Some lessons from Australia on clean energy opportunities and challenges for electricity grids, large and small

Presented by Iain MacGill
Associate Professor, School of Electrical Engineering and Telecommunications; Joint Director (Engineering), CEEM
University of New South Wales, Sydney, Australia

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Iain MacGill
Associate Professor, School of Electrical Engineering and Telecommunications
Joint Director (Engineering), CEEM

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The lessons are also questions
Lessons on sustainable electricity industry transition

With an outstanding international reputation as an innovator in mining and mineral processing research, the SMI-JKMRC is noted for the widespread use of its research outcomes by industry. It is the largest Australian research centre in this field and collaborates with major mining and mineral processing research groups worldwide. Research is sponsored by most of the major mining companies.
CEEM’s research focus

A collaboration between the Faculties of Engineering and Business, working with Science, Built Environment, Social Sciences, Law

- **Sustainable Energy Transformation**
  - Facilitating high future renewable energy penetrations
  - Sustainable energy services in developing countries
  - Clean energy technology assessment

- **Energy & Environmental Market Design, related policies**
  - ‘Designer’ renewable & energy efficiency markets
  - The interface between electricity markets and ‘external’ policies

- **Distributed energy**
  - Technical integration challenges and opportunities
  - Market and regulatory frameworks to facilitate efficient distributed energy investment, participation by energy users
A destination – shaped by energy trilemma
Can we have it all, choose any two, might we get none?

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)
IEA pathways

IEA, World Energy Outlook, 2017

Sustainable Development Scenario

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

Fossil-fuel demand

NPS
SDS

Oil
Coal
Gas

TWh

Other renewable
Solar PV
Wind
Hydro
Nuclear
Oil
Gas
Gas CCS
Coal CCS
Coal
Energy options - Australia spoilt for choice

(Geosciences Australia, 2012)
To date, Australia’s chosen path..

The Australian National Electricity Market

Wholesale value of electricity traded
$11.7 billion

40,000 kilometres of transmission lines

National maximum summer operational demand
32,859 MW

National maximum winter operational demand
31,977 MW

Installed capacity
47,148 MW

Number of metered customers
9.6 million

NEM emissions
162 Mt CO$_2$-e

Lessons on sustainable electricity industry transition

(Finkel Review, 2017)
.. eg. South Australia

(Clean Energy Council Market Update, 2017)
Australia a unique restructuring example

(IEA, Power Markets and RE, 2016)
Wholesale market prices

(Grattan Institute, 2017)
... and volatility

Market volatility—prices above $200 per MWh and below -$100 per MWh

‘Market driven’ investment, divestment

Investment in new generation, and plant retirements

Megawatts

(AER, 2017)
Retail pricing – does this look like success?

(AER, 2017)

(Electricity retail price index)

(The Australia Institute, 2017)
Residential PV penetration

(Finkel Review, 2017)
Distributed ‘rooftop’ PV now an increasingly significant wholesale market issue

1:00 pm
Total MW (PV)
SA: 1,080 MW (432 MW)
Resource adequacy tightening

(Grattan Institute, 2017)
SA blackout – Was it wind?

- A complex question

- Electricity industry run to remain secure, major failures almost always involve multiple factors

- Wind and residential PV added to the challenges

NEM lessons for liberalisation and regulation
.. at present time amongst the world’s most expensive, wholesale, retail and utility scale VRE electricity, fair reliability, amongst world’s most emissions intensive as well .. and who’s to blame? VRE, gas market, market power?

![Graph showing comparison of residential electricity prices](image1.png)

**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)**

![Graph showing auctions/tenders vs the RET - costs vs value](image2.png)

Variable renewables and reliability

Source: IEEFA interpretation of World Bank GDP/ouage data, and various energy data
Renewables costs - Recent policy efforts increasingly auction / tender based

(IRENA, 2017)
How can they reduce renewables costs

- The cost of most renewables is mostly the cost of *Capital*
- ...and the cost of Capital is mostly the cost of *Finance*
- ...and the cost of finance is mostly the cost of *Risk*

Low cost renewables is low financial risk renewables and auction/tenders have excellent risk profile for project developers
... and associated tenders to date

- Falling costs, and these are bundled energy ‘black’ and REC ‘green’
- Reasonably high transparency
- At present, renewables PPAs in Australia are coming in at less than wholesale prices, the ‘clean energy‘ is effectively free

<table>
<thead>
<tr>
<th>Project name</th>
<th>Size (MW)</th>
<th>Fixed feed-in tariff price for renewable electricity over 20 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Royalla Solar Farm (Figure 8)</td>
<td>20</td>
<td>$186/MWh</td>
</tr>
<tr>
<td>20MW Solar Auction 2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mugga Lane Solar Farm</td>
<td>13</td>
<td>$178/MWh</td>
</tr>
<tr>
<td>Williamsdale Solar Farm</td>
<td>10</td>
<td>$186/MWh</td>
</tr>
<tr>
<td>200MW Wind Auction 2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coonooer Bridge Wind Farm</td>
<td>19.4</td>
<td>$82/MWh</td>
</tr>
<tr>
<td>Horndale Wind Farm (Stage 1)</td>
<td>100</td>
<td>$92/MWh</td>
</tr>
<tr>
<td>Ararat Wind Farm</td>
<td>80.5</td>
<td>$87/MWh</td>
</tr>
<tr>
<td>200MW Wind Auction 2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horndale Wind Farm (Stage 2)</td>
<td>100</td>
<td>$77/MWh</td>
</tr>
<tr>
<td>Sapphire Wind Farm</td>
<td>100</td>
<td>$89/MWh</td>
</tr>
<tr>
<td>Next generation solar and wind (plus storage) 2016</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horndale Wind Farm (Stage 3)</td>
<td>109</td>
<td>$73/MWh</td>
</tr>
<tr>
<td>Crookwell 2 Wind Farm</td>
<td>91</td>
<td>$87/MWh</td>
</tr>
</tbody>
</table>

(Auctions/tenders vs the RET - costs vs value) (Climate Council, 2017)
Off-grid supply

- Generally highly subsidised
- PV’s now increasingly competitive as ‘fuel saver’ on diesel grids
- Opportunities for 100% renewables (+storage) on remote grids
- Mini-grids implemented, operated by utilities
  - Growing interest, capability in RE and RE integration although still much to learn

Existing off-grid generation

(AECOM/ARENA, Australia’s off-grid clean energy market, 2014)
Solar SeTUP

(NT Power and Water, 2016)
Pushing higher PV in Diesel grids

15% Annual Energy Penetration (kWh)

Over the year, solar services approx 15% of total electricity demand

60% Instantaneous Power Penetration (kW)

At times solar is servicing up to 60% of the instantaneous electricity demand

(NT Power and Water, 2016)
Higher penetrations – smarter PV, diesel, storage and load control

(NT Power and Water, 2016)
What exists is possible

MW scale solar + battery mini-grids with no synchronous units

- however, *performance under major disturbances?*
- *and what of transition to greater power electronics interfaces*
Where next?
State RE targets in the NEM

(Australia)
23.5% renewable energy by 2020
(33,000GWh of large-scale renewable energy)

(WA)
No renewable energy target
No net zero emissions target

(TA)
State RE targets in the NEM

(NT)
50% renewable energy by 2030
No net zero emissions target

(QLD)
50% renewable energy by 2030
Net zero emissions by 2050

(NSW)
No renewable energy target
Net zero emissions by 2050

(VIC)
25% renewable energy by 2020
40% renewable energy by 2025
Net zero emissions by 2050

(TAS)
100% renewable energy by 2020
Net zero emissions by 2050

(LEGEND)
Shaded regions show the percentage of renewable energy currently

(Climatic Council, 2017)
A framework for policy

**Comprehensive and coherent policy development process**

<table>
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<tr>
<td>- Transmission network planning</td>
<td>- Fundamental market design</td>
<td>- Carbon policies</td>
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<tr>
<td>- Distribution network planning</td>
<td>- Spot market rules</td>
<td>- Renewable &amp; energy efficiency policies</td>
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<tr>
<td>- Grid codes</td>
<td>- Ancillary service market rules</td>
<td>- Fuel policies</td>
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**Robustness and Resilience:** ability to perform reasonably well under a wide range of possible futures
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 clean and sustainable energy future in Europe this month shows its goal of a 20% renewable capacity in China and the United Kingdom, 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 GitLab. Yet academics’ 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 energy-data agencies to coordinate the collection and archiving of a range of important data.

The vast majority of published research is still untouched by these fledgling initiatives. Only one energy journal — Energy Economics — currently requires data and models alongside submissions. Other journals should follow suit.

The open sharing of code and data is also important because it permits more meaningful collaboration across disciplines. Sharing a DNA sequence in an established format is, of course, easier than sharing the unstructured assumptions behind a techno-economic scenario study, for which no standard format exists yet. So the energy community must decide on standards for sharing code, data, and assumptions.

A change in journal policies would help to kick-start these discussions. In policy-focused research, where one ‘truth does not exist, one cannot assess whether a modelled scenario is correct’ and even the important yardstick is not truth, but trust. The arrival of the post-truth world shows that trust in experts is lower than ever — and surely this is partly the experts’ fault.

Stefan Pfenninger is a postdoctoral researcher in the Department of Environmental Systems Science, ETH Zurich, Switzerland.

E-mail: stefan.pfenninger@sys.ethz.ch

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Openmod

Open data, tools

Open 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 modelling among fellow modelers, research institutions, funding bodies, and recipients of our work.

The idea of openmod

Energy models are based on a model that could be well known that closed model, an example is the spreadsheet-based Rogoff paper used for all austerity. The European Commission’s Energy Roadmap 2050 was based on a model that could not be viewed by outsiders, leaving it open to criticism. Assumptions 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.

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Where next?

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

“Keep calm.. & carry on”

Thoughtful, careful, efforts
Thank you... and questions

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