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Is the NEM fit for distributed energy?

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The State of Energy Research Conference

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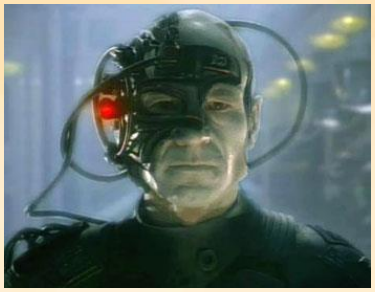
Is the NEM fit for distributed energy?

- At present, likely not, particularly as distributed energy penetrations grow
- …but it could be, and needs to be

A related question - whether distributed energy is fit for the NEM? *Integration is a 'relationship'*

- At present likely not, particularly as distributed energy penetrations grow
- ...but it could be, and needs to be

Relevant perspectives on DE integration



- Technical connection
  - "welcome to the machine" – play nice
  - *For DE, what rules, whose rules?*
- Security
  - "'[cascading] failure is not an option"
  - *For DE, 'first do no harm', but now you really need to assist*
- Commercial
  - "markets for everything" – pay or paid according to whether you add costs or benefits
  - *For DE, current retail market isn't really a market, network value?*
- Social
  - Energy users – clients to citizens to consumers …. to customers?
  - *For DE, real engagement raises issues of knowledge, assistance, trust with data and especially for automation*

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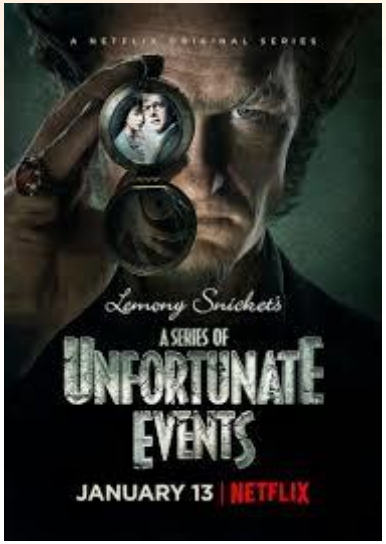
Security when things go wrong,

…From FCAS to spot markets to to RERT + beyond

When things go unexpectedly wrong

…survive major disturbances, then contribute to correcting them

"AEMO conducts investigations of 'unusual power system events' within the NEM. These are known as "reviewable operating incidents" and are generally not considered as "credible contingency events". As such, these events are not normally taken into account in the operation of the NEM."



Power System Incident Reports 2019

Date of Incident	Incident	Report Publication Date
24-25 Jan 2019	Load Shedding in VIC on 24 and 25 January 2019	16 Apr 2019

Power System Incident Reports 2018

Date of Incident	Incident	Report Publication Date
09 Dec 2018	Trip of the Hazelwood Power Station to Rowville Terminal Station No. 1 and No. 2 220 kV Transmission Lines	12 Apr 2019
23 Sept 2018	Trip of Nebo No.1 275 kV Busbar	15 Feb 2019
25 Aug 2018	Queensland and South Australia system separation on 25 August 2018 - Incident Report	10 Jan 2019
25 Aug 2018	Queensland and South Australia system separation on 25 August 2018 - Preliminary Report	10 Sep 2018
31 July 2018	Trip of Nebo-Strathmore 275 kV transmission lines	30 Nov 2018
14 June 2018	Trip of Wurdong No.1 275 kV Busbar	16 Nov 2018
22 May 2018	Trip of Multiple Transmission Elements at Ross Substation	15 Nov 2018
09 May 2018	Trip of a 330 kV busbar at Capital Substation	29 Nov 2018
14 Apr 2018	NSW Bushfires	14 Feb 2019
27 Apr 2018	Trip of a transmission line and an SVC in South Australia	30 Nov 2018
28 Feb 2018	Trip of both Tungatinah-Meadowbank-New Norfolk transmission lines	27 Nov 2018
20 Feb 2018	Trip of Tamworth No. 3 330 kV Busbar	14 Nov 2018
17 Feb 2018	Trip of two Chalumbin-Woree 275 kV transmission lines	19 Nov 2018
16 Feb 2018	Trip of multiple power system elements in the Gladstone area	05 Mar 2019
15 Feb 2018	Trip of Broken Hill 220 kV Busbar	13 Nov 2018
31 Jan 2018	Trip of Eraring No1 Generator Transformer and Eraring - Vales Point 3330kV line	03 May 2018
31 Jan 2018	Offloading of both SMTS-SYTS lines	21 Mar 2018
18 Jan 2018	Trip of Rowville No.2 500 kV Busbar	19 Mar 2019

eg. The NEM – 25 August 2018

Events of 25 August 2018

On Saturday 25 August 2018, there was a single lightning strike on a transmission tower structure supporting the two circuits of the 330 kilovolt (kV) Queensland – New South Wales interconnector (QNI) lines. The lightning strike triggered a series of reactions creating faults on each of the two circuits of QNI at 13:11:39. The QLD and NSW power systems then lost synchronism, islanding the QLD region two seconds later, at 13:11:41.

At the time, 870 MW of power was flowing from QLD to NSW. QLD experienced an immediate supply surplus, resulting in a rise in frequency to 50.9 Hertz (Hz). The remainder of the NEM experienced a supply deficit, resulting in a reduction in frequency.

In response to the reduction in frequency in the remaining interconnected regions:

- The frequency controller on the Basslink interconnector immediately increased flow from TAS to VIC from 500 MW up to 630 MW. This created a supply deficit in TAS, causing the disconnection of 81 MW of contracted interruptible load under the automatic under-frequency load shedding scheme (AUFLS2) to rebalance the TAS power system at 13:11:46.
- The SA–VIC interconnector at Heywood experienced rapid changes in power system conditions that triggered the Emergency APD Portland Tripping (EAPT) scheme. The scheme responded to those conditions, as designed, to separate the SA region at Heywood. This occurred some 6 seconds after the QNI separation at 13:11:47.

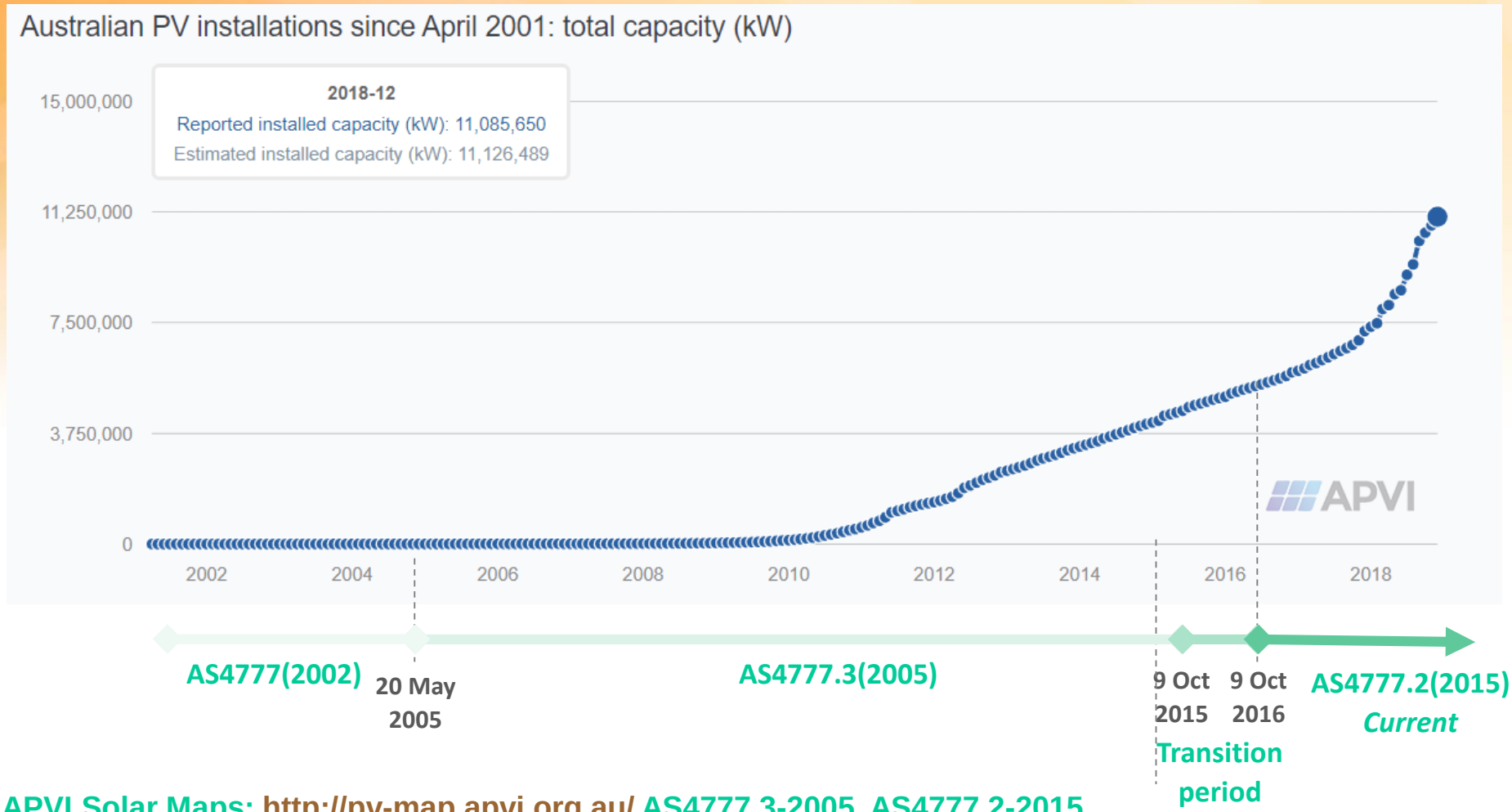
- Distributed (behind the meter) PV

  Approximately 3,096 MW of the total installed capacity of 6,278 MW of distributed (behind the meter) PV across the NEM was generating at the time of the event. Similar to large-scale PV, the distributed fleet of solar PV generally contributed to assist frequency management in QLD and SA over the course of the event by reducing output. It was not able to assist in VIC or NSW, as those regions required an increase in supply. Detailed analysis of the performance of a sample group of inverters indicated:

  – Approximately 15% of sampled systems installed before October 2016 dropped out during the event.
  – Of the sampled systems installed after October 2016, around 15% in QLD and 30% in SA did not provide the over-frequency reduction capability required by the applicable Australian standard.

Distributed PV – expected response

installed capacity, connection standard

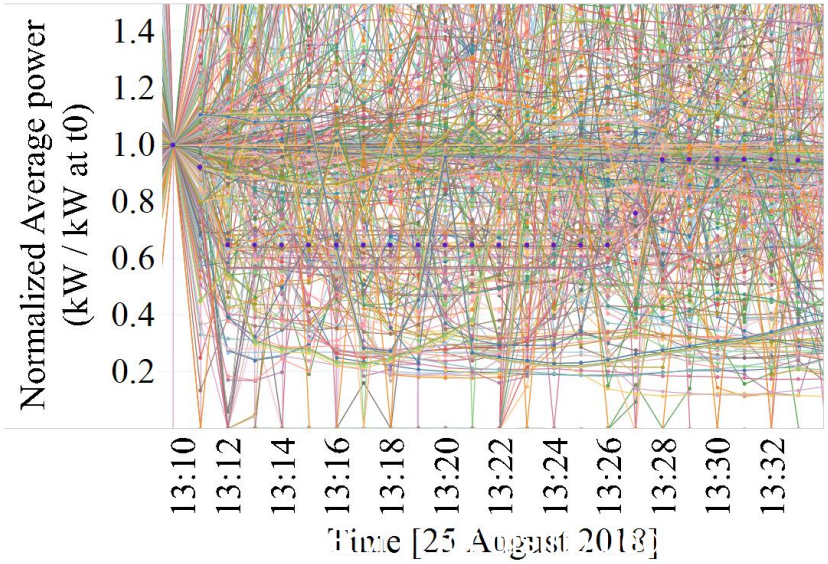


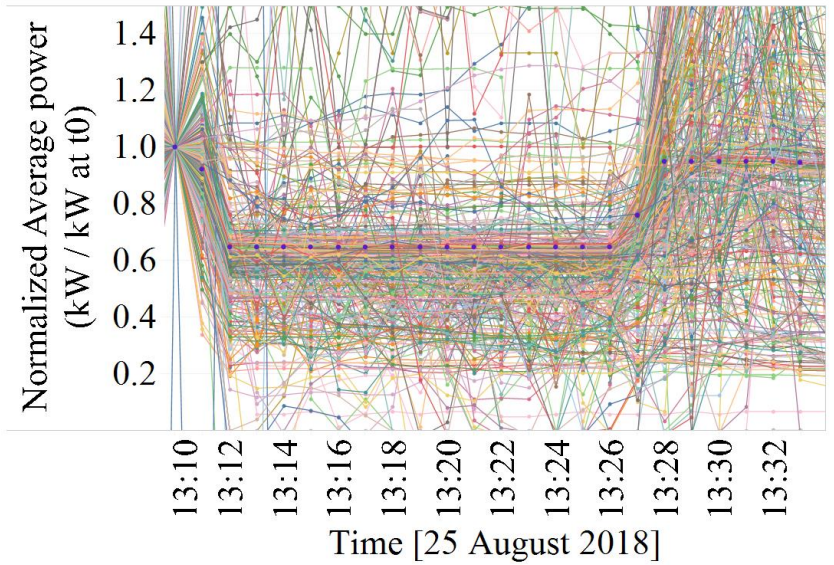
APVI Solar Maps: http://pv-map.apvi.org.au/ AS4777.3-2005, AS4777.2-2015

DE PV Analysis – what happened in the field?

Solar Analytics and UNSW, partnering with AEMO *(Stringer et al)*

	QLD	SA	NSW & ACT	Vic	Tas	Total
Post 2016, 30-100kW	92	68	118	48	4	**330**
Post 2016, <30kW	878	1557	1048	242	7	**3732**
Transition, 30-100kW	6	1	10	4	0	**21**
Transition, <30kW	295	88	182	26	1	**592**
Pre 2015, 30-100kW	5	5	17	11	0	**38**
Pre 2015, <30kW	77	43	249	48	2	**419**
Total	**1353**	**1762**	**1624**	**379**	**14**	**5132**

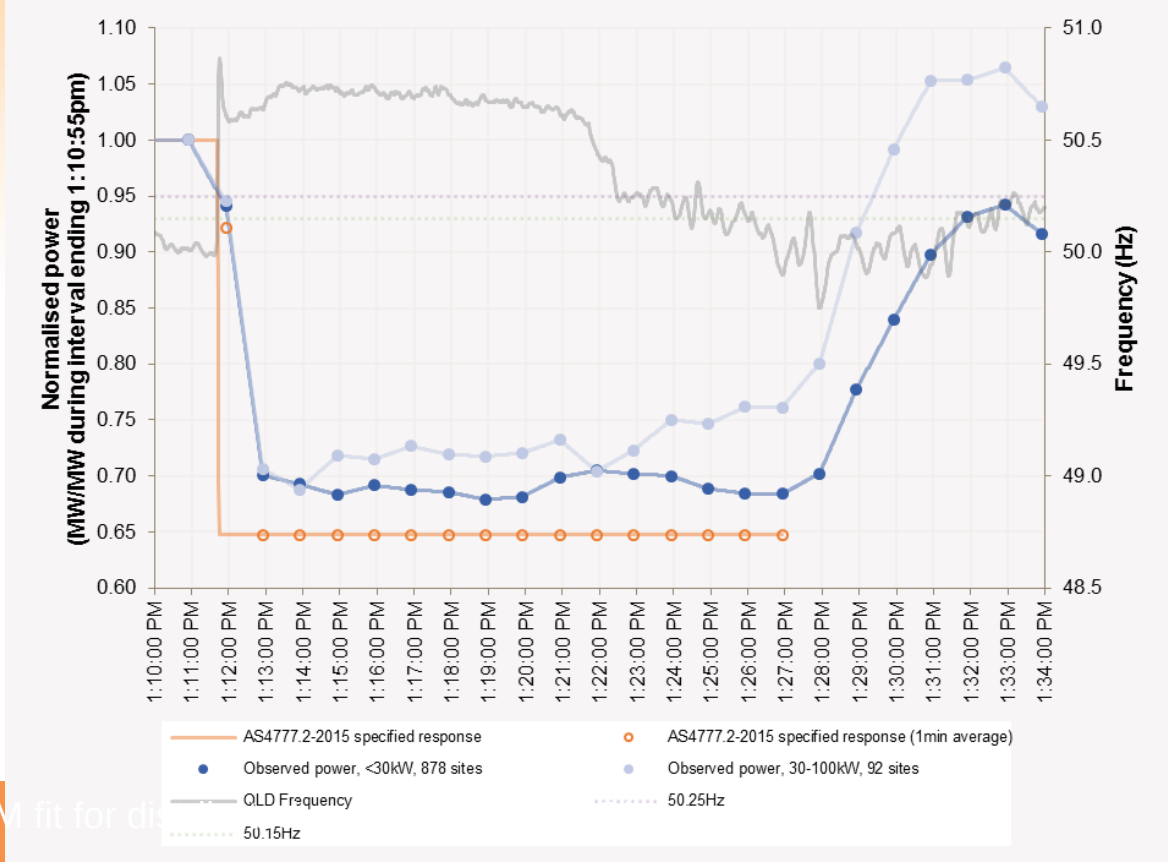




Aggregate Qld Distributed PV response

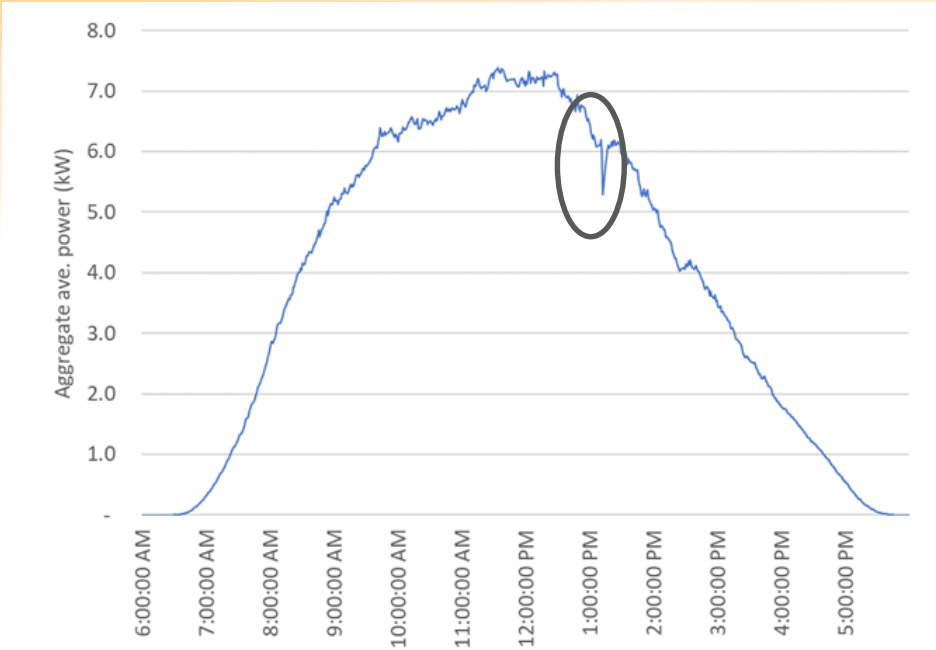
Post 2016 systems

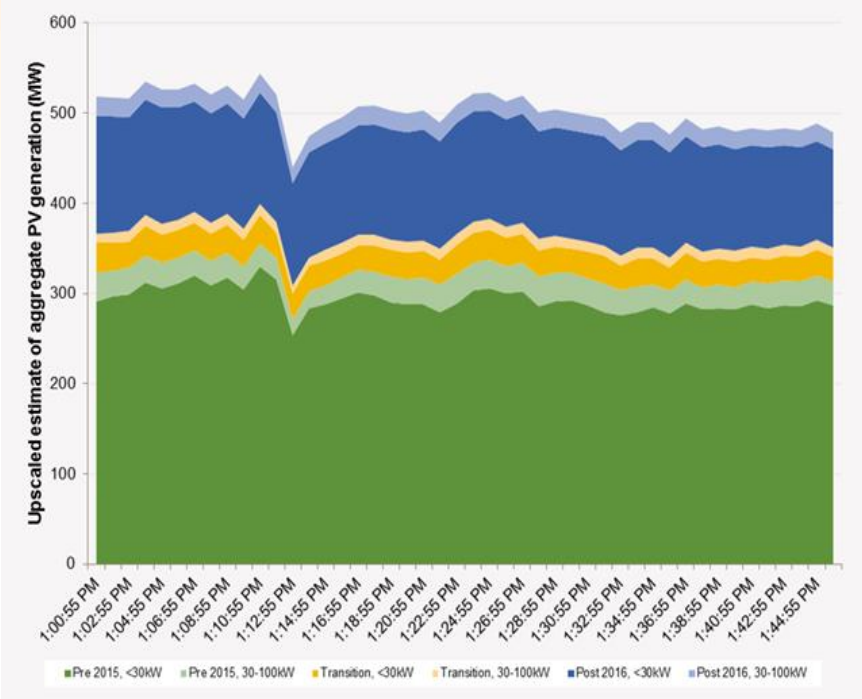
- Evidence that distributed PV acted **rapidly, autonomously** and **in concert** to assist in managing power system security from sustained over frequency
- **However,** 15% of Post-2016 systems did not perform droop response



New South Wales & ACT

- Aggregate suggests15% reduction in distributed PV – problematic given that NSW frequency fell
- Natural solar variation (scattered cloud)? or bad frequency response, **or voltage response?** *Spatial analysis suggests Voltage disturbance at QNI during trip was a key factor*



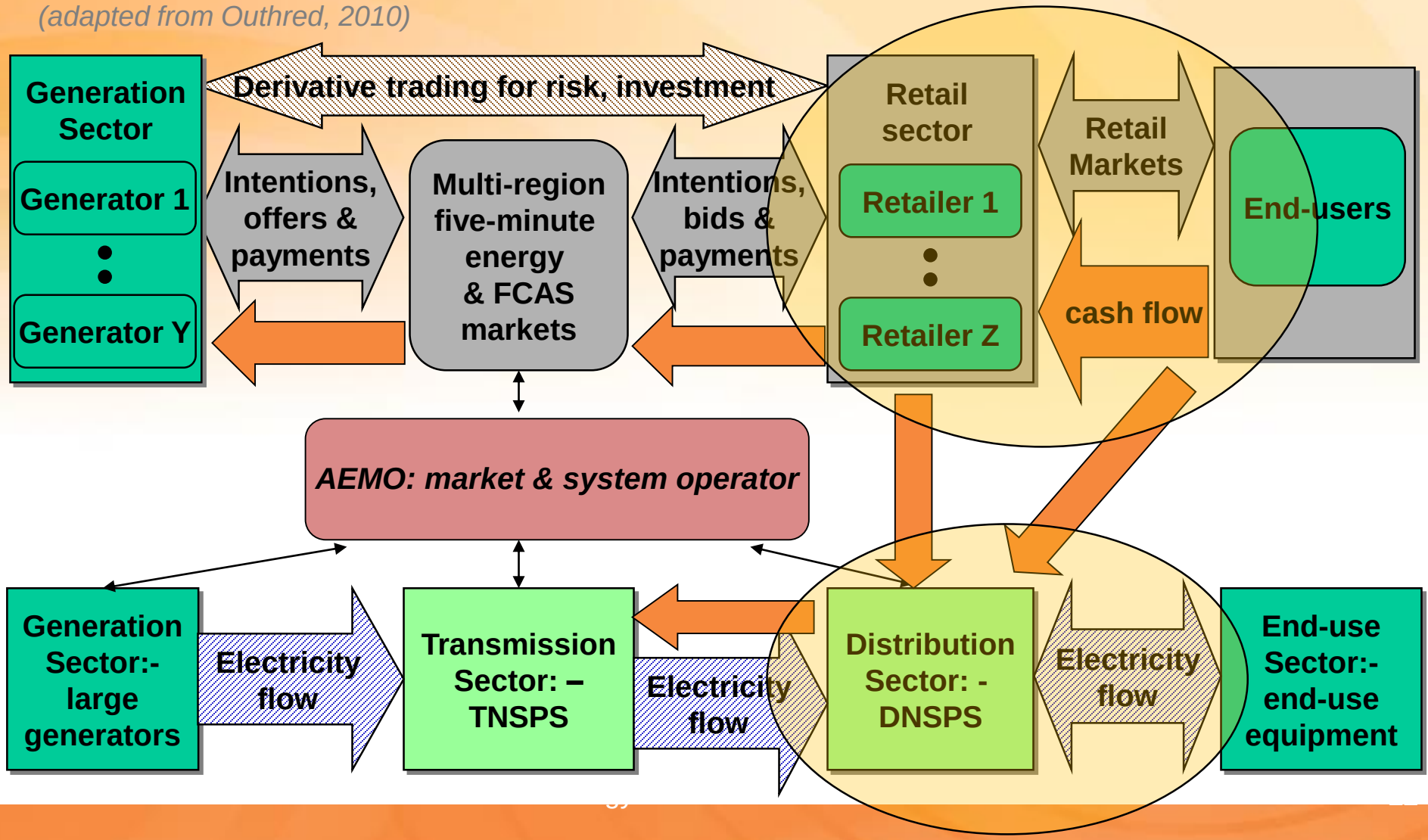


Does distributed PV help or hinder when things go bad in the Australian NEM?

- Currently appears that it can do both depending on the circumstances…
- Many opportunities to ensure that they do more to help when things go wrong
- But lots of work required from a wide range of key stakeholders

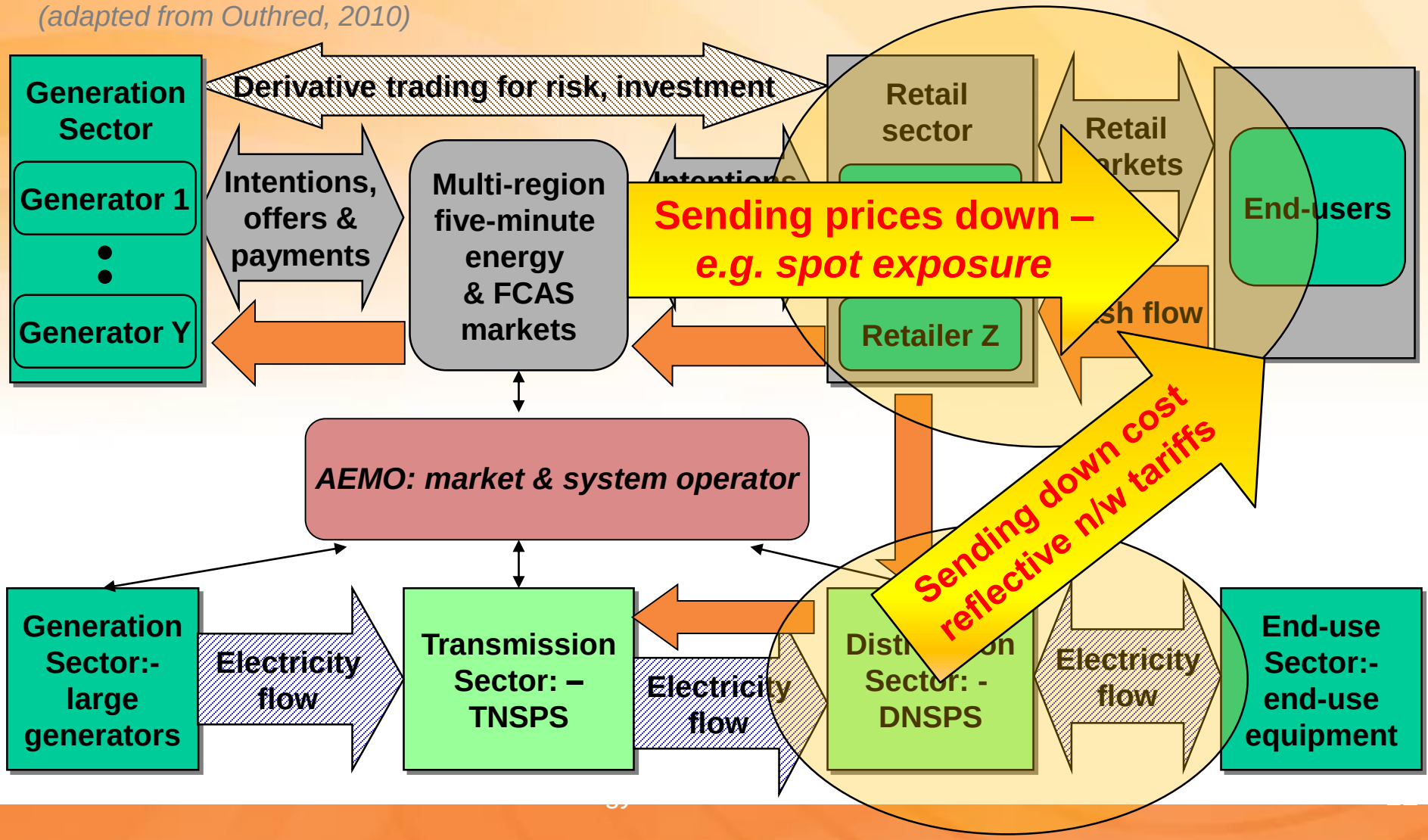
NEM regulatory-commercial end-user interface

(adapted from Outhred, 2010)



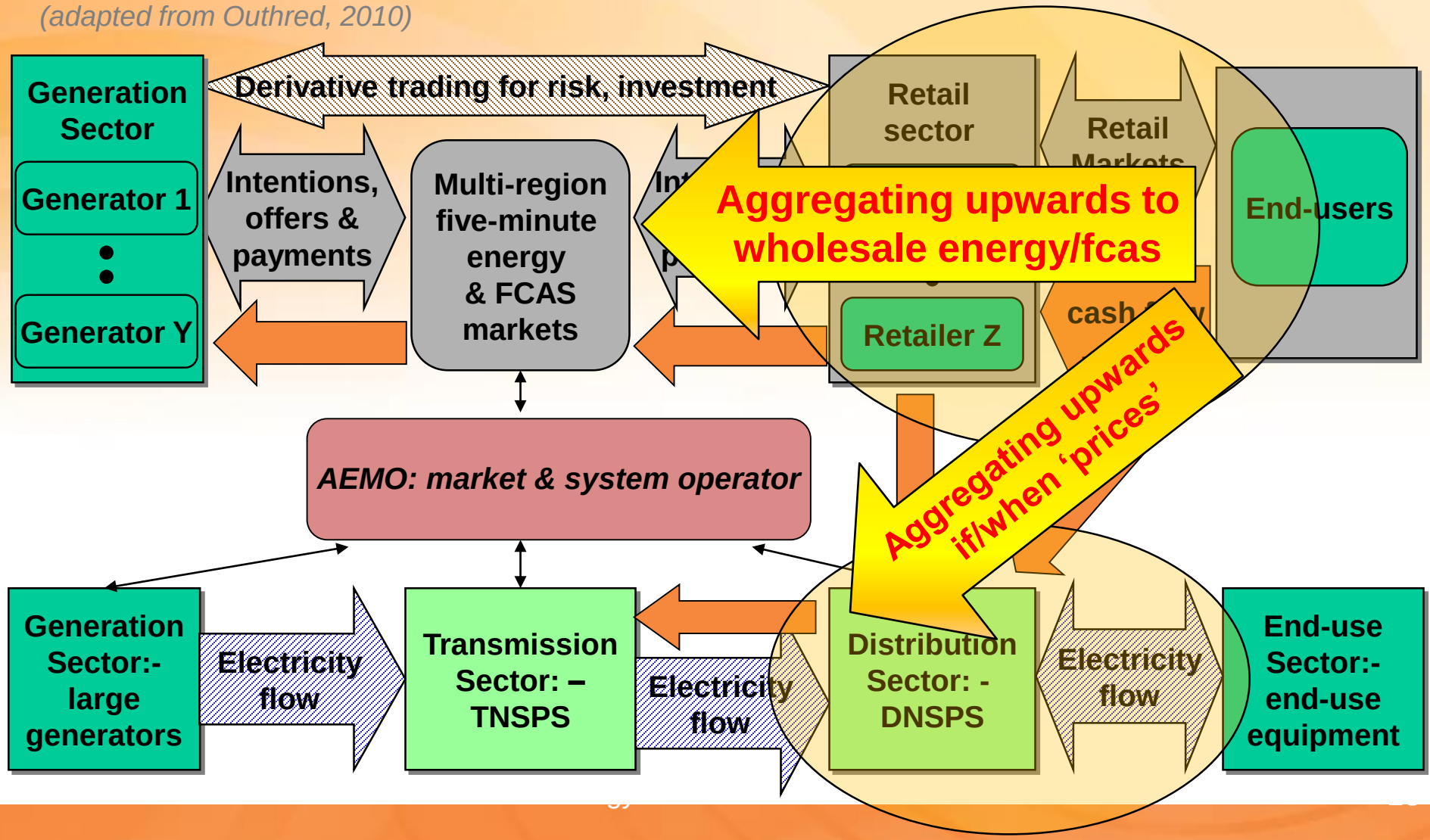
Bringing DE in – *send prices down*

(adapted from Outhred, 2010)



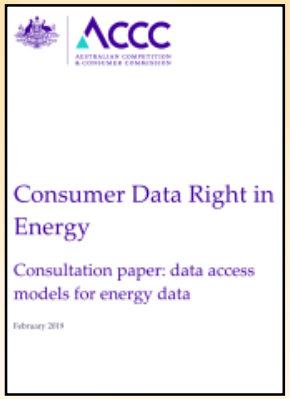
Brining DE in – *aggregate upwards*

(adapted from Outhred, 2010)



Regardless, the key role of energy users

- Ready?
  - Data is key, but currently problematic
  - *..but have to get from data to information to knowledge to wisdom*
- Willing?
  - Incentives to engage
  - Key questions of trust, particularly when automating *(Monash and UNSW leading participation in IEA TCP on demand side management)*
- Able?
  - We need energy service oriented facilitators to assist energy users to engage, build collaborations in valuable ways?
  - *And how do we best facilitate these facilitators?*



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Open data, tools … and processes

Energy scientists must show their workings

Public trust demands greater openness from those whose research is used to set policy, argues **Stefan Pfenninger**.

The global transition towards a clean and sustainable energy future is well under way. New figures from Europe this month show that the continent is on track to reach its goal of a 20% renewable-energy share by 2020, and renewable capacity in China and the United States is also rising. But many technical, political and economic uncertainties remain, not least in the data and models used to underpin such policies. These uncertainties need open discussion, and yet energy strategies all over the world are based on research not open to scrutiny.

Researchers who seek, for example, to study the economic and energy model used by the US government (called NEMS) are met with a forbidding warning. On its website, the Energy Information Administration, which is developing the model, pronounces: "Most people who have requested NEMS in the past have found out that it was too difficult or rigid to use."

At least NEMS (National Energy Modelling System) is publicly available. Most assumptions, systems, models and data used to set energy policy are not. These black-box simulations cannot be verified, discussed or challenged. This is bad for science, bad for the public and spreads distrust. Energy research needs to catch up with the open-software and open-data movements. We energy researchers should make our computer programs and data freely accessible, and academic publishing should shun us until we do.

Our community's models are relevant to policy because they explore alternative scenarios that remain hidden, like the costs of technologies, can largely determine what comes out of such models. In the United Kingdom, opaque and overly optimistic cost assumptions for onshore wind went into models used for policymaking, and that may well have delayed the country's decarbonization.

This closed culture is alien to younger researchers, who grew up with collaborative online tools and share code and data on platforms such as GitHub. Yet academia's love affair with metrics and the pressure to publish set the wrong incentives: every hour spent on cleaning up a data set for public release or writing open-source code is time not spent working on a peer-reviewed paper.

Nevertheless, some academic-led projects are pushing towards more openness. The Enipedia project is building a worldwide open database on power plants, with data such as their locations and emissions. The Open Power System Data project gathers data such as electricity consumption from government agencies and transmission-network operators, and pushes for clarity on the licensing under which these data are made available. The Open Energy Modelling Initiative is emerging as a platform for coordinating and strengthening such efforts.

Regulation can also help. The European Union has mandated open access to electricity-market data, resulting in the creation of the ENTSO-E Transparency Platform to hold it, and there are good arguments for the creation of national

BLACK-BOX **SIMULATIONS** CANNOT BE **VERIFIED,** DISCUSSED OR **CHALLENGED.**

openmod open energy modelling initiative

Openmod in a nutshell

The Open Energy Modelling (openmod) Initiative promotes open energy modelling in Europe.

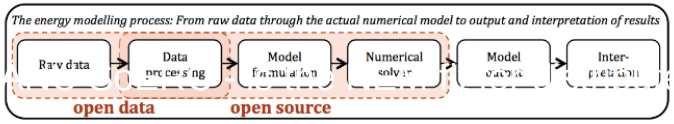
Energy models are widely used for policy advice and research. They serve to help answer questions on energy policy, decarbonization, and transitions towards renewable energy sources. Currently, most energy models are black boxes – even to fellow researchers.

"Open" refers to model source code that can be studied, changed and improved as well as freely available energy system data.

We believe that more openness in energy modelling increases transparency and credibility, reduces wasteful double-work and improves overall quality. This allows the community to advance the research frontier and gain the highest benefit from energy modelling for society.

We, energy modelers from various institutions, want to promote the idea and practice of open energy modeling among fellow modelers, research institutions, funding bodies, and recipients of our work.

The idea of openmod



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Open Source Tools

CEEM's researchers believe in the value of open source modelling in the Energy and Environmental research space. In this regard, we have developed a series of open source tools which are listed below. For a list of some of our under development tools you can refer CEEM's Github page.

NEMOSIS - NEM Open Source Information Service:

Open-source access to Australian National Electricity Market data.

Links: Github , Paper

NEMO - National Electricity Market Optimiser Tool:

NEMO, the National Electricity Market Optimiser, is a chronological dispatch model for testing and optimising different portfolios of conventional and renewable electricity generation technologies. It has been developed since 2011 and is maintained by Ben Elliston through his PhD at CEEM. NEMO is available under a free software license (GPL version 3) and requires no proprietary software to run, making it particularly accessible to the governments of developing countries, academic researchers and students. The model is available for others to inspect and to validate results.

Links: Github, OzLabs

TDA - Tariff Design and Analysis Tool:

We have developed a modelling tool to assist stakeholders wishing to contribute to network tariff design in the Australian National Electricity Market. It is an open source modelling tool to assist stakeholders in assessing the implications of different possible network tariff designs, and hence facilitate broader engagement in the relevant rule making and regulatory processes in the NEM. Our tool takes public energy consumption data from over 5000 households in NSW, and allows users test a wide range of existing, proposed and possible tariffs structures to see their impacts on network revenue and household bills. Demographic survey data of the households allows you to explore the impacts of these tariffs on particular household types – for example, families with young children. The tool can also show how well different tariffs align these household bills with a households' contribution to network peak demand. The tool and data are open source – you can check, validate and add your own data sets; test existing or even design your own tariffs, and validate and even modify the underlying algorithms.

Links: Project page, Github, Researchgate

Solar Apartments and Microgrid Models

The Solar Apartments model can be used to model the electrical and financial flows in apartment buildings with PV (and batteries) installed behind the meter or distributed through embedded networks. The Community Microgrid model can be used to model the electrical and financial flows for a microgrid with behind the meter PV and a centralised battery.

More info and links to download the model can be found here.

NemLite - Open Source model of NEM Dispatch Engine:

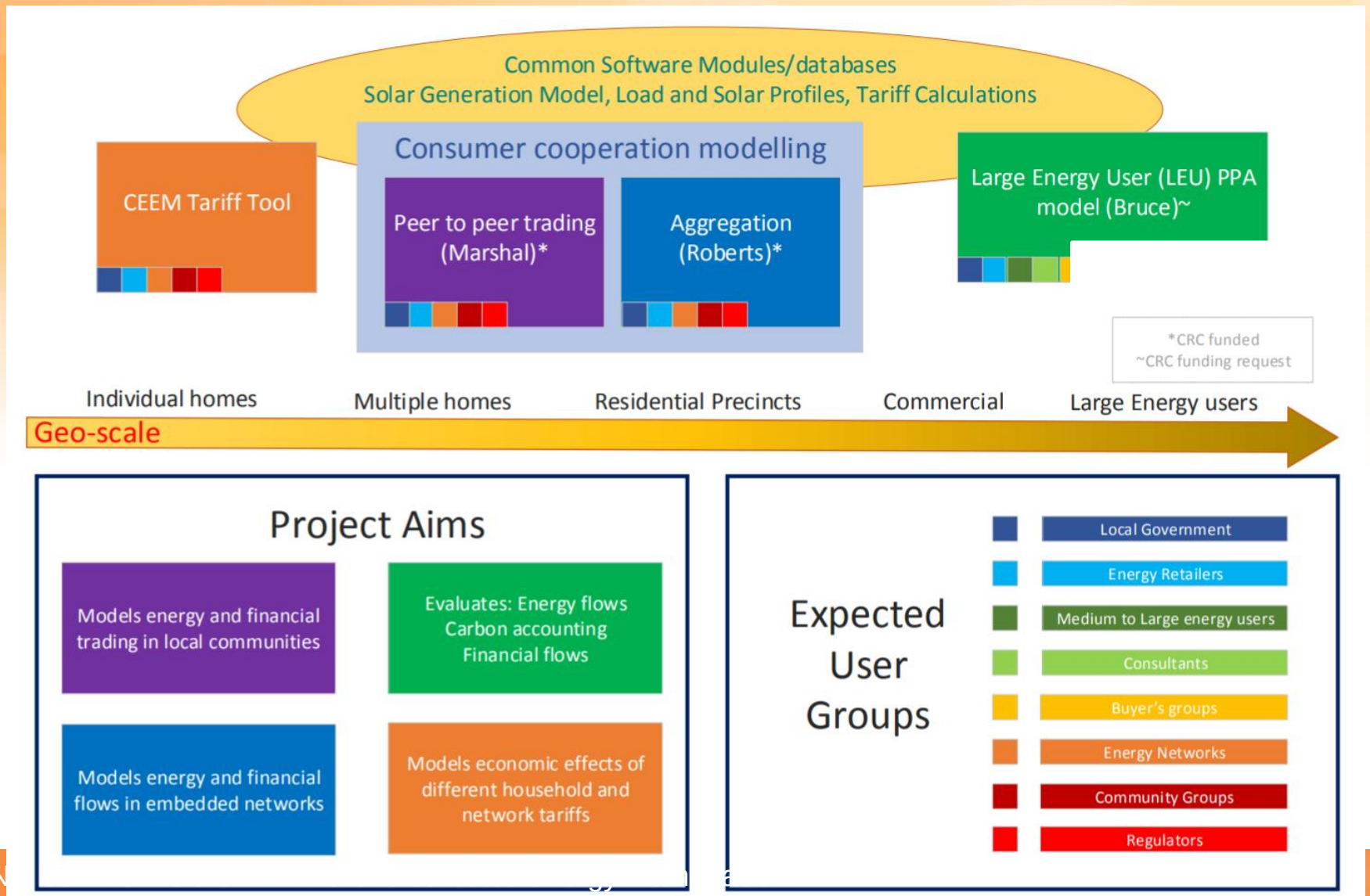
Intended to replicate the performance of the National Electricity Market Dispatch Engine (NEMDE).

Links: Github

Renewable PPA Tool:

Open source tools to assist large energy users, energy consumers, buyers' groups and local government to contract with off-site renewables projects through a PPA and therefore meet their renewables and emissions goals; and assist in PPA monitoring, to ensure value for energy consumers. More information can be found here. These tools can be found here.

SPREE/CEEM open-source DER modelling tools



With thanks from the SPREE/CEEM Energy User Centered Modelling and Analysis Team

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