

TECHNOLOGY CHALLENGES

WHERE INNOVATION HAS
A KEY ROLE TO PLAY

Contributors discuss the challenges and opportunities for Australia in using technology to address the nation's key challenges

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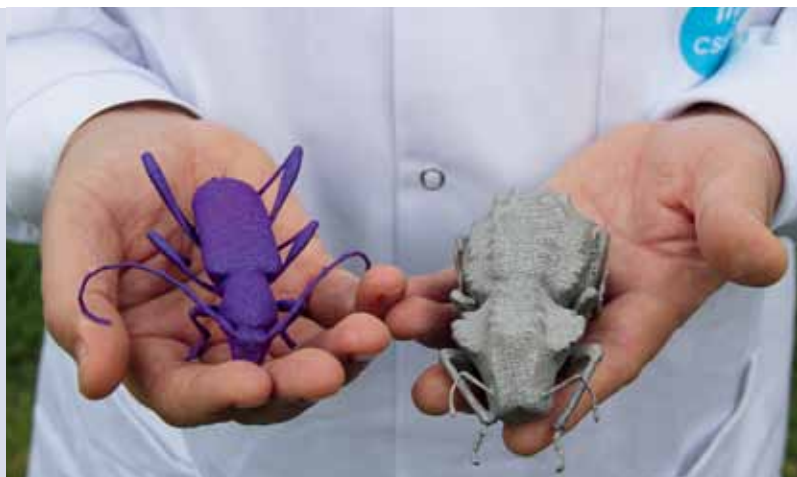
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Energy for Australia: chasing the low-carbon solution

By Bruce Godfrey



Front cover: Technology for national challenges.
PHOTO: iSTOCKPHOTO



Innovative manufacture by CSIRO using 3D scanning systems and 3D printing to make titanium bugs for science research. (Page 11).

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FOCUS

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

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

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

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

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By John Bell
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Innovation policy linked to productivity boost

New policies are urgently needed if we are to use innovation to maintain our standard of living.

What is the relationship between innovation and productivity? This question is, in essence, the topic being addressed by an Expert Working Group established by the Australian Council of Learned Academies (ACOLA). A report for the Prime Minister's Science, Engineering and Innovation Council is currently in preparation.

Productivity is a disarmingly simple concept – outputs divided by inputs. The problem is that, while there are good measures of outputs (for example, dollar value of production), counting all the inputs turns out to be a challenge.

In the past, we added capital, labour, energy and material costs to get inputs. However, there are other factors that also influence productivity. Innovation falls into this category.

During the mid-1990s Australia's overall productivity grew. Some commentators attribute this to micro-economic reform (including the floating the Australian dollar). However, similar growth was observed in other Organisation for Economic Co-operation and Development (OECD) countries, which supports another explanation – the impact of innovation in information and communications technologies (ICT).

Just think back to the days when our banks had significant numbers of tellers. Internet banking and electronic payment systems have had a dramatic impact. This is an example of innovation improving productivity – something

that can be expected when innovation leads to new, more efficient processes.

While innovation can enhance productivity, we need to keep in mind that this is not its only purpose. Innovation provides new products and services that create jobs and increase GDP.

Take the case of the Australian mining industry. Innovation in products and services used in this industry contribute to its international competitiveness. Orica Ltd is an example of an innovative company supplying both explosives and services used by the mining industry to ensure safe and efficient operations.

If innovation is so important, does Australia have the best set of policies to ensure our international competitiveness? Improvements are needed.

Here are six reasons

1 We lie well behind the leaders when it comes to business expenditure on R&D

While research and development is only one element of innovation, business expenditure on R&D (BERD) is widely considered to be a useful indicator of the level of innovation activity. In Figure 1, Israel is the leader with BERD at

TECHNOLOGY TO FACE THE NATION'S CHALLENGES

Australia's resilient economy is facing significant structural change. The Academy's 2013-2017 Strategy Plan notes key areas where technological innovation has a role to play.

These include:

- innovation policy, investment and productivity;
- healthcare for an ageing population;
- transition to low-carbon energy sources;
- natural resources management, including water;
- agricultural productivity;
- infrastructure and transport; and
- improved STEM education.

This edition of ATSE *Focus* addresses most of these issues, with keynote articles contributed by Fellows with expertise in each area.

It omits agricultural productivity – covered extensively in *Focus* 182 (February 2014) – and STEM education, which will be the theme of the next edition of *Focus*.

It additionally covers two important topics – advanced manufacturing and international collaboration.

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

Figure 1 Business enterprise expenditure on R&D 2011.

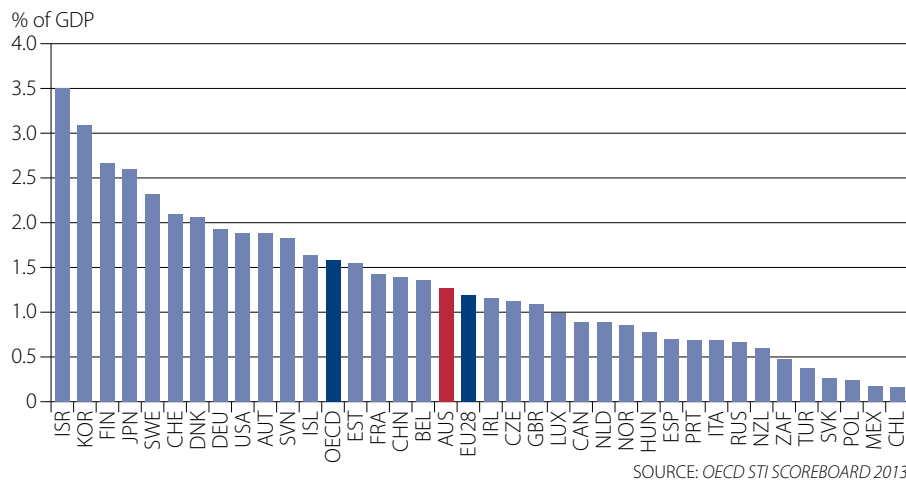


Figure 2 Average management performance in manufacturing.

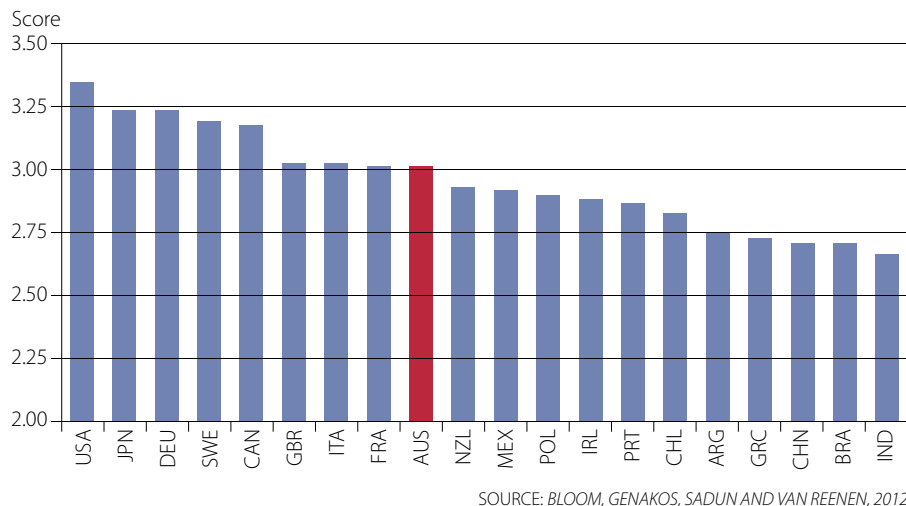
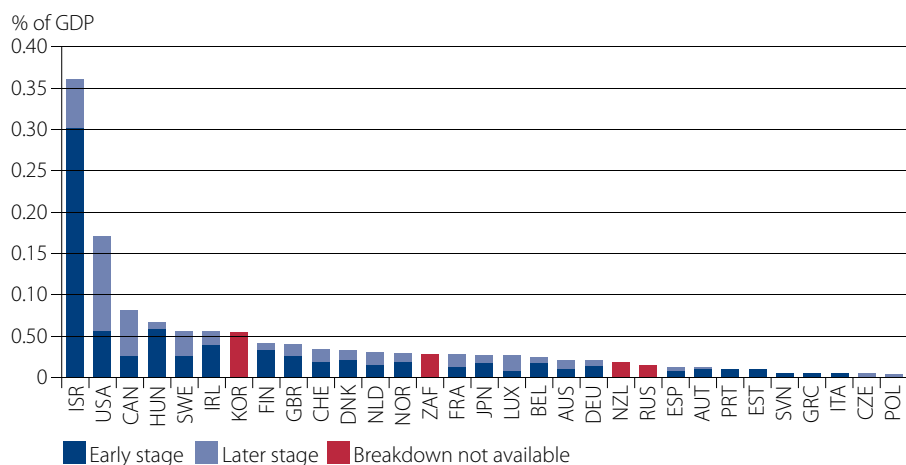


Figure 3 Venture capital investment 2012.



around 3.5 per cent of GDP. By contrast, the level of BERD in Australia is less than half that of Israel and well behind Korea and Finland.

2 Our business management skills are middling

The recent comparative rating shown in Figure 2 confirms earlier work by Professor Roy Green at the University of Technology, Sydney – Australian management performance is well behind the leaders. This is a problem because recent studies have demonstrated that business growth requires both innovation and good management.

3 It is difficult to find venture capital for new technology-based firms

Growing new technology-based firms requires venture capital. Measures such as the Government's Innovation Investment Funds are sound from a policy perspective, but are not achieving the levels of investment that we see in other countries. Figure 3 shows that Canada, in third place, is doing much better than Australia. A lack of venture capital means that some start-up companies with innovations fail, or move offshore before they have established an Australian base.

4 Government assistance for firms is relatively modest by OECD country standards

With the recent discussion about the closure of the car manufacturers in Australia, you could be excused for thinking that in the past Australia is generous in its provision of direct financial support to industry. What Figure 4 shows is that that the assistance for business R&D is anything but generous. By comparison, that bastion of free market economics, the US, provides eight times Australia's level of direct support.

5 Our publicly funded researchers are not well connected to business and industry

We have a strong public sector research base in our universities and government laboratories. However Australia needs to get a bigger dividend from this investment if we are to improve

**Time is not on our side.
Countries in our region are
outpacing us in the growth
of their investment in
research and innovation.**

productivity and grow the economy. Figure 5 shows one of the reasons behind this. Our publicly funded researchers are not well connected with Australian firms. Other countries have done better in recognising the opportunities to build innovation capacity in firms through research collaboration.

**6 It is hard to be a 'fast follower'
if we are not adequately linked
to the rest of the world**

Australia cannot expect to be a leader in many technologies. The smart strategy in such circumstances is to be a 'fast follower' – an early adopter of innovations developed elsewhere. This is particularly important for growing our productivity. As Figure 6 shows, we need to encourage and facilitate much more research collaboration between Australian firms and foreign firms or researcher organisations. We need to recognise that such collaboration, which requires considerable direct contact, is harder for Australian firms.

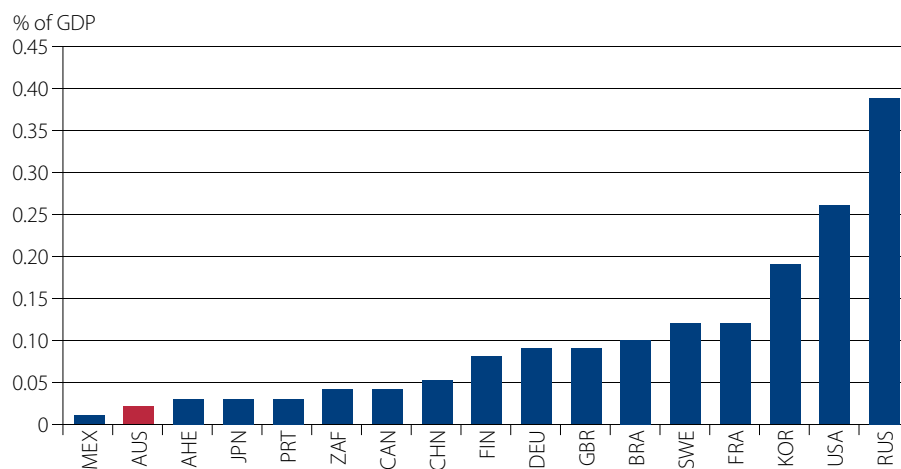
While various explanations can be found for the problems discussed above, the challenge is to find low-cost solutions that can be deployed rapidly.

Time is not on our side. Countries in our region are outpacing us in the growth of their investment in research and innovation.

New policies are urgently needed if we are to use innovation to maintain our standard of living.

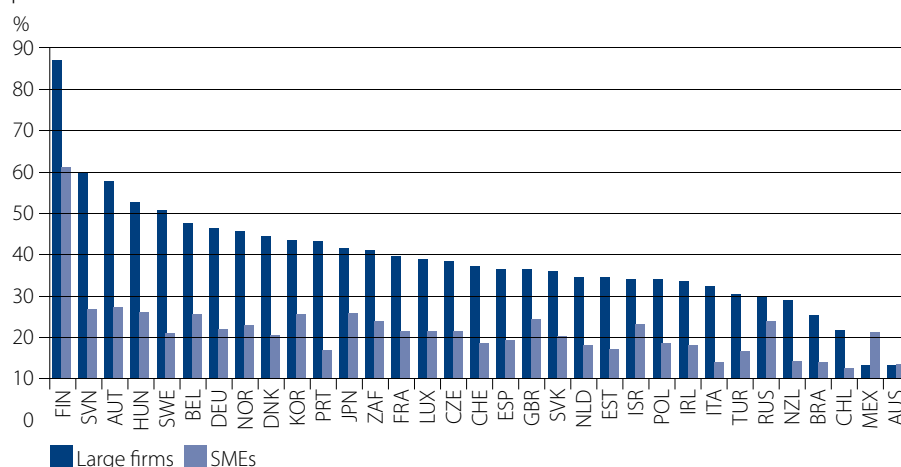
DR JOHN BELL FTSE is a Senior Associate with ACIL Allen Consulting and chairs the Expert Working Group referred to in this article. His experience includes representing Australia at the OECD and leading the OECD's Division responsible for policy and program analysis in science, technology and innovation. He is a former Deputy Secretary and Chief Science Adviser in the Department of Industry, Tourism and Resources, and Chairman of the Commonwealth Coordinating Committee on Science and Technology.

Figure 4 Direct government funding of business R&D in 2011.



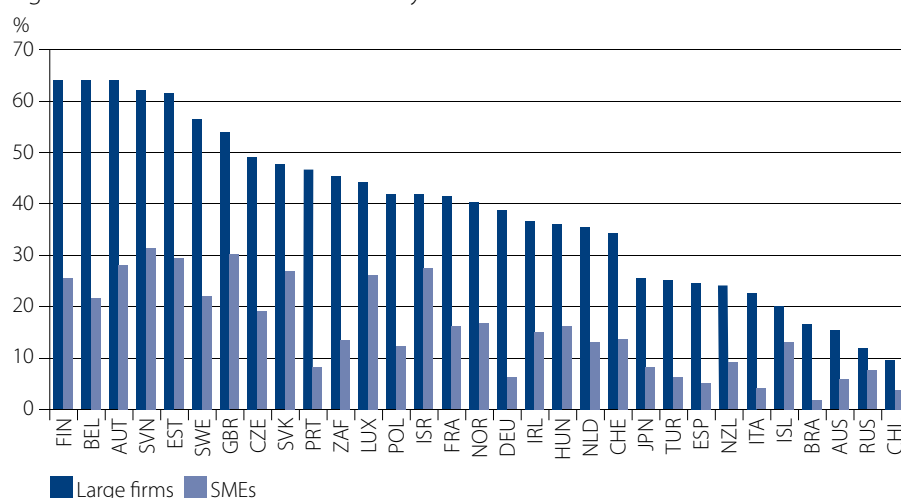
SOURCE: OECD STI SCOREBOARD 2013

Figure 5 Firms collaborating on innovation with higher education or public research institutions.



SOURCE: OECD STI SCOREBOARD 2013

Figure 6 International collaboration by firms.



SOURCE: OECD STI SCOREBOARD 2013



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By Ken Matthews
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Water – an iconic resource.

Building public confidence in water management

Australia needs to use its science to support public confidence in the quality of water management.

PHOTO: ISTOCKPHOTO

Over the past two decades Australia has come a long way in its management of its precious water resources. Though Australians often grumble to each other about the distance we have yet to go, in many other countries the Australian story in water reform is much admired.

But one area where Australia has a lot more to do is the way we use our science to support public confidence in the quality of water management in Australia.

There are seven specific areas where there is a need for Australia's water scientists to help build public confidence in the rationality and evidence basis of Australia's water management decisions.

1 Despite decades of efforts, sustainable levels of water extraction continue to be poorly defined and understood. Knowing how much water can be extracted from a given water system without unacceptable impacts on the environment or on future generations, is a threshold condition for most water decisions. Ultimately, these are political decisions, but the best such political decisions are made against a background of high-quality scientific advice. We need to build better channels for scientific advice to feed into those political decisions.

2 We need, from our scientists, a much better understanding of the water needs of our ecological systems and their likely responses to changes in water availability. Unless we can at least broadly predict

the impacts of changes in water supply on the plants and animals that make up our environment, sensible decisions about permissible rates of extraction cannot be made and, as a consequence, the public will lack confidence in decisions to reserve water for the environment.

3 Scientists have a lot to contribute to decisions about the best ways of utilising our growing stocks of environmental water. The community needs to be confident that water reserved for environmental purposes is being used every bit as efficiently and effectively for its purposes as water used for so-called 'productive' purposes. Scientists should always be key advisers to environmental water managers. If the community is to have confidence in environmental water managers, scientists need to be seen to be playing central roles in planning, monitoring and vouching for the effective use of environmental water.

4 We need much improved understanding of our national groundwater resources. This is not only because groundwater resources are so important for irrigation, urban water supply and groundwater-dependent ecosystems across Australia, but also because of the widespread current public misgivings about the potential impacts on groundwater of unconventional gas sources such as coal seam gas. Development decisions potentially affecting groundwater will not enjoy community acceptance unless reputable scientists can be built in to

decision-making processes to play the role of trusted independent adviser.

5 There is continued strong demand in the community for better scientific understanding of the water resources of northern Australia and how best to manage them. Successive governments continue to propose further development of Australia's north. These decisions will be made with or without a good knowledge base. For contentious decisions to 'stick', the public needs processes that enable them to see, and test, the science underpinnings of northern development decisions.

6 Over the past decade or so, Australian scientists have made spectacular improvements in the quality of their seasonal forecasting. However, even more is required. Not only do we need more accurate seasonal forecasts for both production purposes and to best manage our scarce environmental water, but we also need forecasting models that can provide finer-grained regional specificity. In recent years public confidence in seasonal forecasting has grown, albeit tentatively, but to the extent that our forecasting models are beginning to influence management decisions about environmental water, the public will demand more evidence of their efficacy.

7 'Water-sharing plans' are integral to the unique way Australia manages its local water supplies. Such plans, and the water-sharing decisions that

comprise the plans, are meant to be based on the best available science. This includes the best available ecological and hydrological knowledge. Because water plans are developed in close consultation with affected local communities, the science needs to be presented in an accessible form. In too many water planning processes, stakeholders remain unconvinced about the quality of the science adduced in support of the water-sharing decisions. If community acceptance of the sometimes-tough decisions is to be earned, scientists need to be invited into water planning processes and then deliver comprehensible, accessible advice.

These science-related gaps in public confidence pose an enormous challenge for our science sector. For that reason we need to be better organised as a nation to deliver science input to water management.

Governance arrangements in Australia for water management decisions need to be redesigned to more effectively embed scientists, in the role of trusted independent advisers, in our various

national, regional and local decision-making processes about water.

Moreover, Australia's general processes for planning, resourcing, implementing and adopting scientific research for water management are nowhere near up to the challenge.

Currently, the way priorities for water research are set is unsystematic and non-strategic:

- water research budgets ebb and flow as public attention to water issues rises and falls;
- water research institutions and agencies are created and disbanded by governments in an ad hoc way;
- users of water research do not have the necessary intimate linkages with research providers; and
- providers of research are too often excluded from water policy planning processes and are not sufficiently respected for what they can bring to the table.

In short, our national water science arrangements are not well organised and as a result our science performance suffers and public confidence in water

management decisions is lacking.

Australia's positive reputation in water management around the world is based on its innovative approaches to governance, planning and the use of markets.

It is time now to buttress that reputation by seeking systematically to build public confidence in our water management decisions through the intelligent incorporation of science into the full spectrum of our water management decision-making processes.

MR KEN MATTHEWS AO FTSE is a consultant in water and public administration issues. He retired as Chair and Chief Executive Officer of the National Water Commission (NWC) in October 2010. In these roles, he was responsible for working with State and Territory governments to implement the National Water Initiative inter-governmental agreement to improve water management throughout Australia. He was previously the Secretary of the Department of Transport and Regional Services, and the Secretary of the Department of Agriculture, Fisheries and Forestry. His academic background is in economics, majoring in government at the University of Sydney.

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CONTENT MATTERS



By Bruce Godfrey
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Energy for Australia: chasing the low-carbon solution

PHOTO: JOHN MARMARAS



CSIRO's solar tower in Newcastle.

Energy is essential to Australia's economy. Its availability, affordability and efficient use are key drivers of business productivity and social well-being. Importantly, Australia is a net energy-exporting nation, with considerable national wealth derived from our exports of energy resources, including coal, uranium and liquefied natural gas.

Australia is heavily dependent on fossil fuels to meet our own energy consumption needs. Our electricity supplies are 85 per cent derived from coal, natural gas and diesel; our passenger and freight transport tasks are almost completely dependent on fossil fuels; and much of the space heating in residential and commercial buildings is provided by natural gas.

Individual regions, countries and states are taking action to reduce their emissions, often to gain a 'first mover' advantage for their industrial sectors, as well as seeking to reduce the local and regional pollution effects of energy supply and use. There is a global need to develop and deploy low-emissions energy technologies to meet emissions reduction

targets – and sound environmental, industrial and economic arguments for Australia to play a role in that process.

Australia's energy policies must help ensure the reliable supply of the energy required by our economy and people at an affordable price. Failure to do so will put at risk the investment needed to retain and build international competitiveness. The clear need for strong and consistent links between energy and industry policy is evident.

In recent years, Australia's energy and climate policies have been highly variable, which has hampered timely investment. The need for strong and consistent links between energy and climate policies is incontrovertible. Developing and implementing policies that will deliver a transition to a low-emissions energy future while maintaining adequate, reliable and competitive supply now is Australia's – and the world's – key challenge.

Historically, energy and energy technology transitions have always required a long, difficult and complex journey before successful achievement. The private

sector has brought, and will continue to bring, to market new energy technologies and products for a low-emissions future.

This provides governments with options that can utilise local energy resources, and energy users with choices for the management of their energy supply, use and cost. However, the investment horizon of energy production, generation and transmission projects is very long, typically several decades.

No one policy aspect will achieve sustainable and affordable energy. Energy efficiency and consumer behaviour will deliver approximately one-third of the target, transition to new technology delivered from consistent investment in innovation about one-third and market reform, intelligent grids and smart meters the remainder.

Energy efficiency

Energy efficiency measures would be enhanced by consumers (residential and commercial in particular) having access to additional and better information on consumption. Smart meters and smart appliances will assist consumers

to identify when and where energy is being consumed and to make more informed decisions on saving energy and reducing costs. Existing energy efficiency standards need to be complemented by appropriate oversight and enforcement.

Recent significant electricity price increases have encouraged enhanced energy efficiency, reduced discretionary consumption and also encouraged product manufacturers to improve the efficiency of their processes and products. Putting a price on any environmental externalities associated with energy use provides an appropriate signal for producers and consumers to change behaviour.

Improving the efficiency of energy use in the transport sector can bring many benefits, including reduced reliance on imported liquid fuels, lower emissions of greenhouse gases and reduced stock holding obligations under international oil sharing arrangements.

The ability to reduce fuel costs ought to provide a natural incentive for efficient energy use in all sectors, including the transport sector. However, experience has shown that the demand for transport fuel is relatively inelastic. The short-term transport task that consumers are seeking is not greatly affected by fuel price. Decisions on what vehicles to buy are usually long term ones.

Energy innovation

Well known market failures mean that it is unlikely that the private sector alone will provide sufficient investment in research, development and demonstration (RD&D) of low-emissions technologies. It is appropriate in these circumstances for Australian governments to intervene to provide strategic support for RD&D of new energy technologies – energy policy must have close links with innovation policy.

Energy policy must also encourage improved education and training to maintain a domestic competitive advantage and to enable Australia to have the skills needed to adopt and adapt energy technology solutions from around the globe.

This should include developing home-grown RD&D talent, attracting international talent to Australia and fostering a culture of globally connected researchers and industry to encourage inward streams of investment, information and skills. The long timeframes for RD&D make it especially critical that policies to drive energy innovation are stable and predictable over the long term.

There is considerable global R&D being conducted to develop transport options that use alternative liquid fuels or electric storage systems. The widespread deployment of the latter

could have significant implications for areas outside the transport sector.

The widespread adoption of battery electric vehicles and plug-in hybrid electric vehicles could be an important driver of efficient, low-cost, energy storage devices and will demand substantial changes to the low voltage exchange network. That storage capability could have important implications for the electricity sector both as a demand management tool and by potentially enabling consumers with PV panels to store and use the electricity that they have generated.

Integrated policy

National energy policy cannot be formulated in isolation from the rest of the world or in isolation from other policies.

An integrated, whole-of-government approach is essential, for which there are both horizontal and vertical dimensions.

National energy policy should be coordinated to the optimal extent with environmental policy, technological innovation policy and economic policy. This is the horizontal dimension of energy policy integration.

National energy policy should also be calibrated to the optimal extent with foreign policy and trade policy and with all levels of government. Domestically, this should include Commonwealth, State, Territory and local governments. This is the vertical dimension of energy policy integration.

Creating a market and regulatory environment that encourages domestic and foreign investment in new, low-emissions energy supply and use infrastructure and in innovation is crucial for Australia – and a clear role for Australian governments in conjunction with energy suppliers and users.

NYNGAN SOLAR PLANT CONSTRUCTION BEGINS

First Solar has begun construction of Australia's largest grid-connected solar project – AGL Energy's 250-hectare plant in Nyngan, NSW – starting installation of 1.35 million thin-film photovoltaic modules.

First Solar is also providing engineering and procurement services for the project – and maintenance services for five years post-commissioning. The project, completion of which is anticipated by mid-2015, is expected to produce 102MWAC (megawatt AC output sent to the grid) – enough electricity to power more than 33,000 average NSW homes.

The solar energy supplied will abate more than 203,000 tonnes of carbon dioxide every year – the equivalent of taking more than 53,000 cars off Australia's roads.

First Solar expects to create an estimated 300 direct construction jobs during the building of the Nyngan solar plant.

The Nyngan solar plant is the first of two grid-connected solar projects to have received funding from the Commonwealth Government through the Australian Renewable Energy Agency (ARENA) and the NSW Government. First Solar expects to begin construction of its second project in Broken Hill – also for AGL – mid-year.

DR BRUCE GODFREY FTSE chairs the ATSE Energy Forum. His career has been built in business, innovation investment, government and technology-development fields. Through Wyld Group Pty Ltd he is applying this experience and knowledge to the advancement and commercialisation of technologies (particularly new energy technologies, ranging from solar cells to fuel cells to low-emission coal utilisation). Prior to Wyld Group, he was Managing Director of Ceramic Fuel Cells Ltd and of the Energy Research and Development Corporation. He is Chair of two Advisory Panels for the Australian Renewable Energy Agency.



By Mike Heard

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New manufacturing: will Australia embrace it?

New manufacturing is creation and commercialisation of *ideas*. Exactly where the goods are produced is only one of many business decisions. Production in Australia is not, in itself, the goal.

Australia faces a generational challenge to its manufacturing future. The seminal 1980s reforms of tariff reduction and the Button car plan carried our manufacturing industry into a new century. New brave reforms are overdue.

The challenges of such reforms are national, cultural and political. Unless the nation embraces the need for change, for a campaign to transform societally as well as industrially, Australia will cease to be a manufacturing economy. Given our resources wealth, this scenario is possible. Leadership is required.

An essential step is to give all Australians a radically new understanding of 'manufacturing' in the Australian context and for the future. We could call it 'new manufacturing'.

Without this understanding we will not be united in identifying and planning the right way to build new manufacturing revenue and jobs. All stakeholders, government, industry, research, service providers and society in general must be mobilised in this task.

Manufacturing is far more than production, than our embedded 'Holden-esque' image of hardware products on production lines with attendant workers. New manufacturing is ideas and inventions generated in multiple endeavours from scientific research to global marketing – new materials, processes, business models, market structures.

New manufacturing is creation and commercialisation of *ideas*. Exactly where the goods are produced is only one of many business decisions. Production in Australia is not, in itself, the goal.

Unless Australians understand this, deep reform is impossible.

There are areas of critical importance to which our reforms must be directed.



Innovative manufacture by CSIRO using 3D scanning systems and 3D printing to make titanium bugs for science research.

PHOTO: CSIRO

Nationally coordinated transformation

Given the critical state of manufacturing in Australia, a nationally coordinated approach, agreed by all Australian governments, is required to transform the sector. This will ensure the most efficient and effective national targeting of resources and the implementation of the highest priority reforms and projects.

Much assistance is available to manufacturers from many sources – governments, learned bodies, tertiary education institutions, industry associations and service providers. This assistance does not reach the businesses most in need of transformation. Manufacturers, especially SMEs, are either unaware of, or confused by, a plethora of federal and state agencies and programs. They are also insufficiently knowledgeable about transformative technologies.

The crisis in our automotive sector has brought the need for nationally coordinated action into stark relief. Many of our automotive component manufacturers are bewildered by the challenges they face. They present an example only, but a critically urgent

one, of the need for specific, focused, efficient support to transform.

Science and technology-driven transformation

Science, technology and innovation will be the drivers of transformation of our manufacturing industry enabling us to grow in the high-value-added sectors of the value chain, and for specialised niche products to produce economically, despite our high wage base.

Yet as the very recent OECD country rankings on innovation graphically demonstrate, Australia ranks very poorly on all measures of innovation when compared to leading manufacturing countries.

Collaboration between research and industry

Australian research and intellectual property must catalyse our new manufacturing. Far better collaboration between industry and publicly funded research organisations (PFROs) is critical for the translation of research into economic benefit for Australia. Some initiatives are underway – for example the Federal Manufacturing Centre of

Real Opportunity. Real Responsibility.

At Orica, we are serious about graduate development.

So serious that our Graduate Program led to Orica recently being awarded the prestigious graduate recruitment industry award, the Will Spensley Memorial Award for Innovation. The award recognised the work of our Graduate Sustainability Committee, which was launched to develop Orica graduates' leadership skills and provide a forum for graduates to make a difference to Orica and the communities we operate in. Our graduates have raised funds and volunteered for not-for-profit environmental, health and social causes in Australia, Latin America and North America.

Orica is also serious about science education. As major and founding sponsors of ATSE's hands-on, inquiry-based, in-curriculum program – the STELR Project – Orica has helped more than 360 high schools in Australia become STELR schools. Our graduates and experienced professionals alike are working with the STELR team to support the growth of this outstanding program.

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Excellence (META) and the Advanced Manufacturing CRC in Victoria. However we must do much more.

Fundamentally, accessible data on the research capabilities of public institutions and businesses and on the technology needs of industry does not exist. Such data is vital to identify intersections of competitive advantage as opportunities for collaboration and innovation.

Making such collaboration happen is very difficult. Significant cultural and structural challenges must be overcome within both industry and research institutions. Obviously, unless researchers are incentivised to also collaborate with industry, change will not occur. The views of Australia's Chief Scientist on this matter give hope.

Recent ATSE work (ATSE Position Paper October 2013 'Translating Research into Economic Benefit for Australia: Rethinking Linkages') explored how SMEs with high growth potential could be encouraged to collaborate by government-funded technology intermediaries (for example, the Victorian Centre for Advanced Materials Manufacturing and The Small Technologies Cluster).

New disruptive technologies

New manufacturing will be driven by innovation and shaped by new disruptive technologies that fundamentally alter business practices. Such technological advances include additive manufacturing (3D printing), bio-manufacturing, informatics and sensors and increased use of industrial robotics. They are already driving rapid change in global manufacturing from customised products and services to new business models. Australia lags in this transformation. It must be industry-led, but key national reforms are required to stimulate change.

Our manufacturers lack knowledge of the transformative capability of these technologies. State-based government-funded advanced technology centres for demonstration, training and technical advice are urgently required. Such centres

ATSE is committed to developing evidence-based options to address manufacturing challenges. ATSE is participating in the current project by the Australian Council of Learned Academies (ACOLA) titled *The role of science and research in lifting Australia's productivity*. Through the identification of opportunities for applying knowledge and skills in science and research across a range of industries and sectors including private and public enterprises, this project will examine ways to enhance innovation, creativity and productivity in the Australian workforce and business practices that will drive Australia's prosperity.

require state-of-the-art equipment and facilities, and expert staff.

As an urgent first step these centres should be focused on production-scale additive manufacturing in metals and plastics. The services of these centres must be available at affordable cost to manufacturing businesses.

SME-driven transformation

Australia has very few manufacturers that are 'large' by global standards. The majority of these are foreign-owned enterprises participating in our old manufacturing economy, and are at risk. Many foreign-owned component suppliers will follow the car manufacturers out of Australia.

So Australia must nurture its many 'clever' SMEs to exploit Australian ideas and inventions aimed at Australian

industries of significance, such as food and mining. Such businesses are more likely than traditional manufacturers to embrace disruptive technologies.

Such firms may also participate in high-return areas of global value chains (for example, design, product development and the provision of associated services). The agility of SMEs can be an advantage in entering new niche opportunities.

National policy reforms to nurture our 'clever' SMEs – including to facilitate investment – are absolutely vital. New business mechanisms are also required. For example, tools such as technology roadmaps and intellectual property landscape mapping to help firms leverage competitive advantage and pre-empt the market.

And skills development targeted at

ANSTO CELEBRATES IYCR2014

The Australian Nuclear Science and Technology Organisation (ANSTO) is planning to support the International Year of Crystallography – dubbed IYCr2014 – with a number of its own events.

The study of crystallography is about 100 years old, and the United Nations Educational, Scientific and Cultural Organisation (UNESCO) has declared 2014 the International Year of Crystallography. The IYCr2014 official opening ceremony was in Paris in January.

ANSTO and the Australian Synchrotron use crystallography on a daily basis, exploring our atomic world, looking for answers to our significant medical, environmental and industrial questions. ANSTO will support UNESCO's endeavours to increase public understanding of the benefits of crystallography by hosting a number of research events throughout the year.

(Most of the solid material in the world is made of crystalline structures. Crystals are made up of rows and rows of atoms all stacked up like boxes in a warehouse, in different arrangements. The science of finding this arrangement, or crystal structure, is called crystallography. From getting an A380 into the air to developing a treatment for influenza, the starting point is understanding how their basic building blocks (or atoms) are arranged.)

**LETTERS
TO THE
EDITOR**

ATSE Focus welcomes letters from readers in response to published article or on technological science and related topics.

PLEASE KEEP LETTERS BRIEF. LONGER LETTERS MAY BE RUN AS CONTRIBUTED ARTICLES.

Please address to editor@atse.org.au

areas of Australia's competitive advantage remains to be comprehensively addressed.

Reform-driven transformation

Most of the public debate about manufacturing in Australia focuses on workplace and regulatory reform. Such debate is populist and political and diverts us from debate about areas of fundamental reform. Only if we reform in these fundamental areas will workplace and regulatory reforms add value, and then only at the margin.

It is clearly dysfunctional to force upon manufacturing industry, or on any business that must have operations outside normal business hours, our system of penalty rates. They already face globally high normal-time pay rates and declining productivity. Equally, Australians must not be compelled to work more than our standard 38 hours per week, or outside normal business hours.

With common sense an accommodation is possible. In my experience some people, possibly a significant minority of the Australian workforce, are ambivalent about when they work their 38 hours, or prefer weekends or after normal hours. Employers should not be restricted from offering work outside normal hours to these people at standard pay rates.

Australia has the opportunity to leverage competitive advantages, grow new industries in advanced manufacturing and participate strategically in global value chains. To do so Australia must overcome many barriers and institute far-reaching reforms.

The multiplicity of initiatives across governments, research institutions and industry are at best an inefficient use of scarce national resource and at worst a source of confusion and frustration for manufacturers and organisations supporting them.

National leadership is urgently required from all sectors, and from our Learned Academies. We must create a focused, efficient, national campaign of the highest significance and urgency to drive Australia to its new manufacturing future.

MR MIKE HEARD FTSE has a leading role in the Academy's initiatives in advanced manufacturing. He is a former head of Codan Ltd and 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 diversified technology product businesses, with worldwide sales. He has also served as a Director of laboratory services business Amdel Ltd, a member of the Australian Space Council, and member of the Australian National Telescope Steering Committee. He was a co-founder and inaugural President of South Australia's Electronics Industry Association, now the Technology Industry Association.



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BHP Billiton, proudly supporting education in Western Australia.



By Karen Reynolds
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Meeting the technology challenges in health care

Technology is a necessary part of providing support and care in the home setting within an increasingly ageing population.

It is no secret that we are all getting older and our life expectancy is greater than the generations that came before us.

The *Intergenerational Report* (Treasury 2010) found that the percentage of the total Australian population aged 65 and over was about 14 per cent, with the proportion aged over 85 about two per cent.

The report projects that by 2050 the proportions of the population aged 65 and over will rise to 22 per cent and those aged 85 and over will rise to five per cent. In this time it is projected that health spending is likely to increase seven-fold on those aged over 65, and twelve-fold on those aged 85 and over.

These figures are compelling and have informed change in our aged-care system.

In general, we are in good health and expect to live productive and enjoyable lives in our older years. Our aged-care and health systems are critical in delivering these expectations, particularly as the elderly are known to be more frequent users of health care. The challenge in delivering these expectations into the future will be in maintaining appropriate standards of care while managing growing costs in an increasingly ageing society.

New models of care may offer solutions to the expected increases in demand on health care.

In April 2002, the Australian aged-care system underwent reform under the Living Longer, Living Better package. The reform was directed at building a nationally consistent and sustainable system including giving priority to providing support and care in the home.

The system now provides a range of care options involving a stage-gate process, beginning with low-level community care in the home, right up to respite care in a residential aged-care facility. The reform is intended to "build a responsive, integrated,



Karen Reynolds talking with Rosalie about the assistive technologies recently retrofitted to her home.

consumer-centred and sustainable aged care system" (Australian Institute of Health and Welfare, *Australia's Welfare* 2013).

Technology is a necessary part of providing support and care in the home setting within an increasingly ageing population. Combined with recent changes in aged care towards a consumer-driven model, there is a significant role for technology in providing early and effective care that can be personalised and targeted to address individual needs.

Three challenges

ATSE has identified three National Technology Challenges relating to health and technology. These are to:

- deploy assistive technologies for the aged and disabled to improve quality of life;
- develop technologies for personalised, preventive healthcare; and
- grow and promote a medical device industry in Australia.

The first Technology Challenge aims to improve quality of life for the aged and disabled through deployment of assistive technologies. Promoting good health, independence and allowing

older people to stay at home longer has recognised benefits to both the health system and to individual health outcomes.

Assistive technology is a broad term which encompasses assistive, adaptive, and rehabilitative devices that promote greater individual independence. Assistive technologies enable an individual to perform tasks they would otherwise have difficulty with, and can be described as any item, piece of equipment, or product system that is used to increase, maintain, or improve functional capabilities of individuals with disabilities.

Some examples of assistive technology include wheelchairs and walkers for mobility impairment, emergency response systems such as fall monitors or other alarm systems, and home automation that can be tailored and targeted to individual needs enabling control of the environment, and the potential to remain at home rather than in a care facility.

The Medical Device Partnering Program at Flinders University has been involved in a number of assistive technology developments, including home automation at varying degrees of customisation.

This has ranged from large-scale purpose-built accommodation, to adaptation of existing housing to provide an assisted living environment. The 'smart living' disability apartments at Woodville West in Adelaide consist of eight purpose-built apartments featuring an automated system with integrated call system (to an on-site concierge), environmental controls and communication devices, enabling significantly increased independence for residents.

At the other end of the scale, personalised electronic aids providing environmental and communication device solutions were retrofitted to an existing dwelling at relatively low cost, allowing the resident greater control and independence in their own home.

Technology advances in general, including wireless sensing and remote monitoring, combined with the recent initiative from the Australian Government Department of Health and Ageing in the personally controlled e-health record system makes for an interesting future in personalised, preventative health care (our second Technology Challenge).

Opportunities in telemedicine, where remote health professionals

can make decisions and be informed by remote sensing that can be applied in a real-time aged-care setting in the home, are exciting and imminently possible with careful planning and integration into the healthcare system.

Further, the widespread use of mobile phones, particularly smart phones, provides potential for personalised health, as well as support for an individual or family carer, by providing increased information to inform and empower self-care.

There is clearly great opportunity for new technology development in this area, providing a basis for growth of the Australian medical device and assistive technology industries (Technology Challenge 3).

Translation

However, while a great deal of innovative research occurs in the medical and scientific sector in Australia, translation from the research phase to a bona-fide product and a sustainable business remains problematic.

This is compounded by a lack of critical industry mass in an industry dominated by small to medium enterprises, and limited collaboration between industry, research and end-users.

Addressing these challenges in translation of technology will allow a greater chance of success for technology adoption in the health and aged-care systems.

As we move into a new era of personalised home-based healthcare models, there are significant opportunities and challenges to be addressed in terms of developing both technology and the health and aged-care systems required to support these new models of care.

The ATSE Health Technology Forum is currently working to develop action statements to address the challenges, maximise the opportunities and to assist national policy development.

PROFESSOR KAREN REYNOLDS FTSE is Director of the Medical Device Research Institute (MDRI) and the Medical Device Partnering Program (MDPP) as well as Deputy Dean of the School of Computer Science, Engineering and Mathematics at Flinders University. Bridging the divide between research and industry, she is considered as one of Australia's leading researchers in biomedical engineering and has been recognised for her outstanding contributions, named South Australian Scientist of the Year 2012, elected Fellow of the Australian Academy of Technological Sciences (2011) and awarded Australian Professional Engineer of the Year (2010).

SMART SYSTEM TAKES BHP BILLITON AWARD

Ethan Buston (18) from Wollongong, NSW, has won the Engineering category of the BHP Billiton Science and Engineering Awards.

His SMART (Stroke Management with Augmented Reality Technology) system – a camera-based augmented reality system – aims to aid the recovery and increase the safety of stroke patients. By manipulating what they can see, a clearer visual picture is provided to the patient.

Conroy Cheers (14) from Melbourne took out the Investigations category prize for developing a method to measure the risks of texting while driving, and also making hands-on and hands-free voice calls.

Using a readily available driving simulator, he 'drove' the streets, texting friends, calling his family, and measured how his driving was affected.

Second place in the Engineering category went to Viney Kumar, from Sydney, for the PART program, which is a signalling system for emergency vehicles; and third place went to Jake Coppinger, from Canberra, for Swirlisque, which is a new form of human-computer interaction in the form of a wearable glove.

Swirlisque allows the user to make natural gestures for human-computer interaction. It detects hand gestures and acts upon them in intelligent ways, such as controlling a music player on a smartphone, a computer, a TV, a home media centre, or a light bulb.

Second place in the Investigations category went to Lewis Nitschinsk, from Queensland (Optimal reclamation point of phosphate from waste

water); and third place went to Benjamin Coxon, also from Queensland, (Playground surfaces: force absorption capacity of sand).

Four students were chosen to attend the Intel International Science and Engineering Fair (ISEF) in Los Angeles in May – Conroy Cheers, Lewis Nitschinsk, Viney Kumar and Jake Coppinger.

Since 1981 the BHP Billiton Science and Engineering Awards have been Australia's most prestigious school science awards. The awards are managed by CSIRO and are a partnership between BHP Billiton, CSIRO and the Australian Science Teachers Association. The awards are also supported by Intel Corporation.



Jake's Swirlisque glove in action.

PHOTO: JAKE COPPINGER



By Max Lay
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Technology for cities where we live and move more easily



PHOTO: WORLD BANK

Traffic congestion in Beijing.

Cities are about people coming together for commercial and social reasons, but congestion has been around since ancient Babylon and Imperial Rome.

Most people have pipe dreams about how cities could be improved and beneficially modified, usually by some piece of exciting technology. The title of this article was suggested by the editor and reflects that attitude. The pipe dreams are not new.

Cities are about people coming closely together for commercial and social reasons. Many of the consequential problems that this causes – such those associated with as water supply and sewerage – have long been solved. The major remaining problem is that of traffic congestion which occurs when demand for travel exceeds supply.

Congestion occurred in ancient Babylon and in Imperial Rome. It reoccurred when cities began to expand again during the Industrial Revolution and there are reports from that time of twice daily pedestrian congestion

on roads serving central London and on the bridges across the Thames.

From the early days of the telephone there have been predictions that improved telecommunications would diminish the need for people to work in close proximity in cities. In fact, the reverse has been the case and the social and economic benefits of cities have clearly outweighed the cost of travel.

Many people are prepared to devote an hour or two a day to travel to and from work – and improved travel speeds have simply seen most cities expand outwards from their core, particularly when land-use controls on the city periphery are flimsy and inadequate.

To date there is little evidence of any major impact of cities made 'smarter' by telecommunications, possibly because people remain 'busy' for at least 12 hours a day.

So I'll concentrate on technologies that let us move around and to and from our cities.

It is appropriate to begin with pedestrian (foot) travel. Separating pedestrians from moving vehicles is a *sine qua non* of most successful cities and is hardly a new technology. People can walk about a kilometre in 10 minutes and longer trips may require some form of assistance.

Moving footways have been tried with little success outside airport terminals and access to underground railway stations, as they require well-defined travel patterns and some access control. Trams and local buses have filled some of this vacuum, as new designs provide easier access for both able and disabled pedestrians. In my home town of Melbourne it is remarkable to note how effective the introduction of better tram access – the so-called 'super stops' – has been.

There was time when it was believed that the next step was easily accessed timetables for public transport vehicles and various techniques for allowing the vehicles to meet their publicised timetable. However, it has become increasingly obvious that the most important factor for both customers and operators is the time separation of vehicles. Customers don't need a timetable if they can rely on a vehicle coming every X minutes and operators know how important it is to minimise the time needed to load and unload passengers. Now we are seeing new technology helping with automatic door systems and braking that ensures that the doors are at well-defined platform entry points.

Technology can improve a vehicle's braking and acceleration. Regrettably, a number of Australian transport systems have poor signalling and vehicle control systems, so 'close headway' operations are difficult to achieve.

There is also the historical accident that many of our transport systems involve radial routes leading into a city centre. As traffic has built up, this has created major congestion at the city centre.

It is scarcely new technology, but what is needed is routes that simply run from A to B and back again, with no crossing or merging traffic. This is the pattern in most overseas underground railways. This means that travellers often have to change services but this does not seem to impact operations, provided the traveller interchanges are well-designed.

Another simple technology is the use of a third track to permit the operation of express trains in peak hours, which stop at perhaps every fifth station and travellers take a local, stopping-all-stations train to reach an express train stop. This requires wider transport corridors.

One of the problems in cities is that, by default, land values will be relatively high and providing new or wider transport routes is relatively expensive. In the past, some cities solved this by building elevated tracks above existing roads. Many were quite effective but they were usually ugly and created major urban blight and have been progressively removed.

It is general experience that cities function best if pedestrians have obvious priority at ground level (of

course this excludes the harsh climate cities where the pedestrian level may be one down (for example, Toronto) or one up (for example, Calgary).

This need for separation has led to major investments in urban tunnels. Tunnelling for cities is not new. Marc Brunel built a pedestrian tunnel under the Thames in the 1820s. However, digging tunnels is literally a venture into the unknown and even today can cause major problems, despite the use of new technology.

For example, a road tunnel being built in Seattle using a new super tunnelling machine ran into major problems in January and February of this year and progressed little more than one metre in three months (*Seattle Times*, 26 February 2014). Readers may also recall construction problems with the City Link tunnel in Melbourne and the Lane Cove tunnel in Sydney.

With public transport, tunnelling has allowed some past issues to be resolved. For example, subway routes can be dedicated A to B lines, as advocated earlier. But cities like Paris and London have overcome the overcrowding issue by building deeper long distance subways (the RER routes in Paris and London's new 21-kilometre Crossrail route), where passengers can change from a stopping-all-stations route to the new route with only a few key interchange stops.

Tunnels can be enormously expensive (at least an order of magnitude more expensive than a surface route) and very time-consuming. For example, Boston's central Artery Project (the Big Dig) was about six kilometres long, took 15 years to construct and cost about US\$15 billion. New York began building its 14km 2nd Avenue subway tunnel in 2007 and expects to complete the first phase in 2016. It is costing about US\$2 billion per kilometre or US\$1 billion per subway stop. Crossrail will also cost more than US\$1 billion per kilometre.

The other pieces of new technology in cities are in tall buildings. The need to provide vertical transport (lifts) remains a major constraint and the underlying technology has not changed dramatically. There have been modest improvements in design and construction technology but few quantum jumps.

New height records have often been achieved by 'clever' design of the towers on top of the actual building. Height also requires a larger base in order to resist horizontal moments. Both these aspects can be seen in the current tallest building, the Burj Khalifa in Dubai. The terrorist attack on the previous World Trade Center in New York demonstrated how vulnerable any transport system is when alternative paths are not available in emergencies.

How do we prepare our cities for possible disasters? Are we prepared for natural emergencies and malicious attacks. Are our communication systems smart enough to remain functioning? What impact will rising sea levels due to global warming have.

Where does all this take us? What do we need next?

Last year ATSE ran a workshop on infrastructure planning. One of the key points that arose from the workshop was that before we plan and build and adopt new technologies, we need to clearly understand and articulate our aspirations for our cities.

What sort of city do we want? How big, how many people, how much open space, how much climate modification, what sort of housing, how much time should we have to devote to travelling from home to work, to shops, to recreation?

Are there other cities that we should copy and cities that have developed in ways that we abhor?

If we try to collectively answer these questions, the necessary projects and new technologies will become a lot more obvious and far less of a pipedream.

DR MAX LAY AM FTSE is an internationally recognised expert in road and transport engineering and in the history of engineering and information technology. He is the Chair of the ATSE Infrastructure Forum. He has held senior appointments at the (then) State Electricity Commission of Victoria, BHP Engineering, the Australian Road Research Board (ARRB), VicRoads, SKM and private consultancies. He was Independent Reviewer for the Melbourne City Link Project, and then worked for Thiess on its successful bid for EastLink, becoming a Director of ConnectEast, the company formed to operate the concession. He has been an adviser to Roads Australia on road pricing.



By Michael Manton
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International engagement optimises technological investment

There is overwhelming evidence that international engagement is an essential aspect of science, technology and innovation.

Recognising the need for Australia to engage effectively with the emerging markets of Asia, the Australian Government is investing \$100 million over five years in the New Colombo Plan (NCP). A feature of the NCP is the award of internships to scholarship holders so that they gain insights into the operation of overseas industries, in addition to benefiting from study at an overseas university.

The NCP aims to enhance both institutional and personal links between Australia and Asia, leading to generational change in these relationships. The NCP complements the existing export trade in international education that brings overseas students to our universities. The program also recognises the increasing importance of Asia to the Australian economy and society, complementing the traditional links to Europe and North America.

The Academy of Technological Sciences and Engineering (ATSE) promotes the importance of both personal and institutional links to the development of sustained international collaboration, through programs such as the Australia Japan Emerging Research Leaders Exchange Program (ERLEP).

The fifth exchange of ERLEP (funded in Australia by the Department of Industry and in Japan by the Japan Society for the Promotion of Science and the Engineering Academy of Japan) was completed in February 2014, with eight mid-career researchers visiting a range of Australian organisations over a two-week period. By the end of 2014 when an Australian group travels to Japan, there will be nearly 50 alumni who will be part of the next generation of science and technology leaders in Australia and Japan.

Similar exchanges have been held in the past with Singapore and China.

The exchanges with China commenced in 2006 and led to the establishment of two joint research centres and many individual collaborative projects. A new program of exchange visits is commencing in 2014 with Korea, supported by the Australia Korea Foundation and the National Research Foundation of Korea.

Such investments are justified by overwhelming evidence that international engagement is an essential aspect of science, technology and innovation (STI). The OECD notes that the share of patents with a foreign co-inventor doubled over three decades to 20 per cent in 2008 and the share of scientific publications with a foreign co-author tripled to 22 per cent. These changes reflect the increasing scale and complexity of the challenges in STI.

International collaboration leads to a compounding of resources and knowledge to ensure effective progress on the problems associated with sustaining modern societies and their economies. These problems include not only the Grand Challenges of the US National Academy of Engineering

(such as reverse-engineering the brain), but also the smaller-scale challenges of research and commercialisation in a global market where international partners bring complementary skills and resources.

The Academy is developing and enhancing collaborations with overseas engineering academies to promote its seven key areas for technological innovation. Since 2009 ATSE has been working with member academies of the International Council of Academies of Engineering and Technological Sciences (CAETS) on the challenges of low-carbon energy, first through leadership of a Working Group for Low Carbon Energy and then in leading the CAETS Energy Committee, which was created in 2013. These multinational activities have led to two reports to date: *Deployment of Low Emissions Technologies for Electric Power Generation in Response to Climate Change* in 2010 and *Opportunities for Low-Carbon Energy Technology for Electricity Generation to 2050* in 2013.

The work through CAETS on low-carbon energy is complemented by a



(From left) Professor Michael Manton, ATSE President Dr Alan Finkel and Dr Hideaki Koizumi, International Chair, Engineering Academy of Japan, in Melbourne during the recent ERLEP exchange.

number of bilateral activities. A series of three workshops with the National Engineering Academy of Korea from 2010 on green growth covered a range of topics on low-carbon energy from energy sources to energy transmission and challenges of commercialisation. Over the past three years there have also been two workshops with the Indian National Academy of Engineering on energy, and there are current discussions on off-grid electricity supply for rural areas.

Through the Australia-China Joint Coordination Group on Clean Coal Technology (JCG), ATSE is managing the Australia-China JCG Partnership Fund on behalf of the Commonwealth Department of Industry. The JCG supports exchanges, secondments, workshops and symposiums on the development of low-emission coal technologies. At the seventh meeting of the JCG it was concluded that the complementarity between the skills and R&D frameworks of China and Australia provided a strong basis for continuing expansion of the collaboration.

Particular advances are being made in the design and analysis of end-to-end systems as a precursor to technology deployment. Further activities are developing with the Chinese Academy of Engineering, including a recent workshop on low-emission fossil fuels (March 2014).

The provision of fresh water is a major challenge for Australia and all of Asia. With Australia's population concentrated around the coast of the continent, desalinisation is now used to consolidate the water supplies of the main population centres. This option is not available to much of Asia that largely depends upon the seasonal snow-melt from the glaciers of the Himalayas – Tibetan Plateau (HTP). Moreover there is growing tension between the provision of water and energy in Asia, with increasing numbers of dams planned to supply hydro-electricity along the rivers from the HTP.

While there are differences in the main challenges facing Australia and Asia on water availability, there are common issues on water in urban areas. Over the past few years, ATSE has had workshops on the issues of water policy with Taiwan in 2011, and of water as a factor of green growth with Korea in 2012. Currently there are discussions with the Indonesian Academy of Sciences on urban water supplies.

A driving factor in the economic growth and increasing social mobility in Asia is urbanisation. Cities are the main consumers of water, food and energy across Asia and Australia, and they are the main sources of air and water pollution, greenhouse gases, and changes in land use and biodiversity.

While there is often an emphasis on the mega-cities of Asia, by 2025 nearly 60 per cent of the urban population of the region will live in cities of fewer than one million. Thus there are many commonalities between Australia and Asia in the design and management of cities. The green growth workshop ATSE held with Korea in 2012 included consideration of urban design issues.

In 2013, ATSE in cooperation with Infrastructure Australia held a workshop on infrastructure planning, including speakers from the World Bank, Canada, China and Japan. The workshop highlighted the key role of infrastructure in improving national productivity, as well as the need for rigorous and transparent asset management to ensure that the required functionality of infrastructure is sustained.

In Asia, as well as in Australia and other parts of the developed world, there is a growing challenge of health and ageing. For example, the population of Japan reached a peak of 128 million in 2012, and in Korea the percentage of people older than 65 has risen from three per cent in 1955 to 11 per cent in 2009. Even in China, the population is expected to peak around 2030.

In 2012, ATSE held a workshop on assistive technologies to support health care, leading to the recommendation of a network to promote the application of technologies to improve quality of life and reduce health-care costs. Given the almost universal nature of the challenges of health and ageing, it is likely that this issue will be taken up by the international CAETS community in the near future.

Across the global market place, productivity is recognised as a key factor for economic growth. Japan is undertaking economic reforms to promote growth, Korea aims to increase GDP per capita through a range of reforms, and China continues to steadily improve GDP leading to the lifting of 500 million people out of poverty over the past few decades. It is important to note that the nations

of Asia with growing economies also recognise that increasing social well-being depends upon governance reform as well as economic reform. Thus the development of transparent financial and legal systems is a potential area of cooperation between Australia and Asia. This potential was highlighted by a delegation from the Shanghai Association for Science and Technology visiting ATSE in 2012.

An area for comparison and exchange between Australia and the countries of Asia is the relationship between government, industry and academia. The differences were elucidated at an ATSE international workshop in 2011 in Sydney on strengthening links between industry and public sector research organisations.

The Chinese Government, for example, has had a long-standing policy of absorbing overseas technologies to create new industries in collaboration with the research community. National differences are particularly apparent in the industrial ecosystems of Asia and Australia, with the near absence of very large national corporations in Australia. While the relative relationships between large corporations, government and SMEs are sometimes questioned in Asia, there may be potential advantages for Australian companies to cooperate more closely with Asia.

There has been sustained cooperation between ATSE and other national academies to promote Australian expertise and knowledge and to ensure that Australia is well placed to develop and commercialise technological products.

These links with Europe and North America are strong and continuing. At the same time, the links with the fast-growing economies of Asia are evolving and are proving to be rewarding and exciting.

PROFESSOR MICHAEL MANTON FTSE is a senior adviser on international engagement to ATSE, and is a former member of the ATSE Board. He is a member of the Board of the Australia Korea Foundation. Before his retirement in 2005, he was Chief of the Bureau of Meteorology Research Centre. He lectured in mathematics at Monash University in the early 1970s and was a research scientist for a decade in the CSIRO Division of Cloud Physics before joining the Bureau of Meteorology. Since retirement he has held a part-time position as professor in the School of Mathematical Sciences at Monash University.

ATSE IN ACTION

Nation needs a long-term, consistent energy policy

Australia needs a long-term and consistent energy policy to enable it to transition to least-cost energy and reverse the situation in recent years where Australia's energy and climate policies have been in a state of flux – which has failed to underpin a favourable investment environment. No one policy aspect will achieve sustainable and affordable energy. Energy efficiency and consumer behaviour will deliver approximately one-third of the target, transition to new technology and research and development (R&D) about one-third and market reform, intelligent grids and smart meters the remainder.

These are two key points made by the Academy in its submission to the Department of Industry's Energy White Paper Issues Paper.

"Historically, energy and energy technology transitions have always required a long, difficult and complex journey before successful achievement," the submission says.

"The private sector has brought, and will continue to bring, to market new energy technologies and products for a low-emissions future. This provides governments with options that can utilise local energy resources, and energy users with choices for the management of their energy supply, use and cost.

"The investment horizon of energy

production, generation and transmission projects is very long, typically several decades. In recent years, Australia's energy and climate policies have been in a state of flux, which has failed to underpin a favourable investment environment."

It says effective energy policy is critical to Australia's competitiveness, economic growth and national productivity. The cost of energy is embedded in all goods and services that Australia produces.

It urges the Australian Government to determine the most appropriate balances between – and embed into long-term policy – the key issues of:

- energy security and reliability;
- affordability and international competitiveness; and
- universal availability and sustainability.

It says governments must develop a comprehensive energy policy that, integrated with industry policy and aligned with emission-reduction targets, will deliver reliable, affordable and sustainable energy supply.

The submission says existing technologies are unable to meet the Government's emissions reduction targets and new low-emission energy supply and use technologies will need to be developed and deployed. However, the existing

structure of Australia's energy supply industry is such that it is unlikely to generate sufficient investment in innovation on its own.

"For Australia to be a developer, adopter and smart buyer of technology, it is imperative that there is research, development and demonstration (RD&D) investment and an expertise base here in Australia to harness new technologies and adapt these to Australian conditions.

"There is a critical role for government to foster and support the transition to low-emission energy technologies. New low-emission technologies generally will, at least initially, cost more than existing high-emission ones.

"Energy is a complex field that underpins our economy and way of life. Australia now has to have a mature discussion about our energy policy, including how it is connected to industry, climate and social policies," the submission says.

"To achieve this, ATSE encourages wide dialogue among suppliers and users of energy together with governments to develop solutions for Australia's long-term energy future.

"Without such a mature dialogue, Australia's energy future will continue to be dominated by competing vested interests and a lack of significant investment for that long-term future."

The full submission is on the ATSE website (Publications/Submissions/2014).

ATSE MEETS ROYAL SOCIETY PRESIDENT

The Academy met in Melbourne recently with Sir Paul Nurse PRS, President of the Royal Society, in a joint meeting with Fellows from the Academy of Science.

Those attending included President Dr Alan Finkel FTSE, Mr John Grace FTSE, Professor Margaret Sheil FTSE, Professor Andrew Holmes FRS FAA FTSE and Professor Marilyn Anderson FAA FTSE.

The meeting focused on a number of research commercialisation and translation challenges in Australia and how Sir Paul had dealt with them in the UK.

Sir Paul, who won the Nobel Prize (Physiology or Medicine) in 2001, started his five-year term as President of the Royal Society in 2010. He is a geneticist who works on what controls the division and shape of cells.

He was Professor of Microbiology at the University of Oxford, CEO of the Imperial Cancer Research Fund and Cancer Research UK, and President of Rockefeller University New York.

He is currently Director and Chief Executive of the Francis Crick Institute.



Sir Paul Nurse

ATSE HAS TWO NEW FORUMS

The Academy has formed two new Forums through which it will focus aspects of its work. The Mineral Resources Forum and the Infrastructure Forum will work alongside the Academy's established Forums – Education, Energy, Health Technology and Water.

The Chair of the Mineral Resources Forum is Professor Alison Ord FTSE and the Deputy Chairs are Ms Denise Goldsworthy FTSE and Professor Veena Sahajwalla FTSE.

The Infrastructure Forum Leadership Group consists of Chair Dr Max Lay AM FTSE and Deputy Chairs Professor Cynthia Mitchell FTSE and Mr David Singleton FTSE.

ATSE IN ACTION

STELR shows up well in teacher survey

Teachers from STELR schools were invited to complete an online survey at the end of 2013 to evaluate whether or not STELR was achieving its aims.

The survey results were encouraging, noting increased participation in science, better teacher confidence, greater student awareness and increased science literacy.

Summary results show that:

- many schools are using STELR materials at multiple year levels;
- more than 50 per cent of schools reported an increase in students studying science at Year 11 – one school reported a 100 per cent increase in students studying physics at Year 11;
- boys and girls are more engaged with the STELR modules compared with regular science topics;
- teachers teaching 'out of field' are more confident teaching the STELR modules;
- students are more aware of what is involved in engineering and technological careers and the study pathways necessary to gain access to these careers; and
- the science literacy of students has increased in more than 80 per cent of schools.

STELR is the acronym for Science and Technology Education Leveraging Relevance. The STELR Project is running in more 380 schools in all states and territories with 35,000 students and more than 1000 teachers involved each year. So far STELR has impacted more than 130,000 students. The main relevance theme of this science education program for Year 9 or Year 10 students is renewable energy, which recognises the high level of concern students have about global warming and climate change.

STELR is designed to be taught within the curriculum so that it is available to all students in participating schools. It incorporates contemporary teaching and learning practices, in particular an inquiry-based learning approach that engages and challenges students and teachers. Teachers are fully supported through an initial professional development program and follow-up assistance.

Figures 1 to 3 graphically illustrate some of the key results.

Teacher comments included:

- "Although students may not accredit completing STELR with the reasons they are studying physics, many students (girls) are now see the application of the subject and are considering engineering as a real possibility."
- "The equipment is easy to use and the variety of ways it can be applied is useful in not just year 9. We have also used modified sections for our primary school as well. We will be keeping the program for the indefinite future!"

- "Excellent program with great resources and easy to use equipment."

- "We have been pleased with STELR. We have been so impressed with the equipment that we are trying to use it across (years) 7-10. More importantly, the way STELR approaches inquiry-based learning has influenced how we approach all topics."

- "STELR has been a great success at Gilmore to the point that it is no longer an elective but rather a compulsory unit at year 10."

Figure 1 Since using STELR, the level of awareness amongst the cohort of students of opportunities in technology-related careers has:

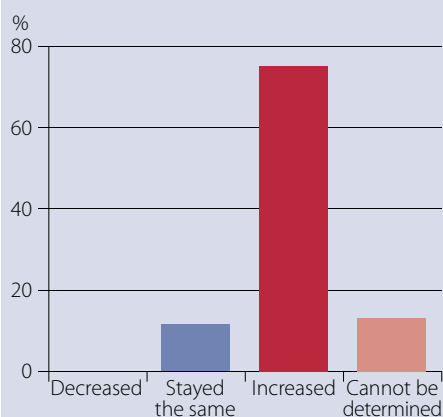


Figure 2 Since using STELR, the level of science literacy and understanding in the cohort of students has:

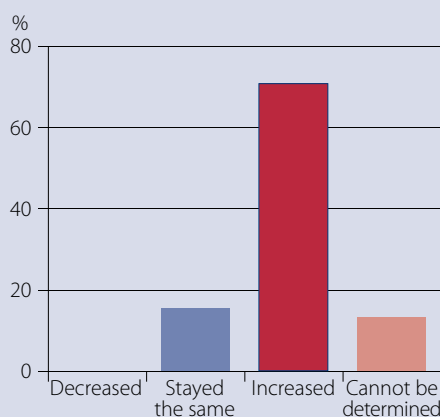
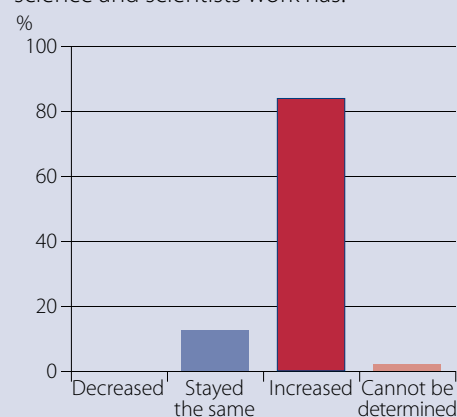


Figure 3 Since using STELR, the preparedness amongst the cohort of students to engage with science ideas and be knowledgeable about the way science and scientists work has:



CORRECTION

In *Focus* 182 (February 2014), page 5, the bottom band of the table inset into the photograph "Total land area approximately 150x106 km²". This should read "... 150x10⁶ km² or 150 million km²".

ATSE IN ACTION

More cash needed to achieve emissions reduction

Australia has considerable potential for large-scale, low-cost emissions reduction through switching baseload electricity generation progressively to low-emissions energy technologies including nuclear, geothermal, carbon capture and storage for fossil-fuel-fired power stations, and other renewables.

But the required investment is well beyond the resources of the Emissions Reduction Fund (ERF) and in some cases further technology development is required.

These are key aspects of the submission by the Academy to the Department of the Environment's Emissions Reduction Fund Green Paper.

The submission says most of the large-scale opportunities are already well known (and listed in the Green Paper) but the challenge of implementing them is quite daunting. In aggregate, considerable savings are likely to be available from improving performance and utilisation of existing domestic and commercial buildings

(particularly in heating, ventilation and air-conditioning and hot water services), private transport (particularly through carpooling and reduced congestion) and agriculture.

In principle ATSE supports the concept of providing a positive incentive for emitters of greenhouse gas to improve their performance. Businesses will become more competitive through government support for capital expenditure and other measures which will both reduce the emissions for which they are responsible and their energy costs, it says.

It notes the ERF needs to be designed to only support measures that are in addition to 'business as usual'.

"The problem is that all pieces of energy using equipment or facilities have finite lives and will need to be replaced at some stage. It will be difficult to separate what replacements are made early only to reduce emissions from those that would be required immediately to continue in business.

"While it would be difficult to develop and administer, a scheme that only allows the incremental cost between a 'normal' and an improved energy efficiency replacement to be tendered into the ERF might be necessary."

ATSE says establishing baselines will be a critical challenge to ensure that the operation of the Fund does not restrain growth and productivity or reward reductions in activity.

"Ideally the baseline should be designed on the basis of emissions per unit of output to overcome this problem but this could well result in the politically uncomfortable scenario that while production becomes more efficient, total emissions actually increase."

The Academy says the Clean Energy Regulator will have a considerable task, particularly in establishing and adjusting baselines and determining eligibility for different types of proposed expenditure and suggests there may be a need for a number of expert technical advisory bodies to be set up to assist the Clean Energy Regulator on technical matters.

The full submission is on the ATSE website ([Publications/Submissions/2014](#)).

Food and Fibre report launched

The Academy launched the third of its Green Growth reports in Sydney on 10 April, concluding a three-year project in which it has examined water, energy and food and fibre.

Mr Ken Matthews AO FTSE, Chair of the Agricultural Biotechnology Council of Australia, launched the report, *Food and Fibre: Australia's Opportunities*, at a workshop which included presentations from the report's author, Professor Snow Barlow FTSE (University of Melbourne), members of the project Steering Committee and other ATSE Fellows, followed by a panel discussion question and answer session.

Food and Fibre: Australia's Opportunities assesses the current state of Australia's agrifood and fibre sector to identify challenges and potential areas of growth, while analysing likely developments in the region and globally to formulate a strategic approach to the sustainable future of this important sector.

The report emphasises the need to support the agricultural innovation system through ongoing investment in research and development in order to achieve the increases in productivity that will be required for this sector to remain competitive and develop emerging export opportunities.

This project has been funded by the Australian Research Council as a Linkage Learned Academies Special Project. This report and the two previous reports, *Sustainable Water Management – securing Australia's future in a green economy* (2012) and *Green Growth – Energy: industry opportunities for Australia* (2013), are on the ATSE website at [Publications/Policy and Technical](#).



MAJOR INFRASTRUCTURE INVESTMENT GAP

NSW Division Fellows heard about the massive infrastructure funding shortfall in the US at a February Division lunch addressed by the President of the American Society of Civil Engineers (ASCE), Mr Randall (Randy) Over. The ASCE is the leading professional society for civil engineers in the US, with some 140,000 members, between them responsible for basically all infrastructure development and management throughout the nation. ASCE is committed to protecting the health, safety and welfare of the public, and as such, to upgrading public infrastructure. In its findings, which parallel the situation in Australia, an ASCE study of public infrastructure has established a total

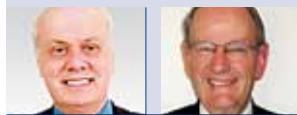
investment gap of \$2 trillion with an annual increase in spending of \$200 billion considered essential. Mr Over outlined the infrastructure challenges facing the US and the key solutions that ASCE had identified.



Randy Over

ATSE IN ACTION

Can EV batteries drive rooftop PV uptake?



By John Baxter and Martin Thomas

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This article was prepared by the authors as a summary of Appendix 2 of the ATSE Submission to the Energy White Paper Issues Paper, the contributors to which were the authors together with ATSE Fellows Dr Alan Finkel, Dr Graeme Pearman, Dr David Rand, Dr John Sligar and Dr Brian Spies.

The world is entering an era of unprecedented development of electric vehicles (EVs) driven by rapid advances in the reliability, performance and durability of Lithium-ion batteries. Over the past 10 years the specific energy (kWh/kg) and cycle-life of such batteries have risen dramatically while manufacturing costs continue to fall.

Roof-top photo-voltaic (PV) cell systems are now installed on close to one in 10 Australian homes and provide an attractive low-emissions-intensity means of slow-charging 'plug-in' EVs.

But are there other more significant synergies between these two technologies?

EV production worldwide, while growing rapidly, is still minute compared with the 63 million conventional cars manufactured annually with internal combustion (IC) engines. Only two Battery Electric Vehicle (BEV) models (Nissan Leaf and Mitsubishi i-MiEV) and one parallel-hybrid Plug-in Hybrid Electric Vehicle (PHEV) model (GM Volt) are currently imported into Australia. However, a far wider range of BEVs and PHEVs are expected to reach our market over the next five years – with the corresponding increase in annual world production volumes of EVs and battery systems inevitably reducing prices.

BEVs use a highly efficient electric motor to power the drive-train. Energy stored in an on-board battery is initially supplied from the grid. PHEVs also have an electric motor but add an IC engine able to drive the wheels either directly via the drive-

train or indirectly via a generator.

Thus the battery, with two reliable sources of supply, offers significantly enhanced vehicle range. PHEVs are further classified as 'series hybrid', where the engine powers only the generator to charge the battery, or 'parallel hybrid' where it is also either continuously or intermittently connected mechanically to the drive-train, optimising the drive cycle through improved acceleration and reduced emissions at higher loads.

Plug-in EVs, once sufficiently adopted in the marketplace, can bring huge benefits to the electricity grid. EV batteries offer significant storage capacity and an essentially off-peak load – typically 10 to 20 kWh for PHEVs and 20 to 50 kWh for BEVs. Such potential load-levelling capacity enables a truly 'intelligent grid' with substantial distributed storage embedded in the low-voltage (LV) layer of the system, inter alia enabling the further expansion of rooftop PV systems on Australia's homes, factories and public buildings.

With an appropriate enabling regulatory and economic framework (including intelligent metering, time-of-use pricing and connection standards), possibly coupled with economic incentives, at least initially, much of this new generation and storage capacity would be funded privately by business and individuals, reducing new funding for conventional generation. 'Plan-based' business models could develop, similar to mobile phone markets, to permit alternative ownership and payment schemes and so encourage PV generation.

In addition, the more challenging option of 'vehicle-to-grid' (V2G) resupply

of electricity back to the grid at times of high demand (and thus premium price) could become attractive, depending on the individual usage profiles and system management. EV owners could be enabled, and indeed be economically motivated, to arbitrage the buying and selling of electricity based on tariffs and time-of-use spot prices available over the daily system supply-demand cycle. Economic benefits could accrue both to EV owners and supply utilities, although much remains to be done to bring V2G to commercial reality.

Optimal integration of the vehicle and the grid requires EVs to communicate intelligently with the grid to sell demand-response services. Most private vehicles are parked more than 95 per cent of the time. System architecture must be configured to allow electricity flow from grid to vehicle (G2V) during charging and from vehicle to grid (V2G) under controlled battery state-of-charge conditions – consistent, of course, with owners' needs.

Thus V2G-enabled vehicles could, if permitted by their owners, assist in grid load-balancing by accepting charge at night (when demand and prices are low) and selling power back in day peaks (when demand and prices are high). While special technologies are needed to control supply quality, such arrangements can provide supply utilities with access to effective 'spinning reserve' to meet sudden ramp demands for power as well as maintaining high-quality voltage and frequency regulation.

V2G-enabled vehicles, in sufficient quantity on the system, could also help buffer the supply variability of PV arrays and wind turbines by storing energy during high insolation and strong winds and returning it at times of high demand or reduced renewable supplies. PV and wind resource value can thus be significantly enhanced by economically driven time-of-use pricing.

Notwithstanding these attributes V2G architectures remain embryonic. Pacific Gas and Electric and Xcel in the US are converting conventional PHEVs to V2G configuration to trial grid interfacing. The University of

ATSE IN ACTION

Delaware is studying the technical and economic modelling of direct battery to grid (B2G) technology.

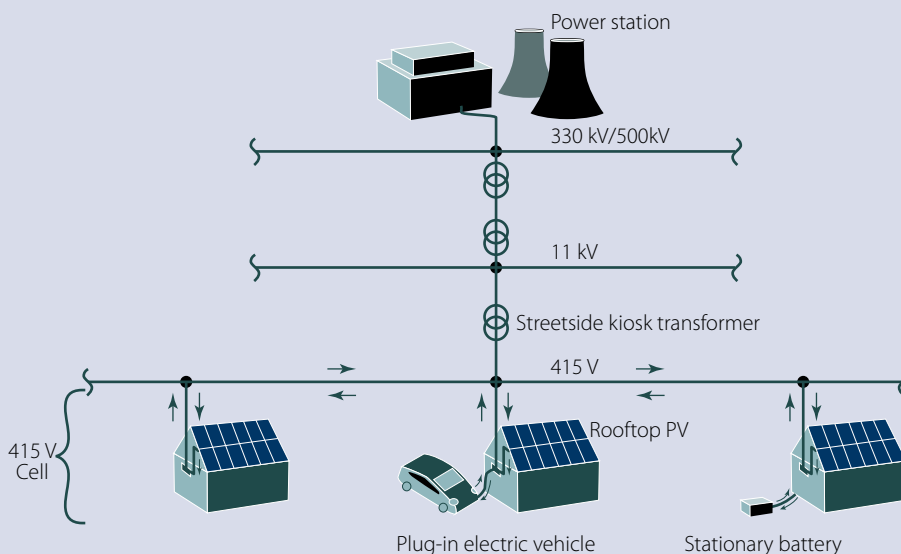
A consortium of IBM, Siemens, EURISCO, Dong Energy, Østkraft, the Technical University of Denmark and the Danish Energy Association is using B2G technology to study how best to balance intermittent supplies from Denmark's extensive wind farms, which deliver 20 per cent of its electricity.

Domestic PV supply is typically provided via DC to AC inverters at low-voltage (from 200V to 400V DC to 240V AC). Supply is intermittent due to solar radiation variability dictated by weather conditions, shading and geographical location. In mid-latitude Australian metropolitan cities such as Sydney or Melbourne, a relatively large (20 square metre) PV installation will, on a sunny day, deliver around 4 kW over an average of 12 daylight hours, producing around 15 kWh. An average Australian household uses about 18 kWh per day, although a typical representative range is 10 to 40 kWh depending on family size, their house, its location and its insulation.

The storage and re-supply capability of EV batteries is highly variable at the vehicle level and dictated by owner needs. Not all EVs are plugged in at the same time – some will be fully charged, some owners may not wish to permit any discharge, no matter how attractive arbitrage may be, while yet others will be happy to maximise arbitrage income and accept the risk of a lower driving range. Experience and a clear understanding of the advantages – and disadvantages – of home-based charge-discharge cycles will establish reliable evidence of the quantum and value of benefits to EV owners and system operators.

Even if PV intermittency issues are ameliorated through customer averaging, structural problems with EV charging and grid architectures remain to be resolved to achieve true 'smart grid' architecture. Current physical and electrical EV charging standards do not yet provide for V2G. North American automotive standard SAE J1772 and the European standard VDE-AR-E-2623-2-2 are designed

Figure 1 Low voltage exchange network comprising multiple 415V cells, each supplied by a streetside kiosk transformer.



only for AC or DC charging, not for discharging, effectively precluding V2G.

Until EV electrical interface standards evolve under market pressure to permit V2G, at least one alternative solution is available: the use of stationary batteries. Household lithium-ion packages are offered by companies such as SolarCity in the US, using modules manufactured by Tesla on its Californian production line. Other stationary battery concepts include recycled and repackaged performance-degraded EV batteries of various different battery technologies.

A current Australian restraint is that capital city low voltage (LV) infrastructure may have insufficient capacity for significant energy transfer between sources (such as PV cells) and storages (such as EVs and stationary batteries) for which it was not designed. Substantial PV capacity addition could overload LV systems causing unacceptably high voltage and phase swings, excessive harmonics and unacceptable neutral voltage drift. Likewise, large-scale EV adoption could in some circumstances overload local LV systems.

The Australian grid has traditionally been designed 'top-down' from the power station through the grid via a network of step-down transformers from 500 kV or 330 kV, down through 33 kV, 11 kV and ultimately the 415 V level of suburban distribution. Suburban LV grid 'cells'

are typically served by a single 1 to 2 MW street-level kiosk or pole-mounted 11 kV transformer delivering a 415 V 3-phase 50 Hz AC supply with floating neutral. Normally each third property taps off one of the three phases and the neutral to provide the conventional 240 V single-phase domestic supply. Such cells typically supply 50 or so properties in one or two suburban streets.

Australian LV architecture provides only for electricity flow in one direction – from supplier to customer – with protection arrangements at transformers to prevent reverse flow. With enhanced EV and rooftop PV penetration significant benefits can be gained by permitting surplus electricity feed-back to the 11 kV network layer, thereby enabling overall network load averaging to be achieved much more broadly than is currently possible.

In order to maximise the potential benefits, Australia must prepare intelligently for the widespread adoption of EVs.

The LV grid layer will need to evolve to what is becoming termed a 'low voltage exchange network', analogous to LANs in computer communications. As cities grow they will demand more electricity.

Provided LV system constraints are removed to enable the grid to become a true exchange network, albeit requiring

CONTINUED ON PAGE 26

ATSE IN ACTION

Antarctic science needs Australian support



Australian scientists working in the Antarctic.

The Federal Government must provide resources and long-term funding for scientific activities in the Antarctic if Australia is to maintain a long-term presence in the region – and it must ensure sufficient supply of trained and/or qualified researchers to meet research needs.

Increasing support for Antarctic research is crucial to Australia's ability to respond to emerging challenges in the region, such as biodiversity conservation and a growing interest in the exploration of the Antarctic's living and non-living resources.

These are two key recommendations in the Academy's submission to the Australian Government's *20-Year Australian Antarctic Strategic Plan*, which notes that Australia has strong strategic national interests in the Antarctic, including a large territorial claim.

It says the Australian Government must ensure there is adequate resourcing of Australia's

activities in the Antarctic to enable Australia to deliver viable research programs, strengthen its science capability and support in the region and maintain an effective air and sea transport system between Australia and Antarctica.

"The credibility of our claim to the Australian Antarctic Territory (AAT) is underpinned by our presence across the region through scientific activities. These activities also have direct national benefits through improving our understanding of the region and of the potential impacts resulting from increased human activity in the region," it says.

"Australia has a strong geopolitical interest in ensuring that Antarctica is used for peaceful purposes and that the Antarctic Treaty is upheld. It is also imperative for Australia to be well informed on the activities of other countries in this important region.

"Australia depends on the Antarctic for

a range of environmental and economic benefits. The Antarctic provides a range of important ecosystem services and is an important area for fisheries management and biodiversity conservation.

"A key element of our science activity across the region is sustained monitoring and surveying of the Antarctic environment and its natural resources," the submission says.

It suggests improved national coordination could be achieved through:

- ensuring that funding mechanisms have sufficient scope for Australia's long-term strategic Antarctic research needs (including long-term monitoring activities); and
- the establishment of a continuing high-level coordination mechanism that includes all agencies with science and policy interests in Antarctica.

National and international collaboration would enable Australia to leverage its investment in research in Antarctica. A flexible strategy for occupying the AAT, including collaboration with international partners, should assist in supporting logistically demanding science programs.

It notes that Tasmania plays an important role as an Antarctic gateway and urges Government support for research facilities in Tasmania these facilities be maintained or increased. It suggests Australia could explore the effects of tourism in the Antarctic – seeking to become a world-leader in best-practice approaches to minimising environmental harm from tourism activities in the region.

The full submission is on the ATSE website at Publications/Submissions/2014.

FROM PAGE 25

significant engineering design and capital investment, it is not unrealistic to expect that enhanced domestic and commercial PV capacity associated with storage offered by EVs could contribute substantially to meeting urban electrical load growth while reducing the need for new capacity simply to meet system peaks.

DR JOHN BAXTER FTSE was previously joint Managing Director of Bishop Innovation, involved in automotive steering product and process R&D, IP management and international IP licensing. He was inventor or co-inventor for many of Bishop's patents families and has authored and co-authored numerous published technical papers on automotive steering and related vehicle dynamics. In 2009 he joined Baxter IP Patent and Trade Mark Attorneys where he is now a consultant specialising in IP commercialisation, particularly the structuring of patents and licence agreements to maximise the commercial value of IP.

MR MARTIN THOMAS AM FTSE was a Principal of consulting engineers Sinclair Knight Merz, responsible for the engineering power and energy projects in Australia and overseas, particularly specialising in industrial energy efficiency. Outside the firm he served as President of the Institution of Engineers Australia and the Australian Institute of Energy, the NSW Electricity Council, the export agency Austenergy and the 2000 Olympic Energy Panel. Following retirement he was Managing Director of the Australian CRC for Renewable Energy. He is a past Vice President of ATSE and immediate past Chairman of the ATSE Energy Forum.

ATSE IN ACTION

Strong focus on SA manufacturing

New challenges for South Australia's manufacturing industries were discussed when the SA Division of the Academy of Technological Sciences and Engineering (ATSE) and the SA Government held a major workshop in Adelaide recently.

The event – titled 'Transforming South Australia's Manufacturing Sector' – at the Adelaide Convention Centre, attracted more than 170 delegates, and was organised by ATSE and the Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE). SA Minister for Manufacturing, Innovation and Trade, the Hon Tom Kenyon MP, delivered the opening address and Dr Alan Finkel AM FTSE, ATSE President and Chancellor of Monash University, the keynote address.

The focus of the workshop was on the significant challenges faced by manufacturers in SA, many of whom operate within the value chains of national automotive and defence industries and have to respond to the

loss of vehicle manufacturing capacity and the irregularity of defence projects. They also have to address the emergence of new industries as potential customers – including mineral and energy resources (including shale gas), 'clean technology', food processing and medical devices – and new 'disruptive' technologies, including additive manufacture/3D printing and growing use of informatics.

Speakers included Mr Geoff Knight, CEO of DMITRE, and Dr Göran Roos, Chair, Advanced Manufacturing Council; Mr Bruce Carter, Chair of the Premier's Climate Change Council; and Mr Raymond Spencer, Chair of the SA Economic Development Board; along with leaders from the additive printing industries, vehicle and component manufacturers, and the resources industry.

The workshop was chaired by Mr Mike Heard FTSE, former CEO of Codan Ltd, a Director of META Ltd and member of the SA Premier's Science and Industry Council.



The Hon Tom Kenyon addresses the Workshop.

Sessions were chaired by Dr Craig Mudge FTSE, from CSIRO's Minerals Down Under Flagship and a specialist in additive manufacturing, cloud computing and big data; Mr Will Angove, Former Federal Government Automotive Supplier Advocate and MD of Automotive Planning Asia Pty Ltd; and Mr Reg Nelson, MD of Beach Energy Ltd.

The workshop identified key issues in manufacturing which are detailed in the theme article on page 11 of this edition of Focus and will be detailed in a workshop communiqué which will be on the ATSE website shortly.

Cell therapy launches SA public lectures

The South Australian Division launched its 2014 Public Lecture series in February in cooperation with the CRC for Cell Therapy Manufacturing with an event titled 'Rebuilding the body, cell by cell: the promise of Cell Therapy'.

The event was chaired by Academy director Dr Leanna Read FTSE, who is also chair of the CRC, with speakers and panellists:

- Dr Sherry Kothari, CEO of the CRC;
- Professor Toby Coates, Renal Transplant Nephrologist, Central Northern Adelaide Renal and Transplantation Service, Royal Adelaide Hospital;
- Associate Professor Simon Barry, Chief Hospital Scientist, Department of Gastroenterology, Women's and Children's Hospital, WCHN, Adelaide; and
- Professor Robert Short FTSE, Pro-Vice-Chancellor and Vice-President (Engineering), UniSA.

The lecture, held at the Science Exchange, Adelaide, focused on the field of regenerative medicine, which emphasises the repair, replacement and regeneration of damaged or diseased tissue.



Part of the lecture audience at the Science Exchange, Adelaide.

Those attending learned that cell-based therapies, such as bone marrow transplants, are already widely used to combat blood disorders and cancers, but new therapies are needed as we face an increasingly ageing population and a corresponding increase in the incidence of chronic and burdensome conditions such as heart disease, diabetes and neurodegenerative disease.

As the cost of drug development escalates, we need to find cheaper and more effective alternatives. Cell-based therapeutic approaches present promising cost-effective treatments with the potential to cure rather than simply manage.

In order to tap into the enormous potential of

cell therapies, however, we need to find more cost-effective ways to manufacture and deliver promising cells – a process that is currently expensive and fraught with difficulties.

The new CRC for Cell Therapy Manufacturing will address these challenges through intervention with smart materials, thus making cell therapies affordable and accessible to Australians, the audience was told.

Planning is well advanced for the next two lectures. A water recycling lecture is scheduled for 6 May and the final lecture will be in the first half of June.

WOMEN IN TSE

Susan Pond with ANSTO women



Two takes on International Women's Day

International Women's Day 2014 (8 March) was celebrated widely, including by ANSTO and Engineers Australia.

ANSTO has three ATSE Fellows on its Board – Dr Susan Pond AM FTSE, an ATSE Vice President, Professor Judy Raper FTSE and Ms Erica Smyth FTSE – and an increasing cohort of women are on the ANSTO team.

Starting out as a chemical engineer, Sarah Ballantyne now wears many hats including Compliance and Quality Manager for ANSTO's Nuclear Business, and Executive Officer for PETNET. She is one of two women on the ANSTO Nuclear Medicine (ANM) Board.

Dr Suzanne Hollins, Senior Research Scientist in ANSTO's Institute for Environmental Research, leads a team of researchers primarily made up of women.

Joanne Lackenby is the Licensing Officer and Environmental Co-ordinator for ANSTO's OPAL research reactor.

Dr Vanessa Peterson is an ANSTO materials science researcher specialising in the broad group of analysis techniques known as neutron scattering, who also leads a research group that uses these techniques to progress materials associated with alternative and sustainable energy technologies.

Dr Helen Maynard-Casely is an instrument scientist for the WOMBAT high-intensity powder diffractometer and her passion for crystallography is helping to inspire a non-science audience to understand the benefits this type of science can deliver.

Jaemin Craufurd-Hill, who among other things is an Executive Board



Vanessa Peterson



Sarah Ballantyne

Member of Women in Nuclear and a Senior Systems Engineer at ANSTO is the only woman currently qualified to drive OPAL, ANSTO's research reactor.

She is just one of the many women in highly technical roles at ANSTO, in areas that have previously been dominated by men.

ANSTO employs 338 women, up from 250 in 2010.

Engineers Australia marked the day with the statement 'Inspiring women to pursue engineering requires change'.

Engineers Australia's *Snapshot: Women in Engineering* shows women still face barriers in pursuing a career in engineering, prompting calls to inspire further change in the profession.

"In the last five years the number of women graduating from engineering and higher educational qualifications has increased more significantly than men," said Chair of Engineers Australia's Women in Engineering Committee, Ms Nee Nee Ong.

"Yet, women make up 11.2 per cent of the engineering labour force and experience higher unemployment. For the most part, women engineers are earning less than their male counterparts and women are found to be in fewer decision-making roles.

"Engineers Australia's recent *Survey of Working Environment and Engineering Careers 2012* highlights these findings.

"Engineers Australia's main area of concern with this gender imbalance is that we are significantly underutilising a key part of our highly skilled workforce, which is clearly detrimental to Australia's economic, productivity and growth agenda," Ms Ong said.

EARTH SCIENTISTS TAKE AAS AWARDS

Dr Julie Arblaster, from the Australian Bureau of Meteorology, has won the 2014 Anton Hales Medal for research in earth sciences. Dr Arblaster has been involved in, and initiated, distinguished research in the Earth sciences, according to the Academy of Science.

"Her research focuses on many aspects of the workings of the global climate system and its sensitivity to changes," her award noted.

"The importance of her research lies in, amongst other things, how it serves to explain many of the causes of climate variability and change. Much of her research pertains directly to the climate of the Australian region, particularly with respect to the ozone hole, El Niño, the monsoon, and Australian rainfall variability."

Dr Maria Seton, from the School of Geosciences, University of Sydney, has won the Dorothy Hill Award for female researchers in the earth sciences including reef science, ocean drilling, marine science and taxonomy in marine systems – awarded by the Academy of Science.

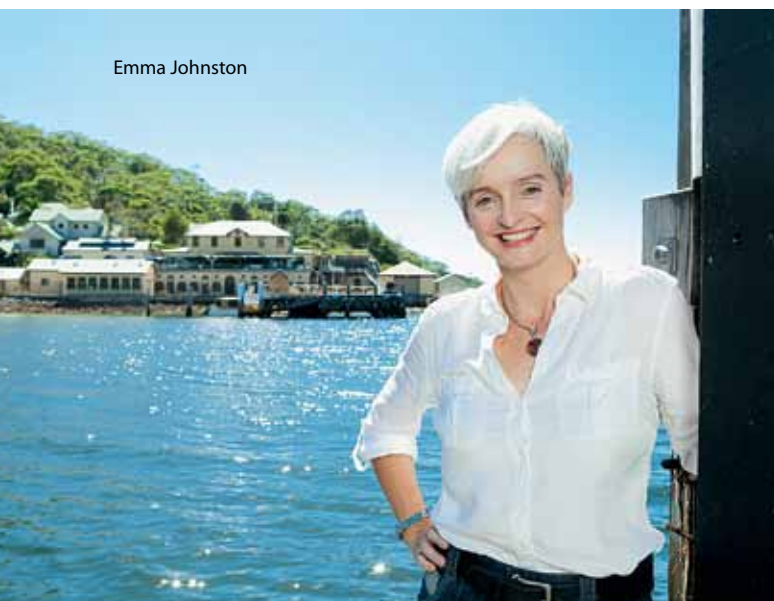
The Academy says: "Dr Seton has made significant contributions to the areas of global plate tectonics, long-term sea-level change, global geodynamics and back-arc basin formation.

"Her work on global tectonics has redefined the way that traditional plate reconstructions are achieved, through the development of an innovative workflow that treats plates as dynamically evolving features rather than the previous paradigm, which modelled the motion of discrete tectonic blocks.

"She has been part of ground-breaking studies on the effect ocean basin changes have had on global long-term sea-level and ocean chemistry."

WOMEN IN TSE

Emma Johnston



Marine ecologist wins Nancy Millis Medal

Professor Emma Johnston, a University of NSW marine ecologist, is the winner of the inaugural Nancy Millis Medal for Women in Science, awarded by the Australian Academy of Science.

Professor Johnston, an ARC Fellow at UNSW and the inaugural Director of the Sydney Harbour Research Program at the Sydney Institute of Marine Science, received the award for her leadership and ground-breaking research in marine ecology.

She combines her expertise in ecology and ecotoxicology to better understand and manage human impact on marine systems. Her work involves traditional laboratory-based studies with novel field-based experiments from Antarctica to the Great Barrier Reef. She is also a co-star of *Coast Australia*, a television series exploring the country's coastline.

The Nancy Millis Medal was established to recognise the contributions of early and mid-career women scientists who have established an independent research program and demonstrated exceptional leadership in any branch of the natural sciences. The award honours the memory of the late Professor Nancy Millis AC MBE FAA FTSE – a highly respected and much-loved microbiologist who catalysed links between academia and industry.

The announcement of the award coincided with International Women's Day (8 March).

Professor Johnston won a Young Tall Poppy Award in 2007 and a NSW Science and Engineering Award for Excellence in Biological Sciences in 2012.

Nancy Millis died on 29 September 2012 aged 90 at Epworth Hospital, Melbourne, where she had been convalescing following a car accident. Professor Millis had an illustrious career, which commenced with the pioneering study of biotechnology in Australia and culminated in her appointment as the Chancellor of La Trobe University from 1992, a position she held until her retirement in 2006. She joined the Academy in 1977, served on the Academy's Council and played a key role in establishment of the Crawford Fund.

INSTANT DNA DETECTION IS THE TARGET

University of NSW PhD candidate Evelyn Linardy is working on a portable DNA testing device that will allow doctors, researchers and border security to identify samples within 10 minutes.

The diagnostic technology, called EzyAmp, can be used to quickly classify pathogens, bacteria, animals and plant life on-site without the need to send off DNA samples to a lab – a much-needed breakthrough.

"There's a whole field out there desperate for instant DNA detection, it's the 'holy grail,'" says Evelyn, who is currently completing her PhD with UNSW and SpeedX Pty Ltd, a medical diagnostic company in Sydney.

Evelyn has already won two prizes for EzyAmp in the 2013 UNSW Innovation awards, but she is now working on speeding up the detective process to less than 10 minutes.

"At the moment we can do it in around 40 minutes, which is better than many technologies currently on the market, but we want it to be like the pin-prick blood glucose reader where you get the results almost immediately," she says.

If successful, the technology will have a big impact on a wide range of industries, from medicine and environmental monitoring to border security.

"For example, the technology can be used by doctors in developing countries trying to work out whether a patient has tuberculosis bugs, or by transit officers in airports trying to assess a bio-threat."



Evelyn Linardy

ROBOGALS WIN SCHOLARSHIPS

Julie Boulton, who is studying a Bachelor of Engineering at the University of Southern Queensland, and Hayley Ovenden, who is studying a Bachelor of Civil Engineering at the University of Newcastle, have won \$5000 scholarships from the Australian Constructors Association.

ACA chief executive, Lindsay Le Compte, said that the winners were selected from a field of excellent candidates from within the Robogals student membership.

"ACA had been a sponsor of Robogals since early 2012, and with these two scholarships has now committed \$100,000 to assist Robogals to get the message to young girls that the engineering sciences provide interesting and rewarding careers."

Robogals is a student-run organisation that was established by Marita Cheng who was named the 2012 Young Australian of the Year. Robogals, which has now established international chapters in addition to its extensive Australian chapter network, aims to increase female participation in engineering, science and technology through fun and educational initiatives aimed at girls in primary and secondary school.

By Cathy Foley
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Women can help bridge the 'valley of death'

Science and technology that lead to innovation are critical for the changes that lead to a better quality of life, greater business opportunities and a happier, healthier and more equitable society.

We don't have to look far from our own backyard to see examples of this. The rapid global expansion of wireless communications is in part possible because of the now widely acknowledged work by John O'Sullivan FTSE and his team at CSIRO. Wi-Fi is now estimated to be used in more than three billion devices worldwide.

Given the huge benefits that innovation can bring – economically and socially – we should be doing everything we can to encourage environments where this type of thinking and practice can thrive. One of the most effective ways

to do this would be to achieve gender balance in our innovation system.

There is strong evidence that companies operating with a gender-balance actually enhance their innovation quotient and gain a competitive advantage. Reports also suggest that advances in gender equity correlate positively with higher gross national product (GNP) and that increasing women's labour force participation and earnings generates greater economic benefits for a family's health and education. Surely this can only be a good thing.

So where exactly are we at? As a nation we have achieved great things. Last year Australia was named the country with the highest quality of life in the world, according to the OECD Better Life Index.

But we still have considerable work to do in many ways, including closing

the gender gap in the workplace. The World Economic Forum reported that in 2013 Australia continued to sit at 24th in closing this gap – just above Ecuador and Mozambique.

Australia still has only 17.6 per cent representation of women on ASX 200 boards (at 14 February 2014), and almost a quarter of boards of the ASX 200 still do not include any women at all.

Women working in science remain hugely underrepresented in leadership roles and some areas of physics and engineering have as little as five per cent female participation.

The Australian Businesswomen's Network says that women are starting small businesses at twice the rate of men. Despite this, a US study has found that female-owned companies are less likely to attract private investment compared to male-owned companies.

If the nexus of women, science and business is the recipe for success in innovation, then how do women, science and business meet?

Equity, diversity and the lost opportunity of not capturing the full human potential are important arguments for having more women involved in science, technology

HIP REPLACEMENTS MAY PROVIDE STEM CELLS

The tissue normally discarded during routine hip replacements could be a rich new source of adult stem cells for use in regenerative medicine, University of NSW-led research has found. With tens of thousands of hip replacement surgeries performed each year, this tissue could have "profound implications" in clinical use, the scientists say.



Melissa Knothe Tate

"In hip replacement surgery, the femoral head and part of the neck are resected to accommodate the neck of the implant," explains study leader Professor Melissa Knothe Tate, the UNSW Paul M Trainor Chair in Biomedical Engineering. "Typically this tissue is discarded, yet it may provide an untapped source of autologous stem cells for ageing adults who were born a generation too early to benefit from banking of tissues like umbilical cord blood at birth."

The study, published in *STEM CELLS Translational Medicine*, was led by the UNSW Graduate School of Biomedical Engineering and involved orthopaedic surgeon Dr Ulf Knothe, of the Cleveland Clinic in Cleveland, and scientists from Ludwig Maximilians University in Munich and Case Western Reserve University in Cleveland.

ANSTO ISOTOPE SUPPLY NOW MORE RELIABLE

ANSTO has announced a new collaborative arrangement to give Australian researchers access, for the first time, to a reliable domestic supply of medical isotopes used in pre-clinical and early stage cancer research.

Through the agreements, Australian researchers and clinicians will benefit from local production of these Positron Emission Tomography (PET) isotopes, which previously had to be imported.

The novel isotopes have significant potential to advance research in therapy management and eventually treatment. Initially copper-64 (Cu-

and business. But I have a new reason.

As the traditional 'social organisers' women bring a lot to the table. Business and science success is all about relationships and networking. You have to meet to do business.

Take the science world as an example. On average it takes about 20 years for a discovery to develop into a product. This has been an international rule of thumb. Everyone wants this to happen faster.

When you look at the reason for the delay, it is often when the development gets caught up in what is often called the 'valley of death' – a black hole in the commercialisation process that can add years to transitioning time. Translating a discovery in the science laboratory to the engineering and development, then finally securing industry adoption can be a tortuous process.

Women can offer a great deal in making that link as years of social conditioning means that it comes naturally to us.

Could the gender gap be a factor holding back the transition of science to industry, leading to missed opportunities? The diversity that women bring as scientists, technologists, engineers and nascent entrepreneurs might be the answer.

If women's participation is a



Cathy Foley reflects on what might be.

demonstrated element for business success and innovation is the essential ingredient for businesses to flourish, then why have we not embraced the opportunity to boost the role of women in science and business? Perhaps if we did we would witness greater translation of research to industry and our economic success would grow even more.

Increasing the participation of women in science, technology and business (big and small) is critical if Australia is to continue to have world leading quality of life, close the gender gap and have internationally competitive businesses.

Economic and social prosperity depends on change. This is one change we need to make now.

DR CATHY FOLEY PSM FTSE was appointed Chief of CSIRO Materials Science and Engineering (CMSE) Division in April 2011. Dr Foley's career at CSIRO has been broad, influential and widely cited. Her research expertise covers solid state physics, such as semiconductors, magnetics, superconductivity and nanotechnology. Highlights of her long career include leading the High Temperature Superconductivity (HTS) group in 1995, instigating CSIRO's presence in quantum engineering in 2001, and developing the fabrication technology which is the basis of CSIRO's successful HTS devices used in award-winning applications such as LANDTEM™ mineral exploration systems.

64), zirconium-89 (Zr-89) and iodine-124 (I-124) will be produced, with yttrium-86 (Y-86) to follow.

Organisations in three states involved in the fight against cancer will now work together on the production and use of these PET isotopes:

- ANSTO in Sydney;
- Austin Health/Ludwig Institute for Cancer Research (Victoria); and
- Sir Charles Gairdner Hospital (Western Australia).

PET works through a combination of gamma rays and a highly sensitive scanner to produce a 3D-image of a subject, clearly outlining areas affected by cancer.

UNESCO DATA TRACKS WOMEN IN SCIENCE

Just 30 per cent of the world's researchers are women. While a growing number of women are enrolling in university, many opt out at the highest levels required for a research career.

But a closer look at the data reveals some surprising exceptions. For example, in Bolivia, women account for 63 per cent researchers, compared to France with a rate of 26 per cent or Ethiopia at eight per cent.

A new interactive tool, Women in Science, presents the latest available data for countries at all stages of development. Produced by the UNESCO Institute for Statistics (UIS), the tool lets you explore and visualise gender gaps in the pipeline leading to a research career, from

the decision to get a doctorate degree to the fields of research women pursue and the sectors in which they work.

In Sweden, for example, women form the majority (60 per cent) of students enrolled in a bachelor's program, but their numbers decline as they move up the education ladder, accounting for 49 per cent of doctoral students and only 36 per cent of researchers. The data tool reveals this trend across every region, highlighting the conflict that many women face as they try to reconcile career ambitions with family-caring responsibilities.

Women researchers also tend to work in the academic and government sectors, while men dominate the private sector, which offers better salaries and opportunities. This is the case even in countries with high proportions of women researchers. In Argentina, for example, 52 per cent of researchers are women but they account for only 29 per cent of researchers employed in the private sector.

Perhaps most importantly, the data tool shows how important it is to encourage girls to pursue mathematics and science. In every region, women researchers are in the minority in science, technology, engineering and mathematics (STEM) fields. In the Republic of Korea, for example, only 17 per cent of researchers are women and they account for just nine per cent of researchers working in engineering and technology.

The data tool is particularly useful for those interested in a global perspective on the gender gap in research, especially in the STEM fields. Available in English, French and Spanish, it can be easily embedded on your website, blog or social media sites. (Go to uis.unesco.org).

By Aleksander Samarin
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Climate changes and renewable energy

All the cosmological, geo-physical, geo-chemical and biological factors which were responsible for the natural, cyclic climate changes in the past are still very much evident.

"The concepts of modern science confirm that all natural phenomena obey its laws. However, they deny that the knowledge of these laws is sufficient to precisely foretell future or to influence the outcome of natural events. In fact, these very laws forbid the exact prediction of future as well as our ability to change it. However, they allow us, be it only in a limited way, to lift the veil concealing the future and assess the probability of future events, relying on the laws of statistics"

– Max Born (1882–1970),
recipient of the 1954 Nobel
Prize for Physics

The information provided by the Australian mass media creates an impression that there are two diametrically opposite interpretations of climate change. The first, by the so-called 'climate sceptics', apparently even denies the existence of this phenomenon, and the second assigns climate change solely to human activity, and particularly to the emissions of carbon dioxide.

Neither of these assessments, of course, is true.

Since the formation of planet Earth some four and a half billion years ago, its climate has undergone very dramatic changes from the extreme cold to very hot weather conditions. These changes were cyclic and mainly due to the cosmological causes, but also as the result of geological changes of the planet itself.

Since the so-called 'industrial revolution' the ever-increasing human appetite for energy undoubtedly also influenced climate change by increasing emissions of greenhouse gases and also by drastic deforestation, as all vegetation provides an extremely effective 'greenhouse sink'.

Apparently it was geologist James Croll who was the first to develop a theory of periodic climate changes based on the fluctuations in the Earth orbit¹. He demonstrated that the Earth's orbit and tilt vary recurrently, causing cycles of ice ages and interglacial periods. He suggested that during periods of high orbital eccentricity ice ages occur on 22,000 year cycles in each hemisphere, and alternate between southern and northern hemispheres for the duration of approximately 10,000 years.

Croll's model was subsequently

improved by a mathematician Milutin Milanković². His calculations showed that, subjected to the influence of other planets of the Solar system, inclination of the Earth's orbit has a 100,000-year cycle, which from the geological data closely matched the 100,000-year pattern of ice ages.

Apart from the variations in eccentricity, axial tilt and precession of the Earth orbit, which were taken into account by Milanković in his mathematical derivations, there were obviously numerous other cosmological factors, such as collision of Earth with asteroids, and also geological events, specifically volcanic eruptions, which – particularly in the past – emitted enormous amounts of volcanic ash into the Earth's atmosphere, screening the Sun's radiation and thus creating 'mini ice ages'. However, the fundamental concepts of Milanković periodic cycles were recently confirmed in several scientific publications, such as by Hays, Imbrie and Shackleton³.

The duration of ice ages and interglacial periods for the past 400,000 years was experimentally determined by the analysis of ice cores. There are more isotopes of

BEATING POACHERS – WITH MATHEMATICS

Environmental scientists have developed a new, low-cost way to save rare animals and plants from poachers and plunderers – using maths.

In a new study, researchers from the ARC Centre of Excellence for Environmental Decisions (CEED), the Wildlife Conservation Society, Imperial College London and the Uganda Wildlife Authority are using a cunning mathematical model to outwit poachers in central Africa.

By studying the poachers' incursion patterns and prioritising patrols, the technology can improve protection of endangered animals and plants where they most need it, while minimising patrol and conservation costs, say Dr Richard Fuller and Dr James Watson of CEED and The University of Queensland (UQ).

"The great thing about this approach is that it can be applied anywhere in the world," Dr Fuller says. "For example we can use it to minimise disturbance of shorebirds in Queensland, or to tackle the weed invasion in Australia."

The scientists carried out the research in Africa's Greater Virunga Landscape – one of the most biodiverse places on Earth, with 13 protected areas covering 13,800 square kilometres. The team studied which areas had the most illegal poaching and logging, the impact on wildlife, and the cost of patrolling the threatened areas.

"We included all this information in a mathematical model that prioritises the location of patrols," Dr Watson says. "For example, since the poachers know well where the patrol bases are, patrollers should target more remote areas – a hotspot for illegal poachers – by extending their patrols. The study shows that this reduces the cost of meeting all

oxygen 18 (O-18) in oceans when they are cold and less when they are warm. Thus, the content of O-18 in air bubbles, entrapped in the Antarctic ice cores, provided reliable source of the Earth's temperature variations. From these studies estimated glacial periods in the past 400,000 years were between 70,000 and 90,000 years, and the interglacials between 10,000 and 30,000 years.

It was the founder of the science of physical chemistry, Svante Arrhenius who suggested yet another cause of cyclic variations in Earth's climate. Arrhenius⁴ assigned this phenomenon to the variations in the level of greenhouse gases, and especially that of CO₂. He calculated that the Earth's temperature would fall by 4°C to 5°C if the CO₂ was reduced by half, and would increase by about 5°C to 6°C should it be doubled.

Gases which are the most plentiful in Earth's atmosphere (nitrogen, oxygen and argon) are either monatomic, or contain two atoms, and are thus unable to absorb or emit infrared radiation. The most predominant greenhouse gas is water vapour and clouds, followed by carbon dioxide, methane and ozone.

From the past records it was established that the rate of cooling or warming due to the factors mentioned above can be fairly rapid, as reported by Samarin⁵. This is in part due to change in the Earth's albedo, the reflection of solar energy from its surface, high for white (such as ice and snow), and low for dark colours (such as soil and vegetation).

As all the cosmological, geo-physical, geo-chemical and biological factors

which were responsible for the natural, cyclic climate changes in the past are still very much evident at present, as was confirmed by André Berger⁶, there is no reason not to believe that the next natural climate change will lead to a substantial cooling of the Earth.

Several very eminent scientists, such as former Plumian Professor of Astronomy at Cornell University, Sir Fred Hoyle⁷, were of opinion that the next ice age might commence sooner, rather than later. Following sudden ending of the Younger Dryas, some 10,000 years ago, the Earth entered its current interglacial period. Recently Benny Peiser⁸ of the Global Warming Policy Foundation (GWPF), revising Sir Fred Hoyle's work, suggested that current increase in CO₂ emissions could delay, but not prevent, the onset of the next ice age.

Perceived dire consequences of global warming, as a result in the increase in CO₂ emissions, led to the international treaty, known as Kyoto Protocol, which imposed binding obligations on some countries to diminish their CO₂ emissions. It is estimated that in the year 2006 known world reserves of oil comprised 1.3 billion barrels, and those of coal, expressed as oil equivalent, 4.4 billion barrels, and natural gas 1.2 billion barrels of oil equivalent.

The daily use in 2006 of these resources was 84,000,000 barrels of coal, as oil equivalent, 52,000,000 of oil, and 10,000,000 of natural gas, as oil equivalent.

It is obvious that fossil fuels must be replaced by the renewable sources of energy for the humanity to survive, if this is at all possible.

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PROFESSOR ALEKSANDER SAMARIN FTSE, an Academy Fellow since 1988, was appointed in 2000 Visiting Professor at the University of Technology, Sydney, first at the Faculty of Science, and then at the Faculty of Engineering. Professor Samarin held several executive positions in industrial research organisations and concurrently part-time academic positions at the University of New South Wales, at the Defence Force Academy and at the University of Wollongong. He was consultant to numerous government research organisations, including ANSTO, and to a number of university advisory committees.

conservation targets in the landscape by as much as 63 per cent. By providing a big picture view of the entire landscape, the model enables us to maximise conservation efforts on a limited budget."

UWA JOINS CRITICAL ZONE

Researchers from The University of Western Australia have established the first Critical Zone Observatory in the southern hemisphere, joining an international think tank to learn more about the earth's outer skin. The UWA Future Farm in Pingelly, 200 kilometres south-east of Perth, has been selected as the site of the new Avon River Critical Zone Observatory.

The research site is part of an international network of environmental observatories (CZEN) that scientists around the world use to study what they call Earth's 'critical zone'.

Assistant Professor Matthias Leopold is coordinating the Avon River Catchment Observatory.

"The critical zone is basically the Earth's outer skin," Professor Leopold says. "It's the zone where soil interacts with rock, water, the atmosphere and living organisms. The critical zone is essential for all terrestrial life because it produces food, influences water quality and regulates microclimate."

"Currently there are 51 registered Critical Zone Observatories in the international network located mostly in Europe and the US. Until now there were none in the southern hemisphere and no Australian universities were part of the network of research sites. The new Avon River Catchment Observatory will help make the network of research sites truly global."

By Lindsay Falvey
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Technology, livestock and feeding the world



A donkey provides transport power in Tibet.

PHOTO: ISTOCK

ATSE *Focus* has featured the continuing challenge of feeding the world's growing numbers and appetite for wealthy diets.

Livestock products are the major group of such wealthy or high-input foods, now soaring in demand.

At present, I find the question whether such diets are 'good for the planet' moot, since market demand has consistently proved itself the dominant force. In addition, and much more important than tender steaks and probiotic yogurts, is the role that livestock products play in maintaining useful lives in poor countries.

In our imbalanced world, a billion or so people are hungry, two billion are food-insecure and a billion have specific nutrient deficiencies – while a billion are victims of excessive food consumption. This note focuses on those suffering from under-nutrition, rather than over-nutrition.

Livestock provide nutrient-dense foods that efficiently underpin sound physical and mental development and income streams for up to a billion of the world's poorest to buy staple foods while also enhancing soil nutrition and crop

yields. Producing meat, milk, eggs and other livestock goods in a manner that minimises environmental and zoonotic disease impact, especially for those whose existence depends of livestock, relies of continuous technological innovation, such as is conducted by the International Livestock Research Institute (ILRI).

As ILRI approaches its 40th anniversary, it is timely to highlight its critical role as the sole centre among the international research centres of the CGIAR that focuses on livestock and its contribution to the Millennium Development Goals of eradicating of poverty and hunger by 2015, which in this case are linked because the poor expend most of their income on food.

In this real world, livestock products are not a luxury – as is often erroneously stated in Western reports – they are the difference between life and death, or at least a means of obtaining a diet that allows children to become functioning adults. It is well-known that protein and energy malnutrition, iron-deficiency anaemia and vitamin A deficiency can be prevented by inclusion of livestock

products in a diet, and that even tiny amounts can improve cognitive development, growth and physical activity.

The serious moral imperative to provide such nutrients may be too easily ignored in many idealistic notions about meat and livestock in wealthy nations that in turn influence agencies charged with remediating such imbalances.

Even at the macro statistical level, indications of the importance of livestock are stark.

FAO advises that livestock provides 17 per cent of dietary global energy and 33 per cent of protein. Mixed crop-livestock systems rely on livestock for power and for manure that provides between 12 and 23 per cent of total global nitrogen used on crops, to produce almost half of global cereal – which for the developing world is represented by 41 per cent of maize, 74 per cent of millet, 66 per cent of sorghum and 86 per cent of rice.

The criticism of livestock heard in wealthy countries might be better directed at home, as it is wealthy nations produce 50 per cent of world beef, 41 per cent of milk, 72 per cent of lamb, 59 per cent of pork and 53 per cent of poultry, and feed up to half of the world's grain to livestock. And of the some 1.3 million employed in livestock food production, most are in poor countries where it is a major and essential human activity, especially where livestock survive and produce milk, meat and eggs on feeds not directly consumable by humans.

Livestock are central to survival in many such dire circumstances through such means as:

- transforming un-arable and waste lands into food;
- providing food and income to the landless;
- nutrient recycling on the majority of the world's farms;
- supporting pastoral and nomadic herders; and
- providing fertiliser for crops and power and traction for small farms.

And as I have argued in *Small Farmers Secure Food* (my 2010 ebook, available from Amazon), it is these small farms that feed almost half the world, including the farmers' families, and are extremely resource efficient. For example, 70 per cent of India's dairy production – and India

is the world's largest dairy producer – is from small enterprises. Within this diverse world, and without disturbing simple lifestyles unless clear improvements are possible, three distinct economic scenarios for livestock technologies now guide the focus of international livestock research.

1 The first relates to systems that are undergoing strong growth by facilitating transition from smallholder livestock in low-production systems to fewer households raising more productive animals more intensively to serve specific markets. Such intensification involves myriad technological developments, each of which would ideally be examined for unforeseen impacts before widespread implementation. But in this rapidly changing scenario, research and technology is often playing catch-up.

2 The second system focuses on systems with fragile growth, usually restricted by harsh environments, remote locations and poor governance. In these situations, livestock allow survival as well as serving

to increase resilience in systems that are perennially marginal. Grazing ruminants that survive and provide low levels of output are critical in such scenarios, and have earned respect from scientists who initially sought to introduce higher producing breeds or technologies only to find that an animal that survives extreme conditions to continue to offer a tiny amount of product is infinitely more valuable than one of higher productivity that dies under extreme conditions.

3 The third scenario is that of high-growth situations in which intensive livestock facilities serve urban markets with essential foods but also introduce risks.

Intensive pig and poultry facilities near cities, for example, are efficient producers of nutritious foodstuffs, yet may also impact on the environment and introduce public health risks. HPAI (Highly Pathogenic Avian Influenza) is a current example.

This is the diverse world in which ILRI works – the real world where livestock are critical to human survival

and wellbeing, and where ever new technologies are demanded of its scientists.

It challenges naïve proposals that intensive Western-style systems are more efficient and should be spread across the globe, yet recognises they are indeed efficient in Western and similar economies where such calculations are financially based.

Elsewhere when efficiency is considered in terms of usage of the meagre supply of natural or waste resources, and where survival and children's development is prized above financial gain, the livestock production systems to which technologies must be oriented includes those extant, often proven over millennia.

PROFESSOR LINDSAY FALVEY FTSE is a Board of Trustees member of the International Livestock Research Institute (ILRI) and a Director of Hassad Australia Pty Ltd, a major investor in Australian agriculture. He has previously been Dean of Land and Food and Chair of Agriculture at the University of Melbourne, and Managing Director of Coffey-MPW Pty Ltd with projects across 60 countries.

Soil carbon map sets baseline

CSIRO has developed a map of Australia's stored soil carbon which is expected to provide a benchmark against which Australia can track future changes in soil carbon storage or carbon sequestration.

Providing the most detailed and accurate representation of soil organic carbon stocks, to a depth of 30 centimetres, at a national scale, the 2010 soil organic carbon map for Australia, draws on soil-sampling data and innovative prediction methods. The map includes an estimate of soil carbon stock and an estimate of the uncertainty for approximately two billion football-field-sized blocks (90 metres by 90m) across Australia.

"This map is the first effective nationwide baseline of organic carbon levels in the top 30cm of soil, which comes with estimates of uncertainty," according to lead researcher, Dr Raphael Viscarra Rossel.

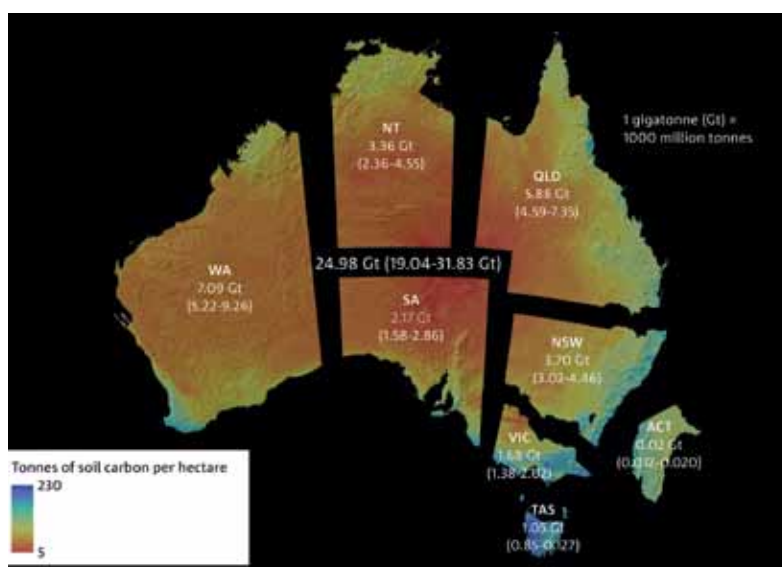
Until now, estimates of soil organic carbon across Australia had not been available or were largely uncertain because of large gaps in data and the limits of past measurement and spatial modelling.

"The map provides a reliable benchmark for Australia to monitor the influence that changes in land cover, climate, land management and greenhouse gas offset activities have on soil carbon stocks and associated carbon dioxide removal from the atmosphere," Dr Viscarra Rossel says.

The map and its prediction methods provide new insight into the environmental drivers that determine the distribution of soil carbon across the nation, its diverse bioregions and its states and territories.

"Australia's largest soil organic carbon stores per hectare occur in the cool, temperate zones, which have higher-than-average rainfall and extensive rainforests and eucalyptus forests," Dr Viscarra Rossel says.

The average amount of organic carbon in the top 30cm of Australian soil was estimated to be 29.7 tonnes per hectare and the total stock for the continent at 25.0 gigatonnes (1Gt = 1000 million tonnes).



The 2010 baseline map of Australia's soil organic carbon stocks showing the national and state and territory estimates and their uncertainty range.

By John Richards
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Skilled workforce essential for Australian space policy

We already provide ground station support but it is difficult to see value in Australia developing its own satellite program.

The late Senator John Button, then Minister for Industry, Technology and Commerce, with the then Minister for Science, the Hon. Barry Jones, launched Australia's first space policy on 22 September 1986. Its objective was to encourage greater involvement by industry in space R&D and to promote commercially viable space-based industries.

The policy was a response to the ATSE report *A Space Policy for Australia*, commonly known as the Madigan report.

Subsequently, the Government established the Australian Space Board, later replaced by the Australian Space Council, which formulated a five-year plan in 1994 to guide Australia's space science and technology, and the involvement of industry. Following the 1996 Federal elections, the incoming Government terminated the program, choosing CSIRO as the principal vehicle for promoting R&D and commercial activities in space.

In the next 10 to 15 years there were attempts to resurrect a policy setting

for Australia's public and private sector space activities, but little of significance happened before a further study by ATSE in cooperation with the Academy of Science (AAS) in 2009. From that work, and related commissioned, government and CSIRO studies, the Government in 2011 developed a set of principles for a new policy. *A Satellite Utilisation Policy for Australia* was launched in April 2013.

Although there is potential for history to repeat, there is no indication yet that the new Coalition Government will depart significantly from the policy developed under its Labor predecessor.

There are common features between the policies, even though they are almost 20 years apart. Earth observation and positioning are key elements of each because of their importance to resource monitoring and management, and the broad infusion of navigation and positioning information into society.

Both policies emphasise the importance of developing value-

added markets in remote sensing. Both underscore the importance of maintaining our international standing as contributors, along with other space-going nations, of products and services.

There are two motivations for doing so – ensuring our continued access to information, in absolute terms and at less than full commercial rates, and buying ourselves a seat at the table of decision-makers.

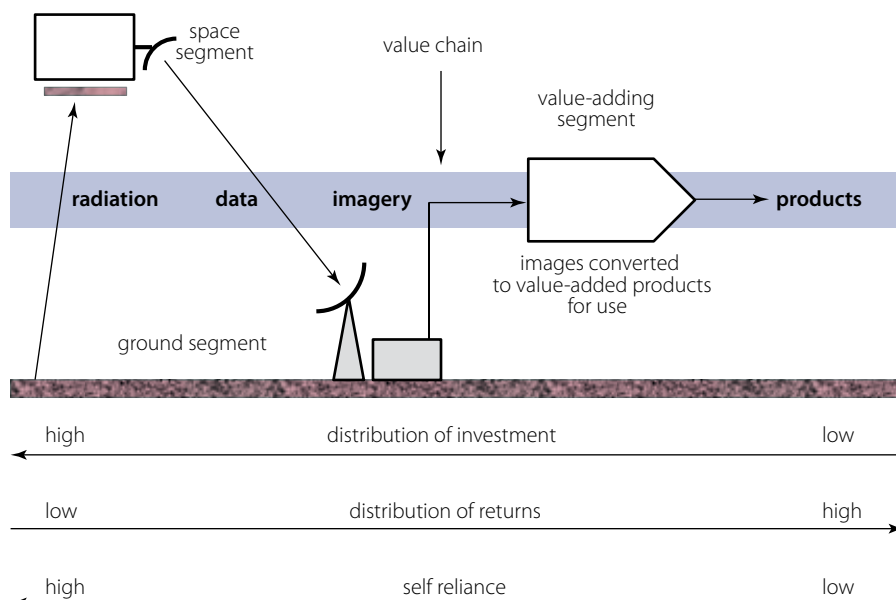
Matters that receive increased attention in the new policy include (a return to) stronger national coordination, domestic infrastructure development and improving our skills in those technology sectors supported in the policy. In an era where traditional manufacturing industry is under threat in Australia, these recommendations make sense. They point to the development of service industries based on value-added products as the foundation for export development and regional aid programs, especially in remote sensing.

The reason for these decisions is evident in the simple space-based Earth observation system in Figure 1. It consists of three segments: the space, ground and value-adding elements.

The first is essentially a transducer that converts upwelling radiation (optical, radar, thermal) into a data stream for downlinking to the ground segment. Apart from satellite control, the ground segment processes the data stream into basic units (mostly imagery) for distribution to users. The value-adding segment converts imagery to products of value to the end user. A single downlinked data stream, leading to a single image, can generate many value-added products covering many application sectors.

The major investments in a space-based remote sensing system lay in the design, manufacture and launch of the

Figure 1 The remote sensing data chain.



satellite(s). The next is in the ground segment. The investment required to develop and implement the value-adding sector is much smaller by comparison.

The software and hardware for image analysis are now relatively inexpensive, so that the investment required is largely in creating a skilled workforce. It is the prospect for generating better returns from investing in value-adding skills, rather than satellite launch and development, which makes it sensible for Australia to focus on the output end of the value chain in Figure 1. That position is an element of both the old and new policies.

It is the opposing natures of the investment and return trends in Figure 1 that have made many nervous over the years in Australia.

Understandably, those who invest heavily in space and ground infrastructure may be reticent to continue subsidising those countries that derive significant value-added returns from a supplier's image products, if the end users themselves are not contributing to the growth and maintenance of the full system.

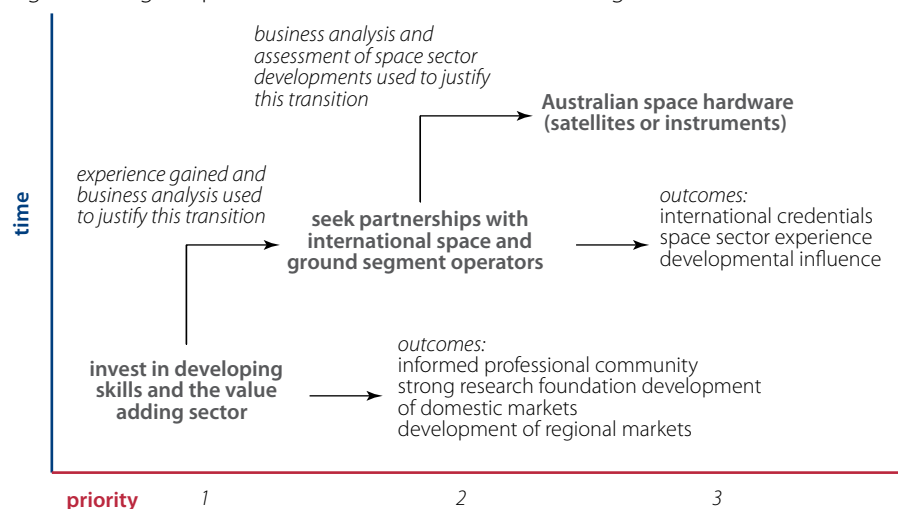
Meaningful contributions can take many forms. Under the 1990s policy Australia provided instrumentation; more generally, excellent work undertaken largely by CSIRO in image interpretation in the 1970s and 1980s gave Australia a reputation as a nation of experts who were helping build the applications base for satellite Earth observation.

But how do we maintain our seat at the table? While Australia's contribution to image interpretation may have secured our international standing in the past, we need to keep this matter under consideration if we intend to build a value-adding service industry using imagery acquired elsewhere.

Options are to contribute to the space and ground segments. We already provide ground station support, and have done so for many years; but what about the space segment?

It is difficult to see value in Australia developing its own satellite program. Not only is this a challenge financially, with fewer returns by comparison to investing in value-adding, but the space segment in earth observation will undergo significant transformation in the coming years with the adoption of clusters of

Figure 2 Staged options for investment in remote sensing.



smaller satellites for data gathering in contrast to current single buses.

We do not, at this stage, know how best to handle the data from clusters. At minimum, decisions have to be made about the desirability of downlinking all recorded data as against on-board processing.

Nevertheless, Australia may still wish to test the water in terms of the space segment as a means for keeping future options open and to demonstrate its willingness to contribute to an industry sector on which we rely so heavily using overseas supply.

A possible approach is to seek partnership with nations that already have proven systems and who are in later generations of development.

That option is outlined in Figure 2, which is structured around three priorities, with exit points. Progression depends on the experience gained at each point, while the level of investment increases with movement across the priorities.

It has the benefit that with fairly small investment to improve workforce skills in image understanding, we can move immediately to expand a service industry that should find significant markets both domestically and in the region. That investment can also position us to know whether there is value in progressing to a space segment, most likely initially in partnership with other nations.

In the 1980s and early 1990s Australia possessed comprehensive skills in remote sensing image analysis. While much of this has lasted in pockets, some important skills bases have dissipated. Application of synthetic aperture radar is an illustration.

To respond to the new policy imperatives and to support a strategy like that proposed in Figure 2, investment in skills development is essential. That would take at least two forms:

- improved education and training; and
- support for broadly based research that will keep our applications specialists at the forefront of the field.

Industry stimulation is also required.

When the field of satellite remote sensing was new there was speculation that end users themselves would analyse imagery. That has not happened in many cases, largely because the interpretation task is non-trivial, especially when several disparate sources of data have to be analysed in combination.

What we haven't done is establish enough domestic skilled agents that can act as the interface between data gathering and interpretation, and the needs of end users, interested only in products that service their needs. Our small sector needs growth to realise the value of earth observation for a greater number of users.

In Figure 1 we have shown a self-reliance trend line. While high costs have obviated serious consideration of an Australian space segment, the scene is changing at the farm level and similar.

The use of drones to gather imagery over small geographical regions is now possible, meaning that for many applications we can control the full process from data acquisition to product development. There will always be the need for space-based, wide coverage for many applications, but data gathering

is now becoming much more flexible.

Notwithstanding the data source, there remains the need for a skilled workforce, so that national investment in education, training and research remains a high priority.

Further reading

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AAS and ATSE, *An Australian Strategic Plan for Earth Observations from Space*, AAS, Canberra, July 2009.

<http://www.space.gov.au/SpacePolicyUnit/Pages/default.aspx>

Australia's Satellite Utilisation Policy, Commonwealth of Australia, Canberra, 2013.

EMERITUS PROFESSOR JOHN RICHARDS AM FTSE has held the positions of Deputy Vice-Chancellor and Vice President of the Australian National University, Dean of the College of Engineering and Computer Science, and Master of University House at ANU. In the 1980s he was foundation Director of the Centre for Remote Sensing at the University of New South Wales.

Evolution stuck in slime for a billion years

Tasmanian researchers have revealed ancient conditions that almost ended life on Earth, using a new technique they developed to hunt for mineral deposits.

The first life developed in the ancient oceans around 3.6 billion years ago, but then nothing much happened. Life remained as little more than a layer of slime for a billion years. Suddenly, 550 million years ago, evolution burst back into action – and here we are today. So what was the hold-up during those ‘boring billion’ years?

According to University of Tasmania geologist Professor Ross Large FTSE and his international team, the key was a lack of oxygen and nutrient elements, which placed evolution in a precarious position.

“During that billion years, oxygen levels declined and the oceans were losing the ingredients needed for life to develop into more complex organisms,” he says.

By analysing ancient seafloor rocks, Professor Large and his Australian, Russian, US and Canadian colleagues were able to show that the slowdown in evolution was tightly linked to low levels of oxygen and biologically important elements in the oceans.

Their research was published in the March issue of the journal *Earth and Planetary Science Letters*.

“We’ve looked at thousands of samples of the mineral pyrite in rocks that formed in the ancient oceans. And by measuring the levels of certain trace elements in the pyrite, using a technique developed in our labs, we’ve found that we can tell an accurate story about how much oxygen and nutrients were around billions of years ago.

“We were initially looking at oxygen levels in the ancient oceans and atmosphere to understand how mineral deposits form, and where to look for them today. That’s a focus of the Centre for Ore Deposit and Exploration Science (CODES), which we established with ARC and industry funding at UTAS in 1989,” he explains. “But the technology we have developed to find minerals can also tell us much about the evolution of life.”

After an initial burst of oxygen, the study plots a long decline in oxygen levels during the ‘boring billion’ years before leaping up about 750 to 550 million years ago.

“We think this recovery of oxygen levels led to a significant increase in trace metals in the ocean and triggered the ‘Cambrian explosion of life’.

“We will be doing much more with this technology, but it’s already becoming clear that there have been many fluctuations in trace metal

levels over the millennia and these may help us understand a host of events including the emergence of life, fish, plants and dinosaurs, mass extinctions, and the development of seafloor gold and other ore deposits,” says Professor Large, who is Chair of the Academy’s Tasmanian division.

CODES was established as an Australian Research Council Centre of Excellence. The study has been funded by the Australian Research Council and is collaboration with the Russian Academy of Science, University of California, the Yukon Geological Survey, Geological Survey of Western Australia, Flinders University, Museum Victoria and Mineral Resources Tasmania

LETTER

IS OUR UNIVERSE FLAT?

There are several somewhat contradicting theoretical cosmological models of the Universe. The Friedmann-Lemaître-Robertson-Walker model is considered by many scientists as the most trustworthy. This model is basically represented by the equations developed by Aleksandr Aleksandrovich Friedmann and derives the curvature of the Universe from the fundamentals of fluid dynamics.

The essential aspect of the local curvature of the Universe is a function of the average density of the Universe divided by the critical energy density, and this ratio is assigned the symbol Ω . If the curvature is zero, then Ω equals 1. If Ω is greater than 1, then the curvature is positive and if Ω is less than 1, the curvature is negative. Apparently the shape of the Universe can affect its ultimate destiny. However, the astronomical observations provide the information only about the visible part of the Universe. The latest data which is based on the Wilkinson Microwave Anisotropy Probe (WMAP) measurements indicates that the visible part of the Universe is ‘flat’, with approximately 0.4 per cent margin of error – that is for this part of the Universe $\Omega = 1$.

There are, however, several ‘sceptics’, such as an astronomer Ron Cowen, who do not exclude the possibility that the Universe, as a whole, can be curved.

– PROFESSOR ALEKSANDER SAMARIN FTSE

PHOTO: UTAS



Ross Large and Professor Valeriy Maslennikov, a Russian colleague, examine black shales in Siberia.



Stuart Khan (left), author of the ATSE report *Drinking Water through Recycling*, at the report's launch in October 2013 (see ATSE Focus 181).

Extreme weather events a risk to our water

Australian water utilities must adapt to extreme weather events if they are to protect vulnerable supplies and ensure clean drinking water into the future, an international report warns.

Events such as flooding, prolonged rainfall, drought, cyclones and bushfires all have an impact on surface water quality, and are predicted to become more frequent and intense in many parts of Australia due to climate change.

"Water quality impacts from these events are diverse but can include the presence of highly toxic chemicals and infectious pathogens," says Dr Stuart Khan from the University NSW School of Civil and Environmental Engineering, who was the lead Australian author on a report commissioned by the US-based Water Research Foundation, which was established to help water utilities better deliver clean drinking water and meet regulatory standards.

"Utilities without appropriate contingency plans will be at a major disadvantage when recovering from and adapting to these future weather-related impacts," he says.

The results of the study identify various water quality impacts resulting from extreme weather. These include aesthetic impacts on colour, taste and odour, the presence of microbial and chemical pollutants, and disruptions to normal water treatment processes from damaged infrastructure.

To collect data, the researchers undertook detailed retrospective case studies of extreme weather events experienced during the past decade. This included surveying staff from 41 water utilities in Australia and the US, including major urban utilities in New York City, Houston, Sydney and Melbourne.

"Interestingly, the water quality impacts were observed to be much worse following a combination of extreme weather events in close proximity, rather than after a very extreme but isolated event."

Dr Khan says while Australian water utilities are "reasonably well prepared to respond to extreme weather events", thanks to an industry-wide focus on risk assessment and risk management, the vulnerability of our water systems requires urgent action.

"We need to focus on building resilience into our future supplies. This means designing systems that are more protected from the impacts of climate change and that have greater flexibility to respond to extreme weather events. This could be partially brought about through a diversification of water sources."

A follow-up project is now underway, focusing on how Australia may be able to include adaptation measures and extreme weather event resilience into future revisions of the Australian Drinking Water Guidelines.

POOR INFRASTRUCTURE PLANNING SHREDS ENGINEERING JOBS

Job vacancies for engineers have fallen for 23 successive months, according to analysis by Engineers Australia, which says this highlights the parlous state of infrastructure investment in Australia.

"Australia has been trapped in a boom/bust infrastructure delivery cycle for decades, and with over 60,000 engineers employed on infrastructure project delivery and planning across the country, this has affected our ability to effectively build and deploy a professional workforce," said Stephen Durkin, Chief Executive Officer of Engineers Australia.

"The short-term political cycle focuses on intermittent, big-ticket infrastructure spending. In contrast, training a professional workforce takes years; by the time graduates are work-ready and able to work independently, we're reasonably talking up to a decade. You simply can't build a professional workforce around political promises.

"In times of low demand, engineers will simply leave the profession to take up jobs in other sectors. Unsurprisingly, when demand again peaks, we are faced with a domestic skills shortfall as we struggle to attract these people back to the profession.

"The engineering profession has gone from major skills shortages to major employment uncertainty in the space of two short years. Without a transparent and coordinated commitment to infrastructure investment, this cycle will continue.

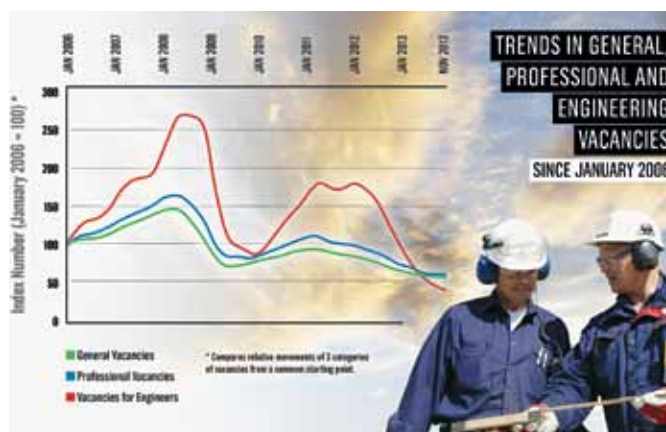
"The politically driven infrastructure delivery cycle is damaging Australia's ability to build a sustainable domestic professional workforce. With resource spending no longer masking the low level of public infrastructure investment, the workforce consequences are now on full display.

"Long-term infrastructure planning in Australia must be independent of politics.

"As Engineers Australia has reported to the Productivity Commission review of public infrastructure, these latest data highlight the hidden costs of Australia's traditional boom/bust infrastructure delivery cycle. Coordinated investment is needed, and urgently," Mr Durkin said.



Stephen Durkin



Tracing the engineering vacancies.



BEBs in action.

Birdon wins US military contract

Port Macquarie (NSW) marine engineering company Birdon has been awarded a contract to supply the US Army with up to 374 Bridge Erection Boats (BEBs) for a total of US\$259 million. The company is the Australian subsidiary of the international Birdon Group.

The boats are mainly used to move and position temporary floating bridges, which usually supplement infrastructure destroyed during military conflict. They are also capable of transporting materiel and personnel and towing BEBs, and may be transported by road, rail and air.

The company said its NAMJet marine propulsion system was a key factor in the winning tender. It explained that the system provides more thrust than other water jets on the market while maintaining high speeds.

Because of US Government procurement requirements, the manufacture and supply of the boats will take place in the US. However, Australian-based staff will support delivery of the contract and Birdon's Port Macquarie facility will be expanded.

ADELAIDE ARRIVES IN MELBOURNE

Australia's second and final Landing Helicopter Dock (LHD) ship, to be known as *HMAS Adelaide* once commissioned, has arrived in Melbourne, completing its voyage from Spain aboard the Heavy Lift Ship, *Blue Marlin*.

Blue Marlin took eight weeks to travel the 10,000 nautical miles to Melbourne where the new LHD will undergo final fitting out.

Adelaide and her sister ship *Canberra* will be the biggest warships ever built for the Royal Australian Navy. The Canberra Class LHDs are bigger than Australia's last aircraft carrier *HMAS Melbourne*. They are more than 230 metres long, 27.5 metres high and will weigh around 27,500 tonnes once completed.

Each ship can carry a combined armed battle group of more than 1100 personnel, 100 armoured vehicles and 12 helicopters and also features a 40 bed hospital.

Once unloaded from the *Blue Marlin* the LHD hull will undergo superstructure and other critical fit-out work and integration of combat and communications systems at Williamstown dockyard. It is expected to be introduced into RAN service in 2015.

DSTO, IBM COLLABORATE ON CYBER SECURITY RESEARCH

The Defence Science and Technology Organisation (DSTO) and IBM Australia have entered into a strategic alliance to conduct collaborative research in a range of high-end defence technologies.

The agreement, signed in Canberra by Chief Defence Scientist Dr Alex Zelinsky FTSE and IBM Australia's Director, Mr Glenn Wightwick FTSE, means the two organisations will collaborate in the highly specialised technology areas of cyber security, analytics and cognitive computing.



Alex Zelinsky



Glen Wightwick

"The alliance is an opportunity to strengthen the ADF's capabilities in cyber security," Dr Zelinsky said.

"Both organisations have deep expertise in these areas and it is a natural fit that we work together in what are some very promising defence related areas of research."

Mr Wightwick said the company welcomed the chance to contribute to defence capability in emerging technologies.

"IBM has a long history of driving innovation – from the invention of the barcode to the creation of cognitive computing systems that learn and interact naturally with people to extend what either humans or machine could do on their own," he said.

"Our researchers push the boundaries of science and technology to make the world work better."

DSTO and Lockheed Martin Australia have also signed a new strategic alliance to collaborate on a range of technologies for strengthening defence and national security.

In recent months DSTO has been actively pursuing new industry partnerships to increase investment in strategic research. It has recently signed a number of strategic alliances with defence companies including BAE Systems, Thales, SAAB Australia, ASC – as well as IBM and Lockheed Martin.

The *Blue Marlin* brings *Adelaide* into Port Phillip Bay, Victoria.





Deploying an Argo float.

Bio robots probe Indian Ocean

Robotic floats armed with revolutionary new sensors will be launched in the Indian Ocean, as part of a new India-Australia research partnership to find out what makes the world's third largest ocean tick – and how both nations can benefit from it.

The Indian Ocean contains vast fisheries and mineral resources that are of strategic importance to both Australia and India. It also plays a direct role in driving the climates of its surrounding regions – home to more than 16 per cent of the world's population.

The new 'Bio Argo' floats, to be launched in mid-2014, will enhance the already successful Argo float technology to measure large-scale changes in the chemistry and biology of marine ecosystems below the Indian Ocean's surface. The Argo floats are a network of 3600 free-floating sensors, operating in open ocean areas, which provide real-time data on ocean temperature and salinity.

The 'Bio Argo' floats will include additional sensors for dissolved oxygen, nitrate, chlorophyll, dissolved organic matter and particle scattering. They will target specific gaps in our understanding of Indian Ocean ecosystems of immediate concern to India and Australia, such as the Bay of Bengal and the waters of north Western Australia.

CSIRO's Dr Nick Hardman-Mountford says the pilot project, led by CSIRO in collaboration with the Indian National Institute of Oceanography (CSIR-NIO) and the Indian National Centre for Ocean Information Services, will improve our understanding of cause and effect in the Indian Ocean's climate and ecosystems.

"By studying the Indian Ocean in this detail, we can investigate the origin and impact of marine heatwaves like the one that devastated the coral reefs and fisheries off north WA in 2011 – and improve our prediction of them in the future," Dr Hardman-Mountford says.

The \$1 million project is funded in part by the Australian Government under the Australia-India Strategic Research Fund.

DSTO CHANCE FOR AMERICAN EXPERT

DSTO is looking for an outstanding US researcher for the Fulbright Distinguished Chair in Advanced Science and Technology.

DSTO sponsors the Distinguished Chair to bring to Australia senior US researchers, at professor, associate professor or equivalent level, to expand their horizons and share their knowledge and experience with their Australian colleagues.

The Distinguished Chair is a four to five month appointment at DSTO or another research institution in Australia linked to DSTO. During the appointment, the Chair will work on a specific research project in a priority area for DSTO and engage with faculty and students through guest lectures, seminars and other opportunities. A national speaking tour is also part of the program.

Applications close 1 August. Details are on the DSTO website.

GAS PIPELINE RESEARCH WINS AIRG MEDAL

A joint research project between Woodside and Chevron Australia to fund the O-Tube facility at The University of Western Australia has been awarded the prestigious 2014 Australasian Industrial Research Group (AIRG) Medal for Australasian Major Industry Technological Innovation.

Known as the STABLEpipe Joint Industry Project, the initiative was presented the award for "the development of the O-Tube program which has significantly improved designs of offshore oil and gas pipelines, while ensuring cost savings for the Australian offshore oil and gas industry".

The world-first facility rapidly circulates 60 tonnes of water to simulate underwater conditions during tropical cyclones and has provided significant cost savings for the JIP partners.

AIRG President Ms Leonie Walsh FTSE – Victoria's Lead Scientist – said that winning the AIRG Medal required industrial research that is not only demonstrated but is implemented at full scale.



Leonie Walsh

The AIRG Medal is an annual award, made to a current industrial research manager, researcher or group of researchers making the most outstanding Australasian industrial research management and or industrial research contribution during the previous year. Two medal awards are made annually, one to large multinational corporate nominees and the other to small to medium enterprises (SMEs).

BIOMEDVIC LAUNCHED

Medical research organisations in Victoria, which are claimed to conduct more than 40 per cent of Australia's medical research, now have a new peak body – BioMedVic.

Biomedical Research Victoria was launched in March by Gordon Rich-Phillips, Victoria's Minister for Technology. Biomedical Research Victoria was formerly known as the Bio21 Cluster. It was established in 2001, as an initiative of the University of Melbourne, Melbourne Health, The Walter and Eliza Hall Institute and the Victorian Government.

Biomedical Research Victoria represents the teaching hospitals, universities, research institutions, CSIRO and other organisations whose scientists contribute to improving the lives of millions of people and whose internationally recognised work is an important driver of economic development in Victoria. It aims to provide a mechanism for this remarkable community to work effectively with government to create the policies, infrastructure and supportive environment necessary to tackle major scientific problems and compete successfully with the emerging life sciences centres in the region.

By Ian Rae
iandrae@bigpond.com



Extraordinary individuals making a difference

When a scientist operating at the interface of research, business and government met a science and innovation policy analyst at a business conference in Tokyo, they decided to write a book. About successful people.

Not wishing to make “yet another collection of US-oriented mini-biographies”, they found their heroes by standing back to consider the big issues confronting mankind – economic, social, personal and technological. That way they arrived at a list of “extraordinary individuals” who are making a difference.

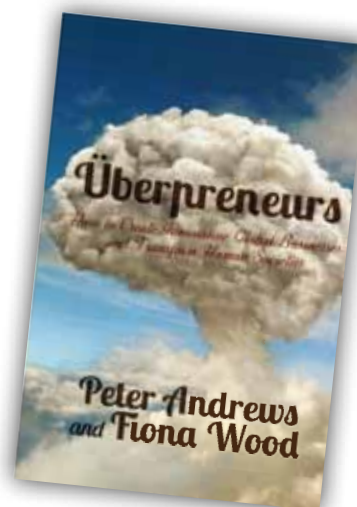
They are not all entrepreneurs, although some are. The authors’ final chapter is devoted to explaining “überpreneurs ... the overtakers”, who have given so much to the world.

There are familiar names, of course, notably in the sections on Big Business (Richard Branson, Jeff Bezos), High Technology (Bill Gates, Craig Ventner, and our very own Barry Marshall) and Happy People (Jamie Oliver, Oprah

Winfrey). In some cases I recognised the achievement being celebrated but had never associated a name with it. How would you go with Ingvar Kamprad (IKEA), Niklas Zennström (Skype) and George Rathmann (Amgen)?

I did not immediately recognise any of the names in the Better World section, so I started my investigation with Muhammad Yunus. He was one of 14 kids in a Bangladeshi family. He gained an MA in economics from Dhaka University and PhD from Vanderbilt in Tennessee. Rather than disappearing into the maw of US academe, he went back to Chittagong where he started a bank that provided start-up funds for poor artisans. He didn’t invent microcredit, he just made it work – his Grameen Bank has 2500 branches, 20,000 staff and eight million borrowers.

Stories like this challenged me to dip into other sections – yes, it’s a ‘dipping into’ rather than a ‘slaving over’ book – and learn about other überpreneurs. Like Amancio Ortega, who came up through the rag trade in north-western Spain, to be a “success in



Überpreneurs, Peter Andrews and Fiona Wood, Palgrave Macmillan 2014, xi + 325 pp.

the cut-throat world of fashion”. He and his wife launched Zara in the 1960s and the rest is ... well, just go down the street and have a look. There are no silver spoons here, just hard-working people from a range of backgrounds and a range of countries.

In each section, Peter Andrews FTSE (former Queensland Chief Scientist) and Fiona Wood charge through the achievements of nine überpreneurs. Their staccato style sometimes distracts from the serious analysis that underlies each case study. Each section is further subdivided on a thematic basis into three sets of three, and for each person there is a list of key sources. There is also an intensive analysis of performance and characteristics of each überpreneur under the headings Opportunistic, Visionary, Innovative (but pragmatic), Persuasive, Pursuing the dream, Confident, Resilient and Courageous.

I think the designated überpreneurs are all alive, so I’d classify the book as a celebration of lives being well lived.

And there are learnings. The text concludes with some pithy advice for governments, educators, friends and families, investors and philanthropists about how to get more überpreneurs and how to foster the work of the ones we have.



Professor John Shine (left), Dr Fiona Wood, Professor Peter Andrews and Professor Peter Coaldrake at the launch of *Überpreneurs* at Queensland University of Technology.

PROFESSOR IAN RAE FTSE, an Honorary Professorial Fellow at the University of Melbourne, is a former Technical Director of ATSE. He was President of the Royal Australian Chemical Institute (2006–08) and has served for more than a decade as a technical adviser to the UN Environment Program.



Stuart Wenham

Stuart Wenham takes international prize

University of NSW Scientia Professor Stuart Wenham FTSE has been awarded the prestigious Institution of Engineering and Technology's (IET) A F Harvey Engineering Research Prize of £300,000.

The award recognises the discovery by Professor Wenham and his team of a mechanism to control the charge state of hydrogen atoms to correct deficiencies in silicon – the most costly part of a solar cell.

"Our patented advanced hydrogenation technology will allow lower-quality silicon to outperform solar cells made from better quality materials, producing higher efficiencies at significantly lower cost," said Professor Wenham, from the School of Photovoltaics and Renewable Energy Engineering.

"It is a great honour to receive the A F Harvey Engineering Prize and the international recognition that it brings to this important innovation. The prize money will go a long way to helping us take the research to the next stage.

"Our UNSW team is now working with the world's biggest solar manufacturers through collaborative agreements with NewSouth Innovations (UNSW's commercial arm) to commercialise this low-cost technology," said Professor Wenham, who acknowledged the Australian Renewable Energy Agency's funding support for the project, which is expected to be completed in 2016.

Professor Wenham will deliver a special IET lecture, 'Trends in Photovoltaic Technology and Applications', in London on 21 May to commemorate his award. He is the third

recipient of the A F Harvey Engineering Research Prize.

Professor Wenham is Scientia Professor of Electrical Engineering and Director of the ARC Photovoltaics Centre of Excellence at the UNSW, and CTO of Suntech-Power Co, one of the world's largest PV manufacturers. Formerly, Professor Wenham was Head of the School of Photovoltaic Engineering, Director of the Key Centre for Photovoltaic Engineering and Associate Director of the Photovoltaics Special Research Centre (1990–98), with responsibility for the device research strand.

He and Professor Martin Green AM FTSE, with graduate student Dr Zhengrong Shi FTSE, were involved in the formation of Pacific Solar Pty Ltd in 1995 as a cooperative venture between the university and Pacific Power, the state's electric utility company. The goal was to commercialise a cost-effective technology for conversion of sunlight into electricity using the photovoltaic (PV) effect.

Professor Wenham is one of Australia's most successful inventors of solar cell technology and has been involved in the successful commercialisation of solar technologies worldwide.

Professor Wenham obtained a Bachelor of Science (Physics Major) 1976–78, a Bachelor of Engineering (Electrical) 1976–1980 and a Doctor of Philosophy (Electrical Engineering and Computer Science) 1981–86, all from UNSW.

Professor Wenham's many awards and distinctions include:

- Australia Prize for Energy Science and Technology 1999 (jointly with Martin Green);

- named one of Australia's Top 100 Engineers in 2011 and 2012 by Engineers Australia;
- IEEE International Electron Devices Society's J J Ebers Award 2011;
- NSW Science and Engineering Award for Climate Change and the Environment 2011;
- Australian Collaborative Innovation Award, jointly with Professor Green 2012; and
- inducted into the Australian Solar Hall of Fame 2012.

KEN MATTHEWS TO CHAIR ABCA

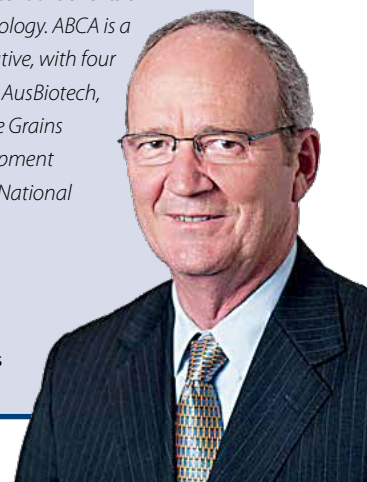
Mr Ken Matthews AO FTSE is the new Chairman of the Agricultural Biotechnology Council of Australia (ABCA).

A former Secretary of two Australian Government departments (Agriculture and Transport), Mr Matthews has had a lengthy and distinguished career at the top of Australian public administration.

Mr Matthews brings to the role of Chairman of ABCA a wealth of experience in industry, technology and agricultural policy as well as policy on matters that affect regional Australia. His time at the helm of the Department of Agriculture also saw the development of the regulatory framework for agricultural biotechnology.

Mr Matthews joins a strong team of biotechnology and industry leaders on the Board and supported by ABCA's Patrons, The Hon John Anderson AO, former Deputy Prime Minister and Leader of the National Party of Australia and a Director of the Crawford Fund, and Professor Adrienne Clarke AC FAA FTSE, Chancellor of La Trobe University.

ABCA is the national coordinating organisation for the Australian agricultural biotechnology sector and was established to pursue recognition of the current and potential benefits of agricultural biotechnology. ABCA is a whole-of-sector initiative, with four founding members – AusBiotech, CropLife Australia, the Grains Research and Development Corporation and the National Farmers' Federation.



Ken Matthews

ATSE IN FOCUS

Seven Fellows win 2014 Australia Day honours

Seven Fellows of the Academy were recognised in the Australia Day Honours list.

Professor Edward Byrne AC FTSE, Vice-Chancellor, Monash University, was recognised for eminent service to tertiary education, particularly through leadership and governance roles with Monash University, to biomedical teaching and research, as a scientist and academic mentor, and as a contributor to improved global health.

Dr John Grill AO FTSE, former head of WorleyParsons, was honoured for distinguished service to engineering, and to business, to the minerals, energy and power supply industries, and as a supporter of advanced education and training.

Dr Andrew Liveris AO FTSE, Chairman, President and CEO of Dow Chemical, was honoured for distinguished service to international business through senior roles with multinational organisations, as a supporter of Australia-US educational and cultural relations, and to the community.

Dr Susan Meek AO FTSE, CEO of the Australian Academy of Science, was honoured for distinguished service to science, to the development and implementation of policy for science and research, particularly gene technology regulation, and through leadership role with professional organisations.

Professor Peter Newman AO FTSE, Professor of Sustainability, Curtin University of

Technology, was honoured for distinguished service to science education as an academic and researcher, through contributions to urban design and sustainability, and to the community.

Mr Philip Laffer AM FTSE, former Chief Winemaker for the Orlando-Wyndham Group, was honoured for significant service to the Australian wine industry as a winemaker, and to trade, marketing and research and development programs.

Professor Graeme Young AM FTSE, from the Flinders Centre for Innovation in Cancer, was honoured for significant service to medicine through a range of research, clinical and academic roles, particularly in the area of gastrointestinal health.

Professor Byrne has been Vice-Chancellor and President, Monash University, since 2009 and was previously Vice-Provost Health and Executive Dean of Medical Science, University College, London (2007-09). From 2003-07 he was Dean, Medicine, Nursing and Health Sciences, at Monash.

He was appointed as an Officer of the Order of Australia in the Australian Day 2006 Honours List for his service to neurology as a clinician and academic and to advances in medical research, particularly in the area of mitochondrial muscle disease.

He will return to London in September to take up a new role as Principal and President of King's College.

He has served as a director of a number of companies, as Deputy Chair of the Group of Eight (Australian universities) and on the Boards of The Australia Japan Business Co-operation Committee and the Committee for Melbourne. He has been a Fellow since 2012.

Dr Grill has been non-executive Chairman, WorleyParsons, which he founded in 1971, since 2013. He was CEO from 1975 to 2012.

He has been Chairman, National Precincts Board, Department of Industry, since 2013 and chairs the John Grill Centre for Project Leadership, University of Sydney. He is a member of the NSW Government's Professional Services Taskforce.

He has been an Honorary Fellow, Engineers Australia, since 2011 and joined the Academy in 2007.

Dr Liveris has been President and Chairman, Dow Chemical Company, since 2006 and Director and Chief Executive Officer since 2004. He joined Dow in 1976.

He has been on the Board of Directors, IBM, since 2010 and is a past Director of Citigroup. He is Co-Chair, US President's Advanced Manufacturing Partnership and serves on many boards, including the US Business Roundtable, the US President's Export Council and the International Council of Chemical Associations.

He chairs the University of Queensland in America Foundation, is Senior Patron, American Australian Association, Member, Board of Trustees, California Institute of Technology (Caltech) and Tufts University and is a Member, Business Advisory Board, University of Technology Sydney.

NEIL WILLIAMS WINS EARTH SCIENCE MEDAL

The former Chief Executive Officer of Geoscience Australia, **Dr Neil Williams PSM FTSE**, has been awarded the Australian Academy of Science's Haddon Forester King Medal, in recognition of a long and distinguished geoscience career.

The Haddon Forester King Medal is awarded every two years to acknowledge original and sustained contributions to the Earth sciences in Australia, particularly relating to the discovery, evaluation and exploitation of mineral deposits including hydrocarbons.

"Dr Williams has made an outstanding contribution to the geosciences during a distinguished career that has encompassed

academia, industry and the public service," Geoscience Australia's Chief Executive Officer, **Dr Chris Pigram** said.

"His outstanding achievement has helped Australia reach a position of world leadership in the use of geoscience as an essential underpinning capability for natural resources management, particularly in the fields of minerals and petroleum exploration," **Dr Pigram** added.

The Academy said: "Dr Neil Williams's career across academia, the minerals exploration industry and government epitomises a lifelong



Neil Williams

ATSE IN FOCUS



Graeme Young

Dr Meek has been Chief Executive, Australian Academy of Science, since 2008 and was previously the inaugural Australian Gene Technology Regulator (2001–08).

A fellow since 2005, she was instrumental in developing the gene technology regulatory scheme in Australia and served on several gene technology bodies.

She established WA's science policy and public sector intellectual property management policy and was Executive Director, Science and Technology Division, WA's Department of Commerce and Trade (1997–2001). Previously she was Manager, Research and Development Branch (1994–97), Manager, Emerging Industries Branch, Department of State Development (1991–94) and Manager, Biotechnology Branch, Technology and Industry Development Authority (1988–91).

Professor Newman has been Professor of Sustainability, Curtin University, since 2008 and Director, Curtin University Sustainability Policy Institute, since 2008. He was Director, Institute for Sustainability and Technology Policy, Murdoch University, (1991–2007).



Andrew Liveris

He was Manager of Strategic Planning and Market Assessment, Australian Co-operative Research Centre (CRC) for Renewable Energy, 1997 to 2000, and has held or holds visiting professorships at National University of Singapore, University of Virginia, University of Pennsylvania and Royal Danish Academy of Fine Arts.

He was Lead Author, 5th Assessment Report on Transport, 2011–14, Intergovernmental Panel on Climate Change and has been Science Director, Program on Sustainable Urban Development, CRC in Spatial Information, since 2010 and a Member, Advisory Committee, Infrastructure Australia and Built Environment Industry Innovation Council, since 2008.

Mr Laffer has been Viticulture and Winemaking Consultant, Premium Wine Brands Pty Ltd (Orlando/Wyndham Group), since 2012. He was Global Viticulture and Winemaking Manager (2010–12), Group Chief Winemaker (2006–10) and Chief Winemaker (1993–2006).

He has served on many wine industry bodies: Member, Geographical Indications Committee, Wine Australia (formerly Australian Wine and Brandy Corporation), since 2009;



John Grill

Director, Grape and Wine Research and Development Corporation, since 2010; President, South Australian Wine Industry Association, 1995–97; Member, Winemakers' Federation of Australia Executive Committee, 1998–2010; Convenor, Viticulture 2000 (Cooperative Research Centre for Viticulture), 1996–2000; Member, Australian Wine Export Council, until 2001 and Member, National Wine Centre Board (1998–2001).

Professor Young has been Professor of Global Gastrointestinal Health, Faculty of Health Sciences, School of Medicine, Flinders University, since 2011 and was

Foundation Professor of Gastroenterology (1997–2011). He was Michell Professor of Medicine; and Head, Department of Medicine, University of Adelaide, 1995–97.

A Fellow since 2008, he was named SA Scientist of the Year in 2013 (See ATSE Focus 180) and Matthew Flinders Distinguished Professor, Flinders University, 2011.

He won the Distinguished Research Prize, Gastroenterological Society of Australia, 2009 and was South Australian of the Year in the Health Category in 2007.



Sue Meek

commitment to the role geoscience can play in our society, but particularly to the discovery, evaluation, and exploitation of mineral deposits including hydrocarbons. Dr Williams's leadership of the national geoscience agency from 1995 to 2010 represents an original and sustained contribution to earth sciences and has placed Australia in a global leadership position in the use and application of high quality science to manage natural resource issues."

When Dr Williams – now an honorary Professorial Fellow at the University of Wollongong – joined the public service in 1991 he brought with him a wealth of knowledge of the minerals industry and economic geology. He assumed leadership of Geoscience Australia's predecessor the Australian Geological Survey Organisation in 1995, eventually becoming the agency's longest serving Chief Executive.

Key achievements under Dr Williams's stewardship included:

- **acquisition of vast amounts of airborne geophysical (magnetics and radiometrics) and gravity data that meant, by the early 2000s, Australia had the world's first complete national coverage of airborne magnetic and gravity maps;**
- **Australia's submission to the United Nations Commission on the Limits of the Continental Shelf in 2008, which resulted in 2.56 million square kilometres being added to Australia's marine jurisdiction;**
- **leadership in establishing the National Geoscience Agreement with the states and the Northern Territory which has become a highly productive partnership supporting resource exploration; and**
- **stimulation of petroleum exploration investment in offshore Australia, with particular success demonstrating the petroleum prospectivity of the Browse Basin off Western Australia and the Bight Basin on Australia's southern margin.**

ATSE IN FOCUS

Stalker Tunnel and Scramjet legacy

Professor Ray Stalker AO FAA FTSE is regarded as a pioneer in the ongoing effort to develop the world's fastest jet engines – scramjets. He developed a series of high-performance wind tunnels or shock tubes, known as 'Stalker Tubes' that have allowed researchers to test new engine and spacecraft designs and won acclaim as the 'father' of hypersonic flight.

Born 6 August 1930, Ray Stalker was educated at the University of Sydney, worked as a Research Officer at the National Research Council in Canada from 1958–60, and became

a Senior Research Fellow at the National Physical Laboratory, England, from 1960–61.

From 1962–63 he was a Lecturer at the Australian National University before becoming Senior Lecturer (1963–67) and Reader (1968–76). He moved to Brisbane in 1977 to become Professor in Mechanical Engineering, University of Queensland, then Head of Department (1983–86), and Australia's first Professor of Space Engineering (1988–93).

He died Brisbane on 9 February, aged 83. He was a Fellow since 1989 and won the ATSE Clunies Ross Lifetime Achievement

Award in 2008.

His achievements were many: Chairman, Canberra Branch, Royal Aeronautical Society 1966–67; Royal Aeronautical Society Australian Division Lecture Prize 1979; AGM Michell Medal, Institution of Engineers Australia 1991; American Institute of Aeronautics and Astronautics Ground Testing Award 1993; International Collaboration Award of the International Society of Air Breathing Engines 1995.

He spent his early years in Dimboola, a dot on the Melbourne–Adelaide road, before attending Geelong Grammar and winning a scholarship to the University of Sydney, which was the only university then to offer a degree in Aeronautical Engineering in

Australia. His goal was a career in aeronautical engineering and he completed degrees in science and aeronautics, won the University Medal in Aeronautical Engineering and the de Havilland prize in Aeronautics.

He stayed on at the University of Sydney to research aerodynamic problems associated with the operation of aircraft control surfaces, such as elevators and flaps, at supersonic speeds.

When he went to Canada the world's first space satellites had been launched and it became apparent that economical space flight would only be possible if space launchers could be returned to Earth after use, and that this would involve flight at very high speeds.

This was when the science of 'hypervelocity aerodynamics' was born. A major problem in hypervelocity aerodynamics was to find ways of building a wind tunnel for research at these very high speeds, and this soon became a major objective of his research in Ottawa.

When he returned to Australia he began to develop an idea for a hypervelocity wind tunnel which he had first tried out in Canada. As it turned out, this was the most successful of the many ideas for hypervelocity wind tunnels which were being tried around the world at that time and with a series of grants from the Australian Research Grants Scheme, he was able to construct a wind tunnel and build up a research team to use it.

He pursued his work in Sweden, the US and Switzerland before moving to the University of Queensland to become Professor of Mechanical Engineering. He built a major research group at UQ, which gained national international prominence for its scramjet work, and he continued to be involved after his retirement in 1994.

His work led UQ to be at the leading edge of hypersonic flight internationally including the challenge of generating positive thrust by a hypersonic engine in flight.

On 30 July 2002, one of its tiny Hyshot test vehicles piggybacked a rocket ride at Woomera to demonstrate hypersonic combustion for the first time, for all of around five seconds at more than mach 7.6. The ABC reported that "operating on a shoestring budget, that breakthrough upstaged a massively funded US program attempting to achieve a similar result".



Ray Stalker with a model of a re-entry capsule for interplanetary missions.

ATSE IN FOCUS

Extraordinary engineering and science career

Professor John Simmonds AM FTSE delivered a moving eulogy at Ray Stalker's funeral. This is an edited version.

It's my privilege to acknowledge the extraordinary engineering and science career of Ray Stalker, the boy from Dimboola, from Geelong Grammar School, the University of Sydney, the National Research Council, Canada, the National Physical Laboratory, England, the Australian National University and the University of Queensland.



John Simmonds

It was an inspired move by Keith Bullock (Professor Keith Bullock FTSE, former UQ Dean of Engineering) 37 years ago to woo Ray here from ANU, where his research was already flourishing. Ray's appointment took the Department of Mechanical Engineering into the big league of international, cutting-edge research. At ANU Ray had built a team around T3, the third in the long series of his unique facilities for studying hypersonics – aerodynamics at speeds above Mach 7. The 'T' in T3 stands for 'tunnel' or 'free-piston shock tunnel', a class of very high speed 'wind tunnel' in the form of a long tube. His first facility, T1, was tiny, T2 was bigger and T3 filled an entire laboratory at ANU.

To replace T3, all we could offer Ray at UQ was an old length of brass tubing, which he modified into a small free-piston shock tunnel of sorts. Ray felt a responsibility to start research here on issues relevant to Queensland; so instead of putting models of space vehicles into this modest facility, he loaded it with sugar cane bagasse for combustion studies relevant to the boilers in Queensland's sugar mills. For a while it seemed that Ray had turned his attention from the awesome challenge of space transport to the cane fields of Queensland.

Ray built T4 and his UQ group on a shoestring budget by interacting with the best people around the world, by putting a very large and eventually irresistible proposal to the ARC on his vision of scramjet-powered

flight, and by gaining major financial support from NASA. His team grew to one of the world's largest space engineering groups based at a university. Remarkably, this group is moving strongly into a third generation.

The measure of a researcher's achievement is impact. Universities have become focused on publications and grants as research measures. But to Ray, these were just necessary steps for him to interact richly with the world community of like minds in the quest for hypersonic flight; to fly aerospace planes with scramjet propulsion across the world in a fraction of the time currently taken, and to put payloads into space more cheaply.

Some years ago Ray took a giant step towards his dream. He used T4 to test the first ever scramjet-propelled vehicle that produced more thrust than drag. He 'flew' a model of a space plane against the oncoming hypersonic flow. The flight was short in time and distance; less than a thousandth of a second and less than a millimetre in the laboratory frame – but the Wright Brothers' first flight was similarly short – with, I am told, comparable impact. This was the beginning of an ongoing and friendly race with NASA.

Ray's impact on people has been immense. His wisdom – and his camaraderie – were sought by world experts in the US and Canada, in the UK, France, Germany and in Japan and India. At UQ, Ray literally made the careers of many of us.

Ray's impact on a large number of current academic, research and honorary staff at UQ is impressive. Then there are the scores of

research students who are applying initiative and creativity inspired by Ray in a wide range of careers. T4 has now been fired 11,493 times, like stressfully launching 11,493 ICBMs.

As Australia's first Professor of Space Engineering he introduced the nation's first degree in Space Engineering, carefully set up so that graduates were also qualified as mechanical engineers. Ray drew people, young and not so young, to him through the excitement of his vision. That is impact.

Ray spent a lot of time at NASA. He walked its corridors of influence, and the corridors of the other US aerospace agencies. It was these contacts that led to a number of us spending rich time at NASA and passing on exciting experiences to our undergraduate students who still hang on every 'NASA' story and value authenticity in their lecturers. They got authenticity in spades from Ray.

Ray was an outstanding engineer, always several moves ahead of the pack. He effectively kept shock tunnels alive in the hypersonic doldrums of the 1970s and he enabled their subsequent rebirth through the many facilities now across the world.

The American Institute of Aeronautics and Astronautics recognised this and Ray with its prestigious Ground Testing Award, and the International Society of Air Breathing Engines followed with its International Collaboration Award.

Ray's honours befit the outstanding man. In terms of national and international impact and acclaim, Ray was, at the very least, the equal of only a handful of truly outstanding researchers in the 100-year history of engineering at UQ – yet he was humble and cared for all in his group. He was fun to be with.



NEW FELLOW GETS CERTIFICATE

NSW Division Chair Dr David Cook FTSE (right) presents a Fellowship certificate to Mr Steven Sargent FTSE at his Sydney office.

ATSE IN FOCUS



Seeds to Svalbard

More than 20,000 samples from 100 countries arrived at the Svalbard Global Seed Vault in March in time for the vault's sixth birthday.

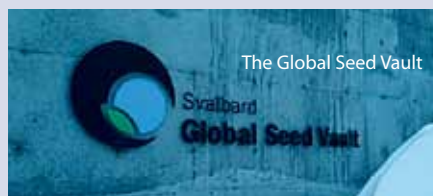
The samples include a shipment of Australian seed, shepherded by Australian Grains Genebank leader Sally Norton, Australian Pastures Genebank curator Steve Hughes, Victorian farmer Tony Gregson AM FTSE and former Deputy Prime Minister the Hon Tim Fischer AC FTSE, who each made the long haul to the northern part of Norway.

The addition of this material to the 'Doomsday Seed Vault' – which protects agricultural systems worldwide from disasters natural or manmade – means there are now more than 820,000 samples, or accessions, of food crops and their wild relatives stored deep in an Arctic mountain on Norway's remote Svalbard archipelago.

Their arrival coincided with the 10th anniversary of the Global Crop Diversity Trust, which maintains the seed vault in partnership with the Norwegian Government and the Nordic Genetic Resources Center.

Dr Norton said that for the first time Australian indigenous wild seed samples of relatives of sorghum, rice and beans were included, along with canola, oats, lupins and both temperate and tropical pastures.

"The Australian Grains Genebank and the work of the Global Crop Diversity Trust is vital for food security not only in Australia but also in the world," said The Hon Tim Fischer, Board Member of the Global Crop Diversity Trust and a former chair of the Crawford Fund,



Leader of the National Party and Deputy Prime Minister.

Dr Gregson, a member of the Fund's board, was making his second trip to the Arctic Circle and has been a long-term supporter of conservation of crop genetic diversity.

Drawing on a global coalition of governments and private donors, the Global Crop Diversity Trust is building an Endowment Fund, which will safeguard the diversity of the major food crops of the world in genebanks when complete. Australia was an early supporter, with funding from the Australian Government and the Grains Research and Development Corporation.

PETER LILLY TO HEAD UWA ENGINEERING ZONE

Dr Peter Lilly FTSE, Senior Manager Research and Development at BHP Billiton and former chair of the WA Division, has been appointed Director of the University of Western Australia's Engineering Zone project, which aims to revolutionise engineering education and research.

Dr Lilly takes up his new role in April, coordinating all activities related to the project including architects, community relations, political engagement and fundraising

Dr Lilly's previous roles include Director of

the WA School of Mines, Director of CSIRO's Minerals Down Under Flagship, Executive Director of Curtin's Institute of Minerals and Energy and National President of Australasian Institute of Mining and Metallurgy.

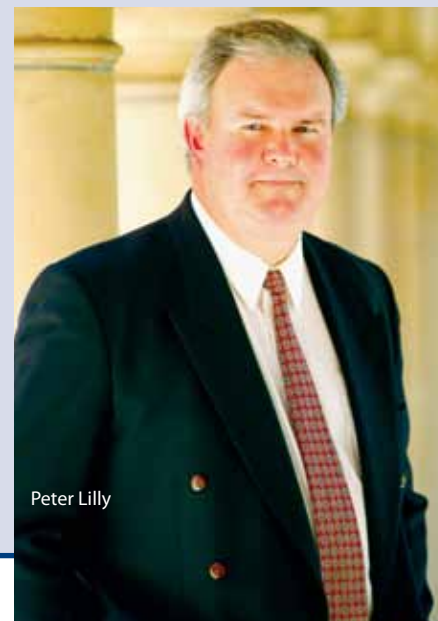
UWA says the Engineering Zone (E-Zone) will provide the physical, technological and resource infrastructure to enable an innovative, multidisciplinary approach to real-world problem solving. Engineers will work with the best minds from other disciplines, including business, science and the humanities, to tackle issues of sustainability, living standards and resource management.

The Engineering Zone is the key teaching and learning facility of UWA's \$400 million New Century Campaign fundraising initiative and is planned to deliver modern learning and research facilities. It will represent the largest investment in engineering education in WA's history.

Based on the overarching principle of collaborative creativity, the Engineering Zone will create spaces for innovative multidisciplinary education and research to confront issues of sustainability, living standards and resource management. It will be located at UWA's Crawley and Shenton Park campuses and at Technology Park in Bentley.

With a focus on Engineering for Remote Operations, the Engineering Zone is planned to enrich WA's reputation as a global centre for excellence in energy and minerals resources and ensure UWA engineers, mathematicians and computer scientists continue to be the most sought-after in the world.

BHP Billiton has invested \$12 million in the Engineering Zone, which is due for construction completion in 2020.



Peter Lilly

ATSE IN FOCUS

Don George was an atomic energy visionary



Don George

Emeritus Professor Don George AO FTSE was an engineer who was hard to stop.

He held the positions of Chair of Mechanical Engineering at the University of Sydney, Chair of the university's Professorial Board, Vice-Chancellor of Newcastle University, Chairman of the Australian Vice-Chancellors' Committee, Chairman of the Australian Atomic Energy Commission (AAEC) and Australian Governor on the Board of the International Atomic Energy Agency.

A Fellow since 1997, he died in NSW on 1 January, aged 87.

Born in Adelaide in 1926, Professor George was educated at Canberra High School and then the University of Sydney, where he graduated as an engineer before spending two years at Newcastle Technical College and then relocating to Broken Hill.

In 1954 Professor George followed his dream of a career in nuclear energy and moved to the UK where he worked for the UK Atomic Energy Authority at Harwell for 12 months before returning to Australia to join the Australian Atomic Energy Commission and became part of the team that built and commissioned Australia's first nuclear reactor.

But controversy surrounded this energy

source even 60 years ago and Professor George felt nuclear power stations in Australia were not going to happen in the foreseeable future, so he resigned in 1959 and became a senior lecturer in Electrical Engineering at Sydney University.

In 1974, Professor George was elected chairman of the university's Professorial Board and then became Vice-Chancellor of Newcastle University. In 1976 he became chairman of the AAEC.

His contribution to Newcastle University was acclaimed, both in the formation of its medical school and in his passion for the Faculty of Engineering and Built Environment, which is recognised as a leading facility.

In 1978, he joined the board of the Asian Institute of Technology, based in Thailand, and began a long association with the institute, which entailed making five trips a year to Bangkok.

In 1981 Professor George led a delegation of Australian universities and colleges of advanced education to China to help the Chinese Government re-establish its tertiary education system after the Cultural Revolution. As chairman of the AAEC, he led Australian delegations to annual meetings of the International Atomic Energy Agency in Vienna.

He remained convinced that nuclear power had a place in the world's future.

After his retirement in 1986 he enjoyed working on his five-acre block on the NSW central coast, growing native plants, listening to classical music and giving a lot of time to his family and six growing grandchildren.

He remained very active with the Asian Institute of Technology, the Central Coast Health Board and later on the Residents Committee at Henry Kendall Gardens retirement village.

HARRY POULOS HONOURED BY US ENGINEERS

Professor Harry Poulos AM FAA FTSE, Senior Principal, Coffey Geotechnics in Sydney, has been elected a Foreign Associate of the US National Academy of Engineering (NAE) for his "contributions to understanding foundation structures and ground support interactions".

He was one of 11 new Foreign Associates

from Germany, Brazil, the UK, Israel, Canada and China elected by NAE in 2014. He has been a Fellow since 1996.

Professor Poulos graduated from the University of Sydney and worked as an engineer at MacDonald Wagner and Priddle before joining the university's staff where he has made enormous academic research contributions to the behaviour of piles.

He has been an honorary member of the American Society of Civil Engineers since 2010 and was awarded the ASCE's J. James R. Croes Medal (1972), the ASCE State of the Art of Civil Engineering Award (1995) and the Thomas A. Middlebrooks Award (2007). In Australia he has won the Warren Medal and the Australian Geomechanics Society's John Jaeger Memorial Award and was named Australian Civil Engineer of the Year in 2003.

He served in the Australian Standards Committee for pile foundations (2010), was President (1982–84) and Councillor (1980–95) of the Australian Geomechanics Society (AGS), served on the Council of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) and was its vice president for the Asia–Australia region (1989–94).



Harry Poulos

Professor Poulos has been involved worldwide in various construction projects, such as pile foundations for skyscrapers in Dubai (Burj Al Arab, Emirates Towers, the Burj Dubai, the tallest skyscraper in the world, where he performed the geotechnical testing), the Docklands Project in Melbourne, and the 700-kilometre Egnatia Odos motorway in Greece, where earthquakes play a role. Other projects included consultations on various offshore structures, such as oil rigs.

ATSE IN FOCUS

Fred Smith: physicist and research leader

Emeritus Professor Thomas Frederick Smith AM FTSE influenced many organisations in a long career that spanned research and administration, including ATSE, where he served as Honorary Secretary in 2005-06.

A former Deputy Vice-Chancellor (Research) at La Trobe University, he was elected a Fellow in 2000 and awarded an AM, for services to science and technology development and science education, in the 2005 Queens Birthday Honours. He died in Melbourne on 1 March, aged 74 years.

Known to all as Fred, he was born in London and grew up in Sunderland in the north-east of England. He completed an honours degree in physics at Sheffield University in 1960 and graduated with a PhD in superconducting materials in 1963.

For the next 10 years he held various research positions at the University of California, San Diego, and at the Atomic Energy Research Establishment in England.

In 1973 he was offered a one-year position at CSIRO in Sydney and decided to settle permanently. In 1974 Fred obtained a senior lecturing position in the Physics department at Monash University and in 1981 he was appointed Chairman of the department and served in this position for 10 years.

In 1991, he moved to La Trobe University as Deputy Vice-Chancellor in charge of Research and remained there until he retired in 2004.

He was the inaugural (1985–87) President of FASTS – the organisation that became Science and Technology Australia (STA) in 2011 – and was succeeded by Emeritus Professor Frank Larkins AM FAA FTSE, later Deputy Vice-Chancellor (International) of the University of Melbourne, who attended his funeral.

He also served as Honorary Secretary of the Royal Society of Victoria and was a Fellow of the Australian Institute of Physics and Institute of Physics (London).

His role at La Trobe was extended to include Chief Executive Officer of the La Trobe University Research and Development Park in October 1995. He was also Acting Dean, Faculty of Humanities and Social Sciences during 1999.



Fred Smith

Professor Smith was actively associated with the Centre for Population and Urban Research for more than a decade and served as a member of the editorial board for the centre's journal, *People and Place*. He was a regular contributor to *People and Place* and contributed to centre reports in the areas of the migration of professionals (particularly the 'brain drain' issue), equality and access in education and social issues, and most recently a study of the Victorian economy.

A number of his friends and colleagues delivered eulogies at his funeral, recalling his administrative capabilities, his love of running, good food and wine, his eminence in physics and latterly his interests in genealogy and social sciences.

INAE HONOURS SURESH BHARGAVA

Professor Suresh Bhargava FTSE, Director of the RMIT University Centre for Advanced Materials and Industrial Chemistry and Deputy Pro-Vice-Chancellor (International Research) in the College of Science, Engineering and Health, has been elected a Foreign Fellow of the Indian National Academy of Engineering (INAE).

Professor Bhargava is the founding director of the Indian Institute of Chemical Technology–RMIT joint research centre in Hyderabad, India, which is jointly funded by the Indian Government and RMIT.

Professor Bhargava specialises in industrial chemistry, catalysis, gold nanoparticles, nanoscience and technology and their use in bioapplications and mercury sensing from industrial waste. He has published more than 252 refereed journal papers, 100 conference papers and 72 confidential industrial reports, with more than 4200 citations. Professor Bhargava also has six patents on different technologies developed in his group, five of them licensed to industry or successfully tested at pilot-plant level.

Professor Bhargava has also won several national and international awards including the Exxon Mobil Award, Ralph McIntosh Medal, WorleyParsons Award, R K Murphy Medal and A G R Matthey Gold Medal.

He has been a consultant and adviser to government bodies and industries around the world including BHP Billiton, Alcoa, Rio Tinto and Mobil Exxon.

The Indian National Academy of Engineering, established in 1987, covers the entire engineering profession, with a specific focus on the promotion and advancement of engineering and technology, along with related sciences and disciplines, and their applications to problems of national importance.

Professor Bhargava has also been elected an honorary foreign fellow of Andhra Pradesh Akademi of Sciences, India, and won the RACI's Applied Research Award, 2013.



Suresh Bhargava

ATSE IN FOCUS



Max Lu

Max Lu named UQ Provost

Nanotechnology researcher and globally respected academic leader Professor Max Lu FAA FTSE, a former Academy Director, has been selected as the University of Queensland's first Provost.

Professor Lu has been UQ's Deputy Vice-Chancellor (Research) since 2009, and served as Pro-Vice-Chancellor (Research Linkages) from 2008-09. Professor Lu was acting UQ Senior Deputy Vice-Chancellor from December 2011 to October 2012. He begins as Provost on 17 March.

UQ President and Vice-Chancellor Professor Peter Høj FTSE said that Professor Lu was selected through an internationally competitive search that attracted candidates "from upper levels of university senior management around the world".

"Max's appointment will deliver a strategic approach that is informed by a deep knowledge of UQ, built on a journey of almost three decades at this wonderful institution," Professor Høj said.

"He is known for his highly collaborative style, his integrity and his transparency in decision-making – key values of UQ."

Professor Høj said Professor Lu's leadership of research strategy and targeted investment in key initiatives had contributed to UQ's improved standing in all major global rankings.

"Max has led the development of major global partnerships with industry, government and other universities. He brings a strong commitment to research and teaching, as well as a strategic approach to international and industry engagement."

Professor Lu came to UQ from China in the late 1980s to study for his PhD, and then

spent three years as a lecturer at Singapore's Nanyang Technological University.

In 1994, he returned to UQ as senior lecturer, and progressed to Chair in Nanotechnology and Director of the UQ Nanomaterials Centre in the School of Chemical Engineering.

"He played an active role in the early development of problem-based learning and online teaching resources in chemical and environmental engineering," Professor Høj said.

"Max's commitment to teaching and mentoring is also reflected in his strong track record in supervising students, including 44 PhD students, 56 honours students and more than 20 postdoctoral fellows.

His contributions have been widely acknowledged nationally and internationally through prestigious awards such as the China International Science and Technology Award, Orica Award, RK Murphy Medal, Le Fevre Prize, ExxonMobil Award, Chemeca Medal and Top 100 Most Influential Engineers in Australia (2004, 2010, 2012, 2013).

In 2013, the Queensland Premier named him as a Queensland Great (see Focus 179).

Professor Høj said the newly created role of Provost replaced the position of Senior Deputy Vice-Chancellor.

"The Provost will be standing deputy to the Vice-Chancellor and will be responsible for strategic leadership on academic matters."

Senior Deputy Vice-Chancellor Professor Deborah Terry left UQ at the end of January to take up the position of Vice-Chancellor at Curtin University in Perth.

Professor Høj said Professor Terry had made "an outstanding contribution, spanning more than 20 years".

CATHY FOLEY TAKES LLOYD REES LECTURE

Dr Catherine Foley PSM FTSE, Chief of CSIRO Materials Science and Engineering, has been awarded the 2014 Lloyd Rees Lecture in chemical physics by the Academy of Science.

The award recognises the contributions of the late Dr A L G Rees to science, industry and education.

Dr Foley was appointed Chief of CSIRO Materials Science and Engineering (CMSE) Division in April 2011.

"CMSE is unique in the range of scientific disciplines it encompasses. We will continue to build our world class science and engineering within and across these disciplines, and capitalise on the opportunities presented by this," she says.

Dr Foley has a world-class reputation in her field, and has served as the President of the Federation of Australian Scientific and Technological Societies (FASTS) and is a member of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC).

Dr Foley's career at CSIRO has been broad, influential and widely cited. Her research expertise covers solid state physics, such as semiconductors, magnetics, superconductivity and nanotechnology.

Highlights of her career include leading the High Temperature Superconductivity (HTS) group in 1995, instigating CSIRO's presence in quantum engineering in 2001, and developing the fabrication technology, which is the basis of CSIRO's successful HTS devices used in award-winning applications such as LANDTEM™ mineral exploration systems.



Cathy Foley

ATSE IN FOCUS

Min Gu wins Wark Medal



Min Gu

Professor Min Gu FAA FTSE, from the Centre for Micro-Photonics at Swinburne University of Technology, has won the 2013 Ian Wark Medal and Lecture, for contribution to the prosperity of Australia

through scientific research, awarded by the Academy of Science.

The Academy's citation noted that modern technology supports the growth and prosperity of global economies but presents significant challenges including the information explosion, energy security and provision of cost-effective health care.

"Since it relies on light rather than electronic signals, photonics can help meet many of these challenges," the Academy said.

"As a pioneer in photonics at the nanoscale, Professor Min Gu has developed green nanophotonic innovations which have significant benefits including low-energy-consumption big data centres, early cancer detection and environmentally friendly solar cells."

Professor Gu is a pioneer and international leading authority on three-dimensional optical imaging science. He has more than 800 publications on photonic crystals and devices, nanophotonics/biophotonics, micro/nanofabrication, confocal and multiphoton microscopy, laser tweezers, optoelectronic imaging through tissue-like turbid media, laser trapping and near-field microscopy, multidimensional optical data storage and photovoltaics.

He is a member of the editorial boards of 14 top international journals. He has been a member of the advisory/steering/organising committees of more than 120 international conferences. He was President (2002–04) and Vice-President (2004–12) of the International Society of Optics within Life Sciences and Vice-President of the International Commission for Optics (2005–11).

He received Swinburne's University Research Excellence Award in 2002 and the Vice-Chancellor's Research Award in 2009. He was awarded the Chang Jiang Chair Professorship (Ministry for Education,

China, 2007), the World Class University Professorship (Ministry for Education, Korea, 2009), the Thousand Talents Award (Ministry for Education, China, 2009), the Einstein Professorship (Chinese Academy of Science, 2010) and Laureate Fellowship (Australian Research Council, 2010).

Professor Gu has conducted many pioneering projects in the area of bio/nanophotonics and his ground breaking research work has been featured more than 2000 times in national and international media reports.

AIBING YU HEADS MONASH CHINA INSTITUTE

Professor Aibing Yu FAA FTSE has been appointed Pro-Vice-Chancellor and President of the new Monash University–Southeast University Joint Research Institute in Suzhou, China.

Monash is the only Australian university to be granted a licence to operate in China, one of the world's largest and fastest-growing economies. The establishment of the Monash University–Southeast University Joint Research Institute will complement the Joint Graduate School (Suzhou) which officially opened in October 2013.

Professor Yu joins Monash from the University of NSW, where he is Scientia Professor of the School of Materials Science and Engineering. Commencing in April, he will report to Academic Vice-President (China and India) Professor Tam Sridhar FAA FTSE. Professor Yu has

also been appointed a Vice-Chancellor's Professorial Fellow of Monash University.

"We are delighted to welcome Professor Aibing Yu to Monash. He will provide leadership and on the ground support, facilitating the university's partnership with Southeast University," Professor Sridhar said.

"This initiative will produce postgraduates and researchers with ideas to change people's lives in the region and the world for the better. Professor Yu's extensive research experience will ensure we achieve this vision."

The Monash University–Southeast University Joint Graduate School and Joint Research Institute are based at the Suzhou Industrial Park (SIP) – one of the largest innovation precincts in China. A hub of 21st century brainpower, it hosts more than 100 Fortune 500 companies and 15 international universities and research institutes.

Professor Yu, a specialist in process metallurgy, obtained a BEng in 1982, a MEng in 1985 from Northeastern University, a PhD in 1990 from the University of Wollongong (UoW) and a DSc in 2007 from the UNSW. He is a recipient of a number of prestigious awards and fellowships including an ARC Federation Fellowship, the Josef Kapitan Award from the Iron and Steel Society (ISS), the Ian Wark Medal from the Australian Academy of Science, Exxon Mobil Award from Australian and New Zealand Federation of Chemical Engineers and NSW Scientist of Year 2010.



Aibing Yu

The Joint Graduate School, Suzhou.



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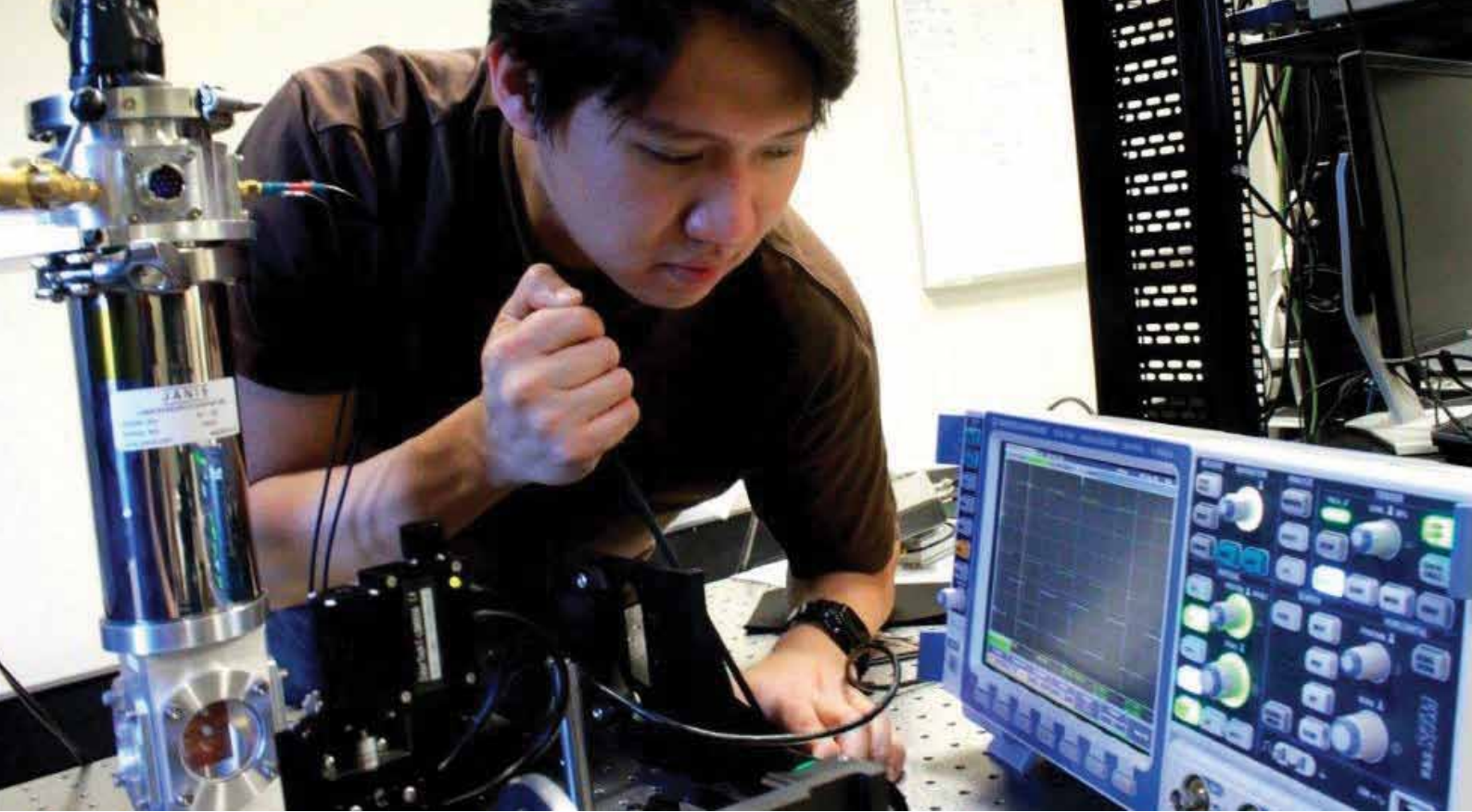
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NEW TECHNOLOGY TO IMPROVE SKIN CANCER DIAGNOSIS

One in two Queenslanders will develop skin cancers during their lifetime, however current detection and diagnosis methods are not always accurate.

Researchers at UQ's School of Information Technology and Electrical Engineering are building pioneering laser technology with the potential to improve the early detection of skin cancer.

The research group is led by Professor Aleksandar Rakic and Professor Stephen Wilson in collaboration with the Institute for Microwaves and Photonics at the University of Leeds. They are working in a part of the electromagnetic spectrum that until recently was almost impossible to utilise – the terahertz region.

The key advantage of using terahertz waves in medical imaging is that it is harmless to humans, unlike conventional medical imaging techniques such as x-rays and MRI that pose some small health risk.

The UQ team has built a world-first prototype laser imaging system based on a terahertz quantum-cascade laser. The engineers have been working closely with clinical collaborators and are currently testing and developing the system.

The UQ School of Information Technology and Electrical Engineering has a strong, internationally recognised research base, and its research higher degree students benefit from expert staff supervision, high quality infrastructure and a strong research culture. More information is available at itee.uq.edu.au

The Federal Government's 2012 Excellence in Research for Australia exercise confirmed The University of Queensland as one of the nation's top two universities, measured by the quality of its comprehensive range of specialised research fields. ERA reported that research at UQ is well above world standard in more specialised fields than at any other Australian university; this reflects UQ's leading global role in many areas of discovery. UQ's outstanding critical mass offers researchers significant interdisciplinary capability.

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Photo: Postdoctoral Researcher Dr Yah Leng Lim adjusts terahertz laser optics in preparation for imaging of skin specimens.

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