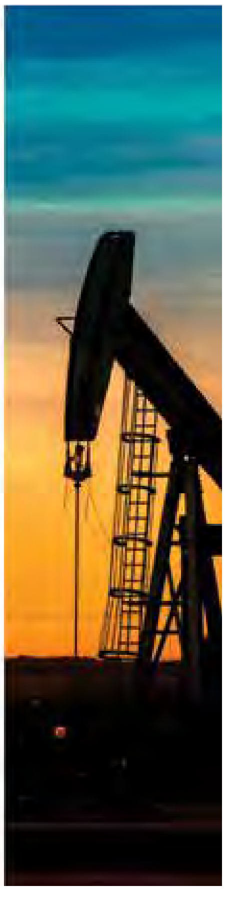
THE UNIVERSITY OF QUEENSLAND
AUSTRALIA
CREATE CHANGE

UQ DOW CENTRE FOR SUSTAINABLE ENGINEERING INNOVATION

Annual Report 2019





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FIRE HYDRANT
Dow Centre
for Sustainable Engineering Innovation

Message from the Vice-Chancellor, President, and Chair of the UQ Dow Centre Advisory Board

The inspiring work of the UQ Dow Centre for Sustainable Engineering Innovation perfectly embodies the University of Queensland's vision of providing "knowledge leadership for a better world".

As a centre of innovation in the area of sustainable energy and materials, the UQ Dow Centre is wholly focussed on developing practical, real-world solutions that will help to reduce carbon emissions and, ultimately, mitigate the most extreme potential impacts of climate change.

Ever since it was founded in 2012 with the financial support of the Dow Chemical Company, the UQ Dow Centre has been sharpening its focus on moving the needle on global sustainability and decarbonisation. Our dedicated team is pursuing this goal through a combination of cutting-edge science; multidisciplinary research and systems analysis; and world-class education.

In 2019, I am delighted to report that the UQ Dow Centre continued to make progress in its four key areas of focus: energy transitions; low-carbon energy and materials; circular economy; and techno-economic analysis.

In the field of energy transitions, the Centre has played a vital role in establishing the international Rapid Switch initiative, which seeks to identify and communicate the industrial, regulatory and social bottlenecks that are constraining the pace of global decarbonisation. This collaboration between UQ, Princeton University (USA), Tsinghua University (China), and IIT Bombay and IIT Delhi (India) is seeking to spread knowledge that will ultimately contribute to better-informed public policy and more sustainable private investment decisions.

Another important development in the Centre's focus on energy transitions this year was the appointment of Dr Jake Whitehead as the inaugural Tritium E-Mobility Research Fellow , with a focus on investigating the challenges and opportunities for broader consumer adoption of electric vehicles. This appointment was made possible because of a generous $1.5 million endowment made by The Trevor and Judith St Baker Family Foundation in 2018.

The UQ Dow Centre's focus on developing low-carbon energy and materials is reflected in our contribution to the Future Fuels Cooperative Research Centre (CRC). The Future Fuels CRC is focussed on supporting the Australian gas and pipeline industry to provide a competitive, low-carbon energy alternative to complement and support intermittent renewable energy. This year, the Centre commenced two projects as part of this CRC: a two-year project that will produce techno-economic modelling of fuel production; and a three-year project that aims to develop a new method of producing hydrogen or syngas by pyrolysing methane in molten salts and metals.

In terms of promoting the shift to a circular economy, the UQ Dow Centre is leading the 'Transforming Waste Resources' research program as part of the Fight Food Waste CRC agreement with the Commonwealth. This important research is mapping resource flows as a method of developing strategies that will help to reduce the $1.2 trillion lost, globally, each year, due to food waste.

The other significant service provided by the UQ Dow Centre is the techno-economic analysis that we undertake to determine which projects are simultaneously economically competitive and scalable, as well as environmentally and socially acceptable. By performing this type of initial research or consultancy – either within UQ, or on behalf of industry – we are able to provide vital direction and input for future research, development, investment and policy making.

> *"The UQ Dow Centre is wholly focussed on developing practical, real–world solutions that will help to reduce carbon emissions and, ultimately, mitigate the most extreme potential impacts of climate change."*

The UQ Dow Centre also continues to contribute to UQ's teaching and learning, with the Centre's leaders supervising 60 HDR students in 2019, with an additional 12 HDR candidates receiving conferral. The Centre's research and teaching staff also demonstrated their commitment to developing the next generation of leaders in sustainability by coordinating, lecturing or tutoring in 16 undergraduate and postgraduate courses this year.

On behalf of the Advisory Board, I would like to thank Professor Greig for his leadership of the UQ Dow Centre and congratulate the entire staff on their many achievements in 2019. I would also like to acknowledge our donors Dow, and The Trevor and Judith St Baker Family Foundation for their support of the Centre, and for their commitment to creating a better world through the pursuit of innovation in sustainable engineering.

It has been my privilege to Chair the Board of the UQ Dow Centre ever since its foundation in 2012 and to witness its development, as it has grown from original concept to become a centre of global relevance, as we strive for a more sustainable future.

Professor Peter Høj AC
Vice-Chancellor and President
The University of Queensland

Director's report

The 20's – The Decade For Action

As we embark on the new decade, the challenges of establishing and maintaining economic wellbeing while confronting a range of sustainability challenges remain ever-present.

The world is growing rapidly. Last year, the global population rose more by more than 80 million, and is expected to rise by two billion by mid-century. A similar number of people are expected to be lifted out of poverty within the same timeframe, and a similar number again will become urbanised. This growth will fuel a tremendous increase in consumption of almost every conceivable commodity, including water, food, materials and energy. We urgently need to confront the challenges of climate change, biodiversity loss, and our increasingly vulnerable supplies of food and fresh water.

In Australia, the recent devastating bushfires triggered a huge amount of debate about links to climate change and the failure of Australia to strive for more aggressive reductions in greenhouse gas emissions. Much of the debate seemed to be to be politically motivated.

As we have reported previously, the UQ Dow Centre, together with the Andlinger Center for Energy and the Environment at Princeton University, founded a new international initiative known as Rapid Switch. The initiative aims to critically evaluate our capacity achieve deep decarbonisation at the required pace to meet climate targets, given the state of technologies, and political, social and economic conditions in various regions. By critically analysing constraints, bottlenecks and unintended consequences that might arise during transitions, and finding ways to avoid or resolve them sector-by-sector and region-by-region, we can help design and accelerate the most viable transition pathways.

The work of Rapid Switch is showing us that rapid deep decarbonisation consistent with the Paris Agreement goals is enormously challenging in any of the world's major regions. All potential pathways involve unprecedented deployment rates of capital equipment and infrastructure, asset stranding, land-use change, behavioural change, and exploitation of the deep subsurface, to be sustained over multiple decades.

It is time to accept the reality that the world will not be able to limit global warming to well below 2°C, let alone 1.5°C, and that we urgently need to strengthen our capacity to deal with the impacts of climate change. We need to get real about climate change. The time has come for Rapid Switch to expand its remit to critically examine the capacity of nations to adapt to the most serious impacts of the changing climate. Such research should cover protecting urban environments and critical infrastructure from flooding, establishing more resilient fresh water supplies, geographic shifts and practices for agricultural production, and forest management practices in the wake of elevated risk of wild fires.

This is not a call to lessen efforts to cut emissions. Those efforts must continue to be expanded and accelerated. Arguments that Australia should not act in the absence of a broad global commitment, especially from the rapidly growing Asian nations are as misguided as suggestions that fast-growing developing nations will 'leap frog' to a low-carbon future. Wealthy countries should lead and demonstrate that a low carbon future can be viable. The innovation, technology cost reductions and industrial capacity that will result from rapid and widespread low-emissions technology deployment in the US, Europe, Australia and other wealthy nations will allow developing nations to follow faster. Such an approach is unlikely to deliver emissions reduction quickly enough to avoid the effects of climate change, but it gets us on the right path and helps contain the risks.

The work of the UQ Dow Centre goes beyond these desktop analyses and seeks to deliver technological innovations that can help accelerate mitigation and improve our resilience. Our research strategy continued to focus on a number of flagship programs that hold the potential to have global impact. At the heart of our approach is an applied, multi-disciplinary focus, assuring projects are subjected not only to technological rigour, through modelling and/or experimental research, but that they can also be cost-competitive. The centre undertook projects across several major programs in 2019:

- Accelerating the uptake of electric mobility.

"At the heart of our approach is an applied, multi-disciplinary focus, assuring projects are subjected not only to technological rigour, through modelling and/or experimental research, but that they can also be cost-competitive."

- Innovative new processes for low emissions production of steel, cement and fuels including hydrogen and synthetic gas.
- Reducing waste in the food value chain.
- Designing next-generation fertilisers to reduce the environmental impact of large-scale agriculture.
- Developing innovative flexible printed energy storage for use in logistics and health care devices.
- Overcoming the critical bottlenecks for widespread deployment of carbon dioxide capture and geological storage.
- Utilising energy as an enabler of improved livelihoods and poverty reduction.

I encourage you to read further to learn about these exciting projects.

In 2020, we will seek to expand our programs to include a new circular economy program. Initially focusing on the plastics value chain, our longer-term plan is to expand the remit to include metals and carbon dioxide utilisation.

The work of the UQ Dow Centre also extends to educating undergraduate and graduate students who go out into the world and create real change, in research institutes, industrial enterprises, governments and NGOs. They are the individuals who will actually shape our future. Helping prepare these young changemakers is one of the most rewarding aspects of university life.

I would like to acknowledge the tremendous support and counsel of our Advisory Board: UQ President and Vice-Chancellor, Professor Peter Høj AC (Chair), Ms Karen Dobson (President and Managing Director, Dow Australia and New Zealand), Dr Weiguang Yao (Global Director, Asia Pacific Chief Technology Officer, Dow), Noel Williams (Specialist Manufacturing Advisor, and UQ Alumni Representative), as well as UQ colleagues Professor Alan Rowan and Professor Vicki Chen. I would also like to thank Dr Andre Argenton (Vice President of Research and Development, Dow) for his insights and contributions to the Advisory Board, which aid the Centre in remaining closely connected with industry. I also take this opportunity to acknowledge my colleagues Professor Ove Hoegh-Guldberg and Professor Peter Halley, both long-standing advisory board members who stepped down this year after multiple years of valued service.

Last but not least, I would like to thank all Dow Centre staff for their continuing support and contributions to our success in 2019. I look forward to re-joining you full-time in the Centre in 2020!

Professor Chris Greig
Dow Chair in Sustainable Engineering Innovation, and Director of the UQ Dow Centre

Key outputs 2019

Projects & funding

3
key research themes, spanning Energy Transitions, Low Carbon Energy and Materials, and Circular Economy

7
discrete research programs

21
projects, including one multi-year techno-economic analysis

$9M+
external research project funding

Centre staff

25
research and professional staff

3
Summer Research Scholars hosted

1
ARC Laureate Fellowship

1
Advance Queensland Industry Research Fellowship

Research outputs

37
publications, including book chapters, and peer-reviewed journal articles

60
HDR students supervised by UQ Dow Centre researchers

12
HDRs conferred, under supervision of UQ Dow Centre researchers

1
patent filed

Student experience

16
courses coordinated, lectured or tutored by UQ Dow Centre staff

2600+
students reached through teaching and coordination

100+
students attended UQ Dow Centre-sponsored Weekend of Startups

140+
students attended UQ Dow Centre-sponsored SENergy student conference

Engagement

74
UQ Dow Centre staff met with more than 74 external organisations

8
International collaboration across 8 countries

43
participated or presented at at least 43 engagement events, including keynotes, media interviews and symposiums

53
total Australian and International collaboration partners

Fast facts about UQ

55,200+
STUDENTS FROM MORE THAN
140
COUNTRIES

3
CAMPUSES

6
FACULTIES

#1 UNIVERSITY IN AUSTRALIA IN THE PRESTIGIOUS *NATURE* INDEX

STATE-OF-THE-ART FACILITIES

#1 IN QUEENSLAND FOR GRADUATE EMPLOYABILITY

QS Graduate Employability Rankings 2019

MORE
NATIONAL TEACHING AWARDS THAN ANY OTHER AUSTRALIAN UNIVERSITY

People

Advisory board

Professor Peter Høj AC

President and Vice-Chancellor, UQ, and Chair of the UQ Dow Centre Advisory Board

Professor Peter Høj commenced as Vice-Chancellor and President of The University of Queensland on 8 October, 2012. Prior to this appointment Professor Høj was Vice-Chancellor and President of the University of South Australia (2007–2012). Before that, he was Chief Executive Officer of the Australian Research Council (2004–2007) and Managing Director of the Australian Wine Research Institute (1997–2004). He is a member of the Medical Research Future Fund Advisory Board. He was educated at the University of Copenhagen, majoring in biochemistry and chemistry, and has a Master of Science degree in biochemistry and genetics, a PhD in photosynthesis, an Honorary Doctorate from the University of Copenhagen, an Honorary Doctorate from the University of South Australia and an Honorary Doctorate from the University of Adelaide. He is a Fellow of the National Academy of Inventors in the USA, a Fellow of the Australian Academy of Technological Sciences and Engineering and a Foreign Member (Natural Sciences Class) of The Royal Danish Academy of Sciences and Letters. In 2019 Professor Høj was awarded a Companion of the Order of Australia for service to higher education especially research and commercialisation.

Ms Karen Dobson

Managing Director of Dow Australia and New Zealand

Karen Dobson is Managing Director of Dow Australia and New Zealand, based in Melbourne, Australia. In this role she is responsible for Dow's business and operations, and advancing the company's strategy and reputation across Australia and New Zealand.

Karen joined Dow as a graduate chemical engineer at the Altona manufacturing plant in Melbourne, and has over thirty years' experience with Dow. She has held a variety of technical, marketing and business roles, including Global Marketing Director for membrane technologies in Dow Water & Process Solutions, Asia Pacific Corporate Marketing & Business Development Director, Global Business Director for mining in Dow Oil, Gas & Mining, and Global Commercial Director for Dow Olympic and Sports Sponsorships. Karen has extensive international business experience, having been posted to roles in Hong Kong, Sydney, Minneapolis and Shanghai. She returned to Melbourne in 2014.

Dr Weiguang Yao

Chief Technology Officer, Asia Pacific R&D; Global Director, New Ventures for Asia Pacific, Middle East and Africa, Dow

Dr Weiguang Yao is the Chief Technology Officer for Asia Pacific R&D. He is responsible for Asia Pacific R&D Strategy to ensure Asia Pacific Resources align with regional growth opportunities. He represents Dow R&D in the Asia Pacific region. He also takes responsibility as Board Director of East China University of Science and Technology. Dr Yao is based in Shanghai. Dr Yao joined Dow in April, 2007 as Sr. R&D Director for Dow Core R&D in Asia Pacific. He was responsible for building Asia Pacific core and business aligned research capability and strategy at Dow, and driving Asia Pacific core R&D innovation for regional growth.

Mr Noel Williams

Specialist Manufacturing Advisor, UQ Alumni Representative

After a career with Dow spanning 36 years as a Chemical Engineer and later as a senior executive, Mr Noel Williams now works in consultancy as a Specialist Manufacturing Advisor and on charitable not-for-profit boards. Most recently in his career at Dow, Mr Williams was appointed as Vice President to lead Dow's Business Development efforts in Asia Pacific, while previously he had been President of Dow in South East Asia, Australia and New Zealand, all based in Singapore. Mr Williams is a past Chairman of the Board of the Institution of Chemical Engineers (IChemE) in Australia, and was a Governor and Treasurer of the American Chamber of Commerce in Singapore. He is a past President and Director of the Australian Plastics and Chemicals Industry Association (now Chemistry Australia). Mr Williams also serves as chairman on the UQ School of Chemical Engineering Advisory Board.

Professor Vicki Chen

Executive Dean, Faculty of Engineering, Architecture and Information Technology, UQ

Professor Chen holds a Bachelor of Science in chemical engineering from Massachusetts Institute of Technology (MIT) and a PhD from the University of Minnesota. She was formerly Head of the School of Chemical Engineering at the University of New South Wales (UNSW), Sydney, where she has strategically and successfully led the School's performance in research, teaching, infrastructure development, and academic recruitment. With multiple Australian Research Council Discovery grants and national and international industry linked research grants, Professor Chen is a highly successful researcher with close to 7000 citations to her name. Professor Chen has also held senior positions as the Director of UNESCO Centre for Membrane Science and Technology and has held other significant roles, leading major multi-institutional, collaborative projects with international industrial partners. Professor Chen's collaborations with industry stakeholders have seen a number of high profile outcomes, including the recent development of antifouling technologies, novel membranes for water purification and brine treatment, and high performance nano-composite membranes for greenhouse gas separation.

Professor Alan Rowan

Director, Australian Institute for Bioengineering and Nanotechnology, UQ

Professor Alan Rowan became Director of the Australian Institute for Bioegineering and Nanotechnology (AIBN) at the University of Queensland in 2016. He oversees a team of 450 researchers and professional staff in the translational research at the interface of Nanotechnology and Biology. He is on the board of the UQ Confucius Institute and Co-Director of the Advanced materials Center at Jilin University China. Professor Rowan is a world renown physical organic chemist and an ARC Laureate Fellow. He is a strong advocate for excellence in fundamental science with the aim to solve societies problems. He has a h-index of 68, more than 320 publications, cited more than 18,000 times, 18 of which are in Science, Nature or the Nature family. In the last three years he has been awarded 9 patents in the area of nanomedicine, and nanomaterials and five companies have been started Encapson 2009, NovioTech 2011, NovioSense 2012 and Secmatix 2014, and NovioCell in 2016, all based upon the initial research conducted in the Rowan group.

Professor Peter Halley

Head of School, School of Chemical Engineering, UQ

Professor Peter Halley is Head of the School of Chemical Engineering 31 December 2019, a Chief Investigator in the Advanced Materials Processing and Manufacturing (AMPAM) Centre and an Affiliate Professor in the Australian Institute for Bioengineering and Nanotechnology (AIBN). Professor Halley is a Fellow of the Institution of Chemical Engineers (IChemE) and a Fellow of the Royal Australian Chemical Institute (RACI). Professor Halley is on the editorial board of Green Materials, Plastics, Rubbers and Composites, Starch and the Journal of Renewable Materials.

Professor Ove Hoegh-Guldberg

Professor of Marine Science at The University of Queensland

Professor Ove Hoegh-Guldberg is Professor of Marine Science at The University of Queensland. In addition to leading research groups focussed on the influence of global climate change on marine ecosystems, Professor Hoegh-Guldberg is Director of The Global Change Institute at the University. The Institute is focussed on supporting and building research programs into the key challenges facing our changing world. Current focal points include clean energy, food systems, healthy oceans and sustainable water as well as the drivers such as climate change, technological innovation and population growth. Professor Hoegh-Guldberg is currently an ARC Laureate Fellow, a member of the Australian Academy of Science and a Coordinating Lead Author for the UN Intergovernmental Panel on Climate Change.

Senior staff

Professor Chris Greig

Chris Greig is a Professor in the School of Chemical Engineering and is currently the Gerhardt R. Andlinger Visiting Fellow in Energy & Environment at Princeton University (2018–2020). Chris obtained his degree and PhD in Chemical Engineering at The University of Queensland and is a Fellow of the Australian Academy of Technology and Engineering. Prior to becoming an academic in 2011, Chris spent more than 25 years in industry, commencing in 1986 as the founder and CEO of a successful process technology company which he sold in 1998. After that, he held various senior executive roles in resources and energy, including as CEO of ZeroGen - a proposed, large-scale carbon capture and storage (CCS) project. He has also held a number of non-executive roles including Deputy Chairman of Gladstone Ports Corporation (one of Australia's largest energy export hubs), Chairman of the Energy Policy Institute of Australia, and Director of two mid-tier engineering and mining firms. Chris won various awards during his industry career, including the Fluor Award for Outstanding Engineering Management, Queensland Premier's New Exporter of the Year Award and the Institution of Engineers Australia Project Management Award. Chris's research interests cover energy transitions, CCS, industry decarbonisation and megaproject investments. His teaching activities include Professional Practice in the Business Environment for final year undergraduate and Masters level engineers, as well as a Masters course called Energy Finance and Investment.

Associate Professor Simon Smart

Simon Smart is a Principal Research Fellow in the UQ Dow Centre and an Associate Professor in the School of Chemical Engineering at The University of Queensland. Simon is currently leading the UQ Dow Centre's flagship projects into low CO_2 production of materials and chemicals, and contributes to the Rapid Switch initiative. He is actively involved in teaching at the undergraduate and Masters level, delivering courses in Energy Systems, Energy Principles and Renewable Energy and Engineering Innovation and Leadership. Outside the UQ Dow Centre, Simon is the Director of the Functional Interfacial Materials and Membranes Laboratory (FIM2Lab) where he works on membranes for natural gas dehydration and carbon capture and utilisation.

Associate Professor Bronwyn Laycock

Bronwyn Laycock is a polymer scientist with an interest in advanced materials for sustainability. She is currently working across a range of projects, including novel biopolymers and their composites, particularly waste-derived, and the applications of these in controlled release formulations (for fertilisers, agricultural chemicals, and veterinary applications). She also has projects in self-assembled conducting peptides, spinifex to carbon fibre conversion, hydrogels for nutrient management, lignin-based polyurethane foams and waste to diesel conversion. Within the UQ Dow Centre, she is delivering the Next-Generation Fertiliser program, and has been instrumental in bringing the Fight Food Waste Transformation program in the Fight Food Waste CRC to the UQ Dow Centre. Bronwyn continues to pursue innovation in areas that will make a step change contribution to sustainability, such as in cost-effective nutrient management, food waste management and recovery, and delivering solutions for plastic use in the circular economy.

Professor Stephen Wilson

Professor Stephen Wilson is leading the global economic modelling component of the Rapid Switch project with the UQ Dow Centre. In 2018, Stephen was appointed as a Professor in the School of Mechanical and Mining Engineering, where he directs energy-related research in the newly formed Centre for Energy Futures. Research in the Centre for Energy Futures ranges from solar thermal generation and supercritical CO_2 cycles to simulation of proposed designs for inertial and magnetic fusion reactor containment. Stephen teaches Professional Practice to final year undergraduate engineers, as well as international Masters students from all engineering schools in the faculty. In addition, Stephen teaches a Masters-level course on Energy Markets, Law and Policy, which he developed in 2017. Stephen is a key member of the Rapid Switch team at UQ, and is the Principal Supervisor or Co-Supervisor of PhD students contributing to the Rapid Switch project.

Professor Lianzhou Wang

Lianzhou Wang is currently Professor in the School of Chemical Engineering, Director of the Nanomaterials Centre (Nanomac), and Senior Group Leader within the Australian Institute for Bioengineering and Nanotechnology (AIBN) at UQ. His research focuses on the design and development of semiconductor nanomaterials for energy conversion and storage application including nanocatalysts for solar hydrogen production, low cost high efficiency solar cells and rechargeable batteries. In 2019, Lianzhou was awarded a prestigious ARC Laureate Fellowship aiming to develop new generation artificial leaves for renewable solar fuel production. As co-Chief Investigator of the Flexible Printed Batteries CRC-P, Lianzhou leads and oversees laboratory research based at the AIBN.

Professional staff

Ms Briony Beaumont

Briony joined the UQ Dow Centre in July 2018 as the Centre Manager. In this role, Briony is responsible for supporting the Director and Advisory Board, contributing to the implementation of Centre strategic initiatives, and overseeing all operational matters within the Centre. This includes operational planning and reporting, budget management, coordination of professional support services, and engagement with UQ Dow Centre stakeholders. Briony holds a Bachelor of Business Management from The University of Queensland, and has a professional background in business-management and governance roles. Briony is also currently completing a Master of Business Process Management with a view to further supporting operational efficiency within the Centre. As Centre Manager, Briony provides a key interface for the Centre's internal and external stakeholders.

Dr Jannie Grové

Jannie has over 25 years of broad experience in project evaluation, development, process design, implementation, commissioning and operation of chemical plants / projects in South Africa, the USA and Australia. Specific industry experience in the oil shale, coal-to-liquids, cement, alumina, vinyl chloride monomer and ethylene production industries includes roles at senior and executive management levels, primarily focused on project development and operations management. His formal qualifications include a Masters degree in Chemical Engineering from the University of Pretoria (South Africa) and a PhD from the University of Queensland. He also holds an MBA from Northwest University (South Africa), in which he graduated top of the class and received the Old Mutual Gold Medal for outstanding academic achievement. In addition to external consulting, Jannie lectures and tutors at UQ and assists with the management of the Printed Energy CRC project on a part-time basis.

Mrs Meagan Wheeler-Rogers

Meagan is a waste industry professional with experience spanning research, consulting, manufacturing, and government environments. She is currently the Program Coordinator for the Transform Program of the Fight Food Waste Cooperative Research Centre, managed through the UQ Dow Centre. Meagan has a Bachelor degree in Marketing and Communication, a Master of Business, a Graduate Certificate in Environmental Management, and is currently pursuing a Master of Environmental Management. Previously, Meagan worked for the Queensland Government Department of Environment and Science in the Waste Policy and Legislation team in a lead role developing the Plastic Pollution Reduction Plan. During her career she has developed a specialisation in plastics, while her diverse background provides her with a broad understanding of the role of materials within societal and environmental systems.

Mrs Mojgan Tabatabaei Zavareh

Mojgan received her Bachelor of Engineering degree in chemical engineering and was awarded top student rank from Iran University of Science and Technology in 1993. As a graduate engineer, she joined the Air Quality Control Company in the position of environment engineer focusing on air pollution, establishing air monitoring facilities in Tehran with collaboration of international organisations including the World Bank and the World Health Organization. She then went on to earn her Master of Engineering degree in chemical engineering from Tehran University, Iran in 1997 and joined the Islamic Azad University as an academic staff. Mojgan has been involved in Front End Engineering Design and detailed design engineering of several mega scale industrial projects in a role of lead and principal process engineer from 2000. She joined the UQ Dow Centre in 2014 as a Techno-economic Analyst of various conceptual design processes.

Research fellows

Dr Jake Whitehead

Jake holds two PhDs in Transport Science and Transport Engineering, a Licentiate in Transport Engineering, in addition to a Master and Bachelor of Civil Engineering. His research career has focussed on analysing the impact of government policies on, and consumer preferences towards, novel transport technologies, including shared, automated and electric vehicles. Jake works closely with many Australian Governments to provide advice on sustainable transport policies, with one of his key achievements being the coordination, development and delivery of Australia's most comprehensive electric vehicle strategy: The Future is Electric - Queensland's Electric Vehicle Strategy. In his current role at the UQ Dow Centre as the inaugural Tritium E-Mobility Research Fellow, Jake is leading research into how novel transport technologies, such as electric vehicles, could support the development low carbon energy systems through the use of smart charging technologies.

Dr Joe Lane

(to December 2019)

Joe is a Research Fellow, with a professional background spanning process engineering, water resource planning and environmental management. Prior to joining the UQ Dow Centre, Joe led the UQ contribution to the development of the Australian Industrial Ecology Virtual Laboratory, a collaboration between ten different Australian research groups, developing innovative tools for coupled environmental-economic analysis. Joe's primary contributions to the UQ Dow Centre have been focussed on systems analysis of food and energy system change. Through 2019, Joe was based at Princeton University in the USA in order to boost global collaboration on the Rapid Switch initiative. Joe's current focus is split between high-level research papers looking at key risks to global decarbonisation, and starting a broad collaboration with Indian and US partners, to focus on long-term challenges for the decarbonisation of India's growing energy sector.

Dr Luigi Vandi

Luigi Vandi is a Research Fellow with a diverse background in Materials Science. His translational research activities have a strong focus on industry relevant-projects, including high-performance composites manufacturing for automotive and aerospace applications. His current focus and expertise is in biocomposites and biopolymers innovations for sustainable developments. In his role at the UQ Dow Centre, Luigi is focusing on the materials development for next generation fertilisers. Successful outcomes would address a global issue with nitrogen and phosphorous losses in agriculture. Being part of a multidisciplinary team at the UQ Dow Centre with a worldwide vision on sustainability, energy and waste management is something, that he finds very valuable and stimulating.

Dr Miaoqiang Lyu

Miaoqiang obtained his PhD from the School of Chemical Engineering at the University of Queensland in 2017, and commenced as a Postdoctoral Research Fellow working on the Advanced Printing Technology for the Flexible Printed Batteries CRC-P in early 2018. He is experienced in material synthesis, characterisations and applications, in particular renewable energy generation and storage areas. In 2018, Miaoqiang was the recipient of an Advance Queensland Industry Research Fellowship (Early Career), and is currently working toward developing printable and self-powered electronics for Internet of Things (IoT) devices.

Research fellows

Dr Paul Luckman

Paul is a Chemical Engineer from The University of Queensland, with a Masters in Biological Engineering and a PhD in Biomaterials Engineering. Paul specialises in bio-polymer process engineering materials and technologies. Dr Luckman has worked on the boundary between academia and industry with a range of companies from start-ups to several of the world's largest users and manufactures of biopolymers to develop product solutions for a range industry sectors such as packaging, agriculture, mining, and food. His research career to date has been entirely collaboratively funded through industry-linked projects including Collaborative and Industry Engagement Fund, two ARC Linkages, an Advance Queensland Innovation Partnerships, and is currently an Advance Queensland Research Fellow. Dr Luckman is currently contributing to the UQ Dow Centre's research as the Program Leader for the Transform Program with the Fight Food Waste Cooperative Research Centre.

Dr Rijia Lin

(to July 2019)

Rijia obtained his Bachelor of Engineering and Master of Science from Sun Yat-sen University (China) in 2010 and 2012 respectively. He was awarded his PhD in Chemical Engineering from The University of Queensland in 2016. While completing his master's degree, he worked on the functionalisation of polymers for CO_2 adsorption. His PhD research focussed on the development of novel porous materials and fabrication of high selective mixed matrix membranes for gas separation and purification. Rijia started working at the UQ Dow Centre as a Research Assistant in July 2017. His worked focussed on developing novel processes for hydrogen production without CO_2 emission via methane pyrolysis in molten metal system, as well as the design of a new membrane reactor for primary methane pyrolysis.

Dr Taiwo Odedairo

(to July 2019)

Taiwo joined the UQ Dow Centre for Sustainable Engineering Innovation as a Postdoctoral Research Fellow in 2017. Taiwo's research at the Centre focussed on novel materials for production of sustainable and environmentally friendly chemicals/fuels and power in industrial processes. Taiwo's work centred around dual-phase catalytic systems for low-cost petrochemical CO_2 utilisation and high-CO_2 content natural gas fields. He received his Bachelor and Master of Science in Chemical Engineering from Obafemi Awolowo University, Nigeria and King Fahd University of Petroleum and Minerals, Saudi Arabia, in 2006 and 2010, respectively. He was awarded his PhD in Chemical Engineering from The University of Queensland in 2016. Prior to his PhD, he worked for two years with Saudi Arabia Basic Industries Corporation (SABIC), a leading petrochemical company. He is an inventor of four granted US Patents, with another four pending.

Dr Torsten Witt

Torsten is a polymer scientist from the School of Chemical Engineering, and has specialised in understanding the structure property-relations of biopolymers in a variety of multi-disciplinary and industry-focussed projects. This has included understanding the role of biology and chemistry in the production of native ordered structures; the influence of biopolymer processing in altering food structure and food quality; and the chemical and physical modification of biopolymers to transform them into renewable biodegradable plastic materials. Torsten obtained his PhD in 2013 with the UQ School of Agriculture and Food Sciences. As a member of the Next-Generation Fertilisers project, Torsten is currently working on producing biodegradable slow release fertiliser to combat environmental nitrogen loss in the Great Barrier Reef catchment area.

Dr Songcan Wang

(to July 2019)

Songcan Wang received his Bachelor of Engineering in 2011, and a Master of Engineering in 2014 from Central South University, China. He was awarded his PhD degree in Chemical Engineering from The University of Queensland, Australia in 2018. During his master's, he worked on the development of functional nanomaterials for energy storage devices. During his PhD, his research focussed on the design of efficient photoelectrodes for solar fuel production. He joined the UQ Dow Centre as a Postdoctoral Research Fellow in May 2018, focusing on research in to the development of printed thin-film batteries.

Dr Yuxiang Hu

Yuxiang Hu received his PhD degree from the School of Chemical Engineering at UQ in 2019, before commencing as a Postdoctoral Research Fellow working on the Advanced Printing Technology for New Generation Flexible Batteries CRC-P in late 2018. Previously, Yuxiang received a Bachelor of Science degree from the School of Chemistry and Chemical Engineering at Nanjing University in 2012, and later obtained a master's degree under the supervision of Prof. Jun Chen in the Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education, Nankai University). His research currently focuses on nanomaterials, catalysis, and metal-ion/oxygen batteries.

Research assistants

Dr Andrew Pascale

(to January 2019)

Andrew obtained a Bachelor of Arts in History and a Bachelor of Science in Electrical Engineering from the University of Notre Dame (USA) in 1998. He earned a Master of Science in Renewable Energy from Murdoch University (Western Australia) in 2010. He was awarded his PhD in Chemical Engineering from The University of Queensland in 2018. In his master's Thesis, he detailed the life-cycle assessment of a community scale hydropower system in rural Thailand - a project for which he had served as a project manager a few years earlier. In his PhD thesis, he refined standard presentations of energy use/carbon dioxide emissions and human welfare relationships to expose intra-country inequalities and allow compelling global challenges connected with the vision of a world characterized by universal high human development and minimal global warming, to be framed for individuals rather than nations. Andrew joined the UQ Dow Centre as a casual research assistant in April 2018, building UQ Dow Centre knowledge and capability in tailoring and expanding the sectors and products contained in the MRIO data underlying the Rapid Switch CGE model. Andrew took a position as a postdoctoral research associate on a Rapid Switch project at Princeton University in early 2019.

Mr José Rehbein

(to February 2019)

José is an Industrial Engineer from Universidad Adolfo Ibanez with a Master of Environmental Management from The University of Queensland. In his early career, he worked as an entrepreneur in the private sector, as well as with the government and universities, developing renewable energy projects and strategic energy planning in Chile. He was awarded and directed seven grants from the Chilean Production Development Corporation, totalling more than US$1M, to develop storage technology, project design optimisation and business innovation for renewable energy. Following graduation from his Master's degree with the highest qualifications, he joined the UQ Dow Centre as a Research Assistant, forming part of the core team working on the Rapid Switch project. His work focusses on spatial analyses for the optimisation of Carbon Capture and Storage (CCS) planning for the world, especially in critical regions such as India and China, building the most complete framework for studying the complexities for planning CCS at a global scale.

Summer research scholars

Mr Mark McConnachie

(November 2018 to February 2019)

Mark McConnachie joined the UQ Dow Centre working as a Summer Research Scholar in late 2018, through to February 2019. During his time with the Dow Centre, Mark worked on furthering a previous project to develop a low emissions magnesium production pathway through process coupling. Mark is currently studying a dual degree of Chemical Engineering and Art History at UQ. Mark's study pathway has lead him to Nepal with Engineers Without Borders Australia, UQ's Student Energy Network, and as an art teacher outside of university. His interests are in climate change and human-centred design, and he aims to continue working in these areas following graduation in 2019.

Ms Stephanie Lim

(November 2018 to February 2019)

Stephanie Lim is a third-year Chemical and Biological Engineering student. From late November 2018 through February 2019, Stephanie participated in a ten-week summer research program under the supervision of Associate Professor Simon Smart at the UQ Dow Centre. Stephanie's project involved modelling the methane pyrolysis reaction with a liquid metal membrane reactor, a proposed CO_2-free technology with the potential for high-yield hydrogen production. She is particularly interested in clean energy production, and plans to build on her experience at the UQ Dow Centre to explore the different opportunities available for a possible career in the energy industry.

Mr Siddhant Singh

(November 2019 - February 2020)

Siddhant (Sid) Singh is a first-year Master of Engineering student majoring in Chemical Engineering. Sid joined the UQ Dow Centre in November 2019 as a Summer Research Fellow, under the supervision of Mojgan Tabatabaei Zavareh and Associate Professor Simon Smart. Sid's research focusses on the techno-economic analysis of various carbon-capture techniques, with greater focus on ammonia and mixed salts (as solvents). His interests lie in clean and sustainable energy. Sid aims to build on his experience at the UQ Dow Centre to gain more insight into these fields throughout his future education and career, and ultimately hopes to develop a clearer pathway to a more sustainable future through engineering innovation.

HDR students

Mr Benoit Clement

Benoit is a PhD candidate within the School of Chemical Engineering at The University of Queensland. Benoit obtained his bachelor's degree in Chemical Engineering from The University of Queensland in 2013. After graduating, Benoit worked on several battery research projects in industry. He is experienced in the field of product development and has participated in the inception of a start-up company. His PhD project is investigating economical routes for manufacturing thin-film batteries en masse, intended for the market of small and flexible electronic devices. Benoit commenced as a member of the Flexible Printed Batteries CRC-P team at the UQ Dow Centre in 2018, and is working to bring next-generation flexible printed batteries to the market while completing his PhD.

Mr Gabriel Rioseco

Gabriel holds a Bachelor of Science and Master of Science in Industrial Engineering, with a specialisation in environmental economics from the University of Concepción, Chile. In 2018 he graduated from the University of Queensland with a Master of Sustainable Energy. In 2018, Gabriel joined the UQ Dow Centre as a PhD student as part of the Rapid Switch project. Gabriel’s research focusses on the economics of energy systems, specifically determining the integration costs of variable renewables, and analysing their impact on the rate of deployment of renewables and broader macroeconomic variables.

Mr Mark Hodgson

Mark is a mature-age PhD candidate sponsored by the Dow Centre. Mark’s research explores methods to mitigate CO_2 emissions associated with the production of cement. He contributes to The University of Queensland’s teaching outcomes via tutoring activities. Previous formal education includes a Bachelor of Engineering (Chemical) and a Bachelor of Economics. He is a Fellow of the Institution of Chemical Engineers, and serves as the Australian committee member of the Institution’s Clean Energy Special Interest Group. Mark’s working career included management of process performance benchmarking and improvement, optimisation, technology revamps, process safety, and technical auditing, within the oil and gas industry (both downstream and upstream). A career highlight was leadership of an international technical best practice working group for a major multi-national.

Ms Sara Zeinal Zadeh

Sara obtained her bachelor's degree in Mechanical Engineering from the K.N.Toosi University of Technology in 2000, after which she worked in the oil and gas industry as project engineer and project manager in Persian Gulf mega-projects. In 2012, she moved to Australia and in mid-2013 took up a one-year research project on Life Cycle Assessment of Solar Energy in Australia at the UQ Energy Initiative. After 12 challenging years dealing with fossil fuels and observing the real-in-site environmental impacts of conventional power generation technologies, she pursued a career change to contribute to improving the environment. Her PhD project involves solar energy technologies, solar policy and social impacts of solar deployment, and is part of the wider Rapid Switch project. Sara has been enhancing her skills in techno-political and techno-social modelling. Sara also tutors and mentors undergraduate students in engineering design and project management courses at UQ. Her aim is to become an academic in the clean energy space.

Mr Tongen Lin

Tongen is a PhD candidate at the school of Chemical Engineering, University of Queensland. He received his bachelor's degree in Chemical Engineering and Technology from Sichuan University in 2013, and later obtained his master's degree from the University of Queensland in 2016. Tongen is currently a final-year PhD student studying under the supervision of Prof. Lianzhou Wang. Tongen's current research focuses on lithium-rich cathode materials for lithium ion batteries. He joined the CRC-P team at UQ in October 2019, and is working on next-generation flexible printed batteries.

Dr Jake Whitehead

Tritium E-Mobility Research Fellow Jake Whitehead strives to support the development of an affordable, reliable, and sustainable electric transport system for us all

As the inaugural Tritium E-Mobility Research Fellow, Dr Jake Whitehead is the first transport-focussed researcher to join the UQ Dow Centre for Sustainable Engineering Innovation.

Holding two PhDs in Transport Science and Engineering, a Licentiate in Transport Engineering, in addition to a Master and Bachelor of Civil Engineering, Jake's research career to date has covered a wide range of transport topics. These interests have included analysing the impact of government policies on, and consumer preferences towards novel transport technologies, including shared, automated and electric vehicles; modelling the impact of congestion pricing schemes on travel behaviour; and, more recently, planning the rollout and design of electric vehicle charging infrastructure networks.

"As a researcher, my motivation comes from knowing that the work I am doing can and will make a positive difference to society," said Jake.

"The major attraction of transport science for me was the fact that my work is constantly focussed on trying to understand what people want, why people make certain decisions, and ultimately, how we might be able to influence those decisions to lead to better societal outcomes."

"Almost every day, for our entire lives, each and every one of us has to make a choice about how we travel from A to B. Through my role as a transport scientist, I see this as a unique and fantastic opportunity to not only influence transport choices, but to fundamentally build broader awareness around the consequences of our actions, and how we can all make positive changes to achieve a more sustainable society."

Jake is a well-travelled researcher, having visited over 60 countries. Completing his two PhDs concurrently between universities in Australia and Sweden, over the course of almost six years, Jake regularly moved back and forth, visiting new nations on each trip to expand his understanding and appreciation of the different opportunities and challenges faced by regions across our planet. These experiences exposed Jake to the diversity of approaches to transport system planning. It also brought into fiercely clear focus the sheer magnitude of the challenge that our global society faces in moving towards a sustainable transport system.

"The negative consequences of our current transport system are stark and clear. Whether it be the hundreds of thousands of premature deaths that occur each year due to motor vehicle pollution, the societal inequity further perpetuated by unfair transport pricing schemes and/or inaccessible transport systems, or the major impact our mobility is having on the planet through the production of greenhouse gas emissions."

It is the recognition of the severity of these negative consequences of our current transport system that motivates Jake to strive for the development of an affordable, reliable and sustainable electric transport system for us all. This motivation has led Jake to deliver a number of major programs in support of this vision, including one career highlight being the development of an electric vehicle strategy for the Queensland Government.

"When I returned to Australia from Sweden after completing my second PhD, I knew that if I was to remain motivated as a university researcher, my work was going to have to be practical, applied and deliver real outcomes for society. This drove me to build my public engagement profile to work closely with governments, businesses and broader society to put my research findings into action."

It not surprising to learn that Jake's research always includes a component focussed on public policy, and how government and corporate actions can influence and deliver changes in human behaviour.

"Whether it be a country, a state, a city, a household or an individual, no matter the size, every decision we make and every action we take has consequences. No matter how small a role we think we may play, we all have a collective responsibility to work together towards a more sustainable future. We can all make a difference, and we all need to start making that difference today."

In his current role as the inaugural Tritium E-Mobility Research Fellow, Jake is focussing on understanding what consumer preferences are towards electric vehicles, how charging behaviour is evolving, and ultimately, whether consumers will be interested in leveraging the excess energy storage potential of their electric vehicles to provide energy services to the grid.

Jake believes that this is an exciting time to be working as a transport Scientist. "More than ever we are seeing a fundamental overlap emerging between the transport and energy sectors, opening new possibilities for multi-disciplinary studies between transport and energy researchers."

"The emergence of electric vehicles is a clear example of this overlap, and a key reason why multi-disciplinary research centres, like the UQ Dow Centre for Sustainable Engineering Innovation, are so important for providing an environment where researchers from varying backgrounds can work collaboratively to support the advancement of these beneficial technologies, while solving some of the additional problems they can present."

Jake aims to use his platform as the inaugural Tritium E-Mobility Research Fellow to not only further build The University of Queensland's reputation as a leader in e-mobility research, but to more broadly increase awareness across society about the significant benefits that e-mobility technologies can deliver. Jake is well-placed to do so, as an active member of the International Electric Vehicle Policy Council, a Co-Author of the Intergovernmental Panel on Climate Change, and Founder of the Clean Transport Coalition.

"I relish the opportunity to work with students, members of the public, businesses, governments and fellow researchers, on building clearer understanding as to not only why the future is electric, but why it is fundamentally beneficial to society on an economic and environmental basis to support the advancement of this technology."

Jake said that Australia is now moving into a new phase of public discourse where governments are trying to understand how to 'manage' the transition to electric vehicles. "Through my research I aim to demonstrate how electric vehicle technology can be transformed from a perceived potential risk to the energy system, into a significant and beneficial opportunity."

"There around 14 million light vehicles in Australia. If these were all electric, with an average driving range of 250 kilometres, collectively this fleet would store enough energy to power the entire country for 24 hours, and still meet average mobility requirements."

The recipient of a prestigious Advance Queensland Industry Research Fellowship, Jake will pursue a three-year project investigating how the potential excess energy storage of electric vehicles can be leveraged to deliver energy sector co-benefits. But Jake's passion for sustainability goes far beyond just transport.

Jake has a fully electrified house, which is powered by a combined solar and battery system, and generates enough excess energy to charge his electric vehicle. He has also followed a plant-based diet for almost a decade, and is a hobby food and worm farmer, with aspirations to grow much more food of his own one day.

"Whether it be a country, a state, a city, a household or an individual, no matter the size, every decision we make and every action we take has consequences. No matter how small a role we think we may play, we all have a collective responsibility to work together towards a more sustainable future. We can all make a difference, and we all need to start making that difference today."

Meagan Wheeler-Rogers

Meagan Wheeler-Rogers is working to help change systems to reduce waste generated within our society

Meagan Wheeler-Rogers joined the UQ Dow Centre for Sustainable Engineering and Innovation in August 2019, as the Transform Program Coordinator for the Fight Food Waste Cooperative Research Centre (FFW CRC).

Meagan works with the Transform Program Leader, Dr Paul Luckman, to manage a portfolio of FFW CRC projects that sit within the Transform Program. These projects all have an overarching aim to increase the valorisation of food waste across Australia.

Meagan is also part of the Translational Polymers Research Group at UQ, and supports the development of UQ Plastics, a multidisciplinary research hub underpinning Australia's transition to a new plastics economy. Her diverse knowledge of waste and plastics and the systems attached to these commodities have proven invaluable in the establishment of UQ Plastics to date. UQ Plastics will assist in addressing the environmental plastic research gaps, and work with industry, governments and the community to transform industries, effect change and mitigate harm.

Meagan is passionate about waste reduction, and holds a diverse range of skills in environmental and commercial systems relating to waste. In particular, Meagan has a strong understanding of how these systems interact, how we can measure impacts, and what methods can be employed to influence them. Her previous study and work experience in marketing have provided her with an understanding of consumer behaviour and decision-making, both of which are critical for understanding this space.

Meagan commenced her career in sustainable marketing with a Bachelor of Marketing and Communication and a Master of Philosophy in Business from the University of South Australia. While obtaining these degrees, Meagan also worked at the University of South Australia on a range of projects for large multinational organisations, non-for-profits, government and non-government organisations. Some notable projects included the Mars Food consumer behaviour tracker and research conducted for Zero Waste SA (now Green Industries SA). This research looked into consumer behaviour linked to waste separation and the South Australian plastic bag ban. Learning about these systems, and the problems they faced, sparked her passion for reducing waste.

After completing her master's, Meagan accepted a role with Rawtec, an environmental consultancy with a focus on waste and recycling, where she learnt the ins and outs of the waste and recycling industry, including the benefits of-, and barriers to-, waste diversion from landfill. Here she delivered several substantial projects for the industry, including the review of the Northern Territory Plastic Bag Ban and the South Australian Recycling Activity Reports. She also worked with several major organisations to improve their waste management practices, and implement best practice recycling and waste management services.

Meagan's previous roles have provided her with an understanding of how different organisations within industry operate, and created a burning desire to influence positive change within society. Meagan was inspired to see change that did not encourage the accelerated consumption of finite resources. This led her to commence a Master of Environmental Management in 2017 at The University of Queensland, and in early 2018 she was offered a role in environmental policy within the Queensland Government Department of Environment and Science (DES).

During this next stage of her career, and through her study and work at DES, Meagan continued to develop her knowledge of the interconnectedness of societal and environmental systems. In addition to developing a deeper understanding of human influence on climate change and desertification, she studied the political and legal systems that could be utilised to address anthropogenic environmental impacts.

At DES, Meagan worked in a number of roles, including as a Senior Policy Officer in the Waste Policy and Legislation team. In this role, her team was responsible for the development of the Queensland Government Plastic Pollution Reduction Plan (PPRP). Here, she co-developed the Plastic Pollution Matrix policy analysis tool, which analyses the priority of addressing plastic issues through scientifically based consideration of their impact and achievability. The PPRP and Matrix were developed collaboratively, involving consultation of more than 200 internal and external stakeholders. Released in late 2019, the PPRP provides an overview of initial actions that should be taken across Queensland to reduce plastic pollution.

> *"These projects will have a direct impact on reducing the amount of food wasted across Australia, and will hopefully help to influence a change in culture, particularly within industry, for how food waste is valued."*

"I discovered during this time that plastic and their additives have a negative effect on both the environment and human health. I tried to find out more, and found significant research gaps in understanding the sources and movements of plastic pollution, particularly within the local context," Meagan said.

"We currently have no effective methods to stop plastic entering the environment and it's very difficult to mitigate the impact of plastic once it's there. The plastic is continually accumulating within the environment and is having a compounding effect on the Earth's systems, human health and the health of flora and fauna. There is simply a lack of knowledge on what the overarching impact this type of exposure has on human health".

Meagan is proud to be working alongside researchers at the University to create change. "The projects supported by the Fight Food Waste CRC will have a direct impact on reducing the amount of food wasted across Australia, and will hopefully help to influence a change in culture, particularly within industry, for how food waste is valued." Meagan said.

"Through the support of such great initiatives working towards a circular economy, the UQ Dow Centre for Sustainable Engineering Innovation is positioned to generate substantial positive change to systems across Australia and hopefully the globe."

Research

Throughout 2019, the UQ Dow Centre continued to lead research across a number of projects, which all aim to make an original and significant contribution to global sustainability

Research at the Centre aligns with three key research themes:

Energy Transitions

- Rapid Switch
- Electro-Mobility

Low Carbon Energy and Materials

- Flexible Printed Batteries CRC-P
- Low-CO_2 Iron
- Low CO_2 Hydrogen
- Next-Generation Fertilisers

Circular Economy

- Transforming Food Waste

Energy transitions

Rapid Switch

Project Leader

Professor Chris Greig.

Team Members

Associate Professor Simon Smart, Professor Stephen Wilson, Dr Belinda Wade, Dr Joe Lane, Dr Andrew Pascale.

Key Partners

Princeton University, Carnegie Mellon University, IIT-Delhi, IIT- Bombay, Tsinghua University, Ashoka Trust for Research in Ecology and the Environment, and the Centre for Policy Research.

The global transition to a low carbon economy: Understanding bottlenecks, constraints and unintended consequences

This research aims to ground political and societal conversations about deep decarbonisation (scenarios consistent with the ambition to keep global average temperature rise to well below 2°C) with real-world assessments of the change required.

Background

Global carbon emissions have been rising for more than a century, as a result of industrialisation-led growth and prosperity, based on fossil fuels. A sharp and abrupt decrease in emissions is urgently needed to limit most adverse effects of anthropogenic climate change, while simultaneously enabling a more prosperous world through economic growth.

Scenarios for a low-carbon transition put forward by The Intergovernmental Panel on Climate Change and the International Energy Agency all lack a critical piece – they do not speak to the pace at which decarbonisation could realistically occur given the state of technologies, and political, social, and economic constraints in various regions.

The Rapid Switch initiative is a polycentric, global network of leading research institutions, which was conceived in the UQ Dow Centre for Sustainable Engineering Innovation. Rapid Switch seeks to identify, anticipate and communicate industrial, regulatory and social bottlenecks and constraints that might impact the pace of decarbonisation of the global economy. Since the formation of the Rapid Switch initiative, research has initially focused on four critical geographic regions: the USA, India, China, and Australia.

This report highlights the Rapid Switch USA project, being co-led by Professor Chris Greig with colleagues at Princeton, and provides a look ahead for both Rapid Switch India and Rapid Switch Australia projects.

2019 Highlights

Rapid Switch USA: Net-Zero America

A growing number of politicians and interest groups have pronounced net-zero emissions (NZE) targets for the USA by 2050 (or sooner).

Rapid Switch

This research, being undertaken at Princeton University, aims to ground political and societal conversations about deep decarbonisation with real-world assessments of the change required. This project will provide more transparent and granular estimates for the scales, costs, and pacing of plant and infrastructure build-outs needed to deliver deep decarbonisation. These, along with assessments of impacts on industries, communities, existing infrastructure and the natural environment, are necessary to inform planning, policy, and investment decision-making in such energy transitions.

To date, a suite of energy-system models has been used to define alternative NZE pathways for USA energy and industrial systems at a course geospatial resolution. The modelling considers CO_2 emissions from energy and industrial systems, as well as non-CO_2 emissions and the role that carbon absorption by soils and trees (the 'land sink') might play over time. The balance in 2050 between remaining non-CO_2 emissions and the land sink determines the allowable emissions from energy and industrial systems: negative 0.17 Gigatonnes per year (Gt/y) of net emissions.

The starting point for identifying each NZE pathway is the USA Department of Energy's Annual Energy Outlook Reference Case projections to 2050 for energy-service demands throughout the economy. These include passenger vehicle road-miles and air-miles travelled, residential and commercial floor area provided with thermal conditioning and light, industrial outputs, and others. Industrial energy service demands were adjusted to minimise 'offshoring' of emissions.

Projected energy-service demands, together with assumptions about market penetration rates of energy end-use technologies were used in a linear-programming optimisation model that chooses the mix of primary energy sources and conversion technologies to meet demands and achieve NZE by 2050. With perfect 30-year foresight, seamless integration of electricity, buildings, industry and transportation sectors, and economically rational decision-making at a central planning level to determine socially optimal choices, the model makes supply-side technology choices to minimise the net present value of total energy supply system capital and operating costs from 2020 to 2050.

A Reference ("business-as-usual") pathway was also modelled, based on the technologies and energy-supply mixes envisioned in the Annual Energy Outlook Reference Case. NZE pathways are underpinned by adoption of high-efficiency end-use energy systems, differing extents of end-use electrification, and a variety of technologies for decarbonizing both electricity and fuels.

Figure 1 shows modelled emissions trajectories for the Reference and four other NZE pathways. Biomass use in each of these NZE pathways grows to about 13 Exajoules in 2050, the estimated amount of biomass that could be supplied without major land-use change. Sensitivity studies have examined pathways with higher biomass. In Figure 1, coal use disappears by 2030 in all NZE cases. The use of liquid fuels falls by at least half by 2050, with increasing fractions coming from non-petroleum fuels over time. The use of gaseous fuels also declines significantly by 2050 in all except Case 3, for which the growth in renewable energy is exogenously constrained. The bulk of gaseous fuel in 2050 is fossil natural gas, except in Case 4, where fossil fuel use is exogenously specified to reach zero in

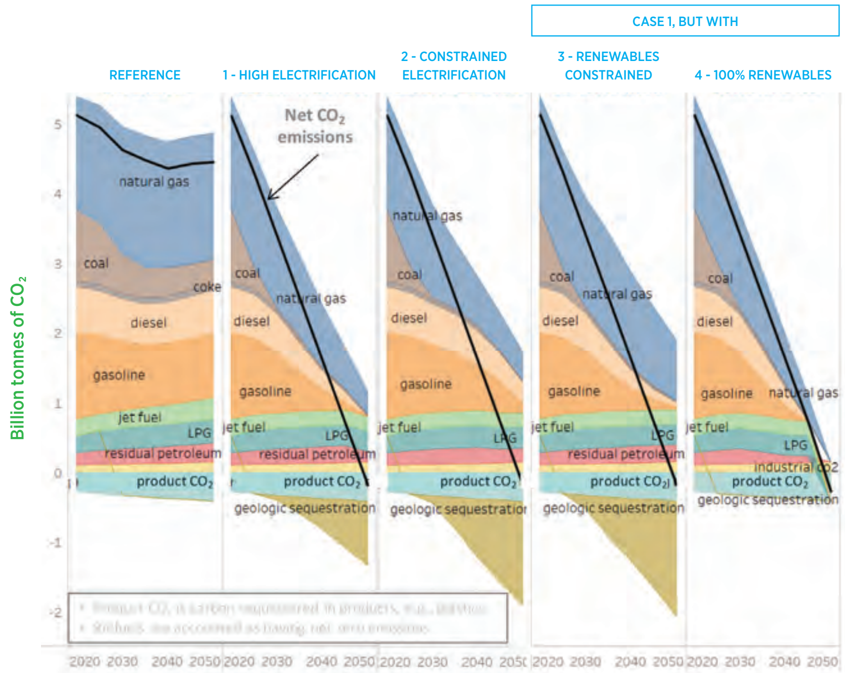


Figure 1. CO_2 emissions for the US energy and industrial system in the Reference and Net-Zero Emissions (NZE) pathways. Fuel names shown here conventionally denote fossil-fuel derived fuels, but in the net-zero pathways, the indicated fuels may be of fossil or non-fossil origin or a mix of both.

2050. Storage of carbon in products like plastics sequesters 0.4 Gt CO_2/year in 2050 in all scenarios, and geologic storage of CO_2 is significant (0.9 to 1.7 Gt per year in 2050), except in Case 4, where it is exogenously disallowed. When the rate of end-use electrification is constrained (Case 2), some 0.4 Gt per year more of CO_2 must be stored by 2050 than with high electrification (Case 1) to offset additional fossil fuel use outside the electricity sector. CO_2 storage requirements are still larger when solar and wind expansion is constrained Case 3).

Case 4 disallows nuclear power in 2050, along with fossil fuels and CO_2 storage, and the result is dramatically more electricity generation from wind and solar PV by 2050 (Figure 2). Interestingly, electricity generation in 2050 is higher in Case 2 than in Case 1 due to the need for electrically-derived fuels in Case 2 to supplement the supply of net zero-carbon fuels made from biomass or fossil fuels. The largest portion of increased electricity generation in every scenario comes from wind and solar resources. In Case 4, wind and solar generation accounts for nearly all generation in 2050. The lowest solar and wind fraction (45%) is in Case 3, where nuclear and natural gas plants with CO_2 capture and storage provide most of the balance. Required annual capacity growth for solar and wind that must be sustained over multiple decades in all cases exceeds the historical maximum build rates recorded for any nation in a single year (Figure 3), except in Case 3. Required annual build of both nuclear and natural gas with CO_2 capture and storage by the 2030s and 2040s in that case is unprecedented (Figure 4).

Despite the large contributions from wind and solar to electricity generation, curtailments are minimised in all cases (Figure 2) by coupling "overbuilt" wind and solar generation with large loads that operate flexibly. These loads include electric industrial boilers installed redundantly with fuel boilers and electrolysers producing hydrogen from water. Considerable amounts of hydrogen are used directly for fuel, or as an intermediate combined with captured CO_2 to make hydrocarbon fuels.

Broader implications of NZE scenarios include significant shifts in demand-side investment behaviours and use patterns; a shift towards more capital-intensive energy supply; significant reliance of the energy supply system on surface or sub-surface natural environments; major reform of markets to incentivise sector couplings; asset stranding; and shifts in employment.

This research receives funding from ExxonMobil and BP, through Princeton University.

2020 Outlook

Rapid Switch USA: Net-Zero America

In ongoing work, the aggregate national-level NZE pathways described in the Net-Zero America project will be downscaled to state or sub-state spatial scales to quantify the on-the-ground magnitude, cost, spatial distribution, and pace of key required plant and infrastructure investments and activities at local levels from 2020 to 2050. From this downscaling, the research team aims to explore potential bottlenecks that could slow the pace of certain pathways. These bottlenecks may include industrial capacity constraints, public opposition associated with shifts in employment profiles, impacts on land, water, air quality and the deep subsurface, as well as financial bottlenecks such as capital constraints and asset stranding.

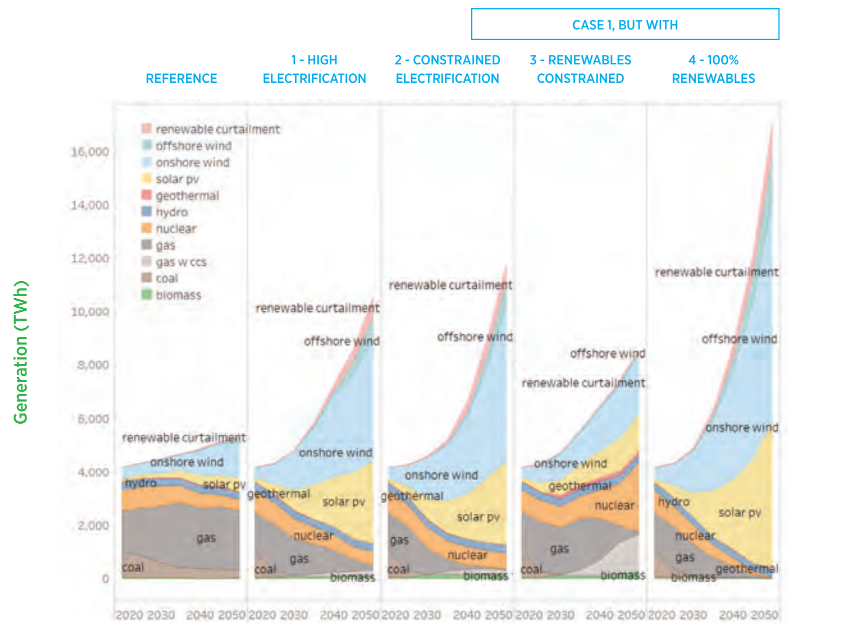


Figure 2. Annual electricity generation for the USA 2020–2050, in the Reference and NZE pathways. Total installed generating capacity in 2050 in these cases (left to right) are 1600, 3800, 3200, 2400, and 6300 GW, respectively. For comparison, total installed generating capacity in the U.S. today is about 1100 GW.

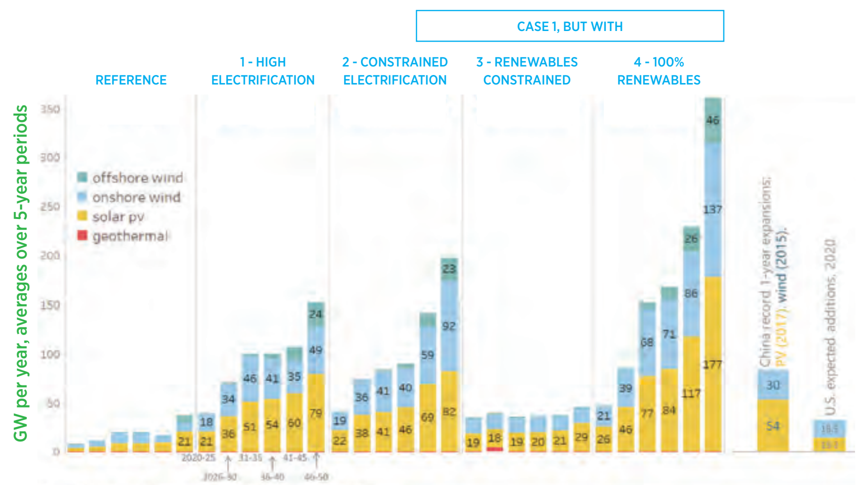


Figure 3. Average annual capacity additions of wind and solar generators in USA NZE pathways.

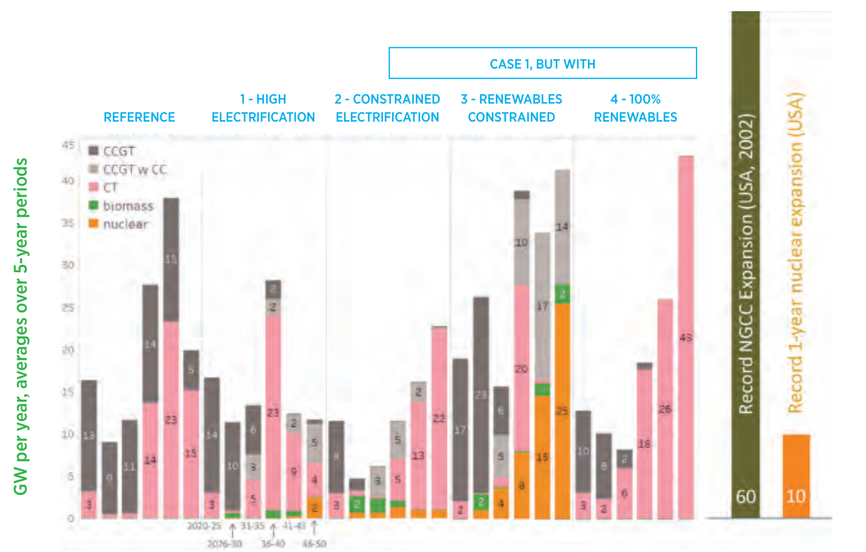


Figure 4. Average annual capacity additions of thermal generators in USA NZE pathways.

Rapid Switch India

Most deep decarbonisation scenarios are underpinned by ambitious reductions in the energy intensity of economic activity, for both developed and developing economies. This assumption is critical to the challenges of supply-side decarbonisation, particularly for the large and rapidly growing economies of China and India. For example, some energy outlooks predict India to achieve the most rapid annual improvement rates resulting in the world's lowest energy intensity by mid-century.

Working with researchers at IIT-Delhi, IIT-Bombay, the Ashoka Trust for Research in Ecology and the Environment, and the Centre for Policy Research (a leading think tank in New Delhi), this project will develop plausible scenarios for India's energy demands through to the middle of this century. This will involve determining, for the industrial, commercial, transport and residential sectors, those factors that will most strongly influence the evolution of overall demand growth, and the form (e.g. fuel sources and carriers) of that growth.

Rapid Switch

The research will provide more robust, demand-related perspectives for use in more popular supply-side energy research and analysis, and will result in the development of a set of tools and capabilities that can support equivalent, high-quality analysis for other developing regions.

Rapid Switch Australia

Deep decarbonisation scenarios (consistent with goals to limit global average temperature rise to well below 2°C) involve an immediate halt in emissions growth and a steep decline to net-zero emissions by around mid-century. This can only be achieved if all companies take serious and sustained actions to reduce the emissions intensity of their investments. Delayed progress increases both the required the rate and extent of decarbonisation to limit warming to below 2°C, leaving companies vulnerable to future higher costs and eroding valuations in the event of more stringent climate policies. In response to these challenges, the Rapid Switch Australia project explores two key ideas:

- The transition to a deeply decarbonised future requires a huge number of investment decisions to be made, quickly, by companies competing for limited capital and incentives. These investment decisions are made under deep uncertainty about future technology options, costs, markets, and incentives, all of which will be changing rapidly. This begs the question 'What drivers and/or policies could lead investors to adopt a 'leader' rather than 'follower' strategy on deep decarbonisation?'.
- To align the activities of companies with global climate goals, methods have been developed to set science-based targets for emission reductions. Whilst over 700 companies have publicly disclosed such targets through the science-based targets initiative's website (sciencebasedtargets.org), targets in themselves are insufficient as they do not provide insight into actual performance.

Led by researchers in the UQ Business School, this research is will investigate the decision-making behaviour of firms and develop models for investment decision-making under uncertainty. The team will also develop and test methods to track corporate climate performance, by benchmarking companies' historical, actual and projected greenhouse gas emissions against science-based targets. The methods will be tested on companies in Australia's electricity sector and export-exposed mining sector, in order to demonstrate their alignment with deep decarbonisation scenarios.

The UQ Dow Centre will also work with researchers in the UQ School of Earth and Environmental Sciences to evaluate the potential for negative emissions technologies to offer a viable means and an ethical case for the continued extraction and export of Australia's fossil fuel endowment in a carbon constrained world.

Electro-Mobility

Project Leader

Dr Jake Whitehead.

Key Partners

Tritium, Evie Networks, St Baker Energy Innovation Fund, Veitch Lister Consulting, and Queensland Government Department of Transport and Main Roads.

It is estimated that each year in Australia there are at least 40 per cent more premature deaths from vehicle pollution than from vehicle accidents. The uptake of electric vehicles offers a promising pathway toward a healthier, more sustainable future

This research aims to identify key technological, social, economic and policy interventions that could accelerate a transition to electric vehicles.

Background

Globally, the problem of transport pollution is also significant, with almost 400,000 premature deaths occurring annually due to transport-produced particulate and ozone pollution, resulting in an estimated US$1 trillion in health damages.

This significant toll from transport pollution stems from our continued dependence on fossil fuels, burnt in internal combustion engines, for mobility. Thankfully, however, given rapid advancements in battery technology over the past decade, electric vehicles (EVs) are now becoming a viable alternative. In addition to providing a pathway towards lower transport pollution, EVs also reduce reliance on foreign energy, can support the uptake of renewable energy, and reduce greenhouse gas emissions, all while bringing down both transport and energy costs.

Despite all of these major benefits, electric vehicles still represent less than 1 per cent of the global vehicle fleet. This relatively modest uptake rate has primarily been due to three consumer barriers:

- a lack of understanding, awareness and experience with electric vehicle technology
- limited charging infrastructure to support long-distance travel, and
- high upfront capital costs for both households and infrastructure providers.

Governments around the world are actively working to reduce these barriers through supportive policy to stimulate both demand for, and supply of, this beneficial technology. However, for electric vehicles to play a major role in future transport and energy systems, further work is required to accelerate their uptake. Potentially negative consequences of EV uptake, such as the impact of uncontrolled charging on the electricity grid, must also be addressed.

Through the generous support of the Trevor and Judith St Baker Family Foundation, the inaugural Tritium E-Mobility Research Fellow, Dr Jake Whitehead, has launched a research program focussed on advancing the performance, economics, and uptake of electric vehicle technology. This program of work will be further enhanced through an Advance Queensland Industry Research Fellowship, enabling Dr Whitehead to specifically investigate:

- current and emerging consumer preferences towards electric vehicle technology

Electric vehicles can support the uptake of renewable energy and reduce greenhouse gas emissions, all while bringing down both transport and energy costs.

- current and emerging EV charging behaviour
- consumers' willingness to participate in smart charging programs
- market opportunities and barriers to the broader rollout of smart charging infrastructure.

The work undertaken by Dr Jake Whitehead is consistent with the UQ Dow Centre for Sustainable Engineering Innovation's commitment to work only on systems which have the potential to have significant impact on sustainability and the economy. To this end, Dr Whitehead's research will establish whether a viable local market exists for smart charging infrastructure, and how the rollout of this infrastructure could support the development of a more affordable, stable and sustainable energy system. Additionally, Dr Whitehead's work aims to improve awareness and understanding of how unlocking the energy storage potential of EVs – in treating them as mobile batteries – can further improve the economics of adoption, and in turn, accelerate consumer uptake.

2019 Highlights

Significant progress has been made throughout 2019, across research strategy and design, grant applications, formal and informal collaborations, as well as public engagement and education.

Advance Queensland Industry Research Fellowship

To further enhance this research project, Dr Whitehead applied for an Advance Queensland Industry Research Fellowship (AQIRF) to establish a three-year study focussed on investigating how electric vehicles can deliver co-benefits to the energy sector. The AQIRF is a prestigious fellowship program administered by the Queensland State Government, which supports PhD qualified researchers in undertaking original research that will benefit Queensland, while partnering with industry. Dr Whitehead was successful in his application, with the new project set to begin in early 2020.

Public Engagement

Recognising that a lack of public awareness and understanding of e-mobility technologies is a key barrier to adoption, during 2019 a concerted effort was made by Dr Whitehead through this project, to participate in a range of public forums, events, courses and interviews to disseminate evidence-based information on e-mobility across Australia, and more broadly.

As a representative of the UQ Dow Centre for Sustainable Engineering Innovation, Dr Whitehead delivered several presentations to raise public awareness and understanding relating to EVs. This included presenting at the UQ Future Conversation Parliamentary Breakfast to Queensland Members of Parliament, the National Electric Vehicle Council workshop, the UQ Sustainability Week EV Expo, and the Gatton Sustainability and STEM Expo, organised by local primary school students. Dr Whitehead also shared his expertise in e-mobility with students at UQ, lecturing classes in Energy Efficiency & Transport (ENGY7301) and Transport Planning (PLAN7116).

In response to growing public and media attention on e-mobility, Dr Whitehead also participated in several radio interviews, and published five articles on The Conversation. These articles were viewed by over 250,000 readers globally, and republished online by several media outlets, including the Australian Broadcasting Corporation (ABC).

Efforts were also made to inject evidence into public policy decisions related to e-mobility, with Dr Whitehead holding several briefing sessions with senior leaders from state and federal governments, leveraging his research at UQ to inform public policy submissions. This engagement included providing expertise to the New South Wales Legislative Committee on Transport and Infrastructure's Enquiry into Electric Buses, in UQ's capacity as a member of the Energy Research Institutes Council of Australia.

Electro-Mobility

Industry Partnerships

Dr Whitehead has forged a number of strong industry partnerships, including with Tritium, Evie Networks, Energy Queensland, Veitch Lister Consulting, Mitsubishi Motors, Tesla Australia, the Queensland Government Department of Transport and Main Roads, National Electric Vehicle Council, Economic Development Queensland, and Brisbane City Council. These industry and government linkages are crucial to ensuring that this project delivers tangible and highly relevant outcomes, to support Australia to become a leader in the production and rollout of smart charging infrastructure, and in turn support and accelerate the uptake of EVs.

Consumer Preferences Towards E-Mobility

In 2019, the ground work was laid for the rollout of an initial first survey which will aid in better understanding consumer preferences towards e-mobility.

The drafting of the initial survey was initiated, with a particular focus on investigating what electric vehicle features are most appealing to consumers, for example, driving range, operating cost, performance, and cost; as well as what the impact of different public policies may be on consumers' purchase decisions.

Primary research work focussing on better understand consumer preferences towards e-mobility is planned for 2020, in line with the project time for the Advance Queensland Industry Research Fellowship.

The information gleaned from this survey will ultimately be used to develop different uptake scenarios for the local EV market, exploring not only the number of electric vehicles in the fleet, but more importantly, where these vehicles are likely to be garaged. In turn, these insights will inform modelling of the potential impact of this spatial distribution of electric vehicles on the energy and transport systems. The findings will inform later stages of the research project, focussing on the opportunities and barriers to rolling out smart charging infrastructure to support the electricity grid. Critically, this work will also consider how best to avoid the worst-case scenario of having a large fleet of electric vehicles with uncontrolled charging.

This modelling work will also be useful in informing other e-mobility projects, including a planned investigation into a sustainable road funding model for shared, electric and automated vehicles. The intention is for this study to investigate different models that would support technology uptake, while managing road congestion, and delivering sufficient tax revenue to support the transport system.

Electric Public Transport

In line with the aims of this project, Dr Whitehead has been leading a feasibility assessment of Zero Emission Buses – including electric buses for the Queensland Government Department of Transport and Main Roads through the Transport Academic Partnership. To date, Dr Whitehead's research has demonstrated that in many cases, electric buses are already economically viable today, on a whole-of-life cost basis, given the significantly lower maintenance and operating costs, compared to conventional diesel or natural gas vehicles. The ambition of this specific study is therefore to support the adoption of electric buses locally, in order to reduce transport costs, and critically, to minimise the significant, harmful air pollutants currently produced by diesel-fuelled heavy vehicles.

Mobility-as-a-Service

E-mobility is often associated with private electric vehicles. The reality, however, is that the transport system is facing major disruptions in the future that are likely to see e-mobility far more commonly associated with a range of shared, and potentially automated, vehicles. We are also currently witnessing the advent of a range of micro-mobility devices, such as electric scooters, bikes and skateboards, given the rapid advancements in battery technology over recent years.

With this in mind, Dr Whitehead recognised the importance of gaining greater insight into what the future of transport might look like, what transport modes and pricing schemes ultimately will be acceptable to consumers, and what these changes might mean in terms of e-mobility. In 2019, Dr Whitehead led the establishment of a Mobility-as-a-Service (MaaS) trial at UQ's St Lucia campus. A Mobility-as-a-Service (MaaS) scheme involves the bundling of different transport modes into a single subscription platform. This represents the first step towards exploring consumers' willingness to change their transport habits. With the intention to formally launch the trial in 2020, this research effort has initially focused on how willing consumers are to switch from a pay-as-you-go approach to transport (the current goCard model), to fixed subscription pricing bundles (with these bundles including a range of modal options, including the possibility of unlimited public transport for a set monthly price). This would include shared e-mobility options, such as electric scooters, electric bikes, and possibly even electric demand responsive transit (DRT) – using electric taxis.

Through this real-world experiment, not only will it be possible to gain an appreciation of how popular subscription pricing for transport may or may not be, but it will also allow for an assessment of whether a sustainable business model exists for MaaS. This will also lead to analysis as to whether MaaS programs can further improve the economics of e-mobility technologies, including electric vehicles, by reducing payback periods through increased utilisation. These findings are also of significant interest to industry partners, such as Tritium and Evie Networks, who have keen interest in understanding how these vehicles might need to be charged in the future, and where the best locations to install this infrastructure might be. The UQ MaaS trial will also provide the opportunity for other research groups across UQ to leverage the on-campus experiments to support and pursue their own research agendas.

2020 Outlook

Building on the momentum gained in 2019, Dr Whitehead will pursue a number of complementary research initiatives in 2020, as follows.

Consumer Preferences and Behaviours in regards to E-Mobility

Leveraging the successful award of an Advance Queensland Industry Research Fellowship, Dr Whitehead will further enhance his research as the Tritium E-Mobility Visiting Fellow in 2020 through the delivery of a series consumer surveys. These surveys will focus on better understanding current consumer preferences towards electric vehicles, the current and emerging charging behaviours of electric vehicle owners, as well as consumers' willingness to use electric vehicles to provide energy services for their homes and businesses.

These surveys are planned to be developed, delivered and analysed over a 12–18 month period, starting in early 2020. The learnings from these surveys will not only be invaluable for better understanding the current market, and likely future uptake of this innovative technology, but will also be crucial for informing the later stages of the three year Advance Queensland project, in assessing the viability of smart charging infrastructure market in Australia.

Recruitment of a dedicated E-Mobility PhD Student

Following the successful application for an Advance Queensland Industry Research Fellowship, Dr Whitehead will be leveraging this grant to support the recruitment of a dedicated e-mobility PhD student. This student will work closely with Dr Whitehead on the development of surveys to assess consumer preferences towards electric vehicles and charging behaviour. In the later stages of the project, the student will also assist the establishment of a smart charging infrastructure trial.

Dr Whitehead plans to explore synergies with collaborators via the International Electric Vehicle Policy Council to establish an international PhD advisory team, establish a joint PhD program with a partner research institution, and in turn establish a framework for comparative studies between Australia and other regions internationally.

Real-world Mobility-as-a-Service Trial at UQ St Lucia

The next stages of the MaaS trial in 2020 will focus on finalising an external CRC funding agreement to assist in the operation and analysis of trial results. In tandem to this process, Dr Whitehead will be supporting researchers in the School of Civil Engineering to administer a survey of UQ students and staff in regards to their preferences towards MaaS subscription pricing. The knowledge gained through this exercise will inform the MaaS packages offered to trial participants when it is launched in the second half of 2020. The intention of this approach is to ensure the initial trial options are close to UQ student and staff expectations. Acknowledging that survey results do not always reflect respondents' real-world behaviours, the pricing of MaaS packages will be adjusted throughout the trial to manage demand, while minimising any potential shortfall between operating revenue and mobility usage costs. As one of the first trials of this kind anywhere in the world, this project is set to put UQ at the forefront of research institutions studying the field of new mobility, including MaaS and e-mobility.

Continuing Public Engagement

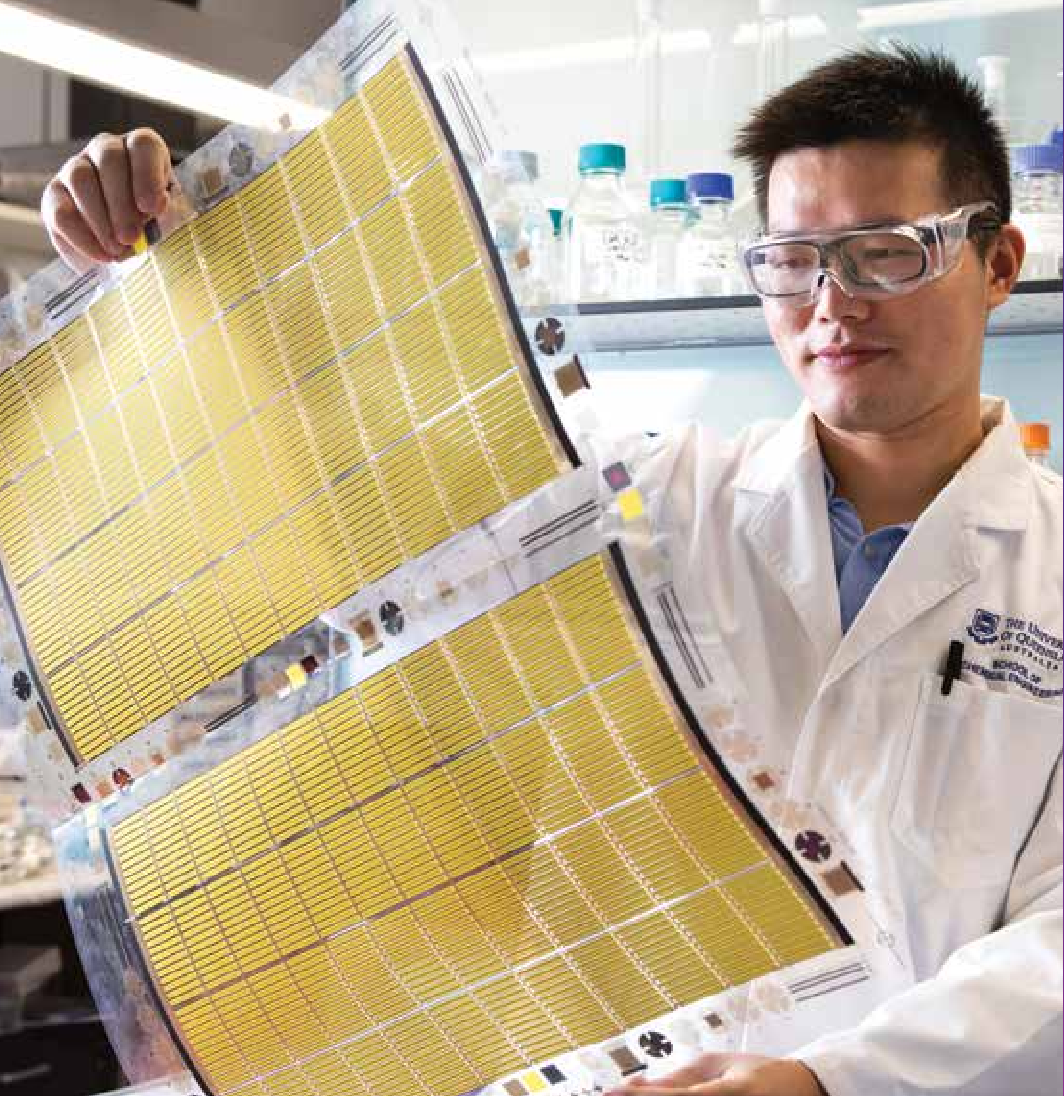
Building on the successes of 2019, Dr Whitehead plans to continue his public engagement activities with a particular focus on building awareness around the broader economic benefits of electric vehicle technology, and well as the related industry development opportunities. These efforts will be important in continuing to build the profile of the endowed Tritium E-Mobility Visiting Fellow position, and broaden opportunities to build additional capacity within the existing project team to continue to explore new e-mobility research projects. Continuing public engagement is also crucial for ensuring public opinion is fairly represented and assessed in the formation of surveys, and other research tools.

Strengthening International Collaborations on E-Mobility

Leveraging his roles as a co-author for the Intergovernmental Panel on Climate Change (IPCC) and member of the International Electric Vehicle Policy Council, Dr Whitehead plans to further strengthen international collaborations on e-mobility. Beyond the recruitment of a PhD student, Dr Whitehead will also foster stronger ties with other leading e-mobility research institutions internationally to support the establishment of comparative studies between nations.

Combined, these efforts will make a significant contribution to the economic and industry development opportunities of e-mobility in Australia to world, and ultimately, advance the performance and economics of e-mobility globally.

Low carbon energy and materials



Flexible printed batteries CRC-P

Project Leaders

Professor Lianzhou Wang, Professor Chris Greig.

Team Members

Dr Miaoqiang Lyu, Dr Songcan Wang, Dr Jannie Grové, Dr Yuxiang Hu, Mr Tongen Lin, Mr Benoit Clement.

Key Partners

Printed Energy, and The University of New South Wales (UNSW).

In partnership with Printed Energy, UQ is leveraging cutting-edge technology to create new opportunities for Australian manufacturing

This research aims to develop thin flexible batteries for use in products such as smart labels, thin flexible medical devices, wearable electronics, light weight disposable sensors, active IoT devices and many more exciting products.

Background

Printed Energy is in the business of developing and commercialising printed battery technology, and UQ and UNSW are research-intensive universities with specialist knowledge in the area of applied battery and photovoltaic (PV) technology.

Printed batteries have potential applications in many fields, including therapeutic devices, food-freshness tracking devices, road race Radio Frequency Identification (RFID) tags and more. The overall purpose of the project is for the project participants to collaborate in initially developing printed batteries into a mature and commercialised technology. Thereafter, the learnings may potentially expand into the development of printed PV technology.

This work involves the identification of suitable materials for use as primary and secondary batteries (through characterisation and the understanding of reactions), the development of environmental barriers (sealants), the optimisation of battery design and performance, the integration of the battery with devices, and finally commercialisation.

2019 Highlights

The work undertaken in 2019 comprised both literature reviews and laboratory testing and analysis, which translated into the manufacture and integration of printed batteries into practical devices (used and tested under real-world conditions). Thus far, the project has already yielded meaningful learnings as the technology was implemented in several actual settings. In this context, printed batteries were used to power RFID tags in several road races including a fun run at the The 2019 Asia Pacific Cities Summit & Mayors' Forum, and races at Rainbow Beach, the Pomona Hill Climb, the Blackall 100 and the Iron Maori.

The company is in the process of scaling up its manufacturing process via roll-to-roll printing. In parallel, Printed Energy continues to explore opportunities with several potential users (including therapeutic device and food freshness device companies).

2020 Outlook

The project has a target end date of 30 September 2020. With the characterisation and physiochemistry of primary and secondary batteries and the identification of suitable sealant materials having been completed, the focus throughout early 2020 will be on completing robustness and performance testing, optimising the scale-up process, integrating the batteries with more devices, and lodging patents to protect the developed intellectual property.

Low CO_2 Iron

Project Leader

Associate Professor Simon Smart.

Team Members

Professor Chris Greig, Mrs Mojgan Tabatabaei.

Key Partners

The UQ Dow Centre is seeks to collaborate with industry partners across the steel supply chain from raw material providers to steel manufacturers.

Iron and steel production is the largest energy-consuming industry in the world and one of the largest CO_2-emitting industries, producing around 5 per cent of the world's greenhouse gas emissions

This research is developing an innovative approach to the most CO_2-intensive step in the value chain, namely iron-ore reduction.

Background

The iron and steel sector presents a significant challenge to achieving sustainability in the production of materials. The main focus of decarbonisation scenarios for the iron and steel sector is carbon capture and storage (CCS) at an estimated cost of between \$70 and \$120 per tonne of CO_2, assuming suitable geological resources to store CO_2 are available. Arguably three of the top four steel producing countries (China, Japan and India) may lack sufficient suitable geology to facilitate large-scale CCS, thereby bringing CO_2 reduction strategies into question. Furthermore, direct reduction with hydrogen or electrolysis technologies for iron production with a high share of renewable energy are not economically attractive without a very high CCO_2 price.

Through this project, the UQ Dow Centre for Sustainable Engineering Innovation seeks to explore decarbonisation pathways that do not depend on coke to reduce iron. Specifically, this project explores whether iron can be produced without ever making CO_2. Originally, the UQ Dow Centre approached this problem by exploring a unique process to co-produce iron and organic chemicals utilising natural gas without direct CO_2 emission through a chemical looping concept. In this scheme, reduction of iron ore and natural gas conversion were facilitated by a molten salt mixture and electrolysis. Despite promising early results, this novel process proved to be overly complex and therefore unlikely to be suitable for larger-scale tests. The UQ Dow Centre have adapted to the complexity of this process, by pursuing a simpler scheme that focuses on iron production, with a solid carbon by-product.

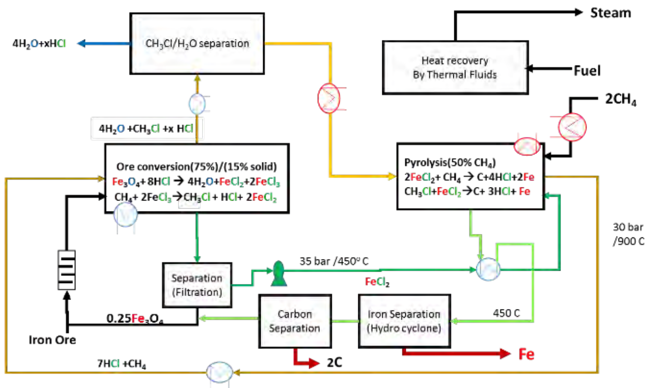


Figure 1 (a) A simplified process flow sheet of the CO_2 free production of iron with CH_4 as the reductant.

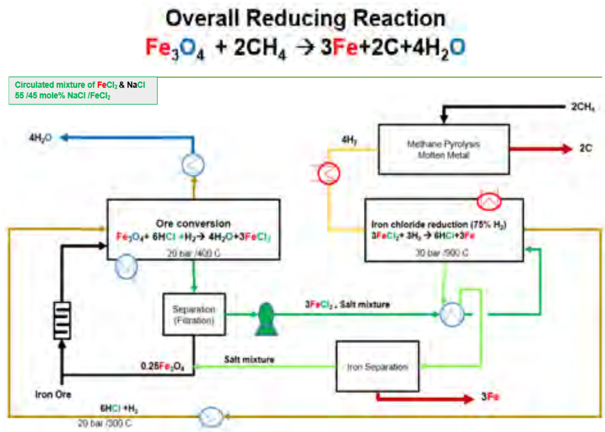


Figure 1 (a) A simplified process flow sheet of the CO_2 free production of iron with H_2 as the reductant.

2019 Highlights

Bench-scale experiments yielded new insights

Throughout 2019, the research team continued to look at using both methane and hydrogen to reduce iron salts (particularly iron chloride) into iron. The use of methane as the reductant for iron production (Figure 1a) has been updated with a new scheme, where hydrogen (produced by pyrolysis of methane) is used directly (Figure 1b). There are process and experimental reasons for this change and it does not preclude methane as the reductant in future designs. From the process perspective, the use of methane as the reductant leads to significant by-products including iron carbide (Fe_3C), which makes compatibility with the existing iron and steel industry more complex.

Further, the use of methane introduces separation or reaction issues depending on whether the unreacted methane is recycled to the ore chlorination reactor directly for conversion into chloromethane, or whether the methane is separated from the pyrolysis reactor off gas prior to recycle. Both options introduce additional complexity and cost.

From the experimental perspective, the use of methane results in the production of polyaromatic hydrocarbons, as well as light alkanes and alkenes. These by-products complicate calculation of the reaction conversion, particularly from the perspective of iron (or more precisely iron carbide) production.

In order to simplify the experimental investigation, the research team chose to use hydrogen directly as the reductant. In this process, iron ore (Fe_3O_4) is first chlorinated and reduced to $FeCl_2$ in the ore chlorination reactor and then reacted with hydrogen to generate iron and HCl. Hydrochloric acid and unreacted hydrogen are recycled back to the first reactor for the chlorination of iron ore. Extensive investigations found that the reaction happens predominantly in the gas phase and thus conversion is determined by the vapour pressure of the iron chlorides in the molten salt. The experiment reached equilibrium conversion even with very short residence times, which suggests that the reaction kinetics are very fast. The gas phase reaction also necessitates a reactor redesign before repeating the techno-economic analysis.

2020 Outlook

This project presents the opportunity to change the way the world thinks about steel production, particularly in the face of the growing need to act on climate change. The research team are actively engaged with multiple potential partners across the steel value chain, from raw material providers to integrated steel manufacturers in order to progress this research."

Low CO_2 Hydrogen

Project Leader

Associate Professor Simon Smart.

Team Members

Professor Chris Greig,
Mrs Mojgan Tabatabaei,
Dr Taiwo Odedairo,
Dr Rijia Lin,
Mr Mark Hodgson.

Key Partners

Future Fuels Cooperative Research Centre, and The University of Adelaide.

Hydrogen may become one of the most important clean energy carriers in a decarbonised world

This research is exploring the techno-economic costs and benefits of different processes for producing clean hydrogen, and leading the development of an innovative process to make hydrogen from natural gas, with out generating CO_2 emissions.

Background

Australia, with its large gas reserves and abundant renewable energy, is well placed to not only be among the first in the world to establish a strong domestic hydrogen economy, but also a major player in the export market. There are many carbon reducing hydrogen production pathways available to produce large scale volumes of future fuels and chemical intermediaries, but none are simultaneously commercially deployed, low CO_2 and cost effective. Development of innovative and sustainable technologies for hydrogen production is a key research theme for the UQ Dow Centre for Sustainable Engineering Innovation, spanning three specific research projects.

Pyrolysis for blue hydrogen production from natural gas

This project seeks to advance zero CO_2 options for the production of hydrogen, chemicals and liquid fuels through alternative chemistry. The current focus is almost exclusively methane pyrolysis with liquid metal and molten salt catalysis to produce hydrogen and solid carbon. The key advantage here is that by using a liquid catalyst, any issues with deactivation that have plagued past efforts on solid catalysis, are eliminated. This project is a collaborative effort with the University of Adelaide, who are involved in the reactor design. The UQ Dow Centre is investigating and optimising the molten catalyst system in order to achieve high conversions, fast kinetics at lowered temperatures and effective carbon separation.

Dry reforming for CO_2 utilisation

This project departs from the typical UQ Dow Centre perspective on CO_2 emissions – using innovative chemistry and process routes to avoid the production of CO_2 in the first place – and instead focusses on how to use innovative chemistry to utilise CO_2 with natural gas to produce syngas. Dry reforming (DR) has long been investigated as a viable pathway for the conversion of methane to chemicals with the added benefit of CO_2 utilisation. However, traditional dry reforming technologies have been plagued by catalyst sintering, stability and coking. We are using catalytic molten metal and molten salt systems to improve the current DR technologies, enhancing overall efficiency and ultimately prevent catalyst deactivation. In particular the molten state of the system means that coke production is no longer a problem as any carbon produced simply floats on top of the melt and can be removed. Indeed, carbon production can be encouraged, through feeding excess methane into the reactor, as it is accompanied by increased hydrogen production. The enables DR to produce high value syngas with H_2:CO ratios in excess of 2 and has the potential to unlock natural gas fields with high CO_2 content, or consider as an alternative option for a conventional CCS where natural gas is available.

Techno-economic analysis of hydrogen production technologies

This project will provide detailed techno-economic analyses to assist in determining technologies most viable for large scale deployment within Australia. Techno-economic models will be developed to evaluate and compare production routes, emissions profiles, energy and chemical efficiency, scale, and economic viability. The project will deliver a preliminary assessment of the economic performance of these processes, compared to published literature information. Models will then be used to analyse sensitivity factors and estimate the major influences on technology viability.

2019 Highlights

Pyrolysis for blue hydrogen production from natural gas

Throughout 2019, the research team have trialled a variety of metal alloys in the laboratory bubble column. In the first instance, the team investigated the impact of small amounts of cobalt, iron and nickel into the alloys due to their catalytic properties. Furthermore, the team also experimented with adding additional tin and bismuth into the melts to lower the melting temperature and decrease alloy cost. As a result of this work, a dynamic model of the reaction inside the bubble has been developed to better understand the driving force for hydrogen adsorption into the metal alloy.

Dry reforming for CO_2 utilisation

Experimentally, the team worked intensively on a new concept for the production of syngas via dry reforming of methane, without losing the catalytic activity of the catalyst. The new system utilizes a heterogeneous catalyst (e.g. Fe/Al_2O_3) in a molten salt for syngas production, where the CO_2 activation occurs mostly on the heterogeneous catalysts and the CH_4 cracking predominantly takes place within the molten salt. The reference salt system has been changed to bromide-based salts rather than chloride-based salts. This resulted in a reasonable increase in conversion. Furthermore, it was found that mixing solid particles into the molten salt enhances the dry reforming reaction, although in some cases this was to the detriment of the methane pyrolysis reaction.

Techno-economic analysis of hydrogen production technologies

To date, there have been an enormous number of studies published which focus on enhancing production yield and improving the energy efficiency of emerging technologies using renewable energy sources to bridge the gap with conventional processes. Efforts contributing to the advancement of these emerging technologies include high-performing reactor designs, minimising environmental impacts, process heat optimisation using renewables as well as energy consumption, product gas cleaning and cost effectiveness of these processes. Although economic benefits of these new technologies have been analysed based on laboratory and pilot scale trials, few demonstration and industrial trials have been reported.

Throughout 2019, the development of flowsheets for conventional and emerging technologies for hydrogen production from natural gas with CO_2 capture was commenced. A design basis including suggested scenarios and other technical parameters were also prepared. In addition, the availability of feedstocks, plant location and energy price were defined as key factors for selection of suitable technologies and economic parameters in each region.

Information from industry partners has aided the research team to define the natural gas composition and suitable scenarios. At the close of 2019, the design basis had been shared with our industry partners for review and feedback. For biomass-based hydrogen production, potential biomass feedstock for Australian contexts and the annual production rate was thoroughly investigated and simulation cases were decided. A review on existing techno-economic analysis models was helpful to identify the major cost items and how to reduce that cost. Additionally, this could give an idea on suitable plant size for each technology.

2020 Outlook

Pyrolysis for blue hydrogen production from natural gas

The focus of the research team in 2020 will centre on the optimisation of the molten catalyst system and improvement of the theoretical reactor design. By the end of 2020, the research team will be designing and building a high temperature, bench-scale bubbling reactor incorporating a solid carbon collection system. This will enable the research team to focus on a larger-scale pilot to demonstrate this technology to industry, which in turn will serve to enhance the commercial value proposition of this technology.

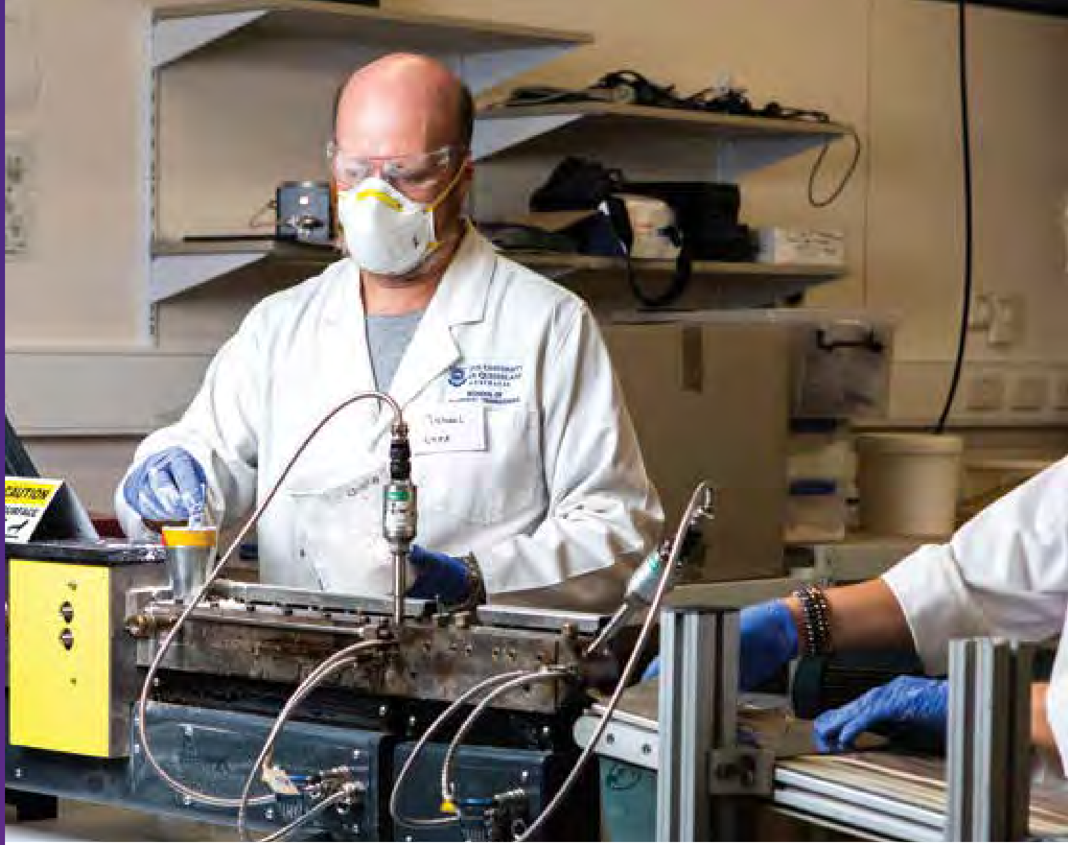
Dry reforming for CO_2 utilisation

This technology offers a clear pathway to large scale CO_2 utilisation, particularly for natural gas and LNG producers, where it presents an alternative to conventional CCS. Furthermore, this technology has the potential to unlock natural gas fields with high CO_2 content which are otherwise uneconomic to develop in the foreseeable future. As the UQ Dow Centre builds on its efforts in 2019, the research team are actively seeking new industry partners, particularly in the natural gas industry, as well as PhD students to further develop this work through 2020 and beyond.

Techno-economic analysis of hydrogen production technologies

The research team will be progressing the process flowsheets, as well as liaising with industry representatives to better establish baseline costs. Collaboration with the systems modelling groups in the Future Fuels CRC will allow the integration of our process models into various temporospatial and market models so as to understand the domestic and export hydrogen markets.

Next-generation fertilisers



Project Leaders

Associate Professor Bronwyn Laycock.

Team Members

Associate Professor Steven Pratt, Professor Susanne Schmidt, Professor Damien Batstone, Dr Paul Luckman, Dr Luigi Vandi, Ian Levett (PhD student), Dr Torsten Witt, and Dr Nicole Robinson.

Key Partners

School of Chemical Engineering, School of Agriculture and Food Sciences, the Queensland Department of Agriculture and Fisheries, James Cook University and the Manildra Group.

Approximately 50 per cent of the nutrients from conventional mineral fertilisers are released into the atmosphere, nearby waterways, or groundwater, creating negative impacts for land degradation, water quality, and the health of delicate ecosystems such as the Great Barrier Reef

This research aims to dramatically improve the efficiency of fertiliser use, reduce excess fertiliser run-off, and in turn reduce negative environmental impacts of fertiliser use.

Background

Modern agriculture relies on mineral fertilisers to replace the main essential nutrients (nitrogen, phosphorous, and potassium) removed with the harvest product. Approximately 50 per cent of the nutrients from conventional mineral fertilisers (being water-soluble salts) are released into the atmosphere, nearby waterways, or groundwater. As a result, plants often only absorb half of the nutrients from fertilisers. This is particularly true when a crop is in its early stages, and cannot absorb the nutrients quickly. In addition, some existing slow-release fertilisers contain non-degradable plastics, contaminating soil with micro-plastics long after the fertiliser has been applied. These insights suggest that modern fertilisers are far from efficient or environmentally sustainable. The resulting environmental impacts are evident in agricultural settings throughout the world. In response to this challenge, the UQ Dow Centre is aiming to improve the efficiency of fertiliser use and reduce negative environmental impacts using material science and applications design.

Since the inception of the project, UQ Dow Centre researchers have focussed on developing and testing new types of fully-biodegradable materials that slow the release of nutrients such as urea (a nitrogen-containing compound, used as a cost-effective source of fertiliser for crops) into soil. The key research questions addressed are:

1. How do different biodegradable polymers form a composite with different fertilisers and how much do they reduce the release rate of fertilisers?
2. Can aluminosilicates trap urea in their structure to increase the amount of fertiliser present in composites and reduce fertiliser release rates?
3. What processing methods can increase the fertiliser component of the polymer-fertiliser composite without increasing the release rate of the fertiliser?
4. Do laboratory-based water release results correlate with soil-based analytical methods or nutrient uptake in real plant systems?

The project has produced a biodegradable fertiliser which releases urea for up to 40 days in soil. Using different processing methods, the loading of fertiliser in the polymer composite increased with minimal increases in fertiliser release. These fertilisers have subsequently been included in two large-scale plant trials in a tropical and subtropical region using a broad acre crop and a horticultural crop. A techno-economic analysis showed that

the cost of the biodegradable polymer and the proportion of fertiliser loaded into the composite were the greatest drivers of fertiliser cost. A prototype has been identified in conjunction with Manildra, which will be produced at a pilot scale for a final field trial and to begin commercialisation processes.

2019 Highlights

Experimental work and techno-economic analysis

Experimental laboratory work producing, testing and characterising polymer–fertiliser composites was undertaken by Dr. Torsten Witt, Dr. Luigi Vandi, as well as the project research interns, Dr Carla Dantas da Silva, Manon Brossat and Fernanda Teodoro Magalhaes. A techno-economic study was produced by Dr. Torsten Witt and used to guide material selection and assess the feasibility of different polymer composites. Materials were produced for plant trials that began in late 2019 at James Cook University and in early 2020 at the Queensland Department of Agriculture and Fisheries.

Research outcomes

The work aimed to identify what polymer–fertilisers composites could be produced that would maximise fertiliser loading while minimising fertiliser release rates. The plant trials were established to validate lab-based fertiliser release studies and to test the fertiliser-composites ability to outperform pure urea in a high water-leaching environment.

Materials meeting the challenging performance targets have been prepared. Data on the composition and release rate of a variety of different polymer–fertiliser composites was also produced and is being prepared for publication where not commercially relevant. A model system for the production of slow release polymer-fertiliser composites was developed which allows a wide range of fertilisers to be used.

New knowledge and insights

Over the course of the project, a wide range of combinations of materials have been tested in order to develop a fundamental understanding of the processes driving release. This has proved to be critical in developing tailored materials that deliver this very challenging commercial target. Some of this will be freely published, while other aspects will be kept as commercial-in-confidence for further development.

In the short term, there may be potential for further research work to be undertaken in chemical engineering to further develop the prototype for commercialisation. If this proves to be successful, a new fertiliser product may become available to the market, which is able to reduce nitrogen loss into the environment and improve nitrogen availability for plants in high leaching environments.

2020 Outlook

Achieving key milestones

The key milestones for the last seven months of the project are to produce the fifth milestone report to DITID in March as well as the final report to all stakeholders. In the intervening time, the plant trials in Toowoomba and Cairns will be finished, analysed and publications will be prepared. Commercialisation discussions with our industry partner will continue.

Exploring future prospects

The research team expect that the project will conclude successfully in 2020 to the satisfaction of all project stakeholders, demonstrating tangible outcomes for industry partners via the UQ Dow Centre and Translational Polymers Research Group. The longer-term implications of the technology developed for slow release means that this knowledge can be turned to a wide range of different commercial applications. As we look to 2020 and beyond, Manildra is actively seeking partners to continue research in a more applied setting with the aim of commercialisation.

The final technical challenges of this project relate to controlling the release more precisely, and also increasing further the nutrient load. This is now being addressed through further research. Resolving these challenges will likely have potential use in the pharmaceutical industry to improve solid dispersion formulations for drug delivery.

Circular economy

Fight food waste CRC

Transform program

Project Leader

Dr Paul Luckman.

Team Members

Associate Professor Bronwyn Laycock, Mrs Meagan Wheeler-Rogers, Dr Joe Lane.

Key Partners

The Fight Food Waste Cooperative Research Centre (CRC) brings together 49 industry and 10 research partners from across Australia.

Food waste costs Australia over $20 billion each and every year, and directly affects Australia's food industry efficiency and reputation as a clean and green food producer

This research aims to identify and prioritise valuable products from waste streams, identify technology gaps and process limitations in waste transformation, deliver a tool kit for optimising technology and feedstock combination choice, and conduct a socio-economic assessment of alternative policy settings.

Background

The scale of this issue is enormous. Globally, if food waste were its own country, it would be the world's third largest emitter of carbon dioxide, behind China and the USA. Governments representing 50 per cent of the world's population have set an explicit national target in line with the United Nations Sustainable Development Goals (SDG) 12.3: By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.

In November 2017, the Australian Government formally committed to address SDG 12.3. The Fight Food Waste CRC subsequently commenced in July 2018, marking the beginning of a 10-year program which will operate until at least 2028. In acknowledgment of the scale and urgency of addressing food waste, The Australian Government Department of Industry, Innovation and Science CRC Program provided a $30 million grant to the Fight Food Waste CRC, matching the $33 million cash and $57 million in-kind funding raised by the 60 CRC participants.

Fight food waste CRC

The CRC comprises three programs, each underpinned by a platform of food safety and security.

These include:

Reduce food waste throughout the supply chain by:

- delivering supply chain analysis tools
- developing a framework for optimal packaging design
- innovative options to optimise food rescue.

Transform unavoidable waste into innovative products by:

- identifying and prioritising commercially valuable products from waste streams
- developing new technologies for waste transformation
- developing decision support tools
- identifying regulatory options to promote.

Engage with industry and consumers to deliver behavioural change by:

- educating future industry professionals
- delivering industry dissemination and skills training
- facilitating household and business behaviour change.

During 2019, the Program Leaders from across the three programs worked together with Fight Food Waste CRC participants and research partners to establish the majority of projects in the initial research portfolio. Progress throughout 2019 was strong, and by 27 November 2019, the inaugural annual Fight Food Waste CRC Science Symposium was held in Melbourne, bringing together the CRC participants and research partners to showcase their research projects and facilitate collaboration across these participants and the food supply chains within Australia.

2019 Highlights

Establishment of initial research portfolio

On 1 January 2019, the Transform Program Leader role transitioned from Associate Professor Bronwyn Laycock to Dr Paul Luckman. During 2019, Dr Luckman worked with government, academia and industry to establish projects from the initial research portfolio for the Fight Food Waste CRC Transform Program. In just one short year, this has resulted in the approval of more than half a dozen projects, including:

- making Australian Country Choice circular
- Fight Food Waste Small to Medium Enterprise Solutions Centre
- converting potato waste into pre-biotics and other valuable products
- waste-to-energy: fuelling sustainable wastewater treatment with food waste
- food waste to smart compost formulations
- nutraceutical extraction from Australian wine industry waste.

During 2019 and into 2020, formal research activities will commence or continue for each of these projects. The aims of these projects include exploring options for the transformation of food waste into higher value products to help industry improve profitability, identifying optimum techno-economically feasibility for closed-loop concepts for products derived from food processing waste streams, and supporting small to medium enterprises to tackle food waste across Australia.

Queensland Fight Food Waste CRC networking event

On 18 September 2019, the Transform Program team hosted the Fight Food Waste CRC Management Meeting, followed by a networking event for Queensland-based Fight Food Waste CRC participants and research partners. These events were held at Customs House, and were attended by 16 stakeholders. This event assisted to strengthen relationships within the Fight Food Waste CRC, which are key to the ongoing success of its aims.

Fight Food Waste CRC inaugural Science Symposium

Over 120 representatives from participant organisations and research partners attended the inaugural Fight Food Waste CRC Science Symposium, Industry Connection Hub Workshop and Annual General Meeting held from 19 to 21 November 2019 in Melbourne. These events enabled discussions and strengthening of networks and collaboration, which was facilitated by the presentation of the approved projects.

2020 Outlook

2020 will see the commencement of research on all established projects within the initial Transform Program research portfolio, as well as the establishment of a second round of projects. These projects will work towards the Transform Program milestones that will be delivered in 2020, namely to:

- survey existing waste streams relevant to partner organisations, including South East Queensland, South Australian and Victorian regional horticulture products. This includes identifying market opportunities and food safety hazards, as well as a review of near-market opportunities.
- complete an initial proof of concept testing for new solutions, and registration of intellectual property for new product solutions.
- review technology needs for different waste streams and products. This includes a survey of existing technologies surveys and market opportunities for technologies.
- complete an initial review of existing policy and legislation in food waste transformation, drawing on a stakeholder survey to identify investment barriers for producers concerned.

Techno-economic analysis

The UQ Dow Centre's approach is to work only on systems which have the potential to have significant impact on both sustainability and the economy

Techno-economic Analysis (TEA) is a highly specialised method of assessment that can aid in determining the technical and economic viability of novel processes.

The UQ Dow Centre routinely assesses potential new projects and processes relating to the sustainable production and use of energy and materials in order to determine whether these are economically competitive and scalable, in addition to being environmentally and socially acceptable. These insights can in turn inform further research strategy, technological development, investment, and policy making.

TEA draws on a number of disciplines and practices such as process modelling, engineering design, and economic evaluation, and typically involves developing and applying advanced quantitative methods for techno-economic, life-cycle, and sustainability analyses.

The UQ Dow Centre's Techno-economic Analyst, Mrs Mojgan Tabatabaei, brings extensive experience in industrial process technologies, and strong techno-economic analytical skills to translate novel concepts and academic research in to industrial applications. Mojgan combines her knowledge of process innovation and economic assessment to undertake in-depth techno-economic analyses for both the UQ Dow Centre and other research groups at UQ.

The UQ Dow Centre also consults with industry clients, to provide the information necessary to aid in decision-making. This may identify opportunities for process improvement given various inputs and assumptions, and the technical and economic feasibility of a process at industrial scale.

Engagement

Inaugural Rapid Switch workshop

On 11-13 June 2019, over 100 experts from academia, government and industry met at the Andlinger Center for Energy and the Environment at Princeton University for the inaugural Rapid Switch workshop

Originating at the UQ Dow Centre for Sustainable Engineering Innovation under the leadership of Professor Chris Greig, the Rapid Switch project is an international collaboration comprising The University of Queensland, Princeton University, Carnegie Mellon University, the Indian Institutes of Technology in Delhi and Mumbai, as well as Tsinghua University in Beijing and others.

UQ's Professor Greig, a 2018 Gerhard R. Andlinger Visiting Fellow in Energy and the Environment at Princeton, led the three-day Rapid Switch Conference and research workshop, marking the beginning of a five-year effort to frame a realistic global response to climate change that accounts for massive economic development in countries such as India and China.

The Rapid Switch project will provide critical technology and region-specific insights to guide decision-making by both policy makers and investors in the low-carbon energy transition. Rapid Switch aims to critically analyse bottlenecks and unintended consequences that may arise during low-carbon transitions, and resolve them sector-by-sector and region-by-region. By doing this in ways that respect local values and conditions, Rapid Switch aims to identify the most viable transition pathways and realistic pace. This means conducting locally informed, deep-dive analyses of proposed energy transitions for specific sectors in specific countries.

Over three days, workshop attendees engaged in interdisciplinary discussions with leading researchers and representatives from industry, including ExxonMobil, Public Service Enterprise Group (PSEG), Siemens, American Tower Corporation, Dow Chemical, St Baker Energy Innovation Fund, The World Bank, Mercator Partners, and China's National Institute of Clean and Low Carbon Energy.

Also attended by researchers from the UQ Dow Centre, UQ Business School and the Centre for Policy Futures, the workshop explored the challenges of rapidly scaling existing technologies and systems that could help limit the amount of carbon dioxide in the atmosphere, decoupling economic growth and energy demand in fast-growing economies, as well as the potential and challenges associated with carbon capture and storage.

Professor Greig is currently leading the Rapid Switch program, which brings together researchers from India, China, the United States, and Australia to examine deep decarbonisation pathways for advanced nations, and low carbon growth strategies for developing nations.

This project will develop real world assessments of the impacts on industries, incumbent infrastructure, communities, and the natural environment, which will help inform policy and investment decision making associated with the transition to a low carbon future.

It is intended that research efforts under the broader Rapid Switch project will expand to include universities in Europe, ASEAN nations and South America in its next phase.

Adapted from:
https://www.princeton.edu/news/2019/06/24/rapid-switch-project-assess-practicality-and-pace-global-climate-strategies

The UQ Dow Centre actively identifies and fosters mutually beneficial partnerships with collaborators at The University of Queensland, across Australia, and globally

The Centre attracts and engages with both distinguished and emerging leaders from around the world, including representatives of world-class research institutions and think tanks, industry, startups, government bodies, not for profit organisations, as well as non-government organisations. Engagement efforts at the UQ Dow Centre focus on 5 core areas:

- Industry
- Public policy
- Research and academic collaborators
- Philanthropic partners
- Media and the broader community.

Industry

By focusing on current industry challenges, the UQ Dow Centre is able to contribute to the sustainability of industrial processes through collaborative projects, including – but not limited to – the Australian Cooperative Research Centres (CRC) Program, Advance Queensland Innovation Partnerships, jointly-funded research projects, the International Rapid Switch project, as well as Techno-economic Analyses undertaken on behalf of industry clients.

Public policy

The Centre seeks to contribute to national and international policy-making through its capacity to deliver systems analysis, and through its focus on scalable, solution-focussed research projects. Researchers at the UQ Dow Centre are regularly called upon by Governments and think tanks to contribute their expertise to policy briefings, working groups, and events.

Research and academic collaborators

The UQ Dow Centre's networks extend across Australia and internationally, to encompass leading Universities and research institutions in the USA, Europe and Asia. The UQ Dow Centre is proud to partner with our research and academic collaborators to pursue multi-disciplinary research projects, publish new knowledge, and contribute to the learning outcomes of undergraduate and postgraduate students.

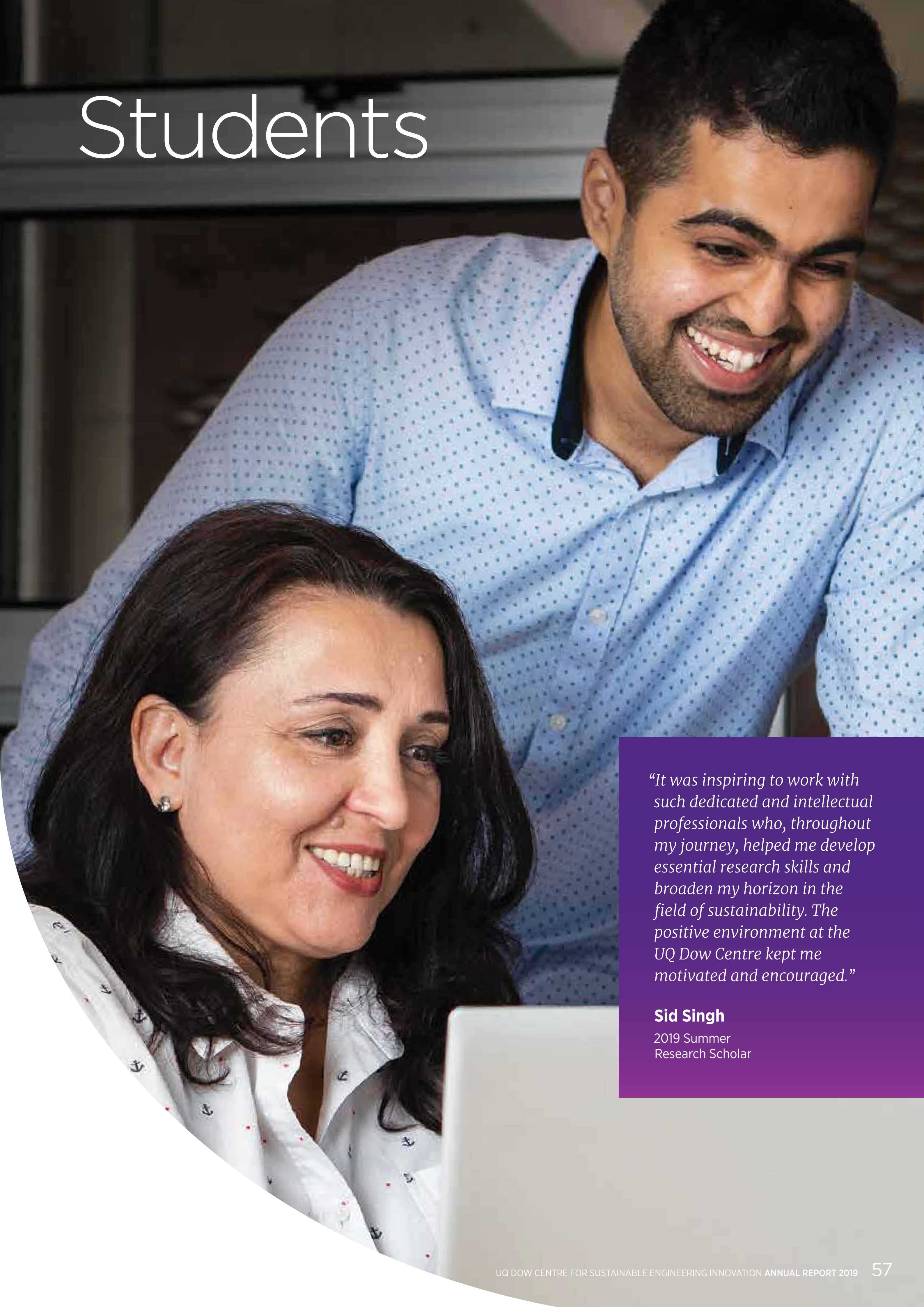
Philanthropic partners

The discovery and impact achieved through the UQ Dow Centre would not be possible without the support of our donors. The generosity of our philanthropic partners has helped to further our objective to deliver solutions to globally significant challenges by generating new knowledge. The UQ Dow Centre warmly acknowledges and thanks each of our supporters for their vision and generosity.

Media and the broader community

UQ Dow Centre researchers are regularly sought for public comment on matters relating to sustainability and innovation. This includes publishing media articles in high-profile publications (such as The Conversation), participating in media interviews, speaking to community groups (such as schools), and contributing to public knowledge relating to the sustainable production and use of energy and materials.

Students



"It was inspiring to work with such dedicated and intellectual professionals who, throughout my journey, helped me develop essential research skills and broaden my horizon in the field of sustainability. The positive environment at the UQ Dow Centre kept me motivated and encouraged."

Sid Singh
2019 Summer Research Scholar

Teaching and learning

Teaching

The UQ Dow Centre remains committed to UQ equipping a new generation of thinkers to tackle the complex issues in rapidly changing social, political and physical environments.

UQ Dow Centre leaders again contributed their experience and expertise to the teaching curriculum at UQ in 2019, through course-coordination, lecturing and/or tutoring UQ students through the following 16 undergraduate and postgraduate courses:

CHEE2010 Engineering Investigation & Statistical Analysis – UQ Dow Centre contributors: Associate Professor Bronwyn Laycock and Dr Luigi Vandi

CHEE3020 Process System Design – UQ Dow Centre contributor: Mrs Mojgan Tabatabaei

CHEE3301 Polymer Engineering – UQ Dow Centre contributor: Associate Professor Bronwyn Laycock

CHEE4001 Process Engineering Design Project – UQ Dow Centre contributors: Dr Jannie Grové and Mr Mark Hodgson

CHEE4002 Impact and Risk in the Process Industries – UQ Dow Centre contributor: Dr Jannie Grové

CHEE7103 Chemical Engineering ME Design Project – UQ Dow Centre contributor: Mrs Mojgan Tabatabaei

ENGG1200 Engineering Modelling & Problem Solving – UQ Dow Centre contributor: Mrs Sara Zeinal Zadeh

ENGY4000 Energy Systems – UQ Dow Centre contributor: Associate Professor Simon Smart

ENGG4900 Professional Practice and the Business Environment – UQ Dow Centre contributors: Professor Stephen Wilson and Dr Jannie Grové

ENGY7000 Energy Principles and Renewables – UQ Dow Centre contributor: Associate Professor Simon Smart

ENGY7004 Energy Sector Investment and Finance – UQ Dow Centre contributors: Professor Chris Greig and Dr Jannie Grové

ENGY7117 Energy Markets, Law and Policy – UQ Dow Centre contributor: Professor Stephen Wilson

ENGG7901 Professional Engineering and the Business Environment: Global Practice – UQ Dow Centre contributor: Professor Stephen Wilson

ENGG7902 Engineering Innovation and Leadership – UQ Dow Centre contributor: Associate Professor Simon Smart

ENGY7301 Energy Efficiency & Transport (intensive) – UQ Dow Centre contributor: Dr Jake Whitehead

ENE372 Rapid Switch – Solving the Challenges of Rapid Decarbonisation (PRINCETON) – UQ Dow Centre contributor: Professor Chris Greig

Associate Professor Bronwyn Laycock, Dr Jake Whitehead, and Professor Chris Greig were also invited to deliver guest lectures to UQ undergraduate and postgraduate cohorts, including students of CHEE4001 Process Engineering Design Project, CHEE4305 Biomaterials: Materials in Medicine, and PLAN7116 Transport Planning.

Student and community outreach

Dr Jake Whitehead, Tritium E-Mobility Research Fellow, contributed to numerous student and community outreach events throughout 2019. Among these was the Learning and Growing Expo in September, where 350 Grade 6 students from Catholic schools across Brisbane were invited to the Gatton Showgrounds to learn more about a range of sustainability and STEM topics.

The expo had over 15 exhibitors, including farmers demonstrating how vegetables are grown and delivered, agricultural biotechnology scientists explaining cutting edge techniques to grow food sustainably, and Dr Whitehead, supported by Rohith Nunna from the UQ Student Energy Network, teaching about e-mobility and the future of transport. Assisted by the student leaders at Our Lady of Good Counsel Primary School, Dr Whitehead taught the students about the environmental, health and economic benefits of e-mobility, using UQ's own Tesla Model S to demonstrate the technology and allow students to explore what an electric vehicle is, what is made up of, how it works, and importantly, how it is charged. UQ student Rohith Nunna also joined Dr Whitehead to support student leaders in discussing renewable energy technologies.

Dr Whitehead also represented the UQ Dow Centre at UQ's Sustainability Week Electric Vehicle (EV) Expo. Dr Whitehead spoke to students and members of the public about the inner workings and benefits of EVs, alongside vehicles from Tesla, the Australian Electric Vehicle Association, as well as UQ's own fleet of EVs.

UQ Summer and Winter Research Programs

The UQ Summer and Winter Research Programs provide current undergraduate (including honours) and master's by coursework students with the opportunity to gain experience working directly alongside leading academics and researchers at UQ. As part of the UQ Dow Centre's commitment to fostering the next generation of researchers, Associate Professor Simon Smart and Ms Mojgan Tabatabaei supervised three students in 2020. These placements provided these students an opportunity to gain a real-world insight in to the field of professional research, as well as develop analytical, critical thinking, and communication skills to support them in their journey toward becoming game-changing graduates.

Student innovation and entrepreneurship

UQ Weekend of Startups

The UQ Dow Centre for Sustainable Engineering Innovation remains committed to fostering student innovation in engineering and sustainability. The UQ Dow Centre was the principal sponsor of the 2019 UQ Weekend of Startups, which took place from 16–18 August. The event was attended by 100 students, alumni and interested members of the entrepreneurial community, and culminated in attendees pitching 13 start-up ideas relating to sustainability, including:

- asteroid mining solutions,
- food solutions using aquaponics,
- battery banks for rural housing, and
- sustainable postage packaging.

Professor Chris Greig officially opened the Weekend of Startups via a pre-recorded video message, emphasising the importance of addressing grand challenges through innovation. Dr James Wiltshire, R&D Technology Leader - Dow Australia & New Zealand, represented Dow by attending the weekend as a mentor to students.

The main prize was presented by Professor Stephen Wilson on behalf of the UQ Dow Centre. In order to continue to encourage high-quality, multidisciplinary solutions to the production and use of energy and materials, the UQ Dow Centre will continue to explore options to support the broader entrepreneurship and innovation ecosystem at UQ in 2020.

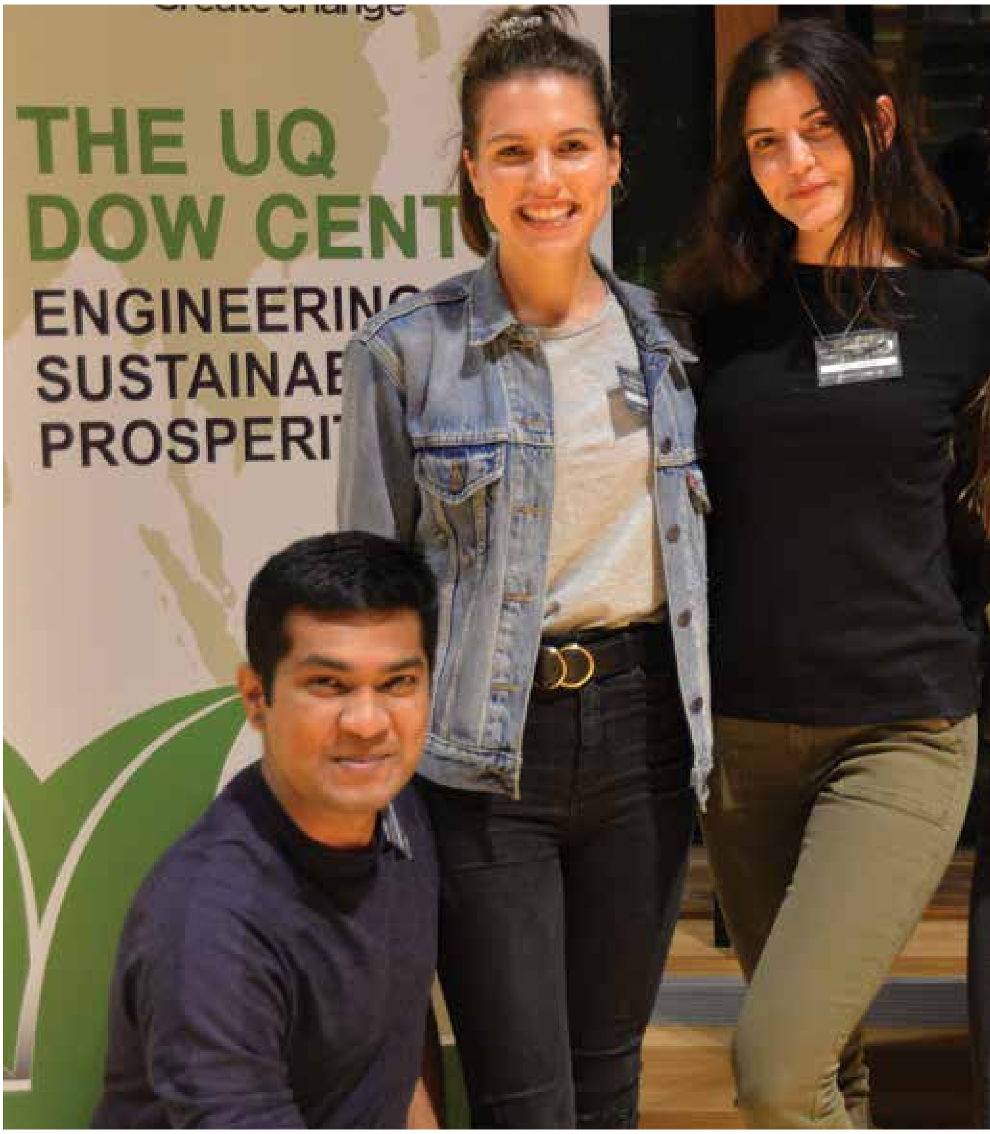
2019 SENergy conference

In 2019, the UQ Dow Centre continued to support the exchange of ideas among UQ students by sponsoring the annual Student Energy Network's 2019 SENergy Conference and Panel Event.

SENergy is a student-led forum that aims to gather multiple diverse student groups to discuss various technical, environmental, social and economic issues relating to energy. SENergy's annual flagship event plays an important role within the UQ student community, by broadening students' perspectives on key topics relating to sustainability, including

the global energy transition; electricity costs, security and reliability; and the impact of energy transitions on the environment and wider community.

The 2019 SENergy event drew together five diverse student societies, including the Society of Petroleum Engineers UQ Chapter, Fossil Free UQ, UQ Politics, Philosophy and Economics Society, UQ South Pacific Islanders Association, and Engineers Without Borders UQ Chapter. Attendees were challenged to consider the implications and challenges of the decarbonisation of Australia's power generation, and whether Australia can transition to a low carbon economy quickly, in light of the various technical, economic, political and behavioural challenges associated with this shift.



2019 HDR candidates

TYPE	STUDENT NAME / PROGRAM	ADVISOR/S	PROJECT TITLE
#	Benoit Clement, PhD	Prof Lianzhou Wang Prof Chris Greig	Development of future generation rechargeable flexible energy storage
#	Leela Dilkes-Hoffman, PhD	A/Prof Bronwyn Laycock A/Prof Steven Pratt Prof Paul Lant	The development and sustainability analysis of high-performance, multi-layered, biodegradable food packaging
#	Mark Hodgson, PhD	A/Prof Simon Smart Prof Victor Rudolph	A global transition to low carbon economy - limits of possibility?
#	Xia Huang, PhD	Prof Lianzhou Wang Dr Bin Luo Dr Ruth Knibbe Prof Eric McFarland	Design of new two-dimensional hybrid materials for lithium sulfure batteries
#	Edward Jiang, PhD	Prof Darren Martin Dr Pratheep Annamalai A/Prof Bronwyn Laycock	Water-based processing of spinifex nanocellulose fibrils into continuous textile fibers
#	Ian Levett, PhD	A/Prof Bronwyn Laycock A/Prof Steven Pratt Dr Christopher Pratt Dr Matthew Redding	Development of novel controlled release fertilisers for improved nutrient delivery efficiency
#	Tong'en Lin, PhD	Prof Lianzhou Wang Dr Bin Luo	Nano-materials for electrochemical energy storage
#	Romy Listo, PhD	Dr Jennifer Munro Dr Peter Ralph Westoby Prof Chris Greig	Power to empower? Exploring the role of energy in women's organising and empowerment in rural India
#	Sajna Manoj, PhD	A/Prof Bronwyn Laycock A/Prof Steven Pratt Dr Luigi Vandi	Drivers and barriers for commercial applications of waste derived diesel
#	Gabriel Rioseco, PhD	Prof Stephen Wilson Dr Joe Lane Dr Brian Fisher Prof Chris Greig	Electricity Modelling in Computational General Equilibrium Models under high Variable Renewable Energy Scenarios
#	Sara Zeinal Zadeh, PhD	A/Prof Simon Smart Prof Peta Ashworth Prof Chris Greig	Rapid Switch to De-Carbonization of Electricity Generation Sector: Understanding the Supply Constraints and Determining the Maximum Deployment Rate of Solar Power
*	Heidi Cooper, PhD	Prof Nicole Gillespie Prof Chris Greig Prof Karen Hussey	The rise of the disempowered citizen and its impact on the development of effective responses to the Climate-Energy nexus
*	Heidy Cruz, PhD	Dr Ilje Pikaar A/Prof Bronwyn Laycock Prof Paul Lant	The fabrication and use of hydrogels as an innovative and cost-effective approach for targeted recovery of reactive nitrogen
*	Xin Fu Tan, PhD	Prof. Kazuhiro Nogita Prof Lianzhou Wang	New Manufacturing Methods For Advanced Lithium Ion Battery Anode Materials
*	Russell Gordon, PhD	A/Prof Mary Fletcher A/Prof Bronwyn Laycock Dr Natasha Hungerford	Mitigating the effects of the plant toxin Simplexin on Australian livestock
*	Craig Jacobson, PhD	A/Prof Simon Smart Dr Ananthanarayanan Veeraragavan Dr Vigya Sharma	Applying systems modelling to tackle energy poverty challenge

Legend

Student whose research forms part of a Dow Centre project

* Student whose research is related to Dow Centre projects. Many of these belong to the Energy and Poverty Research Group and Wang Research Group within the AIBN

~ Student whose research does not relate to Dow Centre projects

TYPE	STUDENT NAME / PROGRAM	ADVISOR/S	PROJECT TITLE
*	Mai Jingjing, PhD	A/Prof Bronwyn Laycock A/Prof Steven Pratt	Characterization and Degradation of Novel Synthetic PHA Materials
*	Gabriel Lopes Fraga	A/Prof Steven Pratt A/Prof Bronwyn Laycock	Environmental footprint of catalytic depolymerisation
*	Thanh Tung Nguyen, PhD	Dr Michael Heitzmann Dr Luigi Vandi	Development of sustainable engineered structural panels
*	Syarifah Nuraqmar Syed Mahamud, PhD	A/Prof Bronwyn Laycock Dr Steven Pratt Prof Paul Lant	Polyhydroxyalkanoate (PHBV) Copolymer Production using Methanotrophic Cultures
*	Chen Peng, PhD	Prof Lianzhou Wang Dr Jung Yun	Development of efficient and stable perovskite solar cells
*	Xiyue Peng, PhD	Dr Bin Luo Prof Lianzhou Wang	Design of New Two-dimensional Materials for Lithium ion Batteries
*	Lingbing Ran, PhD	Dr Ruth Knibbe Prof Lianzhou Wang	High Voltage Lithium-Ion Batteries
*	Thomas Reddell, PhD	Dr Ananthanarayanan Veeraragavan A/Prof Simon Smart	Biomass fired Supercritical Carbon Dioxide Power Cycles: Microgrid Applications and Modelling
*	Scott Spillias, PhD	A/Prof Eve McDonald-Madden Dr Joe Lane	Environmental and societal impacts of cooking fuel and changes to renewable options
*	Jiayong Tang, PhD	Prof Lianzhou Wang Dr Bin Luo	Two-dimensional Hybrid Materials for Capacitive Energy Storage Devices
*	Michael Tarbath, PhD (School of Land and Food, University of Tasmania)	Dr Tina Acuna (University of Tasmania) Dr Shaun Lisson, (Consultant to CSIRO) Dr Elizabeth Pinkard (CSIRO) A/Prof Bronwyn Laycock	Impact of Clear Polymer Film on the Growth and Physiology of Maize
*	Yue Yuan, PhD	A/Prof Bronwyn Laycock A/Prof Mary Fletcher	Modelling the controlled release of toxins from a rumen environment
*	Tianlong Zhang, PhD	A/Prof Bronwyn Laycock A/Prof Steven Pratt	Understanding catalyst performance in CPD diesel production from waste
-	Hayder Alrazen, PhD	Prof Saiied Aminossadati A/Prof Bronwyn Laycock Dr Md Hasan Dr Muxina Konarova	Numerical study of the effects of CNG, H_2 and diesel blends under different parameters
-	Pradeep Basnayake, PhD	Dr Michael Heitzmann Dr Luigi Vandi Dr Juan Torres Dr Juan Medina	Advancing the properties of bio-composites: A study of fire-retarding natural fibre reinforced plastics, and the development of a biodegradable bio-based composite
-	Munkhjargal Bat-Erdene, PhD	Prof Lianzhou Wang Prof Alan Rowan	Two-dimensional nanostructured materials: synthesis and application
-	Abdulaziz Bati, PhD	Prof Joseph Shapter Prof Lianzhou Wang	Investigation of carbon-based hybrid nanomaterials for perovskite solar cells (PSCs)
-	Liam Brownlie, PhD	Prof Joseph Shapter Prof Lianzhou Wang	N-Type Doping of Single-Walled Carbon Nanotubes for Si-CNT Hybrid Photovoltaics
-	Lee Burns, PhD	Dr Paul Luckman Dr Brenton Fletcher Prof Peter Halley	Modification and processing of starches for increased productivity in mineral flotation
-	Alexander Corletto, PhD	Prof Joseph Shapter Prof Lianzhou Wang	Writing CNT Lines
-	Shanshan Ding, PhD	Prof Lianzhou Wang Dr Yang Bai	Designing new perovskite quantum dots with enhanced phase stability for efficient solar energy conversion
-	Xiangqian Fan, PhD	Prof Lianzhou Wang Dr Zhiliang Wang	Designing new semiconducting materials for solar water splitting

Legend

Student whose research forms part of a Dow Centre project
* Student whose research is related to Dow Centre projects. Many of these belong to the Energy and Poverty Research Group and Wang Research Group within the AIBN
- Student whose research does not relate to Dow Centre projects

TYPE	STUDENT NAME / PROGRAM	ADVISOR/S	PROJECT TITLE
~	Mehri Ghasemi, PhD	Prof Lianzhou Wang Dr Jung Yun Dr Miaoqiang Lyu	Basics of charge generation in disordered optoelectronic materials
~	Maria Gokhale-Stec, PhD (Fraunhofer Institut für Betriebsfestigkeit und Systemzuverlässigkeit LBF)	Prof Rudolf Pfaendner Prof Peter Halley (co-advisor, informal) A/Prof Bronwyn Laycock (co-advisor, informal)	Phase morphology development in post-extrusion drawn PLA/PE blends
~	Nur Hamid, PhD	Dr Liu Ye, A/Prof Simon Smart Dr David Wang	Forward Osmosis (FO) Membrane-based Technology in Urbane Wastewater Treatment
~	Ekyu Han, PhD	Prof Lianzhou Wang Dr Jung Yun	Perovskite-based electronic devices for sensing application
~	Mengmeng Hao, PhD	Prof Lianzhou Wang Dr Jung Yun	Development of novel quantum dots sensitized solar cells
~	Syed Haseeb Ali Ahmad	Prof Lianzhou Wang Dr Yang Bai	High performance lead free-perovskite solar cells with improved transport properties
~	Jarrad Humphry, PhD	Dr Michael Heitzmann Dr Luigi Vandi A/Prof Rowan Truss Prof Darren Martin	Reactive processing as a novel processing route for high performance compositive manufacture
~	Yang Jiang, PhD	Dr Baojun Zhao Prof Guo-Xiong Wang Prof Lianzhou Wang Dr Junhong Chen	Development of Advanced Refractory Materials for Copper and Steel Industries
~	Christian Kudisonga, PhD	Dr Luigi Vandi Dr Michael Heitzmann	Novel reactive transfer moulding of thermoplastic composite materials
~	Charmaine Lamiel, PhD	Prof Joao da Costa A/Prof Simon Smart Dr Julius Motuzas Prof Xiu Zhao	2D-3D Carbon Mixed Matrix Membranes
~	Christopher McMahon, PhD	A/Prof Simon Smart Prof Ian Cameron	Trace element modelling and optimisation in an integrated steel works
~	Sabiha Monny, PhD	Prof Lianzhou Wang Dr Zhiliang Wang	Semiconductor nanostructure engineering for photoelectrochemical energy conversion
~	Abdul Quader, PhD	Dr Thomas Rufford A/Prof Simon Smart	Evaluation of pressure swing adsorption systems for CO_2 removal and liquefied natural gas production
~	Gregory Siemon, PhD	A/Prof Simon Smart Prof Ian Cameron	Enterprise-wide optimisation in steelmaking
~	Samira Siyamak, PhD	A/Prof Bronwyn Laycock Dr Paul Luckman	Tailored starch based hydrogels: Renewable material solutions for wastewater and agriculture industries
~	Kelly Smith, PhD	Dr Maureen Hassall Prof Stephen Wilson	Using human factors approaches to improve energy management
~	Armin Solemanifar, PhD	A/Prof Bronwyn Laycock Dr Albertus Mostert Dr Tuan Nguyen Ms Rhiannon Creasey	Bio-inspired conducting peptide nanowires
~	Andrew Wheatley, PhD	Prof Peter Knights Prof Stephen Wilson	Large Scale Asset Procurement and Management
~	Mu Xiao, PhD	Prof Lianzhou Wang Dr Bin Luo	New types of photocatalysts
~	Yue Yuan, PhD	A/Prof Greg Birkett Dr Julius Motuzas A/Prof Simon Smart Prof Joao da Costa	Inorganic mixed matrix for liquid processing
~	Chengxi Zhang, PhD	Dr Wuqiang Wu Prof Lianzhou Wang	Interfacial nanoengineering of electrodes for perovskite solar cells
~	Yurou Zhang, PhD	Dr Jung Yun Prof Lianzhou Wang	Defect Engineering of Halide Perovskite Materials for Optoelectronic Applications

Legend

Student whose research forms part of a Dow Centre project
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~ Student whose research does not relate to Dow Centre projects

2019 HDR conferrals

TYPE	STUDENT NAME / PROGRAM	ADVISOR/S	PROJECT TITLE
#	Clement Chan, PhD	A/Prof Bronwyn Laycock A/Prof Steven Pratt Dr Luigi Vandi Prof Peter Halley	Development of bio-derived and biodegradable polyhydroxyalkanaote (PHA)-based wood plastic composites
#	Yuxiang Hu, PhD	Prof Lianzhou Wang Prof Kazuhiro Nogita Dr Delai Ye	Development of Novel Electrode Materials for Next Generation Rechargeable Batteries
*	Franziska Curran, PhD	Prof Paul Lant Prof Chris Greig A/Prof Simon Smart Dr Justine Frances Lacey	Informing energy projects in developing countries by leveraging lessons learnt from the water sector
*	Pawarisa Luangthongkam, PhD	Dr Steven Pratt A/Prof Bronwyn Laycock Prof Paul Lant	Biosynthesis of Polyhydroxyalkanoates (PHAs) in Methane-utilizing Mixed Cultures
*	Amir Nemati Hayati, PhD	Prof Darren Martin Dr Pratheep Annamalai A/Prof Bronwyn Laycock Prof David Evans	Renewable textiles and foams reinforced with nanocellulose
*	Jingwen Zhu, PhD	Prof Lianzhou Wang Prof Ian Ross Gentle	The Study of 2D MXene Anode Materials for High Performance Sodium Ion Batteries
-	Gloria Bravo, PhD	Prof Suresh Bhatia A/Prof Simon Smart	Engineering models of permeation in mixed-matrix membranes
-	Piyali Chakraborty, PhD	Prof Jason Stokes Dr Heather Smyth Dr Torsten Witt	Mechanistic insights into the texture/mouthfeel perceptions of model beverages
-	Dongxu He, MPhil	Prof Lianzhou Wang Dr Jung Yun Dr Yang Bai	Compositional Engineering for Efficient and Stable All-perovskite Tandem Solar Cells
-	Nghia Khang Tran, PhD	Prof Melissa Fitzgerald Prof Michael Gidley Dr Torsten Witt Dr Amanda Durand Mr Simon Stone	Extraction, Characterisation and Properties of protein from by-product of rice milling
-	Manh Tuan Vu, PhD	A/Prof Simon Smart Dr Rijia Lin Prof Suresh Bhatia	Mixed matrix membranes for H_2/CO_2 separation
-	Lourdes Urban Alandete, PhD	Prof Melissa Fitzgerald Prof Michael Gidley Dr Torsten Witt	Lipid degradation during grain storage: markers, mechanisms and shelf-life extension treatments

Legend

Student whose research forms part of a Dow Centre project
* Student whose research is related to Dow Centre projects. Many of these belong to the Energy and Poverty Research Group and Wang Research Group within the AIBN
- Student whose research does not relate to Dow Centre projects

2019 UQ Dow Centre publications

The following were published by UQ Dow Centre researchers during 2019

Book Chapters

Dilkes-Hoffman, L., Pratt, S. Lant, P. & Laycock, B. (2019) The role of biodegradable plastic in solving plastic solid waste accumulation. In S.M. Al-Salem (Eds.), Plastics to Energy (pp. 469-505). Kidlington, Oxford, United Kingdom: Elsevier.

Pratt, S., Vandi, L., Gapes, D., Werker, A., Oehmen, A. & Laycock, B. (2019) Polyhydroxyalkanoate (PHA) bioplastics from organic waste. In (Eds.), Biorefinery: integrated sustainable processes for biomass conversion to biomaterials, biofuels, and fertilizers (pp. 615-638). Springer International Publishing: Springer.

Journal Articles

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Patents

A patent is currently being filed on "Method for forming carbon fibres from PVC" by Associate Professor Bronwyn Laycock.

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UQ DOW CENTRE FOR SUSTAINABLE ENGINEERING INNOVATION

e: dowcentre@uq.edu.au
t: +61 7 334 63883

The University of Queensland
Brisbane QLD 4072
AUSTRALIA

dowcsei.uq.edu.au