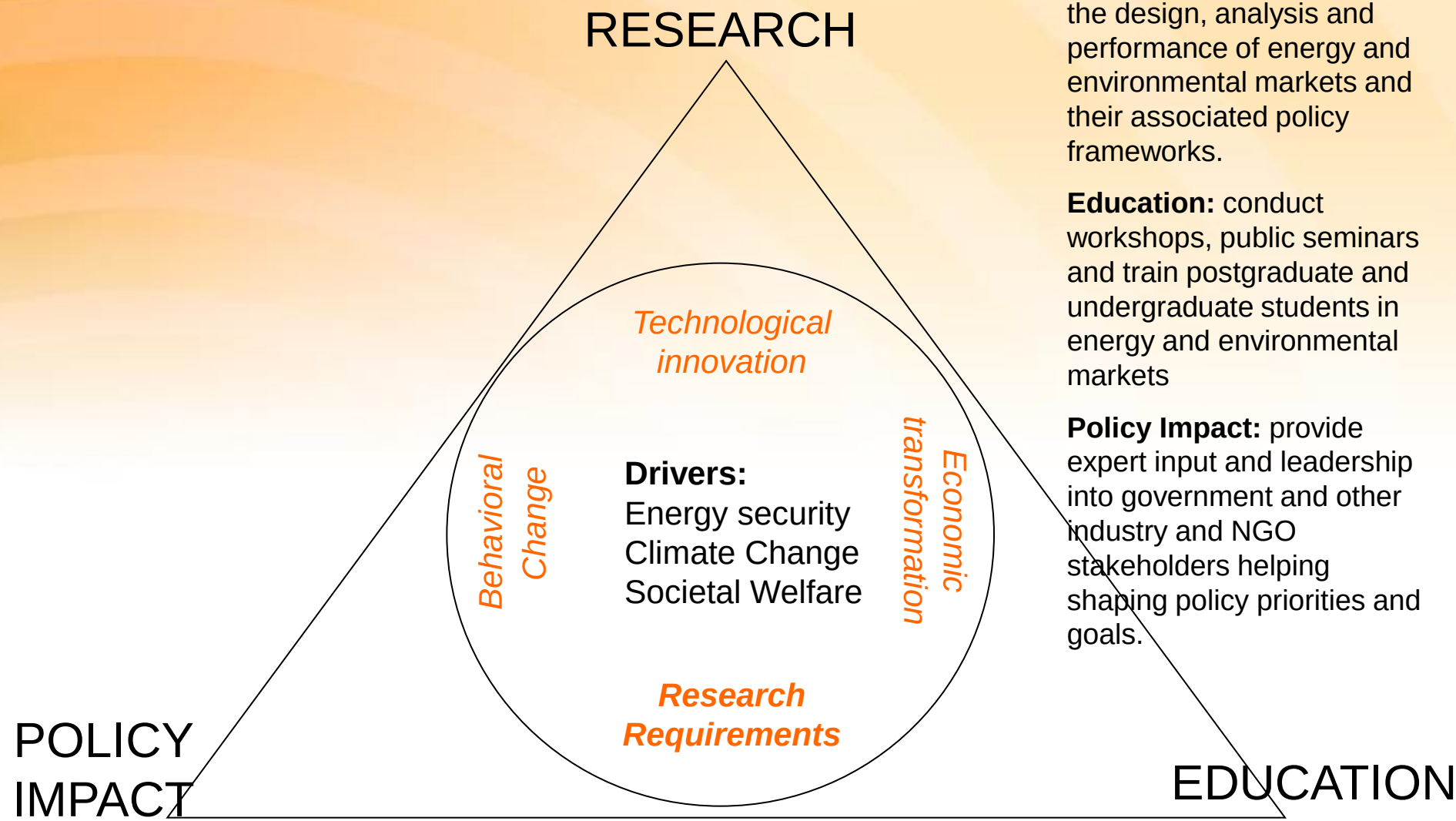
ETH Sustainability and Technology Group Seminar
Zurich, Switzerland
4 April 2014

CEEM‘s Vision

The Centre for Energy and Environmental Markets inspires and informs the transition to a more sustainable energy future nationally and internationally through objective interdisciplinary research.

CEEM‘s core tasks



Research: undertake interdisciplinary research in the design, analysis and performance of energy and environmental markets and their associated policy frameworks.

Education: conduct workshops, public seminars and train postgraduate and undergraduate students in energy and environmental markets

Policy Impact: provide expert input and leadership into government and other industry and NGO stakeholders helping shaping policy priorities and goals.

CEEM's current research agenda

- Sustainable Energy Transformation
  - Facilitating renewable energy deployment
  - Sustainable energy technology assessment
  - Sustainable energy services in developing countries
- Energy & Environmental Market Design, related policies
  - Emissions trading, renewable & energy efficiency market design
  - Interactions between electricty market and emissions trading
  - Accounting approaches in regulated and voluntary markets
- Energy-related decision making for distributed energy
  - Distributed energy options: energy efficiency, distributed generation, demand-side participation
  - Decision drivers - information, pricing, socio-cultural & ‚infrastructures of provision'

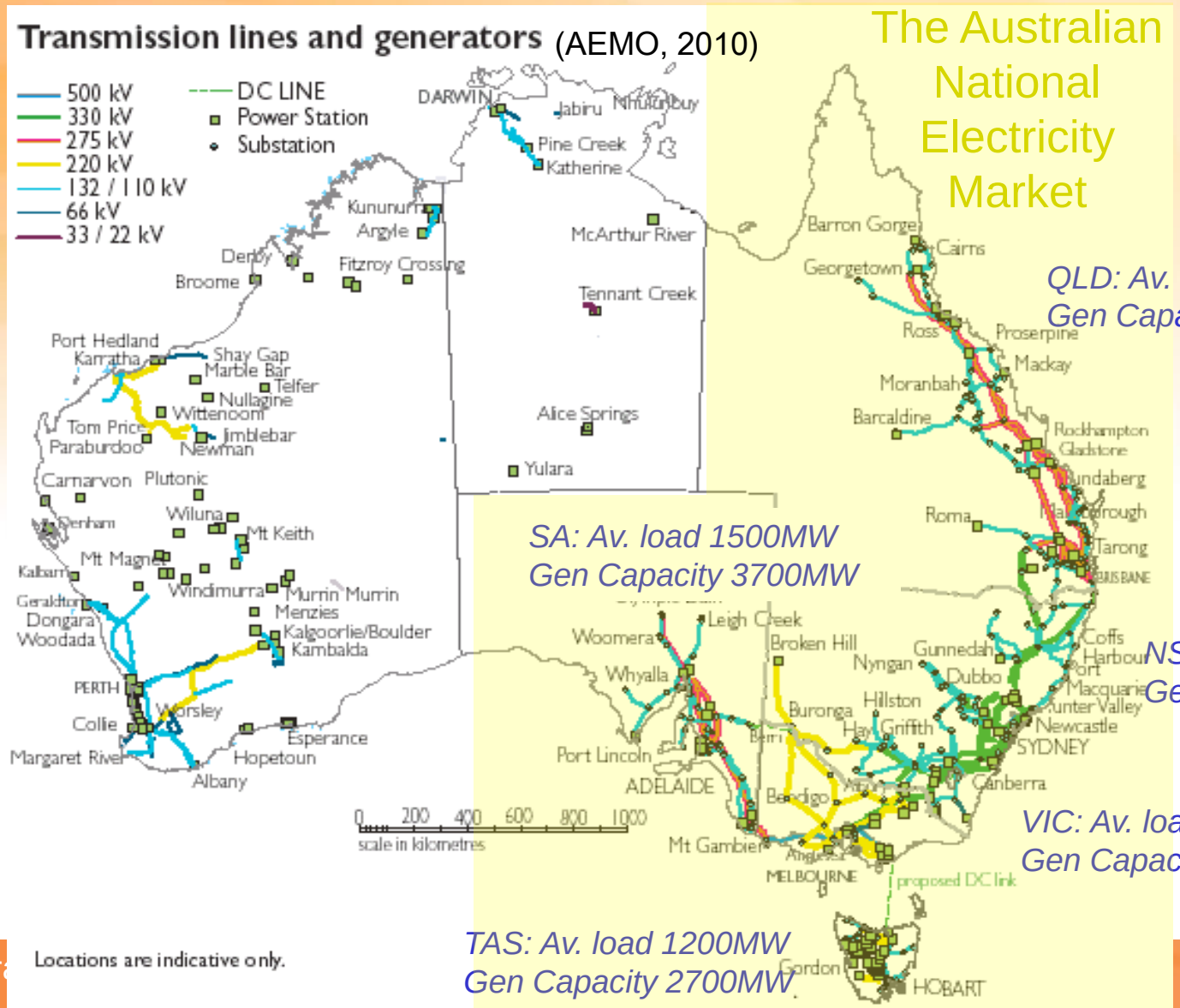
Key partner projects

- "CSIRO Future Grid Cluster", Joint project led by University of Sydney with UNSW, University of Queensland and University of Newcastle, as well as CSIRO CEEM project is *"Policy frameworks for the future grid"*, **MacGill, Betz)**
- *"Achieving cost-effective abatement from Australian electricity generation",* Joint project with University of Melbourne, funded by ARENA, **MacGill, Betz**, **Diesendorf**
- *"Enhancing integrated reporting: implications for internal and external reporting and assurance",* Joint project with the Institute of Chartered Accountants in Australia and CPA Australia, ARC Linkage, Simnett, Green, Cheng, **Balatbat**, Phua
- *"The economic value of 'smart' integration of Electric Vehicles into the Australian electricity industry",* ARC Linkage Project, **MacGill, Betz, Twomey**
- "*High penetration of Photovoltaics in electricity grids*" Australian Solar Institute (ASI), Grant administered by APVA, **MacGill**, **Watt** and **Bruce**.
- **"*The rise of carbon markets in China,*** Joint project with ANU, Tsinghua University, funded by the Australian Government, **Betz**, **Balatbat**, **MacGill**
- *Opportunities and challenges for community power in Australia,* Joint project with UNSW CRC Low Carbon Living, **Diesendorf**, **MacGill**

The elephant in the room – Climate Change

- Currently a lack of domestic and international progress, apparent loss of public and political interest and will
- Some key policies in process of being unwound
- … but even a dead elephant in the room is a problem

The Australian National Electricity Market



NEM in summary

(AER, *State of the Energy Market 2013*)

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	48 321 MW
Number of registered generators	317
Number of customers	9.3 million
NEM turnover 2012–13	$12.2 billion
Total energy generated 2012–13	199 TWh
National maximum winter demand 2012–13	30 491 MW[1]
National maximum summer demand 2012–13	32 539 MW[2]

Figure 1.5
Registered generation, by fuel source, 2012–13

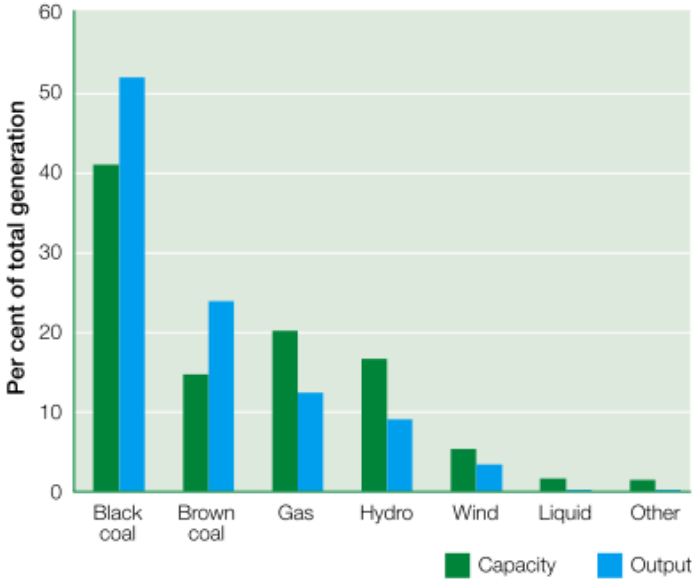
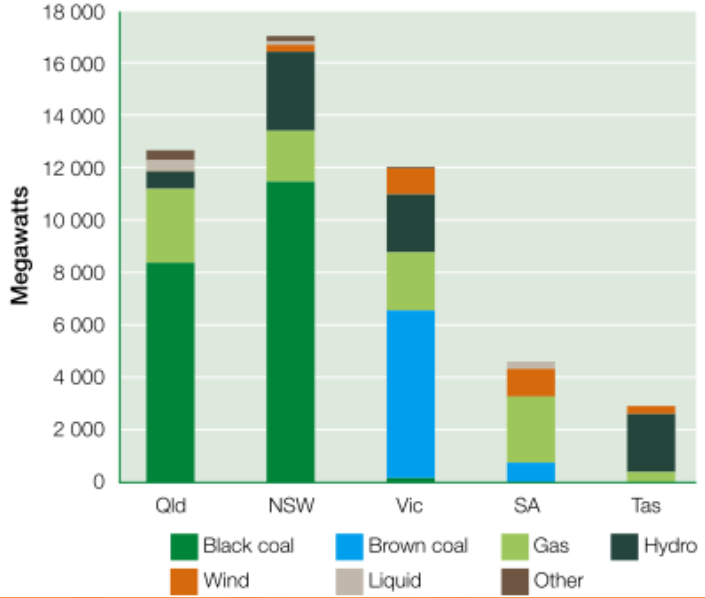
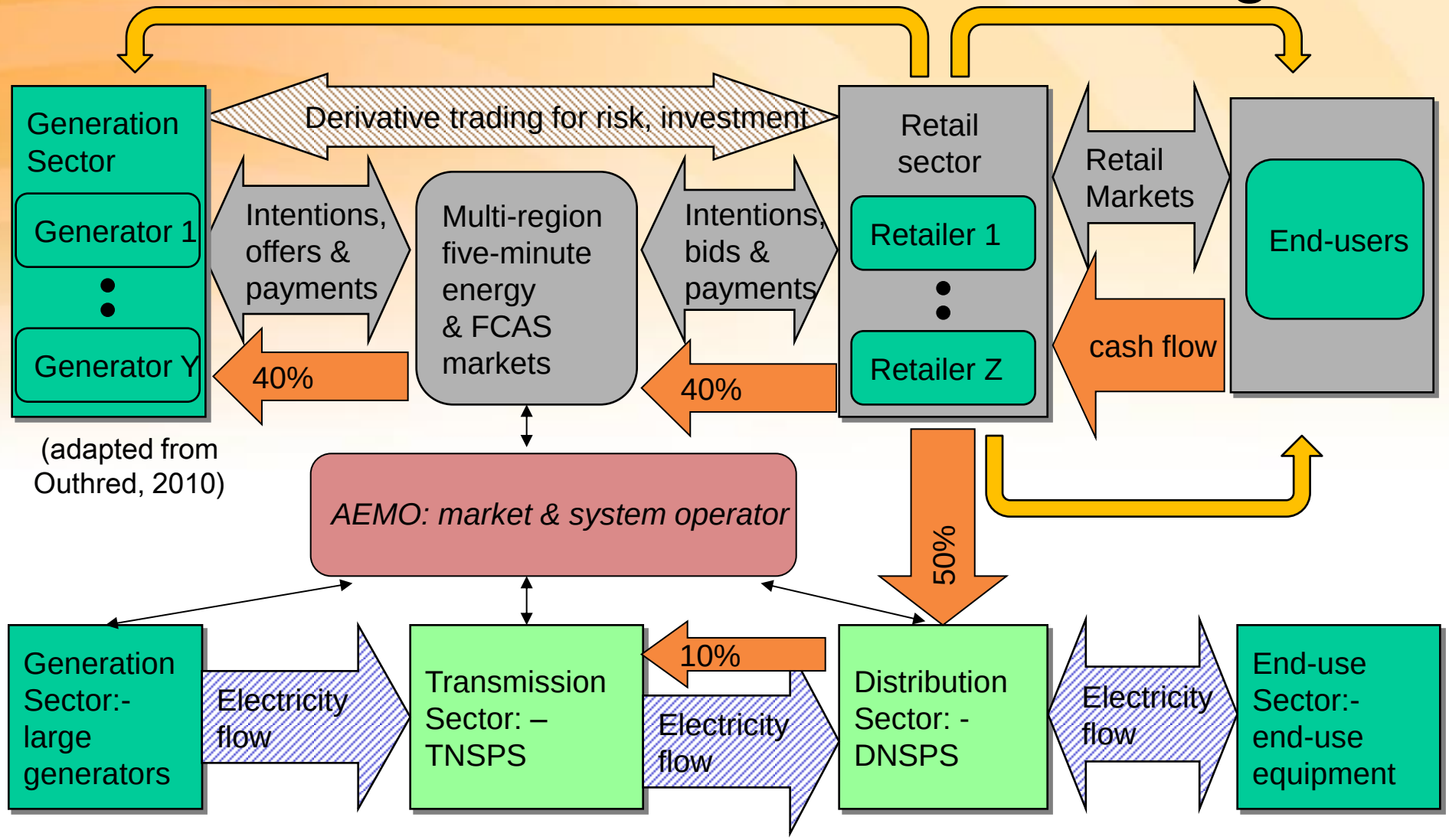


Figure 1.6
Generation capacity, by region and fuel source, 30 June 2013



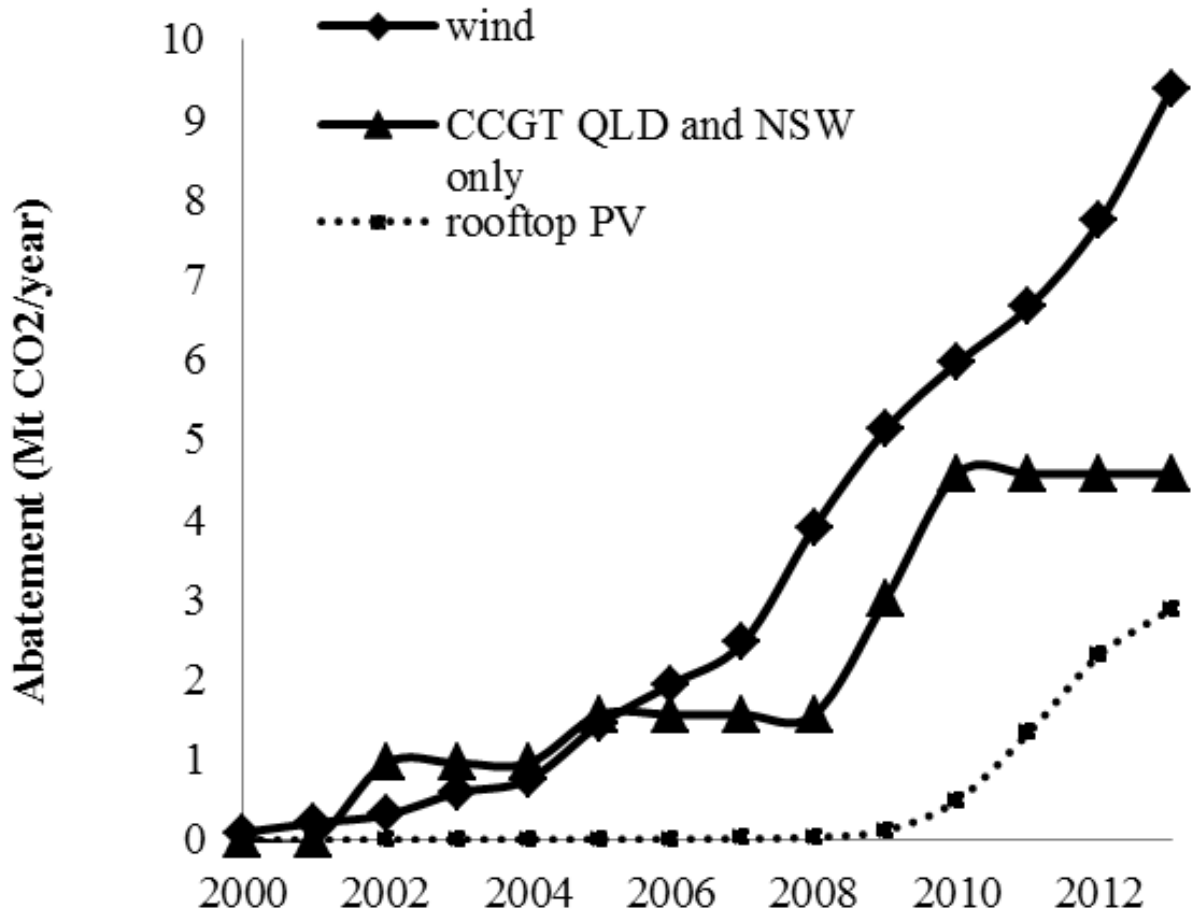
The Australian NEM – commercial regime



(adapted from Outhred, 2010)

(adapted from Outhred, 2008)

Some limited abatement success



(Elgin et al, *CEEM discussion paper*, 2014)

Many forecasts to choose from

NATIONAL ELECTRICITY FORECASTING REPORT

For the National Electricity Market

2013

EXECUTIVE SUMMARY

Annual energy

Electricity demand across the National Electricity Market (NEM) in 2013–14 is forecast to be 2.4% lower than estimated under the medium economic growth scenario in the 2012 NEFR.

Continued increases in rooftop photovoltaic (PV) systems and energy efficiency savings from new building regulations have offset growth in residential, commercial and light industrial annual energy.

Lower-than-expected growth in most industrial sectors reflects the closure of the Kurri Kurri aluminium smelter in New South Wales, changes in operating levels of Victoria's Wonthaggi desalination plant, and the Olympic Dam mine expansion deferral in South Australia. A high Australian dollar in recent years also contributed to the dampening in annual energy growth.

Under the same medium economic growth scenario, the 10-year outlook (2013–14 to 2022–23) sees annual energy forecast to grow by 1.3%.

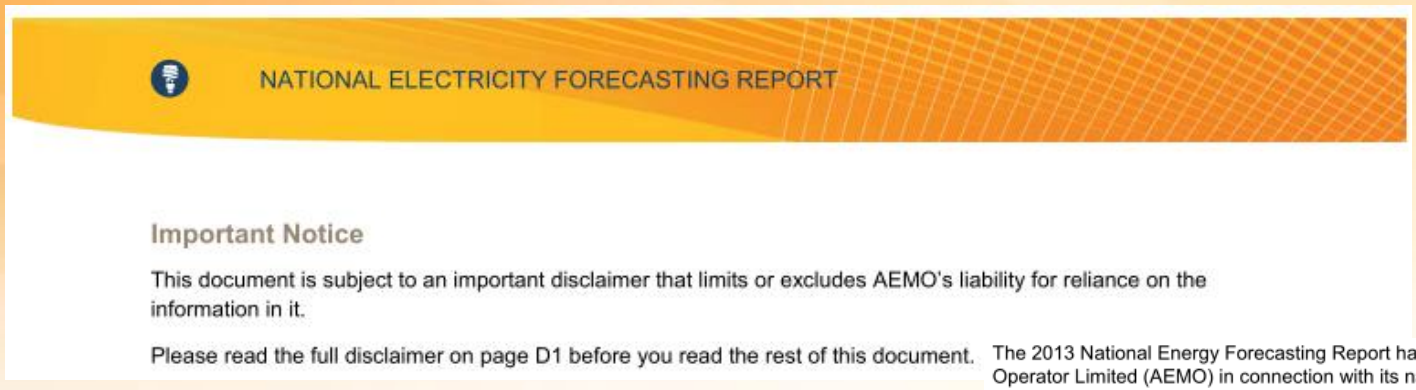
The main growth drivers over this period are the three large industrial liquefied natural gas (LNG) projects in Queensland, population growth in most NEM regions, and an easing in electricity price growth over the 10-year outlook period.

Maximum demand

Maximum demand (MD) forecasts see a combined 728 MW reduction across the NEM for 2013–14 under the medium economic growth scenario in the 2012 NEFR.

This is due to a rise in solar PV installations; increased energy efficiency projections as a result of building standards; and changes in industrial operations, including a revised timing of LNG and new mining projects, reduced operation at Wonthaggi desalination plant and the indefinite deferral of the Olympic Dam mine expansion.

The real executive summary of every technology forecast is the same



NATIONAL ELECTRICITY FORECASTING REPORT

Important Notice

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Please read the full disclaimer on page D1 before you read the rest of this document.

The 2013 National Energy Forecasting Report has been prepared by the Australian Energy Market Operator Limited (AEMO) in connection with its national transmission planning and operational functions for the National Electricity Market. The report is based on information available as at 3 April, 2013, unless otherwise specified.

Disclaimer

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AEMO has made every effort to ensure the quality of this report but cannot guarantee that the information, forecasts and assumptions in it are accurate, complete or appropriate for your circumstances. This report does not include all of the information that an investor, participant or potential participant in the National Electricity Market might require, and does not amount to a recommendation of any investment.

Anyone proposing to use the information in this report should independently verify and check its accuracy, completeness and suitability for purpose, and obtain independent and specific advice from appropriate experts.

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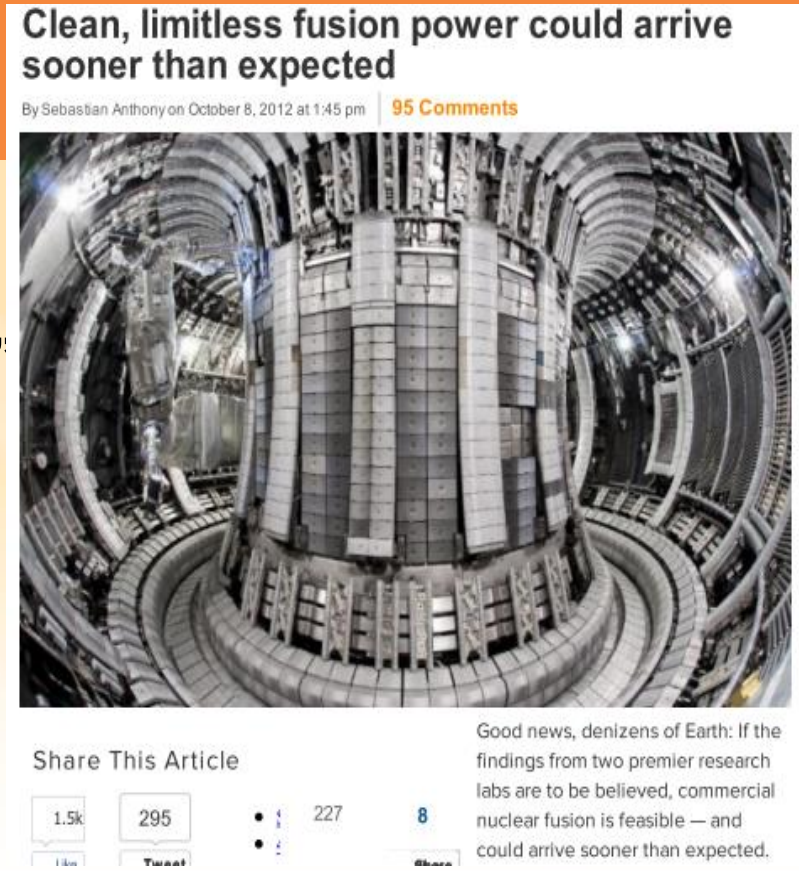
- are not liable (whether by reason of negligence or otherwise) for any statements, opinions, information or other matters contained in or derived from this publication, or any omissions from it, or in respect of a person's use of the information in this report.

Promising but still emerging energy technologies

- Don't always emerge
- Can emerge into a changed, no-longer appropriate context or may discover that the competition has left them behind
  - "A future technology whose time has passed"
- May be trying to enter a relatively low innovation context
- May actually be re-emerging
- May come from a surprising place, new players
- May not even be thought of as an energy technology
- May not actually add net societal value
- Might not emerge from 'standard' market competition
- May need government facilitation
- May well need government protection from incumbents

Fusion…. **or CCS?**

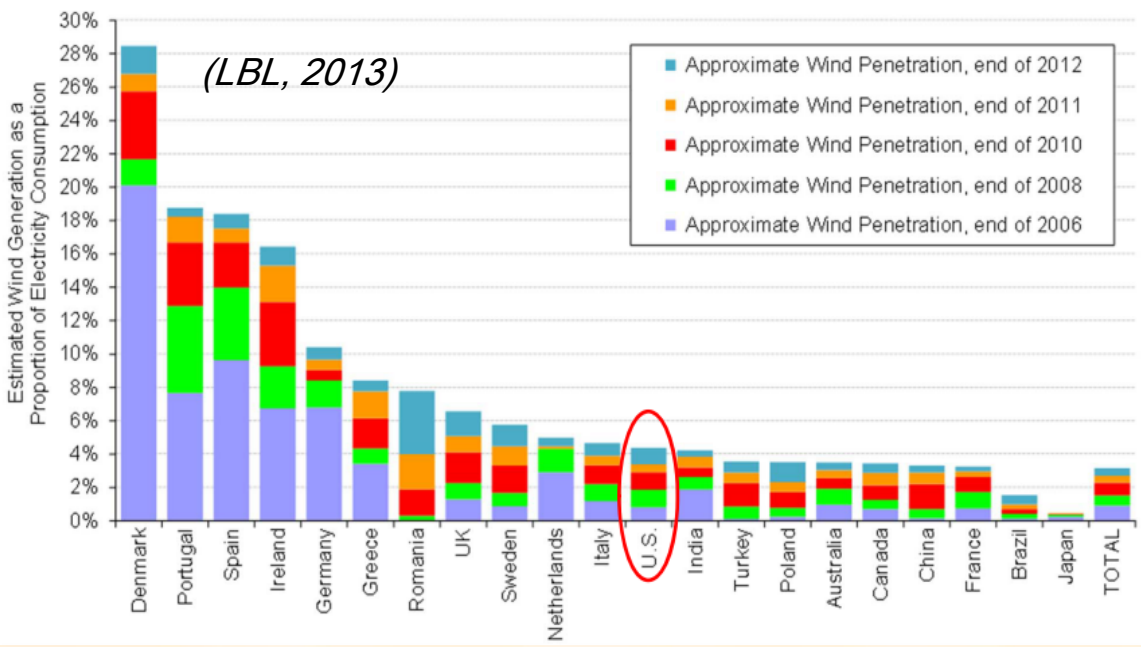
- Fusion “50 years away for 50 years”
- Progress not always an issue of $
- ITER – expected completion 2020 $20b, targeting 500MW for 1000s in 2027.. *&if it does work, so what?*

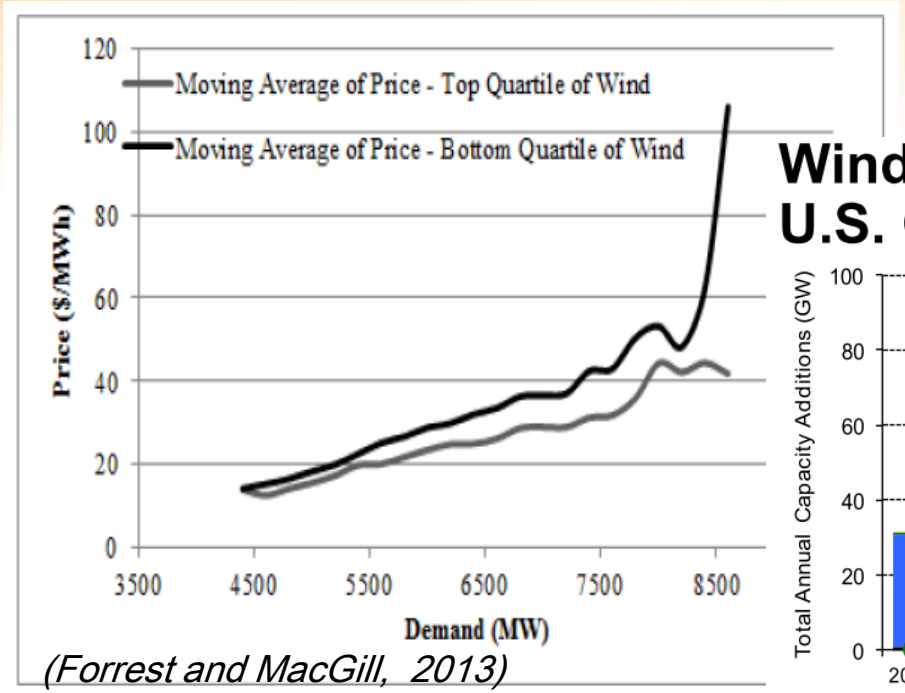


- CCS has also achieved surprisingly little success in Australia or Internationally over the past decade
  - *In Australia, approx. $500m of public funding on CCS to date with no abatement delivered yet*
  - *An inherent technology issue, or a question of the key stakeholders?*

Wind surprising ….

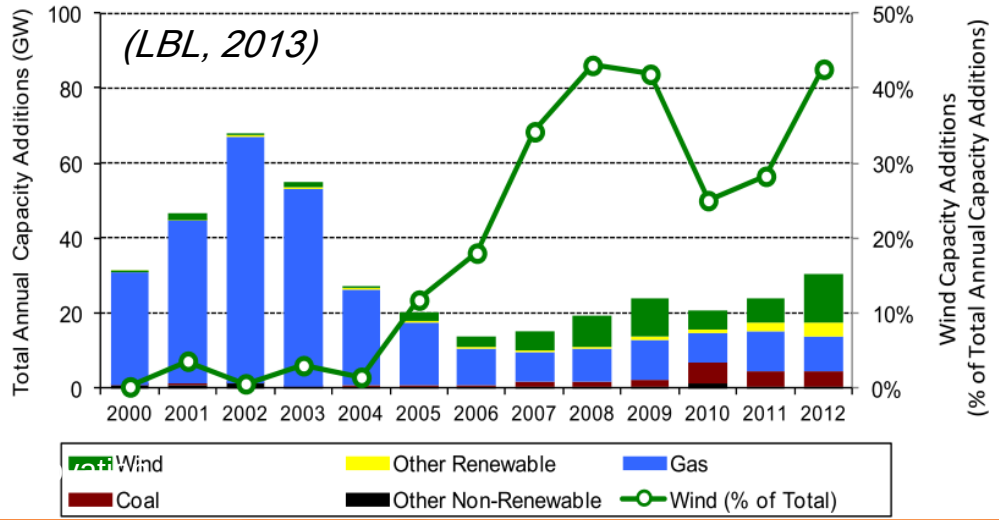
growing penetrations,
major investments
and proving a wholesale
market game changer
Australia now >3GW





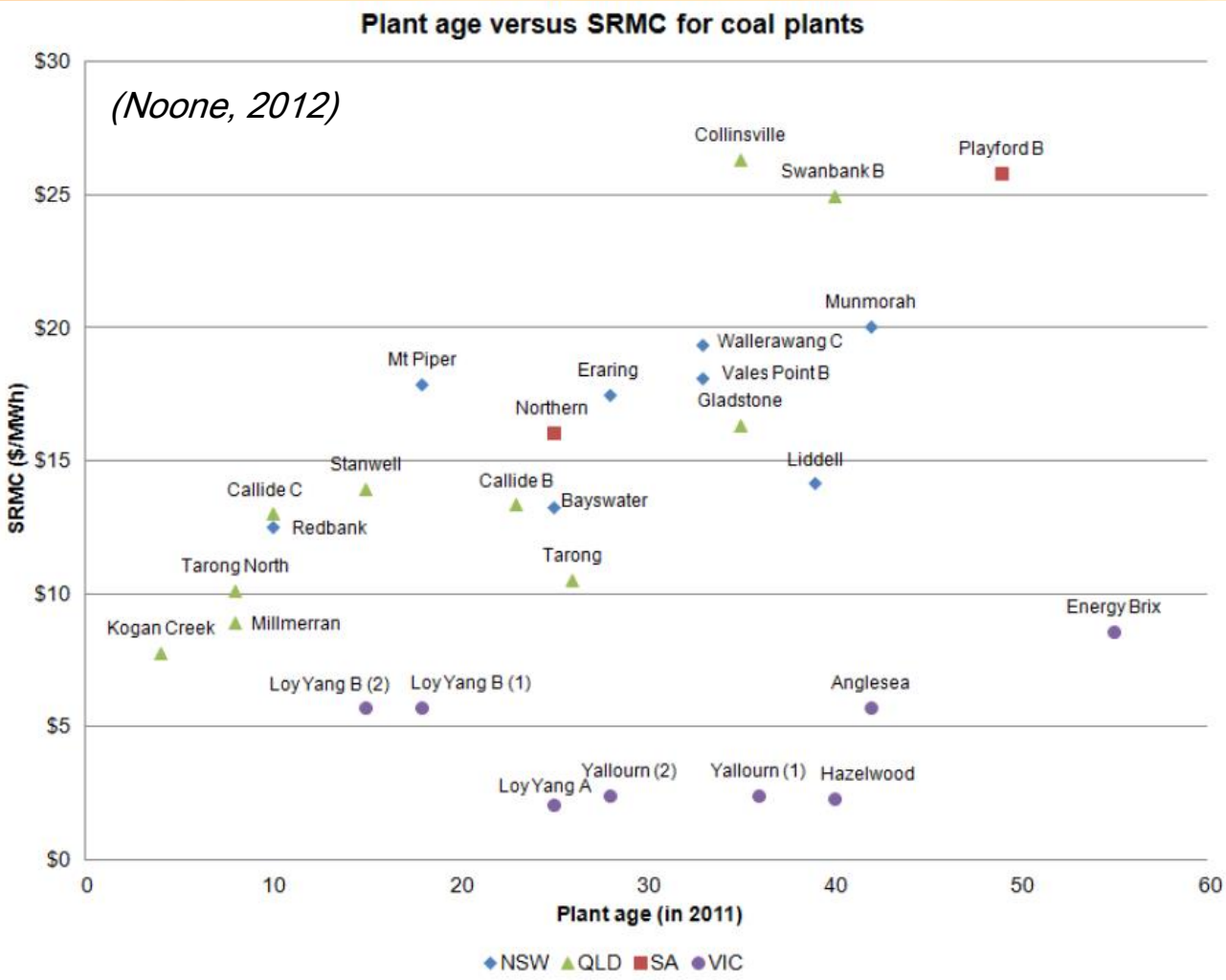
(Forrest and MacGill, 2013)

Wind Power Was the Largest Source of U.S. Generating Capacity Additions in 2012

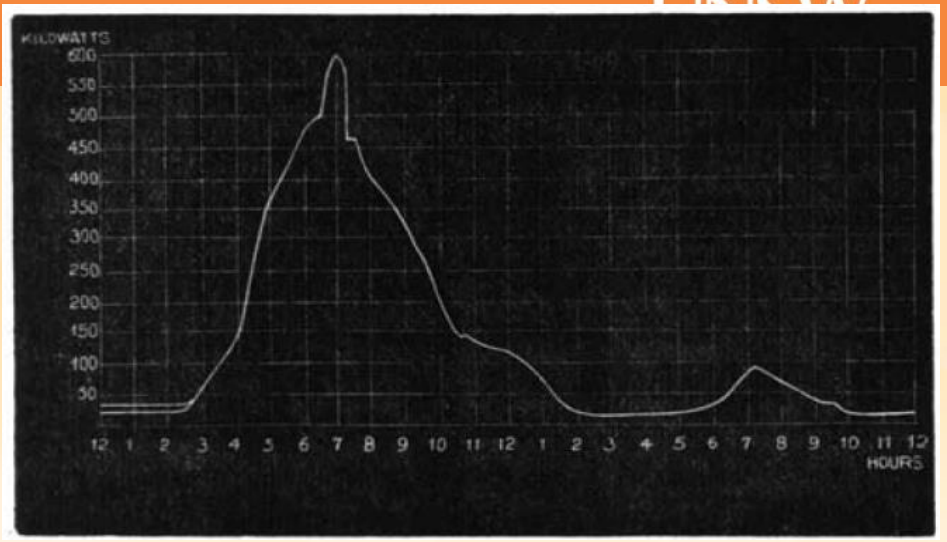


NEM coal plant old & cheap – an exit problem

- 'Steam punk' alive and well in the electricity industry – one of the few industries where 50 yr old technology still competitive



Nothing so new or even smart about smart grid



JOURNAL
OF THE
SOCIETY OF
Telegraph-Engineers and Electricians.

Founded 1871. *Incorporated* 1883.

Vol. XVII. 1888. No. 73.

The One Hundred and Seventy-seventh Ordinary General Meeting of the Society was held at the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday, April 12th, 1888—Mr. Edward Graves, President, in the Chair.

The minutes of the previous meeting were read and approved.

The names of new candidates were announced and ordered to be suspended.

Donations to the Library were announced as having been received since the last meeting from Messrs. J. B. Baillière et Fils; Messrs. De La Rue & Co.; C. H. W. Biggs, Member; and R. H. Krause, Member; to whom the thanks of the meeting were heartily accorded.

The following paper was then read:—

CENTRAL STATION LIGHTING: TRANSFORMERS *V.* ACCUMULATORS.

By R. E. Crompton, Member.

The present paper is the outcome of the discussion which took place on Messrs. Kapp's and Mackenzie's papers on transformers, recently read before this Society. I was asked to give facts and figures in support of the statement I then made, that I believed the distribution of electricity by transformers offered no special advantages over other methods, particularly over distribution by means of accumulators used as transformers.

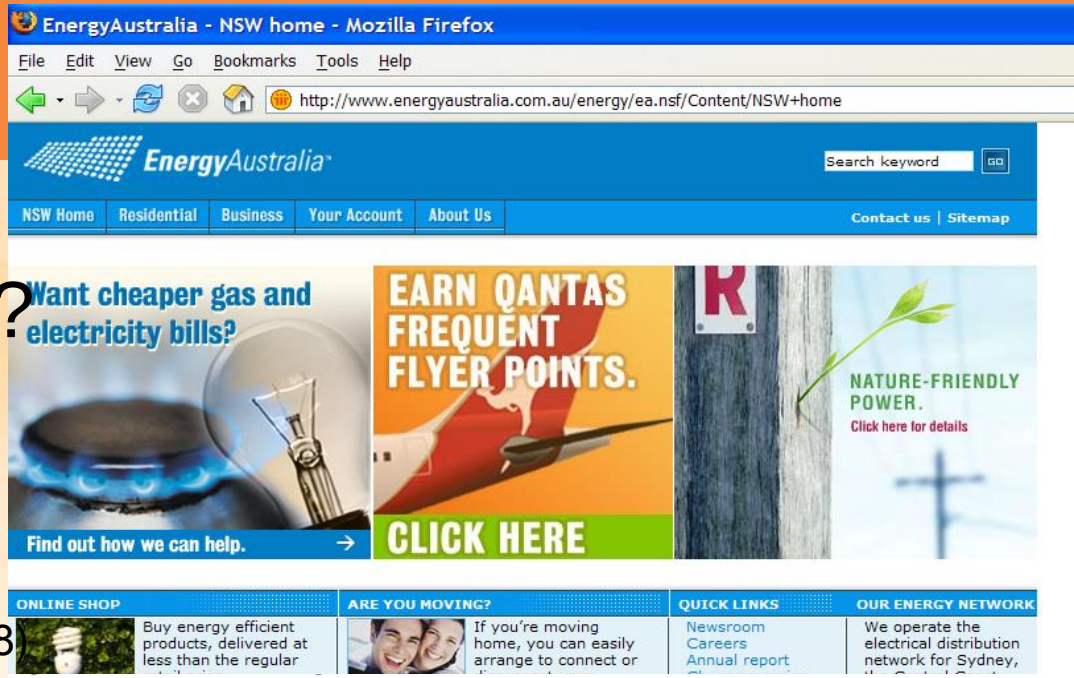
Cost of 10,000 Light, or 600-Kilowatt, Plant.

A.T.—Alternating Transformer Distribution.	£
Generating Station, Buildings, Chimney Shaft, Water Tanks, and General Fittings	11,000
Dynamos and Exciters — 865 Kilowatts, including spare sets, divided as convenient ...	5,540
Motive Power, *i.e.*, Engines, Boilers, Steam and Feed Connections, Belts, &c., at £8 12s. per I.H.P.	12,470
500 Transformers, *i.e.*, one to every pair of houses, at £15 each	7,500
2,000 yards Primary or Charging Main, exterior to area of supply, at £308 per 100 yards	6,160
20,000 yards Distributing Main, 50 m/m. sectional area, at £91 7s. (*see* Table 1)	14,270
Regulating Gear	500
	£57,440

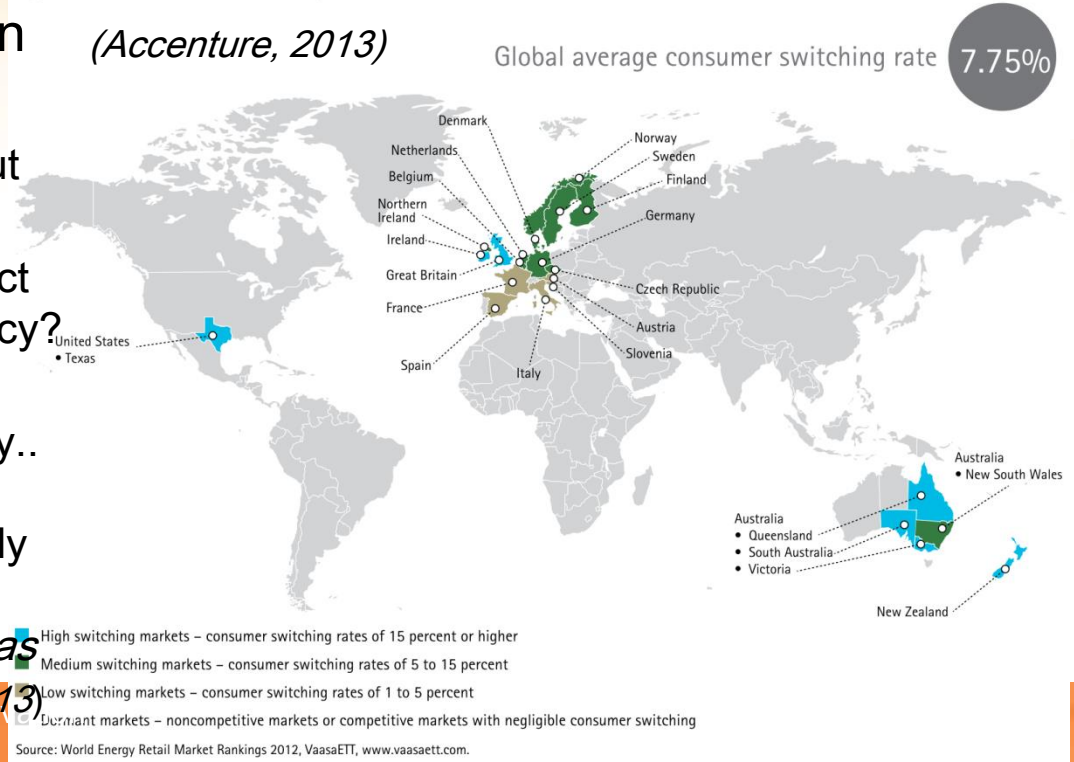
B.T.—Accumulator Transformer Distribution.	£
Generating Station, Buildings, Chimney Stack, Water Tanks, and General Fittings	8,000
Dynamos — 600 Kilowatts, in 6 sets of 100 Kilowatts each...	4,800
Motive Power, *i.e.*, Engines, Boilers, Steam and Feed Connections, &c., at £8 12s. per I.H.P.	8,600
4 Groups of Accumulators, in all 240 cells, in series, at £40 per cell, including Stands ...	9,600
2,000 yards Charging Main, at £306 17s. 6d. per 100 yards (*see* Table 2)	6,137
20,000 yards Distributing Main, 161·25 m/m. sectional area, at £100 12s. 6d. (*see* Table 2) ...	20,125
Regulating Gear	2,500
	£59,762

Innovation through competition: retail mkts?

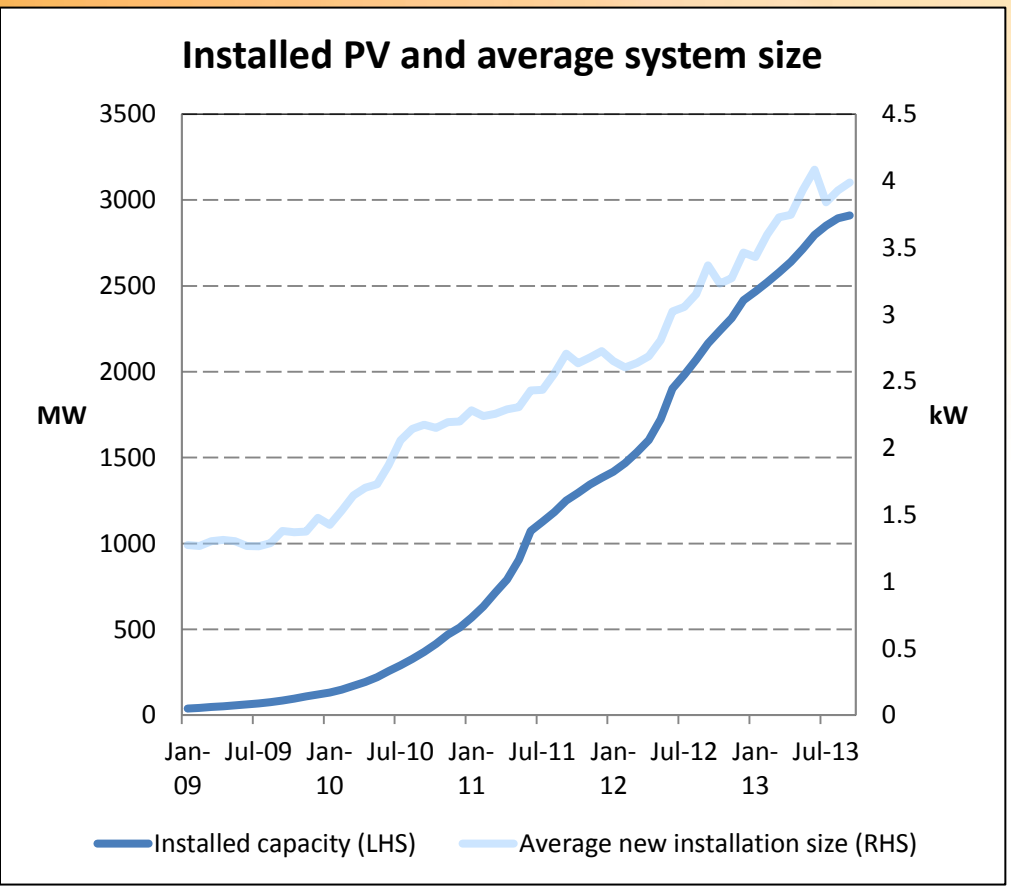
- Little focus on energy services
  - "… an important reason there is effective competition in Victoria is .. because the provision of energy is viewed as a homogenous, low engagement service" (AEMC, 2008)
- Current measures of competition might miss key issues
  - Yes, NEM high switching rates – but real customer choice or just churn?
  - Yes, NEM price spreads – but reflect competition, stickiness, or govt policy?
  - "The thing about the energy retail market is it's effectively an oligopoly.. There are a small number of large players—three—who are effectively providing a commodity." *Jim Myatt, founder of Australian Power and Gas on its sale to AGL (crikey.com.au, 2013)*



(Accenture, 2013)



Some real retail competition - PV

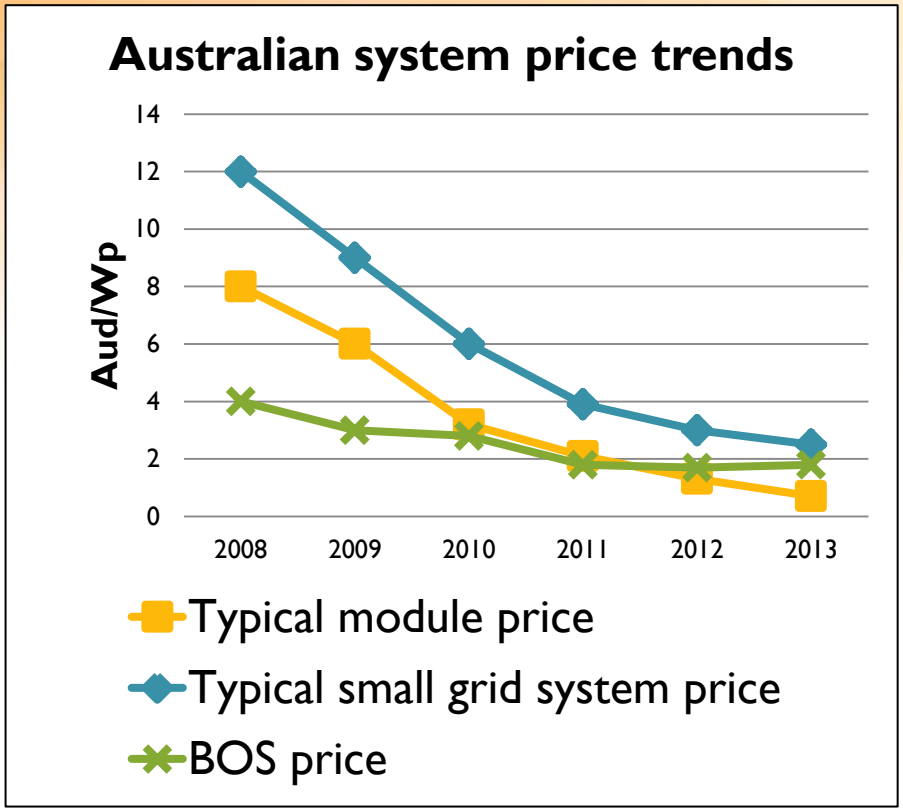


(Noone, 2013)

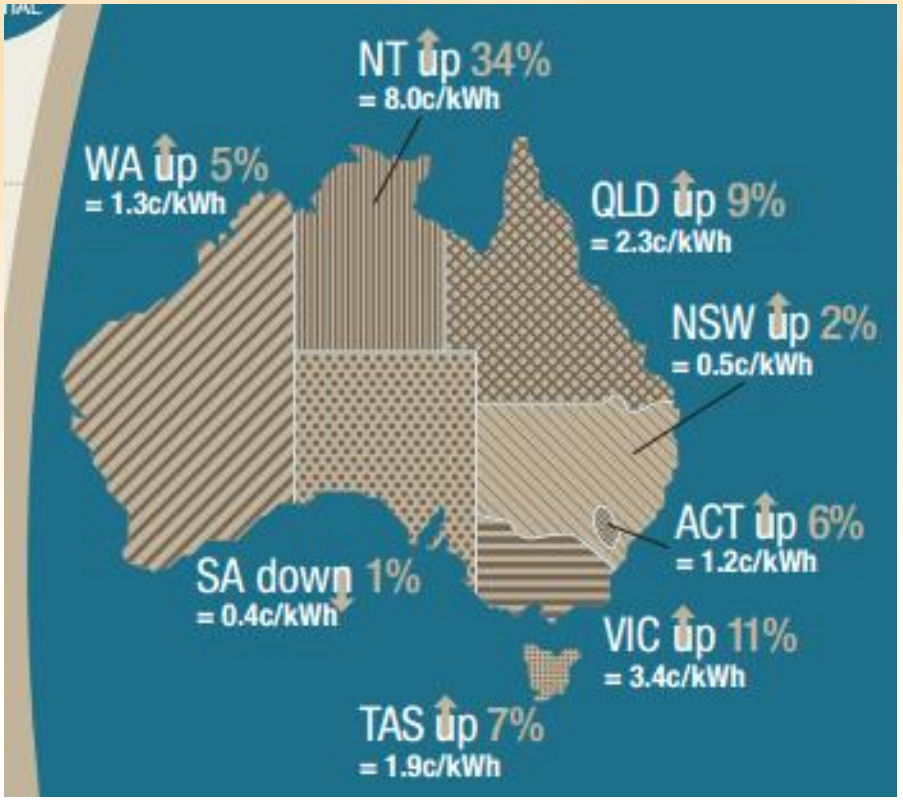
State	#systems	Capacity (MW)	Proportion of dwellings with Solar Power
ACT	14,000	38	10%
NSW	252,000	633	10%
NT	3,000	11	4%
QLD	360,000	986	22%
SA	160,000	450	25%
TAS	18,000	55	9%
VIC	201,000	532	10%
WA	149,000	334	18%
National	1,157,000	3,039	14%

(from www.reneweconomy.com.au)

Market drivers now key in driving uptake



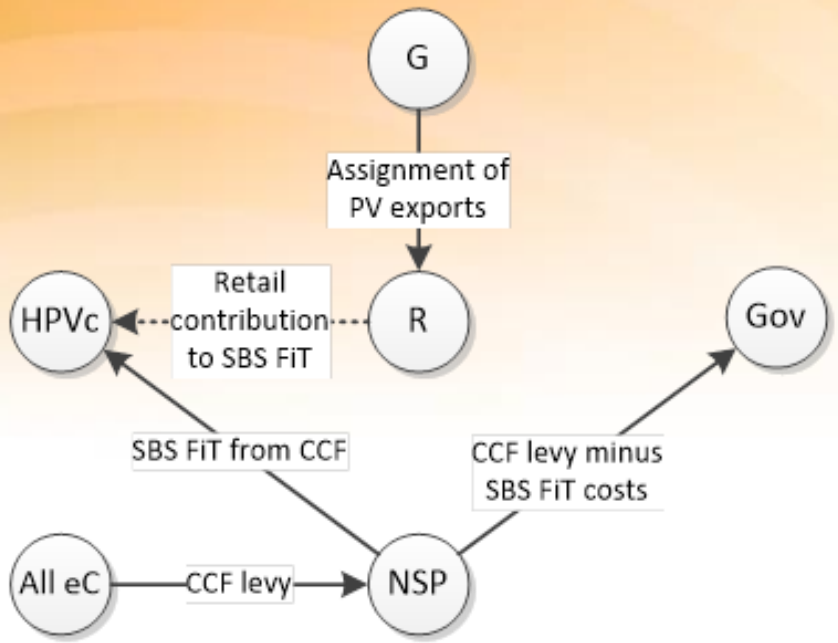
(APVI, 2013)



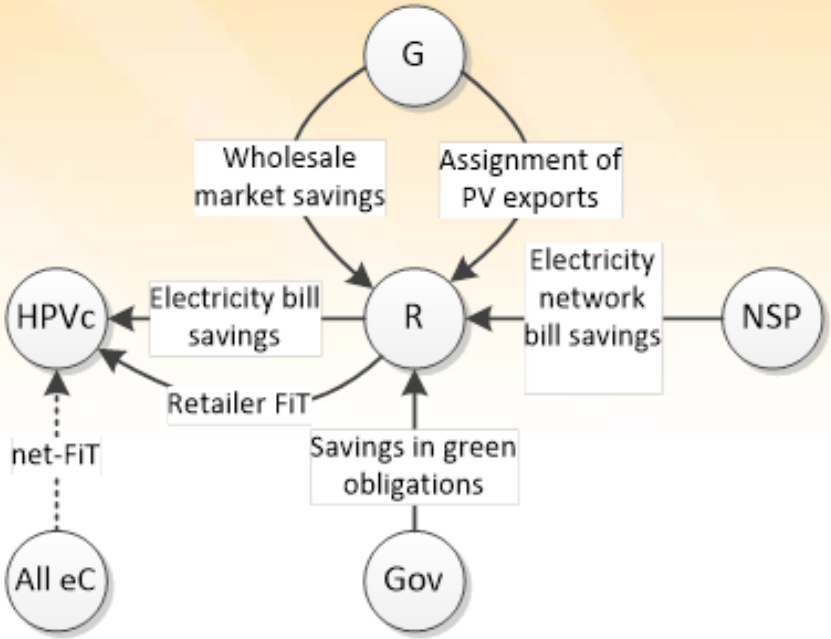
(AEMC,2013)

Market frameworks – follow the money

Cash flows due to addition of PV under GM



Cash flows due to addition of PV under NM

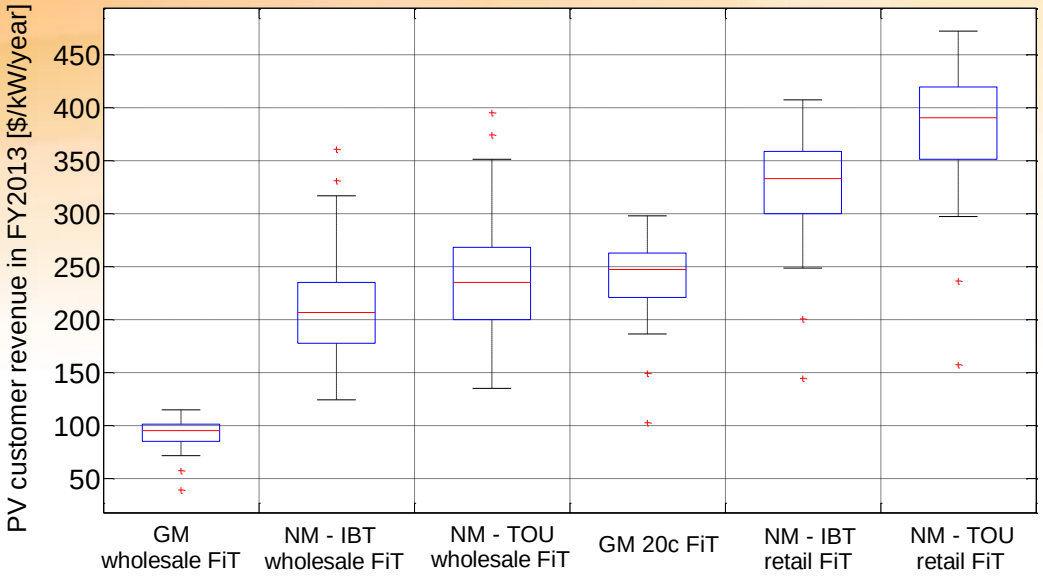


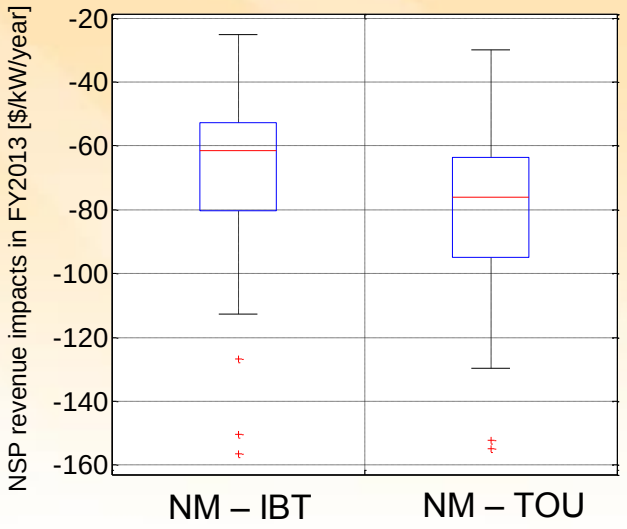
HPVc: Household PV customers
R: Electricity retailers
NSP: Network service providers

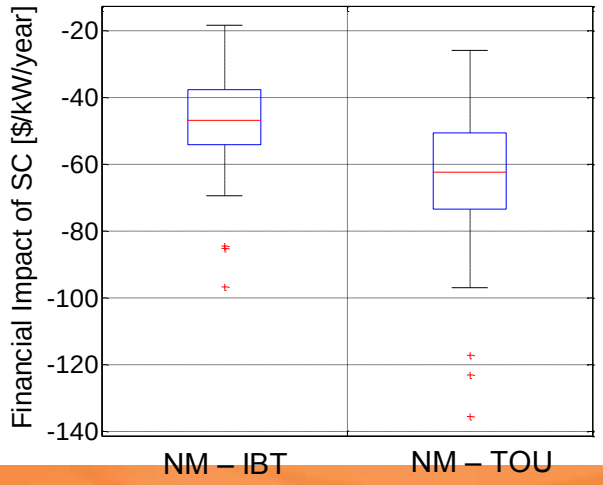
G: Generators
Gov: NSW government
All eC: All electricity customers

(Oliva et al, 2014)

Impacts on networks, retailers







(Oliva et al, 2014)

In response…

"Hundreds of thousands of WA households could be hit with higher electricity prices under a proposed shake-up of bills aimed at recovering the massive cost to the system caused by the popularity of rooftop solar panels.

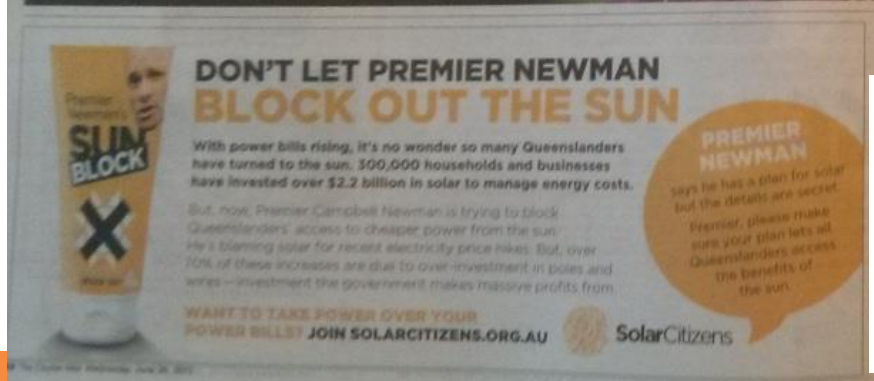
WA's energy chiefs are understood to be pushing for a change in the structure of bills to make customers pay more in fixed charges.

At present, most of a householder's electricity bill stems from the amount of electricity used. Fixed costs, such as the supply charge, make up about 15 per cent of the bill. However, solar panels have slashed consumption for those households, cutting revenue to State-owned power companies, including retailer Synergy and network operator Western Power.

The trend has been highlighted as one of the big issues facing the electricity system and Energy Minister Mike Nahan has been warned that if nothing is done the consequences could be catastrophic.

Either households without solar panels would be left to pick up the tab, forcing their bills to unaffordable levels, or electricity providers would be financially crippled.

WA's take-up rate of photovoltaic cells - initially fuelled by generous State and Federal incentives - stands at more than 10 per cent of households and this figure is expected to double within years." *(West Australian, 2013)*



(Solar Citizens, 2013)

Table 1: Tariff 11 – Bill Impacts for the Typical (Median) Customer

Tariff Component	*Frozen 2012-13*	*Transitional 2013-14*	*Increase*
Fixed charge (cents/day)[1]	26.170	50.219	*91.9%*
Variable charge (cents/kWh)[1]	23.071	26.730	*15.9%*
Annual Bill[2] ***($, GST inclusive)***	***1,184***	***1,451***	***22.6%***

1. GST exclusive.
2. Based on a typical (median) customer on Tariff 11 consuming 4,250kWh per annum.

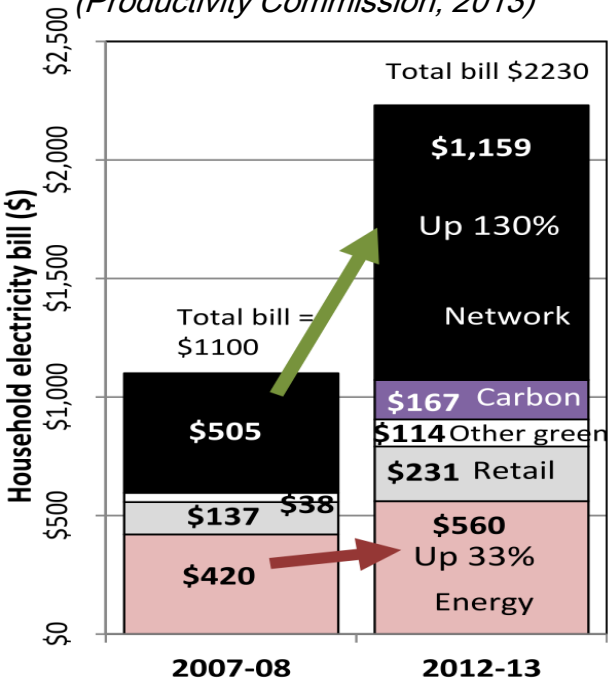
(QCA, 2013)

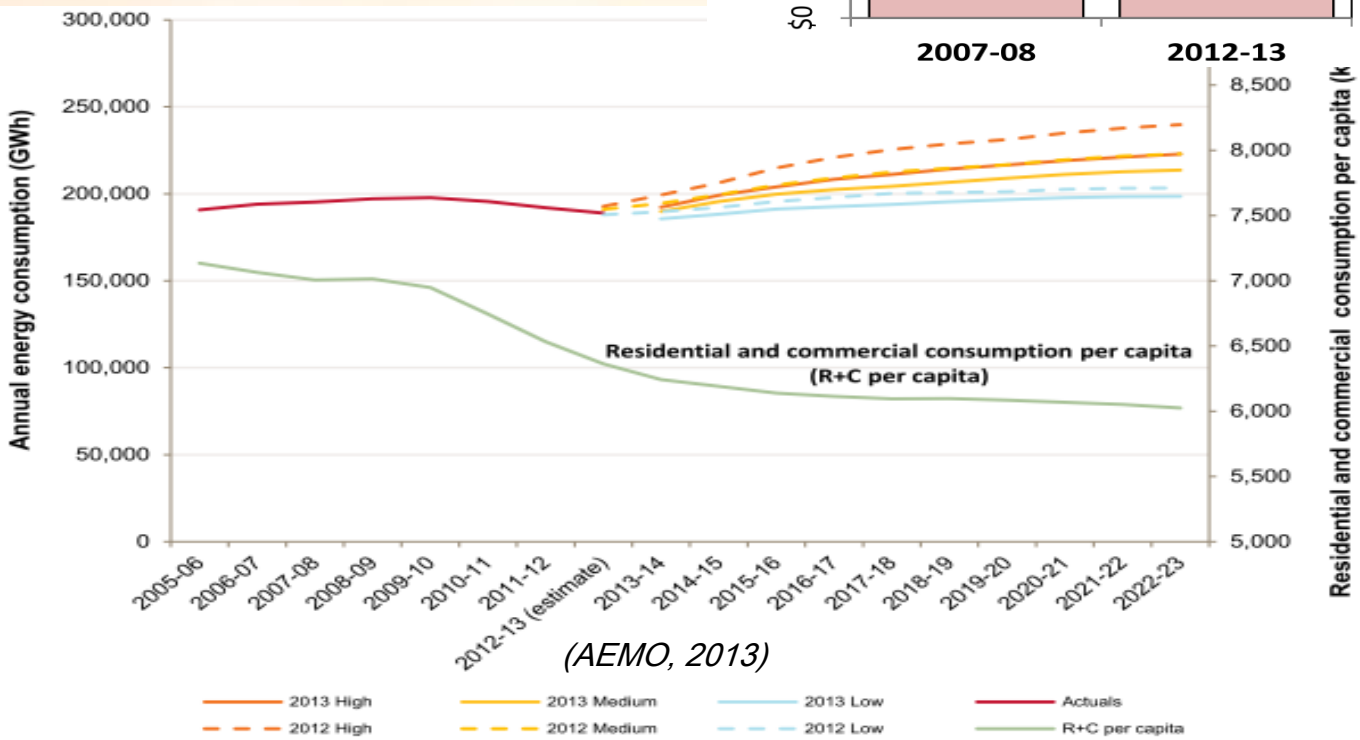
A disruptive energy technology - the heat pump

- Driving peaks (air-conditioning) and hence network expenditure
- Reducing energy consumption (200-400% efficient hot water systems)

New South Wales household electricity bill 2007-08 and 2012-13

(Productivity Commission, 2013)





(AEMO, 2013)

‘death spiral’?

Argued that rising prices encourage end-users to reduce consumption or even leave, meaning fixed costs have to be recovered from less and less consumption and/or customers

History repeats?

Savings from demand reduction depend critically on energy/network tariffs

End-user departure depends critically on DG technology progress, particularly storage

More of an issue for electricity or gas?

(via google news archive)

Thursday, August 4, 1983 — THE NEWS — Page 7A

Utilities grapple new enemy: a rate increase ‘death spiral’

By Jack Danforth
Orlando Sentinel

TACOMA, Wash. — There is a new buzz word surfacing in Pacific Northwest electric utilities these days. It is the "death spiral." The concept is simple, and consumers of electric power from Florida to Alaska have recognized it for years.

A death spiral occurs during periods of rising electric rates. The theory is that as electricity demand increases, electric utilities are forced to build expensive new power plants.

This causes electric rates to rise and consumers to use less power. Electric utilities have large fixed costs, so as demand — thus revenue — is reduced, rates must be increased again, causing further reductions in consumption, and the cycle is repeated: a death spiral.

The recent collapse of the Washington Public Power Supply System, also known as Whoops, has focused attention on the death spiral. In this region, electric rates for some utilities have tripled during the past three years.

The increases and the Whoops collapse have forced utilities, for the first time in the industry's history, to come to grips with the possibility that they have reached the limits of their customers' pocketbooks.

It long has been known that there is a finite amount of money available in the family budget for the electric bill. Consumers have different limits, but when taken as a whole there clearly is an economic wall that electric utilities cannot go past.

For the past 30 years, energy prices have been so low and relative incomes so high that the "wall" was far

alternative sources: gas-fired fuel cells, photovoltaic cells and a more efficient end-use of conventional resources, all of which are distinct possibilities within the next decade.

The old days of building more power plants regardless of the cost are gone. Utilities that continue that philosophy ultimately will be priced out of the market.

Conservation still is a vital cog in our energy policy of the 1980s. It is a dangerous oversimplification to say that conservation at a time of surplus energy only further reduces utility revenues, thus causing higher rates.

Programs as simple as the rebate program in Kissimmee, Fla., are one of the most cost-effective methods of stimulating energy efficiency in the country.

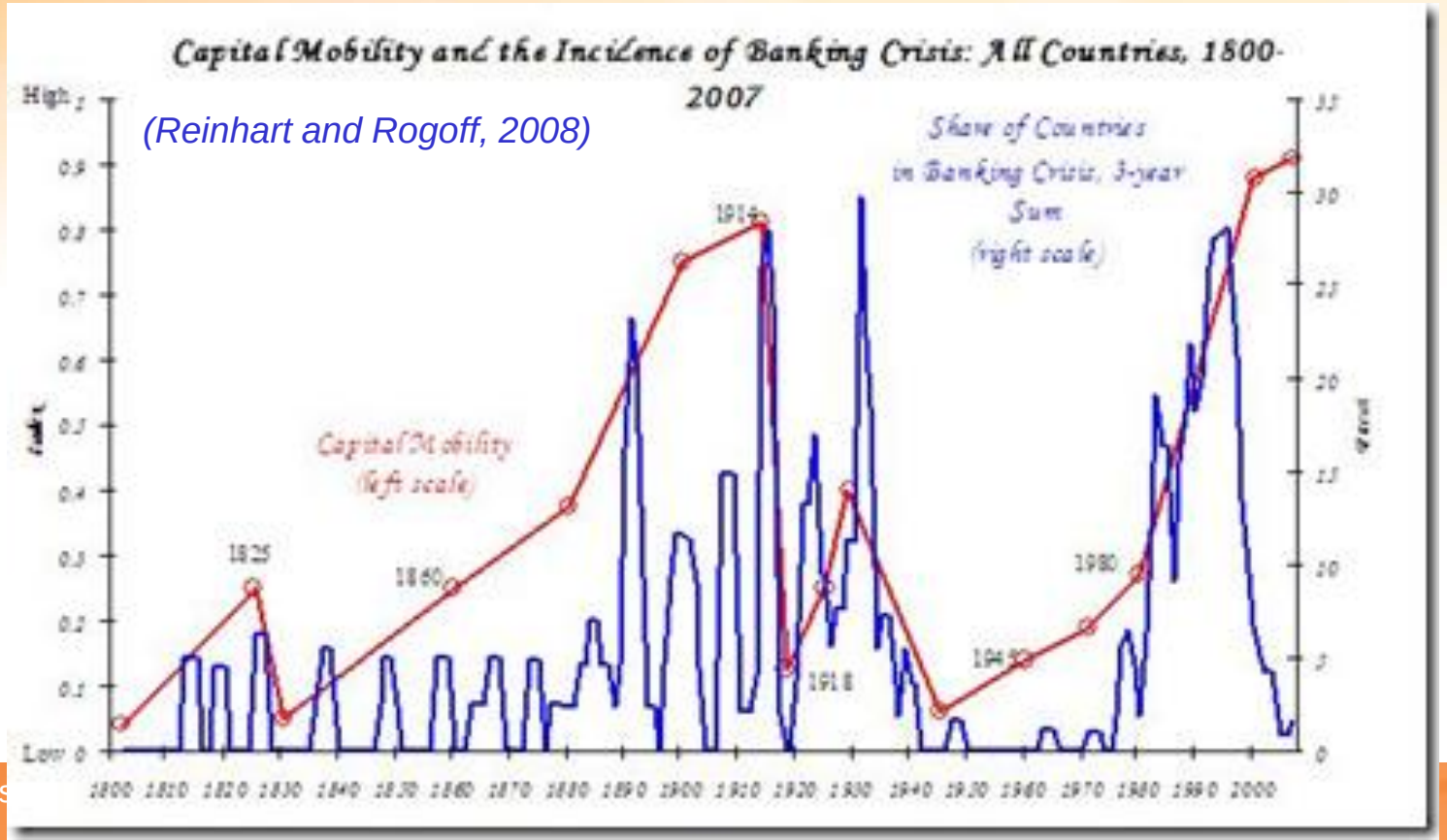
The rebate program concept originated there in 1981 and now is being used successfully by such major utilities as Pacific Gas & Electric in California. In these programs, utilities help customers pay the cost of conservation improvements, which is cheaper than building another expensive plant.

But consumers must understand that it is not a contradiction to promote more use of electricity, more industry and conservation at the same time. In many areas, thousands of kilowatts of electricity are available during off-peak times without building another plant. That results in a lower average cost of energy production.

There are times, of course, in a growing economy, when a new generating plant must be built. But that should not be done until the utility has explored all the cheaper alternatives — conservation and helping industries generate their own power from wasted

Is innovation always socially useful

- *Q: Is 'reform' always a good thing? A: Yes, by definition*
- Certainly possible to have socially –value energy 'innovation' as seen with socially damaging financial 'innovation' in GFC



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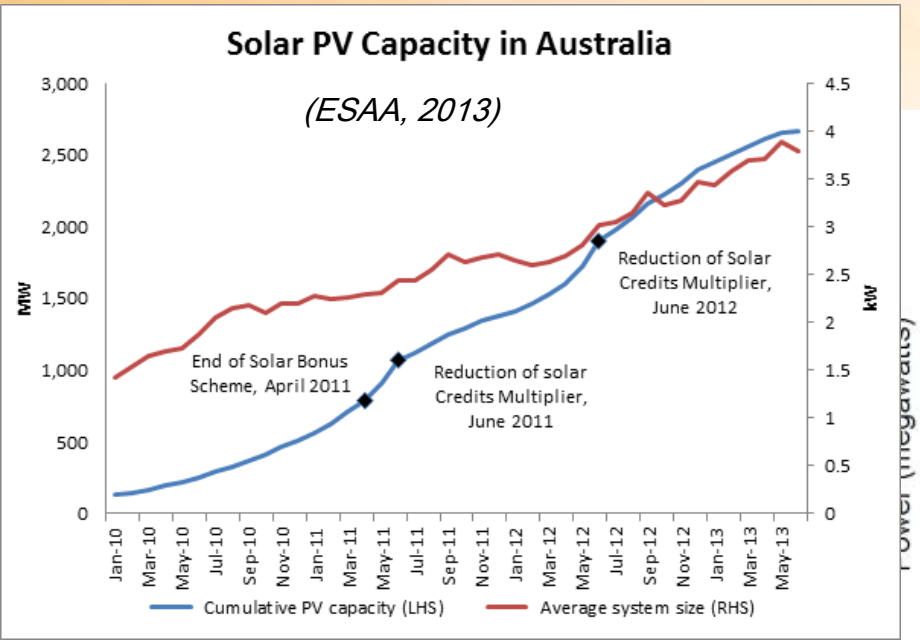
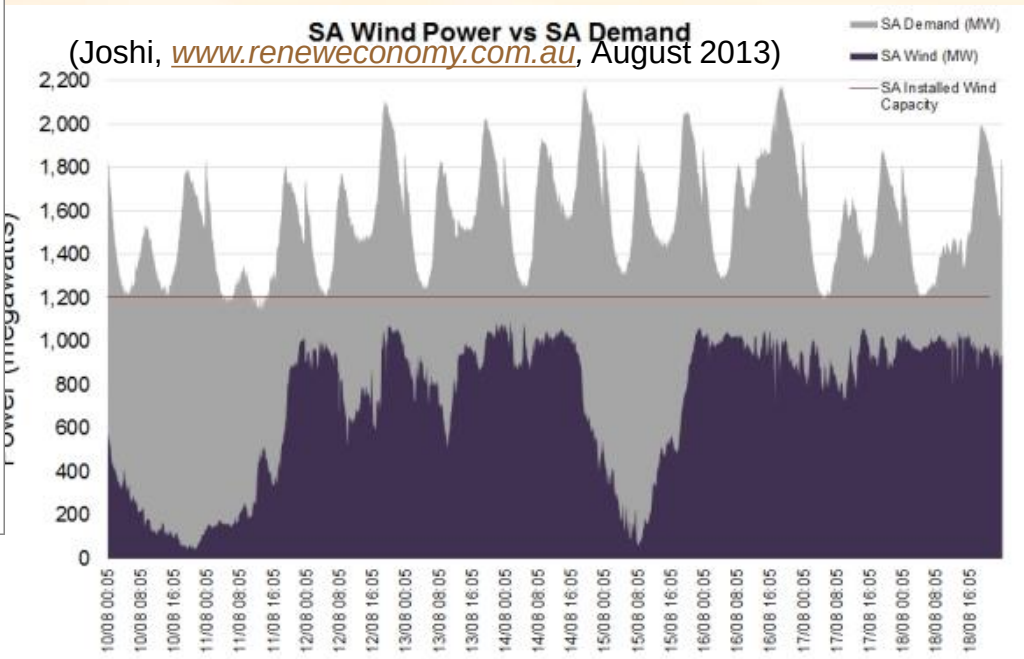
Where next for the NEM?

RE now shaking up existing arrangments

Energy source	South Australia registered generation capacity		Electricity generated in 2012–13 by energy source	
	Megawatts (MW)	Percentage of total	Gigawatt hours (GWh)	Percentage of total
Gas	2,672	50%	6,786	52%
Wind	1,203	23%	3,483	27%
Coal	770	14%	2,238	17%
Rooftop PV[a]	400	7%	497	4%
Diesel	270	5%	12	<1%
Landfill methane/ landfill gas	16	<1%	55	<1%
Hydro	3	<1%	6	<1%
Total	**5,334**	**100%**	**13,077**	**100%**

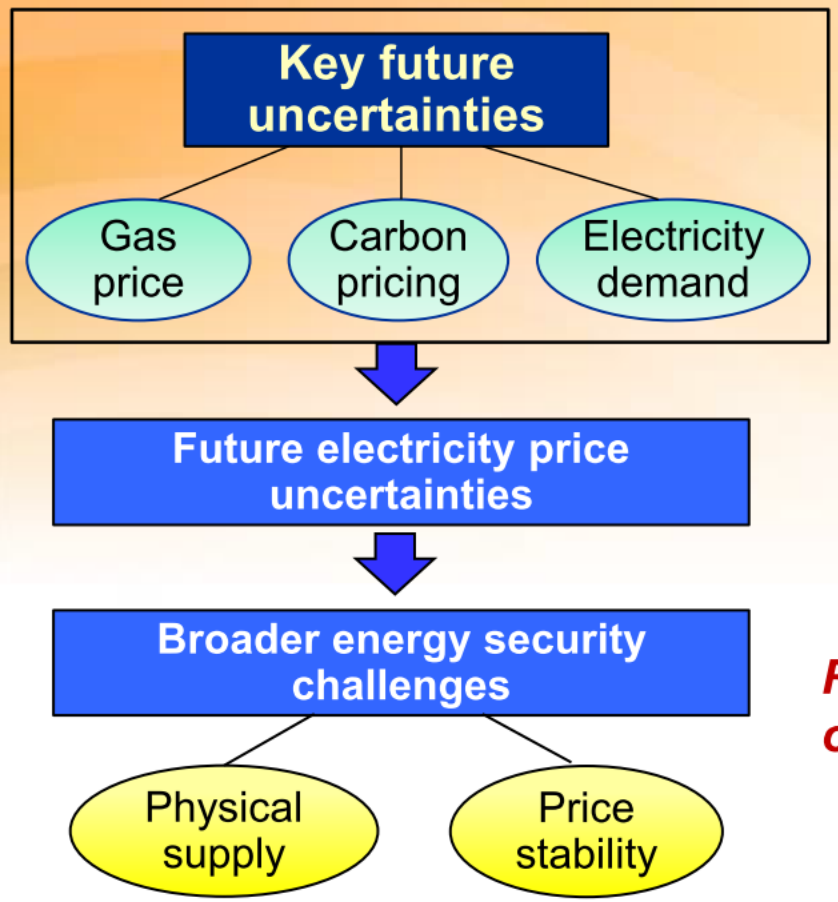
(AEMO, SA Report, 2013)





Data sourced from the AEMO MMS Database: [DISPATCH_UNIT_SCADA] & [DEMAND_AND_NONSCHEDGEN] from [DISPATCHREGIONSUM]
5-Minute Resolution using DUID expressing intial generation at beginning of Dispatch Interval
Summarised using AEMO Registration/Exemption listing
Ketan Joshi - Research/Communications, Infigen Energy. Twitter :@ArghJoshi or @Infigen

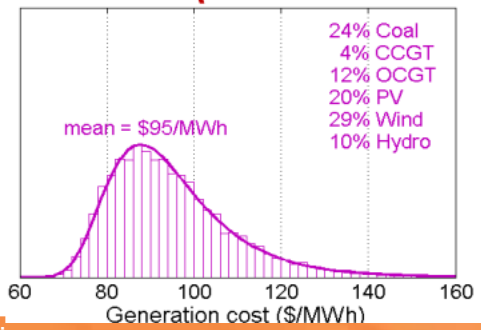
High uncertainty in what happens next?

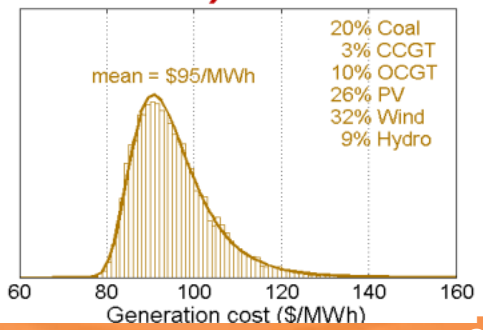


(Vithayasrichareon et al, *IEEE PES*, 2013)

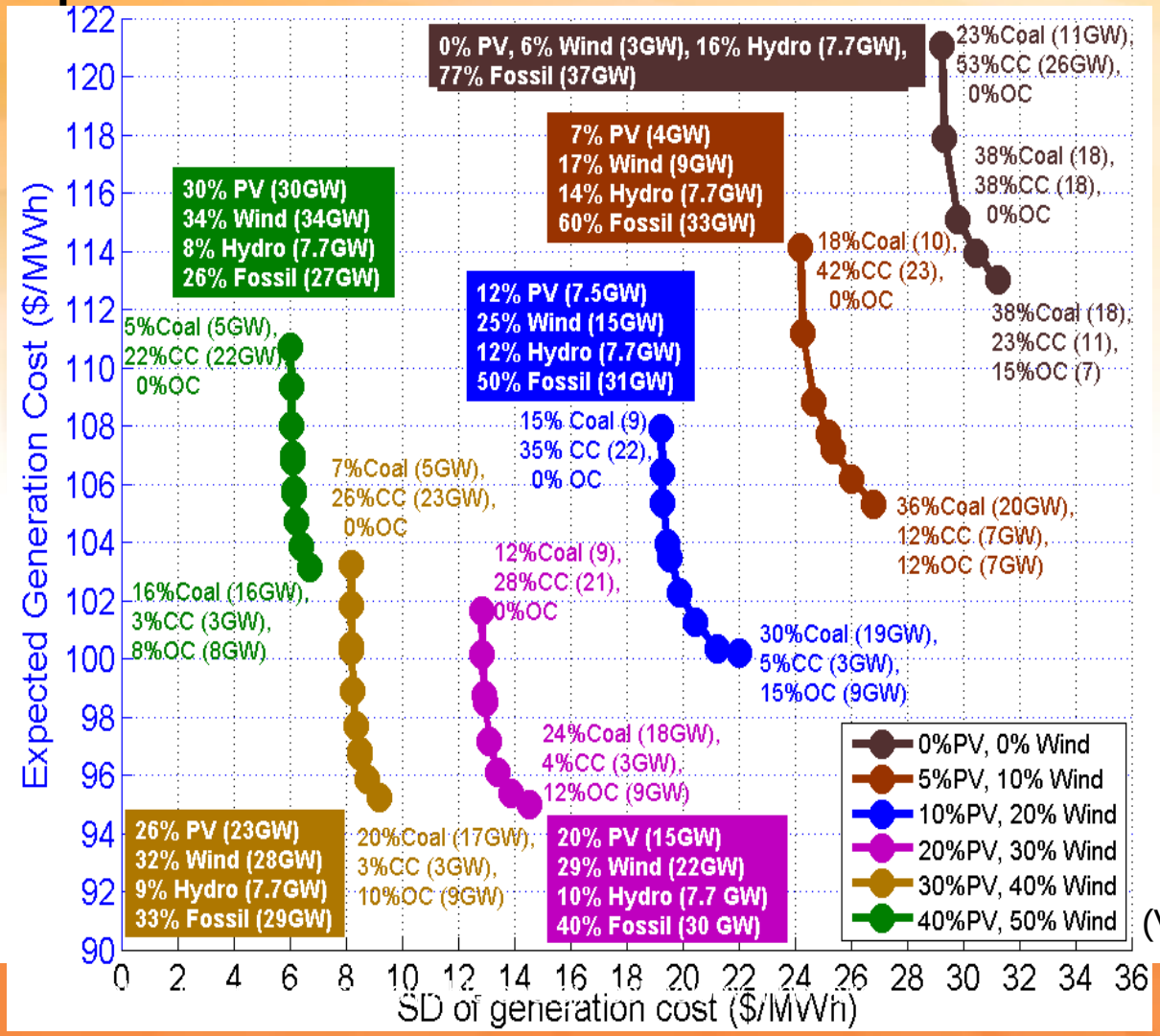
- Uncertainty poses a significant challenge for generation investment and planning.
- Uncertainty leads to *Risk*
  - *the likelihood of unexpected high costs*
- Investment in a certain generation fleet can expose to external price risk
  - *Renewables potentially offer some low risk alternative!*

Risks can be quantified by spread of possible outcomes (i.e. standard deviation)





RE a valuable approach to manage gas and carbon price risk for carbon intensive, now high $ gas NEM



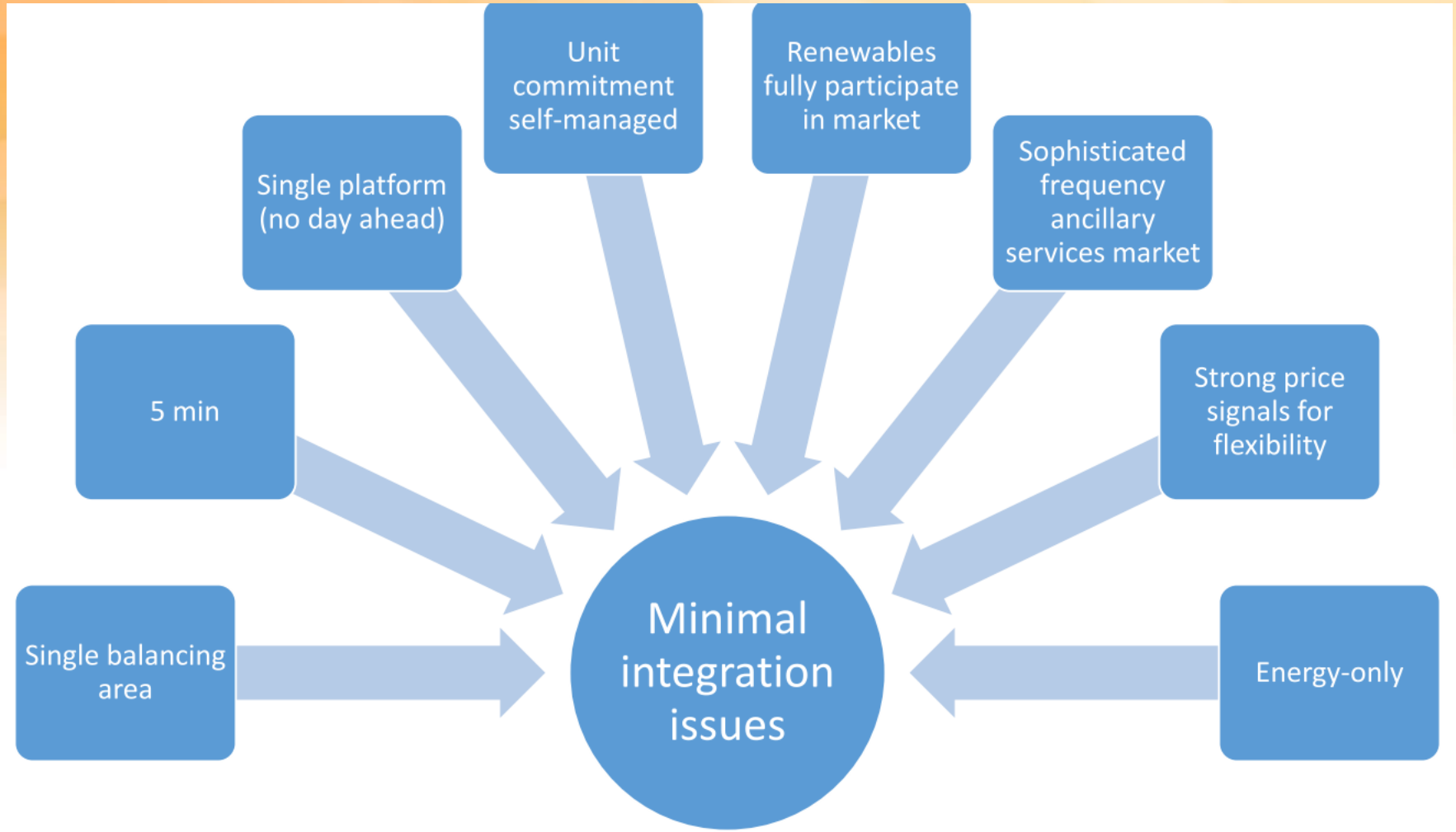
Cost VS cost risk Efficient frontier (EF) containing optimal portfolios

Reductions in both ***expected cost and cost risk (SD)*** as RE increases from 0% to 50%

(Downward movement of EF) Further risk reductions possible with higher RE penetrations.

(Vithayasrichareon et al, *IEEE PES*, 2013)

How well might the NEM perform with high RE?



(Riesz et al, *Wind Integration Workshop*, 2013)

But is NEM governance up to challenge?

Overall objective for the NEM (NEL Sec. 7)

*The national electricity market objective is to promote efficient investment in, and efficient use of, electricity **services** for the long term interests of **consumers** of electricity with respect to **price, quality, reliability and security of supply** of electricity and the reliability, safety and security of the national electricity system*

- Are all objectives reflected in market design?
  - One reason there is effective competition in the Victorian Retail Market is "Because the provision of energy is viewed as a homogenous, low engagement service " AEMC, Effectiveness of Competition in Victoria, 2008

Possible RE policy implications: distributed RE adversely impacted by disfunctional retail markets

- Lack of env. and wider sustainability objectives a **design choice**
  - *As government desires that NEM contributes to achieving such objectives must implement 'external' policies to drive changes*

Possible RE policy implications: not an imposition on participants but an obligation – role of NEM then to faciliate necessary changes

NEM Governance

- Very high transparency in market operation for large generators
  - all participant physical and market behaviour is public (ex-post)
- Formal separation of powers and interfaces between policy making, rule making, operation and enforcement
  - MCE, AEMC, AEMO, AER and ACCC
- Rules for changing the rules
  - Any party can propose a rule change at any time; triggers a formal process with high transparency and consultation
- ..but poor retail mkt, demand-side participation arrangemnets

Looking forward: Serious governance key to successful policy approaches;

- High transparency with significant disclosure obligations to help us know – is it working? for whom?
- Robust against the rent-seekers (often incumbents)
- Fixable: "market and investor' certainty should never over-ride necessary repairs and improvements

Some key NEM governance limitations but appears more robust than some other key environmental markets to date including MRET/eRET, FiTs

Where next?

"The best way to predict your future is to create it!"

Abraham Lincoln

"It depends…."

- but certainly opportunities to improve likely outcomes

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Thank you… and *questions*

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