ANNUAL REPORT 2014

DOW CENTRE FOR
SUSTAINABLE ENGINEERING INNOVATION

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

SCHOOL OF CHEMICAL ENGINEERING

CONTENTS

PREFACE

MESSAGE FROM THE CHAIR OF THE DOW CENTRE ADVISORY BOARD

On behalf of the Dow Centre Advisory Board, I am delighted to welcome you to the Centre's 2014 annual report. This report encapsulates progress towards ambitious sustainability goals, and gives insights into how the centre is adding momentum to The University of Queensland's broad mission of *knowledge leadership for a better world*. As you will see, the centre not only fosters dial-shifting innovation, it also encourages young researchers and innovators to think big and take calibrated risks.

The Dow Chemical Company's ongoing commitment allows the Centre's thinkers, and their collaborators, to prod territory that is under-explored in the Australian context. For instance, they are adding to knowledge of nuclear power as a carbon free source of base load electricity, and engaging with industry and other academics on novel, low-cost, processes for carbon fibre production that may contribute to lighter, more efficient vehicles.

Throughout 2014, it has been very pleasing to witness the assemblage of a team of individuals who share a commitment to transforming sustainability from an aspiration into a reality.

I congratulate Eric and all his colleagues, as well as their collaborators and partners across UQ and in industry and government, for the milestones of 2014. Moreover I thank Dow for the enabling investment and continuing engagement that are making the centre's ambitious goals credible and attainable.

Professor Peter Høj
President and Vice-Chancellor

DIRECTOR'S MESSAGE: EXECUTIVE SUMMARY

At present, technologies and/or processes do not exist to enable the necessary transition from a world powered by the widely available, low-cost, fossil hydrocarbons which have made possible continuously increasing global socioeconomic opportunity and prosperity to a future world with far more prosperous people powered primarily by environmentally and economically sustainable technologies. The Dow Chemical Company and The University of Queensland have generously dedicated resources to support technology innovations as a means of ensuring a prosperous and sustainable future, including the establishment of our Dow Centre for Sustainable Engineering Innovation.

Centre Mission & Goals

The mission of the Dow Centre for Sustainable Engineering Innovation is to ***foster, identify, and facilitate innovations in economically and environmentally sustainable processes associated with the production and use of energy, chemicals, water, and/or food***. The Centre is working to promote activities which address major challenges and opportunities in support of global "Sustainable Prosperity" beyond the traditional industry development horizons.

Unlike other university-based sustainability initiatives, the Dow Centre at The University of Queensland has taken a top down approach looking first at the overall economic potential and sustainability of novel process options as a necessary first step. The Dow Centre only supports applied research where a sound techno-economic and sustainability case has been or can be made, and when the technical success of the research will likely contribute to enabling high impact processes of benefit to society. Once a compelling case has been made from a conceptual process model which assumes success in the research and technology development, then the science and engineering hurdles needed to enable the process are defined and prioritized for targeted research efforts. The Dow Centre, by design, works very closely with and between industry and university groups as well as with governmental agencies to specifically support the work to overcome the technical challenges.

The overall goals of the Dow Centre are to:

- Foster innovation and new ideas for high-impact processes contributing to the sustainable production and use of energy, chemicals, water, and/or food.
- Develop and apply quantitative methods for techno-economic, life-cycle, and sustainability analyses to new processes and opportunities for sustainable production and use of energy, chemicals, water, and/or food.
- Promote education, communication, and cooperation globally to embrace evidence-based options and approaches to environmental and economic sustainability and recognize industry's key roles in enabling solutions.

Our strategy is to:

I. Promote engineering innovation globally and search widely to identify potentially game-changing process ideas related to large-scale sustainable production of water, food, chemicals, and/or energy,

II. Build conceptual engineering models and perform techno-economic, life cycle, and sustainability analyses for new processes, using the best available methods (and our own new methods) focussing on technical and economic risk-based decision making and quantitative risk assessment,

III. Identify the key scientific and engineering problems requiring solution to enable the commercial deployment for high impact processes which are found to be economically and environmentally sustainable,
IV. Work to couple specific research groups with financial sponsors to conduct the work needed to overcome those scientific and engineering barriers to sustainable processes,
V. Build core competency in the technical analyses as an academic centre, teaching and making the skills available to students, and academic and industrial partners, and
VI. Create global relevance of the Dow Centre through local and international outreach promoting public and private involvement and collaborations and greater awareness of the challenges in creating a sustainable and prosperous global community.

2014 Highlights

During the Dow Centre's first full year of operation we have been fortunate to attract an outstanding technical team of twelve engineers and technologists. We have moved into a newly renovated 225m^2 indoor space designed for creative interactions and equipped with state-of-the-art teleconferencing facilities used for our international collaborations. The Centre was formally inaugurated in December 2014 by the Honourable Ian Macfarlane MP, Federal Minister for Industry and Science, Dr. Andrew Liveris, President and CEO of the Dow Chemical Company and several of his executive team, and UQ's Vice-Chancellor, Professor Peter Høj. The Centre's activities and operation have been guided by a distinguished Advisory Board chaired by our Vice-Chancellor, and benefitting from the addition in 2014 of Dr. Weiguang Yao, Global Director, and Asia-Pacific Chief Technology Officer of the Dow Chemical Company.

Dow Centre Opening Event (17 December 2014): From left to right: Prof. Eric McFarland, Dr. Andrew Liveris, Hon. Ian Macfarlane, MP and Prof. Peter Høj

FOSTERING INNOVATION

A central role of the Centre is to identify means for stimulating innovation related to sustainability. In 2014 the Centre's activities included active participation in the development of the sustainable technology challenge for the G20 $100,000 Global Business Plan Competition, which drew innovative entries from most of the G20 nations addressing challenges in sustainable water production and distribution. The Dow Centre organized and conducted UQ's first participation in the Dow Chemical Sustainability Innovation Student Challenge Award (SISCA) which drew a variety of ideas from amongst the UQ student population addressing Dow's major sustainability challenges. Further, the Dow Centre's new "Pitch Program" attracted eleven original proposals in 2014 addressing major challenges in global sustainability from the UQ academic community which were evaluated by our technical team. Four were selected to receive funding.

TECHNO-ECONOMIC AND SUSTAINABILITY ANALYSIS & RESEARCH

The Centre is building core competency in techno-economic analysis, and the team has been engaged in several technical evaluations of potentially important, sustainable technologies. In collaboration with the Global Change Institute, the UQ Energy Initiative and the Centre for Coal Seam Gas, we are examining realistic engineering supply chain, construction, and labour time limitations on making a "Rapid Switch" to any existing carbon-free energy technology assuming the global community made the decision to do so. We are seeking collaboration and support from industry and government agencies for this important scenario planning study.

One process evaluation completed by the Centre team in 2014 was based on the idea of using high-pressure natural gas pipelines and their existing capital assets (compressors) for electrical energy storage by making use of pressure differentials created by the substation compressor network powered by low-cost off peak electricity along the pipelines. The findings, indicated that, although compressed gas storage could be used for large scale (grid level) energy storage at a cost lower than batteries, neither batteries nor compressed gas storage can compete with pumped hydroelectric or fossil fuel-based peaker plants under realistic pricing scenarios and there is no evidence of sustained grid price differentials to support use of any known storage technology except pumped hydroelectric. Despite the U.S. DOE's major initiatives in grid level storage, we question the techno-economic rationale of these initiatives.

The Centre supported our senior technical analyst, Dr. Daniel Klein-Marcuschamer as the technical lead on a joint project between the Dow Centre, the U.S., Department of Energy Joint Bioenergy Institute, and Statoil, investigating the techno-economics of macroalgae as a major source of carbohydrate feedstock for chemicals and fuels. Although "macro"-algae seem more convenient and practically more efficient than microalgae, the analysis has shown that, as in the case of microalgae, the chemical process of recovering sugars or oils from macroalgae is not competitive with alternatives. Furthermore, the feedstock cost is itself an issue with no immediate prospects for solution. The study and a companion piece, also supported by the Dow Centre, addressing more generally the economics of biofuels will appear in publication in 2015.

In 2014 the Centre initiated a program on innovative approaches to carbon fiber production with the goal of lowering the cost sufficiently to enable widespread carbon fiber use in high fuel efficiency lightweight automobiles. The Dow Centre team led by Dr. Bronwyn Laycock in collaboration with researchers at the AIBN have created a new chemical process option with significant promise for carbon fiber production from polyethylene and nanocellulose. The polyethylene-based fiber project has been partially supported by the Dow Chemical Company. The work from UQ has provided the basis to continue the polyethylene program into 2015 with partial funding from Dow and potentially an ARC Linkage grant. An ARC Discovery grant was awarded to the Dow Centre team investigators for nanocellulose-based carbon fiber research that will also fund the 2015 work.

Nuclear power is the only proven technology capable of producing the massive quantities of affordable electricity needed to power the mega cities of the future without producing carbon dioxide. Today's low-cost fossil fuels limit the competitiveness of nuclear power, nonetheless China, India, and Russia are moving aggressively forward on building their nuclear technology base. The Dow Centre has been developing novel chemical processes making use of nuclear processes to allow co-production of valuable chemicals improving the value proposition of nuclear reactors despite low fossil feedstock prices. A major patent application from Dow Centre inventors has been filed and experiments in collaboration with ANSTO are proceeding. Our strategy is to provide the chemical industry with sufficient incentive to build and maintain expertise and competency in nuclear technology so that when western democracies come to embrace nuclear power, there will still exist a knowledge and skills base.

EDUCATION, COMMUNICATION & OUTREACH

As part of the School of Chemical Engineering the Dow Centre's major commitment is to the education of students. Our team has been directly involved in teaching courses and in delivering academic seminars on topics related to the sustainable production of energy, chemicals, water and food. Eleven topical meetings and workshops were organized or co-sponsored by the Dow Centre in 2014 including an international workshop on the Future Directions of the Chemical and Fuels industry and a workshop addressing novel engineering approaches to reducing methane emissions from livestock.

In 2014, the Dow Centre initiated a visiting Fellows program which attracted Ph.D. students from MIT, CalTech, and the University of California to come to the Dow Centre for several months working with the Centre team on techno-economic evaluations related to their thesis research (flow batteries, solar hydrogen, and radiation-based chemical synthesis). Increasing collaboration and exchange of ideas between individuals from top international universities and industry teams and the UQ students and faculty is a major objective of the Dow Centre.

Arguably, an economically sustainable transition away from fossil fuel combustion is the world's most important challenge. From our inception and continuing through 2014 the Dow Centre has been engaged in activities to support public awareness and dialog within Australia regarding nuclear power. Further, this year the Dow Centre has contributed to informing governmental agencies about the nuclear options (Canberra Energy Round Table and Queensland PowerQ Expert Panel), as well as communicating to the community by delivering ten public lectures on nuclear power and participating in industry panels and the televised Awaken Forum on uranium mining and waste storage. Together with the GCI, the Dow Centre has authored a widely cited editorial on nuclear power for Australia, and the Dow Centre has supervised a student team evaluating the business case for spent fuel storage and reprocessing in Australia.

The Dow Centre in 2015

In the year to come most of the Dow Centre's activities will follow the same basic themes as 2014 consistent with the Centre Mission and our overall vision. We will continue to work to foster innovation through promotion of activities that engage the global community in generating ideas in sustainable engineering related to chemicals, fuel, water, and food. Together with workshops, seminars and competitions the Centre plans to implement a new program directed at sustainable technology start-ups (the "Elevator Pitch" program) which we hope to build in collaboration with the UQ Business School and UniQuest. For 2015 the Centre is delighted to have increased participation by Dr. Simon Smart and Dr. Bronwyn Laycock making possible several of our core projects.

We will further build the Dow Centre's core competencies in techno-economic analysis and we plan to develop and introduce an academic course offering within Chemical Engineering on the subject. We will continue the focussed detailed technical efforts in applications of nuclear science to chemical processes (with ANSTO), carbon fibres (with AIBN and Dow), and in any new processes emerging from our promotion activities and brain-storming sessions. We are also moving forward with technical verification on a novel chemical process for conversion of the light alkanes in natural gas. Preliminary results suggest this may be a "game changer". We are intending to sponsor a new research project looking into the social science question, "why do otherwise logical and data driven technologists ignore evidence supporting the safety and potential of nuclear power as the least expensive low carbon options to limit atmospheric CO_2 increases?" We are also hopeful that, our joint program (with GCI, EI, and SMI) on the Rapid Switch modelling of transition scenarios to significant carbon reductions will attract outside support for 2015.

CENTRE ACTIVITIES

FOSTERING INNOVATION

During its first full year in operation, the Dow Centre developed several initiatives that are aimed at fostering innovation, some which will become annual events.

In addition, the Dow Centre started projects which, if successful, may lead to technical innovation and increased sustainability.

Dow Centre Sponsored Meetings & Workshops

NEW FRONTIERS WORKSHOP

UCSB, 6th of February, 2014

The Dow Centre has initiated an effort to bring together engineers and scientists from industry and academia once a year to look at the future of chemicals, fuels, water and energy.

Because the greatest concentration of the global chemical industry research is in the United States The Dow Centre teamed with the Dow Materials Institute at the University of California, Santa Barbara (UCSB) to create an annual workshop to be jointly sponsored and held at the UCSB campus. This workshop focusses on the topic of new horizons in the energy, food, mining and chemical industries. The aim of the workshop is to bring together forward-thinking engineers and scientists to talk, argue, and speculate about the best ways to secure a healthy future for humankind and the planet.

In 2014 the workshop consisted of brief, provocative forward-thinking presentations aimed to stimulate lively discussions moderated by a panel from each session. The discussions centred not only on technological solutions to current problems, but also on proposing processes that are not currently part of the central R&D activities in industry, but that may emerge in the future if major fundamental problems in chemical and material science and engineering were solved.

Discussions were extremely lively with high levels of audience participation. The main message from the talks and discussions was that, although there is little hope of finding immediate solutions, technology must lead the way in offering alternatives to the *status quo*. Most solutions that have been proposed in the recent past were dismissed on technical, economical, or social grounds. Reduction of methane emissions by curbing livestock methane production attracted significant attention, as this source contributes up to ~10% of CO2-equivalent emissions. The Dow Centre organized a follow-up workshop at UQ on this topic in July 2014.

Organisers: Prof. Eric McFarland (UQ), Prof. Craig Hawker (UCSB), Prof. Chris Greig (UQ), Prof. Michael Doherty (UCSB) and Prof. Glenn Fredrickson;(UCSB).

Sponsors: The Dow Centre for Sustainable Engineering Innovation and the Dow Materials Institute (UCSB).

Meeting website:
https://mrlweb.mrl.ucsb.edu/seminars-and-workshops/2015-New-Frontiers-Workshop

THE UQ-DOW INNOVATION WORKSHOP

UQ, 7th of July 2014

Professor Peter Høj, Vice-Chancellor and President, and Professor Anton Middelberg, Deputy-Vice Chancellor Research, of the University of Queensland (UQ), and both members of the Dow Centre Advisory Board, welcomed researchers from UQ and Dow to the Global Change Institute at UQ for a workshop on Innovative Technologies organised by the Dow Centre.

UQ-Dow Day, Poster Session Dr. Karen Dobson, (Dow) and Mr. Joseph John, Ph.D. student (UQ)

Aim of the workshop was to showcase UQ's capabilities and programs and to establish contacts between the two groups. A delegation of Dow scientists from Australia, the United States and China attended the workshop in person, while many other Dow scientists attended by way of a video link and actively participated in the discussions.

Several top UQ scientists and engineers presented the latest developments in their research. Additionally an Oxford style student debate, a poster session, and the final round of UQ's first edition of SISCA highlighted the talent of UQ's top science and engineering students. The students clearly appreciated the opportunity to receive feedback from an industry perspective. Follow up after the workshop resulted in further discussions between Dow and UQ researchers and may eventually lead to collaborations.

Organiser: The Dow Centre for Sustainable Engineering Innovation.

DEVELOPING AND FUNDING SYNBIO RESEARCH IN AUSTRALIA & NEW ZEALAND

UQ, 11th of July 2014

To tackle the current global challenges, more investment is necessary towards powerful technologies that can provide rapid solutions to emerging problems (food production, climate change, contaminated soil and water, etc.). Synthetic biology (SynBio) provides a foundation for biotechnologies that can deliver solutions across a broad range of problems. Moreover, SynBio has a significant economic potential: the global SynBio market in 2013 was $2.1 Bn USD, and is expected to grow to $11.8 Bn USD by 2018. SynBio is an emerging/established discipline in the USA and Europe. In Australia and New Zealand, there is much strength in SynBio research but the community has hitherto been relatively disparate and not collectively focussed on SynBio application and advancement. This workshop focused on bringing that community together and establishing an industry organisation to promote growth and development of this technology in the Australia/New Zealand region.

The workshop involved two major events. Firstly, a full day SynBio session was held at the NanoBio Innovation Conference (Brisbane) on the 10th of July; this served as an introduction to SynBio research undertaken in Australia and New Zealand. The second event was a full day strategic positioning workshop on the 11th of July. Around 40 delegates from Australian and New Zealand universities and other research organisations attended the workshop. The strengths of the current community were identified and a Steering Committee, consisting of one representative from each organisation, was established in order to help push agendas forward.

The Steering Committee held a follow-up Annual General Meeting in Melbourne on the 4th of February 2015 to elect executive members, discuss progress and formalise arrangements for a Synthetic Biology society in Australia/New Zealand. Following up on the workshop, the community has been building momentum across Australia and

New Zealand. This is best evidenced by the fact that since July 2014 an increased number of professional meetings in SynBio either took place in New Zealand and Australia or are scheduled for the near future. The workshop was a great success in terms of achieving its stated goals; the SynBio community in Australia/New Zealand is now well positioned to move forward into an exciting future.

SynBio Workshop Dinner

Organisers: Dr. Claudia Vickers (Australian Institute for Bioengineering and Nanotechnology, The University of Queensland) and Dr. Colin Scott (CSIRO Ecosystem Sciences);

Sponsors: the Dow Centre for Sustainable Engineering Innovation and the Office of Naval Research Global.

REDUCING LIVESTOCK BIOMETHANE EMISSSIONS
Opportunities for New Approaches?

UQ, 17th of July 2014

The technical challenges of reducing greenhouse gas emissions while maintaining a vigorous economy are immense. The reduction of methane emissions from livestock is recognised as one of the few opportunities where reducing the basic emission source might lead to economic gains through better use of the energy in feed. Although considerable research has been directed at this issue worldwide, significant opportunities may still remain to reduce these major emissions.

A workshop was held on the 17th of July 2014 in the Global Change institute at UQ and brought together thirty-three local and international experts in the field of biomethane reduction from livestock. The aim of the workshop was to explore current work in the area of reducing green house gass emissions from livestock along with identifying new strategies, approaches, collaborations, projects and funding opportunities to address the challenge.

Participants in the workshop were exposed to details on past work in the field, the extensive work being undertaken in New Zealand and the challenges faced by the livestock industry. Details surrounding methane production and reduction were explored through the consideration of gut health, the microbiota and the biochemistry of methanogenesis together with perspectives from the related field of anaerobic digestion research. Possible topics for sources of solutions were explored through animal nutrition, herd management, alternative feeds, viruses and exogenous enzymes, as well as improved methods to monitor methane production in animals, both in the field and in laboratory environments.

The main conclusions from the workshop were that the most significant reduction in methane production would most likely be made through improved herd management (earlier finishing, faster weight gain and reducing weight loss through dry seasons). Furthermore interventions were proposed to improve weight gain and feed conversion efficiency through feed supplement addition, control of the microbiota and exogenous enzymes. Improved methane measurement techniques for the field were also identified as a key element to better understand and quantify both the challenge and any proposed solutions.

Current ongoing research by Associate Professor Robert Speight focusses on the development of new enzymes that are suited to cattle as well as innovations in the delivery systems (such as nutrient licks) to allow supplements such as animal feed enzymes to be delivered to free grazing livestock (as opposed to those in feedlots or dairies) in a practical and economic manner.

Organiser: A/Prof. Robert Speight (Queensland University of Technology and Dow Centre Consultant);

Sponsor: the Dow Centre for Sustainable Engineering Innovation.

UQ NEXT GENERATION FERTILIZER INITIATIVE

UQ, 13th of November 2014

The Dow Centre has helped facilitate the startup of a UQ initiative into novel fertiliser research, sponsoring a workshop in 2014 (through the Dow Centre's Pitch Program) that brought together UQ experts from across a range of disciplines with government and industry stakeholders. The initiative, led by Professor Susanne Schmidt (UQ School of Agriculture and Food Sciences) and Professor Damien Batstone (UQ Advanced Water Management Centre), seeks to establish a multi-disciplinary research program into 'next-generation' fertiliser opportunities.

The initiative will develop solutions to global nutrient supply and pollution challenges. It will integrate developments in plant, soil microbiology and materials science, source material from recycled nutrient streams, and fertiliser product development engineering.

Outcomes from this initiative would not only deliver immense local benefits to management of the Great Barrier Reef, but also have global significance in regions (such as China) with rapidly escalating nutrient pollution challenges. With the support of the UQ Global Change Institute, further workshops are planned (in Queensland and China) to expand the stakeholder base and attract seed-funding to commence research activities.

Organiser: Prof. Susanne Schmidt (The University of Queensland);
Sponsor: the Dow Centre for Sustainable Engineering Innovation.

Competitions

THE G20 GLOBAL BUSINESS CHALLENGE (G20 GBC)

In early 2014 a Dow Centre initiative for a $100,000 business plan competition aimed at stimulating entrepreneurship in innovative sustainable engineering technology among students merged with a similar idea from the Queensland University of Technology. A third Brisbane based university, Griffith University, joined the scheme and the result was the "G20 Global Business Challenge" Each of the three Universities supports the competition with $100,000 annually for the duration of at least seven years. The Dow Centre maintained a leadership role by representing UQ on the steering committee and assured that the original purpose of stimulating innovative technology remained the firm focus point of the competition.

The challenge set for the 2014 competition, with over $100,000 AUD in prize money, was to develop an innovative solution to use, recycle and/or manage water to achieve a large-scale beneficial impact. It was aimed at capturing new industry development opportunities through more effective management of water constraints. Proposed solutions were to consider a mix of new technologies and past innovative business models to develop sustainable solutions of practical value and maximum impact.

Submissions from 18 countries were received. Six teams were invited to participate in the final round. All finalist teams were submitted to a two day lock-in period to adjust their plan to a set of constraints set by the jury. Each team was dictated the country in which to execute their plans and a specific bank to work with. Subsequently, in the finals on the 6th of November, each team presented its pitch to a jury comprised of CEO's and Directors of leading companies and government organisations.

One of the participants, Mr Callum Hickey, (early 2015 recruit for the Dow Centre) stated that the G20 GBC offered him "a unique chance to see how a small group of diversified people can make global impact through technology and innovation".

The results were as follows:

- First prize: '*Team Memorial'* from the Memorial University of Newfoundland, Canada. They proposed a system that allows to monitor, pump, treat and recycle salt water to achieve the same irrigation results as with fresh water.
- Second prize: '*BioRangers*', a composite team from the Warsaw School of Economics and the University of Warsaw, Poland. They devised a water purification station powered by solar energy with a mix of technologies that can also provide economic value to local business.
- Third prize: *'Impacts Solutions'* from Griffith University, Australia. Their submission was a sustainable alternative for the treatment of waste brine that would also provide economic benefit to the communities.

SUSTAINABILITY INNOVATION STUDENT CHALLENGE AWARD (SISCA)

In 2014, the Dow Centre organised the inaugural round of Dow's SISCA at the University of Queensland. Three submissions were selected for the final round of presentations on the 7th of July. This date was specifically chosen to coincide with the visit of several Dow Researchers to the UQ-Dow Innovation Day Workshop. The final round took place directly following the workshop.

Final round judges were:

- Prof. Max Lu, Provost and Senior Vice-President, The University of Queensland.
- Dr. Weiguang Yao, Chief Technology Officer, Asia Pacific R&D, Global Director, Energy Materials R&D, Dow Chemical.
- Mr. Tony Frencham, Managing Director, Dow Australia and New Zealand.
- Dr. Andre Argenton, R&D Director, Corporate Venturing and External Technology.

First prize (10,000 AUD) went to a team of four students: Mr. Timothy McCubbin, Mr. Axayacatl Gonzalez Garcia, Mr. Jason Jooste and Mr. Carlos Luna, all four from the Australian Institute of Bioengineering and Nanotechnology at UQ. Their submission proposed *"Bioconversion of C3 Chemicals through Bacterial Fermentation".*

First prize winners with Jury

Second prize ($2,500 AUD) was won by Ms. Pritii Tam Wai Yin from the UQ School of Chemical Engineering for "*Biogenic hydrogen sulphide generation using mining and municipal waste"*.

Runner up ($100 AUD movie voucher) was Ms. Valentina Urrutia Guada from the UQ School of Geography Planning and Environmental Management who proposed a model on "*Emotions management & organizations' environmental performance"*. This model demonstrates how the understanding and management of emotions that influence decision making on environmental issues can help improve achievement of sustainability.

The next round of SISCA will open mid-April 2015.

Other Initiatives

THE PITCH PROGRAM

From January 2014 onwards, the Dow Centre has provided opportunities to gain support and seed funding to anyone with an idea for a potential solution to problems associated with the sustainable production and/or use of water, food, energy or chemicals.

Individuals or groups are asked to submit a proposal with a short summary of the problem and their envisaged solution. If a first analysis shows promise, an invitation to present the proposal to the Dow Centre team follows. Based on the material provided during the presentation and a discussion with the applicant, one team member will further investigate, analyze and assess the proposal and report his findings to the team. Once consensus on the outcome has been reached, the presenter is officially notified.

In 2014 11 proposals were submitted under the Pitch Program. Four Pitches were approved with a total of $358,175 (AUD) awarded:

- Professor Chris Greig (The University of Queensland)
  - ◊ Energy-Poverty Nexus – funding for 2 PhD students over 3.5 years ($227.5k in total to start in 2015).
- Dr. Esteban Marcellin (The University of Queensland)
  - ◊ Gas Fermentation & Methanotroph Fermentation – 6 months' funding for a Research Assistant, consumables and a workshop at $62.5k.
  - ◊ If TEA during the 6 months' period demonstrates a positive outcome another period of 6 months will be funded at $62.5k.
- Professor Susanne Schmidt (The University of Queensland)
  - ◊ Workshop: Next generation fertilisers – the Dow Centre agreed to pay for Catering. Costs came to $675.
- Associate Professor Robert Speight (Queensland University of Technology)
  - ◊ Enzyme Engineering – $5,000 seeding fund. If experiments show good results, further collaboration and funding may follow. To be evaluated third quarter 2015.

The other seven proposals were declined for funding; five of those were presented to the team, while two were declined upon first assessment.

CENTRE BRAINSTORMING

Innovation, more often than not, is unplanned and comes from unstructured and informal engagements of a wide range of thinkers. The Dow Centre supports this reality with irregular, informal gatherings of scholars from across campus who sit together (or join by Skype) and work on problems.

Out of these informal settings, have come several ideas that the Dow Centre team examined or is examining as possible core projects. The outcomes for 2014 include several concepts that have moved into further evaluation stages with techno-economic or feasibility studies which include:

- New concepts in carbon fibre formation using fire suppression technology.
- Realistic constraints to deploying carbon free power production; rapid switch project.
- Crowd sourcing innovation and innovators.
- Energy storage in existing pressurized gas infrastructure.
- Co-produced electricity and chemicals from nuclear processes.
- Opportunities for innovation in smart windows.
- Mechanochemical co-production of chemicals in mining.

ANALYSES AND FEASIBILITY STUDIES

Techno-economic & Sustainability Analyses

THE RAPID SWITCH PROJECT

A Global Transition to a Low Carbon Economy: Limits of Possibility?

Dr. Joe Lane, Dr. Diego Schmeda Lopez, Dr. Simon Smart, Prof. Andrew Garnett (SMI CCSG), Prof. Chris Greig (Energy Initiative) and Prof. Ove Hoegh-Guldberg (GCI).

A massive transformation of the global energy economy is required if we are to make the deep reductions necessary to prevent atmospheric CO2 concentrations exceeding 450 ppm (the 2 Degrees C Scenario or '2DS'). The speed of this transition is poorly understood and often marginalized by policy makers, activists and technology experts/ advocates alike. The project examines the various stabilization wedges[1] that have been proposed to affect the decarbonisation transition for resource constraints, supply chains, manufacturing and organisational limits, constraints and bottlenecks to determine the maximum rate at which the world could realistically decarbonise the energy economy.

Our hypothesis is that 2DS is no longer achievable and if this holds true, we will determine what this means for atmospheric CO_2 concentrations. The initial phase will assume that positive policies and maximum economic incentives are adopted internationally to remove all non-technical barriers to decarbonisation investment decisions. The second phase of the project will consider capital availability and economic growth impacts. The outcomes will inform policy makers and industry leaders to make appropriate decisions about the future based on a proper understanding of the scale and pace of deployment that is realistically achievable.

Preliminary work[2] examined the transition required in the electricity sector from the perspective of infrastructure deployment rates and questioned how challenging the burden of early asset retirement might become in the event of such a rapid transition. Coal-fired electricity was used as the primary lens for examining these issues. The analysis suggests that the transition to a low-carbon power generation fleet could increase the required power plant deployment by up to ~25% over and above the already ambitious and historically unprecedented deployment rates necessary to meet projected demand growth. This increase is driven by the need for early replacement of coal-fired power plant and an increased reliance on intermittent renewables. The analysis also makes clear that the greater the delay at starting a significant transformation, the greater the barrier the human and material resource limitations will become. Lastly, we found that a broad international consensus is not required – instead, reaching agreements and developing economically sustainable pathways to technology transitions in the U.S., China, and India is more likely to be successful and the only means for significantly curbing global emissions.

1) For example see: Pacala, S. & Socolow, R. Science 2004, 305, 968

Davis, S. J., et al. Environmental Research Letters 2013, 8, 011001

2) Under peer review at Wiley Interdiciplinary Reviews: Energy & Environment.

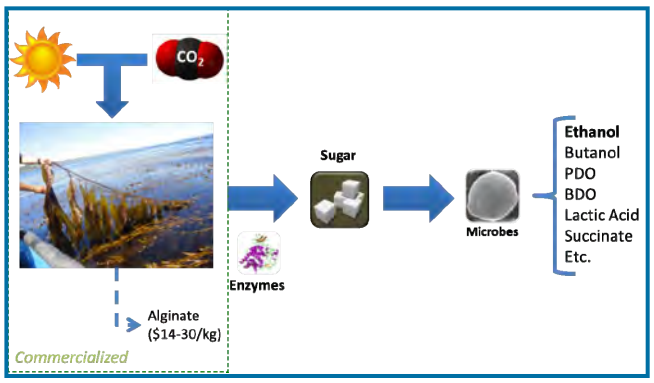
Illustration adapted from Pacala, S. & Socolow, R. Science 2004, 305, 968

USE OF MACROALGAE BIOMASS FOR PRODUCTION OF FUELS AND CHEMICALS

Dr. Daniel Klein-Marcuschamer

Macroalgae biomass has been considered as a prospective feedstock for biofuel production as, among other benefits, it is an abundant source of renewable sugars and its growth does not require arable land, fresh water, or intense care. Successful commercial deployment of macroalgae -based biorefineries, however, depends on their economic viability at industrial scales. A key objective of this study was to carry out a detailed techno-economic analysis (TEA) of a macroalgae biorefinery to understand the economic potential and cost drivers of macroalgae as a feedstock for the production of biofuels and biochemicals.

Ethanol was used as a representative macroalgae-derived product, given the wealth of public information available to model this option, and the analysis was extended to biomass-derived sugars in order to explore the production of other fermentation-derived chemicals. Sensitivity analysis was performed on various cost drivers, such as macroalgae price, yield, solids loading and enzyme loading during hydrolysis.



The results indicate that, at present, this technology is unlikely to be economically viable. With a feedstock price of US$100/MT, depending on the maturity of the other key process parameters (i.e., yield, solids loading, and enzyme loading), the minimum ethanol selling price (MESP) was observed to be in the range of US$3.6–8.5/gal and reduced to US$2.9–7.5/gal with macroalgae priced at US$50/MT. For production of chemicals, sugar prices were in the range of US¢21–47/lb or ¢ 16–40/lb with macroalgae priced at US$100/MT and US$50/MT, respectively. Given the challenging economics of the macroalgae biorefinery, coproduction of alginate was used to demonstrate the importance of multiple revenue sources, though issues regarding market saturation continue to arise when dealing with products of disparate market sizes.

This study was performed in collaboration with the Joint Bioenergy Institute and Lawrence Berkeley National Laboratory. The analysis was the basis of a publication that was recently accepted to a special issue of BioEnergy Research, a peer-reviewed journal focused on the bioenergy community with an impact factor of 3.398 (2013).

COLLABORATION WITH THE BRISBANE AIRPORT CORPORATION

Mr. Joe Lane, Dr. Tony Howes (B.A.C.) and Ms. Maddalene Gabrielli

The Dow Centre has signed a letter of intent-to-collaborate with the Brisbane Airport Corporation, due to their motivation to explore novel solutions to environmental sustainability challenges, and their unique access to resources for applied research across a variety of disciplines.

Under this collaboration, a Chemical Engineering student project has recently assessed opportunities for reducing greenhouse gas emissions via operational changes at the Brisbane Airport. The work identifies the potential for substantial benefits to be delivered through changes to aspects of airport management that are peripheral to the direct responsibilities of the airport owner – most notably in the management of plane activities on the tarmac and the transport of workers and passengers to the airport precinct.

The next phase of the project will be to characterise the global opportunities for reducing greenhouse gas emissions from airports around the world.

COMPRESSED GAS ENERGY STORAGE (CAES)

Mr. Tom McConnaughy, Mr. Conor Young, and
Dr. Daniel Klein-Marcuschamer

Energy storage has attracted significant attention in recent years, as it would enable the integration of intermittent renewable energy technologies into the grid, thus reducing anthropogenic greenhouse gas emissions and potentially lowering electricity prices and their volatility simultaneously. However, deployment of energy storage systems will remain limited unless they become attractive investments compared to alternatives. CAES has been proposed for many different energy storage applications, however, identifying an economically competitive application remains for widespread adoption.

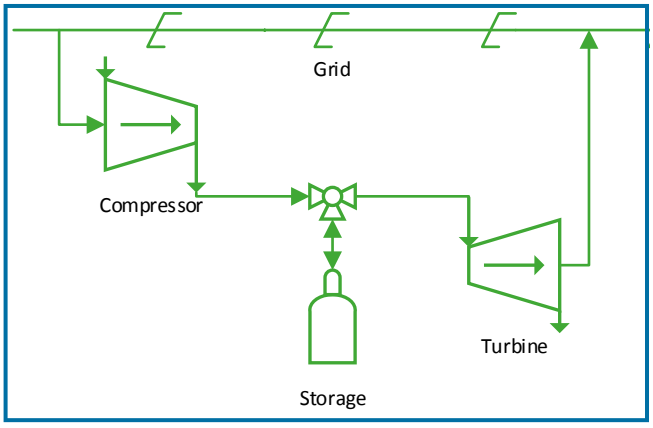
Natural Gas Pipelines

The present study aimed at exploring the techno-economic viability of compression-based energy storage in natural gas pipelines (NGPs) for arbitrage applications. This option has significant technical advantages compared to other energy storage technologies, including scalability and reliance on proven and widely available equipment and infrastructure.

The analysis shows that compression-based storage in non-operational NGPs has relatively low capital costs and storage costs per cycle, with a total non-energy cost of $0.34/kWh-cycle based on one cycle per day. The analysis also showed that, in order to secure an attractive rate of return, the spread between the purchased electricity (during the 6 hours of charging each cycle) and the electricity sold (during the 2 hours of discharging) must be, averaged over the lifetime of the unit, ~$0.30-0.40/kWh. This value is 1-2 orders of magnitude higher than the average day-ahead market spreads observed in the U.S. and Australian markets, given available data. Based on the analysis presented, it was concluded that current conditions in the electricity market do not warrant the expenditure needed for storage. An in-depth analysis would be required to generalise this conclusion to many locations and to identify buying and selling strategies.

Unconventional Applications

Compressed air energy storage systems consist of an electrically driven air compressor, pressure vessels for storage of high pressure air, and an expander motor coupled to a generator to produce electricity from the compressed air supply. Unconventional configurations of CAES were analysed for compression in underutilised water pipelines or tanks, and the system costs were compared to conventional batteries and hydroelectric alternatives.



For arbitrage of peak and off-peak electricity pricing, use of water pipelines for gas storage will only justify the capital expense if the average electricity price difference exceeds $800/MWh. Water pipeline storage may prove feasible in locations where PHS is not possible and if price spreads increase significantly. In data centre UPS applications, CAES is shown to be competitive with battery systems. Household CAES integrated with PV systems are economically favourable to batteries; however, neither have favourable overall economics. Batteries are superior to CAES for peak shaving applications and may be profitable for certain power consumption profiles.

Feasibility studies & projects

THE CARBON FIBER PROJECT

An exploration of irradiation and catalysis to facilitate dehydrogenation and carbonisation of polyethylene (Co-funded by Dow Chemical)

Dr. Bronwyn Laycock, Dr. Jorge Beltramini (UQ), Dr. Xiaoyu Wang, Dr. Ru-Fen Liu (UCSB) and Dr. Pratheep Annamalai (UQ).

Current production of carbon fibers is dominated by the conversion of special grades of solution spun polyacrylonitrile fibers to the carbon fibers. Polyethylene is a much lower cost raw material, and has a very high theoretical carbon yield. The production of polyethylene fibers can be done by melt spinning, which is also cost advantaged over solution spinning.

Air oxidation is Dow's current preferred process for carbon fiber production from polyethylene, and we need to understand and promote low temperature (<100°C) dehydrogenation/cross-linking of commodity grade polyethylene in order to make this process work. This project fits within the scope of the Dow Centre by enabling lightweight technologies for increased fuel efficiency in transport.

Overall, this work seeks to establish fundamental knowledge associated with the chemistry of dehydrogenation and cross linking of polyethylene to further establish a polyacetylene like structure. The goal of the work is to use this knowledge to develop the precursor materials necessary to survive oxidation and carbonization en route to carbon fibers.

This project uses a range of model systems for studying this low temperature dehydrogenation/ crosslinking process:

1. C_{18} and C_{20} linear alkanes and monounsaturated alkenes.
2. Parafilm – a representative solid alkane/wax blend that is amenable to analysis through dissolution.
3. Polyethylene films.
4. Polyethylene fibers.

Two approaches have been undertaken in parallel: catalytic dehydrogenation (promoted by metal-based catalysts) and dehydrogenation/crosslinking facilitated by ionizing radiation (gamma and ultra-violet) with or without a reactive species (such as bromine and/or iodine) present.

Outcomes to date are:

- Metal salts alone do not promote low temperature (<120 °C), efficient dehydrogenation relative to oxidation.
- Gamma irradiation is very sensitive to environment; to get > 60% gel content in PE, need dried degassed samples blended with low molecular weight polybutadiene.
- Very high mass yields (at 800 °C) of carbonised product have been obtained using bromination of polyethylene under UV irradiation. This is promoted by iodine. Zinc oxide is capable of promoting the regeneration of bromine from the evolved HBr, giving us a process that has the potential for efficient recovery and reuse of the process reagents.

This project will continue in 2015.

COPRODUCTION OF CHEMICAL PRODUCTS FROM NUCLEAR RADIATION FOR IMPROVED PROCESS ECONOMICS

Dr. Diego Lopez, Mr. Tom McConnaughy, Mr. Phil Grosso, Dr. Daniel Klein-Marcuschamer, and Dr. Howard Fong.

Arguably, the most important issue in global sustainability is the elimination of carbon dioxide emissions into the atmosphere from power production and transportation. At present there are no cost effective alternatives to fossil fuels and no indication that the major emitting nations will adopt significant carbon free alternatives.

Nuclear power has a demonstrated reliability and safety record that is superior to all other technology options for large-scale power generation. The perceived risk prevents its use in western democracies and the superior economics of coal and natural gas restricts use elsewhere. The Dow Centre has initiated a program to demonstrate improved value from nuclear reactor systems through the co-production of more valuable chemical products.

Outcomes to date are:

- Developed a novel concept of radiation reactive distillation and demonstrated the basic radiation chemistry for use in production of styrene.
- Filed a major patent application for the general process of radiation reactive distillation.

CARBON DIOXIDE-FREE METHANE CONVERSION TO CHEMICALS AND FUELS

Mr. Tom McConnaughy, Mr. Phil Grosso, Dr. Howard Fong, Dr. Esteban Saldana (AIBN), and Dr. Simon Smart.

A major global challenge, fundamentally and practically, is increasing the sustainability of methane utilization.

Methane is the most abundant fossil resource and can be renewable from carbon dioxide. It is superior to molecular hydrogen as a carrier of chemical potential. At present, no industrial chemical conversions exist that utilize methane efficiently and without significant production of carbon dioxide.

The Dow Centre has recently initiated two programs to investigate more efficient methane utilization. One involves oxyhalogenation and the other uses biological conversion.

CROWDSOURCING INNOVATIVE TALENT FOR THE CHEMICAL INDUSTRY

Dr. Daniel Klein-Marcuschamer.

The global reach of communication systems has made possible the ability to "crowd-source" solutions to problems. Several new businesses have emerged based on providing assistance to companies to create challenges amenable to crowdsourced solutions; examples include platforms that have been already utilized by the chemical industry with partial success.

The Dow Centre is developing methods of challenges and analysis in order to examine whether or not within the crowd-sourced solutions the reasoning and methods used by the individuals creating the solutions are a means of identifying unique and valuable talent. By structuring and analysing inputs to open ended problems, we seek to identify people who "Think Differently".

This project was ideated with the collaboration of Dr. Andrew Smith, a member of the Institute for Social Science Research in the Faculty of Humanities and Social Sciences at UQ and the founder of Leximancer. Leximancer is a set of text analysis tools that allows the identification of common concepts across documents or descriptions. Proof of concept of the methods in this invention has been achieved and the Dow Centre is now engaging the private sector to carry out a pilot program in crowdsourcing of talent.

EDUCATION, OUTREACH & COMMUNICATION

Teaching & Supervision

THE DOW CENTRE VISITING FELLOW PROGRAM

In 2014, the Dow Centre initiated a Visiting Fellow program. Visitors from industry, government and academia are invited to spend a period of one to four months in the Dow Centre and work closely with the team on a subject that is of mutual interest.

The first participants in the program were three doctoral students who worked with the Dow Centre team on techno-economic aspects (chapters) for their thesis research. In 2014 the Centre Fellows were:

- Mr. Nirala Singh, Ph.D. student in Chemical Engineering at the University of California, Santa Barbara. Nirala worked with the Centre team and developed a techno-economic model of H2/Br2 flow batteries. The results were submitted to the Journal of Power Systems for publication.
- Mr. Samuel Shaner, Ph.D. student in Nuclear Engineering at the Massachusetts Institute of Technology. Sam worked with the Centre on a combined chemical/nuclear reactor model and the production of chemicals using nuclear radiation.
- Mr. Matthew Shaner, Ph.D. student in Chemical Engineering at the California Institute of Technology. Matt worked with the Centre on several projects. One was the development of a techno-economic model of solar hydrogen generation and direct comparisons to grid electricity. A manuscript will be submitted shortly. A second project involving the cost of ionizing radiation sources is ongoing.

In the continuing program, in 2015 the Dow Centre will make two Scholarships available to enable students to travel to Brisbane and stay for a period of up to four months over the winter period (coinciding with the northern hemisphere academic summer holidays).

UQ ENERGY CLUB

The Dow Centre mentored a team of students working on a real-world problem and presenting their findings directly to industry members and the UQ Energy Club.

For 2014, the project was to develop a commercialization strategy for nuclear waste management and fuel reprocessing.

SHORT COURSES & LECTURESHIPS

The following were taught in 2014:

- *Applications of theory and theory directed experiments*: Prof. Horia Metiu (UCSB), 9-15 September, jointly hosted with Prof. Debra Bernhardt from the Australian Institute of Bioengineering and Nanotechnology. Prof. Metiu offered a lecture series for UQ graduate students, post-docs, and faculty.
- *Physical Principles of Energy Conversion*: Prof. Eric McFarland: Lecture series for students at UCSB and UQ to be attended by video link, Second Semester 2014.
- *"Solar Energy Costs from the Bottom-Up",* Prof. Eric McFarland: CINF Summer school on 'Reactivity of Nanoparticles for more efficient and sustainable energy conversion', Technical University Denmark, Kobaek Strand, Denmark, 8 -15 August 2014.

UQ Campus Events

Q & A PANEL ON CLIMATE CHANGE

UQ Sustainability Week Event

Each year in August, the University of Queensland encourages all its Schools, Centres and Institutes to organise a special event to raise awareness of sustainability issues.

The Dow Centre's 2014 contribution to 'Sustainability Week' was a panel debate, adapted from the ABC's Q & A program. (A panel of 5 'experts', usually politicians, writers, journalists, scientists or otherwise well-known personalities, answers questions on current events or moral dilemmas raised by the audience or submitted via social media. It is a very popular discussion program in Australia). The lunch time event involved a panel of four experts and a host, while the audience consisted of University staff and students. The subject under discussion was: *"Does anyone care about climate change?"* The lively discussion continued during a light lunch provided by the Dow Centre.

The Dow Centre 'Sustainability Week' activity for 2015 will probably focus on the Dow Centre office space. There is one bare concrete wall in the outdoor area that is in need of a mural. The plan is to organize a competition for the best mural design with a 'Sustainability' theme.

MOVIE NIGHTS

Converting its multi-function collaborative area into a movie theatre, the Dow Centre hosted a screening of 'Pandora's Promise' with opportunity for discussion afterwards. It was an invitation only event, attended by Dow Centre team members, members of the UQ Energy Initiative and a group of students working on an energy related project mentored by Prof. Eric McFarland.

Inspired by the success of the evening, the Dow Centre in collaboration with the UQ Energy Initiative, will make movie nights a regular event open to everyone interested and show films and documentaries with themes related to sustainability. Free pizza and soft drinks should assist raising that interest. Each term, one movie or documentary relating to a specific sustainability issue will be presented.

CAMPUS PRESENTATIONS

- Prof. Eric McFarland: "*Is environmentally and economically sustainable energy production possible?*" Guest lecture in 2nd year chemical engineering course, UQ, 18 September 2014.
- Prof. Eric McFarland: "*Nuclear Power: Why Now*?" lecture in 4th year Mechanical Engineering course, UQ, 21 October 2014.
- Dr. Daniel. Klein-Marcuschamer: "*Techno-economic analysis of biomass-based technologies*", UC Berkeley, November 2014.
- Prof. Eric McFarland: "*Sustainable Chemical and Fuel Production by Techno-economic Based Research*", Seminar at the Australian Institute for Bioengineering and Nantotechnology at The University of Queensland, Brisbane, Australia, 12 June 2014.
- Prof. Eric McFarland: "*Techno-economics in Sustainability*", Talk at Industry Partner Event organised by the School of Chemical Engineering at The University of Queensland, Brisbane , Australia, 26 June 2014.
- Prof. Eric McFarland: "*Creating technologies relevant to a sustainable future: bottom-up or top-down?*", Keynote talk at AIBN Nano-Bio Conference at The University of Queensland, Brisbane, Australia, 8 July 2014.

- Prof. Eric McFarland: "*Does anyone care about climate change?*" Panel Discussion, The University of Queensland, Brisbane, 19 August 2014.
- Prof. Eric McFarland: *"Nuclear Power: An, imperfect, carbon-free energy option - amongst few.*", Talk nuclear energy for 'Energy Express Series', UQ Energy Initiative, Brisbane, 29 October 2014.
- Prof Eric. McFarland: "*Advanced nuclear technology – low cost, low carbon, power generation for competitive industries* ", Talk at Energy Perspectives 2014, a conference organised by the UQ Energy Initiative, Brisbane, 20 November 2014.

Government & Industry Engagement

QUEENSLAND DEPARTMENT OF ENERGY & WATER

PowerQ Energy Expert Panel

At the invitation of the Honorary Mark McArdle, MP, Prof. Eric McFarland became a member of the Electricity Expert Panel developing a 30 year electricity strategy for Queensland.

The Panel is charged to set out the Government's strategic goals and action plan to transition the electricity sector to a system that is resilient, cost-effective and consumer-focused to support the economic and lifestyle aspirations of all Queenslanders.

PowerQ commits to the establishment of the Panel in order to critically examine emerging electricity market challenges and opportunities. The objectives of the Panel are to provide the Queensland Government with future-focused fresh perspectives, expert insights and tailored strategic direction.

PRESENTATIONS, DEBATES, ROUNDTABLE & PANELS

- Prof. Eric McFarland: *"The transformation of the global energy system: What are the policy and technology options and what can we learn from the UK energy narrative?"* Roundtable Discussion on Energy Policy, Energy Policy Institute Australia, Canberra, 17 June 2014.
- Prof. Eric McFarland: "Challenges to promoting innovation across borders", Panel discussion, USA Embassy innovation event, Brisbane, 16 October 2014.
- Prof. Eric McFarland: "The Future of Nuclear Energy", panel discussion, Rio Tinto Breakfast panel organised by the University of Queensland Energy Initiative, Brisbane, 27 October 2014.

INDUSTRY VISITORS

- NuScale: SMR Nuclear Technology; Mr. Chris Colbert, 1 April 2014. Roundtable discussion on new generation small nuclear reactors.
- Dow Chemical: Dr. Andre Argenton and Dr. Chris Derstine, 4-7 July 2014. Discussions research collaboration opportunities in general and the Carbon Fibre project in particular.
- Dr. Asahi Kasei: Takashi Onoe, 21 September. Polymer and membrane expert.

Other Engagement Activities

KEYNOTE TALKS & PRESENTATIONS

- Prof. Eric McFarland: "*Creating technologies relevant to a sustainable future: bottom-up or top-down*?" Seminar at King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia, 8 April 2014.
- Prof. Eric McFarland: "*Fostering Relevant Innovative Solutions and Technologies for Sustainability* ", Presentation at AIRG Winter Meeting 2014, Melbourne, Australia, 27 August 2014.

DEBATES, ROUNDTABLE & PANEL DISCUSSIONS

- Prof. Eric McFarland: "*Uranium: Friend or Foe*" Panel Discussion for Awaken Forum, Broadcasted by SBS ONE on 17 December 2014.
- All Dow Centre Staff: "Nuclear Energy" roundtable discussion with Dr Alexander Bychkov and Dr Greg Storr, organised by Dow Centre, Brisbane, 27 October 2014.

PUBLICATIONS & PATENTS

Publications by Dow Centre Team

- Prof. Ove Hoegh-Guldberg & Prof. Eric. McFarland: "*Let's go nuclear, for the reef's sake*", The Australian, 30 June 2014.

Patents

- *"Carbon fibres from bio-polymer feedstocks":* Dr. Nasim Amiralian, Prof. Darren Martin, Dr. Bronwyn Laycock, Prof. Eric McFarland & Dr. Pratheep Annamalai, Application no 2014901123 *Provisional filed 21 March 2014, now submitted to PCT.*
- *"Production of chemical products using electromagnetic and particle radiation":* Prof. Eric McFarland, Mr. Philip Grosso, Dr. Howard Fong & Dr. Daniel Klein-Marcuschamer. Application US 62/085,976 *Provisional filed 1 December 2014*

Publications Featuring the Dow Centre.

- Mr Jamie. Walker: "*Nuclear Power 'could save reef'*, iSentia, The Australian, 30 June 2014.
- "*Sustainable Prosperity*" Discovery at UQ, p39, 2014.
- "*Clean energy goals could be thwarted by skills and resources shortage*", UQ press release, 17 December 2014.
- "*Dow-UQ sustainable engineering research centre opened*", UQ press release, 17 December 2014.

TEAM MEMBERS

TEAM MEMBERS

Professor Eric McFarland, Director.

Eric is the Dow Chemical Chair Professor in the School of Chemical Engineering. Eric has an international reputation for his research in catalysis and fundamental chemical science related to energy and chemical conversions.

Eric studied nuclear engineering at the University of California, Berkeley and the Massachusetts Institute of Technology (MIT) where he received his Ph.D. and later joined the Nuclear Engineering Department faculty. He moved to the University of California, Santa Barbara (UCSB) where his research focus shifted to chemical reaction phenomena and catalysis. Prior to his move to The University of Queensland in 2014, he was a Professor of Chemical Engineering at UCSB. Eric has worked extensively with industry and started and led several technology companies based on university research, among them Symyx Technologies and Gas Reaction Technologies. Eric also studied medicine, received his M.D. from Harvard Medical School and practiced emergency medicine part-time until 2005. He has continued to serve as a volunteer physician for several relief agencies.

Professor Lars Nielsen, Deputy Director.

Lars heads the Systems and Synthetic Biology Group at the Australian Institute for Bioengineering and Nanotechnology (AIBN). Using thermodynamic principles, novel approaches are developed for the rational design of complex pathways as well as handling complex, transient dynamics in developing tissue. A team of 50 people use these novel approaches in the design of bioprocesses as diverse as the production of blood cells for transfusion and the production of industrial biopolymers.

Lars has contributed extensively to genome scale modelling, developing the first models for animals and plants and the first multi-tissue model to describe C4 metabolism. Much of his group's work is focussed on integrating flux analysis with comprehensive omics analysis (genomics, proteomics, metabolomics) and he heads the Queensland Node of Metabolomics Australia.

Lars was part of the team that devised the concept plan that led to the UQ-Dow Donation agreement in 2012 and the birth of the Dow Centre. He remains closely involved with the Dow Centre as its Deputy Director.

Ms. Celestien Warnaar, Centre Manager.

After moving to Australia and qualifying as a business administrator, Celestien took up a position at The University of Melbourne in 2004 and has since worked in several senior administrative roles. In 2009, she joined the ARC Centre of Excellence for Functional Nanomaterials at The University of Queensland, and worked as its Centre Manager, taking responsibility for the centre's operational needs. In July 2013 she joined the Dow Centre where she assists the Director and manages all operational matters.

Dr. Howard Fong, Senior Consultant (from February 2014).

Howard received his Bachelor of Science in Chemical Engineering from San José State University in 1971, and Ph.D. in Chemical Engineering from the University of California, Berkeley in 1975. He joined Shell Development Company (Shell Oil Company) at the then Westhollow Research Center in Houston, Texas, in 1975, and rose to the rank of Managing Engineer, the highest technical rank of the Royal Dutch Shell Group. He retired from Shell in April of 2010. Howard has broad and deep knowledge of the petrochemical industry and specializes in new technology assessment, development and commercialization, functioning primarily at the interface between technology and business. He is the holder of over 30 patents and several of the major developments he helped initiate have been piloted and commercialized.

Since retirement, Howard is working with, a number of start-up companies in vastly different technology fields, helping to identify opportunity spaces, provide critical techno-economic evaluations and chart the paths for successful commercialization.

Mr. Philip Grosso, Senior Consultant (from April 2014).

Phil contributes to the Dow Centre by providing economic analysis and process development services. Phil has over 40 years of industrial engineering experience, mostly at DuPont and Kaiser Chemical. While at Kaiser Aluminum, Phil served in several positions, including Vice President of Technology and Vice President and General Manager of the Harshaw Division in the manufacture of catalysts. He currently serves as a senior level consultant to the chemicals and metals industries. Phil has substantial experience in the design of new chemical processes and is an expert at reducing costs in existing chemical processes, including natural gas reformers. Phil holds a Master's Degree in Chemical Engineering from Cornell University.

Dr. Daniel Klein-Marcuschamer, Senior Analyst (from February 2014).

Daniel is a consultant for the Dow Centre, working on projects across the board, providing expertise in techno-economic analysis of chemical processes. In addition, he is the CTO and co-founder of Versa Sorghum Solutions, a project development company that manages renewable energy projects, principally in Latin America. Previously, Daniel was the Director of Techno-economic Analysis at the Joint Bioenergy Institute (JBEI), and Project Scientist at Lawrence Berkeley National Laboratory (Berkeley Lab). In recognition of his successes, Daniel was the 2012 recipient of the Berkeley Lab Early Career Award for Exceptional Achievement and the 2012 JBEI Technical Contribution Award.

Daniel is the author of seven patents, among them four currently licensed, and has authored numerous peer-reviewed publications in the field. His work has been highlighted by The Economist, *Science* Magazine, Biofuels Digest, Science Daily, The Age, The Sydney Morning Herald and The Australian, among others. He has lectured at the Massachusetts Institute of Technology and at the University of California, Berkeley.

Daniel graduated *Summa Cum Laude* with a B.S. in Chemical Engineering from the University of Texas at Austin and holds a Ph.D. in Chemical Engineering from the Massachusetts Institute of Technology.

Dr. Bronwyn Laycock, Senior Research Fellow (part-time, from April 2014).

Bronwyn is currently working across a range of projects, including biopolymer research, carbon nanofibre production and peptide based conducting nanowires. Her work for the Dow Centre focuses on the conversion of bioderived and polyethylene into carbon fibres for lightweighting applications.

Bronwyn has a diverse background in translational research including degradable polymers, biomaterials, organic and organometallic synthesis, pulp and paper chemistry, and general polymer chemistry. As a Project Leader and Deputy Program Leader within the CRC for Polymers, she managed a project that delivered an oxodegradable thin film polyethylene that was commercially licenced by Integrated Packaging. This work earned the team a Joint Chairman's Award for research/commercialization (CRC for Polymers).

A former Senior Research Scientist (CSIRO Division of Molecular Science), she was awarded the Joint CSIRO Medal for Research Achievement in 2009 for her work on the extended wear contact lens project (within the Vision CRC), which was successfully commercialised by Ciba Vision as the Focus Day/Night and the O2Optix lenses. More than half of all contact lenses sold in the world today are silicone hydrogel lenses, which had their genesis in Australia through the CRC program, bringing much increased comfort to millions of people worldwide. In 2007 alone, the licence revenues from the sale of these products earned the Vision CRC more than $15 million.

Bronwyn has extensive experience in statistical analysis in diverse processes such as wastewater chemistry, kinetics of chemical reactions, etc. She has four years' experience in the pulp and paper industry, working on novel chlorine-free bleaching technologies.

Dr. Simon Smart, Senior Research Fellow (part-time, from August 2014).

Simon is a Senior Lecturer in the School of Chemical Engineering at The University of Queensland. In the Dow Centre he has primarily been involved in the Rapid Switch project. Along with Prof. Chris Greig and Prof. Paul Lant, Simon is a co-founder of the Energy and Poverty Research Group (EPRG) under the UQ Energy Initiative, whose research revolves around understanding how poverty and energy are interconnected in the developing world, including remote indigenous communities in Australia. The EPRG, which collaborates with the Dow Centre, takes a transdisciplinary approach to the challenge from modelling, analysis, scenario and policy formulation in order to develop holistic solutions that are reliable and affordable.

Other research foci include developing enabling technologies for clean energy and water applications. This work involves the design and development of inorganic and hybrid nanocomposite materials for membranes and membrane reactors. In conjunction with UQ's Functional Interfacial Materials and Membranes Laboratory (FIM^{2}Lab) where he is deputy-director, Simon is pursuing a range of novel membrane morphologies.

Simon has 48 publications including eight book chapters and 40 international peer-reviewed journal articles.

Mr. Barry Ball, Consultant (till August 2014).

Barry is Executive Director, Strategic Engagement, CRC for Water Sensitive Cities. His key duties are to co-lead the Adoption of Portfolio Plan for the CRCWSC. The plan is based on understanding and supporting the needs of stakeholders and provides the mechanism to support the transition of cities to water sensitive cities.

Barry was previously the Director for Strategy and Policy at the Global Change Institute at The University of Queensland. Barry has worked in both State and Local Government in his 40 year career, predominately in the water sector. His most recent role in Brisbane City Council was Assistant Director, Strategic Planning.

Barry has held positions on the Urban Water Advisory Committee for the National Water Commission and Board positions on Queensland Urban Utilities, the CRC Catchment Hydrology and CRC Coastal Zone. In 2010 Barry was awarded an Australian Public Service Medal for his achievements in water policy.

Associate Professor Robert Speight, Consultant.

Robert is Associate Professor in Microbial Biotechnology at Queensland University of Technology, focused on enzyme development and protein production systems for industrial biotechnology applications.

Previously, he was at the Australian Institute for Bioengineering and Nanotechnology (AIBN) at The University of Queensland, working with Professor Lars Nielsen. At the AIBN he researched biofuel and protein technologies (focused on animal feed enzymes) in parallel with operational management of the Systems and Synthetic Biology Group. He was the project manager of the Queensland Government funded multi-partner Queensland Sustainable Aviation Fuel Initiative, working with companies such as Boeing, Virgin Australia and GE. He was also a start-up manager for the Dow Centre.

After post-doctoral work with Professors Nicholas Turner and Sabine Flitsch at The University of Edinburgh, he co-founded the industrial biotechnology company Ingenza Ltd. He led the biotechnology research team that worked extensively on the directed evolution of amine and amino acid oxidase enzymes for altered specificity and improved stability in industrial chemical manufacturing processes. The team also developed high throughput screening technologies and novel biofuel and biopharmaceutical microbial production strains.

Robert has a degree in chemistry from Imperial College London and a Ph.D. in biochemistry from the University of Cambridge.

Dr. Pratheep Annamalai, Research Fellow (from April 2014).

Pratheep is Materials Engineer at the Australian Institute for Bioengineering and Nanotechnology at The University of Queensland. His research interests focus mainly on the formulation, processing and evaluation of polymer nanocomposites for industrial applications and biobased polymers and nanocomposites as sustainable materials.

During 2014 Pratheep was part of the Dow Centre team that worked on the Carbon Fiber Project.

Before joining UQ, Pratheep studied Chemistry at The University of Madras, received his Ph.D. in Chemistry from The University of Pune (India), then went on to work as postdoctoral researcher on polymer membranes at The University of Montpellier II (France), and on smart polymer nanocomposites at the Adolphe Merkle Institute of The University of Fribourg (Switzerland).

Mr. Joe Lane, Postdoctoral Research Fellow (from July 2014).

Joe is a Research Fellow, with a professional background spanning process engineering, water resource planning, and environmental management. His past research has focused on the science of sustainability assessment, putting priority on bridging the gap between methodological robustness and practicality for decision makers. Much of that work used the Life Cycle Assessment (LCA) methodology – analysing applied case studies in the urban water industry, but with a strong focus on developing improved datasets and impact assessment models for this task. Prior to joining the Dow Centre, Joe also lead the UQ contribution to the development of the Australian Industrial Ecology Virtual Laboratory – a collaboration between nine different Australian research groups, developing innovative tools for coupled environmental-economic analysis.

Joe has contributed to the Rapid Switch project, compiling preliminary analysis of global energy system forecasts. Joe also manages the Dow Centre interactions with the Brisbane Airport Corporation and has been reviewing opportunities for solutions to sustainability challenges associated with water and plant nutrients management. As a part of the latter, Joe has assisted the startup of a multidisciplinary UQ research initiative into novel fertiliser products and processes.

Dr. Xiaoyu Wang, Postdoctoral Research Fellow (from July 2014).

Xiaoyu was awarded a Bachelor of Science in Materials Engineering from YanShan University, China in 2003 and a Ph.D. in Chemical Engineering from The University of Queensland, Brisbane in 2014. She has a background in inorganic materials engineering, and worked as a research chemist and laboratory manager in a chemistry laboratory centre in China for four years. Xiaoyu also worked on coal seam gas water treatment as her Ph.D. topic. After completion of her Ph.D, Xiaoyu joined the Dow Centre in 2014 where she is working on the Carbon Fibre project full time.

Mr. Thomas McConnaughy, Analyst (from July 2014).

Tom graduated in 2012 from UCSB with an undergraduate degree in chemical engineering and a technology management focus. Following graduation he worked as a process engineer in the pharmaceutical industry. The work focused on specification, installation, and commissioning of equipment involved in the process of formulation and filling.

During his time with the Dow Centre, Tom has worked on projects involving chemical production and energy. Concerning chemicals, Tom is the project manager of the Dow Centre's program for improving sustainability of global methane utilization, focusing on finding an economic opportunity for small scale natural gas reserves. Tom is also engaged in TEA and process modelling of radiation chemistry involving photochemical process source economics, reactive distillation, and liquid fluoride thorium reactors. Additionally, procedures for breaking produced water and tailings oil/water/solid emulsions from oil sands operations is being actively investigated. Along with Mr. Conor Young, a paper detailing a TEA of compressed air energy storage in four unconventional applications was completed. He has also partnered with Conor to develop an equipment costing and complexity framework.

Dr. Diego Schmeda Lopez, Analyst (from November 2014).

Diego started work at the Dow Centre as a short term research assistant on the Rapid Switch project and was promptly awarded a full time contract to work on new projects in 2015.

He received his Bachelor and Master of Science in Mechanical Engineering from the Federal University of Rio Grande do Sul, in Porto Alegre, Brazil in the years of 2007 and 2010 respectively. He was awarded his Ph.D. in Chemical Engineering from The University of Queensland in 2014.

Before entering The University of Queensland Diego worked as project and process engineer in the plastic industry at Fitesa Fiberweb in Brazil, and in the steel industry at Acepar in Paraguay. In these roles he supervised the installation, commissioning and operation of production lines, participated in major refurbishments and supervised a team that analysed, identified and implemented efficiency opportunities.

During his Masters, he worked on the topic of energy generation, sustainable use of energy and energy efficiency. During his Ph.D., he researched the development of industry friendly metallic materials for membrane applications and developed stainless steel hollow fibres.

Mr. Conor Young, Analyst (from July 2014).

Conor studied a Bachelor of Mechanical and Materials Engineering (Hons) at The University of Queensland, graduating in July 2014. During his time at the Dow Centre he has been involved in research projects as well as assisting in an administrative capacity, organising centre events and updating website and social media content.

Conor currently works on the smart windows project, which aims to quantify the energy savings possible from thin-film window modifications in order to reduce heat transfer. He also works on the mechanochemical synthesis project, which investigates the possibility of producing valuable chemicals during ore grinding operations. Along with Mr. Tom McConnaughy, Conor completed a paper detailing a TEA of compressed air energy storage in four unconventional applications. He also partnered with Tom to develop an equipment costing and complexity framework.

Ms. Sara Z. Zadeh, Ph.D. Student (from October 2014).

Sara is Ph.D. student at the Dow Centre. She obtained her Bachelor degree on Mechanical Engineering from the K.N.Toosi University of Technology in 2000. Since then, 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 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 has now decided for a career change and to contribute to improving the environment. Her Ph.D. project involves renewable energy technologies, sustainable energy development and renewables policy. Her aim is to become part of the UQ researcher and lecturing community.

STRUCTURE & GOVERNANCE

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Centre Structure

The Dow Centre for Sustainable Engineering Innovation is a Centre within the School of Chemical Engineering that works in close collaboration with the Australian Institute for Bioengineering and Nanotechnology (AIBN), the Global Change Institute (GCI), the UQ Energy Initiative and the Centre for Coal Seam Gas.

The Dow Centre Director reports to the Dow Centre Advisory Board and the Head of the School of Chemical Engineering.

The Dow Centre Advisory Board consists of members with interest and expertise in sustainability representing UQ and the Dow Chemical Company. The Advisory Board meets approximately three times a year and receives monthly updates from the Director.

The Advisory Board met on three occasions in 2014, the 7th of May, the 1st of August and the 21st of November.

During the meeting of the 1st of August the Advisory Board approved the addition of an eighth member: Dr. Weiguang Yao, the Dow Chief Technology Officer, Asia Pacific R&D and Global Director, Energy Materials R&D. The Advisory Board advised and approved the KPI's on which the Centre's performance would be evaluated.

Advisory Board Members in 2014

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

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 from 1 June, 2007. 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 was educated at the University of Copenhagen, majoring in biochemistry and chemistry, and has a Master of Science degree in biochemistry and genetics, a Ph.D. in photosynthesis, an Honorary Doctorate from the University of Copenhagen and an Honorary Doctorate from the University of South Australia.

Professor Høj is a member of the Australian Research Committee (ARCom), Co-Deputy Chair of the Strengthened Export Controls Steering Group, member of the edX University Advisory Board and in 2014 was appointed as a senior consultant to Hanban in the Oceania Region.

He served on the CSIRO Board 2011-2014, a private member of the Prime Minister's Science Engineering and Innovation Council (PMSEIC) from 1999-2004, and as an ex-officio member from 2006 -2007.

He is 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.

Professor Anton Middelberg, Deputy Vice-Chancellor Research, The University of Queensland (till November 2014).

Professor Anton Middelberg was the Deputy Vice-Chancellor (Research) at The University of Queensland, where he led the university-wide research portfolio. He obtained his Bachelor (1989) and Ph.D. (1993) degrees from the University of Adelaide and his Master of Arts from Cambridge (2001).

After appointment as the youngest lecturer in engineering at the University of Adelaide, and a Fulbright Fellowship at UC Berkeley, he accepted a position at Cambridge University. There he was rapidly tenured and promoted twice against quota to become the Reader in Biological Engineering. In this role he reported directly to the university's General Board and was a member of the Governing Body of Selwyn College and a Fellow of the Cambridge-MIT Institute.

In 2003, he returned to Australia as a Federation Fellow of the Australian Research Council (ARC) to progress his research into bio-inspired nanotechnology. His research into virus-like particle and nanoemulsion self-assembly has attracted more than $10million in research funding since 2003, including from the ARC, National Health and Medical Research Council (NHMRC) and the Bill and Melinda Gates Foundation.

Professor Robyn Ward AM FAHMS, Deputy Vice-Chancellor Research, The University of Queensland (from November 2014).

Professor Robyn Ward has recently joined the University of Queensland as Deputy Vice-Chancellor (Research), after many years of work within hospital and academic settings in New South Wales. This includes roles as Director of the Prince of Wales Cancer Centre and Clinical Associate Dean at UNSW. She remains Director of the Translational Cancer Research Network, a multi-institutional group based in NSW and supported by the Cancer Institute NSW. For the Commonwealth, she chairs the Medical Services Advisory Committee and is a long standing member of the Pharmaceutical Benefits Advisory Committee. Professor Ward is also the chair of the NHMRC's Human Genetics Advisory Council and Member of the NHMRC council.

Throughout her career, Professor Ward has shown a sustained capacity for innovative research into the range of issues that underlie the problem of human cancer. At UNSW Australia she led an independent research group that has produced over 200 journal articles, letters and monographs, as well as several patents. As Head of the Adult Cancer Program at the Lowy Cancer Research Centre UNSW, and prior to that as a clinician researcher at St Vincent's Hospital Sydney, she has made several important contributions to translational cancer research in the area of bowel cancer, including studies of the precursor lesions of this common disease, and the development of novel immunotherapies. More recently, she has used her expertise as a medical oncologist and clinical cancer geneticist to better define population-based screening strategies for hereditary bowel cancer. By recognising that constitutional epimutations of tumour suppressor genes can predispose to cancer, she has also helped to better define the medical management of individuals and families with these epigenetic changes.

Dr. Weiguang Yao,
Chief Technology Officer, Asia Pacific R&D; Global Director, Energy Materials R&D, Dow Chemical Company (from August 2014).

Dr. Weiguang Yao is the Chief Technology Officer for Asia Pacific R&D. He is responsible for Asia-Pacific R&D Strategy to make sure Asia-Pacific Resources align with regional growth opportunities. As Global Director for New Ventures in Asia Pacific, Middle East and African regions, he identifies and prioritizes Dow's long-term new ventures and technology opportunities in these regions, helping define how Dow can further expand its value capture in these markets by building on existing capabilities. He also takes responsibility as Board Director of Advanced Electrolyte Technologies Co., Ltd (DOW-UBE JV), East China University of Science and Technology.

Dr. Yao joined Dow in April, 2007 as Sr. R&D Director for Dow Core R&D in Asia-Pacific. Prior to joining the company, Dr. Yao was General Manager of Pacific Technology for Momentive Performance Material (formerly GE Silicone).

Dr. Yao is a graduate of Yamagata University in Japan with a doctorate in polymer science and engineering, a master degree in chemical engineering from East China University of Science and Technology, and a bachelor degree in physics from Yancheng Normal University in China. He holds 17 patents and a patent application, including seven US granted patents, and is the author of numerous publications.

Mr. Craig Arnold,
Managing Director, Australia & New Zealand, Dow Chemical Company (till May 2014).

Mr. Craig Arnold was President of Dow Chemical Australia and New Zealand, based in Melbourne, Victoria, overseeing the company's growth and operations in the two countries. One of Dow's leaders with strong global exposure and key leadership and strategic roles in various Dow businesses, Mr. Arnold was a prime architect of The Dow Chemical Company's Advanced Manufacturing Plan for Australia.

Mr. Arnold was a member of the PACIA Board, UTS Business Advisory School Board and the Steering Team of the University of Queensland Dow Centre for Sustainable Engineering and Innovation. He was Advisory Board member to the Centre of Excellence, the Centre for Innovative Materials for Sustainable Energy, University of New South Wales. In addition, he was a frequent invitee & member of the Prime Minister's Business Advisory Forum (BAF) and the Victorian Gas Taskforce.

Currently Mr. Arnold is the Commercial Vice President for Europe, the Middle East and Africa for Dow Industrial Solutions, where he is responsible for managing the customer facing activities, as well as driving growth and expanding markets for business unit across the region. Mr. Arnold is South African and relocated to Australia from a role in Houston, United States, as Vice President of Dow's Oil & Gas global business. He holds a bachelor's degree in Chemical Engineering from the University of Witwatersrand in Johannesburg.

Mr. Tony Frencham, Managing Director, Australia & New Zealand, Dow Chemical Company (from May 2014).

Mr. Tony Frencham is the geographic leader for Dow in Australia and New Zealand and is responsible for country operations and business development, based in Melbourne, Australia.

With a business career spanning over thirty years, and the past twenty-five years with Dow, Mr. Frencham has served in a variety of business and executive roles in Asia, Europe, the United States, the Middle East, and Australia.

He is currently the Board Vice Chairman of the Plastics and Chemicals Industries Association; a member of the Carbon Nexus Board for Deakin University; a member of the Business School Advisory Board for the University of Technology, Sydney; and a Board member of the University of Queensland Dow Centre for Sustainable Engineering Innovation.

Mr Frencham earned a Bachelor's of Applied Science with Distinction (Chemistry) from LaTrobe University in 1982, a Graduate Diploma in Applied Polymer Science from Monash University in 1987, and a Post Graduate Diploma in Management from Deakin University in 1994.

Mr. Noel Williams, Appointed Representative, Dow Chemical Company.

After a career with Dow Chemical spanning 36 years, Mr. Noel Williams currently works in consultancy as a Specialist Manufacturing Advisor. Most recently in his career at Dow, Noel 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.

After graduating in Chemical Engineering from Queensland University, a career with Dow began with assignments in manufacturing in Australia, the US, and Hong Kong, in plastics and chemicals technologies. Upon returning to Australia, he held responsibilities in a variety of plant management roles, Manufacturing Manager and Operations Director for Dow Australia led to active participation in the Australian industry, interface with the local community and participation in Industry / Government task forces.

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 also a past President and Director of the Australian Plastics and Chemicals Industry Association. Mr Williams also serves on the UQ Chemical Engineering School Advisory Board.

Professor Peter Gray , Director, Australian Institute for Bioengineering and Nanotechnology, The University of Queensland.

Professor Peter Gray was appointed the inaugural Director of the Australian Institute of Bioengineering and Nanotechnology (AIBN) at UQ in 2003. Previously, he was Professor of Biotechnology and Director of the Bioengineering Centre at UNSW, and a Senior Principal Research Fellow at the Garvan Institute of Medical Research in Sydney.

Professor Gray has had commercial experience in the USA working for Eli Lilly and Co and for the Cetus Corporation, as well as previously holding academic positions at University College London, and at the University of California, Berkeley. His research interests are focussed on engineering mammalian cells to produce the complex proteins called biologics which are gaining rapid acceptance as human therapeutics, and on developing human stem cells bioprocesses suitable for clinical application. Professor Gray was one of the founders and is a past President of the Australian Biotechnology Association, AusBiotech. He is a Fellow of the Australian Academy of Technological Sciences and Engineering (ATSE) and of the Australian Institute of Company Directors, and has been named as one of Australia's 100 Most Influential Engineers.

He is a Vice-President of ATSE and serves on the Boards of Biopharmaceuticals Australia Pty Ltd, Institute for Photonics and Advanced Sensing (IPAS), ACYTE Biotechnology Pty Ltd, Stem Cells Ltd, ECI Inc, New York, and a number of State and Federal Government Councils and Committees.

Professor Ove Hoegh-Guldberg FAA, Director Global Change Institute, The University of Queensland.

Professor Ove Hoegh-Guldberg is Director of the Global Change Institute and Professor of Marine Science at The University of Queensland, Brisbane, and Deputy Director of James Cook University's Centre for Excellence in Coral Reef Studies.

Professor Hoegh-Guldberg is a global expert on environmental change and marine ecosystems, and is one of the world's most cited authors on climate change with more than 15,000 citations from >250 papers, books and patents. He is also a dedicated scientific communicator on the threat posed by ocean warming and acidification, first raising the alarm with respect to the seriousness of climate change for coral reefs in a landmark paper published in 1999. Ove is the Coordinating Lead Author for the 'Oceans' chapter of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Working with Sir David Attenborough, Sylvia Earle, Tom Brokaw, Philippe Cousteau and many others, Professor Hoegh-Guldberg has attempted to take education beyond the walls of academia to millions. In 2014 alone, he educated over 2000 students through a massive open online course. He has received the Eureka Prize, a Queensland Premier's Fellowship and the 2014 Climate Change Award (Prince Albert II, Monaco), and is currently an ARC Laureate Fellow and member of the Australian Academy of Science. He is also Chief Scientist of the Catlin Seaview Survey, which is producing the largest baseline of coral reef health globally.

Professor Peter Halley
Head, School of Chemical Engineering, The University of Queensland.

Professor Peter Halley is Head of the School of Chemical Engineering, a Group Leader in the Australian Institute for Bioengineering and Nanotechnology (AIBN), the Director of the Centre for High Performance Polymers (CHPP), and a chief investigator in the Advanced Materials Processing and Manufacturing (AMPAM) centre.

Professor Halley works at the translational research interface between universities and industry. He has worked in industry (SRI international, Sola Optical, Moldflow), has worked in three cooperative research centres (CRCs), has acquired and managed continuous government and industry research projects since 1994, was heavily involved in the spinoff of Plantic Technologies from the CRC food packaging in 2002, and was involved in the research that led to the TenasiTech (TPU nanocomposite) spinoff from UQ in 2007.

Professor Halley leads the CHPP - a virtual cluster of over 80 academics, researchers and students across UQ. In the CHPP he leads a processing research group (CHPP-processing) of 40 academics, researchers and industry partners focusing on the rheology, processing and product design of biopolymers, nanostructured polymers and high value engineering polymers.

Professor Halley is a fellow of the Institute of Chemical Engineers (IChemE) and a fellow of the Royal Australian Chemical Institute (RACI). He is also an active member of the Society of Plastics Engineers (SPE), the Polymer Processing Society (PPS) and the Society of Rheology (SOR). Professor Halley is on the editorial board of the plastics, Rubbers and Composites, Starch and Journal of Renewable Materials.

PERFORMANCE INDICATORS

KEY PERFORMANCE INDICATORS

Contributions to sustainable engineering innovations in 2014:

Three major contributions were:

1. Generating highly visible activities and public discourse in promotion of nuclear power.
2. Finding a new pathway for the dehydrogenation of polymers and biopolymers for the production of carbon fibres.
3. Developing techno-economic analyses and evidence for decisions regarding electrical energy storage and the use of macroalgae for fuels and chemicals.

Amount of external funding raised:

In 2014 the Centre was directly involved in the raising of $785,500 (AUD):

- $535,500 ARC grants
  - ◊ $345,500 for DP over 3 years with Prof Darren Martin.
  - ◊ $190,000 LIEF in 2015 with Prof Lianzhou Wang.
- $250,000 Dow Chemical R&D (attracts overheads)
  - ◊ $75,000 2014.
  - ◊ $75,000 2015.
  - ◊ $100,000 over 3 years used in ARC LP application (result expected winter 2015).

Number of licensed patents:

No patents were licensed in 2014.

Number of new commercial activities with significant Dow Centre participation:

The Dow Centre has not been directly involved with commercialization activities in 2014.

Number of completed process evaluation reports/ publications:

Five evaluations were completed:

- Macroalgea.
- Biofuels.
- Rapid Switch Preview.
- Compressed Air Energy Storage.
- Pipeline Energy Storage.

www.dowcsei.uq.edu.au

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