

FOCUS

UNCONVENTIONAL GAS IS HERE

IT PRESENTS CHALLENGES
AND OPPORTUNITIES

SOUND POLICIES AND PUBLIC ACCEPTANCE,
BASED ON FACT – NOT FEAR – ARE KEY TO
BALANCING PROSPERITY AND ENVIRONMENT



AGRIBUSINESS

2030

2016 ATSE NATIONAL
TECHNOLOGY
CHALLENGES DIALOGUE

The Academy's inaugural National Technology Challenges Dialogue is a two-day event in Sydney on 15 and 16 June, 2016.

Agribusiness 2030 is an exciting opportunity to exchange ideas between the nation's most eminent entrepreneurs, decision makers, government officials, researchers, academics and business leaders, who will explore:

- the future of agribusiness in the digital age
- how this will play-out domestically and globally
- the opportunities and challenges this offers Australia.

Importantly, this event also highlights ATSE's consistent commitment to leading the public discussion on Australia's future prosperity with a focus on using the best of Australian and international technologies to address our national challenges.

It also incorporates ATSE's Annual Innovation Dinner on 15 June where the Clunies Ross Awards for innovation commercialisation will be presented. These exciting awards bring together Australia's top leaders and innovators from research, industry and government and provide a valuable networking opportunity at the nation's premier annual awards for innovation commercialisation.

Dialogue details and registration will be available on the ATSE website early in 2016.

Save the date – 15/16 June 2016 – Agribusiness 2030

Contents



3

Massive challenges, but we must meet them

By Craig Simmons

8

Looking after our land and water

By John Williams & Ann Milligan

11

The opportunities and challenges for unconventional gas

By Peter Cook & Vaughan Beck

- 13 Time for a new approach to the social licence issue
- 16 Science is key to future onshore gas development
- 19 Regulatory reforms required for unconventional gas
- 23 Alan Finkel is new Chief Scientist
- 24 New leaders for ATSE Forums
- 24 Rethinking Australian urban transport
- 25 New technologies are agribusiness key
- 25 Name change and graphic upgrade for ATSE
- 29 Collaboration trumps complexity in additive manufacturing
- 40 ATSE in *Focus*

Front cover photo: 123rf.com



ATSE *Focus* is produced to stimulate discussion and public policy initiatives on key topics of interest to the Academy and the nation. Many articles are contributed by ATSE Fellows with expertise in these areas. Opinion articles will be considered for publication. Items between 800 and 1400 words are preferred. Please address comments, suggested topics and article for publication to editor@atse.org.au.

Deadline for the receipt of copy for next edition of *Focus* is 15 January 2016.

COPYRIGHT

This publication contains copyright material. Some of the material is owned by Australian Academy of Technological Sciences and Engineering Ltd ACN 008 520 394 (ATSE) and some material is owned by others. All copyright and other intellectual property rights in the materials remain with the owner. No material in this publication may be copied (except as legally allowed) or further disseminated without the express and written permission of the holder of that copyright, with the exception of copying for educational purposes. Copyright © ATSE 2015

PUBLISHER

CEO: Dr Margaret Hartley FTSE

Editor: Bill Mackey

Australian Academy of Technological Sciences and Engineering (ATSE)

Address:

Level 1, 1 Bowen Crescent, Melbourne

Postal Address:

GPO Box 4055, Melbourne, Victoria 3001

Telephone: 03 9864 0900

Facsimile: 03 9864 0930

Email: editor@atse.org.au

ACN 008 520 394

ABN 58 008 520 394

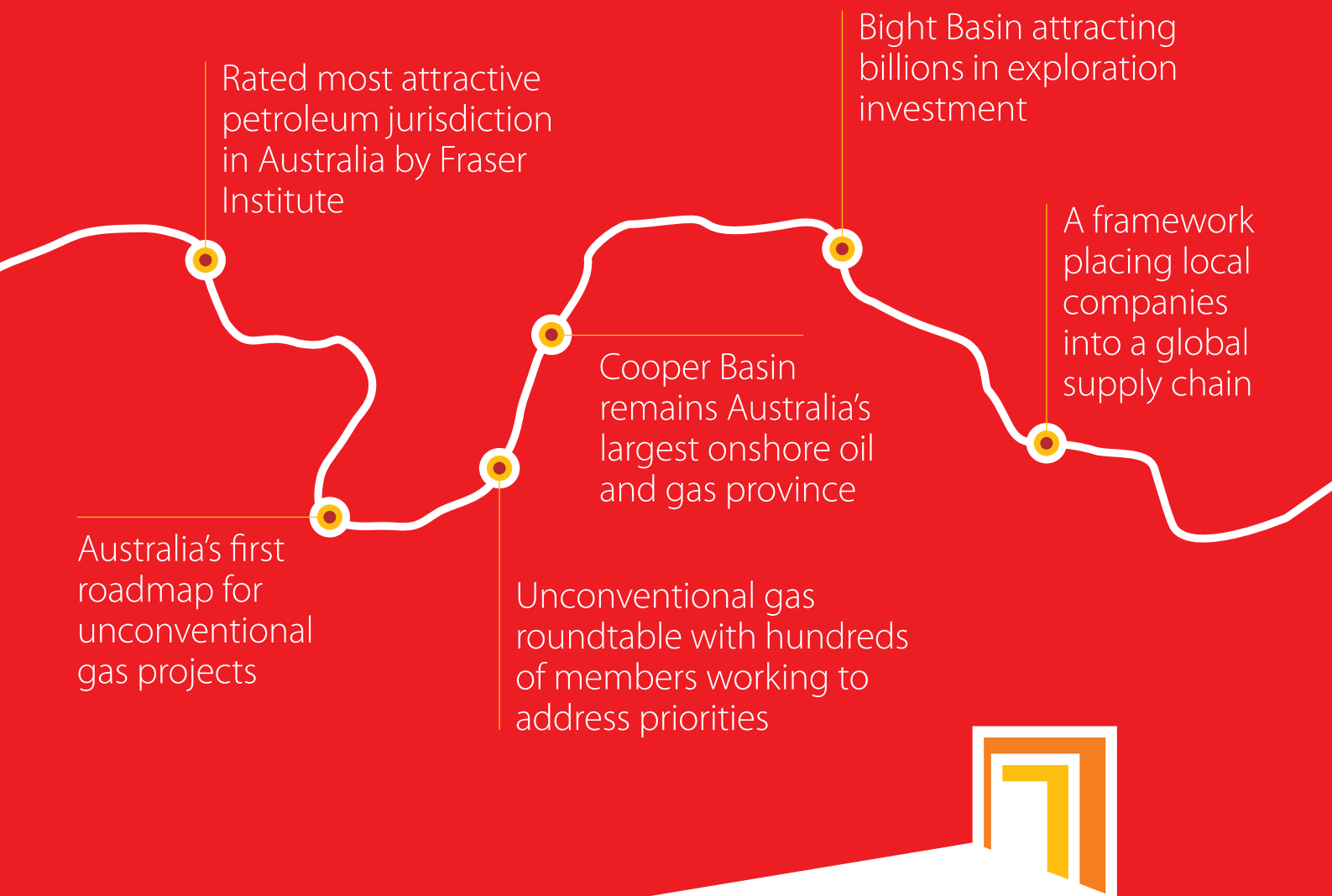
Print Post Publication No 341403/0025

ISSN 1326-8708

Design and production:

Coretext 03 9670 1168 www.coretext.com.au

South Australia's door is open.



South Australia's trusted regulatory framework continues to meet community and industry expectations. It has already paved the way for global exploration companies to begin developing our vast gas reserves. We are also the first state to create a comprehensive roadmap for unconventional gas projects – developed by hundreds of stakeholders. Additionally, deep water exploration in the Bight Basin continues, all within a robust regulatory environment.

To find out more visit www.petroleum.statedevelopment.sa.gov.au

DSD0005





BY CRAIG SIMMONS
craig.simmons@flinders.edu.au

Massive challenges, but we must meet them

UNCONVENTIONAL GAS We need a much greater effort to quantify the likelihood of 'something bad' happening due to 'fracking' or coal seam gas extraction, and over what time and spatial scales it may occur.



Coal seam gas (CSG) and 'fracking' are fighting words in Australia and in many countries around the world.

They badge one of the most contentious, controversial and emotive issues of our time.

There are legitimate public concerns about what impact CSG and fracking may have on human health and the environment. There are myriad complex social, economic and environmental factors at play.

The potential for unconventional hydrocarbon development both in Australia and overseas is enormous. Obviously energy market supply and demand issues will control how these resources are ultimately developed into the future.

Coal seam gas and the associated fracking process are part of what we broadly refer to as 'unconventional hydrocarbon development'. These gases and hydrocarbons are called 'unconventional' because unlike their conventional counterparts, the gas does not rise naturally and become trapped beneath a seal. Rather, the gas is trapped *in situ*, held within the pores and cracks in the rock under water pressure.

Unconventional gas – coal seam gas, shale gas and tight gas – are variations on a theme. There are some similarities but there are also some key differences. They vary in their geology type, the depth of the geologic layers, and the permeability of the rock.

In some, but not all, cases hydraulic fracturing is used to break up the rock and increase the permeability of the rock so that these gases may flow to a production well, making it easier and cheaper to



PHOTO: ISTOCK

A complex social, environmental and economic issue.

extract them. Fluids used for gas fracking are usually about 90 per cent water, 9.5 per cent material such as sand, and 0.5 per cent other chemicals. These chemicals aid the fracking process in several ways – reducing friction and distributing the sand that props fractures open, preventing bacterial growth (which can gum up the cracks in the rock), inhibiting scale and corrosion in the casing and cleaning.

But it is this chemical concoction that is at the very heart of public concerns regarding fracking and coal seam gas production.

Water is an absolutely critical part of each and every part of the unconventional gas extraction process – from production through to potential impacts. It is used for drilling and fracking and to enhance additional production in many formations. It is withdrawn when producing the gas, it must be stored or reused in the form of wastewater,

or disposed of via injection into aquifers.

Depressurisation of the water in the aquifer is a key part of the CSG production process because this allows the gas to be released from pores and fractures in the rock. The 'produced' water will vary in characteristics such as volume, quality and flow rates depending on how the gas is produced, the wetness of the source rocks, and the geology type.

Arguably the greatest public concern related to water impacts is fracking and the use of chemical additives that potentially contaminate freshwater supplies. Fracking has been used since 1947 across all areas of oil and gas production and, to date, the technology has been used in some 2.5 million wells worldwide. The *Wall Street Journal* reported that fracking accounted for 49 per cent of US oil production and 54 per cent of natural gas output last February.

Hydraulic fracturing is a mature technology but the extensive use of drilling, the cocktail of chemicals and the scale of operations make unconventional gas production novel in many countries. Public interest and concern about fracking continues to run high around the world.

Numerous US cities and local governments have banned it. Germany, France, Scotland, Wales and Luxembourg have bans or moratoria on its use.

There is a long list of public concerns about and technical risks in unconventional gas production:

- potential contamination of groundwater from fracking chemicals and released methane;
- leakage of methane gas and its impact on climate change;
- potential toxicity of the 600+ chemicals used and risks to operators and local residents;
- waste disposal and containment of fracking materials;
- fracking-induced minor earthquakes and land-stability issues;

- environmental damage and pollution caused by many thousands of vehicle trips to gas wells to deliver water and chemicals, as well as surface spills and land clearing;
- competition and tension among alternative land uses, including farming;
- a new industry with many uncertainties and unknowns;
- large scale and significance of production projects;
- long production timeframes;
- cumulative impacts of multiple projects or wells and difficulty managing them;
- immature science, regulation, compliance and monitoring;
- weaknesses in public consultation;
- water issues managed outside normal water allocation processes; and
- piecemeal (partial) approval processes when a whole-of-landscape 'systems' approach is required.

There has been community concern around these and other issues and their possible effects on the environment, human health and land values, accompanied by calls for greater transparency and a need for

baseline monitoring. People are still worried whether the chemicals used have undergone proper health and safety testing.

Fracking risk depends not only on the chemicals used but also on local conditions of geology and groundwater, as no two wells are the same.

The public issues are a broad and hugely complex, interacting and competing range of difficult social, economic, environmental, political, legal and governance matters. Science is necessary but insufficient in advancing or solving such problems. There are many other psychosocial factors at play.

Novelty (whether mining is new or old in a region) and financial compensation are among the many factors that will be important determinants in social acceptability.

In the US farmers often own the mineral rights under their property and hence derive significant income from both the installation of the production bore and from royalties in perpetuity as gas production proceeds. The situation is vastly different in Australia.

Although moves are afoot to improve

SCIENTIFICALLY SPEAKING... CONTENT MATTERS

Australia's leading custom publisher for science and innovation

Professionally written and produced **publications** and **books**

Information products that show R&D at work

Print and digital publications crafted to enhance stakeholder and community engagement

FISH, the industry magazine for the Fisheries Research and Development Corporation (FRDC), is now available for iPad. The new digital version of **FISH** makes the entire printed magazine available free of charge including industry analysis, fisher interviews and research news.

FISH magazine is available as an app. Please follow these steps:

- Open Google Play or the App Store on your device
- In the search function type: FRDC FISH Magazine.



CORETEXT
CONTENT MATTERS
www.coretext.com.au

PO Box 12542, Melbourne VIC 8006, Australia

T +61 (0)3 9670 1168

enquiries@coretext.com.au

compensation strategies, the Crown owns the natural resources beneath the land surface. In addition to developing a much more rigorous scientific understanding of these issues, it will be critical to deeply understand and appreciate the fundamental social determinants that influence a 'social licence' to operate.

In many ways, the long list of things that could go wrong with unconventional gas production is both unhelpful and unscientific. The list articulates the long list of possibilities. It says nothing about probabilities.

A much greater effort must be undertaken to systematically quantify the likelihood of impacts using a range of empirical analyses (drawing upon large empirical datasets that are available) and theoretical analyses to determine how likely 'something bad' happening may be and over what time scales and spatial scales it may occur. We need to be much more quantitative and scientific about this contentious discussion.

In general, there is an emerging consensus in international reports. They do record documented cases of environmental impact, including groundwater contamination and induced seismicity in other phases of the unconventional gas and oil production and development cycle, although these are more common in shale gas than in coal seam gas production.

These are also the same kinds of impacts associated with conventional oil and gas operations: leakage from retention pits and tanks, leakage from poorly cased and inadequately cemented wells, induced seismicity from injection of wastewater into subsurface waste disposal sites, well blowouts and air emissions associated with vented volatile hydrocarbons.

These impacts are documented to have a very low incident rate (0.1 per cent of wells drilled in Texas) and are mostly associated with surface activities and waste disposal. They are also subject to state regulation.

The breakout box ('Incidence rates') summarises the likelihood of impacts based on empirical evidence. Work by the National Centre for Groundwater Research and Training in Adelaide to quantify the likelihood of impacts from unconventional gas production will soon be completed. It will provide the first comprehensive, systematic and quantitative international meta-analysis of empirical datasets and provide important new theoretical analyses to quantify the likelihood

Incidence rates

GROUNDWATER CONTAMINATION

Incident rates* for groundwater contamination calculated from data chiefly in US EPA (2015), Groundwater Protection Council (2012) and Texas Railroad Commission files (State oil and gas regulatory agency) (2015).

Waste management and disposal	.0003
Production and on-lease storage	.0003
Casing failure	.0002
Drilling and completion	.0003
Fracking stimulation	0
Site development	0
Spillage of frack water and chemicals	0
Surface spill volume/volume of fluids handled	.0007
Subsurface blowouts with possible leakage to subsurface formations	.0004

* Number of incidents of groundwater contamination per number of fractured wells drilled. This excludes the 57 legacy well incidents in the Texas/Ohio data set from US Groundwater Protection Council (2012) (see below).

Data sets from the US Groundwater Protection Council (2012) are available for the incidence of groundwater contamination from oil and gas operations in states such as Texas (1993–2008) and Ohio (1983–2008).

The Incident rate was .00179 – 396 incidents in drilling of 221,092 wells (85 per cent in Texas). It is estimated that 65 per cent involved hydraulic fracturing – nine per cent of Texas wells were multi-stage, horizontally fractured shale wells.

PRINCIPAL CAUSES (PERCENTAGE OF INCIDENTS)

- Waste management and disposal: 28 per cent (57 of 75 incidents from legacy with disposal sites that were outlawed in 1969)
- Production and on-lease storage and transport: 26 per cent
- Drilling and completion (including cement isolation problems): 22 per cent
- Orphan well-related: 18 per cent
- Casing failure: eight per cent
- Stimulation (including hydraulic fracturing): nil

Water use and management are important parts of the unconventional gas production cycle. Water management includes the use of water injected and the flowback of the injected water as well as the produced waters from the fractured formation. Large volumes of water are typically produced. Increasing evidence suggests that improper handling of flowback and produced waters contributes to the majority of the environmental impacts in the hydraulic fracturing cycle.

Data from the US Groundwater Protection Council reveal a 90 per cent reduction in incidents from regulated wells in Ohio over the period 1983–2007 – presumably through increased regulation and compliance measures as well as improvements in technology, engineering, understanding, expertise and experience.

INDUCED SEISMICITY

Induced seismicity is caused mostly by change in pore fluid pressure in the subsurface in the presence of faults with specific properties and orientations. The factor that appears to have the most direct correlation in regard to induced seismicity is the net fluid balance – the total balance of fluid introduced into or removed from the subsurface. A report by the US NRC in 2012 documented the incidence of induced seismicity in the US. Of 35,000 wells, there were eight induced seismicity events. The maximum magnitude of 'felt events' was 4.8 on the Richter Scale. It concluded that the re-injection of co-produced water into aquifers, and associated pore pressure increase, is the dominant mechanism – not the hydraulic fracturing phase of the production process.

Researching social, economic and environmental impacts and opportunities of the natural gas industry

The Gas Industry Social and Environmental Research Alliance (GISERA) is a proven research and governance model for understanding the socio-economic and environmental impacts of the natural gas industry in Australia.



With an initial focus on Queensland's CSG-LNG industry, GISERA has utilised the significant trusted research capabilities of the CSIRO and partnered with Australia Pacific LNG and QGC to provide industry, government and the community with quality assured scientific research regarding the natural gas industry. To date, the research has focused on six program areas:

- Agriculture
- Biodiversity
- Greenhouse Gas Emissions
- Water
- Marine
- Socio-Economics

GISERA aims to achieve credibility, trust and respect from all stakeholders through the open and transparent conduct and communication of its activities and research. The governance arrangements of GISERA are designed to provide for and protect research independence and transparency. The knowledge generated by CSIRO and others through GISERA is made widely available. This transparent communication approach helps industry, government and communities make informed decisions about managing the impacts on society, the economy and the environment of natural gas developments.



Contact us

Shelley Masterson
Phone: +61 7 3833 5554
Email: gisera@gisera.org.au
www.gisera.org.au

of water-related impacts. Theoretical analyses are also necessary because empirical data alone may be necessary but insufficient (that is, absence of evidence is not evidence of absence). One may, for example, argue that we may have missed an impact by either sampling in the wrong place or not waiting long enough for the impacts to be realised.

There appears to be an emerging technical and scientific view that, based on evidence to date, unconventional gas production is safe – provided that it is subject to very tight regulation and compliance.

Each development case must be assessed on a case-by-case basis and underpinned by rigorous science, evaluation and environmental impact assessments. These will necessarily involve cumulative impact and risk assessments – a critical part of the overall evaluation, regulation, conditioning and compliance processes that are necessary to ensure both public health and environmental health.

Therefore, enhancing the quality of science will be essential to underpin robust management, decision-making and regulation. The Commonwealth's Bioregional Assessment Program is one vital platform for achieving this. The Statutory Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) also provides scientific advice to decision-makers on the impact that coal seam gas and large coal mining development may have on Australia's water resources.

But publicly available IESC advice continues to show that there are still many 'known unknowns' and a plethora of problems with environmental impact assessments. Thus, science and engineering remain insufficient to provide absolute confidence to the public when it comes to many individual project development applications.

These scientific issues include a lack of baseline data, deficient and uncertain conceptual and numerical models (for example, role of faulting or aquifer connectivity, inadequate model parameterisation), quantification

Fluids used for gas fracking are usually about 90 per cent water, 9.5 per cent material such as sand, and 0.5 per cent other chemicals that aid the fracking process in several ways ... it is this chemical concoction that is at the heart of public concerns regarding fracking and coal seam gas production.

and mitigation of uncertainty, limited understanding of cumulative impacts and an inability to make a robust assessment of risk.

The large costs involved in doing expensive studies for environmental impact assessments – especially prior to project approval – often lead to patchy and highly inadequate assessments as corners appear to be cut. This is problematic given the proposed scale of operations, their potential lifetime economic production values and potential environmental impacts.

There is also a quagmire of real and perceived conflicts of interests and just plain interests. There are many important issues to contend with in regulation and compliance including whether we have the significant tools, expertise, time and resources required to do what is needed for the public and common good in terms of risk identification, quantification and management – now and long into the future.

Proper respect by industry and government for the time and effort required to consult effectively with affected communities is also urgently required in order to reduce community opposition and build a genuine social licence to operate.

Unconventional gas production is a complex social, environmental and economic

issue. There are no easy solutions and there are clearly 'many miles to go before we sleep'. But we cannot abdicate our responsibility and accountability. We must demand a process of continuous improvement. We must declare and combat systemic weaknesses.

This is fundamental to building the urgently needed trust in science, regulation, compliance and the industry and government organisations involved.

These are massive challenges and we do not know if they have tractable solutions. But we must rise to the challenge if we are to make real progress. ☉

Acknowledgement

The author gratefully acknowledges valuable discussions with and materials provided by William Fisher, Ken Matthews and Jim McDonald.

Professor Craig Simmons FTSE is a leading groundwater scientist, recognised for major national and international contributions to groundwater science, education and policy reform. He is Deputy Chair of the Statutory Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) and Director of the National Centre for Groundwater Research and Training, as well as Matthew Flinders Distinguished Professor of Hydrogeology and Schultz Chair in the Environment at Flinders University. He was named the 2015 South Australian Scientist of the Year. Professor Simmons is Deputy Chair of the Academy's Water Forum.

**CONTRIBUTIONS
ARE WELCOME**
FOCUS



Opinion pieces on technological science and related topics, preferably between 600 and 1400 words, will be considered for publication. They must list the full name of the author, if a Fellow of the Academy. Other contributors should provide their full name, title/role and organisation (if relevant) and email address. Please address to editor@atse.org.au



BY JOHN WILLIAMS
jwil3940@bigpond.net.au,
and ANN MILLIGAN
ann.milligan@gmail.com

Looking after our land and water

UNCONVENTIONAL GAS A whole-of-system framework is needed to deal with the interacting impacts of multiple land uses, including gas development, on the necessity of retaining landscape functionality.

Projects related to unconventional gas production are often seen as a threat to the land, water and infrastructure resources available to existing or future land uses, particularly in Queensland, NSW, Western Australia and Victoria. These land uses include food and fibre production, urban areas and human amenity, and conservation of biodiversity, as well as other mining activities.

But, in principle, unconventional gas production should be no different from any other land-use development within a landscape. It is essentially another demand on the land's resources, to be managed as part of whole-landscape assessment and strategic land-use planning.

When considering all development options within a landscape, it is a defensible proposition that only those landscape activities that allow the landscape to maintain its function indefinitely are acceptable. It would be folly to secure one natural resource while putting at risk renewable long-term resource use.

Australian governments and the mining industry seem to have accepted this proposition, and are working towards whole-of-landscape analyses and assessment of the cumulative impacts of multiple land uses.

A whole-of-landscape framework that takes account of long-term cumulative impacts could involve:

- understanding regional landscape capacity, and determining if there is capacity for the development without crossing landscape limits;
- updating current development approval processes, so that new developments

can be approved only on the basis of landscape limits and the expected cumulative impacts of the existing and proposed developments; and

- using insights gained from whole-of-landscape cumulative risk assessment aligned with the limits and thresholds to landscape function, to establish regulation, leading practice, monitoring and compliance arrangements to manage risks.

All land uses have the potential to reduce the capacity of our natural resources to supply long-term human and ecological needs.

The potential impacts of extracting unconventional gas could be significantly smaller than the impacts and degradation of land and water resources already experienced in Australia, provided enough tools, time and money are committed to protect the public and common good in terms of risk identification, quantification and management.

Agricultural, rangeland, forestry, water-supply and urban land uses over the past two centuries have taught us what can happen when we neither understand nor take care to manage their impacts. It is accepted that operations related to extracting unconventional gases pose risks to natural resources and their long-term uses, and there is now significant documentation of the risks involved.

Policy, governance, regulation and monitoring are seeking to manage those risks. For example, the NSW and Queensland governments have set up the *Regional Strategic Land Use State Planning Policy* and the *Strategic Cropping Land Act*, respectively. The Western Australian Government has just announced a regulatory framework for shale and tight gas to protect that state's waters, environment

and public health. The Minerals Council of Australia published a Cumulative Environmental Assessment Industry Guide this year.

In recent years the Federal Government has established bodies such as: the Standing Council on Energy and Resources, which is encouraging cumulative risk assessment and strategic land-use planning, such as through the Multiple Land Use Framework; the Independent Expert Scientific Committee, to examine water-related impacts from coal seam gas and large-scale coal mining; and the Bioregional Assessment Programme.

The bioregional assessment work is assembling what is known about bioregions located over unconventional gas basins. The reports include information about terrestrial and water-dependent ecological assets, land use, geology, hydrology (surface and groundwater) and water quality. Where there are adequate data and models, the outcome of this work could be a synthesis delivered to support scientific advice on impacts on and risks to water resources.

WATER RESOURCE IMPACTS

Unconventional gas is found in sedimentary basins across Australia, at depths ranging from a few hundred metres (usually coal seam gas) to several kilometres (for example, shale and tight gas). Groundwater often puts coal seam gas under pressure, and needs to be extracted (as 'produced water') so the gas can flow to the surface. Large volumes and low quality (generally salty) are typical. However, to release shale gas and tight gas water needs to be brought to the site to provide very-high-pressure pulses to hydraulically fracture ('frack') the gas-bearing rock.

The following issues have received various levels of attention in state legislation.

- Where there are hydraulic connections, over time, there will be impacts on freshwater aquifers when water is extracted to de-pressurise coal seams, and when water pressures subsequently change.
- 'Produced water', salts and other substances brought to the surface during dewatering need to be managed safely for humans and biodiversity. Methods for managing large salt loads remain an issue for coal seam gas production, although in some cases the water, after treatment, is being delivered to agricultural users.
- Once coal seam gas production has ceased, the coal seams will need to be recharged with water. Methods of recharge have so far received little attention. Re-injection is one option. Over time the water extracted will need to be replaced – from somewhere.
- As gas fields run out of gas, there will be a growing legacy of abandoned gas wells that will need to retain integrity to avoid connections across stratigraphy over many thousands of metres, including confined aquifers and strata of water-bearing material with very different chemistry. The long-term management of abandoned gas wells is a matter that requires careful attention in terms of regulation and governance.
- Sourcing the large volumes of water needed for fracking in shale may lead to over-extraction from streams and aquifers. This will need to be managed within regulatory processes, such as National Water Initiative-compliant water entitlements and aquifer management plans, so as to minimise changes to flow regimes and the potential for contamination of aquifers.

Information and analyses now being produced should help policy, governance, community and industry leaders to manage those and other important issues. For instance, information from the bioregional



SOURCE: ECOLOGICAL AUSTRALIA

FIGURE 1. ROADS AND OTHER INFRASTRUCTURE IN A COAL SEAM GAS FIELD NEAR DALBY STATE FOREST, SOUTHERN QUEENSLAND, 2013.

assessment process is expected to help decision-makers managing the sourcing of water for fracking in shale, and protecting water and soil resources from contaminants. However, it is important that modelling of impacts on groundwater and surface water for decision-making is sophisticated, transparent, based on clear assumptions and fully adequate data, and independent of industry pressures.

BIODIVERSITY, FOOD AND FIBRE, AND COMMUNITIES

Many land uses, including unconventional gas projects, entail clearing of vegetation, introduction of invasive species including weeds, extra traffic and noise, interruption to long-established traditional or heritage practices and rights, and fragmentation of habitat patches. A number of scientific studies have confirmed that fragmentation of bushland has negative effects on native fauna.

By its scale and nature, the 'footprint' of an

unconventional gas production field cuts across landscape and biological habitat (Figure 1). Some coal seam gas developments in Australia have an average of 1.1 well pads and 1.6 kilometres of road per square kilometre of land, although multidirectional drilling technology is now helping reduce those numbers. The fewer the well pads, gas-gathering systems, road and firebreaks, the smaller the intrusion on habitat and other land uses.

Food and fibre production also is perceived to be at risk from the cumulative fragmentation involved in a gas field, and there are fears of loss or contamination of strategic agricultural land and its vital water resources. To date, cumulative fragmentation has not received enough attention in overall landscape assessment and planning.

When land owned by the Crown, beneath good surface soils owned by landholders, is committed to new unconventional gas projects, landholders may see a lack of support for their rights, a lack of consultation, inadequate compensation, negative impacts on amenity and inadequate benefits for their neighbours and their communities. Work to resolve this tension continues.

WA farmers are reported to have formed an agreement with oil and gas companies on land protection and access. In the NSW Namoi River catchment, experience has shown a balanced coexistence of mining and various forms of agriculture can be possible with careful management supported by bioregional planning and cumulative risk assessment.

THE WAY FORWARD

The way forward will be to recognise that a realistic whole-of-system framework is essential, to deal with the strong interacting impacts of multiple land uses, including gas development, on the long-term need to retain landscape functionality.

Strategic environmental assessment prior to development of unconventional gas

► *More on page 12*





Department
of Industry
Resources & Energy



Find out more about our work at
www.resourcesandenergy.nsw.gov.au



BY PETER COOK
pjcook@co2crc.com.au
and VAUGHAN BECK
sa.vaughanbeck@atse.org.au

The opportunities and challenges for unconventional gas



The discovery and development of unconventional gas has been one of the most significant technology-driven developments of the past decade. Shale gas has made the US self-sufficient in hydrocarbons and potentially a net gas exporter. Coal seam gas (CSG) has enabled eastern Australia to become one of the world's great exporters of LNG.

But while these developments have produced major economic benefits, they have also resulted in concerns regarding their environmental and social impacts.

The ATSE International Conference and associated Academies Workshop on Unconventional Gas in Sydney in September brought together academicians and authorities from eight countries – the US, Canada, the UK, China, South Africa, Argentina, Germany and Switzerland.

Some 150 researchers, bureaucrats, regulators and operators participated in keynote presentation and panel discussions that summarised the current state of knowledge regarding unconventional gas – both coal seam, and shale – and highlighted areas of dispute and uncertainty.

Together these meetings provided an outstanding opportunity to critically analyse the evidence relating to the opportunities and the challenges of unconventional gas developments.

The workshop involved academicians, invited experts and government observers. The participating academicians considered the conclusions and observations from the Conference, as well as recent national unconventional gas (and oil) reviews in



Former Minister for Resources and Energy Martin Ferguson AM was the Conference dinner keynote speaker.



Ms Chloe Munro FTSE, Chair and CEE of the Clean Energy Regulator.

reaching a number of conclusions.

In all, 35 key findings were made and these are summarised below.

1 UNCONVENTIONAL GAS RESOURCES
Provided best practice is followed, unconventional gas can be produced in a manner that is environmentally responsible and that provides significant societal benefits.

2 COMMUNITY CONCERNS
Gaining community support for unconventional gas developments requires sustained engagement, the recognition of prevailing community values, the communication of scientific, technical and

socio-economic information by trusted sources, certainty in the regulatory regime, and confidence that long-term socio-economic benefits will accrue to communities most affected by developments and that there will be no adverse health impacts.

3 NEW KNOWLEDGE
Ongoing research in sedimentary basins will reduce gaps in our knowledge of unconventional gas, decrease project costs and impacts, improve regulations and contribute to the development of a risk-based approach to regulation and to the management of environmental and community impacts.

SENATE GAS INQUIRY

A Senate Select Committee on Unconventional Gas Mining, chaired by Senator Glenn Lazarus, is inquiring into the adequacy of Australia's legislative, regulatory and policy framework for unconventional gas mining including coal seam gas and shale gas mining.

Agreed on 12 November, the inquiry, which will report to the Senate by 30 June 2016, will have reference to a range of matters including: a national approach to the conduct of unconventional gas mining; the health, social, business, agricultural, environmental, landholder and economic impacts of the industry; and harmonisation of federal and state/territory government legislation, regulations and policies.

4 HYDRAULIC FRACTURING

Provided best practice is followed, including ensuring that there is comprehensive knowledge of the sub-surface, hydraulic fracturing is most unlikely to cause damaging induced seismic events or result in widespread, systemic impacts on drinking water resources – of which there is no evidence from hydraulic fracturing of shales in the US. But to win public confidence, best practice and regulation need to be adopted, along with full disclosure of the intended activities and the composition of injected fluids.

5 GROUNDWATER

Poor well construction and improperly decommissioned wells are risks to groundwater and it is important to adopt leading construction practice and be able to demonstrate lifetime well integrity and remediation responsibility for unconventional gas wells. Along with this, it is important to adopt best practice for wastewater disposal and management of materials and spills of chemicals at the surface, which can lead to groundwater contamination.

6 LANDSCAPE AND THE ENVIRONMENT

Local and cumulative environmental impacts of unconventional gas developments, such as habitat fragmentation and potential loss of threatened species, must be evaluated using a cumulative risk-assessment framework and this should inform planning and decision-making such as siting and the location of associated infrastructure.

Better planning of infrastructure, such as well pads, access roads and gathering and transmission pipelines, is important if integrated land management is to be followed and environmental and biodiversity impacts minimised.

7 EMISSIONS


Fugitive emissions must be considered in the context of a life-cycle assessment of GHG emissions. Fugitive emissions are typically several per cent of the total lifetime production of methane from an unconventional gas well. These fugitive emissions result in a diminution of the potential reduction in greenhouse gas emissions by switching from gas to coal. They can be identified by monitoring and remediated through measures such as green completions and best available practice.

8 REGULATIONS

If regulations are to meet community expectations, protect the environment and reduce costs to industry, they must have clarity of purpose, transparency and engender trust. Regulatory best practice can be achieved when operators are required to identify and manage agreed risks consistent with the 'as low as reasonably practicable' (ALARP) principle. It is broadly accepted that such an approach is the most effective way to avoid damaging impacts on the environment and safety, protect community interests and land-owner rights and help facilitate the achievement of a social licence to operate.

The 2015 ATSE Unconventional Gas

Conference and Workshop provided an outstanding example of how the Academy and its fellow Academies can bring a credible and informed perspective to an important and controversial topic.

In so doing, ATSE can assist government, industry and the community at large to communicate the technical issues and challenges, and thus contribute to developing a way forward that addresses community concerns and confers great national and international benefit. 


Professor Peter Cook CBE FTSE is one of Australia's foremost scientists in the areas of energy and greenhouse gas technologies, is a Professorial Fellow at the University of Melbourne and a consultant. He chaired the Australian Council of Learned Academies (ACOLA) Review of Unconventional Gas (2012–14) and chaired the 2015 ATSE Unconventional Gas Conference and Workshop. Professor Cook was Associate Director of the Bureau of Mineral Resources (now GA) (1982–90) and Executive Director of British Geological Survey (BGS) (1990–98). He was subsequently (1998 to 2003) the Executive Director of the Australian Petroleum CRC, and Chief Executive of the CRC for Greenhouse Gas Technologies (CO2CRC) (2003–11).

Dr Vaughan Beck FTSE is ATSE's Senior Advisor, Technical, and was previously its Executive Director – Technical, responsible for the Academy's research projects and the development of policy advice to government. Dr Beck led the development of significant research reports for ATSE on a wide range of technical policy issues, often leading multidisciplinary teams and involving industry, academic, research and government stakeholders. He was Deputy Chair of the 2015 ATSE Unconventional Gas Conference and Workshop. Before joining ATSE he was foundation Director of the Centre for Environmental Safety and Risk Engineering at Victoria University, and subsequently Pro Vice-Chancellor (Research) at Victoria University.

◀ From page 9

LOOKING AFTER OUR LAND AND WATER

fields, including the use of cumulative risk analysis tools applied at the catchment and appropriate regional scales, is now technically feasible. These approaches need to be coupled and supported by an enabling regulatory environment and spatially adequate explicit ecological, hydrological and geological data.

These tools and the social process involved should then have the potential to manage risks and minimise the ways in which unconventional gas developments affect the functionality of our landscapes – that is, the integrity of the hydrological, geochemical and ecological processes on which humans depend. 

Dr John Williams FTSE is a founding member of the Wentworth Group of Concerned Scientists and holds the prestigious Farrer Memorial Medal for achievement and excellence in agricultural science. He is one of Australia's most respected and trusted scientists, with extensive experience in providing national and international thought-leadership in natural resource management, particularly in agricultural production and its environmental footprint. He is currently Adjunct Professor at ANU Crawford School of Public Policy and Adjunct Professor at Charles Sturt University Institute of Land Water and Society.

Ms Ann Milligan is an Honours graduate in agricultural science from the University of Western Australia. She was a researcher in plant nutrition and groundwater hydrology with CSIRO for 11 years. Since 1985 she has been writing, editing and publishing about the science and management of natural resources. She was a communication manager for the Cooperative Research Centre for Freshwater Ecology and later eWater CRC. She currently works freelance, including as newsletter editor for the Peter Cullen Water & Environment Trust and for Friends of Grasslands Inc.



BY DAVID BRERETON
d.brereton@smi.uq.edu.au

Time for a new approach to the social licence issue

UNCONVENTIONAL GAS

Faced with conflicting messages and masses of data, individuals tend to resort to trusted sources and 'gut feel', rather than taking time to absorb new information.

T

The future expansion of unconventional gas in Australia depends not only on overcoming economic and technical factors,

although these are important constraints in the short term, but also on new projects obtaining societal permission.

This is the realm of the so-called 'social licence to operate' (SLO) – a term which is now widely used in the extractive resources industry, and increasingly in other sectors that have significant environmental footprints, such as forestry, farming, unconventional gas extraction, wind energy and large-scale infrastructure projects.

In broad terms, a resource project, or industry, can be said to have secured a social licence when it has the ongoing approval of impacted communities and other key local stakeholders.

This 'licence' is usually not formalised in any way, but instead is manifested by community attitudes and behaviours that demonstrate positive acceptance – not just begrudging tolerance – of the project in question.

The SLO can be contrasted with the regulatory licences granted by governments, which provide the legal terms and conditions under which projects can be developed and operated.

The increasing focus on SLO in the resources sector reflects a growing understanding by companies and governments that projects that lack community acceptance are more likely to experience disruption and delays and, in some cases, may not proceed at all.

The SLO of the unconventional gas sector



Activists press their point on the steps of the Victorian Parliament.

in Australia is still not secured. The initial social disquiet about large-scale coal seam gas (CSG) development in Queensland appears to have died down. This is partly because companies have improved their practices, partly because the Queensland Government has strengthened the regulatory framework (for example, by setting up a comprehensive groundwater monitoring and 'make good' protocol) and partly because, with the passage of time, communities have become more accustomed to the presence of the industry.

However, in other parts of Australia, most notably New South Wales and Victoria, the industry is still a long way short of achieving a social licence. Instead, we have seen: organised resistance by landowners to company representatives coming on to their properties (the 'Lock the Gate' campaign); well-organised information campaigns using

social media; direct action by protestors, including the blockading of drilling sites; and the emergence of hitherto unseen political alliances between environmentalists and farmers.

There has also been some very effective political lobbying at the state level, resulting in a moratorium being imposed on further exploration in Victoria.

In this highly charged environment, governments and industry are struggling to provide assurance to local communities and other stakeholders that unconventional gas extraction can be undertaken without causing any long-term environmental harm.

The 2014 ACOLA report *Engineering Energy* concluded that the environmental risks associated with the industry were manageable if best practice was followed – a message that was reinforced at the recent ATSE



CLEVER RESOURCEFUL SOLUTIONS

The minerals we help to mine shape the world we live in.

An Australian company with a global footprint, Orica has operations in more than 50 countries and customers in more than 100. On average, we deliver 1,500 blasts every day.

We're focused on developing long-term partnerships with our customers to reduce the total costs of mining, improve productivity and achieve sustainable environmental outcomes.

We combine the progressive thinking of our Global R&D and Technical networks to find solutions for the challenges encountered at every stage of the mining value chain.

To deliver for our customers, we rely on excellence in Science, Technology, Engineering and Mathematics.

We are therefore proud to be the principal Sponsor of ATSE's STELR Project and to have helped more than 400 schools in Australia and beyond become STELR schools.

Blasting Systems | Ground Support | Mining Chemicals

orica.com



Unconventional Gas Conference in Sydney.

But this has been a difficult message to convey to local communities and other interested publics – for several reasons.

The debate about unconventional gas is not just a dispute over how to interpret the data or what the science means. As discussed in the Engineering Energy report, many people who are opposed to development of these resources operate from different value frameworks, which prioritise things such as the preservation of rural landscapes and lifestyles, biodiversity protection, and strong action to address human-induced climate change.

These groups are unlikely to be persuaded to change their position solely in response to scientific evidence that gas extraction can be done safely.

This aside, in a world where people are deluged with – and can also readily access – large amounts of information from a diversity of sources, it is increasingly difficult to get a message through. Faced with conflicting messages and masses of data, individuals tend to resort to trusted sources (often people like themselves) and ‘gut feel’, rather than taking time to absorb new information.

There is also substantial evidence that levels of trust in political institutions and processes in Australia and other parts of the world have diminished over the past two to three decades. Government is no longer seen as an independent arbiter, because communities no longer trust their elected representatives to look after their interests. Levels of trust towards multinational corporations and big business are likewise low, especially relative to environmental non-governmental organisations. This means that information coming from government and industry sources is now viewed sceptically by many in society.

The Engineering Energy report put forward several suggestions about how these challenges might be addressed. Two in particular are worth noting here.

1 MAKE GREATER USE OF MULTI-STAKEHOLDER PROCESSES

A fairly common government response to controversial issues in Australia, and elsewhere, has been to establish independent expert groups to act as a source of authoritative advice. Such committees can play a valuable role, but experts often work from similar paradigms and tend to defer to each other on

matters within each person’s area of expertise. Rules of confidentiality can also inhibit transparency and may inadvertently reduce public confidence in the process.

A more innovative response is to make greater use of open deliberative forums at the regional level to represent a variety of viewpoints and interests, share knowledge and experiences, and encourage forward-looking discussions about how to maximise the societal benefits of unconventional gas development. If they are set up and run well, these forums could provide a useful mechanism for building trust amongst the different stakeholders.

Some elements of this approach can be seen in the Queensland Gasfields Commission, which has played an important role in securing increased public support for CSG extraction in Queensland’s Western Downs.

2 DEVELOP ALTERNATIVE NARRATIVES

Unconventional gas development is still perceived by many communities as a high-risk, low-reward option and as something over which local people have little control. Many others living outside impacted areas are also concerned about potential impacts on water and greenhouse gas emissions. The dominant narrative of more jobs and more revenue for governments does not resonate well with these groups.

In the Engineering Energy report, we argued that developing some alternative narratives around the opportunities presented by this new industry could help to build a broad-based social licence and

could positively position unconventional gas projects in the future energy mix.

The content of any such narrative should be the outcome of a dialogue between stakeholders, government and industry, rather than being predetermined and then marketed. However, possible themes include:

- leveraging off industry technology, infrastructure and know-how to enhance the reliability of water supply and increase agricultural production and food security in farming areas;
- using unconventional gas development to facilitate the transition to a low-carbon economy; and
- creating opportunities to kick-start development in remote areas of Australia and provide a point of economic engagement for the Indigenous people living in those regions.

There is no guarantee that either of these initiatives, by themselves, would deliver a stronger social licence for the unconventional gas industry. However, given that current approaches by government and industry are struggling to get traction, there is little to be risked – and potentially a good deal to be gained – from trying something different. ☺

Professor David Brereton was appointed as foundation Director of the Centre for Social Responsibility in Mining (CSRM) at the University of Queensland in late 2001. He held this position until mid-2012, during which time CSRM grew into a world-leading centre of research expertise on the social challenges facing the mining and minerals sector. He then became Deputy Director of Research Integration in the CSRM’s parent body, the Sustainable Minerals Institute, with responsibility for driving cross-disciplinary initiatives to improve the sustainability performance of the minerals

SCIENCE COUNCIL URGES NATIONAL AGENDA

Commonwealth Science Council members have expressed strong support for the Government’s focus on innovation and its connection with science and technology.

At its third meeting, in Canberra in October, members recommended that the Government work to develop a comprehensive and whole-of-government National Innovation and Science Agenda.

As part of the broad discussion on the Agenda, the Minister for Education and Training presented the final report from the Research Infrastructure Review and the Minister for Industry, Innovation and Science led discussion on capability mapping against the practical challenges associated with science and research priorities. Both updated the meeting on plans to boost commercial returns from research.

Commonwealth Science Council members include Professor Ian Frazer AC FAA FTSE, Professor Tanya Monro FAA FTSE, Mr Michael Chaney AO FTSE, Mr David Knox FTSE and Ms Catherine Livingstone AO FAA FTSE.



BY DAMIAN BARRETT
damian.barrett@csiro.au



Science is key to future onshore gas development

UNCONVENTIONAL GAS Communities, governments and industry need independent, trusted and unbiased information. Science plays a key role in ensuring that sound policies and public decisions can be made.

Onshore gas development within Australia has the potential to meet domestic energy demands, contribute to the economic wellbeing of communities and the nation and supply energy to the global community.

Successful development of Australia's natural resources demands world's best

practice regulatory, operational and participatory approaches.

Coal Seam Gas (CSG) presents both opportunities and challenges for communities. Unlike mining, CSG has a dispersed footprint across landscapes, which are neither remote nor sparsely populated. Rather, CSG is developing in relatively populated areas and potentially alongside intensive agriculture.

It is critical that communities, State and Federal Governments and industry are able to derive information from sources that are independent, trusted and unbiased on issues that are of concern. Science plays a key role in ensuring that sound policies and public decisions can be made, based on a platform of best evidence.

For more than five years, the Gas Industry



The reality of unconventional gas production

It is important that targeted science-based information continues to be undertaken and provided to stakeholders throughout the various cycles of the industry. As CSG developments move from construction to operational phases a distinct set of concerns emerge to characterise each phase – and science can help to predict and solve the challenges and opportunities that are associated with each.

We must understand the range of impacts and opportunities that emerge from the developments if we are to ensure sustainable benefits are realised.

Understanding the socioeconomic changes over time and the differences within and between communities can help realise sustainable benefits for stakeholders. Our economic research has demonstrated the reversal of rural decline during the construction phase of the industry (2008-2014).

Rural decline, a phenomenon typically associated with rural loss of youth and skills to cities, (especially women), and increased rural poverty, was reversed during the construction phase in the Surat Basin.

CSG development in the Surat Basin was associated with a net increase in employment in residents, a migration in of females and males (in equal proportion), and an increased skill level in youth. Moreover, the research was able to identify the extent of family income increases compared to non-CSG areas (plus 15 per cent) and the number of new jobs for residents excluding FIFO workers. The research found that in the Surat Basin 1,400 new local jobs were created between 2006 and 2011 and that there was a shift in jobs from the agriculture to non-agriculture sectors.

Information that is able to portray an accurate picture of the employment changes to local communities and regions is useful for planners and policy makers.

In addition, our social research has identified factors that contribute to the community's acceptance of CSG development in the region. When the community feels

that the area is adapting and responding effectively to change through good local planning – and access to timely and accurate information – and when there is good environmental management, job and business opportunities, along with high levels of trust among industry and community then it is more likely to accept CSG development.

The research has also shown that views about community adaptation and CSG development vary across the region and that there are differences between those people who live in town and those who live out of town.

Finally, the research has identified opportunities for investing in wellbeing because, even though the level of community wellbeing in 2014 was robust and higher than other rural areas in Queensland, 50 per cent of people were still concerned for the future wellbeing of their community.

Monitoring these changes over time is the aim of follow up research in 2016, which will provide an important longitudinal perspective to the science.

With plans to broaden GISERA's focus to a national model, the focus will remain on informing communities and industry about potential impacts and opportunities of onshore gas development in their regions as well as providing targeted science for governments to develop policy and legislation. ☺

■ Copies of GISERA's research, including the *Community functioning and well-being report*, can be accessed at www.gisera.org.au/publications/scientificreports

Dr Damian Barrett directs research on unconventional gas in CSIRO's Energy Flagship and is the Director of the Gas Industry Social and Environmental Research Alliance (GISERA), a partnership between CSIRO, Australia Pacific LNG and Queensland Gas Company to foster collaborative public good research into the social and environmental challenges and opportunities associated with Australia's growing gas industry. In addition, he is an Adjunct Professor with the Centre for Water in the Minerals Industry (CWMI) at the Sustainable Minerals Institute, University of Queensland. He has more than 20 years research experience in CSIRO, the Cooperative Research Centre (CRC) for Greenhouse Accounting, the eWater CRC and the University of Queensland.

Social and Environmental Research Alliance (GISERA) has operated in Queensland's Surat Basin. By utilising the significant research capability of the CSIRO and in partnership with major industry, GISERA has established a unique governance structure to ensure the delivery of independent and transparent advice on gas development issues. It has delivered this based on the highest quality science.

PHOTO: AUSTRALIA PACIFIC LNG



Our vision is to create sustainability and excellence in Australia's power engineering.

What is the API?

The Australian Power Institute (API) is a not for profit national organisation established by the Australian power industry to boost the quality and numbers of power engineering graduates with the skills and motivation for a career in the energy industry which encompasses:

- Generation, transmission and distribution utilities
- Manufacturers and suppliers to the industry
- Consultants to the industry
- End users of electricity in their operations.

Value Proposition

To deliver a sustainable supply of highly skilled power engineering professionals working effectively to meet the challenges of creating Australia's new energy future, and underpin the technical and commercial success of member companies in the energy sector.

The key objectives of API are to achieve the following:


- Provide a sustainable supply of quality power engineering graduates to industry
- University power engineering teaching and learning provides relevant industry skills
- Value added continuing professional development programs
- A respected organisation leading the national development of power engineering skills.

Further Information

Contact - Mike Griffin (Chief Executive)

0419 643 795

 mike.griffin@api.edu.au

 www.api.edu.au and www.powerengineering.org.au





BY SAMANTHA HEPBURN
samantha.hepburn@deakin.edu.au

REGULATORY REFORMS REQUIRED FOR UNCONVENTIONAL GAS

UNCONVENTIONAL GAS Landowners have a right to be compensated for the impact that the project will have upon their surface estate – but the constitutional framework does not currently support a right of veto.

The existing state-based regulatory system is largely ill-equipped to respond effectively to the variety of specific issues and concerns that the onshore unconventional gas industry raises. Regulatory reforms are required that recognise the distinct challenges associated with developing unconventional resources, including the fact that unconventional developments typically extend over broad areas and therefore require a greater concentration of infrastructure to make production economically viable.

This has the potential to result in broader-scale cumulative surface and subsurface impacts. The environmental review processes in many states are not structured to respond to this type of evaluation because the impact assessments are not grounded in longer-term cumulative evaluation.

This needs to change because in many instances site-specific baseline studies have not been completed, making it difficult to predict what the impact of a project might be, for example on a specific groundwater aquifer, at the time when approval is sought.

To date, the relevant departments have relied upon environmental management conditions but, given the monitoring issues necessary to ensure proper and effective management, it is preferable to mandate cumulative impact assessment that occurs at regular intervals.

Other challenges relate to protecting groundwater quantity and quality, issues around hydraulic fracking and the regional effects these activities can have on the landscape.

To ensure a robust, risk-managed progression of onshore unconventional gas, strong regulatory and policy initiatives that

reflect the spectrum of social, economic and environmental impacts are vital at the state level. This includes the implementation Codes of Integrity for hydraulic fracking and well integrity. It may also require the implementation of specific measurement standards for fugitive emissions and any potential seismicity issues.

A clear acknowledgement of the difficulties associated with land access is also crucial. Landowners affected by unconventional gas development have a right to be compensated for the impact that the project will have upon their surface estate – but the constitutional framework does not, as it currently stands, support a right of veto.

The public resource framework in Australia vests ownership of gas in the state, which allows the state to licence out the right to explore for or extract that gas. These permissive licences carry rights of access because the state is entitled to access resources that it owns.

This, inevitably, can generate conflict when private landowners feel they should be entitled to refuse access. The best way forward is to ensure that negotiation processes are strongly regulated, through conduct and compensation agreements entered into by licence holders and private landowners. Further, the implementation of a Code of Conduct regulating the manner and form in which access entitlements by resource title holders can be exercised is an important means of reducing resource conflict.

It is important to distinguish rights that affected private landholders have to compensation as opposed to royalties that the State receives which may then be reinjected back into the affected communities.

Compensation payments are assessed on the basis of the impact that the proposed project will have upon the interests of the

surface estate owner. Royalties are received by the State, as owner of the gas, and represent a component of the agreement between the gas company and the state.

The money generated by the production of gas resources can be significant and, consequently, it is important to ensure that a reasonably component is injected back into the community so that it may benefit from the commercialisation of the resources.

At the Federal level, coal seam gas proposals must be referred and assessed for 'significant impact' on water resources under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*. There is no capacity for shale and tight gas projects to be evaluated under the *EPBC Act* because the trigger to refer applications is expressly restricted to water resources impacted by coal seam gas development.

Under the National Partnership Agreement on Coal Seam Gas and Large Coal Mining Development, to which most states are signatories, coal seam gas applications require referral to the Commonwealth's Independent Expert Scientific Committee (IESC) for assessment prior to approval.

There is no similar process or trigger to refer tight and shale gas operations for independent scientific assessment. ☉

Professor Samantha Hepburn is a Law Professor at Deakin University and the Director of EMI Partners. She is one of Australia's pre-eminent legal scholars whose research involves the examination of a range of different energy, natural resource, property and land law issues. She teaches and researches in the area of property and land law, as well as mining, energy and environmental law and has published books and articles in these areas. She has a strong research interest in unconventional gas regulation in Australia and is also examining the regulatory development of carbon capture sequestration both in Australia and internationally.



An international issue – a protester in Britain.

WOMEN IN TSE

Report on women in the science workforce

Australia needs a multifaceted strategy to broaden participation in the science and technology workforce, according to a new report, *Women in the Science Research Workforce: Identifying and Sustaining the Diversity Advantage*.

Written by Professor Sharon Bell, Deputy Vice-Chancellor at Charles Darwin University, and Professor Lyn Yates, Foundation Professor of Curriculum and Pro Vice-Chancellor (Research) at the University of Melbourne, the report also calls for a detailed longitudinal study of the scientific research workforce to increase understanding of workforce dynamics and the emergent patterns of generational change.

It says what is needed is a move away from the 'heroic' science paradigm to a new scientific workforce and career paradigm that eliminates the barriers for women, and improves opportunities for a greater diversity of participants – addressing:

- the postdoctoral 'tipping point';
- the impact of career breaks;
- the ubiquity of short-term contracts and project-based support;
- an unforgiving – and in some disciplines alienating – competitive culture; and
- disincentives to sectoral mobility and transitions.

THE REPORT RECOMMENDS

1 Creating mechanisms that enable women to thrive and excel, not just 'survive', in science and technology careers, including supporting flexible, non-traditional career paths and periods of significant leave, with attention to programs that support teams of researchers, the retention of scientific and professional 'currency', and professional re-entry.

2 Acknowledging the rapidly changing nature of academia and correct the increasing disjunction in the aspirations of higher-degree research students through provision of improved career knowledge and professional opportunities.

3 Dismantling the barriers to 'career branching' and mobility between academia and industry in keeping with changing employment patterns and the need for sectoral mobility.

4 Recognising that a scientific research career is a marathon, not a sprint, and those who have the ability to succeed may

not fit the stereotype of the 'ideal research worker' who can accumulate academic and social capital uninterrupted.

5 Changing funding regimes and employment practices to improve the security of employment in the higher education and research sectors, where longer fixed-term contracts, five years rather than three years, would make a significant difference to career prospects and planning and help to accommodate the pressures that accumulate with family formation.

6 Adopting a more inclusive understanding of the 'scientific research workforce' to include emerging roles in cognate fields that demand high levels of scientific knowledge and skills and cultivate awareness of relevant career options and pathways in the private sector and industry.

The research for the report was supported by an ARC Linkage Grant and copies are available on the LH Martin Institute website.

CHANGING THE WAY WE SEE SCIENCE

Liz Killen, a recent UNSW chemical engineering graduate with a passion for science outreach and communication, has won the 2016 Sir Robert Menzies Memorial Scholarship in Engineering, which she will use to complete a Masters of Science Communication degree at Imperial College London.



Sharon Bell

Lyn Yates

Lab-at-Rig® boosts rock analysis

A CSIRO-led innovation that enables fast automated analysis of rock materials directly from drill sites is being commercialised, opening the way for millions of dollars' worth of potential cost and time savings.

The Lab-at-Rig® technology that CSIRO has developed in partnership with Imdex and Olympus, under the Deep Exploration Technologies Cooperative Research Centre (DET CRC), enables the chemistry and mineralogy of rocks found within a drill hole to be analysed within minutes of drilling.

The Lab-at-Rig® system, fitted to a diamond drill rig and Imdex's AMC Solids Removal Unit, includes: a sample preparation unit that

collects solids from drill cuttings and dries them; Olympus X-ray fluorescence and X-ray diffraction sensors to provide chemistry and mineralogy of the sample respectively; and the ability to upload data to REFLEX's cloud-based platform where it can be analysed and provided back to the explorer.

This technology provides a great advantage over the current process which can take three months and often millions of dollars and involve setting up the drill sites, drilling, extracting, sampling and logging the drill cores, sending them to a lab for analysis, entering data into a database and finally providing information back to the company.

Lab-at-Rig® offers a one-hour cycle for the whole process, enabling rapid decision-making and cost savings.

"Lab-at-Rig® is an important breakthrough for the industry because of the potentially massive cost savings in drilling, exploration and overall mining operations," said CSIRO Lab-at-Rig® Futures Project Leader Dr Yulia Uvarova. The new technology features automated

WOMEN IN TSE

A chemical engineer, Liz spent her Honours year exploring how microscopic tubes could be used to stop bacteria growing in water pipes. She's now turning her attention to better understanding how we can engage our society in learning and talking about science and maths.

"I am passionate about increasing the science, technology, engineering and maths (STEM) literacy of Australian society, and uptake of students of STEM subjects at schools. While this master's title is science communication, the principles apply equally as well whether it's in sciences, such as physics and chemistry, or mathematics and technology. Understanding how to engage is key, which in turn can be applied to both the education and public engagement aspects of engineering and sciences."

Liz is no stranger to the importance of good communication for promoting STEM subjects. Throughout her senior high school years, university degree and work at ANSTO she worked as a science and maths tutor and with programs such as Scientists in Schools and the Aspire Ambassador program, which encourage students to attend university and study STEM courses.

The scholarship will cover college fees and provide funds for living expenses for the duration of her degree.



Liz Killen

DEAKIN CARBON FIBRE RESEARCHER AWARDED

Deakin University researcher Dr Nisa Salim has received a Victoria Fellowship, following an Endeavour Fellowship and the Australian Institute of Nuclear Science and Engineering's Gold Medal, both awarded during the past 18 months.

Dr Salim has worked as an Associate Research Fellow with Deakin's carbon fibre research facility, Carbon Nexus, since completing her PhD at the Institute for Frontier materials in 2013. She will use her two travel Fellowships to visit other world-leading carbon fibre industries and research facilities.

The Victoria Fellowships were established by the Victorian Government in 1998. Each year, up to 12 early career researchers receive travel grants of around \$18,000 each, to "encourage innovation and the commercial application of research".

In November, Dr Salim will use her Endeavour Fellowship for a six-month visit to Rice University, the University of Southern Mississippi and the University of Kentucky. The Victoria Fellowship will fund a further two-month

visit in 2016 to major automotive and aerospace industries in the US, to gain an understanding of industry requirements on low-cost and high-strength carbon fibres. Dr Salim will also visit Europe, spending time



Nisa Salim

with a major carbon-fibre spinning company and the RWTH Aachen University in Germany.

ENGINEERS MOVE ON GENDER BIAS

Engineers Australia's Women in Engineering has taken action to mitigate gender bias in engineering workplaces, launching the Action Plan for Mitigating Gender Bias.

"There is extensive research which highlights the importance of diversity in creating effective, innovative, creative teams and organisations," said Ms Nee Nee Ong, Chair of Engineers Australia's Women in Engineering committee. While we are seeing a greater understanding for the need of diversity, there is still a need for a cultural shift towards mitigating gender bias. Most of the time people do not realise they are inhibiting diversity. Engineers are human and as such, all possess some bias. With the understanding of bias and how to mitigate it, individuals and organisations are able to be more open to diversity.

"To this end, we developed this Action Plan for Mitigating Gender Bias, the third in a series of Industry Blueprints developed by the Women in Engineering National Committee in association with industry partners and gender diversity experts. This third Industry Blueprint works in conjunction with the two previous blueprints, which focused on the need for diversity, introducing women engineering groups within organisations, and providing effective workplaces to retain women in engineering."

The Action Plan for Mitigating Gender Bias is available on the EA website.

analysis of mineralogy and geochemistry of drill-hole cuttings direct from the drill site, while still offering the relevant sampling methods and current quality control processes used.

"If mining or exploration companies have real-time information about the mineralogy and chemistry in the drill-hole they can efficiently plan what to do next, whether that is to drill deeper, drill further holes, try elsewhere or stop.

"Ultimately, Lab-at-Rig® will provide improved decision-making and productivity for mineral resource operations," Dr Uvarova said.

"Our 'light bulb' moment was in 2011 when a group of DET CRC researchers was watching a diamond drilling operation near Adelaide and observed the fluid carrying the drill cuttings to the surface. They asked the question: 'What if we could analyse the cuttings separated from that fluid in real time?'"

Yulia Uvarova in a proof-of-concept study for Lab-at-Rig®.



Enhancing Australia's prosperity through technological innovation

The Australian Academy of Technological Sciences and Engineering (ATSE)

ATSE is made up of some of Australia's leading thinkers in technology and engineering. One of Australia's four Learned Academies, it's an eclectic group, drawn from academia, government, industry and research, with a single objective in mind – to apply technology in smart, strategic ways for our social, environmental and economic benefit.

To achieve that goal, ATSE has formed a variety of expert, independent forums for discussion and action – platforms to move debate and public policy on issues concerning Australia's future. These focus on energy, water, health, education, built environment and innovation – and the international collaboration necessary to ensure that Australia is abreast of world trends.

It's an open, transparent approach – one that government, industry and community leaders can trust for technology-led solutions to national and global challenges.

Each year, the Australian Government recognises the importance of the work we do by awarding the Academy an establishment grant to help with:

- Fostering research and scholarship in Australia's technological sciences and engineering;
- Providing and conducting administrative support, workshops, forums and similar events to enable the Academy and its Fellows to contribute on important national issues;
- Managing the development and execution of our programs; and
- Supporting relationships with international communities.

The Australian Academy of Technological Sciences and Engineering (ATSE)
1/1 Bowen Crescent
Melbourne Victoria 3004
Australia

+613/ (03) 9864 0900
info@atse.org.au
www.atse.org.au



ATSE IN ACTION

Alan Finkel is new Chief Scientist

ATSE President Dr Alan Finkel AO FTSE will resign from this role in December to take up a new appointment as Australia's Chief Scientist.

Dr Finkel, who also steps down as Chancellor of Monash University at the end of the year, has been ATSE's President for nearly three years, succeeding Professor Robin Batterham AO FREng FAA FTSE – himself a former Chief Scientist. He succeeds current Chief Scientist Professor Ian Chubb AC FTSE, who has served with distinction since May 2011. Professor Chubb's term concludes at the end of 2015.

Dr Finkel is an engineer, entrepreneur, publisher and philanthropist. He received his Bachelor of Engineering in 1976 and Doctorate in Electrical Engineering from Monash University in 1981, following which he served for two years as a neuroscience research fellow at the John Curtin School of Medical Research, Australian National University.

For 25 years Dr Finkel ran Axon Instruments, an American company he founded, that made electronic instruments used by pharmaceutical companies in the discovery of new medicines. He is well-known as publisher of Cosmos magazine, which promotes science awareness.

Dr Finkel has a passionate interest in education. He established the Australian Course in Advanced Neuroscience to provide advanced training to young scientists. He also established a secondary school science program named STELR, administered by ATSE, which is currently running in nearly 500 secondary schools around Australia.

Dr Finkel currently serves as the Chairman of the Australian Centre of Excellence for All-Sky Astrophysics, a research consortium that is preparing to analyse the data from the world's largest radio telescope, which will be built by the end of this decade.

ATSE has begun the process of choosing a new President to replace Dr Finkel.

Announcing the appointment, Prime Minister Malcolm Turnbull said Dr Finkel was a prominent engineer, respected neuroscientist, successful entrepreneur and philanthropist with a personal commitment to innovation and commercialisation.



Ian Chubb

ANNOUNCING THE APPOINTMENT, PRIME MINISTER MALCOLM TURNBULL SAID DR FINKEL WAS A PROMINENT ENGINEER, RESPECTED NEUROSCIENTIST, SUCCESSFUL ENTREPRENEUR AND PHILANTHROPIST WITH A PERSONAL COMMITMENT TO INNOVATION AND COMMERCIALISATION.

His experience in science and the commercial sector meant he was uniquely qualified to act as one of the government's key advisers on science and innovation, and on ways to translate "our great scientific research into tangible outcomes for Australians and our economy".

Industry, Innovation and Science Minister Christopher Pyne congratulated Dr Finkel, who was selected from a high-calibre field following an international search.

"Dr Finkel is renowned for his outstanding research, industrial and entrepreneurial achievements in Australia and overseas, his leadership and service in the university and education sector, the academies and national science bodies, and his experience in providing high-quality expert advice to government," Mr Pyne said.

"His will be a vital role in shaping Australia's economic future and leading our national conversation on science, innovation and commercialisation across the research, industry and education sectors and with the wider community."

The new Chief Scientist will provide independent advice to the government on science, innovation and commercialisation



Alan Finkel

and lift the profile of Australian scientific endeavour domestically and internationally.

Dr Finkel said he was thrilled with the opportunity to contribute to framing Australia's participation in the agile 21st century.

"My personal experience across research, business and STEM education will guide my ability to formulate relevant advice," Dr Finkel said. "We exist in a competitive international environment and to compete effectively, business needs science, science needs business, Australia needs both."

Mr Pyne also praised the Professor Chubb.

"Professor Ian Chubb has made an incredible contribution to science in Australia and we thank and commend him on his outstanding contribution as Australian Chief Scientist and also as an eminent university administrator and academic over the course of his distinguished career," Mr Pyne said.

Dr Finkel's appointment was welcomed broadly – including by the Opposition, the Greens, Professor Chubb, the Academy of Science, Universities Australia, Engineers Australia, CSIRO, Go8, Science and Technology Australia, the Clean Energy Council and the Australian Conservation Foundation.

ATSE IN ACTION

New leaders for ATSE Forums

Mining expert Ms Denise Goldsworthy FTSE has taken over as Chair of the Mineral Resources Forum, heading a new leadership team that includes Deputy Chairs Dr Paul Zulli FTSE, formerly of Blue Scope Steel, and Professor Jocelyn McPhie FTSE, from the University of Tasmania. Ms Goldsworthy was formerly Deputy Chair.

Dr John Williams FTSE, a member of the Wentworth Group of Concerned Scientists and former Deputy Chair of the Water Forum, is its new Chair, supported by two new Deputy Chairs, Professor Craig Simmons FTSE, who leads the National Centre for Groundwater Research and Training at Flinders University, and the Hon Karlene Maywald FTSE, former Chair of the National Water Commission.

Professor Doreen Thomas FTSE, from the University of Melbourne, is the new Chair of the Education Forum, supported by Professor Ian Cameron FTSE, from the University of Queensland, who continues as Deputy Chair, and Professor Barry Fraser FTSE, of Curtin University, who joins the leadership group.

Professor Karen Reynolds FTSE, from Flinders University, continues as Chair of the



Denise Goldsworthy



George Morstyn

Health Technology Forum, supported by Deputy Chair Professor Greg Tegart AM FTSE and new Deputy Chair, Dr George Morstyn FTSE.

These changes follow the ATSE Board approving changes to the Topic Forum Guidelines in August to allow for a staggered process to rotate leadership positions in ATSE's eight Topic Forums. This will help foster leadership stability for the Forums by ensuring that only half of the Forum leaders change in a given year. The other Forums (Industry and Innovation, Agriculture, Energy and Infrastructure) will elect new leaders in 2016.

The Board acknowledges the work of the outgoing Forum leaders: Health Technology



Doreen Thomas



Jocelyn McPhie

– Professor Neil Foster FTSE (Deputy Chair); Mineral Resources – Professor Alison Ord FTSE (Chair) and Professor Veena Sahajwalla FTSE (Deputy Chair); Water – Mr Ken Matthews FTSE (Chair) and Professor Ana Deletic FTSE (Deputy Chair); and Education – Professor Robin King FTSE (chair) and Professor Judy Raper FTSE (Deputy Chair).

RETHINKING AUSTRALIAN URBAN TRANSPORT

Cars and trucks are choking Australian cities and costing billions of dollars in traffic congestion, harming human health and adding to greenhouse gas emissions, according to a new report from the Australian Council of Learned Academies (ACOLA).

The report, *Delivering Sustainable Urban Mobility*, warns that Australia is heading down the wrong path and a new approach to urban transport is needed – one that prioritises people rather than any particular mode of transport. The report finds that the cost of urban congestion in our capital cities will increase four-fold in two decades, reaching \$53.3 billion by 2031, unless there is a change of direction.

The report also highlights the infrastructure required for cars – both on the move and parked – with the average car parked at home 80 per cent of the time, parked elsewhere for 16 per cent and on the road only four per cent of the time.

Australia's Chief Scientist Professor Ian Chubb AC FTSE delivered the opening speech at a Canberra event where Minister for Cities and the Built Environment Jamie Briggs launched the report.

"Australian cities are under pressure and we need to find a way of putting people first in urban transport and planning," Professor Chubb said. "New technology can be part of the solution but what we need is

long-term, nimble policy development that incorporates the benefits of science and innovation as well as many other disciplines."

The report finds that city planning needs to take a three-pronged strategic approach, including finding ways to reduce or avoid travel, shifting to more environmentally friendly transport and improving the energy efficiency of transport.

The report also says urban areas need to change from having a dense CBD with sprawling suburbs to polycentric cities with 'nodes', which will bring people closer to places of work and recreation.

Dr Bruce Godfrey FTSE, Chair of the report's Expert Working Group, said investment in urban mobility was urgent, especially with the growing transport demands of Australia's ageing population.

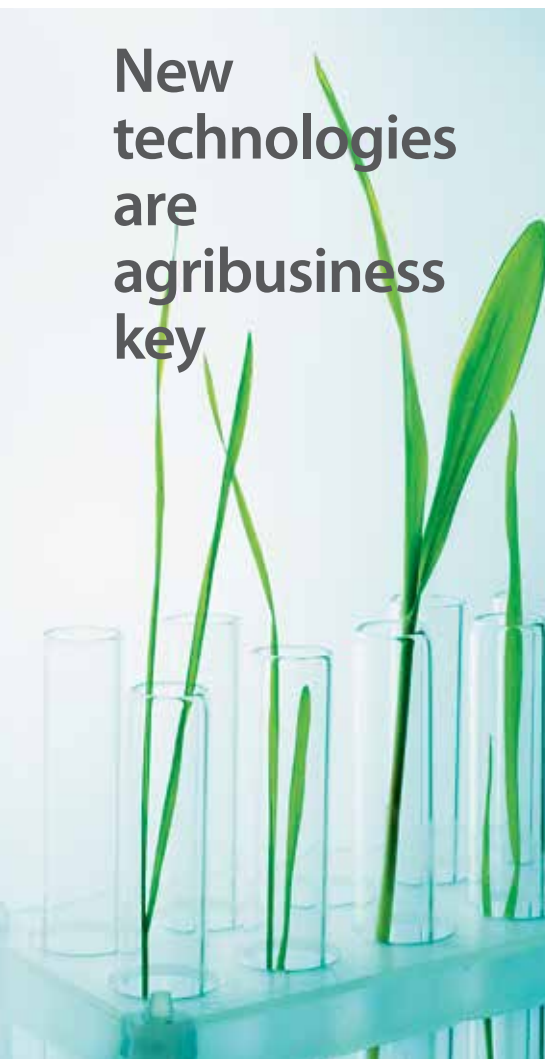
"The lack of investment in transport over the past 40 years means Australia has a major infrastructure deficit which stood at \$100 billion in 2014 and is forecast to grow to \$350 billion by 2025," Dr Godfrey said.

The report makes 26 key findings and says there needs to be a focus on accessibility, technology and careful planning to enhance sustainable transport solutions.

THE REPORT IS AVAILABLE AT WWW.ACOLA.ORG.AU

ATSE IN ACTION

New technologies are agribusiness key



Bringing technology to food production.

Australia's agriculture and food sectors play a crucial role in the national economy, particularly through exports and in rural and regional development and employment.

Seizing export opportunities for high-quality agrifood products over the coming decades, as well as maintaining the strength of our domestic market, will require a range of new technologies to underpin continued productivity growth and international competitiveness.

These are key points made in ATSE's submission to the House of Representatives Standing Committee on Agriculture and Industry inquiry into Agricultural Innovation.

The submission noted that Australian agriculture has a long history of innovation – driving its resilience and adaptability – and new technologies, including new practices, and their rapid adoption and adaption to local conditions had been central to historical

increases in productivity and profitability in Australia's agriculture and food sectors.

The best Australian farmers were operating increasingly close to the upper limit of currently known potential yields and technical efficiency, it said.

"Further growth in productivity for these farmers will increasingly require step-changes in production technology and practices. Fundamental research, and emerging technologies that arise from this research such as gene technology, robotic systems and distributed sensor networks, make significant contributions to generating these needed step-changes.

"Notwithstanding the efficiency of our best farmers, there continues to be a long tail of farmers unable to access or utilise the knowledge and capital required to match these outputs."

Agricultural value chains were becoming more integrated and connected, facilitated by emerging information and communication technologies allowing real-time demand analysis and management, the submission said.

"These are enabling changes in management practices, which are equally important in stimulating innovation and improving efficiency. There are huge opportunities to be captured through the use of ICT to prove the provenance of high-value, high-quality produce.

"Australia should seek to use scientific and technological advances to target high-value and high-margin produce with a global reputation for food safety, not aim to be the most cost efficient producers of cheap food.

"In concert with increased productivity, emerging technologies will also be fundamental for improving the sustainability and natural resource management practices of Australian agriculture, which are fundamental to the future competitiveness and ongoing operation of this sector.

ATSE considers that the competitiveness of Australia's agriculture and food sectors relies, more than ever, on strong and stable support for science, research and development, and its translation to economic advantage through the adoption of new technologies and practices.

"Investment in the fundamental research which enables these technologies must be recognised as the key to future growth in Australia's agricultural sector.

"Technology also has an important role in social practice and business model innovation, as well as underpinning community health and well-being, all of which contribute to the sustainability and profitability of the agricultural sector."

■ *ATSE will host Agribusiness 2030: 2016 ATSE National Technology Challenges Dialogue in Sydney next June – a dialogue exploring opportunities and challenges for Australian agribusiness to 2030 through the prism of technological innovation. The dialogue will cover applications of technology in agriculture including robotics, digital technologies and data analytics, as well as biotechnology and molecular genetics.*

NAME CHANGE AND GRAPHIC UPGRADE FOR ATSE

THE AUSTRALIAN ACADEMY OF TECHNOLOGY AND ENGINEERING is the new business name for the Academy. Launched in November, this new, simpler name will be used for all operational and promotional purposes.

The Academy's acronym ATSE will be unchanged, as will its nearly 30-year-old logo.

The **BUSINESS NAME** is demonstrated in a new graphic device now being used on ATSE documents and the website.

Fellows will continue to be recognised by the established postnominal – FTSE.

The Academy's formal full **COMPANY NAME** (The Australian Academy of Technological Sciences and Engineering) will continue to be used on formal and contractual documents, but Fellows of the Academy have voted for popular use of the business name in other cases.

The Australian Academy of Technology and Engineering will progressively appear on the Academy's website and most printed material.

"Our newly adopted business name will give clarity to the role of our Academy," said Academy President Dr Alan Finkel AO FTSE. "It will ease pronunciation difficulties and errors by others in their references to the Academy and help us to promote science, research and innovation to the wider community."

ATSE IN ACTION

Collaboration trumps complexity in additive manufacturing



Eric Klemp addresses the workshop.

National and international expert presenters at a recent Adelaide workshop (Transforming South Australia's Manufacturing, the third organised by ATSE and the SA Government) agreed that SMEs adopting additive manufacturing (AM) must have economical access to the necessary facilities and expertise to conduct the necessary iterative design and process experimentation and testing.

All of the models they presented incorporated a centre of AM capital facilities, and operational and research expertise available to various manufacturers on a fee-for-service or annual subscription basis.

It was apparent there are three key requirements for such a centre:

- 1** It needs a relatively broad range of AM materials, process and equipment capabilities.
 - 2** It requires ready access to the sophisticated research and measurement facilities and expertise demanded by the iterative optimisation process.
 - 3** It should be readily accessible to the manufacturers it seeks to serve.
- Such a centre – taking South Australia as an example – would need to:
- partner with, and be the local gateway and facilitator of access for, manufacturers to AM capability, rather than duplicating existing equipment and expertise;
 - invest in the most needed AM processes and equipment not held by partners, then provide them with reciprocal access; and
 - enable and encourage universities to provide access to their research, measurement and analysis capability, materials science, nanotechnology and other skills vital to the iterative optimisation process.

The fees for service and/or annual subscriptions for manufacturers using the centre would fund research projects for the universities involving materials and process optimization, and universities would have the right to publish generic outcomes from research projects under guidelines agreed

with industry partners of the centre.

Government subsidies would be required to establish such a centre but, over time, as AM became established in industry, demand for the services of the centre would grow and government subsidy could progressively diminish, they said.

Federal and state funds were rightly available for projects to mitigate the very serious impacts of the loss of South Australia's automotive industry and vital supply chain. Use of a portion of these funds to establish a generic advanced manufacturing capability in the state – of potential value to the majority of existing manufacturers – would seem to be a wise investment.

The model presented at the Adelaide workshop by keynote speaker Dr Eric Klemp of the Direct Manufacturing Research Centre (DMRC) at Paderborn University in Germany attracted interest. He said that suppliers of AM equipment and raw materials were invited to be industry partners of DMRC. All research results from the projects they support that were generic and 'pre-competitive' were available to all partners. In this way a pool of AM know-how was generated, including how to optimise performance from a particular AM machine using a particular material.

He suggested the capital cost of establishing an SA centre could be mitigated this way and advised that existing partners of DMRC would give serious consideration to a request by a South Australian additive manufacturing centre to be a partner of DMRC.

ADDITIVE MANUFACTURING

Additive manufacturing (AM) is a generic advanced manufacturing technology essential to any diverse complex manufacturing economy. Successful adoption of AM is itself a complex undertaking and, for other than very large businesses, prohibitively expensive and risky if attempted in-house and alone.

Manufacturing in Australia comprises a few relatively large organisations and many SMEs. Economy-wide adoption of AM requires models of collaboration, initially government-subsidised, between governments, industry and research institutions. Such collaboration can provide access for individual businesses to AM knowledge and physical capability at reasonable cost.

AM is applicable to the manufacture of complex tooling, components and finished products in many materials including various metals and plastics. It may be utilised for modelling, prototyping, short runs, mass customisation and, in specific circumstances, long production runs. It is an essential generic technology for a diverse

manufacturing economy – valuable to small, medium and large manufacturers across virtually all manufacturing sectors.

Strategic thinking about the end-use objective opens new design options that may be uniquely implemented using AM. 'Can this part be made more economically by AM?' is usually the wrong question. The right one is 'What do I need to do, and why?'

A first-principles design approach and a technology that can implement highly complex designs leads to the interrelated evaluation of various AM materials, manufacturing processes, layering dimensions and machinery brands and models. Optimisation of the outcome is an iterative process involving several variables.

All of this points to a collaboration model between governments, research institutions and businesses – an important step in reversing the culture which sees Australia near last among OECD nations in collaboration focused on innovation.

– DR MIKE HEARD FTSE

ATSE IN ACTION

STEM the theme at Parliament briefing

Leanna Read addresses the event.

'Can STEM Save South Australia?' was the topic of a Science Meets Parliament SA event in October, supported by ATSE with SA Chief Scientist Dr Leanna Read FTSE as a key presenter.

It was the first in a new series of Science Meets Parliament SA events planned for 2015–16, where the format is a brief presentation followed by Members of Parliament meeting with top SA scientists in

a 'speed dating' arrangement. The events are organised by ATSE, the Academy of Science (AAS), RiAus, and the three SA universities, by agreement with the Speaker of the SA House of Assembly, and involving Leesa Vlahos MP and Steven Griffiths MP, representing the government and opposition parties.

Dr Read and Professor Martin Westwell of Flinders University combined in a presentation outlining the challenges in increasing the uptake of senior-secondary

and post-school STEM subjects by SA students. They described a new STEM strategy being developed by the SA Government that aims to improve students' STEM education in line with international innovation and good practice.

The 17 MPs and senior staff attending then participated in a 'speed-dating' sequence of meetings with 16 key STEM stakeholders, including SA university Deans, secondary school Principals, industry organisation leaders and Fellows.

Those attending agreed the format provided a unique setting for MPs and scientists to meet and establish useful links for future engagement.

A follow-up note from Ms Vlahos, Parliamentary Secretary to the Minister for Health, was illustrative.

"I just wanted to thank the members of the Science Meets Parliament Advisory Panel. You've been magnificent in bringing last night's event together and re-igniting the light of science in our parliament.

"Personally, I thought the night was a great success and a unique opportunity for our Parliamentarians to meet science stakeholders and thought leaders. It was a thought-provoking event that stimulated policy ideas and forged new connections.

"I've only had positive feedback to date and interest in future events from my colleagues. I look forward to the discussion of the next round of events in 2016 shortly and keeping the flame alight."

KEY EDUCATORS ADDRESS STEM TEACHING

Some of Australia's key educational thinkers attended an ATSE workshop in Canberra in November to explore what makes an inspirational STEM (science, technology, engineering and maths) teacher.

The workshop focused on the importance of initial teacher training and the role of teacher certification bodies. It noted that many factors had contributed to the falling interest in STEM subjects by high school students over the past few decades, but Australia's future economic prosperity would be affected unless the decline was reversed and an increasing number of high school graduates chose STEM education pathways and careers.

The speakers, led by Australia's Chief Scientist, Professor Ian Chubb AC FTSE, covered the importance of STEM to Australia's economy, varieties of initial teacher training programs, regulation and certification frameworks, and continuing professional development.

Other speakers included ATSE President, Dr Alan Finkel AO FTSE

and Emeritus Professor Robin King FTSE, former Chair, ATSE Education Forum.

The workshop was organised by Professor John Richards AM FTSE and attended by ATSE CEO Dr Margaret Hartley FTSE, STELR Manager Ms Pennie Stoyles and Education Forum executive Mr Dan Raftopoulos.



(From left) John Richards, Robin King, Pennie Stoyles, Ian Chubb and Alan Finkel.

ATSE IN ACTION

Bataan workshop a new milestone

A recent workshop at Mariveles National High School-Cabcaben in Bataan, Philippines – conducted by STELR Manager Pennie Stoyles – marked a major milestone in the six-year relationship between sponsor Orica and ATSE's STELR Project.

A renewed partnership forged between Orica and ATSE last year is focused on consolidating STELR in Australian schools, as well as expanding the program into Asia-Pacific, targeting countries and communities where Orica and its customers operate.

Orica is the founding and major sponsor of STELR (Science and Technology Education Leveraging Relevance) and has been involved since 2009. STELR aims to engage students in science, technology, mathematics and engineering (STEM) through a hands-on renewable energy module that now reaches more than 35,000 students each year.

"Working with the Department of Education in the Philippines, STELR identified three schools close to the Orica Limay site to trial the program with a view to bringing other schools on board over time," said Orica's John Philip de Jesus, who coordinated the workshop.

"The Government demonstrated their support by sending a representative from Manila as well as the division department head, which was very much appreciated by Orica and STELR."

India was also represented at the workshop, with the school local to Orica's Gomia site – Pitts Modern School – in attendance with support from Orica.

"The objective in the first year of this



Pennie Stoyles (front, centre) at the Bataan workshop.

renewed partnership with STELR was for schools in communities where we operate in Asia to be introduced to the program. So to have teachers at four schools related to Orica sites in two countries trained and equipped at this stage is a major achievement," Orica's Global Community Manager Natalie Bain said.

The link was extended at a subsequent seminar near Jakarta, Indonesia, with teachers from two high schools near Orica's Bontang site in East Kalimantan attending a major inter-country seminar which included STELR training.

STELR has been working with the SEAMEO QITEP (South East Asia Ministers of

Education Organisation, Quality Improvement in Teaching and Education Personnel), which is hosted by the Ministry of National Education, Indonesia, for a number of years to align STELR to the local curriculum.

"While offering the program to schools local to the Bontang site has been on our radar for some years, this is the first time we have been able to involve Bontang area schools directly with the Indonesian Government's blessing," Ms Bain said.

The STELR Project is set to expand further in December with Orica bringing the program to schools in WA's Pilbara region.

RACING'S JULIUS TOTALISATOR RECOGNISED BY ENGINEERS

The world's first operational computer – the Australian Julius Totalisator – has been recognised with an Engineering Heritage International Marker in a ceremony at the Brisbane Racing Club, where the most complete machine is housed.

"For a country that stops for a horse race, it is amazing how little is known of the rich Australian history that exists in the totalisator industry," said Mr Chris Warnock, President of Engineers Australia's Queensland Division.

"Invented in 1913, the Julius Totalisator is the earliest known on-line real-time data and computation system. The electromechanical machine simultaneously receives numbers of win and place bets from multiple points on the racecourse, records bets, displays win and place odds for

each runner as betting proceeds and issues a ticket for each bet.

"Foundation member and 1925 President of Engineers Australia, Sir George Julius, first invented the Totalisator as a system to recording votes in order to negate fraud. However Government was not interested in the invention, so he set his sights on the racing industry," said Mr Warnock.

Brisbane Racing Club Chairman Mr Neville Bell said the Julius Totalisator revolutionised the racing industry.

"With the Julius Totalisator, racing clubs around the world were now able to cater for larger crowds, improve security and turnover, reduce operational costs, and improve public display of betting information making it more attractive to punters. The Julius Totalisator played a large part in racing becoming a major industry."

ATSE IN ACTION

Hugh Bradlow looks to the future

Telstra's Chief Scientist and ATSE Director Professor Hugh Bradlow FTSE addressed a record crowd of 100 Fellows and guests at the third talk in ATSE NSW Division's infrastructure luncheon series in Sydney in October.

Exponential advances in technology, leading to fast-paced disruption and overturning of traditional business models was timely, he said, echoing the vision of the Prime Minister of "a nation that is agile, that is innovative, that is creative".

Addressing 'The Digital Revolution', he described a world driven by rapid advances in cloud-based computing and storage, crowd sourcing, robotics and immersive communications, which would have profound implications for society. He described how the next wave of emerging technology will be about our relationships – with other people (mediated by technology), with technology and with the real world.

High-speed, media-centric broadband would transform work, as immersive communications solutions enabled people to work from anywhere. Telehealth would be revolutionised by wearable interfaces and sensor that sent vital data to health professionals. Driverless cars, smart infrastructure and true artificial intelligence were just around the corner, he said – in a world where everything that could be measured would be measured, and that things that could be connected would be connected.

He noted that computers could now absorb and process the 250,000 medical journal articles published each year, leading to expertise and knowledge much greater than any human medical practitioner and suggested healthcare would evolve to a focus on wellness and be proactive rather than reactive.

Professor Bradlow predicted that transport would be transformed, with driverless cars desirable because they were safer and would make more efficient use of our roads. Commuters would order their transport as needed – a driverless car would pick them up and deliver then smoothly and safely to their destination. Driverless cars



Hugh Bradlow talks the future.

My vision for 2030 is that it will be illegal for people to touch the steering wheels of their cars. Every house in Australia will be self-sufficient in energy and can be off-grid.

– Hugh Bradlow

could potentially save 1000 lives and 45,000 hospitalisation injuries each year, he said.

He said nearly half of all existing jobs would be affected by computerisation. Jobs involving driving would be hardest hit, but there could be a 20 to 50 per cent reduction in the workforce. STEM would be a new literacy, underpinned by the need to invent and commercialise the new technologies, manage risk and deal with the inevitable bugs and problems that arose.

Government actions could help nudge technologies and society in the right direction, he said. "Governments must embrace uncertainty, not pander to vested interests that resist change. Ultimately the economics will decide."

NEW TECHNOLOGIES NEED GRASPING

New technologies offer unprecedented opportunities for economic growth and community wellbeing but only if Australians are ready to adapt and learn, according to a new report from the Australian Council of Learned Academies (ACOLA).

Technology and Australia's Future explores what it takes to win in the technology race and manage the human costs of disruptive technology. Australia's Chief Scientist Professor Ian Chubb AC FTSE, who launched the report in Canberra, said decisions made today would impact generations of Australians.

"We need to be agile as a nation and we need to decide whether we want to equip ourselves with the skills and knowledge to forge our future or allow others to impose a future on us," Professor Chubb said.

"In reality, of course, there is no choice about whether – the only choice is about how."

The report draws on the expertise of Australia's four Learned Academies and considers how new technologies arise, how their impacts occur, to what extent they can be predicted, what technologies mean to people and how society's interaction with technology influences behaviour.

Technology and Australia's Future makes 18 major findings, including the disruptive role that new information and communication technologies, especially data analytics, can have on existing business – from transportation to mining, healthcare and education.

Other findings focus on the skills that Australia needs to invent and harness new technologies and develop competitive strengths that outlive the resources boom.

The report (SAF08 in the Securing Australia's Future program) was led by an Expert Working Group, co-chaired by Professor Rob Evans FAA FTSE and including Professor Ron Johnston FTSE and Emeritus Professor John O'Callaghan FTSE.

THE REPORT IS AVAILABLE AT
WWW.ACOLA.ORG.AU

NEWS

The Infinity Swing in action.

CSIRO gets into the 'swing' on energy

CSIRO took an eight-person, energy-generating swing to two of the nation's most prominent locations in November to kick-start a conversation about energy sustainability in Australia.

Thousands of Australians had the chance to hop on the Infinity Swing and see their movements turned into energy to power a stunning light and sound installation, which was placed in Customs House Square in Sydney and Federation Square in Melbourne.

Participants saw their swing power a light above the seat and heard an original ambient music composition that changed with the speed and strength of their swinging. When all eight seats were in motion the word 'INFINITY' was illuminated.

CSIRO research director Dr Glenn Platt said the Infinity Swing aimed to spark a conversation about how energy could be sustainable and affordable for every Australian now and into the future. "Energy isn't frivolous and it isn't free, so the challenge for Australia is how to keep energy affordable and available while protecting our planet," he said.

Energy sustainability is one of the greatest challenges facing the world. Cost, electricity demand, emergence of new technologies and environmental imperatives will all have an impact on how our energy is sourced in the future.

"Getting the energy mix right is an opportunity for Australia," CSIRO Executive Director Dr Alex Wonhas said. "The CSIRO Infinity

Swing is about starting this discussion and showing the community how science and technology has a key role to play in developing smart energy solutions."

AUSTRALIA WORLD LEADER IN ROOFTOP SOLAR

Australia leads the world in rooftop solar photovoltaic uptake on a per capita basis, new analysis by the energy industry has found.

The analysis, in *Renewable Energy in Australia – How do we really compare?*, also shows that South Australia and Tasmania have some of the highest per capita wind generation in the world, alongside leading US states such as Iowa and Texas.

"Australia has not been a laggard on renewable generation, with this analysis clearly showing that we have made progress in terms of sourcing energy from wind and solar and this can be expected to continue," the Energy Supply Association of Australia's Chief Executive, Matthew Warren, said.

"On the solar front, while we are ranked sixth in the world for total solar per capita, which covers solar photovoltaic and solar thermal, when it comes to solar on the roofs of our homes we are leading the way."

More than one in seven households (15 per cent) now have rooftop solar PV systems. SA and Queensland lead the way, with 25 per cent and 24 per cent of households sporting rooftop solar respectively, and some suburbs in Adelaide and Brisbane have more than 50 per cent of their rooftops covered in solar panels.

"We have double the penetration rates of the next best country, Belgium, and more than three times the level in Germany, which is considered a leader in solar generation," Mr Warren said.

Australia is ranked 11th in the world for wind per capita, ahead of China and France, while in a regional assessment SA ranked second and Tasmania third. For wind and solar combined Australia is ranked eighth in the world, while at a jurisdictional level SA is second, behind Iowa. About 39 per cent of total SA energy generation is supplied by wind and sun.

STUDENTS BUILD ELECTRIC JET SKI

A team of students from The University of Western Australia has built Australia's first electric personal watercraft, commonly referred to as a jet ski. The Renewable Energy Vehicle Project (REV) prototype is much quieter than a petrol-powered jet ski and produces no emissions.

The water-cooled three-phase motor was designed and built by Perth company Submersible Motor Engineering, while engineering support was provided by Perth's Total Marine Technology.

The prototype carries about eight kilowatt-hours of energy in lithium-ion batteries, which gives it a drive time of about 30 minutes. More batteries can be fitted, and a future DC charging system could bring the recharging time down to about seven minutes.

Professor Thomas Braunl said the innovation combined the fun of riding a jet ski with the environmental friendliness of an electric vehicle.

"We eliminated the two negative aspects of petrol-powered models: excessive noise and heavy pollution of water and air," he said. "We have worked for more than two years on this project, and the major challenge was to make everything water-tight and safe, from batteries, to switches and motor controllers."

The electric watercraft has the potential to be popular with eco-tourism operators on lakes where petrol-powered boats are banned.



The electric jet ski in action.



Cattle on Glenflorrie Station.

Managing our cattle stations from space

A new Australian cattle technology that combines pasture monitoring from space with automatic weighing and drafting of cattle is being presented to the pastoral industry.

The groundbreaking Precision Pastoral Management Systems (PPMS) package developed by the Cooperative Research Centre for Remote Economic Participation (CRC-REP) is claimed to save labour, time and money, improve livestock productivity, increase sustainability and protect vegetation and wildlife in Australia's – and potentially the world's – arid rangelands and savannahs.

The PPMS is an online cloud-based software system that automatically draws on data from multiple providers and is customised

to an individual's station. In addition the PPMS analyses this data and presents it in a format that allow beef producers to quickly grasp the major trends in performance of their cattle and pasture. It incorporates remote livestock management (automated weighing and drafting), telemetry, satellite land and pasture observation, water management and cloud-based analytics into a single package.

It was demonstrated at an October field day at Glenflorrie Station in Western Australia's Pilbara region and field days are planned in the Northern Territory and Queensland in 2016.

"We are really excited at the potential benefits that this R&D project looks to deliver to the pastoral industry," said Mr Murray Grey of Glenflorrie Station.

"The ability to monitor cattle liveweights in real time on such a broad scale while simultaneously monitoring feed on offer and make critical decisions before it impacts on the bottom line, is a game-changer in my opinion," he said.

"PPMS is an integrated package of tools and technologies that automates the management of livestock remotely, musters and drafts animals automatically, reports on pasture condition and availability," said research leader Ms Sally Leigo, of the Northern Territory Department of Primary Industry and Fisheries (NT DPIF).

"PPMS is a game-changer for rangelands grazing because, for the first time, it puts hard data on cattle liveweights and feed availability in the hands of the manager, while reducing costs, lifting earnings and sustaining the pastoral landscape."

The technology was developed in Australia, with trials over three years on five commercial Australian cattle stations.

The research team and funding involved NT DPIF, CRC-REP, Precision Pastoral Pty Ltd and the Queensland Department of Agriculture and Forestry.

PHOTO: DAMEN/DMS MARITIME/KNUD E HANSEN A/S COURTESY AUSTRALIAN ANTARCTIC DIVISION



An impression of the new vessel in action.

NEW ICEBREAKER TO REPLACE AURORA

The Australian Government has previewed Australia's new icebreaker, showcasing a modern, sophisticated ship that will offer scientists unprecedented and extended access to the Southern Ocean and Antarctica.

The vessel, expected to be commissioned in October 2019, will form the centrepiece of Australia's Antarctic presence and influence the shape of Australia's Antarctic program for decades to come.

The new, custom-built icebreaker will be faster, larger, stronger and offer increased endurance compared with the ageing Aurora Australis, which has been battling the stormy Southern Ocean since 1989. The new ship provides a modern platform for marine science research in both sea ice and open water.

A multi-beam bathymetric echo sounder will enable seafloor mapping, while portable

and flexible science laboratories will offer scientists space to conduct cutting-edge research.

The procurement represents the single biggest investment in the history of Australia's Antarctic program, with additional funding committed by the Australian Government to modernise shore-side infrastructure and equipment at Australia's Antarctic stations and in Hobart, where it will be based.

Australian company DMS Maritime Pty Ltd has been selected as preferred tenderer to undertake the ship design and building process, and will then operate and maintain the icebreaker. The Department of the Environment and DMS Maritime Pty Ltd have commenced formal contract negotiations. The icebreaker is expected to be built by Damen Shipyards, of Holland, a global shipbuilder that has produced a broad range of vessels including scientific, hydrographic, naval and ice class ships.

NEWS



How the new Inner Harbour ferries will look.

Six new ferries for Sydney Harbour

Sydney's ferry network will be boosted by the arrival over the next two years of six new ferries, built in Hobart by Incat, to operate on Sydney's Inner Harbour. They will service commuter and tourist travel on the inner harbour routes from Watsons Bay in Sydney's east to Cockatoo Island in the west, stopping at the new Barangaroo wharf.

The new 35-metre, 400-passenger vessels will have greater capacity than the current fleet. The interior will be more spacious with inside seating, and outdoor viewing areas, a large walk-around deck and additional features for passengers – including Wi-Fi access, real-time journey information and charging stations for electronic devices – to be included. Visitors to Hobart will be familiar with the Incat-built 34-metre Mona Roma MR1 that transports visitors between Hobart city and MONA (Museum of Old and New Art).

Incat won the order in a competitive tender process. It has recently completed two fast ferries for London operator Thames Clippers, and is building four fast ferries, two 24-metre and two 33-metre boats for Sydney company Manly Fast Ferry.

Incat, renowned internationally for its vessel design and construction, has built more than 70 vessels, with ships in service around the world. With three vehicle ferries delivered since 2013 to South America, Europe and the Far East, a fast crew boat to Azerbaijan and two passenger ferries to the UK Incat is the world's largest fast ferry builder.

MCITY DESIGNED FOR DRIVERLESS CARS

The University of Michigan (UM) in the US state of Michigan has opened Mcity, the world's first controlled environment specifically designed to test the potential of connected and automated vehicle technologies that may lead the way to mass-market driverless cars.

Mcity was designed and developed by UM's Mobility Transformation Center (MTC) in partnership with the Michigan Department of Transportation (MDOT).

Mcity is a 13-hectare simulated urban and suburban environment that includes a network of roads with intersections, traffic signs and signals, streetlights, building facades, footpaths and construction obstacles. It is designed to support rigorous, repeatable testing of new technologies before they are tried out on public streets and highways.

Mcity will allow researchers to simulate the environments where connected and automated vehicles will be most challenged. Even seemingly minor details a vehicle might encounter in urban and suburban settings have been incorporated into Mcity, such as road signs defaced by graffiti and faded lane markings.

The types of technologies that will be tested at the facility include connected technologies – vehicles talking to other vehicles or to the infrastructure, commonly known as V2V or V2I – and various levels of automation all the way up to fully autonomous, or driverless vehicles.

MTC is a public-private partnership between industry, government and academia. MTC brings together faculty and students from across UM to explore a web of engineering, business, law, urban planning,

policy and social challenges. About \$10 million has been invested in the test facility, with funding coming from UM and MDOT. Other key participants include Ford, General Motors, Honda, Nissan and Toyota.

NT'S LAST LEVEL CROSSING GONE

A new rail overpass 12 kilometres south of Alice Springs on the Stuart Highway removes the last remaining level crossing in the Northern Territory's National Highway network.

NT Chief Minister Adam Giles said the works included construction of a 40-metre-long bridge and reconstruction of the 700-metre road approaches on either side of the bridge line. He said about 2000 vehicles a day passed over the crossing, with traffic movements between Alice Springs and the Joint Defence Facility at Pine Gap, the Alice Springs Prison and the industrial area at Brewer estate, providing significant commuter demands on the route.

INCAT FERRY FOR DENMARK

Australian shipbuilder Incat has secured a contract for the construction, delivery and long-term charter of a large fast vehicle ferry for Danish company Mols-Linien A/S. This will be Tasmanian-based Incat's fourth vessel in the Mols Linien fleet. Called KatExpress 3, the fast ferry will carry up to 1000 tonnes of cargo, equivalent to up to 1000 passengers and 417 cars. Delivery of the wave-piercing catamaran is scheduled for the first quarter of 2017. KatExpress 3 is likely to replace the company's smallest ferry Max Mols, an Incat 91-metre vessel built in 1997.

Print me a house

An Italian collective called the World's Advanced Saving Project (WASP) has unveiled BigDelta, which it says is the world's biggest 3D printer which can create budget-friendly mud huts in one continuous printing session.

The 12-metre-high machine was unveiled in Italy by its makers who say their 3D printer may provide a solution to housing shortages for the world's poor, inspired by traditional clay house architecture and construction methods. BigDelta can make houses out of mud, clay, water, dirt and natural fibres, avoiding the expense and environmental consequences of cement, WASP says, noting that clay houses require little maintenance and can last for years with thin applications of new clay over their external surfaces every five years or so.

BigDelta operates much like a conventional filament-based 3D printer but on a much larger scale. WASP says its giant frame is lightweight and easy to assemble and transport. The frame supports the giant printing nozzle that extrudes the walls and ceilings of entire houses in a circular motion, layer on layer, from the ground up.



BigDelta



(Above) Scale models of the mud huts.



(Left) The printer nozzle that extrudes construction mud.

EPITAXIAL IS THE NEW WORD AT UNSW

The University of NSW is hosting a new \$3.3 million industry-focused laboratory for advanced materials.

The Epitaxial Growth Laboratory is the latest of eight specialist Australian National Fabrication Facility (ANFF) research nodes funded by the Australian Government through the National Collaborative Research Infrastructure Strategy (NCRIS).

It provides researchers with access to state-of-the-art micro- and nano-fabrication facilities, with a strong focus on supporting Australian industry.

The new laboratory houses three tools that use an advanced crystal growth technique known as molecular beam epitaxy (MBE). This allows for the fabrication of materials one atomic layer at a time. MBE techniques enable new technologies by allowing researchers to enhance the performance of existing materials, and to create new materials not possible by any other method.

"The UNSW Epitaxial Growth Laboratory provides researchers and industry with a one-of-a-kind capability in advanced materials fabrication for devices that have the potential to revolutionise sectors such as telecommunications, health, and energy," said Education and Training Minister Senator Simon Birmingham, who opened laboratory.

"The ANFF brings together around 20 Australian universities and CSIRO to

support high-quality research that has the potential to deliver economic growth and innovation," Senator Birmingham said.

A number of Australia's leading research scientists and representatives from industry were on hand to help launch the new laboratory, including the NSW Chief Scientist and Engineer, Professor Mary O'Kane FTSE, and the CEO of ANFF Ltd, Mrs Rosie Hicks.

"This new laboratory will allow researchers to custom design completely new materials, with properties that cannot be found in nature," said Professor Andrew Dzurak, who is the ANFF director at UNSW.

"The new epitaxial growth facilities, combined with our existing ANFF laboratories, will enable Australia's researchers to address key national and global challenges, for the wellbeing of everyone on our planet," Professor Dzurak said.

"The research to be supported includes new solar energy technologies, advanced quantum devices, and new sensors for medicine and the environment."



PHOTO: GRANT TURNER/MEDIAKOO

UNSW's Dr Stephen Bremner (left) showing Education Minister Simon Birmingham one of the molecular beam epitaxy (MBE) tools in the new laboratory.

NEWS

Army chooses Thales Hawkei



The Australian Government will purchase 1100 Australian-built Hawkei protected vehicles and more than 1000 trailers to strengthen Australia's defence force. Under a \$1.3 billion agreement, the vehicles will be manufactured by Thales Australia in Bendigo, creating 170 jobs there and another 60 jobs elsewhere in Victoria.

Hawkei in operation.

Soldiers on operations will benefit from the Hawkei's increased protection and mobility. The

powerful 4x4 vehicle can be adapted for different missions and enable troops to operate in high-risk areas. It is the only protected mobility vehicle in the ADF that can be transported by ADF helicopters. The Project LAND 121 Phase 4 contract to deliver the vehicles was signed in October.

Since 2004, Thales has been producing the Bushmaster, widely recognised as one of the finest vehicles of its type in the world. As Bushmaster production winds down, the start of pilot Hawkei production in early 2016 will secure the highly skilled Bendigo workforce for full-rate Hawkei production in 2018. The 3.5-year production phase is scheduled to begin in mid-2017, with first deliveries expected towards the end of 2017.

Thales is a global technology leader for the aerospace, transport, defence and security markets, with 61,000 employees in 56 countries, Thales has more than 20,000 engineers and researchers and employs about 3200 people at more than 35 sites across Australia.

Hawkei is named after the largest Australian death adder snake, *Acanthophis hawkei*.

\$75 MILLION INVESTMENT FOR NEW MANUFACTURING

Eleven Victorian businesses will receive a total of \$27 million to establish or expand their high-value manufacturing operations under the Next Generation Manufacturing Investment Program. Complementary investment by each company will bring total investment in high-value manufacturing in Victoria under the program to \$75 million.

The \$60 million program is jointly funded by the Australian, Victorian and South Australian governments. The Victorian grants follow the announcement in August of \$29 million in grants to assist 15 SA companies invest about \$73 million in high-value manufacturing.

Successful Victorian applicants include:

- Marand Precision Engineering Pty Ltd – \$5 million to help expand its capacity to manufacture and assemble vertical tails for the Joint

Strike Fighter F-35 at its Moorabbin site, including an expanded temperature-controlled workshop and precision milling and assembly equipment;

- Walkinshaw Automotive Group Pty Ltd – \$5 million to help establish facilities in Springvale to undertake local market modifications of vehicles from global original equipment manufacturer vehicle product ranges, and manage manufacture of component parts;
- Catalent Australia Pty Ltd – \$3.4 million to help capture new pharmaceutical and complementary medicine business by adding production capacity and productivity improvements at its Braeside facility; and
- Bombardier Transportation Australia Pty Ltd – \$3.2 million to help expand its rail vehicle manufacturing capacity and capability at its Dandenong site, including installation of assembly lines for robotic welding and electrical propulsion equipment, and extension of its final assembly and testing facilities.

INNOVATIVE CENTRE FOR CARS OF TOMORROW

Researchers at Deakin University will be at the forefront of the international car industry's future design and innovation. The International Centre for Innovative Manufacturing (ICIM), launched in Geelong, will be led by Deakin University and General Motors Global Research and focus on developing world-leading innovative and competitive solutions for manufacturers and suppliers into the future.

Members will include Korean steel-maker POSCO and Korean national research laboratories, including the Korean Institute for Industrial Technology and the Korea Institute for Materials Science. Another Korean company, Sungwoo HiTech, will also be involved, along with US-based commercial software group Livermore Software Technology Corporation and global virtual prototyping company ESI Group.

The partnership will be driven by researchers at Deakin's School of Engineering and Institute for Frontier Materials, and include members from industry and suppliers. The ICIM board of directors includes General Motors' Dr Tom Stoughton as Chairman and Deakin's Professor Jeong Yoon as Chief Investigator.


BAE SYSTEMS WINS F-35 CONTRACT

BAE Systems Australia is the latest of some 30 Australian companies that have won production work for the global F-35 Joint Strike Fighter program. Under a long-term agreement with Northrop Grumman Corporation valued at US\$15 million, BAE Systems Australia has begun exporting high-end circuit boards and sub-system assemblies for the Joint Strike Fighter.

"The Joint Strike Fighter is currently the largest defence program in the world and Defence has been working closely with Australian industry to promote their participation," said Defence Materiel and Science Minister Mal Brough.

Adelaide-based BAE Systems will export parylene-coated circuit boards, which will be used in the Joint Strike Fighter's communication, navigation and identification (CNI) system. The parylene coating protects the boards from harsh conditions in the aerospace environment.

NEWS



The new technique can reveal fingerprints on metal, plastic and glass.

Glowing fingerprints help fight crime

A CSIRO scientist who had his home broken into has developed a new crime scene identification technique to help fingerprint criminals.

By adding a drop of liquid containing crystals to surfaces, investigators using a UV light are able to see invisible fingerprints 'glow' in about 30 seconds.

The strong luminescent effect creates greater contrast between the latent print and surface enabling higher resolution images to be taken for easier and more precise analyses.

CSIRO materials scientist Dr Kang Liang believes that this technique could be used for more challenging evidence where conventional 'dusting' is not appropriate.

CSIRO tested the method on nonporous surfaces including window and wine glass, metal blades and plastic light switches, with successful results – tiny crystals rapidly bind to fingerprint residue, including proteins, peptides, fatty acids and salts, creating an ultrathin coating that's an exact replica of the pattern.

Fingerprint identification has been used as a key method by law enforcement and forensic experts for more than 100 years. Adding CSIRO's method to the mix could save valuable time, costs and enhance investigations.

"When my house was broken into I saw how common a practice fingerprinting is for police," Dr Liang said.

"Knowing that dusting has been around for a long time, I was inspired to see how new innovative materials could be applied to create even better results. As far as we know, it's the first time that these extremely porous metal organic framework (MOF) crystals have been researched for forensics."

MOF crystals have a number of benefits in that they are cheap, react quickly and can emit a bright light. The technique does not create dust or fumes, reducing waste and risk of inhalation. The method could have other valuable applications including new biomedical devices and drug delivery.

CSIRO is now looking to partner with law enforcement agencies to apply the technique.

RMIT HELPS 'LIGHT UP' THE BODY

RMIT's \$3 million Research Node of the \$40 million ARC Centre of Excellence for Nanoscale BioPhotonics (CNBP) is open and will enable researchers to study the florescent properties of nanoparticles and biomaterials.

It will allow them to understand how they can be used to 'light up' areas in the living body, to explore what is happening deep inside cells at the nano or molecular level.

The CNBP is a collaborative centre, with research-focused nodes at the University of Adelaide, Macquarie University and RMIT University, and is a \$40 million initiative.

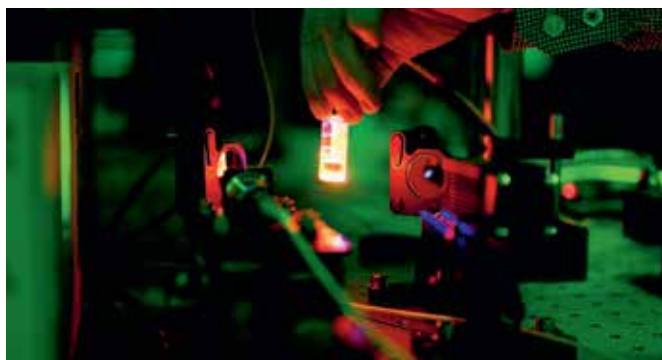
"Our goal is to incorporate advanced nanoscale materials into new biomedical devices that will let us deliver light directly into targeted cells inside of the body", said RMIT Associate Professor and CNBP Node Leader, Brant Gibson.

"We can then look for specific molecular substances inside those cells, measuring and analysing these substances to see how the body is working. This will help us better understand fertility, pain, heart disease and a whole host of other human related health conditions."

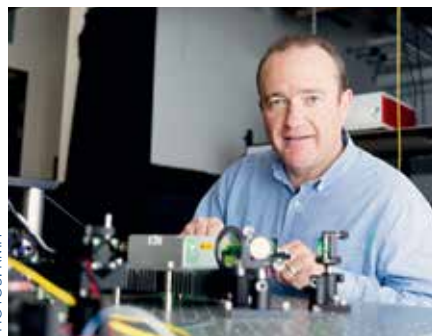
The research is challenging. In some cases, the cellular substances being examined may only be a few atoms across or about a nanometre in size. To date, they have been incredibly difficult to detect.

RMIT's new laboratory facilities, housing specialised optical and nanomaterial work areas, high-end instrumentation and two state-of-the-art microscopy systems will support this high-tech activity.

Professor Calum Drummond FTSE, RMIT Deputy Vice-Chancellor Research and Innovation, said at the opening of the new facility: "We're delighted to be a research node of the Centre for Nanoscale BioPhotonics and proud to be supporting such an exciting and progressive area of nano-discovery. With the investment in these new facilities, we'll see ambitious and transformational science, revolutionising our ability to understand how the human body works."



In the CNBP laboratory at RMIT.



Associate Professor Brant Gibson at work.

PHOTOS: RMIT

NEWS

'METS Ignited' promotes resources innovation

The Mining Equipment, Technology and Services (METS) Growth Centre, known as METS Ignited, based at Queensland University of Technology (QUT), aims to ensure Australia's mining equipment, technology and services sector is well placed to provide innovative solutions to the global resources sector.

METS Ignited, established under the Australian Government's \$225 million Industry Growth Centres initiative, is designed to boost Australian industry's competitiveness, productivity and capacity to innovate, and was launched by Industry, Innovation and Science Minister Christopher Pyne.

"The resource sector's continual drive to increase efficiency and productivity means there is a demand for improved equipment, technology and services," Mr Pyne said.

"The future prosperity of the mining equipment, technology and services sector will depend on its ability to remain globally competitive and seize these global opportunities. This new Growth Centre will ensure this very important sector of Australian industry receives the support it needs to prosper in an increasingly competitive and globalised market."

METS says its vision is to lift exports from the sector from the present rate of \$15 billion a year to \$30 billion by 2030. Dr Peter Lilly, former WA Division Chair and Director of The University of WA's Engineering Zone (E-Zone) project, is a director of METS.

COLLABORATION KEY TO RESOURCES POTENTIAL

CSIRO has released a new report, Unlocking Australia's resource potential, which has a framework for innovation to help to realise Australia's energy and mineral resources potential. At a time when Australia and the resources industry are looking to innovation to drive future prosperity, the report draws on the insights of 26 senior leaders in some of Australia's largest minerals and energy companies. It also analyses past case studies, current barriers and trends to map the future through innovation.

Released by CSIRO and the Mining Equipment, Technology and Services Growth Centre (METS Ignited), the framework explores the ingredients of successful innovation across the resources sector.

"Despite Australia's great past record and rewards from resource sector innovation, many companies and agencies are struggling to realise full value from their innovation investments for a number of reasons," said CSIRO Executive Director of Environment, Energy and Resources Dr Alex Wonhas.

"Our research shows that many of the same features that gave rise to past innovation successes, are those identified by industry leaders as needed to break through existing barriers to innovation. Strong collaboration, visionary leadership, measured

risk-taking, perseverance and government participation were key ingredients of successful past innovation and may be even more important in the future."

Collaboration was found to be particularly important for driving future innovation success.

NOBEL 'EGGHEAD' CRACKS ANAESTHETIC CODE

One of the world's most in-demand anaesthetics can now be produced on the spot, thanks to the thermos-flask-sized device that recently won Flinders University inventor Professor Colin Raston an Ig Nobel prize.

Professor Raston and his team of researchers successfully synthesised lidocaine using their desktop Vortex Fluidic Device (VFD), in a development with huge implications for the traditional mass production methods of the global pharmaceuticals industry.

It is so easy to produce lidocaine with the VFD – which made global headlines earlier this year when it unboiled an egg – that Professor Raston, the device's inventor, says it can be made in even the most remote locations, with only basic instructions, in less than an hour.

He says the ability to produce lidocaine, one of the World Health Organization's (WHO) "most important medicines for a basic healthcare system", in high-need areas such as war zones and developing countries signals a paradigm shift in pharmaceutical manufacture.

■ *Lidocaine is a local anaesthetic that prevents pain by blocking signals from nerve endings in the skin. Typically applied it can be used on various parts of the body to cause numbness or loss of feeling for patients undergoing certain medical procedures. It is also used to relieve pain and itching.*

STUDY REVEALS PILBARA WATER SYSTEMS

A new study has delivered an unprecedented account of water resources in WA's Pilbara region, providing an understanding of local water systems and the potential impacts of climate change on water availability. The Pilbara Water Resource Assessment project, a \$3.5 million partnership between CSIRO, BHP Billiton and the WA Government, will allow water managers and local industry to plan for future water use in an area rich in resources and environmental assets.

The study revealed some of the mechanisms responsible for filling the Pilbara's groundwater stores. It found that between 8 and 30 millimetres of rainfall was required before runoff started in most catchments, which leaks through streambeds to provide the main source of aquifer replenishment. Water from these shallow alluvial aquifers then recharged deeper paleochannels or dolomite aquifers,

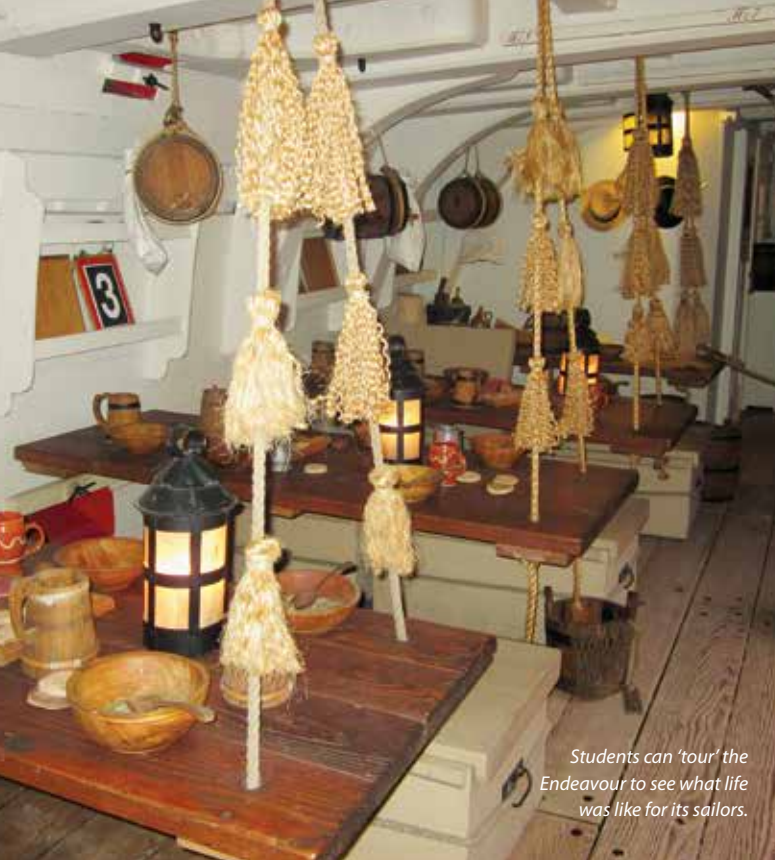
which stored large quantities of water in inland areas.

It also examined how ecosystems dependent on the region's groundwater sources had changed as a result of wet and dry periods, finding they expanded during wet periods and contracted during dry periods but had remained relatively stable in number over the past 23 years.

Past innovation successes, such as CSIRO's longwall automation technology for coal mining, provide insights for future breakthroughs.



NEWS



Students can 'tour' the Endeavour to see what life was like for its sailors.

Technology brings iconic ship to classrooms

Students from around Australia can now take a tour of the iconic ship HM Bark Endeavour without leaving school, thanks to a new digital technology.

The historically and scientifically significant sailing vessel moored in Sydney's Darling Harbour is a replica of the ship that Captain James Cook and famous botanist Joseph Banks sailed to Australia almost 250 years ago.

It attracts more than 35,000 schoolchildren each year, but the new technology enables students from across the country and around the world to experience HMB Endeavour remotely.

CSIRO developed a way to bring the ship to the classroom to teach kids about science – the mechanics of pulley systems, how food was stored onboard and the specimens that Joseph Banks collected on his journey. The ship has been fitted with live-streaming panoramic cameras so that students can look around the ship as if they were really there. A museum educator uses a tablet computer to guide the students around HMB Endeavour and communicate with them along the way.

ULTRATHIN LENS HAS HUGE POTENTIAL

Researchers at Swinburne University of Technology, collaborating with Monash University, have developed an ultra-thin, flat, ultra-lightweight graphene oxide optical lens with unprecedented flexibility.

The ultrathin lens enables potential applications in on-chip nanophotonics and improves the conversion process of solar cells. It also opens up new avenues in:

- non-invasive 3D biomedical imaging;
- photonic chips;
- aerospace photonics;
- micromachines; and
- laser tweezing – the process of using lasers to trap tiny particles.

Optical lenses are indispensable components in almost all aspects of technology including imaging, sensing, communications, and medical diagnosis and treatment. The rapid development in nano-optics and on-chip photonic systems has increased the demand for ultrathin flat lenses with three-dimensional subwavelength focusing capability – the ability to see details of an object smaller than 200 nanometres.

Recent breakthroughs in nanophotonics have led to the development of a number of ultrathin flat lens concepts, however their real-life application is limited due to their complex design, narrow operational bandwidth and time-consuming manufacturing processes.

"Our lens concept has a 3D subwavelength capability that is 30 times more efficient, able to tightly focus broadband light from the visible to the near infrared, and offers a simple and low-cost manufacturing method," said research leader in nanophotonics at Swinburne's Centre for Micro-Photonics (CMP) Associate Professor Baohua Jia.

The researchers produced a film that is 300 times thinner than a sheet of paper by converting graphene oxide film to reduced graphene oxide through a photoreduction process.

CMP Director Professor Min Gu FAA FTSE said: "The newly demonstrated laser nano-patterning method in graphene oxides holds the key to fast processing and programming of high-capacity information for big data sectors."

Professor Dan Li, Co-director of the Monash Centre for Atomically Thin Material, which provided the graphene oxide film for the research, said the work opened up a new high-tech application for graphene oxide and showed how nanotechnology can add significant value to natural graphite.

COMPOSITES GLOBAL R&D GOES TO GEELONG

Quickstep Holdings, Australia's largest independent manufacturer of aerospace-grade carbon fibre composites, is moving its global R&D centre from Munich to Geelong, in regional Victoria.

The new centre, to be located at Deakin University's Waurin Ponds campus, will support Quickstep's automotive and aerospace facilities in both Australia and Germany.

The Victorian Government has supported the move, with funding in addition to the \$1.76 million grant that was provided in November 2014 by the Geelong Region Innovation and Investment Fund (GRIIF), an initiative backed by the Australian and Victorian governments and Ford Australia.

Quickstep has been chosen by Lockheed Martin as sole supplier of composite wing flaps for the C-130J 'Super Hercules' military transport, and is the approved supplier for the international F-35 Lightning II Joint Strike Fighter (JSF) program – the largest aerospace program in the world.

Mr David Marino, the Managing Director of Quickstep, said that with the move of its R&D facility to Geelong, the company would benefit from access to Deakin's 'carbon cluster' with its skilled researchers, laboratories and industry networks, as well as close working relationships with partnered research institutions.

The manufacture of carbon composite components is forecast to increase substantially over the next 10 years, for both the aerospace/defence and automotive sectors.

NEWS

Entrepreneurship is the economic key

A new report from the Office of the Chief Scientist highlights entrepreneurship as the key to a high-growth, innovation-led economy, able to capitalise on Australia's investment in research and skills.

The report, *Boosting High-Impact Entrepreneurship in Australia*, finds that Australia has one of the highest rates of business creation in the world, but few start-ups have the capacity to grow beyond the local level. Producing more high-impact entrepreneurs with global ambitions and the ability to disrupt large markets using science and technology will be crucial to Australia's future, the report finds.

Highlighting the priority given to entrepreneurship in the most successful start-up nations, the report calls for new thinking in government and universities. It identifies a mix of programs in universities, from harnessing entrepreneurs as role models to hands-on learning through incubators, accelerators and overseas placements, as the best approach.

Entrepreneurship courses at Australian universities need to grow beyond business schools and into mainstream study, particularly in science, technology, engineering and mathematics fields, it says.

"Australians aren't short of talent but we need to get better at turning our creativity into successful products and services," Australia's Chief Scientist Professor Ian Chubb AC FTSE said.

"To be a more innovative country we need to encourage an entrepreneurial mindset at every level of education – starting in schools, continuing in higher study and enduring throughout working lives.

"In other countries, forward-looking universities are the epicentre of vibrant start-up economies. Universities should be at the core of building a culture of entrepreneurship in Australia."

The report was prepared for the Office of the Chief Scientist by Colin Kinner, Director of Spike Innovation, and is available from the OCS website. The report notes that Australia creates a lot of new knowledge, but had a poor record of commercialising that knowledge in Australia, said Education and Training Minister Senator Simon Birmingham.

"Our researchers are in the top 10 in the OECD for contributing to research publications, but we are ranked last on the proportion of businesses which collaborate with research institutions on innovation," Senator Birmingham said. "This report reinforces that we need to do more to turn great ideas into products and practices that help build businesses and create jobs in Australia."

CSIRO TURNS IT ON

CSIRO has started its ON program to focus on building connections with the Australian entrepreneurial community to accelerate CSIRO's entrepreneurial capacity to create impact for Australia. Ms Liza Noonan has been appointed Executive Manager Innovation to lead the ON program. She has extensive experience in the innovation industry and was most recently General Manager of Springboard Enterprises Australia, an accelerator platform for women entrepreneurs. Prior to this she led Alcatel-Lucent's ng Connect program in Australia.

"The ON program will be key to delivering more breakthrough innovation from CSIRO. One of the first initiatives of ON is a new

Accelerator for CSIRO concepts with high impact potential," Ms Noonan said.

The Accelerator program started in July this year and was open to all CSIRO staff. They submitted 240 ideas ranging from a handheld 3D thermal imaging system to a virtual power station. Nine teams were selected to be a part of the first Accelerator cohort. The program includes concepts such as the development of ultra-low gluten barley, which may revolutionise the gluten-free market worldwide by providing an alternative solution to the high-fat and low-fibre diets of many gluten avoiders today.

"This program is different to other accelerators out there," Ms Noonan said. "These are deep tech projects that cross a wide range of industries, from manufacturing to agriculture. Our end goal is to get technology out to market that will address major challenges we face as a nation."

UNSW ENGINEERING OPENS ITS DOORS TO INDUSTRY

The University of NSW's Faculty of Engineering has launched a slate of Industry Research Fellowships that will open its brainpower, laboratories and facilities to researchers from industry seeking to improve products, overcome obstacles and solve challenges.

UNSW is offering 25 Fellowships, for which applications closed on 2 December. Industry Fellows can spend up to six months on campus full time, or up to a year part-time. Once completed, Fellows can apply to renew, extend or continue their projects. During their stay, Industry Fellows will have access to UNSW research expertise and facilities to work on projects, or collaborate with UNSW researchers to transfer knowledge to industry or products to market. By 'embedding' industry staff in the university, UNSW Engineering hopes to foster and further grow research engagement between the faculty and business in ways that will accelerate the development of technologies that can reach commercial application.

"The purpose is to bring people who work in industry closer to the research that happens in universities, and improve the two-way communication for the development of technology," said Professor Mark Hoffman FTSE, Dean of Engineering at UNSW, announcing the initiative. When researchers at university design projects, they often don't have a strong knowledge of what industry needs. Similarly, industry doesn't always have a full understanding of the capability within universities. So if we can have people from industry actually working alongside our researchers and students, both sides can better understand the technologies needed and partner in their development," he added.

Professor Hoffman acknowledged that the road runs both ways – business needs to connect with universities as much as universities need to connect with business, and that corporate Australia needs a mindset that sees universities as partners – which has historically not been the case.

"It takes two to tango," Professor Hoffman said. "The best place for us to start is to make it easier for industry to engage with UNSW, and show what we can offer."

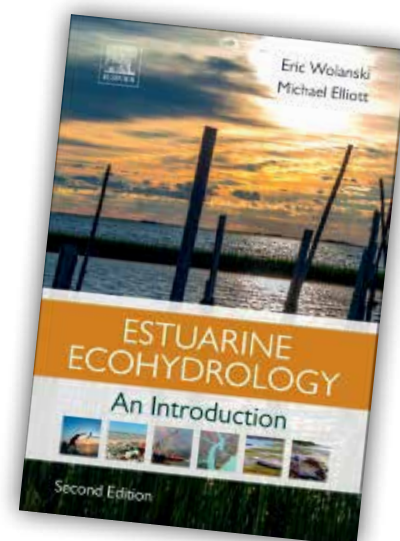
■ *UNSW Engineering – comprising nine schools and 24 research centres – is Australia's biggest engineering faculty and ranked among the world's top 50. It is also home to Australia's largest cohort of engineering undergraduate, postgraduate, domestic and international students.*



Mark Hoffman

By Ian Rae
iandrae@bigpond.com

A fascinating journey in coastal environments



This book is a successor to Eric Wolanski's 2007 *Estuarine Ecohydrology*. It takes the reader on a fascinating journey across

(and sometimes under) coastal environments, but it expands the coverage, doubles the page count and adds recent work to the reference list.

Dr Eric Wolanski FTSE, an estuarine oceanographer at James Cook University and the Australian Institute of Marine Science, is joined by co-author Michael Elliott, Director of the Institute of Estuarine & Coastal Studies and Professor at the University of Hull. Both have made substantial multidisciplinary contributions to an important and challenging field that requires the attention of a range of disciplinary specialties and, in some circumstances, more art than science.

As in the first edition, the text is richly illustrated with photographs, diagrams and flow charts and there is a sprinkling of differential equations describing the movements of water and sediment. The photographs, many of them Australian, illustrate points made in the text. I think they could perform even better if they were in colour but I can guess there were budgetary limits.

A comparison of the two editions reveals some interesting additions and enhancements. There is more about chemical pollution, including up-to-date references to work on the ability of plastic debris to deliver persistent organic pollutants and some metals to marine organisms that ingest the rubbish.

Other new sections to catch my eye dealt

with ship waves, mud and human health, and climate change.

I liked the section on tideless estuaries, lagoons and other waters with intermittently closed entrances. They exemplify the important point made in both editions that "most estuaries have not reached a steady state yet; they are still evolving and under infilling conditions may be regarded as geologically ephemeral features".

This made me think of one that is not mentioned in either edition, comprising Lake Alexandrina, the Coorong and the Murray River mouth, which is an estuary that has been heavily engineered in an attempt to create a steady state.

As in the first edition, stress is placed on the need to manage an estuary in conjunction with the drainage basin that feeds it and the coast where it discharges – a task made difficult by the widespread lack of appreciation that the estuary is the core of an extended ecosystem.

Fragmentation of "legal guidelines, acts, laws and treaties regulating" estuaries make their management an almost impossible task. Ruining an estuary is commonly accepted as a consequence of economic development, from harbour deepening to prawn farming.

The first edition ended on a gloomy note, treading water (one might say!) until a political solution was found. For coastal coral reefs worldwide there seemed to be no other politically acceptable solution than 'do nothing about land-use and global warming and hope for the best'.

A decade on from that, the outlook is brighter. Wolanski and Elliott approve of biodiversity offsetting as "ecohydrology in

ESTUARINE ECOHYDROLOGY: AN INTRODUCTION (SECOND EDITION)
BY ERIC WOLANSKI AND MICHAEL ELLIOTT (ELSEVIER, 2016 (SIC), XII + 321 PAGES, ISBN: 978-0-444-63398-9).

practice" and they provide guidelines for what needs offsetting or restoring, and why. Their hope for estuaries and coastal waters is that governance and ecohydrology can be integrated.

There are not many examples of good practice that eco-engineers and their communities can draw on, but the authors describe two successes in Micronesia. There, as in so many of the examples in *Estuarine Ecohydrology*, mangroves play important roles. I can attest that this is not only true in the tropics, because the value of mangroves is being rediscovered on the western shores of Port Phillip Bay, where the white mangrove, *Avicennia marina*, rules the waves. ☺

PROFESSOR IAN RAE FTSE, an Honorary Professional Fellow at the University of Melbourne, is a former technical Director of ATSE. He was President of the Royal Australian Chemical Institute (2006–08) and served for a decade as a technical adviser to the UN Environment Programme. He is co-editor of the Australian Academy of Science journal *Historical Records of Australian Science*.

ATSE IN FOCUS

Graeme Jameson takes PM's Innovation Prize

Professor Graeme Jameson AO FREng FAA FTSE, Laureate Professor of Chemical Engineering at the University of Newcastle and Director of its Centre for Multiphase Processes, has won the inaugural \$250,000 Prime Minister's Prize for Innovation.

Graeme Jameson's technologies use trillions of bubbles to add billions of dollars to the value of Australia's mineral and energy industries.

He created the Jameson Cell in the 1980s to concentrate base metals such as copper, lead and zinc. And it's all done with bubbles. Advancing century-old flotation technology he developed it into a cloud of minute bubbles that are pushed through a slurry of ground-up ore where they pick up mineral particles and carry them to the surface.

His technology found many more applications, most profitably in the Australian coal industry, where the Jameson Cell has retrieved fine export coal particles worth more than \$36 billion.

Professor Jameson, an ATSE Fellow since 1991, is working on a newer version of his technology. The NovaCell can concentrate larger ore particles, and save up to 15 per cent of the total energy expended in extraction and processing in mining – and reducing greenhouse gas emissions.

Professor Jameson has won numerous awards, including: NSW Scientist of the Year (2013), Peter Nicol Russell Medal (2005), Ian Wark Medal (2003), Chemeca Medal (2002), KL Sutherland Memorial Medal (1998), RK Murphy Medal (1993), Clunies Ross Award (1991), Whiffen Medal (1991) and John A Brodie Medal (1983).

He is an Honorary Fellow of the Institution



Graeme Jameson



Ken Silburn

of Engineers Australia and Foreign Member of the US National Academy of Engineering.

The other 2015 prize winners were:

- Professor Graham Farquhar AO FRS FAA, Australian National University, Prime Minister's Prize for Science;
- Associate Professor Cyrille Boyer, University of New South Wales, Malcolm

McIntosh Prize for Physical Scientist of the Year;

- Dr Jane Elith, University of Melbourne, Frank Fenner Prize for Life Scientist of the Year;
- Dr Ken Silburn, Casula High School, Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools; and
- Mrs Rebecca Johnson, Windaroo State School, Queensland, Prime Minister's Prize for Excellence in Science Teaching in Primary Schools.

Dr Silburn is a strong supporter of ATSE's STELR program and Casula High School is one of nearly 500 participating schools across Australia.

Dr Silburn's citation notes: "Fifteen years ago Casula High School was just an average state school in Sydney's south-western suburbs with just eight students doing science at Year 12. But something extraordinary has happened. Two-thirds of Year 11 and 12 students now choose science subjects and they are performing well above the state average.

"The transformation is largely due to the work of Dr Ken Silburn, the head of science at Casula. Ken has transformed the way his students engage with science, through extension programs, interactive and hands-on activities, and a great deal of encouragement.

"In the classroom, Ken focuses on what his students are most interested in or fascinated by, and makes it a big part of his science teaching curriculum. A highlight is the use of space science as a core element of the classes."

PAGE 48 – 'THE GRAEME JAMESON STORY'



Greg Tegart

GREG TEGART NAMED ACT SENIOR CITIZEN

Professor Greg Tegart AM FTSE, an Academy stalwart and former chair of the Health Technology Forum, has been announced as the 2016 ACT Senior Citizen of the Year. Professor Tegart was recognised for his work in developing assistive technologies for aged and disabled people. In recent years, Professor Tegart's world-leading work has enabled many Australians to lead more empowered and independent lives.

Professor Tegart and other ACT award recipients will now join awardees from other states and territories as finalists for the national Australian of the Year awards, to be announced on 25 January 2016. Professor Tegart is a former Secretary of the Australian Department of Science and Technology and then Secretary of the Australian Science and Technology Council. He has since held various academic positions in Australia and overseas.

ATSE IN FOCUS

Scott Sloan is NSW Scientist of the Year



Scott Sloan

Laureate Professor Scott Sloan FRS FREng FAA FTSE, from the University of Newcastle, has been named New South Wales Scientist of the Year 2015.

Professor Sloan is a geotechnical engineer whose research has led to the development of safer transport and energy infrastructure worldwide. Professor Sloan and his team at the ARC Centre of Excellence in Geotechnical Science and Engineering have forged new methods of predicting at what point geostructures, including public roads and buildings, are likely to collapse, allowing engineers to design safer and cheaper infrastructure. The awards were organised by NSW Chief Scientist and Engineer Professor Mary O'Kane FTSE whose office said Professor Sloan's cutting-edge research had led to the development of safer, cheaper transport and energy infrastructure worldwide.

Professor Sloan's research underpins construction of the Pacific Highway on the state's north coast and big road projects in Boston and Chicago. It has also been used to predict tunnel stability in work to extend the London Underground and Italy's railway network.

Presenting the award, NSW Premier Mike Baird said the benefits of Professor Sloan's work reverberate around the world.

"His research is being used widely in the construction of a range of infrastructure, including roads, railway lines, tunnels, building foundations, dams, port facilities, pipelines and mining operations, as well as offshore oil and gas facilities," Mr Baird said.

Professor Sloan said: "Being named NSW Scientist of the Year continues a great year of acknowledgment of my career and research.

"It also acknowledges the great geotechnical team at Newcastle, which leads the world in its field and is home to a number of outstanding researchers of all ages."

Mr Baird presented Professor Sloan with a cash prize of \$55,000 and also gave \$5000 cash prizes to eight other category winners for excellence in the fields of mathematics, biological sciences, engineering and innovation.

Professor Sloan was educated at Monash University where he was awarded his Bachelor of Engineering and Master of Engineering Science degrees. He then studied at the University of Cambridge where he was awarded a PhD in 1981 for numerical analysis of incompressible and plastic solids using finite elements.

In 1984, Professor Sloan accepted a Lectureship in Civil Engineering at the University of Newcastle. He is currently the founding Director of the 180-strong ARC Centre, as well as the 70-strong Priority Research Centre for Geotechnical and Materials Modelling at Newcastle. These Centres are focused on the geotechnical aspects of energy and transport infrastructure, and combine advanced computational modelling, field measurements, laboratory testing and physical modelling to develop more cost-effective design procedures for the engineering profession.

Professor Sloan has received various accolades in recognition of his research contributions, including the 2000 Telford Medal and the 2007 Telford Premium from the ICE London; a Centenary Medal in 2003 (for service to Australian Society in Civil and Geotechnical Engineering); the 2005 Desai Medal and 2008 Booker Medal from the International

Association for Computer Methods and Advances in Geomechanics; the 2005 Thomas A Middlebrooks Award from the American Society of Civil Engineers; and a 2010 Fellows Award from the International Association of Computational Mechanics (for outstanding contributions to computational geomechanics). In 2011 he delivered the 51st Rankine Lecture, the oldest and most prestigious honour given to a geotechnical engineer.

■ Chemical engineer and inventor of the Jameson Cell Laureate Professor Graeme Jameson AO FREng FAA FTSE was named NSW Scientist of the Year in 2013.

ALAN FINKEL STEPS DOWN AS MONASH CHANCELLOR

ATSE President Dr Alan Finkel AO FTSE will retire as Chancellor of Monash University at the end of 2015 after eight years in the role.

He will be succeeded in January 2016 by Mr Simon McKeon, former chair of CSIRO and 2011 Australian of the Year.

"After eight years with me as Chancellor Monash University is ready for a fresh injection of ideas, and the timing is good in the sense that our Vice-Chancellor has been in the role for more than a year and the university is performing well on many fronts," Dr Finkel said.

"With his broad legal, financial, business, charitable and sporting experience, Simon will be a wonderful Chancellor of Monash University."

Monash Vice-Chancellor Professor Margaret Gardner AO said Dr Finkel had been "an outstanding Chancellor of Monash, deeply engaged with its research, its students and leading the enhancement of its campuses".

Dr Finkel was the first Monash graduate to be appointed as Chancellor and has been significantly involved in the development of philanthropy and capital developments at the university.



Alan Finkel

ATSE IN FOCUS



Veena Sahajwalla

Veena named top innovator

Professor Veena Sahajwalla FTSE, Director of the Centre for Sustainable Materials at the University of NSW, was named the winner among 10 finalists in the Innovation category of the Financial Review/Westpac listing of Australia's 100 Women of Influence.

She was one of four ATSE Fellows named as finalists in the Awards, which were announced in October.

The overall winner – Australia's "most influential woman" – was Ms Ann Sherry, CEO of cruise line company Carnival Australia.

Professor Sahajwalla was recognised for her world-leading research on transforming waste at high temperature to create new resources for industrial production, such as polymer injection technology to create 'green steel' – cited by the Society of Manufacturing Engineers in 2012 as "an innovation that could change the way we manufacture".

Ms Kathy Hirschfeld FTSE, a non-executive

director of Transfield Services, was named among 11 finalists in Board/Management category. Ms Hirschfeld has had a long and varied career in engineering and manufacturing, including almost 20 years'

service on three continents with BP.

Professor Cynthia Mitchell FTSE, Deputy Director of the Institute for Sustainable Futures at the University of Technology Sydney, was named among eight finalists in the Public Policy category. Professor Mitchell is a strong advocate of water planning and policy and has implemented generational shifts in water planning. She is Deputy Chair of the ATSE Infrastructure Forum.

Dr Erica Smyth FTSE, Chair of Toro Energy and the Diabetes Research Foundation of WA, was named among 10 finalists in the Diversity category – from which the winner was chosen. A geologist by training, Dr Smyth pioneered the role of women in the mining industry, on listed energy company boards, and on government mining and defence committees.

CRAIG SIMMONS JOINS US ROUNDTABLE

A Flinders University scientist's internationally respected expertise in coal seam gas and fracking has seen him appointed to a prestigious new US entity. South Australia's Scientist of the Year, Professor Craig Simmons FTSE, who leads the National Centre for Groundwater Research and Training at Flinders University, has been named a member of the US National Academies Roundtable on Unconventional Hydrocarbon Development.

The roundtable will examine issues related to the development of unconventional hydrocarbon resources such as shale oil and gas. It is a joint activity of all US National Academies – the US National Academy of Sciences, the US National Academy of Engineering and the US National Academy of Medicine. Its members are among the world's most distinguished scientists, engineers, physicians and researchers.

It will serve as a neutral forum where experts from government, industry, academia, and non-governmental and international organisations can meet on an ongoing basis, and will identify and help to advance activities of broad value to key stakeholders. It will also assist in informing decision-making about development of these resources. Professor Simmons' invitation recognises his world-leading research in hydrology and unconventional hydrocarbon development.

"Unconventional gas sources, such as coal seam gas and fracking, are huge issues in Australia and overseas and I am delighted to have the opportunity to work with the US National Academies to gather, critically examine and communicate facts and data regarding the scientific, engineering, human and environmental health and safety, regulatory, economic and societal aspects of unconventional hydrocarbon development," Professor Simmons said.

"It is an incredible opportunity for bilateral and international exchange of ideas, information and experiences on such a critical, complex and contentious issue."

Flinders University Acting Vice-Chancellor Professor Andrew Parkin congratulated Professor Simmons on his appointment.

"This prestigious and remarkable appointment by the US National Academies is a great testament to Professor Simmons' international standing and credibility as a scientist. It is also a major international recognition of both an Australian scientist and Australian science."

Professor Simmons is Matthew Flinders Distinguished Professor of Hydrogeology and Schultz Chair in the Environment at Flinders. He is a member of the Federal Government's Statutory Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development.



Erica Smyth



Kathy Hirschfeld



Craig Simmons



Cynthia Mitchell

ATSE IN FOCUS

Calum Drummond gets the trifecta



Calum Drummond receives his Victoria Prize certificate from the Minister.

Professor Calum Drummond FTSE, Deputy Vice-Chancellor Research and Innovation at RMIT University, has won the 2015 Victoria Prize for Science and Innovation in the Physical Sciences Category.

The Victoria Prize celebrates leadership, determination and creativity. It also highlights the many ways in which research and development of international significance are conducted in Victoria.

The Victoria Prize for Science and Innovation is awarded to outstanding science leaders and was presented by the Victorian Minister for Industry, Energy and Resources, the Hon Lily D'Ambrosio.

Professor Drummond's citation reads: "Awarded for outstanding contributions to advancing the fundamental understanding of the key factors governing molecular assembly, and particle and surface interactions in liquids. This fundamental research in chemistry has enabled the development and commercialisation of advanced high-performance materials for economic and societal benefit."

Professor Ana Deletic FTSE, from Monash University, won the same prize in 2012 and

previous winners include Professor David Solomon AM FRS FAA FTSE, Professor Eric Reynolds FTSE, Professor David Boger FRS FAA FTSE and Professor Graeme Clark AC FRS FAA FTSE.

Professor Drummond has also won the 2015 HG Smith Memorial Medal from the Royal Australian Chemical Institute (RACI).

The Award conditions note: "The Medal shall be awarded annually to a member of the RACI who, in the opinion of the RACI Board, has contributed most to the development of some branch of chemical science; this contribution will be judged by research work published or accepted for publication during the 10 years, or equivalent relative to opportunity, immediately preceding the award."

Professor Drummond also received a Doctor of Science, conferred by the University of Melbourne. Nearly 200 of his scholarly published works were assessed by an external panel, and the panel determined that he had attained "global authoritative standing" in his field of science.

The body of work was entitled "Advances in Physical Chemistry: Focus on Colloid and Surface Chemistry".

Professor Drummond has also been appointed to the Board of the new Innovative Manufacturing CRC, along with Dr Alexander Gosling AM FTSE, Chair of the Victorian Division, and Professor Mary O'Kane, NSW Chief Scientist and Engineer.

BOB BILGER A FAMED COMBUSTION EXPERT

Bob Bilger was internationally renowned for his expertise in combustion science, achieved in an engineering career that lasted 55 years and influenced a wide variety of colleagues and students.

South African-born, New Zealand-educated – with a 1957 Rhodes Scholarship and a DPhil in Engineering Science from Oxford – Professor Robert Bilger FAA FTSE was recognised internationally for his research, particularly in the theory and investigation of turbulent diffusion flames.

He had been associated with the Mechanical Engineering Faculty of the University of Sydney from 1965, when he

brought his skills to Australia.

After Oxford, he spent two years in the UK and two years in the US with Northern Research and Engineering Corporation before coming to Sydney – where he stayed until retirement, apart from a one-year leave during which he served as Technical Director of Handley Page Aircraft in the UK.

His death in Sydney on 1 October, aged 80, ended his long association with the university and an array of special friendships he had forged.

He was widely known and respected in his roles as Professor in Mechanical Engineering at the University of Sydney and former Executive Director of The Warren Centre.

He came to Sydney as a senior lecturer in 1965, became Associate Professor in 1975 and then Professor the following year. He served as Head of Department 1977–79 and 1981–83. He served on the Board of the Warren Centre for Advanced Engineering from 1982–85 and as its Executive Director (1981–85).

His 1987 Fellowship citation noted that he was recognised internationally for his research in combustion science and had made "significant contributions" to research on photochemical smog, vehicle emissions and fuel consumption.

Professor Bilger consulted widely to government and industry, served on many government and society organisations, was a Fellow of the Institution of Engineers Australia and a long-serving member and Director of The Combustion Institute, based in the US.

Professor Roger Tanner FRS FAA FTSE, a long-time colleague at the University of Sydney, contributed this warm tribute: "In April this year we celebrated Bob's 80th birthday at Barrenjoey House in Palm Beach. He was in excellent form and spoke well, looked well. It was hard to see his quick decline from there, and I will miss him greatly."



Bob Bilger

ATSE IN FOCUS

Women again prominent among new ATSE Fellows

The Academy has elected 26 new Fellows for 2015, including key business identities, leading academics, prominent commercial innovators, professional and business leaders and high-ranking public sector figures.

The new Fellows include eight prominent women – sustaining again the Academy's policy of electing one-third of its new Fellows from female candidates – and one Foreign Fellow.

They come from a wide array of sectors and specialisations, including agriculture, engineering, government, water management, biotechnology, ICT, resources, defence, manufacturing, chemicals, photonics, robotics, geotechnics, veterinary and medical research. All are leaders in their field. The full list follows.

2015 FELLOWS

DR GEOFF ALLAN FTSE

Deputy Director-General, NSW Department of Primary Industries (NSW)



Dr Allan is regarded as one of the doyens of aquaculture in Australia, having contributed to its development across a number of sectors. He was a pioneer of prawn farming research, before turning his attention to developing cost-effective aquaculture diets, which led Australia to become a global leader in this field. It is estimated his work has helped the Australian industry grow three-fold over 20 years to a \$1 billion industry, and reduced the cost of production to the Australian aquaculture industry by about 10 per cent a year over this period, by about \$100 million.

PROFESSOR ALEXANDER BAITCH FTSE

Principal, BES (Aus) Pty Ltd (NSW)



Professor Baitch is an internationally recognised and influential leader in the engineering profession, particularly in the field of complex emerging electricity

distribution technologies and technical standards. He is one of Australia's most experienced electrical power system engineers. He has made notable contributions to the development of Australia's power systems and is an internationally recognised leader in complex emerging electricity distribution technologies. He has made significant contributions to electricity system stability and efficiency and to the advancement of technologies in the fast-moving domain of distributed generation. He served as National President of Engineers Australia in 2014.

DR PAUL CLEARY FTSE

Chief Research Scientist, CSIRO (Victoria)



Dr Cleary is an outstanding talent in computational modelling and has delivered major impact through novel modelling methodologies, software tools and

application to numerous industrial applications. His research standing has been built through novel developments in particle-based computational modelling and in using these to create fundamental insights into the flow of particles, fluids, solids and bubbles in complex multiphase systems. His research has had a significant impact on the development and worldwide adoption of particle-based methods for modelling fluid and particles flows.

PROFESSOR MICHAEL FRATER FTSE

Rector, University of NSW/ADFA (ACT)



Professor Frater's research has had a profound impact on communications technology in civilian and military applications worldwide. He has been a

leader in international efforts to establish technologies and standards for video compression and has developed

communication systems for military applications as well as underwater communications. He is an authoritative consultant for government communications authorities in Australia and was communications adviser for the Athens Olympics. Through his leadership of UNSW Canberra at the Australian Defence Force Academy he has developed the Academy into a formidable R&D support base for the Australian military.

DR VANESSA GUTHRIE FTSE

Managing Director, Toro Energy Ltd (WA)



Dr Guthrie is recognised as an Australian leader in uranium mining and extraction and nuclear power options and combines this with strong

communication skills. She is the Deputy Chair of the Minerals Council of Australia (MCA) and chairs the MCA's Uranium Forum. She previously held senior appointments in the minerals and gas industries with Woodside, Alcoa, WMC and Pasminco. A geologist/environmental scientist by training, she has been recognised nationally for her achievements as the WA Chamber of Minerals and Energy's Outstanding Professional Woman, and Women in Mining UK's '100 Inspirational Women in Mining' (2013).

DR ROBERT (MARK) HODGE FTSE

Chief Executive, Defence Materials Technology Centre (Victoria)



Dr Hodge is an engineer and experienced strategic leader of research, technology development and commercialisation with a sustained record of

translation into business value and defence capability. Under his leadership, DMTC research has created and sustained Australian industry capability across materials and advanced manufacturing fields through collaborative innovation-based activities. Sixteen years of private and public sector experience in Australia and the US established his international reputation for translating high-quality research into

ATSE IN FOCUS

commercial and practical outcomes. He champions collaborative R&D programs across the national innovation system and is recognised for his strategic advice to government and industry at all levels.

DR ROGER LUMLEY FTSE

Technical Manager, AW Bell Pty Ltd (Victoria)



Dr Lumley is recognised nationally and internationally for innovative achievements in transforming research discoveries into commercial products, notably in the aluminium, diecasting and foundry industries. He is a former Principal Research Scientist with CSIRO and has worked in powder metallurgy, developed novel treatments to improve the mechanical properties of cast and wrought aluminium alloys, and discovered a unique method of heat treating aluminium diecastings that can double their strength. AW Bell is the only aerospace-certified foundry in Australasia and is working on the Collin Class Submarine Remediation Program and has gained contracts to export castings for biomedical equipment.

PROFESSOR JOHN MACKENZIE AO FTSE

Research Associate, Curtin University (WA)



Professor Mackenzie has been a world leader in virology research for the past 40 years. His work has encompassed research into viral ecology and molecular phylogenetics with the major aim of investigating how ecological factors affect the occurrence and natural transmission cycles of specific viruses and influence public health responses. More recently he has made a major contribution internationally, principally through the World Health Organization, by improving the detection and ability to respond globally to diseases of concern with pandemic potential. He is a former Professor of Microbiology and held a second Chair in Tropical Diseases at the University of Queensland.

PROFESSOR ROBERT PARK FTSE

Professor, University of Sydney (NSW)



Professor Park is an international leader in the pathology and genetics of cereal rust pathogens. Through his personal science and leadership of the world-renowned Australian Cereal Rust Control Program he has made major contributions to the national effort to control these diseases. His research underpins the estimated \$1 billion benefit that resistance breeding contributes annually to the cereals industry. His research group has played a pivotal role in breeding cereal cultivars that carry inbuilt genetic resistance to stem, leaf and stripe rust, a troika of the most feared cereal diseases.

MR ROSS PILLING FTSE

Chairman and Managing Director, BASF Australia Ltd (Victoria)



Mr Pilling has made major contributions to the application of science and technology in the chemicals industry. He has built a relevant Australian-based chemical company through a deeper and broader engagement between BASF's global organisation and Australia's research community. In 2014, Mr Pilling led BASF through a major transformation, refocusing on five key growth industries. He is a Director of PACIA (Plastics and Chemicals Industry Association), which developed a Strategic Industry Roadmap outlining how the Australian industry can work with governments and other stakeholders to take advantage of opportunities in the Asian region.

DR SIMON POOLE FTSE

Director, Finisair Australia (NSW)



Dr Poole has been a world-leading researcher and entrepreneur in photonics over more than 30 years, with achievements covering R&D and the commercialisation of advanced technology, including the promotion of export-competitive Australian industry. He is noted for the successful commercialisation of advanced technology on an international

scale. He led the establishment of an export-competitive photonics industry in Australia, with significant contributions in R&D leadership, innovative entrepreneurship and capital-raising. He has founded manufacturing companies in Australia that have generated nearly \$800 million in high-value-add export revenues over the past 20 years. He won a Clunies Ross Award in 2013.

PROFESSOR FRIEDER SEIBLE FTSE

Dean of Engineering and IT faculties, Monash University (Victoria)



Professor Seible is a world leader in the design and construction of structures under extreme loadings. His substantial global contribution has delivered improvements in the capacity of buildings and bridges to withstand earthquakes and bomb blasts. Professor Seible works to explore the potential of new materials across a range of disciplines including fibre-reinforced polymers, where the design, construction and strengthening of myriad structures is able to connect engineering and medicine to discover and create exciting new applications. Professor Seible is a Fellow of the US Academy of Engineering and a Foreign Fellow of the Chinese Academy of Engineering.

MR DOUGLAS SHEARS FTSE

Chairman, ICM Australia Pty Ltd (Victoria)



Mr Shears is a leading agribusinessman. His national and international contributions include creating high-profile food brands, initiating Australia's 'clean, green' image, creating the first commercial organic food consumer product, enhancing water-use efficiency in agriculture, and refining food flavour and freshness technologies. Mr Shears established ICM Australia, a leading privately owned agricultural and pastoral company. He is a former owner and developer of the brands Uncle Tobys and Berri Fruit Juices, as well as feedlots, and horticultural and herb and spice businesses. He is a former Director of CSIRO and Member of the Prime Minister's Science Council.

ATSE IN FOCUS

PROFESSOR ANNE SIMMONS AM FTSE

Professor, University of NSW (NSW)



Professor Simmons is an outstanding innovator, mentor and role model for young women in engineering and has helped shape biomedical

engineering in Australia. She is one of the leading experts in Australia and prominent internationally in medical device technology innovation and commercialisation. Prior to her current appointment, she headed the Graduate School of Biomedical Engineering at UNSW. Professor Simmons has had successful careers in both industry and academia. For nearly 20 years with the Nucleus Group, she was involved with the development, commercialisation and distribution of a range of novel medical devices and technologies.

PROFESSOR MICHELLE SIMMONS FAA FTSE

Professor, University of NSW (NSW)



Professor Simmons is ARC Laureate Fellow and Director of the ARC Centre of Excellence for Quantum Computation and Communication

Technology at UNSW. She leads a team of some 180 researchers developing a radical, uniquely powerful, ultra-secure computing technology. As a consequence of both her leadership of the Centre and her own ground-breaking research program in the development of atomic-scale electronics, Australian researchers are now at the international forefront of classical and quantum computing technologies in silicon. Her research has important implications for the semiconductor industry and is anticipated to be transformational in the field of quantum computation.

DR JENNIFER STAUBER FTSE

Chief Research Scientist, CSIRO (NSW)



Dr Stauber is Australia's foremost ecotoxicologist who has pioneered the development and application of environmental assessment techniques for contaminants for regulators and industry. She is a leading international

expert on contaminants in aquatic systems, whose research on metal bioavailability, ecotoxicology and direct toxicity assessment underpins the Australasian water and sediment quality guidelines used for environmental regulation of chemicals. Dr Stauber serves as expert ecotoxicologist on several technical advisory committees for Australian government departments, EPAs and the resources industry on issues as diverse as coal seam gas, hazardous waste, mining, desalination, acid sulfate soils and water quality.

MR DAVID STEWART FTSE

Director-General, Department of Premier and Cabinet, Queensland (Queensland)



Mr Stewart is a civil engineer with demonstrated expertise in successfully implementing major government transport and infrastructure

projects, using innovative technologies and delivery mechanisms. He has led government agencies, where he has focused on policy development, service delivery and planning and delivering large, complex and challenging infrastructure programs. On several occasions Mr Stewart has been named by Engineers Australia in its Top 100 Engineers listing. He has held roles in industry and government, including with Arup, Costain, Concrete Constructions, Brisbane City Council, and Queensland and NSW departments.

PROFESSOR SALAH SUKKARIEH FTSE

Professor, University of Sydney (NSW)



Professor Sukkarieh is Professor of Robotics and Intelligent Systems, School of Aerospace Mechanical and Mechatronic Engineering, and Director of

Research and Innovation at the Australian Centre for Field Robotics. He is a pioneer in the research, development and application of robotics and intelligent systems. He has worked with a range of companies and government organisations to apply these technologies in industrial and civilian applications for Australian and international benefit. He is a world leader in autonomous navigation and mapping for robotic aircraft

and in the application of this technology to operational systems in aerospace, biosecurity and agriculture.

PROFESSOR ELIZABETH TAYLOR AO FTSE

Consultant, Taylor Professional Services Pty Ltd (NSW)



Emeritus Professor Taylor is an acknowledged leader of Australia's engineering profession – in education, accreditation, the participation of women,

professional practice and humanitarian aid. She serves as a consultant or volunteer to government inquiries, organisations and advisory bodies. She chairs Engineers Australia's Accreditation Board, RedR Australia and International RedR and chaired the Board of Professional Engineers Queensland. She is a former Dean of the Faculty of Engineering and Physical Systems, and Pro Vice-Chancellor and Executive Dean of the Faculty of Sciences, Engineering and Health at Central Queensland University, and a former President of the Australian Council of Engineering Deans.

Professor Branka Vucetic FTSE

Professor, University of Sydney (NSW)



Professor Vucetic is recognised as a world leader for her contributions to channel coding theory and its applications in wireless communication

systems. Her innovations have had a world-changing impact on technology. She led a team that invented soft output detection and decoding methods that made mobile phones more reliable. She also produced significant achievements in the field of signal processing for multiple-input multiple-output antennas and wireless sensor networks that are leading the next phase of transformational smart infrastructure technologies. She held various research and academic positions in the UK, Yugoslavia and Australia before joining the University of Sydney in 1986.

ATSE IN FOCUS

PROFESSOR DAVID WHITE FTSE

Professor, University of WA (WA)



Professor White is the world's leading expert on pipeline geotechnics. His contributions have transformed geotechnical practice in pipeline engineering throughout the offshore sector. He has developed new field and laboratory techniques to measure engineering properties of seabed sediments that are relevant to pipeline design; led joint industry projects that have transformed the geotechnical understanding and design methodology for pipelines throughout the offshore oil and gas sector; and pioneered a revolutionary flume for assessing pipeline and seabed stability during storms. A Cambridge-educated engineer, Professor White is a former ARC Future Fellow and was WA Young Scientist of the Year (2011).

PROFESSOR MARY-ANNE WILLIAMS FTSE

Director, Disruptive Innovation, University of Technology Sydney (NSW)



Professor Williams is an international authority on artificial intelligence (AI) and human-robot interaction. Her research has changed design paradigms in intelligent systems and significantly advanced decision-making under risk and uncertainty in open, complex and dynamic environments. The results of her work have been adopted by industry, including IBM, Infosys, Boeing and Visual Risk, and leading international research groups at CNRS France, Stanford University and Carnegie-Mellon University. Her high standing both in academia and industry is acknowledged through numerous awards, invitations and distinguished appointments.

DR PAUL WOOD FTSE

Director, P&R Wood Partners (Victoria)



Dr Wood is recognised internationally as a scientist and commercial R&D leader particularly for his unique discoveries for the diagnosis of human and bovine tuberculosis (TB). As a researcher at CSIRO he

was responsible for the discovery of a novel patented technology for diagnosing TB in beef cattle. He moved to CSL to lead its veterinary products R&D. The unique TB technology was developed at CSL for human diagnosis and was commercialised internationally by CSL and subsequently Cellectis. Dr Wood spent four years as Executive Director of Pfizer Animal Health in the US and shared a Clunies Ross Award in 2013.

DR KATHERINE WOODTHORPE FTSE

Chair, Antarctic Climate & Ecosystems CRC (NSW)



Dr Woodthorpe has advanced Australia's ability to derive substantial value from translation of research outputs into tangible outcomes and benefits for scientists, research organisations, governments and industry. She has made substantial contributions to the Australian technology and science translation landscape over the past 25 years. During this time, she has had a significant influence on government policies that now enable and encourage technology-based companies to achieve their potential. She has been a leader at the nexus of industry and academia through her senior governance roles with technology companies, CRCs and NCRIS, UTS Council and university-owned ventures.

PROFESSOR ZHIGUO YUAN FTSE

Professor, University of Queensland (Queensland)



Professor Yuan is a distinguished researcher whose innovations in the field of integrated urban water management coupled with a strong industry engagement have significantly increased the efficiency and productivity of Australia's water industry and its global reputation. He has made major contributions to the science and practice of wastewater process engineering, overall systems optimisation, and infrastructure operation and maintenance with an emphasis on sewer corrosion management. His collaboration with Australia's major water utilities has achieved documented savings exceeding \$400 million. He is Future Technologies

Program Leader for the CRC for Water Sensitive Cities and won a Clunies Ross Award in 2015.

2015 FOREIGN FELLOW

DR KE LIU FTSE

Vice President, Haldor Topsoe (China)



Dr Liu has made outstanding contributions in coal gasification, IGCC, catalysis and olefins production. His influential leadership in shaping modern coal refining technologies spans basic science through to its application, with more than 80 patents. He and his teams have several world-firsts: a technology to measure catalyst coking in-situ, a catalyst for production of ethylene, an on-board gasoline processor for fuel cell cars and the world's largest IGCC plant. In recent years he led a highly influential team at Shenhua Research/National Institute of Clean and Low-carbon Energy (NICE), tackling reducing emissions from the use of coal.

The new Fellows include eight prominent women – sustaining again the Academy's policy of electing one-third of its new Fellows from female candidates – and one Foreign Fellow.

ATSE IN FOCUS

The Graeme Jameson story

Graeme Jameson grew up steeped in engineering. "My father, grandfather and great-grandfather were all engineers, which takes you back to the steam era. They were all practical people."

By the time young Graeme was deciding on what course his career in the family trade would take, all sorts of new technologies were emerging in the aftermath of World War II.

"My imagination was captured by the birth of the plastics industry, and the growth and power of the nuclear industry." That moved him towards chemical engineering. But his path led not to either of those areas, but to a lifetime working on bubbles – improving the efficiency and application of the mineral-processing technology known as froth flotation.

Froth flotation is a process by which water-attracted (hydrophilic) particles are separated from water-repellent (hydrophobic) particles in a container of liquid. The hydrophobic particles are picked up and swept away by bubbles – thin films of liquid surrounding air – which form a froth on top of the body of liquid. The froth eventually bubbles over the lip of the container, carrying its load of hydrophobic particles with it. This means that hydrophobic mineral particles containing base metals such as copper, zinc and gold, for instance, can be separated from the hydrophilic particles of waste or gangue material with which they occur. The process was patented in England in the 1860s, but first

commercialised in Broken Hill in 1896.

Graeme had his first close look at flotation working part-time at a tin smelter while he undertook his engineering degree at the University of New South Wales. The company had a flotation machine with which valuable metals had been recovered and used to make bearings for the war effort.

In his final undergraduate year, Graeme undertook a project on the unusual properties of bubbles. And when he went to the University of Cambridge to do his PhD it seemed almost a natural progression that he would end up under the supervision of Professor John Davidson, one of the world's most eminent bubble scientists.

After completing his doctorate and working for two years in the oil industry in California, Graeme went back to academia at Imperial College London in the mid-1960s.

A colleague suggested he look at the problem of the recovery of fine mineral particles using flotation. It was an attractive proposition. Not only did it fit with his prior research, but Graeme also recognised its particular application to the Australian mining industry. In deposits such as at Mount Isa, the material being mined, while of high quality, was increasingly finely dispersed, and many of the particles were too small to be picked up by the flotation technology of the time, where the bubbles were about three millimetres in diameter.

By the time he returned to Australia in the late 1970s, after more than a decade of work

in London, Graeme knew he had a solution. The bubbles needed to be much smaller, about 10 times smaller, and they also needed to be produced at a rate of billions per second. All he had to do was find a way to generate them.

It was his former supervisor, John Davidson, who inadvertently provided the answer when he published a paper that included an equation which allowed the prediction of the size of bubbles generated under prescribed liquid conditions. On the basis of this work, it turned out that a key factor was the shear rate – and a suitable shear rate for Graeme's purposes could be established when a jet of liquid plunged into the container to form the froth.

"It's like the froth you get when you squirt a hose into a bucket with detergent when you're washing the car."

And that became the heart of the Jameson Cell. A jet of a slurry of mineral particles, together with the air it draws in, is injected from the top of the cell through a large nozzle, the downcomer. The result is the production of a turbulent cloud of billions of small bubbles about 0.3 mm in diameter in the cell beneath.

But the invention of innovative technology is only part of any story of commercialisation. The next bit – persuading companies to invest the vast amounts of money needed to buy and install new technology – is often tougher. Luckily, in the mid-1980s Mount Isa Mines (now Glencore Xstrata) had a team of highly qualified and

WENDY CRAIK HEADS CLIMATE AUTHORITY

Former National Farmers Federation head Dr Wendy Craik FTSE is the new chair of the Climate Change Authority.

She is one of five new appointments to the Board, which already include Professor Ian Chubb FTSE.

Dr Craik, a former Productivity Commissioner, is Deputy Chancellor of the University of South Australia.

She was chief executive of



Wendy Craik

the Murray–Darling Basin Commission from 2004–08.

Environment Minister Greg Hunt, announcing the appointment, said Dr

Craik would bring a wealth of experience to the role.

The Climate Change Authority was established by the Gillard Government to provide independent advice on emissions caps and targets under its carbon scheme. It is working on a review of emissions trading schemes and due to report this year.

MEERA VERMA NOW HEADING BIOSA

SA Division Chair Dr Meera Verma FTSE has been appointed Acting CEO of BioSA, an initiative of the South Australian Government that focuses on bringing innovative SA products and technologies to global markets.

BioSA claims to have facilitated significant company and job growth, increased exports and attracted investment capital to SA over the past 14 years, emphasising Adelaide's "world-class facilities in research and commercialisation, and a network of high-growth, emerging technology companies".

ATSE IN FOCUS



Graeme Jameson with the then NSW Governor, Dame Marie Bashir AC CVO FTSE, when named NSW Scientist of the Year in 2013.

talented research metallurgists at Mount Isa who were prepared to look at and actively help test Jameson's new cell.

"Those sort of people don't exist at mines these days," Graeme says.

Once the technology had been demonstrated, the company eventually decided to buy and use the technology, which it has now sold on to hundreds of mines in 24 countries. The advantages of the Jameson Cell

include the fact that it recovers 95 to 98 per cent of fine particles between 0.05 and 0.12 mm in diameter. There are no moving parts in the cell itself, which means that it can be made tough and requires relatively low maintenance – very important to an industry in which the workplaces are often in remote and harsh environments.

The only energy used in the Jameson Cell is the electricity to pump in the slurry jet, and the efficiency of the system is such that fewer cells are needed to do the same job as previously. Not only that, but the technology is relatively inexpensive, with a short payback time, and is easily scaled up.

Mount Isa Mines soon found other applications, primarily at its coal mines where the Jameson Cell could scavenge the high quality fine particles of coal, increasing the yield of mines overnight by 3.5 per cent or billions of dollars. But that has only been the beginning. As the technology has been improved by Graeme, his students and others, it has also found application in Canada extracting bitumen from oil sands, along the Dead Sea recovering potash, and in Australia cleaning up waste water and removing suspended solids in the food and wine industries.

Meanwhile, Graeme and his students have been busy extending the capacity of the Jameson Cell to pick up particles at both ends of its range, both finer and coarser. Initially, they developed a cell that made use of shock waves to increase the chance of ultrafine particles contacting bubbles. The Concorde Cell has been successfully trialled at a nickel concentrator in Western Australia, a platinum

mine in South Africa and a copper mine in New South Wales.

But Graeme thinks his new technology to capture coarser particles, the NovaCell, is much more important and it's not hard to see why. The two great costs of base metal mining are those of extraction and of concentration. Each runs at about 43 per cent of the total. All the other expenses – transportation, taxes, royalties – only amount to 14 per cent. And for mining and concentration, by far the greatest cost is energy.

Most of the energy expended in concentrating the ore is used in grinding it to the necessary particle size for flotation. If that particle size could be made larger, less grinding is required, thus less energy and resulting in less wear and tear on the grinding equipment. In fact, Graeme estimates that his NovaCell can reduce overall mining costs by between 10 and 15 per cent, or multiple billions of dollars.

Once again, the solution was relatively simple. As usual in innovation, you just had to see it. The problem with large particles is that they are often torn off the bubbles to which they attach by the turbulent mixing established in the Jameson Cell. The solution is a gentler action to generate and agitate the bubbles. This can be achieved by filling a container with mineral particles and bubbling water and fine bubbles gently up from the bottom in the process, which creates a kind of liquid, a fluidised bed.

So, once again, Graeme Jameson has the answer. The next step will be commercialisation – convincing industry to adopt his new technology.

DST GROUP SIGNS HTS DEAL

DST Group has joined with Siemens and Queensland University of Technology (QUT) in an Australian-first research agreement to advance the use of high temperature superconducting (HTS) technologies in Australia.

Chief Defence Scientist Dr Alex Zelinsky FTSE signed the agreement in a ceremony at the Pacific 2015 Maritime Exposition. It consolidates existing relationships and enables the partners to coordinate capabilities and knowledge regarding the performance

and applications of HTS technology to academic, industrial and defence challenges.

Dr Zelinsky said that the partnership would focus on transitioning research to outcomes that could deal with real-world problems, starting with its potential applications to defence.

"This agreement is in line with our strategic goal to partner with the best talents in industry and academia to achieve a capability edge for defence," Dr Zelinsky said.

DST Group has strategic alliances with 12 defence companies and research agencies, and partners with 28 universities across



(From left) Alex Zelinsky, Professor Arun Sharma (QUT Deputy Vice-Chancellor), Michael Wycisk (Siemens AG) and Jeff Connolly (Siemens Australia CEO).

Australia to deliver game-changing capability for the future of the Australian Defence Force.

ATSE IN FOCUS

Suresh Bhargava wins Chemeca Medal

Professor Suresh Bhargava, Deputy Pro Vice-Chancellor (International Research) and the Director of the Centre for Advanced Materials and Industrial Chemistry at RMIT University, has been awarded the 2015 Chemeca Medal, the most prestigious award for chemical engineering in Australia and New Zealand.

He was recognised for his “outstanding contribution” to the profession and practice of chemical engineering and for his continued service to the profession. Professor Bhargava won the 2011 ExxonMobil Award in recognition of his significant ongoing contributions to chemical engineering. A world-renowned interdisciplinary scientist, Professor Bhargava has also created many chemical technologies through his outcome-focused research and is recognised for linking industrial and international partners in developing tertiary education in Australia.



Suresh Bhargava

He has received prestigious national and international awards, including the Indian National Science Academy's PC Ray Chair (distinguished lecture series 2014), RMIT University Vice-Chancellor's Research Excellence Award (2006 and 2014), Applied Research Award (2013), RK Murphy Medal (2008, Royal Australian Chemical Institute), John A. Brodie Medal (2010, Australian Institute of Chemical Engineering) and the Indian Institute of Chemical Engineers Chemcon distinguished speaker award (2010).

Professor Bhargava provides consultancy and advisory services to many government and industrial bodies around the world including BHP Billiton, Alcoa World Alumina, Rio Tinto and Mobil Exxon.

PETER GRAY PULLS STUMPS AT AIBN

Academy Vice-President Professor Peter Gray, who has headed the University of Queensland's Australian Institute of



Peter Gray

Biotechnology and Nanotechnology since 2003, is retiring from the role and returning to Sydney to live.

He is a pioneer of biotechnology R&D in Australia. Before joining AIBN he was Professor and Head of Biotechnology at UNSW

Professor Gray was born in Sydney and educated at the University of Sydney and the UNSW. He has held academic positions at University College London and at the University of California, Berkeley, and has had commercial experience in the US working for Eli Lilly and Company and the Cetus Corporation.

He was a founder and a past President of the Australian Biotechnology Association (Ausbiotech) and has led the Academy's Research Engagement for Australia (REA) initiative over the past year.

Professor Gray's main research interests have been in the production of biopharmaceuticals by mammalian cell cultures, and his research group has an extensive collaborative network of international research groups and corporations. He has been an ATSE Fellow since 1992, and is a Fellow of the Australian Institute of Company Directors and Engineers Australia. Professor Gray has served on the boards of several companies and research organisations both in Australia and overseas, and is active on a number of government committees in the areas of pharmaceuticals, education and training.

With his colleagues at AIBN he has built a major research institute of international standing that is active at the interface between the biological, chemical and physical



NSW Division president Richard Sheldrake (right) presents the Malcolm Chaikin Medal to Peter Farrell.

sciences, as exemplified by research programs developing new therapeutic processes based on stem cells, and clean energy production from nanotechnology in fuel cells.

PETER FARRELL TALKS KEY DRIVERS

Dr Peter Farrell AM FTSE, founder and Chairman of ResMed Inc and one of Australia's foremost entrepreneurs and innovators, delivered the fourth Malcolm Chaikin Oration to more than 60 Fellows and guests at an ATSE dinner in Sydney in September following the NSW Division's annual meeting.

His oration outlined ResMed's key drivers: entrepreneurship to create value though recognising opportunities combined with innovation based on success in the marketplace.

Most important, he said, were world-class people, integrity, a clear path to commercialisation, timeliness, competitive technology assessment “and the alpha factor – do we really love it?”.

Dr Farrell said the five characteristics that made a leader were moral courage over the long term, judgement and common sense, a sense of priority, effective allocation of time and energy, and a sense of humour.

Dr Farrell founded ResMed in 1989 and has seen it grown into a global player with annual revenue of US\$1.7 billion, 4500 employees, 5000 patents and designs and operations in more than 50 countries. The company has 1500 staff based in Australia.

ResMed's focus is on products that diagnose, treat or help in the control of sleep disorders, such as sleep apnoea and chronic obstructive pulmonary disease.

ATSE IN FOCUS

Maree Smith's pain drug awarded



Professor Maree Smith (centre) with Johnson & Johnson Medical CEO Gavin Fox-Smith and AusBiotech CEO Dr Anna Lavelle FTSE

The University of Queensland's Professor Maree Smith FTSE and the company founded on the ground-breaking pain drug she developed won awards at the AusBiotech 2015 conference.

Spinifex Pharmaceuticals, a company founded by UQ's commercialisation company Uniquet, was successful in the Australian Company of the Year category of the Johnson & Johnson Innovation 2015 Industry Excellence Awards.

Professor Smith, the inventor of Spinifex's lead drug candidate for chronic pain, took out the Industry Leadership Award, which recognises passion, enthusiasm and commitment to the industry.

Uniquet CEO Dr Dean Moss said the awards added to an impressive list of achievements for Spinifex and Professor Smith.

"Spinifex was acquired in July this year by global pharmaceutical giant Novartis AG for an upfront cash payment of US\$200 million, plus undisclosed clinical development and regulatory milestone payments," Dr Moss said.

"It is thought to be one of the largest deals in Australian biotechnology history – a reflection of the wonderful work of CEO Tom McCarthy and his team in growing the company, developing an attractive pipeline and guiding their chronic pain treatments through the regulatory and approval process.

"These treatments, which are based on Professor Smith's work, are now on the threshold of the marketplace. They are set to bring a new approach to pain management for millions of pain sufferers around the world.

"Professor Smith has pursued translational research at UQ for more than 20 years and played an active and integral role in the global biotech industry. It's wonderful to see her tireless efforts recognised on the national stage."

FOREIGN FELLOW BOB WHITE HEADED NAE IN US

Dr Bob White FTSE, President Emeritus of the US National Academy of Engineering (NAE) and ATSE Foreign Fellow since 1995, died in Maryland on 14 October, aged 92.

He was best known as the US's top weatherman, overseeing the launch of pioneering weather satellites and sounding early warnings about the threat of climate change.

Dr White served under five US Presidents – Kennedy, Johnson, Nixon, Ford and Carter. He was appointed Chief of the US Weather Bureau by President John Kennedy in 1963. Two years later, President Lyndon Johnson made him chief of the newly created Environmental Science Services Administration, an operation that merged the Weather Bureau and the federal Coast and Geodetic Survey.

In 1970, that organisation became the National Oceanic and Atmospheric Administration, which Dr White led under Presidents Richard Nixon, Gerald Ford and Jimmy Carter before stepping down in 1977.

In the 1970s he was the chief negotiator for the US in bilateral agreements with the Soviet Union for exploration of the world's oceans and with France on oceanography.

Dr White was described by *Time* magazine as "as dervish-like as the environment he has set out to control", according to the *Washington Post*. "He was credited with helping persuade Kennedy of the potential peaceful

uses for satellites during the space race with the Soviet Union. Kennedy was assassinated months after selecting Dr White for the Weather Bureau post," the *Post* said.

"Under Dr White's leadership, the US launched the first operational system of full-time weather-monitoring satellites. That system – along with weather balloons, weather buoys at sea, airplanes and increasingly powerful computers – allowed scientists to gather ever-more sophisticated data.

"The data, in turn, were used for frost predictions for farmers, maritime weather forecasts and preparation for natural disasters such as storms, hurricanes and tornadoes."

Dr White was honoured for his extensive contributions through numerous prestigious awards, such as the Vannevar Bush Award and the Tyler Prize for Environmental Achievement, as well as honorary degrees.

Dr White is survived by his wife of 67 years Mavis, and his children Richard and Edwina (Nina) White. His brother, Pulitzer-Prize-winning author, journalist and historian Theodore H. White, died in 1986.

Dr White was elected a Member of the NAE in 1968 and served as President from 1983–95.

During his tenure he helped the NAE fulfil its mission of technical leadership and to advance understanding of engineering in the technical and policy communities, the news media, and the general public.

He is also credited with strengthening the institution's role in the growth of the International Council of Academies of Engineering and Technological Sciences (CAETS) as well as other international engineering academies, thereby creating new opportunities for global collaboration in the advancement of engineering.

In addition, he strengthened the NAE identity through initiatives such as the establishment of the Charles Stark Draper Prize for Engineering, the world's premier international award for engineering achievement.



Bob White

ATSE IN FOCUS

Railway honour for Buddhima Indraratna



Buddhima Indraratna (right) receiving the RTSA Individual Award from NSW Transport and Infrastructure Minister Andrew Constance.

Professor Buddhima Indraratna, Professor of Civil Engineering and Founding Director, Centre for Geomechanics and Railway Engineering, University of Wollongong, has

been awarded the 2015 RTSA Individual Award to honour his contribution to the railway industry in the Asia-Pacific region.

The Railway Technical Society of Australasia (RTSA) is a joint Technical Society of the Institution of Engineers Australia and the Institution of Professional Engineers New Zealand. Its main objective is to promote cooperation of academic, industrial, commercial and government organisations in advancement of railway technology and management.

The award citation recognised Professor Indraratna's overall career achievements and the impact he has made to the rail industry worldwide, influencing the technical standards and rail practices with respect to track design, as well as construction and maintenance through both fundamental and applied research. In particular, the citation acknowledged his efforts that have

revolutionised track infrastructure in terms of design innovations and extended longevity, enabling faster trains carrying heavier loads.

Professor Indraratna, who founded the Centre for Geomechanics and Railway Engineering at the University of Wollongong, is also a Program Leader of the ARC Centre of Excellence in Geotechnical Science and Engineering, which focuses on transport infrastructure as a major theme.

He has won an array of previous awards: Engineers Australia Transport Medal (2011), BHERT Award for Railway Innovations (2009), CS Desai Medal (2014) by the International Association for Computer Methods and Advances in Geomechanics, Thomas Telford Premium (2015) by the Institution of Civil Engineers and the Inaugural Ralph Proctor Lecture for Transport Geotechnics of the International Society for Soil Mechanics and Geotechnical Engineering.

O'BRIEN STILL DISCOVERING APOLLO 12 AFTERMATH

Dust storms have been discovered on the surface of the Moon as delayed effects of an Apollo mission, changing the image of the airless Moon from being inert with no movements except the impacts of meteorites, which sporadically pock-mark its smooth surfaces.

Adjunct Professor Brian J. O'Brien FTSE, of the University of Western Australia's School of Physics, using measurements by the matchbox-sized Apollo 12 Dust Detector Experiment he invented in January 1966, says "after Apollo 12 astronauts left, the first few sunrises caused dust storms of decreasing strength that swirled like ground mist across the moonscape and settled in a few hours. The dust storms occurred because surfaces had been disturbed by Apollo rocket exhausts during landing and departure, and each dust storm progressively smoothed those disturbed surfaces."

The Apollo 12 experiment consisted of three solar cells with a vertical solar cell facing east. Each sunrise during the first three lunar days this vertical cell measured sudden changes in brightness of the dawn moonscape consistent with sunlight scattering or being dimmed by moving clouds of dust. Over these three days the horizontal solar cell accumulated 30 per cent of the total dust measured over the following six years.

This fine but sharp-edged and sticky dust caused serious problems with Apollo moving parts, such as inside chronometers, and cut into the cuffs of the astronaut's spacesuits causing them to leak in the vacuum of the Moon.

The new report by Professor O'Brien and UWA student Monique Hollick (now published online in the *Journal of Planetary and Space Science*) also reports an accompanying discovery – a new phenomenon

of "horizon brightening". The dawn horizon became about one to four per cent brighter than direct sunlight seamlessly at the completion of sunrise for about an hour after 14 of the first 17 sunrises. The effect was not detected on the following 61 lunar days.

Professor O'Brien's simple model explains the two new discoveries by combining for the first time two extremes of lunar forces, the dynamic energising effects of sunrise and the natural stabilising cohesive forces of lunar dust.

"Curiously," he says, "the cohesive effects were discovered and reported from Apollo 14 in 1971 then ignored until I publicised them in 2011."

Professor O'Brien warns that future spacecraft may meet such unexpected new operational problems from dust on their second and third days on the Moon. He extends his warning about lunar dust to the international competitors for the \$30 million Lunar XPrize to land and work a lunar rover, whose closing date has recently been extended to 2017.

"Nobody predicted this dust discovery, although now it makes common sense. However, several of our dozen previous discoveries were also unpredicted."



Brian O'Brien with Apollo tape and Dust Detector.

Graduate Research Training.

www.unimelb.edu.au/research/



Join Australia's Best Minds

The University of Melbourne is seeking high calibre PhD students to contribute to projects at the forefront of international research.

At the University of Melbourne, one of Australia's leading research universities, you will become part of a dynamic research community, working alongside the best and brightest researchers in the country.

Our generous scholarship programs provide students with financial support and opportunities for international fieldwork and travel.

To find out more about undertaking a graduate research degree at Melbourne, visit: www.unimelb.edu.au/research/

dream large





UQ Boomtown Toolkit[®] - for the ups and downs of rapid change

Recent development of the substantial coal seam gas reserves in Queensland has stimulated significant social and economic changes. These impacts can be difficult to gauge and respond to as data is not always available, easily understood, and accepted as relevant and credible by residents, industry, and government.

Researchers at The University of Queensland (UQ) have developed the UQ Boomtown Toolkit[®] which is a novel approach to social impact assessment. It is designed to enable communities near large projects to gain long-term benefits from the opportunities presented during periods of rapid change. This adaptive assessment approach is now accessible as an online tool kit. The tool kit is being introduced in several local government areas in Queensland to help industry, government, and communities work together to generate positive outcomes.

The UQ Boomtown Toolkit[®] includes eight 'tools'. Used individually or together they promise to facilitate more

effective planning and monitoring of social change from large infrastructure projects. This research is supported by the UQ Centre for Coal Seam Gas (CCSG) with researchers and PhD students from UQ's Centre for Social Responsibility in Mining. The UQ CCSG supports 31 research higher degree students across UQ. Learn more about UQ CCSG at ccsg.uq.edu.au

ccsg.uq.edu.au

The Federal Government's 2012 Excellence in Research for Australia exercise confirmed The University of Queensland as one of the nation's top two universities, measured by the quality of its comprehensive range of specialised research fields. ERA reported that research at UQ is well above world standard in more specialised fields than at any other Australian university; this reflects UQ's leading global role in many areas of discovery. UQ's outstanding critical mass offers researchers significant interdisciplinary capability.

Join more than 4,000 students currently pursuing a research higher degree at UQ. Visit uq.edu.au/grad-school



**THE UNIVERSITY
OF QUEENSLAND**
AUSTRALIA

Create change