Centre for Energy and Environmental Markets

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA



Examining the impact of energy storage systems on demand-side participation

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Possible take-home messages up front

- Storage – in its many possible forms – has a key role to play in facilitating DSP
  - Battery Energy Storage Systems (BESS) both possible collaborator and competitor with key DSP options
  - A useful set of options that will be more valuable if and as we transition towards higher renewable energy penetrations
- 'Cost Reflective Tariff' reform to date seems to involve steep declining block tariffs, increasing fixed charges, 'non-peak demand' or 'minimum default' demand charges.
- *All limit consumer options to use DSP + storage to reduce bills while also reducing longer-term network expenditure.*
- Is this desirable in an electricity industry that critically requires clean energy transformation, hence greater DSP + storage?

Energy storage

- *"The general method and specific techniques for storing energy derived from some primary source in a form convenient for use at a later time when a specific energy demand is to be met"* (wikipedia)

- Essential yet complex in the 'just in time' electricity industry
- Potential storage across all steps of the conversion chain with very different characteristics of scale; energy, power, operating characteristics, location…
  - Primary energy resources; coal, gas, hydro…. wind, PV?
  - Primary energy conversion; thermal plant, rotating plant
  - Network via bi-directional electricity storage using other energy forms; eg. pumped hydro, Battery Energy Storage Systems (BES)
  - Energy service final energy storage; eg. hot water, refrigeration
  - Energy service; chosen timing of energy service delivery

Nothing so new about distributed storage

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

A.T.—Alternating Transformer Distribution.	£	B.T.—Accumulator Transformer Distribution.	£
Generating Station, Buildings, Chimney Shaft, Water Tanks, and General Fittings	11,000	Generating Station, Buildings, Chimney Stack, Water Tanks, and General Fittings	8,000
Dynamos and Exciters — 865 Kilowatts, including spare sets, divided as convenient ...	5,540	Dynamos — 600 Kilowatts, in 6 sets of 100 Kilowatts each...	4,800
Motive Power, *i.e.*, Engines, Boilers, Steam and Feed Connections, Belts, &c., at £8 12s. per I.H.P.	12,470	Motive Power, *i.e.*, Engines, Boilers, Steam and Feed Connections, &c., at £8 12s. per I.H.P.	8,600
500 Transformers, *i.e.*, one to every pair of houses, at £15 each	7,500	4 Groups of Accumulators, in all 240 cells, in series, at £40 per cell, including Stands ...	9,600
2,000 yards Primary or Charging Main, exterior to area of supply, at £308 per 100 yards	6,160	2,000 yards Charging Main, at £306 17s. 6d. per 100 yards (*see* Table 2)	6,137
20,000 yards Distributing Main, 50 m/m. sectional area, at £91 7s. (*see* Table 1)	14,270	20,000 yards Distributing Main, 161·25 m/m. sectional area, at £100 12s. 6d. (*see* Table 2) ...	20,125
Regulating Gear	500	Regulating Gear	2,500
	£57,440		£59,762

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.

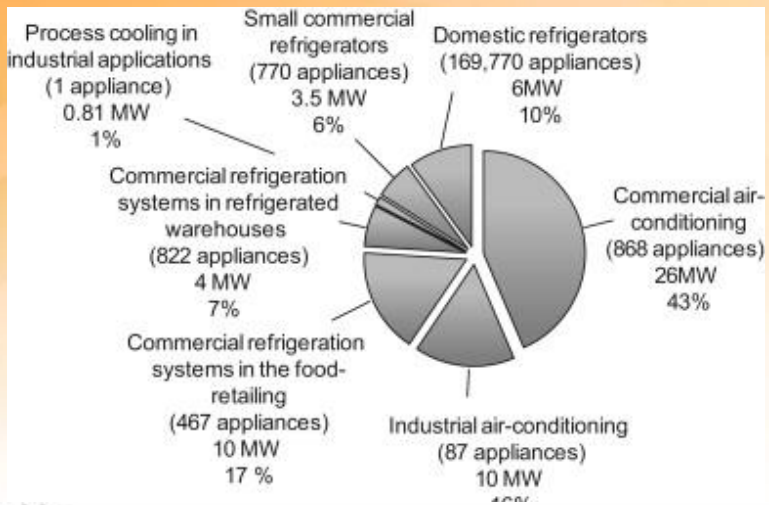
The following paper was then read:—

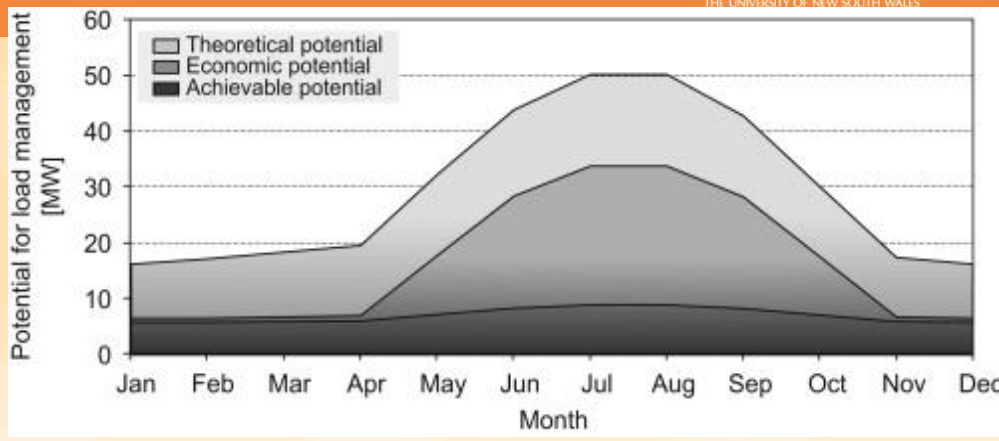
CENTRAL STATION LIGHTING: TRANSFORMERS *V.* ACCUMULATORS.

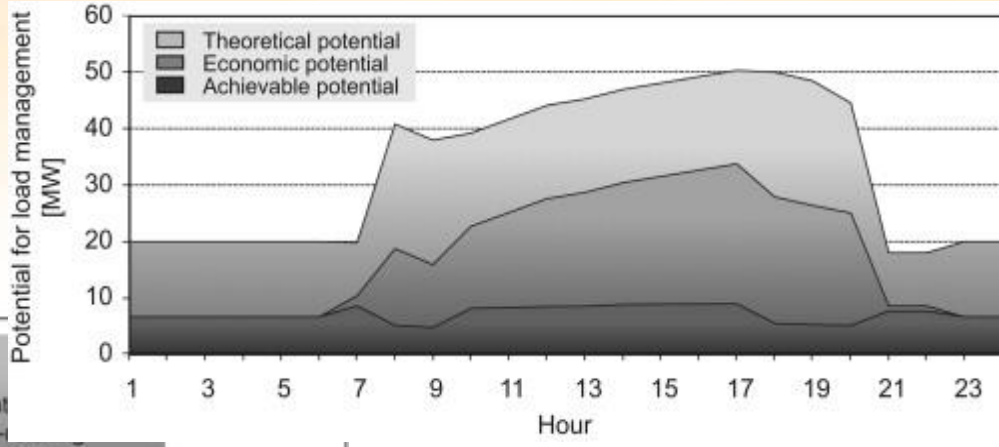
By R. E. Crompton, Member.

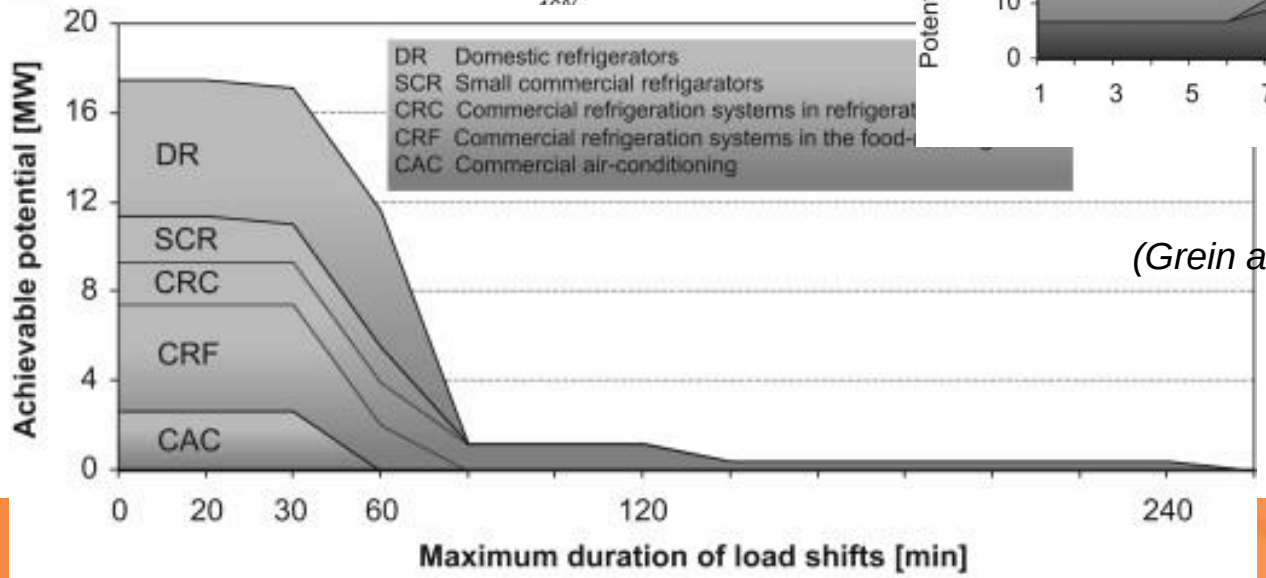
The present paper is the outcome of the discussion which took place on Messrs. Kapp's and Mackenzie's papers on transformers, recently read before this Society. I was asked to give facts and figures in support of the statement I then made, that I believed the distribution of electricity by transformers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

All options: demand-side and BES are complex







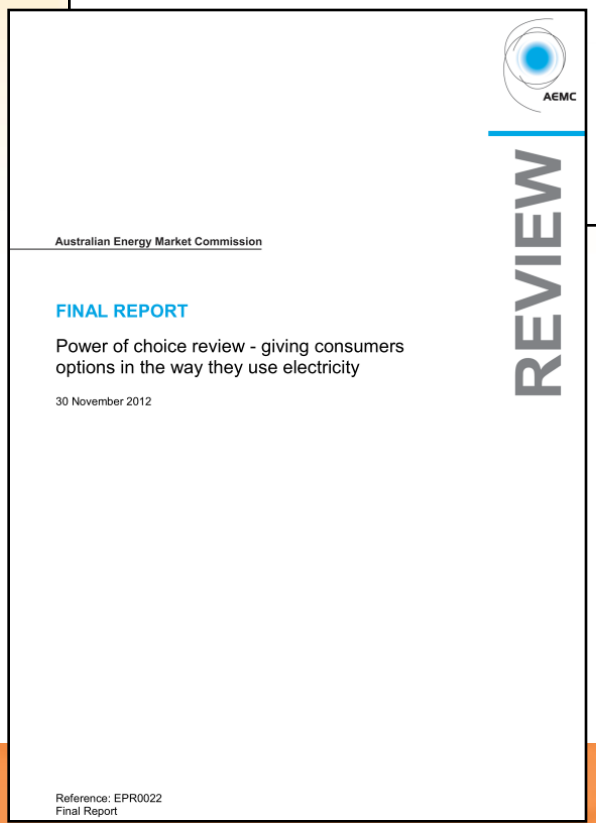


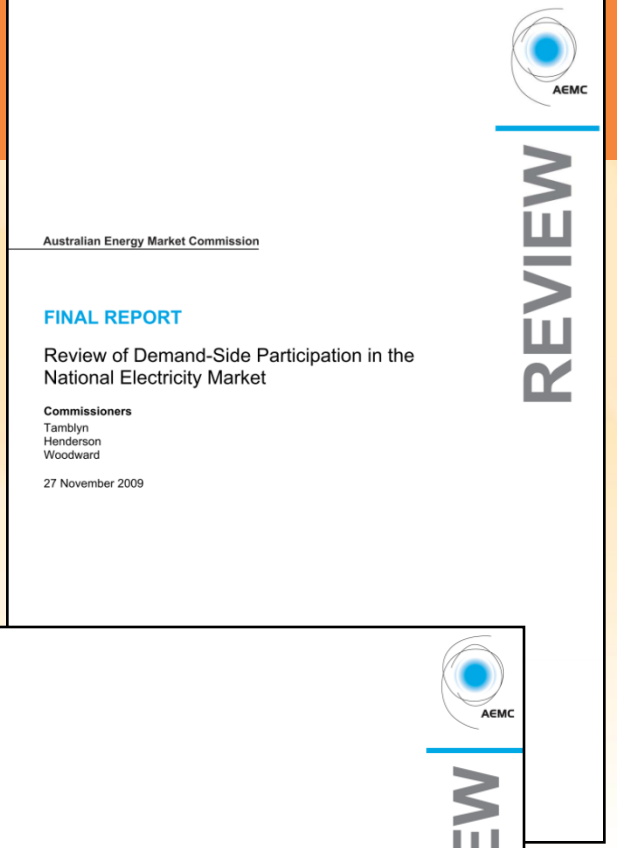
(Grein and Pendt, Energy Policy, 2011)

Demand-side participation

- "DSP provides a tool for consumers to actively participate in the market, by offering a suite of options for them to manage their electricity consumption and, in turn, their electricity expenditure. It includes actions such as energy efficiency, peak demand shifting, changing consumption patterns, and consumers generating their own electricity." (AEMC)

- In practice, a complex concept in the electricity industry
  - from paying your bills to being paid for service provision





Energy users – a changing industry context

- From clients
  - Early tailored industrial or commercial (lighting) applications
- ..to citizens
  - Electricity as an essential public good – rural electrification
- ..to consumers
  - The vertically integrated utility of growing size and scope
- ..to customers
  - Electricity industy ‘reform’, liberalisation, deregulation, restructuring

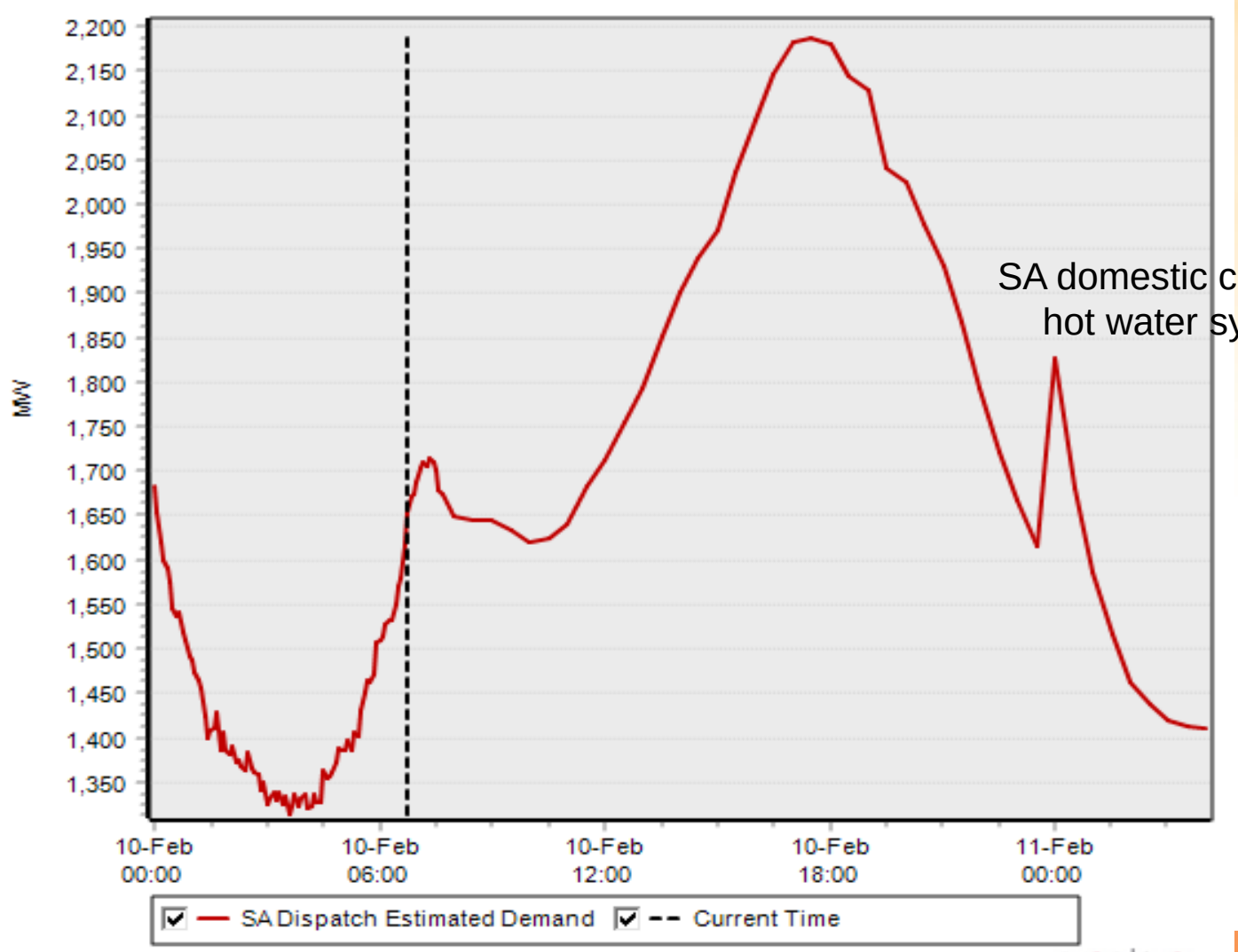
- *..to perhaps now partners, competitors?*

…all the way to Prosumers

- **"Prosumer** a portmanteau formed by contracting either the word **pro**fessional or, less often, **pro**ducer with the word con**sumer**."
  - prosumer (professional–consumer) as market segment?,
  - prosumer (producer–consumer) as having greater independence from mainstream economy.
  - Differentiates traditional passive consumer from consumers taking more active role in service provision

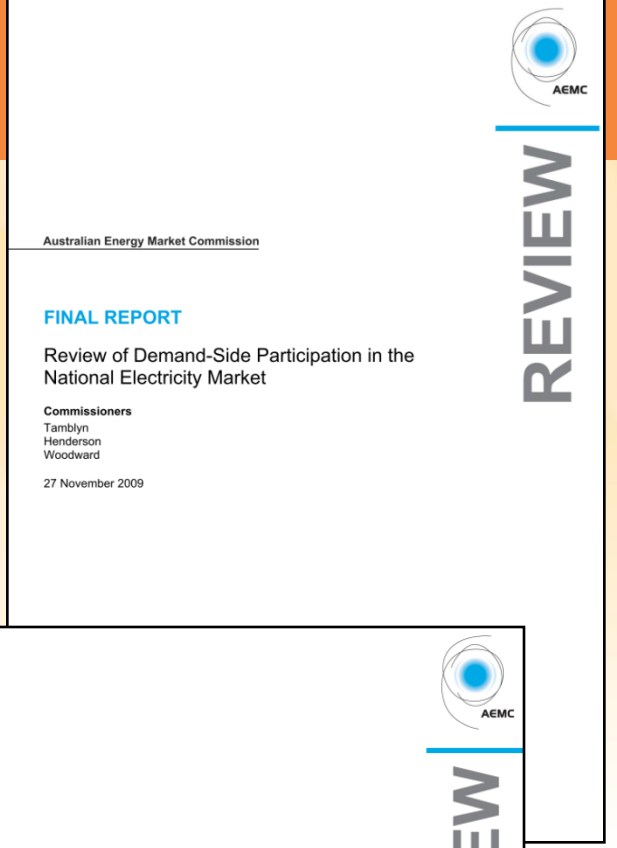
(www.wikipedia.org)

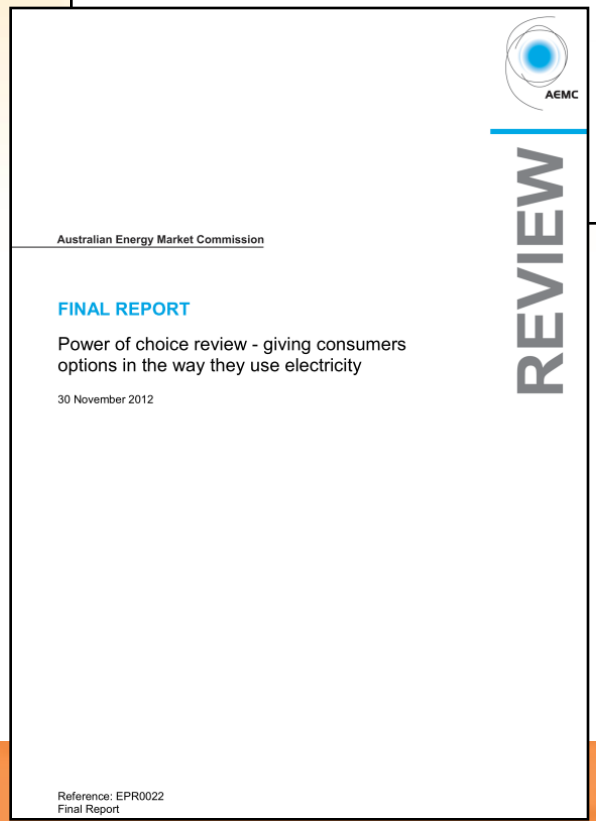
Nothing new about DSP



Energy storage and DSP

- Storage of some form required for meaningful DSP
  - Needn't be battery storage of course; *the most flexible – a universal electricity resource - yet most expensive*
- ..a point not well recognised in earlier DSP work by AEMC and others which doesn't, or barely, mentions storage
- A facilitating environment for DSP more generally, will benefit new storage options while storage expands DSP opportunity





Why DSP and storage?

Efficient markets are characterised by effective participation of both the supply and demand side. The supply side of the market provides a product or service at a price, and the demand side (ie consumers) responds to the price/value of the product or service being offered.

(AEMC, Power of Choice, 2012)

While there is some evidence of uptake of DSP in the NEM over recent years, the efficiency of the electricity market can be improved by more active participation by the demand side. This will require changes to some aspects of how the supply side of the electricity market operates and interacts with consumers.

- Storage and DSP have a range of possible value propositions across scale, time and location
  - *Note that additional storage and DSP not currently 'necessary'; industry functioning 'ok' without it*
- Commercial context supports only some of these value propositions, in an incomplete manner, at present
- Yet key enabling role in 'clean energy' industry transition

DSP and storage have a range of possible value propositions

- Improved customer reliability
- Reduced network peak demand, hence expenditure
- Reduced generation capacity requirements
- Facilitating integration of generation technologies with energy storage challenges – PV, but also ‘baseload’ plant
- Ancillary service provision
- ‘leaving the grid’ options
- *While not currently ‘necessary’ value will increase with clean energy transition, paticularly in terms of renewable energy integration*

Commercial context supports only some of these value propositions at present

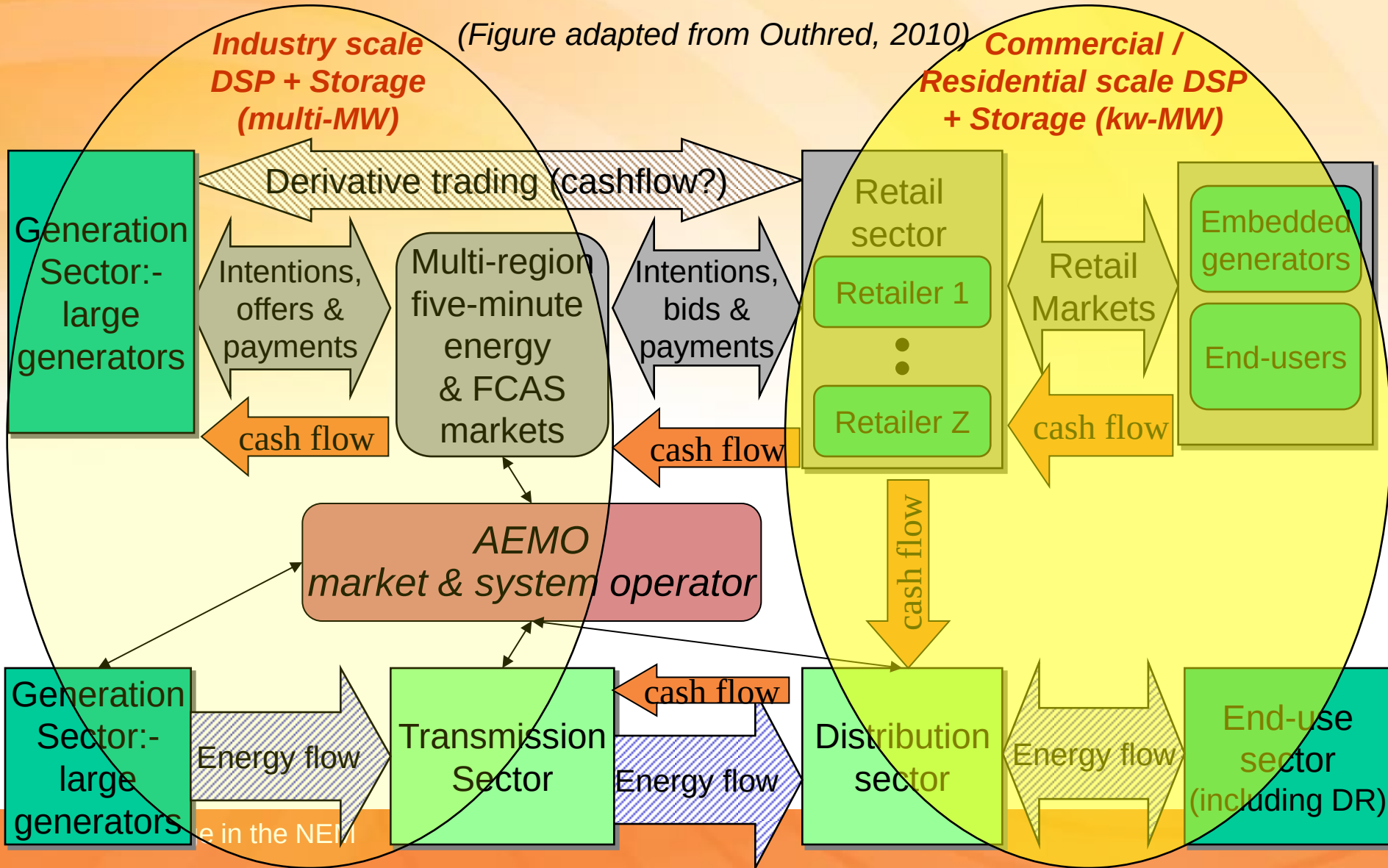
- Improved customer reliability – UPS market well established
- Customer arbitrage around their TOU tariffs and peak demand charges… if they face these
- Increased self-consumption of PV generation paid a low 'export' rate, the current context for new household PV

However, all are incomplete commercial contexts, and what of

- Network value?
- Ancillary services?
- Contingency management?

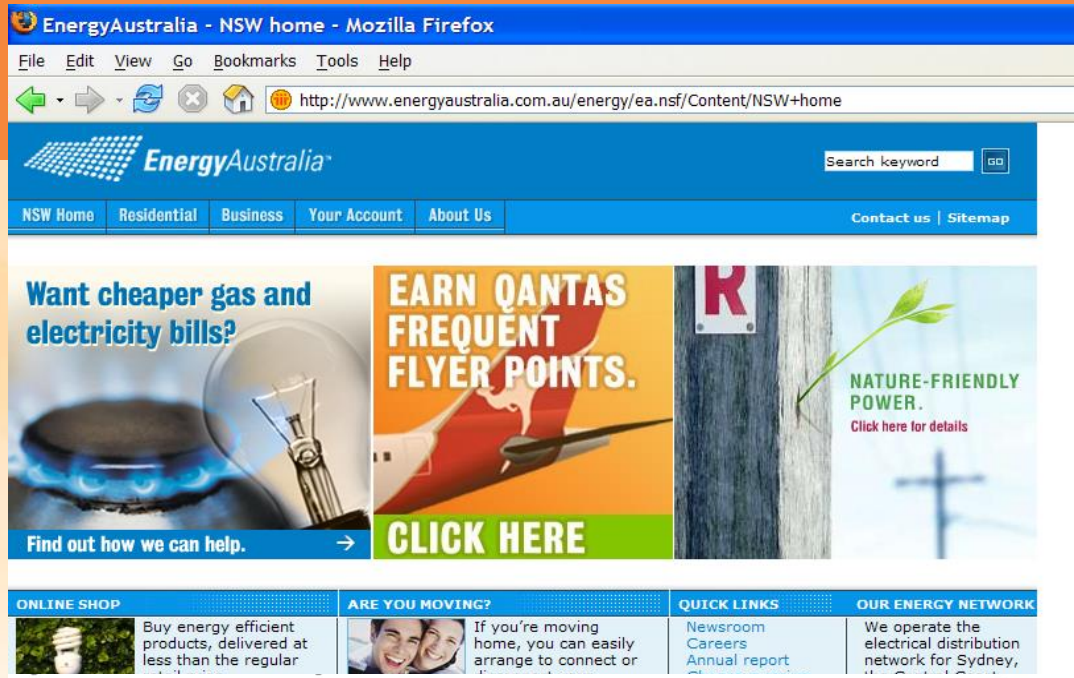
Two 'worlds' for DSP and Storage in NEM

(Figure adapted from Outhred, 2010)

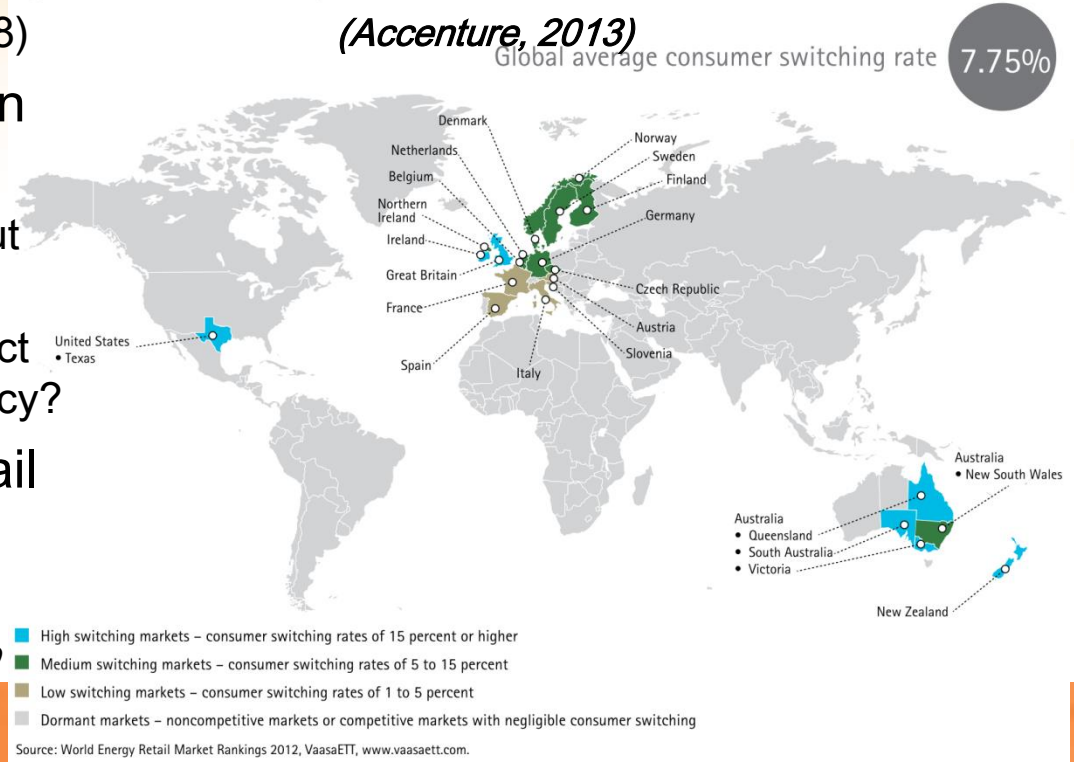


Current retail market isn't actually a market

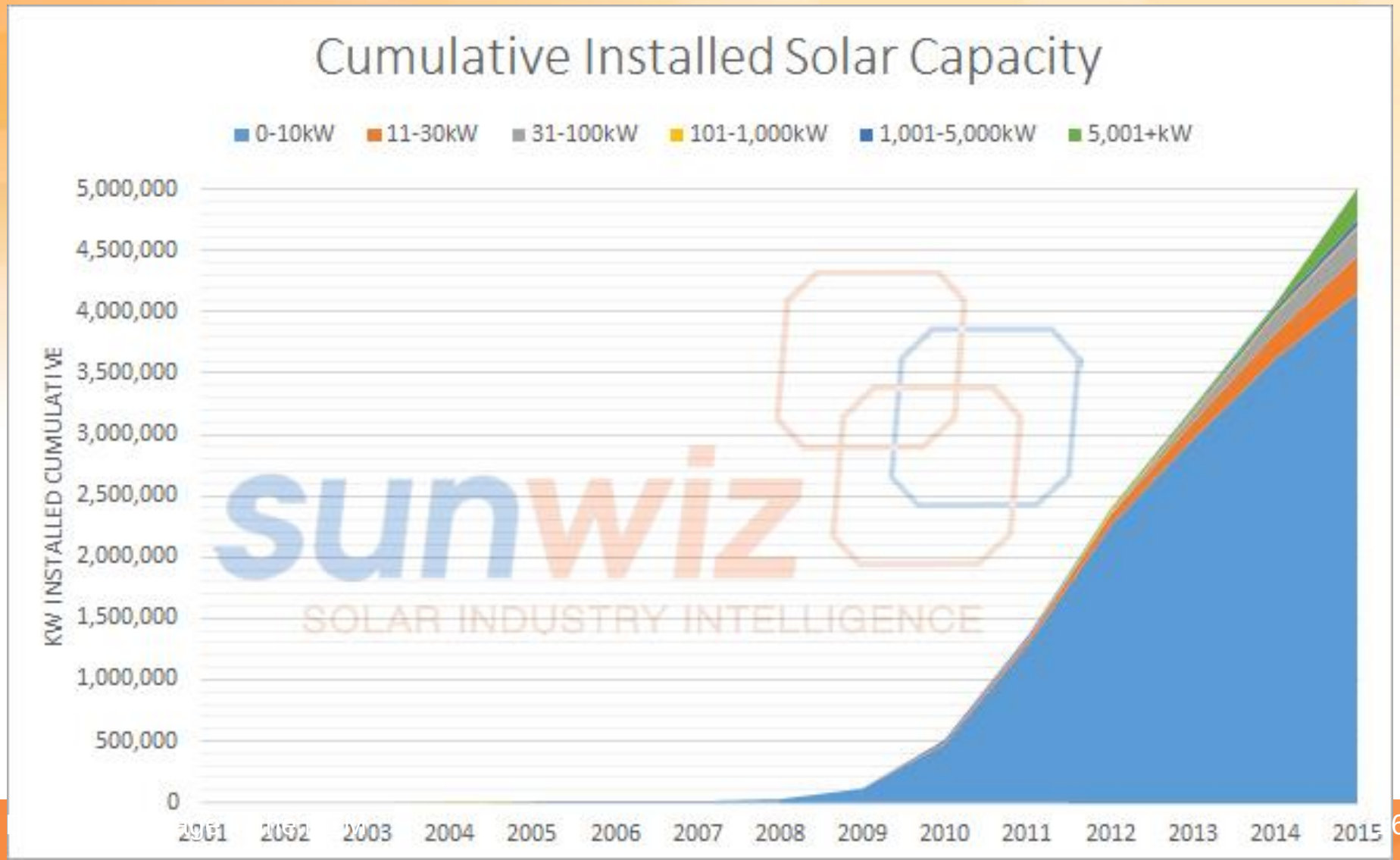
- Tariffs rather than prices
- Little focus on energy services
  - "… an important reason there is effective competition in Victoria is .. because the provision of energy is viewed as a homogenous, low engagement service" (AEMC, 2008)
- Current measures of competition might miss key issues
  - Yes, NEM 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.." *Jim Myatt, founder of Australian Power and Gas on its sale to AGL (crikey.com.au, 2013)*



(Accenture, 2013)

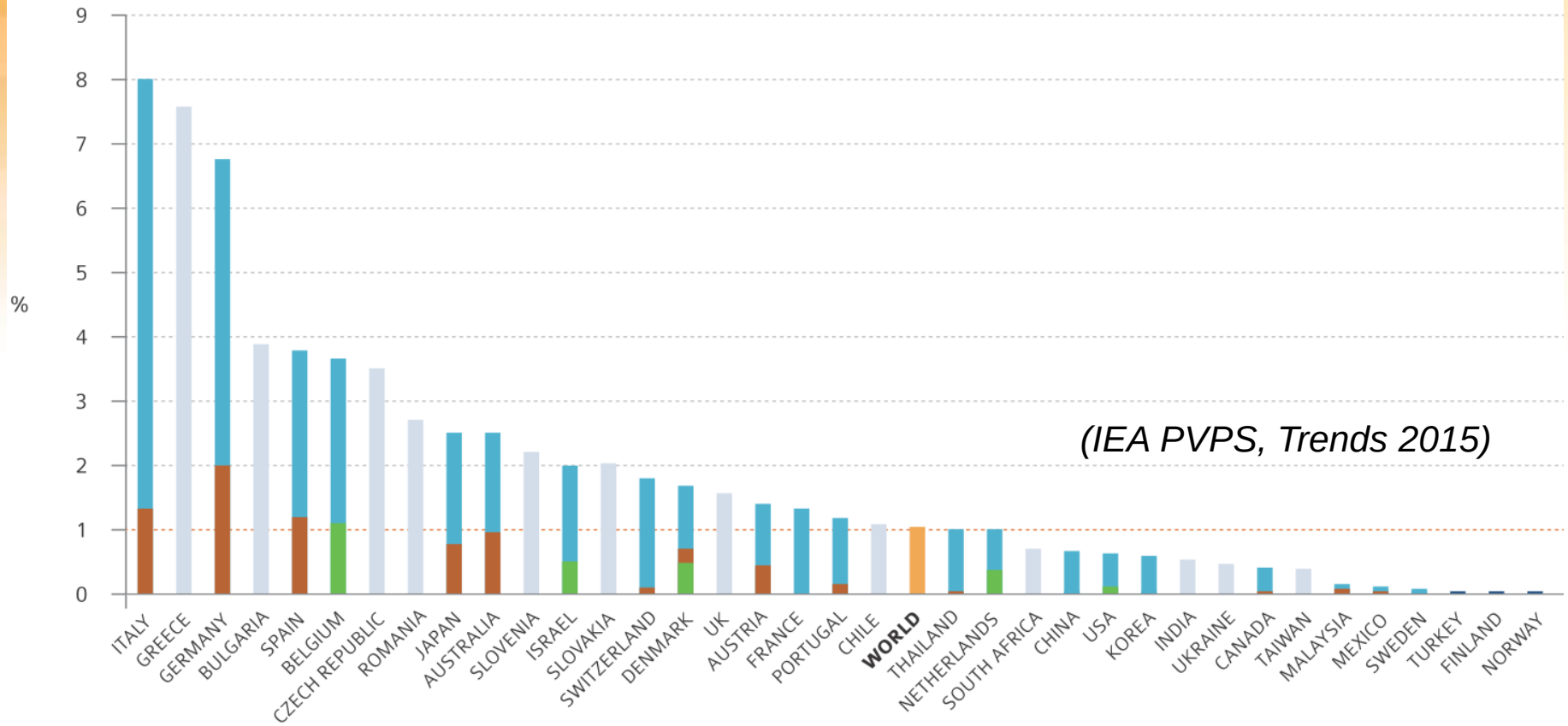


PV now offering some real competition



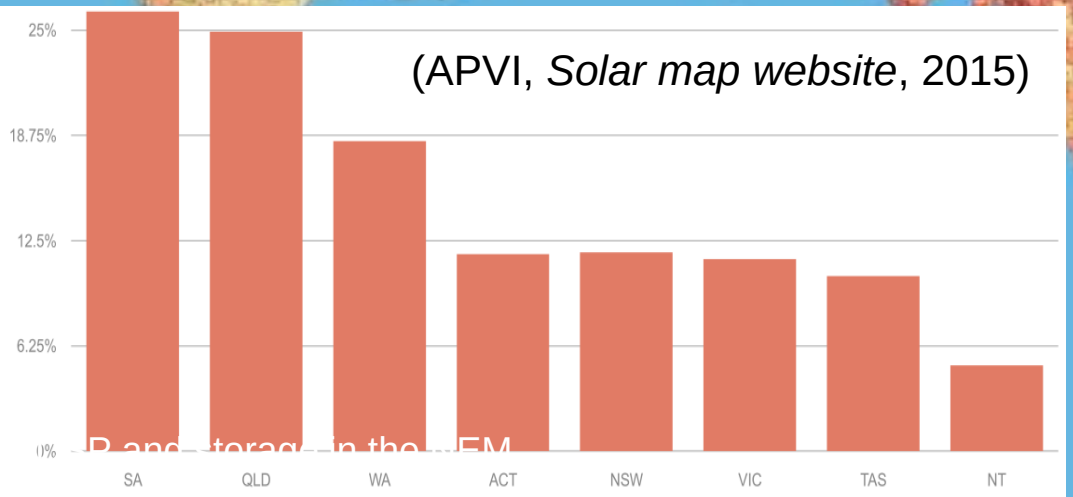
Australian PV penetration significant

FIGURE 22: PV CONTRIBUTION TO THE ELECTRICITY DEMAND IN 2014



(IEA PVPS, Trends 2015)

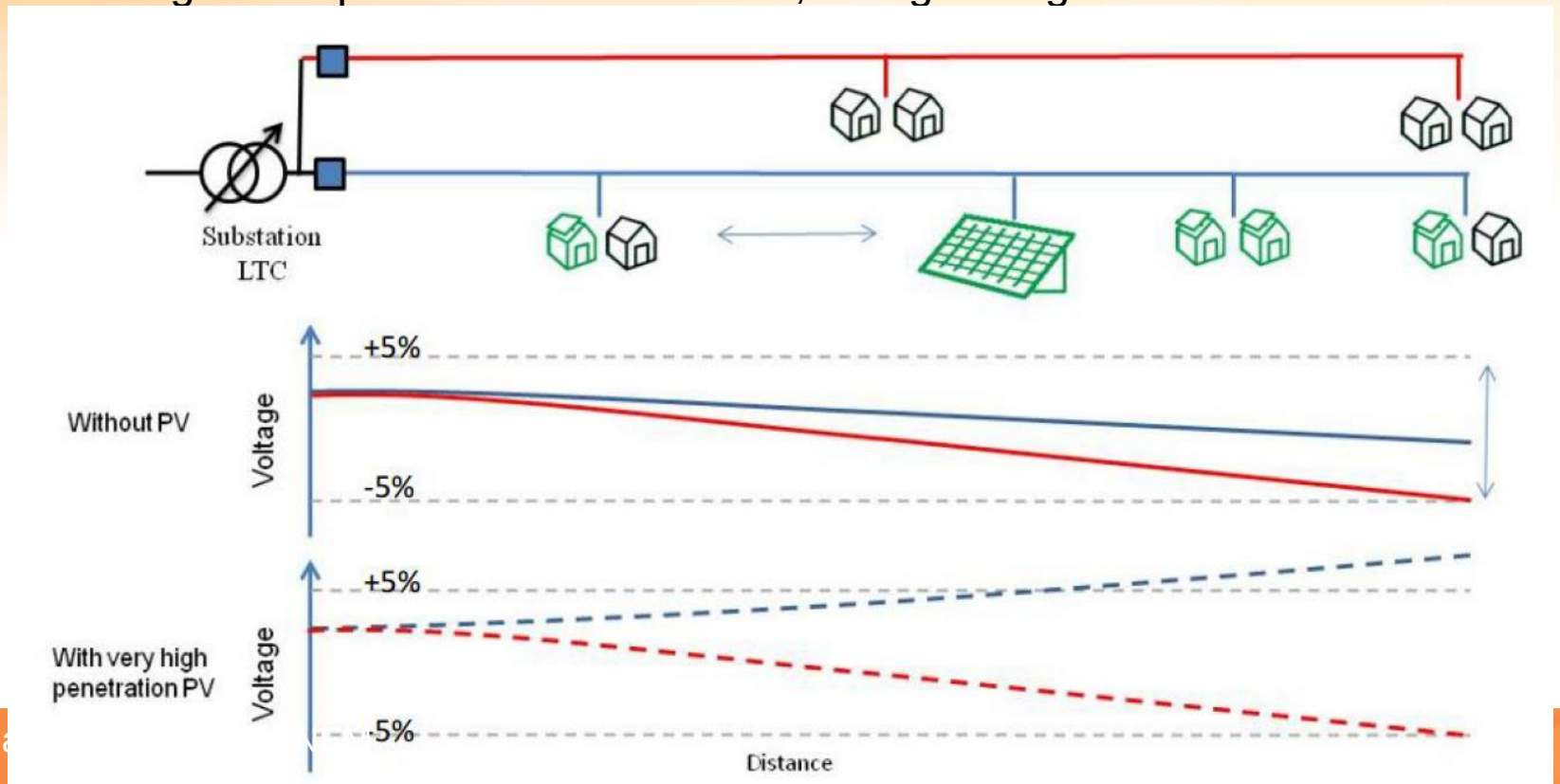
A world leading residential PV penetration (%dwellings with PV)



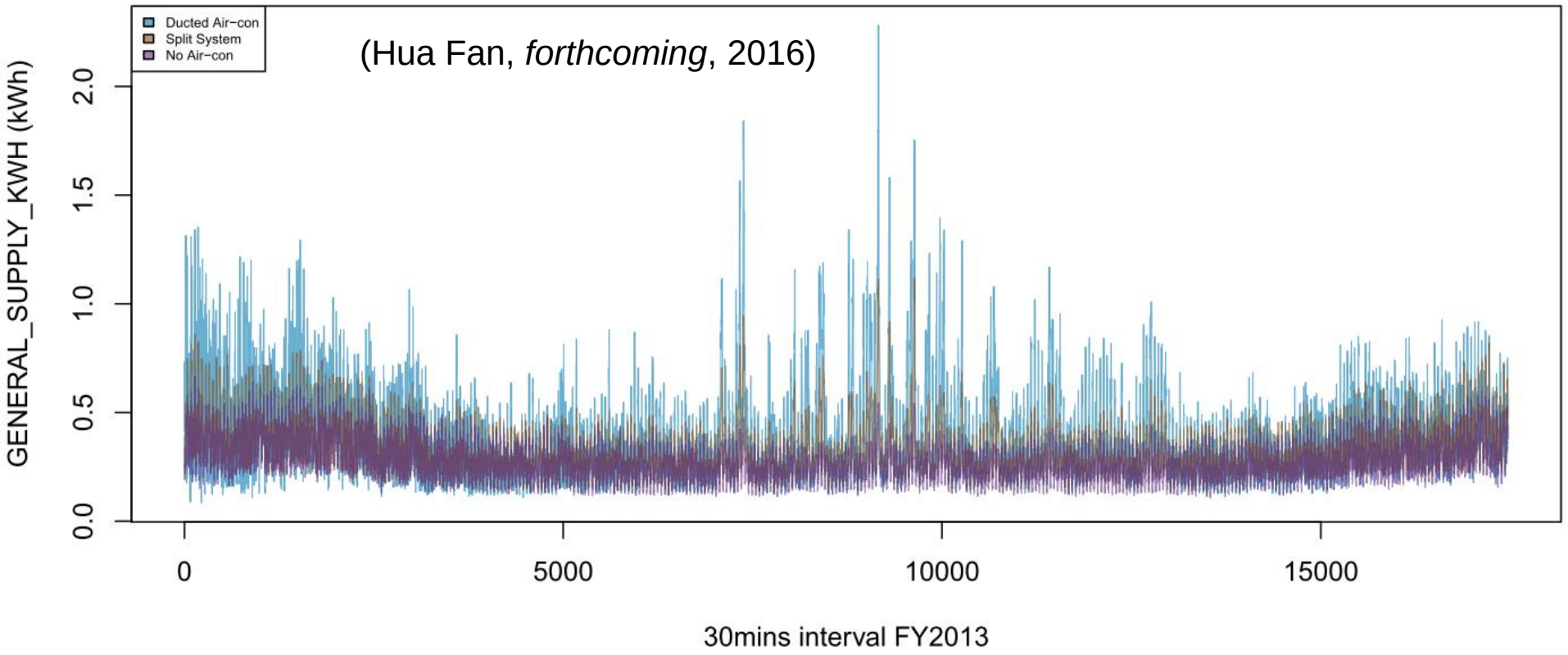
(APVI, *Solar map website*, 2015)

Storage for RE integration – technical context..

- Technical context - shared contributions to shared outcomes
  - eg. Voltage management depends on all distribution technologies and behaviours – distributed generation but also loads, network operation
  - A balancing act b/n low voltage driven between peak demand, and high voltage from periods of low demand, or high PV generation

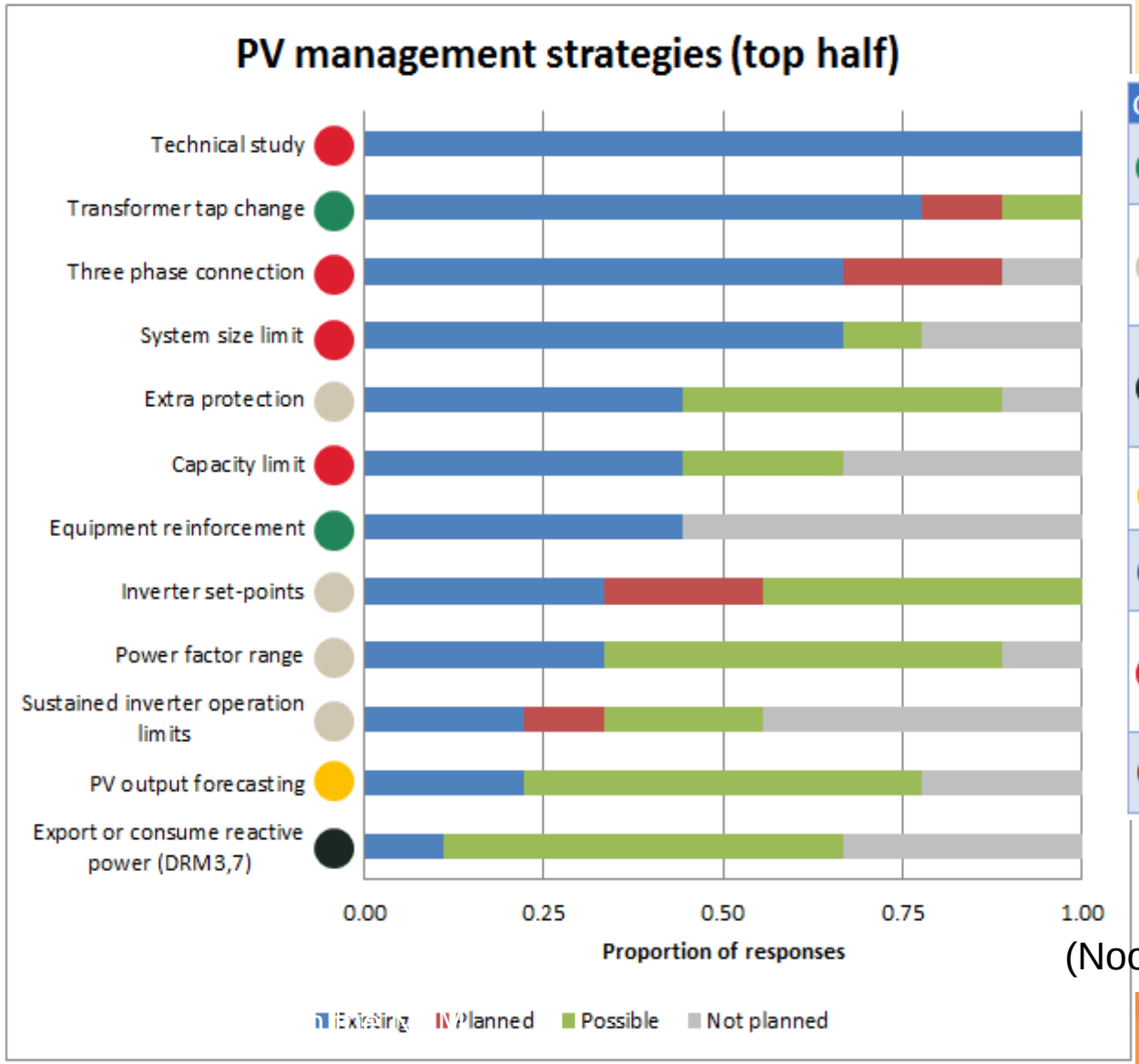


Whose problem is storage trying to solve?



- Is PV effectively being penalised (inverter trips) by high transformer tap settings used to manage air-conditioning? *Why not mandate low V cutoff or even storage for A/C units?*

Regardless, range of management strategies



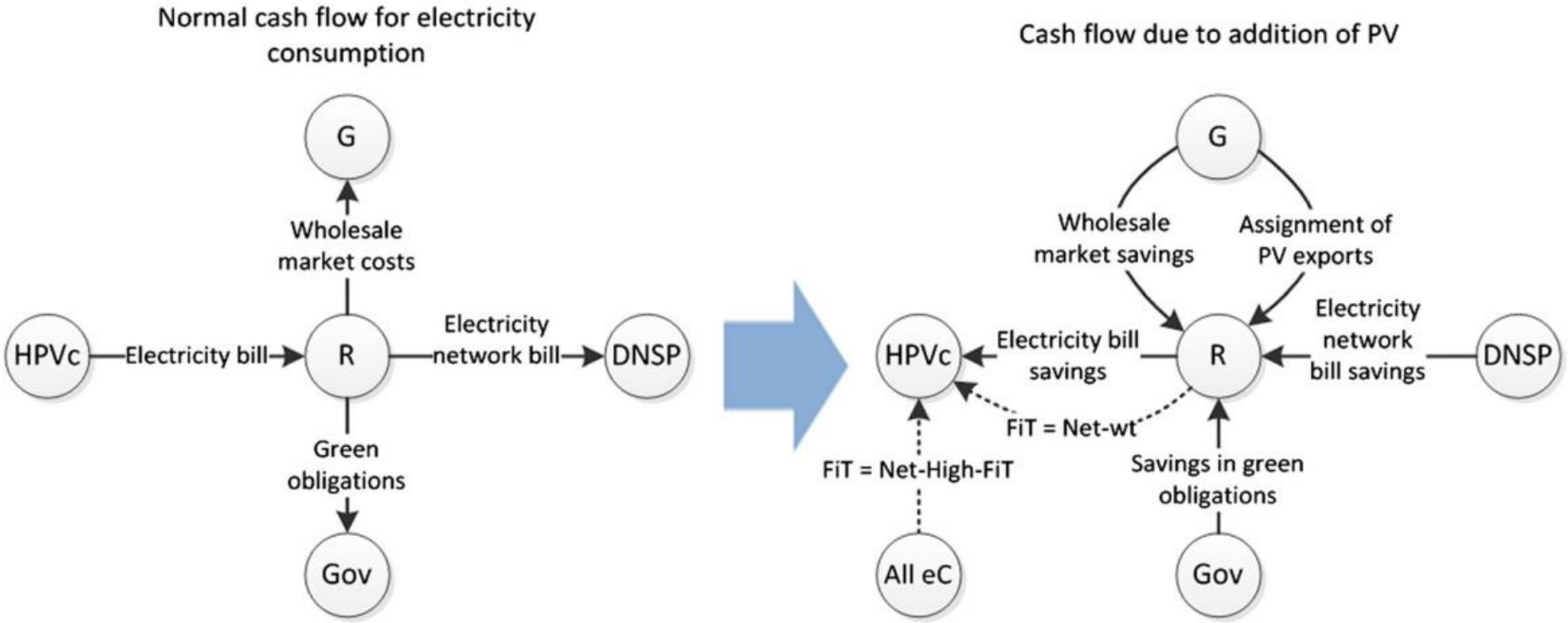
Category	Description
System operation	Activities that can be undertaken by the DNSP
PV operation	Requirements on how PV systems interact with the network
Demand response	Relating to the proposed AS4777 demand response functions or a price signal
Forecasting	Forecasting of PV system output
Storage	Energy storage by either the DNSP or the customer
Deployment regulations	Requirements pertaining to initial connection of the PV system
Generation	Applicable to mini-grid situations only

(Noone, *APVI/CEEM report*, 2014)

Possible economic implications

- PV doesn't 'cause' most of these adverse impacts – an outcome of characteristics of all resources connected to network including demand as well as PV
- Managing impacts not a question of technical feasibility but of economics, broader considerations
  - What are our most economically appropriate responses?
    Some low cost options that can do most of what much higher cost options (such as storage) might do
  - Who should pay?
    Within broader constraints set by electricity industry's key role providing an essential public good

The real challenge at present – *follow the money, particularly falling revenues..*



(Oliva et al, 2015)

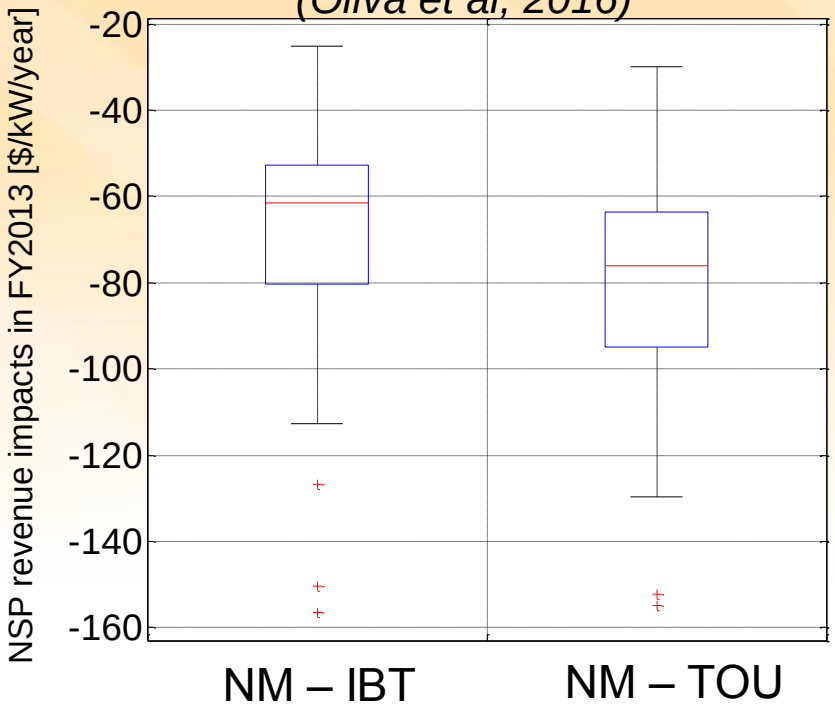
HPVc: Household PV customers
R: Electricity retailers
DNSP: Distribution network service providers

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

Potentially highly adverse revenue impacts on retailers, DNSPs

- Net metering with low export rate favors household self consumption with volume based flat, TOU tariffs
- Possible major revenue impacts for key industry stakeholders

(Oliva et al, 2016)



(Ausgrid/IPART, 2012)

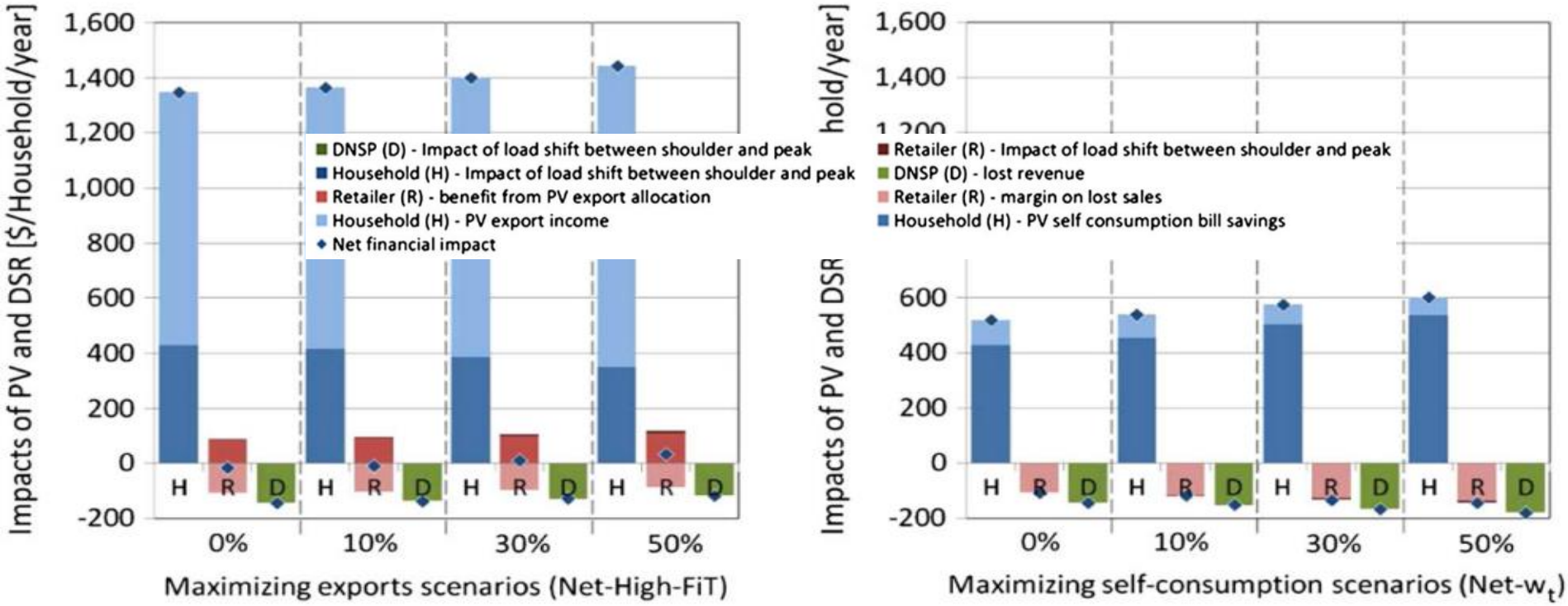
PV unit size	Median annual net exports (kWh)	Median daily net exports (kWh)	Median annual export ratio
1.0 kW	393	1.1	32%
1.5 kW	616	1.7	35%
2.0 kW	1,007	2.8	41%
3.0 kW	1,703	4.7	49%
4.0 kW	2,378	6.5	52%
5.0 kW	2,921	8.0	50%

For PV and DSP / Battery storage

with low-export rate on net-FIT, household incentives to max. self consumption via load shifting or storage worsen adverse retailer and NSP revenue impacts *(despite reducing adverse network impacts of PV, and evening peak demand)*

(Oliva and MacGill, 2015)

Flat tariffs case

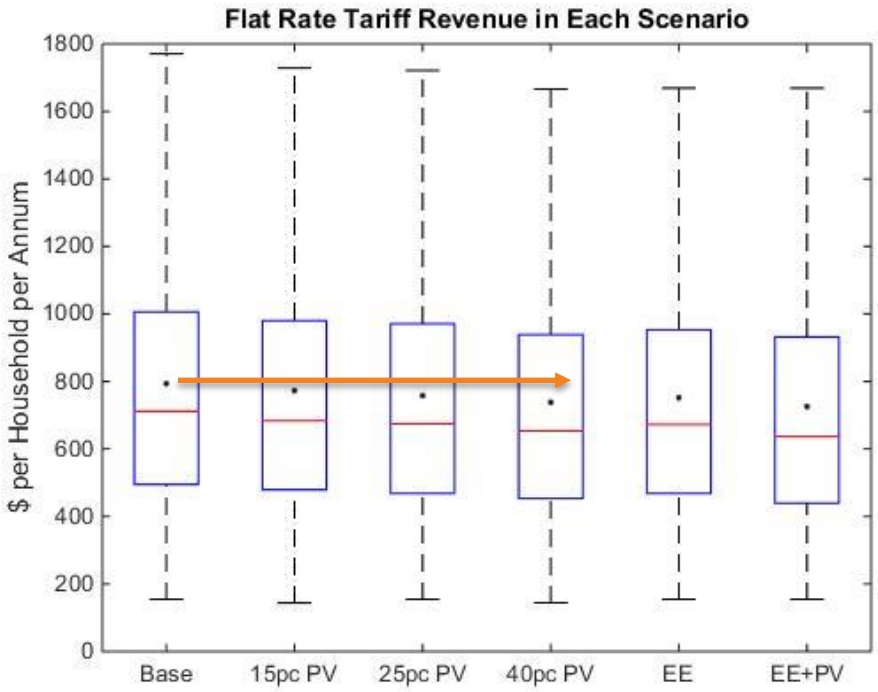


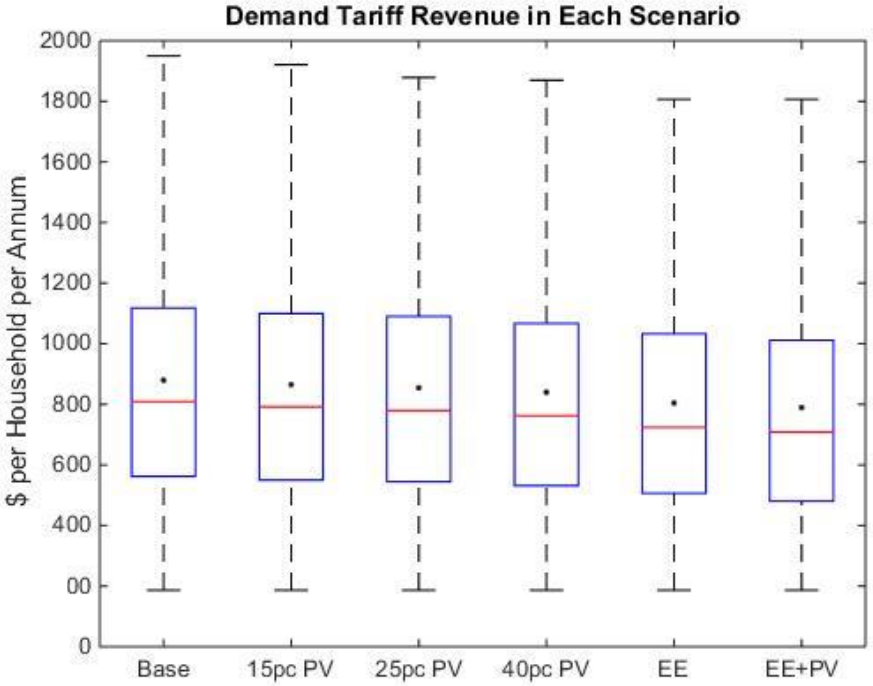
Possible industry responses

- For DNSPs under monopoly economic regulation, revenue cap based on approved expenditure can correct revenue shortfalls over time by changing tariff levels and/or structures

- The risks
  - No unprofitable customers for DNSPS if can get approval for expenditure required to serve them; *how do we incentive them to facilitate PV households to deploy DSP and storage in order to reduce peak demand hence required network capacity and longer-term expenditure*?
  - Network tariffs have wide range of cross-subsidies already – between households with and without Air-C, city versus regional and rural, as well as those with PV versus those without. *If solar cross-subsidies are to be targeted, what about the rest of these?*

Different network tariffs can certainly change value of PV, EE, other possible household interventions in terms of network revenue





S. Young, A. Bruce, I. MacGill (2016), "Australian Electricity Network Customer Revenue by Tariff Type in a Variety of Scenarios", submitted to IEEE PES GM.

Currently

- seems to be greater efforts to address solar PV cross subsidies than likely much larger subsidies for ducted air-conditioning, and particularly rural and regional customers…
  … and this despite environmental benefits of PV, adverse network expenditure aspects of serving rural supply and high peak Air-C demand

Campaign launched to fight WA 'solar tax'

By Jonathan Gifford on 7 December 2015

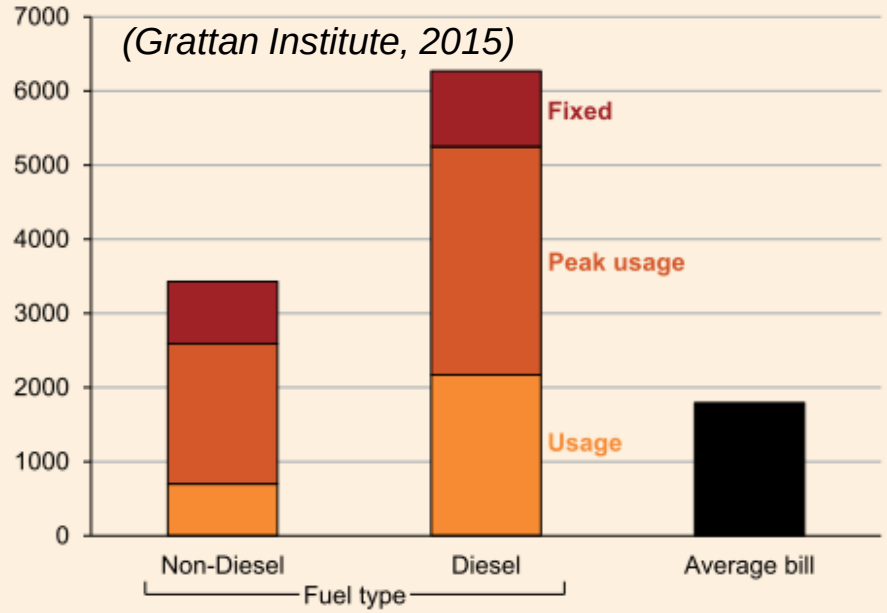
PV Magazine

Infinite Energy

The Australian Solar Council has launched a campaign to challenge a proposed doubling of grid connect
(US$585) has been proposed by government-owned utility Synergy.

Figure 5.1: The cost of supplying electricity varies greatly across Horizon Power's networks

Cost structure to supply electricity to average household and yearly electricity bill, Horizon Power non-interconnected systems, $2015



Possible risk with renewables + energy storage

- A potentially influential confluence between those who support energy storage for wide ranging roles it can play in better integrating renewable energy into electricity industry while saving users and networks $
- …and those perhaps happy to see renewables saddled with costly energy storage obligations, or arguing for ‘light handed’ network regulation on basis that competition will discipline DNSP behaviour

Bootleggers and Baptists

From Wikipedia, the free encyclopedia

Bootleggers and Baptists is a catch-phrase invented by regulatory economist Bruce Yandle[1] for the observation that regulations are supported by both groups that want the ostensible purpose of the regulation and groups that profit from undermining that purpose.[2]

For much of the 20th century, Baptists and other evangelical Christians were prominent in political activism for Sunday closing laws restricting the sale of alcohol. Bootleggers sold alcohol illegally, and got more business if legal sales were restricted.[1] "Such a coalition makes it easier for politicians to favor both groups. … [T]he Baptists lower the costs of favor-seeking for the bootleggers, because politicians can pose as being motivated purely by the public interest even while they promote the interests of well-funded businesses. … [Baptists] take the moral high ground, while the bootleggers persuade the politicians quietly, behind closed doors."[3]

Contents

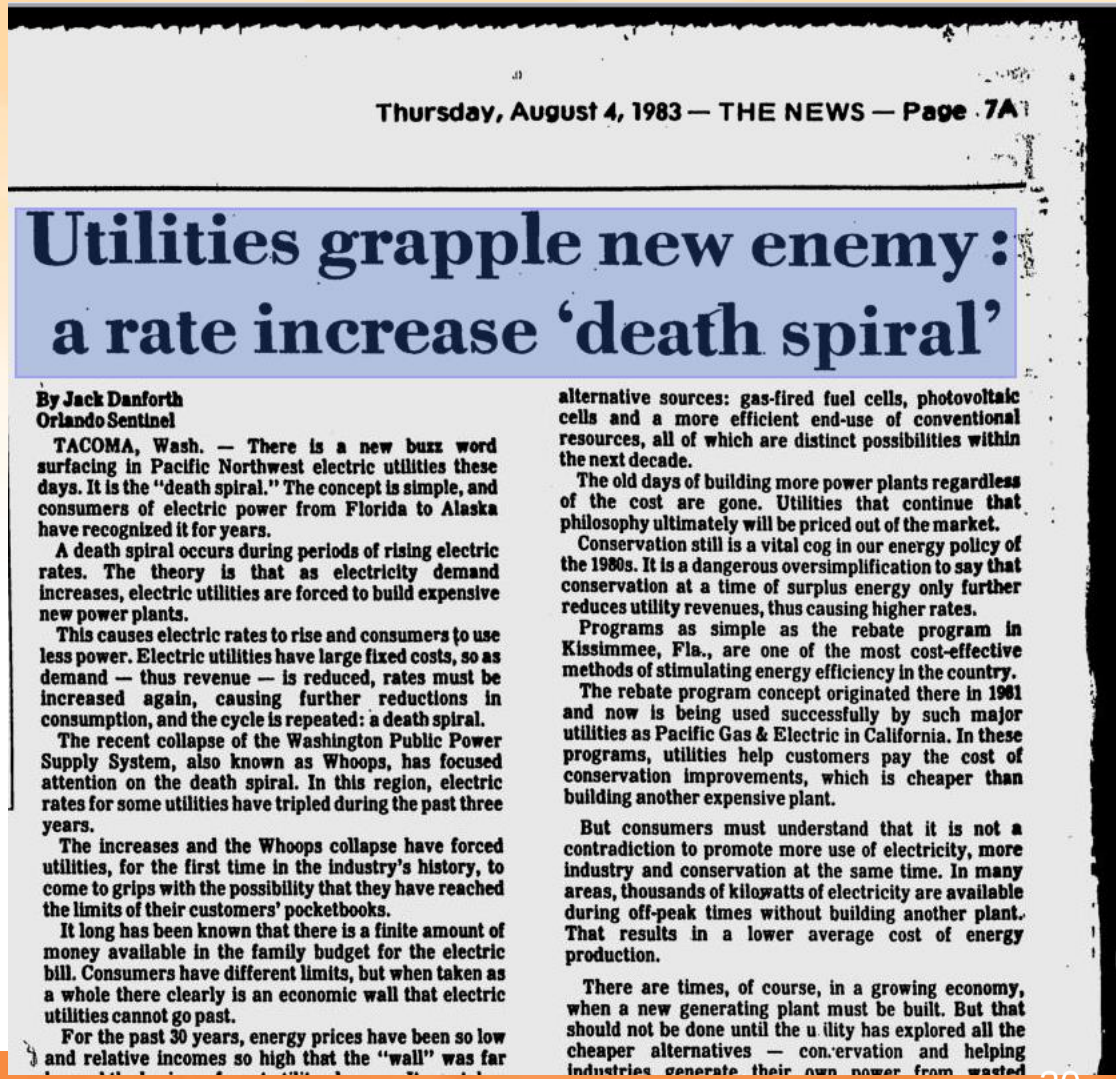
Californian police agents dump illegal alcohol in 1925, Prohibition-era photo courtesy Orange County Archives.

Nothing new about the '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 However; s*avings from demand reduction depend critically on energy/network tariffs..and End-user departure depends critically on DG technology progress, particularly storage*

Perhaps more of an issue for electricity than 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

Leaving the grid – the ultimate DSP

- The grid is a very valuable asset – not because we've spent a lot of money on it (sunk investment), but because of the very valuable service it provides.
- With regard to possible grid defection, storage deployment etc, all market forecasts are wrong… although some may be useful
- Do not under-estimate the costs and challenges of off-grid supply – average demand and PV generation is irrelevant to understanding reliability of supply
- *However, distributed storage, DSP and generation providing an increasingly attractive option and alternative – may provide a useful discipline network pricing*

Facilitating DSP and hence storage – *in principle* (AEMC, Power of Choice, 2012)

The recommendations form a package of integrated reforms and act to facilitate efficient DSP in two ways:

- Enabling consumers to see and access the value of taking up demand side options; and
- Enabling the market to support consumer choice through better incentives to capture the value of DSP options and through decreasing transaction costs and information barriers.

The Power of choice review has identified opportunities for consumers to make more informed choices about the way they use electricity. Consumers require tools - information, education, and technology, and flexible pricing options - to make efficient consumption decisions. Recommendations presented in this report will support these conditions and enable consumers to have more control of their electricity expenditure.

Facilitating DSP + storage *in practice?*

'Cost Reflective Tariff' reform to date seems to involve steep declining block tariffs, increasing fixed charges, 'non-peak demand' demand charges

All limit consumer options to use DSP + storage to reduce bills while also reducing longer-term network expenditure

Queensland pushes through massive rises in fixed electricity charges

41

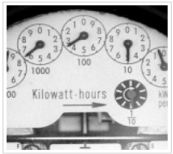
By Giles Parkinson on 19 June 2015

A victory for McMansions? Fixed charges to households surge, while small business may pay two-thirds of their bill on fixed charges, as government owned utilities move against solar and energy efficiency.

Print

The Queensland government managed to get some sympathetic coverage on the ABC and in the local mainstream media – and even some specialist websites who should know better – about the supposed "fall" in electricity bills in the upcoming year.

But what they did not mention – presumably because it wasn't in the Queensland Competition Authority press release – was a huge jump in fixed charges that will penalise households and small business, and reduce the incentive to install rooftop solar.



Fixed charges for households will jump more than 20 per cent to $1.07 a day, meaning that with GST, households will pay a minimum $428 a year on fixed charges, no matter how little electricity they consume.

The consumption rate has been cut to 22c/kWh but this means nothing for households that consume around 7kWh a day – pensioners and single person households for instance, and others who pay attention to energy efficiency.

Their annual bill will now be more than $1,050 – which equates to a rate of 42c/kWh, probably the highest in the world. And their ability to offset that with solar is greatly reduced because so much of the cost is unavoidable.

But small businesses – butchers, restaurants, takeaway food installations, or anyone using refrigeration and cooking – face an even greater proportion of fixed charges under the new scheme.

Demand Charge –

$37.730 per kilowatt per month of chargeable demand.

Energy Charge –

All Consumption	**10.529 c/kWh**
plus a Service Fee per metering point per day of	**5,072.121 c**

According to the new tariff 44 (above) – which will now be compulsory for businesses consuming more than 100MWh a year (275kWh a day) – the fixed charge will be $50 a day, or $8,000 a year including GST.

The consumption rate is slashed to just 10.6c/kWh, or around $27 a day, which means that if a business uses just over 100MWh a year, its bill will be two-thirds unavoidable fixed charge, and one-third on consumption.

But it gets worse. If, on just one day a month, the business's consumption goes over 30kW on average in any one 30 minute period, the business will be hit with a "demand charge". If it uses 40kW in that time period, for instance, it will pay another $400 for that month, even if that day's consumption was a one-off.

And to top it off, all consumers will face as-yet unspecified "metering charges".

As we reported last year, fixed charges for the biggest consumers have jumped even more extravagantly to nearly $500 a day

Possible take-home messages up front

- Storage – in its many possible forms – has a key role to play in facilitating DSP
  - Battery Energy Storage Systems (BESS) both possible collaborator and competitor with key DSP options
  - A useful set of options that will be more valuable if and as we transition towards higher renewable energy penetrations
- 'Cost Reflective Tariff' reform to date seems to involve steep declining block tariffs, increasing fixed charges, 'non-peak demand' or 'minimum default' demand charges.
- *All limit consumer options to use DSP + storage to reduce bills while also reducing longer-term network expenditure.*
- Is this desirable in an electricity industry that critically requires clean energy transformation, hence greater DSP + storage?

Where next?

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

Abraham Lincoln

"That depends…"

– *certainly opportunities to improve outcomes from what look to be current directions*

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Thank you… and *questions*

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