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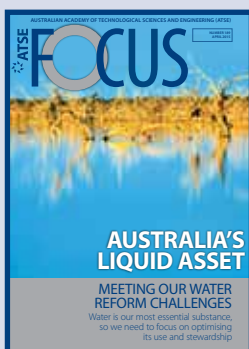
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Water is a matter of life and death.

PHOTO: ISTOCKPHOTO.COM



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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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By Ken Matthews
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Water reform needs to be back on the national agenda

Our national water research effort is fragmented, non-strategic and lacks leadership. Budgets and resources are allocated without clear logic and process.

Stimulated by the Millennium Drought, Australia made great progress over the early years of this century in reforming and improving the way we manage our precious national water resources.

But, sadly, that reform progress has now ground to a halt. Because the seasons in most areas of Australia have been much better, the attention of governments has shifted to other policy problems.

But in Australia, the next drought is never far away and much remains to be done to manage our water resources better. Late last year, ATSE published an important Position Statement calling on all the governments of Australia to work together to develop a new decadal strategy for improving national water management – to tackle the next generation of water reforms.

Specifically, what new reforms should we be tackling?

First, and most importantly, the Commonwealth and State governments need to work together to rebuild national collaborative processes, institutions and incentives to restore momentum to the water reform process.

Changes to government policies, programs and legislation are central to the necessary changes to water management in Australia but COAG (the Council of Australian Governments) no longer

pays serious attention to water reform issues. Key institutions driving reform have been abolished or had their budgets cut. Incentives for state governments to resume reform progress no longer exist.

New reform processes therefore need to be built. One possibility would be for the Commonwealth Government to define specific state-by-state water reforms it would like to see undertaken by specific state governments and provide an incentive payment, tailored to the degree of difficulty of the particular reform, to encourage that state to tackle the task.

But, however it is done, water reform needs to be put back on the national agenda.

The menu of other possible reforms is a rich one. For example, there is a clear and pressing need for the northern states of Australia to develop national principles to guide new water developments, and future water management, in northern Australia.

Indeed, all states of Australia – whether northern or southern – would benefit from an agreed set of national principles and practical guidelines for decision-making on the development of new irrigation infrastructure, including dams.

There is a need also to build community confidence that the growing volumes

of water reserved for environmental purposes are being well used. Again, developing and adopting national principles and guidelines for the best use of environmental water would be a welcome reform in all states of Australia.

Greater transparency and better forms of public participation in decisions about the use of environmental water are needed. Reserving water for the environment is the right thing to do. It is vital to demonstrate its value and benefits to enthusiasts and sceptics alike.

There is a manifest public policy need to reform and improve the way Australian governments go about decisions on mining and coal seam gas developments and their interaction with groundwater and surface water resources. There is strong community dissatisfaction with the current processes.

We need better ways of taking decisions about cumulative, long-term potential impacts of mining and energy developments. We need processes that are based on evidence, logic and respectful community participation, if decisions are to be accepted by those affected.

Although we have made great

progress in Australia in water trading, there is still much more we can do. Water trading should be as smooth, speedy and low cost as share trading. There is a major reform challenge to develop a truly national water trading exchange to enable truly free trade, subject only to externality impact assessments.

Water regulation is also ripe for further reform. Water managers need to deal with economic regulators, health regulators and environmental regulators – each of these areas of regulation have many opportunities for improvement.

Regulation is not cost-free and clever regulatory re-design can often achieve policy objectives at lower cost and with less distortion. Current arrangements are slowing innovation, discouraging smaller start-up enterprises, and loading costs into water prices.

A particular area of regulation warranting review is the regulations slowing the (inevitable) introduction in Australia of recycled water for potable purposes.

In Australia urban water management arrangements have not been subject to the same reform pressures as other areas of water management and other public utilities elsewhere in the Australian economy. We need policy and legal reforms to facilitate the coming transition from large centralised urban water supply systems to

wholly or partly decentralised systems.

Although it is a provocative idea to some, there is no intrinsic reason why water supply to urban communities should be largely run by the public sector, rather than the private sector.

Our arrangements for managing the national water science effort have plenty of scope for improvement, also. Currently we have no strategic national R&D priorities. Our national water research effort is fragmented, non-strategic and lacks leadership. Budgets and resources are allocated without clear logic and process.

As a natural resource, water management should be driven by good science. Current water science management arrangements are letting us down.

Finally, many Australians ask why the nation has been unable to capitalise in export markets on its past water-reform successes.

Australia has a great story to tell about its water management expertise and its reform story is admired internationally. But small and medium-sized Australian firms have struggled to succeed in global markets, while other countries, some of whom have a much less impressive water-reform story to tell, have established themselves as the global 'go to' suppliers of water management services.

We need to reform processes and institutions in Australia to facilitate

the success overseas of Australian water management companies.

These reform opportunities are examples. But the examples make clear that there is much more to do on the water-reform front. As the driest inhabited continent on the globe Australia would be expected to continue to provide international leadership in the admittedly difficult process of water reform.

For its part, ATSE urges the governments of Australia to resume the water-reform journey. We now need other advocates for change to stand up and encourage governments to re-engage.

We need at least another decade of progress before we can be confident that our water resources are being managed as well as they could be. There is much to be done but the economic, environmental and social returns are potentially enormous.

MR KEN MATTHEWS AO FTSE is Chair of the ATSE Water Forum. He retired as Chair and Chief Executive Officer of the National Water Commission (NWC) in October 2010 and was previously the Secretary of the Federal Department of Transport and Regional Services, and the Secretary of the Department of Agriculture, Fisheries and Forestry. Mr Matthews' academic background is in economics, majoring in government. He is a Fellow of the Australian Institute of Management, the Institute of Public Administration – Australia, and ATSE.

Khan to advise on global water quality

Dr Stuart Khan, a University of NSW environmental engineer exploring the impacts of extreme weather events on water quality, has been appointed to a top World Health Organisation body drafting future water strategies.

He beat a competitive field of applicants from 56 countries to be appointed to the WHO Water Quality and Health Technical Advisory Group (WQTAG), which will draft the latest edition of the global drinking water guidelines, due out in 2020, and examine new

directions for water quality and use including potable re-use of wastewater.

Dr Khan is a member of Australia's equivalent national body, the Water Quality Advisory Committee to the National Health

and Medical Research Council, and was the principal author of the Academy's 2013 report *Drinking Water Through Recycling*.

Dr Khan said the current hepatitis A scare linked to frozen berries from China underscored the importance of water quality and regulation – particularly, for example, around the use of treated effluent for agricultural irrigation.

Dr Khan's current research is looking at updating Australia's drinking water guidelines with a new chapter on extraordinary measures, such as extra chlorination, that could be implemented by utilities in the event of a natural disaster.

Chlorination is usually tightly controlled due to the background carcinogenic risk of disinfection byproducts but Dr Khan said in circumstances such as a flood, where the turbidity of water was elevated to up to 4000 times safe levels, extra chlorine was vital for health.

Dr Khan said his appointment to the WHO group meant the research could be taken to a global level, with the potential for extreme weather guidance to be included in the updated world drinking water guidelines.



Stuart Khan at the launch of the Academy report.



By Karlene Maywald
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The Murray River – notable progress, enormous cost.

Water in regional Australia: who's holding the baby?

Communities are now suffering from reform fatigue and the willingness to commit to new reform investment has waned.

Australia has much to be proud of about water reform but we risk losing the hard-won gains if we allow complacency to set in.

During the past two decades both State and Federal governments invested heavily in water security and the water-reform agenda. Communities are now suffering from reform fatigue and the willingness to commit to new reform investment has waned.

In October 2014, the National Water Commission (NWC) released its final assessment – *Australia's water blueprint: national reform assessment 2014*. This report highlights the substantial progress and investment Australia has made in recent decades, but warns of the significant risks to water security if backsliding from reform principles were to become commonplace.

There are some very worrying trends emerging. The Council of Australian Governments (COAG) no longer has

water on its agenda and the NWC has been wound down and will be abolished pending passage of legislation through the Australian Parliament.

The much hailed National Water Initiative (NWI) remains unfinished business, yet this critical COAG agreement no longer has COAG oversight.

So who is left holding the baby?

In its final report the NWC emphasised the importance of strong leadership for the full realisation of benefits of water reform and to embed proven NWI principles into the decision-making of all Australian governments.

The absence of COAG leadership and the fact that water no longer holds centre stage will require state and territory governments to 'step up to the plate' in the national interest. The big question is: are they up to it?

Our track record here has not been so good. Take, for example, the Murray–Darling Basin.

The progress made in the MDB over the past decade is particularly notable but it has come at enormous cost and was plagued by years of uncertainty, raging debate, political posturing and increasing environmental degradation. Finally the commitment of the Australian Government to more than \$13 billion eventually resulted in the historic signing of the intergovernmental agreements that have given life to the Murray–Darling Basin Plan (*The Basin Plan*).

The plan provides a pathway to rebalance the available water between consumptive and environmental uses and provide greater certainty for communities.

It is encouraging that the Australian Government has maintained its commitment to reforms in the Murray–Darling Basin, but much of the work to deliver on *The Basin Plan* must be done by the states.

All governments must stay the course if *The Basin Plan* is to be

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 author, title/role and organisation and email address. Please address to editor@atse.org.au



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Adrian Clark | CEO Landis and Gyr Australasia

Mervyn Davies | Director of a number of major networks

Glenn Platt | CSIRO

Mike Cleary | AEMO

Tony Vassallo | Sydney University

DATE	Wednesday 20 May 2015	COST	Individual Tickets: \$250
TIME	8:15am - 6.00pm		Partner Organisations - Table of 5: \$1,000
VENUE	NSW Department of Trade and Investment Centre Level 47, MLC Centre, Martin Place, Sydney		ATSE Fellows: \$125

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delivered in full and on time.

A critical point in time for implementation of *The Basin Plan* will be the negotiation of adjustments to the Sustainable Diversion Limits scheduled for 2016.

It is possible that with investment in environmental works and measures, better river management and removal of constraints that the same environmental outcomes can be achieved with less water.

For communities to have any confidence in this process, governments must not bow to pressure from interest groups. A robust and transparent process must be used to establish the bona fides of any proposal that results in a reduction to the amount of water to be returned to the environment.

This will be a real test of leadership and it will be imperative that all interest groups maintain pressure on governments not to backslide from the hard-won gains so far.

The NWC report also identified specific areas of unfinished business that require further attention including:

- legislative reform in Western Australia and the Northern Territory;
- further unbundling of water rights;
- greater specificity around the ecological objectives and outcomes of water reform, underpinned by an appropriate monitoring effort;
- scheduled water plan reviews based on a transparent process involving evaluation and public reporting;
- specific pathways to achieve Indigenous objectives through water planning; and
- incorporation of all water uses within the one water planning framework.

Most of these are particularly relevant to the Australian Government's focus on developing the water resources of Northern Australia.

In the rush to realise the benefits of these developments, there is a risk that the lessons of the past will not be heeded.

Applying the sound principles of the National Water Initiative will ensure the long-term sustainability of projects and protect the environment. Importantly it will ensure that we

do not leave another MDB legacy for future generations to clean up.

In the absence of COAG leadership the state and territory governments hold the authority.

We all have a collective responsibility to hold them accountable. We are all collectively responsible for holding the baby.

THE HON KARLENE MAYWALD FTSE is Chair of the Australian National Water Commission. She is also the Managing Director of Maywald Consultants Pty Ltd, providing water policy and government relations advisory services. She also holds Board and Advisory roles in the water, health and enterprise development sectors. She was a Member of the South Australian Parliament from 1997 to 2010 and was a Cabinet Minister from 2004–10. Her Portfolio responsibilities included the River Murray, Water Security, Small Business, Regional Development, Consumer Affairs, Science and Information Economy, and Assisting the Minister for Industry and Trade. Ms Maywald made significant contributions to Murray–Darling Basin reforms and long-term water security in SA.

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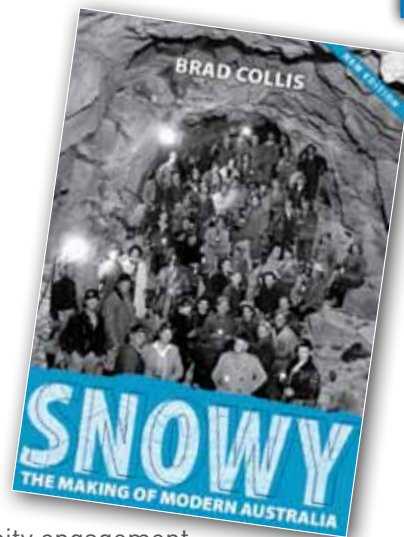
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By Tony Wong
tony/wong@monash.edu



Have we got enough urban water? How can we best use it?

Cities and towns have more than enough water. Having a diversity of water sources is the insurance needed for water supply security.

At the turn of the century, almost every major city in Australia was experiencing severe drought conditions and undertaking major infrastructure investment for greater water-supply security through the construction of desalination plants and, in some cities like Brisbane, infrastructure for wastewater recycling.

One could argue that we now have 'enough' water to service the projected population in these cities for the next 20 to 30 years.

Cities can access a range of water sources in addition to the conventional schemes of capturing rainfall runoff from rural and forested catchments by dams and, in Western Australia, groundwater recharge.

These alternative water sources include urban stormwater, recycled wastewater, groundwater and desalinated water. Many of these sources are available within city boundaries and

their ready access may be framed under the general concept that our cities are themselves water-supply catchments.

Average annual volumes of stormwater runoff from many of the major Australian cities are more than 80 per cent of their water demands – a great water resource potential (albeit that this water resource is generated intermittently) that could defer or eliminate the need for augmentation of conventional, centralised water-sourcing infrastructure.

Further, at least 50 per cent of water used in cities and towns becomes wastewater conveyed through the sewerage system to a sewage treatment plant and treated to water quality standards for discharge into the environment – a wasted resource.

By any measure, one could argue that we have 'more than enough' water to support our growing cities – yet we are not realising the full potential of these water resources. Why is this the case?

Existing water services and planning processes are not only poorly equipped to support projected population growth but slow to respond to economic or climatic uncertainty. This is a common observation all over the world as many cities and towns are trying to meet 21st century challenges by re-investing in 19th century strategies and infrastructures.

Traditional government mechanisms, and ongoing drive to chase the diminishing returns from micro-economic efficiencies, have reinforced the traditional compartmentalisation of infrastructure and service provision. This compartmentalisation has been physical, in terms of infrastructure, and institutional in terms of responsibility for service provision, operation and maintenance, and is the major impediment to a holistic approach to urban water management.

The fact that many desalination plants in Australia's major cities (with the exception of Perth) have come online at a period when dams are filling has certainly taken the shine off these facilities.

Some have argued that this period of significant investment in desalination plants has been a 'period of maladaptation'. The Productivity Commission has also chimed in, arguing that the scale of investments has been ill-conceived.

Hindsight is great but we do need to be cognisant of the circumstances of the time when decisions were made to commission desalination plants – many cities were literally running out of water with projections that if the trend of low inflows to dams were to continue, "Armageddon" (yes, this word was used in government briefings) would prevail.

Governments wanted certainty through their investments in 'rainfall-independent' water sources such as seawater desalination.

Irrespective of the debate, we cannot

\$1 MILLION FOR NEW WATER RESEARCH

Groundwater research has been boosted with the Murray–Darling Basin Authority announcing \$1 million to fund studies by the National Centre for Groundwater Research and Training (NCGRT).

MDBA chief executive Dr Rhondda Dickson said the three-year collaborative research program would provide important technical and scientific support for decision-making in the Murray–Darling Basin.

The NCGRT, based at Flinders University, will use the funding to continue investigations into how groundwater and surface water interact, the way groundwater is replenished, and the impact of social and economic factors on groundwater management.

NCGRT Director, Professor Craig Simmons FTSE, said he was delighted to be working with the MDBA in this new partnership.

"We estimate that almost one-third of Australia's total fresh water exists underground within the area of the Murray–Darling Basin. The more we learn about this resource, the better our understanding of water in the Basin as a whole."

The NCGRT is an Australian Government initiative, supported by the Australian Research Council and the National Water Commission.



Craig Simmons

deny the fact that these desalination plants now provide cities with an important underpinning mid-term water supply security, and thus a period of water supply stability, and that this window of opportunity has in many ways further enabled the development and implementation of more sustainable and resilient strategies.

Initiatives and innovation in integrated urban water-cycle management and water-sensitive urban design, such as water recycling and stormwater harvesting, take time to incubate at a whole-of-city scale. Much of this needed infrastructure is complex and diffused, and challenges current institutional arrangements for urban water services.

Future cities face many challenges, including enhancing liveability and resilience to the impact of climate change and growing populations. Urban communities are an important feature of complex socio-physical systems that are in continuous interactive and evolving processes.

Beyond the apparent water economy of demands and consumption, there is a more subtle water economy that is inextricably linked to the economy and prosperity of the city. These links can be found in areas as diverse as public health and wellbeing, productive urban landscapes, climate responsive urban design, carbon footprints and energy efficiencies – key urban liveability ingredients.

The urban water challenge is therefore not just confined to drought resilience. Floods and degrading waterway health are ever-present considerations in our urban water management. The quality of the urban water environment and access to affordable water to support urban landscapes are essential contributions to realising urban liveability.

The National Water Commission's 2011 report on the future direction of urban water in Australia challenged the urban water sector to "enhance its effective contribution to more liveable, sustainable and economically prosperous cities in circumstances where broader social, public health and environmental benefits and costs are clearly defined and assessed".

The perspective of realising more liveable cities and towns is now a policy



Careful urban water use supports enhanced streetscapes.

agenda for many governments and the way we manage water in the urban landscape influences many aspects of the liveability of our urban environments.

Water and associated 'green technologies and infrastructures' are an essential element of place-making, both in maintaining and enhancing the environmental values of surrounding landscapes and in the amenity and cultural connection of the place.

Urban planning now has to deliver multiple objectives that strategically place green spaces and corridors that provide greater amenity, enhance urban biodiversity, protect water environments from urban stormwater pollution, promote harvesting of stormwater, influence micro-climates and provide safe detention and conveyance of flood waters.

Water planning and emerging technologies for fit-for-purpose water production, resource recovery (water, energy and nutrients) from our sewerage system, and multi-functional hybrid centralised and decentralised water infrastructure must blend with urban planning.

In essence, a whole-of-government approach will be necessary to harness the full potential of urban water in this endeavour. Future urban water reform will need to be directed at institutional and macro-economic policy adjustments to facilitate an integrated multi-sectoral and whole-of-government framework for urban water management.

In summary, there is no doubt that another drought is coming. The resilience of Australian cities and towns to climatic extremes and the associated multi-threat implications are going to be tested time and time again.

How we prepare for this eventuality and use this as an opportunity to continue to protect and enhance the liveability of our cities and towns will define our resilience to an uncertain climatic future.

Cities and towns have more than enough water. Having a diversity of water sources is the insurance needed for water supply security.

This, however, needs to be achieved with a keen eye on other urban water benefits that can be accrued through a macro-economic approach to urban water sustainability and resilience, and urban liveability.

PROFESSOR TONY WONG FTSE is Chief Executive of the Cooperative Research Centre for Water Sensitive Cities, with research hubs in Brisbane, Melbourne, Perth and Singapore. He is internationally recognised for his research and practice in sustainable urban water management, particularly Water Sensitive Urban Design. His expertise has been gained through national and international consulting, research and academia, and he has led a large number of award-winning urban design projects. He was the Engineers Australia 2010 Civil Engineer of the Year, cited as having defined "a new paradigm for design of urban environments that blends creativity with technical and scientific rigour".

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By Neil Andrew
ncandrew@bigpond.net.au

The heart of the nation's water

It was the Millennium Drought (2000–09) that set new parameters for river sustainability and gave a sobering but timely impetus to the need for sustainable water extractions.

One hundred and ninety years ago Hamilton Hume was the first European to glimpse the mighty Murray and five years later Captain Sturt sailed down it. While Sturt's diaries attest to the importance of this waterway, neither pioneer could have imagined the productive potential of this national asset.

Today, over two million people living in the Murray–Darling Basin, and more than a million people outside it, directly depend on this vital water resource.

Consequently, as a nation we are working towards ensuring a sustainable future for the Basin.

This is a challenging task. It demands the careful balancing of the needs of about 60,000 productive industries and communities, which together generate 40 per cent of our food and fibre, with the need to restore and maintain the health of thousands of kilometres of river and 30,000 wetlands.

This is a balance that maintains the social and economic benefits of wealth generation (estimated at in excess of \$15 billion annually), while maintaining and enhancing the environmental assets that communities value. Caring for these assets helps ensure long-term river health.

Periodic drought is an inevitable feature of Australian life. The Basin covers about 14 per cent of the driest



Neil Andrew checks drip irrigation pipes.

inhabited continent on Earth and 90 per cent of the rain that does fall evaporates or is transpired. The river system has an average annual flow of 32,800 gigalites (GL) – which is 16 per cent of the Nile, three per cent of the Mississippi and just 0.25 per cent of the Amazon. Conserving this unpredictable water resource has always been essential to the long-term development of our nation.

A series of locks and weirs were constructed around 100 years ago, principally as a boost to navigation (most notably, along the Murray) and this infrastructure ensured a secure water source, which fuelled the development of irrigation. This enthusiasm for agricultural production and community life continued to the point where we now divert about 42 per cent of the total surface water that runs into the Basin's rivers.

As a result, over time there has

been a reduction in river flows of about 75 per cent. Major water storages such as Hume and Dartmouth and numerous on-farm storages also have the capacity to retain more than the annual inflow.

As surface water consumption has increased (quadrupling from 1930 to 1990) we have experienced escalating environmental problems. Our storage and productive use of this scarce resource has resulted in many wetlands experiencing 'man-made droughts' in up to 60 per cent of years compared to five per cent of natural droughts pre-development.

Without sufficient flow to flush out the almost two million tonnes of salt that leaches out of our ancient soil and rocks, salinity can quickly build up and the lower reaches of the river system silt up – leaving constant dredging as the only way to keep the river mouth open and allow sedimentary flow to the sea.

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

By the mid-1990s it was evident that diversion levels were more than the Murray–Darling Basin system could sustain. Without intervening action, the damage would be terminal. Cooperation between political parties and federal and state governments resulted in a Basin-wide audit of water use and a cap on consumptive water extraction.

By the early 2000s it was apparent that the health of dependent plants and animals within the river network could only be sustained if infrequent high flows could be supplemented by deliberate environmental inundations of small to medium flows.

The first step in redressing the balance was The Living Murray partnership, which allocated almost \$1 billion to fund research, initiate on-farm efficiencies and improve water delivery infrastructure, and recover approximately 500 GL of water. Funds were also allocated to construction and infrastructure works to benefit the environment. The recovered water was then used for the restoration of six environmental ‘icon’ sites on the Murray. Measurable improvements in

wetlands and instream health followed.

It was the Millennium Drought, between 2000 and 2009, which set new parameters for river sustainability and gave a sobering but timely impetus to the need for sustainable water extractions.

In 2007, at the height of the drought, the Prime Minister announced a major reform, which was ultimately enshrined in the *Water Act 2007*, to deliver a Basin-wide sustainable level of water diversion, supported by a \$10 billion package of initiatives.

It took a while for the package to be accepted, but by 2012 a thoroughly investigated and considered limit on overall extraction from the Basin’s surface and groundwater was determined by the reconstituted and independent Murray–Darling Basin Authority (MDBA).

The MDBA is bound by the *Water Act 2007* and reports to the Federal Minister for Water. Calculating sustainable diversion limits (SDLs) for each river valley in the Basin has been challenging and has drawn on the expertise of a range of scientists, economists and community leaders.

The MDBA used a hydrological

computer modelling platform, which incorporated the Basin’s 114-year climate record, to assess the long-term environmental outcomes of different SDL options. It also commissioned several social and economic assessments to understand the social and economic costs and benefits of these options.

The SDLs are not intended to protect the catchment against the ravages of drought, but they do represent the first quantifiable and balanced attempt to minimise the economic and environmental impact of future dry periods.

Although the final determination of SDLs must be – and was – a judgment call, the MDBA’s methods were independently reviewed by CSIRO, which confirmed the approach was sound and based on the best available science.

As will be self-evident, the process (involving extensive consultation and negotiations) has not been easy. For obvious reasons, views on what constituted sustainable extraction initially polarised irrigators and environmentalists.

► [More on page 20](#)

Call to better manage our hidden water

Two of Australia’s leading water scientists have called on the Federal Government not to overlook the nation’s greatest natural resource – our vast reserves of underground fresh water – in developing a new national water policy.

Professor Craig Simmons FTSE and Dr Rick Evans, in an online Fairfax article, pointed out that groundwater constituted more than 95 per cent of Australia’s available fresh water, but that current policy discussion focuses almost entirely on building more surface dams.

“Surface water dams are costly to build, economically questionable, involve destroying local ecosystems, cause social and political acrimony and, worst of all in our hot climate, they evaporate. In the north of Australia, they lose metres of water per year into the sky. These losses may increase as the climate warms,” they said.

Professor Simmons is Matthew Flinders Distinguished Professor of Hydrogeology at Flinders University and Director of the National Centre for Groundwater Research and Training. Dr Evans is Principal Hydrogeologist at Jacobs and immediate past president, Australian chapter, International Association of Hydrogeologists (IAH).

“A renewed fit of dam construction will not only waste precious water,” they said. “It will also cause Australia to miss major opportunities to generate billions of dollars’ worth of mineral and food exports, create thousands of jobs, sustain cities, towns and regional communities and restore native landscapes across the continent. It

will invest a lot of money for a relatively meagre return.”

Instead, they argued, Australia should focus on ‘conjunctive management’ of both surface and underground water resources because trying to manage one without the other did not make sense.

They said an October 2014 Commonwealth options paper all but ignored groundwater and failed to give due weight to conjunctive water management – the integrated management of both surface water and groundwater resources. It instead steered discussion towards building up to two dozen new surface dams, mainly in the North.

“In a hot, dry land like ours – where evaporation rates often exceed annual rainfall – a promising water storage system is ‘underground dams’, otherwise known as managed aquifer recharge (MAR). You pump or soak water down into the aquifer during the wet season, and withdraw it again for use during the dry.

“This has been shown to work well with stormwater in the city of Adelaide, in the outer metropolitan area of Perth and in the Burdekin Delta in Queensland. It is a widely recognised solution to both the Australian and world problem of approaching water scarcity.

“When done well, conjunctive water management can be more cost effective, more environmentally sustainable and a more water-efficient way of using the total resource,” the scientists said.

Designing and managing underground dams was potentially a major new Australian export industry in its own right, they added.



By Craig Simmons
craig.simmons@flinders.edu.au

The groundwater discussion has moved a long way on from the days of the windmill and tank.



PHOTO: ISTOCKPHOTO.COM

Stewarding our hidden groundwater asset

We must create an enduring, proactive, non-partisan approach to water reform and reject water reform that waxes and wanes as droughts come and go and political parties change.

Groundwater makes up almost all of the available freshwater on our planet: 97 per cent of fresh water on Earth lies in the ground beneath our feet.

Groundwater supplies half of the world's drinking water and 43 per cent of the water used to grow food.

UNESCO reports current global groundwater extraction is approaching 1000 cubic kilometres a year – more than 13 times the annual flow over Niagara Falls – and it shows no signs of slowing. Groundwater depletion and pollution are huge international issues.

Groundwater provides more than 30 per cent of Australia's total water consumption and generates national economic activity worth in excess of \$34 billion a year.

In Australia, there are myriad current, pressing issues in which groundwater

is crucial. Securing the Great Artesian Basin, the successful implementation of the Murray–Darling Basin (MDB) Plan, the impacts of unconventional gas and hydraulic fracturing on groundwater, mining and groundwater, proposals for the future development of Northern Australia, the role of groundwater in urban and rural water security and the impacts of climate change on groundwater are just a few of the hugely important contemporary issues that will require rigorous groundwater science, management and policy.

As a nation we have made good progress in groundwater science, management and policy over recent decades, but the journey is far from over. A number of important changes that are occurring in Australia mean we must remain vigilant and not become complacent.

The National Groundwater Action

Plan, a \$105 million investment from the Commonwealth Government administered by the National Water Commission, finished in June 2012. This was the lifeblood of government investment in groundwater in Australia.

Many State, Territory and Commonwealth government agencies continue to report a serious de-skilling in their capacity and capability to address groundwater issues. And yet all of this is occurring at a time when there are many important groundwater management and policy issues that require urgent attention.

These include:

- returning overallocated aquifers to sustainable levels of extraction;
- licensing and metering issues – you cannot manage what you do not measure;
- dealing with compliance and illegal use;
- disincentives to groundwater



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trading largely due to illegal use and the large number of already overallocated aquifers;

- double accounting and double allocation issues in surface water and groundwater and making the principles of conjunctive water management work in practice;
- assessing the value of groundwater and ensuring charges and prices reflect the true cost of groundwater management; and
- replacing old groundwater monitoring infrastructure, largely built in the 1960s to 1980s, which is reaching the end of its life.

Groundwater is far more important than we often think but it is not well understood nor appropriately valued.

Groundwater is often ignored. The recent Commonwealth Water Infrastructure Options Paper examining options for new water infrastructure and dams in Australia all but ignores groundwater. Attention to groundwater and groundwater management is deteriorating at an alarming rate, especially at a time when there are so many groundwater-related matters of national importance, such as coal seam gas, that we must deal with.

Given the national significance of groundwater, it is time to discuss whether or not the National Water Initiative (NWI) – COAG's principal water policy

agreement – is adequate for water reform. A key feature is the integration of the water resource and treating the interaction between groundwater and surface water.

While the broad principles within the NWI do apply to groundwater (market approach, ecological sustainability, community planning approaches and so on) there are a number of features of groundwater that are substantially different to surface water that do not have a high profile within the NWI.

The NWI was written at the height of the Millennium Drought and focused on the overuse of water, with a strong focus on the Murray–Darling Basin. However, since that time a number of key issues have arisen that likely require some rethinking and rebalancing of the NWI with respect to groundwater.

These issues include:

- mining and unconventional gas development in remote areas;
- changes to technology such as managed aquifer recharge (MAR) and desalination; and
- the use of groundwater in drought response.

These issues have highlighted some of the deficiencies of the NWI policy instrument specifically with respect to groundwater. Other distinctions regarding groundwater have been highlighted in the development of the MDB plan.

These include, for example:

- groundwater quality and salinity;
- the nature of aquifers – such as the important distinction between confined and unconfined aquifers;
- groundwater mining and over-drafting often applied to paleoresources and large regional aquifers;
- the difficulty of developing a consistent approach across geology types; and
- overall, the comparatively low knowledge base of groundwater relative to the size of the management challenges.

These distinctions are not well represented in the NWI policy instrument.

A wide range of fundamental groundwater science and technical issues still exist at an international level, including, but not limited to the following:

- acquiring urgently needed and grossly lacking fundamental data at appropriate spatial and temporal scales to support analyses that are relevant to critical questions that are being asked;
- quantifying and reducing uncertainty in our analyses, which is a massive problem. Given that the confidence levels in our predictions are often unacceptably low, how do we explain this to policy makers? How do we reduce uncertainty and risk?;
- dealing with geologic heterogeneity, where the properties of our complex aquifer systems can vary by enormous and often



Australia's 'other' Murray River – at Dwellingup, WA.

unquantifiable amounts, which continues to pose a major challenge in understanding how groundwater systems behave;

- addressing the continuing and pressing need to develop mature and robust groundwater models to predict groundwater processes that are underpinned by strong geologic and hydrogeologic conceptual models and comprehensive data;
- predicting the cumulative impacts on groundwater as the groundwater resource is developed and as progressive, cumulative intensification of mineral and energy resource development occurs is a major unresolved challenge; and
- integrating all of the essential interdisciplinary subjects that are critical in 21st century hydrogeology, such as climate science, ecology, socioeconomics, public policy and law, is an ongoing challenge.

Contemporary groundwater problems have moved well beyond classical hydrogeology, which was primarily concerned with water supply, namely, how much water was stored in or could be extracted from an aquifer.

All of these current and foreseeable scientific challenges are not only scientifically interesting, they are essential to ensuring good groundwater management that is based upon rigorous science.

There are many opportunities for a coordinated national and international response to these challenges. These include:

- technologies such as managed aquifer recharge, which will allow us to top-up aquifers or use them as a storage facility, minimising evaporation and the huge environmental and financial costs associated with dam construction;
- promoting and applying the principles of 'conjunctive water management' – the integrated management of both surface water and groundwater resources. In Australia's climate, where surface water is often scarce, conjunctive water management offers huge advantages. MAR will be one important part of conjunctive water management in Australia and in addressing vital issues regarding the development of Northern Australia and national agricultural competitiveness;
- working together as a nation to develop a consensus opinion on the groundwater issues in Australia and developing and

implementing recommendations for dealing with those problems. This will build upon and prioritise the important work that has already begun with the National Groundwater Strategic Plan;

- agreeing upon national principles for good groundwater management that are underpinned by sound, accepted groundwater models for major aquifers in Australia;
- increasing the contribution of science to quality national water management and policy formulation and debate. We need a clear articulation of groundwater research priorities formalised through a national groundwater research plan that is developed by and agreed upon by groundwater researchers, policy makers, managers and industry;
- building a national groundwater policy and planning forum where groundwater policy makers, managers, industry and scientists work together to define and solve important groundwater policy, management and technical issues. Such a forum will assist us in developing and promoting a community of practice in groundwater by creating a soft institutional build to allow such a community to thrive;
- ensuring we have sufficient capability and capacity to deal with current and future groundwater challenges and risks; and
- continuing to raise the profile of groundwater in Australia. We need champions to drive groundwater issues forward and to combat systemic ignorance by raising awareness of groundwater issues through much better communication of the key issues. We have an ongoing obligation to explain the challenges, complexity and societal relevance of hydrogeology to policy makers, funding agencies and to society as a whole.

There are tremendous opportunities to harness and capitalise on Australian groundwater expertise for international markets, especially as other countries such as China and India face increased challenges in groundwater availability, pollution and management.

These groundwater challenges and opportunities for Australia illustrate some of the important and outstanding issues we must confront head-on regarding groundwater management, policy and science if we are to progress

groundwater reform in Australia.

The reform journey must continue. But in order for this to happen we must address problematic institutional legacy and funding issues with agencies, funding and political attention present in droughts and absent when it rains – following the 'hydro-illogical cycle' of drought, awareness, concern, panic, rain, apathy ... and back to drought.

Regrettably, the hydro-illogical cycle persists. We appear to be in its 'apathy' phase in Australia at present. This is a dangerous place to be. This cycle creates a tendency towards short bursts of work that are here today and forgotten tomorrow – water 'hits and runs'.

We must continue national water reform with the clear understanding that droughts are a part of what it means to be Australian.

Recognising the need for an integrated, whole-of-water-cycle approach for effective water resources management, groundwater will be one critical part of any water reform strategy.

We must continue national water reform recognising the huge number of social, environmental and economic challenges and opportunities in which groundwater plays a critical role.

We must create an enduring, assertive, proactive, non-partisan approach to water reform in Australia and reject water reform that waxes and wanes as droughts come and go and political parties change.

We must safeguard Australia's groundwater expertise, capacity and capability. If we rise to this challenge, the pay-offs for current and future generations will be huge.

PROFESSOR CRAIG SIMMONS FTSE is a leading groundwater scientist, recognised for major national and international contributions to groundwater science, education and policy reform. Director of the National Centre for Groundwater Research and Training, he is one of Australia's foremost groundwater academics and has been a significant contributor to global advances in the science of hydrogeology for many years. He is a member of the Statutory Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). Professor Simmons is Matthew Flinders Distinguished Professor of Hydrogeology and Schultz Chair in the Environment at Flinders University.



By Snow Barlow, Tony Fischer and Iven Mareels

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Optimising water use in agricultural production

The water productivity of Australia's major field crop, wheat, has increased almost four-fold in the past 100 years through R&D-driven agronomic and breeding advances.

Water has always been the key driving force of productivity in this land of "droughts and flooding rains".

In global terms Australia is not well endowed with rainfall or water resources and consequently the efficient use of these scarce resources continues to be a major driving force in lifting the productivity of agriculture in an increasingly food-limited world.

The major objective in any water-limited agricultural system is to maximise the proportion of available water used by the cropping system in the process of plant transpiration. In this way the plant uses this water to capture carbon from the atmosphere and convert it into food and fibre products.

Conversely, these systems seek to minimise the amount of water lost to the atmosphere through direct evaporation from water bodies and soil or by non-crop plants such as weeds, as this does not result in any useful carbon gain.

Dryland farming dominates Australian field cropping, with rainfall usually falling well short of crop or pasture demand. Thus, Australian cropping is confined largely to the cooler winter season and involves drought-tolerant crops such as wheat, barley, winter pulses and canola, with limited summer cropping of sorghum, cotton, mung bean and negligible maize or soybean.

For our dryland cropping, the efficient use of the limited water from rainfall is paramount to productivity.

For crops, it is common to calculate water productivity (WP) as the production relative to crop water use or evapotranspiration (ET), but this overlooks important technologies, which permit farmers to increase the soil storage of rainfall between crops for use by subsequent crops.

Generally, increasing water stored in the



No-till sowing of wheat – conserving fallow rainfall through crop residue ground cover and weed control.

soil at sowing has no opportunity cost and is particularly important in the northern wheat cropping zone and increasingly so in southern zones. As farmers have adopted the key principles of conservation agriculture – no tillage, retention of crop residues and herbicide control of fallow weeds – soil water storage as a percentage of fallow rainfall has increased from less than 20 per cent to as high as 40 or 50 per cent and erosion has diminished dramatically.

In the past 20 years, farmers in the southern cropping zone with more winter rainfall have also embraced these principles, resulting in 25 or 50 millimetres of extra water stored, which is used efficiently by crops. Water stored reasonably close to the soil surface also allows farmers to sow in the absence of planting rains.

The principles for maximising in-crop WP, normally expressed as kg/ha/mm of ET, are mostly the same for dryland and irrigated crops. Timely and generally early sowing is the first. The sowing date has advanced notably for dryland winter crops in the past 40 years, due to better fallow water storage, and especially due to reduced-till direct seeding and to larger scales of mechanisation

– more than 80 per cent of dryland crops are now direct-seeded in Australia, the highest percentage in the world.

WP also benefits from maximising the transpiration component of crop ET and minimising in-crop soil evaporation, which can amount to 50 to 150 mm of the precious ET. This waste is reduced especially by rapid early crop growth, and also by residue on the soil surface.

Optimum early growth is a question of soil fertility. Managing this is the realm of crop agronomy, as is the control of weeds and many pathogens and pests. Good farmers, helped by modern varieties and appropriate crop rotations, lose little in crop growth from such constraints.

Transpiration needs to be converted to crop growth and then to grain, the ratio of growth to transpiration being transpiration efficiency (TE), and that of grain to total growth or biomass at harvest is harvest index (HI).

The TE of our crops is largely determined by the dryness of the air, so growth in the cooler, moister months is most efficient.

The second determinant is the



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photosynthetic characteristics of the crop, but breeders have made limited progress here and only one of our major grain crops – sorghum – uses the more efficient C4 photosynthetic system. TE in our other crops does however benefit about 0.2 per cent a year from CO₂ rise. Where breeders have made good progress is in lifting HI, especially through the use of dwarfing genes, something very evident under well-watered conditions (when values approach 0.5).

The water productivity of Australia's major field crop, wheat, has increased almost four-fold in the past 100 years through R&D-driven agronomic and breeding advances. Our best wheat crops currently achieve a world-leading WP of 25 kg/ha/mm of ET, with both yield and WP continuing to rise at about one per cent a year.

While there is moderate scope for further improvement as more farmers manage optimally, further increases in the WP of the best crops are becoming more difficult.

However, there are promising new avenues such as improving seasonal forecasts to permit farmers to better match crop growth to rainfall, new soil-applied materials to reduce in-crop evaporation, and better genetics for flowering tolerance of drought and heat (and even frost) to lift HI.

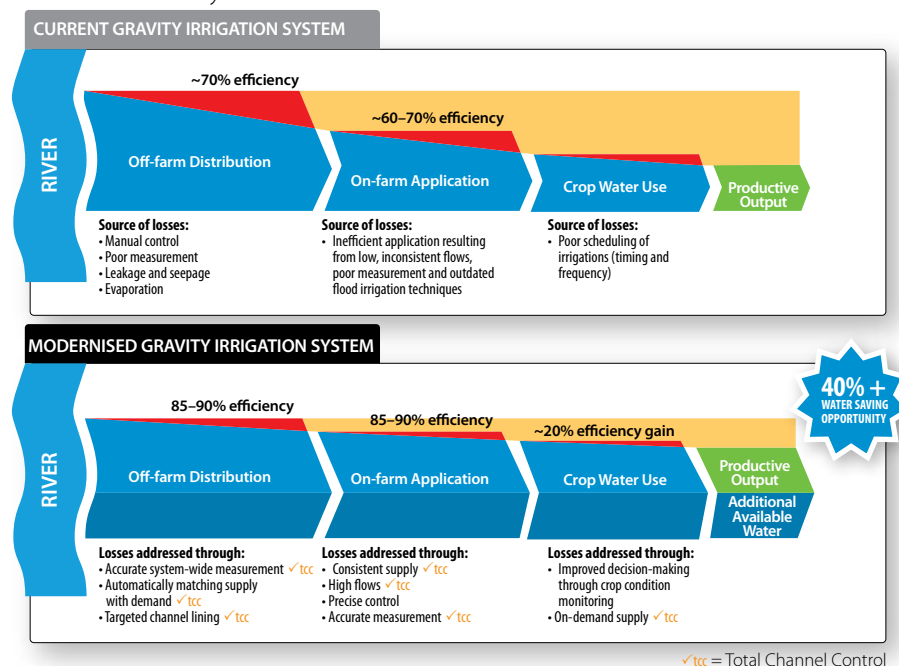
In the more distant future, changed leaf photosynthesis through genetic engineering could raise TE.

Optimising efficiency

Australian agriculture currently uses about 8000 gigalitres (GL) of water to irrigate 2.5 million hectares of agricultural land. This is less than two per cent of the 430,000 GL of the national water yield. More than 80 per cent of this irrigation currently occurs within the Murray–Darling Basin. Globally, agriculture utilises about 70 per cent of the available water.

Although Australia's irrigation systems have undergone considerable modernisation there is considerable scope to further optimise the efficiency with which irrigation water is utilised to produce high-quality food and fibre. Currently more than 60 per cent of irrigated land uses surface irrigation, 28 per cent uses spray irrigation and the remaining 10 per cent uses drip or

Pathways to improving the water efficiency of gravity irrigation through optimisation of off-farm distribution, on-farm application and crop water use efficiency.



micro-spray irrigation (micro irrigation).

The choice of irrigation system is largely one of cost – both in installation and subsequent running costs. Micro irrigation is largely employed in the perennial horticultural and viticultural production systems where the higher installation costs are justified by high values of the products. Over the past 30 to 40 years there has been considerable investment in pressure irrigation either in the form of spray or micro irrigation. There is limited scope to further improve these systems beyond the continued system integration and improvement of water management and irrigation scheduling.

The major opportunities for further optimising the use of irrigation water in agriculture lie in the modernisation and management of gravity flow systems where the majority of water is used.

A key part of increasing the water use efficiency in both surface flow and pressure irrigation is the optimisation of systems management to improve the efficiency and timeliness of water delivery. The efficiencies at each step in the water value chain are multiplicative rather than additive.

By using technology and management to increase the efficiency of each step in the water delivery chain – from the dam or river to the farm, to the crop and

then by the crop – from approximately 70 per cent to 90 per cent, can result in a doubling of the system water use efficiency from 35 per cent to 70 per cent.

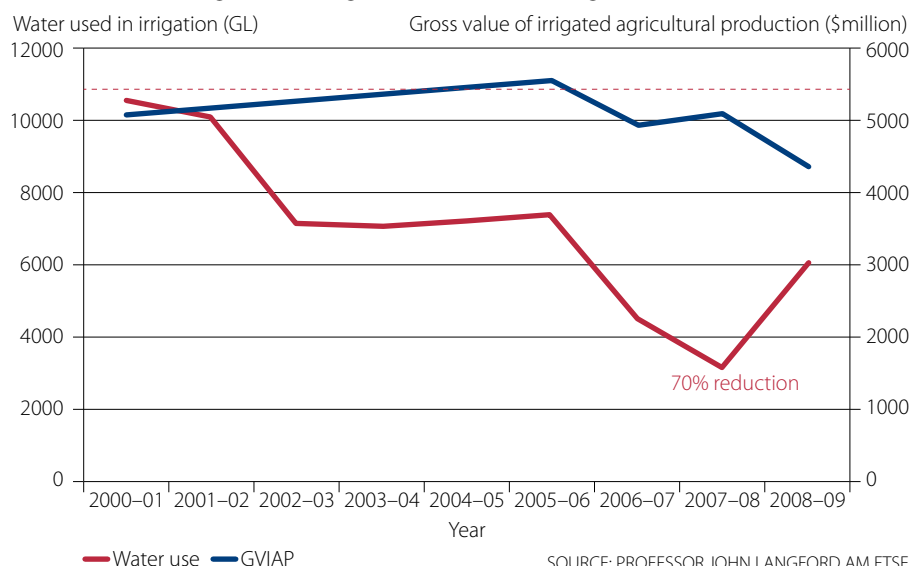
The technologies and management techniques available to improve the efficiency of off-farm water delivery from 70 to 90 per cent include accurate system-wide monitoring and measurement, reduction of channel losses through lining and automatically matching supply to demand in a timely fashion whilst eliminating outfalls.

On-farm, the efficiency of water delivery to the crop can be improved from 70 to 90 per cent by providing consistent supplies of high-flow water to optimise soil infiltration, precise control of the timing and duration of irrigation events and the accurate measurement of the water applied. Timing is of the essence and is the main objective pursued by the automation of water delivery from dam to crop.

The efficiency of crop water use can be increased from 70 to 90 per cent by minimising the time from crop establishment to canopy closure (all water is evaporated through the plant), precise timing of irrigation to match plant demand and the choice of more water efficient crops. As with dryland crops, plant genetic improvement can also increase water use efficiency.

The key to implementing these

The gross value of irrigation agricultural production (GVIAP) in relation to the water use in irrigation during the Millennium Drought (2000–09).



SOURCE: PROFESSOR JOHN LANGFORD AM FTSE

technologies and management techniques is the use of sensor technologies and closed-loop information systems to provide real-time information to water and farm managers for either automated or manual decision-making.

Water markets

Smooth transparent national and regional water markets operating in a knowledge-rich environment are integral to the wide implementation of water efficiencies.

Together with accurate measurement

and real-time information systems coupled to more accurate seasonal weather forecasts, such markets enable irrigation water to be utilised by agricultural enterprises with the highest economic returns. This is particularly the case in Australia's highly variable climate where water availability can vary greatly between years.

The effectiveness of water markets and trading in making our irrigated agriculture more resilient was demonstrated during the recent Millennium Drought, where these allowed water to move to higher value uses, thereby maintaining production as the volume of water available varied. This was clear evidence of the value of taking a 'national whole-of-system approach' to optimising the value created by the water available to Australian agriculture.

In a world where natural resources, particularly water, are under increasing pressure from the needs of a burgeoning population and agriculture already uses 70 per cent of the available water, the optimisation of the value created by the available water in any agricultural production system has become critical.

In both dryland and irrigation cropping systems, Australian agricultural science and engineering has made substantive contributions to the development of water-efficient production systems that are resilient in a very variable climate.

With continued investment in research and innovation there is the potential to achieve further efficiency gains through the application of science and technology, and in particular the application of an integrated systems approach to optimising water production efficiency.

◀ From page 12

The heart of the nation's water

The current SDL of 10,873 GL (2750 GL recovery amount) seems to reflect a balanced decision – one that will deliver a healthy working Basin through optimising economic and social outcomes, while giving ensured environmental water recovery. The 10,873 GL SDL is subject to renegotiation up or down by five per cent, and a transition period is in place until 2019 when the SDLs become enforceable.

Environmental water recovery is occurring through the Commonwealth Government's \$12.9 billion 'Water for the Future' program. Water savings accrued from infrastructure works, modernisation projects and direct purchasing of water rights (from voluntary sellers at market price) are now held by a statutory 'water holder', known as the Commonwealth Environmental Water Holder (or CEWH). This body delivers the environmental water in a manner consistent with the Basin Plan and is independent of the MDBA.

Much remains to be done and there are still hazards ahead. However, thanks to the bipartisanship of the major political parties and the objectivity of the key stakeholder groups involved in the Basin reforms, real progress is being made.

There is widespread recognition that the future of the Murray–Darling Basin as a productive and environmentally sustainable area depends on the progressive implementation of this Plan.

THE HON NEIL ANDREW AO FTSE was an irrigator in the Riverland of South Australia and Nuffield Scholar in Agriculture (1975) prior to being elected to the Federal Parliament in 1983. He was Speaker of the House of Representatives from 1998 to 2004 and Chief Government Whip in 1997. Post politics he served as National Chair of the Crawford Fund and was a Commissioner on the Australian Centre for International Agricultural Research's Council. An arbitrator and mediator, he has chaired reviews of the grain and citrus industries in South Australia and was recently appointed Chair of the Murray–Darling Basin Authority.

PROFESSOR SNOW BARLOW FTSE is Professor of Horticulture and Viticulture at the University of Melbourne. In 2009 he was awarded the Australian Medal in Agricultural Science.

DR TONY FISCHER AM FTSE is an Honorary Research Fellow at CSIRO Plant Industry. His contributions to crop science have been recognised by the award of both the Colin Donald and William Farrer medals.

PROFESSOR IVEN MAREELS FTSE is Dean of the Melbourne School of Engineering, the recipient of the 2014 IEEE Control Systems Society Technology Award and the 2008 Clunies Ross Medal for smart water management technology.



By Rob Vertessy
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Tasmania's Trevallyn Dam in flood.

Living with Australia's variable climate

Although Australians must contend with the world's most acute rainfall and runoff variability, they are now equipped with world-leading forecasting capability.

Rainfall variability in Australia is amongst the highest in the world. This is because Australia is a large island continent subject to multiple significant climate drivers. These include the El Niño–Southern Oscillation in the Pacific to our east and the Indian Ocean Dipole to our west.

Both of these drivers switch between phases that either drive warm, moist oceanic air masses towards our shores or push them away from our continent.

To our north we have the fickle behaviour of the Monsoon, which sometimes brings drenching rains to northern Australia and sometimes deep into our continent, but on other occasions either arrives late or fails to arrive at all.

To our south we have the erratic behaviour of the Southern Annular Mode, a circumpolar wind system that controls the latitudinal position of eastward moving storm tracks. Sometimes these tracks traverse our southern shores, while on other occasions they are drawn poleward into the Southern Ocean, away from land.

Finally we have the dynamic behaviour of the Sub-tropical Ridge to contend with.

The changing latitudinal position of this ridge of high pressure has a significant bearing on the distribution of rainfall across the southern half of Australia.

Superimposed on these climate drivers are a range of short-term weather phenomenon such as tropical cyclones, east-coast lows and west-coast troughs that can suddenly bring significant but short bursts of rainfall, even if the prevailing climate conditions are dry.

High rainfall variability makes for high runoff variability and Australian streamflows are the most variable in the world. This makes water management challenging, particularly when it comes to meeting the needs of a diverse range of users including households, irrigators, power generators, industries, recreational users and the environment.

We have adapted to this by having very large capacity water storages relative to mean annual runoff. However, it is not possible to drought-proof our water supply system and when scarcity sets in, competition for access to water can be fierce.

The Millennium Drought,

spanning the period 1995 to 2010, resulted in Australia's most serious water security crisis, affecting most capital cities, many rural towns and significant 'foodbowl' catchments such as the Murray–Darling Basin.

During this drought, many water storages were severely depleted. This led to aggressive water restrictions, significant reductions in water allocations for irrigation and a rush to build desalination plants in our capital cities. The severity of this event exposed many frailties in the way we were managing water in Australia, including under-investment and a lack of diversity in water supply, over-allocation of water entitlements, inefficient irrigation systems, excessive constraints on water trading and inadequate water reserves for the environment. Another gap exposed was the poor optics we had on the status of our water resources, particularly future water availability.

In early 2007 the Australian Government announced the National Plan for Water Security, significantly increasing the involvement of the Commonwealth in national water affairs. This 10-year,

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\$10 billion plan was introduced to deepen national water reforms and fund programs to increase our water security. It strove to do so by setting sustainable diversion limits for the Murray–Darling Basin, refurbishing inefficient irrigation systems, removing constraints to water trade, building up a reserve of water entitlements for the environment and augmenting water supplies.

As part of that reform, the Bureau of Meteorology (the Bureau) was funded to establish a national water information capability. This entailed the capture of water information collected by more than 180 different agencies and the provision of a variety of water information products and services that would give water policy-makers, water managers and water users far better intelligence on the changing status of our water resources.

The addition of this new function to the Bureau complemented existing capabilities in weather forecasting, seasonal climate forecasting and flood warning. Together these capabilities constitute vital environmental intelligence that enables Australians to better prepare for variability in rainfall and runoff. This capability will only become more valuable in the future as climate change intensifies the global hydrologic cycle, resulting in even deeper drought and flood events.

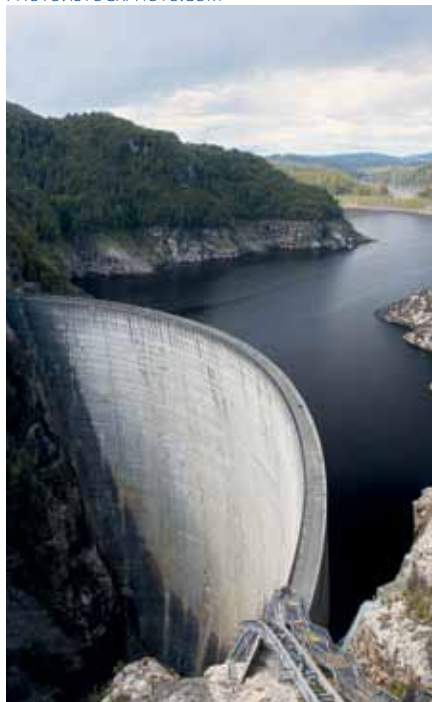
The Bureau's rainfall forecasting capability spans a range of timescales, ranging from a few hours to multi-decadal.

Rainfall 'nowcasting' provides forecasts for a few hours, covering a range of a few hundred kilometres at fine spatial and temporal resolution (one km in space and 10 to 20 minute intervals).

Nowcasts are generated using the Bureau's STEPS model, blending pattern analysis of rainfall fields observed with real-time high-resolution Doppler radar and rainfall forecasts from numerical weather prediction models. STEPS nowcasts are updated every 10 minutes and are available for most capital cities.

Numerical Weather Prediction (NWP) provides rainfall forecasts for hourly intervals out to seven days, across Australia and globally. The Bureau's NWP system, known as ACCESS, is run at various spatial scales, with a coarse resolution version run for the globe (40km), a medium resolution

PHOTO: ISTOCKPHOTO.COM



Managing water storage –Tasmania's Gordon Dam.

version run for the Australian region (12km) and finer resolution models run for our capital cities and their hinterlands (four km). Forecasters edit the model output to remove known model bias and re-issue the forecasts on a six-kilometre grid across the continent and coastal waters.

Beyond seven days it is not possible to generate skilful categorical forecasts of rainfall. This is where probabilistic approaches must be used. To predict rainfall from two weeks to three months ahead, the Bureau uses a seasonal forecasting system known as POAMA. Seasonal forecasting systems like POAMA are similar to NWP systems used for weather forecasting but are coupled to ocean models.

They are run many times over, with varying initial conditions, so as to produce an 'ensemble' of possible rainfall outcomes. The rainfall forecast is expressed as a probability distribution, indicating the chance of exceeding a particular value. POAMA operates at fairly coarse spatial resolution (250km) and is updated twice weekly.

Finally, the Bureau, in collaboration with CSIRO, uses a coupled atmosphere-ocean model variant of the ACCESS NWP model to make long-term projections of rainfall for a variety of climate change scenarios. These projections are performed every five years as part of the climate change assessments performed by the

Intergovernmental Panel on Climate Change.

Different scenarios are run, assuming different levels of net greenhouse gas emissions, and the rainfall projections from ACCESS are combined with projections from other global climate models to assess predictive certainty. As these models are run at very coarse resolution, they must be 'downscaled' to provide meaningful estimates at the regional scale. Such downscaling has recently been performed for all of Australia's Natural Resource Management (NRM) regions.

As with rainfall, the Bureau's runoff forecasting capability also spans a variety of timescales. For hours to up to three days ahead, the Bureau issues flood forecasts using its HyFS system. These forecasts are issued for designated catchments but only when they are receiving rain likely to give rise to flooding.

HyFS is used to predict the magnitude and timing of the flood peak, and is vital for defending against the public safety and property damage risks posed by flooding. Flood forecasts are provided for more than 150 river basins and more than 700 calibrated locations and are updated every few hours during the course of a flood event.

Looking out a bit further in time, the Bureau issues short-term flow (STF) forecasts out to seven days using its Short-term Water Information Forecasting Tools (SWIFT) system. Continuous streamflow forecasts are provided for 62 catchments and 114 forecast locations and are updated daily, using the Bureau's ACCESS NWP system for rainfall input.

The STF forecasts are designed to assist water managers in river and reservoir operation, timing environmental flow releases, as well as informing flood guidance and management. As with rainfall forecasts, streamflow forecasts beyond seven days are probabilistic.

The Bureau's Seasonal Streamflow Forecasting (SSF) system generates probabilistic forecasts of streamflow volumes for the next three months at a site or for total inflows into major water supply storages. It uses a statistical approach based on Bayesian Joint Probability methods relating extant climate indicators, antecedent catchment conditions and historical rainfall and streamflow at a site to forecast future streamflow.

Seasonal forecasts are updated monthly and are currently available for 101 locations in 52 river basins across Australia. They can help irrigators, reservoir operators and environmental flow managers to assess water availability for the months ahead, informing water order, water trade and water release strategies.

Although Australians must contend with the world's most acute rainfall and runoff variability, they are now equipped with world-leading forecasting capability.

The Bureau will continue to improve its forecasting methods as science and technology progress. The history of rainfall and runoff forecasting shows that improved observational methods, faster computers and smarter algorithms lead to greater forecasting skill and greater utility value for end users. That trend is sure to continue. ▀

DR ROB VERTESSY FTSE has been Director of Meteorology and CEO, Bureau of Meteorology, since September 2012 and previously headed its Climate

and Water Division, which included responsibility for the National Climate Centre, the national flood forecasting and warning service, and the agency's new water information function. Dr Vertessy spent the first 20 years of his career as a researcher at CSIRO specialising in catchment hydrology. He was Chief Executive of the CRC for Catchment Hydrology (2002–04) and Chief of CSIRO Land and Water (2004–07) and advised the Government on the establishment of a national water information strategy before joining the Bureau of Meteorology to lead implementation of a new national water information function.

ATSE tackles water resource recovery

ATSE has commenced a major new study on water resource recovery opportunities, funded by the Australian Water Recycling Centre of Excellence.

The study, led by Professor John Burgess FTSE, aims to produce a report to serve as a resource for the Australian water industry and policy-makers and provide valuable information and analysis for potential investors in water resource recovery in Australia.

A strategic planning workshop in December 2014 kicked off the project, identifying issues, barriers and opportunities related to water resource recovery.

The background to the study is that population growth, increasing demand for natural resources, rising costs and community expectations place a confluence of pressures on policy-makers to manage natural resources and on the water industry to develop innovative and more efficient processes.

Resource recovery can preserve original natural resources,

minimise waste generation and maximise benefits from waste products such as avoided cost or revenue gain.

There is already a significant body of work on resource recovery technologies but there is a crucial gap for a report that holistically analyses the potential industry opportunities for resource recovery in Australia, identifies barriers to successful commercial deployment and pathways to realise the opportunities.

Pressure on the water industry to develop innovative and more efficient processes.

Aiming to fill that gap, the project will consider resource recovery as the extraction of resources from wastewater, with particular focus on the recovery of resources for use as energy and nutrients, for example:

- recovery of nutrients and carbon through biosolid re-use;
- enhancing biogas production; and
- utilising biogas to generate energy.

The project will only consider water recycling as a mechanism for nutrient recovery – in other words the focus of the project is not water recovery itself except that it accompanies and enables other resource recovery. The project will consider resource recovery from water opportunities at three broad scales, including energy:

- internal for in-house recovered resource utilisation;
- regional – recovered nutrients used for irrigation by farmers in the immediate vicinity; and
- large-scale – recovered resources entering mainstream market for fertiliser, etc.

The project will collate existing examples of resource recovery in Australia, such as biogas recovery from wastewater treatment plants and biosolid reuse for nutrient recovery. The project will consider examples from other countries, including the US and Europe, where resource recovery technologies have been commercially deployed, and will analyse what regulatory, policy and social factors contributed to the success of those initiatives.

The report will consider how successful commercial deployment of resource recovery technologies could be replicated in Australia.

The project will analyse the market, regulatory, policy, legal, technology and other barriers to successful commercial deployment of water resource recovery technologies in Australia. It will consider factors that influence industry opportunities, such as value chains, social perception, risk aversion, technology development and deployment.

The Australian Water Recycling Centre of Excellence funded a 2013 ATSE study on the future of potable water re-use in Australia. The report from that study focused on direct potable re-use (DPR) systems, where treated water is returned immediately to the drinking water supply system. This differs from indirect potable re-use (IPR), where water is pumped into 'environmental buffers' such as rivers, lakes or aquifers for temporary storage.



ATSE IN ACTION

Research Engagement for Australia report lodged

The Academy has completed a major project aimed at better measuring the impact of research engagement and business–research collaboration in Australia.

The project has generated an important ATSE report, delivered to the Federal Government in March, which proposes a suite of metrics collectively titled Research Engagement for Australia (REA).

These metrics use external dollars attracted by universities to support research, from industry and other end users, as indicators of engagement. Although this is distinct from measuring impact, which is limited by the long time lags involved and difficulties in establishing causal links, engagement is a necessary first step in achieving impact. This external income is divided by three different denominators to give indicators of engagement per number of staff, share of national engagement activity and engagement intensiveness.

Importantly, these REA metrics are calculated for each discipline within a university (as determined by two-digit Field of Research codes) such that results are only ever compared within disciplines (for example, Engineering at University X versus University Y) and not between them (for example, Engineering with History or Archaeology).

Consultations on this model have shown widespread support across the university and research sectors.



Driving research–business links can enhance product development.

As a follow-up to this significant report, ATSE is now working with state governments and universities in Queensland and South Australia to further refine the REA metrics, using data supplied directly by the universities. It is hoped that this ongoing work will help inform the Federal Government's policy development process around the *Boosting Commercial Returns from Research* and *Industry Innovation and Competitiveness Agenda* initiatives, and ultimately lead to an improvement in Australia's rates of business–research collaboration.

For some time, groups including ATSE have expressed concern about Australia's poor performance on business–researcher collaboration. This lack of cooperation is a barrier to the translation of research outcomes into economic and societal benefits.

A significant contributor is a lack of

incentives and recognition for university researchers who engage with industry and external groups. Initiatives such as Excellence in Research for Australia (ERA) recognise and reward excellence in research – and rightly so – but have the unintended consequence of disincentivising researchers from engaging with business and pursuing research impact.

To address this issue, ATSE put forward a proposal last August for a new set of metrics to better measure research engagement, which resulted in the Federal Department of Education and Training commissioning an ATSE report to further develop this idea, which commenced in October 2014.

The Academy convened a steering committee of ATSE Fellows, representatives from the Departments of Education and Training and Industry and Science, the Australian Research Council, the other Learned Academies, and the research and university sectors. The project team, led by Professor Peter Gray FTSE, also engaged widely with the university sector, including all of the major sector representative groups.

The project work was primarily conducted by Dr Tim Cahill, former director of ERA at the ARC, along with Dr Matt Wenham in the ATSE Office.

The REA Report is on the ATSE website at [Activity>Industry and Innovation](#)

TGA must stay independent

The Therapeutic Goods Administration (TGA) must remain independent to best protect the Australian population, ATSE said in its recent submission to the Department of Health's Expert Review of Medicines and Medical Devices Regulation discussion paper.

ATSE's submission highlighted several domestic benefits gained from the operational systems and reputation of the TGA, said areas of its regulatory framework should be protected, and made recommendations for change to further strengthen aspects of the TGA.

The submission briefly discusses:

- the need for continued support to the Clinical Trial Exemption and Clinical Trial Notification schemes;
 - current TGA resourcing and the need for public funds to cover public good activities;
 - the adoption of support measures for small to medium enterprises, similar to those undertaken by other international regulators;
 - the need for greater dissemination of information to the community;
 - the introduction of fast-track approval processes in Australia based on clear evidence for benefit to patients and unmet clinical need;
 - recent and continuous development of regulations for emerging technologies;
 - the TGA's leadership in undertaking international collaboration to reduce regulatory burden and duplication;
 - current TGA approval timeframes; and,
 - the adoption of online systems.
- ATSE also noted that regulations would need to continue to be developed for new and emerging areas such as complementary medicines, dietary supplements and stem cells.

The submission is on the ATSE website at [Activity>Health>Submissions](#)

ATSE IN ACTION

ATSE launches Gender Equity Working Group

Amid the acclaim of International Women's Day in March, ATSE was quietly working to establish a new Working Group on Gender Equity.

This followed earlier moves by the Academy to promote women within ATSE and across the STEM sector, driven by various female Fellows and strongly supported by ATSE Vice President Dr Susan Pond AM FTSE and ATSE CEO Dr Margaret Hartley FTSE.

The ATSE board has accepted a recommendation from Dr Pond and approved the establishment of the Working Group on Gender Equity, whose initial objectives are to:

- ensure that female Fellows derive maximum

benefit from their membership of ATSE;

- support ATSE's drive to increase the number of female Fellows elected; and
- promote gender equity in academia, research and business, especially in the STEM area.

Members of the Working Group are:

- Dr Mark Toner FTSE, Gender Matters (Chair);
- Dr Rosalind Dubs FTSE, Company Director;
- Mr Michael Edwards FTSE, Boeing Research and Technology Australia;
- Ms Kathryn Fagg FTSE, Company Director;
- Professor Douglas Hilton FAA FTSE, WEHI; and
- Dr Marlene Kanga AM FTSE, IOMniscient Pty Ltd.

ATSE's Gender Equity Policy targets

"...maximising participation and retention of women at all levels in technological sciences and engineering is a priority in terms of maximising productivity and innovation in Australia, as well as seeking social equity. The Academy reaffirms its commitment to the importance of the full participation of women in technological sciences and engineering in Australia, and in ATSE."

In recent years the proportion of female Fellows in ATSE has increased, rising from six per cent in 2010 to 10 per cent in 2014.

The ATSE board currently has equal numbers of male and female Fellows and the number of female Fellows participating in ATSE committees and forums has also increased.

The Working Group's first meeting will be held in April with future meetings to be held quarterly.

UNCONVENTIONAL GAS CONFERENCE AND WORKSHOP PLANNED

Following the ACOLA Securing Australia's Future Project 6 – Engineering Energy: Unconventional Gas Production, to which ATSE was a major contributor, there has been strong interest, both nationally and internationally, in holding an international Unconventional Gas Conference in Australia to explore the opportunities and challenges for unconventional gas production.

ATSE believes that unconventional gas is an issue of profound national importance that has the potential to impact on Australia's future prosperity.

The exploration and production of unconventional gas has encountered opposition in many areas of Australia for several complex reasons. Against this background ATSE intends to contribute to the development of evidenced-based policy and community understanding of the issues.

There is every possibility that sensible policies addressing the opportunities and challenges presented by unconventional gas can be developed.

ATSE is planning a two-day conference and one-day workshop on

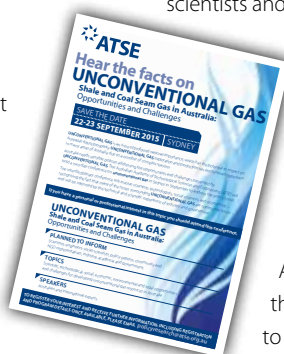
unconventional gas in Sydney in September. The Chair of the ACOLA report, Professor Peter Cook CBE FTSE, will also chair the Conference Committee.

The Conference will be interdisciplinary in scope, involving social scientists and economists as well as scientists and technologists,

as many issues surrounding unconventional gas are community issues. ATSE plans to provide the opportunity for the conference to be informed by the technical and scientific experience of industry and government.

The workshop component of the event will involve participants from partner international Learned Academies, who will discuss and synthesise results from their national reports on unconventional gas, with a view to informing policy development in Australia and overseas.

Fellows will be informed of the development of the event as planning progresses, and will be welcome to participate in the Conference.



SIX RESEARCHERS HEADING TO KOREA

Six emerging research leaders from Australian institutions will visit Korea in May under the Australia Korea Emerging Research Leaders Exchange Program (AK-ERLEP).

This second AK-ERLEP exchange will enable them to progress individual and institutional linkages, with funding from the Australia Korea Foundation, DFAT, and the Korean National Research Foundation. The first AK-ERLEP exchange enabled six Korean researchers to visit Australia in August 2014.

The Australian researchers are focused on promotion of healthy ageing, environmental sustainability and capturing the benefits of ICT in a digital economy. During their visit, they will visit an average of six research institutes to establish and develop linkages.

The six researchers selected are Professor Seok-Hee Hong, ARC Future Fellow, School of IT, University of Sydney; Dr Jonghyuk Kim, Senior Lecturer, Computer Vision & Robotics, ANU; Dr Yansong Shen, Research Fellow, Chemical

Engineering, Monash University; Dr M Akbar Rhamdhani, Faculty of Science, Engineering & Technology, Swinburne University; Dr Sarah Jeong, School of Nursing & Midwifery, University of Newcastle; and Dr Matthew Lewis, Centre for Mental Health & Wellbeing, Deakin University.

The National Research Foundation in Korea is organising the two-week program for the researchers, with a debrief session to take place in Seoul on 22 May, hosted by the Australian Embassy.

ATSE IN ACTION

Updated collaboration report launched

The updated report *Science Technology Innovation: Australia and India* was launched by Trade and Investment Minister Andrew Robb in January, during Australia Business Week in India (ABWI).

The report, by Australian and Indian scientists, identified the benefits increased collaboration projects would deliver for both countries, while also driving science and technology innovation in the 21st century.

The *Science Technology Innovation* report, first released in 2013, is a collaboration of the Australia India Institute (AII) and ATSE, with support from Rio Tinto. The report Task Force was jointly led by Australia's Professor Robin Batterham AO FREng FAA FTSE, former Academy President, and India's Dr Ramesh Mashelkar FRS FTSE. Professor John Webb OAM was the convenor.

The 2014 edition has been updated with recent developments in the collaborative relationship in science technology innovation between India and Australia.

Professor Amitabh Mattoo, Chief Executive of the Australia India Institute and Professor of International Relations, University of Melbourne, said this was the first ever report written collaboratively by more than 100 experts from Australia and India.

"This is a path-breaking report on an area of critical importance to the two countries. We look forward to working with the two governments for the implementation of the recommendations of the report," Professor Mattoo said.

The report contains a set of commissioned articles on key aspects of collaboration, including the impact of globalisation, the international context, the challenge of inclusive innovation, grass roots innovation and financing for innovation. It also contains an analysis of the Australia India Strategic Research Fund, Australia's single largest bilateral project of its kind with any nation to date.

Ms Nicola Watkinson, Senior Trade and Investment Commissioner – South Asia,

Dr Mashelkar at the 2013 report launch.



Australian Trade Commission, said the report demonstrated how both countries were developing a closer working relationship across many areas.

"Indian companies are increasingly partnering with Australian research institutions and life sciences companies for their R&D programs. They are also licensing Australian life sciences products and technologies, and exploring contract research opportunities with Australian research institutions," Ms Watkinson said.

There are 250 collaborative agreements between Australian and Indian research institutions – an increase of 400 per cent since 2003.

120 meet in Perth on coal technology

More than 120 key low-emissions coal technology leaders met in Perth in February at the ATSE/CERI Workshop, part of the 8th Australia-China Joint Coordination Group (JCG) on Clean Coal Technology Meeting, to promote closer low-emission coal technology linkages between Australia and China.

It was a very successful meeting that explored some new areas of technology, including how bioenergy with CCS (BECCS) might be combined with coal combustion or gasification to achieve true zero emissions.

The previous two ATSE/CERI RD&D workshops focused on advanced low-emissions coal (LEC) technologies under active development world-wide, such as gasification, PCC and oxyfiring.

The Perth workshop continued this theme, but also introduced some new areas that are gaining strength – including how BECCS combined with coal combustion or gasification can achieve true zero emissions,

chemical looping, catalysis of carbon dioxide reaction and microbial conversion of coal into methane.

The meeting also heard reports by Australian and Chinese researchers on developing partnerships and on research success achieved through the JCG Partnership program.

Key inputs came from Dr David Brockway FTSE, Dr Vaughan Beck FTSE, Ms Denise Goldsworthy FTSE and Professor Dongke Zhang FTSE.

CERI is the China Huaneng Group Clean Energy Research Institute, with which ATSE has an ongoing relationship.



David Brockway and CERI's Dr Xu Shisen at the Perth workshop.

ATSE IN ACTION

Technology is a key to healthcare, says ATSE

Technologies can play a major role in reducing healthcare costs, improve health outcomes and enhance quality of life when socially accepted and widely adopted.

They can also enhance Australia's economy if they are developed from a strong Australian industry base which draws on world-class research and development (R&D).

To deal effectively with changing demographics and patterns of disease, Australia must develop and deploy advanced technologies that are effective across the whole population, including the aged and people with disabilities.

These are three key points made in the Academy's recent response to the National Disability Insurance Agency's Discussion Paper 'Towards Solutions for Assistive Technology'.

ATSE said the rapid, national, large-scale deployment of assistive technologies (AT) is essential if the growth in healthcare costs

is to be contained, to reduce unnecessary hospitalisation and enable self-management of health.

Central to the deployment of AT is the need to develop policies and funding mechanisms to support efficient home services and the widespread use of AT. This could bring significant cost savings to both State and Federal governments and health and aged care consumers.

Policies and funding models needed to be consistent, robust, auditable, long-term and directed to those most in need.

ATSE said advancing technological solutions for a healthy Australia had been a focus of the Academy for a number of years, referencing its 2014 Position Statement on Health Technology and three subsequent Action Statements.

The response also referenced ATSE's



2010 report *Smart Technology for Healthy Longevity*, which surveyed the field in Australia and overseas and put forward nine recommendations to enable greater knowledge and uptake of health technologies in Australia.

It also referenced ATSE's 2014 interdisciplinary research project *Assistive Health Technologies for Independent Living* on behalf of the Australian Council of Learned Academies.

The response noted that some members of the Assistive Health Technologies for Independent Living Expert Working Group, and others, were forming a national network – named Smart and Enabling Technologies for Independent Living (SETIL) – to support technology development and uptake in the disability and aged care sector. Two ATSE Fellows, Professor Greg Tegart AM FTSE and Dr Erol Harvey FTSE, are involved in SETIL.

Partnerships the key to energy research



Long-term Federal support, stable policies and government subsidies and incentives could help encourage investment in research and development in the energy industry, ATSE has told ARENA in a response to the agency's request for input into its future R&D policies.

ATSE believes that industry is able to invest in R&D but some businesses are unwilling to invest due to increasing costs associated with high energy, labour, equipment and development costs in Australia.

Unlike the UK, the Australian regulatory environment for transmission and distribution

companies does not strongly encourage and support investment in research, development and demonstration (RD&D), ATSE said, and the lowering of incentives under RET revisions will most likely further disincline investment.

Also, the current economic squeeze on the Australian power industry (especially transmission and distribution companies) was actively deterring funding of R&D. In comparison, the UK, Europe and China were each investing in RD&D projects in priority areas and some countries have a mandated share of the electricity tariffs directed to research.

ATSE suggested to ARENA that industry–researcher partnerships could address a number of issues, including:

- electricity networks facilitating the charging of electric vehicles;
- storage at building scale, precinct scale and network scale;
- renewable liquid biofuels;
- total system approaches that address how demand or supply can be reduced at times when renewable energy is low; and

- end-use efficiency (buildings, appliances and systems).

ATSE said storage (including pumped hydro) and renewable biofuels were very important priority areas that ARENA should consider incorporating into future R&D priorities. Storage was a key priority area for Australia if intermittent energy-producing technologies were to be effectively used.

The Academy emphasised the need to incentivise for researchers to collaborate with industry and referenced its work with the Department of Education and Training to explore options for developing a metric of research engagement.

Providing incentives to both parties could help establish new industry–researcher partnerships to develop and deliver projects. For industry this may be financial incentives; for researchers it could include performance metrics that encourage industry collaboration.

The submission is on the ATSE website at [Activity>Energy>Submissions](#)

ATSE IN ACTION

ISME project gaining traction for STEM

The Academy's role in the new national science and maths education project (ISME) is well underway, with the first teacher training session – a 'train the trainer' and professional learning workshop – held at Southern Cross University, Lismore, in March.

Conducted by Mr Peter Pentland, ATSE's Executive Manager ISME and STELR, the Lismore workshop was designed to allow teachers from four pilot schools – Lismore, Richmond River, Kadina and Trinity Catholic College – to learn how to use equipment designed to encourage greater student participation in maths and science in their senior years.

The briefing saw him explain the contents of the equipment sets to the group of around 20 teachers before giving them the opportunity to recreate module scenarios as they would in the classroom setting.

Mr Pentland said the project involved at least five authentic, multidisciplinary classroom modules using cutting-edge science and engineering contexts and the latest educational theory from partner universities and other research institutions to excite and engage students.

"The modules will involve hands-on, inquiry-based science and mathematics activities supported by background information and career profiles of recent graduates working in relevant industries.

"The idea is to produce modules of work for secondary schools to make more kids choose to study maths and science in Years 11 and 12 and then go on to do these subjects at university."

Workshops and training

Once the new modules have been finalised they will be managed and distributed by ATSE as a part of the STELR program, which has been utilised in more than 440 secondary schools across Australia and New Zealand.

The first module to be developed is about sustainable housing. Prototype laboratory equipment has been developed that enables students to assess the effectiveness of building materials to passively control energy flows into and out of buildings.

ISME modules will support the National



Peter Pentland and Southern Cross University's Geoff Woolcott at the workshop.

Curriculum in Science and Mathematics as well as individual state curricula. The development of the new modules will be overseen by a Curriculum Committee, which comprises education academics from three universities and a practising teacher. The Curriculum Committee held its first meeting in Sydney in March.

Each university has recruited four schools to pilot the program. The schools have been provided with class sets of STELR Renewable Energy equipment. The schools will implement the STELR Renewable Energy program as this is the basis for the new modules.

ATSE will conduct workshops for teachers from pilot schools linked to the University of Wollongong and Charles Darwin University during the next few months.

Teachers at all the pilot schools will receive

professional learning training in STELR. Academics involved in training pre-service teachers from the universities will receive training so that they will be able to deliver the professional learning workshops in the future. This will build stronger relationships between the universities and secondary schools in their local regions.

When teachers are familiar with STELR philosophy and methodologies they will trial the new modules as they are developed. The schools will provide feedback on the modules, adjustments will be made where necessary and then the modules will be made available to schools throughout Australia.

This will be done through the networks of the Australian Science Teachers Association and the Australian Association of Mathematics Teachers.

ISME

The Inspiring Science and Mathematics Education (ISME) project is a collaboration between Southern Cross University, the University of Wollongong, Charles Darwin University and ATSE, through its Science Technology Education Leveraging Relevance (STELR) Project. The consortium received \$996,500 through the Australian Maths and Science Partnerships Program Competitive Grant Round, announced last year by Education Minister Christopher Pyne.

ATSE IN ACTION

ATSE backs IMNIS mentoring program

The Academy is supporting a new student mentoring program being developed by two former Clunies Ross Award winners, which aims to tackle the disconnect between academia and business.

The IMNIS (Industry Mentoring Network In STEM) concept came out of consideration of what type of activity, if sustained and replicated across Australia, might start to shift the culture of academic-industry interactions?

The IMNIS concept capitalises on the value of mentor relationships and the power of networks and plans to link PhD students with experienced mentors in industry to enhance students' understanding of business issues and language, and encourage better long-term collaboration between business and publicly funded research organisations.

OECD data shows that Australia consistently has one of the lowest levels of academic-industry engagement, despite government and business investment.

While mentoring programs and other course-related industry placement schemes already exist (usually course and institution specific), IMNIS aims to establish in the longer term a sustainable national industry mentoring network system to complement these existing activities.

The advantages of the IMNIS concept compared to existing programs are that it will:

- be scaleable across Australian universities and all STEM-based industry sectors;
- be capable of involving large numbers of PhD students;
- have a relatively low operational cost per student; and
- be able to capture the goodwill of the

PHOTO: ISTOCKPHOTO.COM



IMNIS – bringing people together.

numerous industry professionals who wish to give back to the STEM community.

The target is to recruit some 500 students STEM PhD students into IMNIS nationally, with a matching 500 industry-based mentors. IMNIS aims to have students see the program as highly prestigious, competitive and providing them with tangible benefits.

IMNIS seeks to recruit as mentors people who have strong industry backgrounds and commercialisation knowledge. While companies may support/encourage individuals to be mentors, IMNIS is not an industry placement or recruitment program.

IMNIS will be developed via a staged process, with small-scale pilot studies being implemented first. The results of these pilot studies will be used to shape and refine as needed the ongoing IMNIS program.

ATSE has established an IMNIS Steering Committee comprising:

- Professor Calum Drummond FTSE, Deputy Vice-Chancellor Research and Innovation

and Vice-President, RMIT;

- Dr Margaret Hartley FTSE, ATSE CEO;
- Dr Anna Lavelle FTSE, CEO AusBiotech Ltd;
- Mr Peter Laver AM FTSE, ATSE Senior Adviser, Research and former BHP senior executive.
- Dr Peter Lilly FTSE, Director, Engineering Zone (EZONE UWA), University of WA; and
- Professor Judy Raper FTSE, Deputy Vice-Chancellor (Research), University of Wollongong.

The IMNIS Project team is:

- Dr Paul Wood, IMNIS Executive Officer, who has held senior R&D roles in CSIRO, CRCs, CSL and Pfizer;
- Ms Ronnie Wood, who has more than 30 years' experience in the education and training sector;
- Dr Tony Radford, a biotech executive with 30 years' experience in pharmaceuticals and diagnostics; and
- Mr John Kirby AM, Deputy Chairman and non-executive Director of Village Road Show Ltd.

Paul Wood and Tony Radford were recipients of the Clunies Ross Award in 2013 for their work in improving tuberculosis diagnosis in cattle and humans.

Two pilots will be run in 2015, each for at least six months, to facilitate development of the IMNIS Project on a small scale. Experience gained in the pilots will facilitate the next stage of IMNIS development.

Pilot 1 will run in Victoria, target some 50 mentee students and focus on biotechnology, with participation from Melbourne, Monash and La Trobe universities. The industry coordinating organisation is Ausbiotech, with oversight from Dr Lavelle.

Pilot 2 will run in Western Australia and focus on energy and mineral resources with participation from all four WA universities – UWA, Curtin, Edith Cowan and Murdoch. It will also target some 50 mentees. The coordinating organisation will be UWA's EZONE, with oversight from Dr Peter Lilly.

The aim is to eventually deliver mentoring networks nationally, covering a wide spectrum of STEM fields of study and focusing on the ATSE National Technology Challenge areas.

The IMNIS team has had provisional discussions with a Melbourne company, Mentorloop, which has developed software for managing not-for-profit mentoring programs that enables mentees and mentors to connect and communicate in real time.

AGRICULTURE REPORT DUE IN JUNE

The final report of the study into the future of agriculture in Australia is due to be launched in June. ATSE is providing project management support for this ACOLA Securing Australia's Future Project 7 *Australia's Agricultural Future*, with an Expert Working Group, chaired by Dr Joanne Daly PSM FTSE. The EWG is currently drafting the report.

The project examines the drivers of demand; the returns, resources and risks; and the social and political context of Australia agriculture. The EWG met with the three groups of consultants preparing reports for the project late last year and, on receipt of their reports in January, held a discussion workshop in February.

WOMEN IN TSE

NHMRC launches gender policy

The National Health and Medical Research Council (NHMRC) has announced a new gender equity policy to support the retention and progression of women in health and medical research.

The revised Administering Institution Policy aims to address the under-representation of women in senior research positions across Australia and applies to all institutions that receive NHMRC funding. In 2014, women accounted for 63 per cent of all applications for NHMRC early career fellowships, but this figure fell to just 11 per cent for the most senior and experienced NHMRC fellowships.

Institutions will have until the end of 2015 to update their gender equity policies and submit them to the NHMRC for consideration. They should have:

- a strategy that addresses the under-representation of women in senior positions in health and medical research;
- mentoring and skills training strategies that promote and seek to increase women's participation;
- provision for parental/maternity leave and carers' leave, and transitional support to encourage return to work;
- work arrangements that cater for individuals with caring responsibilities;
- remuneration equity between men and women with the same responsibilities;
- employment strategies that encourage the recruitment, retention and progression of women in health and medical research; and
- strategies to address the need for the provision of support for childcare.

The revisions and requirements were developed following extensive consultation with the research sector and follows the NHMRC's survey of existing policies last year.

"By and large, this sector is highly responsible and wants to do the right thing by their staff. But unfortunately, when the statistics show that women are leaving research in numbers that increase drastically over the course of their careers, I think we can all acknowledge that we all need to do more," said NHMRC CEO Professor Warwick Anderson AM.

CANCER RESEARCHER IS NSW WOMAN OF THE YEAR

UNSW pancreatic cancer researcher Professor Minoti Apte OAM has been named the 2015 NSW Woman of the Year for her contributions to medical research, tertiary education and the Indian community.

Professor Apte is director of the Pancreatic Research Group and is an acknowledged world leader in alcohol-induced pancreatic injury and pancreatic cancer research.

Professor Apte's work investigates pancreatic cancer at a cellular level to find out how and why the cancer is so aggressive and spreads so quickly. She was the first in the world to develop a method to isolate pancreatic stellate cells (PSCs), a technique that provided a tool for studying the path that pancreatic fibrosis (scarring of the pancreas) takes.

Her group established that PSCs were responsible for producing the prominent scar tissue in pancreatic cancer and that there was a close communication between PSCs and cancer cells. This important finding

proved that cancer cells recruit normal pancreatic cells from their microenvironment and turn them into co-conspirators to help the cancer grow and spread to distant parts of the body.

She is currently leading pre-clinical studies that are primed to suggest new treatments for pancreatic cancer, the fifth leading cause of all cancer deaths in Australia.

Accepting the award Professor Apte called on State and Federal governments to make increased funding in medical research a higher priority and called for better support for women seeking to balance family and career.



Minoti Apte

WOMEN DOMINATE YOUNG RURAL SCIENCE GRANTS

Young women won nine of the 11 grants, totalling close to \$250,000, awarded to Australia's best young researchers, innovators and scientists to progress research that will help increase productivity on farms and across rural industries.

"The Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry recognise the cream of Australia's home-grown scientific talent and awards them each up to \$22,000 in grant funding," Agriculture Minister Barnaby Joyce said, announcing the awards at Outlook 2015 in Canberra.

The 2015 Minister's Award, for an extended research project, was won by Dr Alice Hayward, from the Queensland Alliance for Agriculture and Food Innovation at the University of Queensland, for her research on avocados. Other grants were awarded to projects including:

- reducing the time it takes to identify herbicide resistance in significant agricultural weeds from up to nine months to three weeks;
- developing an electronic shepherd that will analyse dog barks or noises associated with sheep in distress and alert the farmer when an attack by wild dogs is happening;
- computer modelling to help identify appropriate techniques to decrease the impact of bushfire smoke taint on wine flavours and quality; and
- developing a diet for young female pigs to reduce lameness that can affect one in 30 pigs.

THE 2015 WINNERS ARE:

- Australian Grape Wine Authority award – Julie Culbert, South Australia;
- Australian Meat Processor Corporation award – Jessica Tan, SA;
- Australian Pork Ltd award – Tracy Muller, Queensland;
- Australian Wool Innovation award – Greg Falzon, NSW;
- CSIRO Biosecurity Flagship award – Nadine Chapman, NSW;
- Dairy Australia award – Jean Drayton, NSW;
- Fisheries R&D Corporation award – Emma Wilkie, NSW;
- Grains R&D Corporation award – Aaron Preston, NSW;
- Horticulture Innovation Australia Ltd award – Alice Hayward, Queensland;
- Meat & Livestock Australia award – Sarah Stewart, WA; and
- Rural Industries R&D Corporation award – Sonia Liu, NSW.

WOMEN IN TSE

Engineers call for more women

Engineers Australia marked International Women's Day in March with a call to encourage more women to pursue a career in engineering.

"We are significantly underutilising a key part of our highly skilled workforce. Engineering is a creative and intellectually challenging profession which offers a diverse and satisfying career for both men and women," said Ms Nee Nee Ong, Chair of Engineers Australia's Women in Engineering National Committee (WIENC).

"Currently Australia produces around 9500 engineering graduates each year, of which only about 16 per cent are women. This proportion falls further upon entry to the workforce, with women making up only 11.2 per cent of the engineering labour force.

"Adding to this, there are significant losses of female engineers over career timeframes, female engineers experience higher unemployment levels than their male counterparts and tend to earn less as well.

"Clearly, women still face barriers in pursuing a career in engineering."

PAY GAP BIGGEST IN MANAGER RANKS

New data released recently by the Workplace Gender Equality Agency (WGEA) shows women in management ranks get paid less than their male peers.

Based on full-time total remuneration, the largest gender pay gap occurs at key management personnel level (28.9 per cent), followed by other executives/general managers (27.5 per cent), then other managers (24.6 per cent) and senior managers (23.5 per cent).

At the 'key management personnel' level, the largest gender pay gap is found in Administrative and Support Services (44.7 per cent), followed by Arts and Recreation Services where the gap is 35.1 per cent.

Administrative and Support Services also has the largest gender pay gap at the 'other manager' level (23.1 per cent). Financial and Insurance Services has the largest gender pay gap for other executives / general managers (34.4 per cent), while Retail Trade has the largest gender pay gap for senior managers (28.7 per cent).

Director of the WGEA, Ms Helen Conway, said the data revealed for the first time how the gender pay gap existed at every level of management across WGEA's reporting population of more than 11,000 employers.

"The data clearly shows women in management aren't accessing the same earning opportunities as men. This is partly due to the fact that women gravitate to roles the market typically assesses as being of lower value.

"Employers who are committed to creating equal access to opportunities for women and men need to work harder to remove barriers that inhibit women from entering these higher-paying roles.

"A lack of quality flexible work, the legacy of workplace cultures built on the male breadwinner model and gender bias are likely to be among the barriers that need to be tackled," Ms Conway said.

Pay inequity also persists below management ranks with pay gaps favouring men in every non-manager occupation. Even in female-dominated roles such as community and personal service

work, and clerical and administrative roles, there is a gender pay gap in favour of men.

The data shows that, overall, the pay gap in each manager and non-manager occupational category was higher when calculated based on total remuneration compared to base salary, suggesting women are receiving a smaller portion of discretionary payments.

Research shows women face a double bind when negotiating pay whereby attempts to assertively argue their value are viewed more harshly than when a man exhibits the same behaviour, which results in women being less likely to put forward their case for higher pay.

The WGEA is an Australian Government statutory agency created by the Workplace Gender Equality Act 2012 charged with promoting and improving gender equality in Australian workplaces.



PHOTO: UNSW

These University of NSW students face lower management wages than their male peers.

NSW LAUNCH FOR SCIENCE 50:50

Science 50:50, the initiative to inspire Australian girls and young women to pursue degrees and careers in science and technology, was officially launched in NSW in March at a Women in Science Symposium at the National Maritime Museum.

Science 50:50 is driven by ARC Laureate Fellow Professor Veena Sahajwalla FTSE. In addition to the Fellowship, focused on e-waste, she was awarded the Georgina Sweet Award, which is the funding source of the scholarships the Science 50:50 will provide. The aim of the event – and the campaign – was to inspire Year 12 girls to go into a science field and to announce the scholarship competition opening mid-year.

W21 SYDNEY WORKSHOP

The US Studies Centre at the University of Sydney will host the inaugural W21 one-day workshop on 'Leadership for Gender Equality and Organisational Excellence', on 27 May. It will be facilitated by Professor Iris Bohnet, of Harvard University, who is a world-leading scholar on women, leadership and gender equality.

The event will be organised with the Behavioral Insights Group, Center for Public Leadership, Harvard Kennedy School, and the Women and Public Policy Program, Harvard Kennedy School. The workshop will focus on what works to close gender gaps, based on insights from behavioural economics, which incorporates psychology and economics and draws on evidence, often derived from field experiments, to understand what works. It has been used to inform decision- and policy-making in many different domains, ranging from fiscal policy to energy consumption to marketing.

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Xinhua Wu, from Monash,
with a printed jet engine.



Monash prints jet engines

Monash University researchers and their spin-out company AMAERO, along with collaborators from CSIRO and Deakin University, have printed two jet engines. One was on display at the International Air Show in Avalon, in February, while the second is displayed in Toulouse at the French aerospace company Microturbo (Safran).

The engines are a proof of concept that has led to aerospace companies lining up to develop new components at the Monash Centre for Additive Manufacturing in Melbourne and created advanced manufacturing opportunities for Australian businesses.

"It was our chance to prove what we could do," says Professor Xinhua Wu FTSE, Director of the Monash Centre for Additive Manufacturing.

"But when we reviewed the plans we realised that the engine had evolved over years of manufacture. So we took the engine to pieces and scanned the components. Then we printed two copies." It was a complex project that took a year and funding from Monash University, the Science and Industry Endowment Fund (SIEF) and other sources.

"Xinhua and her Monash team have demonstrated their mastery of additive manufacturing in metal," said Jean-François Rideau, from Microturbo (Safran). "Monash and AMAERO are already key partners for our new developments and we are keen to have their help in developing new technologies for our future engines."

JEANS MEANS A SAFER RIDE

A collaboration between Deakin University and Australian jeans manufacturer Draggin Jeans means that Australia's famous motorcycle denims, already the safest jeans in the world, will become a lot safer.

Dr Chris Hurren, Textiles Research Fellow within Deakin's Institute for Frontier Materials, has been working on further improving the abrasion resistance of Draggin's denim jeans. By modifying the placement and types of fibres used in the protective layer, Dr Hurren has been able to almost double the abrasion resistance of the current fabric.

Kevlar is well known for its outstanding strength, being used in

The CEO of Draggin Jeans showed just how safe his jeans were in the late 1990s when he allowed himself to be dragged along a road in his jeans at more than 100 km/h, then got up and walked away without a scratch. Draggin Jeans has since become the world leader in denim/Kevlar motorcycle clothing.

bullet-proof clothing, body armour, sports equipment, brakes and various other applications. Synthesised from polymers, it is lightweight, yet has five times the strength of steel on an equal-weight basis. But if Kevlar is not used correctly it provides little or no protection to the wearer. The structure of the protective layer is key to protecting riders when they slide.

Central to developing the protective layer is rigorous testing with Deakin's belt abrasion tester, the only one of its kind in Australia. This provides researchers with a good understanding of the way the product performs and has given Draggin an edge over its competitors.

Dr Hurren said that 75 per cent of motorbike accidents occur at below 50 km/h, which gives riders a good chance of surviving. If they are wearing protective clothing, they are 80 per cent less likely to sustain injuries. But less than 45 per cent of motorcyclists wear protective clothing below their torso, despite the fact that most injuries affect this half of the body.

Based at Fishermans Bend, Draggin Jeans developed the first denim jeans to meet European standards for abrasion, burst and tear resistance. The jeans are made with natural fibres and lined with soft, breathable Kevlar knitted so that the loop of the weave faces the road, which acts to slow down the fallen motorcyclist, reduce friction and minimise injury.



Dr Chris Hurren and the jeans.

LIGHTNING MAINTENANCE GOES TO BAE AND TAE

BAE Systems will carry out heavy maintenance of the RAAF's Lockheed Martin F-35 fighter jet in Australia from 2018 and Tasman Aviation Enterprises (TAE) will service its engines.

Work under the contract will be undertaken at RAAF Williamtown, NSW, where BAE Systems currently supports the total sustainment of the Hawk MK 127 Lead-In Fighter fleet.

Australian Defence Minister Kevin Andrews said the deal showed the economic benefit of the country's participation in the stealth fighter program.

"The F-35 is the most advanced fighter aircraft in development or production anywhere in the world and securing this work in Australia is a great outcome for these companies," he said. "The assignment of regional (Southern Pacific) maintenance, repair, overhaul and upgrade responsibility to BAE and TAE will enable them to demonstrate the capability and capacity of Australian industry to support this leading edge capability."

Mr Andrews said BAE Systems Australia was one of Australia's leading Defence firms and had been a long-standing provider of sustainment services to a range of military aircraft.

TAE, based at RAAF Amberley, Queensland, was a leading aerospace engine maintenance service provider, supporting both military and commercial aircraft in the Asia-Pacific region.

Maintenance work for the North Pacific region would be done in Japan, Reuters reported.

By Sue Wilson
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Maths teacher 'gender bias' affects girls later

The context of rapid social and technological changes on a global scale heightens the demands on critically aware citizens to be mathematically literate.

In addition, mathematically literacy is an important aspect of equity in modern society, hence mathematics education involves issues of inclusion and social justice.

Against this international background, ongoing publicity has been given to widely reported concerns in Australia about the inertia in levels of mathematical and scientific literacy demonstrated in international surveys such as Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA).

This occurs in an educational environment marked by falling levels of participation in mathematics and science – both in senior high schools and in some university courses – and a lack of trained mathematics and science teachers.

These issues are not exclusive to Australia and, at the same time, maths anxiety is reported as an issue in many countries. Students' self-perception as learners of mathematics is vital to encouraging them to study at higher levels, and girls in particular report that support from teachers has an important impact on their decisions.

Recent research (Lavy & Sand, 2015)

has reported that some teachers mark boys' primary school mathematics tests more favourably than girls, impacting girls' uptake of advanced mathematics and science subjects in high school. Entrance rates into mathematics and science degrees at university level could also be traced back to the impacts of teachers' gender bias in primary school, according to this research.

Higher levels of mathematics and science education have been linked by the OECD to greater employment opportunities and higher earnings, meaning a primary teacher's attitude towards mathematics can have a serious impact on a child's future success.

The researchers followed nearly 3000 students in Israel, from 6th grade to the end of high school. As a measure of 'teacher bias', they compared school 6th grade mathematics test marks given by teachers who knew the students' sex, with previous external test marks for the same students, with identifying characteristics removed.

The researchers identified that a worrying number of teachers gave boys higher mathematics test results than girls who had received equal marks on the external test. The researchers studied the long-term effects of this bias.

The study found that the effects of this teacher bias persisted for girls, leading to poorer results through their high school years. However, many

boys whose teachers over-assessed their performance in the early years went on to be successful in mathematics and science.

How students see themselves as learners is vital to encouraging them to study at higher levels. Results from long-term studies of the 'pipeline' into STEM (science, technology, engineering or mathematics) degrees (Maltese & Tai, 2011) have shown that the way students rate their abilities in mathematics and science in 8th grade has a positive effect on how likely they are to earn a STEM degree.

Girls in the study reported they were getting less support from "biased" teachers – support that is important for their future studies. A study of first-year STEM students developed by international universities (Wilson, Lyons & Quinn, 2014) found that Australian girls (more than boys) rated personal encouragement from teachers as very important in choosing university courses.

The bias shown in the study reflects the gender stereotype that girls and women cannot do mathematics. Research has shown that stereotype threat impacts mathematics achievement (Maloney, Schaeffer & Beilock, 2013) and that employers also show bias against hiring women for mathematical tasks (Reuben, Sapienza & Zingales, 2014).

But studies of international test results (Guiso *et al.*, 2008) show the gender gap disappears in countries with more gender-

GOVERNMENT ADDS NEW COMMERCIALISATION AWARD

The Government has added a new award to the 2015 Prime Minister's Prizes for Science, which will recognise the practical and commercial successes of Australian scientists.

Minister for Industry and Science Ian Macfarlane said the new prize, the Prime Minister's Prize for the Commercial Application of Science, would promote building better links between researchers and industry and encourage entrepreneurship in our business and research communities.

In their 15th year, the Prime Minister's Prizes for Science recognise outstanding achievements in science research and excellence in science teaching, and are Australia's pre-eminent annual science awards.

The new prize for commercialisation of science complements the

other prizes, which have recognised discoveries such as the cervical cancer vaccine, technology that made wireless computing fast and reliable, evidence of dark matter and dark energy in the universe, and technologies that help to make the oil and gas industry safer and more efficient.

The introduction of the new prize means total prize money has increased to \$700,000 across the six prizes to be awarded in 2015:

- the **Prime Minister's Prize for Science** (\$250,000) recognises a significant advancement of knowledge through science;
- the **Prime Minister's Prize for the Commercial Application of Science** (\$250,000) is awarded for the translation of science knowledge into a substantial commercial impact;

equal cultures such as Norway and Sweden, indicating that these are cultural biases that may be altered.

These studies raise red flags for the teaching profession, and prompt reflections on what teachers can learn from such research carried out in other countries and its implications for the classroom.

In their study, Lavy & Sand reported that older, single teachers show more bias towards boys. The sex of the teacher is also an important factor to consider. Most primary teachers are female and this factor is relevant to the discussion of the implications for the classroom.



Students get excited about a school science project. Breaking the anxiety barrier in maths is another challenge.

MS SUE WILSON is a lecturer in science education and mathematics education at the Canberra campus of the Australian Catholic University. Her research interests are investigating bibliotherapy to address maths anxiety in primary pre-service teachers and Education for Sustainability in pre-service teacher education. She is the ACT Coordinator of the Interest and Recruitment in Science (IRIS) study and the Coordinator of the ACT Education for Sustainability in Pre-service Teacher Education project. She is the Vice-president of the Canberra Mathematical Association, Vice-President of the Council of Australian Capital Territory Education Associations and a Director of the Australian Professional Teachers Association.

Maths anxiety is a real issue

In many countries across the world children are being tested at an unprecedented level, along with an increased emphasis on accountability and standards.

Concerns have been raised about what is being tested: is it the knowledge and skills of the student or the educational quality of the teacher or school? Many question the time (Center for American Progress, 2014) and energy taken to prepare students for tests. Another major concern that has been raised is the stress caused by students' anxiety about the tests.

Academic and popular writing contains examples of stories of people who do not perform well in test or evaluation situations. Many concerns that are raised about testing, particularly by parents, relate to the stress they see in their children. Maths test anxiety (Hembree, 1988) has been identified as a major factor in maths anxiety and students with maths anxiety may not achieve their full potential unless their maths anxiety is addressed (Wilson, 2014).

Some female primary teachers report that they are unwilling to teach Year 5 or 6 because of their feelings about maths (Wilson, 2009). Researchers of primary students (Beilock *et al*, 2010) reported that if female teachers have high maths anxiety, this can affect students' achievement, especially female students, reinforcing the attitudes and responses assimilated from the society around them.

Many adults' feelings of fear and failure and anxiety about mathematics date from their early school experiences (Buckley, 2013). Avoiding mathematics can limit future opportunities in our modern technological society. Maths anxiety is reported as an issue in many countries, and across different cultures, and is independent of ability.

Maths anxiety and avoidance limits choices and chances for individuals to achieve their goals. This has profound and lasting consequences for those who are excluded from access to opportunities. Being mathematically literate is an important aspect of equity in our society. Research addressing maths anxiety in teachers is important in breaking the cycle of maths anxiety reproduced in classrooms. The impact of how teachers position their students in relation to mathematics has profound and lasting consequences.

It is important to broaden the current discussions beyond the lack of mathematical computation skills to understanding what causes such widespread maths anxiety in our society and why it is so persistent; then, how it might be addressed.

Current research, such as Wilson (2014), which aims to address the issue, is investigating the level of maths anxiety in beginning pre-service teachers, how they describe their mathematics experiences, what influenced the way they think about themselves as learners and potential teachers of mathematics and how they might reconstruct these perceptions of themselves.

Addressing maths anxiety in pre-service teachers is particularly important because it can interrupt the anxiety cycle before teachers enter the classroom, and heighten teachers' awareness of the importance of social and emotional wellbeing in their interactions with their students.

– Sue Wilson

- the **Frank Fenner Prize for Life Scientist of the Year** and the **Malcolm McIntosh Prize for Physical Scientist of the Year** (both \$50,000) acknowledge the work of our best early to mid-career scientists; and
- the **Prime Minister's Prize for Excellence in Science Teaching in Primary Schools** and the **Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools** (both \$50,000) recognise excellence in science teaching with prize money shared equally between the recipient teacher and their school.

Nominations for shortlisting closed on 26 March, with shortlisted nominees required to submit complete applications by 28 May.



Molten slag is spun out into droplets and cooled for use in cement manufacture.

Furnace waste helps make cement

Australian technology that harvests blast furnace waste and converts it into a new product to make cement is being trialled for commercialisation in China, where 60 per cent of the world's iron waste is produced.

The process, known as Dry Slag Granulation, also reduces water use and greenhouse gas emissions (GHG), and is the focus of an agreement signed by CSIRO and the Beijing MCC Equipment Research and Design Corporation (MCCE).

The agreement, to demonstrate CSIRO's Dry Slag Granulation (DSG) technology at industrial scale, is a landmark for Australia-China research collaboration and for environmentally friendly metal production, according to Director of the CSIRO Mineral Resources Flagship, Mr Jonathan Law.

"The benefits from wide uptake of DSG technology on blast furnaces will be profound in helping the global industry to reduce water and energy use and GHG while sustaining metal production," he said.

The DSG technology that is fitted to blast furnaces includes a spinning disc and granulation chamber that separates molten slag into droplets under centrifugal forces, uses air to quench and solidify the droplets, and extracts a granulated slag product as well as heated air.

The process produces a 'glassy' product that is ideal for cement manufacture, but has significantly lower associated GHG than cement produced by conventional methods.

Air at 500°C to 600°C extracted from the DSG process can be used onsite for drying, preheating or steam generation. The technology also saves water and eliminates the underground water pollution that can be associated with alternative wet granulation processes.

"The benefits each year from full commercialisation and adoption of DSG technology are in the order of 60 billion litres of water, 800 petajoules of heat energy and 60 million tonnes of GHG," Mr Law said. "Those savings are equivalent to 14 per cent of Australia's energy use and about 10 per cent of our GHG each year."

Under the agreement MCCE is to scale-up and demonstrate the technology at industrial scale and, upon success, commercialise it in China and then potentially worldwide. The agreement is the culmination of more than a decade of DSG technology development by CSIRO and industry partners including Arrium and BlueScope.

AUSSIE 'OZBOT' STANDING TALL

OzBots are proving tough and fearless allies for a growing number of Australian law-enforcement agencies.

The OzBot was designed by specialists from Deakin's Centre for Intelligent Systems Research (CISR) after an initial approach by Victoria Police. At only 14.5 centimetres tall, it can climb stairs, carry a person and even tow a car. Since its genesis several years ago, the OzBot has evolved into a family, consisting of the 18-kilogram OzBot MK8 – and its sturdy little brother, OzBot Jnr.

The remotely controlled OzBots are already in service within a number of Victorian and Queensland police units, such as the Special Operations Group, Bomb Response Unit and Police Negotiators. Their potential in other fields is also emerging, with applications in areas such as domestic law enforcement, aeronautics and environmental management being explored.

An OzBot base platform has also been used to demonstrate the Australian Defence Force-funded 'OzTouch' haptically enabled manipulator. This state-of-the-art technology allows technicians to remotely touch and feel things such as Improvised Explosive Devices (IEDs) or landmines.

The OzBot provided a new level of situational awareness for technicians interrogating objects of interest, said inventor, Dr James Mullins. "Operators can be 500 metres from the object, but interact with it as if they were using their bare hands."

His Deakin colleague and OzBot co-inventor, Dr Mick Fielding, added that the OzBots were usually used as a 'first responder' in security events, providing operators with live video, illumination and bi-directional audio.

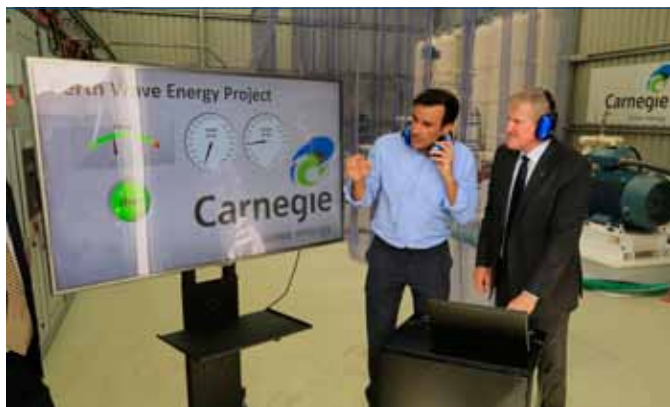
"The OzBot helps to protect operators in many hazardous environments," Dr Fielding added.

"It can be tasked to incidents where there is a threat from chemical, biological or radiological materials, bomb disposal, or hostage situations.

"It can also be used to inspect beneath aircraft while engines are spooled or under conditions that are unsafe for people and – given their small size – can be used to conduct searches along the aisles of an aeroplane or within cargo areas."



James Mullins (left) and Mick Fielding.



Carnegie wave energy making power, water

Carnegie's Perth Wave Energy Project at Garden Island in Western Australia has broken ground by supplying the first wave-generated power to the state's electricity grid. It was officially switched on in February by Industry and Science Minister Ian Macfarlane.

The project has \$13 million of Federal Government funding through the Australian Renewable Energy Agency (ARENA) and the Government is investing a further \$13 million in developing the next generation of Carnegie's wave technology.

"This project will supply power to Australia's largest naval base, HMAS Stirling, in a tremendous achievement for both Carnegie and wave energy in Australia," Mr Macfarlane said.

"It's the first time in Australia's history that a renewable wave power array has been connected to one of our major electricity grids. The project has the dual benefit of also including a desalination plant, which produces zero-emission fresh water from the waves."

Carnegie's CETO 5 wave energy technology is a world-leading, home-grown product that has been developed over 10 years by Carnegie, with submerged buoys that operate under water, away from large storms and not visible from land, moving with the motion of the waves to drive offshore seabed pumps.

High-pressure water from CETO 5 buoys drives onshore hydroelectric turbines with 720kW peak capacity and feeds a desalination plant, providing renewable energy and fresh water.

"Australia has great potential for further wave energy applications, with the resources on our south and south-west coast among the best in the world. It makes sense to tap into this renewable potential that will help diversify our energy mix," Mr Macfarlane said.

"The Carnegie project is great evidence of a commercial success in renewable energy. This type of practical application will guide future development of Australia's renewable energy sector."

ANOTHER \$25 MILLION FOR CCS RESEARCH

The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), which is globally recognised for its work on carbon capture and storage (CCS) at its Otway geological storage test facility, will receive a further \$25 million from the Australian Government.

"The grant ensures that this critical research continues for five more years and we expect to see important technological improvements to

Carnegie CEO Dr Michael Ottaviano (left) and Minister Macfarlane switch on the Perth project.

CCS modelling, monitoring and verification as a result," said the Minister for Industry and Science, Ian Macfarlane.

"The end goal is the wide-scale deployment of an effective system for capturing carbon dioxide and storing it safely underground. Given Australia's reliance on coal-fired electricity and our abundance of fossil fuels, funding this scientific research into CCS is a sensible investment in the nation's future.

"Australia has world-leading CCS projects underway as well as developing new processes for converting coal mine methane to energy. This funding for the CO2CRC Otway project underlines the Australian government's support for CCS and low-emissions technologies in Australia."

The Australian Government funding, which will be provided to CO2CRC under the CCS Flagships Program, will be matched by cash and in-kind contributions from CO2CRC members. This includes \$10 million from the Australian coal industry's Coal21 Fund and a \$5 million Victorian Government grant announced in September 2014.

ROOFTOP SOLAR PV WITH BATTERY TRIALS

The Australian Renewable Energy Agency (ARENA) has provided \$3.3 million funding for Synergy, a WA Government energy corporation, to trial a combination of rooftop solar photovoltaic (PV) with battery storage at a new housing development in Alkimos Beach, north of Perth.

ARENA CEO Ivor Frischknecht said the model being trialled included new tariff options for consumers and had the potential to be replicated in future residential developments across Australia.

"The trial will involve combining 1.1 MWh of centralised lithium-ion battery storage with more than 100 rooftop solar PV systems," Mr Frischknecht said, noting that "cost-effective energy storage will become increasingly important in the quest to include more renewables in our electricity grids".

The four-year trial, starting next year, will provide new information about how to deliver value from solar PV for consumers, developers, electricity retailers and network operators with enabling technologies.

Mr Frischknecht said residential electricity storage would allow network operators to manage demand more effectively by delivering stored power into the grid at peak times.

An Alkimos Beach home with rooftop solar PV.



Aircraft recycling takes flight

Thousands of tonnes of aluminium alloys that make up about 80 per cent of the world's aircraft still go to landfill, but Deakin University researchers have developed the technology that should open the way to recycling the bulk of the 200,000 aircraft currently traversing the airways.

This would see about six million tonnes and billions of dollars' worth of high-performance aluminium alloys retained within the airline industry.

With up to half of all aircraft due to retire in the next 10 years, the breakthrough has come at the right time.

Recycling aluminium alloys would also achieve massive energy savings, with smelters in Australia, for instance, accounting for 10 per cent of the nation's power use.



Thomas Dorin found that copper is the key to recycling aluminium alloys.

Deakin metallurgist Dr Thomas Dorin and his co-workers have developed the ground-breaking process and built a prototype at Deakin's Institute for Frontier Materials – and the recycling process enhances the alloys' performances.

"Our technology could lead to the recycling of around 500,000 tonnes of aircraft aluminium annually," Dr Dorin said.

"It could save the airline industry – and other industries that use aluminium alloys – millions of dollars, as well as achieving major energy savings and reducing the world's greenhouse gas emissions."

Pure aluminium is highly stable. About 70,000 tonnes – mostly packaging – is recycled in Australia each year; about two-thirds of the aluminium ever made is still in existence.

But alloys have not been so easy to recycle. Containing elements such as copper, magnesium and manganese, these alloys provide the strength-to-weight ratio and corrosion resistance needed to make aluminium strong, safe and ideal for aircraft.

The Deakin breakthrough came when Dr Dorin realised the thermal conductivity of copper achieved the rapid solidification needed to refine the alloy impurities in recycling aluminium alloys.

Dr Dorin – who made the move from France to Australia over a year ago – says the new aluminium alloy recycling process is cheaper and simpler than any existing process, achieving the final product in only one step. It also results in reduced impurities, improved corrosion resistance and toughness – allowing the alloy to be reused for similar applications.

It will also work for other aluminium alloys, such as those used in the automotive, construction, marine or sports industries.

DSTO LINKS WITH AIRBUS

DSTO has formed a new strategic alliance with Airbus Group Australia Pacific.

The alliance will see the two organisations work closely together on a range of research and development projects related to aerospace defence technologies.

In particular, it will facilitate collaboration between DSTO and the Airbus Group in defence aircraft systems (including helicopters) and communications. Initially it will focus on maximising the capability of ADF aerospace fleets throughout their service life, and on improving communications capability.

Chief Defence Scientist, Dr Alex Zelinsky FTSE, said the alliance was a further step forward in strengthening the ADF's aerospace capabilities.

CAVE IS A VIRTUAL FUTURE FOR ENGINEERING

Walking inside a virtual jet engine to 'see' potential design flaws is just one possibility offered by the virtual reality (VR) CAVE within Deakin University's new state-of-the-art engineering facility, based within the Centre for Advanced Design in Engineering Training (CADET).

Due to be launched this year, the Cave Automated Virtual Environment (CAVE) is set to offer some of the best future-focused engineering and design facilities in any Australian university.

A partnership between Deakin University and the Australian Government, CADET will feature more than \$6 million worth of cutting-edge technologies and specialist learning aids – focused on digital manufacturing, rapid prototyping, 3D printing, modelling and visualisation technologies.

CADET aims to enable students, researchers and industry to experience and master the tools and techniques that will create the next generation of Australian manufacturing.

"Imagine being inside a 25 cubic metre area where you are surrounded by 3D virtual reality and you can see, hear and touch everything in the environment," said Deakin mechatronics expert Dr Ben Horan, who designed the laboratory.

"Users will be able to move around and through models of new designs, such as machinery, prototypes, buildings, or even human scenarios, at any scale, depending on the nature of the project."

"What makes our CAVE unique is that we have designed it to be versatile enough to support a wide range of research applications through the integration of an array of cutting-edge technologies," he said.

"The VR CAVE offers high realism and high resolution. It is totally immersive, with full peripheral vision. For instance, you could be physically exploring the inside of an aircraft design and not only be able to visualise in high resolution 3D vision, but, through haptics technology, be able to use your hands to touch and feel the various components of the aircraft interior – all before the creation of any physical prototype."



Mechatronics expert Ben Horan designed the CAVE.

Researchers conquer ballistics armour

Less than a decade ago the Defence Science and Technology Organisation (DSTO) put out a challenge to Australian scientists – find a way to put curves into ballistics materials.

Now Australian researchers have helped develop the capability to produce shapes that enable the manufacture of non-spliced combat helmet shells, which are lighter, stronger, better performing and cheaper to produce than previous designs.

Deakin University's Institute for Frontier Materials Deakin chief investigator Dr Minoo Naebe and research engineer Mr Madhusudan Suryanarayana worked in collaboration with the Defence Materials Technology Centre (DMTC), the Victorian Centre for Advanced Materials Manufacturing (VCAMM), Pacific ESI, Ballistic and Mechanical Testing, DSTO and independent manufacturer Australian Defence Apparel (ADA).

The team developed a unique process – Double Diaphragm Deep Drawing (D4) – to curve and harden the Kevlar-style ballistic fibres into the correct shape. They designed a special plant using thermal (heat) forming to shear the fibres in ultra-high molecular weight ballistic fabric – and managed to achieve perfectly shaped shells that are 20 to 30 per cent lighter than current helmets.

"The technology will help Australian industry to deliver world-class armour at lower cost to the Australian Defence Force, and allied military and paramilitary customers," Mr Suryanarayana said.

He explained that one important benefit of the D4 process is that it eliminates the need to cut or splice the fibres, as in existing helmets, thus avoiding any compromise in strength and improving the mechanical and ballistic performance.

"Current standard-issue ballistic combat helmets are made with a combination of spliced high tensile synthetic fabrics (Aramid-based), such as Kevlar, and are put together by hand through expensive matched metal tooling," he said. "With our process, the labour-intensive manual lay-up is no longer needed and we can use a range of high modulus fibre systems, including carbon fibre composites."

The helmet shells meet the highest safety standards, including the requirements outlined in the US standard for Advanced Combat Helmets (ACH).

VCAMM Project Manager and D4 inventor James Sandlin said that D4 is the world's fastest composite forming process, taking only 20 minutes to produce each shell, as opposed to the 45 to 60 minutes of current techniques.

"There are also numerous non-military potential applications," Mr Sandlin said. "The technology could be applied in areas as diverse as aerospace, automotive, shipping, construction, furniture, sports or radomes (radar covers)."



The helmet shells meet the highest safety standards.

FIFTY YEARS OF SPACE COLLABORATION



PHOTO: K. McDONNELL

Australia has celebrated more than 50 years of space collaboration with the US – it is 55 years since the original space communication and tracking agreement was signed between Australia and the US in 1960.

The Minister for Industry and Science, Ian Macfarlane, said the two nations had partnered for more than half a century to achieve many breakthrough discoveries and historic firsts in the realm of space exploration.

"From the television coverage of the first moonwalk and the first fly-bys of Mercury and Venus, to the amazing surface views of Mars and first-time encounters of Pluto, the United States and Australia have shared many significant space exploration moments," Mr Macfarlane said.

The two countries' major cooperative activity is the CSIRO-managed Canberra Deep Space Communication Complex at Tidbinbilla, outside Canberra, one of three Deep Space Network stations capable of providing two-way radio contact with robotic deep space missions.

The Complex's sister stations are located in California and Spain. Together, the three stations provide around-the-clock contact with more than 35 spacecraft exploring the solar system and beyond.

NASA provides about \$20 million a year to the Canberra Deep Space Communication Complex, totalling more than \$800 million in funding over the past 50 years, which includes employment for more than 90 people.

The first of the two new NASA antenna dishes, Deep Space Station 35, incorporates the latest in Beam Waveguide technology that increases the sensitivity and capacity for tracking, commanding and receiving data from spacecraft located across billions of kilometres of space. Now operational, Deep Space Station 35 was officially commissioned in February.

The new dish for Deep Space Station 35 is hoisted into place.

By John Wilson
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The irony of the 'AAA' rating in infrastructure funding

Credit ratings measures make it very difficult for state governments to directly borrow for large infrastructure projects that will improve productivity, liveability and sustainability.

There seems general acceptance in the wider society that we need better infrastructure, but the question of who pays is very vexed – we don't want higher taxes, we don't want user pays, we don't want to sell assets and we don't want to borrow.

As Sir Rod Eddington AO FTSE, the former Chairman of Infrastructure Australia, remarked "there seems a profound disconnect between our aspirations and reality".

There are really only two sources for funding of infrastructure projects: government or private funds. Government funds are ideal and appropriate where the project has significant long-term public good and many intangible benefits, whereas private-sector funds can be used on projects that are more commercial in nature with a defined income stream, such as toll roads.

A recent trend has been for both sides of government, at both State and Federal level, to borrow through the private sector for most major projects using the public-private partnership (PPP) mechanism.

This 'off-the-books' borrowing protects a government's AAA rating but at a considerable cost since the interest

rates associated with private-sector borrowings are significantly higher than government bonds. However, 'Is this the best value approach to infrastructure procurement?' is a valid question.

Financial industry agencies such as Standard and Poor's and Moody's measure the credit rating of governments and industry considering the debt-to-earnings ratio of organisations and the ability to repay debt. The findings suggest that a AAA rating given to organisations with a debt/income ratio in the order of a figure not exceeding 1.3.

Ironically, such tight measures make it very difficult for state governments to directly borrow for large infrastructure projects that will improve productivity, liveability and sustainability.

This government approach to fiscal management is in great contrast to most commercial companies that have credit ratings in the BBB and CCC range, finding the AAA rating a 'straightjacket' and too restrictive to enable investments through borrowings for new initiatives and growth.

The difference in lending rates between the AAA and CCC ratings is reported to be in the order of 2.0+ per cent on a sliding scale.

Currently, there is great political

pressure on governments to maintain AAA ratings as a badge of honour to promote tight fiscal management to the electorate and to ensure internal discipline to prevent a downward spiral in borrowings.

Governments in arguing to maintain a AAA rating describe all debt as 'bad', whereas one must distinguish between 'bad' short-term debts, where recurrent expenditure is greater than income, and 'good' debt that should be considered long-term, value-adding investment borrowings.

The obsession by governments to maintain the AAA rating (which is, ironically, rated by the private-sector agencies) results in government turning to the private sector for 'off-the-books' borrowing. However, the total repayments are in the order of 30 to 60 per cent greater than if governments raised infrastructure bonds at around the Reserve Bank bond rates. Effectively, governments are borrowing 'off the books' at rates commensurate with a CCC rating – ironically, to protect the AAA rating.

Further, the repayments don't magically disappear, but just increase in size and are rebadged or disguised as 'availability' payments. Such circular logic would make Joseph Heller, author of the classic novel *Catch 22*, very proud.

This 'off-the-books' borrowing concept for large infrastructure projects makes no sense when compared on a local level to financing one's family home. For example, consider a family with a net annual income of \$100,000 wanting to purchase a family home for \$500,000.

The family could consider two very different options:

1 The traditional home owner/occupier scenario where the family borrows the \$500,000 at four per cent over 25 years at an annual repayment rate of around \$30,000; or alternatively

FIRST INLAND RAIL TENDERS OPEN

The Government has called the first tenders for the proposed Brisbane-to-Melbourne Inland Rail project and tasked former Deputy Prime Minister John Anderson AO, a Director of the Crawford Fund, to head the Inland Rail Implementation Group.

The first tenders, advertised in March, were for engineering design and environmental services.

"Inland Rail is a game-changer," said Deputy Prime Minister and Minister for Infrastructure and Regional Development Warren Truss. "It will transform freight movements through south-east Queensland, across regional New South Wales and rural Victoria, linking with the existing national network to move produce around the nation more efficiently.

"These first tenders will help develop planning for some of the key segments of the Parkes to Narromine and Narrabri to North Star sections. I have charged the Australian Rail Track Corporation with developing a 10-year delivery plan for Inland Rail and appointed former Deputy Prime Minister John Anderson to head the Inland Rail Implementation Group, to oversee that work."

2The 'off-the-books' borrowing scenario where the family considers the debt/income ratio of 5 as excessive and 'too risky', and contracts a developer to build, own and maintain the home and lease it back to the family over 25 years, after which the family will own the home.

Under the latter arrangement, the family will keep their debt low (maintain their AAA rating) but will pay 'availability' payments. These repayments are larger, reflecting the additional interest rates of two to five per cent to both service the debt through a third party and to maintain the asset, resulting in overall effective interest rates of six to nine per cent and repayments in the order of \$40,000 to \$50,000 each year.

The 'off-the-books' borrowing characterised in Option 2 avoids the initial debt, but switches the family from a traditional home owner and occupier to the more expensive proposition of a long-term tenant of an asset owned by a third party developer/investor.

Clearly this should be considered quite a ludicrous way to finance the family home, but this is the very principle that is currently being employed to some of the large PPP infrastructure projects with 'off-the-books' borrowings – but the numbers are 10,000 times larger.

For example, consider two recent projects in Victoria that typify the trend occurring around Australia:

Wonthaggi Desalination Plant was a \$5.7 billion capital project that could have been delivered with government infrastructure bonds at four per cent plus an additional, say, two per cent operating costs, resulting in 25-year debt at an interest rate of six per cent. Instead, through the PPP mechanism and 'off-the-books' borrowing, users are charged a totally excessive 'availability' payment of 11.5 per cent over 25 years, resulting overall in a project that is about 1.6 times more expensive.

Peninsular Link is a toll road delivered through a PPP mechanism using an 'off-the-books' borrowing mechanism and 'availability' payment of around nine per cent over 25 years, compared to government borrowings of four per cent and an operating cost of around one per cent. The five per cent versus nine per cent

differential results in a project that is about 1.4 times more expensive.

Clearly, both projects can be considered significant wins for the finance industry directly sponsored by the general public.

Government's obsession with the AAA rating and 'off-the-books' borrowings through the PPP mechanism results in 'availability' repayment rates that are in the order of 30 to 60 per cent greater than if governments borrowed directly through the raising of infrastructure bonds. Rather than paying smaller bond dividends the governments are paying the debt through larger payments commensurate with a CCC rating and euphemised as 'availability' payments.

This obsession by both sides of government with the AAA rating and 'off-the-books' borrowing begs the question, 'Is this the best value public infrastructure procurement option for us, the general public?' We need governments to be bold and to deliver best-value, long-term infrastructure projects that deliver productivity and liveability benefits to for the community, without being held ransom to the constraints of an artificial AAA rating that delivers direct benefits to the finance industry.

PROFESSOR JOHN L WILSON is Executive Dean, Faculty of Science, Engineering and Technology, Swinburne University of Technology, and has more than 30 years' experience in industry and academia. He has a background in civil engineering, with research expertise in earthquake engineering, and is an active public advocate for STEM education, the engineering profession and improved infrastructure planning and procurement. He is currently Engineers Australia spokesperson for infrastructure in Victoria, Vice-President, Australian Council of Engineering Deans, and Chair of the Australian Earthquake Loading Standard.

SINGLE AIR TRAFFIC CONTROL COMING

Australia's OneSky initiative will bring civil and military air traffic control together under one air traffic management system for the first time, improving aviation efficiency and safety, according to the Government.

Minister for Infrastructure and Regional Development Warren Truss announced that Airservices Australia, in partnership with the Department of Defence, would enter into an Advanced Work contracting arrangement with Thales Australia, the critical next step for delivering OneSky.

Mr Truss said that the single, modernised system would enhance navigation and communication capabilities to allow Australia to keep on top of global changes in aircraft technology.

"Once implemented, Airservices Australia and Defence will share technology and information, giving Australia the most advanced and integrated air traffic control system in the world. It will place us in a position to manage forecast growth of air traffic movement in Australia, of as much as 60 per cent by 2030, minimising delays for the travelling public.

Minister for Defence Kevin Andrews said that a harmonised civil-military air traffic management system – the first in the world – would help streamline infrastructure and processes between military and civilian air traffic controllers.

OneSky will be introduced from 2018 and replace the current civilian system, The Australian Advanced Air Traffic System, which was first developed and commissioned in the late 1990s.

The Government says the procurement of a single system takes

advantage of a once-in-a-generation opportunity where both civil and military systems are due for renewal, realising combined savings of several hundred million dollars.

Air traffic control at work.



The Titan Krios electron microscope with (from left) Professor Aidan Byrne (ARC), Professor David de Kresten FTSE (Monash) and Professor James Whisstock (Monash).



\$20M microscopy centre launched

A unique \$5 million electron microscope is operating at Monash University, which will transform the way we view the human immune system and advance Australian research towards better treatment for diseases from cancer and malaria, to diabetes, rheumatism and multiple sclerosis.

The FEI Titan Krios cryo-electron microscope is the centrepiece of the \$20 million Clive and Vera Ramaciotti Centre for Structural Cryo Electron Microscopy. Standing three metres tall, weighing about one tonne, and with a powerful 300 kV electron gun, it was launched in February.

The Ramaciotti Centre and its new microscope are central to the work of the ARC Centre of Excellence in Advanced Molecular Imaging, of which Monash University is a lead partner.

"We want to transform our understanding of the human immune system," says Professor James Whisstock, Director of the Imaging Centre.

"To achieve this, we need to be able to observe the molecular structures at the heart of immune response. Our immune system, and thus our health, is ultimately driven by the interactions of these large biological molecules. And those interactions depend on the 3D shapes and structures of the molecules involved."

"The Titan Krios is powerful enough to resolve those intricate 3D shapes, identifying the position of individual atoms within a biological molecule and creating exquisitely detailed models including the molecules' loops and side chains.

"It fills a gap, seeing things that X-ray crystallography and the Synchrotron can't see. And Australian scientists have been queuing up to get time on Titans in Europe and America. Now they can do the job in Australia.

The new facility has been funded with support from the Ramaciotti Foundations, the Australian Research Council, Monash University, the Walter and Eliza Hall Institute of Medical Research, La Trobe University and the National Health and Medical Research Council.

NEW MEDICAL DEVICE TO MAKE MINES SAFER

Dehydration can be a serious health issue for Australia's mining industry, but a new product to be developed with input from Flinders University's Medical Device Partnering Program (MDPP) is set to more effectively help mine managers implement their health and safety policies.

Hydralert is a compact device placed in urinals to analyse a person's hydration level in real time and provide immediate feedback. Hydration data can then be subsequently downloaded by occupational hygienists to target hydration promotion and trend data amongst workgroups.

The concept is one of two projects to receive expert design and development assistance from the MDPP, headed by ATSE director and former SA Scientist of the Year Professor Karen Reynolds FTSE, as part of the South Australian Government's Medical Technologies Program (MTP).

The prototype developed by the MDPP will later be integrated into clinical trials by Occulert Pty Ltd.

Manufacturing and Innovation Minister Susan Close said the MTP provided support for the early stage development of commercially viable medical and assistive devices such as Hydralert.

The second company to receive MTP funding is AMNY Medical Pty Ltd, medical device company, which will use the support of the MDPP to develop a central component of a novel airway surgery system, aimed at eliminating the need for complex anaesthesia techniques and reducing morbidity associated with neck extension during airway surgery.

LETTER

THE RISKS ARE TOO HIGH

Erica Smyth states in her article 'The nuclear energy debate needs to be on our table' (ATSE Focus, February 2015) that there is no perfectly safe way to generate electricity.

She mentions that the Chernobyl nuclear accident resulted in 43 deaths, but she does not say that these deaths were just those that occurred at the time of the Chernobyl disaster. The jury is still out on the number of deaths that will result in the long-term from Chernobyl, but some estimates put the number in the thousands – many more than 43.

The body count is not yet in for Fukushima, but while it is likely to be less than for Chernobyl, the human and economic costs have been enormous.

Smyth argues that accidents like Fukushima show us that nations generating nuclear power need to "look at even the most unlikely" of scenarios in order to protect against future disasters.

It is all very well to take the attitude that all our mistakes are now behind us and we will be more careful in future. But the Fukushima, Chernobyl and Three Mile Island disasters have all clearly demonstrated that governments, civil authorities and companies are not necessarily very good at risk assessment, are prone to human error and tend not to learn from past mistakes.

I was one of Smyth's anti-nuclear contemporaries in the 1970s. In the intervening 40 years, it has become clearer than ever to me that no one can be trusted with a nuclear power station. The risks are too high.

– PROFESSOR ROD TUCKER OAM FAA FTSE



By Ian Rae
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Beliefs that Bias Food & Agriculture. Questions I'm Often Asked by Lindsay Falvey. Institute for International Development, 2013, xii +316 pp, ISBN: 9780980787566 (paperback).

Agriculture and human values

Lindsay Falvey FTSE is a prolific author and in this book he continues to expound on agriculture and human values. The Q&A format, with the author providing both questions and answers, is a rhetorical device that smacks more of the 19th century than the 21st, although it's popular in faith communities in the form of the catechism.

But whereas a catechism is brief and to the point, Dr Falvey has chosen questions that call for discursive answers. This makes for a good deal of repetition: the reader can get the main points by browsing in just a few of the 10 chapters. For those who doubt, and equally for those who want more, there are superscript numbers directing to a list of 491 references, and there is a seven-page index.

Take Chapter 3 as an example. After

some preamble, the question is posed: If Western nations have solved this problem of food availability centuries ago, why don't we just use our aid to insist that other countries follow our model? After 24 pages of reflection, Dr Falvey comes to answering the question, and takes a couple of pages to tell us that "famine is an omnipresent global risk" because Western ways are not infallible and that modern science would do well to build on organic techniques that use fewer chemicals and less labour.

Having recently visited Bhutan, I was interested to see what he had to say about Gross Domestic (or Natural) Happiness. His avatar raises it as a "naïve idea" and in his response Professor Falvey admits it is a "nebulous concept ... popularised by social idealists seeking to

appeal to economically disenfranchised voters in countries" like Australia.

There's something in it, however, and we may have benefited already, Dr Falvey thinks. His reflections move from happiness to well-being, however, and he references Thai work on physical, mental, social and spiritual well-being but does not refer to the much wider Western literature on the subject.

The extensive discussion of inconsistencies between agricultural practice in Western and traditional societies, especially those of South-East Asia, is a regular theme of his.

This book, his 23rd, would make a useful centrepiece for a faith-based discussion group, whether the faith be religious or socio-economic.

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.

LETTER

RESEARCH INTERACTION IS GETTING TOUGHER

I have read a significant number of articles recently on the need for better communication between academic and public sector research with industry, including the ATSE call for a research impact and engagement measure.

I agree that our record in Australia in terms of application and use of the public and academic research effort has not been good, but I want to say strongly that it was easier to interact with industry in this country 20 years ago than it is now – simply because a large number of companies which conducted in-house research no longer do so. There are very significant examples of this which I need not elaborate.

Sir Paul Nurse, the President of The Royal Society, in an address in Melbourne a few years ago, clearly stated that in order to build bridges between academia and industry, industry needs to have people doing research.

I have seen first-hand two companies funding the same research program, where one benefited immensely from the program and the other did not, simply because the benefiting company had a champion within the organisation who understood the research and knew how to apply it within that industry.

I was very fortunate in my career to have a close association with Alcoa in Western Australia which extended from the 1970s and exists to some extent now. Through this association and friendship we were able to help Alcoa go from wet disposal of its waste to a dry disposal technology which is now used in many parts of the world.

Also, I had a brief stint with BHP (before it became BHP-Billiton) with the chief scientist when I was able to travel the world and see first-hand many of the issues that confronted the company. This experience was invaluable and has helped me immensely in my own research. Needless to say, BHP-Billiton no longer has a chief scientist and this interface, I believe, no longer exists.

It is true that the academic evaluation of research is based entirely on publications, citations, h indices, etc. This evaluation is driven by university rankings and by government itself.

Significant funding comes to the university as a result of these measures. I should also add that the number of PhDs being produced in Australia now, for example in engineering, is huge for a market where there is little demand. Hence these people, if they are going to be employed in relation to some technological area, will ultimately end up overseas.

In conclusion, it is great to say that we need more interaction between academic and public sector research with industry but it needs to be recognised that this interaction has become – and is becoming – more difficult all the time as fewer and fewer industries in Australia conduct in-house research.

–PROFESSOR DAVID V BOGER FRS FAA FTSE

Deep sea expedition into Perth Canyon abyss

A group of scientists from The University of Western Australia's Oceans Institute have been working at sea to unlock the secrets of a deep ocean canyon off Fremantle the size of the Grand Canyon.

A UWA team led by Professor Malcolm McCulloch, with researchers from the WA Museum, CSIRO and Italy's Institute of Marine Sciences, were among the first to explore life in the vast Perth Canyon, 50 km off Fremantle.

The underwater canyon formed over tens of millions of years and extends from the continental shelf edge of WA to depths of more than 4 km. Major up-swelling of essential nutrients in the canyon makes it a global marine hotspot, attracting blue whales and other large fauna that migrate to the waters seasonally to feed. Despite being so close to Perth and Fremantle, little is known about life in its deep abyss.

Professor McCulloch and his team were on board the Schmidt Ocean Institute's Research Vessel, *RV Falkor*, during a 12-day trip in March and used a deep-diving, remotely operated vehicle (ROV) to discover and collect deep-sea corals and sea water from the canyon. Chemical and biological analyses of these rare samples will provide critical new data about the canyon's marine ecosystems. This will help determine the likely future impacts of warming seas and ocean acidification on the deep-sea life and waters in these remote and previously inaccessible habitats.

Besides giving researchers the chance to better understand the Perth Canyon, the work should also help to better understand the likely threats to other deep ecosystems in the region and similar environments worldwide.

INVESTIGATOR STARTS WORK IN SOUTHERN OCEAN

Australia's new scientific research vessel *Investigator* is on its maiden research voyage to the Southern Ocean to deploy a series of marine monitoring moorings that will remain in the ocean for more than a year and return data live via satellite.

The voyage will map the ocean's physical, chemical and biological properties in the area around the moorings using a TRIAXUS towed sensor. This will enable the relationship between the atmosphere and the ocean to be better understood. In parallel, scientists will also map ocean

ecosystems using a state-of-the-art, bio-acoustic fish-finding sonar.

The maiden voyage is a collaboration between CSIRO, the Antarctic Climate and Ecosystems CRC, the Integrated Marine Observing System, the Bureau of Meteorology and the University of Tasmania's Institute for Marine and Antarctic Studies. Scientists from Monash and Swinburne universities and UNSW are also undertaking research.

Investigator earlier completed cold water trials, which took the vessel to 65°S 146°E, about 2500 km south of Hobart. The voyage to the ice-edge tested key capabilities of the ship, which is designed to operate in water temperatures of -2°C to +32°C, from the Antarctic ice edge to the tropics.

Voyage work included testing seafloor and sub-seafloor sonar mapping and gravity meter readings; operating on-deck scientific equipment-handling systems such as winches, A-Frame and boom; operating communications systems and video conferencing live from the ice-edge; and testing cold water survival and ship manoeuvring systems.

70 LEADERS AT AIRG 50-YEAR MEETING

More than 70 research leaders and managers from Australia and overseas attended the Australasian Industrial Research Group's (AIRG) 50th Anniversary Meeting in Melbourne in February, the theme of which was *Past Challenges and Future Opportunities*.

With support from Monash University, the Australian Government Department of Science and Industry, CSIRO, Bluescope and Robert Weller and Associates, the two-day program featured more than 20 speakers and a dinner address by Mr Edward Bernstein, President of the Industrial Research Institute, USA, who presented the *IRI 2038 Futures Study* report. The meeting celebrated 50 years of AIRG's operation, built on the inaugural interest of research-focused companies including Mauri Bros. and Thomson, CSR, Philips Industries, Kraft Foods, Parke Davis, BHP, Kodak and APM.

The conference scene-setters were delivered by Professor Stephen Martin, CEO of CEDA, and Ms Susan Wilson, from Innovation Australia. International speakers included: Mr Michel Judkiewicz, Secretary General, European Industrial Research Management Association; Dr Lee-Hwan Kim, Executive Deputy Chairman, Korea Industrial Technology Association; Mr Seiji Oshima, Director-General, Japan Research Industries and Industrial Technology Association; Mr Gerson Pinto, President, ANPEI, Brazil; Mr Kees Eijkel, CEO, KennisPark Twente, Netherlands; and Dr Siobhán Jordan, Director of Interface, UK.

Other key speakers included Ms Amanda Caples, Deputy Secretary, Innovation and Technology, Victorian Government, and Professor Ian Smith, Pro-Vice Chancellor (Research & Research Infrastructure) Monash University.

ATSE Fellows were prominent – Dr Leonie Walsh FTSE, Victoria's Lead Scientist and AIRG President; Professor Gordon Wallace FTSE, University of Wollongong; Dr Errol McGarry FTSE; and Mr Alexander Gosling AM FTSE, former AIRG President.

Mr Michael Egan, from CSIRO's SME Engagement Centre, was awarded the AIRG Medal for Australasian Technological Innovation for establishing an operational model and service to boost collaboration between SMEs and research organisations. Mr Egan leads a team of five research facilitators, meeting with some 500 Australian SMEs each year to explore their business innovation needs and provide tailored support and advice. They facilitate research projects that are led by the SME and involving the placement of a researcher inside the business, achieving its highest-ever number of placements in 2014 – 48 projects worth more than \$4.5 million.

RV Investigator tackles the Southern Ocean.



Researchers put new spin on nanofibre

Researchers at Deakin University's Institute for Frontier Materials have designed three machines based on the electrospinning principle, which uses an electrical charge to create tiny fibres from a liquid, to make the world's newest fibre – nanofibre.

Potential applications for nanofibre include such mind-boggling products as high performance filters, bandages for wound healing, oil-



Electrospinning uses an electrical charge to create tiny fibres from liquid.

water separation membranes, defence clothing or even artificial blood vessels!

The unique properties of nanofibre – which stem from its high surface-to-volume ratio, permeability, light weight, strength and the breadth of materials from which it can be made – make it ideal for myriad uses that require water resistance, breathability, wind resistance, durability or one-way fluid transmission. These characteristics make nanofibre the best filtration material in the world, collecting oil, dust or other pollutants from air or liquid.

Two of Deakin's new machines produce non-woven nanofibre, while the third directly processes polymer solution into continuous nanofibre yarn – a world first – opening the way for a plethora of new applications.

According to nanofibre expert, Professor Tong Lin, who is an ARC Future Fellow at Deakin, "the next generation of fibre will be nanofibre, and will be used – perhaps in combination with conventional fibre – in many other types of application, ranging from environmental protection to biomedical, textiles and electronics areas."

Professor Lin and his colleagues are refining nanofibre fabrics to a new level of sophistication. For example, the team has discovered that non-woven nanofibre has an exceptional ability to convert mechanical energy into electric power and so could work as a fabric energy harvester. They are also developing a nanofibre membrane with one-way transport for oil, which is highly resistant to water. This innovation will be useful in advanced membrane materials for fuel recovery and environmental protection.

Nanofibre has potential biomedical use in wound dressings, tissue engineering and scaffolding, and knitting blood vessels. Its permeability and potential biodegradability (it can be made from materials like collagen or elastin) mean low rejection or infection risk if used in the human body.

NATURE INSPIRES SEAMLESS SUIT

The maple leaf was the inspiration for a radically new wetsuit that has been created by Deakin University engineers, who based their research on the theory of biomimicry, or copying from nature.

"The maple leaf is made from one material, but the veins in the leaf give it structure, which is very common in nature," said Deakin engineer and product developer Dr Paul Collins.

Blue bonded polymer strips provide the veins or 'exoskeleton' of support to the wetsuit – reducing the number of seams needed from about 20 to only three. This offers surfers a more comfortable and longer-

life garment and, importantly for commercial viability, lower production costs.

Dr Collins joined forces with two students who share a passion for surfing – Deakin PhD student Danny Hurst and Gordon TAFE fashion design student Mark Lee. Working with leading surfers and surfwear manufacturers Quiksilver and Ripcurl, the trio has designed a wetsuit that provides greater freedom of movement, less chance of rashes and longer life than any others on the market.

"We did a lot of research on human movement, using techniques such as 3D body mapping to identify the stresses and strains on a wetsuit," Dr Collins said.

Cutting-edge technology is also playing a key role in another promising sports design project being undertaken by Dr Collins and PhD student, Nadine Lippa, from the US.

Working in partnership with Deakin's School of Exercise and Nutrition Sciences, the two are exploring the development of bespoke 3D-printed running shoes, which they believe has strong commercial potential.

"Deakin owns one of only a handful of 3D printers in the world that can print the flexible rubber that is used for the soles of running shoes," Dr Collins said. "Using biomechanics, we can see how individuals strike the ground and then design shoes for each individual, to improve their running gait and reduce the stress on their knees."

Dr Collins is passionate about preparing his students for the future – and incorporating 'design' in engineering.

"Engineers are increasingly focused on project-based collaboration, supported by state-of-the-art infrastructure, whether this be 3D printing, virtual reality or body mapping. This is the reality of modern engineering," he explained. "Engineering is not just about steel and concrete. It can have applications in many contexts – especially in the area of product development and product design."



Blue polymer strips provide a supportive 'exoskeleton' for the high-tech wetsuit.

CSIRO & NICTA TO MERGE?

CSIRO and NICTA say they are in discussions about how they can collectively work better as a single entity.

"We are exploring the best way to harness the research strengths and capabilities in digital technology of both organisations," said NICTA in a media announcement. "In taking the relationship forward, the focus is on developing an outwardly-focused, entrepreneurial culture, with multidisciplinary research that generates commercialisation outcomes and impact for Australia. Underpinning this would be world-class research and science, utilising the skills from both organisations and those in universities and industry."



Baxter hones his capsicum-picking skills.

Teaching Baxter to see things as we do

'Baxter', Queensland Institute of Technology's newest robot, is helping researchers break down the technological boundaries that stop robots from working safely side-by-side with humans – seeing and perceiving the world as we do.

"Once robots can see and understand the environment they operate in they can make decisions that allow them to work safely beside us," said Professor Peter Corke, QUT's world-renowned roboticist and Director of the Australian Centre for Robotic Vision (ACRV).

"Current industrial robots are dangerous for humans to work around because they're simply not equipped to recognise and avoid obstacles suddenly in their way.

"Baxter uses a range of sensors to detect movement around it, as well as spring-loaded joints, which stop it continuing a pre-programmed movement if it meets an unexpected obstacle. We've tried to 'rush' Baxter before and can certainly vouch for his quick reflexes."

Researchers at the ACRV, officially launched at QUT in March by the Minister for Employment and Training, Christopher Pyne, have already programmed Baxter to use computer vision to play an unbeatable game of Connect Four. They are now training Baxter to recognise and pick ripe capsicums.

The ACRV brings together Australia's top computer vision and robotics researchers, who are creating the next generation of robots that can see and understand complex, real-world environments. They are researching the use of robotic vision to create advanced farming tools, tackle Crown of Thorn starfish outbreaks on the Great Barrier Reef and develop low-cost solutions for key health and medical problems.

"Robotic vision is the key enabling technology that will allow robotics to transform labour-intensive industries, disrupt stagnant markets and see robots become a ubiquitous feature of the modern world," said ACRV Chief Operating Officer Dr Sue Keay.

"We consider that 'seeing' is far more than just processing images," she said. "It's a complex process tightly coupled to both memory and action, which gives robots the understanding they need to robustly perform tasks that involve objects and places while at the same time providing rapid and continuous feedback for control.

"Robotic automation has transformed manufacturing, household cleaning and soon cars but robotics has made relatively little headway in other industries where the world is complex and time varying, like retail.

"Robots that can see, learn and respond as humans do will increase productivity in industries critical to Australia's economy."

The ACRV is an ARCI Centre of Excellence involving experts from QUT, the University of Adelaide, ANU, Monash University, NICTA and partnering international universities.

MOTION SIMULATOR SHAPES VEHICLE DESIGN

Deakin University's Universal Motion Simulator (UMS), at the Waurn Ponds campus, near Geelong, is saving the aircraft, defence and automotive industries serious money.

Since it was commissioned in 2010, the UMS – the first of its kind in Australia – has been used by designers and engineers to test new vehicle designs, long before the innovations ever hit the production line.

Developed by researchers within Deakin's Centre for Intelligent Systems Research, the UMS takes users on the ultimate, self-directed simulated journey. Unlike stationary virtual systems, where the user doesn't actually move, the gigantic robotic arm of the UMS delivers realistic accelerations and manoeuvres at high speeds in any direction, and is able to replicate all the gut wrenching G-forces of a military jet.

Whether it be changes in suspension, centre of gravity or ergonomics, the UMS can test virtual vehicle or aircraft prototypes under any conditions, from stormy weather, to rough terrain, to engine failure – with specific scenarios programmed into its computer software system.

It enables simulation of the most unusual vehicle motions, such as the large tilt angles found in rugged terrain or the slipping or rollover scenarios of a tank in the desert, and is also being used to train aircraft pilots through either fixed wing or helicopter aircraft simulations.

According to Deakin's lead UMS engineer Dr Kyle Nelson, the highly customised industrial robot that forms the basis of the UMS system offers a far greater range of motion, flexibility and degree of realism than the previous generation of 'Stewart platform'-based simulators.

"The UMS brings together technologies, such as haptics (touch), robotics motion control and virtual prototyping to create the ultimate simulation," Dr Nelson said.

"The haptic vehicle controls – including cyclics, collectives, pedals and steering wheels – provide realistic sensations, while the high-resolution, 3D, head-mounted display and 36-camera motion capture and tracking system help give a sense of complete immersion within the simulated environment"

Deakin engineers are currently working to refine the electronic stability control of passenger vehicles and are also using the UMS to simulate military vehicles, such as tanks and armoured personnel carriers. They are designing replica vehicle cabins that can be fixed to the simulator for improving armoured vehicle design and training military drivers.



Deakin's UMS in action.

ATSE IN FOCUS

Six Fellows recognised in Australia Day Honours



Alexander Gosling



Jim Patrick



Jim Hallion

Six Academy Fellows were recognised in the Australia Day Honours for their service to various elements of the Australian community.

The late **Professor John Freney AO FTSE**, former Chief Research Scientist with the CSIRO Division of Plant Industry, was honoured "for distinguished service to conservation and the environment through research into greenhouse gas production, climate change and the efficient use of nitrogen fertiliser".

Professor Jim Patrick AO FTSE, Senior Vice-President and Chief Scientist, Cochlear Ltd, was honoured "for distinguished service to science through the development of cochlear implant technology, to biomedical research and engineering innovation, and to education and professional associations".

Dr Alexander Gosling AM FTSE was honoured "for significant service to business, through innovative support for research and development, and to the community".

Mr Jim Hallion AM FTSE was honoured "for significant service to public administration in South Australia particularly to transport infrastructure, energy and agriculture".

Professor Milton Hearn AM FTSE was honoured "for significant service to science through major contributions to advances in chemical engineering".

Mr Menno Henneveld AM FTSE was

honoured "for significant service to engineering, particularly road transport infrastructure".

Professor Patrick, an Adjunct Professor at Macquarie University, has been Senior Vice-President and Chief Scientist, Cochlear Ltd, since 1981; he is Manager of Global Research Programs. He has been an Associate Professor, Department of Otolaryngology, University of Melbourne, since 2001; and Honorary Special Research Fellow, Bionics Institute; Member and Adjunct Professor, Graeme Clark Centre for Bionic Ear and Neurosensory Research, La Trobe University.

Professor Freney died in Canberra on 2 January, aged 85. A Fellow since 1986, he was a former Chief Research Scientist with the CSIRO Division of Plant Industry in Canberra and Senior Fellow, School of Resource Management, University of Melbourne. In spite of his retirement at 65, he continued his scientific work and continued to mentor scientists, edit books and present at international meetings.

He was honoured with his Doctorate of Agricultural Science in August of 2014. He was appointed Adjunct Professor, Shanxi Academy of Agricultural Sciences, Taiyuan, China, in 2006.

Dr Gosling has been Principal Partner, Capstone Partners Pty Ltd, since 2007. He is a Founding Director, Metallic Waste Solutions Pty Ltd; Past Chair and Director of Invetech; and Founding Director, PA Technology Asia Pacific. He is a former National President, Australasian Industrial Research Group.

Mr Hallion is Chief Executive, Department of the Premier and Cabinet, SA, and previously served as Chief Executive, Department of Transport, Energy and Infrastructure, Department of Primary Industries and Resources (DPIR) and Department of Industry and Trade. He was a Member of the Australian Centre for International Agricultural Research while at DPIR. He is a Commissioner, Murray-Darling Basin Commission and Interstate Water Trading Board.

Professor Hearn is Professor of Chemistry and Science Lead, Victorian Centre for Sustainable Chemical Manufacturing, Monash University, and was Professor of Biochemistry, Department of Biochemistry and Molecular Biology, 1986 to 2002, and Director, Special Research Centre for Green Chemistry, Australian Research Council (2003–12).

Mr Henneveld was Commissioner, Main Roads WA (2002–10) and Managing Director (2010–12). He is now Principal, Menno Henneveld Consulting, and Strategic Adviser, Infrastructure, to Laing O'Rourke Australia. He was General Manager, WA Water Corporation, 1991 to 2002; and Project Director for the WA's first major seawater desalination plant. He was formerly Vice-President, World Road Association; Chairman, Australian and New Zealand Road Transport and Traffic Authorities (Austroads); and Member, National Engineers Registration Board.

ROYAL FELLOW HONOURED

The Prime Minister announced that the Academy's Royal Fellow, His Royal Highness The Prince Philip, Duke of Edinburgh, would be awarded Australia's highest honour as a Knight of the Order of Australia honouring "the contribution of the Duke of Edinburgh to Australia throughout The Queen's 62-year reign".

Mr Abbott said Prince Philip's long life of service and dedication should be honoured by Australia.

During Australia's Bicentenary, Prince Philip was appointed a Companion in the Military Division of the Order of Australia for "service to the Australian Defence Force as Admiral of the Fleet in the Royal Australian Navy, Field Marshal in the Australian Army and Marshal of the Royal Australian Air Force".

The Duke of Edinburgh joins The Prince of Wales, who was appointed a Knight of the Order of Australia in 1981.

ATSE IN FOCUS

Bronwyn Evans

Fellows will guide Industry Growth Centres

Three Fellows have been appointed to the Australian Government's Industry Growth Centres independent Advisory Committee – Mr John Grill AO FTSE (Chair), Ms Catherine Livingstone AO FAA FTSE, Dr Andrew Liveris AO FTSE – and Dr Bronwyn Evans FTSE, CEO of Standards Australia, will chair one of the five Growth Centres, the Medical Technologies and Pharmaceuticals Growth Centre.

This Advisory Committee will provide a direct link to both the Australian and global business communities and steer the rollout of the Industry Growth Centres.

The Minister for Industry and Science Ian Macfarlane announced the committee members as well as the Chairs for the Industry Growth Centres – Mr Andrew Stevens (Advanced Manufacturing), Ms Elizabeth Lewis-Gray (Mining Equipment, Technology and Services), Mr Peter Schutz (Food and Agribusiness), Mr Reg Nelson (Oil, Gas and Energy Resources) – and Dr Evans.

"The independent Advisory Committee and the Chairs of the Industry Growth Centres will provide Australian businesses with an extended reach into expanding international markets," Mr Macfarlane said.

"A significant goal for the Growth Centres will be to forge better links between industry



Catherine Livingstone



Andrew Liveris

and Australia's world-class researchers, to maximise the return on our \$9.2 billion annual investment in science and research."

Mr Grill is Chairman and former Chief Executive Officer of engineering company WorleyParsons. He has more than 40 years' experience in the resources and energy industry, starting his career with Esso Australia. He has extensive project delivery experience having worked on many of the world's largest mining and infrastructure projects. He is also on the board of Neuroscience Research Australia and the Australian Chamber Orchestra.

In 2012 Mr Grill donated \$20 million to the University of Sydney to establish the John Grill Centre for Project Leadership. The multidisciplinary centre aims to improve the skills of managers responsible for delivering major projects worth tens of billions of dollars.

Ms Livingstone is Chairman of Telstra Corporation Limited and President of the Business Council of Australia. She is also a director of WorleyParsons Limited, the George Institute for Global Health and Saluda Medical Pty Ltd; and is President of the Australian Museum Trust. She is a member of the Prime Minister's Business Advisory Council; and the Commonwealth Science Council.

Previously, she was Chairman of CSIRO and the Australian Business Foundation, and was President of Chief Executive Women. She served on the boards of Macquarie Group, Goodman Fielder and Rural Press, and was a member of the NSW Government Innovation and Productivity Council. She has also worked with Price Waterhouse, and spent nearly 20 years in the field of implantable medical devices, including six years as CEO of Cochlear Limited.

Dr Liveris is Chairman and Chief Executive Officer of The Dow Chemical Company, a \$54 billion global chemical, advanced materials, agrosiences and

plastics company based in the United States. A 39-year veteran of Dow and recognised global business leader, Dr Liveris' career has spanned roles in manufacturing, engineering, sales, marketing, and business and general management around the world. An advocate for the criticality of manufacturing, Dr Liveris served as Co-Chair of President Obama's Advanced Manufacturing Partnership.

Dr Liveris is a Director of IBM, a Member of the Executive Committee and Past Chairman of the U.S. Business Council, is vice chair of the Business Roundtable and a member of the President's Export Council. He serves as President and Chairman of the International Council of Chemical Associations.

Dr Evans has been CEO of Standards Australia since October 2013. Prior to this, Dr Evans held the position of Senior Vice President, Quality, Clinical and Regulation, with Cochlear Limited. From 2009-2012, Dr Evans was Chair of the Medical Technology Association of Australia (MTAA), the national association representing companies in the medical technology industry.

CHUBB ROLE EXTENDED

The appointment of Australia's Chief Scientist Professor Ian Chubb AC FTSE has been extended to the end of 2015.

The Government said Professor Chubb had agreed to continue as Australia's Chief Scientist until the end of the year to continue his important work in advising on science, technology, engineering and mathematics, which is a priority under the Industry Innovation and Competitiveness Agenda.

Professor Chubb will also continue to work with the Government on developing and implementing science and research priorities through the Commonwealth Science Council.

The Government will shortly commence an international recruitment process for a new appointee. Professor Chubb began his tenure in 2011 and is Australia's seventh Chief Scientist since the role was established in 1989.



Ian Chubb

ATSE IN FOCUS



Lyn Beazley (left) with Australian of the Year 2015 finalists.

Lyn Beazley named WA's Australian of the Year

Professor Lyn Beazley AO FTSE is Western Australia's 2015 Australian of the Year, recognised for her work as a scientist.

She was national finalist in the Australian of the Year award announced on Australia Day.

Science has been a lifelong passion for Professor Beazley, a prominent Fellow of the Academy in WA, whose goal is for every Australian child to learn and love science.

After graduating from Oxford and Edinburgh universities, she has dedicated more than 30 years to the field of neuroscience, researching recovery from brain damage and changing clinical practice in the treatment of infants at risk from pre-term delivery.

As Chief Scientist of WA, 2006–13, Professor Beazley advised the WA Government on science, innovation and technology, as well as fulfilling the role of science ambassador in Australia and internationally.

She has been determined to demonstrate that science is not just a theoretical exercise, but a practical one too. She helped set up a nationwide 'hotline' for laboratory technicians in schools, worked for healthier waterways across WA by establishing Dolphin Watch and was involved in the negotiations for the Square Kilometre Array, the radio telescope project

that is arguably the world's largest science endeavour.

She has been a Fellow since 2009.

Professor Beazley has recently been named Chair of the WA Innovator of the Year Advisory Committee, of which former WA Governor Dr Ken Michael AC FTSE is a member.

MIKE RAUPACH WAS A WORLD-CLASS RESEARCHER

Professor Michael Raupach FAA FTSE was renowned as a distinguished scientist and world-class researcher who, throughout his career, published more than 150 scientific papers and 50 reports, and edited two books.

Professor Raupach was appointed Director of the ANU Climate Change Institute in early 2014, after a long and productive career at CSIRO.

He died in Canberra after a brief illness in February, aged 64.

ANU Vice-Chancellor Professor Ian Young AO FTSE said Professor Raupach was an eminent climate scientist who made a tremendous contribution to climate research and to ANU during his time at the university.

"Mike was a dedicated scientist and wonderful science communicator. He will be deeply missed by his many friends and

colleagues both at ANU and throughout Australia's science community," Professor Young said.

Before joining ANU, Professor Raupach was a CSIRO Fellow and leader of the Continental Biogeochemical Cycles research team in the Division of Marine and Atmospheric Research.

From 2000–08 he was an inaugural co-chair of the Global Carbon Project, an international project studying the natural and human influences on the global carbon cycle, and the interaction of the carbon cycle with climate. He was a contributing author of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (Working Group 1).

Professor Raupach led the PMSEIC report *Challenges at Energy–Water–Carbon Intersections*, putting to good use his research history investigating changes to climate and land systems resulting from the movement of water, heat, carbon and nutrients between land and atmosphere.

He joined CSIRO, with the Centre for Environmental Mechanics, in Canberra, in 1979 as a Research Scientist. After a period overseas he returned to CSIRO and in 1991 became Program Leader, Atmospheric and Plant Processes, with CSIRO's Centre for Environmental Mechanics in Canberra.

He held that position until 1997 and in 1996–97 served as Deputy Head of the Centre for Environmental Mechanics. In 1997–98 he was the Program Leader of Environmental Processes and Resources at CSIRO Land and Water.

From 1998 to 2002 he worked as a Research Scientist, CSIRO Land and Water, and was a Science Leader with the CSIRO Earth Observation Centre, 2002–05, before joining CSIRO Marine and Atmospheric Research.

Earlier in his career, Professor Raupach was a Postdoctoral Research Fellow at the Department of Meteorology, University of Edinburgh (1977–78), Visiting

Lecturer, Department of Meteorology, University of Reading (1986) and Research Fellow with the Department of Applied Mathematics and Theoretical Physics, University of Cambridge (1986–87).



Mike Raupach

ATSE IN FOCUS



Veena Sahajwalla



Mark Cassidy

Two Fellows feature in Go8 promotion

Engineers Professor Mark Cassidy FTSE and Professor Veena Sahajwalla FTSE are among a raft of ARC Future Fellows whose work is featured in a new Go8 publication, *Thinking Ahead: An Investment Worth Making* – a selection of the research undertaken by Future Fellows at the Go8 universities.

The prestigious ARC Future Fellowships, introduced in 2009, provide support for outstanding mid-career researchers. The scheme aims to attract top research talent to this country and to help us retain our own high-achieving researchers.

The 96-page document features the work of Future Fellows in five areas: engineering and technology, energy and climate change, social impact, health, and life sciences.

The University of Western Australia's **Professor Cassidy** leads a team investigating safe offshore infrastructure development and engineering in one of the world's most significant oil and gas production areas.

Professor Cassidy's research aims to devise novel foundation solutions in WA's problematic undersea soil conditions. His group investigates offshore geotechnics, predominantly to develop wavestructure soil-interaction models for the analysis of oil and gas platforms, mobile drilling rigs and pipelines off the North West Shelf.

The shelf has deep and expansive untapped reservoirs but also offers some of the most intriguing seabed challenges. With much of the scientific understanding of deep sea exploration benchmarked in the Gulf of Mexico within a soft clay seabed, little knowledge could be transferred and adapted to the unique North West Shelf environment. This created an opportunity for revolutionary

research and the pioneering of new standards for the oil and gas industry in Australia.

Professor Cassidy recently visited the Keppel Offshore and Marine Technology Centre in Singapore as a result of two ARC Linkage Grants. This research investigated the operational procedures and design of the foundations for mobile drilling rigs. These foundations exhibit significant failure rates in the offshore oil and gas industry, which contributes about \$22 billion each year to the Australian economy.

Professor Cassidy is also the Deputy Director of the newly formed ARC Centre of Excellence in Geotechnical Science and Engineering.

Research at the University of New South Wales by **Professor Sahajwalla** is aimed at making the steel industry 'greener' by delivering the science needed to utilise industrial waste as a carbon resource.

Working at the multidisciplinary juncture between materials science and engineering, Professor Sahajwalla's expertise lies in understanding extremely reactive, high-temperature environments (above 1500°C). In these environments liquids and solids behave aggressively and transformations occur rapidly to the molecular structure of solid materials – especially as it applies to carbon.

Professor Sahajwalla's expertise has seen her create innovative ways of harvesting carbon from waste products. As well as enhancing the international competitiveness and environmental sustainability of Australian industries, this 'green steelmaking' seeks to allow ferrous alloy producers to consume substantial amounts of difficult-to-recycle industrial waste, and reduce the amount of waste being sent to landfill and illegal dumps.

The technology will have a significant impact on the environment through in greenhouse gas reductions, savings on raw materials and enhanced waste recycling.

Her long-term collaboration with OneSteel – Australia's largest manufacturer of steel long products – has seen her Polymer Injection Technology for steelmaking fully commercialised, with sub-licensing to electric arc furnace steelmakers worldwide currently underway. This collaboration was recognised by the Australian Collaborative Innovative Award, which she received jointly with OneSteel in 2012.

MARINE SCIENCE A KEY, SAYS GUNN

The next 10 years will be important to people working in the marine science community, according to Australian Institute of Marine Science (AIMS) CEO, Mr John Gunn FTSE.

"Not only are Australia's oceans predicted to contribute about \$100 billion annually to our economy by 2025, but we will also see significant population growth along our coastal fringe and face the challenges of balancing the use of our marine and coastal resources with maintaining the health of our marine ecosystems," Mr Gunn said.

Mr Gunn was speaking at the AIMS headquarters in Townsville during a visit by the Hon Karen Andrews, Parliamentary Secretary to the Minister for Industry and Science.

Mrs Andrews said AIMS continued to play an important part in understanding Australia's marine territory, a significant asset.

"Australia has the world's third-largest marine jurisdiction, with sovereign rights over much of this vast estate and associated fishing, mineral and petroleum resources. Our oceans encompass some of our most iconic ecosystems, including the world-renowned Great Barrier Reef, and have an important place in our national identity," she said.

"We know that growth in our marine-based industries has been extraordinary, almost doubling over a decade to contribute around \$47.2 billion – a significant proportion of our GDP – in 2011-12."



John Gunn

Gates and Dale behind banana biofortification

PHOTO: ERIKA FISH



James Dale and the super bananas.

The world's first human trial of pro-vitamin-A-enriched bananas, expected to lift the health and wellbeing of millions of Ugandans and other East Africans, is underway.

The Queensland University of Technology (QUT) project, led by Distinguished Professor James Dale FTSE and backed with close to \$10 million from the Bill & Melinda Gates Foundation, is one of the most significant biofortification projects in the world today.

"Human trial is a significant milestone for this project, which started in 2005 and should see pro-vitamin-A-enriched banana varieties being grown by Ugandan farmers around 2020," Professor Dale said.

"The Highland or East African cooking banana, which is chopped and steamed, is a staple food of many East African nations but has low levels of micronutrients, particularly pro-vitamin A and iron.

"The consequences of vitamin A deficiency are dire, with 650,000 to 700,000

children worldwide dying from pro-vitamin A deficiency each year and at least another 300,000 going blind.

"There is very good evidence that vitamin A deficiency leads to an impaired immune system and can even have an impact on brain development.

"Good science can make a massive difference here by enriching staple crops such as Ugandan bananas with pro-vitamin A and providing poor and subsistence-farming populations with nutritionally rewarding food."

The bananas have been harvested from the QUT field trial in Innisfail, north Queensland, and transported to the US for the world-first human trial, lasting six weeks, with conclusive results to be known by the end of the year.

Professor Dale, who joined the Academy in 2014, said initial laboratory tests were performed at QUT in Brisbane and field trials conducted in far north Queensland before field trials in Uganda.

He said over the next three years an elite line of banana plants would be selected and used in multi-location field trials in Uganda.

Legislation to enable genetically modified crops to be commercialised in Uganda is currently at committee stage within the Ugandan parliament. With Ugandan Government support, legislation and regulations to enable the commercialisation of genetically modified crops should be in place by 2020. Regulations enabling field trials of genetically modified crops already exist.

Professor Dale said once approved in Uganda, there would be no reason why the same technology couldn't be used to enrich crops in surrounding East African countries including Rwanda, parts of the Democratic Republic of Congo, Kenya and Tanzania.

"In West Africa farmers grow plantain bananas and the same technology could easily be transferred to that variety as well," Professor Dale said.

"This project has the potential to have a huge positive impact on staple food products across much of Africa and in so doing lift the health and wellbeing of countless millions of people over generations."

Professor Dale said the biggest challenge

facing the project was purely one of logistics – going from a small-scale project to one on a national scale – but the university was working in partnership with a team of scientists in Uganda who would, over the coming years, be joined by five Ugandan PhD students currently working in Professor Dale's team.

RON SANDLAND CHAIRS WEATHER DATA FORUM

Dr Ron Sandland AM FTSE, a former CSIRO Deputy CEO, has been appointed chair of the Technical Advisory Forum, which comprises leading scientists and statisticians and will review the Bureau of Meteorology's official temperature data.

The Bureau of Meteorology is responsible for the nation's climate record and establishment of the Forum will provide an independent framework for quality assurance tests and analysis of the Bureau's data sets for greater transparency.

The Bureau's climate information services were reviewed in 2011 by a panel of international experts, which recommended that a Technical Advisory Group should be established "in order to review progress on the development and operation of the ACORN-SAT data set".

The Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) dataset is an important part of Australia's official climate record.

Dr Sandland holds a PhD in statistics from the University of New South Wales. His research interests concern applying statistics to solve challenging real problems in areas as diverse as growth of organisms, analysis of mark-recapture experiments, ore-reserve estimation and quality improvement.

He was appointed Deputy Chief Executive of CSIRO in 1999 and led the Flagship Initiative. This involved six major cross-disciplinary research programs and was aimed at addressing problems of a national priority.

He is an Honorary Life Member of the Statistical Society of Australia and has been an ATSE Fellow since 1995.



Ron Sandland

ATSE IN FOCUS

Fellows feature in 50 Most Powerful Women in Business

Three Fellows were named among the 50 most powerful women in business in Australia by *The Australian's Deal* magazine in February.

Catherine Livingstone AO FAA FTSE, Chair of Telstra and first female BCA President, was listed in second place after mining magnate Gina Rinehart.



Catherine Tanna

Ms Livingstone has been chair of Telstra, one of Australia's largest companies, with revenues of \$26 billion, since 2009.

She is a former CSIRO Chair, President of the Australian Museum Trust and a Director of WorleyParsons and Saluda Medical.



Deborah Rathjen

Ms Catherine Tanna FTSE, CEO of Energy Australia, the Melbourne-based energy company that services more than 2.7 million customers, was listed at 19. She is

on the Board of the Reserve Bank.

Dr Deborah Rathjen FTSE, CEO of Adelaide-based Bionomics, was listed at 46. She has more than 20 years' experience in the biotech industry and is a former member of PMSEIC.

The 32-page edition was led by a full-page feature on Toro Energy Chair and ANSTO Director Ms Erica Smyth FTSE and Toro CEO Ms Vanessa Guthrie, which focused on the transformation of the role of women in the resources industry.

RICHARD WILLIAMS TO HEAD HERIOT-WATT UNI

Professor Richard Williams OBE RAEng FTSE has been appointed as the new Principal and Vice-Chancellor of Edinburgh's Heriot-Watt University.

With a wealth of experience as a senior academic leader, impressive research credentials, and a strong track record in



Richard Williams

working successfully with governments and industry across the world, Professor Williams was a natural choice to lead one of the UK's foremost science and business universities, according to the appointment announcement.

Professor Williams, a Foreign Fellow since 2008, moves to the position from the University of Birmingham, where he has held the positions of Pro-Vice-Chancellor and Head of the College of Engineering and Physical Sciences for the past five years. Before that he was Pro-Vice-Chancellor for Enterprise and Knowledge Transfer and International Strategy at the University of Leeds.

The university said: "His significant experience in international strategy and relations also clearly aligns with a globally focused university with campuses in Dubai and Malaysia and our network of academic learning partners world-wide."

Professor Williams said: "I am delighted to be joining a university that has a proud heritage and evident track record of outstanding achievement in science, engineering and business and with such a profound global reach. Heriot-Watt has an ambitious and sound strategic plan. I look forward to working with students and colleagues across the campuses in the UK, Malaysia and Dubai, along with our many partners and businesses in the ensuring the university's future growth and success."

Professor Williams is an engineer, leader and innovator who has brought several new concepts, processes and methodologies into practice in the chemical, materials, energy and instrumentation sectors, with a strong interest in the effective translation of scientific and engineering knowledge.

He is Vice-President of the Royal Academy

of Engineering, an honorary professor of the Chinese Academy of Sciences and recognised as one of the UK's top 20 inspiring science and innovation leaders by the Engineering and Physical Sciences Research Council.

He studied at Imperial College London graduating in BSc (Eng) Mineral Technology (1983) and PhD (1995). He worked as a trainee metallurgist for Anglo American Corporation (1979-80) and De Beers Industrial Diamonds Research Laboratory (1982-86).

He was appointed lecturer in Chemical Engineering at the University of Manchester Institute of Science and Technology (now University of Manchester) in 1986. In 1993 he was appointed Royal Academy of Engineering-Rio Tinto Professor of Minerals Engineering at the University of Exeter and, aged 33, was one of the UK's youngest engineering professors.

He is a founding director of the Manufacturing Technology Centre (Ltd) (CATAPULT) in Coventry, Alta Innovations Ltd, Alta Birmingham China Ltd and founder of several spin-out enterprises from his own research (relating to instrumentation, modelling and energy utilisation).

DI DAVIDSON JOINS BIOSECURITY BOARD

Ms Dianne Davidson FTSE has been appointed a Director of the Board of the Plant Biosecurity Cooperative Research Centre. She is one of three new Directors, appointed for two-year terms, who bring a diverse range of knowledge, skills and expertise to the Board.

Ms Davidson, a Fellow since 2001, is currently the Deputy Chancellor of the University of Adelaide. She has a

strong working knowledge of plant industry production, operations and marketing after providing consulting services to viticulturists and horticulturists for more than 30 years.



Di Davidson

ATSE IN FOCUS

Six Fellows elected to FIEAust rank

Engineers Australia (EA) has elected six ATSE Fellows as Honorary Fellows (HonFIEAust) – including new Fellow Marlene Kanga, former President of EA, and Queensland Fellow Kathy Hirschfeld, only the eighth and ninth women to win this honour.

Its 2014 Honorary Fellows included Professor Edwin (Ted) Brown AC FREng FTSE, Emeritus Professor Mark Bush FTSE, Professor Hugh Durrant-Whyte FRS FAA FTSE, Ms Kathy Hirschfeld FTSE, Dr Marlene Kanga AM FTSE and Dr Chris Roberts FTSE.

Professor Ted Brown commenced his career in 1960 at the State Electricity Commission of Victoria's large-scale, open-cut, brown coal mines at Yallourn and Morwell, engaged in geological investigations, slope stability studies and extensive laboratory studies of the physical properties of brown coal. He worked at James Cook University and Imperial College, London.

On his return to Australia in 1987, he was appointed Professor and Dean of Engineering at Queensland University; Deputy Vice-Chancellor (UQ) in 1990; and Senior Deputy Vice-Chancellor (UQ) from 1996 to 2001. He has been a teacher and mentor to engineers around the world, very active in professional societies and through directorships on a number of government and non-government boards, and has made significant contributions to the governance of those organisations.

Professor Mark Bush, from the Mechanical Engineering Department of the University of WA, remains active in research. He became Lecturer in Mechanical Engineering at UWA in 1984 and lectured in thermodynamics, fluid mechanics, computational mechanics and materials engineering, receiving awards for teaching and research supervision.

He was promoted to Winthrop Professor in 1998, served as Head of the Department of Mechanical and Materials Engineering from 1998 to 2001 and Dean of the Faculty of Engineering Computing and Mathematics from 2003–07. He was included in EA's Engineering Elite survey in 2003 and in its Top 100 Engineers in 2004.

He is WA division Chair and Deputy Chair of the ATSE Assembly in 2015.

Professor Hugh Durrant-Whyte, the former CEO of NICTA, is a leading national and international figure in the research, development and commercial exploitation of robotics systems in applications including cargo handling, mining and defence. He has made substantial contributions in both research and commercial applications of robotics technologies, especially in large-scale field applications of key importance to the Australian economy.

His vision of robotics science and application, and the passion with which he articulates this vision, have played a critical role in raising the visibility of Australian robotics in government, industry, academia and the community. His research contributions have focused on two main areas – autonomous vehicle navigation and multisensor data fusion.

Ms Kathy Hirschfeld is a non-executive director of Transfield Services, ASC Pty Ltd, InterOil Corporation and Toxfree Solutions. She is a Senator of the University of Queensland, an advisory board member of the Australian Institute of Bioengineering and Nanotechnology, and a board member of UN Women Australian National Committee. Her previous directorships include Snowy Hydro Ltd, Queensland Reconstruction Authority and New Zealand Refining Company.

In her executive career with BP, Ms Hirschfeld led businesses in oil refining, logistics, and exploration and production in Australia, the UK and Turkey. She was Managing Director of the BP Bulwer Island Refinery in Brisbane, and of BP's joint venture refinery in Turkey. EA recognised her as one of Australia's most influential female engineers in 2007. She is a member of Chief Executive Women and has been a Fellow since 2009.

Dr Marlene Kanga is Acting Chair of the Board of Innovation Australia, Chair of the R&D Incentives Committee, Department of Industry, a member of the Board of Sydney Water Corporation and Director of iOmniscient Pty Ltd, which has developed patented software technology for intelligent video analytics systems.

She was National President of EA in 2013 and is a board member of the International



Mark Bush



Kathy Hirschfeld



Hugh Durrant-Whyte

Network for Women Engineers and Scientists (INWES) and a member of the of the Executive Council of the World Federation of Engineering Organisations (WFEO).

Dr Kanga, a chemical engineer, was listed among the Top 100 Engineers in Australia in 2013 and 2014 and the Top 100 Women of Influence in 2013. She is the 2014 FEIAP (Federation of Engineering Institutions in Asia and the Pacific) Engineer of the Year.

Dr Chris Roberts is President and Chief Executive Officer of Cochlear Ltd, the global leader in providing hearing solutions for the hearing impaired. Since assuming the role in 2004 more than 170,000 people have been given the gift of hearing. He holds a Bachelor of Engineering with Honours in Chemical Engineering from UNSW, an MBA from Macquarie University and a PhD from UNSW.

Before his current role, Dr Roberts made significant contributions to the technical world in the development of orthopaedics, pacemaker development and respiratory and sleep medicine – he is a former Executive VP of Resmed and remains on its Board. He was Chairman of Research Australia from 2004–10.

ATSE IN FOCUS



Robin Batterham

Robin Batterham wins Willis Connolly Medal

Academy Immediate Past President Professor Robin Batterham AO FREng FAA FTSE has been awarded the 2014 AusIMM Sir Willis Connolly Memorial Medal.

Professor Batterham is Kernot Professor of Engineering at the University of Melbourne. Until retirement he was Group Chief Scientist, Rio Tinto Ltd. He was previously Chairman of the International Energy Agency Expert Group on Science for Energy and Chief Scientist to the Australian Government.

He has had a distinguished career in research and technology in the public and private sectors in areas such as mining, mineral processing, mineral agglomeration processes and iron-making.

Professor Batterham's current research interests centre on energy systems including geothermal energy, energy reduction in comminution and in dewatering of low-grade materials. He maintains a long-term interest in innovation.

The Australasian Institute of Mining and Metallurgy (AusIMM) was founded in 1893 and provides services to professionals engaged in all facets of the global minerals sector. It represents 14,000 members drawn from all sections of the industry and supported by a network of branches and societies in Australasia and internationally.

The Sir Willis Connolly Memorial Medal commemorates the contribution to science, engineering and technology in Australia by Sir Willis Connolly. It particularly commemorates his achievements as a communicator. The medal is awarded to an outstanding communicator from the broad arena of

science, engineering and technology whose ability to communicate has advanced the professionalism, the industry or management of science, engineering and technology.

LEIGH CLIFFORD BACKS MELBOURNE'S CENTRE FOR NEURAL ENGINEERING

A major donation to the University of Melbourne's Centre for Neural Engineering (CfNE) will provide critical funds to advance links between life sciences, engineering and physical sciences and drive the next wave of medical breakthroughs in Australia.

Mr Leigh Clifford AO FTSE, Mrs Sue Clifford and their family are donating \$5 million to the university to endow The Clifford Chair in Neural Engineering.

The new Chair will help facilitate the development of new medical point-of-care devices, providing clinicians with the information they require to undertake faster, more reliable diagnoses and better management of patients especially those located in Indigenous and rural communities.

It will also work across a number of disciplines to deliver new biotechnologies, treatments and improved engineered systems that replicate biological networks.

Mr Clifford, a Fellow since 2006, Chairman of Qantas Ltd and former CEO of Rio Tinto, is an engineering alumnus of the university and Deputy Chairman of 'Believe – the Campaign for the University of Melbourne'. The campaign is aiming to raise \$500 million by the end of 2017 to support key research, scholarship and

engagement goals.

Mr Clifford supports new and innovative engineering, as he believes this will drive Australia's future, particularly in the area of healthcare.

"The Chair will bring together researchers and experts from engineering, medicine and science to improve health outcomes for every Australian – not just those living in major metropolitan cities," Mr Clifford said.

"The gift will allow researchers to concentrate on progressing their pioneering and collaborative work ensuring people across Australia, and the region, have equitable access to healthcare. The idea of small, low-cost and easy-to-use devices for the best patient management is only one example of what is possible in the future," he said.

The CfNE is a cross-disciplinary research and development centre with a focus on the world-wide convergence of the engineering, physical and life sciences. Through the Centre, potential treatments for conditions such as epilepsy, Parkinson's disease and spinal injuries are being researched and developed.

"This gift will enable us to address some of the long-term and complex challenges facing healthcare," said Professor Stan Skafidas FTSE, CfNE Director. "Bringing together interdisciplinary teams allows them to build



Stan Skafidas holds the point-of-care device.

technologies that will change lives and help dictate the future of healthcare.

"It will also help CfNE in our work towards addressing some of the major challenges in neuroscience and neurological and psychiatric disorders."

"This is an exciting challenge as we work together to create not only portable diagnostic tools, but the next generation of bionic devices and implants."

ATSE IN FOCUS

Neil Andrew heads Murray–Darling Basin Authority

Former Speaker of the House of Representatives, Chair of the Crawford Fund and South Australian Federal Liberal MP the Hon Neil Andrew AO FTSE has been appointed the new chairman of the Murray–Darling Basin Authority (MDBA). He has had a life-long association with the irrigation industry, particularly irrigated horticulture and viticulture.

Mr Andrew was elected an Honorary Fellow in 2006.

He was appointed Speaker of the House of Representatives after the October 1998 Federal election. He held the SA seat of Wakefield from 1983 until 2004, when he retired from Parliament.

In retirement he has remained actively engaged in high-level agricultural work. In December 2013, Mr Andrew released a report in Canberra that detailed the benefits of Australia's work in international agricultural aid programs, written by a taskforce he chaired for the Crawford Fund.

The Australian Government announced the appointment.

"I am delighted that Mr Andrew, who has a long association with the Murray–Darling Basin issues, has agreed to serve as the new Chair," Minister for the Environment, Mr Greg Hunt said.

"Mr Andrew has considerable

expertise in both public sector governance and irrigated agriculture, and he will make a valuable contribution as Chair of the Authority."

Parliamentary Secretary to the Minister for the Environment, Mr Bob Baldwin, said the appointment of Mr Andrew would provide strong oversight for the implementation of the Basin Plan in full and on time.

"Minister Hunt and I will be working closely with Mr Andrew and members of the Murray–Darling Basin Authority on key water reforms being pursued by the Australian

Government, including the Basin Plan.

Mr Andrew's four-year term commences 1 February. He succeeds the Hon Craig Knowles.

The Murray–Darling Basin Authority, which was established under the *Water Act 2007*, comprises a part-time Chair, a full-time Chief Executive and four part-time Authority members. The Authority members draw upon their collective expertise and experience to oversee implementation of the Basin Plan.

The Authority is also responsible for the operation of the River Murray system and delivery of basin-wide natural resource management programs on behalf of basin governments.

GRAEME JAMESON JOINS NAE

Laureate Professor Graeme Jameson AO FEng FAA FTSE, from the Centre for Multiphase Processes at the University of Newcastle, has been elected a Foreign Member of the US National Academy of Engineering (NAE) "for development of innovative flotation technology for advanced mineral processing".

He was one of 12 foreign engineers elected and brings Australian membership of NAE to seven. Professor Jameson is a Foreign Fellow of the Royal Academy of Engineering and has been an ATSE Fellow since 1991.

New NAE fellows will be inducted at a three-day meeting in Washington, in October.

The National Academy of Engineering was established, along with the National Academy of Science, to give advice to the US Congress on matters relating to science and engineering. Part of the induction process is a session on testifying before Congress.

"As an overseas member, it's unlikely that I'll be called upon to testify, but you never know," Professor Jameson said.

Professor Jameson AO was named 2013 NSW Scientist of the Year, and awarded \$55,000 in prize money. Earlier that year he received The Antoine M. Gaudin

Award, which is considered the world's most important prize in the field of engineering science and industrial technology.

NSW Chief Scientist and Engineer, Professor Mary O'Kane FTSE, said Professor Jameson was a worthy winner of the state's most prestigious science award.

His trailblazing technology has turned mineral processing on its head and proved an economic boon. His internationally renowned Jameson Cell is used in more than 300 mineral-processing plants across 20 countries – using floatation to remove oil, grease and other suspended solids from industrial wastewater and effluent.

The technology contributes more than \$3 billion in mineral exports to the Australian economy every year. The technology used in the Jameson Cell continues to evolve and is now being applied to other industrial practices, including the extraction of oil from tar sands in Canada and the removal of blue-green algae from waterways in Central Australia.

The other Australian Foreign Members of NAE are Professor Brian Anderson AO FRS FTSE, Dr Robin Batterham AO FEng FAA FTSE, Dr Graeme Bird FTSE, Professor Tom Healy AO FAA FTSE, Professor Jorg Imberger AM FAA FTSE and Dr Harry Poulos AM FAA FTSE.



Neil Andrew



Graeme Jameson receives his 2013 award from then NSW Governor Dame Marie Bashir.

ATSE IN FOCUS

Rail expert honoured with award

Professor Buddhima Indraratna FTSE, Professor of Civil Engineering at the University of Wollongong, and a world-leading geotechnical expert on road and rail infrastructure, has been awarded one of the highest honours in this field.

Professor Indraratna has won the Ralph Roscoe Proctor Award for his major contributions to transport infrastructure research and development and for the impact his research has had on the transport industry worldwide.



Buddhima Indraratna

The International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) established the Ralph Roscoe Proctor Award and the associated named lecture in August 2013 in Paris to recognise the most distinguished professionals in the field of ground transport infrastructure.

Professor Indraratna, the Foundation Director of Centre for Geomechanics and Railway Engineering at the University of Wollongong, will accept the award and deliver the Inaugural Ralph Proctor Lecture in Portugal next year at the International Transportation Geotechnics Conference.

Ralph Roscoe Proctor was a US Army engineer who, through his dedicated efforts after World War I, invented the theory of soil compaction for railroads, highways and dams. He developed what is now known as the Proctor Compaction Test to evaluate the desired water content of any type of soil to obtain its optimum compaction level when used for earth-fill structures including roads, railways, airfields, dams and land reclamation.

Proctor's soil compaction theories are still a teaching essential and the implications of the Proctor Compaction Test are also familiar to sports field curators worldwide as one of the methods, for example, that can be used to adjust the life, pace and bounce in turf cricket pitches, given the type of foundation soil.

The award recognises Professor Indraratna's decades of research excellence and outstanding professional contributions to research and impact on the way modern rail and road transport embankments are designed and built, not only in Australia but also where his R&D outcomes have been absorbed in industry practices in several European countries including the UK and France, as well as the US, China, India and Japan.

TONY LAWRENCE: SHIPPING AND RESOURCES LEADER

Dr Tony Lawrence FTSE had a long and distinguished career in the concrete, steel, coal and shipping industries, becoming Managing Director and later Chairman of McIlwraith McEachern – one of the biggest names in shipping and coal in Australia in the 1980s.

After graduating in physics from The University of Western Australia, he started his career with Australian Iron and Steel at Port Kembla, becoming slab and plate mills superintendent in 1964 and completing an MBA at University of NSW.



Tony Lawrence

From 1967–72 he was NSW Manager of Rocla Concrete Pipes before spending four years as GM and CEO of Seatainer Terminals. He was Chief Executive (1976–80) of R W Miller Ltd, a major coal and shipping company, then spent three years heading Aquila Steel, with its steel, aluminium and concrete business extending to Brazil, Canada, Singapore and Europe.

He joined McIlwraith McEachern as Managing Director in 1982, expanding its shipping operations into coal production, capturing world-wide markets for its thermal and metallurgical coal.

He was President of the Australia–Korea Business Council and headed the Australian Coal Trade and Technology Committee.

He was well respected internationally and well-known in Australian business circles.

He was a Chartered Engineer (CEng), Chartered Professional Engineer (CPEng), a Founding Fellow of the Australian Institute of Directors and a member of many other organisations.

Dr Lawrence, a Fellow since 1994, died in Sydney in January 2015, aged 82.

RODERICK MACDONALD: ARCHITECT OF NOTE

Mr Roderick MacDonald FTSE was one of Victoria's best-known architects and planners, with an impressive array of buildings in his portfolio.

He helped develop the master plan for the Australian National University and during his career designed many distinctive buildings on Australian campuses and some of Melbourne's prominent buildings.

After war service in New Guinea, he graduated in architecture from the University of Melbourne and worked in private practice, becoming chairman of Melbourne firm Eggleston Macdonald in 1983, a position from which he retired in 1997.

His 'credits' included feasibility studies for the National Capital Development Commission, Canberra, and the National Museum of Victoria and master planning for the ANU precinct, Caulfield Institute of Technology (which became Monash University), the University of Melbourne Institute of Education, BHP research laboratories and Epworth Hospital.

His building projects are a 'who's who' of buildings at ANU, various Melbourne universities and Newcastle University, and he played a leading role in the restoration of Melbourne's iconic Shrine of Remembrance.

His reputation was strong in his professional heyday and his Academy proposer was Founding President Sir Ian McLennan.

He was a Life Fellow of the Royal



Roderick Macdonald

Australian Institute of Architects, a Member of the Royal Australian Planning Institute and had been a Fellow since 1984.

He died in Melbourne on 16 October 2014, aged 91.

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CREATING A SUSTAINABLE FUTURE

Advanced Water Management Centre

The University of Queensland's (UQ) Advanced Water Management Centre (AWMC) is working towards a sustainable future, recognising the importance of protecting our water resources and critical infrastructure.

Working closely with the Australian water industry and collaborators, AWMC researchers have spent over a decade investigating the optimal management of sewer systems, including the development of tools and reliable technologies to support strategic decisions and cost-effective sewer operation. Sewer systems are critical infrastructure for modern urban societies, protecting us against sewage-borne diseases and noxious odours, and enabling us to safely live in increasingly larger cities.

Today's underground sewer infrastructure is under serious threat due to deterioration, with estimated asset losses worth billions of dollars globally. The AWMC research has involved answering fundamental questions about the key in-sewer processes which influence corrosion, and application of in-field preventative measures. The research has already delivered documented savings of hundreds of millions of dollars to the Australian water industry, winning the B/HERT 2014 Award for

Outstanding Excellence in Collaboration for the SCORe project (Sewer Corrosion and Odour Research) and the 2014 IWA Project Innovation Global Award.

Led by Director Professor Zhiguo Yuan, the AWMC has over 50 academic and research staff and more than 60 research students. The AWMC has an outstanding track record of successful research, development and application projects, many with industry and research collaborators. More information is available at awmc.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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