THE UNIVERSITY OF
MELBOURNE

POSTERA CRESCAM LAUDE

Melbourne
Energy Institute

MELBOURNE ENERGY INSTITUTE

ANNUAL REPORT 2019

CONTENTS

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MESSAGE FROM
THE DIRECTOR

Sitting in my study, on a beautiful autumnal afternoon in early 2020, I find it hard to reflect on MEI's achievements over 2019 given the bushfires of last summer and the now rapidly growing threat of COVID-19.

These are sobering times that put our efforts in the energy sector into some perspective.

Security and resilience are terms that we use in the sector a lot. But they now have very personal and immediate meanings for us all.

A related, 2019 initiative that I would nonetheless like to highlight was MEI's support of the Australian Energy Regulator (AER's) Value of Customer Reliability (VCR) Review. This project is an example of how a University can play a responsive role in important policy processes by bringing together and coordinating expertise that has been developed over many years prior.

The VCR Review drew on the multi-disciplinary skills of University of Melbourne economists, engineers and statisticians. The AER ran this process admirably, with the outputs of the VCR Review obtained transparently and rigorously.

MEI was proud to contribute to this process, and I thank my colleagues sincerely for their efforts. Efforts that will help our energy system to be more reliable where it needs to be, and more affordable where it needs to be.

Of course, there is much more that our students and staff have done over 2019, and I encourage you to read this Annual Report as a testimony to their many achievements.

You are likely reading this Report on-line, rather than one of the few, shiny hard copies that we print these days. You might even be in self-isolation in your own study. Or glancing at this Report whilst really watching MasterChef.

Whatever you are doing right now, it probably doesn't hurt for us all to keep in mind the life sustaining services that energy provides us. And to be grateful for the many dedicated people who run our mind bogglingly complex and massive energy system.

Powering the NBN so that we can self-isolate and remain (reasonably) productive. Watching MasterChef in cozy loungerooms with family or friends, as relief from the work and worries of the day. Fresh and clean food. Clean clothes and linen.

I hope that you and your families remain safe over the year ahead, and I thank you all for your support over 2019.

All the best,

Professor Michael Brear
FTSE, FCI, FIEAust
Director, Melbourne Energy Institute

THE MELBOURNE ENERGY INSTITUTE

The Melbourne Energy Institute (MEI) delivers influential, interdisciplinary research on the transition to a clean energy system. We work with the community, industry and government on some of the world's most pressing energy challenges.

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.

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 researchers work together in four programs:

- Energy Systems
- Environment and Resources
- Hydrogen and Clean Fuels
- Power Generation and Transport

THE MEI TEAM

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MEI is run by a team of dedicated staff who look after our external and internal engagement and our four research programs.

Professor Michael Brear
Director

Anita La Rosa
Institute Manager

Chloe Mumford
Administration and Events Assistant

Associate Professor Terry Jones
Project Manager

Professor Pierluigi Mancarella
MEI Program Leader Energy Systems, and Chair Professor of Electrical Power Systems

Dr Robyn Schofield
MEI Program Leader Environment and Resources, Senior Lecturer, and Director of the Environmental Science Hub
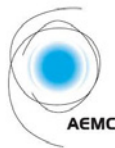
Professor Paul Webley
MEI Program Leader Hydrogen and Clean Fuels, Professor Department of Chemical Engineering, and Director Clean Energy Laboratory

Professor Richard Sandberg
MEI Program Leader Power Generation and Transport, and Chair of Computational Mechanics

OUR PARTNERS

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MEI is proud to work alongside our industry and government partners. Collaborative research and knowledge transfer are central to MEI's work, and we welcome new partners.

ADB ASIAN DEVELOPMENT BANK

AEMC

AEMO AUSTRALIAN ENERGY MARKET OPERATOR

AER AUSTRALIAN ENERGY REGULATOR

AusNet services

Australian Gas Infrastructure Group

BHP

CO2CRC BUILDING A LOW EMISSIONS FUTURE

CSIRO

Australian Government Department of Defence

Ford

FUTURE FUELS CRC

GE

GRATTAN Institute

IBM

Meridian.

MITSUBISHI HEAVY INDUSTRIES

POWERSHOP

SIEMENS Ingenuity for life

VICTORIA State Government

COVER IMAGE AND OPPOSITE PAGE: At Mt Mercer windfarm in Victoria, the Melbourne Energy Institute is working with Meridian Energy Australia to develop a real-time wind forecasting engine. This project will demonstrate state-of-the-art, short term forecasts, using a combination of sophisticated measurements, numerical weather prediction, mesoscale modelling and data science.

HIGHLIGHTS
OF 2019

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MEI WORKS WITH THE AUSTRALIAN ENERGY REGULATOR ON THE VALUE OF CUSTOMER RELIABILITY REVIEW

On 18 December 2019, the Australian Energy Regulator (AER) released the Final Report on its Value of Customer Reliability (VCR) Review.

VCRs seek to reflect the value that different types of customers place on the reliable supply of electricity. This is of course important since outages not only cause lost productivity and revenue, but also a reduction in convenience, comfort, safety and amenity. However, reliability also requires network investment which is paid for ultimately by consumers through network charges. There is therefore an inherent trade-off between reliability and cost, with VCRs estimating how much customers are willing to pay for a specified level of network reliability.

The AER's Report sets out the VCR values for unplanned (standard outages) of up to 12 hours in duration for both the National Electricity Market and the Northern Territory. This report details the largest VCR study ever conducted in Australia, with over 9,000 residential, small business and industrial energy customers completing the survey.

MEI was commissioned to provide expert services to assist the AER with this VCR Review. The commissioned work included advice on the design of customer surveys, advice on various technical and statistical matters, and quality assurance of the results.

MEI assembled a multidisciplinary team from the University to undertake this work, including:

- Professor Ian Gordon and Professor Graham Hepworth, Department of Mathematics and Statistics
- Professor Pierluigi Mancarella, Leader, MEI's Energy Systems Program; and
- Dr Veronika Nemes, Department of Economics.

MEI also engaged the services of an eminent econometrician, Professor Kenneth Train, from the University of California at Berkeley.

Professor Michael Brear, Director of the MEI, said "the AER is to be congratulated on this Review. Importantly, the methodologies used throughout this project were systematically and openly discussed and improved with stakeholders, and the results were obtained transparently and with a sound evidence base."

This is the second time that MEI has made a substantial contribution to an important National process in recent years, having previously been commissioned by the *Finkel Review* to analyse the security of the National Electricity Market (NEM).

"MEI's ongoing commitment to deep and focused research in the energy sector is not just about education, discovery or commercialisation. Doing our best research every day also means that we are always ready to provide high quality analysis and advice to industry and government. MEI is able to garner these resources when our partners need them", Professor Brear said.
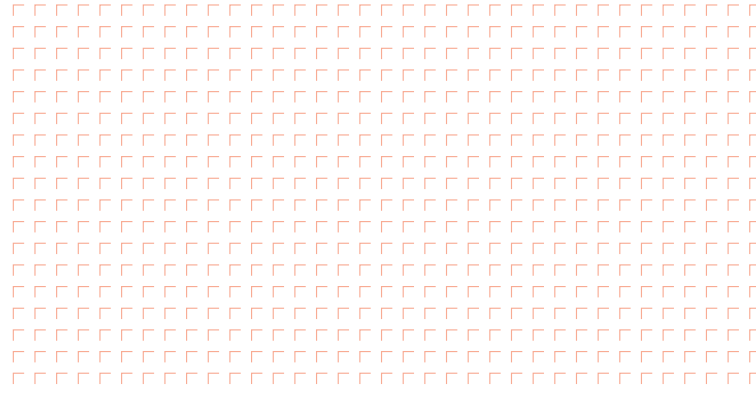
GENERAL ELECTRIC COLLABORATION: ENHANCING GAS TURBINE EFFICIENCY WITH MACHINE LEARNING TECHNIQUES

Gas turbines are a major global electricity producer and the dominant form of aircraft propulsion.

Whilst global electricity demand continues to grow, aircraft passenger numbers are projected to increase by 40-50% over the next 10 years. Technology advances which increase gas turbine efficiency are therefore major drivers in both sectors to reduce pollutant emissions and maintain affordability.

Enhancing our capability to predict and model the complex turbulent flow in gas turbines using Computational Fluid Dynamics (CFD) assists in achieving these aims. However, current design tools are unable to capture some turbulent flow features with sufficient accuracy for use in product design, mainly due to the deficiencies and inaccuracies of their underlying turbulence models.

Professor Richard Sandberg is the Leader of MEI's Power Generation and Transport Program and leads MEI's partnership with General Electric. His team applies novel machine learning techniques, such as Gene Expression Programming (GEP), to gain an in-depth understanding of the flow physics and improve the predictive accuracy of these turbulence models. GEP uses biologically inspired natural selection and evolution to extract meaningful physical insights and to create novel models from 'gold standard' high-fidelity data sets.

Current research has found that these novel, data-driven models provide error reductions of up to 80% over industry-standard models. Importantly, these dramatic improvements are achieved even when the newly developed models are applied to cases with significantly different operating conditions from the case on which they were trained, suggesting robustness of the approach. These approaches of course have many other applications that are also being investigated.
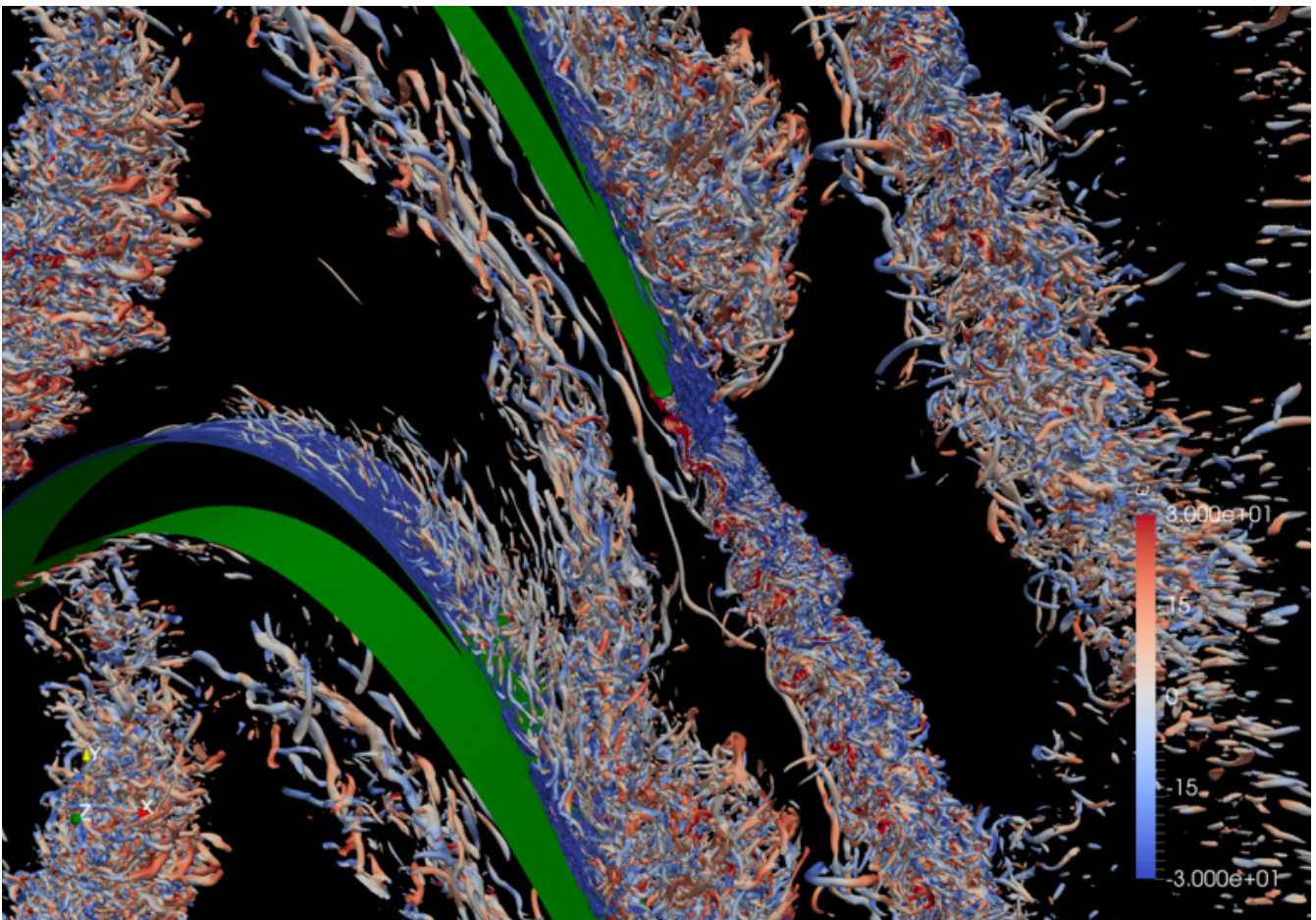
High-fidelity simulation of low-pressure turbine stator-rotor interaction to study loss incurred by wake-blade interaction

PROA ANALYTICS, START-UP OF MEI ALUMNI, DELIVERS A NEM FIRST

In 2019, *Proa Analyics*, a start-up consisting of MEI alumni, became the first independent provider of solar or wind farm forecasts to be integrated into the National Electricity Market Dispatch Engine (NEMDE) run by the Australian Energy Market Operator (AEMO).

NEMDE uses forecasts from solar and wind farms to schedule gas, coal, hydro, batteries, and other generators more efficiently. AEMO only permits independent providers of these forecasts to integrate into NEMDE once those forecasts have passed AEMO's rigorous standards for accuracy and reliability.

The Proa Forecasting System (PFS) met this AEMO requirement on the 95 MW Tailem Bend Solar Project in South Australia, in partnership with farm owner and operator Vena Energy Australia.
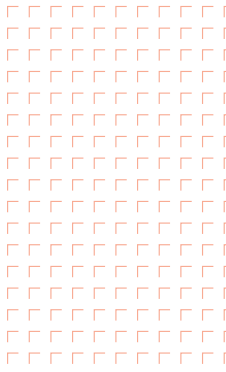
Proa is now implementing the PFS on other solar farms across the NEM.

Dr Victor Depoorter, Proa co-founder, Technical Director and University alumnus, said "Proa's solar forecasts are the combination of several forecast techniques. We have developed new methods to track cloud movement from satellite images, which give us a view of clouds across the whole of Australia, and from skycam images, which give the most detailed view of local cloud conditions. We combine these with live measurements from the solar farm and leading numerical weather prediction models from agencies across the world including from Australia's own Bureau of Meteorology."

"Proa is excited about the potential for self-forecasting. It will have tremendous benefits to solar and wind farms by reducing costs, as well as the power system overall, by improving the efficiency of all generators in the NEM. As more batteries come online, forecasts will help them determine when to recharge and discharge. Underlying all these benefits is that better information will lead to better decisions," said Dr Depoorter.

The Proa Forecasting System (PFS) installation at the 95 MW Tailem Bend Solar Project in South Australia

REDUCING IMPACT ON THE ELECTRICITY NETWORK

David Byrne, Associate Professor of Economics at the University of Melbourne, has been instrumental in the design and evaluation of a *Power Changers* large scale randomised controlled trial at Victorian energy distributor Jemena.

The demand response trial used smart meter data to incentivise households to reduce power use during peak times to help create energy grid stability in the short-run, and more efficient energy grid investment in the long-run. It was designed to create behavioural change to reduce the cost of running the power system.

More than 600 households in suburban Melbourne registered for the four-month trial, which resulted in a decrease of average peak electricity consumption of between 23 and 35 per cent on hot days.

The project won Best Customer Innovation at the 2019 Digital Utility Awards and was runner-up in Energy Network Australia's 2018 Innovation Award.

Associate Professor David Byrne partnered with Jemena and the Victorian Government on the Power Changers project.
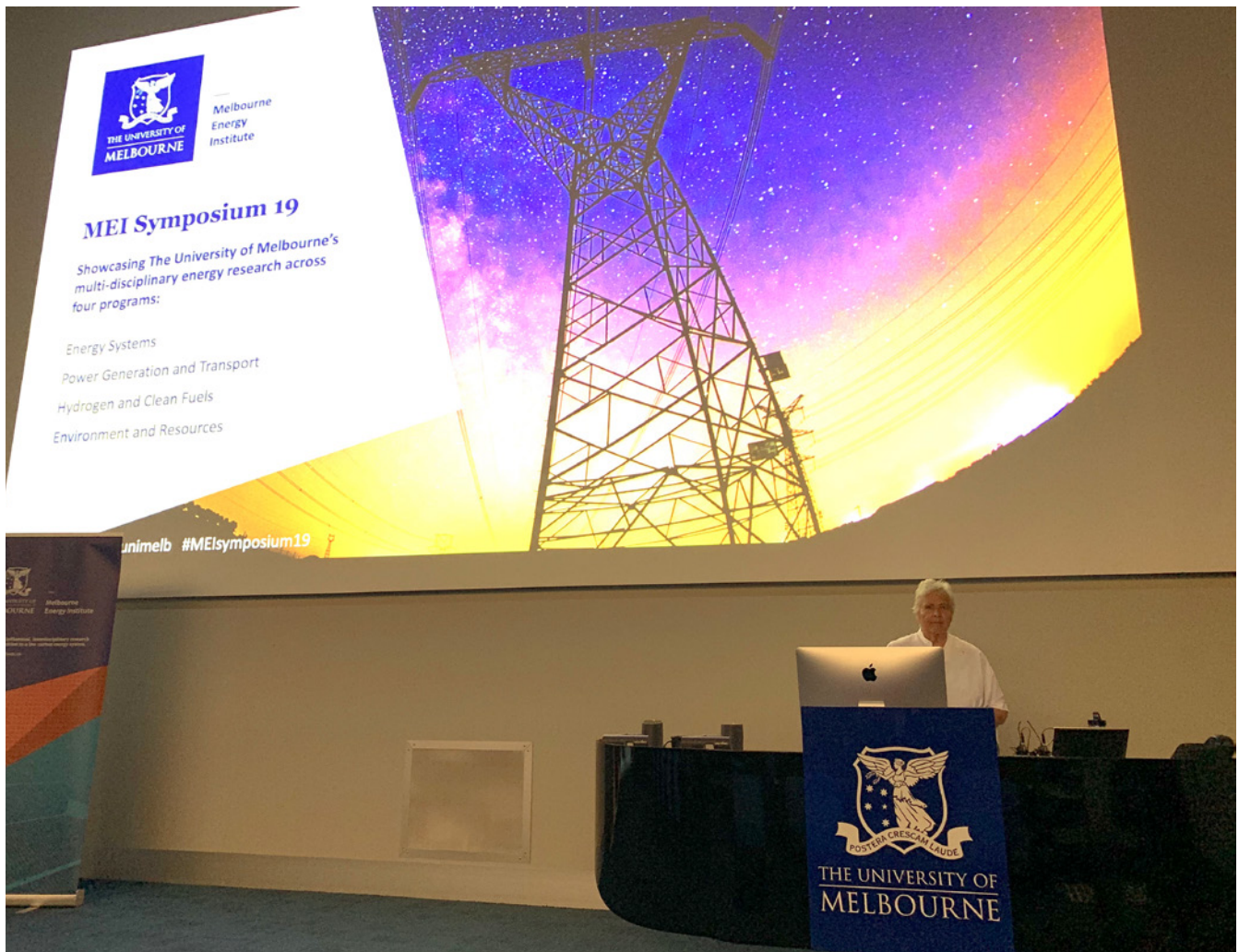
MEI SYMPOSIUM 19

MEI held its second Symposium on 12 December 2019, showcasing the University's energy research across MEI's four programs: Energy Systems; Environment and Resources; Hydrogen and Clean Fuels; and Power Generation and Transport.

The Symposium was a resounding success with over 400 graduate students, staff and industry professionals from across the country attending to hear about the energy research that the University is undertaking. As an end of year event, the Symposium was also an opportunity to celebrate the past year's accomplishments.
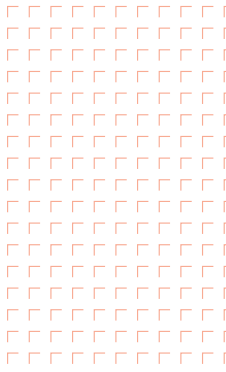
The morning opened with the Chair of the Energy Security Board, Dr Kerry Schott AO, delivering the Opening Keynote speech on designing the future market.

Several MEI-affiliated academic staff and graduate students then presented to large audiences. Other graduate students also took part in an extensive poster exhibition. In all, about 50 graduate students presented their research at the MEI Symposium.

Read more about the MEI Symposium 19 and other public engagement activities later in this report.

Dr Kerry Schott, Chair of the Energy Security Board, delivering her keynote speech at MEI Symposium 19 on how to design the next energy market.

ENERGY FUTURES: HYDROGEN, WORTH THE HYPE?

Following the release of the much-anticipated National Hydrogen Strategy to the COAG Energy Council in November 2019, the Chief Scientist of Australia, Dr Alan Finkel AO, gave an overview of the National Hydrogen Strategy at one of our Energy Futures seminars.

Co-hosted by MEI and the Grattan Institute, the seminar explored the possibilities of hydrogen in the decarbonisation of Australia. Australia's competitive advantages, including local expertise and infrastructure, proximity to Asian markets, and abundance of renewable energy, could mean we become a globally significant player through hydrogen exports, with important domestic spill-over benefits.

Dr Finkel explained how the dual objectives of the strategy are to build a clean, innovative and competitive hydrogen industry, and to position Australia's hydrogen industry as a major global player by 2030.

Dr Finkel was joined in discussion by Professor Sandra Kentish, Head of the University's School of Chemical and Biomedical Engineering, Professor Paul Webley, MEI's Hydrogen and Clean Fuels Program Leader, and the Grattan Institute's Energy Program Director Tony Wood. The seminar was followed by an extensive Q&A session with the audience.

Chief Scientist of Australia, Dr Alan Finkel AO, presented details of the much-anticipated National Hydrogen Strategy at our Energy Futures seminar in December 2019.

MEI RESEARCH PROGRAMS

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ENERGY SYSTEMS

The Energy Systems Program considers how different energy technologies interact with one another and society. The program includes the technical and economic analysis of energy networks, wholesale and retail energy markets, and energy system planning.

CAPABILITIES

- Energy network, system and market integration of renewable energy sources
- Distributed energy resources and smart grids
- Integrated energy networks and multi-energy systems
- Risk and resilience assessment of future energy systems
- Demand modelling using randomised control trials, big data and machine learning
- Retail energy markets and consumer behaviour control trials, big data and machine learning

IMPACT

- Modelling work commissioned by the Finkel Review
- AEMO demand and reserves forecasting using AMI data and machine learning approaches
- Modelling of electricity consumer behaviour for Billcap, Click Energy and Simply Energy
- Collaboration with AEMC and AER on power system resilience and reliability

KEY RESEARCHERS

Professor Lu Aye

Professor James Bailey

Professor Howard Bondell

Professor Michael Brear

Associate Professor David Byrne

Dr Sangeetha Chandra-Shekeran

Associate Professor Robert Crawford

Professor Rob Evans

Professor John Freebairn

Professor Ross Garnaut

Professor Fiona Haines

Associate Professor William Ho

Professor Glenn Hoetker

Mr Terry Jones

Professor Chris Leckie

Professor Pierluigi Mancarella

Professor Chris Manzie

Dr Leslie Martin

Professor Brendon McNiven

Associate Professor Monica Minnegal

Dr Reihana Mohideen
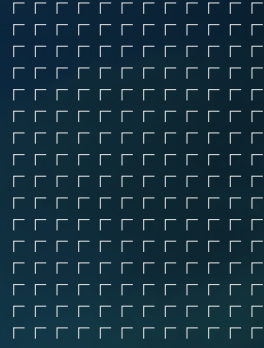
Professor Prof Nando Ochoa

Dr Behzad Rismanchi

Professor Prakash Singh

Professor Kate Smith-Miles

Professor Doreen Thomas

Dr Maria Vrakopoulou

ENVIRONMENT AND RESOURCES

The Environment and Resources Program examines the interactions between our energy systems and the environment. This program includes energy resource extraction and use, and how current energy systems influence environmental and human health, including legal and economic implications.

CAPABILITIES

- Air quality and health impacts
- Environmental chemistry and fluid dynamics
- Geology and geochemistry of oil, gas and other basin resources including carbon capture 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 RESEARCHERS

Professor Robin Batterham
Dr Sangeetha Chandra-Shekeran
Professor Peter Cook
Professor Michael Crommelin
Professor Shyamali Dharmage
Professor Robyn Eckersley
Professor John Freebairn
Professor Ross Garnaut
Professor Lee Godden
Professor Ralf Haese
Professor Fiona Haines

Dr Leslie Martin
Professor Stephan Matthai
Associate Professor Monica Minnegal
Professor Jason Monty
Associate Professor Kathryn Mumford
Professor Peter Rayner
Professor Mike Sandiford
Dr Robyn Schofield
Professor Mark Stevenson
Dr Anita Talberg
Professor Doreen Thomas
Dr Claire Vincent

MEI RESEARCH PROGRAMS

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HYDROGEN AND CLEAN FUELS

The Hydrogen and Clean Fuels Program integrates research into production, distribution and use of hydrogen in the energy system. The program studies electrolysis and clean fuel production, as well as hydrogen and clean fuel distribution and use in industrial and transport applications.

CAPABILITIES

- Process engineering and techno-economics of hydrogen production from renewables and fossil fuels with carbon capture and storage (CCS)
- Advanced gas turbine and reciprocating engine systems running on hydrogen and hydrogen-derived fuels
- Assessment of hydrogen integration into the natural gas network, including Power to Gas (P2G) concepts
- Catalysis and process engineering of converting hydrogen to clean, liquid fuels
- Sub-surface storage of hydrogen

IMPACT

- Reciprocating engine research with hydrogen and synthesis gas fuelling for Caterpillar, Ford and other partners
- Support of the Council of Australian Government's (COAG's) National Hydrogen Strategy
- Provision of expert advice to the Hydrogen Energy Supply Chain (HESC) Project
- Optimisation of integrated energy systems featuring hydrogen for the Future Fuels CRC and other partners

KEY RESEARCHERS

Professor Robin Batterham	Professor Pierluigi Mancarella
Professor Michael Brear	Professor Paul Mulvaney
Dr Robert Gordon	Associate Professor Kathryn Mumford
Dr Eirini Goudeli	Professor Geoff Stevens
Professor Ralf Haese	Dr Mohsen Talei
Professor Sandra Kentish	Professor Paul Webley
Dr Gang Li	Associate Professor Yi Yang
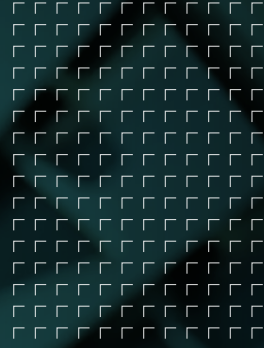
POWER GENERATION AND TRANSPORT

The Power Generation and Transport Program brings together researchers who investigate several forms of renewable and low emission power plants for stationary and mobile applications. This includes advanced wind, solar, gas turbine, reciprocating engine and energy storage technologies.

CAPABILITIES

- Carbon Capture and Storage
- 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, lighting, and high temperature applications
- Advanced computational methods and machine learning in energy 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 Australia Defence Force
- Modelling of real-word, solar PV performance across Australia with AEMO
- Operational forecasting of wind and solar farm power generation with Meridian Energy Australia and others

KEY RESEARCHERS

Professor Robin Batterham	Professor Jason Monty
Professor Michael Brear	Professor Paul Mulvaney
Dr James Bullock	Associate Professor Guillermo Narsilio
Professor George Franks	Dr Behzad Rismanchi
Dr Robert Gordon	Professor Richard Sandberg
Dr Eirini Goudeli	Professor Geoff Stevens
Professor Lloyd Holleberg	Dr Mohsen Talei
Dr David Jones	Dr Claire Vincent
Professor Sandra Kentish	Professor Paul Webley
Dr Patricica Lavieri	Professor Rachel Webster
Professor Dan Li	Dr Wallace Wong
Professor Chris Manzie	Associate Professor Yi Yang

STUDENTS OF MEI
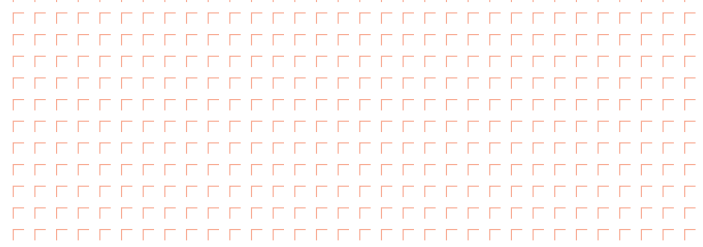
AACHEN AND THE UNIVERSITY OF MELBOURNE JOINT PHD PROGRAM

The RWTH Aachen - University of Melbourne (RUM) Joint PhD program enables graduate researchers to work with leading academics at both universities. This program was developed over 2019, and commenced formally in late 2019.

In the first cohort, up to 10 joint PhD candidates will be trained by collaborative teams undertaking energy-related research. Candidates will spend at least a year at both the University of Melbourne and Aachen University in Germany, and are eligible to graduate with a jointly awarded PhD degree recognised with a testamur from each University.

SPOTLIGHT ON A STUDENT

MEI has numerous talented graduate students working on important energy projects. Meet some of our wonderful students whose work is contributing to a more sustainable energy transition.

Morgan Li is a PhD candidate in Mechanical Engineering at the University of Melbourne, researching how a turbulent boundary layer evolves when the surface condition varies from rough to smooth. She plans to submit her thesis in February 2020, after which she will join the physics of fluids group in the University of Twente in the Netherlands as a postdoctoral researcher.

Davy Brouzet has recently finished his PhD in Mechanical Engineering at the University of Melbourne, handing in his thesis in late October 2019. His research used high-fidelity numerical simulations to explore the sound generated by turbulent premixed flames. He is now hoping to conduct aero-acoustics, turbulence or combustion research with an industry-oriented mindset.
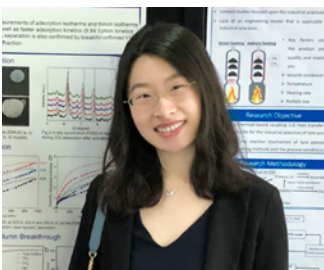
Jianhua Zhao is a final-year PhD candidate in Chemical Engineering at the University of Melbourne. Her research looks at the adsorbent materials for carbon capture and storage (CCS), developing narrow-pore zeolite for natural gas and coal seam gas purification, fabricating mixed-matrix membrane for CO_2 and N_2 removal. After she finishes her PhD, she hopes to work on the development of clean energy technologies and materials in either industry, academia or government institutes.

Maria Panagiotidou is a PhD candidate in the Department of Infrastructure Engineering at the University of Melbourne. Her research looks at retrofitting residential buildings and strategising which have minimal operational greenhouse gas emissions and minimal life-cycle costs. After graduation she hopes to work on projects that bring academia and industry together to develop sustainable energy solutions in the building sector.

Dr Abbas Ihsan recently completed his PhD in Mechanical Engineering at the University of Melbourne. His research investigated the least cost performance of a dispatchable, low carbon emission hybrid power plant. Since his degree completion, he has begun work at a solar manufacturing company.

Dr Nasim Pour recently completed her PhD at the University of Melbourne, which investigated the sustainability of bioenergy with carbon capture and storage (BECCS) as carbon removal technology. Her research applied environmental and techno-economic analyses to assess the feasibility and sustainability of different BECCS options, focusing on the potentials and challenges for using organic wastes as a resource for BECCS.

Javad Jazaeri, PhD candidate in Electrical Engineering at the University of Melbourne, has recently submitted his thesis on demand side management using thermal storage of residential buildings. As the energy transition takes place, his research will support a higher uptake of rooftop PV and electric vehicles while helping to ensure a reliable and affordable supply of electricity.
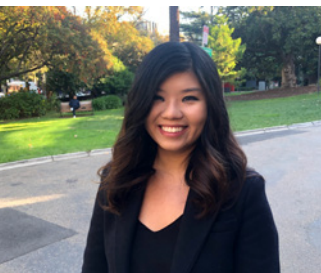
University of Melbourne student, **Jia Sheen Nah**, has recently submitted her PhD dissertation titled 'Empirical Studies of Consumer Search and Market Power'. Her research looks at the roles of search and negotiation in pricing outcomes of electricity plans.

Glen Currie is a PhD candidate working on social-technical planning of the future energy system. His research aims to increase our understanding of consumer roles in the future electricity system to help balance increasingly complicated technical, social, political and consumer demands. Having recently submitted his thesis, he plans to apply his skills to a role in designing and leading the energy transition.

Meghalim Phukan is a PhD candidate researching geological carbon storage, exploring the mineral precipitation from CO_2-saturated water in basalts and its potential for self-sealing of fractures and joints.

Thomas Moore has spent his PhD developing and modelling new, hybrid materials for carbon capture and storage. With plans to complete his PhD in March 2020, he's on the look-out for a position in clean energy research.

ENGAGEMENT

MEI*network*

The MEI*network* is an annual program that offers education activities focused on the energy sector, with an additional focus on professional development and engagement across sector and academic networks.

The MEI*network* provides energy sector professionals and University of Melbourne graduate students with a comprehensive view of the opportunities and challenges that the energy sector faces.

The success of the MEI*network* is only possible with the significant cash and in-kind support of our industry and government partners. We work closely with partners to develop the program to ensure that it reflects current industry trends and challenges.

The four activities of MEI*network*19 were as follows.

ENERGY SYSTEMS SHORT COURSE

The Energy Systems Short Course teaches skills in analysing the financial, technical, and environmental performance of energy projects. The course centres on practical and hands on modelling exercises. Participants develop their own spreadsheet models, and learn how to answer questions such as: Is a proposed wind farm or gas turbine a good investment? What is the probability that it will earn a commercial rate of return? What is the best financing structure for the project?

The course is taught by Dr John Burgess, a chemical engineer with extensive industrial and research experience, having previously had a distinguished career at BHP. Dr Burgess is also an Honorary Professorial Fellow at the University of Melbourne.

ENERGY SYSTEMS SEMINAR SERIES

The MEI*network* Seminar Series aims to give participants a sound understanding of the complete supply and value chain of one of our primary energy vectors. The 2019 seminar series covered the current state and future of Australia's natural gas supply, transport, use and export. The prospects of hydrogen displacing natural gas were also discussed. Each seminar was delivered by specialists from industry and the University.

ENERGY HACK

Hosted with Energy Hack founding partner Powershop Australia, and with the support of our partners, the Energy Hack brought students, industry, government and academia together to build ideas that could help shape the future of the energy industry.

After six weeks of working to develop a project, Energy Hack 19 finalists pitched their ideas to an expert judging panel for a chance to win $35,000 in prize money.

Hack team SPARK won the $20,000 first prize money for their idea, an 'app-first device-second' service-based home energy platform with a tailored user experience and innovative energy consumption monitoring.

MEInetwork19 Short Course participants learning modelling.

Team SPARK, winners of Energy Hack 2019.

MEI SYMPOSIUM 19

Held in December 2019, the MEI Symposium provided an opportunity for graduate students and research staff to showcase energy research undertaken across the University of Melbourne. They were joined by energy industry professionals and researchers from across Australia, both as presenters and attendees.

The Chair of the Energy Security Board, Dr Kerry Schott AO, delivered the Opening Keynote speech, discussing the design of the future energy market.

Over twenty other topical seminars followed, with speakers from diverse parts of the energy sector, including presentations from EPA Victoria and CSIRO.

The Symposium covered MEI's four research programs, with prizes being awarded to the best presenter and poster in each theme.

Congratulations to the following students who were awarded best graduate presenter or poster in each session:

ENERGY SYSTEMS

Best Presentation
Han Wang - PhD candidate
Department of Electrical and Electronic Engineering

Presentation title: Techno-economic analysis of multi-services provision from smart community energy systems

Best Poster
Michael Liu - PhD Candidate
Department of Electrical and Electronic Engineering

Poster title: Fairness assessment of volt-watt schemes for residential PV systems

POWER GENERATION AND TRANSPORT

Best Presentation
Davy Brouzet - PhD Candidate
Department of Mechanical Engineering

Presentation title: Numerical simulations of reacting flows: Impact of chemistry modelling on combustion noise

Best Poster
Yaomin Zhao - Postdoctoral Research Fellow
Department of Mechanical Engineering

Poster title: Improving gas turbines with high-fidelity simulation and machine learning

HYDROGEN AND CLEAN FUELS

Best Presentation
Dr. Joshua Lacey - Post-doctoral Research Fellow
Department of Mechanical Engineering

Presentation title: Clean combustion in hydrogen-fuelled, reciprocating engines

Best Poster
Yidi Lei - PhD Candidate
Department of Chemical Engineering

Poster title: Retrofitting pipelines by insitu coating

ENVIRONMENT AND RESOURCES

Best Presentation
Achyut Mishra - PhD Candidate
Peter Cook Centre for Carbon Capture and Storage Research
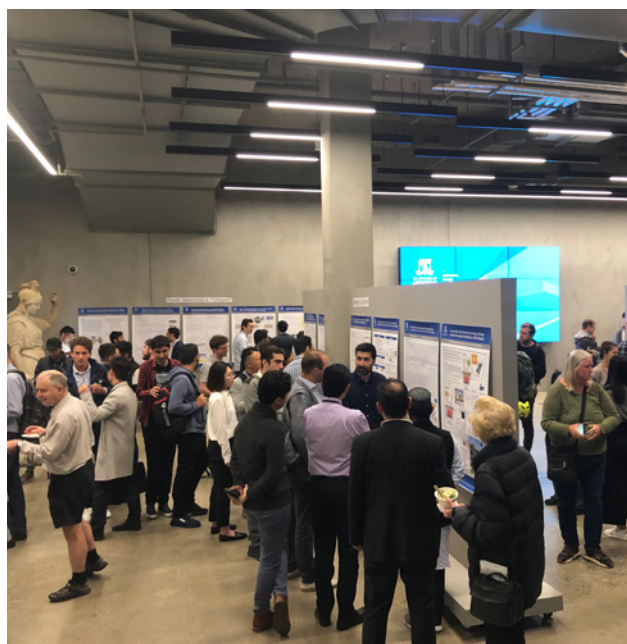
Presentation title: Improvements in the estimation of trapping capacities of CO_2 storage reservoirs

Best Poster
William Nacmanson - PhD Candidate
Department of Electrical and Electronic Engineering

Poster title: On the role of pre-curtailed residential PV for primary frequency response

SEMINARS, LECTURES AND WORKSHOPS

ENERGY FUTURES SEMINAR SERIES

The Energy Futures Seminar Series, run in partnership with policy think-tank Grattan Institute, presents a range of views on the immediate and longer-term impacts of energy policy and technological change. Industry experts are invited to present at the seminar, with each event ending with an in-depth audience Q&A.

Energy Futures Seminar #1: Whither Australian energy policy over the next three years?

Seminar Overview: This Energy Futures seminar provided a forum to debate what will happen to Australia's energy policy over the next three years.

Held at the University of Melbourne on 23rd July, the seminar discussed emerging trends in the energy transition and their influence on state and federal policy.

Speakers

Rachel Watson, Chief Executive Officer, Pacific Hydro

Anna Collyer, Partner and Head of Innovation, Allens

Michael Brear, Director Melbourne Energy Institute and Professor of Engineering, University of Melbourne

Tony Wood, Energy Program Director, Grattan Institute

Energy Futures Seminar #2: It's time for a longer-term view on delivering the great energy transition

Seminar Overview: Held on 12th September, the seminar provided a platform for debate and discussion around what new foundations are needed to underpin the policy reform agenda.

Speakers

Madeleine Morris, Reporter, 7.30, ABC

Tony Wood, Energy Program Director, Grattan Institute

Chloe Munro, Professorial Fellow, Monash University

Richard Bolt, Vice President of Strategy and Innovation, Swinburne University of Technology

Energy Futures Seminar #3: Hydrogen, worth the Hype?

Seminar Overview: MEI and Grattan were honoured to host Dr. Alan Finkel, Chief Scientist of Australia, to present the much-anticipated National Hydrogen Strategy. During the seminar, Dr Finkel explored the possibilities of hydrogen in the decarbonisation of Australia. Dr Finkel was joined in discussion by an expert panel from MEI and the Grattan Institute.

Speakers

Alan Finkel, Chief Scientist of Australia, Deputy Chair of Innovation and Science Australia

Sandra Kentish, Head of the School of Chemical and Biomedical Engineering, University of Melbourne

Tony Wood, Energy Program Director, Grattan Institute

Paul Webley, MEI Program Leader Hydrogen and Clean Fuels, Professor Department of Chemical Engineering, University of Melbourne

Anna Collyer, Partner and Head of Innovation, Allens, discussing energy policy with our expert panel at the Energy Futures seminar in July 2019.
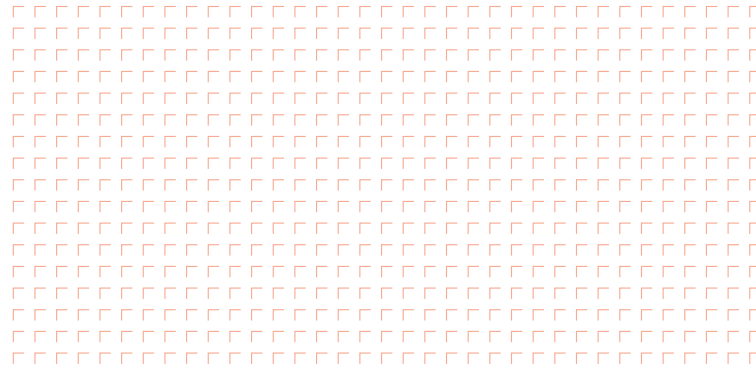
AEMO QUARTERLY DYNAMICS SEMINAR SERIES

The Australian Energy Market Operator (AEMO) publishes its Quarterly Energy Dynamics report, providing energy market participants, businesses, consumers, governments and the wider energy community with information on the market dynamics, trends and outcomes.

MEI was again very pleased to host AEMO's Dr Jonathan Myrtle, Team Leader of Market Insights, at a seminar in each quarter in 2019 to discuss key findings from the latest AEMO report. Each Quarterly Dynamics report has been presented to a packed lecture theatre, with Dr. Myrtle facilitating engaging Q&A discussions with the diverse audience, comprising representatives from industry, government, the community and the University.

INTEGRATING ULTRA-HIGH LEVELS OF VARIABLE RENEWABLES IN ELECTRIC POWER SYSTEMS

MEI hosted visiting US professor, Dr Benjamin Kroposki, Director of the Power Systems Engineering Centre at the National Renewable Energy Laboratory (NREL), who presented on variable renewables in electric power systems.

WIND VARIABILITY AND IMPACT ON MARKETS

Dr. Ross Baldick, Professor Emeritus in the Department of Electrical and Computer Engineering at The University of Texas at Austin, discussed the growth of wind in Texas and the challenges to electricity system operation under high levels of wind.

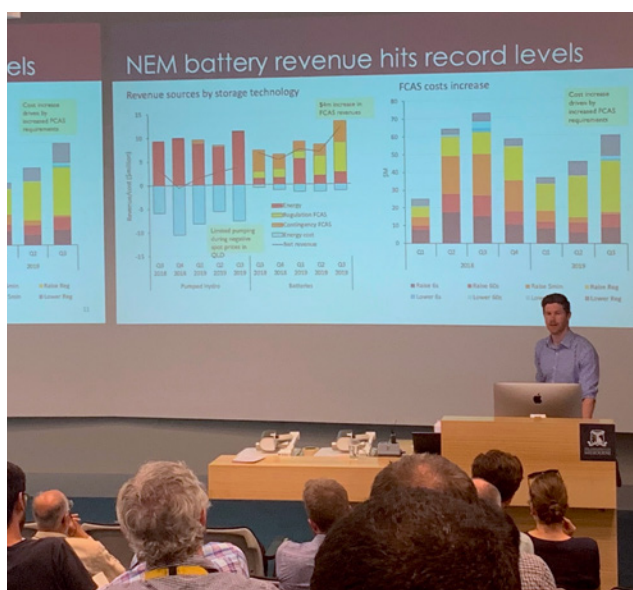## CLIMATE AND ENERGY TRANSITION IN AUSTRALIA

Ross Garnaut, Professorial Research Fellow in Economics and MEI Fellow at the University of Melbourne, delivered the seminar series Climate & Energy Transition in Australia at the University from 17 April-15 May 2019. Over six seminars Professor Garnaut built the case for the energy transition in Australia, calling on knowledge of climate science and studies of the economic benefits of mitigation.

BOOK LAUNCH: SUPERPOWER BY PROFESSOR ROSS GARNAUT

MEI hosted the launch of Professor Ross Garnaut's new book Superpower. In the book, Professor Garnaut argues that with Australia's unparalleled renewable energy resources and excellent scientific skills, we could be the natural home for an increasing proportion of global industry.

AUSTRALIA GERMANY NEW ENERGY FUTURE WORKSHOP

MEI hosted the Australian Academy of Technology and Engineering (ATSE) and its German equivalent, the German Academy of Science and Engineering (acatech), and the Federation of German Industries (BDI) for ATSE's Australia-Germany New Energy Futures workshop. The purpose of this visit was to focus on industrial collaboration and research projects along the entire value chain of hydrogen and Power-to-X technologies. The workshop and visit were part of a multi-year project to investigate different approaches to energy transitions in selected G20 nations.

AEMO's Dr Jonathan Myrtle, Team Leader of Market Insights, discuss key findings from the Q3 2019 Quarterly Energy Dynamics report.

Professor Ross Garnaut delivered the seminar series Climate and Energy Transition in Australia at the University of Melbourne.

POPULAR ARTICLES

The following articles were authored by MEI researchers and Fellows and published in Pursuit, the University of Melbourne's academic research publication, and The Conversation, a news website that publishes stories written by academics and researchers.

THE OPPORTUNITIES AND RISKS OF DECARBONISING AUSTRALIA'S TRANSPORT

In this article published in Pursuit in May 2019, Professor Michael Brear discusses the opportunities and risks of decarbonising Australia's transport. He explains how, if carefully managed, we could achieve deep abatement, cleaner air and financial savings.

pursuit.unimelb.edu.au/articles/the-opportunities-and-risks-of-decarbonising-our-transport

THE NEXT BIG SCIENTIFIC THING

As part of 2019 National Science Week, Pursuit spoke with several science researchers from the University of Melbourne about what they think is going to be the next big thing in their area. Professor Michael Brear was interviewed and provided insight into how energy is central to our future.

pursuit.unimelb.edu.au/articles/the-next-big-scientific-thing

2019 BUDGET: THE VERDICT PART 2

Professor David Byrne assesses the implications for energy and climate in part two of the University of Melbourne's coverage of the 2019 Federal budget.

pursuit.unimelb.edu.au/articles/2019-budget-the-verdict-part-2

AUSTRALIA COULD FALL APART UNDER CLIMATE CHANGE. BUT THERE'S A WAY TO AVOID IT

In this article published in The Conversation in November 2019, Professor Ross Garnaut discusses the policy framework required for Australia to transition to zero carbon emissions.

theconversation.com/australia-could-fall-apart-under-climate-change-but-theres-a-way-to-avoid-it-126341

HOW DATA COLLECTED FROM MOBILE PHONES CAN HELP ELECTRICITY PLANNING

Published in The Conversation in March 2019, Professor Pierluigi Mancarella co-authored an article explaining how mobile phone data can be used for electricity infrastructure planning in developing countries.

theconversation.com/how-data-collected-from-mobile-phones-can-help-electricity-planning-110803

IRAN'S NUCLEAR PROGRAM BREACHES LIMITS FOR URANIUM ENRICHMENT: 4 KEY QUESTIONS ANSWERED

Professor Martin Sevior explains uranium enrichment technology in this article published in The Conversation in July 2019, and discusses how Iran has exceeded the limit for uranium enrichment set under its nuclear deal.

theconversation.com/irans-nuclear-program-breaches-limits-for-uranium-enrichment-4-key-questions-answered-119992

GOVERNMENT SUBMISSIONS

INQUIRY INTO ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW

Dr. Pedro Orbaiz and Professor Michael Brear authored a submission to the NSW Parliament's Inquiry into Electric buses in regional and metropolitan public transport networks in NSW. The report discussed how the incorporation of electric buses and other zero emission vehicles into a public transport system can realise significant environmental, social and economic benefits if done properly. Without proper analysis and careful management, significant technical and economic problems are likely to result with public amenity also compromised.

INQUIRY INTO THE PREREQUISITES FOR NUCLEAR ENERGY IN AUSTRALIA

In October 2019, MEI's Director Professor Michael Brear, was asked to give evidence for the inquiry into prerequisites for nuclear energy in Australia. The hearing was commissioned by the House of Representatives Standing Committee on the Environment and Energy, and examined circumstances and prerequisites necessary for any future government's consideration of nuclear energy generation.

COMMUNICATIONS AND MEDIA

MEI has devoted resources and expertise to the production and dissemination of the Institute's research through both traditional and digital communication channels. Contributing to the national energy debate and presenting a range of views on relevant and critical industry issues, including energy policy, is one of MEI's key objectives.

NEWSLETTERS

ENERGY@MELBOURNE – MELBOURNE ENERGY INSTITUTE NEWS

MEI's monthly newsletter, energy@melbourne, is one of our key communication tools. With a subscriber list of over 5000, information about MEI's research as well as important news and events is sent directly to the inboxes of key industry, government, community and academic stakeholders.

BRIGHT SPARKS - MELBOURNE ENERGY INSTITUTE INTERNAL NEWSLETTER

MEI's internal newsletter, Bright Sparks, communicates news and events to over 1000 subscribers including students, academics and professional staff members. Each month we aim to communicate educational and professional opportunities for our energy researchers, including seminars, events and conference announcements, calls for papers, and employment opportunities through MEI's links with industry, government and other research providers.

MEDIA

ABC news - What is load shedding and who decides whose power is cut when there's not enough electricity?

Professor Micahel Brear was interviewed by ABC News to discuss load shedding and how it works. Professor Brear explained that during times of peak electricity demand, sometimes people are cut off from power to prevent a system blackout. The interview was aired on ABC television in December 2019, at the beginning to the summer peak energy period. The interview also featured in an ABC news online article in the following month.

www.vimeo.com/377693895/27d141645f

www.abc.net.au/news/2019-12-06/what-is-load-shedding-and-how-does-it-work/11650096

The Age - 'Black gold' rush: Investors line up for petrol stations despite fuel's uncertain future

Professor Michael Brear was interviewed by The Age about the impact of e-vehicle infrastructure on the traditional petrol station set up, and how the potential future regulation of vehicles for greenhouse gas emissions will impact the liquid-fuel supply chain. The article appeared in multiple national Fairfax online and broadsheet newspapers, including The Age, Sydney Morning Herald, and Business Insider.

www.theage.com.au/business/companies/black-gold-rush-investors-line-up-for-petrol-stations-despite-fuel-s-uncertain-future-20191218-p53l4e.html

Channel 9 news - Renewables in Victoria

Professor Pierluigi Mancarella was interviewed by Channel 9 News about the state of renewable energy in Victoria, and the integration of distributed generation in our current electricity system. The interview aired in November 2019.
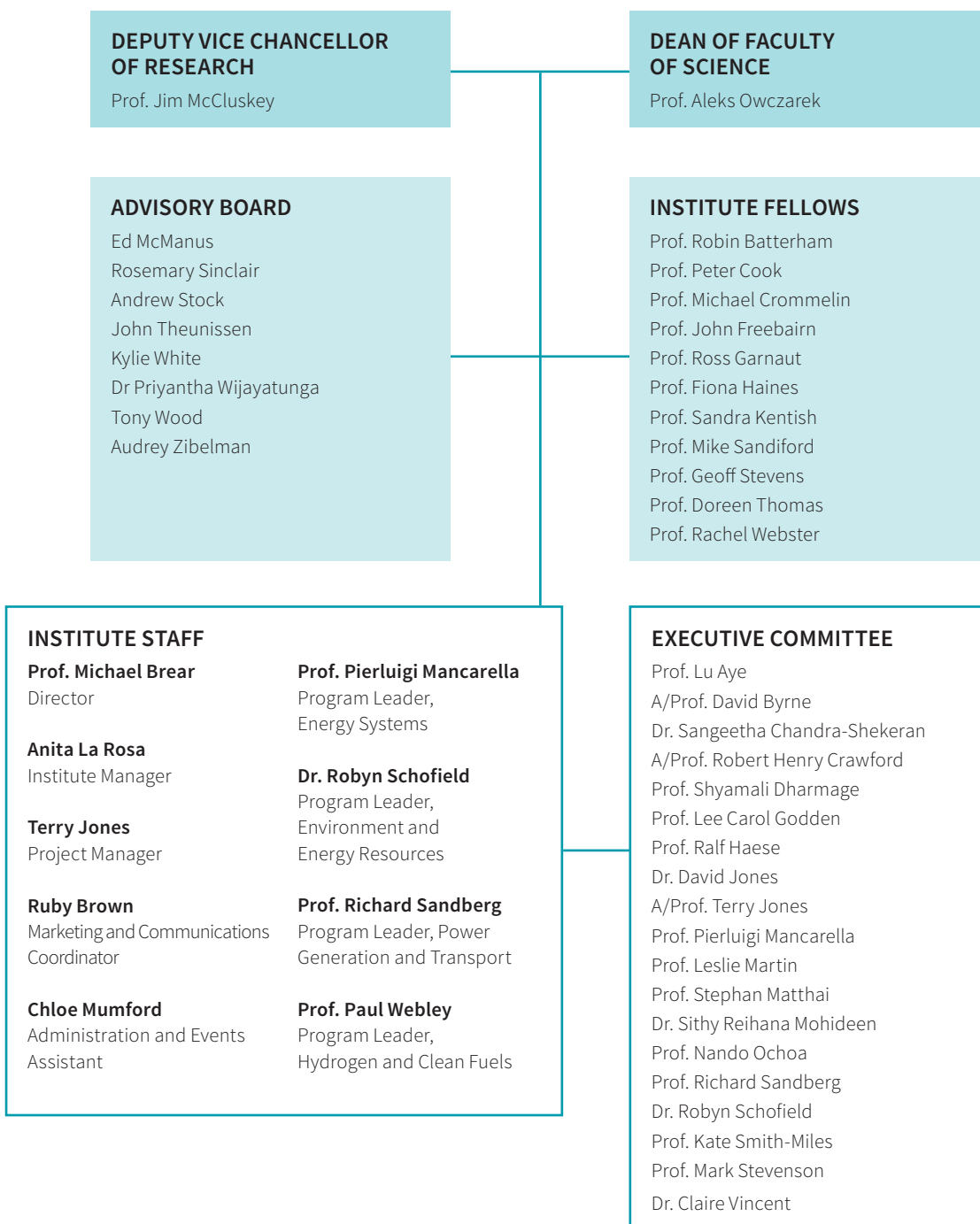
Crikey - Should Australia go nuclear?

Following the government's announcement into the first federal parliamentary inquiry into nuclear power in over a decade, online news publication Crikey interviewed Professor Michael Brear about the history of nuclear in Australia.
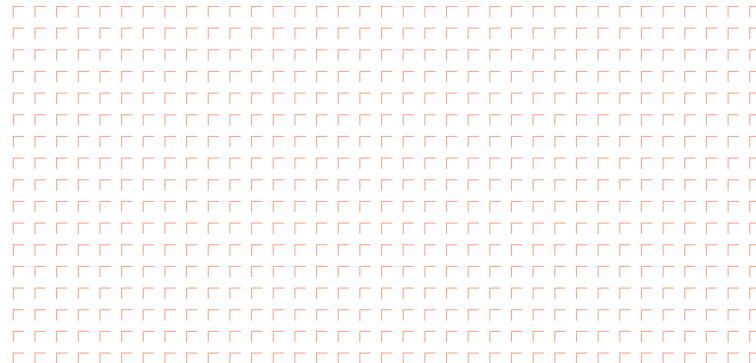
www.crikey.com.au/2019/08/14/nuclear-energy-australia/

GOVERNANCE

The Institute reports to the Deputy Vice Chancellor (Research), Professor Jim McCluskey, for research matters and the Faculty of Science Dean, Professor Aleks Owczarek, for operational matters. The Institute Staff and the Executive Committee operate the Institute, and the Advisory Board and Fellows provide strategic advice. A small team of professional staff support the Director in all Institute activities.

DEPUTY VICE CHANCELLOR OF RESEARCH

Prof. Jim McCluskey

DEAN OF FACULTY OF SCIENCE

Prof. Aleks Owczarek

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Director

Anita La Rosa
Institute Manager

Terry Jones
Project Manager

Ruby Brown
Marketing and Communications
Coordinator

Chloe Mumford
Administration and Events
Assistant

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Program Leader,
Energy Systems

Dr. Robyn Schofield
Program Leader,
Environment and
Energy Resources

Prof. Richard Sandberg
Program Leader, Power
Generation and Transport

Prof. Paul Webley
Program Leader,
Hydrogen and Clean Fuels

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Prof. Richard Sandberg
Dr. Robyn Schofield
Prof. Kate Smith-Miles
Prof. Mark Stevenson
Dr. Claire Vincent

FINANCIAL SUMMARY

INTERNAL INCOME	$
Core funding from Deputy Vice-Chancellor (Research)	$1 157 000
Other income	$156 000
Balance carry forward 2017	$1000
TOTAL INCOME	**$1 314 000**
EXPENDITURE	
Institute staff salaries	$570 000
Administration and general costs	$12 000
Events and communication	$12 000
Research project support salaries	$272 000
Research project seed funding	$210 000
Partnership development	$232 000
TOTAL EXPENDITURE	**$1 309 000**
BALANCE END 2019	**$6000**
EXTERNAL INCOME	
ARC	$1 944 000
Industry – direct contract and leveraged	$5 585 000
Government	$1 922 000
Philanthropy	-
TOTAL EXTERNAL INCOME	**$9 451 000**