Australian National University

ANU ENERGY CHANGE INSTITUTE

ANNUAL REPORT

2019

CONTENTS

MESSAGE FROM THE DIRECTOR

Dear colleagues:

This has been a watershed year for the Energy Change Institute, with the research record that we have established over many years placing us in a prominent position to contribute significantly to national and international energy developments.

In 2019 the ECI received a record number of international delegations from Korea, China, the Mekong River countries and Singapore. Of key significance were two symposia we held at ANU: one from a delegation of Norwegian energy companies; another jointly with the Australian-Germany Energy Transition Hub hosting a delegation of hydrogen experts from Germany. It was at the latter round table that Australia heard for the first time of Germany's plans to source green hydrogen from Australia.

In addition, the ECI hosted the inaugural State-of-Energy-Research Conference (SoERC) which over two days enabled industry stakeholders, government agencies and researchers to gain a broad-ranging perspective of the frontiers of energy research in every discipline from science and technology to the human and social sciences. Organised in collaboration with our colleagues in the Energy Research Institutes Council for Australia (ERICA), the SoERC conference is now on a firm trajectory to becoming a must-attend event on the energy calendar.

However, perhaps the most significant achievement this year highlighted the standing the ECI has achieved as a key player in national energy policy. At the request of the Australian Energy Security Board and the International Energy Agency, we co-hosted the international Future Electricity Markets (FEM) Summit from 10 - 12 November in Sydney. Again drawing on our collaborators in ERICA, this brainstorming forum provided over-the-horizon perspectives of how an adaptive, flexible and resilient electricity market might operate in a fully decarbonised world.

It is to be hoped that both SoERC and the FEM Summit process will continue to drive the momentous transition of the energy sector both in Australia and internationally.

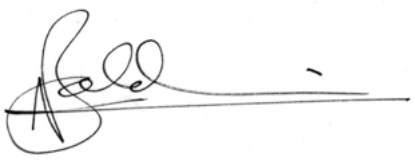
Early in the year, the ECI hosted a workshop on 100% Renewable Energy attended by more than 50 experts from around the country. The workshop examined the current trends in wind and solar which place Australia at the forefront of major countries in per capita installed capacity p.a., and articulated the need for increased investment in storage and transmission in order to unshackle future deployment.

A major highlight of the year was the launch of the ECI Grand Challenge, *Zero-Carbon Energy for the Asia-Pacific*, in Parliament house on 19 September. It was opened by the Minister for Energy and Emissions Reduction, the Honourable Angus Taylor, and showcased to the Parliament and over 100 key stakeholders the research vision for the Grand Challenge - to help future proof Australia's energy export economy based on renewable energy. The significance of the Grand Challenge research program was reinforced by the recent release of the National Hydrogen Strategy at the November COAG Energy Council, which emphasised the opportunities presented by a potential Australian hydrogen export economy.

The Grand Challenge has now recruited more than a dozen outstanding early career researchers. We have also benefited significantly from the secondment of two staff from the Department of the Environment and Energy who have contributed their policy skills and expertise to the Grand Challenge. The secondees were jointly-funded by the Department and by the ECI, with our contribution coming from a generous gift to the Institute from property developer JWLand. Together with our team of established researchers, these new appointments will power our multidisciplinary research program over the coming years through collaboration with our key stakeholders in industry, government and the wider community.

In part due to the Grand Challenge, the ECI has grown and is now approaching 200 members plus their PhD students. We have recorded these achievements and expanded our membership base despite an ever decreasing recurrent budget, that we augment each year through external leveraging. As we enter a new budget cycle towards the end of next year, we will look to re-establish the University's commitment to the ECI for a further five years at a level that reflects the significance and excellence of the activities supported by the Institute.

We hope that you will join with us in providing the compelling research, education and external engagement outcomes that support this.



Professor Ken Baldwin
Director, ANU Energy Change Institute

HIGHLIGHTS

Energy Change Institute Open Day 2019
12 February 2019

The Energy Change Institute Open Day showcased the latest energy research from ANU and partners. Highlights included keynote presentations from Greg Wilson, G.M. Consulting, formerly of the National Renewable Energy Laboratory, USA, and Professor Armin Aberle, Solar Energy Research Institute of Singapore and ECI Board member. ECI staff delivered a State-of-the-Institute presentation followed by updates on new ECI members' research including the Battery Storage and Grid Integration Program and the *Zero-Carbon Energy for the Asia-Pacific* Grand Challenge.

ANU Women in Energy Network
12 February, 4 July and 2 December 2019

In 2019 the ECI hosted three ANU Women in Energy network events with the aim of providing networking opportunities and building a sense of community. Speakers included Audrey Zibelman, CEO of the Australian Energy Market Operator (AEMO), Nicola Falcon, General Manager for Forecasting at AEMO and Kate O'Carroll, Ausnet Services. Speakers, panel members and participants shared their varied gender-related experiences working in the energy sector.

Audrey Zibelman and Fleur Yaxley talking with the ANU Women in Energy Network

100% Renewable Energy Futures Workshop
13-15 February 2019

The ECI hosted a three-day workshop on the role of renewable energy in Australia's low-carbon transition, attended by 50 international and national experts. The workshop culminated in the co-signing of a communique to inform both federal and state policy. The communique highlighted the urgent need to: address additional electricity transmission; additional energy storage and demand response mechanisms; electricity market reform; and a solid electricity infrastructure investment framework.

Bruny Island Smart Battery Trial
May 2019

The end of the multi award-winning CONSORT Bruny Island Battery Trial was marked by the release of the final project reports by ARENA, and by holding a knowledge sharing symposium attended by government bodies, industry and consumer groups, energy and renewable energy companies, and universities. The three year CONSORT project, located on Bruny Island off Tasmania, successfully demonstrated ANU-developed technology for automatically coordinating household batteries to provide optimal grid support at minimum cost, while maximising the profit of battery owners. The project was a multi-disciplinary effort, comprising three universities (ANU, University of Tasmania, University of Sydney), a renewable energy start-up (Reposit Power) and a network utility (TasNetworks), and involved research into smart-grid optimisation, energy economics, and social research related to the energy transition.

State-of-Energy-Research Conference
3 and 4 July 2019

The Energy Research Institutes Council for Australia (ERICA) hosted Australia's first two-day national research-only energy conference at ANU. The State-of-Energy-Research Conference (SoERC) included high-level plenary overviews with parallel invited talks, industry panel discussions and poster sessions. SoERC covered all aspects of energy research ranging from fundamental science, engineering and technology, to the energy implementation disciplines of economics, regulation, security, sociology and policy. Plenary speakers included Professor Ross Garnaut, University of Melbourne, Professor Martin Green, UNSW and Professor Maria Forsyth, Deakin University. The ECI, host of the inaugural ERICA Secretariat, were responsible for organising SoERC.

Associate Professor Lachlan Blackhall Entrepreneurial Fellow Inaugural Address

11 July 2019

Dr Lachlan Blackhall, head of the Battery Storage and Grid Integration Program and ANU Vice-Chancellor Entrepreneurial Fellow, delivered the Entrepreneurial Fellow Inaugural Address. Dr Blackhall outlined the mandate and activities of the Program, jointly funded by the ACT Government and the ANU, against the backdrop of past energy transitions in Australia beginning with the replacement of gas lighting by electricity. Over 150 years later, energy storage is now central to the planned operation of electricity grids, and electricity markets, globally. A pervasive theme of Dr Blackhall's presentation was that energy transitions will continue to evolve in response to the needs of people: for equitable access to energy, to ensure the equilibrium of supply and demand, to provide reliability, security and to provide new opportunities for greater community agency.

New DER lab to help drive Australia's low carbon energy future

4 September 2019

A new million dollar laboratory is set to provide a state-of-the-art testing facility to mirror the energy grid. The Distributed Energy Resources (DER) Laboratory at ANU will be available for use by researchers, industry and regulators. Funded by the ACT Government, the new lab will be led by Dr Bjorn Sturmberg and will develop and test the technologies and control systems needed for Australia's future energy system.

Norway Australia Energy Transition

12 November 2019

The Royal Norwegian Embassy, in cooperation with the Energy Change Institute hosted an Australia-Norway Energy Transition Symposium. The Symposium provided a platform for industry players, government and research organisations to exchange technological advancements and develop cooperation in the energy transition domain. Leading Norwegian and Australian experts discussed and exchanged experiences and solutions.

Future Electricity Markets Summit

18 – 20 November 2019

The ANU Energy Change Institute (in collaboration with the Energy Research Institutes Council for Australia – ERICA), the International Energy Agency and the Energy Security Board hosted the International Future Electricity Market Summit in Sydney. This invitation-only event brought together over 100 leading experts to confront the challenges of implementing an end-to-end electricity market design to integrate traditional generation and transmission assets, large scale variable renewable energy generators and storage technologies with distributed energy resources, such as roof-top solar, to millions of customers.

ANU Energy Update and Solar Oration 2018 and 2019

29 November 2018

Opened by Andrew Barr, ACT Chief Minister with keynote presentations by Sarah McNamara, Chief Executive of the Australian Energy Council and Ian Cronshaw, a consultant with the International Energy Agency. Panel discussions followed on 2018 World Energy Outlook themes: Electricity and Producer Economies. The evening lecture, Solar Oration, was delivered by the inaugural Chief Executive Officer of the Australian Renewable Energy Agency (ARENA), Ivor Frischknecht.

2 December 2019

Opened by the Honorable Pat Conroy, MP, Shadow Minister for Climate Change. The keynote presentation was delivered by Audrey Zibelman, CEO, Australian Energy Market Operator (AEMO) and Ian Cronshaw, formerly of the International Energy Agency, provided a special presentation on the 2019 World Energy Outlook. The afternoon involved panel sessions on the recently agreed National Hydrogen Strategy by Australia's Chief Scientist Dr Alan Finkel, as well as a debrief on the Future Electricity Markets Summit. In the evening, the 2019 Solar Oration was delivered by Fleur Yaxley, a senior executive in the renewable energy industry who discussed the rapid rise of wind and solar.

2019 Solar Oration speaker Fleur Yaxley

MISSION

Photo credit: James Prest

A key solution to the challenge of climate change is a world-wide shift to low-carbon forms of energy. Energy change that drives this transformation to a clean economy will also offer wider benefits to society by increasing economic productivity, and by improving energy access and security.

The ECI provides authoritative leadership in energy research, education and public policy through a broad portfolio ranging from the science and engineering of energy generation and energy efficiency, to energy economics, regulation, security, sociology, policy and security.

A defining feature of the ECI is that we are both technology and policy neutral. That is, we undertake research and education in key areas of energy technology and energy policy without favouring one particular area over another. This can and should create an open forum for good ideas leading to energy change.

GOVERNANCE

Photo credit: James Prest

The ECI comprises more than 150 academic staff and their postgraduate research students, bringing the total complement close to 300 researchers.

The wider ECI membership meets every year at the Annual Business Meeting, which establishes the activity for the coming year.

Operationally, the ECI is governed by an Executive comprising representatives from ANU Colleges:

Professor Ken Baldwin - Director
ANU College of Science

Professor Andrew Blakers (alternate Dr Matthew Stocks)
ANU College of Engineering & Computer Science

Professor Kylie Catchpole (alternate Dr Marnie Shaw)
ANU College of Engineering & Computer Science

Professor Frank Jotzo (alternate Dr Paul Burke)
ANU College of Asia and the Pacific

Professor Yun Liu (alternate Dr Annie Colebatch)
ANU College of Science

Dr James Prest - Education Convenor
ANU College of Law

Dr Lachlan Blackhall (alternate Dr Sid Chau)
ANU College of Engineering and Computer Science

Dr Igor Skryabin – Research and Business Development Manager
ANU College of Science

The Executive meets regularly throughout the year as required.

The strategic directions of the ECI are reviewed each year when the Executive meets with the ECI Advisory Board.

ECI Advisory Board

Professor Armin Aberle, CEO
Solar Energy Research Institute of Singapore

Mr Brad Archer, Chief Executive Officer
Climate Change Authority

Ms Nicola Falcon, GM Forecasting,
Australian Energy Market Operator (AEMO)

Dr Bruce Godfrey, Principal
Wyld Group Pty Ltd

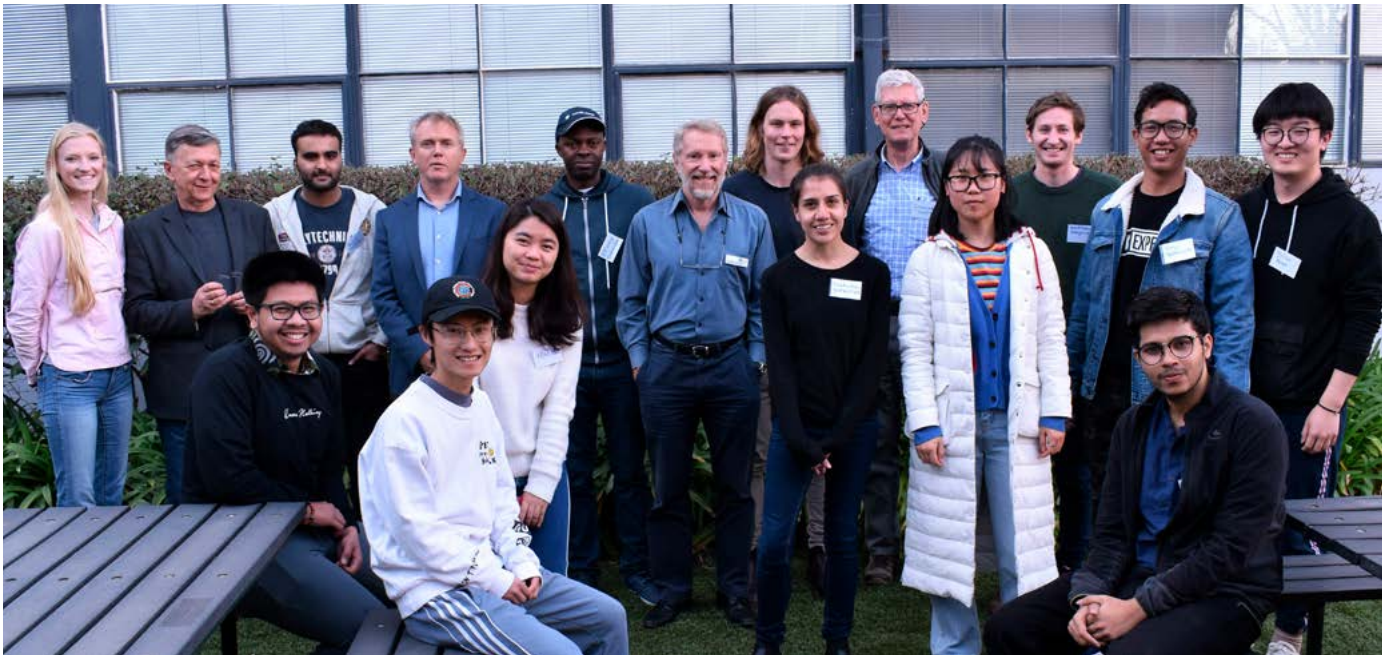
Professor Mark Howden, Director
ANU Climate Change Institute

Mr Gene McGlynn, Executive Director
Climate Change and Sustainability, ACT Government

Dr Sarah Pearson, Chief Innovation Officer and Chief Scientist
Department of Foreign Affairs and Trade

Ms Fiona Wright, Acting General Manager
Evoenergy

EDUCATION



2019 Master of Energy Change students, convenors Igor Skryabin and James Prest, and ECI Director Ken Baldwin

Master of Energy Change

The Energy Change Institute coordinates the ANU Master of Energy Change degree program, a postgraduate degree combining a strong basis in the fundamentals of science and technology, with the opportunity to explore the economics, governance, and policy issues related to energy change.

This unique interdisciplinary offering, based on the expertise of the University's research staff across many fields, is equipping the next generation of energy practitioners and decision makers from Australia and overseas with the knowledge and skills to help lead the energy revolution.

The degree is equally relevant to those with a technical or non-technical background, as it bridges the gap between scientific and engineering aspects of energy with insights from the humanities, law and economics. It provides students the flexibility to focus on areas of energy innovation most relevant to their professional needs, interests and skills.

The degree includes two foundation courses and enables choices from 46 elective courses from almost all ANU Colleges. The foundation courses are:

- Principles of Energy Generation and Transformation
- World Energy Resources and Renewable Technologies.

These courses are aimed at providing students who do not have a technical background with an understanding of the principles underpinning energy technologies.

Students must also choose one course from each of the following areas:

- Energy governance and law
- Energy policy and economics
- Science of climate change
- Sustainable systems/environmental problems.

In addition to the formal coursework, Master of Energy Change students can undertake in-depth research projects with experts from the ANU, and/or supervised internships with industry and government.

Students are also encouraged to participate in the wider activities of the ECI, which include a multitude of seminars, conferences and workshops at ANU engaging with government and industry on various energy topics.

The Master of Energy Change program prepares graduates for careers in energy-related national and international roles in business, government, and NGOs. Our graduates find employment in energy companies, technical and business consultancy, all levels of government departments and agencies covering energy and climate, as well as in sustainability management, energy and greenhouse audit, energy market analysis and climate and energy project development and financing.

Marketing of the degree continues via video, internet and traditional channels. We are confident that the degree will continue to grow, offering exciting learning opportunities to our students based on our leading edge research and very strong links with the local and national energy sector. We continue to receive applications from across Australia, as well as the Asia Pacific, Middle East, Africa and the Americas.

ECI welcomes first exchange student from École Polytechnique

In 2019, the ECI welcomed its first exchange student from the École Polytechnique in Paris. Rajat Walia experienced life as an ANU student in Semester 2.

In 2018 the ECI and the Paris-based institute École Polytechnique established the student exchange programme, enabling students from two universities to spend six months studying at the partner institute. École Polytechnique is one of the most prestigious and selective French grandes écoles, specialising in science, engineering and innovation.

ANU Master of Energy Change students are encouraged to apply to participate in the exchange program by spending part of their degree program at Ecole Polytechnique (where the majority of courses will be taught in English).

The Prosser Scholarship

The Jennifer and Ian Prosser Scholarship, established in 2018, is offered exclusively to first year Master of Energy Change students with preference given to domestic students that have lived in a remote, rural or regional area of Australia.

Funding has been provided by Jennifer and Ian Prosser, Canberra residents who value the importance of an interdisciplinary approach to energy change.

W energy.anu.edu.au/education/scholarships/master-energy-change-scholarship

For Further Information contact the Master of Energy Change degree program Convenors

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University Medal accolade for Master of Energy Change student

A Master of Energy Change student has received a prestigious ANU award in recognition of exceptional academic excellence. Hilman Fathoni is the first Master of Energy Change student to be honored with an ANU University Medal.

"Winning the University Medal feels like a dream to me," says Hilman. "It never entered my mind that I would be qualified or even become the first Master of Energy Change student to receive such an award.

Hilman's award winning research explored off-grid renewables development in rural and remote areas of Indonesia. An international student from Indonesia, Hilman's research is motivated by his belief in the importance of socio-cultural drivers and his interest in energy justice.

"Energy poverty is such a significant global issue," says Hilman. "The challenges of energy access in many developing countries are immense and require innovative, low carbon solutions especially in the wake of climate change. This also often raises the critical question of justice that has long plagued the energy and climate sector.

"What my research has taught me is how non-linear and highly nuanced the nature of our pathway forward will need to be in order to achieve universal energy for all and a just transition in the future."

There are two major findings from Hilman's research. The first is the political implications of distributing renewables as an alternative means of energy especially in challenging the incumbent system and dominance of centralised, fossil fuels in rural electrification.

The second, equally interesting finding, drawn from on-the-ground observations in several remote sites in Sumba, Indonesia shows how energy injustice within rural communities is shaped and influenced by a variety of factors such as geography, socio-cultural hierarchy, local power structures and historical legacy.

With an undergraduate degree in geological engineering Hilman worked in the private sector and for an NGO focusing on energy in Indonesia prior to studying at ANU. He was drawn to study the ANU Master of Energy Change degree due to the unique multidisciplinary focus on energy. "I was attracted to the degree's holistic curriculum, something which I found quite rare among other graduate programs focusing on energy," says Hilman who received an Australia Awards scholarship.

"The reason I chose the ANU was also due to the University's strength, particularly in the field of social science such as public policy, development studies and anthropology." He is particularly grateful to the ANU Zero-Carbon Energy for the Asia-Pacific Grand Challenge project in supporting field work for his research project.

Hilman is now considering furthering his education with a PhD in community energy access, rural development and/or energy poverty.

"Winning the University Medal feels like a dream to me"

Moving to Australia to embark upon further study is not just about the research. "I am going to miss a lot of things about Australia when I return home," says Hilman. "For example, I think I have found a new love for barbecuing and it is pretty easy to do that in many public parks in Australia. As I go back to my country, I will treasure those quiet free-of-traffic-jam moments especially here in Canberra!"

Student Profile: Master of Energy Change nurtures public policy

A former student of Environmental Science, Jessica Catling has been working for the Federal Government since her undergraduate years. It was her involvement in the Clean Technology Program and a few other renewable energy grant programs that led her to enrol in the Master of Energy Change degree at ANU.

"A lot of people in the public service have an excellent understanding of the government but not necessarily the technical aspects of renewable energy. I found that when I was doing my work, I lacked that technical understanding. And just the fundamentals for understanding some of the concepts was really what I wanted to learn and was interested in," said Jessica.

"The Master of Energy Change degree helps me to stay on top of the latest schools of thought"

The fact that this ANU degree covers environmental science as well as economics and business appealed to Jessica. "In government, there is always the need for an economic argument for why a particular program should go ahead and to understand the practical barriers to implementing renewable energy. The Master in Energy Change aligns with my interests in sustainability and offers a lot of flexibility. I like that I have access to economics units," she said.

In her new role as a 'Products and Services Specialist' in the Carbon Neutral Program, Jessica helps businesses throughout the application process to get their product or service certified as carbon neutral. "The Masters' program in particular has helped me understand just how to draw up their carbon counts and to understand their energy usage. It was not one specific elective that helped me in the carbon counting. It was to have a holistic understanding of the systems involved," said Jessica.

"The Master of Energy Change degree helps me to stay on top of the latest schools of thought. It is also a really good opportunity for networking and hearing opinions from people who have worked in businesses, corporations or with communities," said Jessica.

Jessica has this advice for prospective students. "We are at the beginning of a massive transition and there is going to be a lot of opportunity for people that are interested in getting involved. If you start now, there is opportunity for you to get into this space".

When asked about her own aspirations for contributing to this space, Jessica said, "There is no way that I could try and address every single thing that is affecting the environment or climate change. So, I just want to focus on one particular part where I think I can make a difference."

Jessica believes that her calling lies in working with the community. "I would like to be involved in on-the-ground projects that help people and communities become more sustainable. I worked in a sustainable community at Costa Rica for a short period and saw what it was like to lead a more sustainable lifestyle. There is a lot to learn and address."

Professional Short Courses

The Energy Change Institute offers state-of-the-art professional short courses and briefings for government departments and commercial participants. ECI short courses are designed to provide updates on recent advances in the science and technology, and in the social, policy, economic and governance aspects of energy change for policy makers and professionals.

A typical course comprises a numbers of sessions presented by leading ANU academics. Courses can be tailored to meet the needs of a specific audience, and can be scheduled over consecutive days or spread over weeks. Alternatively, a short briefing session on a specific topic can be arranged.

Short course: Energy Essentials for Professionals

28 May 2019

In response to many enquiries, the ECI hosted a one-day short course entitled: 'Energy Essentials for Professionals'. The course was tailored for professionals with a background in technology, policy, business or economics.

The course covered:

- Energy technology and efficiency fundamentals
- Interplay between technologies, their grid integration, storage and policy development
- Foundations of energy law and economics.
- Energy Futures – an outlook on future energy systems and their transformation both in Australia and internationally.

Course participants included professionals from the Department of the Environment and Energy; Department of Defence; the Clean Energy Regulator, the Office of National Intelligence, Department of Home Affairs, Department of Finance and the ACT Government.

Professional Short Course Convenor

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Research and Business Development Manager
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W energy.anu.edu.au/education/professional-short-courses

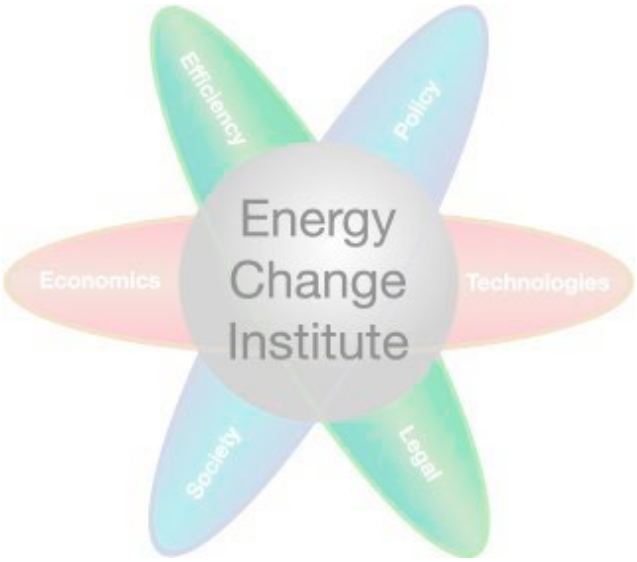
RESEARCH

The expanded ECI research program covers a broad spectrum from energy science and engineering to implementation expertise in the economic, legal, sociological and policy issues surrounding energy change. This broad portfolio of research activity is unique in the country.

The ECI continues to add new researchers to its portfolio. The number of staff members stand at approximately 200 members which together with postgraduate students yields more than 300 researchers in total.

In 2019 we added one new research cluster – Hydrogen Economy – to the ECI portfolio, which is reported here, bringing the total number of clusters to 20.

Further, we are pleased to include a synopsis of the Battery Storage and Grid Integration Program (BSGIP) which saw its first full year of operation in 2019, supported by joint funding between the ACT Government and the ANU. BSGIP research falls under the Smart Grid research cluster, and also has activities in the Energy Storage and Recovery research cluster.



Artificial Photosynthesis

Carbon Capture & Storage

Energy & Security

Energy Economics & Policy

Energy Efficiency

Energy for Development

Energy Regulation & Governance

Energy Sociology & Risk

Energy Storage & Recovery

Energy-Water Nexus

Enhanced Oil & Gas Extraction

Fusion Power

Hydrogen Economy

Nuclear Science

Renewable Fuels

Smart Grid

Solar Photovoltaics

Solar Thermal

Sustainable Transport

Wind Energy

To find out more, go to energy.anu.edu.au/research

Hydrogen Economy

The Hydrogen Economy Cluster comprises over 30 members, making it one of the largest ECI research clusters, reflecting the importance of this emerging technology.

Hydrogen has the potential to provide the missing link between naturally variable sources of renewable energy - such as wind and solar - and industrial energy users that have yet to find a viable alternative to fossil fuels. Additionally, zero-carbon hydrogen could be a key energy vector, allowing renewable energy to be stored and transported around the world.

The broad portfolio of hydrogen research at ANU is unique in Australia. It spans the hydrogen value chain, including technological expertise in generation and storage, as well as social license issues, governance, and economics.

The Hydrogen Economy Cluster comprises 30 members and is the largest ECI research Cluster.

The Cluster addresses the 3 key research areas of the Hydrogen Economy:

- Hydrogen generation
- Storage transportation and usage
- Techno economic, governance and regulatory analysis

Hydrogen generation

Several emerging technologies are under active development by ANU researchers, and have the potential to drastically reduce the cost of producing hydrogen.

Advances in electrocatalysts are needed to increase the efficiency of electrolysis. Researchers in the Research School of Chemistry (RSC) are investigating bio-mimetic electrodes for water splitting that are highly efficient. At the Research School of Engineering (RSE) and RSC, new types of catalysts based on low-cost, metal-oxide materials are being studied. The next steps are to develop prototypes for mid-scale H_2 generation by photo- and electrochemical water splitting.

Concentrated solar thermal systems can provide the heat needed to split water, without the need for fossil fuels. The Solar Thermal Group (RSE) is developing high-temperature hydrogen generation technologies using concentrated solar energy. They are studying thermo- and electro-chemical pathways from proof-of-concept to advanced reactor and system design.

Photo-electrochemical (PEC) routes allow hydrogen generation directly from sunlight, removing the need for electricity inputs. ANU researchers are developing this approach for high-efficiency solar hydrogen generation:

Photo credit: James Prest

- Employing the latest advances in silicon tandem solar cells (Solar Group, RSE),
- Developing thin-film, multi-junction III-V semiconductor photoelectrodes (Semiconductor Optoelectronics and Nanotechnology Group, Research School of Physics)
- Designing heterojunction nanostructured solar cells (Nanotechnology Research Lab, RSE)
- Combining well-established photovoltaic technology with low-cost earth-abundant catalysts (Nanotechnology Research Lab, RSE)

Storage transportation and usage

ANU researchers are investigating safer, cheaper, and more effective ways to store and transport hydrogen.

The Functional Materials Research Group (RSC), are developing hydrogen storage and conversion based on organic hydrogen carriers. This work aims to develop safe, inexpensive, environment-friendly and scalable hydrogen storage technology at ambient temperature and pressure. The group works with Evoenergy on prototyping ANU technology solutions at Canberra's first H_2 refuelling station.

A research team from Law examined the legal and regulatory issues at State/Territory and national level associated with grid injection of renewable gas arising from gas safety legislation applicable to gas distribution and transmission companies

Hydrogen may also be stored and transported using ammonia as a vector. The Solar Thermal Group (RSE) has significant expertise in ammonia storage from over two decades experience developing a solar thermochemical energy storage system based on the reversible ammonia reaction.

Techno economic, governance and regulatory analysis

A wide range of social science analysis is needed to address the barriers and drivers of investment in hydrogen supply chain and infrastructure, including consideration of the practical and regulatory prerequisites for development of an Australian hydrogen economy at scale. ANU researchers are investigating the social, economic, and political drivers of demand in Australian and overseas markets. Modernised governance and policy frameworks (drawing upon overseas experience where appropriate) are required to facilitate large-scale investments for hydrogen production and export industry.

Research at ANU is examining in detail proposals sketched in outline in the *National Hydrogen Strategy*, particularly the proposed system to track the provenance of hydrogen. The project will examine the details of establishing a Renewable Gas Certificate of Origin and Certificate Registry to link buyers and sellers, providing assurance of environmental credentials. This work will analyse existing and emerging international initiatives for renewable gas certification frameworks, particularly in the EU.

Major Events and Activities:

The ECI Hydrogen Economy Cluster is a key participant in the ANU Grand Challenge (Zero Carbon Energy for the Asia Pacific) Hydrogen Fuels project and in 2019 hosted a number of visiting international delegations, particularly from Germany, Norway, and Korea. These include:

- *Hydrogen, our future*, Italy-Australia discussion, Italian Centre, Adelaide, in conjunction with Hydrogen Safety International Conference. This resulted in an *MOU signed between ANU ECI and ENEA*, the Italian National Agency for New Technologies and Energy.
- *Hosting H2Korea delegation at ECI, 12 August 2019*
- *Hosting the Visiting German industrial hydrogen delegation, led by Acatech (National Academy of Science and Engineering and BDI (Federation of German Industries), 17 September 2019*
- *Hosting the Australia-Norway Energy Transition Symposium 12 November 2019Participation in the CSIRO Australian Hydrogen Hub study;*
- *Coordinating ANU Input to the National Hydrogen Strategy via two detailed written submissions and meetings with the Taskforce staff in Canberra during 2019.*

Cluster Members:

Cluster Convenor: Dr Igor Skryabin

Dr Emma Aisbett

Dr Fiona Beck

Professor Nick Birbilis

Associate Professor Paul Burke

Professor Kylie Catchpole

Dr Hongjun Chen

Dr Annie Colebatch

Dr Joe Coventry

Associate Professor Llewelyn Hughes

Professor Chennupati Jagadish

Professor Frank Jotzo

Dr Siva Karuturi

Professor Wojciech Lipinski

Professor Yun Liu

Professor Warwick McKibbin

Associate Professor Ron Pace

Dr James Prest

Dr Robin Purchase

Dr John Pye

Professor Sean Smith

Professor David Stern

Dr Matthew Stocks

Professor Robert Stranger

Professor H. Hoe Tan

Dr Juan Felipe Torres Alvarez

Professor Antonio Tricoli

Dr George Tsekouras

Associate Professor Takuya Tsuzuki

Dr Mahesh Brahmadesham Venkataraman

Dr Zongyou Yin

Battery Storage and Grid Integration Program

Established in April 2018, the Battery Storage and Grid Integration Program has a mandate to build a globally leading energy storage and grid integration laboratory, designing and implementing the building blocks for powering our future electricity system.

The Battery Storage and Grid Integration Program is funded by the ACT Government and The Australian National University (ANU) and is jointly hosted within the ANU by the Research School of Electrical, Energy and Materials Engineering (RSEEME) and the Research School of Chemistry (RSC).

Since its founding, the Program has grown rapidly, now comprising over 30 staff and students with diverse academic, industry, gender and cultural backgrounds. With a strong focus on interdisciplinary research, development and demonstration (RD&D), the Program is delivering on a number of priority projects supporting national infrastructure. The Battery Storage and Grid Integration Program is working with over two dozen industry partners and is supported through further funding support from The Australian Renewable Energy Agency (ARENA), The ACT, NSW and Federal Governments, and the ANU.

The Battery Storage and Grid Integration Program is undertaking research across the development, integration, operation, and optimisation of energy storage in electricity grids, and electricity markets, globally. These activities are categorised into four thematic streams outlined in more detail below.

Research Themes

BSGIP
Energy Storage

Designing, building and characterising new battery storage devices, based on a fundamental understanding of different chemical and material behaviours. Exploring opportunities for battery recycling, reuse and failure analysis based on characterisation capabilities.

BSGIP
Devices, Optimisation and Control

Developing systems and capabilities for the effective optimisation, control, coordination and orchestration of battery and energy storage systems, and electric vehicles in modern power systems.

BSGIP
Data and Analytics

Progressing the state of the art in modelling, forecasting and prediction to understand the behaviour and performance of power systems with a high penetration of distributed energy resources (DER) including solar PV, battery storage and electric vehicles.

BSGIP
Regulation, Markets and Models

Undertaking social research and designing and implementing policy, economic and market models to support the deployment of energy and battery storage including residential, precinct and grid-scale battery storage and electric vehicles.

BSGIP GROUP

Projects

The Battery Storage and Grid Integration Program is undertaking several significant projects which are outlined below.

Operating envelopes for orchestrating distributed energy resources (evolve Project)

Associate Professor Lachlan Blackhall leads the evolve project, a collaboration with industry partners to develop a platform which will support the dynamic management of distributed energy resources (DER) and distribution connected assets (DCA) through publishing real-time operating envelopes. The operating envelopes provide the safe participation limit for individual and aggregate resources and will allow DER assets to manage their market participation without breaching the physical or operational limits of the distribution network. This $13 million three-year project is funded by ARENA, NSW Government, and a consortium of industry partners including network operators and DER aggregators. The evolve platform and capabilities will be first deployed in 2020.

Local energy models and shared battery storage (Community Energy Models Project)

Dr Marnie Shaw leads the ARENA-funded Community Energy Models project which aims to explore how community energy models (e.g. shared battery systems) can support increasing amounts of renewable energy in the grid, reduce energy costs for consumers, and address important issues around energy equity. This $1.3 million ARENA-funded project includes as partners several distribution network operators and community energy groups across Australia. The project also includes a strong social research stream. Early results indicate that there are viable models for operating shared batteries which can support increased renewable energy deployment while reducing the cost of electricity for community members.

Understanding grid behaviour, vulnerabilities and resilience

Dr Elizabeth Ratnam has secured funding through the Global Connections Fund to deploy advanced sensors into the distribution grid to capture real-time streaming data on voltage, current and phase angle. The promise in this project is the potential to observe disturbances in the grid in real-time, mitigating operational risks through the development and deployment of sophisticated phasor-based control systems.

Facilities

The Battery Storage and Grid Integration Program is currently building two world-class laboratories to support its research, development and demonstration activities.

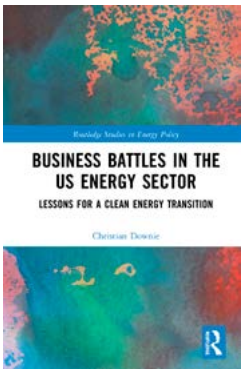
Battery chemistry and storage laboratory (Battery Lab)

Dr Alexey Glushenkov and his team within the Research School of Chemistry are exploring the potential for new battery storage technologies including lithium-ion, sodium-ion, and potassium-ion batteries, hybrid capacitors, and supercapacitors. Over $1 million in funding from ACT Government and the ANU will support the development of a specialist laboratory within the ANU for characterisation, development and performance testing of battery materials, electrolytes and devices. The facility will be operational in early 2020.

Grid simulation and DER testing laboratory (DER Lab)

Dr Bjorn Sturmberg leads a collaborative team, successfully funded under the ACT Government Priority Investment Program and the ANU National Institutes Grant, to build a world-class Distributed Energy Resources (DER) laboratory at ANU. The DER Lab will include an electrically equivalent distribution network, transformers, batteries, solar generation as well as high-speed, in-the-loop monitoring, control and optimisation capabilities. The DER Lab will support the development and testing of important capabilities including new monitoring and communication devices, smart controllers, and aggregation (e.g. Virtual Power Plant) and market participation capabilities. The DER Lab represents an important national facility for collaborative development and testing of new capabilities to support the operation of electricity systems with a high-uptake of renewable and distributed generation and energy storage. The DER Lab will be open to researchers, educators and industry partners from mid-2020.

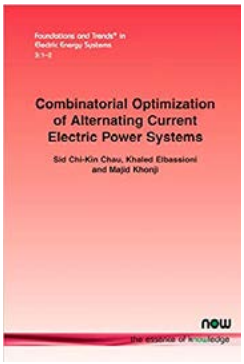
New Books



Business Battles and U.S. Energy Policy: Lessons for a cleaner world

Dr Christian Downie

This book is ground breaking in its study of business actors in climate and energy politics. While various studies have demonstrated the influence of business actors across multiple policy domains, this is the first to examine the behaviour of business actors in energy centric industries in the US that will be vital for achieving a clean energy transition, namely the oil, gas, coal, utility, and renewable industries.



Combinatorial Optimization of Alternating Current Electric Power Systems

Sid Chi-Kin Chau, Khaled Elbassioni, and Majid Khonji

The electric power grid, which has been an indispensable part of our society, is being put under increasing pressure to meet the demands of a major surge in global energy consumption. As a result, the power grid needs to undergo transformations to meet the new challenges for a more sustainable society.

ZERO-CARBON ENERGY FOR THE ASIA-PACIFIC – AN ANU GRAND CHALLENGE

The Energy Change Institute leads an ANU strategic initiative, *Zero-Carbon Energy for the Asia-Pacific*, in which the University is investing $10 million from 2019 to 2023. This initiative recognises that Australia is a potential renewable-energy powerhouse and a resource-rich nation, whose immediate neighbours in the Asia-Pacific will account for two-thirds of the world's energy demand growth in the coming decades.

Decarbonising further energy use and cutting existing emissions in the region are essential if the world is to have any change of meeting its goals for limiting climate change. In a rapidly decarbonising world, Australia's carbon emitting exports will need to shift to zero-carbon embedded renewable energy exports in order to maintain our role as an energy export powerhouse.

2019 was the first full year of operation the Grand Challenge to which we recruited an outstanding team of early career researchers and administrative staff. This includes two secondees jointly funded from the Department of the Environment and Energy, generously supported by ECI donor JWLand.

With a total complement of approximately 40 academic staff, Grand Challenge fellows and support team members, we now have the critical mass to drive our research programs forward in our five projects:

- Renewable electricity systems
- Hydrogen and hydrogen-based fuels
- Renewable refining of metal ores, especially green steel
- Energy policy and governance in Asia-Pacific countries
- Indigenous community engagement

A summary of the future prospects for Australia underpinned by our research vision is shown in Figure 1

The left-hand map shows the consequential emissions arising from Australia's major commodity exports, 95% of which are to the Asia-Pacific contributing ~11% of the region's energy emissions.

Alongside this is shown the opportunity to create new industries by exporting the equivalent amount of energy (now exported in coal and gas) as green electricity (20% of the total or 440 TWh/y) plus green hydrogen (80% or 53 megatonnes p.a.). This will require renewable electricity generation 14 times that of our total existing electricity production (currently 260 TWh/y).

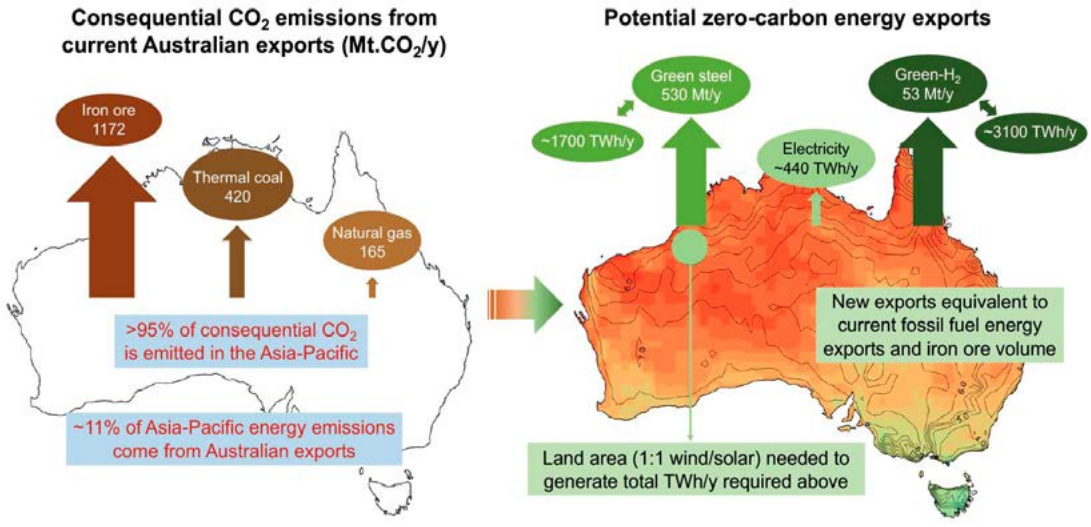
In addition, we can significantly value-add to our mineral exports by transforming iron ore into green steel (530 megatons p.a.) using renewable electricity and hydrogen. This will require a further six times the current annual electricity production.

Not only could this yield a prosperous export future, but it would also significantly assist the decarbonisation of the Asia-Pacific as our traditional export markets transition to a zero-carbon economy.

2019 has already yielded significant Grand Challenge research outputs, which include more than a dozen published journal papers with a similar number under review, plus three Grand Challenge Research Papers and three Grand Challenge Working Papers. These research outputs include contributions from a range of disciplines including Indigenous engagement, economics, international governance, and engineering as well as several interdisciplinary papers.

In the coming year the Grand Challenge will continue to deepen and expand its engagement with key Federal Government Departments - especially the new Department of Industry, Science, Industry and Resources, and the Department of Foreign Affairs and Trade (including Austrade). We will also engage closely with Federal Government agencies such as ARENA, CSIRO and ASTRI, and with our local ACT Government and relevant State Governments. We aim to expand our portfolio of industry partner collaborators (including CWP Renewables and Evoenergy) to other companies with interests in renewable systems research, hydrogen production and green steel, and will look to leverage industry support through external funding programs.

Figure 1



The Grand Challenge breakfast launch. From left to right: Andrew Dickson, Asian Renewable Energy Hub; The Hon Angus Taylor MP, Minister for Energy and Emissions Reduction; Ken Baldwin, ECI Director; Brian Schmidt, ANU Vice-Chancellor; Jane O'Dwyer, ANU Vice-President, Engagement and Global Relations

Launch Event at Parliament House

The Grand Challenge breakfast launch event was held at Parliament House on Thursday 19 September attracting more than 100 stakeholders. Guests heard from the Honorable Angus Taylor, Minister for Energy and Emissions Reduction; Professor Brian Schmidt, Vice-Chancellor, ANU; Professor Ken Baldwin, Director of ZCEAP; Ms Jane O'Dwyer, Vice-President, Engagement and Global Relations, ANU; and Mr Andrew Dickson, Asian Renewable Energy Hub. Other noteworthy guests included Pat Conroy, Member for Shortland, Zali Steggall, Independent for Warringah and Shane Rattenbury, ACT Climate Change Minister. Following the breakfast launch, there was a well-attended stakeholder briefing session for those interested in collaborating with the Grand Challenge. The ZCEAP team is now following-up leads with a number of tailored briefing sessions.

Zali Steggall, MP

Kioloa Retreat

The ANU Kioloa campus on the South Coast provided the location for a two-day winter retreat. It was the first opportunity for the ZCEAP team to congregate and discuss ways of collaborating and progressing the research agenda. Several specific research outputs were identified including submissions to major journals and special issue proposals.

PUBLIC POLICY

The ECI continues to engage in the development of public policy through its extensive relationships with government departments and agencies.

This year's public policy highlights included:

Federal Government

ECI members, led by Professor Ken Baldwin, provided a submission on the National Hydrogen Strategy Discussion Paper (March 2019) and the National Hydrogen Issues Paper (July 2019). ECI members also met with members of the Chief Scientist's National Hydrogen Taskforce on 21 March 2019.

The ECI and the Australian ITER Forum provided submissions to the Inquiry into the Prerequisites for Nuclear Energy in Australia. Professor Andrew Stuchbery and Professor Tim Senden presented oral evidence on behalf of the ECI to the Inquiry. September 2019.

ECI members provided a submission to the Senate Select Committee on the effectiveness of the Australian Government's Northern Australia agenda. Contributors included Professor Ken Baldwin, Professor Tony Dreise, Associate Professor Janet Hunt, Dr Lily O'Neil, Dr Kathryn Thorburn, Mr Brad Riley and Dr Emma Aisbett. September 2019

The Energy Change Institute, with numerous contributions from its members, provided a submission to the Senate Select Committee Inquiry into Jobs for the Future in Regional Areas. September 2019.

State Government

Submission to the Department of Water and Environmental Regulation on the "Climate Change in Western Australia – Issues Paper", by the Grand Challenge team *Zero-Carbon Energy for the Asia-Pacific* Grand Challenge, led by Dr Lee White, November 2019.

Regulatory Bodies

Dr Bjorn Sturmberg, Dr Marnie Shaw and Dr Lachlan Blackhall provided a submission to the Australian Energy Market Commission responding to the consultation paper on Regulatory Sandbox Arrangements to Support Proof-Of-Concept Trials. January 2019.

The Battery Storage and Grid Integration Program, led by Dr Lachlan Blackhall, provided a Submission to the Energy Security Board Post-2025 Market Design Issues Paper. September 2019.

Communiques

Social Equity in the Energy Transformation: Symposium Communique. Associate Professor Sara Bice, Associate Professor Carolyn Hendriks, Dr Rebecca Colvin, Dr Emma Aisbett and Professor Baldwin synthesised the key themes from the 'Social Equity in the Energy Transformation Symposium, hosted by the ECI in late 2018, creating a communique that sets out key research and policy directions.

Individual contributions

ECI researchers contribute to public policy development through their individual research expertise as part of their everyday activities – particularly in the disciplines of economics, law, sociology and policy. Amongst many individual achievements throughout the year, ECI researchers contributed to the following areas of public policy:

Dr Lachlan Blackhall, Head of the Battery Storage and Grid Integration Program at ANU provided a submission to the Open Energy Networks Consultation Paper. August 2019.

Professor Andrew Blakers provided the following individual contributions:

- Submission to Climate Change Authority review. July 2019.
- Submission to Chief Scientist's Hydrogen Taskforce. July 2019.
- Submission to the NSW Government Inquiry into sustainability of energy supply and resources in NSW. September 2019.
- Oral evidence and submission to the Federal House Standing Committee on the Environment and Energy Inquiry into the prerequisites for nuclear energy in Australia. September 2019.

ANU Public Policy

The University has a major role in providing expertise to governments and the wider community through its Public Policy Fellows program in which the ECI is a major player, contributing five Public Policy Fellows

Currently the ECI has five Public Policy Fellows:

Professor Ken Baldwin
Director, Energy Change Institute
ANU College of Science

Professor Andrew Blakers
ECI Solar Photovoltaics
College of Engineering and
Computer Science

Professor Quentin Grafton
ECI Energy Economics and Policy
Crawford School of Public Policy

Professor Frank Jotzo
ECI Energy Economics and Policy
Crawford School of Public Policy

Professor Warwick McKibbin
ECI Energy Economics and Policy
Crawford School of Public Policy

EVENTS

The ECI organised and hosted many public events in 2018 and 2019, ranging from public lectures by eminent speakers of global standing, to seminars and discussions of a technical nature, engaging experts and practitioners in the field of energy change in discussions around science, technology and policy.

More information about these events can be found at energy.anu.edu.au/news-events.

Flagship events

2018 ANU Energy Update
28 November 2018

The annual ANU Energy Update brought together Australian researchers, policymakers, industry and members of the public to provide an update on the latest world energy trends from the International Energy Agency *World Energy Outlook*. Sarah McNamara, Chief Executive of the Australian Energy Council delivered a keynote speech on 'How the energy transformation changes everything'.

2018 ACT Government/ ANU Solar Oration
28 November 2018

Ivor Frischknecht, inaugural Chief Executive Officer of the Australian Renewable Energy Agency (ARENA) delivered a speech on 100% renewable energy systems.

2018 ECI Open Day
11 February 2019

The annual ECI Open Day showcased the latest in energy research at ANU to key stakeholders, with ECI participants and industry collaborators giving presentations on their work.

2019 ANU Energy Update

Dr Alan Finkel, Australia's Chief Scientist, Dr Fiona Beck, ANU, Ed Gaykema, ActewAGL and Andrew Dickson, Asian Renewable Energy Hub discussing the National Hydrogen Strategy

Audrey Zibelman, CEO, Australian Energy Market Operator discussed the energy transition followed by a special presentation by Ian Cronshaw, formerly of the International Energy Agency, on the 2019 World Energy Outlook. Afternoon panel sessions focused on the National Hydrogen Strategy presented by Dr Alan Finkel, and the recently held Future Electricity Markets Summit.

2019 ACT Government/ ANU Solar Oration

Fleur Yaxley, a senior executive in the renewable energy industry, delivered the 2019 Solar Oration, discussing the rapid rise of wind and solar energy.

Meetings

ECI Annual Business Meeting
23 May 2019

The ECI Annual Business Meeting is an opportunity for ECI members to participate in setting the directions of the ECI over the coming year. This year Nicola Morris, Chief Operations Officer of the Australian Renewable Energy Agency (ARENA) provided the keynote address.

Women in Energy meetings
11 February 2019

Women in Energy meeting. Panel members from left to right: Nicola Falcon, AEMO; Marnie Shaw, ANU; Liz Ratnam, ANU and Emma Aisbett, ANU.

Held in conjunction with ECI Open Day was the second Women in Energy meeting. Drawing together women from across the campus whose research touches on energy, this meeting discussed gender related issues and how they impact upon the workplace. Keynote speaker was Nicola Falcon, General Manager for Forecasting at the Australian Energy Marketing Operator (AEMO) and panel members included Dr Marnie Shaw, Dr Elizabeth Ratnam and Dr Emma Aisbett.

4 July 2019

Kate O'Carroll, Ausnet Services, provided a lunch-time talk during day 2 of the State-of-Energy-Research Conference. Kate's talk focused on the importance of creating your own network of support.

2 December 2019

Women in Energy morning tea with Audrey Zibelman, CEO of the Australian Energy Market Operator and Fleur Yaxley, a senior executive in the renewables industry. This morning tea was held in conjunction with ANU Energy Update.

ECI Public Lectures, Conferences and Symposia

Ken Baldwin speaking at the State-of-Energy-Research Conference

Building sustainable cities with effective transport
30 November 2018

Danish ambassador Tom Nørring discussed why Denmark, together with the other Nordic countries, is at the forefront when it comes to the development of sustainable cities.

Energy Conversations: Zero-Carbon Energy for the Asia-Pacific
3 December 2019

Dr Emma Aisbett, Associate Director Research, *Zero-Carbon Energy for the Asia-Pacific* Grand Challenge and panel members explained the significance of this initiative to the public. Panel members included Dr Paul Burke, ANU; Mr Andrew Dickson, CWP Renewables; Mr Stephen Devlin, Evoenergy and Mr Shane Rattenbury, ACT Government.

The future of nuclear power
20 February 2019

Guest presentation by Mikhal Chudakov, Deputy Director General, International Atomic Energy Agency.

Australia: The renewable energy superstar
14 February 2019

Experts attending an ANU workshop: *100% renewable energy futures* presented an overview of the renewable revolution at this evening public lecture.

Visit SPIDER and learn how to make a small sun of Earth
17 April 2019

On the occasion of the Italian Research Day, the Embassy of Italy; co-supported by the ANU Energy Change Institute and the ANU Mathematical Sciences Institute, hosted a virtual visit of the SPIDER Laboratory, in Padua, Italy.

Energy Conversations: The role of Social Licence to Operate in a just energy transformation
30 May 2019

Associate Professor Sara Bice, Crawford School of Public Policy explored the interesting history of the term 'Social Licence to Operate' and just what exactly does it mean. Panel members Associate Professor Janet Hunt, Centre for Aboriginal Economic Policy Research, ANU Dr Rebecca Colvin, Climate Change Institute, ANU; Andrew Dyer, National Wind Farm Commissioner

The State-of-Energy-Research Conference
3 – 4 July 2019

Ross Garnaut speaking at the State-of-Energy-Research Conference

The Energy Research Institutes Council for Australia (ERICA) - a peak body of 12 university research institutes organised Australia's first two-day national research-only energy conference. Hosted by the ECI, it attracted an audience of energy experts from across Australia.

Energy Conversations: Green Steel – forging a new industry in Australia
27 August 2019

Dr John Pye outlined several exciting technologies currently under development to transition from the dominant blast furnace and basic oxygen furnace to new approaches that are no longer dependent on the combustion of fossil fuels.

The ACT Government's new Climate Strategy: an overview and critique
8 October 2019

Shane Rattenbury, ACT Minister for Climate Change and Sustainability, explained the new ACT 2019-2025 Climate Change Strategy, Canberra's Living Infrastructure Plan and future directions for ACT climate policy. Followed by a panel discussion with ANU experts: Dr Arnagretta Hunter, Dr Matthew Stocks, and Associate Professor Cris Brack.

Net Zero: the UK's 2050 emissions target
16 October 2019

Vice Chair of the UK Committee on Climate Change, Professor Julia King (Baroness Brown of Cambridge) was in Australia to discuss how the UK has the potential to achieve deep emissions reductions.

Norway-Australia Energy Transition Symposium
12 November 2019

The Symposium provided a platform for Norwegian and Australian industry, government and research organisations to exchange technological advancements and develop cooperation in the energy transition domain.

Future Electricity Markets Summit
18-20 November 2019

Leading experts converged upon Sydney to discuss the future shape of electricity markets in engineering, economics, regulatory and policy dimensions. Hosted by the International Energy Agency, the Energy Change Institute (in collaboration with the Energy Research Institutes Council for Australia – ERICA) and the Australian Energy Security Board.

In conversation with Ross Garnaut
25 November 2019

Ross Garnaut discussed his new book - Superpower: Australia's Low-Carbon Opportunity.

Overcoming fossil fuel resistance to climate action: Lessons from the US
28 November 2019

Dr Christian Downie discussed his latest book – *Business Battles in the US Energy Sector: Lesson for a clean energy transition*.

Indonesia electricity generation technology cost assessment
5 December 2019

Speakers: Professor Kaliappa Kalirajan, applied economist and policy analyst in the Crawford School of Public Policy and Dr Arif Syed, Visiting Fellow, Arndt Corden Department of Economics, Crawford School of Public Policy.

Roundtables

Mekong – Australian Renewable Energy Dialogue
6 June 2019

A high-level delegation consisting of officials from Cambodia, Laos, Myanmar, Thailand, and Vietnam visited ANU as part of a Canberra Fellowships Program tour to build a Mekong – Australia Renewable Energy Dialogue. ECI members who briefed the delegation included Professor Ken Baldwin, Dr Emma Aisbett, Dr Thang Do, Dr Lachlan Blackhall, Dr Matthew Stocks, Professor Andrew Blakers and Dr Joe Coventry.

H2Korea delegation
12 August 2019

H2Korea delegation

A delegation from Korea, *H2Korea*, took part in a roundtable discussion on Korea's priorities and how Australian institutes can help, followed by hydrogen-related lab tours. Organised by Dr Fiona Beck, the delegation meet with the following ECI members: Dr Emma Aisbett, Professor Frank Jotzo, Dr Igor Skryabin, Professor Antonio Tricoli, Dr Hongjun Chen, Dr Zongyou Yin, Associate Professor Ron Pace, Associate Professor Takuya Tsuzuki, Associate Professor Llewelyn Hughes and Dr Siva Karuturi.

German Energy Delegation
17 September 2019

A high-level delegation from Germany visited ANU for discussions about the energy transition with a special interest in hydrogen and renewables, in particular the regulatory/policy aspects and technology. The delegation was led by the German Academy of Technology (Acatech) and the main industry association, BDI.

ACT's Sustainable Energy Policy 2020-2025
16 October 2019

ECI members took part in a roundtable discussion with ACT Government representatives to provide feedback on the ACT Sustainable Energy Policy 2020-25 Discussion Paper. ECI members included Dr James Prest, Professor Andrew Blakers, Dr Elizabeth Ratnam, Dr Joe Coventry, Dr Lee White, Dr Thomas Longden and Dr Igor Skryabin.

OUTREACH

Part of ECI's mission is to disseminate information on energy change through outreach activities. The following list gives a sample of the types of activities ECI members have been involved in.

International engagement

Professor Ken Baldwin met with a delegation from Singapore hosted by CSIRO in Sydney to discuss opportunities for Australia and Singapore to engage in the hydrogen economy (22 February 2019). In addition, **Dr Emma Aisbett** met with Professor Andrew Wee, Vice-President for University and Global Relations from the University of Singapore, to discuss collaboration in energy research associated with the Grand Challenge (2 October 2019).

Ms Zartaj Gul, Minister of State for Climate Change, National Assembly of Pakistan took part in a tour of the Solar Thermal and Solar Photovoltaic facilities at ANU (above). Ms Gul was in Australia as a participant of the Australian Government Special Visits Program – the Government's premier program to identify individuals who are likely to be future leaders in their countries. ECI members included **Professor Wojciech Lipinski, Dr Igor Skryabin, Dr John Pye** and **Dr Matthew Stocks**. 26 April 2019.

In conjunction with the Australian Academy of Science **Dr Igor Skryabin, Professor Kylie Catchpole, Dr Hongjun Chen** and **Dr Joe Coventry** met with visiting researchers from Indonesia and Malaysia. The researchers were briefed on ANU research in hydrogen, photovoltaics and solar thermal and were given tours of relevant ANU laboratories. 31 May 2019

A high-level delegation from Tsinghua University, China, met with ANU researchers to discuss climate and energy issues of importance to both countries. ECI members who participated in the event included **Professor Ken Baldwin, Professor Frank Jotzo, Associate Professor Jane Golley, Dr Tom Longden** and **Dr Zainul Abdin**. 11 November 2019

Associate Professor Matthew Hole was instrumental in organising the following two fusion energy events:

- First International Tokamak Physics Activity meeting outside of the ITER partner countries. ITER (International Thermonuclear Experimental Reactor) is the world's largest fusion experiment and is under construction in the South of France. 8 – 11 April 2019.
- Mini course/Workshop on the application of computational mathematics to plasma physics (right). The event was supported by the Australian Nuclear Science and Engineering, the Simons Foundation Collaboration on Hidden Symmetries and Fusions Energy, the Australian Research Council and the Mathematical Sciences Institute, ANU. This workshop included speakers from Germany, the USA and Japan. 24 – 27 June 2019.

Professor Ken Baldwin, on behalf of the Energy Change Institute, signed an MOU with the Italian Agency for New Technologies, Energy and Sustainable Economic Development (ENEA). ENEA is an Italian Government-sponsored research and development agency. The agency undertakes research in areas which will help to develop and enhance Italian competitiveness and employment, while protecting the environment. The MOU acknowledges cooperation and sharing of knowledge and best practices in an ongoing effort to meet an increased energy demand with a focus on clean energy. 26 November 2019.

National Engagement

Professor Ken Baldwin and **Professor Kylie Catchpole** assisted with the delivery and development of the Science at the Shine Dome 2019 Symposium, *Power Up Australia, the sustainable way (right)*, organised by the Australian Academy of Science. The symposium provided an important update regarding Australia's future in regards to sustainable energy. 28 – 30 May 2019.

Coinciding with the end of the award-winning CONSORT Bruny Island Battery Trial project, **Professor Sylvie Thiebaux** and **Dr Paul Scott** presented at an industry symposium. Attendees included ARENA, the Australian Energy Market Operator, the Australian Energy Market Commission and the CSIRO, consumer bodies energy and electricity generators, retailers and aggregators, renewable energy companies and universities. May 2019.

MEDIA AND COMMUNICATIONS

The media is a key partner helping the ECI to engage and educate the wider community on topics relevant to energy change.

ECI members regularly provide expert commentaries on news relevant to energy technology and energy policy. Below are some examples:

National energy policy

"Renewables need urgent investment to ease Australia's transmission bottlenecks, experts warn". Report on a communique arising from the ANU 100% Renewables Workshop, 19 February 2019, The Guardian.

"Experts warn renewables not to blame for power blackouts", featuring Honorary Professor Hugh Saddler, 11 February 2019, The World Today, ABC Radio.

"Bad news. Closing coal-fired power stations costs jobs. We need to prepare", written by Associate Professor Paul Burke, Professor Frank Jotzo and Rohan Best, 29 March 2019, The Conversation.

"Policy matters more than targets", written by Professor Warwick McKibbin, 23 April 2019, Australian Financial Review.

"Climate policy and Australia's energy future", interview with Associate Professor Paul Burke, 9 May 2018, ABC RN The Economists.

"While others face climate reality, our government denies the undeniable", written by Honorary Professor John Hewson, 1 August 2019, Sydney Morning Herald.

Decarbonisation of energy

"Getting to the heart of coal seam gas protest – it's not just the technical risks", written by Hedda Ransan-Cooper, ANU; Selen A. Ercan, University of Canberra, and Sonya Duus, University of Canberra, 4 December 2018, The Conversation.

"Australia can't run away from a carbon price any longer", written by Professor Warwick McKibbin, 5 December 2018, Australian Financial Review.

"Russian firm set to challenge the future of Australian LNG", written by Dr Elizabeth Buchanan, 8 January 2019, The Australian.

"How to neutralise your greenhouse gas footprint", written by Professor Andrew Blakers, 14 March 2019, The Conversation.

"'The perfect storm': hydrogen gains ground on LNG as alternative fuel", featuring commentary by Dr Fiona Beck, 8 April 2019, The Guardian.

"The future of solar thermal power once promised so much, but has the shine worn off?" Featuring commentary by Dr John Pye, 9 April 2019, ABC News.

"Energy use in Australia". Interview with Professor Ken Baldwin, 16 May 2019, ABC Nightlife.

"Renewable hydrogen getting cheaper, Australia could lead global market", featuring commentary by Professor Ken Baldwin, 5 June 2019, Renew Economy.

"Australia's pathway to becoming an energy superpower", featuring commentary by Professor Ken Baldwin, 8 June 2019, 10 Daily.

"A chance for lift off: Indonesia's solar sector" written by Associate Professor Paul Burke, 16 July 2019, Policy Forum.

"It's official: Large-scale Renewable Energy Target achieved more than a year early", featuring commentary by Dr Matthew Stocks, Professor Ken Baldwin and Professor Andrew Blakers, 4 September 2019, PV Magazine.

"New Canberra lab aims to cut energy bills and emissions", featuring commentary by Dr Bjorn Sturmberg, 5 September 2019, The Canberra Times.

"Green energy plan to make Australia powerplant of Pacific", featuring commentary by Professor Ken Baldwin, 19 September 2019, Canberra Times,.

"Snowy 2.0: Australia's divisive plan for a vast underground 'battery', featuring commentary by Dr Matthew Stocks, 17 October 2019, BBC.

"Some good news for a change: Australia's greenhouse gas emissions are set to fall", written by Professor Andrew Blakers and Dr Matthew Stocks, 24 October 2019, The Conversation.

Transport and energy

"Is hydrogen getting ready to boom?", featuring commentary by Professor Ken Baldwin, 11 July 2019, The Motor Report.

Energy storage

"Green is the new black: how renewables and storage will replace coal", written by Associate Professor Lachlan Blackhall, 29 November 2018, Sydney Morning Herald.

Fusion Power

"China attempts to create an artificial Sun", with commentary by Associate Professor Matthew Hole, 15 November 2018, ABC News.

Energy Diplomacy

"It's time for Australia to scale up its energy diplomacy", written by Dr Christian Downie, 11 June 2019, The Lowy Interpreter.

"Lambasting China over its emissions might impress the US but it could be costly for Australia", written by Professor Frank Jotzo, 25 September 2019, The Guardian.

"Politicians must mine the divide between coal lobbies and energy companies", written by Dr Christian Downie, 23 October 2019, The Conversation.

MEDIA RELEASES

The ANU publicises a range of research and expert commentary via media releases. Coverage generated by an ANU media release can have broad reach. Below are some examples of energy-related media releases:

ANU experts comment on National Hydrogen Strategy
22 November 2019

Australia's renewables power past Renewable Energy Target
4 September 2019

New lab to help drive Australia's low carbon energy future
4 September 2019

ANU researchers set solar record with next-gen cells
29 August 2019

Nature offers potential for endless renewable fuel supplies
7 August 2019

Scientists unlock the potential of ultra-thin 2D materials
22 May 2019

ANU finds 530,000 potential pumped-hydro sites worldwide
1 April 2019

Pumped storage hydropower a "game-changer"
25 March 2019

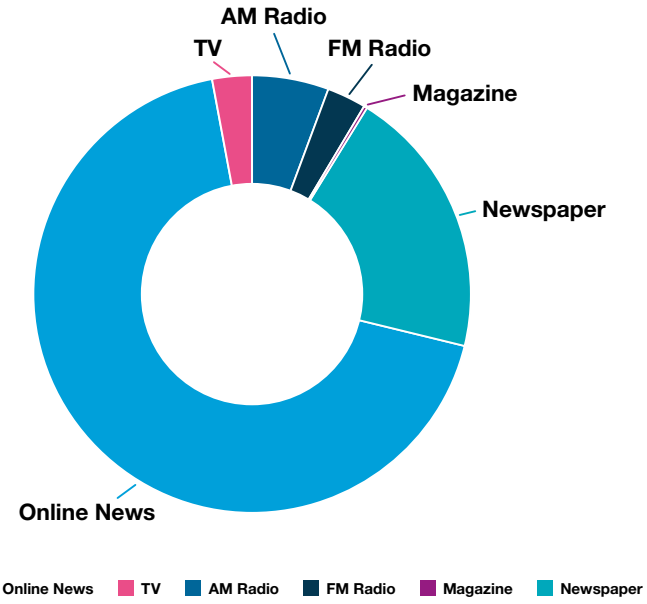
Australia streaks ahead to be renewables world champion
8 February 2019

Cheaper, more efficient solar technology a step closer
19 December 2018

Media Type Breakdown (Volume)

Media generated by Energy Change Institute members for the 10 months from 1 January 2019 to 31 October 2019 reached an audience of more than 39 million people (isentia Media Monitoring)

Media Type Breakdown - Volume



Communications

ECI Communications in 2019 focused on promotion of ECI research and events, building and supporting ECI membership, strengthening partnerships and connections between ECI members and external stakeholders in government, industry, NGOs and the community and promoting the Master of Energy Change degree.

Our main communication channels have been events, media relations and digital communications, including ANU websites, a regular e-marketing program to our database of 6,000+ subscribers and social media (including Twitter: @ANUEnergyChange, and Facebook: ANU Energy Change).

HONOURS, AWARDS AND APPOINTMENTS

Professor Ken Baldwin – Australian Institute of Physics Award

Professor Ken Baldwin was honoured with this award for outstanding service to the discipline of Physics over many years, including leadership, outreach and research. In particular, the Australian Institute of Physics recognises his role in promoting the Understanding of Science through the initiation and championing of "Science meets Parliament". Professor Baldwin has been a key contributor to science policy in Australia and served as the President of FASTS (now STA). He is the current and founding Director of the ANU Energy Change Institute.

Professor Andrew Blakers – Academic Appointment

Professor Andrew Blakers was appointed Chair of the International Advisory Panel of the Solar Energy Research Institute of Singapore. Professor Blakers convenes the Solar Photovoltaics Research cluster and is a member of the Energy Storage and Recovery cluster and the Sustainable Transport cluster.

Professor Quentin Grafton – Australian Laureate Fellowship

Professor Quentin Grafton was awarded an Australian Laureate Fellowship from the Australia Research Council for a five-year sustainable water use project that aims to improve our understanding of the relationship Indigenous Australians have with water. Professor Grafton is a member of three ECI research clusters: Energy and Security; Energy Economics and Policy and; Energy-Water Nexus.

Associate Professor Matthew Hole – Academic Appointment

Associate Professor Matthew Hole was appointed to the Academic Board of the joint PhD program in Fusion Science and Engineering, Padua and Ghent Universities. Professor Hole convenes the ECI's Fusion Power research cluster.

Distinguished Professor Chennupati Jagadish - Thomas Ranken Lyle Medal; IEEE Electron Devices Society Education Award and Beattie Steel Medal

Awarded by the Australian Academy of Science, the Thomas Ranken Lyle Medal recognises outstanding achievement by a scientist in Australia for research in mathematics or physics. Distinguished Professor Jagadish has made pioneering contributions to semiconductor physics in particular materials physics and optical physics. Professor Jagadish was honoured with a second award, the IEEE Electron Devices Society Education Award from distinguished and sustained contributions globally to education, training and mentoring. Professor Jagadish is a recipient of a third award - the 2019 Beattie Steel Medal by the Australian Optical Society. This prestigious award is given to outstanding leaders with a strong and sustained record of authority, enterprise and innovation in the field of optics in Australia or New Zealand. Professor Jagadish is a member of the ECI's Solar Photovoltaics research cluster.

Professor Tim Senden – Elected Fellow of US National Academy of Inventors

On his election as a Fellow of US National Academy of Inventors for his contributions to invention, innovation and commercialisation Professor Tim Senden has been recognised to have demonstrated a highly prolific spirit of innovation in creating or facilitating outstanding inventions that have made a tangible impact on the quality of life, economic development, and welfare of society. He will be inducted into the Academy on April 10, 2020 at the Heard Museum in Phoenix, Arizona, USA. Professor Senden is a member of the Carbon Capture and Storage and the Enhanced Oil and Gas Extraction research clusters.

Dr Zongyou Yin – 2019 ANU Vice-Chancellor's Award for Early Career Academics

Dr Zongyou Yin was recognised for his research in two-dimensional materials science. He is best known for his demonstration of the world's thinnest phototransistor with one atomic layer of molybdenum disulphide semiconductor. This work, published in the international nanoscience and nanotechnology communication journal ACS Nano, has received over 2400 citations and sparked a new research field. Dr Yin is a member of the Enhanced Oil and Gas Extraction, Hydrogen Economy and Renewable Fuels research clusters.

Bruny Island smart battery trial continues to shine

Having already won three awards, noted in the previous ECI Annual Report, the **CONSORT Bruny Island Battery Trial** team collected a fourth accolade in November 2018 – taking home the Energy Network's Australia's Energy Networks Industry Innovation Award. Presented to CONSORT partner, TasNetworks, the award recognised leadership in the design, development and application of a ground breaking Australian energy network initiative. The trial of household solar and battery storage uses a world-leading software platform developed at ANU. ECI members include **Professor Sylivie Thiebaux, Dr Paul Scott, Dr Dan Gordon and Dr Hedda Ransan-Cooper**. CONSORT is a collaboration between three universities (the ANU, the University of Sydney and the University of Tasmania), electricity network provider TasNetworks and Canberra-based start-up Reposit Power.

OUTLOOK

As we move into the new decade, the Energy Change Institute will look to consolidate its position as a leading organisation in the energy sector that has the breadth and depth of research expertise to support the nation as it undergoes the transition to renewable energy.

We will look to broaden the reach of the ECI Grand Challenge *Zero-Carbon Energy for the Asia-Pacific* to the export economy, thereby providing the research understanding needed to future-proof Australia's ongoing trade and maintain our role as an energy export powerhouse.

ADVISORY BOARD MEMBERS

Professor Armin Aberle – CEO, Solar Energy Research Institute of Singapore

Armin Aberle serves as CEO of the Solar Energy Research Institute of Singapore (SERIS) at the National University of Singapore (NUS). His research focus is on photovoltaic materials, devices and modules. In the 1990s he established and led the Silicon Photovoltaics Department at the Institute for Solar Energy Research (ISFH) in Hamelin, Germany. He then worked for 10 years in Sydney, Australia as a professor for photovoltaics at the University of New South Wales. In 2008 he joined NUS to establish SERIS, as the Deputy CEO and the Director of the Silicon PV Department. Since 2012 he has served as SERIS CEO. He is presently the Director of the Institute's Silicon Materials & Cells Cluster and the Novel PV Concepts Cluster.

Mr Brad Archer – Chief Executive Officer, Climate Change Authority

Brad Archer has extensive experience working on climate change, renewable energy and energy market issues. He joined the Climate Change Authority in November 2018. Previously, he was head of the International Climate Change and Energy Innovation Division in the Australian Government Department of the Environment and Energy, where his responsibilities included advising on clean energy innovation, Australia's greenhouse gas inventory, and international climate change policy. Brad has been working on climate change policies for the Australian Government since early 2011. Prior to this he worked on a range of issues in the Treasury, which he joined in 1991. Brad has qualifications in economics and information management.

Ms Nicola Falcon – GM Forecasting, AEMO

Nicola Falcon heads the Australian Energy Market Operator's Forecasting division and is responsible for demand and supply forecasting for both electricity and gas. She is also responsible for delivering integrated system modelling and cost benefit analyses for AEMO's Integrated System Plan, and reliability assessments to provide decision support for AEMO's planning and operations teams, and industry. Nicola has a background in operations research, and has nearly 20 years' experience in the energy sector specialising in providing strategic advice on issues relating to electricity markets and systems, backed by robust market modelling, statistical, economic and commercial analysis.

Dr Bruce Godfrey – Principal, Wyld Group Pty Ltd

Bruce Godfrey's career has been built in business, innovation investment and technology development fields. He has focused on the advancement and commercialisation of technologies (particularly new energy technologies – renewable, enabling and low emission fossil), investment readiness of products and companies, and innovation policy and programs. A Fellow of the Academy of Technology and Engineering (ATSE), he is a Director and Vice-President Diversity of the Academy as well as Chair of ATSE's Energy Forum. He has chaired Expert Working Groups for the Australian Council of Learned Academies (ACOLA) on Delivering Sustainable Urban Mobility (2015) and on Energy Storage (2017).

Professor Mark Howden – Director, ANU Climate Change Institute

Mark Howden is the Director of the Climate Change Institute at the Australian National University. He is also an Honorary Professor at Melbourne University's School of Land and Food. Mark's work has focussed on how climate impacts on, and innovative adaptation options for, systems we value: agriculture and food security, the natural resource base, ecosystems and biodiversity, energy, water and urban systems. He has been a major contributor to the Intergovernmental Panel on Climate Change (IPCC) Second, Third, Fourth and Fifth Assessment reports and various IPCC Special Reports, sharing the 2007 Nobel Peace Prize with other IPCC participants and Al Gore. Recently Mark sat on the US Federal Advisory Committee for the 3rd National Climate Assessment and he participates in several other international science and policy advisory bodies.

Mr Gene McGlynn – Executive Director, Climate Change and Sustainability, ACT Government

Gene McGlynn started as Executive Director, Climate Change and Sustainability, in the ACT Government in July 2018. In this role, he looks after a range of policies and programs to ensure the ACT meets its emission reduction goals while improving the environment and helping all citizens make the transition to a net zero emissions future. Prior to this, Gene worked as a consultant and for more than 20 years worked for the Australian government in climate change and energy policy. He has worked in renewable energy, energy efficiency, transport, building policy and energy markets. He has also worked internationally at the OECD in Paris and the Energy Charter Secretariat in Brussels.

Dr Sarah Pearson – Chief Innovation Officer and Chief Scientist, Department of Foreign Affairs and Trade

Sarah Pearson is an internationally experienced Open Innovation practitioner, innovation ecosystem builder, scientist and advocate for collaborative innovation and entrepreneurship in Australia. In her current role Sarah is responsible for leading, developing and scaling innovation practice and culture across DFAT and through whole of government activity. Sarah is also a member of Questacon's Advisory Council, and member of the Investment Committee for CSIRO's $200M VC fund, Main Sequence Ventures. She is an inventor on eight international patent applications for cancer diagnosis and novel confectionary. Sarah was awarded a PhD from the University of Oxford in particle physics, and has published research in the areas of particle physics, medical physics, artificial intelligence, innovation, science communication and science policy.

Ms Fiona Wright – Acting General Manager, Evoenergy

Fiona Wright is the Acting General Manager of Evoenergy. In her role, she is responsible for the management of ACT's electricity and gas networks, including network planning, design and operations. Starting with the business as a cadet engineer in 1993, Fiona has over 20 years' experience in the energy industry. She understands the complexities of the regulatory environment and the importance of agility in a rapidly changing energy landscape. She's passionate about delivering lasting and innovative energy ecosystems designed for consumers. She holds a Bachelor of Engineering (Electrical) and a Master of Business.

EXECUTIVE MEMBERS

Professor Ken Baldwin - ANU College of Science

Professor Ken Baldwin is the inaugural Director of the Energy Change Institute at the ANU, and Director of the ANU ECI Grand Challenge: *Zero-Carbon Energy for the Asia-Pacific*. He has held positions including: Project Steering Committee for the Australian Energy Technology Assessment (2011–2013); Socio-Economic Modelling Advisory Committee of the South Australian Nuclear Fuel Cycle Royal Commission (2015-2017); Inaugural chair, Energy Research Institutes Council for Australia (2018-2019); and Steering Committee for CSIRO Hydrogen Research, Development and Demonstration Report (2019). Professor Baldwin won the 2004 Australian Government Eureka Prize for Promoting Understanding of Science, for "Science meets Parliament.

Associate Professor Sara Bice – ANU College of Asia and the Pacific

Sara Bice is Associate Professor at the Crawford School of Public Policy, The Australian National University. She is Vice Chancellor's Futures Scheme Senior Fellow for her work on The Next Generation Engagement program, Australia's largest study into community engagement in infrastructure, to date. She is President of the International Association for Impact Assessment, the world's leading organisation for impact assessment practitioners, researchers and clients, representing almost 7,000 members in 120 different countries. Sara is Associate Professor (Special International Guest) at the School of Public Policy and Management, Tsinghua University, Beijing. Sara is an award-winning author and her latest co-edited book, Public Policy in the Asian Century is available from Palgrave Macmillan.

Dr Lachlan Blackhall – ANU College of Engineering & Computer Science

Lachlan Blackhall holds a BE, BSc and a PhD in engineering and applied mathematics and was the co-founder and former Chief Technical Officer of Reposit Power. At Reposit, he pioneered the development of distributed control systems to monitor, optimise and control grid-connected energy storage, as well as the development of virtual power plant technology to aggregate distributed energy storage to deliver services and capabilities to energy networks, markets and utilities. Lachlan has been heavily involved in the entrepreneurship, innovation, technology and investment domains for almost two decades. This involvement has included starting a number of companies, being involved in the mentoring and development of entrepreneurs and their ideas, and working to advise or invest in a number of companies.

Professor Andrew Blakers - ANU College of Engineering & Computer Science

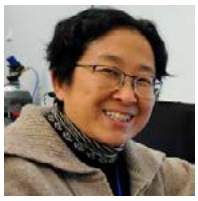
Andrew Blakers is Professor of Engineering at ANU. He was a Humboldt Fellow and has held Australian Research Council QEII and Senior Research Fellowships. He is a Fellow of the Academy of Technological Sciences & Engineering, the Institute of Energy and the Institute of Physics. He is a Public Policy Fellow at ANU. He has published approximately 300 papers and patents with research interests in the areas of silicon photovoltaic solar cells and solar energy systems. He was a leader of the team that developed PERC silicon solar cell technology, which currently has approximately 30% of the worldwide solar market and cumulative module sales of around $30 billion (mid-2018). He also has interest in sustainable energy policy and is engaged in detailed analysis of energy systems with high (50-100%) penetration by wind and photovoltaics with support from pumped hydro energy storage (for which he won the 2018 Eureka Prize for Environmental Research).

Professor Kylie Catchpole - ANU College of Engineering and Computer Science

Professor Kylie Catchpole, Research School of Engineering, has research interests in new materials for solar cells and solar fuels as well as the broader energy transition. She has a physics degree from the ANU, winning a University Medal, and a PhD from the ANU. She was a Post-doctoral Fellow at the University of New South Wales and the FOM Institute for Atomic and Molecular Physics, Amsterdam. She has published over 100 papers, which have been cited over 8000 times to date. Her work on nanophotonic light trapping was listed as one of MIT Technology Review's '10 most important emerging technologies'. In 2013 she was awarded a Future Fellowship from the Australian Research Council and in 2015 she was awarded the John Booker Medal for Engineering Science from the Australian Academy of Science.

Professor Frank Jotzo – ANU College of Asia and the Pacific

Frank Jotzo is Professor at the ANU Crawford School of Public Policy, where he directs the Centre for Climate and Energy Policy. He is co-director of the Australia-Germany Energy Transition Hub, joint editor-in-chief of the journal Climate Policy, and a lead author of the Intergovernmental Panel on Climate Change 5th and 6th Assessment Reports. He has been involved in a number of policy research and advisory exercises, including as senior advisor to Australia's Garnaut Climate Change Review, and advisor to national governments and Australian State and Territory governments. He has led collaborative research programs including on decarbonisation, coal transition, and China's climate and energy policy. As an environmental economist, his research focuses on policy relevant aspects of climate change, energy, and broader issues of environment, development and economic reform. He teaches at the Crawford School.



Professor Yun Liu - ANU College of Science

Yun Liu graduated from the Xian Jiaotong University, China with her BSc, MSc and PhD. She has since held a position at the National Institute of Advanced Industrial Science and Technology (AIST), Kyushu, Japan (1998-2001) before the commencement of her Postdoctoral Fellow position at the Research School of Chemistry, ANU in 2001. She was awarded fellowships of the AIST (1998-1999), the Science and Technology Agency (1999-2001, now renamed as the Fellow of Japan Society for the Promotion of Science) and the Australian Research Council (ARC) Queen Elizabeth II (2006-2010). She was made a fellow of the Australian Institute of Physics (FAIP) and Certified Materials professional (CMP). She was also a member of the Materials of Australia (MMA) and the Society of Crystallographers in Australia and New Zealand (MSCANZ).

Dr James Prest - ANU College of Law

James Prest lectures in law at the ANU specialising in environmental law. He is a Member of the IUCN Commission on Environmental Law and works on renewable energy law and major projects legislation. After graduating from the ANU and gaining admission to practise in the Supreme Court of the ACT in 1995 he worked many years as a legal policy officer at the Department of Prime Minister and Cabinet. He also held positions as a Research Officer at the Law and Bills Digest Group of the Parliamentary Library in Canberra and as an adviser at Parliament House. Dr Prest is a co-convenor of the Master of Energy Change degree program.

Dr Igor Skryabin, ECI Research and Business Development Manager - ANU College of Science

Igor Skryabin's career has spanned both industry and academia. His major technical contribution has been in the development and commercialisation of solar technologies. Igor has published more than 100 research papers and is an inventor of more than 30 patents and industrial designs, granted in Australia and overseas. Igor is a co-convenor of the Master of Energy Change, and a Board Member of the Australian Photovoltaic Institute and of the Asia-Pacific Sustainable Energy Centre in China.

ECI MEMBERS

Artificial Photosynthesis

Dr Nick Cox	ANU College of Science
Professor Tom Faunce	ANU College of Law
Professor Mark Humphrey	ANU College of Science
Professor Elmars Krausz	ANU College of Science
Dr Hemant Kumar Mulmudi	ANU College of Engineering and Computer Science
Professor David Ollis	ANU College of Science
Dr Ron Pace	ANU College of Science
Dr Robin Purchase	ANU College of Science
Professor Robert Stranger	ANU College of Science

Carbon Capture and Storage

Associate Professor Rowena Ball	ANU College of Science
Professor Justin Borevitz	ANU College of Science
Associate Professor Stewart Fallon	ANU College of Science
Dr Anna Herring	ANU College of Science
Associate Professor Penny King	ANU College of Science
Professor Mark Knackstedt	ANU College of Science
Dr Mohammad Saadatfar	ANU College of Science
Professor Tim Senden	ANU College of Science
Professor Sean Smith	ANU College of Science
Professor Adrian Sheppard	ANU College of Science
Dr Xiaolin (Shannon) Wang	ANU College of Engineering and Computer Science
Dr Jas Ward	ANU College of Science
Dr Nicholas White	ANU College of Science
Dr Zongyou Yin	ANU College of Science

Energy and Security

Adjunct Professor Chris Barrie	ANU College of Asia and the Pacific
Professor John Blaxland	ANU College of Asia and the Pacific
Professor Roger Bradbury	ANU College of Asia and the Pacific
Ms Elizabeth Buchanan	ANU College of Arts and Social Sciences
Dr Christian Downie	ANU College of Asia and the Pacific
Professor Quentin Grafton	ANU College of Asia and the Pacific
Dr William Grant	ANU College of Science
Associate Professor Llewelyn Hughes	ANU College of Asia and the Pacific
Dr Jennifer Hunt	ANU College of Science
Professor Rory Medcalf	ANU College of Asia and the Pacific
Associate Professor Brendan Taylor	ANU College of Asia and the Pacific

Energy and Economics and Policy

Dr Imran Habib Ahmad	ANU College of Science
Dr Emma Aisbett	ANU College of Asia and the Pacific

Professor Robert Breunig	ANU College of Asia and the Pacific
Dr Paul Burke	ANU College of Asia and the Pacific
Professor Bruce Chapman	ANU College of Asia and the Pacific
Honorary Associate Professor Simon Corbell	ANU College of Engineering and Computer Science
Professor Robert Costanza	ANU College of Asia and the Pacific
Dr Thang Do	ANU College of Asia and the Pacific
Dr Matthew Dornan	ANU College of Asia and the Pacific
Dr Christian Downie	ANU College of Asia and the Pacific
Mr David Gourlay	ANU College of Science
Professor Quentin Grafton	ANU College of Asia and the Pacific
Associate Professor Carolyn Hendriks	ANU College of Asia and the Pacific
Honorary Professor John Hewson	ANU College of Asia and the Pacific
Associate Professor Llewelyn Hughes	ANU College of Asia and the Pacific
Professor Frank Jotzo	ANU College of Asia and the Pacific
Professor Kaliappa Kalirajan	ANU College of Asia and the Pacific
Associate Professor Andrew Kennedy	ANU College of Asia and the Pacific
Dr Ida Kubiszewski	ANU College of Asia and the Pacific
Dr Thomas Longden	ANU College of Asia and the Pacific
Professor Warwick McKibbin	ANU College of Asia and the Pacific
Adjunct Professor Robert McMullan	ANU College of Asia and the Pacific
Dr John (Jack) Pezzey	ANU College of Science
Associate Professor Ben Phillips	ANU College of Arts and Social Sciences
Professor Israr Qureshi	ANU College of Business and Economics
Dr Maria Racionero	ANU College of Business and Economics
Professor Martin Richardson	ANU College of Business and Economics
Honorary Associate Professor Hugh Saddler	ANU College of Asia and the Pacific
Professor Ligang Song	ANU College of Asia and the Pacific
Professor David Stern	ANU College of Asia and the Pacific
Dr Bjorn Sturmberg	ANU College of Engineering and Computer Science
Dr Lee White	ANU College of Asia and the Pacific
Dr Paul Wyrwoll	ANU College of Asia and the Pacific
Dr Yixiao Zhou	ANU College of Asia and the Pacific

Energy Efficiency

Professor Xuemei Bai	ANU College of Science
Dr Sid Chau	ANU College of Engineering and Computer Science
Dr Grace Chiu	ANU College of Business and Economics
Professor Denis Evans	ANU College of Science
Mr David Glavas	ANU College of Science
Dr Adrian Lowe	ANU College of Engineering and Computer Science
Dr Chathurika Mediwaththe	ANU College of Engineering and Computer Science
Mr Bartholomew Meehan	ANU College of Science

Dr John (Jack) Pezzey	ANU College of Science
Dr Digby Race	ANU College of Science
Honorary Associate Professor Hugh Saddler	ANU College of Asia and the Pacific
Dr Marnie Shaw	ANU College of Engineering and Computer Science
Mr John Sullivan	ANU Facilities and Services Division
Dr Xiaolin (Shannon) Wang	ANU College of Engineering and Computer Science
Mr Tom Worthington	ANU College of Engineering and Computer Science

Energy for Development

Associate Professor Sara Bice	ANU College of Asia and the Pacific
Dr Paul Burke	ANU College of Asia and the Pacific
Dr Matthew Dornan	ANU College of Asia and the Pacific
Dr Edwina Fingleton-Smith	ANU College of Science
Associate Professor Jane Golley	ANU College of Asia and the Pacific
Associate Professor Alastair Greig	ANU College of Arts and Social Sciences
Professor Stephen Howes	ANU College of Asia and the Pacific
Professor Frank Jotzo	ANU College of Asia and the Pacific
Dr Thomas Longden	ANU College of Asia and the Pacific
Dr Arianto Patunru	ANU College of Asia and the Pacific
Dr Digby Race	ANU College of Science
Professor Budy P Resosudarmo	ANU College of Asia and the Pacific
Dr Abidah Setyowati	ANU College of Asia and the Pacific
Professor David Stern	ANU College of Asia and the Pacific
Mr Jeremy Smith	ANU College of Engineering and Computer Science
Professor Israr Qureshi	ANU College of Business and Economics

Energy Regulation & Governance

Associate Professor Sara Bice	ANU College of Asia and the Pacific
Dr Tim Bonyhady	ANU College of Law
Dr Katherine Daniell	ANU College of Science
Dr Thang Do	ANU College of Asia and the Pacific
Dr Christian Downie	ANU College of Asia and the Pacific
Professor Peter Drahos	ANU College of Asia and the Pacific
Professor Tom Faunce	ANU College of Law
Professor Neil Gunningham	ANU College of Asia and the Pacific
Associate Professor Llewelyn Hughes	ANU College of Asia and the Pacific
Professor Andrew MacIntosh	ANU College of Law
Dr John (Jack) Pezzey	ANU College of Science
Dr James Prest	ANU College of Law
Dr Hedda Ransan-Cooper	ANU College of Engineering and Computer Science
Dr Abidah Setyowati	ANU College of Asia and the Pacific

Energy Sociology & Risk

Associate Professor Sara Bice	ANU College of Asia and the Pacific
Dr Grace Chiu	ANU College of Business and Economics
Dr Rebecca Colvin	ANU College of Science
Dr Katherine Daniell	ANU College of Science
Associate Professor Alastair Greig	ANU College of Arts and Social Sciences
Emeritus Professor Andrew Hopkins	ANU College of Arts and Social Sciences
Associate Professor Llewelyn Hughes	ANU College of Asia and the Pacific
Dr Digby Race	ANU College of Science
Dr Hedda Ransan-Cooper	ANU College of Engineering and Computer Science
Professor Israr Qureshi	ANU College of Business and Economics

Energy Storage and Recovery

Dr Charles-Alexis Asselineau	ANU College of Engineering and Computer Science
Professor Nick Birbilis	ANU College of Engineering and Computer Science
Dr Lachlan Blackhall	ANU College of Engineering and Computer Science
Professor Andrew Blakers	ANU College of Engineering and Computer Science
Dr Annie Colebatch	ANU College of Science
Dr Joe Coventry	ANU College of Engineering and Computer Science
Professor Rod Boswell	ANU College of Engineering and Computer Science
Dr Evan Franklin	ANU College of Engineering and Computer Science
Dr Peter Kreider	ANU College of Engineering and Computer Science
Professor Wojciech Lipinski	ANU College of Engineering and Computer Science
Professor Yun Liu	ANU College of Science
Dr Adrian Lowe	ANU College of Engineering and Computer Science
Dr John Pye	ANU College of Engineering and Computer Science
Dr Ali Shirazi	ANU College of Engineering and Computer Science
Professor Sean Smith	ANU College of Science
Dr Matthew Stocks	ANU College of Engineering and Computer Science
Dr Stephen Tims	ANU College of Science
Dr Juan Felipe Torres Alvarez	ANU College of Engineering and Computer Science
Associate Professor Takuya Tsuzuki	ANU College of Engineering and Computer Science
Professor Raymond Withers	ANU College of Science
Dr Mahesh Brahmadesham Venkataraman	ANU College of Engineering and Computer Science

Energy-Water Nexus

Dr Katherine Daniell	ANU College of Science
Dr Thang Do	ANU College of Asia and the Pacific
Professor Stephen Dovers	ANU College of Science
Professor Quentin Grafton	ANU College of Asia and the Pacific
Dr Barry Newell	ANU College of Engineering and Computer Science

Associate Professor James Pittock	ANU College of Science
Dr Paul Wyroll	ANU College of Asia and the Pacific

Enhanced Oil & Gas Extraction

Professor Mark Knackstedt	ANU College of Science
Professor Tim Senden	ANU College of Science
Professor Adrian Sheppard	ANU College of Science
Professor Andrew Stuchbery	ANU College of Science

Fusion Power

Associate Professor Boyd Blackwell	ANU College of Science
Dr Cormac Corr	ANU College of Science
Professor Bob Dewar	ANU College of Science
Associate Professor Matthew Hole	ANU College of Science
Professor John Howard	ANU College of Science
Dr Robin Purchase	ANU College of Science
Dr Stephen Tims	ANU College of Science

Hydrogen Economy

Dr Emma Aisbett	ANU College of Asia and the Pacific
Dr Fiona Beck	ANU College of Engineering and Computer Science
Professor Nick Birbilis	ANU College of Engineering and Computer Science
Associate Professor Paul Burke	ANU College of Asia and the Pacific
Professor Kylie Catchpole	ANU College of Engineering and Computer Science
Dr Hongjun Chen	ANU College of Engineering and Computer Science
Dr Annie Colebatch	ANU College of Science
Dr Joe Coventry	ANU College of Engineering and Computer Science
Associate Professor Llewelyn Hughes	ANU College of Asia and the Pacific
Professor Chennupati Jagadish	ANU College of Science
Professor Frank Jotzo	ANU College of Asia and the Pacific
Dr Siva Karuturi	ANU College of Engineering and Computer Science
Professor Wojciech Lipinski	ANU College of Engineering and Computer Science
Professor Yun Liu	ANU College of Science
Professor Warwick McKibbin	ANU College of Asia and the Pacific
Associate Professor Ron Pace	ANU College of Science
Dr James Prest	ANU College of Law
Dr Robin Purchase	ANU College of Science
Dr John Pye	ANU College of Engineering and Computer Science
Professor Sean Smith	ANU College of Science
Professor David Stern	ANU College of Asia and the Pacific
Dr Matthew Stocks	ANU College of Engineering and Computer Science
Professor Robert Stranger	ANU College of Science

Dr Igor Skryabin	ANU College of Science
Professor H. Hoe Tan	ANU College of Science
Dr Juan Felipe Torres Alvarez	ANU College of Engineering and Computer Science
Professor Antonio Tricoli	ANU College of Engineering and Computer Science
Dr George Tsekouras	ANU College of Engineering and Computer Science
Associate Professor Takuya Tsuzuki	ANU College of Engineering and Computer Science
Dr Mahesh Brahmadesham Venkataraman	ANU College of Engineering and Computer Science
Dr Zongyou Yin	ANU College of Science

Nuclear Science

Professor Keith Fifield	ANU College of Science
Professor David Hinde	ANU College of Science
Honorary Associate Professor Tony Irwin	ANU College of Science
Dr Greg Lane	ANU College of Science
Professor Andrew Stuchbery	ANU College of Science
Dr Stephen Tims	ANU College of Science

Renewable Fuels

Dr Hongjun Chen	ANU College of Engineering and Computer Science
Associate Professor Michael Djordjevic	ANU College of Science
Professor Graham Farquhar	ANU College of Science
Associate Professor Colin Jackson	ANU College of Science
Dr Carsten Kulheim	ANU College of Science
Professor Wojciech Lipinski	ANU College of Engineering and Computer Science
Associate Professor Ron Pace	ANU College of Science
Dr Dean Price	ANU College of Science
Dr John Pye	ANU College of Engineering and Computer Science
Associate Professor Antonio Tricoli	ANU College of Engineering and Computer Science
Dr Zongyou Yin	ANU College of Science

Smart Grid

Dr Lachlan Blackhall	ANU College of Engineering and Computer Science
Dr Jamie Bright	ANU College of Science
Dr Sid Chau	ANU College of Engineering and Computer Science
Dr Nicholas Engerer	ANU College of Science
Dr Evan Franklin	ANU College of Engineering and Computer Science
Dr Dan Gordon	ANU College of Engineering and Computer Science
Dr Hassan Hijazi	ANU College of Engineering and Computer Science
Dr Chathurika Mediwaththe	ANU College of Engineering and Computer Science
Dr John Pye	ANU College of Engineering and Computer Science
Dr Elizabeth Ratnam	ANU College of Engineering and Computer Science
Dr Paul Scott	ANU College of Engineering and Computer Science

Dr Marnie Shaw	ANU College of Engineering and Computer Science
Dr Igor Skryabin	ANU College of Science
Dr Bjorn Sturmberg	ANU College of Engineering and Computer Science
Dr Kerry Taylor	ANU College of Engineering and Computer Science
Professor Sylvie Thiebaux	ANU College of Engineering and Computer Science
Dr Guanglei Wang	ANU College of Engineering and Computer Science

Solar Photovoltaics

Dr Fiona Beck	ANU College of Engineering and Computer Science
Professor Andrew Blakers	ANU College of Engineering and Computer Science
Dr Kate Booker	ANU College of Engineering and Computer Science
Professor Kylie Catchpole	ANU College of Engineering and Computer Science
Professor Rob Elliman	ANU College of Science
Dr Nicholas Engerer	ANU College of Science
Dr Marco Ernst	ANU College of Engineering and Computer Science
Dr Kean Chern Fong	ANU College of Engineering and Computer Science
Associate Professor Lan Fu	ANU College of Science
Dr Daniel Hiller	ANU College of Engineering and Computer Science
Professor Chennupati Jagadish	ANU College of Science
Dr Siva Karuturi	ANU College of Science
Dr Ziyuan Li	ANU College of Science
Dr Daniel MacDonald	ANU College of Engineering and Computer Science
Dr Hemant Kumar Mulmudi	ANU College of Engineering and Computer Science
Dr Hieu Nguyen	ANU College of Engineering and Computer Science
Dr Matthew Stocks	ANU College of Engineering and Computer Science
Dr Sachin Surve	ANU College of Engineering and Computer Science
Dr H. Hoe Tan	ANU College of Science
Dr Yimao Wan	ANU College of Engineering and Computer Science
Associate Professor Klaus Weber	ANU College of Engineering and Computer Science
Dr Thomas White	ANU College of Engineering and Computer Science

Solar Thermal

Dr Charles-Alexis Asselineau	ANU College of Engineering and Computer Science
Dr Joe Coventry	ANU College of Engineering and Computer Science
Dr Peter Kreider	ANU College of Engineering and Computer Science
Dr Apurv Kumar	ANU College of Engineering and Computer Science
Professor Wojciech Lipinski	ANU College of Engineering and Computer Science
Dr Adrian Lowe	ANU College of Engineering and Computer Science
Dr John Pye	ANU College of Engineering and Computer Science
Dr Juan Felipe Torres Alvarez	ANU College of Engineering and Computer Science
Associate Professor Antonio Tricoli	ANU College of Engineering and Computer Science
Dr Mahesh Brahmadesham Venkataraman	ANU College of Engineering and Computer Science

Dr Xiaolin (Shannon) Wang	ANU College of Engineering and Computer Science
Adjunct Professor Alan Weimer	ANU College of Engineering and Computer Science

Sustainable Transport

Professor Andrew Blakers	ANU College of Engineering and Computer Science
Dr Paul Burke	ANU College of Asia and the Pacific
Dr Sid Chau	ANU College of Science
Dr Grace Chiu	ANU College of Business and Economics
Dr Thomas Longden	ANU College of Asia and the Pacific
Dr Elizabeth Ratnam	ANU College of Engineering and Computer Science
Professor David Stern	ANU College of Asia and the Pacific
Dr Matthew Stocks	ANU College of Engineering and Computer Science
Dr Bjorn Sturmberg	ANU College of Engineering and Computer Science
Dr Lee White	ANU College of Asia and the Pacific
Dr Paul Wyrwoll	ANU College of Asia and the Pacific

Wind Energy

Dr Rebecca Colvin	ANU College of Science
Dr Elizabeth Hanna	ANU College of Science
Associate Professor Andy Hogg	ANU College of Science
Dr Frank Mills	ANU College of Science
Dr James Prest	ANU College of Law
Dr Horst Punzmann	ANU College of Science
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