GROUP OF EIGHT

ENERGY RESEARCH

The Group of Eight Limited
Group of Eight House
Level 2, 101 Northbourne Avenue
Turner ACT 2612
www.go8.edu.au

Contents

The Go8 universities are referred to in the following abbreviated forms throughout this paper.

Monash University	Monash
The Australian National University	ANU
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The University of New South Wales	UNSW
The University of Queensland	UQ
The University of Sydney	Sydney
The University of Western Australia	UWA

Group of Eight Energy Research

The Group of Eight (Go8) is a coalition of leading Australian universities*, intensive in research and comprehensive in general and professional education.

The Go8 member universities recognise that the issue of energy usage and transformation is one of vital importance not only to Australia but to the world as a whole. The universities aim to make substantial contributions to the technologies and policies that will enable the delivery and use of energy in a sustainable manner.

Energy is a multi-dimensional subject, so the term "energy-related" in this report includes:

- Identification, extraction and delivery of primary energy sources
- Conversion of these primary energy sources to secondary energy forms and their delivery
- Use of primary and secondary energy in an efficient manner
- Environmental impacts of energy supply and use
- Economic/social impacts and regulatory/policy issues related to energy supply and use

This report aims to identify areas of energy research undertaken by the Go8 member universities that have both quality and critical mass.

*Go8 member universities are:

- The University of Western Australia
- The University of Adelaide
- Monash University
- The University of Melbourne
- The Australian National University
- The University of Sydney
- The University of New South Wales
- The University of Queensland

Clean Coal Technologies

The University of Western Australia

Clean Coal Technologies

The University of Western Australia's commitment to clean energy conversion has been reinforced with the completion of a new $3.8million laboratory providing state-of-the-art equipment and support to enable world class research. Expertise includes:

- Coal combustion
- Coal gasification
- Coal-to-liquids
- Electrolysis
- Pyrolosis
- Methane cracking
- Catalysis
- Carbon storage
- Carbon monitoring
- Oxyfuel combustion

Professor Dongke Zhang
Email: dongke.zhang@uwa.edu.au

Professor Hui Tong Chua
Email: huitong.chua@uwa.edu.au

Professor David Lumley
Email: david.lumley@uwa.edu.au

Monash University

Clean Coal Technologies

Monash University researchers are leading the way in development of clean coal technologies such as Oxy-fuel combustion, Coal gasification technology and Pre-combustion carbon dioxide capture technologies.

Their work will form part of the solution to drastically cut the emissions from brown coal based power generation. Their development will involve a partnership of industry, researchers from the CSIRO and Cooperative Research Centre for Greenhouse Gas Technologies (CRCCO2) and governments as well as collaboration with national and international partners in countries such as China, Germany, Japan and USA. Monash has had a long tradition of research excellence in the area of brown coal science and technology, which has been a priority research area since its inception.

Prior research in Monash covers almost every aspect of brown coal science and technology, including its structure and properties, its drying, carbonisation, liquefaction, pyrolysis, combustion and gasification, its non-fuel use as well as the environmental aspects of brown coal utilisation.

Today Monash continues to enjoy an excellent international reputation in brown coal science and technology. Under the Victorian Government's ETIS Program involving almost $10 million in research grants in this field, the University was involved in nine of the ten projects.

Professor Paul Webley
Email: paul.webley@eng.monash.edu.au

Associate Professor Sankar Bhattacharya
Email: sankar.bhattacharya@eng.monash.edu.au

Associate Professor Alan Chaffee
Email: alan.chaffee@sci.monash.edu.au

The University of Adelaide

Clean Coal Technologies

The South Australian Coal Research Laboratory (SACRL) within the School Chemical Engineering carries on the leading work of the CRC for Clean Power from Lignite, particularly in relation to South Australian low-rank coals. The group's research focus is on gasification/combustion to provide environmentally responsible commercial solutions for industry. Main areas of expertise:

- Solids fuel combustion including:
  - Characterisation of solid fuels
  - Fluidised-bed gasification and combustion of solid fuels
  - Thermal processing of fossil, biomass and waste fuels
  - Assessment of process options for solid fuels
  - Process options for post-combustion pollutant removal
  - Pyrolysis of low-grade coal

Associate Professor Peter Ashman
Email: peter.ashman@adelaide.edu.au

Dr Philip Kwong
Email: philip.kwong@adelaide.edu.au

Dr Adam Kosminski
Email: adam.kosminski@adelaide.edu.au

The University of New South Wales

Cleaner Fossil Fuels

The School of Petroleum Engineering (SCOPE) undertakes research on Coal Seam Methane recovery including the development of drilling systems, methods and equipment and the technology of hydraulic fracturing.

The Reactor Engineering and Technology Group is primarily driven by the industrial challenge to improve current plant operation in resource utilisation, recovery and to create novel processes with superior material and energy economy within an environmentally sustainable framework. Three key research areas are catalyst design and synthesis, reaction diagnosis and kinetics and reactor modelling and analysis. Current projects deal with clean fuels synthesis via GTL, BTL and CTL processes with particular focus on efficient catalyst development and energetically-smart reactors using advanced process tomography techniques.

Research in catalysis energy is focused on clean alternative fuels, on optimising alternative liquid fuel production as relevant to New South Wales and Australia and on novel routes to extending fuel reserves in order to ensure security of supply. UNSW's catalysis energy group has a long history of optimising catalytic processes for the production of hydrogen and methanol, with world patents issued in several areas. They also focus on gas to liquid, coal to liquid and biomass to liquid conversions for the production of clean transport fuels.

Professor Sheik S Rahman
Email: sheik.rahman@unsw.edu.au
Professor Adesoji Adesina
Email: a.adesina@unsw.edu.au
Emeritus Professor David Trimm
Email: d.trimm@unsw.edu.au

The University of Queensland

Novel Clean Coal Processing Technologies

- Storage in Enhanced Coal Bed Methane
- Ultra Clean Coal
- Underground Coal Gasification
- Oxygen and Oxyfuels
- Chemical Looping
- Gasification of coal/biomass

Professor Victor Rudolph
Email: v.rudolph@uq.edu.au
Dr Paul Massaroto
Email: paulm@cheque.uq.edu.au
Associate Professor Joe da Costa
Email: j.dacosta@uq.edu.au
Associate Professor Alex Klimenko
Email: a.klimenko@uq.edu.au
Dr Bo Feng
Email: b.feng@uq.edu.au
Dr Matthew Cleary
Email: m.cleary@uq.edu.au

Gas Cleaning/Separation/Reaction

- Gas Cleaning
- Gas Separation
- Reaction and Gas to Liquids

Professor Victor Rudolph
Email: v.rudolph@uq.edu.au
Associate Professor Joe da Costa
Email: j.dacosta@uq.edu.au
Professor S Bhatia
Email: s.bhatia@uq.edu.au

Modelling/Simulation/Control

- Adsorption, Modelling and Simulation
- Computational Fluid
- Sustainability Metrics
- Thermodynamics of Ash Slag in Coal Gasification
- Control and Diagnostics

Professor S Bhatia
Email: s.bhatia@uq.edu.au
Professor Victor Rudolph
Email: v.rudolph@uq.edu.au
Associate Professor Joe da Costa
Email: j.dacosta@uq.edu.au
Dr Michael Macrossan
Email: m.macrossan@uq.edu.au
Professor Ian Cameron
Email: i.cameron@uq.edu.au
Associate Professor Alex Klimenko
Email: a.klimenko@uq.edu.au
Dr Matthew Cleary
Email: m.cleary@uq.edu.au.

Coal Seam Gas

- Resource characterisation
- Extraction technologies

The Clean Coal group has been able to attract almost $15M in research funding for 25 projects in the last 5 years, including ARC Discovery ($4.9M), ARC Linkage ($3.7M) and others ($5.3M). The last figure includes industry, state government, Centre for Low Emission Technologies (cLET), CO2CRC and the Cooperative Research Centre for Coal in Sustainable Development (CCSD). These funds provided support for 20 Research Fellows and 22 PhD students, laboratory equipment and infrastructure. This is part of an extensive collaborative network, including 46 internal UQ collaborators, 5 Australian universities and 29 overseas institutions/universities.

Associate Professor Sue Golding
Email: s.golding1@uq.edu.au

Dr Joan Esterle
Email: j.esterle@uq.edu.au

Professor Victor Rudolph
Email: v.rudolph@uq.edu.au

Dr Paul Massaroto
Email: paulm@cheque.uq.edu.au

Carbon Capture and Storage

The University of Western Australia

CCG: Monitoring and Verification

UWA is building on world-class research expertise in carbon capture and storage (CCS), to develop new technologies to capture and inject/sequester CO_2 into deep geologic formations to help meet environmental targets to reduce global greenhouse gas emissions. This includes a mix of science and engineering research including rock and fluid physics, subsurface site selection and reservoir characterisation, and geophysical monitoring and verification of injected CO_2 over time. Expertise includes:

- 3D seismic imaging
- 4D seismic monitoring and verification
- Reservoir engineering
- Experimental and numerical modelling of CO_2 injection
- Multiphysics
- Geomechanics
- 3D model building and numerical simulation
- Chemical reaction engineering
- Homogeneous combustion catalysts for combustion
- CCS geoscience feasibility analysis
- CO_2 rock and fluid mechanics
- 3D site characterisation
- Hydrocarbon process engineering
- Thermodynamics and CO_2 capture at cryogenic conditions
- Subsurface CO_2 monitoring and verification

Professor David Lumley
Email: david.lumley@uwa.edu.au

Professor Eric May
Email: eric.may@uwa.edu.au

Professor Klaus Gessner
Emai: Klaus.gessner@uwa.edu.au

Monash University

Carbon Capture and Storage

Researchers at Monash University are using adsorbent technology to develop an efficient method for carbon capture, storage and dissipation. The team is developing a way to use paper to capture and dissolve CO_2 emissions to assist in reducing global warming. The aim is to create paper with fibres that are moulded to Zeolite (an absorbent material in the form of small pellets) that will suck up the CO_2 and then dissolve it.

One research team is taking part in a unique carbon dioxide pre-combustion capture project that trials three technologies to find the most cost-effective for removing CO_2 from brown coal gasification power generation.

The Monash technology component is one of three being tested by the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), one of the world's leading carbon capture storage (CCS) research collaborations, in partnership with HRL Developments.

Associate Professor Alan Chaffee
Email: alan.chaffee@sci.monash.edu.au

Professor Paul Webley
Email: paul.webley@eng.monash.edu.au

Professor Gil Garnier
Email: gil.garnier@eng.monash.edu.au

The University of Adelaide

Carbon Capture and Storage

The Australian School of Petroleum is a part of the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), one of the world's leading collaborative research organisations focused on carbon dioxide (CO_2) capture and geological storage (geosequestration). Researchers are predominantly involved in storage research projects comprising both fundamental and applied areas of research. Main areas of expertise:

- Geological storage: site characterisation; capacity evaluation
- Injectivity/containment assessment
- Transport infrastructure (pipelines)
- Laboratory modelling and actual field experimental injection of CO_2 into deep underground formations (Otway Basin)

Dr John Kaldi
Email: john.kaldi@adelaide.edu.au

Dr Mark Bunch
Email: mark.bunch@adelaide.edu.au

The University of Melbourne

Carbon Capture Technologies

The separation of carbon dioxide from the flue gases is a major research focus within the Melbourne Energy Institute through the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) that has a major research node at the university. Leading research is being undertaken into the use of both solvent and membrane technologies for carbon capture.

Professor Geoff Stephens
(Chemical Engineering)
Email: gstevens@unimelb.edu.au

Associate Professor Sandra Kentish
(Chemical Engineering)
Email: sandraek@unimelb.edu.au

The University of New South Wales

Carbon Capture and Storage

The UNESCO Centre for Membrane Science and Technology studies ways to optimise the morphology and post-fabrication treatment of hollow fibre membranes to overcome these challenges. Hollow fibre membrane spinning and characterisation facilities were established in the Membrane Centre in early 2008, allowing custom-made hollow fibres to be fabricated and tested. Carbon dioxide is a main contaminant in natural gas production as well as a significant contributor of greenhouse gases from coal fired power plants. Gas separation via hollow fibre membranes offers attractive advantages over conventional amine absorption technology in terms of their ability to withstand high pressures and smaller process footprint. However, challenges remain in terms of maintaining membrane lifetime and performance in the presence of other contaminants in natural gas as well as long-term ageing and degradation of membrane properties.

Research into the economics of carbon dioxide capture and storage (CCS) is being undertaken in collaboration with the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC). Work underway includes (a) estimating the costs of CCS for major sources of CO_2 emissions across Australia, (b) developing software for estimating the costs of CCS for given sources and potential injection sites and (c) assessing the economic viability of CO_2 injection into oil and gas fields and coal bed methane reservoirs for CO_2 storage and enhanced recovery.

The School of Biological, Earth and Environmental Sciences (BEES) has a research group focused on advanced methods of coal characterisation and the relation of coal properties to different aspects of advanced utilisation. Other activities undertaken by the group include evaluation of sites for geological storage of CO_2, geological factors affecting coal seam gas storage and production (partly with CSIRO), and also the characteristics and beneficial use of ash and other coal utilisation products.

Professor Vicki Chen
Email: v.chen@unsw.edu.au

Mr Guy Allinson
Email: g.allinson@unsw.edu.au

Professor Colin Ward
Email: c.ward@unsw.edu.au

Professor Dianne Wiley
Email: d.wileyWunsw.edu.au

Dr Lila Gurba
Email: l.gurba@unsw.edu.au

The University of Queensland

Carbon Capture Technologies

- Advanced zero emission power system
- CO_2 sorbents for high temperature applications
- CO_2 sorbents for low temperature applications
- Calcium looping technology

Dr Bo Feng
Email: b.feng@uq.edu.au

The University of Sydney

Carbon Capture and Storage

One of the long-term options for mitigating climate change is injection of carbon dioxide in deep geological formations. Coal strata may be a suitable host because of its affinity to CO_2, and the release of methane that would offset geosequestration cost. However, our understanding of the impact of CO_2 on the properties of coal is still in its infancy owing to the complex structure of coal which include porosities of different orders of magnitude, and to the coupling between hydrological, mechanical, thermal and chemical processes at play. The project, funded by an ARC Discovery grant jointly with the Geomechanics group at Monash University, is to conduct tri-axial and diffusion tests and develops new dual and multiple-porosity models for simulating the fate of injected CO_2.

Professor David Airey
Email: d.airey@civil.usyd.edu.au

Associate Professor Abbas El-Zein
Email: abbas.elzein@sydney.edu.au

Carbon Capture and Storage

Brief synopsis of key research areas:

- Process Systems Engineering
- Clean-coal technologies—Integration of carbon capture with coal-fired power generation
- Carbon capture via mineral carbonation
- Particulate processes

Facilities include: Laboratory for multiscale systems, pilot plant facilities, Raman Spectrometer, distributed control system. The principle approaches are computer-aided process engineering: multiscale modelling, simulation, optimisation, design and control.

Dr Ali Abbas
Email: ali.abbas@sydney.edu.au

Associate Professor Andrew Harris
Email: andrew.harris@sydney.edu.au

Biofuels and Bioenergy

The University of Western Australia

Biofuels and Bioenergy

Bioenergy research at UWA is a multi-disciplinary and highly collaborative effort in the quest for achieving international excellence. The university's strong partnerships with highly skilled, experienced individuals and Centres of Excellence ensure that its research is producing leading edge, innovative and creative solutions. Expertise includes:

- Bio-diesel
- Biomass energy
- Bio-fuel
- Genomics
- Natural gas chemistry and chemical engineering
- Reaction engineering and kinetics
- Reaction mechanisms and thermodynamics
- Anaerobic and biogas production
- Pyrolysis oil upgrading
- Hot gas cleaning

Professor Steven Smith
Email: steven.smith@uwa.edu.au

Professor Dongke Zhang
Email: dongke.zhang@uwa.edu.au

Professor Colin Raston
Email: colin.raston@uwa.edu.au

Professor Kadambot Siddique
Email: ksiddique@fnas.uwa.edu.au

Monash University

Biofuels and Bioenergy

Monash has an extensive program of biofuel and bioenergy research activities that investigate the use of a number of different raw materials and processing methods.

An example of one of the many research projects in this field involves a team from the engineering and arts faculties that is developing a system to produce competitively-priced chemicals and alternative diesel fuels from second-generation feedstocks such as waste construction wood and plantation residues. This $1.4 million project, is being funded by the Federal Government Department of Resources, Energy and Tourism and the Renewable Oil Corporation.

Monash also has substantial skills in the use of marine algae for the capture of CO_2 from power stations and the subsequent manufacture of biodiesel. Monash is working with Biomax on an ARC Linkage Grant.

Professor Milton Hearn
Email: milton.hearn@sci.monash.edu.au

Associate Professor Tony Patti
Email: tony.patti@sci.monash.edu.au

Professor Gil Garnier
Email: gil.garnier@eng.monash.edu.au

Associate Professor Damon Honnery
Email: damon.honnery@eng.monash.edu.au

Dr Prabhakar Ranganathan
Email: prabhakar.ranganathan@eng.monash.edu.au

Professor Paul Webley
Email: paul.webley@eng.monash.edu.au

Professor John Beardall
Email: john.beardall@sci.monash.edu.au

The Australian National University

Artificial Photosynthesis

Artificial Photosynthesis is a program to ensure our economic and environmental future through novel, biologically-inspired energy and manufacturing technologies. These technologies will exploit research at ANU, aimed to produce fuel, foods and fibre on a large scale. Such technologies minimise water consumption and have environmental impact. This research looks towards:

- totally renewable electrolytic hydrogen generation from seawater
- non-polluting electricity generation using organic based photo-voltaic systems
- carbohydrate production requiring vastly less water than conventional agriculture.

Artificial Photosynthesis links biological sciences, synthetic and computational chemistry, as well as biophysics and photo-physics. ANU has world-leading research groups in all of these areas able and willing to collaborate targeting research in natural and artificial

Professor Elmars Krausz
Email: elmars.krausz@anu.edu.au

Dr Ronald Pace
Email: ron.pace@anu.edu.au

The Australian National University, Artificial Photosynthesis continued

photosynthesis. Unique experimental capabilities exist in laser and optical spectroscopies, fast kinetic infra-red and isotope exchange mass spectrometry. Importantly, ANU hosts the leading synthetic chemistry groups in Australia. These activities have a strong graduate teaching and training focus.

Biosolar Energy

This project is concerned with the steps required to define, design and produce oil, hydrogen and industrial feed stocks from selective microalgae. The co-location of two sustainable technologies, solar thermal energy and oil and biomass production by microalgae underpins this sustainable technology. This process starts in the controlled laboratory environment and ends when the biomass is transformed to (a) crude algal oil via either a process of mechanical extraction or a process of pyrolysis, or (b) hydrogen by a process of pyrolysis and shift reaction. Microalgae producing industrial feed stocks will be selected from natural variants or via genetic manipulation. The research areas related to this proposal are: I) genetics, molecular biology and plant physiology, II) engineering of bio-diesel and III) engineering of biomass gasification for the production of hydrogen.

Mass spectrometry, elemental and isotopic analyses, calorimetry, oxygen and carbon dioxide gas exchange, controlled environment facilities, micrometeorology.

Professor Graham Farquhar
Email: graham.farquhar@anu.edu.au

The University of Adelaide

Biofuels/Bioenergy

The Microalgal Engineering Research Group Research addresses the development of renewable energy from micro-algae. Research activities form a key part of the Asia-Pacific Partnership on Clean Development program to produce, harvest and extract lipids from marine micro-algae for the large scale production of bio-fuels. Main areas of expertise:

- Industrial scale microalgae culturing, harvesting, lipid extraction and alternative biodiesel technologies
- Energy production from waste biomass with a specific focus on second-generation bio-energy using marine microalgae
- Integration of wastewater treatment and microalgal production processes
- Independent assessment of biofuel production
- Conceptualise and scale-up processes that are economically and environmentally sustainable

Dr David Lewis
Email david.lewis@adelaide.edu.au

Biomass/Waste to Energy

Research primarily focuses on the clean combustion and utilisation of biomass, including wood, waste and other fuels that are nominally carbon neutral to deliver world-class research outcomes for industry. Main areas of expertise:

- Characterisation of biofuels
- Gasification, pyrolysis and anaerobic digestion of waste materials and biomass
- Optimisation of combustion systems to account for specific properties of alternative fuels
- Development of alternative fuel burner configurations
- Thermal processing of fossil, biomass and wastes fuels
- Process options for post-combustion pollutant removal
- Waste to energy technology assessments

Associate Professor Peter Ashman
Email: peter.ashman@adelaide.edu.au

Professor Keith King
Email: keith.king@adelaide.edu.au

The University of Melbourne

Bioenergy

The University of Melbourne has a multidisciplinary team focused of bioenergy focusing on the production of woody and agricultural biomass in a sustainable, socially-responsible manner; developing new technologies for efficient fermentation of ligno-cellulosic biomass and the downstream processing of fuels from ligno-cellulosic and algal biomass; and developing engines capable of working at high efficiency regardless of fuel composition.

Professor Tony Bacic
(Bio21, Botany)
Email: abacic@unimelb.edu.au

Professor Peter Scales
(Chemical Engineering)
Email: peterjs@unimelb.edu.au

The University of New South Wales

Bioenergy

Research and Development is focused on second generation technology using cellulosic biomass not in competition with food grade raw materials. Projects have involved funding and collaborative R&D with leading research agencies and companies such as Dupont, US National Renewable Energy Laboratory, US Department of Energy, BASF (Germany), CSR and Manildra (Australia). The current R&D is supported by the NCRIS Biofuels Sub-Program, and the NSW and South Australian State Governments.

Professor Peter Rogers
Email: p.rogers@unsw.edu.au

The University of Queensland

Microalgal Biofuels

The Solar Biofuels Consortium (www.solarbiofuels.org) was established to accelerate development of high-efficiency biofuel production processes using microalgae and advanced bioreactors. The Consortium now includes 8 international research teams with ~70 researchers that conduct bio-discovery, marine biology, structural biology, molecular biology, microbiology, genomics, metabolomics, culture optimisation and bioreactor scale up within a coordinated research program. This capacity exploits synergies between biology and engineering, in a rapidly expanding and valuable area of biotechnology that is focused on providing clean fuels for the future, reducing CO_2 emissions and contributing to CO_2 capture and storage. Since its recent launch in 2007, collectively the consortium has already secured funding of ~$4 million. Ben Hankamer works closely with IMBcom (cc Peter Isdale) on the commercialisation of this technology.

Associate Professor Ben Hankamer
Email: b.hankamer@uq.edu.au

The University of Sydney

Biomass and Biofuels

Areas of expertise include basic research into the combustion of biofuels as well as practical applications in areas which include materials physics, plasma deposition and processing, renewable and sustainable fuels. Sophisticated diagnostic methods and physical techniques are used to identify reaction products and obtain reaction kinetics. Design and synthesis of model compounds play a significant part of the projects in the production and use of biomass, surface immobilised enzymes are investigated to facilitate the production of biofuels.

Professor Thomas Maschmeyer
Email: thomas.maschmeyer@sydney.edu.au

Professor Brian Haynes
Email: haynes@chem.eng.usyd.edu.au

Associate Professor Andrew Harris
Email: andrew.harris@sydney.edu.au

Professor Assaad Masri
Email: assaad.masri@sydney.edu.au

Sustainable Energy

Areas of expertise include biodiesel synthesis, CO_2 sequestration using algae, conversion of algal feedstocks into biodiesel, zero emission process design, process modelling, simulation, flowsheet optimisation for renewable energy technologies, hydrogen storage and photocatalytic splitting of water to generate hydrogen. Our research typically occurs at the interface between established scientific disciplines, i.e. chemistry, physics, biology, engineering and materials science. Because of this we adopt a multi-scale, multi-disciplinary approach that enables us to bring a wide range of skills to bear on pressing environmental and sustainable development problems.

Professor Thomas Maschmeyer
Email: thomas.maschmeyer@sydney.edu.au

Professor Brian Haynes
Email: haynes@chem.eng.usyd.edu.au

Associate Professor Andrew Harris
Email: andrew.harris@sydney.edu.au

Solar Energy

The University of Western Australia

Solar Energy

Expertise includes:

- Solar cells
- Nanomaterials
- Biometrics
- Diatoms

Professor Colin Raston
Email: colin.raston@uwa.edu.au

Dr John Livingstone
Email: johnliv@ee.uwa.edu.au

Monash University

Solar Energy

Solar energy research at Monash is largely focused on the development of low cost and light-weight dye sensitized solar cells (DSSCs), a new type of solar energy device that is now recognised as the most significant alternative photovoltaic technology to silicon wafer-based solar cells.

Several researchers in the Faculty of Engineering have been actively involved in this area and have made concerted efforts in dealing with key materials related issues for this technology. Worked has involved the development of nanostructured electrodes and construction of solar cell devices, including flexible DSSCs on plastic substrates. These solar cells are thin and flexible and can be produced on a mass-scale using the same technology used to print polymer banknotes.

Further work has taken place on the fabrication of DSSCs on flexible substrates using solid-state and ionic liquid electrolytes and tandem DSSC devices.

Research has also investigated the use of ionic liquids and conducting polymers for DSSC applications. The research team in the Department of Materials Engineering has close collaborations with researchers in the School of Chemistry (Monash University), University of Melbourne, University of Wollongong, CSIRO and other Australian and international institutions. Research activities in this area are funded by the ARC, the ARC Centre of Excellence for Electromaterials Science (ACES) and the Victorian Consortium for Organic Solar Cells (VICOSC).

An international team led by Monash University has used chemicals found in plants to replicate a key process in photosynthesis paving the way for a new approach that uses sunlight to split water into hydrogen and oxygen. The breakthrough could reduce the use of fossil fuels by making hydrogen—touted as the clean, green fuel of the future—cheaper and easier to produce on a commercial scale.

Monash researchers in collaboration with CSIRO and Princeton University have developed a coating that can be impregnated with a form of manganese, a chemical essential to sustaining photosynthesis in plant life. The process of "oxidising" water generates protons and electrons, which can be converted into hydrogen gas instead of carbohydrates as in plants. The production of hydrogen using nothing but water and sunlight offers the possibility of an abundant, renewable, green source of energy for the future for communities across the world to heavily reduce the need for fossil fuels.

Professor Yi-Bing Cheng
Email: yibing.cheng@eng.monash.edu.au

Dr Udo Bach
Email: udo.bach@sci.monash.edu.au

Professor Alan Bond
Email: alan.bond@sci.monash.edu.au

Professor Leone Spiccia
Email: leone spiccia@sci.monash.edu.au

The Australian National University

Solar Energy

Our research is in photovoltaic (PV) and solar thermal energy conversion and hybrid PV/thermal systems. Solar energy research at The ANU has internationally prominent research in:

i. Development of advanced characterisation, surface passivation, and impurity reduction techniques for crystalline solar cells

ii. Advanced silicon concentrator solar cells

Professor Andrew Blakers
Email: andrew.blakers@anu.edu.au

Dr Keith Lovegrove
Email: keith.lovegrove@anu.edu.au

The Australian National University, Solar Energy continued

iii. SLIVER solar cell technology, which reduces by an order of magnitude the amount of expensive hyper-pure silicon in crystalline solar cells yet maintains 20 per cent cell efficiency

iv. Combined Heat and Power Solar (CHAPS) systems, which are linear solar concentrating devices that produce both electrical and thermal energy with a combined 65 per cent

v. Paraboloidal dish solar thermal concentrating systems to produce high temperature output for thermal applications, including energy storage via ammonia thermochemistry, and hydrogen production

vi. Air based solar thermal collectors and phase change energy storage, leading to the greenhouse-neutral house as a project concept

The ANU solar group established in 1991 includes an Australian Research Council (ARC) Research Centre. Our facilities include extensive photovoltaic research clean rooms, diffusion and oxidation furnaces, lifetime testers, photolithographic facilities, metal deposition systems, laser machining, LPCVD, APCVD, PECVD, RIE, RTA, screen printer, fume cupboards, microscopes, an electronics workshop, and mechanical workshops; a thermochemical energy storage laboratory; and extensive outdoor facilities including the 400m^2 'Big Dish' thermal concentrating system, 400m^2 parabolic trough systems and non-concentrating solar air and water heaters.

The University of Adelaide

Solar Photovoltaics

Research in the School of Physics and Chemistry is focussed on the development of advanced materials for low-cost optical wavelength conversion that can be applied to existing flat-panel Si-based photovoltaic (PV) infrastructure. There is some research into photovoltaic panel technologies in the School of Electrical and Electronic Engineering. Main areas of expertise:

- Band-gap engineering
- Fabrication of complex multilayers of alternating large bandgap and small bandgap materials
- Low cost technology improvements to existing Si-based PV technologies
- Solar photovoltaic systems and converter topologies for low-cost stand-alone and grid-connected applications

Professor Jesper Munch
Email: jesper.munch@adelaide.edu.au

Associate Professor Nesimi Ertugrul
Email: nesimi.ertugrul@adelaide.edu.au

Solar Thermal Energy

Members of the Centre for Energy Technology are actively involved in research and development of the next generation of solar energy systems, with emphasis on solar thermal systems. In particular, research is aimed at the integration of solar energy with other energy sources for the most cost effective way to generate green electricity. Main areas of expertise:

- Solar thermal power systems
- Solar energy integration in conventional power stations
- Passive solar powered cooling, refrigeration and heating
- Air and waste water treatment using solar photocatalytic oxidation processes
- Solar thermochemical processing of minerals
- Investigation of high intensity radiation within hazardous atmospheres

Associate Professor Eric Hu
Email: eric.hu@adelaide.edu.au

Professor Gus Nathan
Email: graham.nathan@adelaide.edu.au

Mr Richard Craig
Email: richard.craig@adelaide.edu.au

The University of Melbourne

Organic Solar Photovoltaics

The University of Melbourne is the leading partner in the Victorian Organic Solar Cell Consortium that is currently developing flexible, large-area plastic solar cells that can be printed reel-to-reel. In order to transfer this organic PV technology from 'Research to Rooftop', the University of Melbourne is working with a number of research groups and industrial partners.

Professor Andrew Holmes (Chemistry)
Email: aholmes@unimelb.edu.au

Dr David Jones (Chemistry)
Email: djjones@unimelb.edu.au

The University of New South Wales

Photocatalysis and Thermal Catalaysis

The Particles and Catalysis Research Group focuses its energy research from a number of perspectives. Using the sun's energy as a clean fuel source, it is currently designing photocatalysts and engineering systems for solar induced processes. The photocatalytic research entails developing particles for water purification and air quality control, with the intention of using the sun as the sole energy source. Moreover, photoactive materials are being created capable of solar water splitting for hydrogen generation as a clean fuel source.

In the context of thermal catalysis for clean and energy efficient technologies, the research group is developing thermal nanocatalysts for: (1) converting natural gas to liquid fuels (Fischer-Tropsch reaction); (2) generating hydrogen fuel streams via the water-gas-shift reaction and; (3) preferentially oxidising carbon monoxide in the presence of hydrogen in fuel cell feed streams to prevent their deactivation.

Professor Rose Amal
Email: r.amal@unsw.edu.au

Photovoltaics

UNSW is a world leader in solar cell technology, with a substantial portfolio of patented technologies, commercialisation agreements and international awards to its name. Its research program is structured to address near, medium and long-term needs. Grid parity—matching the cost of fossil fuelled electricity—remains the greatest challenge for photovoltaic power and the team at the university's ARC Photovoltaics Centre of Excellence is focused on pairing cutting-edge technology with market reality. Under the leadership of internationally recognised solar innovators, Scientia Professors Stuart Wenham and Martin Green, the Centre is a world leader in low-cost, first-generation silicon solar cell technology. The Centre's five research groups are Buried Contact, High Efficiency, Thin Film, Third Generation PV and Silicon Photonics.

In commercial terms, deals have been brokered for the team's breakthrough buried-contact and semiconductor technologies with some of the world's largest solar cell manufacturers, including Chinese giant, Suntech Power, which was founded by UNSW alumnus Dr Zhengrong Shi.

Professor Martin Green
Email: m.green@unsw.edu.au

Professor Stuart Wenham
Email: s.wenham@unsw.edu.au

Solar Thermal Technology

The Solar Thermal Energy Laboratory at UNSW has 30 years of research and development experience in solar thermal collector design, testing and performance simulation. The rooftop laboratory is used heavily by industry for commercial testing and development of both flat plate and concentrating solar thermal collectors. Current research areas involve cogeneration of heat and power using thermoelectric, the development of micro-solar thermal collectors for local hydrogen production, and the development of concentrating collectors for solar cooling.

Dr Gary Rosengarten
Email: g.rosengarten@unsw.edu.au

The University of Queensland

Organic Photovoltaics

The organic and dye sensitised solar cell program at the University of Queensland is focused on the development of new materials and architectures for next generation devices. The work is carried out in the Centre for Organic Photonics and Electronics—a multi-disciplinary initiative between the disciplines of Physics and Chemistry. The centre has extensive facilities for materials design, synthesis and characterization and the full fabrication and testing of prototype and scaled solar cells. A particular focus of the program is the development of new device concepts beyond the thermodynamic limit and the creation of novel new light harvesting systems.

Professor Paul Meredith
(Physics)
Email: p.meredith@uq.edu.au

Professor Paul Burn
(Chemistry)
Email: p.burn@uq.edu.au

Photocatalysis

Photocatalysis is an important chemical process that underpins the development of critical solar energy technologies. The UQ work by the ARC Centre of Excellence for Functional Nanomaterials includes new photocatalysts preparation, solar-thermal reactor development and photoelectrochemical cell design with applications in water/air purification, hydrogen production from splitting water, self-cleaning coating, and low cost solar cells.

Professor Max Lu
Email: maxlu@uq.edu.au

Associate Professor Lianzhou Wang
Email: l.wang@uq.edu.au

The University of Sydney

Solar Energy

The Solar Energy Group has been highly active and prominent in developing direct solar energy collection concepts and technology since 1975. It has expertise in licensing for commercialisation, world leading technology in the areas of solar selective absorber coatings, evacuated tube design, optical solar collector design and thermal solar collector design. For large-scale solar electricity generation, cost reductions are still needed to compete with low cost traditional electricity in developed nations. This overlying concern is an integral element of the work undertaken in Applied and Plasma Physics.

Professor David McKenzie
Email: d.mckenzie@physics.usyd.edu.au

Power Engineering

The University of Western Australia

Power Engineering

Expertise includes:

- Power systems
- Power network systems and controls
- Renewable energy
- Smart grids
- Smart home
- Smart vision sensors
- Energy systems

Professor Tien Tam Nguyen
Email: tam@ee.uwa.edu.au

Professor Victor Sreeram
Email: sreeram@ee.uwa.edu.au

Monash University

Power Engineering

Monash researchers from the Department of Electrical and Computer Systems Engineering (ECSE) are actively involved in the analysis of power systems, variable speed drives, condition monitoring of electrical plant, high voltage engineering, quality of electrical supply, asset and demand management and electric traction.

The Centre for Power Transformer Monitoring, Diagnostics and Life Management (CPTM) conducts research and development of new technologies, computer algorithms and equipment for monitoring, diagnostics and life management of power transformers.

The Power Electronics Group undertakes research in a range of areas. Some examples include, power electronic drives for d.c. and a.c. machines, transients in power systems, transformers, harmonics in power systems and equipment, power electronic converters, dynamic stability analysis of power systems, reliability evaluation of electrical power systems, industrial control and monitoring systems, consumer and appliance electronic controls, load demand modelling, renewable energy systems, economics of power electronics design and electric traction.

Dr Valery Davydov
Email: valery.davydov@eng.monash.edu.au

Associate Professor Grahame Holmes
Email: grahame.holmes@eng.monash.edu.au

Dr Tadeusz Czaszejko
Email: tadeusz.czaszejko@eng.monash.edu.au

Dr Brendan Mcgrath
Email: brendan.mcgrath@eng.monash.edu.au

Professor Peter Wallace
Email: peter.wallace@eng.monash.edu.au

The University of Adelaide

Power Engineering and Electrical Devices

Members of the Centre for Energy Technology within the School of Electrical and Electonic Engineering have leading expertise in the areas of electrical drives, power electronics and control and have been involved in the design of specialised electric motor drives for a range of applications. We also have experience in data-acquisition, condition monitoring of electrical machines and electrical power quality monitoring. Main areas of expertise:

- Power electronics
- Electrical motors and generators
- Data acquisition systems for measurement and monitoring
- Electrical power quality, conditioning and associated standards
- Distributed generation system integration and control
- Power system protection

Associate Professor Nesimi Ertugrul
Email: nesimi.ertugrul@adelaide.edu.au

Dr Wen Soong
Email: wen.soong@adelaide.edu.au

The University of Melbourne

Smart Grid Technology

The University of Melbourne hosts the ARC Research Networks on Intelligent Sensors, Sensor Networks and Information Processing group (ISSNIP) researching smart grid technologies that improve efficiency, intelligence, reliability, security, and affordability focused on:

- Interoperability and communications through the various existing and new systems
- Usage monitoring and management, including rapid fault detection and localisation, as well as intelligent sensing and control

Associate Professor Marimuthu Palaniswami
Email: palani@unimelb.edu.au

The University of Melbourne, Smart Grid Technology continued • Advanced operating concepts • Modelling and simulation of all aspects of power distribution, utilisation, communications and information feedback for system control	
The Green Internet The University of Melbourne operates a Green Internet project that models of power consumption in the Internet to devise methods for improving the power efficiency of the Internet as its size and capacity increases. The project adopts a multi-level, multi-disciplinary approach to the issue of power consumption in ICT and the Internet, providing a unique and systematic analysis of the engineering and environmental challenges posed by the global and ever-increasing demand for Internet services.	**Professor Rod Tucker** Email: r.tucker@unimelb.edu.au

The University of New South Wales

Electrical Energy Systems Research in a wide range of areas associated with the generation, transmission, storage and utilisation of electrical energy, as well as in measurement, materials and electrical equipment. The main research areas are high voltage engineering, machines and drives, power electronics, renewable energy integration and electricity industry restructuring.	**Professor Faz Rahman** Email: f.rahman@unsw.edu.au
Energy Storage Vanadium Redox-cell batteries for remote area and large-scale grid connect applications—commercial prototype design and development and field testing. Other battery technologies including Lithium Ion and fuel cells, and batteries for electric vehicles.	**Professor Maria Skyllas-Kazacos** Email: m.kazacos@unsw.edu.au
Renewable Energy Integration and Smart Grids Research on the technical, economic, commercial and policy challenges of renewable wind and PV energy integration. Small-scale grid connect power electronics and drives, distribution network impacts including peak demand. Grid connect and renewable technology equipment standards and testing. Optimal scheduling of distributed generation and storage in 'smart grids'. Regulatory and policy challenges for distributed energy systems.	**Dr Iain MacGill** Email: i.macgill@unsw.edu.au **Dr Muriel Watt** Email: m.watt@unsw.edu.au

The University of Queensland

Power and Energy Systems The Power and Energy Systems Research activities evolve around power system security and condition assessment of critical infrastructure. The research group is also involved with generation and transmission planning issues in a deregulated electricity market environment. The group is actively working on a number of challenging problems relevant to renewable energy and distributed generation integration to the main national grid. The group is a major partner of the Australian Power Institute. A number of initiatives have been funded by this organisation and the former Queensland Power Engineering Alliance.	**Professor Tapan Saha** Email: saha@itee.uq.edu.au

The University of Sydney

Energy Storage Low cost, efficient energy storage is a key technology for future smart electricity networks. We are developing new components for flow and other battery technology based on new materials and designs. Advanced flow batteries for grid connected and mobile applications, using innovative carbon electrodes for energy storage. The focus is on using nanocarbons to provide high electrical conductivity and surface area.	**Professor Tony Vassallo** Email: anthony.vassallo@sydney.edu.au
Integration of Small, Distributed Energy Systems Integration of small, distributed energy systems is a rapidly increasing component of modern power systems. Optimisation and operation of these systems requires new tools and approaches to maintain power quality. The research is based on a multidisciplinary systems approach. Modelling PV, solar thermal and other sustainable energy production, dispatch and economics. Effects of plug-in electric vehicles on existing and future energy sources, role of energy storage in renewable integration. Design and analysis of co- and tri-generation for buildings.	**Professor Tony Vassallo** Email: anthony.vassallo@sydney.edu.au

Smart Grids

The Centres of Excellence in Power Engineering and Telecommunications conduct interdisciplinary research on smart grids. The university and EnergyAustralia have signed an agreement in 2009 for a $5 million partnership to carry out smart grid research and development and train the next generation of electrical engineers. The research activities in smart grids involve:

- Power quality monitoring and management
- Distributed power system control
- Integration of renewable energy sources into smart grids via power electronic systems
- Design and optimisation of wireless communication networks for smart grids
- Design of phone based home energy management systems
- Design of smart metering devices and networks

Professor Branka Vucetic
Email: branka.vucetic@sydney.edu.au

Dr Dylan Lu
Email: dylan.lu@sydney.edu.au

Energy Efficiency

The University of Western Australia

Energy Efficiency

Expertise includes:

- Energy conversion and energy efficiency
- Gas processing

Professor Dongke Zhang
Email: dongke.zhang@uwa.edu.au

Professor Eric May
Email: eric.may@uwa.edu.au

The University of Adelaide

Combustion

The Centre for Energy Technology is actively involved in research and development of the next generation combustion systems to burn fossil fuels in cleaner and more efficient ways and technologies that enable integration with sustainable energy sources. Our researchers have extensive industrial and research experience in the fields of combustion science and technology, particularly in relation to clean coal, ultra-lean pre-mixed combustion, MILD combustion, porous burners, combustion for minerals processing, precessing jet burner technology, and gasification. The CET has expertise in the following combustion fields:

- Characterisation of solid fuels
- Combustion optimisation for mineral processing
- Development of gas, liquid and solid-fuel industrial burner configurations
- Fluidised-bed gasification and combustion of solid fuels
- Pyrolysis of low-grade coal
- Development of artistic and ceremonial burners for high profile events, such as Olympic opening ceremonies

Professor Gus Nathan
Email: graham.nathan@adelaide.edu.au

Associate Professor Bassam Dally
Email: bassam.dally@ adelaide.edu.au

Associate Professor Peter Ashman
Email: peter.ashman@adelaide.edu.au

Built Environment

The School of Architecture, Landscape Architecture and Urban Design has a research focus on sustainability and building performance, including:

- Dimensions of sustainability and the role of architecture and landscape architecture
- Sustainability and environmental performance evaluation
- Computer simulation of life-cycle performance in buildings, including environmental impacts and costs

Associate Professor David Jones
Email: david.jones@adelaide.edu.au

Energy Integration

The Centre for Energy Technology conducts research to investigate the best holistic methods for energy system integration, including different thermal systems (solar, geothermal, fossil fuel biomass) to increase efficiency and reduce costs. Researchers also address how alternative energy sources can be integrated into the energy transmission network through alternative carriers and storage methods. CET expertise is also used to assist in optimising existing systems by analysing their energy usage and optimising their operation for maximum efficiency. Main areas of expertise:

- Integration of alternative energy systems into existing infrastructure and systems
- Thermodynamic and economic technology evaluations
- Monitoring and analysis of energy systems
- Experimental and computational modelling of energy systems
- Optimisation of energy efficiency of industrial processes by combining experiments, modelling and control strategies
- Methanation and other alternative energy carriers

Professor Gus Nathan
Email: graham.nathan@adelaide.edu.au

Dr David Battye
Email: david.battye@adelaide.edu.au

The University of Melbourne

The Built Environment

University of Melbourne researchers are providing a comprehensive understanding of where and how embodied energy is being consumed and adapting strategies to address

Dr Robert Crawford
(Architecture)
Email: rhcr@unimelb.edu.au

The University of Melbourne, The Built Environment continued the increasing demands for energy in the built environment in a cleaner, more efficient manner. Current research at the Melbourne Energy Institute into energy consumption in the built environment covers the monitoring of energy consumption in buildings, modelling of embodied and operational energy and improvements to energy efficiency through improved building, infrastructure and system design.	

The University of New South Wales

Energy and Eco-efficient Manufacturing Key research areas include energy and eco-efficiency of products and manufacturing processes, sustainable manufacturing, and End-of-Life Assessment of products.	Dr Sami Kara Email: s.kara@unsw.edu.au
Energy Efficiency Policy The Centre for Energy and Environmental Market's (CEEM) conducts detailed research on energy efficiency policy. This includes an evaluation of policies ranging from command and control measures through to market mechanisms such as tradeable certificate schemes, as well as the impact of the social context on end-users' energy demand and potential interest in energy efficiency.	Professor Robert Passey Email: r.passey@unsw.edu.au
Energy Relevant Materials Research UNSW undertake a wide range of materials research relevant to improved energy efficiency of energy supply and use. For example, the ARC Centre of Excellence for Design in Light Metals addresses research issues on novel processing and fabrication techniques for optimising the performance of the applications of light alloys and light metal hybrid materials.	Professor Mark Hoffman Email: mark.hoffman@unsw.edu.au
Process Control Research developing new approaches to decentralised control, robust control, fault tolerant control and controllability analysis for industrial process systems, based on the concept of passive and dissipative systems.	Associate Professor Jie Bao Email: J.Bao@unsw.edu.au
Process Modelling and Optimisation The Laboratory for Simulation and Modelling of Particulate Systems (SIMPAS) aims to better understand the mechanisms governing particle packing and flow through rigorous simulation and modelling of the particle-particle and particle-fluid interactions, model different particulate and multiphase processes at different time and length scales, and formulate strategies for product/process design, control and optimization in mineral/metallurgical/material/chemical industries.	Professor Aibing Yu Email: a.yu@unsw.edu.au
Sustainability Assessment Sustainable planning and decision making frameworks. Tools for assessing organisational environmental performance and options including carbon footprinting, Life Cycle Assessment and Management, Ecological Footprint, Triple-Bottom line reporting.	Dr Sven Lundie Email: s.lundie@unsw.edu.au Professor Deo Prasad Email: d.prasad@unsw.edu.au
Sustainable Built Environment There are a number of researchers withint he Faculty of Built Environment, led by Professor Deo Prasad who focus on demand side efficiency and low emission and low carbon buildings and cities. This includes simulation modelling of performance, time of day factors and innovative solutions for low energy buildings. They also investigate integrated design that includes building integrated technologies such as photovoltaics. Research on interdependent issues of sustainability in the built environment from the scale of materials and product ecology, through the design and performance of buildings, buildings and urban environments in ecological process, to the social and cultural influences of urban design, governance and education	Professor Deo Prasad Email: d.prasad@unsw.edu.au
Sustainable Engineering Systems Research into issues of sustainability in engineering systems, in particular the implications and implementation of sustainability concepts and practices for civil infrastructure—including buildings, roads and transport, water supply, waste disposal—in the areas of planning, design, construction, operation and maintenance.	Professor David Carmichael Email: d.carmichael@unsw.edu.au

Sustainable Materials and Processes

SMaRT undertakes a wide range of energy-related materials research focusing on sustainability of materials and processes, including innovative recycling of waste materials, adding value to waste resources, lowering of energy and emissions in materials technologies, environmentally sustainable materials and processes, ferro-alloys, non-ferrous metals processing, associated chemical reactions and interfacial phenomena. Major industry collaborations including OneSteel.

Professor Veena Sahajwalla
Email: veena@unsw.edu.au

The University of Queensland

Energy In Mining And Minerals Processing

- Development of energy-efficient mining technologies (CRCMining)
- Development of energy-efficient minerals processing technologies (Sustainable Mining Institute and JKMRC)

Professor Hal Gurgenci
Email: h.gurgenci@uq.edu.au

The University of Sydney

Energy Efficiency: Built Environment

Experimental and numerical study of displacement air-conditioning. The use of displacement air-conditioning can significantly reduce energy consumption in buildings. Our current research in this area focuses on furthering our understanding of the fluid mechanics involved in the function of this type of air-conditioning system. The long-term objective is to develop analysis and optimisation tools to aid in the design of displacement air conditioning systems.

Dr Michael Kirkpatrick
Email: michael.kirkpatrick@sydney.edu.au

Energy Efficiency: Built Environment (2)

We carry out fundamental studies of the mechanical processes that occur in the structure of a vacuum glazing. Experimental investigations of the response to stress are combined with theoretical and computational models, enabling us to identify specific design features which optimise the mechanical robustness of the structure. Vacuum systems and ovens as required for fabrication of small scale samples of vacuum glazing, XPS for analysis of surface processes crucial to vacuum stability, ball drop tower with fast framing photography to study the initiation of cracking under impact, finite element analysis for prediction of stress patterns in the structures.

Professor Marcela Bilek
Email: m.bilek@physics.usyd.edu.au
Professor David McKenzie
Email: d.mckenzie@physics.usyd.edu.au

Energy Efficiency: Combustion

This is a world leading group with unique capabilities in advanced laser diagnostics and computer modelling of combustion processes. Projects at the interface of fundamentals with innovative engineering practice, in the areas of combustion, heat transfer and chemical reaction engineering, include turbulent reacting sprays, explosions, ultra-high-efficiency boilers, miniaturised chemical plant for commodity and specialty chemicals, and utilisation of renewable feedstocks such as biomass. At the process system level, this group is developing innovative approaches to the design and construction of chemical plant. Based on printed circuit manufacturing techniques, they are creating highly integrated, highly intensified chemical plant that can operate extremely efficiently even at small scale. This work involves fundamental studies of reaction process, in the laboratory as well as using computational chemistry; process design and simulation; and pilot-plant testing. Computational Fluid Dynamics (CFD) are used and developed as the primary tool for application of fundamental science to complex engineering problems that typically involve turbulent flows, chemical reactions, heat transfer and particle dynamics.

Professor Assaad Masri
Email: assaad.masri@sydney.edu.au
Professor Brian Haynes
Email: haynes@chem.eng.usyd.edu.au

Energy Efficiency: Green Distributed Systems and Data Centres

Global warming and climate change trends call for urgent action to manage information and communication technologies in a sustainable manner by minimising energy consumption and utilising resources more efficiently. Distributed computing and Data Centre environments have become the de facto platforms for many applications. These systems bring a range of heterogeneous resources that should be able to function continuously and autonomously. However, distributed systems and data centres expend a lot of energy which raises a range of important research issues related to the use and

Professor Albert Y Zomaya
Email: albert.zomaya@sydney.edu.au

The University of Sydney, Energy Efficiency: Green Distributed Systems and Data Centres continued

virtualisation of ICT resources in a way offers significant potential to contribute to the goal of what has been described as 'green computing'.

Currently, several projects run in the Centre for Distributed and High Performance Computing that deal with several important questions related to the development of new algorithms and tools for energy-aware resource management allocation for large-scale distributed systems and data centres enabling these systems to become more environmentally sustainable.

Transport

The University of Western Australia

Transport

Expertise includes:

- Transport modelling
- Transport demand modelling
- Cars and fuel
- Transport project evaluation and scheduling
- Artificial intelligence applications in business and transport

Professor John Taplin AM
Email: john.taplin@uwa.edu.au

Associate Professor Doina Olaru
Email: doina.olaru@uwa.edu.au

Monash University

Transport

Monash University conducts transport research from a multidisciplinary perspective at both macro and micro levels. Researchers in Department of Industrial Design in the Faculty of Art and Design focus on improving industrial machinery and transport vehicles, while the Institute of Railway Technology develop more efficient modes of rail transport.

The Institute of Transport Studies looks at a range of issues such as public transport planning and management, transport operations, travel demand, transport and traffic planning and management.

Now in its 22nd year, the Monash University Accident Research Centre (MUARC) is leading force in transport research focusing on all aspects of road and motor vehicle safety. With offices in Australia, South Africa, Malaysia and Italy, MUARC achieves positive impact on an international scale.

Associate Professor Arthur De Bono
Email: arthur.debono@artdes.monash.edu.au

Mr Ravi Ravitharan
Email: ravi.ravitharan@eng.monash.edu.au

Associate Professor Geoff Rose
Email: geoff.rose@eng.monash.edu.au

Professor Rod McClure
Email: rod.mcclure@muarc.monash.edu.au

The University of Melbourne

Engine Optimisation

The University of Melbourne's Advanced Centre for Automotive Research and Testing (ACART) focuses on research to achieve improved fuel consumption and lower emissions for passenger vehicles and trucks. ACART's research focuses on:

- Chassis and engine dynamometer testing to Euro IV for gasoline and diesel
- Environmental wind tunnel testing
- Alternative fuels (biofuels, CNG, diesel, hydrogen, LNG, LPG and petrol)
- Combustion and engine simulation
- Laser and other diagnostics for combustion and fuel sprays
- Modelling and control of conventional and hybrid powertrains

Dr Michael Brear (Engineering)
Email: mjbrear@unimelb.edu.au

The University of Queensland

Alternative Fuels

Dimethyl ether (DME) from coal/biomass, Combustion of DME in diesel engines, Standards for DME utilisation.

Dr Bo Feng
Email: b.feng@uq.edu.au

The University of Sydney

Transport

The Institute of Transport and Logistics Studies (ITLS) is Australia's Key Centre of Excellence in Transport and Logistics Research and Education. Expertise includes modelling freight traffic, alternative fuel utilisation and education and informative strategies. The aim of this research is to develop a new methodology to assess the environmental impacts of urban freight transport policies. The major innovations offered by the approach are: the development of an exposure-based module within the environmental evaluation

Professor Stephen Greaves
Email: stephen.greaves@sydney.edu.au

The University of Sydney, Transport continued

component; an integrated emissions and noise model that is based on the operational characteristics of trucks; and a mathematical modelling approach that incorporates greater behavioural reality into the different tour/stop profiles of trucks. The outcomes of the research will be of importance to freight operators, local councils and road authorities charged with managing freight traffic, and public health authorities.

Fossil Fuels

The University of Western Australia

Expertise includes:

- Reservoir geology
- Petroleum geomechanics
- Structural geology
- 4D geophysics
- Hydraulic fracturing
- Reservoir engineering
- Multiphase fluid modelling
- Petroleum exploration and production
- Enhanced oil recovery
- Natural gas analysis
- Crude oil flow assurance

Professor David Lumley
Email: david.lumley@uwa.edu.au

Professor Campbell McCuaig
Email: campbell.mccuaig@uwa.edu.au

Associate Professor Brendan Graham
Email: Brendan.graham@uwa.edu.au

The Australian National University

Enhanced Fossil Fuel Extraction

We have developed a world class experimental X-ray microtomographic (micro-CT) facility at ANU, and led the development of a unique High Performance Computing infrastructure for image reconstruction, novel phase identification, 3D visualisation, structural characterisation and prediction of physical properties directly from digitised 3D images. This creates a new numerical laboratory approach to the study of complex materials. The numerical laboratory has applied this novel capability to the oil and gas industry. The ability to measure and characterise petroleum reservoir rocks at the pore scale has proven to be of great importance in reserves estimates and reservoir characterisation studies aimed at assessing the production potential of reservoirs. This result has had a major impact on the petroleum industry worldwide. We now lead a major applications based project for the international petroleum industry. The current experimental facility is capable of acquiring 3D images made up of $2{,}000^3$ voxels on complex material samples up to 6cm diameter with resolutions down to two microns. The computational infrastructure developed during this project includes the establishment of optimised and massively parallel algorithms for image reconstruction, novel phase identification, 3D visualisation, structural characterisation and prediction of physical properties directly from digitised tomographic images. The group is expanding to meet the increasing needs of scientific and industry collaborators, and we are also building similar facilities for the international oil and gas corporations.

This technology was jointly developed by ANU and Professor Val Pinczewski and Christoph Arns at UNSW.

Dr Mark Knackstedt
Email: mark.knackstedt@anu.edu.au

Oil Field Mapping

Interconnections between different sections of an oil field, and the effectiveness of enhanced recovery measures, are important for efficient use of a limited natural resource. These can be measured by introducing chlorine-36, an artificial long-lived radio-isotope, into the reservoir, and monitoring the time development of its appearance in production wells. This requires the ultra-sensitive measurement technique of Accelerator Mass Spectrometry, well-developed at the 15 million volt 14UD accelerator at the ANU. Links and programs with the oil industry have been established.

Professor Keith Fifield
Email: keith.fifield@anu.edu.au

The University of Adelaide

Combustion Science and Engineering

The Centre for Energy Technology undertakes research in the fields of combustion science and technology, with the aim of developing technologies that burn fossil fuels in cleaner and more efficient ways. Various research programs address technologies such as ultra-lean

Professor Gus Nathan
Email: graham.nathan@adelaide.edu.au

Associate Professor Bassam Dally
Email: bassam.dally@adelaide.edu.au

The University of Adelaide, Combustion Science and Engineering continued

pre-mixed combustion, MILD combustion, combustion for minerals processing, precessing jet burners and gasification. Main areas of expertise:

- Pollution control
- Gasification, pyrolysis, and fluidisation
- Laser diagnostics
- Soot and fume formation
- Mixing and two-phase flows
- Modelling of coal combustion and multiphase fluids

Dr Zeyad Alwahabi
Email: zeyad.alwahabi@adelaide.edu.au
Dr Peter Kalt
Email: peter.kalt@adelaide.edu.au

Energy Transmission

The Centre for Energy Technology is one of the nodes of the Energy Pipelines Co-operative Research Centre. Through this program and other ongoing projects it undertakes leading research covering more productive materials, life extension and asset management, design, and public safety and security of supply of Australia's natural gas pipeline network. This research activity will also investigate new pipelines for other energy gases that will be required in the transition to a cleaner, renewable future. Main areas of expertise:

- Pipeline materials and the welding/joining of these pipelines—both current and future materials
- Pipeline failure modes in natural gas, CO_2 and hydrogen pipelines
- Design, materials and operating issues for current, ageing and future new pipelines
- Hydrogen storage
- Methanation and other alternative energy carriers

Associate Professor Peter Ashman
Email: peter.ashman@adelaide.edu.au
Professor Gus Nathan
Email: graham.nathan@adelaide.edu.au

Petroleum Engineering

The Australian School of Petroleum is Australia's pre-eminent centre for education, training and research in petroleum geoscience, engineering and management. It undertakes research in the areas of petroleum engineering, petroleum geoscience and petroleum management with the overall aim of understanding and reducing risk for the petroleum industry. It is one of four nodes of the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC). Main areas of expertise:

- CO_2 geosequestration, primarily site selection, characterisation and monitoring
- Modelling of sedimentary basins
- Petroleum geomechanics
- Structural geology, formation damage, hydraulic fracturing
- Sedimentary and reservoir geology
- Seals research group
- Reservoir analogues research group
- Centre for improved petroleum recovery

Professor Steve Begg
Email: steve.begg@adelaide.edu.au

The University of New South Wales

Enhanced Fossil Fuel Extraction

Refer to ANU entry.

Professor Val Pinczewski
Email: v.pinczewski@unsw.edu.au
Mr Christoph Arns
Email: c.arns@unsw.edu.au

The University of Sydney

Turbulent Combustion

Using well-designed laboratory burners that are also relevant to industrial combustors, research is conducted to advance knowledge of the turbulent combustion process of fossil fuels and to enable the generation of reliable numerical design tools. Issues such as the formation of pollutants, chemistry and mixing, droplet-gas interactions are addressed using experimental and computational methods.

Professor Assaad Masri
Email: assaad.masri@sydney.edu.au

Fuel Cells

Monash University

Fuel Cells

Monash University scientists have revolutionised the design of fuel cells used in the latest generation of hybrid cars using a specially-coated form of popular high tech outdoor and sporting clothing material Goretex as the key component. Using this method could make the vehicles more reliable and cheaper to build.

Fuel cell research at Monash also involves exploring the development of mesoporous electrodes to improve the performance of solid oxide fuel cells. These fuel cells can perform with a variety of gases—like natural gas, coal-derived gases and biomass-derived gases. This technology is critical to power generation efficiency and to reduce carbon dioxide emissions from power plants. This should have a significant impact on business and society.

Research in this area also extends to the investigation of high-temperature and low methanol crossover membranes for proton exchange membrane fuel cells.

Professor Doug Macfarlane
Email: douglas.macfarlane@sci.monash.edu.au

Dr Bjorn Winther-Jensen
Email: Bjorn.WInther-Jensen@eng.monash.edu.au

Professor Huanting Wang
Email: huanting.wang@eng.monash.edu.au

The Australian National University

Hydrogen Fuel Cells

The development of efficient low temperature Proton Exchange Membrane Fuel Cells (PEMs) has been hindered by the high cost of the membrane electrode assemblies (MEAs) currently built by wet chemistry techniques. The Space Plasma Power & Propulsion (SP3) Group at the Australian National University are adapting plasma processing techniques, typical of the microelectronics and materials industries, to manufacture the first plasma based fuel cell that improves the fuel cell efficiency while reducing its cost. The SP3 group has two staff members and a technician, two post-docs, four PhD students, and two physics honours students. A number of plasma processing systems are available and the group has 25 years experience in the design and manufacture of such systems for industry and universities. We have a number of diagnostic systems: Langmuir probes, energy selective ion energy analysers, network analysers, optical emission spectroscopy, FTIR spectrometers and ellipsometers for thin film diagnostics and access to Rutherford Back Scattering (RBS), focused ion beams (FIBs) and Atomic force microscopy (AFM).

Professor Rod Boswell
Email: rod.boswell@anu.edu.au

The University of Adelaide

Energy Storage

Fundamental and applied research is conducted by the Schools of Chemistry and Physics and Chemical Engineering in the key areas of energy usage and demand, environmental chemistry and in particular the development of hydrogen storage with metal-organic frameworks. Main areas of expertise:

- Molecular modelling of natural gas/methane/hydrogen storage on nanoporous solids for the design of materials and processes

Professor Stephen Lincoln
Email: stephen.lincoln@adelaide.edu.au

Professor Mark Biggs
Email: mark.biggs@adelaide.edu.au

The University of Queensland

Hydrogen Storage and Utilisation

While various people in the UQ were active in Fuel Cells in the past, the current focus is on Hydrogen Storage. In a major current project, Professor Arne Dahle is investigating hydrogen storage in Mg alloys in collaboration with Griffith and Curtin Universities. The group is also part of the National Hydrogen Materials Alliance. There is a UniQuest spinoff company in Hydrogen storage (Hydrexia).

Professor Arne Dahle
Email: a.dahle@uq.edu.au

Geothermal, Wind and Wave Energy

The University of Western Australia

Geothermal Energy

Developing multidisciplinary research to exploit and use low geothermal energy as an emission-free source of power for modern cities. From kilometers below the earth hot fluids are rising towards the surface and bringing with it another form of promising renewable energy. Expertise includes:

- Geophysics
- Geochemistry
- Modelling
- Geology
- Engineering
- Continuum mechanics
- Fluid dynamics

Professor Klaus Regenauer-Lieb
Email: Klaus@segs.uwa,edu,au

Professor Hui Tong Chua
Email: huitong.chua@uwa.edu.au

Professor Xiaolin Wang
Email: xlwang@mech.uwa.edu.au

The University of Adelaide

Geothermal Energy

The South Australian Centre for Geothermal Energy Research (SACGER) is a newly established, world-class centre for Geothermal Energy Research. In collaboration with members of the Centre for Energy Technology, research is undertaken to enhance the integration of geothermal energy with other energy sources and into the broader energy system as well as develop innovative cooling systems with low water and energy consumption. Main areas of expertise:

- Hybrid systems
- Thermodynamic analysis
- Innovative cooling systems
- Prediction and mitigation of fouling due to geothermal fluids

Associate Professor Bassam Dally
Email: bassam.dally@adelaide.edu.au

Dr Guillaume Backe
Email: guillaume.backe@adelaide.edu.au

Dr Yung Ngothai
Email: yung.ngothai@adelaide.edu.au

Wind and Wave Power

Research at the Centre for Energy Technology is focussed on the optimisation of wind and wave turbine components relating to noise and vibration, efficiency and aerodynamic optimisation. Main areas of expertise:

- Wind turbine design, particularly for high efficiency and low-speed urban environments
- Aero-acoustics and noise reduction
- Wind energy potential evaluation and optimal turbine positioning
- Wave energy resource assessment
- Assessment of environmental effects of wind farms
- Wind-tunnel testing, wind turbine system testing and measurements
- Integrated solar and wind energy systems
- Wave energy systems

Dr Maziar Arjomandi
Email: maziar.arjomandi@adelaide.edu.au

Professor John Cheung
Email: john.cheung@adelaide.edu.au

Associate Professor Richard Kelso
Email: Richard.kelso@adelaide.edu.au

The University of Melbourne

Geothermal Energy

In order to help realise Australia's geothermal energy prospects the University of Melbourne geothermal group is leading the development of new, more efficient and accurate targeting methodologies for predicting geothermal resources.

Professor Mike Sandiford
(Earth Sciences)
Email: mikes@unimelb.edu.au

The University of New South Wales

Geothermal

Research in the area of geothermal energy development from hot rocks, particularly in drilling, hydraulic fracturing and reservoir development. Funding includes major grants from the Energy Research and Development Corporation, the Australian Greenhouse Office and Aus-Industry.

Professor Sheik S Rahman
Email: sheik.rahman@unsw.edu.au

The University of Queensland

Geothermal Energy

The Queensland Geothermal Energy Centre of Excellence (QGECE) has recently been established at the University of Queensland with the support of the Queensland State Government through an award of $15m. The work will be conducted under four program headings: Power conversion; Air-cooled heat exchangers; Reservoir geology and management; Power generation and transmission.

Six UQ academics across the Schools of Mechanical and Mining Engineering, Chemical Engineering, IT and Electrical Engineering, and Earth Sciences are working in the Centre along with 7 research fellows at various level of seniority and 13 post-graduate students.

Professor Hal Gurgenci
Email: h.gurgenci@uq.edu.au

The University of Sydney

Wind and Tidal Energy

Utilisation of wind and wave energy is of major importance to our society. Simple and advanced devices are tested to determine optimal control methods to maximise energy absorption. Key areas of expertise include wave energy prediction, wind tunnel testing and computational model development on modern wind turbines and farms. Facilities include: Large Area Fluids Laboratory, Small flumes, 30m Wind-Current-Wave flume, Recirculating water/air tunnel, Wind tunnels, Computational Fluid Dynamics.

School of Civil Engineering
Email: office@civil.usyd.edu.au

Energy Economics, Policy and Law

The University of Western Australia

Energy Economics, Policy, Modelling and Law

The interactions between government/community and the energy and minerals industries are many and complex and it is vitally important, both for Australia and the industry, that governments take an integrative approach to public policy (versus an issue by issue approach) because that reflects the real world in which industry operates.

UWA is tackling the challenge of climate change through its expertise in agricultural and resource economics, water management, biodiversity, oceanography, population health and enabling sciences.

Expertise includes:

- Asset management
- Mining and energy law
- Energy security
- Mineral economics
- Asia-Pacific region
- Australia's regional relations
- Electoral geography
- Energy security
- Environmental security
- Climate change policy and legislation
- Climate change adaption
- Plant adaptation to climate change
- Environmental law, mining law, natural resource law,
- Integrated bioenergy
- Mine rehabilitation
- Bio-sequestration of carbon dioxide
- Fisheries policies
- Geopolitics
- Globalisation, Indian Ocean rim,
- International relations, political boundaries, political geography
- Public policy, natural resource law, mining and energy law
- Value-chain assessment of energy trade and impact of new technologies

Professor David Pannell
Email: david.pannell@uwa.edu.au

Mr John Chandler
Email: john.chandler@uwa.edu.au

Professor Kadambot Siddique
Email: ksiddique@fnas.uwa.edu.au

Associate Professor Melinda Hodkiewicz
Email: Melinda.modkiewicz@uwa.edu.au

Associate Professor Sharon Mascher
Email: Sharon.mascher@uwa.edu.au

Professor Ken Clements
Email: ken.clements@uwa.edu.au

Monash University

Energy Economics, Policy, Modelling and Law

The Centre of Policy Studies (COPS) at Monash University is a leader in the field of energy economics, policy and modelling. As well as conducting its own research, the Centre is called on to supply information for government and industry from all over the world.

The Centre was behind the economic modelling for the Carbon Pollution Reduction Scheme for the Federal government's Garnaut Review and has conducted studies on the economics of biofuels for the United States International Trade Commission. Other research currently being undertaken by the Centre includes investigating the way that Vietnamese government can adapt to climate change, reviewing United States carbon mitigation policies different ways in which China can cope with greenhouse-related issues.

Extensive research into energy law is also undertaken at Monash in relation to green technologies, electricity, the renewable energy market, environmental policy/law and energy efficiency.

Professor Philip Adams
Email: philip.adams@buseco.monash.edu.au

Ms Rowena Cantley-Smith
Email: rowena.cantleysmith@law.monash.edu.au

The Australian National University

Environment and Socio-Economic Policy

Research concentrates on the environmental, societal and economic effects of the implementation and integration of energy sources. Research into the economics and policy of a transition to a low-carbon energy system is undertaken in the context of emerging energy sources. Key themes are the design of emissions trading or taxes and of support policies for low-carbon energy sources, and their economic impacts including on innovation, investment, production and consumption structures. The legal aspects of energy systems in a climate context (both impacts and mitigation), and thus emissions and energy systems implementation, are studied in a regulatory context. Research into the risks, uncertainties and perceptions associated with various energy sources are combined with integrative approaches to energy systems. ANU has the greatest concentration of researchers on environment and climate, energy economics and policy, and regulatory frameworks in Australia. We combine expertise from the Fenner School of Environment and Society, ANU College of Science, the ANU College of Asia and the Pacific, and the ANU College of Law.

Professor Will Steffen
Email: will.steffen@anu.edu.au

Dr Frank Jotzo
Email: frank.jotzo@anu.edu.au

The University of Adelaide

Environment and Climate Change

The Environment Institute tackles some of the most serious environmental challenges facing Australia and the world. Research undertaken within the Institute will deliver know-how and understanding that will underpin a step change improvement in the management of natural resources such as water, soil, land and native flora and fauna, particularly under changing climate and economic conditions. The Institute brings together leading research groups in the fields of science, engineering and economics relating to the management and use of natural resources and infrastructure. Main areas of expertise:

- Australian Centre for Ancient DNA Evolution and Change (evolution and environmental change through time using preserved genetic records in human, animal, plant and sedimentary material)
- Australian Centre for Evolutionary Biology and Biodiversity (systematics, evolutionary biology and biodiversity science)
- Centre for Energy Technology (cleaner energy generation, storage, distribution and utilisation of energy)
- Landscape Futures Program (integrated solutions to the management of natural resources)
- Marine Biology Program (ecology of fish, invertebrates and plants in estuaries and reef systems)
- Water Research Centre (water management)

Professor Mike Young
Director
Email: mike.young@adelaide.edu.au

Professor Barry Brook
Climate Change Research Leader
mail: barry.brook@adelaide.edu.au

Energy Economics and Policy

The Institute for Mineral and Energy Resources (IMER) is one of Australia's first interdisciplinary research institutes specifically designed to address one of the biggest challenges facing Australia - to continue to grow the economically critical mineral and energy resources industries in a technically, economically, socially and environmentally sustainable manner. IMER addresses the complex research challenges faced by the mineral and energy sectors by providing integrated research, education, professional development and consulting services across all aspects of the mineral and energy resources industries, from exploration through processing to international trade. IMER includes the Centre for Tectonics and Resource Exploration, Centre for Energy Technology, and South Australian Centre for Geothermal Energy Research. Other main areas of expertise:

- Minerals and energy economics:
  - Assessment of economic structure and issues impacting investment and job creation
  - Cost benefit analysis
  - Global resources trade
  - Project evaluation

Professor Stephen Grano
Director
Email: stephen.grano@adelaide.edu.au

Associate Professor Barry Burgan
Minerals and energy economics
Email: barry.burgan@adelaide.edu.au

Professor Adrian Bradbrook
Minerals and energy law
Email: adrian.bradbrook@adelaide.edu.au

Associate Professor John Spohr
Mining and energy policy, social impact
Email: john.spohr@adelaide.edu.au

The University of Adelaide, Energy Economics and Policy continued

- Minerals and energy law:
  - Proposals for devising laws to promote renewable energy sources worldwide
  - Laws on energy efficiency
  - Native title
- Mining and energy policy and social impact:
  - Sustainable communities
  - Workforce development
  - Environmental impact assessments
  - Evaluating the effectiveness of household energy efficiency schemes, particularly for low income households
  - Socio-economic impact assessment of energy resource developments to inform decision making processes, project implementation and evaluation

The University of Melbourne

Energy Policy and Social Justice

Research includes the analysis of the cost of climate change, addressing key social justice concerns with respect to energy policy. It focuses on the use of market structures in curtailing demand through adoption of measures targeted at enhancing the efficiency of households' energy consumption through, for instance, government rebates to retrofit low-income homes with energy efficient lighting, ceiling insulation, weather sealing, and solar hot water/ heat pumps; improving access to mains gas; and government subsidies for disadvantaged households to upgrade to more energy efficient appliances, particularly refrigerators.

Associate Professor Jeremy Moss
(Philosophy) Social Justice Initiative
Email: jmoss@unimelb.edu.au

Energy System Modelling

Energy system modelling focuses on development on an short time scale models that will account for predictable covariance's in the weather system and the way they impact on renewable energy supply systems under various mandatory RET scenarios. This research is designed to inform investment in, and optimal deployment of, renewable energy power supply.

Dr Roger Dargaville
(Earth Science)
Email: rogerd@unimelb.edu.au

Energy Resource Law

The Energy Law and Regulation program is concerned with all aspects of governance of the energy industries within Australia and beyond. It involves both the design and evaluation of the institutional framework applicable to the energy industries, including arrangements at numerous levels of government (international, national, state, regional and local) together with intergovernmental mechanisms required to achieve co-operation across and within levels of government.

Professor Michael Crommelin
(Law)
Email: m.crommelin@unimelb.edu.au

The University of New South Wales

Energy and Environmental Markets and related policies

The Centre for Energy and Environmental Markets undertakes interdisciplinary research in the design, analysis and performance monitoring of energy and environmental markets and their associated policy frameworks. It brings together researchers from the Australian School of Business, the Faculty of Engineering, the Institute of Environmental Studies (IES), and the Faculty of Arts and Social Sciences, working alongside a growing number of partners. Its research areas include the design of spot, ancillary and forward electricity markets; market-based environmental regulation including emissions trading and renewable energy targets; the integration of stochastic renewable energy technologies into the electricity network; energy efficiency, distributed generation and distributed energy systems; as well as the broader policy context in which all sustainable energy technologies and policy measures reside. Partners include the Environmental Economics Research Hub (EERH), Economics Design Network (EDN), Climate Strategies (Cambridge University), Fraunhofer Institute for Systems and Innovation Research., CSIRO and the Australian Energy Market Operator (AEMO). IES undertakes research on sustainable energy and sustainable urban transportation: technology assessment and policies and strategies for implementation and more general theories of sustainability and the sustainable development process.

Dr Regina Betz
Email: r.betz@unsw.edu.au

Dr Mark Diesendorf
Email: m.diesendorf@unsw.edu.au

Dr Iain MacGill
Email: i.macgill@unsw.edu.au

City Futures Research dedicated to developing a better understanding of our cities, their people, the policies that manage their growth, the issues they face, and the impacts they make on our environment and economy. Partners include the NSW Government and Landcom.	**Professor Bill Randolf** Email: b.randolph@unsw.edu.au
Climate Change Law and Policy Energy relevant research in areas such as international issues including climate change and security and responsibilities; human rights including corporate responsibility; and international and national regulation of adaptation and mitigation responses including carbon capture and storage, carbon markets and wider legislative frameworks.	**Professor Rosemary Rayfuse** Email: r.rayfuse@unsw.edu.au **Associate Professor Andrea Durbach** Email: a.durbach@unsw.edu.au
Sustainable Energy in the Developing World Research to identify and disseminate ways to overcome barriers to the use of photovoltaic energy systems (PVES) and other renewable energy resources to facilitate sustainable development in the developing world. Partners include AusAid. Wider research in sustainable economic development with a focus on the Asia Pacific Region, adaptive strategies in addressing the impacts of climatic change and managing resources and social and economic constraints on uptake and application of innovative environmental technologies.	**Professor Hugh Outhred** Email: h.outhred@unsw.edu.au **Associate Professor John Merson** Email: j.merson@unsw.edu.au

The University of Sydney

Law Expertise is broad ranging and covers domestic and international environmental law, more specifically energy and carbon taxes, emissions trading schemes, renewable portfolio standards, demand side management programs, feed in laws to support renewable technologies, mitigation, new generation and infrastructure, energy project disputes and smart grid regulation.	**Professor Rosemary Lyster** Email: rosemary.lyster@sydney.edu.au **Dr Kate Miles** Email: kate.miles@sydney.edu.au
Policy The main focus of research is the policy developments around greenhouse gas emissions abatement, both within and beyond Australia, and how these are influenced by as well as shape energy security preoccupations. The research focus concentrates essentially on the subordination of policy to economic growth imperatives and on the actual and potentially different growth trajectories. Dr Rosewarne is also collaborating with colleagues in social sciences at UTS on a research project that explores lobbying efforts designed to promote low-carbon economic development paths.	**Dr Stuart Rosewarne** Email: stuart.rosewarne@sydney.edu.au
Energy and emission trading markets, and energy security Research is focused on two strands: (1) energy and emission trading markets with particular reference to the electricity sectors of Australia and the European Union, and (2) energy security. With respect to energy and emission trading markets, the research focus concentrates on the policies driving these markets and the outcomes arising from actual market operations such as wholesale and end-use energy prices, energy poverty and generation adequacy. With respect to energy security, the research focus concentrates on the conceptualisation of energy security and how this is reflected in public policies. Dr Chester is also collaborating with (a) French energy researchers on a project to determine the actual reasons inducing or constraining companies to invest in new electricity generation capacity; (b) UK energy researchers on an international comparative project to determine the impact on low-income households of electricity price increases; and (c) US energy researchers on the policy parameters for the transition of regional labour markets, dominated by coal-fired electricity generation, towards a renewable energy regime.	**Dr Lynne Chester** Email: lynne.chester@sydney.edu.au

Nuclear Energy

The Australian National University

Tracing of Radioisotopes

The next two decades are likely to see a substantial increase in the use of nuclear power worldwide. The integrity of radiation containment systems of power plants, nuclear waste storage, and mining operations are of public concern. The Accelerator Mass Spectrometry (AMS) group at the ANU's Department of Nuclear Physics is at the forefront in developing new ultra-sensitive methods to establish baseline levels for key radioactive isotopes in the environment, and to detect emissions at a lower level than any other method. The goal is to integrate these techniques into the monitoring programs of existing and developing facilities, giving improved environmental protection and safety.

Dr Steve Tims
Email: steve.tims@anu.edu.au

Generation IV Reactors

Members of the Department of Nuclear Physics are partners in the establishment (in the USA) of a Total Absorption Gamma-ray Spectrometer, for studies of the structure of neutron-rich nuclei. Amongst other applications, such as investigating stellar nucleosynthesis, a goal of the facility will be the measurement of key nuclei to help predict the time evolution of the decay heat developed in spent fuel from Generation IV nuclear reactors.

Dr Greg Lane
Email: gregory.lane@anu.edu.au

Nuclear Data

Under the auspices of the International Atomic Energy Agency (IAEA), the ANU is an active member of the International Network of Nuclear Structure and Decay Data Evaluators. The Department of Nuclear Physics is responsible for developing and maintaining the BrIcc conversion coefficient database, used in basic research and in a wide range of applications, including nuclear energy research.

Dr Tibor Kibedi
Email: tibor.kibedi@anu.edu.au

Nuclear Science Education

Through the Department of Nuclear Physics, the ANU has maintained a continuous educational and training effort in Nuclear Science at undergraduate, postgraduate and postdoctoral level. In 2007 a Master of Nuclear Science degree was introduced, giving graduates the opportunity to study the fundamentals and applications of nuclear science, including materials analysis, dating techniques, nuclear medicine, accelerator-based nuclear science, and nuclear energy. The program provides focused courses and laboratory-based training, giving graduates the scientific background needed to inform policy debate on nuclear issues. Department members also engage with Government and the public in nuclear and energy issues.

Professor Andrew Stuchbery
Email: andrew.stuchbery@anu.edu.au

The University of Sydney

Nuclear Energy

Institute of Nuclear Science (INS) hosted in the School of Physics, the University of Sydney. Main research interests of INS are (i) research into Accelerator Driven Systems (ii) Generation IV nuclear reactors with special emphasis on Accelerator Driven Molten Salt reactors and (iii) nuclear safeguards and non-proliferation issues.

An Accelerator Driven System (ADS) is a nuclear reactor that operates under subcritical conditions implying that Chernobyl type accidents cannot happen in these reactors. It uses thorium as fuel which is abundantly available in the earth's crust (Australia has world's largest thorium resources), it does not produce plutonium (a weapon material) and above all it can incinerate its own nuclear waste and waste from the existing conventional nuclear reactors. ADS provides practical solutions for all of the problems associated with conventional nuclear reactors.

INS has research collaboration with different departments of the Australian Nuclear Science and Technology Organisation (ANSTO) as well with several international universities and research institutes.

Dr Reza Hashemi-Nezhad
Email: reza@physics.usyd.edu.au

Fusion Energy

The Australian National University

Fusion Energy

Fusion, the process that powers the stars, holds the promise of limitless, clean and safe base-load power for future generations. The penultimate step on the path to fusion is the ITER tokamak, a multibillion dollar international device being constructed in France to investigate the new physics of burning reactor plasmas; complex self-organised systems dominated by energetic particles.

The recently upgraded $30 million Australian Plasma Fusion Research Facility at the ANU, based on the H-1 Heliac, is the focus of Australian high temperature plasma research. Key objectives are to perform research into the basic properties of magnetically confined plasma and foster Australian excellence in plasma theory, fusion science and advanced instrumentation and techniques. The ANU is working together with members of the Australian ITER Forum, an organisation spanning the entire Australian research sector with an interest in fusion science and engineering, to promote a formal role for Australia in the ITER international fusion project.

Dr Boyd Blackwell
Email: boyd.blackwell@anu.edu.au

Professor John Howard
Email: john.howard@anu.edu.au

Professor Robert Dewar
Email: robert.dewar@anu.edu.au

Dr Matthew Hole
Email: matthew.hole@anu.edu.au

Facilities

The University of Western Australia

Facilities and Energy Support

The world class Centre for Offshore Foundations and the Oceans Institute at the University of Western Australia has invested millions in research facilities and infrastructure to support energy research. Expertise includes:

- Centrifuge model testing
- Foundation analysis, design and engineering
- Geotechnical engineering
- Offshore geomechanics, soil mechanics, soil–structure interaction, Computational wave hydrodynamics
- Deep water oil and gas production structures, spar platforms
- Floating production systems
- Floating and moored structure dynamics, flow visualisation,
- Hydrodynamic model testing, offshore
- Economic geology, geochemistry, mineral exploration targeting
- Electrical energy and power systems, power network systems and control
- Power electronics, alarm monitoring

Professor Mark Randolph
Email: randolph@civil.uwa.edu.au

Professor Mark Cassidy
Email: mcassidy@civil.uwa.edu.au

Professor Liang Cheng
Email: cheng@civil.uwa.edu.au

Monash University

Facilities

Monash University has a wide collection of both fabrication and characterisation infrastructure either in or allied to the energy research space.

Some examples include Monash University's role as the lead agency in the $60m Melbourne Centre for Nanofabrication that contains a solar-cell production facility. The Centre is the national hub for fabrication, resulting in strong partnerships with key agencies from around Victoria.

The University is also home to the $37 million Monash Centre for Electron Microscopy. The Centre houses one of the world's most powerful electron microscopes, the double aberration corrected Titan 80-300 cubed transmission electron microscope, worth over $9 million. The Titan is fitted with spherical abberation correctors, which pushes its resolution into the sub-Angstrom range enabling researchers to solve fundamental problems in metallurgy, physical chemistry, optoelectronics, semiconductor physics, biomaterials and in many other areas of physical science.

A $6.5 million clean room and biolab is located on the Monash campus for microfabrication; and is being used to conduct research into the microfabrication of solar cell devices .

Facilities in the Micro/Nanophysics Research Laboratory include a complete UV photolithography capability with thick-film spin coating, mask aligner, triple-target sputtering system and wet etching and RIE/plasma etchers. There is also a collection of impedance and network analysers, laser Doppler vibrometers, a microPIV system, high-speed video cameras, bio lab with access to PC2 facilities, various laser and fluorescence microscopy gear, scanning mobility particle spectroscopy system, portable Raman spectrometer, and high-voltage and high-frequency amplifiers.

The wind tunnel at Monash University's Clayton campus is one of the largest of its kind in the Southern Hemisphere. The facility is used by Monash researchers and industry to test vehicle aerodynamics, building structures, environmental testing, wind turbine aerodynamics and unmanned air vehicles which assists in the development of vehicles with greater fuel efficiency.

Monash is also closely involved with CSIRO's Future Manufacturing Flagship as part of the Victorian Organic Solar Cell Consortium (VICOSC).

Professor Ian Boyd
Email: ian.boyd@mcn.monash.edu.au

Associate Professor Joanne Etheridge
Email: joanne.etheridge@mcem.monash.edu.au

Professor James Friend
Email: james.friend@eng.monash.edu.au

Mr David Burton
Email: david.burton@eng.monash.edu.au

The University of Adelaide

Facilities

There are a wide range of facilities with Centre for Energy Technology and other associated research Centres and Institutes at The University of Adelaide. These include:

- Combustion/reacting flows:
  - Dedicated combustion laboratory with three test bays for assessing open flames, a 20kW MILD combustion furnace and natural gas supply capable of 1MW output at 100kPa
  - Four laser laboratories suitable for reacting and non-reacting flows
  - Numerous lasers, including particle image velocimetry and laser Doppler velocimeter systems, as well as CCD/ICCD cameras
  - A small bench-scale, high-temperature tube reactor
  - A range of laboratory and pilot-scale fluidised-bed reactor systems (bubbling, spouted and circulating) from 5-50 kW
  - Analytical facilities in support of waste and biofuel characterisation
- Biofuels: laboratory and pilot-scale facilities for the culturing, production and harvesting of fresh-water and marine microalgae, with associated analysis and monitoring equipment
- Solar: high intensity solar simulator producing up to 1300 suns and blackbody surface temperatures exceeding 1800^{o}K
- Wind/wave:
  - A large wind tunnel (4m x 4m cross-section @ 35m/s), under construction, with unique capability in Australia for the testing and development of wind turbines, and specialist capability in buildings, aeronautical engineering and fire research;
  - A small wind tunnel (0.6m x 0.6m cross section @ 30m/s);
  - Three specialist water tunnel facilities and two specialist multi-phase flow wind tunnels
  - Comprehensive experimental facilities and tools for noise measurement
  - In-house and commercial computational fluid dynamics codes
- Electrical:
  - 2D/3D finite-element software for electrical machine analysis
  - High-accuracy electric power analyser
  - Precision dynamometer test facilities for electrical machines

Dr Jordan Parham
Email: jordan.parham@adelaide.edu.au

The University of Sydney

Laser Diagnostics in Fluids

An advanced laser diagnostics facility is available with capabilities to measure flow fields as well as temperature and selected species concentration in complex non-reacting and reacting flows. Techniques such as particle imaging velocimetry, Rayleigh scattering and laser induced fluorescence are applied. Capabilities for high-speed imaging to provide spatio-temporal information in such flows have also recently become available.

Professor Assaad Masri
Email: assaad.masri@sydney.edu.au

GROUP OF EIGHT

The Group of Eight Limited
Group of Eight House
Level 2, 101 Northbourne Avenue
Turner ACT 2612
www.go8.edu.au