THE UNIVERSITY OF MELBOURNE

MELBOURNE ENERGY INSTITUTE

Melbourne Energy Institute

ANNUAL REPORT 2014

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Background

Concerns about energy resource security, the adverse environmental impacts of energy production and inequities in access to energy services are crucial to national and global policy considerations.

The increasing recognition that our energy systems need to be made more sustainable, environmentally benign and adaptable, while also providing reliable and affordable supply to more people presents a daunting challenge. In particular, the prospect that rising greenhouse gas concentrations are contributing to unprecedented and potentially irreversible climate change makes redesigning our energy systems one of the most important challenges of our time. Framing pathways to a more certain energy future is inherently interdisciplinary. Such pathways must be informed by a deep understanding of environmental impacts, regulatory frameworks and social equity issues. The delivery of such pathways requires new research strategies that transcend traditional lines of enquiry to link many different ways of thinking that inform how modern societies work and prosper. The Melbourne Energy Institute engages researchers across seven faculties at the University of Melbourne to help meet this challenge. It is one of a family of five institutes that together comprise the Melbourne Research Institutes.

Message from the Director

Since 2010, the Melbourne Energy Institute has worked with faculties including Economics, Science, Engineering, Law, Architecture, Medicine, Arts and Environment to help develop interdisciplinary energy research programs. New funding secured for these programs totals approximately $35 million.

The year 2014 marked the Institute's fifth year of operation. Working in partnership with faculties including Business and Economics, Law, Engineering, Science, Architecture, Building and Planning, and Arts we are delighted to continue our program of expanding the University's energy research portfolio. New funding secured for these programs in 2014 was $3.2 million and since, the Institute's launch in 2010, totals over $35 million.

While programs have been varied in scope covering energy resources, production, distribution and consumption, waste capture and storage, and economics and policy, the connecting theme has been developing University capacity in meeting the challenges of large-scale, low-emission energy systems.

The building of significant partnerships between industry and government departments and agencies has been central to the growth of the Institute's interdisciplinary energy programs.

In 2014 the Institute furthered research in areas such as energy market design, carbon capture and storage, renewable energy integration, energy storage mechanisms, the ethics of renewable energy, direct geothermal energy, future grid scenarios, and sedimentary basin management.

The Institute's engagement with international research group the Basin GENESIS Hub was a highlight in 2014. The Hub will receive $5.4 million of funding over five years, $1 million of which will be used to build new University of Melbourne capability. Led by new R@MAP Professor Louis Moresi, the utilisation of big data sets and increased computing power will allow the Hub to model interactions between processes on the earth's surface and deep below. This new technology will vastly improve understanding of the complex interplay between surface and deep earth processes with significant applications for the energy sector.

Professor of Geological Carbon Storage Ralf Haese has overseen the installation of the $3.5 million purpose built Fluid Flow Geochemistry Laboratory that will support the national carbon capture and storage technology development in Australia.

Our contribution to our national energy debate continues with our Energy Futures Seminar Series providing a forum for academia, community, industry, and government to discuss critical future energy issues. Seminars exploring the future of the gas market, energy storage and the Renewable Energy Target Review attracted audiences of 300-700.

The Institute's international outlook has been maintained in 2014 with the growth of the Australian-German College of Climate and Energy Transitions to a strong cohort of 16 students. The College is in partnership with the Potsdam Institute for Climate Impact Research and the Melbourne Sustainable Society Institute. A Melbourne–Myanmar Energy Program was also explored with Yangon Technological University in 2014.

Looking forward, 2015 will see a number of exciting developments including groundwork for an Energy Systems Research Centre lead by Prof Michael Brear and further growth of the sedimentary basin management initiative.

Prof Mike Sandiford

Major Initiatives

BASIN GENESIS HUB

The Basin GENESIS Hub will model interaction between processes on the earth's surface and deep below in five dimensions.

Faculties:

Science, Arts, Law and Engineering

Lead Academics:

Prof Louis Moresi and A/Prof Tim Rawling

Partners:

The University of Sydney, Curtin University's Petroleum Group, CSIRO Earth Science and Resource Engineering, National ICT Australia (NICTA), Geoscience Australia and the California Institute of Technology

The Basin GENESIS Hub is an international research group that takes a radical new approach to analysing sedimentary basins and also harnesses technology in a completely novel way. The Hub is expected to receive $5.4 million dollars of funding over five years, $1 million of which will be used to build University of Melbourne capability.

Using big data sets and increased computing power the Basin GENESIS Hub will model interaction between processes on the earth's surface and deep below in five dimensions. This new technology will vastly improve understanding of the complex interplay between surface and deep earth processes with significant applications for the energy sector. New R@MAP Professor Louis Moresi leads the University of Melbourne division of the project.

The researchers will incorporate data from multiple sources to create 'five-dimensional' models, combining three-dimensional space with the extra dimensions of time and estimates of uncertainty. The modelling will span scales from entire sedimentary basins hundreds of kilometres wide to individual sediment grains. Key geographical areas the research will focus on are the North-West shelf of Australia, Papua New Guinea and the Atlantic Ocean continental margins.

The Hub's technology builds upon the exponential increase in computational power and the increasing amount of available big data. The Hub will harness the capacity of Australia's most powerful computer, launched in 2013.

Funded through the Industry Transformation Research Hub program, the Basin GENESIS Hub is based at the University of Sydney with partners including Curtin University's Petroleum Group, CSIRO Earth Science and Resource Engineering, National ICT Australia (NICTA), Geoscience Australia, the California Institute of Technology, and five national and international industry partners.

SEDIMENTARY BASIN MANAGEMENT INITIATIVE (SBMI)

Sedimentary basins underpin much of Australia's national wealth. They host resources that provide for more than 90% of our primary energy production and the great majority of our groundwater resources.

Faculties:

Science, Arts, Law and Engineering

Lead Academics:

A/Prof Will Howard, Prof Mike Sandiford, Prof Fiona Haines, Prof Michael Crommelin and A/Prof Tim Rawling

Partners:

The University of Newcastle, The University of Adelaide, Carlton Connect Initiative, NICTA, NSW Office of Chief Scientist, Geoscience Australia and NOPTA

Sedimentary basins are the locus of much of our agricultural production and rural population centres, and they support a significant part of Australia's endangered riverine and rangeland ecosystems. Increasingly, our sedimentary basins are being explored for new resources and services, such as unconventional gas, sub-surface storage of CO2 waste and geothermal energy. The current scale of investment in our sedimentary basins is unprecedented and competition for access to basin resources is already raising challenging social, political and regulatory issues.

To avert the potential for conflict over competing access regimes, there is a need for new approaches to the management of sedimentary basins. Improved management will be essential to reducing adverse environmental and social impacts, the potential for resource sterilisation and economic risk arising from the interacting usage of multiple resources. There is a need for effective, targeted regulatory frameworks and for the development of more meaningful engagement strategies with communities, who have direct interest in the way the sedimentary basins on which they live are managed.

As sedimentary basins represent a range of diverse interests and needs governments and industries are placed in a position of substantial social responsibility. A whole-of-society approach to resource management that considers the economics, environmental and social costs and benefits is required. This research project explores how our usage and management of sedimentary basins could be optimised in the future, while identifying the research needed to get there.

Activities supporting the SBMI in 2014 include a workshop, panel discussion and a Position Analysis within the Carlton Connect Conference, a discussion and Q&A panel at the Murray-Darling Association and articles in The Conversation and G20 Watch. The appointment of project leader Will Howard in 2014 as Associate Professor is a major achievement for the University of Melbourne.

Major Initiatives

THE AUSTRALIAN-GERMAN COLLEGE OF CLIMATE AND ENERGY TRANSITIONS

The College has a vision for a zero emissions future. Their mission is to deliver the research capability that will get us there.

Faculties:

Science, Arts, Law, Engineering and Land and Environment

Lead Academics:

A/Prof Malte Meinhausen, Prof Ross Garnaut, Prof Robin Batterham, Prof Mike Sandiford, Prof Robyn Eckersley, Prof John Wiseman and Prof Brendan Gleeson

Partners:

Potsdam Institute for Climate Impact Research, Humboldt University, Technical University of Berlin and University of Potsdam

Climate change and energy transitions and their intrinsic multiple challenges, are some of the most pressing issues facing society today. These challenges are inherently interdisciplinary and require a global perspective. In order to address these challenges the Melbourne Energy Institute provided seed funding to help establish a postgraduate PhD research program, the Australian-German College of Climate and Energy Transitions.

Inaugurated in 2013, the College is a collaboration between the University of Melbourne and a consortium of universities and research institutes in Germany. The College adopts an international focus in its research, education and training and aims to provide a collaborative, cohort based PhD research environment in which research excellence can be achieved. The program is based at the University of Melbourne and is complemented by a six-month exchange in Berlin at the Potsdam Institute for Climate Impact Research.

Research areas of the candidates are varied in scope covering the integration of renewable energy into existing energy infrastructure, to evaluating societal stability during internally and externally induced transitions. The interrelating theme is fostering capacity in world-class climate and energy research at the University. The College has four main research areas; these are climate systems, climate impacts, mitigation strategies and energy systems.

In 2014, the College began developing its PhD curriculum. This includes hosting bi-weekly Science and Bretzels and Hot Seat seminars providing PhD candidates with access to insights from renowned speakers across a range of fields, from within and outside of academia. It also includes an Energy Reading Group; this group brings together researchers from across the University to discuss current energy concerns. The College plans to implement a Climate Governance Reading group in early 2015.

MELBOURNE UNIVERSITY RENEWABLE ENERGY INTEGRATION LAB (MUREIL)

MUREIL simulates the National Electricity Market to address whether the market will be able to cope with increasing renewable penetration.

Faculties:

Science and Engineering

Lead Academics:

Dr Roger Dargaville and Prof Michael Brear

Partners:

The University of New South Wales, Australian Energy Market Operator, GE, Bureau of Meteorology and Australian Renewable Energy Agency

The Energy System Modelling Initiative has produced several modelling approaches to simulate the National Electricity Market and to address the question of whether the market, as it currently stands, will be able to cope with increasing renewable penetration.

In order to optimise for the least cost transition from current infrastructure to low carbon energy systems, linear programming and genetic algorithm approaches have been employed. Results suggest that wind power, solar photovoltaic and solar thermal will dominate the energy system, with some limited fossil fuel use to keep costs within reason. Across the models, neither nuclear power or carbon capture and storage come out as winners against the less expensive renewable technologies. Papers detailing these results are to be released in mid 2015.

The lab carries out energy market simulations using the output from the linear programming method and a Monte Carlo approach with Carnot Game Theory. Results show that increased market volatility would make for a difficult investment environment, and that the financial incentives to actually build a high penetration renewable energy system would be low.

Results suggest that a shift to a capacity market would provide more stability, but would favour technologies with dispatchable generation. A second paper proposes that the key to facilitating more renewables is to create a more advanced market with shorter dispatch intervals and “gate closure” (the time before dispatch that bids needs to be locked in) would improve market accessibility for renewables.

Major Initiatives

ENERGY MARKETS PROGRAM

The Energy Markets Program is a joint initiative between the MEI and the Centre for Market Design with the ambition of establishing the University as an internationally recognised hub for energy economics research.

Faculty:

Business and Economics

Lead Academic:

Prof Peter Bardsley, Dr Leslie Martin and Dr David Byrne

Partner:

Department of Treasury and Finance (State and Federal)

The Centre for Market Design's Energy Market Program looks at market challenges around next generation electricity, including applied research in the area of market failure, market design, information and incentive problems underlying areas of public policy.

The price increases to household energy bills sparked concern across a range of areas. To address this, in 2014 the program successfully obtained an ARC linkage grant for the project 'Technology Transforming Markets: Large-Scale Field Experiments in Electricity Use'.

The project will draw on an existing industry partnership with innovative start-up company Billcap to provide the first published insights into the behaviour of consumers in a competitive and smart-meter enabled retail electricity market. It will assess the ability of smart meters to facilitate household energy conservation, thereby decreasing the magnitude of peak consumption and its costs, reducing pollution, and making better use of scarce resources. Another aim is to enhance consumer welfare by providing individualised feedback that will help customers manage their bills and opt into rate plans that best suit their needs.

The program is an example of the way partnerships between the University and government create the opportunity for research that is of high value for policymakers and academics alike. The ARC linkage project is one example of the synergies between the Institute and the Department of Economics that arise from economists' methodologies for dealing with strategic interaction between firms, such as large power generators, which are a key characteristic of energy markets.

The technical skills of the Melbourne School of Engineering and graduate students complement the computational aspects of both estimating demand and supply elasticities and modelling strategic interaction amongst large power generators in the Australian energy market. The Institute seeded the Centre's Energy Market Program and provided support for Dr Leslie Martin's position as Lecturer in Energy Market Design.

cmd CENTRE FOR MARKET DESIGN

A CONSORTIUM OF

Australian Government The Treasury

Victoria Department of Treasury and Finance

The University of Melbourne Faculty of Business & Economics

GEOTHERMAL PROGRAM

Substituting common heating and cooling systems with direct geothermal can reduce energy consumption by up to 75 per cent.

Faculties:

Science and Engineering

Lead Academics:

Prof Ian Johnston and Dr Guillermo Narsilio

Partners:

Victorian Government (Department of Economic Development, Jobs, Transport and Resources), Geotechnical Engineering, Direct Energy, Golder Associates, the University of Cambridge, Southampton Universities, KAIST, Korea Universites and UCSD

The imminence of global climate change has meant that policy makers, society and academics alike are searching for ways to make our energy systems more sustainable and environmentally benign. Mitigating the impacts of climate change through employing renewable energy technologies with low greenhouse gas emissions, is rapidly becoming a global priority. One way to achieve this is through employing direct geothermal systems.

Direct geothermal systems use shallow ground as a heat source and sink for heating and cooling buildings, using ground heat exchangers and heat pumps. Therefore providing an exciting way for homes and businesses to reduce their own energy bills. The project is trialling a number of different types of instrumented vertical and horizontal ground loop systems, including energy piles (building foundations fitted with HDPE piping) and borehole installations to depths of 30 to 50m. It is being found that substituting common heating and cooling systems with geothermal systems in both residential and industrial areas can reduce energy consumption by up to 75 per cent and thus reduce greenhouse gas emissions. Furthermore, under Melbourne and Victorian conditions, direct geothermal systems are even more efficient than in many other parts of the world because of the temperate climate, the optimal ground temperatures and the more balanced thermal energy demand.

In collaboration with partners, Dr Narsilio, from the Department of Infrastructure Engineering will develop new models for studying the performance of ground heat exchangers, including energy piles, to improve the design and efficiency of geothermal systems for cooling and heating buildings, contributing to reducing energy consumption and greenhouse gas emissions. The trial has received substantial support from the Victorian Government and an Australian Research Council fellowship, under the prestigious Future Fellowship scheme.

Dr Narsilio and O. Mikhaylova (PhD Candidate) inspect the instrumented geothermal system at the Elizabeth Blackburn School of Sciences.

Major Initiatives

GEOLOGICAL CARBON STORAGE PROGRAM

The Geological Carbon Storage Program of the Peter Cook Centre for Carbon Capture and Storage Research has established the University and Victoria as a leading international centre of carbon capture and storage research.

Faculties:

Science and Engineering

Lead Academics:

Prof Ralf Haese and Prof Stephan Matthai

Partners:

Victoran Government, CO2CRC and Federal CCSNet Education Infrastructure Fund (EIF)

Taking a holistic approach to issues of sustainability posits carbon capture and storage (CCS) as an essential element in effective emissions reductions. The Geological Carbon Storage program of the Peter Cook Centre for CCS Research at the University of Melbourne was established in 2012. The Program is undertaken in collaboration with government, research and industry partners and is funded by Rio Tinto, the State Government of Victoria and the CO2CRC.

Research in the CO2 Capture program supports and underpins the development of enhanced technologies for carbon capture and storage in Australia. The project is unique in its ability to allow direct interaction with the end-users of the research as it is based in the Latrobe Valley and the Gippsland Basin. This interaction with the end-users ensures research objectives are informed by on-the-ground knowledge and are supported by the local community. In this way, the Centre has become hub for knowledge, analysis and services for the public, students, industry and government alike.

With the appointments of Prof Ralf Haese, Chair of Geological Carbon Storage and Prof Stephan Matthai, Chair in Reservoir Engineering, the University has now established itself as the leading University research team in the field of CO2 storage complementing the long record of achievement in carbon capture research lead by Prof Geoff Stevens. The CO2 Capture Program fills an important gap as it undertakes both research to reduce capital and operational costs of CO2 capture technology, and research with the aim to reduce the risks associated with the injection and geological storage of CO2. The unique opportunities provided by the Otway subsurface laboratory facility managed via the CO2CRC place the University and Victoria as a leading international centre of CCS research.

Since arrival, Prof Haese has established four significant new research projects with a combined value of $1.5 million relevant to Victorian and New South Wales CO2 storage potential. In addition, Prof Haese has guided the establishment of a $3.5 million investment in a state-of-the art laboratory dedicated to CO2 storage research, with funding from the federal CCSNet Education Infrastructure Fund (EIF). The new laboratory facility is expected to open officially in early 2015.

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State Government Victoria

CO2CRC CRC FOR GREENHOUSE GAS TECHNOLOGIES

Rio Tinto

University of Melbourne Flagship Energy Research Programs

CLEAN AIR AND URBAN LANDSCAPES RESEARCH HUB

The research hub on Clean Air and Urban Landscapes (CAUL) will take a comprehensive view of cities and how they might work better to support human and environmental well-being.

Faculties:

Science, Arts, Law and Engineering

Lead Academics:

Prof Peter Rayner

Partners:

RMIT University, The University of Wollongong and The University of Western Australia.

The CAUL research hub has total funding of $8.9 million over six years from the National Environmental Science Programme (NESP). It is led by Prof Peter Rayner of the School from Earth Sciences at the University of Melbourne.

The NESP hubs are not defined research programmes but portfolios of expertise. For CAUL, these include experts on air quality, biodiversity, urban design, public health and green infrastructure distributed among consortium members.This diversity of expertise is obviously required since cities are the most complex interactive systems humans have yet constructed. This complexity means that any intervention touches off consequences from the chemical to the political.

The mandate of NESP is to advise on practical solutions. The programme is run out of the Department of the Environment rather than a traditional research funding agency. This has direct impacts on the conduct of the research. Every research project will include a component focusing on practical solutions. The hub is developing communications and knowledge translation strategies as it is in an early phase of navigating its place in the research and policy landscape.

The hub must understand its remit since much of the critical business around governing cities happens outside the Commonwealth Government. The Department recognises this as CAUL is required to make strong links with other levels of government and community groups.

The CAUL must also build a research community across diverse disciplines and locations. This inevitably takes time so the 6-year duration of the funding is most welcome. Organisations like the MEI are natural partners and we look forward to fruitful collaboration over the next six years.

University of Melbourne Flagship Energy Research Programs

CARLTON CONNECT INITIATIVE

The Carlton Connect Initiative strives to bring together talented people who share a desire to tackle some of our biggest sustainability and social resilience challenges.

Partners:

IBM Corporation, NICTA and The Melbourne Business School

The University's strategy *Research at Melbourne: Ensuring excellence and impact to 2025* emphasises three 'Grand Challenges' facing the world today. These challenges are, understanding our place and purpose, fostering health and wellbeing and supporting sustainability and resilience. The Carlton Connect Initiative was developed as part of the University's response to the third of these challenges.

The Carlton Connect Initiative is a major University of Melbourne program aiming to establish a sustainable research and innovation precinct based on multi-sectoral collaboration on the eastern edge of the Parkville Campus. The Initiative is centred around the former Royal Women's Hospital site.

The Initiative aims to bring a vigorous and impact-oriented approach to tackle issues of sustainability and social resilience. The Carlton Connect precinct, while still in its initial stages, presents a global network of collaborators and world-class scientists across a range of disciplines, providing a rich and unique ecosystem for innovation opportunities. The Initiative has started fostering innovation-focused networks in a number of areas including water, urban futures, energy, food, social equity, pervasive information technology, climate change and adaptation, innovation and entrepreneurship and risk and resilience.

Director of the MEI, Prof Mike Sandiford, leads the Initiative's Energy Stream. With some Carlton Connect energy projects already in their early stages, including work on energy storage, biofuels, sedimentary basin management, renewable energy integration and climate and energy transitions – Prof Sandiford will be working with research leaders to develop these and other related programs to maturity.

For more detail regarding the Carlton Connect Initiative please visit: www.carltonconnect.com.au

FUTURE GRID LABORATORY

The Future Grid Laboratory has had a long-standing association with the power industry and has an excellent appreciation of the technical problems and challenges future power grids will present.

Faculties:

Business and Economics and Engineering

Lead Academics:

A/Prof Mohammad Aldeen, Prof Iven Mareels, Prof Robin Evans, Prof Terry Caelli, A/Prof Michael Brear and Dr Tansu Alpcan

The Future Grid Laboratory has the technical and practical know-how to work with the power industry to address problems associated with integration and control of renewable and embedded sources of energy and the impact on voltage levels.

The Laboratory has capability in the following areas:

- Dynamic modelling, fault detection and identification;
- Stability analysis and control;
- Integration of renewable energy sources and embedded generation;
- Signal processing and data mining;
- Sensor networks and condition monitoring;
- Energy storage devices and systems;
- Electricity market economics and pricing.

As well as technical advice, the Future Grid Laboratory can provide financial advice on investment decisions such as optimal utilisation of assets, infrastructure condition monitoring using sensor network for data acquisition and placement and control devices. Other activities of the Laboratory include electricity market economics and pricing.
On the operation and control side, the Laboratory has had extensive experience in dynamic fault detection, fault level monitoring, demand side technologies, stability analysis, device and network modelling, smart meters data, mining and electricity pricing.

FUTURE GRID LAB

University of Melbourne Flagship Energy Research Programs

THERMODYNAMICS LABORATORY

The Thermodynamics Laboratory in the School of Engineering undertakes fundamental and applied studies of combustion and combustion engines.

Faculty:

Engineering

Lead Academics:

Prof Michael Brear, A/Prof Chris Manzie, Dr Yi Yang, Dr Robert Gordon and Dr Mohsen Talei

Partners:

AEMO, Advanced Centre for Automotive Research and Testing (ACART), California Institute of Technology, CERFACS in France, Ford Motor Company, Princeton University, The University of New South Wales, and Sandia National Laboratory: Combustion Research Facility

The Thermodynamics Laboratory in the School of Engineering undertakes fundamental and applied research in transport and power generation. The Laboratory has three main areas of related research:

- the combustion of conventional and alternative fuels;
- the control of conventional and hybrid systems;
- the modelling and dynamics of transport and energy systems.

The Thermodynamics Laboratory houses a wide range of research facilities, both experimental and computational, and supports a team of 5 academic staff and roughly 25 full time researchers and students. This work involves close collaboration with both industry and government, in particular the Ford Motor Company, the Australian Energy Market Operator (AEMO) and Princeton University.

Current projects include:

- Achieving cost effective abatement from Australian electricity generation;
- Enabling low greenhouse gas emissions from road vehicles through the proper use of alternative fuels;
- Optimising flex fuel engine performance;
- Optimal design of controlled aerodynamic bodies: from concept to prototype;
- Towards an event based model of combustion generated sound.

ELECTRIC VEHICLES RESEARCH GROUP

The Electric Vehicles Research Group is exploring the management of electricity usage in regard to electric vehicles.

Faculty:

Engineering

Lead Academics:

Prof Iven Mareels, A/Prof Marcus Brazil, Dr Tansu Alpcan and Dr Julian de Hoog

Partners:

SP Ausnet, United Energy, Ergon Energy, CSIRO, DiUS Computing, Axiflux and NICTA

Electric vehicles show great promise as a technology that will allow greater energy security and greenhouse gas reduction in the transport sector. However, the charging of electric vehicles puts additional strain on the electricity grid, and if uncontrolled can lead to unexpected and undesirable effects.

The Melbourne School of Engineering researchers and industry partners have been working to develop the understanding the type of demand-response system required to manage high penetration of electric vehicles.

In order to examine the impact of electric vehicle charging, the program is built on real household demand data, vehicle travel profiles and models of actual distribution networks as provided by the programs industry partners. These findings showed that with uncontrolled vehicle charging, existing networks can only sustain 10-15% penetration of electric vehicles. However, with an optimal charging policy (informed by electricity market spot price, state of charge of individual batteries, present and anticipated network loads) 80% penetration could be sustained with current network infrastructure.

The Electric Vehicle Research Program aims to:

- to identify limitations in existing distribution networks with respect to electric vehicle charging;
- to develop optimal "smart charging" policies with respect to the increasing introduction of intermittent renewable energy sources.

Melbourne Energy Institute Projects in Development

VICTORIAN ORGANIC SOLAR CELL CONSORTIUM

The Victorian Organic Solar Cell Consortium (VICOSC) has been involved in developing organic solar cells.

Faculty:

Science

Lead Academics:

Prof Andrew Holmes and Dr David Jones

Partners:

The State Government of Victoria, ARENA, The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Monash University, Innovia and BlueScope

The solar photovoltaic (PV) cell is in an energy technology that has the potential to dramatically reduce the dependence on more traditional sources of electricity in developed countries such as Australia. It also provides a cheap, easily deployable source of electric power for remote regions beyond the reach of the grid in developing countries. Unlike traditional electricity-producing solar panels, organic cells offer the potential to allow printing directly onto materials such as roofing and windows, and therefore open intriguing building integrated design opportunities.

The 10plus10 challenge is to develop organic photovoltaic solar cells that can be printed in commercial settings that yield 10% efficiency and 10 years durability. Realising the challenge of printable solar organic cells would provide a wide range of specialist manufacturing opportunities in Victoria, and would build on the work of VICOSC.

VICOSC has thus far has achieved significant success in translating laboratory-based research on organic solar cells to large scale, industrially relevant printing processes. With support from federal and state government and industry, the consortium has helped position Victoria as a global leader in this field.

Program highlights for 2014 include:

- Victorian Government printing program extended to 31 March 2014. The program optimised the printing of A4-A3 sized modules after purchase of three new printing presses;
- Funding from the Victorian Government and the Australian Renewable Energy Agency (ARENA) to look at a materials development and device architecture optimisation program up to 31 March 2014 ($3.25 million over 3 years). The program delivered some of the best performing materials reported.
- Australia-India Strategic Research Fund (AISRF) workshops on “Smart Functional Nanomaterials” and “Nanomaterials for Energy Generation” held in the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCSCR), Jakur, Bangalore and the Bio21 Institute at the University of Melbourne.

The VICOSC program has now been completed and has been followed by the ARENA funded Australia-USA Institute for Advanced Photovoltaics (AUSIAPV) to examine over the horizon technologies to allow large-scale implementation of solar technologies and a capacity building through training and education of postgraduate students. The key research is focused on key issues delaying rapid commercialisation, such as stability, industrial relevant solvent systems and high performance materials.

ENERGY STORAGE: PUMPED HYDRO AND LIQUID AIR

In partnership with the engineering company Arup, this project explored the applicability and economic viability of pumped hydro energy storage for Australia.

Faculties:

Science and Engineering

Lead Academics:

Prof Paul Webley, Prof Robin Batterham, Dr Roger Dargaville, and Mr Tim Forcey

Partners:

Carlton Connect Initiative, Arup, University of Birmingham and Highview

Pumped Hydro Energy Storage

New pumped hydro storage facilities are under construction in China and Europe and are under consideration in the US. This is because pumped hydro storage is seen as an economic method to complement the expansion of variable renewable electricity generation sources such as wind and solar photovoltaic. Despite the overseas activity, no large-scale hydro storage facilities have been built in Australia in the last 30 years. Among the reasons for this lack of local activity, is limited understanding of pumped hydro storage economic benefits and a view that suitable development sites are rare. The Institute found that coastal cliff top seawater 'turkey-nest' type facilities, such as has operated on the island of Okinawa for 14 years, located at constrained 'fringe of the grid' locations, could provide electricity market benefits and complement the further development of renewables in locations such as South Australia, Western Victoria, Western Australia, Northern Queensland and King Island, Tasmania.

In the course of its research, the Institute developed innovative costing, site identification (topographical analysis) and economic benefit analysis tools. More information about these findings is available on the Institute's report 'Opportunities for Pumped Hydro Energy Storage in Australia' published in early 2014.

Liquid Air Energy Storage

The Institute also investigates the feasibility of emerging technology liquid air energy storage.

The Carlton Connect and Arup funded Liquid air energy research project is wrapping up phase one. Results of the modelling study suggest that under volatile market conditions the storage system can have payback periods of less than ten years, however under current market conditions the payback period is too long to be economically viable. As the condensing and expansion parts of the system are separate, the system can be configured in terms of compressors, storage tank and expansion turbines to take maximum advantage of market variability. Round-trip efficiency of 50% is easily achievable, and while higher efficiency is possible with more steps in the compression stage, the additional capital expense does not make it cost effective.

Work will continue to look at opportunities in Australia to combine with appropriate large industrial energy users with waste heat streams. A publication of the initial results is about to be submitted.

Melbourne Energy Institute Projects in Development

RECOVERY OF BIODIESEL LIPIDS FROM MICROALGAL BIOMASS

This project focuses on novel technologies for extracting biodiesel lipids from microalgae that have the potential to significantly progress biofuel production.

Faculties:

Science and Engineering

Lead Academic:

Dr Greg Martin

Partner:

Aurora Algae

Large-scale cultivation of microalgae for the sustainable production of biofuels and other products has great potential. Growth and processing of microalgae is complex and much technological and scientific development is required to make production efficient and cost-effective. In particular, the conversion of the microalgal biomass into fuels such as biodiesel requires considerable attention.

In this project, the Algal Processing Group in the Department of Chemical & Biomolecular Engineering have partnered with a leading microalgae biotechnology company, Aurora Algae. The Algal Processing Group has developed a novel and efficient process for breaking microalgal cells and extracting lipids for biofuel production. The goal of this project was to fully establish the feasibility of this process and better understand the fundamental mechanisms of cell breakage and solvent extraction. The project was supplied with large quantities of algal biomass material from Aurora Algae's world-leading outdoor production facility in Karratha, Western Australia.

Through this partnership, the project has established the effectiveness of the cell disruption and solvent extraction processes on Aurora Algae's production strain, and uncovered new insights into the mechanisms of cell weakening that occur in the first pre-incubation step of the process. This project has enabled an accurate assessment of expected yields and purities that could be achieved industrially, establishing this process as the only effective and scalable method that has so far been developed. The project has resulted in three manuscripts, one that is under review and two that will be submitted for publication.

GAMES AND MECHANISMS FOR SHAPING THE EVOLUTION OF POWER GRID

Using a market-based and game-theoretic approach, this project looks at how to shape the future evolution of the electrical power grid to achieve efficiency, resilience, and cost-effectiveness.

Faculties:

Science, Business and Economics and Engineering

Lead Academics:

Dr Tansu Alpcan, Prof Subhrakanti Dey, Prof Rob Evans, A/Prof Mohammad Aldeen, A/Prof Michael Brear, Dr Simon Loertscher, Prof Peter Bardsley and Mr Dylan McConnell

Peak demand periods, which typically occur over several hot summer days, have been known as one of the reasons for high electricity tariffs as well as underutilised and expensive grid infrastructures. This project provides powerful analytical frameworks that allow electricity retailers or demand-response aggregators to manage the peak electricity demand periods.

Underpinning this is an understanding that distribution of energy is as important as its generation. Recent developments in renewable energy, distributed power generation, and information technologies, motivate a transformational change of the existing power grid. The question of how to provide the right incentives to power generators, distributors and users to facilitate a more efficient resilient, and cost effective power grid has yet to be answered.

The problem at hand is clearly multifaceted, and concerns economists, engineers, policy experts and environmental scientists. Hence, the project aims to bring together the expertise of researchers from these diverse fields that have an interrelating interest in mechanism-design for optimal allocation of scarce resources.

In this project, advanced tools from mechanism design theory and game theory have been utilised to tackle the peak demand problem.

Project outcomes include:

- efficient tools for electricity retailers to efficiently manage the electricity demand and also to affect the electricity price during peak demand periods;
- development of novel game theoretic mechanisms modeling actions and incentives of actors participating in the smart grid environment including regulators, generators, distributors, and users;
- creating a synthesis of economical and engineering aspects of the problem using analytical methods.

This project is aligned with the Melbourne School of Engineering's Future Grid Laboratory and the Faculty of Business and Economics Centre for Market Design.

What will Australia's energy future look like?

The Energy Futures Seminar Series brings together industry, government and academia around critical energy research issues putting them into the public domain for community debate and policy scrutiny.

Run in partnership with policy think-tank Grattan Institute, the Energy Futures Seminar Series presents a range of views on the immediate and long-term impacts of changes in energy policy and the development of novel energy technology solutions.

In 2014, the series explored issues around novel energy storage, changes peak demand and associated challenges for the electricity system, the impacts of possible changes in the Renewable Energy Target in Australia and the future of gas supply and demand in Eastern Australia.

The topics explored have attracted the attention of audiences 300-700, with a growing online audience via the seminar live web-stream. In 2014, the live-web stream and follow up media coverage of the seminars allowed national and international audiences to engage with the seminars.

The Future of Australia's Energy Market - Grid defection or grid disaster?

A key challenge we face in the coming decade is how to fairly and efficiently manage the new energy landscape and the introduction of distributed technologies, to avoid a grid disaster.

The combination of increasing energy efficiency and cheap distributed solar is creating the perfect storm for utilities, and the traditional model of the electricity supply industry. Previously, the electricity supply industry was predicated on centralised supply from large power stations to passive consumers, and an ever-increasing demand in energy. This dynamic has dramatically changed, with the arrival of distributed solar generation and an unforeseen decline in energy consumption; these changes are challenges to the operation of the system.

The cost of rooftop solar has decreased by a factor of five over the past six years. These plummeting costs are being driven by substantial worldwide deployment and investment, with over $100 billion spent on solar technology in 2013 alone. As a result, self-generation of electricity has been affordable on a small scale for the first time in the history of the supply electricity. In Australia, and many places around the world, the cost of solar has fallen below the retail price of electricity. This has resulted in the emergence of a new class of electricity customers, the 'prosumer', that both consume and produce power. Over 1.4 million households in Australia now have rooftop systems installed, both consuming and producing electricity, representing a significant shift from the historic 'hub and spoke', one directional flow of electricity to unengaged users.

At the same time, broader residential energy consumption has been declining. In part, this is due to the increasing energy efficiency of appliances, such as the emergence of high performance heat pumps, but is partly due to conservation efforts in response to surging retail prices.

This decline is also unprecedented in the history of the industry, and in combination with distributed generation is creating challenges for utilities, and the way electricity is priced.

Network companies, who own and operate the 'poles and wires', are stuck with the costs of maintaining the grid to meet peak demand, which is effectively a fixed cost. However, at present this cost is largely recovered through a tariff based on the consumption. Both self-generation and energy efficiency result in a decline in grid consumption, and yet the utility still needs to recover the same fixed cost, as such the tariff is increased. This higher price encourages further energy efficiency, or more installation of solar and the cycle continues. Described by the industry as a 'death spiral', is the extreme price increase that may cause a mass exodus from the grid, as consumers look to secure their own energy needs independent from the system.

This phenomenon is creating headaches for regulators and companies across Australia. The grid defection scenario raises several issues related to equity, and also potentially results in a substantial waste of resources and assets. In Australia, the distribution networks alone have assets worth over $60 billion, and the declining use represents a substantial loss to Australian productivity. A key challenge we face in the coming decade is how to fairly and efficiently manage the new energy landscape and the introduction of distributed technologies, to avoid a grid disaster.

Dylan McConnell
Research Fellow
Melbourne Energy Institute

Energy Futures Seminar Series 2014

Energy Storage – What Scale? What Cost? What Impact?– 27 February 2014

Tim Forcey	Energy Advisor, Melbourne Energy Institute
John Wood	Chief Executive Officer, Ecoult - developer and marketer of the CSIRO Ultrabattery®
Tosh Szatow	Director and Co-Founder, Energy for the People
Rob Clinch	Associate, ARUP
Craig Chambers	Market Sector Director, Power Generation, AECOM
Terry Jones	Manager, Distributed Energy and Innovation SP AusNet
Giles Parkinson	Founder and Editor, RenewEconomy

Coping with hotter summers: the challenge for our electricity system – 30 April 2014

Lucy Carter	Energy Fellow, Grattan Institute
Lane Crockett	Executive General Manager, Australia, Pacific Hydro
David Karoly	Professor of Atmospheric Science School of Earth Sciences, The University of Melbourne
Julian Turecek	General Manager, Wholesale Market Operations, Energy Australia

RET Review – What does it mean for renewable energy in Australia? - 17 September 2014

Tony Wood	Energy Program Director, Grattan Institute
Anthea Harris	Chief Executive Officer, Climate Change Authority
Ivor Frischknecht	Chief Executive Officer, Australian Renewable Energy Agency
Cathy Alexander	Research Fellow, Melbourne Sustainable Society Institute

The Future of Gas Supply and Demand in Eastern Australia – 13 November 2014

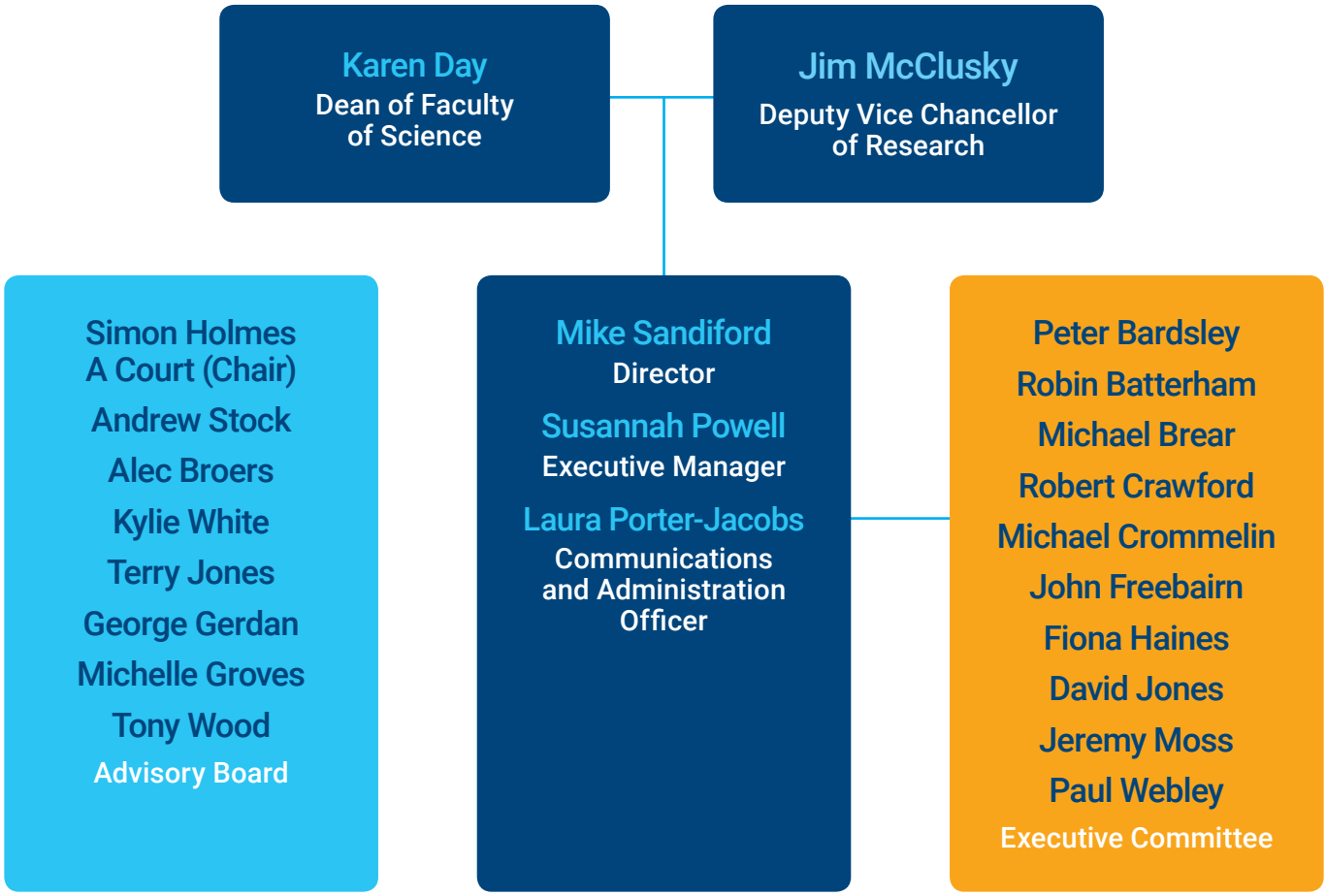
Mike Sandiford	Director, Melbourne Energy Institute
Ursula Alquier	Victorian Coordinator , Lock the Gate
Peter Cleary	Vice President LNG Markets, Eastern Australia Commercial Santos
Craig Memery	Energy Consumer Advocate , Alternative Technology Association
Tony Wood	Energy Program Director, Grattan Institute

Governance

The Institute reports to the Deputy Vice Chancellor of Research, Professor Jim McClusky, for research matters and the Faculty of Science Dean, Professor Karen Day, for operational matters.

The Director and Executive Committee govern the Institute and the Advisory Board provides strategic advice. The Executive Committee is made up of senior academics from the Faculties of Engineering, Law, Arts, Science, Business and Economics, and Architecture, Building and Planning.

A small team of professional staff support the Director in the administration of Institute activities.



New Funding Initiatives

Confirmed new funding for Institute led and supported activities in 2014

Funding Source	Name	CI/proponent	Faculty	Funding Period	Total ($k)
Australian Research Council	Transforming electricity markets	Dr Leslie Martin 1 Dr David Byrne	FBE	2014	177
Australian Research Council	Basin GENESIS Industry Transformation Research Hub	Prof Louis Moresi 1	SCI/ENG	2014	1,000
Australian Research Council	Direct geothermal systems	Dr Guillermo Narsilio 2	ENG	2014	720
AuScope	Energy geophysics	A/Prof Tim Rawling 1	SCI	2014	350
Geoscience Australia	SBMI - Groundwater geodynamics	Prof Mike Sandiford 2	SCI	2014	410
CO2CRC	1.0.1 Otway 2B - Part 1	Prof Ralf Haese 1	SCI	2014	526
Australia Institute	Future gas demand	Mr Tim Forcey 1	SCI	2013	10
				Total ($k)	**3,193**
				Multiplier	**3.5**

1. Appointments facilitated by MEI investment
2. Projects seeded by MEI investment

Expenditure

Melbourne Energy Institute 2014 Budget

Operations	
Salaries	$338,000
Administration and general expenses	$53,000
Events and communications	$16,000
Subtotal	**$407,000**

Research	
Capability	$350,000
Project Seed Funding	$159,000
Partnership development seed funding	$58,000
Director's discretionary	$12,000
Subtotal	**$579,000**

Total	**$986,000**

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Views expressed are not necessarily endorsed or approved by the University. The information in this publication was correct at the time of printing. The University reserves the right to make changes as appropriate.

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