The future Australian National Electricity Market: how affordable, secure and sustainable? …and how renewable, distributed and competitive?

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Joint Director (Engineering), CEEM

ZHAW School of Management and Law Seminar
Zurich, 6 June 2019
Australian NEM

- Although not actually National
- And not primarily a Market, but a power system

<table>
<thead>
<tr>
<th>Participating jurisdictions</th>
<th>Qld, NSW, Vic, SA, Tas, ACT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEM regions</td>
<td>Qld, NSW, Vic, SA, Tas</td>
</tr>
<tr>
<td>NEM installed capacity (including rooftop solar PV)</td>
<td>55 590 MW</td>
</tr>
<tr>
<td>Number of large generating units</td>
<td>240</td>
</tr>
<tr>
<td>Number of customers</td>
<td>9.7 million</td>
</tr>
<tr>
<td>NEM turnover 2017–18</td>
<td>$17 billion</td>
</tr>
<tr>
<td>Total electricity demand 2017–18¹</td>
<td>203 TWh</td>
</tr>
<tr>
<td>National maximum demand 2017–18²</td>
<td>32 469 MW</td>
</tr>
</tbody>
</table>

(AER, State of the Energy Market, 2018)
Still, NEM a leading global example of a highly restructured electricity sector

(IEA, 2016)
The Australian National Electricity Market (NEM)

(adapted from Outhred, 2010)

Generation Sector: large generators

Derivative trading

Multi-region five-minute energy & FCAS markets

Intentions, offers & payments

Intentions, bids & payments

Retail sector

Retail Markets

Retailer 1

Retailer Z

Embedded generators

End-users

End-use sector (including DR)

AEMO: market & system operator

Generation Sector: large generators

Transmission Sector

Distribution sector

Energy flow

Energy flow

Energy flow

Intentions, offers & payments

Intentions, bids & payments

Retailer Z

Retail Markets

Retailer 1

Embedded generators

End-users

End-use sector (including DR)

Cash flow

Cash flow

Cash flow

(adapted from Outhred, 2010)
The future NEM

- How affordable?
- How secure?
- How sustainable?
Represents possible destination: our long-term interests difficult decisions seem required – choose any two?

Balancing the ‘Energy Trilemma’

Energy Security
The effective management of primary energy supply from domestic and external sources, the reliability of energy infrastructure, and the ability of energy providers to meet current and future demand.

Energy Equity
Accessibility and affordability of energy supply across the population.

Environmental Sustainability
Encompasses the achievement of supply and demand-side energy efficiencies and the development of energy supply from renewable and other low-carbon sources.

“To promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to –

- price, quality, safety, reliability, and security of supply of electricity; and
- the reliability, safety and security of the national electricity system.”

National Electricity Law (Schedule to the National Electricity (South Australia) Act 1996), s.7

(World Energy Council, 2016)
Electricity emissions intensity comparison
*(shrink that footprint)*

<table>
<thead>
<tr>
<th>Country</th>
<th>Direct</th>
<th>Indirect</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>1.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>1.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>1.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>0.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>0.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>0.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>0.01</td>
<td></td>
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</table>

Australian residential energy prices index
*(Australian Energy Statistics Update 2017)*

- **Figure 1.9**: Comparison of residential electricity prices (before and after tax) (Australian cents per kWh) (May 2017 prices in Australia, 2015 prices in European countries)

- **Energy Consumers Australia Energy Consumer Sentiment Survey June 2018**
Including growing security and reliability challenges

<table>
<thead>
<tr>
<th>Issue</th>
<th>What we are seeing</th>
<th>Operational implications</th>
<th>Potential avenues to address</th>
</tr>
</thead>
</table>
| Changing supply mix          | • More variable renewable energy  
• Less dispatchable generation  
• Older resources                                                                 | • Increased variability and uncertainty in the resource mix  
• Increased reliance on directions                                      | • Forecasting improvements  
• Valuing flexible performance  
• Strategic reserves  
• Day-ahead markets  
• Integrated system planning                                      |
| Changing electricity demand  | • Higher ramps for peaks  
• Lower minimum demand  
• More active consumers  
• More distributed energy resources (DER)                          | • Increased variability and uncertainty in demand  
• Erosion of baseload  
• Increased ramping requirement                                      | • Forecasting improvements  
• Use of DER  
• Valuing flexible performance  
• Strategic reserves  
• Day-ahead markets  
• Integrated system planning                                      |
| Changing impact of weather   | • Temperature changes  
• Extremity of weather events                                                  | • Increased demand  
• Increased stress on system over prolonged heat periods  
• Increased risk of disruption  
• Increased uncertainty                                                  | • Planning operating standards  
• Use of DER  
• Optimising utilisation of demand side response – for reserves to manage uncertainty and support greater system resilience  
• Forecasting improvements                                              |
..yet perhaps can have it all

Falling variable renewables costs clearly a game changer

Egypt receives two bids under $0.03/kWh in 200 MW solar tender

The lowest bid was submitted by Spanish developer Fotowatio, which offered US$0.02791 per kWh. Slightly higher, at $0.02799 per kWh, was the offer of Saudi power company, ACWA.

AUGUST 7, 2018  EMILIANO BELLINI
Lessons on sustainable electricity industry transition

IEA SDS

Centre for Energy and Environmental Markets

Sustainable Development Scenario

- Address climate change
- Achieve universal energy access
- Improve air quality

New Policies Scenario

- 44% Efficiency
- 36% Renewables
- 6% Nuclear
- 9% CCS
- 2% Other

Sustainable Development Scenario

Fossil-fuel demand

- Oil
- Coal
- Gas

TWh

- Other renewable
- Solar PV
- Wind
- Hydro
- Nuclear
- Oil
- Gas
- Gas CCS
- Coal CCS
- Coal

IEA, World Energy Outlook, 2018
NEM scenarios
No electricity sector plan as such at present…but AEMO National Tx planning provides range of scenarios
The future NEM

▪ How renewable?

▪ How distributed?

▪ How competitive?
To date for Australia’s electricity sector


The future is already here — it’s just not very evenly distributed.

(William Gibson)
Recently, greater NEM-wide RE deployment

- South Australia has one of world’s highest regional penetrations of variable renewables

Year ending February 2019 were:
- total NEM 21.2%,
- New South Wales 12.0%
- Queensland 8.4%
- Victoria 20.8%
- South Australia 52.8%
- Tasmania 97.1%
THE CONSTRUCTION BOOM FOR LARGE-SCALE RENEWABLE ENERGY PROJECTS
(PROJECTS UNDER CONSTRUCTION OR FINANCIALLY COMMITTED)

(Clean Energy Council, 2019)

- **Total planned projects**: 14,841
- **Total investment**: $24.5b
- **Total jobs**: 13,233

**Victoria (VIC)**
- **3140 Megawatts**
- **$5034m Investment**
- **2894 Jobs**

**Tasmania (TAS)**
- **3800 Megawatts**
- **$4714m Investment**
- **2320 Jobs**

**Other regions**
- **262 Megawatts**
- **$580m Investment**
- **358 Jobs**

- **45 Megawatts**
- **$83m Investment**
- **170 Jobs**

- **4941 Megawatts**
- **$10,003m Investment**
- **4681 Jobs**

- **395 Megawatts**
- **$945m Investment**
- **500 Jobs**

*As at 15 March 2019*
Two market ‘worlds’ for renewables integration

(adapted from Outhred, 2010)

Centralised Renewables eg. Wind, PV, CSP

Distributed Renewables eg. PV, CHP

Generation Sector: large generators

Transmission Sector

Distribution sector

Retail sector

Retail Markets

End-users

Embedded generators

Energy flow for High Renewables

Energy flow

AEMO: market & system operator

Derivative trading (cashflow?)

Multi-region five-minute energy & FCAS markets

Intentions, offers & payments

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Cash flow

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Cash flow
What exists is possible… but challenges ahead.

Phase 1
No relevant impact on system integration

Phase 2
VRE has a minor to moderate impact on system operation

Phase 3
VRE generation determines the operation pattern of the system

Phase 4
The system experiences periods where VRE makes up almost all generation

Phase 5
Growing amounts of VRE surplus (days to weeks)

Phase 6
Monthly or seasonal surplus or deficit of VRE supply

Key transition challenges
- Power supply robustness under high VRE generation
- Greater variability of net load and new power flow patterns
- Minor changes to operating patterns
- Longer periods of energy surplus or deficit
- Need for seasonal storage

(EIA, World Energy Outlook, 2018)
## Elec. Markets for high RE – NEM Status

*(IEA, Next Generation Wind and Solar, 2016)*

<table>
<thead>
<tr>
<th>System-friendly strategy</th>
<th>Policy tool</th>
<th>Country example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System service capabilities</strong></td>
<td>Grid codes that require advanced capabilities</td>
<td>Participation of advanced technologies and services markets</td>
</tr>
<tr>
<td></td>
<td>Advanced design of system services markets</td>
<td></td>
</tr>
<tr>
<td><strong>Location of deployment</strong></td>
<td>Integrated planning of grid infrastructure and generation</td>
<td>Integrated planning in Brazil</td>
</tr>
<tr>
<td></td>
<td>Locational signals in remuneration schemes</td>
<td>Mexican auction differentiation levels in Chile</td>
</tr>
<tr>
<td><strong>Technology mix</strong></td>
<td>Technology-specific auctions that reflect the value of each technology as determined in long-term planning</td>
<td>Technology mix in South Africa</td>
</tr>
<tr>
<td></td>
<td>SV reflected in multi-technology auctions</td>
<td>Technology mix in Mexico</td>
</tr>
<tr>
<td><strong>Economic design criteria</strong></td>
<td>Partial exposure to market prices via premium systems</td>
<td>German and US renewable systems</td>
</tr>
<tr>
<td><strong>Integrated planning, monitoring and revision</strong></td>
<td>An integrated long-term plan for VRE and flexible resources, updated regularly</td>
<td>Integrated system planning in Denmark</td>
</tr>
</tbody>
</table>

- NEM reasonably placed but grandfathering of existing plant – RE and conventional – raising issues; need these for Distributed Resources too.
- NEM reasonably placed although some FCAS issues needing attention; AEMO security review underway, non-synchronous generation penetration limits seem particularly key to high RE.
- NEM improving ISP but are scenarios sufficiently ‘stretched’, AEMC Tx framework reporting regime coming; what of possible strategic investment; queues for RE projects growing; Dx integrated planning required too.
- NEM temporal and regional pricing and use of RET means project developers see some technology, temporal and locational signalling – does State moves to auctioning reduce this? Merit Order Effect hits renewables harder than conventional plant – appropriateness of energy-only market for both RE as well as fossil-plant investment (and exit) requirements to be considered, growing o/s experience to draw upon.

In the broader policy context, simply Shambolic here in Australia at present, and gravely damaging opportunities for effective and efficient RE integration.
Not just adding RE but losing thermal plant

**Figure 1:** Entry and exit of generation capacity in the NEM, 2007 to 2020

(AEMO, Quarterly Dynamics, 2019)
Resource adequacy tightening

(Grattan Institute, 2017)
Wind, PV curtailment not necessarily bad

The visible grey shaded area represents an estimate of the volume of wind curtailed over the period.

The key constraint was effective from 19th July.

Please accept my apologies for the x-axis. I'm not proficient enough in newer versions of Excel to make it behave nicely with large sets of date-based data, unfortunately.
In South Australia

- Present arrangements appear to be struggling with existing wind and PV penetrations
- And the evident solution of increased Tx investment doesn’t necessarily solve the wider NEM integration challenge as penetrations continue to climb

**Figure 6.4:** Impact of direction on SA prices - 22-25 September 2017

**Figure 27** Directions for system security in South Australia and Victoria

Source: AEMC analysis of NEM data

Note:
The future NEM

▪ How renewable?
▪ How distributed?
▪ How competitive?
PV’s ultimate scalability

Distributed energy storage in the NEM - aggregating up, sending price signals down
Australian PV

- Over 80% is ‘rooftop’ PV
- World leading residential PV penetration
- ~15% new Residential PV includes energy storage

RESIDENTIAL ENERGY STORAGE SYSTEM INSTALLATIONS

(Australian Clean Energy Council, 2018)

Australia’s residential PV penetration

(Finkel Review into NEM Security, 2017)
Global perspectives

**Figure 5.6** Solar PV capacity growth and total generation, 2006-23

(IEA, Renewables 2018)
Li Ion energy storage even more scalable
PV + BESS – large, small or all?

- Can distributed PV + storage do everything that large utility scale plant can?
  - Speed of response?
  - Ride-through major power system disturbances
  - Operational envelope subject to local network conditions

- Can it do things that large utility PV + storage can’t?
  - Local network services
  - Consumer self-reliability
  - Improved consumer bills

- Where is it most valuable?

**Figure 7.23** Annual additions of behind-the-meter and utility-scale battery storage, 2012-2017

(IEA, World Energy Outlook 2018)
Distributed ‘rooftop’ PV an increasingly significant wholesale market, as well as security, issue
Distributed energy has 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
- Clean energy provision

However, only some of these possible value propositions are appropriately incentivised under current ‘commercial’ settings
But a disfunctional world for DER integration
The future NEM

- How renewable?
- How distributed?
- How competitive?
Structure of NEM – ownership of GW

(AER, State of the Energy Market, 2018)
Evident exercise of market power

(AER, State of the Energy Market, 2018)
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 industry ‘reform’, liberalisation, deregulation, restructuring
- ..to perhaps partners, competitors, or even ‘deserters’?
  - Demand Response, Self-generation, Energy Storage…

Now all of the above – how do we design appropriate interface?

(MacGill & Smith, Consumers or prosumers, customers or competitors?—Some Australian perspectives on possible energy users of the future., EEEP, 2017)
Do we have a ‘real’ retail electricity market?

 Depends who you ask

- Internationally, NEM often argued to be a leading example
- …but Current measures of competition miss key issues
  - Yes, NEM high switching rates – but real customer choice or just churn?
  - Yes, NEM price spreads – but reflect competition or stickiness

Certainly little focus on energy services and engagement

“…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)

- An oligopoly of large ‘gentailers’

DSP in the NEM - aggregating up, sending price signals
NEM retail market share

(AER, State of the Energy Market, 2018)

Note (figures 1.10 and 1.11): Includes residential and small business customers. All data at June 2018, except Victoria (June 2017).
What might a real mkt look like? A focus on

- Consumer energy services rather than ‘commodity’ kWh/MWh prices
- Consumers’ long-term interests, including need for energy transition
- Facilitation for energy users to participate in a wide range of services
  - Aggregating up vital for distributed storage to contribute value that takes coordinated behaviour, not necessarily all the way to wholesale where NEM currently has limited locational pricing, opaque derivatives, market power and inefficient by design because don’t include env. externalities
  - Sending prices down also vital in appropriate circumstances, not necessarily all the way down to all consumers as very consumer and context dependent; and major reform of interface b/n supply + demand sides of electricity sector and Network Service Providers required before genuine ‘price discovery’ can occur.
  - We need ESCOs, not retailers - have to properly support new players with innovative business, community and other models for efficiently delivering end-user energy services, coordinated end-user participation
Possible ‘coordination’ paths forward

Single Integrated Platform (SIP) - The single platform model envisages a unitary point of entry to the entirety of the NEM and WEM. Under this option, the platform would be an extension of the wholesale market. AEMO would provide the platform as part of its market and system responsibilities and along with the individual distribution utilities will develop a single integrated platform that will use a set of agreed standard interfaces to support the participation in the integrated multi-directional market by retailers, aggregators, and VPP platform companies. The SIP will then simultaneously solve local security constraints and support wholesale market entry. Under this configuration, access to the platform will be a one-stop shop that provides market participants the opportunity to participate anywhere in the NEM or WEM without having to develop separate systems or tools to integrate with the various individual distribution platforms. Network businesses will be linked into the platform, with distribution business providing information on local constraints to AEMO. AEMO would consider this information and economically dispatch these resources alongside other resources (transmission connected load, large scale generation etc.).

Two Step Tiered Regulated Platforms - A second alternative is a model where there is a layered distribution level platform interface operated by the local distribution network and an interface between the distribution network’s platform and AEMO. Under this design, individual distribution networks can design interfaces that best meet their system requirements. Participants would then need to communicate directly with the distribution level platform for the local constraint issues and the distribution network would optimise these resources against local network constraints based on bids from the aggregators servicing the area.

Distribution networks would provide an aggregated view per the transmission connection point. AEMO would take this information and consider the overall system security and economic dispatch.

Independent DSO - A third option, that is a variant of the second, is for an independent party - a DSO that is separate from AEMO and the distribution utility. Under this model the independent DSO would work with the distribution utility to optimise the dispatch of the DER based upon local system constraints that are provided by the network business, provide the aggregated bids to AEMO for incorporation into the larger dispatch. This option will be more complex than the others and may be significantly more costly.
Regardless, a broader design challenge across regulation, markets and external policies and with a focus on robustness, rather than efficiency.

Comprehensive and coherent (Riesz et al, 2017) policy development process

1. Regulation
   - Transmission network planning
   - Distribution network planning
   - Grid codes

2. Market Design
   - Fundamental market design
   - Spot market rules
   - Ancillary service market rules

3. External Policy Drivers
   - Carbon policies
   - Renewable & energy efficiency policies
   - Fuel policies

Robustness and Resilience: ability to perform reasonably well under a wide range of possible futures.
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 to a clean and sustainable energy future is under way. New figures from Europe this month show that the continent is on track to meet its goal of 20% renewable energy by 2020, and renewable capacity in China and the United States is also rising. But many technological, political and economic uncertainties remain, not least in the data and models used to underpin such policies. These uncertainties often open up discussion, and yet energy strategies across the world are based on research 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, promises: “Most people who have requested NEMS in the past have found out that it was too difficult or too large.”

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 boxes simulations cannot be verified, discussed or challenged. This is bad for science, bad for the public and public distrust. Energy research needs to catch up with the open software and open data movements. We encourage energy researchers to make their computer programs and data freely accessible, and academic publishing should start and set the pace.

Our community’s models are relevant to the work of many other communities. This is true for research in the fields of energy policy, economics, finance, climate change, energy security, energy planning, energy efficiency, and so on. It is also true for work in the fields of energy data, energy data analytics, and energy data science.

Openmod

Openmod in a nutshell
The Open Energy Modeling (openmod) initiative promotes open energy modeling in Europe.

Energy models are widely used for policy advice and research. They 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 data. We believe that more openness in energy modeling increases transparency and credibility, reduces unwieldy computer 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 encourage models 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 to through the actual numerical model to output and interpretation of results

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

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

NEMO - National Electricity Market Optimisation Tool:
NEMO, the National Electricity Market Optimisation 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 licence (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 those 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

Local Solar Sharing Scheme Model:
Intended for modelling embedded networks, local solar and peer to peer electricity networks. This software was developed by Ron Stolinger, Luke Marshall and Bob Passay at CEEM. A working build with a simple user interface for OSX can be found here.

Links: Github

NemLife - Open Source model of NEM Dispatch Engine:
Intended to replicate the performance of the National Electricity Market Dispatch Engine (NEMDE).

Links: Github

aggregating up, sending price signals down
SPREE/CEEM open-source DER modelling tools

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

- CEEM Tariff Tool
- Consumer cooperation modelling
  - Peer to peer trading (Marshak)*
  - Aggregation (Roberts)*
- Large Energy User (LEU) PPA model (Bruce)~

Geo-scale

Individual homes  Multiple homes  Residential Precincts  Commercial  Large Energy users

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
The future NEM

How affordable, secure and sustainable?
- In part an outcome of past, often poor, choices, but excellent opportunities to improve outcomes

How renewable, distributed and competitive?
- Achieving goals seems likely to require effectively integrating much higher levels of renewable generation
- Which seems likely to require higher levels of energy user engagement and participation in terms of both establishing social consensus as well as providing flexibility
- Which will likely require greater levels of genuine, meaningful competition in energy services…. or abandonment of much of the current ‘competitive construct’
Thankyou from the SPREE/CEEM Energy Modelling and Analysis Team

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linkedin.com/company/ceem.unsw/
github.com/unsw-ceem

Distributed energy storage in the NEM - aggregating up, sending price signals down
Thank you… and questions

Many of our publications are available at:
www.ceem.unsw.edu.au