Is the NEM fit for distributed energy?

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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*
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.”
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

Australian PV installations since April 2001: total capacity (kW)

- **2018-12**
  - Reported installed capacity (kW): 11,085,650
  - Estimated installed capacity (kW): 11,126,489


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DE PV Analysis – what happened in the field?

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

<table>
<thead>
<tr>
<th></th>
<th>QLD</th>
<th>SA</th>
<th>NSW &amp; ACT</th>
<th>Vic</th>
<th>Tas</th>
<th>Total</th>
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<tbody>
<tr>
<td>Post 2016, 30-100kW</td>
<td>92</td>
<td>68</td>
<td>118</td>
<td>48</td>
<td>4</td>
<td>330</td>
</tr>
<tr>
<td>Post 2016, &lt;30kW</td>
<td>878</td>
<td>1557</td>
<td>1048</td>
<td>242</td>
<td>7</td>
<td>3732</td>
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<tr>
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<td>6</td>
<td>1</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Transition, &lt;30kW</td>
<td>295</td>
<td>88</td>
<td>182</td>
<td>26</td>
<td>1</td>
<td>592</td>
</tr>
<tr>
<td>Pre 2015, 30-100kW</td>
<td>5</td>
<td>5</td>
<td>17</td>
<td>11</td>
<td>0</td>
<td>38</td>
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<tr>
<td>Pre 2015, &lt;30kW</td>
<td>77</td>
<td>43</td>
<td>249</td>
<td>48</td>
<td>2</td>
<td>419</td>
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<tr>
<td><strong>Total</strong></td>
<td>1353</td>
<td>1762</td>
<td>1624</td>
<td>379</td>
<td>14</td>
<td>5132</td>
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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 suggests 15% 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

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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)

Sending prices down – e.g. spot exposure

Sending down cost reflective n/w tariffs

AEMO: market & system operator
Brining DE in – aggregate upwards

(adapted from Outhred, 2010)

AEMO: market & system operator

Aggregating upwards if/when ‘prices’

Aggregating upwards to wholesale energy/FCAS

Derivative trading for risk, investment

Intentions, offers & payments

Multi-region five-minute energy & FCAS markets

Intentions, offers & payments

End-users

Retail Markets

Retail sector

Generator Y

Generator 1

Generator

Sector:
large
generators

Sector:

Transmission

Sector: –

TNSPS

Distribution

Sector: -

DNSPS

Electricity

sector

electricity

flow

Electricity

flow

Electricity

flow

cash flow

End-use
Sector:-
end-use
equipment

Retailer Z

Retailer

sector

intentions,
bids &
payments

Intentions,
offers &
payments

Electricity

flow

End-use:

sector

end-use
equipment

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End-use:

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end-use
equipment

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End-users

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Generation

Sector

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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?*
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 underway. New figures from Europe this month show that the continent is on track to reach a goal of 20% renewable energy share by 2020, and renewable capacity in China and the United States is also rising. But many technological, political and economic uncertainties remain, and just how the data is used and underpinned by such policies. These uncertainties spread across the world as research is open to scrutiny. Researchers who seek, for example, to study the economic and environmental model used by the US government (called NEMS) are met with a forbidding wall. On this week’s Energy Information Administration website, the model, is exceptionally opaque. Most people who have requested NEMS in the past have found out that it was too difficult to get it.

At least NEMS (National Energy Modelling System) is publicly available. Most assumptions, systems, models and data used to set energy policy are currently made in the black box. Even if simulations cannot be verified, discussed or challenged, this is bad for science, bad for the public and bad for trust. Energy research needs to catch up with the open software and open-data movements. We need to look at using open-source code to estimate the impact of policy changes or to compare results from different models. A new government is expected to introduce more transparency. The Enipedia project is building a worldwide open database of open-source energy models, with data such as the locations and emissions. The Open Power System Data Project gathers data on electricity production, consumption and emissions, with data such as the locations and emissions. The Open Power System Data Project gathers data on electricity production, consumption and emissions, with data such as the locations and emissions.

The Open Energy Modeling (openmod) initiative promotes open energy modeling 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 for 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 modeling increases transparency and credibility, reduces wasteful coupled work and improves overall quality. This allows the community to advance the research frontier and gain the highest benefit from energy modeling 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

The energy modeling process: From raw data through to the actual analytical model to output and interpretation of results.
SPREE/CEEM open-source DER modelling tools

Common Software Modules/databases
- Solar Generation Model, Load and Solar Profiles, Tariff Calculations

Project Aims
- Models energy and financial trading in local communities
- Evaluates: Energy flows, Carbon accounting, Financial flows
- Models energy and financial flows in embedded networks
- Models economic effects of different household and network tariffs

Expected User Groups
- Local Government
- Energy Retailers
- Medium to Large energy users
- Consultants
- Buyer’s groups
- Energy Networks
- Community Groups
- Regulators

*CRC funded ~CRC funding request
With thanks from the SPREE/CEEM Energy User Centered Modelling and Analysis Team

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