THE UNIVERSITY OF MELBOURNE

Melbourne Energy Institute

Research Capabilities and Impact

The Melbourne Energy Institute (MEI) engages with the University's energy sector partners in government and industry. Since the Institute was launched in 2010, it has delivered influential, interdisciplinary research on the challenges of transitioning towards a low carbon energy system.

The University of Melbourne and MEI

The University of Melbourne undertakes world-leading research in many disciplines. It has the largest research expenditure of any Australian university, and the largest cohort of research students in Australia. Our researchers work with the community, industry and government on some of the world's most pressing challenges.

MEI has over 300 specialists across Architecture, Economics, Engineering, Health, Law, Planning, Science and Social Science. They include a former Chief Scientist of Australia, several recipients of Australia Day Honours, several Fellows of Learned Academies and numerous Fellows of Professional Societies.

MEI staff work together in four programs:

1. Energy Systems
2. Energy Technology
3. Energy, Community and the Region
4. The Environment and Energy Resources

Working with MEI

MEI works closely with industry and government. Our current partners include the Asian Development Bank (ADB), the Australian Energy Market Operator (AEMO), AusNet Services, BHP, Billcap, Commonwealth and State Governments, C02CRC, CSIRO, the Department of Defence, Ford, GE, Mitsubishi Heavy Industries, Powershop and Toyota. Collaborative research and knowledge transfer are central to MEI's work, and we welcome new partners.

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Recent MEI Highlights

Power System Security Assessment of the future National Electricity Market

MEI was commissioned by the *Independent Review into the Future Security of the National Electricity Market* (the Finkel Review) to undertake a power system security analysis in early 2017.

This work was led by our Chair of Power Systems Engineering, Prof. Pierluigi Mancarella, and focused on an aspect of power system security called *frequency response adequacy*. This involved assessing whether a given generation portfolio can maintain a system frequency of around 50Hz without disruption to energy supply.

The University's report to the Finkel Review had two main findings:

1. Without implementation of appropriate operational measures, the NEM will experience increasing issues of frequency control in all modelled scenarios.

2. There is significant potential to use several operational measures and electricity market designs to ensure frequency response adequacy in renewable-rich power systems.

Our report then showed how a number of technologies and services can provide so-called *Fast Frequency Response* (FFR), and therefore legitimately play a role in supporting frequency response adequacy. This includes demand response, energy storage of several forms and the so-called synthetic inertia in newer wind turbines, amongst others. Means of increasing the system inertia, such as synchronous condensers, could also assist in providing this support.

This deeply technical analysis by the University supported the Finkel Review's own recommendations, and we continue to work with industry and government for the Finkel Review's implementation.

The role of pumped hydro storage in Australia's energy transition

In 2017, MEI, Energy Australia and ARUP released a report that examined the feasibility of sea-water pumped hydro energy storage at Cultana in South Australia.

This work was funded by the Australian Renewable Energy Agency (ARENA), and represented the culmination of several years of work by MEI on pumped hydro energy storage.

Pumped hydro energy storage is not a new technology. Indeed, it is by far the largest form of energy storage used in electricity systems globally. However, the use of sea-water pumped hydro energy storage is much less common. In 2010, MEI published a book by one of our affiliates, Prof. Peter Seligman, titled *Australian Sustainable Energy – by the numbers*. That book examined many different decarbonisation options, including what future role pumped hydro might play.

Prof. Seligman's book appears to be the first of several Australian studies that considered the role of pumped hydro storage. Notable, subsequent projects now in development include Snowy Hydro's *Snowy 2.0 Project*, Hydro Tasmania's *Battery of the Nation*, as well as the *Cultana Pumped Hydro Project*.

For this Cultana project, MEI undertook wholesale market modelling of the pumped hydro plant, determining its optimal power and storage capacities and associated financial performance. This required maximisation of wholesale market revenue, not only through buying and selling energy, but also by providing several support services for the South Australian energy system.

MEI's Capabilities and Impact

Energy Systems

Leader: Prof. Pierluigi Mancarella

Our Energy Systems Program considers how systems of different energy technologies behave. This considers wholesale and retail energy markets, energy networks and system planning.

Capabilities

- Distributed energy resources, smart grids and integrated, multi-energy systems
- Demand modelling using randomised control trials, big data and machine learning
- Retail energy markets and consumer behaviour
- Risk and resilience assessment of future energy systems
- Wholesale energy market design and operations and renewable energy integration

Impact

- Modelling work commissioned for the Finkel Review
- AEMO Expert Advisory Panel membership
- AEMO demand forecasting using AMI data and machine learning approaches
- Modelling of electricity consumer behaviour for Billcap, Click Energy and Simply Energy

Key Personnel

Prof. Lu Aye, Prof. Michael Brear, A/Prof. David Byrne, A/Prof. Robert Crawford, Prof. Rob Evans, Prof. Ross Garnaut, Prof. Terry Jones, Prof. Chris Leckie, Prof. Pierluigi Mancarella, Prof. Chris Manzie, Dr. Leslie Martin, Prof. Nando Ochoa, Prof. Kate Smith-Miles, Dr. Claire Vincent

Energy Technology

Leader: Prof. Richard Sandberg

Our Energy Technology Program brings together researchers who investigate different energy technologies. This examines several forms of renewable and low emission power plant for stationary and mobile applications, as well as energy storage and fuels.

Capabilities

- Carbon capture and storage (CCS)
- Conventional and alternative fuels and emissions chemistry
- Gas turbine, reciprocating engine, hybrid and electric powertrain dynamics and optimisation
- Wind turbines/farms, solar PV and energy storage dynamics and optimisation
- Low drag vehicles for land, sea and air
- Materials for advanced photovoltaics, displays, energy storage, lighting, and high temperature applications

Impact

- Energy efficient lighting for CSIRO and partners
- Propulsion, engines and fuels for Ford, DST Group, MHI and Toyota
- Improved aircraft engine aerodynamics for General Electric
- High temperature materials for the Australian Defence Force
- Modelling of real-world, solar PV performance across Australia with AEMO

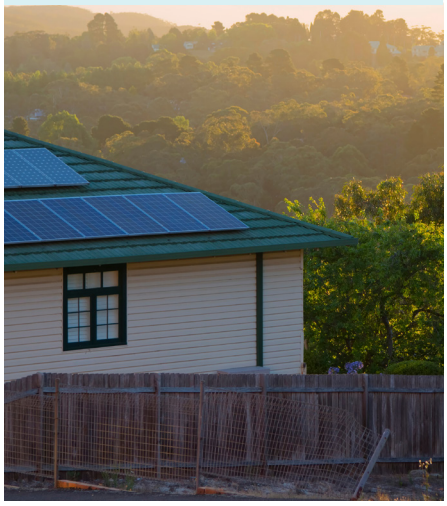
Key Personnel

Prof. Robin Batterham, Prof. Michael Brear, Prof. George Franks, Dr. David Jones, Prof. Sandra Kentish, Prof. Dan Li, Prof. Chris Manzie, Prof. Paul Mulvaney, Dr. Guillermo Narsilio, Prof. Richard Sandberg, Prof. Geoff Stevens, Prof. Paul Webley, Prof. Rachel Webster

Energy, Community and the Region

Leader: Dr. Reihana Mohideen

Our Energy, Community and the Region Program examines how individuals, communities and states rely on and interact with energy technologies and energy systems. Examination of equity and national development are features of this work.



Capabilities

- Delivering social, environmental, gender and human rights impact assessments
- Modelling and evaluating consumer behaviour, energy services and energy markets
- Analysing big data, including social media and historic economic data
- Analysing emerging energy technology trends, including access and uptake in Asia

Impact

- Providing recommendations to local and state governments concerning energy transitions
- Commissioned work for the Asian Development Bank on the energy transition in Asia and implications for social inclusion and gender equality
- Advising Australian and other governments on community energy models and research programs to improve stakeholder engagement in infrastructure and services
- Engaging with industry, academic institutions, governments and civil society to establish a 'knowledge hub' on the energy transition in Asia

Key Personnel

A/Prof. David Byrne, Dr. Sangeetha Chandra-Shekeran, Prof. Ross Garnaut, Prof. Lee Godden, Prof. Fiona Haines, Dr. Leslie Martin, Dr. Reihana Mohideen

Environment and Energy Resources

Leader: Dr Robyn Schofield

The Environment and Energy Resource Program examines the manifold interactions between our energy systems and our environment. This program looks closely at energy resource extraction, carbon dioxide sources and sinks as well as atmospheric and geo-chemistry.

Capabilities

- Air quality and health impacts
- Environmental chemistry and fluid dynamics
- Geology and geochemistry of oil, gas and other basin resources including carbon storage
- Modelling of the carbon cycle and climate change
- Resource economics
- Resource law

Impact

- Deepen our understanding and minimise uncertainties in geological carbon storage for CO2CRC, ANLEC R&D and BHP
- Determine anthropogenic trace gas distribution and residence time to inform UNFCCC processes
- Model the consequences of nations' energy policies to inform governments and UNFCCC
- Measuring and forecasting air pollutants in cities to inform urban design and policy development

Key Personnel

Prof. Peter Cook, Prof. Michael Crommelin, Prof. Shyamali Dharmage, Prof. John Freebairn, Prof. Lee Godden, Prof. Ralf Haese, Prof. Stephan Matthai, A/Prof. Malte Meinhausen, Prof. Jason Monty, Prof. Peter Rayner, Prof. Mike Sandiford, Dr. Robyn Schofield, Prof. Mark Stevenson, Prof. Doreen Thomas, Dr. Claire Vincent