

FOCUS

NUCLEAR ENERGY FOR AUSTRALIA?

ITS ROLE IN THE NATION'S SUSTAINABLE ENERGY MENU

Contributors discuss the key technological, economic, social and environmental issues relating to nuclear power generation.

Resources / Solving the energy ‘trilemma’

April 2013 / 1 / Alan Thomson



+ Like Goldilocks’ porridge, the best energy must not be too expensive, not too unreliable and not too carbon intensive.

How do you decide on the perfect energy source to meet all your future needs?

Anyone familiar with the global energy debate knows it can be impenetrable, volatile, subtle and highly complex – often simultaneously.

Yet at its heart lie three basic issues – affordability, security and climate impact.

It is this ‘trilemma’ that keeps engineers, economists, environmentalists, NGOs, politicians and consumers in a constant state of heated debate as the parties argue their case for the best way of meeting our energy needs now and in the future.

It is certainly a tricky balancing act. People worried about carbon emissions argue for greater use of nuclear, solar, wind and tidal power to reduce our reliance on fossil fuels and keep the spirit of the Kyoto Protocol alive.

Anyone interested in geopolitics will point to arguments over energy security; the influence of OPEC; or the ability of certain states to turn off the gas taps if they don’t feel that they are being accorded enough respect, to take just a few examples. In these cases, they might favour domestic solutions such as hydro, coal and shale gas where available.

And pity the poor consumers who have to pay for it all. Over the generations we have been told that practically limitless free energy lies just around the corner, if only the technology can just be refined for nuclear fusion / fission / solar / wind / biofuels (delete according to age / location).

All this while populations in many regions worry more about whether they can even afford energy to cook or heat their homes rather than how it might impact climate change effects or be vulnerable to geopolitical insecurity.

Like Goldilocks’ porridge, the best energy must not be too expensive, not too unreliable and not too carbon intensive. Unlike Goldilocks, however, few are likely to see a fairy tale ending to this story any time soon.

For most of us in the real world, the only answer to meeting our future energy needs lies in diversity.... *Read the rest of Alan’s blog at: www.thoughts.arup.com/post/details/282/solving-the-energy-trilemma.*

Contributor /
[Alan Thomson](#)



I lead Arup’s energy business in the UKMEA region.

A civil engineer by training, with over 25 years of experience, I’ve worked on a diverse range of energy related projects covering all modes of energy generation, distribution and storage. I am a Fellow of the Institute of Civil Engineers.

Since joining Arup in 2004, I’ve also launched the UK Energy Legislation Timeline which is now an industry recognised reference document.

Email me:
energy@arup.com

Thoughts /

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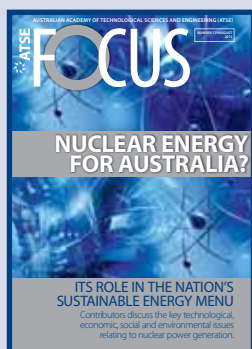
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Front cover: The Australian nuclear debate is complex.

PHOTO: iSTOCKPHOTO.COM



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FOCUS

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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

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Putting nuclear in the debate

The environmental importance of nuclear power is perversely illustrated by the worsening CO₂ emissions from Japan and Germany as they mothball their nuclear plants post-Fukushima.



By Alan Finkel

alan@finkel.net

Imagine two worlds, 50 years from now. In both, electricity supplies the vast majority of the energy needs. In both, technology has transformed lifestyles in ways we cannot even imagine today. But in one there are rolling blackouts; in the other the electricity supply is absolutely reliable.

Might the utilisation of nuclear energy be the difference between these two worlds?

It's a question we need to ask, but on the issue of nuclear energy Australia has its head in the sand. We have avoided debate on the nuclear power option and that has blinkered our vision.

This is disappointing because, as a huge and reliable supplier of uranium to the world's reactors, Australia has a moral responsibility to address issues of how the uranium is used and disposed of after use.

But beyond *moral* responsibility, there is also a pressing *environmental* reason for Australia and other countries to actively consider nuclear electricity generation.

To substantially reduce global greenhouse gas emissions the world has to massively reduce its dependence on fossil fuels. The only way to do this is to convert our electricity supply to use low-emissions sources, then generate two or three times more so that we can use the additional electricity for transportation and heating.

That has to be the goal. The question is, how do we generate the massive amounts of clean electricity that we need to achieve it?

ATSE has previously argued that Australia needs a mix of new and existing technologies. If nuclear is not included as part of the mix it will be difficult to achieve the abundant, reliable supply of low-emissions electricity needed to meet our goals.

In short, nuclear power is a transformational opportunity.

A current example of the

environmental importance of nuclear power is perversely illustrated by the worsening carbon dioxide emissions from Japan and Germany since they mothballed their nuclear plants post-Fukushima.

Meanwhile, across the border from Germany in France, 78 per cent of the electricity comes from nuclear and 12 per cent from hydro. In France, the grid average emissions level due to electricity generation is a mere 85 grams per kilowatt hour – 10 times lower than the 850 grams per kilowatt hour grid average emissions in Australia. These figures speak for themselves.

What's needed in Australia and elsewhere is a large-scale, always-available source of electricity to supplement the anticipated large-scale deployment of

intermittent solar and wind electricity.

But nuclear is not the only solution. Perhaps coal with carbon capture and storage, or geothermal, will grow to the required scale. However, the rate at which these can be adopted at commercial scale is unknown and cannot be relied upon.

Natural gas and hydroelectricity can also fill the need, but each has its problems.

Natural gas from conventional, shale and coal-seam sources is abundant, modest in cost and flexible. But although it has a much better emissions profile than coal it does not come close to the near-zero emissions of solar, wind and nuclear. Hydroelectricity is ideal, but there isn't enough of it and local environmental objections will prevent large-scale new construction.

PHOTO: ISTOCKPHOTO

Nuclear power is a transformational opportunity.



So one of the challenges is to show why nuclear electricity must be considered as part of the mix if confidence is high that some of these alternative sources will become practical at the needed scale.

Another challenge is to identify solutions that do not require governments to accept too much political or actual risk. If we are ever to have a successful nuclear industry in Australia it is essential that it be extremely safe, with generators that produce little long-lived or weapons-grade waste, with durable management of the waste that is produced, and protected transport of materials.

To achieve the required level of safety we would need a vigorous regulatory system and the adoption of internationally proven, standardised reactor designs. The latter might even include small modular reactors of 300 MW or lower capacity. These have been used in ships and submarines for nearly 60 years with an excellent safety record.

It's not an impossible dream. Despite public perception to the contrary, the nuclear industry has an enviable safety

record. Consider that there were no deaths from nuclear radiation at Fukushima, and the ongoing risk of radiation-linked cancers from that event is near zero.

Indeed, death rates from nuclear energy are so low that a case can be made to deploy nuclear electricity generation specifically to reduce death and disease.

James Hansen, well-known climate change activist, acknowledges this argument. He and a colleague this year published a paper calculating that between 1971 and 2009, 1.8 million deaths were avoided by generating electricity at nuclear rather than fossil fuel power stations.

Per terawatt hour produced, nuclear electricity causes less than one-hundredth of the deaths caused by the coal industry, even in wealthy regions like the US and Europe.

And then there are the financial challenges. Nuclear construction is ploughing ahead in China and India, but has stalled in the US. Although 24 applications have been submitted to the Nuclear Regulatory Commission, most are held up, not specifically because of safety concerns, but for financial reasons.

The Economist magazine identifies natural gas as the culprit. The gas price fell from \$13 per million BTUs in 2008 to just \$2 last year, although it has since risen back to near \$4. This low price reflects the technology-driven growth of the shale gas industry, which is transforming energy economics in the US.

So for nuclear to compete on economic terms it has to be cost-competitive against natural gas in those countries that have abundant gas reserves. In the absence of a substantial carbon tax or new ways to reduce the cost of nuclear, this is not currently the case.

One of the challenges is to identify ways that nuclear capacity might be built and operated at lower cost, in a robust regulatory regime. One has to ask: is the most effective way to promote consideration of nuclear electricity to advocate for a carbon tax? In Australia today, the opposite is the case. Pre-election policies from both sides have rejected carbon taxes. From one side, the policy is to eliminate carbon pricing entirely. From the other side, the decision is to replace the carbon tax with an emissions trading

FIVE KEY POINTS FROM THE NATIONAL NUCLEAR ENERGY FOR

Some 200 national and international experts and delegates from diverse backgrounds met at Sydney's Powerhouse Museum in July to debate Australia's potential use of nuclear energy at the conference 'Nuclear Energy for Australia?'

Organised by the Academy, through its Energy Forum and the NSW Division, and attracting an impressive array of overseas and Australian speakers, the two-day conference saw robust discussion and debate on a variety of topics related to nuclear energy.

Academy President Dr Alan Finkel told the conference Australia had economic, environmental, social and public health responsibilities to broaden the public and political debate on nuclear energy. Issues for debate include technology evaluation, system economics, attraction of capital, reduction of emissions, and management of radiation safety and waste disposal. He said the nation had pressing climate change reasons to consider a transformational opportunity to achieve its declared clean energy targets.

The conference heard presentations from leading international and Australian authorities spanning the opportunities and threats inherent in nuclear and other energy options available to Australia.

The five key points, captured in a communiqué issued after the conference, were:

1 Nuclear is a viable technology for Australia

Nuclear power generates 11 to 12 per cent of the world's electricity. For Australia, nuclear is a suitable candidate to replace ageing coal power stations, despite recognised challenges. Exhaustive discussion found no supportable reason to omit consideration of nuclear from the generation mix.

2 Australia must be prepared

To ensure Australia is prepared when the need arises, action is needed now to plan and put in place the necessary legal and regulatory instruments, as well as adequate educational and training facilities.

3 Public and political acceptance is crucial

Public acceptance and bipartisan, long-term energy policies are essential prerequisites for large-scale nuclear investment. Wide-reaching consultation is critical. The keys to success are transparent policy development, widespread community consultation and a robust regulatory system, capitalising on Australia's strong regulatory history.

4 Nuclear reduces emissions

Nuclear power offers negligible greenhouse gas and other emissions, as do renewable energy sources, but with better health and safety outcomes. Only nuclear (of the proven technologies) can replace coal as a baseload (constantly available, high capacity) low-emission source. Natural gas offers partial emission reductions but cannot achieve Australia's ambitious reduction targets.

5 Nuclear risks are well studied and manageable

All forms of energy conversion entail some level of risk, however small. Australia has a proud record of risk management. Nevertheless, the public still has concerns on nuclear power that need to be openly discussed. These must be properly acknowledged and addressed.

scheme destined to reduce the permit price to a level where it will have no impact.

The rejection of carbon pricing is a mistake.

Price of fossil fuels makes a difference. In Japan, to reduce the massive burden of expensive fossil fuel imports the Japanese Government and energy companies are already seeking to re-open some of the nuclear plants closed after the Fukushima disaster. In Australia, coal is so cheap that without a carbon tax it is difficult for alternatives to compete.

In the meantime, much of the world is living in an alternative reality. There is a common perception that solar and wind are already starting to make a dent in global carbon dioxide emissions. The average person would believe this is the case, but it is simply not true. From 2000 to 2009 total world solar and wind generation combined rose by 260 terawatt hours but total world electricity generation increased by 4700 terawatt hours, mostly from coal and gas – the combined new solar and new wind generation was less than one-tenth of the total increase.

This is why global carbon dioxide emissions continue to rise by almost one per cent every year. Earlier this year, we passed 400 parts per million, a symbolic milestone. At 40 per cent above the historical average, this is a level that the planet has not seen for more than a million years. None of us know exactly what the impact of these elevated levels will be, but it is unlikely to be desirable.

We need to do something. So far, solar and wind have failed to meet the growth in global electricity demand. If we go the extra mile and replace fossil fuels with electricity for transport, heating and industrial processes we need to generate the required electricity using large-scale, low-emissions solutions. Nuclear energy should be considered as a contributor.

But at the end of the day, the real challenge is societal. How do engineers deliver the level of comfort that society demands? For much of the population nuclear power represents the sword of Damocles waiting to strike us down. This is totally out of proportion to the real risks.

Clearly the way forward is to advocate

for a strongly regulated industry, with standard designs and standard operating procedures. But then how does one preserve the elements of competition that lead to better designs and lower costs?

When evaluated by the lessons of history, nuclear energy may well turn out to be one of the most extraordinary and exciting opportunities mankind could ever have been bequeathed. Australia cannot afford to dismiss this opportunity without an open debate.

DR ALAN FINKEL AM FTSE is an engineer, entrepreneur and philanthropist. He has been Chancellor of Monash University since January 2008 and President of ATSE since January 2013. For 20 years Dr Finkel ran Axon Instruments, an American company that made electronic instruments and was later CTO of Better Place Australia, a company that will provide clean energy to run Australia's future fleet of electric cars. Dr Finkel established two magazines – *Cosmos*, which promotes science awareness, and *G magazine*, which promotes environmental sustainability. Dr Finkel currently serves as the Chairman of the Australian Centre of Excellence for All-Sky Astrophysics.

AUSTRALIA CONFERENCE

Key conference speakers were:

- Professor Peter Guthrie, Professor of Sustainability, Cambridge University, UK – The global challenge of sustainability;
- Dr Ron Cameron FTSE, Head, Nuclear Development Division, OECD Nuclear Energy Agency, France – Australia and the world nuclear energy situation;
- Mr Seong-key Cho, General Manager, Overseas Nuclear Project Development, KEPCO, Korea – Korea's nuclear role;
- Dr Massimo Salvatores, Senior Scientific Advisor to the Director of the Nuclear Energy Division, CEA, France – Nuclear technology options;
- Dr Timo Äikäs - Executive Vice President, Posiva Oy, Finland – Waste disposal technologies and community acceptance;
- Mr Ian Hore-Lacy, Senior Research Analyst, World Nuclear Association, UK – Why nuclear power?;
- Professor Tony Owen, Professor of Energy Economics, UCL International Energy Policy Institute, Australia – Liberalised electricity markets and long-term capacity adequacy;
- Professor Andrew Pitman, ARC Centre of Excellence for Climate System Science, UNSW – Climate change: status of the science;
- Emeritus Professor Ian Lowe AO FTSE, Professor of Science, Technology and Society, Griffith University – Social attitudes and concerns;
- Mr Ben Heard, Director, ThinkClimate Consulting, Australia – Achieving community support;
- Mr Michael Angwin, CEO Australian Uranium Association – What is the Australian uranium industry capable of?;
- Dr Carl-Magnus Larsen, CEO Australian Radiation Protection and Nuclear Safety Agency – Health impacts of nuclear accidents;
- Dr Robert Floyd, Director-General Australian Safeguards and Nuclear Proliferation Office – Why nuclear safeguards and security matter;
- Professor Dale Bailey, Royal North Shore Hospital and Sydney University – Achievements in nuclear-related technologies;
- Professor Ken Baldwin, Director, Energy Change Institute, ANU – Renewable and low-emission technologies;
- Dr John Sligar FTSE, Director Sligar and Associates – Managing the addition of nuclear and renewables;
- Mr Bruce Wilson, Acting Executive Director Bureau of Resource and Energy Economics – Comparative costs and scenarios;
- Mr Martin Nicholson, Director MN Information Technology Group – Potential Impact on the Australian Economy;
- Dr Ian Duncan FTSE, Consultant – Nuclear Regulator for Australia;
- Professor Graham Davies, Dean of Engineering, University of NSW – Meeting our human resource needs;
- Professor Paul Greenfield AO FTSE, Chairman ANSTO – ANSTO's role in protecting Australia's interest and options in global nuclear science and technology; and
- Dr Djurica Tankosic, President Global Nuclear, WorleyParsons – Engineering and construction opportunities.

The conference organising committee was led by Mr Martin Thomas AM FTSE, Chair of the Academy's Energy Forum.

Conference speakers have contributed a number of articles in this edition of *ATSE Focus*. All conference presentations and media releases are available on the ATSE website (www.atse.org.au)

Australia and the world nuclear energy situation

In Australia, concerns over the affordability of the changes needed to decarbonise the electricity sector represents the best argument in favour of nuclear.



By Ron Cameron
ron.cameron@oecd.org

A nuclear power plant.

PHOTO: ISTOCKPHOTO

Governments throughout the world have to deal with the energy challenge – to find the correct equilibrium for a national energy system built around the concepts of energy security, low carbon and affordability, often depicted as the energy triangle

Moving too far in any one direction has a direct effect on the others. Countries with high security of supply from unmitigated coal do not achieve low carbon energy systems, while those who set high standards for low carbon emissions have affordability issues.

Security of energy supply has two dimensions: the external, or geopolitical, dimension and the internal dimension that includes technical, financial and economic issues.

Nuclear energy has some distinct advantages in strengthening the *external dimension* of energy supply security. This includes the facts that: it is a quasi-indigenous source of electricity, with a large part of its value sourced domestically; it has a low dependency on fuel supply (and even then the majority of the uranium comes from well-distributed and politically stable countries); and it is capable of providing large amounts of baseload

power at stable costs with no vulnerability to changes in greenhouse gas policies.

With regard to the *internal dimension*, it is a stable form of generation with good price stability and high levels of reliability.

In terms of the mitigation of climate change, electricity systems produce about 40 per cent of all greenhouse gas emissions. The decarbonisation of the electricity system has been set as a major goal in many countries and is strongly advocated by international organisations. For example, the International Energy Agency (IEA) has promoted a greenhouse gas reduction scenario (the 2DS scenario) that can maintain the rate of increase in global temperatures to 2°C.

While many other initiatives and policies will contribute to the decarbonisation required in the 2DS scenario, most of these are behind schedule and the necessary reductions in greenhouse gas emissions are not occurring at the rate required. Without significant action, the ‘window’ for 2DS is predicted to close by 2017. In a recent publication, the IEA note that “the global energy system is not getting cleaner, despite efforts to advance clean energy” and “the world’s governments are failing on almost every level to clean up their energy systems,

and must intervene to support nuclear power”.

The rush to introduce renewable energy sources, such as wind and solar, has significantly increased electricity costs and is causing concern in the number of the European countries who took the early initiative to promote renewable energy targets. Costs to industry in European countries have risen by more than 38 per cent since 2005, while the corresponding costs in the US have decreased by four per cent. This significantly affects the competitiveness of European industry.

In addition, the investments needed in infrastructure and support for low-carbon technologies has led to significant increases in household electricity prices in many countries. The four countries (Denmark, Germany, Spain and Italy) with the highest household prices are those with the most aggressive renewable energy targets. Australia sits just behind this leading group in terms of household prices of electricity, with prices having increased by 70 per cent over the past four years.

Nuclear today

Nuclear power provides about 13 per cent of global electricity demand and about

20 per cent of that in OECD countries. Since 1971 it has avoided the commission of more than 80 billion tonnes (80 Gt) of carbon dioxide. Currently, there are some 434 reactors. Between 1995 and 2013 the number of reactors remained virtually unchanged, but the installed capacity grew by more than nine per cent (341 to 371 GWe) due to upgrades and replacements. Its share of electricity generation varies from four to 78 per cent in OECD countries.

Currently, there are 68 reactors under construction – the majority in China, but also significant construction in Russia, India and Korea. For the first time since the 1980s, construction is occurring in the US and construction is planned in the UK. However, the rate of construction is not sufficient to provide the level of greenhouse gas mitigation that is required under the 2DS scenario put forward by the IEA. This projects the need for 1100 GWe of nuclear power by 2050 and would require a construction rate of about 16 GWe per year, which would see nuclear energy providing around 20 per cent of global electricity.

For a short period of time in 2005–10, new construction starts were increasing at a rate compatible with the type of growth needed. However, following the Fukushima accident, the growth stalled while many countries undertook reviews of their nuclear programs or conducted a series of stress tests of the reactors.

Germany, Switzerland and Belgium all took decisions to phase out their nuclear programs but many other countries reaffirmed their commitment to increasing nuclear power, such as Canada, the UK, Poland, the Czech Republic, Turkey, Vietnam, Russia, Korea, UAE and India. After a period of review, China has announced a resumption of its nuclear growth, with a projected increase of 40 GW over the period to 2025.

Major challenges

Major challenges still lie ahead for nuclear power, including:

1 Public acceptance – which declined markedly after the Fukushima accident but is now recovering in many countries;

2 Institutional and legal frameworks to provide long-term stability and political commitment to the introduction of nuclear power;

3 Adherence to construction programs and budgets for the new generation of nuclear reactors – sufficient numbers of reactors must be built of the Generation III type to enable lessons to be learned from experience and costs to be reduced;

Security of energy supply has two dimensions: the external, or geopolitical, dimension and the internal dimension that includes technical, financial and economic issues. Nuclear energy has some distinct advantages in strengthening the *external dimension* of energy supply security.

4 The re-establishment of industrial infrastructure and supply chains if the required rate of nuclear build is to proceed;

5 Radioactive waste disposal remains a concern for the public and demonstration of the ability to manage high-level waste is essential – good progress is being made in Finland, Sweden and France, with these three repositories expected to be operational by 2025;

6 Liberalised electricity markets do not provide for price certainty and discourage investors in high-capital-cost technology, such as nuclear – innovative funding methods are now being used in countries such as Finland, France and Turkey, either cooperative or build, own, operate (BOO) models; and

7 The development of skilled human resources and knowledge management systems.

A good fit?

Australia has many advantages in availability of fossil fuels and the opportunity for relatively efficient deployment of renewables, but it has also significant uranium resources and good geology for waste disposal. Despite government efforts, Australia remains a very large per capita emitter of CO₂ and carbon capture and storage (CCS) is not proceeding at the rate expected. More serious efforts must be devoted to electricity system decarbonisation.

Renewables offer significant potential, especially in meeting peak loads in warmer months but are intermittent and cause significant system costs for grid connection, reinforcement and back-up. These system costs increase over-proportionally with penetration level, in the absence of affordable storage. Some form of baseload is needed and the choice seems to be either coal with CCS or nuclear.

Dealing with the GHG emissions of fossil fuels and the intermittency of renewables will lead to increasing prices to the consumer for electricity.

On a basis of already relatively high electricity prices, the issue of affordability for households and competitiveness for industry becomes critical. Nuclear power offers low operational costs over long periods, but needs longer-term electricity price stability, bipartisan support and better public acceptance to gain access to the market.

In Australia, the concerns over the affordability of the changes needed to decarbonise the electricity sector represents the best argument in favour of nuclear. But many non-economic issues need to be addressed before this could become a reality.

DR RON CAMERON PSM FTSE is Head of the Nuclear Development Division of the OECD Nuclear Energy Agency, which provides advice to 30 member governments on policy and strategic issues related to all aspects of nuclear power development and the nuclear fuel cycle. Previously, he held senior roles at the Australian Nuclear Science and Technology Organisation. He has more than 30 years' experience in nuclear science and technology in the UK, Australia and with the International Atomic Energy Agency (IAEA), involving both power and research reactors. He has had extensive involvement in nuclear policy advice, international affairs and strategic planning.

**CONTRIBUTIONS
ARE WELCOME**

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

Managing the addition of nuclear and renewables

Adopting nuclear technology will slow the need to double the generation fleet and add high-voltage DC transmission lines, as well as reduce the necessary system transition funding pressure over time.



By John Sligar
sligarj@sligar.com.au

The Australian national electricity market (NEM) provides power to more than 90 per cent of the Australian population. The NEM supplies the eastern section of Australia with a length of about 5000 kilometres stretching from North Queensland to Tasmania and South Australia to the eastern coast. It has operated a deterministic energy market with a high level of reliability for more than 10 years. It operates with a reserve margin of above 15 per cent and has recently suffered two highly disruptive changes brought about by the Renewable Energy Target scheme (RET) and the advent of a carbon tax.

The market is competitive with a wholesale power price about \$55 per MWh and a demand pattern of daily evening peaks together with annual summer peaks. There are strong intra- and relatively weak inter-connections arising from the previous

state-based power systems. Because of the large unit size the transmission lines are well loaded, feeding 11 load centres made up of cities and aluminium smelters. Fault levels are considered normal and the low voltage distribution networks feed customers in a one-way flow regime.

The NEM has about 50 GW of generation plant – mainly some 50 large coal-fired generators – and supplies about 200 TWh of power per annum. About 95 per cent of this plant is directly dispatchable with unit capacity of 100 to 750 MW feeding the transmission network at about 25 kV. This concentration of fossil generation releases significant greenhouse gas.

Black (53 per cent) and brown (29 per cent) coal provide more than 80 per cent of the power generated, with hydro (10 per cent), gas and wind comprising the balance.

The system operator maintains a

national transmission development plan (NTNDP) for the next 20 or so years, covering expected demand and requirements to fulfil this. The prediction for 2030 is set out in Table 1. Concurrently it has prepared a report (AEMO 100 per cent Renewables) illustrating how the power system might look from 2030 or some future date with all generation arising from renewable resources, also shown in Table 1.

This latter report identifies generation resources slightly differently in that dispatchable resources are subdivided into 'base-dispatchable', consisting of geothermal, biomass and bagasse, and 'peak-dispatchable', consisting of hydro, pumped storage, central solar/ integrated storage and biogas. Wave has been added to the non-dispatchable list with wind and solar. While numbers may vary due to technology development the shape, direction, and order

POWER SYSTEMS

Power systems are made up of three components. The first is the demand from customers, which defines the remainder of the system developed to serve them. The second is the connections to link customer load with the generators, made up of a high-voltage network to move large tranches of power over long distances together with a low-voltage network to connect to the customer at the desired voltage level. The third is the generators that provide the power to meet customer needs. These are intimately tied together as a power system. The power system recognises two types of generation: dispatchable and semi-dispatchable. The former represents generation resources that have an availability of about 95 per cent, which need no support from the system but provide inertia support. Examples include fossil fuels, nuclear, water, geothermal and biomass. The latter represent generation resources with an availability of about 35 per cent, which need significant support from the system to be a contributor but which provide little inertia support for the system. Examples of this form of generation resource include wind, solar and wave. Renewable generation is present in both categories, with wind and solar predominating.

Table 1 Generation resources and output % in the future

Resource	NTNDP TWh	NTNDP %	AEMO 100%
Coal, black	135	62	-
Coal, brown	36	17	-
Gas CCGT	19	9	-
Gas OCGT	2	-	-
Hydro	16	8	~ 8
Wind	37	17	~ 14
Solar PV	2	-	~ 26
Solar CST	-	-	~ 9
Biomass/bgse	5	-	~ 12
Geothermal	-	-	~ 26
Biogas	-	-	~ 3

Source: AEMO NTNDP 2030, AEMO 100% Renewables (draft)

of magnitude are considered appropriate.

It identifies a change in the operation of the power system from a deterministic basis to a stochastic base with attendant limitations because of its probabilistic nature. While maintaining overall reliability the frequency is seen to become more variable. The necessary reserve margin for this system is set at about 215 per cent, requiring considerable investment to double the required generation capacity for stable operation. The ongoing disruption from the emission trading scheme (ETS) is noted.

2030 plus

By 2030 or beyond, system demand has increased in a new market of unknown design arising from changes to the existing competitive market. The daily peak has changed from evening to noon with an annual winter peak. The wholesale cost of power has risen to about \$115/MW.

With respect to delivery of power the same strong intra- but weak inter-connection remains a problem. New transmission lines necessary to bring renewable generation from remote areas, where it is located, tend to be lightly and variably loaded in character with the natural availability of the resource. The number of load centres has been reduced to six cities with the closing of all aluminium smelters. Assembly networks have developed to raise the wind generation voltage from about 600 V up to transmission line voltage. Generation feeding the low-voltage networks has resulted in two-way flow in these networks with safety and other problems in these exchange networks.

The major change has been in generation, with some 10,000 small generators and one million very small generators feeding the system. About 35 per cent of these are dispatchable compared with about 95 per cent previously. Unit capacity has fallen to 2 to 5 MW with a generation voltage of about 600 V. Assembly networks have developed in remote regions and exchange networks have replaced distribution networks to cope effectively with the number of generators.

PHOTO: ISTOCKPHOTO



Impression of a nuclear fuel rod.

Power system in transition

Managing the transition from the present towards 100 per cent renewable generation in an orderly manner, while comparing the effects of adding nuclear or renewable generation, will mean:

- 1** The operation of the system will change from a deterministic basis to a stochastic one with attendant changes in the management of the system. System load factor will fall from about 55 per cent to about 26 per cent as the reserve margin needs to rise from about 28 per cent to about 215 per cent. We will need to develop a management protocol for cyber attack, requiring considerable additional investment.
- 2** The prime change will be the loss of smelters and other manufacturing loads previously dependent upon cheap

power. There will be ongoing rises in the residential and commercial loads as a function of population growth.

3 With respect to the high-voltage transmission network there will be a reduction in load centres from 11 to five. Rotating inertia contribution to system stability will decrease, combined with additional flow from demand management and non-dispatchable generation. The additional AC and DC transmission lines will be relatively lightly and variably loaded because of the nature of the natural generation contribution. Assembly networks will be necessary to bring together the small low voltage generators to raise them to transmission line voltage, which will also require considerable additional investment.

LETTERS TO THE EDITOR

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4 With respect to the low-voltage exchange network replacing the previous distribution network, generation will be allowed within the network, resulting in potential two-way flow of power complicating safety and other considerations significantly. As the load in these networks rises local congestion will become a significant factor, especially as the present one million owners of small photovoltaic generators are also customers and voters.

The major result of these initiatives will be reduced greenhouse gas release. In achieving this, the generation capacity needs to be doubled at least to cover the required reserve margin of some 215 per cent for reliable operation. The competitive advantages of previous generators will change and there will be significant stranded assets.

With the changed relationship between service component and demand component in many power system fees and charges, the relationship between these needs to be revised to avoid financial problems

in the various organisations supporting the operation of the power system.

There is a need for considerable additional investment in all sections of the power system which is beyond the capability of the Australian investment industry. There is an ongoing need for international investment in the power system which requires focused, specific guided government policies to ensure continued reliable development of the industry.

The addition of significant tranches of renewable generation will reduce the release of greenhouse gases from the power system. It will hasten the necessary changes outlined above. In particular, it will eventually require doubling the generation fleet because of increased reserve margin requirements and addition of numerous high-voltage DC transmission circuits. It also assumes that renewable technologies are at commercial scale for efficient generation when required. It also assumes that the necessary investment funds will be available when required.

The addition of significant tranches of

nuclear generation will reduce the release of greenhouse gases from the power system. It will slow the changes set out above, in particular it will slow the need to double the generation fleet and add high-voltage DC transmission lines and provide extra time for less developed renewable technologies to prove their commercial worth. In particular, it will relieve the necessary investment funds pressure over time.

DR JOHN SLIGAR FTSE is the Director of Sligar and Associates, a small consultancy focusing on the future of the energy industry in Australia and Asia. It seeks to determine what changes will need to take place by 2050, how the transition will proceed and how organisations can take advantage of these changes. Other activities include new power industry technologies, power station management and coal technology.

Dr Sligar trained as a chemical engineer and was Chief Scientist of Pacific Power, the then largest electrical utility in Australia, managing about 150 investigators and researchers on various aspects of future generation technologies and immediate plant problems.

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CONTENT MATTERS

ANSTO: protecting Australia's interests and options

Nuclear energy is likely to be a significant part of the global energy mix well into the future as the need to decarbonise while maintaining reasonable costs is proving challenging.

ANSTO's OPAL research reactor.



By Paul Greenfield

vspgreen@mac.com

The world is increasingly seeing ever-larger cities, which are dependent on the availability of low-cost, dispatchable and predictable power supply. Having reliable supplies of a high quality energy source such as electricity is paramount in the operation and liveability of these major urban centres.

While the precise mix of future supply options cannot be predicted for any location with certainty, it is likely to involve a mix of centralised and de-centralised generation from a range of sources. For many countries, nuclear energy will be part of this mix.

ANSTO needs to retain its critical role in understanding nuclear systems that could be a source of future energy supply for Australia, and develop, with other energy actors, the optionality that this country will need in a carbon-constrained world.

The demand for energy in the Asia-Pacific region, let alone the world, will continue to grow as countries develop and increasingly urbanise. In 1800, only three per cent of the world's population lived in cities, a figure that had risen to 47 per cent by the end of the 20th century. In 1950, there were 83 cities with populations exceeding one million – by 2007 the (then)

ABOUT ANSTO

The Australian Nuclear Science and Technology Organisation (ANSTO) operates the OPAL multipurpose research reactor at Lucas Heights, Sydney, and the Australian Synchrotron at Clayton, Melbourne. The research reactor is used to generate radio-pharmaceuticals for Australian and overseas medical diagnoses and procedures and is a source of neutrons for a range of sophisticated instruments.

As well as operating these neutron and light sources on behalf of other researchers, ANSTO has its own and collaborative research efforts in materials research, life sciences and radionuclide chemistry, environmental research and uranium ore and radioactive minerals processing. The organisation provides advice to Australian governments on global trends in the development of nuclear energy. Australia retains a small but effective community of researchers connected to the long-term development of nuclear fusion and the materials that are used in these challenging conditions. In the absence of an operating nuclear energy industry, the role of research and development into matters nuclear and the international linkages that are sustained by ANSTO are vital if Australia desires to keep open the nuclear energy option. These linkages keep ANSTO abreast of areas such as reactor safety and reliability, new technology and policy developments and the changing regulatory and economic conditions being faced by the industry elsewhere.

Far Eastern Economic Review (FEER) estimated that this number had risen to 468.

FEER anticipated that, by 2025, Asia alone would have at least 10 megacities, including Jakarta (24.9 million people), Dhaka (26 million), Karachi (26.5 million), Shanghai (27 million) and Mumbai (33 million). The Nigerian Government estimates that Lagos will have expanded from its current 15 million to 25 million residents by 2015.

Australian cities are small in comparison, but they face the same issues. Liveable cities require energy and, in particular, electrical

energy – for lighting, heating, cooling, transport, industry and commerce.

Nuclear energy is likely to be a significant part of the global energy mix well into the future – but the need to decarbonise both electricity and transport fuels and achieve real cuts in carbon while maintaining reasonable costs is proving challenging even for mature economies with strong histories of innovation.

Decarbonising electric power

Energy systems only change comparatively slowly, and expectations that rapid

changes can be made cost effectively or sustainably have not been met in the real world situation. At present many countries are seeking to achieve reductions in their carbon intensity of around five to 20 per cent, but many scientists and climate modellers believe that far deeper cuts are required – and some countries have set targets that anticipate cuts of 80 per cent to current carbon levels.

The analyses of the requirements to make cuts at this level all show that renewables plus gas cannot achieve reliable baseload power, so it is inevitable that nuclear is a critical option for countries that do not have significant hydro resources.

Only two countries have achieved a genuine shift away from today's technology. The first of these is Brazil, which has transformed its transport sector through the broad application of biofuels in preference to fossil fuels. Brazil, a developing country with comparatively low carbon intensity, is clearly on a different trajectory to more established economies. France, the other country that has shown genuine and sustainable reduction in its carbon intensity, has underpinned its result by extensive use of nuclear power.

The UK has mitigated its growth in carbon intensity largely by a fairly comprehensive switch to gas in preference to coal and the use of an interconnect to France under the English Channel, which allows it to benefit from the low carbon intensity of French nuclear energy. The rather smaller changes in the US have resulted from a fuel switch from coal to gas and the use of nuclear power plant up-rates to leverage the existing fleet of nuclear reactors.

Most countries that have limited nuclear capacity and that are relying on a gas-plus-renewables strategy are likely to face insurmountable challenges in making the shift to sustainable low-carbon intensity. It is also important to recognise that the current policy settings and technological options available will simply not be able to make the change that is required without fundamental change in both the transport sector and in relation to electricity production.

Going deeper

The transport sector in many countries remains heavily dependent on fossil fuels, and in some economies industry process heat is also dominated by fossil

fuels. After 20 years of innovation and the search for a sustainable hydrogen economy, there is no credible shift that is not based on electricity that will replace the use of fossil fuels in these sectors.

The implication is clear.

Decarbonisation will require for the developed and the developing world the adoption of electricity as the primary energy source in transport and industrial applications, other than high-temperature process heat. In the case of process heat, it is likely that high-temperature gas reactors will become more important as deep cuts in carbon become necessary to protect future generations from climate change. The obvious consequence is that more hydro and nuclear plants will be required to provide reliable transportation energy sources and to support ongoing industrial expansion in the developing world.

The challenge for Australia is clear. Current policy settings exclude the nuclear option but the recent white paper on energy indicated that nuclear could be considered if renewables and alternative baseload technologies were unsuccessful.

Of the top 25 or so economies, Australia is alone in not being able to benefit from nuclear as a power source. Countries such as Germany, which has announced programs for eliminating nuclear power from its generation mix, already benefit from a low-cost nuclear energy electricity supply from countries such as France. The same is true for Denmark and Italy.

The development of nuclear energy around the world slowed briefly in the wake of the Japanese earthquake and tsunami and the resultant Fukushima accident in 2011. However, the industry has moved back into a period of growth. This can be seen across Asia, where there are 110 nuclear power reactors in operation, 47 under construction and firm plans for another 96 to be built.

Addressing the challenge

ANSTO has taken steps to improve its knowledge base with respect to providing advice to government. Proactive assessment of technologies has been undertaken more rigorously over the past few years, and this capability could be expanded in order to provide deeper insight into the nuclear options that are being adopted in the region and may be applicable in remote settings and grid applications.

ANSTO has also partnered with

UNSW TO OFFER NUCLEAR PROGRAM AGAIN

The University of New South Wales will offer Australia's only graduate program in nuclear engineering, beginning in 2014. Professor Graham Davies, Dean of the Faculty of Engineering, announced the new program at the *Nuclear Energy for Australia?* conference in Sydney.

"The UNSW Faculty of Engineering is a leader in energy research. By establishing a Nuclear Engineering Program and research group, we are adding a crucial element to our energy portfolio," Professor Davies said.

The Australian Nuclear Science and Technology Organisation (ANSTO) and the Sir William Tyree Foundation have each made donations to help establish the Nuclear Engineering Program. Imperial College, London, will also support the new UNSW program through a strategic research partnership.

"Irrespective of whether nuclear power is ever added to Australia's energy mix, there is a growing need for highly skilled engineers to maintain and operate existing and planned nuclear facilities around the world," Professor Davies said.

"This graduate program will prepare our students for international employment opportunities in the energy sector, as well as open pathways into a variety of nuclear careers in Australia that are not energy related."

The UNSW Nuclear Engineering Program will initially offer one and two-year masters degrees, with a scholarship scheme to help support students as well as funding for PhD research.

UNSW was the first Australian university to offer a nuclear engineering program. In 1954, then Vice-Chancellor Philip Baxter secured a £125,000 grant from the NSW Government to establish the Institute of Nuclear Engineering. This institute later became the School of Nuclear Engineering and was open until 1986.



Graham Davies

the university sector to restart nuclear engineering programs, and the current expansion of ANSTO's nuclear facilities has provided an opportunity to strengthen nuclear engineering capabilities and the domestication of core nuclear skills that can assist in underpinning regional and local nuclear build if government were to so decide.

In order to achieve these objectives ANSTO:

- operates a research reactor and the associated regulatory environment;
- proactively develops nuclear engineering, science and technology;
- links with Australian institutions that have capabilities in the nuclear field; and
- maintains international linkages and networks related to nuclear engineering, nuclear policy advice and nuclear best practice.

Whether or not nuclear power generation is added to the options available to Australian communities rests with future government policy; it would certainly appear unlikely in the very short term. As indicated from the evidence of studies that seek to show the link between energies and emissions, Australia faces significant

challenges in addressing carbon intensity. In this context it would be appropriate to acknowledge that Australia's capacity to engage with the full scope of global nuclear power options is dependent on ANSTO and some international engineering companies that have nuclear portfolios offshore.

Much can be learned from the type of policy development that has underpinned new build programs in democratic countries such as Finland and the UK. The pressing questions for Australia are:

- Can the open discourse on all technology options be maintained now that the energy white paper has explicitly recognised that nuclear can be a future option?
- What role should ANSTO play if this consideration is more urgent than is currently recognised?

Other policy questions include Australia's appetite and ability to have the higher prices and greater carbon footprint of Germany or Denmark or that would permit exploring lower-price options and reduced carbon footprint of countries like Sweden, France and South Korea. The CSIRO e-Future modelling tool (www.efuture.csiro.au/#scenarios) allows

exploration of these scenarios, which would allow a deeper public discourse based on realistic policy frameworks and timescales.

The cities of the future will not escape from the challenge of availability and predictability of power supply. Australia has one of the highest carbon intensities in the world, the slope of the curve has not changed in the past 10 years and we are firmly embedded in today's technology.

Retaining and growing the best possible knowledge – and creating an ability to introduce nuclear as an option into our future energy mix – is a practical and prudent path to adopt.

DR PAUL GREENFIELD AO FTSE is Chair of the Australian Nuclear Science and Technology Organisation (ANSTO) and a Director of ATSE. He also chairs the International Water Centre, a joint venture between four universities, and the International Energy Centre, a joint venture between three universities and Xstrata Coal. He has a PhD in Chemical Engineering from the University of NSW. Dr Greenfield was Vice-Chancellor (2008–11) of The University of Queensland. He has extensive experience as a company director and has worked widely with industry on a range of projects spanning the biotechnology, water and energy sectors.

Nuclear power has economic upsides



By Martin Nicholson

In late 2012, two government agencies produced models of Australia's future electricity generation mix out to 2050. The Department of Resources, Energy and Tourism (DRET) released the Energy White Paper (EWP) and CSIRO released eFuture.

The EWP reflected current government policy and did not include nuclear power while the CSIRO web-based modelling tool had provision to include nuclear.

The features of these models, and the scenarios from which they are drawn, make it possible to assess their respective impacts on the economy out to 2050 and hence to determine the specific impact of excluding nuclear energy from the mix.

The key areas of national economic impact evaluated are:

- the cost of greenhouse gas abatement;
- the cost of health damage from burning fossil fuels to generate electricity;

- the cost of electricity generation and its impact on retail costs;
- the jobs created in developing a nuclear power industry;
- the capital costs involved; and
- the cost of delaying the introduction of nuclear power.

My analysis shows that nuclear energy will:

- save \$130 billion in abatement cost;
- save about \$20 billion in health damage from burning fossil fuels;
- lower the generating cost of electricity by 20 per cent, reducing electricity bills;
- create 29,000 direct and indirect jobs in the nuclear industry; and
- require no additional capital investment to include nuclear power to replace alternatives.

Further delaying nuclear beyond 2025 could cost more than \$8 billion a year in abatement and health costs.

MR MARTIN NICHOLSON is Director, MN Information Technology Group. He studied mathematics, engineering and electrical sciences at Cambridge University. He spent most of his working life as business owner and CEO of a number of IT companies in Australia before researching energy and climate change. He has published two books – *Energy in a Changing Climate* (2009), on energy and its impact on climate change, and *The Power Makers Challenge* (2012), which explores the value of nuclear power as the primary low-emission electricity energy source for this century.



The Olkiluoto nuclear plant in Finland.

Local acceptance played a key role when selecting the site for spent fuel disposal. This was due to the fact that the municipality had a veto right in the decision-making process and a possibility to stop the site selection process.

Finland has faced the problems



By Timo Äikäs

More than 25 per cent of electricity consumed in Finland is produced with nuclear power. There are four nuclear power plants operated by two companies, TVO and Fortum, which jointly established Posiva Oy in 1995 to take care of the disposal of their spent nuclear fuel.

Legislation requires all nuclear waste generated in Finland be disposed of in Finland. Both companies are responsible for the onsite storage, processing and disposal of operational waste generated in their own power plants. Both plant sites already feature an operational disposal facility into which the operational waste generated during the operation of the plant is placed. Waste generated from the eventual decommissioning of the power plants is to be disposed of in the same facilities.

Site selection work started in 1983, screening potential candidate sites across the whole country. After the countrywide identification of potential sites and communication with local communities, five candidate sites were selected for investigation in 1987. Each of the sites was

subject to an extensive program of surface-based investigations and modelling studies. At least 10 deep bore-holes (up to 1000 metres deep) were drilled at each site.

The Finnish Government stipulated that a disposal site should be selected by 2000 and disposal commissioned in 2020. The spent fuel would be cooled in the interim storage facility for 40 years and would then be suitable for disposal.

In 1999 the Olkiluoto site in Eurajoki municipality (population 6000) was selected to host the deep repository. The site is located in the immediate vicinity of TVO's power plant, which is close to the town Rauma (population 39,000).

The environmental impact assessment procedure, which took place in all candidate municipalities in 1997–99, was an important tool for communication. It also provided a means for local people to voice their concerns and they actually balanced the discussion – bringing up not only the disadvantages but also the advantages of the project.

Local acceptance played a key role when selecting the site for spent fuel

disposal. This was due to the fact that the municipality had a veto right in the decision-making process and a possibility to stop the site selection process. In order to proceed with the final disposal preparations, local acceptance is required, but it cannot be created within a short period of time.

The Finnish Authority for Radiation and Nuclear Safety (STUK) has been an independent source of information for communities, which have been able to rely on STUK to supervise Posiva's work and results.

MR TIMO ÄIKÄS is the Corporate Advisor of Posiva Oy and graduated from the University of Turku in Finland in 1977 with a Master of Science in Engineering Geology. He started his professional career as a consultant working on construction, tunnelling and groundwater supply projects in Finland and abroad. He has worked in successively more senior roles for TVO in nuclear waste management. He headed the georesearch and engineering functions at Posiva before becoming Executive Vice President in 2009 and Corporate Advisor earlier this year.

Shaping a low-emission technology portfolio



By Ken Baldwin

Deployment of renewable energy sources – in particular wind and rooftop solar – are increasing rapidly in Australia, and with the continuing decreasing cost of these technologies this trend looks likely to continue.

According to the Australian Energy Technology Assessment (BREE 2012), wind is currently the cheapest form of electricity generation for new builds, with a levelised cost of electricity below \$100/MWh. Domestic rooftop solar has reached grid parity in most parts of the country, and by 2020 will be competitive on a large-scale commercial basis.

There are also prospects for other forms of low-emission technologies, including wave, geothermal and renewable biomass, although these are more dependent upon factors such as the price on carbon and first-mover barriers, compared to wind and solar.

Given the high cost of carbon capture and storage, it is unlikely that this will be deployed until much later (if at all) when carbon prices justify the required level of investment.

There are a number of important issues that arise with deploying renewables on a large scale. The first of these is intermittency, which can be addressed both by a combination of sources, and by a large geographic spread on our extensive national grid.

Experience both in Australia and overseas also shows that grid stability is less of a concern than anticipated, with grids capable of coping with high (more than 50 per cent) renewable penetration. More serious issues arise in the threat to the business model of the grid from widespread disseminated and behind-the-meter generation.

In the context of potential nuclear deployment in a carbon-pricing world, it is more likely that nuclear will take over the niche in the National Electricity Market NEM currently held by conventional

fossil fuel generation, rather than displacing renewable energy options.

To achieve the renewable energy future, Australia needs to:

- minimise government policy uncertainty to provide industry with certainty to plan investment;
- consider all options – including nuclear – recalling the Energy White Paper statement: *“Australia as a society must have a mature debate about our future energy directions. The more we limit our energy options, the higher will be the risk and cost of meeting our climate change and energy goals”*;
- address NIMBY-ism through education, providing leadership to deal with misinformation or lack of information on wind turbines, coal seam gas and nuclear power;

- address threats to the electricity grid through smoothing demand peaks and troughs; and
- tackle social equity issues, by addressing the risk that those who can least afford it will pay for excess generating/network capacity.

PROFESSOR KEN BALDWIN is the Director of the Energy Change Institute at the Australian National University, where he is also Deputy Director of the Research School of Physics and Engineering. Since 2011 he has been a member of the Project Steering Committee for the Australian Energy Technology Assessment (AETA), produced by the Bureau of Resources and Energy Economics (BREE) in the Department of Resources, Energy and Tourism. Professor Baldwin is an inaugural ANU Public Policy Fellow, and a winner of the Eureka Prize (2004), the W.H. Beattie Steele Medal (2007) and the Barry Inglis Medal (2010).

NIMBY-ism threatens wind and nuclear power and coal seam gas.



How can community support be achieved?



By Ben Heard

It is commonly assumed that Australians are 'anti-nuclear'. It is consequently often assumed that achieving community support for nuclear power is a large, perhaps insurmountable obstacle.

Neither assumption is true. The perception of Australian

attitudes to this issue is substantially out of step with the reality.

Through both direct outreach nuclear advocacy and recently published surveys of Australian attitudes to nuclear power, it is clear that while majority community support for nuclear cannot be taken for granted, it is well

within reach. An effective effort in building community support cannot be developed until this is understood.

The key elements in building community support for nuclear energy are:

- trust Australians;
- invite them to join a conversation;
- establish common ground;
- acknowledge legitimate concerns;
- provide the information required; and
- provide the positive vision Australia needs.

To win community support, nuclear energy proponents must deliver a positive vision of what a nuclear-powered Australia might look like, contest bad information, put positive information into context and acknowledge shortcomings, acknowledge existing support and occupy the middle ground.

There is existing support for nuclear energy evident in recent surveys, which showed 39 per cent support (against 40 per cent opposition) for the development of nuclear power plants 55 per cent support (against 29 per cent opposition) for the statement "we've seen the future and it's nuclear".

The greatest risk to this effort may lie in misjudging or underestimating Australians, and failing to realise the position of relevant strength from which such an effort will begin.

BEN HEARD is Director of ThinkClimate Consulting, which provides evidence-based analysis to aid decision-making on climate change and sustainability. He has a Masters of Corporate Environmental and Sustainability Management (MCESM) from Monash University and is one of Australia's most prominent nuclear advocates, presenting his work to audiences around Australia. He has written on nuclear power extensively in print and online media and in December 2012 launched *Zero Carbon Options*, an independently funded report with a first-of-a-kind direct comparison of nuclear and renewable options for the replacement of coal-fired electricity in Australia.

Figure 1 Strong supporter base

Australia should develop nuclear power plants for the generation of electricity. (Essential Vision, October 2012)

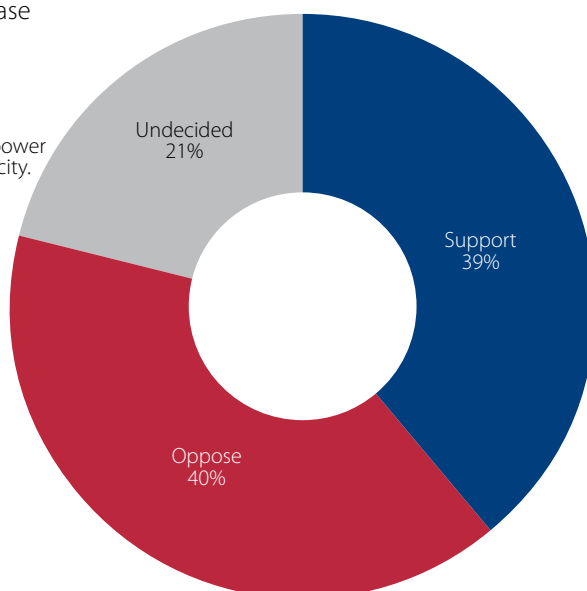
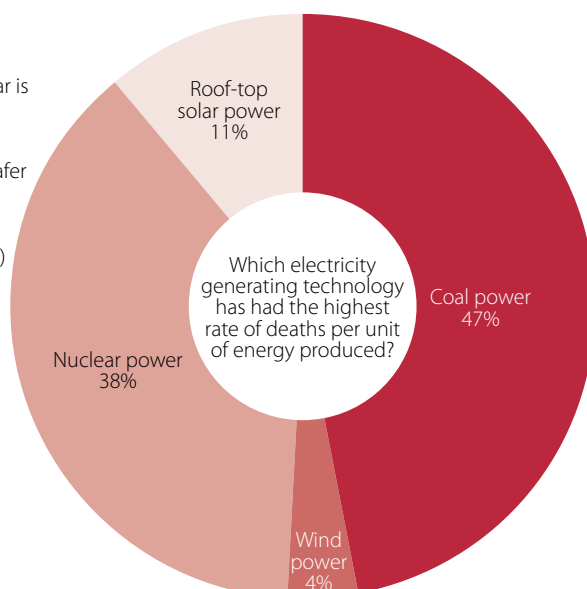


Figure 2 Address key areas for knowledge development

38% of respondents believe nuclear is more dangerous than coal. (Virulent Ideas 2012)

Nuclear power is about 10 times safer than coal in terms of accidents, and over 600 times safer than coal in terms of pollution.. (ExternE 2005, cited in *Lancet* 2007)



Leonie Walsh named Lead Scientist

Ms Leonie Walsh FTSE has been appointed Lead Scientist for the Victorian Government, to work closely with key scientific roles in agencies from within Victoria and around Australia to provide

strategic advice across the whole of government on issues impacting on Victoria's future.

Ms Walsh brings a wealth of experience to the role, having held senior R&D and product development positions internationally with Dow Chemical and locally with Visy Industries. She will be supported in the role by the Department of State Development, Business and Innovation, the state's lead economic and regional development agency.

In her capacity as President of the Australasian Industrial Research Group, Ms Walsh has led the development of new models for

collaborations between small to medium enterprise and researchers around major technology challenges facing society.

The Victorian Minister for Innovation, Services and Small Business, Louise Asher, said the appointment would enhance connections between Victoria's scientific and research community and industry.

"Ms Walsh will be responsible for fostering linkages across the innovation value chain, including industry groups, academic organisations and other publicly and privately funded science and technology based organisations," Ms Asher said.

"Ms Walsh will promote awareness in the community of the importance of science, technology and innovation in the state's future economic, social and environmental wellbeing."

WOMEN DOING BUSINESS GLOBALLY

A new generation of female global entrepreneurs is emerging in Australia, according to research conducted by the University of Melbourne and Women in Global Business (WIGB).

The first year's results are published in *Australia's Underestimated Resource: Women Doing Business Globally*, a new report released by the Parliamentary Secretary for Trade, Kelvin Thomson, and the Minister for the Status of Women, Julie Collins.

WIGB (www.wigb.gov.au), a joint federal, state and territory government initiative, commissioned the five-year study to shed light on women's growing contribution to Australia's economy through international trade.

The report focuses on Australian women active in global markets, both as employees responsible for the international operations of large companies, and as independent owner-operators. It found a large, active group of women-owned businesses operating across a wide range of foreign markets. These are predominantly young, small to

medium enterprises that internationalised in the past six years. Twenty-nine per cent of the women-owned organisations earn more than 50 per cent of their sales revenue internationally.

The research found baby boomers make up the largest demographic (54 per cent are 50 years old or more). These women are very well educated (over 70 per cent hold a bachelor degree or higher). Almost half (44 per cent) speak a foreign language.

The countries most frequently identified as the 'most important market' were the US (26 per cent), China (18 per cent), the UK (9 per cent) and New Zealand (7 per cent). Thirteen per cent of those businesses where the first international venture occurred in the past five years chose China.

Almost all those surveyed intended to continue expanding their global reach, suggesting positive flow-on effects for Australian exports and jobs.

CAROL COUCH TO HEAD WATER FLAGSHIP

Dr Carol Couch has been appointed Director of CSIRO's Water for a Healthy Country National Research Flagship, which is the largest research partnership focusing on water in Australia, with an investment of more than \$80 million dollars a year.

Dr Couch has a wealth of experience in both research and science administration and brings an international perspective to CSIRO. Dr Couch led the development of the first Water Plan for the State of Georgia in the US and also led the Georgia Drought Management Committee emergency response during the 2006–09 regional drought. She was lead scientist and adviser for aspects of water-quality investigations conducted by the US Geological Survey across multiple US states and led a team of scientists in the development of a national synthesis program for ecology for the US.

Dr Couch joined CSIRO in July 2011, leading its research on ecosystems and contaminants.

"Australia's water challenges are many and varied, but the Flagship's integrated, multidisciplinary approach to research and a commitment to strengthening partnerships with government, industry and communities, places it in the strongest position possible to provide timely, relevant and high-quality science for decision making," Dr Couch says.

"It is a challenging role but I am genuinely excited about the opportunity to lead the Flagship and direct research that can inform the management of water resources both in Australia and internationally."

She replaces Dr Bill Young, who is on secondment to a senior leadership role with the World Bank, South Asia Region Water Initiative, based in New Delhi, India.

The Water for a Healthy Country Flagship, established in 2003, is one of 11 National Research Flagships established by CSIRO as part of the National Research Flagships Program.



Leonie Walsh



Carol Couch

Women in Physics lecture tour

Professor Elisabetta Barberio, from the University of Melbourne, has been selected to present this year's Women in Physics lecture tour. She'll talk to both public audiences and school and university students across Australia.

Professor Barberio was chosen for both her significant contribution in the field of particle physics and her commitment to physics outreach.

She currently leads the ATLAS analysis effort at the ARC Centre of Excellence for Particle Physics at the Terascale. In 2012, her group had an important role in the discovery of the Higgs-like particle at the Large Hadron Collider that has recently been confirmed as the Higgs boson.



Elisabetta Barberio

PHOTO: CASAMENTO PHOTOGRAPHY

DSTO SCHOLARSHIPS FOR FEMALE STUDENTS

The Defence Science and Technology Organisation (DSTO) is offering scholarships in science and engineering for female high school and undergraduate students through the Australian National University, the University of New South Wales and the University of Adelaide.

Each of the three universities will award four scholarships to female students enrolled in undergraduate programs in either engineering, computer science, physics, chemistry or mathematics. The scholarships will be available from second semester 2013 over a four-year study period.

The students will be mentored by DSTO scientists for the duration of their studies and undertake projects relevant to DSTO. Selection will be made on the basis of academic merit, either through an applicant's Year 12 or undergraduate results.

Other factors such as interest in a career in defence, community leadership, involvement in extracurricular activities and referee reports will also be taken into account. Scholarship students who have completed a minimum of two years full-time study will also have the opportunity to participate in DSTO's summer vacation program.

"These scholarships demonstrate DSTO's commitment to broadening Australia's scientific base, which will provide Defence with access to a diverse, strong pool of talented scientists for the future," the Minister for Defence Science and Personnel, Warren Snowdon, said when announcing the scholarships.

ELISHEBA RADKE WINS THIESS-MCA AWARD

Elisheba Radke, who is studying for a Bachelor of Chemical and Metallurgical Engineering at the University of Queensland, has won the 2013-14 Thiess-Minerals Council of Australia Women in Engineering Scholarship.

Elisheba has an excellent academic record and a wide involvement in extracurricular activities, both on-campus (Women in Engineering) and off-campus (Women in Mining and Resources Queensland and community involvement). Her career goal is to work for a mining company in a remote region.

The Thiess-MCA partnership is helping identify the next generation of talented female engineers. Now in its sixth year, the award is open to all female undergraduate engineering students studying in Australia and provides \$8000 per annum for the final two years of study. It aims to advance the role of women in the resources sector.

Minerals Council of Australia Chair Mr Peter Johnson said the strong field of 75 eligible applicants for the scholarship showed there was a talent pool of women studying engineering disciplines, which would help increase the number of female engineers in the minerals sector.

The MCA also presented certificates to the three winners of the 2012 MCA scholarships for the Australian Institute of Company Directors (AICD) Company Directors Course – Vanessa Torres (BHP), Karin Baxter (BMA) and Sabina Shugg (Momentum Partners).

The MCA Women in Mining Dinner in June also featured detailed discussions around gender diversity, the aim of which is to:

- partner with MCA membership companies to identify industry-wide initiatives to increase female representation in the mining sector;
- achieve a consistent and informed understanding of the business case for improving gender diversity within the mining sector; and
- ensure that 'leading practice' gender diversity practices are embedded in the industry's culture.

NINA IS ONE TO WATCH

A University of NSW computer scientist who solved a long-standing computational problem has cracked a prestigious list of up-and-coming artificial intelligence (AI) researchers.

Dr Nina Narodytska, an adjunct researcher from UNSW and NICTA, is the first Australian to be featured in 'AI's 10 to Watch' – a list of top early career researchers compiled by the Institute of Electrical and Electronics Engineers (IEEE).

Dr Narodytska, who undertook a PhD and postdoctoral study at UNSW before moving to the University of Toronto in Canada in May, has been investigating optimisation theory for things like transport

networks, personnel rostering and logistical management of supply chains.

She has also been exploring ways that AI can be used for resource allocation and other problems in the areas of social welfare. This is a rapidly evolving field that lies at the boundary between computer science and economics.



Nina Narodytska

O'Kane Report a CSG landmark

The New South Wales Government should take steps to build public trust in its capacity to oversee a safe coal seam gas industry in the state, according to an initial report by the NSW Chief Scientist and Engineer, Professor Mary O'Kane FTSE.

Professor O'Kane confirmed wide-ranging community concerns about CSG in the report, part of her continuing independent review of CSG activities across the state.

She said the NSW Government and industry faced significant challenges going forward.

"CSG is a complex issue which has proven divisive chiefly because of the emotive nature of community concerns, the competing interests of the players, and a lack of publicly available factual information," Professor O'Kane says.

She said the debate had been fuelled by:

- unanswered concerns surrounding landholders' legal rights, land access and use, and human health;
- environmental concerns, particularly relating to impacts on water;
- engineering and operational processes; and
- industry regulation and compliance.

"The challenges faced by government and industry are considerable and a commitment from all parties will be required to improve the existing situation and build trust with the community," she said.

Professor O'Kane's initial report acknowledged that CSG extraction, like all forms of energy production, posed human health and environmental challenges. But it found many of those concerns could be offset by ensuring: engineering best practice; superb monitoring by industry; diligent and transparent compliance checks by regulators; and a rapid and effective response, then remediation, should an incident occur.

Professor O'Kane said the NSW Government could build public confidence by taking steps to prove its intent and capacity to oversee a safe CSG industry in New South Wales, including that:

- 1** It commits to establishing a world-class regime for extraction of CSG, including an insistence on industry best practice at all stages of CSG extraction – as well as:
 - the training of all employees and contractors;
 - rigorous, high-level monitoring and stringent compliance inspections;
 - hefty penalties for licences breaches, including possible licence revocation;
 - having a central, comprehensive, spatially enabled, open, whole-of-environment data repository as part of the commitment to transparency; and
 - developing a system within government to assess cumulative impacts of multiple industries operating in sensitive environments.

- 2** It commissions the design and establishment of a whole-of-environment data repository for all NSW environment data – including all data collected according to legislative and regulatory requirements associated with water management, gas extraction, mining, manufacturing and chemical processing activities.



Mary O'Kane

- 3** It establishes a pre-major-CSG, whole-of-state subsidence baseline using appropriate remote sensing data going back, say, 15 years – and that, from 2013 onwards, an annual whole-of-state subsidence map be produced so that patterns can be traced for the purpose of understanding and addressing any significant cumulative subsidence.

- 4** It requires all coal seam gas industry personnel, including subcontractors working in operational roles, be subject to mandatory training and certification requirements and that these mandatory training and certification requirements be included in the codes of practice relevant to CSG.

- 5** It continues and extends its role as a champion of research relevant to the hard problems related to under-earth, especially the development of sophisticated predictive underground models and a formalisation of engineering processes for cumulative impact assessment. The NSW Government should lead by example in encouraging and funding such research to be undertaken and discussed in NSW and should

exhort other governments and organisations to take a related approach through mechanisms such as COAG and international partnerships.

"The issue of CSG is a very tough one and requires a commitment from government to sound policy implementation based on highly developed data," Professor O'Kane says. "Further research will also be essential to filling knowledge gaps."

Professor O'Kane says the independent review will continue well into next year.

"There is indeed more work to be done. As the review continues, the team will be undertaking further work in relation to landholders' legal rights; examining appropriate levels of industry insurance; conducting a full industry compliance study; reviewing government best practice in the management of CSG extraction; and analysing in-depth the methods for CSG risk and assessment."

NEW SUPER CERAMIC MAY MAKE SAVINGS

A new super-strong ceramic developed by researchers at The University of Western Australia may enable power plant operators to save money on delays and costly repairs, and may prolong the life of expensive mining equipment.

Dr Jingzhou Yang, Winthrop Professor Xiaozhi Hu and Professor Zhaozhui Huang have created a unique new Iron-Sialon ceramic matrix composite that resists wear under high temperatures, developed from very common and cheap ferro-silicon alloy and commercial-grade industrial alumina powders.

The development of the new composite involved sintering – or heating industrial alumina and ferro-silicon alloy powders at a temperature below their melting point – at up to 1700°C – in nitrogen for several hours. The alumina then transforms to the more wear-resistant ceramic, Sialon.

Dr Yang said the resistance to wear, fracture and thermal shock in the alumina-based ceramic linings currently used thermal power plant boilers wasn't good enough, so power plants needed to be stopped for long periods to repair worn equipment, which reduces the reliability of the power supply – leading to the research to develop a new, more wear-resistant ceramic matrix composite.

Shale gas could help our GHG score

Increased use of gas, including shale gas, in place of coal for electricity generation could significantly decrease Australia's greenhouse gas (GHG) emissions, according to a new report.

The *Engineering Energy: Unconventional Gas Production* report, which for the first time examines the spectrum of issues facing the development of a shale gas industry in Australia, was launched by Australia's Chief Scientist, Professor Ian Chubb AO, at a function in Canberra in June organised by the Australian Council of Learned Academies (ACOLA),

"Shale gas could be an important new energy option for Australia, but the challenges will need to be carefully managed", said Professor Peter Cook CBE FTSE, Chair of the ACOLA Expert Working Group that produced the report and a co-author.

GHG emissions could be decreased provided 'green completion schemes' and associated codes of best practice were adopted to minimise the GHG emissions associated with shale gas production.

Engineering Energy: Unconventional Gas Production makes 51 key findings, providing Australia an opportunity to fully assess its shale gas resources and reserves and to consider the potential social, economic and environmental



Peter Cook at the Canberra launch of the *Unconventional Gas Production* report.

impacts while exploration is still at an early stage.

"While the rapid development of a shale gas industry has had a major impact in North America, the Australian experience will be very different," Professor Cook said.

"Overall, we found that there is great potential for shale gas in Australia but the benefits will not be easily won. It will cost more than in the US and it will require great skill, capital and careful management of any impacts on ecosystems and natural resources.

"To be successful, any shale gas industry will require an informed and supportive community, and transparent and effective regulations and companion codes of practice".

The framework for the report is that energy needs will require Australia to keep turning to opportunities for alternative sources such as

shale oil gas and coal seam gas. As technology and geological knowledge continue to advance, and the consequent economics of extracting unconventional natural gas become more feasible, Australia could be in a position to produce unconventional gas.

This demands a comprehensive look at the scientific, social, cultural, technological, environmental and economic issues surrounding the reality of alternative energy sources such as unconventional gas.

ATSE is one of the four Australian Learned Academies that come together through ACOLA to contribute to national policy development and innovative solutions to complex global problems and emerging national needs.

The *Engineering Energy: Unconventional Gas Production* report is part of a multi-project, three-year research program called Securing Australia's Future, which is funded by the Australian Research Council and conducted by ACOLA for the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) through the Office of the Chief Scientist. Securing Australia's Future delivers evidence-based research and findings to support policy development in areas of importance to Australia's future.

The Expert Working Group behind the report comprised Professor Cook (Chair), Dr Vaughan Beck FTSE (Deputy Chair), Professor David Brereton, Professor Robert Clark AO FAA, Dr Brian Fisher AO PSM FASSA, Professor Sandra Kentish, Mr John Toomey FTSE and Dr John Williams FTSE.

The *Engineering Energy: Unconventional Gas Production* report is at www.acola.org.au.

ATSE focuses on energy at CAETS

ATSE was strongly represented at this year's annual meetings of CAETS – the International Council of Academies of Engineering and Technology – in Budapest, in June, by the Academy President Dr Alan Finkel AM FTSE, Dr Vaughan Beck FTSE, Professor David Beanland FTSE and Mr Martin Thomas AM FTSE. A highlight for ATSE was Dr Beck's presentation of the CAETS Energy Project Report from a multilateral project he led following a 2009 report on deployment. The Report, *Opportunities for Low-Carbon Energy Technologies for Electricity Generation to 2015*, will be a significant resource for CAETS academics.

Another key presentation was from David Beanland – a report backed by his new book *The Challenge Facing Engineering Educators Everywhere – the UNESCO Experience*.

Energy Forum Chair Martin Thomas prepared a country position paper for Australia that was circulated to all delegates to inform the CAETS nuclear energy discussion session.

An exciting prospect to emerge at the bilateral discussions was an informal agreement with the Indian National Academy of Engineering (INAE) that India and Australia would work together to target some of the key issues confronting India in the area of energy engineering – solar power, energy storage and

micro-grid management.

Progress in this area would be transformational, solving an intractable deployment problem, in much the same way that the introduction of mobile phones solved the problem of India being unable to provide landlines to its citizens.

This is one of five strategic relationships with sister academies that INAE plans to build – the others are with Germany, France, Britain and Canada.

The ATSE team had worthwhile discussions with a number of other academies including China, South Korea, Britain and the US.

Key challenges in STEM education

While Australia does well in the major international ranking studies for science, technology, engineering and maths (STEM) education, it faces several key challenges if it is to maintain or improve upon its current position.

A new ACOLA report, *STEM: Country Comparisons*, released in June, compares for the first time STEM education strategies on an international basis and identifies the key strategies of successful STEM countries.

From 22 studies of STEM policies and practices around the world the *STEM: Country Comparisons* report makes 24 key findings

which highlight a number of challenges for Australia with STEM participation and provides a basis of ideas to tackle these.

"STEM education is almost universally recognised as important," said report co-author Professor Russell Tytler, Deputy Chair of the ACOLA expert working group that produced the report. Mr David Hind FTSE was a member of the expert working group.

"A key problem for Australia lies in the distribution of student achievement with a long tail of underperforming students when compared to our major competitors."

The report found that Australia was suffering serious capacity gaps in STEM teaching, with teacher shortages, particularly in regional Australia, and a large problem of teachers teaching out of field, which is particularly pronounced in mathematics.

STEM-strong countries were all found to share a focus on curriculum reform to make STEM engaging and a strong commitment to

learning and achievement for all, guided by a national STEM policy framework.

STEM education has long been seen as pivotal to increasing our nation's productivity. The report found that many nations have evolved dynamic and productive strategies in their focus on advancing STEM.

"Australia lacks a sense of national urgency around STEM performance in contrast to some of our closest competitors. This report provides a framework of evidence-based findings on which to address the challenges facing STEM education in Australia," Professor Tytler said.

The *STEM: Country Comparisons* report (available at www.acola.org.au) is part of the Securing Australia's Future program, which delivers evidence-based research and findings to support policy development in areas of importance to Australia's future.

Pyne visits STELR in Adelaide

Federal Shadow Education Minister Christopher Pyne visited Prince Alfred College, Adelaide, in June and spent an hour participating in a Year 9 STELR renewable energy class, chatting with the students and gaining first-hand experience of the STELR inquiry-based educational approach.

Mr Pyne, a South Australian MP, was a guest of the ATSE South Australian Division.

He was welcomed by ATSE President Dr Alan Finkel AM FTSE, ATSE Director and former SA Division Chair, Professor Mike Miller AO FTSE and STELR Manager Peter Pentland.

The event was hosted by Dr Paula Mills,

winner of the SA Division's science teacher of the year award in 2012.

The STELR Project is currently being used as a part of the classroom science curriculum in more than 345 schools nationwide, improving the science and maths competencies of more than 35,000 students each year.

Since STELR's inception in 2008, more than 1500 teachers have been trained in inquiry-based teaching techniques using STELR's highly-acclaimed, Australian-designed and manufactured equipment. STELR schools are distributed across all states and territories.

ATSE argues its gender position

ATSE President Dr Alan Finkel AM FTSE has argued the Academy's gender equity achievements in a letter published in *Nature* in June (Vol 498, page 171).

Headed 'Gender equity in Australian academies', the letter says ATSE "has taken steps to ensure that women are appropriately recognised and included in its activities", noting that over the past three years "ATSE has led the way in identifying and promoting female talent across the science and technology sector in Australia" and within the Academy.

Dr Finkel notes that gender imbalances can adversely affect all stages of a scientific career, from tertiary education to employer recruitment, retention and promotion, with implications for a country's productivity and prosperity.

"One key element of ATSE's gender equity policy," he notes, "is to identify women candidates for fellowship nomination through active search and mentoring processes. Last year, 10 of 37 elected Fellows were female and women now comprise 40 per cent of ATSE's governing Board."

The letter responded to an earlier item in *Nature* (Vol 497) By Professor Doug Hilton FAA FTSE, noting that only eight per cent of the Academy of Science's Fellows were women and that the 2013 intake of AAS Fellows had not included any women.



Christopher Pyne (second from right) and Alan Finkel (right) talk to students at Prince Alfred College.

Government procurement processes criticised

A one-per-cent improvement in government procurement across the country could lead to more than \$600 million in savings, according to Engineers Australia's *Government as an informed buyer* report, released in July.

"About one-quarter of spending across all Australian governments is dedicated to procurement, and this represents approximately 10 per cent of Australia's GDP," said Dr Marlene Kanga, National President of Engineers Australia.

"Procurement is not only a core function of government, but a core driver of our economy. The Federal Government alone signed over 30,000 contracts in 2010-11, representing a combined value of about \$80 billion in expenditure.

"Technologically complex procurements need technologically competent professionals, and these skills can't simply be outsourced. Effective project management is a necessary part of successful procurement, but it is not enough.

"Engineering-intensive procurements need to be backed by engineering expertise. Engineering expertise drives innovation, reduces project risk and improves financial and project outcomes.

"The trend towards outsourcing has seen the professional ranks of government severely thinned. Nowhere is this more evident than for the engineering profession. Just 30 years ago governments employed about 100,000 engineers. Today this number is less than 20,000."

MP CALLS FOR A CHIEF ENGINEER

The retiring Federal Member for Mallee, John Forrest, has called for the appointment of a Chief Engineer to guide the nation's infrastructure investment priorities, pointing out that Australia has a Chief Scientist, a Chief Medical Officer, a Chief Nurse, a Chief Veterinary Officer, a Chief Consul-General, a Solicitor-General, a soon-to-be-appointed Chief Allied Health Officer, but no Chief Engineer.

His proposal has been welcomed by Engineers Australia.

"With billions of dollars spent on infrastructure every year, it is crucial that these projects are planned and delivered in a transparent manner that takes account of the national interest, not just the competing interests of the states, and not just during the election cycle," says Rupert Grayston, Deputy Chief Executive of Engineers Australia.

"With the proven track record of independent bodies like Infrastructure Australia, we believe that appointing a Chief Engineer would significantly add to government's ability to effectively plan and deliver infrastructure in Australia.

"If we are to successfully transition from a resource-dependent economy to a high-tech, high-value economy, then effective infrastructure planning and investment is a simple necessity."

Mr Forrest has an MSc (Aberdeen) and a BE (Melbourne) and was a consulting engineer prior to entering Parliament in 1993.

Mr Forrest, 63, has held the north-west Victorian seat of Mallee since 1993 for the Nationals and will stand down at the September election. He is the only civil engineer in Parliament.

Mallee is Victoria's largest Federal electorate and stretches from Mildura to Swan Hill and Horsham. It is the Coalition's safest seat in the nation, with Mr Forrest winning by a 23.3 per cent margin at the last election.



Whales accompany *Indigo V*.

SCIENCE GOES TO SEA TO STUDY MICROBES

Scientists undertaking a UNSW-led expedition to study microbes in the Indian Ocean have weathered huge seas and had a close encounter with whales during the first leg of their voyage from South Africa to Mauritius.

Researchers set sail in late May from Cape Town in an 18-metre yacht – *Indigo V* – and reached Mauritius. The expedition will restart in September, sailing from Mauritius to the Maldives, on to Phuket, in Thailand, and then to the final destination, Singapore.

On the way to Mauritius the yacht encountered a wild storm with sustained gusts of more than 45 knots and waves more than 15 metres "They were the biggest waves I have ever seen," says expedition leader Dr Federico Lauro, a UNSW microbiologist and national sailing champion, who is an experienced ocean sailor.

The boat was also surrounded at one stage by a pod of Bryde's whales, which swam so close the sailors could smell the whales' breath.

"We pulled up the sails, so we could get out of their way, but the pod kept following us. When we changed course, the whole pod would change course with us," Dr Lauro says.

"The scientific part of the expedition has been successful beyond our wildest dreams," he says.

Ocean microbes help sustain life on earth but little is known about those in the Indian Ocean, which contains some of the most under-sampled waters on the globe.

The yacht is equipped to record water characteristics such as temperature, salinity and pH. Water samples are routinely collected, filtered and the microbes frozen for genetic analysis back in the laboratory. An onboard study also checks the health of the phytoplankton, which provide much of the oxygen we breathe, and how this relates to nutrient levels, currents, water temperature and latitude.

The team includes researchers from UNSW, Macquarie University and the University of Technology, Sydney, as well as from the Desert Research Institute and the University of California in the US, the University of Copenhagen and the Technical University of Denmark in Denmark, and the Singapore Centre on Environmental Life Sciences Engineering.

NICTA in ICT education boost

A national educational program has been launched to make careers in information and communications technology (ICT) more appealing to primary and secondary school students.

Funded with more than \$6 million from the Australian Government – with matching contributions to come from industry, universities and state governments – the program is a response to the worrying shortage of high school students choosing to study ICT-related courses in science, technology, engineering and mathematics (STEM), which has led to a shortage of skilled ICT workers capable of doing the jobs required to build and sustain an advanced digital economy.

NICTA will coordinate this initiative, called the Digital Careers program.

A number of factors, including widespread perceptions by students and their parents that ICT careers are insecure, poorly remunerated or boring, have driven tertiary enrolments in ICT courses down by more than 50 per cent. In 2010, the most recent year for which there is verifiable national data, 4300 Australians obtained tertiary qualifications in ICT, down from 9093 in 2003, according to the Australian Computer Society (ACS).

Advanced software developers, software engineers and data scientists are in particularly short supply.

The Digital Careers program will bring together NICTA, the Australian Information Industries Association (AIIA), the Australian Computer Society (ACS), Australian Council of Deans of ICT (ACDICT), Federal and State governments, universities and industry participants to collectively support and deliver a national package of education and careers projects.

"Collaboration is the key to this project and NICTA is delighted to coordinate this initiative by governments, universities and industry to bring young Australians into exciting careers in ICT," said Professor Hugh Durrant-Whyte FRS FAA FTSE, CEO of NICTA. "I encourage anyone who wants to make a real contribution to Australia's economy and build a creative, dynamic and lasting career for themselves to consider a tertiary qualification in ICT."

Professor Ian Chubb AO, Australia's Chief Scientist, said: "The *Health of Australian Science* report we published last year, while giving Australian science an overall positive bill of health, found critical vulnerabilities.

"For instance, in 2002 about 22 per cent of graduates from Australian universities were in science, technology, engineering and mathematics-related degrees. In the same year, 52 per cent of graduates in China were from these areas. By 2010, Australian STEM graduate numbers had dropped to 18 per cent of the total.

"The downstream effect on innovation in Australia will be significant unless we reverse this trend."

NICTA'S 'LAST MILE' WINS AWARD

National ICT Australia (NICTA) and Tip Top Bakeries ANZ have taken out this year's Smart Logistics Conference award for Excellence in Transport and Logistics with software that has improved the efficiency of Tip Top's fresh bread delivery network. NICTA's software – Cost to Serve Solution – was able to provide NICTA and Tip Top with a thorough understanding of how to optimise 'last mile' logistics costs.

Last mile logistics is known as being a notoriously difficult problem to manage, model and control. As Tip Top distributes from 100 distribution centres to more than 20,000 customer locations, approximately 80 per cent of its transport costs are on last mile logistics. NICTA and Tip Top's

winning entry lowered last mile distribution costs, reducing the distance driven by Tip Top trucks.

Deloitte Access Economics independently analysed the transformation possible for Australian supply chains, concluding that if the leading 20 fast-moving consumer goods companies adopted NICTA's intelligent fleet logistics technology, road transport costs could fall by \$800 million a year.

APPS INDUSTRY A WINNER FOR AUSTRALIANS

Australians are taking a big bite out of the multi-billion-dollar mobile and tablet applications industry, a media researcher says.

From broadcast media to start-up companies, the nation is taking advantage of the booming apps market, helping to create more jobs and attracting businesses worth millions of dollars, says Dr Ben Goldsmith of the ARC Centre of Excellence for Creative Industries and Innovation (CCI) at Queensland University of Technology (QUT).

"The IBISWorld Survey shows that there are 364 apps companies in Australia," he says. "The report reveals that the industry employs 1500 people, generates \$295 million every year and has an annual growth of 177 per cent."

Dr Goldsmith has found that these companies create apps in all areas including games, finance, books, education, health and maps, and around 200 of the apps companies are in Sydney.

"The apps industry is spawning a range of business opportunities because it's something that both companies and individuals can do," he says. "You don't have to build a large development studio to be in the business."

"There isn't a 'typical' apps entrepreneur – they come from different backgrounds, such as software development, marketing, design, investment and venture capital. Some are just very gifted kids."

He says the industry isn't just about designing and developing applications. Companies have begun to specialise in areas such as mobile marketing, advertising, security, testing users' experience and developing templates for others to build their own apps.

Dr Goldsmith says that Sydney is emerging as the centre of the Australian industry with a really vibrant start-up culture. The software company Atlassian, started by two Sydney friends in an apartment, now sells \$100 million worth of software a year worldwide and is worth \$1 billion.

Another Sydney-based company Gruden has also expanded internationally and has helped build the app store for China Mobile, he says.

"With the growth of the mobile and tablet market, the apps industry is a diverse and rapidly growing area. So there's immense potential for Australian companies and I'm optimistic that we'll rise up to the challenge."



Ben Goldsmith checks the apps.

Tick for largest solar project

NSW will get two big solar plants, worth about \$450 million, after funding arrangements were finalised between AGL Energy Ltd (AGL), the Australian Renewable Energy Agency (ARENA) and the NSW Government.

The AGL solar projects will include a 102 MW solar plant at Nyngan and a 53 MW solar plant at Broken Hill, with ARENA providing \$167 million and the NSW Government contributing \$65 million.

First Solar (Australia) Pty Ltd will provide engineering, procurement and construction services for both projects, using its advanced thin-film PV modules.

"The Nyngan and Broken Hill solar plants will be the nation's largest solar projects, with the Nyngan plant also being the largest in the southern hemisphere," says AGL Managing Director Michael Fraser.

"We expect these projects to create approximately 150 construction jobs in Broken Hill and approximately 300 in Nyngan. This will provide significant financial flow-on benefits to both communities. The projects are expected to add nearly two per cent to the gross regional product of each regional economy," Mr Fraser says.

On an annual basis, the projects will produce approximately 360,000 megawatt hours of electricity, which will be sufficient to meet the needs of more than 50,000 average NSW homes.

Construction of the Nyngan project is expected to commence in January 2014, with completion scheduled by mid-2015. Construction of the Broken Hill project will start six months later in July 2014, and is scheduled to be completed around November 2015.

The Federal Minister for Climate Change, Mark Butler, says the two sites would cover a combined area four times the size of the Sydney CBD.

"This project is 15 times larger than any other solar power station in Australia and represents a big step forward towards making solar a bigger part of Australia's energy mix."

THERMOCELL BREAKTHROUGH

Harvesting waste heat from power stations and even vehicle exhaust pipes could soon provide a valuable supply of electricity.

A small team of Monash University researchers working under the Australian Research Council (ARC) Centre of Excellence for Electromaterials Science (ACES) has developed an ionic-liquid-based thermocell device with the highest power outputs yet reported and no carbon emissions.

Thermocell technology is based on harnessing the thermal energy from the difference in temperature between two surfaces and converting that energy into electricity.

The new thermocell could be used to generate electricity from low-

A new, carbon-neutral thermocell could harvest waste heat from power stations and convert it into electricity.



grade steam in coal-fired power stations at temperatures around 130°C. This would be implemented by having the steam pass over the outer surface of the hot electrode to keep it hot while the other electrode is air or water-cooled.

Monash University researcher and Australian Laureate Fellow Professor Doug MacFarlane, who led the research with PhD student Theodore Abraham, says the breakthrough included the development of a novel ionic-liquid-based redox electrolyte.

"We have found that it can work at elevated temperatures typical of important heat sources, as opposed to water-based systems, which cannot operate at temperatures above 100°C," Professor MacFarlane says.

"The device offers the possibility of a cheap and flexible design suitable for harvesting waste heat in the 100°C-to-200°C range."

CALL FOR ENERGY RESERVE AUTHORITY

John Hofmeister, the US-based former President of Shell Oil Company, has called on Australia to stop "playing politics with energy" before it is too late.

He says an obsession with short-term political expediency will invariably lead to severe energy shortages and environmental destruction.

Speaking ahead of his keynote address to the conference 'All-Energy Australia 2013' in Melbourne in October, Mr Hofmeister – who spent considerable time in Australia in the past two decades – called for the establishment of an independent Australian Energy Reserve Authority (ERA) that would set future policy direction.

Mr Hofmeister says the Authority should be run along the lines of the Reserve Bank with four primary objectives:

- to assure the uninterrupted supply of affordable energy from all sources;
- to establish needed infrastructure to move energy from where it is produced to where it is consumed;
- to ensure environmental protection to improve land, water and air quality; and
- to deliver efficiencies through technology.

"It should have between six and 10 governors drawn from multiple fields of expertise, including industry and the environment, consumer and financial interests," he said. "Appointees would be subject to Federal Parliamentary approval and they would have 10-year terms, but importantly they would act with total autonomy."

He says Australia has achieved nothing bickering about the merits or demerits of a carbon tax or emissions trading scheme.

"If politicians are allowed to zigzag the nation through public policy spurts and busts you will end up exactly where you are now in 20 or 30 years, having accomplished absolutely nothing."



John Hofmeister

NGL already making an impact

The National Geosequestration Laboratory (NGL) has made significant steps towards establishing itself as one of the world's leading R&D providers in the field of carbon storage and geoscience in the eight months since its funding was announced.

Major equipment upgrades and laboratory enhancements to the

Australian Resources Research Centre (ARRC) and construction of a new world-class CO₂ research facility at The University of Western Australia are due to commence, adding to the recent installation of a state-of-the-art micro CT scanner at Curtin University.

Both universities are NGL partners, along with CSIRO, and the new facilities will complement the extensive research expertise offered by the three organisations. The NGL is being established through \$48.4 million in



Linda Stalker

funding from the Federal Government's Education Investment Fund, and builds on the successes of the WA Energy Research Alliance.

The NGL is already providing initial scientific research behind the South West CO₂ Geosequestration Hub project, which is funded through the Federal Government's Clean Energy Initiative, and examining the potential for large-scale carbon capture and storage in south-west WA.

The study area has the potential to store up to 240 million tonnes of CO₂ in the Lesueur rock formation, and the NGL is working closely with the WA Government to determine the feasibility of the site.

"CCS is part of a portfolio of solutions that will help Australia and the world to achieve large cuts in emissions, while continuing to satisfy our growing energy needs," says Dr Linda Stalker, NGL Science Director.

"There is no single solution, but CCS has the potential to significantly reduce greenhouse gas emissions by removing large quantities of CO₂ that would normally be released into the atmosphere, and instead storing it safely deep underground."

LASER TO DETECT METHANE LEAKS

University of Adelaide researchers are developing a new type of laser system that will monitor levels of methane, the main component of natural gas, across large areas. This will provide a useful tool for monitoring greenhouse gas emissions.

The system has the potential to detect methane leaks from long-distance underground gas pipelines and gas fields, including coal seam gas extraction operations, and to measure methane emissions from animal production.

The researchers, based in the university's Institute for Photonics and Advanced Sensing, headed by Professor Tanya Monro FTSE, have conducted a preliminary study and are developing the laser system for further testing.

The system uses laser-based remote sensing technology called DIAL. Laser pulses are emitted with alternate frequencies, one of which is absorbed by the methane. The methane concentration is measured by observing the difference between the amounts of light scattered back

to the detector. The laser system will then be swept through a circle to determine the methane concentration over a wide area.

To produce a powerful, cost-effective laser system, the researchers are developing an erbium-YAG laser source. These lasers have the advantage of emitting light that cannot be seen by humans and is not hazardous to the human eye – important when the lasers are to be used in the environment and not confined to a regulated laboratory.

CLIMATE CHANGE IMPACT "MORE SEVERE" FOR REMOTE COMMUNITIES

People living in remote Australia are likely to be more severely affected by climate change than other sectors of the national population, according to a study by the CRC for Remote Economic Development (CRC-REP).

It warns that communities and outlying settlements on Cape York and in Central Australia and the Kimberley face greater risks to their wellbeing as the climate warms than people in other parts of Australia.

The study by the CRC-REP and CSIRO investigates the likely relationship between climate change and liveability (or state of wellbeing) of remote Australians.

"Globally, climate change is expected to bring a number of downsides for people generally – the spread of tropical diseases, mental health issues, allergy and lung problems, water quality and availability issues, and impacts on agriculture and social cohesion," Principal Research Leader Dr Digby Race says.

"However, the three areas we focused on in remote Australia all have large populations of people with poor health, infrastructure and socioeconomic status, and many children.

"In general, urban centres like Broome, Kununurra and Alice Springs are less sensitive to the impacts of climate change due to their relatively high socio-economic status. Outside these urban areas, however, there are scattered small populations who may be more sensitive to these impacts than those in other parts of Australia."

SCIENTISTS GET THE DROP ON AEROSOLS

The seasonal influence of aerosols* on Australia's tropical climate can now be included in climate models following completion of the first long-term study of fine smoke particles generated by burning of the savanna open woodland and grassland.

Australia's biomass burning emissions comprise about eight per cent of the global total, ranking third by continent behind Africa (48 per cent) and South America (27 per cent).

Lead researcher, CSIRO's Dr Ross Mitchell, says fine particles generated by burning of the tropical savanna of Northern Australia are a globally significant aerosol source, with impacts on regional climate and air quality.

Burning is widespread during the May to October dry season, with about 30 per cent of WA and NT savanna regions burnt each season and similar seasonal burning in Queensland. The majority of burning is carried out deliberately to reduce woody undergrowth and promote subsequent grass growth for grazing, although fires also occur naturally through lightning strikes.

* An aerosol is a suspension of fine solid particles or liquid droplets in a gas, such as clouds or air pollution (for example, smog and smoke).

Desert 'greening' from rising CO₂

Increased levels of carbon dioxide have helped boost green foliage across the world's arid regions over the past 30 years through a process called CO₂ fertilisation, according to CSIRO research.

In findings based on satellite observations, CSIRO and the Australian National University found that this CO₂ fertilisation correlated with an 11 per cent increase in foliage cover from 1982 to 2010 across parts of the arid areas studied in Australia, North America, the Middle East and Africa, according to CSIRO research scientist, Dr Randall Donohue.

The fertilisation effect occurs where elevated CO₂ enables a leaf to extract more carbon from the air or lose less water to the air during photosynthesis, or both.

If elevated CO₂ causes the water use of individual leaves to drop, plants in arid environments will respond by increasing their total numbers of leaves. These changes in leaf cover can be detected by satellite, particularly in deserts and savannas where the cover is less complete than in wet locations, according to Dr Donohue.

"In Australia, our native vegetation is superbly adapted to surviving in arid environments and it consequently uses water very efficiently," he says. "Australian vegetation seems quite sensitive to CO₂ fertilisation."

"Our work was able to tease out the CO₂ fertilisation effect by using mathematical modelling together with satellite data adjusted to take out the observed effects of other influences such as precipitation, air temperature, the amount of light, and land-use changes."

"On the face of it, elevated CO₂ boosting the foliage in dry country is good news and could assist forestry and agriculture in such areas. However, there will be secondary effects that are likely to influence water availability, the carbon cycle, fire regimes and biodiversity, for example."

This study was funded by CSIRO's Sustainable Agriculture Flagship, Water for a Healthy Country Flagship, the ARC and Land and Water Australia.

NEW IMPETUS FOR CARBON REDUCTION RESEARCH

A new network of research facilities to boost Australian development of commercial-scale carbon capture and storage (CCS) will significantly enhance Australia's CCS research capability, according to Dr Richard Aldous, Chief Executive of the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC).

CO2CRC is eligible for \$51.6 million from the Australian Government's Clean Energy Future package, administered by the Education Investment Fund (EIF), to support CCSNET, a network of field facilities, onshore and offshore monitoring systems and world-class laboratories, announced Resources and Energy Minister Gary Gray.

The CCSNET network comprises:

- the Otway Subsurface Laboratory – a major subsurface laboratory based at the CO2CRC Otway Project in Victoria, where CO₂ has been stored safely underground since 2008;
- GipNet – CSIRO-driven submarine environment monitoring program in Victoria's offshore Gippsland Basin; and
- CCS Labnet – new imaging and analytical research capability at ANU and Melbourne, Monash and Adelaide universities.

"The network will help to answer many of the outstanding research questions for large-scale CCS projects," Dr Aldous says. "CCSNET will provide a unique basis for quality national and international CCS research,

education and training. It reaffirms Australia's strong global role in taking this technology forward."

CCSNET will also attract matching funds from research institutions, as well as industry and state government co-investors. CCSNET will primarily support Victoria's CarbonNet Project, which is funded under the \$1.18 billion CCS Flagships program, but the facilities will also be available for other Australian projects and potentially international collaborators.

CO2CRC MARKS 10 YEARS

The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) has marked 10 years of achievement and scientific excellence in CCS research and development.

Achievements over the past decade include Australia's first demonstration of geological carbon storage and the development of a low-cost, environmentally friendly capture technology currently being trialled at a pilot plant in Victoria.

CO2CRC has established a network of more than 150 expert CCS researchers, robust international collaborations and the CO2CRC Otway Project, a globally significant CO₂ storage field laboratory – assets that will be invaluable for the 2015–20 research program currently being planned.

"CO2CRC has exceeded all expectations, keeping Australian scientists and engineers at the cutting edge of this important new technology" says Dr Richard Aldous, CO2CRC Chief Executive. "Since 2003 we have engaged with 26 industry partners, 11 research partners and six government partners, the majority of which are still with us, as well as several small-to-medium enterprises and a wealth of supporting participants."

"Over the life of the CRC, 174 peer-reviewed journal articles have been published, as well as 167 conference papers, nine books or book chapters, and nearly 400 reports."

CO2CRC commenced on 1 July 2003, growing from roots in the Australian Petroleum CRC, and has proven a successful example of the CRC model, in which multidisciplinary teams address end-user-driven research. CO2CRC is a joint venture comprising participants from Australian and global industry, universities and other research bodies from Australia and New Zealand, and Australian and international government agencies. Its resources come from the Australian Government CRC Program, other government programs, CO2CRC participants and wider industry.

URBAN STRUCTURES COULD MAKE US HOTTER

An expansion of concrete and asphalt on the fringes of our cities could see urban temperatures rise by as much as 3.7°C by the year 2050, University of NSW research suggests.

The build-up of heat in cities – the "urban heat island effect" – would amplify climate change, the UNSW researchers found. New areas on the fringes of cities were the most prone to temperature increases. Sydney's urban fringes could see temperatures rise between 1.1°C and 3.7°C, while rural areas near these new suburbs could see increases of between 0.8°C and 2.6°C.

While the study, prepared for the ARC Centre of Excellence for Climate Systems Science, focused on Sydney, the mechanisms that caused warmer nights in Sydney were applicable to any city with similar characteristics, the researchers say.

The urban heat island effect occurs because urban structures can store more heat than open ground. This accumulated heat is released during the night, which is why night-time temperatures increase even more than daytime temperatures.

Our soil carbon blowing away

PHOTO: A. NAIRN

Australian soils are losing about 1.6 million tonnes of carbon each year from wind erosion and dust storms, affecting agricultural productivity, our economy and carbon accounts, according to new research.

Topsoil is rich in nutrients and carbon – an essential ingredient for the healthy soils – but is increasingly being blown away by events such as the ‘Red Dawn’ in 2009.

Recent research estimated that the ‘Red Dawn’ dust storm that passed over the east coast of Australia, including Sydney, on 23 September 2009 cost the economy of NSW \$300 million, mainly through household cleaning and associated activities.

When wind lifts carbon dust into the atmosphere it changes the amount and location of soil carbon. Some carbon falls back to the ground while some leaves Australia or ends up in the ocean.

CSIRO research scientist Dr Adrian Chappell and an international team of experts in wind erosion and dust emission recently calculated the extent of these carbon dust emissions.

“Carbon stored in our soils helps sustain plant growth. Our modelling shows that millions of tonnes of dust and carbon are blowing away, and it is uncertain where all that ends up,” Dr Chappell says. “We need to understand the impact of this dust carbon cycle to develop more accurate national and global estimates of carbon balances and to be able to prepare for life in a changing climate.

“Australia’s carbon accounts, and even global carbon accounts, have not yet taken wind or water erosion into consideration and when this happens it could have significant impacts on how we manage our landscapes. While soil organic carbon lost through dust is not a major contributor to Australia’s total emissions, it is a major factor in our deteriorating soil health.”

USING SATELLITES TO MOVE BEEHIVES

An online tool that uses images from NASA satellites is set to revolutionise the way Australia’s beekeepers find sources of nectar and pollen for their bees. Called ‘BeeBox’, the online tool is the first of its kind in the world and uses historical and current satellite imagery to help beekeepers predict where and when eucalypt trees will flower.

BeeBox, which has been developed with funding from the Rural Industries R&D Corporation, can be accessed for free from home or a mobile device and uses imagery direct from NASA satellites to provide the most up-to-date and accurate information about complex eucalypt flowering cycles.

A dust storm turns the sky red in Mildura, Victoria.

The lead developer of BeeBox, Jonathan Arundel from the University of Melbourne, says historical satellite imagery has been used to produce maps that show eucalypt growth cycles across south-east Australia over the past decade.

“BeeBox provides beekeepers with a level of information they’ve previously never had access to and should help them better predict eucalypt flowering cycles and hence inform the movement of their hives.”

ROBOTIC TRACTOR FOR PRECISION PLANTING

A robotic tractor and seeding machine with unprecedented planting accuracy will improve agricultural productivity for farmers and enable cropping on 20 per cent more land, according to University of NSW inventors.

Broadacre farming currently requires an operator in the cabin of large tractors, but this can be unproductive, says Associate Professor Jay Katupitiya from the School of Mechanical and Manufacturing Engineering at UNSW.

Furthermore, large tractors are expensive and compact the soil as they move, creating crop lines, which render roughly 20 per cent of land on large paddocks unusable and means cropping must happen in the same direction every year, which degrades soil health.

To solve this problem, Professor Katupitiya has partnered with the Grains Research and Development Corporation (GRDC) to develop a lighter, cheaper agricultural machine that can accurately follow and plant seeds along a predefined path without a human operator.

“This system has the ability to lay seeds within one to two centimetres of lateral accuracy on rough agricultural terrain, which is an unprecedented level of precision for an autonomous machine,” he says.

Achieving this precision with existing technology has been challenging because the forces generated by a plough digging into soil often cause seeding implements to veer off course. But advanced control systems and sensors, and an optimised design, enable the UNSW invention to automatically correct against these deviations.

“The flexibility of being able to access more land and plant crops in different directions has advantages for crop growth through better uptake of remnant nutrients, and a better yield.”

The research team behind the invention were finalists in the 2012 Eureka Prize for Innovative Use of Technology. It is now working with the GRDC to pursue further development and commercial production.



The UNSW robotic tractor and seeding machine.



Broadband will boost farming technologies

A new CSIRO report says Australian farmers can help to tackle the global food shortage and significantly increase their productivity by taking advantage of new smart farming technologies enabled by next generation broadband networks.

The *Smart Farming: leveraging the impact of broadband and the digital economy* report compiles research from a number of agricultural projects which indicate that by connecting farms to broadband-enabled sensor networks, farmers will be able to take more control of their operations by analysing the wealth of new information made available in easily accessible web tools.

"With food demand predicted to increase 50 per cent in the next 20 years, the main challenge facing the agricultural sector is not so much growing 70 per cent more food in 40 years, but making 70 per cent more food available on the plate," says Colin Griffith, Director of The Australian Centre for Broadband Innovation (ACBI).

"To tackle this challenge and help farmers make better decisions, we're trialling new broadband-enabled technologies such as cattle tags to track livestock as well as a range of sensor networks that measure water salinity, soil moisture and even the heartbeat of oysters.

"Initial studies indicate that these tools can help increase farming productivity in crop and pasture yields by targeting the use of water and fertilisers as well as in livestock production through better rotation of animals and pastures.

"For example, we have seen cotton growers using the soil moisture sensors almost doubling their yields per megalitre of water when they

CSIRO's new soil moisture sensor on the Kirby Smart Farm.

vary irrigation rates according to the localised needs of the soil and plants, rather than taking the one-size-fits-all approach for a whole field."

CSIRO and the University of New England have set up a demonstration Smart Farm in Armidale, NSW, to investigate and demonstrate the impact of broadband and related digital services for Australia's rural sector. The Kirby Smart Farm is a 2800-hectare working commercial farm located 10 kilometres north-west of UNE's Armidale campus. The farm focuses on Merino wool and beef cattle, but various grains for livestock feed are also produced.

The farm was also one of the first connected to the NBN terrestrial wireless broadband service.

The *Smart Farming: leveraging the impact of broadband and the digital economy* report was launched during the Digital Rural Futures Conference in June.

ACBI provides unique opportunities to create innovative broadband-enabled services demonstrate their use in real world situations and evaluate their potential commercial and social value. Supported by CSIRO in partnership with National ICT Australia (NICTA), ACBI is a collaborative national research initiative. ACBI's goundation funding was provided by the NSW Government with matching resources from CSIRO and NICTA. More recently, the Tasmanian Government has become a partner and ACBI is in the process of extending this support with other state governments.

PHONE APP DETECTS FOREIGN BEES

Researchers have developed smartphone apps as a means of immediately detecting an exotic bee or bee-pest incursion on Australia's shores through remote monitoring.

The project has been funded by the Pollination Program, a joint initiative of the Rural Industries Research and Development Corporation (RIRDC) and Horticulture Australia Ltd (HAL), and is being run by the National Centre for Engineering in Agriculture (NCEA) at the University of Southern Queensland.

Bait boxes are placed near Australian ports to attract bees hitching a ride into the country, and potentially carrying pests such as the Varroa mite, which has devastated honeybee industries around the world.

These are currently monitored manually, which can be time-intensive, expensive and irregular.

NCEA's Dr Cheryl McCarthy says remote monitoring provides a lower-cost and more effective alternative, potentially saving time and money and improving biosecurity.

"We've had two bait boxes fully operational in Brisbane and Cairns for the past six months. Their interiors are photographed every 15 minutes and the images uploaded to the internet along with other data," Dr McCarthy says.

"The use of smartphone technology has allowed us to monitor the boxes 24/7. The images have all been of sufficient visual quality to clearly indicate the presence of bees in the bait box, proving the smartphone apps are an efficient way for us to detect an exotic bee incursion.

"Ideally, once we have worked on the success of ensuring our decoys are working at the best levels, we can have a network of at least 100 remotely monitored bait boxes deployed around Australia's shores and ports."



The CSIRO Australian Animal Health Laboratory, Geelong.

CSIRO goes international to beat deadly viruses

Researchers from Australia, Singapore and the US are joining forces, through a A\$20 million partnership, to help pre-empt and prepare the world for the next human pandemic.

Dr Gary Fitt FTSE, CSIRO Biosecurity Flagship Director, told Australia's leading biosecurity researchers at a meeting in Canberra that recent global events highlighted the need to ramp up research into viruses that spread from animals to humans.



Gary Fitt

"We now know that 70 per cent of new diseases in people have originated in animals," Dr Fitt said. "We are lucky to have a strong biosecurity system, backed by world-class science, but we live in an increasingly connected world with trade and people movements putting us at greater risk."

Recently, a new SARS-like virus has emerged from the Middle East and has killed 45 of 82 people infected since September 2012. Known as Middle East Respiratory Syndrome (MERS), it has spread from the Middle East to the UK, Germany, France, Italy and Tunisia. In China there is a new strain of highly pathogenic bird flu, known as H7N9, which is spreading undetected, killing people instead of chickens. It is unknown how it spreads.

CSIRO and Duke-NUS (an alliance between Duke University in North Carolina and the National University of Singapore) have signed a relationship agreement with a view to forming the International Collaborative Centre for One Health to assist in taking a new approach to tackling these deadly viruses.

Dr Linfa Wang FTSE, CSIRO Science Leader and Director of the Program in Emerging Infectious Diseases at Duke-NUS, said that responding to these emerging threats requires a different approach to the past and must integrate medical, veterinary, ecological and environmental research.

"Bringing all of these disciplines together to develop a One Health approach rather than working independently is what our new international partnership is all about," Dr Wang said.

"We are combining CSIRO's world-leading bat virology research with Duke-NUS medical expertise in the development of new and more effective methods for the discovery, treatment, prevention and control of new and emerging diseases in people."

Research is already underway, with the team at Duke-NUS working to develop new tests for early and rapid detection of emerging infectious diseases. CSIRO scientists with expertise in bat virology will then test and validate these new platforms at the Australian Animal Health Laboratory, the

world's most advanced high containment facility, located in Geelong, Victoria.

This work builds on CSIRO's major achievements in biosecurity research, which have already had a profound impact on Australia's biosecurity status, including the delivery of a biological control for one of the world's most invasive pests – the silverleaf whitefly – and the recent development of an equine Hendra virus vaccine.

Dr Gary Fitt has extensive experience in agricultural sustainability and the interface between natural and managed environments and won an ATSE Clunies Ross Award in 2006 for his cotton research. He spent 20 years in Narrabri, including four years as CEO of the Cotton CRC. He was Deputy Chief, CSIRO Ecosystem Sciences, Brisbane, before taking up his current role last year.

Dr Linfa Wang, a Fellow since 2010, is an internationally recognised leader in the field of emerging viruses. He played a key role in identification of bats as the natural host of SARS-like viruses. His research achievements extend from the rapid discovery and characterisation of highly pathogenic viruses to the development of cutting-edge technologies with applications in novel diagnostics, vaccines and therapeutics for the combating of emerging viruses.

CSIRO TEST BOOSTS STEM CELL SAFETY

CSIRO scientists have developed a test to identify unsafe stem cells – the first safety test specifically for human induced pluripotent stem cells (iPS).

The breakthrough is a significant step in improving the quality of iPS cells and identifying unwanted cells that can form tumours. The test also determines how stable iPS cells are when grown in the lab.

Dr Andrew Laslett and his team have spent the past five years working on the project. The research has focused on comparing different types of iPS cells with human embryonic stem cells. iPS cells are now the most commonly used pluripotent stem cell type for research.

"The test we have developed allows us to easily identify unsafe iPS cells. Ensuring the safety of these cell lines is paramount and we hope this test will become a routine screen as part of developing safe and effective iPS-based cell therapies," says Dr Laslett, Research Group Leader – Stem Cells, CSIRO Materials Science and Engineering.

Dr Laslett's team has shown that certain ways of making iPS cells carry more risks. When the standard technique is used, which relies on viruses to permanently change the DNA of a cell, unwanted tumours are more likely to form. In comparison, cells made using methods that do not alter cell DNA, do not form tumours.

Dr Laslett hopes the study and the new test method will help to raise the awareness and importance of stem cell safety and lead to improvements in quality control globally.



Andrew Laslett



Launching the LHRS (from left) Dr Cathy Foley, Professor Sakkie Pretorius (Deputy Vice-Chancellor (Research), Macquarie University) and Professor Stephen Crain (Director, CCD Centre of Excellence).

Safeguarding us against helium shortages

Macquarie University has launched a state-of-the-art Liquid Helium Recovery System (LHRS), in partnership with the CSIRO and as an initiative of the ARC Centre of Excellence in Cognition and its Disorders (CCD).

Helium, a rare and non-renewable resource, poses a very significant investment risk for researchers worldwide, such as those in CCD who work with helium-dependent magnetoencephalography (MEG) systems.

To alleviate this risk, the CCD has entered into a collaborative project with CSIRO to develop one of Australia's first onsite helium recovery and reliquefaction systems. The system is designed to capture all the boil-off helium gas, pressurise, store and reliquefy it for cryogenic cooling of the superconducting sensors. Contamination is kept to a minimum by providing an all-metal, leak-tight recovery system.

"Unlike other recycling processes, where the helium gas that boils off during MEG operation needs to be taken for offsite processing, this onsite system offers one of the highest recycling rates (greater than 90 per cent recycled,) with significant sustainability outcomes, providing an independent and secure supply for the CCD," says CSIRO Chief of Materials Science and Engineering, Dr Cathy Foley PSM FTSE.

When global market shortages in helium occur, such as those earlier in 2013, research is threatened and potential new discoveries postponed. There are only about a dozen helium extraction plants in the world where it is economical to retrieve the helium gas from the natural gas mixture which has been trapped below the ground. Lighter than air, once helium is lost to the atmosphere, it escapes the Earth permanently.

The MEG systems are used in the CCD's research programs to study children's brain development. The CCD, based in the Australian Hearing Hub, currently houses two purpose-built MEG systems, including the world's first MEG system designed for use with pre-school children, and an adult system, the first of its kind in the Southern Hemisphere. A third MEG system being installed will be another world-first system, specially designed for use with children and adults who have cochlear implants.

\$10 MILLION FOR BIONIC VISION RESEARCH

Bionic Vision Australia (BVA), led by the University of Melbourne, will receive \$8 million and Monash Vision Group (MVG), led by Monash

University, will receive \$1.9 million from the Federal Government to extend their research programs for another year.

Announcing the funding, Innovation Minister Senator Kim Carr said both research teams were working on different methods to develop bionic vision, and both had made major breakthroughs.

Both the original funding of \$50 million and the new funding extensions have been awarded under the ARC's Research in Bionic Vision Science and Technology Initiative, which was developed in response to the Australia 2020 Summit.

BVA is developing technology that implants a device in the rear of the eye (the retina) to enable vision in blind patients suffering from degenerative retinal conditions. MVG is developing a device to implant in the visual cortex of the brain, providing treatment for progressive blindness.

ATSE Fellows have a strong involvement with MVG. Professor Arthur Lowery FTSE – a 2007 ATSE Clunies Ross Award winner – is its Director and serves on its Advisory Board with Professor David de Kretser AC FTSE, former Governor of Victoria (Chair), Professor Lyn Beazley AO FTSE, WA's Chief Scientist, and Professor Jim Patrick FTSE, Chief Scientist at Cochlear Ltd.

Professor Hugh Durrant-Whyte FRS FAA FTSE, CEO of NICTA and a 2009 ATSE Clunies Ross Award winner, is a member of the BVA Board.

Researchers from the University of NSW's Graduate School of Biomedical Engineering are part of the BVA consortium, which is developing two prototype devices that could help restore sight in people with degenerative eye conditions.

"The UNSW research team is currently focused on working with the surgical team to refine the design of the implant to ensure that the device is safe to implant and continues to deliver beneficial information to the visual system of blind recipients," says UNSW Scientia Professor Nigel Lovell FTSE, who leads the consortium's Electrical Stimulation Strategy program.

WORLD'S WIDEST X-RAY BEAM

The Australian Synchrotron, a machine the size of a football field that accelerates electrons to close to the speed of light creating very bright light that is used for research, including imaging, has a new beamline.

A new \$25 million Imaging and Medical Beamline (IMBL) will enable live imaging at incredibly high-resolution inside the human body and facilitate exciting new research, diagnostics and treatments.

It is also envisaged the new line will enable clinicians to develop new treatments, including a new form of radiation therapy that will target tumour cells while sparing healthy tissue.

Opening the new facility Innovation Minister Senator Kim Carr said the new line was the world's widest synchrotron X-ray beam and would lead directly to advances in medical diagnosis and treatment.

CANCER APP FOR SMARTPHONES

ANU undergraduate Sanjay Sreekumar has developed a smartphone application for the early detection of breast cancer. The app is designed to allow individuals to self-monitor for early signs of breast cancer. By providing monthly inputs of breast irregularities, the application can help identify if further medical screening is required.

Mr Sreekumar is currently improving the app by adding visual aids and multiple languages. He wants to get the word out to breast cancer organisations and promote the app internationally. In future he hopes to extend his software design skills to other health areas.



Coral-based sunscreen

CSIRO, in partnership with skincare company Larissa Bright Australia, has created the world's first UVA/UVB sunscreen filters that mimic the natural sun protection used by corals on the Great Barrier Reef.

The breakthrough paves the way for a new generation of sunscreens which harness the same protective barriers developed by Australia's Great Barrier Reef corals over millions of years to survive in the harsh Australian sun.

The new UV filters are resistant to both UVA and UVB rays and are clear and colourless, which means they can be used in any cream emulsion.

CSIRO scientists have spent the past two years adapting the coral's sunscreen code so that it can be safely used as an ingredient in human sunscreen. The coral's sunscreen was improved to create a suite of 48 new sunscreen filters. The research builds on work by scientists at the Australian Institute of Marine Science (AIMS) who were the first to discover the natural sun screening ability of coral on the Great Barrier Reef.

SOCIAL MARKETING STUDY FOR DSTO EATING

The Defence Science and Technology Organisation (DSTO) is using social marketing tools for a study that could be used to improve the eating choices of Defence personnel.

Ms Julia Carins, a nutritionist at DSTO for more than 10 years, is conducting the research as part of her PhD studies at Griffith University. In coming months she will monitor cafeterias at Defence bases across Queensland to better understand food choices. The information she gathers will inform what strategies Defence could put in place to encourage people to eat a healthier diet.

Ms Carins has recently completed a comprehensive literature review of studies where social marketing has been used to address healthy eating. Her paper 'Eating for the better: A social marketing review' has been accepted for publication in the journal *Public Health Nutrition*.

Chief Defence Scientist Dr Alex Zelinsky FTSE says Defence personnel have physically

demanding roles so it is important they make wise food choices.

"This research will help determine if social marketing can be an effective tool in helping people to make those healthy decisions," he says.

ANTS FIND HOME WITH 'PHOTO LIBRARY'

Ants keep a collection of 'snapshots' taken close to the nest so they can find their way home from unfamiliar locations.

Scientists at The Vision Centre (VC) and the Research School of Biology at the Australian National University found that Australian jack jumper ants, just by briefly scanning the panorama, can quickly determine where their nest is from 15 metres away, even from areas that they have never visited before.

They found that the ants use two navigation strategies – relying on recall of surrounding landmarks or path integration – keeping track of the distance and the direction that they've travelled on their foraging journey to compute the direct route home.

When deprived of path integration – by being placed in an area they had not traversed – the ants returned to their nest using what the scientists describe as 'snapshots', taken one to five metres from the nest, to successfully navigate the route home.

"So when they're lost, they match these snapshots with what they see and through this comparison are able to determine the home direction," says Dr Jochen Zeil of the VC and ANU.

SEVENTEEN PROPOSALS FOR CRCs

The 16th selection round for Cooperative Research Centres has closed with 17 proposals being received. Five existing CRCs have sought extensions and 12 new proposals have been submitted. Two proposals that were not funded in the last round have been revised and presented again. The list of applications can be found on the CRC website.

The CRC Committee will examine all the applications and recommend those to go forward to Stage 2 and be presented to the Minister. Those invited forward will submit exemplar projects and attend an interview in Canberra in November. Successful applications are generally announced in December.



Researching Defence food choices.

1000 UP FOR THE SYNCHROTRON

Australian scientists have published the 1000th science paper from research partnerships with the Australian Synchrotron, located in Melbourne.

Monash University researchers Dr William Gee and Professor Stuart Batten entered the 1000th paper into its publications database in July. It considers the development of new molecular tools needed to explore and develop materials with advantageous properties.

The Australian Synchrotron, operated by ANSTO, was established six years ago, and is one of the largest stand-alone pieces of scientific infrastructure in the southern hemisphere.

Fellows lead Advanced Manufacturing Council

The June launch of the Australian Advanced Manufacturing Council saw the first such industry-led group formed, linking some of Australia's leading manufacturers and international technology leaders.

The CEOs of the companies comprising the Council met to chart the future direction of the high-value manufacturing industry in Australia. The launch meeting, supported by the Australian Industry Group, included global CEO of The Dow Chemical Company, Dr Andrew Liveris FTSE, and Cochlear CEO, Dr Chris Roberts FTSE.

The Australian Advanced Manufacturing Council will drive national priority and policy change to foster Australia's comparative advantages in advanced manufacturing. The group is a private sector initiative aimed at refocusing Australia's approach to investment and industry to deal with contemporary global dynamics.

"Manufacturing underpins sustainable, diverse economies," Australian Industry Group Chief Executive Innes Willox said.

"The Australian economy is now exposed to significant risks arising from the combination of the end of the mining boom and the global financial crisis and its aftermath. We need to set about correcting the imbalances that have emerged both for our longer-term resilience and to fill the growth gap that is rapidly becoming more evident as the mining boom retreats," Mr Willox said.



Andrew Liveris

Dr Liveris, as CEO of Dow's \$60 billion global operations, has led the conversation in the US that is enhancing a US manufacturing resurgence and a re-shoring of capabilities. He was co-Chair of President Obama's Advanced Manufacturing Partnership, and was recently appointed Chairman of the US Business Council.

"Since 2010, manufacturing has been a bright spot in the US, as the economy continues to recover from the financial crisis," Mr Liveris said. "Nearly 500,000 manufacturing jobs have been created since January 2010.

"Australia can benefit from this country's highly skilled and trained workforce, like Germany and Singapore, and be as competitive as the US on input costs. Australia has the ingredients for a dynamic advanced manufacturing economy – we just need to foster the right environment."

Companies on the Council include Agilent Technologies, Boeing, Cochlear, Dow, Incitec Pivot, Marand Engineering, Pacific Brands, ResMed, Siemens, Sutton Tools and Zip Industries.

\$175M NEW HORIZONS FOR MONASH

Researchers at Monash University's New Horizons Centre will use two hectares of new teaching and research laboratories to work on problems in future manufacturing, modelling and simulation, biological engineering and renewable energy.

Australia's first Industry Innovation Precinct, in manufacturing, is also housed at New Horizons, meaning research in advanced manufacturing will have a direct link to Australian industry.

Launching the \$175 million research hub, Innovation Minister Senator

Kim Carr said it was a vital piece of research infrastructure for Australia.

"This centre represents a new approach – bringing university and CSIRO researchers together on a global scale to work in large teams on both blue sky and applied research," Senator Carr said.

GIANT PRINTED BUGS REVEAL INSECT ANATOMY

Minute insects, from the Australian National Insect Collection, have been super-sized by up to 40 times using a novel 3D scanning system and printed using a state-of-the-art 3D printer.

The 3D bugs show new potential for entomologists studying the anatomy of miniscule creatures by enabling them to physically handle the insects and study their features up close.

Scientists believe this technology will soon enable them to determine characteristics, such as gender, and examine surface characteristics which are otherwise difficult due to insects' minute size.

Originally created for a national art exhibition, CSIRO Science Art Fellow Eleanor Gates-Stuart, says the bugs the team is working with are micro-sized, some only clearly visible under the microscope.

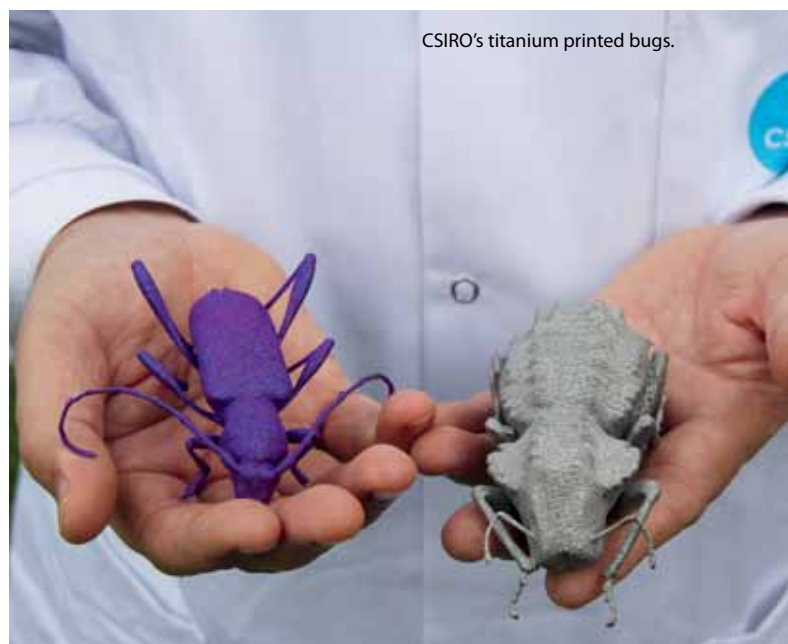
"We combined science and art to engage the public, and through the process we've discovered that 3D printing could be the way of the future for studying these creatures," she says.

To create the bug, scientists scan the insect to generate a computer-aided design (CAD) file. The CAD file is then entered into the 3D printing machine to produce a titanium 'giant'.

CSIRO's Additive Manufacturing Operations Manager Chad Henry says that compared to conventional methods of manufacturing, 3D printing is highly efficient and environmentally friendly. "The process is perfect for building fine-scale features to capture all of the intricate details of the bugs," he says.

The 3D printing machine adds layer upon layer of titanium to build up each bug. Up to 12 bugs can be produced at a time and after 10 hours in the machine the bugs emerge from the titanium powder.

CSIRO's additive manufacturing facility, Lab 22, is currently being used to manufacture a range of prototype products including biomedical implants, automotive, aerospace and defence parts for Australian industry.



The new AFFRIC buildings at Waurin Ponds.



AFFRIC buildings open in Geelong

Geelong's credentials as a global centre for cutting-edge manufacturing took a step forward in July with the opening of the Fibre Processing and Carbon Nexus buildings, part of the \$103 million Australian Future Fibres Research and Innovation Centre (AFFRIC).

The Fibre Processing building will accommodate CSIRO researchers, who will work closely with their Deakin University counterparts to develop new, high-tech and environmentally friendly fibres to revolutionise the textiles industry.

The Carbon Nexus building will house a 90-metre carbon fibre production line and furnace where researchers will produce leading-edge composite materials for commercial research purposes.

Innovation Minister Senator Kim Carr opened the two new buildings at Deakin University, for which the Australian Government has provided \$38 million in funding, noting that the applications for advanced fibre manufacturing and the benefits to the Geelong economy and Australia are immense.

"New-generation fibres, like carbon fibre, smart fibrous materials and sustainable textiles are revolutionising industries across the economy, including in the aerospace, defence, automotive and textile sectors," Senator Carr said.

"Australia's future as a high-wage, high-skill nation, that makes things and leads the world in innovation depends on our ability to bring researchers and industry together in places like AFFRIC."

AFFRIC is a collaboration of Deakin University, CSIRO and the Victorian Centre for Advanced Materials Manufacturing (VCAMM). Based at Deakin's Geelong Waurin Ponds Campus, the Centre brings together Australia's top fibre and manufacturing scientists to conduct research on all aspects of fibre



Jane den Hollander (left) and Anita Hill at the opening.

manufacturing, including carbon fibre development, natural fibres, smart fibrous materials and fibres enhanced with nanomaterials.

"Deakin and Geelong are vigorously forging a reputation as a global leader in the development of carbon fibre composites and sending a message to industry that Geelong is a place where you can invest, drive innovation, create jobs and be part of a thriving University city," said Deakin Vice-Chancellor Professor Jane den Hollander.

CSIRO's Acting Group Executive, Manufacturing, Materials and Minerals, Dr Anita Hill FTSE, said CSIRO scientists, working in partnership with Deakin's scientists, would deliver breakthrough technologies, materials and textiles to assist Australian manufacturers to compete, grow and prosper.

AFFRIC, with a projected 385 researchers, including 165 new positions, has already created around 500 jobs and injected \$160 million into the region during the building and construction phase. Once the project is fully operational it is expected to contribute \$25 million a year to the economy in the Geelong region and help position the area as the international hub for research in advanced fibrous materials.

The *Francisco*.



TASMANIAN-BUILT FERRY IS WORLD'S FASTEST SHIP

Australian shipbuilder Incat's 99-metre catamaran ferry *Francisco* has been trialled in Tasmania at 58.1 knots – or 107.6 kmh – making it the world's fastest ship.

The dual-fuel ferry, which operated in the trial with one turbine on LNG and the other on marine distillate, can carry 1000 passengers and 150 cars, and has an enormous duty-free shop on board.

The vessel's high speed comes from the combination of Incat's wave-piercing catamaran design, the use of lightweight, marine-grade aluminium, and the power produced by the two 22MW GE LM2500 gas turbines driving Wartsila L1720 SR waterjets.

Francisco – named for the first Latin American Pope – has been constructed for South American company Buquebus, for service on the River Plate, between Buenos Aires, Argentina, and Montevideo, Uruguay.

Francisco is the eighth Incat vessel to be operated by Buquebus and its associated companies. It will be the largest catamaran it has operated, and the world's first dual-fuel high-speed ferry to operate on LNG as its primary fuel.

IPAS has plenty to 'Bragg' about

Adelaide University's world-leading researchers at the Institute for Photonics and Advanced Sensing (IPAS) are now housed in a new \$92 million headquarters.

Named 'The Braggs' – for legendary researchers Sir William Henry Bragg and his son Sir William Lawrence Bragg, who won the 1915 Nobel Prize for Physics – it houses more than 10,000 square metres of research and teaching space, as well as state-of-the-art laboratories.

The Braggs, funded in part with a \$29 million grant from the Federal Government, includes unique laboratories, including for glass processing,



(From left) Professor Sir David Payne, Director of the Optoelectronics Research Centre (ORC) at the University of Southampton, Professor Andre Luiten and Professor Tanya Monro from IPAS.

optical fibre fabrication, luminescence dating and atmospheric sensing, as well as a 420-seat lecture theatre and two floors of state-of-the-art teaching laboratories.

The Institute was established to build on the success of the university's Centre for Expertise in Photonics research into the generation and control of light.

IPAS scientists work with photonics and soft glass optical fibre to improve measurement and sensing technology. This has direct applications in fields from defence and manufacturing, to health and the environment. Current projects

include a new sensor to detect early-stage gastric cancer, and optical fibres that identify corrosion in military planes.

The Institute is headed by Professor Tanya Monro FAA FTSE, who is an ATSE Director. The IPAS Board includes Dr Cathy Foley PSM FTSE, Professor Peter Gray FTSE (another ATSE Director) and Professor Andrew Holmes FRS FAA FTSE.

Opening The Braggs, the Minister for Innovation Senator Kim Carr paid tribute to Professor Monro. "The team here is led by an outstanding scholar in Professor Tanya Monro, who is a role-model for women scientists across this nation. She is a justly decorated and inspiring research leader," Senator Carr said.

ACOLA REPORTS TABLED AT PMSEIC

The 27th meeting of the Prime Minister's Science Engineering and Innovation Council (PMSEIC) on 21 June in Sydney heard a progress report from the Chief Scientist about his National Science, Technology, Engineering and Mathematics (STEM) Strategy.

Two ACOLA reports – *Engineering Energy: Unconventional Gas Production* and *STEM: Country Comparisons* – were tabled, following their launch earlier in June. These reports were produced as part of the Securing Australia's Future program, undertaken on behalf of PMSEIC by the Australian Council of Learned Academies (ACOLA).

The meeting received recommendations developed from the findings contained in these two final project reports. These recommendations were developed by the Office of the Chief Scientist

in consultation with relevant government departments and the expert working groups responsible for the reports.

Relevant departments will respond to the recommendations with an action plan at the next PMSEIC meeting, later this year.

The meeting also received a report from the Office of the Chief Scientist – *The Threat of Antibiotic Resistance: Building a New Frontline Defence* – which will be released as an Occasional Paper shortly.

INNOVATION CHALLENGE IN THIRD YEAR

Entries have closed for the \$70,000 *The Australian* Innovation Challenge awards, run by *The Australian* newspaper in association with Shell and supported by Innovation Australia.

Professor Veena Sahajwalla, of the University of NSW, won the overall prize in the professional categories last year for 'green' steelmaking – a process that transforms old tyres into a raw material for use in electric arc furnace steelmaking. The method diverts waste from landfill while boosting the efficiency of mini-mills.

Now in its third year, the Innovation Challenge targets breakthroughs to commercialisation or adoption.

Innovation policy figure and former CSIRO deputy chairman Dr Terry Cutler FTSE FAHA is heading the awards judging panel.

"Innovating and the impulse to innovate is an expression of hope – hope that it is possible to envision a different world, a better place, and to instigate change to make that happen," he said. "Ingenuity, inventiveness and imagination are the raw materials for innovation that makes a difference."

The awards, which are open to individuals and teams, have seven professional categories, each carrying a prize of \$5000. The overall winner of the professional categories will receive a further \$25,000. An eighth category, Backyard Innovation, is open to the public and has a \$10,000 prize.

The categories are: minerals and energy; environment, agriculture and food; education; health; ICT; manufacturing and hi-tech design; community services; and backyard Innovation.

ANU GETS NATION'S MOST POWERFUL COMPUTER

Australia's newest and fastest supercomputer is the centrepiece of the new National Computational Infrastructure (NCI) facility at the Australian National University.

According to ANU researchers it can perform the same number of calculations in one hour that 7 billion people armed with calculators could perform in 20 years. It has a capacity comparable to around 30,000 ordinary laptop computers working together as a single system.

The supercomputer, which also ranks as one of the largest in the world, will enable scientists to gain new and valuable insights into issues of pressing national importance such as climate change, water management and earth science. It is the result of the close collaboration between the NCI and Fujitsu.

NCI will provide scientists with a number-crunching power of quadrillions of operations per second and data storage measured in petabytes (millions of gigabytes). It also features a high-capacity data storage and cloud computing systems in a purpose-built, state-of-the-art data centre.

Supported by partner agencies CSIRO, the Australian Bureau of Meteorology, Geoscience Australia, Intersect Australia and the Queensland Cyber Infrastructure Foundation, NCI is a space for collaboration and a centre of supercomputing excellence that attracts scientists from around the world.



Geoscience goes to the cloud to integrate data

Cloud computing and one of the world's most powerful supercomputers will form the backbone of a national, integrated geoscience data network being developed by CSIRO, Geoscience Australia and AuScope.

The network is supported by world-class visualisation and spatial information storage software and features 'virtual laboratories' that allow researchers to process big data online, in the cloud and in a fraction of the time traditionally taken on a desktop.

It is set to break down barriers and open access to Australia's wealth of geoscience data – enabling researchers from across disciplines to tackle society's biggest challenges including natural disasters, climate change, water security and the sustainable development of our mineral and energy resources.

The network will utilise the National Computational Infrastructure's supercomputer, which has the processing power of more than 15,000 desktop computers.

The national geoscience data network expands on the AuScope Grid, which is a portal for Australia's geoscience information that is available to industry and the wider community.

At the forefront of e-research and data interoperability, the AuScope Grid was developed by AuScope in collaboration with several universities, government and research organisations, including Geoscience Australia and CSIRO.

(AuScope Ltd is a non-profit company formed to facilitate the implementation of a world-class infrastructure system for earth science through the delivery of a range of technologies and capabilities in data acquisition, management, modelling and simulation across the geospatial and geoscience spectrum.)

The AuScope Grid and geoscience data network infrastructure will support and enhance current collaborative projects such as UNCOVER, which aims to increase investment in research to achieve mineral exploration success. The AuScope Grid project was an initiative of the Australian Government conducted as part of the National Research Infrastructure Strategy.

Project leader from CSIRO, Dr Robert Woodcock, says that the network aims to overcome systemic, compatibility problems to save researchers, government and industry time and money.

"The network will make the approach to data more uniform across organisations, so that information can be brought together more readily and at little to no cost, regardless of where it comes from and who is accessing it," Dr Woodcock says.

The AuScope Grid is an integral part of building a national geoscience data network.

Senior adviser at Geoscience Australia, Dr Lesley Wyborn, says that the network will make valuable earth science data available to users in real-time from a range of sources across the country, which is what researchers need in order to solve today's societal issues.

"The early version of the network is focused on the minerals exploration industry, but it does have potential to be expanded into real-time accurate prediction of the impact of natural hazards," Dr Wyborn says.

CSIRO AND DSTO SIGN RESEARCH LINK

Australia's two largest publicly funded research agencies, CSIRO and the Defence Science and Technology Organisation (DSTO), have signed a Strategic Relationship Agreement aimed at high-impact research priorities.

Technologies that will come under the umbrella of the agreement include horizon scanning and emerging technologies, manufacturing

technologies, advanced materials, intelligent processing, energy storage, autonomous systems, sensors and biotechnology.

Under the alliance the two organisations will also share professional development training programs for staff, undertake staff exchanges and joint community outreach



Megan Clark and Alex Zelinsky.

activities and share infrastructure including participation in each other's innovation precincts.

"This agreement puts two powerhouses together to support high-tech development for Australia," CSIRO Chief Executive Dr Megan Clark DTSE says.

Chief Defence Scientist Dr Alex Zelinsky FTSE, who leads DSTO, says the agreement is a significant step in conducting world-leading collaborative research for dual-use technologies, which had both defence and civilian applications. The two organisations would work together to transition their dual-use research into practical outcomes for national benefit.

NMI BUILDS MINUTE MATERIALS MICROSCOPE

A new microscope that enables scientists and industry to measure materials and structures a million times smaller than a grain of sand is now in operation at the National Measurement Institute (NMI) in Sydney.

Minister for Innovation, Industry, Science and Research, Senator Kim Carr, said Australia's first metrological scanning probe microscope (mSPM) would open up new business opportunities for Australian industry.

The mSPM was designed and built to extremely exacting specifications by NMI scientists and engineers. Measurements made by the mSPM are directly traceable to the SI (Standard International) unit of length, the metre. This makes them comparable with similar measurements made anywhere in the world, satisfying the principle 'once measured, accepted all over the world'.

Permeable reactive barriers can cut water acidification



By Buddhima Indraratna
indra@uow.edu.au

The acidification of coastal waterways because of acid sulphate soil is a significant environmental, economic and social problem within Australia.

Increased population since the 1960s and the installation of deep flood mitigation drains in south-east New South Wales to enhance the usability of agricultural land have exposed naturally occurring pyrite to oxygen, thus generating sulphuric acid.

This acidic groundwater often has high concentrations of potentially toxic metals such as dissolved aluminium, iron, zinc, nickel and manganese. Acidic drainage from acid sulphate soil has the potential to cause severe environmental, economic and social impacts, including the loss of fish, biodiversity and agricultural productivity, visual amenity and the corrosion of concrete and steel infrastructure.

The University of Wollongong (UoW) has been researching the remediation of acid sulphate soil on the Shoalhaven Floodplain, in south-east NSW, for more than 20 years. Engineering strategies such as watertable manipulation using

fixed-level weirs, self-regulating tilting weirs, modified two-way floodgates and acid neutralisation through the installation of a subsurface alkaline horizontal semi-impermeable lime-fly ash barrier have been trialled.

The weirs were successful in raising the groundwater table above the pyrite layer and decreasing the rate of discharge of acidic products from the groundwater into the adjacent drains, while the modified floodgates allowed for tidal buffering of acidic drainage. These techniques are, however, unable to remediate existing acidity stored within the soil and are not feasible in low-lying areas that are subject to flooding during significant rainfall.

In addition, biological oxidation of pyrite under submerged conditions can also prevail if the organic content and

sulphidic constituents of the soils are high. While the lime-fly ash barrier improves groundwater quality, it only has a localised impact. Its longevity is also uncertain because, ultimately, the barrier will become ineffective due to coating of the concrete by aluminium and iron-bearing precipitates

PHOTO: DR ALEXANDRA GOLAB



Construction of the permeable reactive barrier, near Nowra.

CSIRO takes water basin skills to the Koshi River

CSIRO Scientists are applying their knowledge of transboundary river basin management to improve the livelihoods of people living in some of the poorest parts of Asia.

CSIRO and its partners have begun work in the Koshi River Basin, which stretches from China, across the Himalayas, through Nepal and discharges into the Ganges River in India.

The Koshi Basin is home to millions of people who rely on its fertile floodplains for their livelihoods.

There is growing pressure to address development challenges in the Koshi Basin, in particular population growth and an increasing demand for energy, while working within constraints of natural hazards exacerbated by a changing climate, such as floods, drought, landslides, sediment movement and debris flow.

In a collaborative four-year project, scientists from CSIRO's Water for a Healthy Country Flagship will provide technical assistance to the

International Centre for Integrated Mountain Development's (ICIMOD) Koshi Basin Program.

CSIRO scientists will develop an integrated basin-wide modelling system to improve management of the Koshi River Basin. This system will incorporate information on water availability, freshwater environments and the ecosystem services they provide and social considerations such as the effect of changes in water availability on livelihoods. The system will contribute to development in the Koshi Basin in a socially and environmentally sustainable manner and support national and transboundary water reforms.

Initial work will consist of a review and analysis of the existing knowledge base, capacity building and the development of a prototype model for the Koshi River Basin that incorporates information on water, climate, hydropower, freshwater environments, irrigation and social issues including poverty alleviation.

or by exhaustion of the neutralisation capacity of the lime and fly ash.

These outcomes led to the current research on the remediation through the application of a permeable reactive barriers (PRBs) – commonly a trench filled with reactive material specially selected to treat the contaminants of concern that utilise the natural flow of groundwater to treat contamination through physical, chemical and/or biological processes.

While this technology has been widely used for the remediation of subsurface contamination of organic compounds, acid mine drainage, radionuclides and heavy metals, research has just begun in Australia to investigate the use of permeable reactive barriers to treat acidic groundwater from acid sulphate soil terrain.

Before installation of a pilot-scale permeable reactive barrier, extensive laboratory testing was undertaken to determine the most suitable reactive media for use within the barrier. Recycled concrete was recommended as a suitable reactive media for the barrier based on tests on 24 different types of alkaline materials (for example, recycled concrete, limestone, oyster shells, calcite-bearing zeolitic breccia, air-cooled blast furnace slag, lime and fly ash) due to its high neutralising capacity, its ability to remove aluminium and iron from solution, its cost and availability.

A pilot-scale alkaline permeable reactive barrier was installed on an appropriate site in October 2006. The recycled concrete aggregates, from

demolished concrete structures, were sourced from a refuse depot, used to fill the barrier and were protected from physical clogging by soil and other fine particles entering the barrier by lining the trench with geotextile fabric.

The UoW team has monitored the site continuously over the past six years. A monitoring network of 38 observation wells, 18 piezometers and 2 data loggers was installed up-gradient, inside and down-gradient of the barrier to monitor its performance regarding variations in watertable, hydraulic gradient, permeability and groundwater chemistry.

Groundwater samples are frequently collected for analysis of aluminium, iron and other major trace metals using standard methods for water and wastewater examination.

Since installation, the groundwater pH up-gradient of the barrier has continuously been very acidic (average pH 4.3). The groundwater pH down-gradient was on average > 5.6 due to dilution of existing acidic groundwater with the alkaline effluent from the barrier.

While the barrier cannot prevent the oxidation of pyrite in the soil, it can dramatically improve the down-gradient groundwater quality. Since installation, the barrier has maintained a neutral pH (~7.3) and removing some 95 per cent dissolved aluminium and iron from the groundwater. This has been attributed to the dissolution of calcium-bearing minerals within the recycled

concrete and the release of alkalinity.

However, a slight decrease in groundwater pH and aluminium and iron removal efficiency over time has been observed. This indicates that some coating of the surface of the recycled concrete has occurred due to the precipitation of aluminium- and iron-bearing minerals. This has adverse effects on the reactivity of the recycled concrete and thus the longevity of the barrier.

Current UoW research is assessing the changes in groundwater flow behaviour through the barrier due to this precipitation in order to develop a time-dependent model combining groundwater flow with chemical precipitation. This model will be used to analyse the effects of acidic flow induced clogging and barrier effectiveness (that is, longevity of the barrier) for the benefit of future permeable reactive barrier design in acid sulphate soil terrain.

PROFESSOR BUDDHIMA INDRARATNA FTSE is a civil engineering graduate of Imperial College, London, and obtained his PhD from University of Alberta. He is Professor of Civil Engineering and Founding Director of the Centre for Geomechanics and Railway Engineering at the University of Wollongong, undertaking national and international research contracts and consulting jobs. He is also a Program Leader of the ARC Centre of Excellence in Geotechnical Science and Engineering and UoW Coordinator of CRC for Rail Innovation. DR LAURA BANASIAK, UoW Research Fellow, contributed to this research initiative and article.

CSIRO's work is supported by AusAID and it is working in conjunction with Australia's International Centre of Excellence in Water Resource Management (ICE WaRM) and eWater to deliver a coordinated approach to water resource management, combining excellence in training (ICE WaRM), world-class modelling software (eWater) and robust science (CSIRO).

ICIMOD is a regional intergovernmental learning and knowledge sharing centre serving the eight regional member countries of the Hindu Kush Himalayan region – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan.



Life in the Koshi River Basin.

PHOTO: NABIN BARAL, ICIMOD

Testing rocks to protect our water

A team of researchers from the National Centre for Groundwater Research and Training (NCGRT) is testing the densest layers of the Earth's rock, sediment and clay, which rule the fate of 97 per cent of the Earth's fresh water.

Engineers Dr Wendy Timms, Dr Steve Bouzalakos and a team from NCGRT and the University of NSW are employing what they have dubbed "an environmental time machine" to investigate for the first time how water penetrates these stubborn, water-resistant layers deep underground.

The answer is: with immense difficulty and over vast spans of time. But all this has immediate consequences for sustainable use of our precious groundwater, whether it is for drinking, for growing food, for mining and energy extraction or for carbon dioxide and nuclear waste disposal, Dr Timms says.

"If we don't understand the rates at which water sinks into the ground, we may unintentionally pump aquifers dry, with serious consequences for the communities and industries that depend on them. This is a core issue in managing the waters of the Murray–Darling Basin, for example – and, increasingly, the water supply in many of our cities also," Dr Timms says.

"If we cannot tell if an overlying layer is waterproof, we can't be sure that drilling for gas, or burying hazardous wastes may not contaminate other waters above or around it. If we can't be certain a layer is impermeable, we may not be able to safely store carbon dioxide below it, to slow climate change.

"So these rocks, although out of sight and largely out of mind, in fact lie at the heart of some of the most contentious issues Australians face today – water security, contamination, and global warming."

Dr Timms's team is using a rare device – one of only two in the world – known as a geotechnical centrifuge, to test the rate at which water penetrates dense material. Its two-metre arm spins at high speed, creating forces 500 times those of the Earth's natural gravity.

"We call it an environmental time machine because in a single day of testing we can emulate what happens in rock over more than 20 years," Dr Bouzalakos says.

"For the first time we can accurately assess how quickly water moves through these dense layers and use that to predict things like how quickly an aquifer will recharge, or whether it will leak into other surrounding aquifers.

"For example, when you drill for coal seam gas,

you may want to test whether there is any chance that the gas might leak into somebody's drinking water or stock water, or to see if there is a connection to shallow aquifers."

So far the team has measured about 100 samples of rock collected from major basins across the continent, from depths of up to a kilometre, to test the rates at which water can penetrate them. It is a small start on a very large piece of exploration which aims, ultimately, to find out how much fresh water Australia actually has, and how often it is replenished. It is thought that more than 90 per cent of the nation's supplies exist underground, rather than in rivers, lakes and dams on the surface.

The National Centre for Groundwater Research and Training is an Australian Government initiative, supported by the Australian Research Council and the National Water Commission.

HEAT HELPS CHECK AQUIFER RECHARGE

Water scientists are using heat to measure the extent to which some of Australia's inland rivers and streams could dry up due to over-extraction of groundwater.

During the Millennium Drought a number of rivers and streams in the Murray–Darling Basin dried up, partly as a result of over-extraction from the aquifers that normally keep them flowing.

In a bid to understand the problem better and to help water managers secure water supplies, researchers at the National Centre for Groundwater Research and Training (NCGRT) are measuring water temperature both above and below the surface.

"By measuring the rate at which warmer water from the surface trickles into the cooler water below ground we can gain an idea of how quickly or slowly an aquifer is being recharged," says Dr Martin Andersen of NCGRT and the University of NSW.

"We've installed data loggers at various points in the Murray–Darling Basin both above and below ground, which are recording temperature changes throughout the day, allowing us much greater insight into the movement of water between streams and underground aquifers."

Although other methods, such as natural radioactive tracers are more appropriate when looking at deeper groundwater systems, where temperature changes are undetectable, in these shallow systems natural changes in heat make an excellent tracer for water movement as it is freely available and easy to measure.

DEEP SPACE 'FLASHES'

CSIRO's Parkes radio telescope in NSW has detected mysterious 'flashes' of radio energy from the distant universe that may open up a whole new area of astrophysics.

The surprising finding, made by a team of scientists from 10 institutions in Australia, the US, the UK, Germany and Italy, was published in *Science* (5 July 2013).

Four flashes were detected, each from a different direction and each lasting for only a millisecond (a thousandth of a second). The characteristics of the radio signal – how it is 'smeared out' in frequency from travelling through space – indicated that the flashes came from up to 11 billion light-years away.

No gamma rays or X-rays were detected in association with the flashes, and the astronomers have ruled out the flashes being from phenomena such as gamma-ray bursts, the merger of two neutron stars, merging black holes, or evaporating black holes.



NCGRT Research Associate Dayna McGeeney samples water from a rock core using the centrifuge.



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Fellows win Queen's Birthday Honours

Five Academy Fellows were recognised in the Queen's Birthday Honours.

Emeritus Professor Alan Robson AO FTSE, Chair of the 2014 ATSE Clunies Ross Awards Committee, and Emeritus Professor Tom McMeekin AO FTSE, former Chair of the Tasmanian Division, were made Officers of the Order of Australia.

Mr Peter Knight AM FTSE, former Chair of the WA Division, and Dr Richard Sheldrake AM FTSE, elected to the Fellowship in 2010, were both made Members of the Order.

Emeritus Professor Antoni Emil Karbowski AM FTSE, a Foundation Fellow who died in July 2011, was awarded an AM posthumously.

Professor Alan Robson, already a Member (AM) in the General Division of the Order of Australia, was honoured for distinguished service to tertiary education through governance and administrative roles, to the advancement of scientific and medical research, and to the community.

An Academy stalwart since his election in 1987, Professor Robson was Deputy Vice-Chancellor then Vice-Chancellor of The University of Western Australia (UWA) for 17 years before his retirement in 2011.

He is an internationally recognised agricultural scientist with particular research interests in the mineral nutrition of plants and soil fertility.

Professor Robson is a former chair of the Australian 'Group of Eight' research-intensive universities, former Deputy Chair of Universities Australia, the body representing all universities in Australia, and former Chair of the World Wide Universities Network, which includes 16 of the world's leading research universities across eight nations.

Professor Tom McMeekin was honoured for his distinguished service to science particularly in the development of food safety standards and education.

Acknowledged as one of the world's leading food microbiologists, whose

proven expertise has impacted on food safety internationally, Professor McMeekin pioneered the development of predictive microbiology and established the University of Tasmania (UTAS) as the world leader in predictive modelling of microbial behaviour in foods.

He was the Professor of Microbiology at the School of Agricultural Science at UTAS and was instrumental in the establishment in the Australian Food Safety Centre of Excellence. The work he and a group of scientists did established new systems of predicting food safety around the world.

Mr Peter Knight was honoured for significant service through support to the homeless and to engineering. He is a former ATSE Councillor and Chair of the WA Division of the Academy, graduated from UWA with a Bachelor of Engineering in 1961 and was 1995 West Australian Citizen of the Year.

He is a former managing director of Clough Ltd, a board member of the St George's College Foundation (WA) and director (1998–2012) of St Bartholomew's House, an organisation focused on reducing homelessness.

He was named 1993 Professional Engineer of the Year by Engineers Australia.

Dr Richard Sheldrake, Director-General of the NSW Department of Primary Industries, was recognised for significant service to public

administration in NSW and to the community. He was elected a Fellow in 2010.

After studying agricultural science at the University of Sydney and undertaking a PhD at the University of Newcastle, Dr Sheldrake started work as a research scientist in the dairy industry in the 1970s, where he was involved in a mastitis research project that helped farmers implement mastitis control, and later gained international recognition as a DPI researcher investigating the control of mycoplasmal pneumonia in pigs.

Since then he has served as director-general for several departments in the agricultural and natural resources sector – Agriculture, Natural Resources, Industry and Investment, and Primary Industries – as well as a period in the Department of Environment.

Professor Antoni Emil Karbowski was honoured posthumously for his significant contribution to tertiary education. He was a prominent electrical engineer and pioneer of modern telecommunications.

Professor Karbowski was head of the Department of Communications at the University of NSW from 1964 until his retirement in 1987. Born in Poland, he held a PhD and DSc from the University of London and worked as a senior research engineer, head of the Microwave Laboratory and head of the Optical Systems Group at the Standard Telecommunication Laboratories (STL), UK, between 1955 and 1964 before coming to Australia.



Alan Robson



Tom McMeekin



Richard Sheldrake

Ian Brown wins Keith Farrer Award



Dr Anne Astin presents the award to Ian Brown.

Dr Ian Brown FTSE, CEO and MD of Clover Corporation, has been awarded the Keith Farrer Award of Merit by the Australian Institute of Food Science and Technology, which acknowledges achievements in food science and technology.

The award was presented at the 46th ASIFST Convention in Brisbane in July.

The Award honours ATSE Foundation Fellow Dr Keith Farrer, who died in June 2012, aged 96, and is remembered as the 'father' of Vegemite.

Dr Brown's 32-year career spans technical and commercial roles across the cereal, ingredient, food and nutrition industries both internationally and locally. In furthering his personal research activities and applying them collaboratively between companies and the scientific sector, Dr Brown has been successful in commercialising key food and nutritional ingredients including Hi-Maize®, the world's first commercial source of resistant starch.

He is CEO and Managing Director of the Australian publicly listed company Clover Corporation, which under his leadership has experienced an increase in profits from \$465,000 to \$4.4 million, and is a Special Visiting Professor at the University of Colorado and an Adjunct Professor at the Flinders University of South Australia.

President of the AIFST, Jo Davey, said: "It is unique in the food sector to see an individual that holds full-time senior industry positions with such an impressive scientific record of published papers, book chapters and keynote presentations.

"Additionally, he has also been awarded a

PhD by one of Japan's leading universities and is listed on 24 patents."

Foundation Fellow and Honorary Fellow, Dr Keith Farrer OBE FTSE, who died in Melbourne on 6 June 2012, aged 96, was a giant in the food technology industry, a driving force behind the establishment of the Academy and its Foundation Vice President. The Academy's book ATSE 1975-2005 The First 30 Years details much of his role in the Academy's establishment.

He was one of the original six-member steering committee of the Australian Industrial Research Group (AIRG) that took up the challenge of the establishment of an applied science academy. He chaired the Executive Committee of the formation Council, established in July 1974 and was a signatory of the original Academy's Memorandum of Association dated 31 October 1975.

He spent 43 years with Kraft Foods Ltd, starting as a research chemist (1938) becoming senior research chemist (1945) and then from 1949 to 1981 serving as the senior technical officer for Kraft's total R&D effort and science matters. He was Manager Research and Development (1949-76) then served as Chief Scientist until he retired in 1981.

He is widely acknowledged for his work in developing Vegemite as an important source of vitamin B1 during his time at Kraft. Dr Farrer was proud of the R&D work that he and his team at Kraft undertook which, among other things, saw Vegemite included in rations for Australian servicemen during World War II.

FELLOWS AMONG TOP EDUCATION NAMES

Four ATSE Fellows were named by *The Australian* newspaper among Australia's top 50 education influencers.

Heading the list at number 11 is Mr Michael Chaney AO FTSE, followed by Professor Margaret Sheil FTSE (34), Emeritus Professor Alan Robson AO FTSE (43) and Dr Terry Cutler FTSE FAHA (50).

Mr Chaney is Chairman of Woodside Petroleum Ltd and National Australia Bank, and Chancellor of The University of Western Australia (UWA). In 2011 he was appointed chair of the Australian Government's International Education Advisory Council, which was tasked with providing advice on the challenges and opportunities facing the international education sector in Australia.

The Government released the Council's report in February 2013 and is now considering the Council's advice in developing a five-year strategy to support the sustainability and quality of the international education sector in Australia.

Professor Sheil is the former head of the Australian Research Council and is now Provost of The University of Melbourne. She was previously Deputy Vice-Chancellor (Research) at The University of Wollongong.

Professor Robson was Deputy Vice-Chancellor then Vice-Chancellor of UWA for 17 years before his retirement in 2011. He is chairman of the Higher Education standards Panel and an internationally recognised agricultural scientist with particular research interests in the mineral nutrition of plants and soil fertility.

Dr Cutler, described by *The Australian* as "one of the country's original poster boys for innovation", headed the team that produced the 2009 report on innovation titled *Venturous Australia*. He is a Director of CSIRO.



Michael Chaney



Margaret Sheil



Terry Cutler

Fellows prominent in 2013 Top 100 Engineers listing

Nearly 25 per cent of Australia's "most influential" engineers are Fellows of ATSE, according to Engineers Australia's 2013 Top 100 Engineers listing. Five of the 24 ATSE engineers honoured are women.

Published in *EA Magazine*, the Top 100 lists engineers in 11 categories – Academia/Research, Associations, Community, Contractors/Services, Consulting, Industry, Innovation/Expertise, Manufacturing, Politics, Public Service and Utilities.

Eleven per cent of the group are women, 38 per cent live in NSW, 23 per cent graduated from the University of NSW and 34 per cent are civil engineers.

ATSE dominated the **Academia/Research** listing, providing seven of the 10 names in the category: Professor Hugh Durrant-Whyte FRS FAA FTSE (CEO, NICTA), Professor Peter Lee FTSE (VC, Southern Cross University), Professor Max Lu FTSE (Senior Deputy VC and Deputy VC Research, University of Queensland), Dr Adi Paterson FTSE (CEO, ANSTO), Professor Judy Raper FTSE (Deputy VC Research, University of Wollongong), Professor Ian Young AO FTSE (VC, ANU) and Professor Alex Zelinsky FTSE (Chief Defence Scientist and CEO, DSTO).

ATSE President and Monash University Chancellor Dr Alan Finkel AM FTSE was named in the **Associations** listing and Mr John Grill FTSE, Chair of the John Grill Centre for Project Leadership, was named in the **Community** listing.

In the **Contractors/Services** listing, Mr David Stewart FTSE, Chief Executive Australia Hub, Laing O'Rourke, and Mr Hamish Tyrwhitt FTSE, Chief Executive, Leighton Holdings, were both named, and Dr Robert Care AM FTSE, Arup's Chair, UK, Middle East and Africa, was ATSE's sole listing in the **Consulting** category.

ATSE Fellows contributed two names to the list of 11 comprising the **Industry** category: Dr Bob Every AO FTSE (Chair, Wesfarmers) and Mr David Knox FTSE (Managing Director and CEO, Santos).

Professor Rose Amal FTSE (Director, ARC Centre of Excellence for Functional Nanomaterials, UNSW), Professor Karen Reynolds FTSE (Director, Medical Devices Research Institute, Flinders University) and Professor Stuart Wenham FTSE (Director, ARC Photovoltaics Centre of Excellence, UNSW)

were named in the **Innovation/Expertise** category.

Dr Andrew Liveris FTSE (Chair, President and CEO, Dow Chemical), Mr Doug Rathbone AM FTSE (CEO and Managing Director, Nufarm), Dr Chris Roberts FTSE (CEO, Cochlear) and Mr Julian Segal FTSE (Managing Director and CEO, Caltex) were named in the 14-strong **Manufacturing** category.

In the **Public Service** listing, two ATSE Fellows were named: Dr Geoff Garrett AO FTSE (Queensland Chief Scientist) and Professor Mary O'Kane FTSE (NSW Chief Scientist and Scientific Engineer).

Ms Susan Murphy FTSE (CEO, WA Water Corporation) was ATSE's only name in the **Utilities** category.

All four members of the 2013 selection panel were Fellows:

- Professor Paul Douglas FTSE, former CEO of SKM and Professorial Fellow, University of Melbourne;
- Professor Michael Dureau AM FTSE, Deputy chair of the Warren Centre for Advanced Engineering and an adjunct professor, University of Sydney;
- Dr Bronwyn Evans FTSE, Senior VP – Quality, Clinical and Regulation, Cochlear; and
- Air Vice-Marshal Julie Hammer (Retd) FTSE, former RAAF electronics engineer and former President of Engineers Australia.

MAX LU NAMED A QUEENSLAND GREAT

The Queensland Government has recognised The University of Queensland's Deputy Vice-Chancellor (Research), Professor Max Lu FTSE, for his significant contributions to society.

He was among six "Queensland Greats"



Max Lu (right) receives his award from Queensland Premier Campbell Newman.



Hamish Tyrwhitt



Mary O'Kane



Rose Amal

named at a Queensland Week ceremony in Brisbane in June.

"Max is a consummate Queensland Great who projects Queensland innovation onto the world stage, and attracts international investment to Queensland research and development," said UQ's President and Vice-Chancellor, Professor Peter Høj FTSE.

"His research output alone is tremendous, and when you add his inventions, his mentoring of young researchers, his linking of research with industry, and his community and philanthropic work, he is nothing short of phenomenal.

Professor Lu is known for his work on nanoparticles and nanoporous materials for clean energy and environmental technologies. He first came to UQ in 1987 to study for his PhD, and spent three years lecturing at Singapore's Nanyang Technical University before returning to UQ in 1994.

Last year, then-Chinese president Hu Jintao and premier Wen Jiao Bao presented Professor Lu with a prestigious science and technology award in a ceremony in the Great Hall of the People in Beijing.

Professor Lu has received prestigious ARC Federation Fellowships twice (2003 and 2008). He has served on a number of government committees and advisory and working groups, including the Prime Minister's Science, Engineering and Innovation Council (2004, 2005, 2009) and ARC College of Experts (2002–04).

He is a board member of the Australian Synchrotron, National eResearch Collaboration Tools and Resources, and Research Data Storage Infrastructure.

Three win Laureate Fellowships

Three Fellows are among Australia's leading researchers who have been awarded 2013 Australian Laureate Fellowships – Professor Tanya Monro FAA FTSE, Professor Arthur Lowery FTSE and Winthrop Professor Mark Cassidy FTSE.

Professor Monro, an Academy Vice President, also won the Georgina Sweet Australian Laureate Fellowship.

Professor Monro is an ARC Federation Fellow (2008) and is the Director of the Institute for Photonics and Advanced Sensing (IPAS) at The University of Adelaide. She is also a Professor of Physics at the School of Chemistry and Physics (CoEP).

Professor Monro started at The University of Adelaide in early 2005 as the inaugural

Chair of Photonics and the Director of the DSTO Centre of Expertise in Photonics. From 1998–2004 Professor Monro worked within the Optoelectronics Research Centre at the University of Southampton in the UK. She has published more than 450 papers in journals and refereed conference proceedings.

Professor Monro is a member of the South Australian Premier's Science and Industry Council, and regularly serves on a range of committees for the Australian Academy of Science and other key national bodies in the area of science policy and the evaluation of science.

Professor Monro has a number of awards including: the 2012 Pawsey Medal from the Australian Academy of Science; 2012 Nova Systems Community Achievement Award in

South Australia; 2011 Australian of the Year in South Australia; 2010 Telstra Business Woman of the Year, White Pages Community and Government Category (National & South Australian winner); and 2010 South Australian Scientist of the Year.

Professor Lowery – who won an ATSE Clunies Ross Award in 2007 – is the Director of the Monash Vision Group based at Monash University, which aims to develop a bionic eye implant by 2013 and is funded by the Australian Research Council's (ARC) Special Research Initiative in Bionic Vision.

Professor Lowery is an engineer, innovator and educator with a proven success record transforming ground-breaking technical innovations into successful international businesses. His core competencies are in management of research and development, communications technology, intellectual property management, export marketing and innovative teaching.

Professor Lowery built the global Photonic Design Automation (PDA) industry from his fundamental research in semiconductor laser modelling. In 1996 he founded Virtual Photonics Pty Ltd (later Inc), with Dr Phil Gurney, to commercialise OPALS, a software tool for designing optical



Professor Monro's project aims to develop a suite of light-based sensing technologies capable of quantifying the dynamic environment within a living cell. This will extend our capacity to harness light-matter interactions at the nanoscale, providing new insights in fields ranging from plant biology to medicine.

Sam Luxton was an engineering leader

Emeritus Professor Russel Escourt Loxton spent 25 years at the University of Adelaide, before his retirement in 1999 and won national acclaim for his expertise in air conditioning, for which he won a 1999 ATSE Clunies Ross Award.

Nicknamed 'Sam' after Sam Loxton, a member of Bradman's 1948 'Invincibles', for his prowess at cricket as a student at Geelong Grammar School, Sam Luxton became a highly respected figure in engineering circles.

His death in Adelaide on 24 May, aged 80, brought down the curtain on a long and successful career in education and engineering. He was an ATSE Fellow for more than 30 years.

He gained a Bachelor of Mechanical Engineering with Honours from the University of Adelaide and then moved to the University of London, to undertake his PhD at Queen Mary College in Aeronautical Engineering, completing his thesis, 'An investigation of drag and heat transfer effects at high speeds', in 1960.

Following this, he returned to Australia to take a position at the University of Sydney, where he progressed from lecturer to Associate Professor over the next 14 years. In 1974 Professor Luxton was appointed to the Chair of Mechanical Engineering at his Alma Mater, the University of Adelaide. He retired from the faculty in 1999.

Among his notable achievements were a paper published in *Nature* on the role of Coriolis force, together with a body of work on boundary layers, heat transfer and noise control, notably on combustion-generated noise.

A series of patents on minimising energy use in air conditioning and on a precessing burner for minimising emissions, as well as numerous publications, spawned Australian owned and operated companies with both Australian and export markets.

He was also a major contributor to the development of the Olympic torch and

cauldron for the Sydney Olympics.

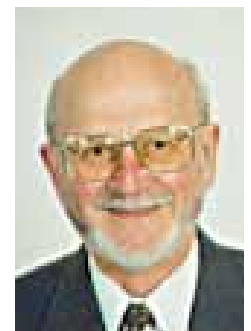
As consultant to the Australian Science and Technology Council, he drafted the 1977 Council's

Report to the Prime

Minister on Australia's needs and skills base to achieve energy self-sufficiency expeditiously.

A key recommendation was the establishment of a National Energy Research, Development and Demonstration Council (NERDDC), which was the origin of the current Clean Energy Council and the Australian Renewable Energy Agency.

He subsequently served on the NERDDC Council and chaired the Standing Committee responsible for energy use in industry, in motor vehicles and buildings.



Sam Luxton



Professor Lowery's project will deliver the science for a new generation of green optical networks, by identifying optimum combinations of electronic and photonic signal processing to solve fundamental data bottlenecks. It will implement these technologies in powerful electro-photonic chips, upon which superior energy-efficient internet switches can be built.

communications devices and circuits. In 1997 GOLD (Gigabit Optical Link Designer) was launched to an enthusiastic and rapidly growing market. GOLD was developed in a joint project with Telstra and The University of Melbourne. Virtual Photonics Inc merged with BNeD Inc, a competitor out of the Hienrich Hertz Institute (Berlin) that had obtained government funding and VC money, to form VPI Virtual Photonics Inc in late 1998 (known in the industry as VPI, but now officially VPIsystems).

Professor Lowery was appointed Chair of Electrical and Computer Systems Engineering at Monash University in September 2004. He is also a Science Leader in the ARC's Centre of Excellence in Devices for Ultrahigh bandwidth Optical Systems (CUDOS).

Professor Cassidy was an inaugural ARC Future Fellow and is Director of the Centre for Offshore Foundation Systems

at The University of Western Australia. He is also the Deputy Director of the ARC Centre of Excellence for Geotechnical and Science Engineering and in 2011 was appointed as a member of the ARC College.

He graduated in Civil Engineering from the University of Queensland in 1994 and, as a Rhodes Scholar, attained a doctorate in Engineering Science from the University of Oxford in 1999.

Professor Cassidy's research interests are



Offshore gas lies at the heart of Australia's prosperity with \$120 billion of infrastructure under construction, but its future requires new technology to safely build offshore foundations in our weak and problematic soils. Professor Cassidy's project will provide engineers with science-based tools to unlock the natural gas 'stranded' in our deep oceans.

in offshore geotechnics and engineering, predominantly developing wave-structure-soil interaction models for the analysis of oil and gas platforms, mobile drilling rigs and pipelines.

His achievements and awards include: the 2007 Malcolm McIntosh Prize for Physical Scientist of the Year in the Prime Minister's Awards for Science; and the 2006 Western Australian Premier's Prize for Early Career Achievement in Science.

These three Fellows were among 17 outstanding researchers awarded a total of \$47 million in research funding in the 2013 Australian Laureate Fellowships. The Australian Laureate Fellowships scheme, administered by the ARC, supports outstanding Australian and international researchers to build Australia's ability to make new discoveries and pursue innovative studies, as well as mentoring early career researchers.

Professor Luxton served at state and national levels for ATSE, including roles as chair of the SA Division (1988–91) and National Councillor. He was also a national councillor for the Society of Automotive Engineers, Australasia (1981–94).

He served on the committee of the national accreditation programs for Mechanical Engineering Courses (1974–80) and Thermodynamics and Fluid Mechanics (1963–78), some years as Chairman. He also served as overseas examiner for the Institution of Engineers, Australia in both India and PNG.

It was also largely through his efforts that the Sir Ross and Sir Keith Smith Fund was established. The fund supports research and education in the fields of aeronautics and astronautics in South Australia for South Australians.

At the School of Mechanical Engineering at Adelaide, he established the combustion research group, later to become the Centre for Energy Technology, and greatly expanded the air conditioning research group. His many

formal roles at The University of Adelaide included Head of School (1974–79, 1988–91) and Dean (1978–81), while also teaching every subject in the School and acting as a mentor, guide and colleague to so many.

Professor Luxton's many honours include the George Julius Medal (shared, 1979), the Albert Ludgate Award (shared, 1983), the AGM Michell Award (1986) and the ATSE Clunies Ross Award (1999).

• Focus thanks Professor Gus Nathan and Associate Professor Fred Zochel of The University of Adelaide for this material.

ANDREW MICHELMORE HEADS MCA

Mr Andrew Michelmores FTSE has been elected Chairman of the Minerals Council of Australia Board, replacing Mr Peter Johnson. He has been on the MCA Board since 2008.

Mr Michelmores is the Managing Director and Chief Executive Officer of MMG and has more than 30 years' experience in the metals

and mining industry, including 12 years at WMC Resources Ltd, where he was Chief Executive Officer.

Prior to that, he held senior roles in the company's nickel, gold, alumina, copper, uranium and fertiliser businesses.

Mr Michelmores, a Fellow since 2003, is a chemical engineer and was Victoria's 1976 Rhodes Scholar, following completion of his engineering degree.

He has been a strong supporter of the Clunies Ross innovation and commercialisation initiative, serving as Director and Governor of the Ian Clunies Ross Foundation from 1999 to 2002.



Andrew Michelmores

Three Fellows on Manufacturing Precinct Board



Calum Drummond



Paul Greenfield



Mike Heard

Dr Calum Drummond FTSE, Professor Paul Greenfield AO FTSE and Mr Mike Heard FTSE have been appointed to the Board of the Government's Manufacturing Precinct.

Dr Drummond is Group Executive, Manufacturing, Materials and Minerals, CSIRO, and a Director of ATSE. He is one of Australia's leading materials scientists whose research interests are in the area of advanced materials, including application to energy storage and biomedical products. He also has a strong interest in the commercialisation of research for Australia's benefit.

Professor Greenfield is chair of ANSTO and an ATSE Director. He is a former Vice-Chancellor of the University of Queensland and has extensive experience as a Board Director. He has consulted and worked widely with industry on a range of projects, as well as on the economic evaluation of projects. His interests lie in biotechnology, environmental management, and R&D management and commercialisation.

Mr Heard, the former Managing Director and CEO Codan Ltd, spent his career in applied R&D, engineering and management of manufacturing businesses with the past 20 years spent transforming Codan from a small Adelaide radio manufacturer to one of Australia's great diversified technology product businesses, with worldwide sales. He is a member of South Australian Premier's Science and Industry Council.

The Board includes representatives from leading manufacturers, unions and the research sector, chaired by Mr Albert Goller, former Managing Director and Chair of Siemens Australia and New Zealand.

JOHN CURTIS WAS A PIONEER IN TELECOMMUNICATIONS

Mr John Curtis CB FTSE, who died in Brisbane on 10 July 2013, aged 93, had been a Fellow since 1979 and was the former Managing Director of Telecom Australia, the predecessor company to Telstra.

A telecommunications engineer with degrees in engineering, science and arts, Mr Curtis worked for the Postmaster General's Department (PMG), which was responsible for Australian postal and telecommunications services – mail, parcels, telegrams, local and 'trunk' (long-distance) phone services – for decades before the tasks were split between Australia Post and Telecom.

Born in Closeburn, near Brisbane, in 1920, Mr Curtis was responsible for the technical planning of the telecommunications network in Queensland and later headed the PMG in that state as Director Posts and Telegraphs, Queensland (1971–73). In his subsequent role as Deputy Director General at the PMG Melbourne headquarters (1973–75), his responsibility included oversight of key

engineering initiatives and much of the planning and administrative work in preparation for the formation of Telecom and Australia Post.

When Telecom Australia was formed in



John Curtis

1975 he was appointed Managing Director, and was responsible for the planning, development and provision of all public telecommunication services in Australia.

This included management of one of Australia's early technology-based enterprises employing more than 2000 professional engineers, with assets exceeding \$6 billion and an annual investment program of some \$900 million. He was a member of the Australian Telecommunications Commission and the Overseas Telecommunication Commission, responsible for Australia's international telecommunications function.

He was a member of the Institution of Engineers, Australia, and a Companion of the Order of the Bath, an ancient British Order, founded in 1725.

ED BYRNE TO HEAD KING'S COLLEGE

Professor Edward Byrne AM FTSE, President and Vice-Chancellor of Monash University, has been appointed Principal and President of King's College, London.

Professor Byrne will be taking office in September 2014 when Professor Sir Richard Trainor leaves

to take up the post of Rector of Exeter College, Oxford.

During his tenure at Monash, Professor Byrne has led the university through a period of exceptional development in Australia and internationally.

Professor Byrne has demonstrated outstanding commitment to research excellence throughout his career, including drawing together people from different disciplines to address global challenges and ensuring the quality of student education, the student experience and student employability.

Sir Richard said: "In my opinion this is a terrific appointment and I feel confident that, in addition to making his own unique and important contribution, Ed will continue to build on the many successes we have had at King's especially over the past decade."



Ed Byrne

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HOW DOES AUSTRALIA MEET ITS ENERGY NEEDS IN 2035 AND BEYOND?



Energy experts from The University of Queensland's Global Change Institute have found that renewable energy will be critical for Australia to meet its energy needs into the future.

A recent report, *Delivering a competitive Australian power system: The challenges, the scenarios*, co-authored by UQ energy economist John Foster, investigates a business-as-usual approach to power generation and compares it with investment in large-scale renewable energy, nuclear power and carbon capture and storage.

A mix of large-scale renewable energy generation, including solar and wind, together with existing coal-fired power, will deliver a power system that best meets Australia's needs for 2035, Professor John Foster said.

The inter-disciplinary report recommends an immediate investment in multiple energy technologies to meet carbon abatement targets and ensure a robust power system into the future.

Key insights from the study found:

- The resilience of Australia's power system is currently poor (better only than India and South Africa) and is not compensated by low electricity costs.

- On the current trajectory, the power system is not on-track to cut emissions by 80%, in line with Australia's 2050 emissions targets, even with a high carbon price.
- Australia will benefit from investment in large-scale renewable energy projects to operate alongside coal in the foreseeable future.

A full summary of the report is available on the Global Change Institute website: gci.uq.edu.au/publications

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.

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