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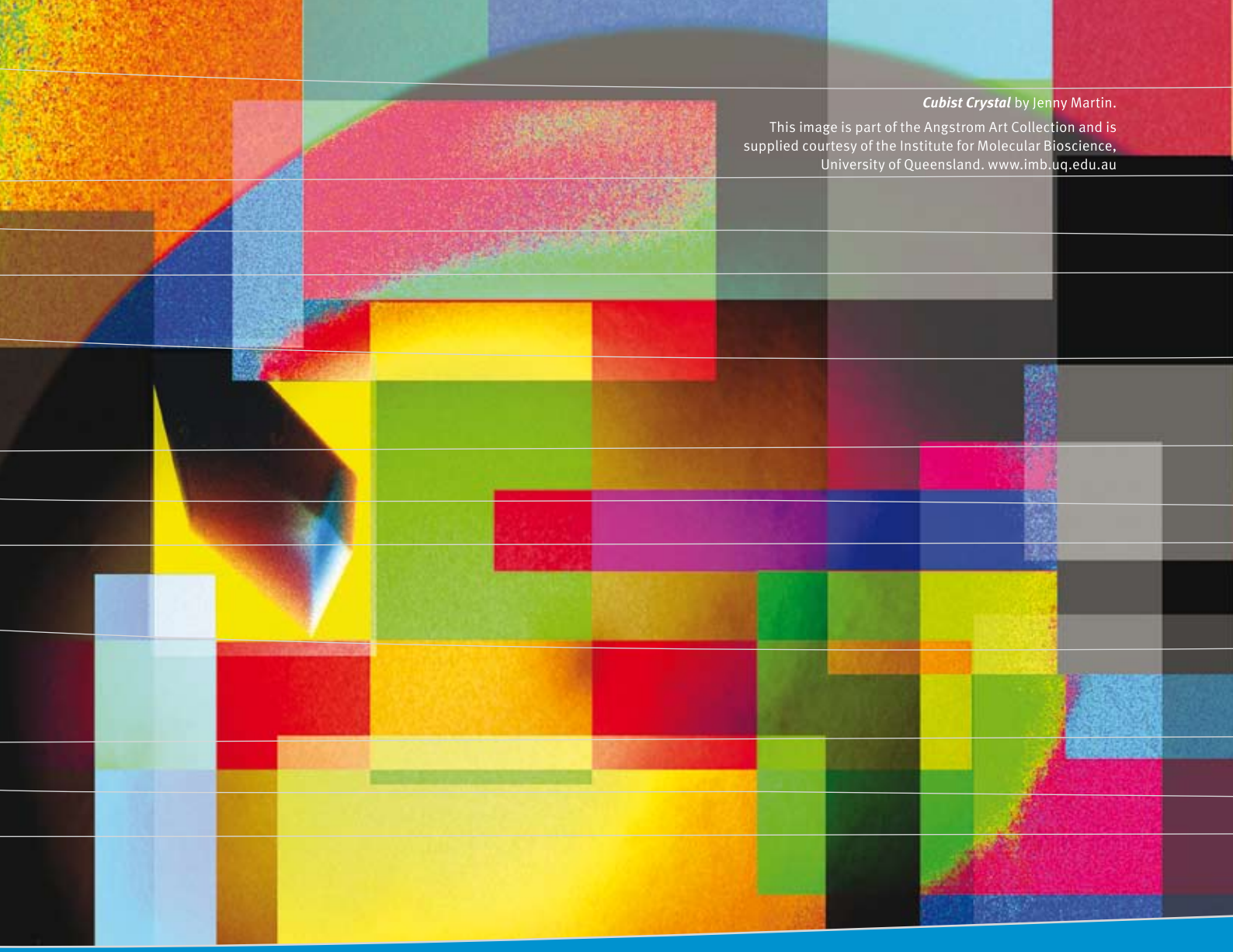
Adapting to our changing climate

Contributors discuss key aspects of climate change and its impacts, international moves to ameliorate its effects, what those effects might be and what Australia can do about them



Cubist Crystal by Jenny Martin.

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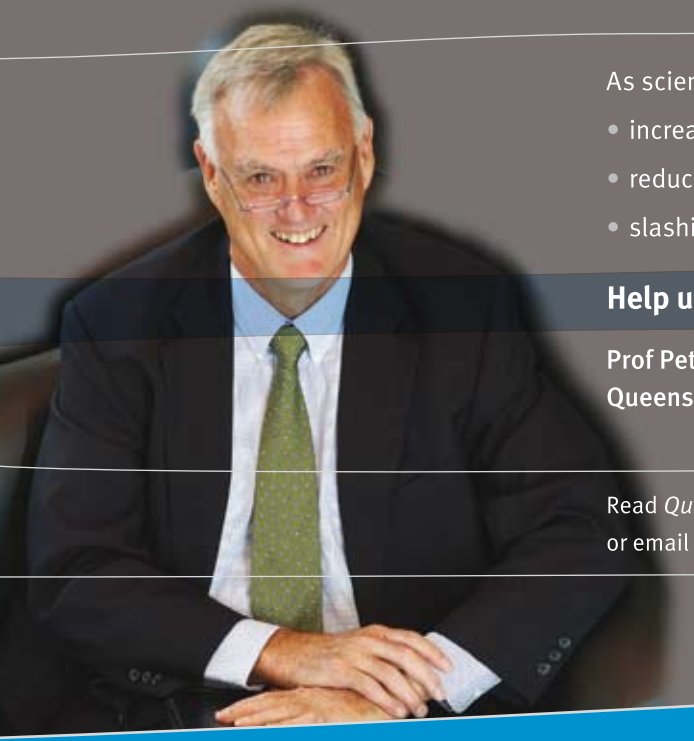

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Cover: Southern Ocean recovery of equipment used to measure ocean temperatures and take water samples to determine the carbon content of sea water. By absorbing carbon dioxide and heat, oceans influence the rate of climate change. Deep ocean measurements are used to determine the recent rate of change. Photo: CSIRO

References

The subject of climate change is contentious. The articles published on the topic in this edition of ATSE *Focus* are from respected contributors, representing a variety of points of view on various aspects of the topic. The format of ATSE *Focus* does not permit publication of lists of references or extensive footnoting. Readers are reminded that each author's email address is provided at the start of each article and requests for references or further information can be directed to the authors. *– Editor*

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 pieces on topics of national interest, particularly the Academy's key interest areas – climate change, water, energy and education – will be considered for publication. Items between 800 and 1500 words are preferred. Please address articles for publication and letters to the editor to editor@atse.org.au.

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Chief Executive Officer: Dr Trevor Evans
Editor: Bill Mackey
Technical Consultant: Dr Vaughan Beck FTSE

AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING (ATSE)

Address: Ian McLennan House, 197 Royal Parade, Parkville Victoria 3052
Postal Address: PO Box 355, Parkville Victoria 3052

Telephone: 03 9340 1200
Facsimile: 03 9347 8237
Email: editor@atse.org.au

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The widening scope of climate change

Warming has already taken the planet into a condition where human experience no longer provides a reliable indication of the future

By Graeme Pearman
graemepearman@megalink.com.au

In recent decades research has shown clearly that the Earth is warming and that this warming is largely due to carbon dioxide (CO_2) and other greenhouse gases that have increased in the atmosphere due to human activities. We now have some confidence that we can anticipate future warming and concomitant changes to climate. In responding to global warming we have several options and challenges, some of which are briefly considered below.

What the science has and has not told us

The knowledge of climate change contained within peer-reviewed scientific publications is periodically assessed by the Intergovernmental Panel on Climate Change (IPCC). For example, in the first part of IPCC's recent report (February 2007), 750 authors assessed the underpinning science of climate change by examining 6000 journal articles, approximately half of which were published since 2001.

New research published in recent months has heightened concern about the probability of faster and more intrusive change than anticipated just a year ago. For example:

- observed changes to biological systems (migration, breeding/flowering times, behaviour, fecundity, genetics) appear to have been a response to changed climate;
- a 20 per cent decrease in Arctic sea-ice extent last northern hemisphere summer raises the possibility that this ice sheet may disappear earlier than 2050, as the IPPC projected, with consequences for economic and political instability now being considered;
- global CO_2 emissions continue to grow at a rate that is at the high end of projections;
- the capacity of the oceans to absorb CO_2 has decreased over the past two decades, something that was anticipated for the future but not previously observed;
- regions of low productivity appear to be increasing in the north and south Atlantic and Pacific oceans, consistent with greater stability of the warmer ocean surface; and
- anticipated rates of change of temperature and sea level have under-predicted what has now occurred, possibly reflecting a tendency for scientific conservatism.

These findings remind us that the warming has already taken the planet into a condition where human experience no longer provides a reliable indication of the future. It also reminds us that we may have limited predictability particularly of the non-linear responses of both the physical and biological world of what, until now, have been regarded by the wider community as 'small' climatic changes.

We hear that 'the science is now in'. This is as if, somehow, there was a point at which we did not know anything about the issue, and then it all became clear. Of course this is absurd. There was no such point, nor will there be.

For example, the complexity of responses of ecosystems to climate change and the huge numbers of species involved means it is unlikely that we will anticipate many of the biological changes that will result from planetary warming. Strategic planning and decision-making need to incorporate flexibility in the face of such uncertainty.

We must continue to build our knowledge as best we can and ensure that mechanisms exist for that knowledge to be applied to decision-making in a timely way. Increasingly, that knowledge is not just about pushing the frontiers of particular disciplines, but about the integration of physical, biological, social, technological and economic knowledge into reasoned options for the management of businesses and state jurisdictions.

Understanding probabilities and managing risk

When scientists conduct experiments or examine data they choose the probability of between 95 and 99 per cent certainty to reject or accept a hypothesis. Yet these probabilities have little to do with the probability used in risk assessment, which is inversely related to the degree of impact.

For example, we are not 99 per cent certain that the current Australian drought is due to greenhouse gases and global warming, but the magnitude of the impact if it is – implying that drought will continue and intensify – has such serious ramifications that it should not be dismissed in risk appraisal and policy development.

Adapting to change

Increased aridity and sea level, the loss of biodiversity and the distortion of trade relationships are the major potential threats to Australia's environment resulting from climate change.

Projections of Australian warming show declining rainfall from a few per cent to as much as 10 per cent through this century, with concomitant increases of evaporation. It is likely to exacerbate the already water-impoverished environment and escalate conflict over the sharing of water between irrigation, river flow for natural ecosystems, power generation and potable use. It has implications for the use of rural land for production, for food prices and for food-commodity exports.

Embedded in this complexity are unanswered strategic questions such as:

- Is it therefore advisable to embark on the development of a biofuel industry?
- How do we balance the many adaptive options, such as recycling water, desalination, the use of ground water, long-distance and energy-intensive pumping, and so on?

The water, coastal communities and natural-ecosystems sectors are those that, for Australia through this century, most rapidly approach the limit of their natural coping range and thus demand managed adaptive responses. Other sectors – such as agriculture and forestry, energy security, heat-related diseases, tourism, food security and major infrastructure – appear to be more naturally resilient, but also exceed their natural coping capacity before the end of the century.

Indeed, the first three of these sectors exceed the adaptive range and enter the vulnerability range with temperature changes of equal to or less than a global warming of 2°C. Warming can only be contained to this

level with final-equilibrium-equivalent CO_2 concentrations of about 450 parts per million by volume (pmmv), something that we are fast approaching. This implies a global peaking of emissions sometime between 2000 and 2014 – a huge challenge.

One of the least publicly examined findings of the IPCC is that 2˚C warming would have a 50 per cent chance of causing the extinction of 20 to 30 per cent of all species. From a biological point of view it is hard to imagine any ecosystem remaining resilient or in anyway recognisable as its original functioning whole with such an impost. The consequence for the delivery of ecosystem services could be profound.

The real threat here is that we know little or nothing about how this might unfold. It is likely that one such ecosystem highly vulnerable to warming (combined with the effects of ocean acidity) will be the Great Barrier Reef. Virtually all projections have the Reef as highly vulnerable by as early as 2050.

Other ecosystems seen as vulnerable are the eastern Australian Alps, eastern Queensland, Kakadu, the Murray–Darling Basin, the Queensland wet tropics, southwest Western Australia and the sub-Antarctic islands.

Reducing future change

A further challenge is to work across political jurisdictions and across societal sectors to lower our greenhouse gas emissions. This means making major changes to the way we obtain and use energy.

How do we meet the obvious amenities of energy use without releasing CO_2 into the atmosphere? Fortunately, there are many options – including modifications to the efficiency of existing fossil-fuel conversion systems, the capture of CO_2 and its sequestration under the ground and the expansion of nuclear power generation. In addition, there is potential in the so-called renewable energies of solar thermal, solar photovoltaic, wind, tidal and geothermal.

Two points stand out. First, policy to deal strategically with a changed world (sourcing and usage of energy) requires the application of rigorous balancing of all options against the following issues:

- economic costs are poorly defined in this changing world of carbon trading, increased market share and technology improvements;
- in some cases, even the technological feasibly remains uncertain;
- the rate at which alternative energy sources can be brought online, both for meeting energy demands and in terms of emissions reduction; and
- in the real world, community perceptions about each technology, that may or may not be soundly or objectively based, nevertheless exist and constrain changes.

These facts strongly point to the establishment of a portfolio approach, where the risk of investment is limited by investment across a number of options and through time with an evolving relative contribution.

Second, in the many studies carried out thus far – including those of Nicholas Stern, the IPCC, the Australian Business Roundtable, AGL/WWF, Monash University, the Climate Institute, Australia21 and McKinsey to name a few – the costs to the Australian economy of making quite massive changes to our energy system is likely to be in the order of less than 0.1 per cent of GDP per annum. Such analyses need more work, but they jointly point to the conclusion that the costs of inaction are likely to be much greater.

Inequities

A changing climate will impact very differently on different regions of the world, and even the regions of Australia. Yet no two nations have the same capacity to respond to those changes, given their differential degrees of development, technology or organisational skills. Further, there is a huge discrepancy between the current or accumulated contribution to planetary warming by individual nations (or persons).

How will these inequalities feed into global or regional agreements concerning mitigation and adaptation responses to climate change? Will there be a willingness to transfer wealth between jurisdictions in an attempt to share these responsibilities? Are there important opportunities for doing just that?

The regional sharing of mitigative actions with New Zealand and our developing neighbours to the north and east could potentially provide for a rapid and phased reduction of emissions, which simultaneously treats issues that exist aside from climate change but might be exacerbated by it.

These might include lower global emissions, more sustainable forestry and land-use practices, the provision of jobs and improved social security for the local peoples, protection of unique ecosystems and provision of other collateral advantages, such as traded Australian access to resources needed in our transitioning economy. ◀

DR GRAEME PEARMAN AM FAA FTSE trained at the University of Western Australia. He joined CSIRO in 1971 and was Chief of Atmospheric Research from 1992 to 2002. His personal research focused on the global carbon budget. He now directs a consultancy contracting to the private and public sectors. Awards include the CSIRO Medal, a UN Environment Program Global 500 Award and a Federation Medal.

Australia's climate response priorities need to change

Australia will best contribute to world betterment by adopting a positive strategy for achieving sustainability

By Ken Dredge
khdredge@ozemail.com.au

Australia can best contribute to achieving global sustainability by leveraging its skills base and research capability to develop and advance innovative technologies that tangibly improve resource efficiency and reduce carbon emissions. There has to be a significant lift in both basic research and development areas. This needs national guidance and priority for creation of major paths for guidance and funding.

The October 2007 CAETS conference in Tokyo, an international meeting of academies of engineering and technological sciences, highlighted the evident focus of nations on their particular needs and interests. Climate issues were accepted as important, but all nations are following strategies that meet their specific needs. The difference between developed economies and less-well-off nations is stark. Advanced nations are focusing on the development and application of new technologies to reduce climate impact. For less-developed nations, lifting living standards takes priority over containment of emissions.

In this context, Australia is in an unusual and vulnerable position. Australia is small in terms of population, energy use and emissions. Its economy depends on low-cost energy for industry. It features as one of a few coal-exporting countries, but the quantities involved are small relative to total coal-production volumes. It has a significant proportion of world uranium resources. Its 'limiting resource' is water. The CAETS conference provided valuable information on likely trends in energy and emission-related areas as follows.

Energy sources

1 **Coal use for energy production will continue to increase for at least several decades.** While the carbon efficiency of electricity generation from thermal coal is improving, until emerging nations have access to new, cost-effective technologies, CO_2 emissions will increase.

Biofuels were evidently the subject of much effort in many countries. However, effectiveness of this concept was variable, while cost, human impact and environment concerns were reported. For example, Brazil was cited as pursuing expansion of cane crops for fuels – identified as highly effective on cost and emission measures, but this may come at the cost of loss of virgin jungle habitat.

Solar generation was identified as capable of tangible improvement in efficiency with continued research and development.

Nuclear energy is clearly going to be an important part of energy supply into the future. Continuing evolution of the technology was reported. However, it was not slated to replace coal as the major energy source.

Technology developments

2 The broad attention of technologists around the world is moving to sustainability solutions. However, substantially increased expenditure on related research and development was not evident.

Japanese achievements in **high voltage direct current (HVDC)** transmission technology suggest that long-distance high-power transmission may be feasible. This could revolutionise the scene for solar and wind energy, in particular, by allowing sharing of energy sources and markets across time zones and between regions.

Carbon capture from thermal coal generation through liquid/gas extraction is at the stage of a workable concept. It is the subject of operational trials that will, in time, be progressed to commercial operation. Carbon storage has worked in special cases. Extension to general use has yet to be proved.

Energy storage is important to successful reduction of carbon intensity, but no breakthroughs have been identified.

Australia's role

3 How will our small nation best contribute to global sustainability? We have a situation where a large

Tarong Power Station cooling towers.

proportion of the world's population aspires to lift its living standard, to approach the level that is the norm for the developed world. Moreover, in the absence of new developments, this improvement will rely on increased use of coal-based energy.

Where Australia will best contribute to world betterment is through adopting a positive strategy to achieving sustainability, by progressing achievements in technology that reduce the carbon intensity of everyday activity. The basic structure exists for this to happen. Eminent centres for research in critical areas are already in place, and universities have established groups for basic research to identify and develop breakthrough concepts in areas such as nanotechnology and biotechnology.

One example of tangible action is the Coal 21 project, which marshals funds from a levy on exported coal to support research and development. However the current level of activity is too small to have the needed impact in the desired timeframe.

At one end of the range of needs, the current volume of fundamental research into potential breakthrough technologies is modest. One can conceive of improvements in storage and transmission of energy, replication of photosynthesis that could actually consume carbon emissions, carbon capture and photovoltaic energy generation, which could all dramatically change the emissions scene. This needs an order-of-magnitude increase in the number of basic research projects addressing those challenges. While the reality is that only a small proportion of such ventures may succeed, the benefit from even a few successes would be significant on a global scale.

At the big end of the spectrum of challenges, we have nascent power-generation projects, such as ZeroGen and oxyfiring, which seek to progress identified emission-reduction technologies towards commercial viability. These developments are needed to provide trial-product streams needed for testing concepts such as geosequestration in real conditions. They involve large chunks of capital and operating cost imposts, which are daunting at any level other than national.

Serious funding is needed for a vision of this magnitude. Achieving the required level of activity in development of long-term sustainability solutions in the timeframe needed – the first half of the 21st century, for example – needs national guidance and direction that recognises Australia's small size and its vulnerabilities.

The necessary developments will not emerge from imposing drivers, such as a carbon tax, into the Australian market, particularly if the rest of the world does not have the same rules. In fact, a negative strategy – creating burdens on current energy use – has potential to cause short-term damage to the nation that may never be recovered. However, they may well support take-up of technologies in subsequent phases of development.

Timing is critical: a 50-year plan is the minimum needed because lead times are significant at every stage.

What we must do

4 We need a national plan for achievement across the board that initiates, encourages and optimises progress and the effectiveness of funds and investments in people, so that tangible results are realised in an urgent timeframe. Perhaps this warrants creation of the equivalent of the National Health and Medical Research Council (NHMRC) for the purpose.

No single arrangement meets the varying situations that have to be addressed. For a start, we could have:

- A **long-term environment research investment fund**, possibly set up like the Future Fund, which accepted investments from long-term-focused sources such as superannuation funds, and possibly supported by government. This fund could finance work that would be likely to deliver intellectual property in time. This fund could reasonably expect to earn returns in the long term from those ventures that succeeded.
- An **emissions reduction fund** that significantly supported the major capital works and operational trials of ventures that are needed to test and prove technologies at large scale, but which are not economic. The prime funding for this activity would most likely have to be derived from a loading on domestic energy use. It would be justified on the basis of public acceptance of the urgent need to act on emissions reduction.

Commercial developments would be left to normal mechanisms, with private investment the main vehicle for funding and development. However, national guidance and oversight is not inappropriate in the circumstances. ◀

KEN DREDGE FTSE, with degrees in chemical engineering and economics, was Chair of Tarong Energy Corporation Ltd from 1999 to 2007. His experience covers mining, energy and associated businesses at management and board levels. At MIM Holdings Ltd he held positions including Executive General Manager of Mount Isa Operations and Executive Director. He was Managing Director of Dominion Mining Ltd, 1994–98. He is currently Chair of APS Consolidated Pty Ltd, a company that makes GPS-based systems for mining equipment, and a Director of Queensland Ores Ltd.

It's time to move forward

Society needs integrated climate change perspectives and paradigms to assist the judgements it must make

By Brian Sadler
brian.sadler@bigpond.com

In 1985 the Villach statement issued a warning to climate-affected enterprises and global society ... "Many important economic and social decisions are being made today ... based on the assumption that past climatic data are a reliable guide to the future ... This is no longer a good assumption ... ".

Today, many commercial and public enterprises have found it necessary to act on this warning, making judgements and actions to manage vulnerability. Nevertheless, 23 years after Villach, human nature and politics fuel a continuing polarisation of public perception, which diminishes the opportunity for informed collective response.

Informed action is more easily impeded than promoted and dominant patterns of human social behaviour imply that such inefficiencies will repeat themselves with evolving climate issues. Debate needs to move forward. For technological professions the endgame is about societal outcomes, not scientific victory. Their challenge is to give best-practice service to the risk-management processes through which enterprises and societies succeed and survive.

It is time to move understanding forward from the archaic polarisation exhibited in public media. Contemporary climate change, natural climate variability and change, and anthropogenic forcing are real. Climate impacts are real and serious. The intellectual challenge is not in the substance but the detail – how these phenomena come together, and how to positively support appropriate adaptive and mitigative response by society.

Society needs integrated climate change perspectives and paradigms to assist judgements it must make. Natural change, or variability, and anthropogenic change are not mutually exclusive or independent. Contemporary climate needs to be studied and interpreted as natural phenomena nudged and forced by underlying human influences. This challenge to traditional outlook and practice is bigger than it first seems.

Socio-technical service to a socio-political and socio-economic world

Society does not run on scientific certainty. Society runs on judgements (including scientific opinion and judgement), which exploit and offset risks according to the level and seriousness of the opportunity or threat. Economic decisions, for example, accept modelling of human instincts and market behaviour to steer big and small risk-management decisions on national and corporate investments and policy, central banking and infrastructure development.

Many of these judgemental props are less robust than climate change modelling. We may debate their detail and worry more or less about their implications, but we accept their use as essential tools in the risk-management judgements and decisions that are necessary to everyday sustenance of society.

If a society insists on waiting to satisfy perceptions of deterministic certainty, the society will never act until after the event and might miss big and dangerous issues. Such a society would almost certainly lack vigour and would probably suffer an early demise, as would a contemporary society which ignored the use of science.

We are human and social beings, not anthropoids. Not always for the better, we overlay these judgements on risk with subjective interpretations. This is also a human necessity insofar that, as individuals, we cannot be across all the issues that threaten us.

In the plethora of modern issues that confront us, we give trust to particular groups, experts or political instruments to act in our interest in problem resolution. We also resort to elements of personal experience and ideology. We hope that these processes are good enough

"Even if you are on the right track, you will get run over if you just sit there ... "
– Will Rogers (1879–1935)

to bring up the issues most critical to our society.

As social beings, we also colour our attitude to such societal action (implicitly or explicitly) by perceived impact on our personal or business interests, but should hold these interests apart from our professional advice. It is to such a human society and world of risk management that the professional technologist attempts to lend judgements on the serious issue of climate change.

Three matters colour this standpoint on climate change as a serious, immediate and ongoing societal issue:

- first, successful society manages risk, not just certainty;
- second (amplified below), society, by its nature, deals less than perfectly with action on chronic risks (such as salinity or climate change); and
- third, there are ethical responsibilities governing learned and professional behaviours in warning society of emergent risks and in advising on rational responses.

The issue-attention cycle of societal action

2 In the 1970s, American researcher Anthony Downs published what he called the 'Issue Attention Cycle' of human behaviour in ecological issues. In this he described a cyclic behaviour of response to chronic risks involving societal response. This cycle charted a classical picture of latent knowledge, discovery, euphoric alarm, self interest, opposition, demand for action, tokenistic action, 'enough-for-now' decline of perceived need for action, waning interest, rediscovery and return through the cycle.

Dryland salinity in Australia provides a classic illustration of this cycle over the 20th century. The salinity phenomenon was eloquently explained by Western Australian railway engineers before the Royal Society in London in the early 1900s. However, many rounds of Downs' cycle may be identified in WA (and national) history of salinity.

My entry to this process was several cycles from the beginning, in the 1960s, when a parliamentary enquiry into salinisation of the Collie River was advised by the government chemist that the case before them was not proven. In differing political circumstances, the wheel turned again in the 1970s. A period of strong (but incomplete) action followed. In another turn, the issue was caught up in national enquiries, pursuing its bumpy cycling of discovery, alarm, denial and complacency in other states.

The human reality of Downs' cycle suggests that climate change will follow the same cyclic track through history, in this century, as did salinity in the last. This is not very encouraging, given judgements of urgency, but it is human nature.

Stepping back to such broader societal perspectives we might see cause to ask: How does a learned Academy, such as ATSE, best engage in offering knowledge to these processes? Some members may be positioned to express opinions from a professed expertise and detachment. Many may rightly wish to express more subjective views, as eminent members of society, but not profess expertise, or wish to be represented as so doing.

Should an Academy devote more energy to support and encouragement of good process and informed debate rather than declarations of scientific imprimateur?

Natural and anthropogenic drivers of climate: some professional and personal opinions

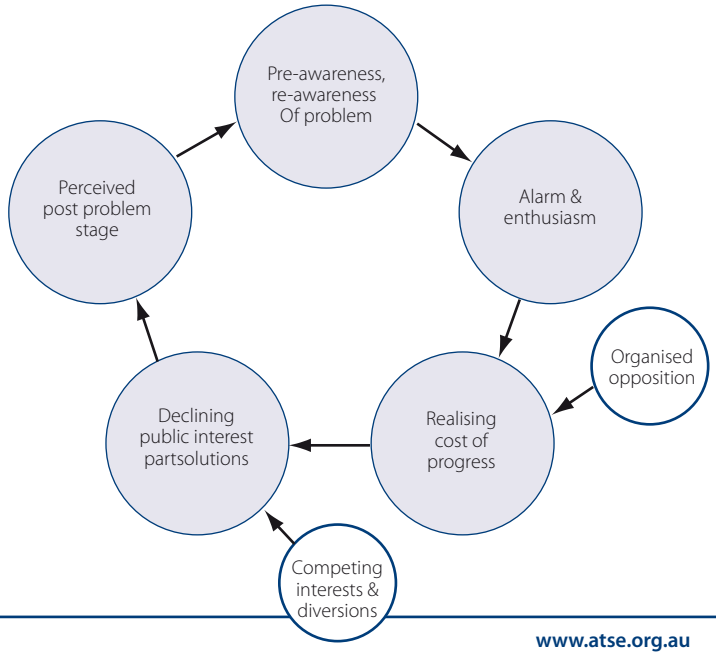
3 The time is long past for decision analysis to treat natural climate variability and natural climate change as an issue separate from anthropogenic change. Equally, it is barren ground to examine anthropogenic change as if it were not interwoven with natural climate variability and change. These matters are inextricably linked and public declarations that treat them in isolation are becoming increasingly archaic.

A common base from which most might agree to move debate and response positively forward is:

- global warming, including ocean warming and consequent change in atmospheric circulation, is unequivocally evident in scientific observation;
- despite a long period, in human terms, of quasi-stability, climate is not naturally stable and there are natural forces which can/do perturb, change or destabilise climate as it affects society;

The Issue Attention Cycle

Downs, A.J. Up and down with ecology: the issue-attention cycle. The Public Interest, Vol.29 Summer 1972, pp 38-50



- the *very high confidence* of the IPCC that there is an anthropogenic component of observed change, reflects an urgent and serious risk-management issue for Australian and global society – the issue demands both mitigative and adaptive response;
- best practice and responsibility to enterprise, clients and society mean it is no longer professionally valid to disregard climate change in advising on action affected by climatic risks – this demand is widely evident in actions of climate-affected enterprise;
- no matter which direction we might elect to enter the science of contemporary global and regional climate, the only logically valid accounting stance is one of viewing the current climate regime as non-stationary. In this regime, natural variability and natural non-stationarities are affected by underlying trends of global and regional anthropogenic forcing (including carbon forcing and aerosols);

Environment and sustainable growth

A statement from the Tokyo Convocation of CAETS, the International Council of Academies of Engineering and Technological Sciences

At the 17th CAETS Convocation, held in Tokyo on 23 to 26 October 2007, a wide range of global energy and environmental issues was reviewed and discussed by more than 230 CAETS academy representatives and specialists. The state-of-the-art of various technologies for improving energy efficiency, energy production with reduced carbon dioxide (CO_2) emissions, carbon-free electricity generation (including nuclear power) and CO_2 capture and storage (CCS) was reviewed and discussed. The Convocation also considered water resources and pollution, control of noise pollution, recycling of materials and electronic devices, global environment-monitoring systems and various strategies and measures for realising sustainable growth. It recognised the need for urgent international and national development and implementation of counter measures for foreseeable local and global energy and environmental challenges.

Convocation participants noted that much progress has been made in controlling air, water and other environmental pollution in developed countries, but that air pollution remains a serious problem especially in rapidly developing countries, that millions of the planet's inhabitants still lack clean drinking water and sanitation, and that environmental noise is a constraining factor for sustainable development.

The Convocation focused particularly on the impacts of increasing CO_2 concentrations in the atmosphere resulting from human activities as the world economy grows. Greenhouse gas emissions in the newly industrialising countries are increasing rapidly to rival those of the highly developed countries. As reported by the Intergovernmental Panel on Climate Change (IPCC), most of the observed global warming since the mid-20th century is very likely due to human-produced emission of greenhouse gases and this warming will continue unabated if present anthropogenic emissions continue or, worse, expand without control.

Convocation participants agreed that the adverse effects of global warming could be dramatic in the medium to long-term future. The Japan Earth Simulator and other global earth-system-modelling centres are making many sobering predictions of the likely impacts as CO_2 concentration, global mean temperatures and sea levels continue to rise.

CAETS, therefore, endorses the many recent calls to decrease and control greenhouse gas emissions to an acceptable level as quickly as possible. The Council recognised that it is the responsibility of the academies of engineering and technological sciences worldwide to: alert their governments and citizens to the dangers posed by unbridled damage of the natural environment and future shortages or depletion of natural resources for fossil fuel; to work actively to apply existing solutions; and to foster new and improved technology as part of the global effort to avert dangerous human interference with the climate system.

In light of the Convocation deliberations, and in order to realise sustainable growth and enhance the quality of life, while reducing the use of fossil fuels for energy and curtailing greenhouse gas emissions, CAETS recommends that the following measures be

- a challenge for scientists, particularly evident to practitioners at the adaptive end of the chain, is how best to integrate these natural and anthropogenic forcing phenomena into practical interpretation of climatic risks (given that the traditional planning assumption of defining risk from past climate has broken down); and
- in a risk management sense, the best available science needs to be available to society – this demands ongoing dialogue, but it also carries a significant intellectual challenge to our 'language' of climate description and manner of dialogue. ◀

BRIAN SADLER PSM FTSE is an engineer and hydrologist with 48 years' experience in water resources management, planning and policy at state and national levels. Internationally, he has actively contributed in fields centred on public participation, planning and the role of water in society. He has been active on issues of adaptation to climate change since the late 1980s and was Chairman of the Indian Ocean Climate Initiative Panel from its formation in 1998 until 2006. After 40 years with the State of Western Australia, he is now an independent consultant and an Adjunct Professor at the University of Notre Dame, Australia.

What is CAETS?

CAETS – the International Council of Academies of Engineering and Technological Sciences, Inc. – is an independent non-political, non-governmental international organisation of engineering and technological sciences academies, one member academy per country.

Its objectives are to:

- advise governments and international organisations on technical and policy issues related to its areas of expertise;
- contribute to the strengthening of engineering and technological activities to promote sustainable economic growth and social welfare throughout the world;
- foster a balanced understanding of the applications of engineering and technology by the public;
- provide an international forum for discussion and communication of engineering and technological issues of common concern;
- foster cooperative international engineering and technological efforts through meaningful contacts for development of programs of bilateral and multilateral interest;
- encourage improvement of engineering education and practice internationally; and
- foster establishment of additional engineering academies in countries where none exist.

CAETS is a non-profit corporation, incorporated in the District of Columbia, USA – caets@nae.edu

CAETS Member Academies

Founding Members (1978)

ATSE
Royal Academy of Engineering of the United Kingdom
Academy of Engineering – Mexico
National Academy of Engineering – United States
Royal Swedish Academy of Engineering Sciences

Members Elected

Danish Academy of Technical Sciences (1987)
Swiss Academy of Engineering Sciences (1988)
National Academy of Technologies of France (1989)
The Finnish Academies of Technology (1989)
The Engineering Academy of Japan (1990)
Royal Belgian Academy Council of Applied Sciences (1990)
The Norwegian Academy of Technological Sciences (1990)
Canadian Academy of Engineering (1991)
Netherlands Academy of Technology and Innovation (1993)
Hungarian Academy of Engineering (1995)
Chinese Academy of Engineering (1997)
National Academy of Engineering – Argentina (1999)
Engineering Academy of the Czech Republic (1999)
Indian National Academy of Engineering (1999)
Royal Academy of Engineering – Spain (1999)
The National Academy of Engineering of Korea (2000)
Croatian Academy of Engineering (2000)
National Academy of Engineering – Uruguay (2000)
German Academy of Technical Sciences (acatech) – Germany (2005)

urgently addressed through well-planned implementation programs and research and development, including partnerships between governments and international organisations experienced with the relevant environmental issues.

1 Energy-saving technologies must be greatly improved and disseminated as quickly as possible among both developed and emerging countries. Key initiatives considered most promising in the short term (in the next two decades or so) include the improvement of the efficiency of electric power generation and transmission and energy storage by batteries, effective use of heat pumps, advancement of the efficiency of internal combustion, electric and hybrid vehicles, improved energy-efficiency in commercial buildings and residences, and utilisation of light-emitting diode (LED) technology for illumination.

2 The opportunities provided by information, communication and control technologies for reducing energy consumption, for example, by reducing the need for travel and through development of optimised logistics and smart power systems, should be exploited aggressively, along with efforts to reduce energy consumption in ICT devices and systems themselves.

3 Development of renewable and alternative energy sources must be promoted and their application should be encouraged. Breakthroughs in the technologies for hydro-electric, nuclear, solar, wind, biomass and geothermal energies, and high-voltage DC power transmission in combination with high-frequency power conversion should be explored for near to medium-term exploitation; their appropriate use should be considered in light of the situation of each region. Development of innovative technologies for remote exploration and enhanced extraction of oil, gas and mineral resources from the oceans must be encouraged.

4 Studies must proceed to determine under what circumstances technologies for the capture and storage of CO_2 are feasible and cost effective. Other proposals to reduce emissions should also be encouraged and their effectiveness evaluated. Since, for some time to come, the use of fossil fuels will inevitably play a key role in economic growth to meet the needs of expanding populations for an acceptable quality of life, immediate attention to the development of more effective (cleaner) and efficient use of coal and oil is essential.

5 The increased use of nuclear power generation as an energy source must be addressed as a key issue for sustainable growth. CAETS recommends the promotion of studies on new-generation reactors in the short and medium-term and fusion research for the long term. Research to enhance safety measures, waste handling, economical performance and obstacles to non-proliferation are necessary for conventional reactors and associated fuel-cycle facilities.

6 Other promising technologies warranting priority for medium to long-term development, including hydrogen production, transport and storage and application of fuel cells for vehicles, should be explored. The discovery and environmentally sound management of gas hydrates should also be promoted.

7 Together with advances of the new technologies referenced above and the more effective and efficient use of traditional energy sources, the modification of social infrastructures, consistent with the conditions of each economy, must also be seriously considered. For example, development of well-organised public transportation systems should be investigated and implemented as appropriate to offer an alternative to the expansion of automobile fleets.

8 Nations should work together to ensure development and sustained operation of the Global Climate Observing System (GCOS) and the Global Earth Observation System of Systems (GEOSS), to provide the data and information needed to support global, national and regional strategies for sustainable development, including, for example, evaluating the total emissions of greenhouse gases and enabling more reliable projections of climate change.

9 Governments of all countries should work towards a new post-Kyoto climate change framework, codifying the urgent and concerted actions needed to suppress the emission of greenhouse gases.

CAETS members are well prepared for presenting objective data to facilitate the debate on these issues by governments and national communities. By engaging their national leaders, CAETS academies will encourage increased investment in research and development on energy, and promote polices to encourage avoidance and mitigation of environmental pollution and global warming. Through their leadership in the technological sciences and engineering, the CAETS academies will continue to contribute to the goals of sustainable development worldwide. Engineers and technologists must work together for the benefit of humankind and promote wise utilisation of the gifts of nature as represented by the Chinese character for engineering, 工. ◀

Oceans of change

Sea-level rise will have significant implications around the world by 2100, particularly for coastal cities

By John Church
john.church@csiro.au

The oceans' roles in climate change

The oceans play three major roles in the climate system:

- they absorb, store, transport and release huge quantities of heat, and are the ultimate source of rain;
- they are central to the global carbon cycle; and
- the sea level changes as a result of changes in ocean volume.

All three roles are central in understanding current climate change resulting principally from the anthropogenic release of greenhouse gases.

By absorbing carbon dioxide (CO_2), the oceans slow its build up in the atmosphere. They absorb vast quantities of heat, thus slowing the warming of the Earth's surface. The pattern of ocean surface warming and changes in ocean circulation affect regional climate. Warming of the ocean results in expansion of the ocean water and thus sea-level rise. This rise is augmented by additions of water to the ocean from ice presently grounded on land.

I summarise current understanding of each of these three roles below.

A huge flywheel

The oceans have a huge heat capacity, about 1000 times that of the atmosphere. They absorb vast amounts of heat, transport it thousands of kilometres and release it back to the atmosphere. Particularly important is the oceans' transport of heat from the equatorial regions towards the poles.

The most well-known role of the oceans in climate is the El Niño-Southern Oscillation (ENSO) phenomena. Normally, the warmest surface waters in the world are in the western equatorial Pacific Ocean, the 'boiler house' of the global atmosphere. During ENSO events, the western Pacific cools and the central and eastern equatorial Pacific warms. As a result, the strongest atmospheric convection moves east, bringing drought to Australia and floods to the tropical/mid-latitude regions of western North and South America.

This is but one way in which the ocean plays a key role in climate variability. How ENSO might vary in response to anthropogenic climate change is a major issue for Australia.

The oceans have warmed over the past 50 years, with the greatest warming being in the upper few hundred metres. Our most recent estimates of ocean heat content show that from 1961 to 2003, the upper 700 metres of the oceans alone have absorbed an average rate of about 0.36 Watts per square metre. Widespread observations of abyssal ocean warming have not yet been included in this estimate, and the total ocean heat content increase could be as much as 50 per cent greater than the above values.

Observed changes in ocean salinity indicate a freshening in sub-polar latitudes and an increase in salinity in mid-latitudes, consistent with the way that climate-

Deploying an Argo float for ocean measurement.
Photo: CSIRO

Letters to the Editor

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change models simulate the changes in evaporation and precipitation. Considerable inter-annual variability of the North Atlantic meridional overturning circulation has been observed, but in the most recent analyses no clear trend has been detected. Climate models indicate about a 25 per cent decrease in this overturning by 2100.

A repository for carbon and ocean acidification

2 The oceans contain about 38,000 Gigatonnes (one Gigatonne = 10^9 tonnes) of carbon, about 60 times as much carbon as the pre-industrial atmosphere and 20 times as much as in the terrestrial biosphere and soils. Each year the oceans exchange about 90 Gigatonnes with the atmosphere as near-surface ocean temperatures, seasonal variation of the surface mixed-layer depth and biological activity wax and wane with the seasons.

Atmospheric CO_2 concentrations have increased from pre-industrial values of about 280ppm (parts per million) to today's values of in excess of 380ppm. As a result, the oceans are presently absorbing 2.2 ± 0.5 Gigatonnes of carbon each year. The rate-limiting step in this uptake is the transport of carbon from the surface layer into the interior, primarily by ocean circulation.

CO_2 dissolved in the ocean forms a weak acid. Since 1750, the surface ocean pH (a measure of acidity) is estimated to have decreased by about 0.1 units. For the range of possible CO_2 emission scenarios considered by the Intergovernmental Panel on Climate Change (IPCC), a further decrease of 0.14 to 0.35 in the surface pH is expected during the 21st century.

The decreased pH means some marine organisms will find it more difficult to form shells made from either of the two forms of calcium carbonate, calcite and aragonite. Significant impacts on corals and on pelagic ecosystems are expected.

Rising sea level

3 Sea levels have varied by more than 120 metres over ice-age cycles through the past one million years. As the world warmed into the previous interglacial period, about 125,000 years ago, paleo data indicate sea-level rose as quickly as one metre per century, and reached levels between four and six metres higher than present day values at temperatures that might occur during the 21st century.

Sea level then fell to more than 120 metres below present day values about 20,000 years ago. From the end of the last ice age to about 7000 years ago, sea level rose at an average rate of about one metre per century, with peak rates of four metres per century. Sea level then rose slowly over the next several thousand years, with little net change in sea level from ancient Roman times, about 2000 years ago, until the 18th century.

Since 1870, global averaged sea level has increased by about 20 centimetres, with the rate of rise increasing during this period. Satellite-altimeter data indicate that sea level has been rising at the higher rate of more than three millimetres per year from the start of the record in 1993. It is as yet unclear if this is a further sustained increase, or if it is decadal variability.

The major contributions to sea-level rise since 1961 are from expansion of the oceans as they warm – thermal expansion, which will continue for centuries after greenhouse gas concentrations have been stabilised – and the melting of non-polar glaciers. The contributions of the ice sheets of Greenland and Antarctica are less well understood, but data for the 1990s indicate that both ice sheets have been contributing small, but likely increasing, amounts to the rate of rise.

The IPCC Third Assessment Report in 2001 projected sea-level rise of 9 to 88cm over the period 1990 to 2100. After inclusion of their allowance for ice sheet instability, the IPCC Fourth Assessment Report in 2007 projected an 18 to 79cm (or more) rise from 1990 to 2095 – the two sets of projections are similar, except the lower end of the 2007 projections are higher than the equivalent 2001 values. Both tide-gauge and satellite-altimeter observations indicate that the sea level rose at close to the upper limit of the 2001 projections from their start in 1990, consistent with a 21st century sea-level rise closer to the upper end then the lower end of the projections.

The change in average sea level has a significant impact on the frequency of high sea levels of a given magnitude. For the two longest Australian sea-level records (Sydney and Fremantle), there has been about a three-fold increase in the frequency of extreme sea-level events of a given magnitude during the 20th century. For a 50cm sea-level rise, a value that could be exceeded by 2100, current one-in-a-100-year events would occur several times a year, even without any change in the intensity of storms.

The largest potential contributors to sea-level rise are the Greenland and West Antarctica Ice Sheets, which contain enough ice to raise global sea level by about seven metres and six metres respectively. Surface melting of the Greenland Ice Sheet has been increasing over recent decades. Models indicate that for a globally averaged warming of about 3°C, a temperature that could occur in the latter half of the 21st century with unmitigated climate change, melting will exceed precipitation leading to an ongoing contribution of the Greenland Ice Sheet to sea level.

This projection is consistent with paleo data indicating sea level was four to six metres higher than present values during the last interglacial period. Crossing this threshold would lead to major impacts around the world – avoiding it is a major challenge for our society.

While complete surface melting of the Greenland Ice Sheet would take a millennium or more, a more rapid response of the Greenland Ice Sheet could result from this surface melt making its way to the base of the ice sheet and lubricating movement of the ice sheet into the ocean.

For the West Antarctica Ice Sheet, the major concern is that warmed ocean water is penetrating beneath the ice sheet that is grounded below sea level, melting it at its base. There are observations indicating both of these processes may already be occurring. However, our current understanding is too limited to estimate how much faster sea level could rise.

Sea-level rise will have significant implications around the world by 2100. Tens to hundreds of million people would be affected by sea-level rise at the upper end of the projections. The impacts would be particularly severe for coastal cities and low-lying deltaic regions, which are also sinking from sediment compaction. Rising sea levels will lead to the erosion of beaches, 70 per cent of which have been retreating over the past century.

Marine ecosystems

In addition to playing a central role in determining the rate and regional distribution of climate change, the oceans are also affected by climate change.

They contain a huge range of species and are a significant source of protein for millions of people around the world. Marine ecosystems and biodiversity are being, and will increasingly be, affected by warming and acidification of the oceans. ◀

DR JOHN CHURCH FTSE is an oceanographer with the Centre for Australian Weather and Climate Research and the Antarctic Climate and Ecosystems Cooperative Research Centre. He was co-convening lead author for the chapter on sea level in the IPCC Third Assessment Report and co-chaired the WCRP Understanding Sea-level Rise and Variability Workshop. He was awarded the 2006 Roger Revelle Medal by the Intergovernmental Oceanographic Commission, a CSIRO Medal for Research Achievement in 2006 and the 2007 Eureka Prize for Scientific Research. He was Co-Chair of the international Scientific Steering Group for the World Ocean Circulation Experiment 1994–98 and Chair of the Joint Scientific Committee of the World Climate Research Programme from 2006–08.

Garnaut: general issues and particular interests

Emissions targets "will place daunting and increasingly urgent demands upon the nation's will and political capacity to change"

By Gavan McDonell
gavangavan@gmail.com

Professor Ross Garnaut and his Review hardly need introduction. Senior economic adviser to various governments, former Ambassador to China, corporate chairman and ANU researcher, he was appointed last April by the states and territories to chair a review of the impacts and policy demands of climate change. The then Commonwealth Government subsequently confirmed its participation.

The Review is to focus on regional and distributional implications, economic and strategic opportunities for Australia, costs and benefits of mitigation and the weight of scientific opinion that developed countries need by 2050 to reduce their greenhouse gas emissions (GHGs) by 60 per cent, compared with the levels of 2000. A draft report is due in June and a final report by 30 September. The interim report was issued in late February.

Major themes of that report include:

- Mainstream scientific opinion suggests that the world is moving towards high risks of dangerous climate change more rapidly than previously understood, largely because of accelerating world economic growth, notably in China and India.
- Australia is, on one hand, exceptionally sensitive to the negative impacts of climate change; on the other, it has exceptional opportunities to do well in a world pursuing global mitigation. Australia would be possibly the biggest loser among developed nations from unmitigated climate change, but also has a first-rate skills base, rich energy resources and other advantages. Consequently, it is in Australia's national interest to be a leader in the change process and this includes setting targets higher than the present ones. Apart from its large coal (if carbon capture and storage proves commercial), renewable and nuclear supplies, an important opportunity is the development of Australia's world-competitive financial expertise and markets into a regional hub. There are issues here, though (see below).
- Reaching an adequate global agreement on mitigation, and its centerpiece – a global emissions trading scheme (ETS) – will be long and difficult. It can be accepted as virtually certain that such arrangements *will be based on per capita emissions*. Since Australia is now, with the US, one of the largest per capita emitters (both about four times the world average) the proportionate reduction of emissions here will be both larger and steeper than in most of the developed world. It will be important to achieve regional cooperative mitigation agreements: first, as exemplars for the sorts of regional compacts that will be necessary for a global scheme; and second, because, for example, in Indonesia and Papua New Guinea, it has neighbours with opportunities, especially through forestry measures, for large, low-cost emissions credits, which could be tradable with Australia.
- What amounts to a revolution in thinking about and funding for basic research in climate-change-related areas will be required if necessary technologies and policies are to be implemented.

Much media comment upon the interim report has dwelt on its argument that Australia should accept higher emission-reduction targets. The plain fact is that the search for an international consensus will be extremely difficult and that *any* worthwhile target, including the present one, will place daunting and increasingly urgent demands upon the nation's will and political capacity to change. The challenge now is to take practical steps towards effective reform.

The interim report says that the notion of a global ETS is based upon the scientific conclusion that if the world wishes to avoid a mean global temperature increase of 2°C, widely considered the maximum level of warming beyond which 'dangerous climate change' would result, then it will be necessary to stabilise GHG concentrations at 445 to 490ppm CO_2-equivalent by 2050, *with emissions peaking between*

2000 and 2015. Hence the urgency.

A global ETS would have a budget, consistent with the above, of emissions allocated by country, arrangements for trading fractions of those allocations between under- and over-emitters, and regional and national specifications for devolving budgets and trading opportunities among sectors and enterprises. Somewhere in the middle of all that have to be the global, national and regional markets and their governance, a principal concern of the Review.

The report details some of the intricacies involved in the development of an Australian ETS and acknowledges the contribution of the Task Group on Emissions Trading, which reported to the previous Federal Government last June. However, what will be the single most important element in any Australian mitigation program yet is one which so far has received little attention – even in this interim report – is how the National Electricity Market (NEM) (which I outlined in ATSE *Focus* 142, September 2006) is to be transformed into an effective vehicle for emissions reduction. According to the interim report, nearly 60 per cent of Australia's emissions derive primarily from electricity use in stationary energy, industrial and mining processes, which are also the fastest-growing emitters, increasing almost 50 per cent since 1990. No other sector is in the same league for size and strategic importance. There are two aspects of the NEM to note here:

- about 20 per cent of costs come from energy sales, while perhaps up to 60 per cent come from the networks; and
- it is widely recognised that the political economy of both NEM membership and policy are heavily influenced by generator and network incumbents – these, naturally, strive to protect their interests, not the least of which are competitive order and stable regulatory policies.

Australia has one of the most energy-*inefficient* economies in the developed world. Network cost reductions, apart from increasing energy efficiency, and directly decreasing emissions, could strongly offset and even outweigh energy-cost increases arising from a carbon price. Research and action in other countries, but not here, has shown the outstanding opportunities in this area; but their realisation will require root changes in the technology, organisation, competitive arrangements and governance of networks, and consequently of the whole NEM. Here is the nub of reform.

Coal-fired generators (the major suppliers of energy) and network utilities (largely state-owned monopolies), dominate membership of the NEM. They also have well-developed and resourced coordinating organisations and lobby groups who can represent them in NEM decision processes, such as those for Rule change, *vis-à-vis* the regulators. There are no public or community members of the NEM, though such bodies can make proposals for Rule change.

Climate change is a rare topic in NEM discussion. The NEM has been a self-focused system bent upon the tasks of articulating the largest and most complex – and perhaps most comprehensively misunderstood – technological system this country has ever developed. It has been shielded from external examination by its very complexity. At a recent, major industry conference, a summing up for the regulators, intended to be an eagle's eye view of the NEM's past and present challenges, made no mention of climate change. The Council of Australian Governments (COAG) has an agenda item for climate change adaptation in agriculture, but not for the NEM. The last meeting of the Ministerial Council on Energy relegated climate change to the last few paragraphs of its communiqué.

Two years after the most recent attempt to tidy up the NEM, little had been done about demand management, with its huge potential for innovation and efficiency, until a Rule change proposal was submitted in late 2007 by a thinly resourced NSW environmental group. Meanwhile, the national generators, presumably supported by associated mining interests, recently served notice that they will seek free emissions permits under any future ETS.

If action in the centrally strategic sector of the NEM is delayed until the final lines of the ETS are drawn we can be confident that budgets and targets will be overshot. The widest and most searching examination of policy options, including the full assumption by the Commonwealth of oversight of the national power system and related policy, is required.

The best international expertise and experience should be engaged. The NEM and its design require clearly independent review, but the NEM has been shielded from the analytic attentions of the Federal Treasury. What is said to be a new-found warmth between that agency and the present Labor administration could well yield good fruit here. ◀

PROFESSOR GAVAN MCDONELL FTSE has directed four public enquiries for State and Federal governments, including the NSW commission recommending (subsequently implemented) abandonment of planned power stations worth $12 billion, the restructuring of the power industry and development of linked regional markets. He has published extensively on electricity markets. Formerly a senior investment banker advising on energy and transport strategy in the Caucasus and Central Asia, he is currently advising on research into Asian energy markets. Founder of the Interdisciplinary Environmental Studies Program at UNSW, he received the rarely awarded Doctor of Engineering for his work in infrastructure economics and policy.

Garnaut releases ETS paper

Professor Ross Garnaut has released his discussion paper on an Australian emissions trading scheme (ETS), stating that the introduction of an ETS signals the opportunity for profound, long-term structural change for Australia.

"An emissions trading scheme will be the centrepiece of Australia's climate change policy," Professor Garnaut said. "If we get the design right, it will help build a more resilient economy for the long term."

The paper argues for the need to design the scheme on the basis that it will ultimately be part of a global agreement on greenhouse gas mitigation. It suggests fixed and clear limits on emissions through the establishment of defined emissions 'trajectories', which would transparently map the pathway to emissions reduction targets/commitments. Permits would be regularly released in line with the trajectory.

"A long-term, firm trajectory for emissions reduction – which could only be tightened, not loosened, in line with emerging international commitments – would provide greater investor confidence and strengthen the credibility of the scheme," he said.

The ETS discussion paper supports the auctioning of all permits, arguing that any increase in the price of goods or services, such as energy, will not be prevented through the free allocation of permits.

"The auctioning of permits will generate very large amounts of revenue, and the Government will face many competing demands on how that is used," Professor Garnaut said. "These will include from households affected by increased prices of goods and services, employees and communities dependent on emissions-intensive industries, and non-traded sectors whose costs are directly impacted.

"The revenue should be spent on improving the productive or adaptive capacity of the economy, in ways that are consistent with reducing greenhouse gas emissions. Special attention must be given to consumers who will ultimately bear the cost of a carbon price, and in particular, low-income households."

The discussion paper supports transitional assistance to trade-exposed, emissions-intensive industries (such as steel and aluminium manufacturers), which are unable to pass on the cost of a carbon price.

Design features put forward in the paper include:

- creation of an 'Independent Carbon Bank' to monitor and enforce compliance with the scheme;
- auctioning of all permits, in order to maintain the simplicity, credibility and transparency of the scheme;
- allowing the unlimited banking or hoarding of permits, and lending of permits by the Independent Carbon Bank;
- no price controls for permits, such as price caps or floors;
- application of a penalty with a make-good provision for non-compliance;
- making the coverage as broad as possible, with a recommendation to include agriculture and forestry as soon as practicable;
- usage of permit revenue to provide assistance to households, particularly low-income households, and adjustment assistance for communities and employees of affected sectors; and
- provision of transitional assistance to trade-exposed, emissions intensive firms.

"This reform will cost, but that cost will be manageable if we safeguard the simplicity and credibility of the market and use the proceeds to transition Australia to a low-carbon economy," Professor Garnaut said.

He encouraged Australians to "get interested" in the detail of the ETS design, saying the reforms of the following two years would have sweeping implications for the nation. Submissions are invited on the discussion paper (at www.garnautreview.org.au), by 18 April 2008.

WILL CLIMATE CHANGE DAMAGE OUR INFRASTRUCTURE?

The Academy has virtually completed an assessment of the likely impacts of climate change on Australia's physical infrastructure.

The Steering Committee for this ARC Project has approved the draft of the Project Report, prepared by project leader Professor Len Stevens AM FTSE. The final report is expected to be launched at an event in Canberra in the second quarter of 2008.

This assessment is an initial scoping study, with the aim of identifying the important impacts of climate change on Australia's physical infrastructure and to provide broad recommendations for future action. The purpose of the report will be to stimulate discussion and to induce action by relevant authorities. The issues of emission controls and climate-change effects on natural systems, health and agriculture are outside the scope of this study.

The ATSE study involved a qualitative assessment of risk of the impact of climate change on Australia's physical infrastructure. The assessment also considered how existing physical infrastructure could be adapted to the effects of climate change and some consideration was also given to the requirements for future infrastructure.

The study considered generic categories of existing infrastructure in several geographical regions across Australia, but did not consider individual infrastructure at specific locations. This study included a literature survey of the current status of the relevant disciplines, an electronic survey of Fellows of the Academy, two workshops, and teleconferences involving Fellows and other experts in particular fields of infrastructure.

The study noted that although most of Australia's physical infrastructure has been designed to resist climatic effects, the impacts of future climate change need to be carefully assessed.

Flawed climate-change advice from big science

Intellectually fatigued government-led enthusiasms, dizzy from media spin, degenerate into complex power plays

By Brian J. O'Brien
brianjobrien@ozemail.com.au

Greenhouse enthusiasms have been active for 20 years. Such group longevity can bring intellectual fatigue. A warning sign of decadence in scientific rigour is when fundamentals are sloppy or poorly articulated. 'Climate change' now has two greatly different meanings: one scientific, for the UN Intergovernmental Panel on Climate Change (IPCC), the other political, for the UN Kyoto Protocol. 'Greenhouse effect' has two greatly different meanings: one scientific, the other (30 times smaller) populist, ill-defined and used by many scientists filled with passionate intensity.

Intellectually fatigued government-led enthusiasms, dizzy from media spin, degenerate into complex power plays, focused on processes not on outcomes; on carbon taxes versus emissions trading, not on climate. Think environment, fallen from its glorious action days of the 1970s into plastic bags yet again in 2008, photographing whale killings at locations carelessly unrecorded.

Two fatal flaws that Australian policies must avoid

Here I use IPCC reports to draw attention, as before, to a synergistic pair of fatal flaws in Australian policies, which rarely articulate their reason for existence – the most variable climates of this land of droughts and flooding rains, where a typical Australian dam must be 10 times larger than its counterpart in the US to manage a river of comparable average flow. I have made these arguments before ('Australian Greenhouse Governance: The Twilight Zone', ATSE *Focus* supplement No 106, March/April 1999 and *ATSE: Climate Change Science: Current Understanding and Uncertainties*, February 1995).

Consider:

- Flaw 1 – policies focusing only on climate changes caused by human activities;
- Flaw 2 – policies focusing only on global instead of Australian climates.

Synergies of these two flaws lock Garnaut into a Catch-22 situation.

Emissions trading cannot control natural climate changes, so Garnaut ignores them, obeying his Terms of Reference. But 2007 IPCC findings suggest (see quotes below) that natural climate changes are not as unlikely as implied in 2001 IPCC to continue dominating Australian climates. Governments cannot successfully command a majestic, hemispheric El Niño–Southern Oscillation (ENSO) to stop. Thus it does not matter what the Garnaut Review finds, it will be irrelevant to actual Australian climates. Catch 22.

Canute taught his courtiers the lesson that a king could not stop the tide rising. Could ATSE dare to be the Canute of Australian climate change?

2007 IPCC reports on global vs local climate changes

Between 1990 and 2007, IPCC Reports increased confidence that future global climate change would be dominated by climate change caused by human activities. Every IPCC report cautioned it had more confidence in forecasts at a global scale than at local scale.

The 2007 IPCC Synthesis Report Summary for Policymakers (SPM) has two key conclusions – one global, the other local.

QUOTE 1: "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely [over 90 per cent] due to the observed increase in anthropogenic GHG concentrations. It is likely [over 66 per cent] there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica) (Figure SPM.4)."

2007 vs 2001 IPCC reports on ENSO and El Niño

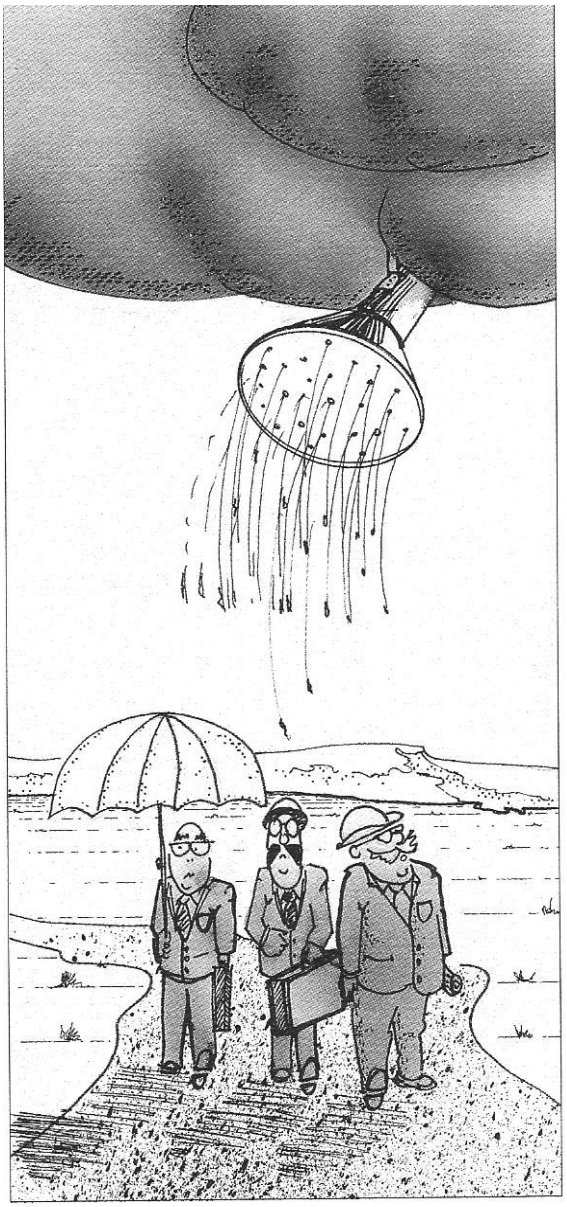
In 2001, IPCC WGI SPM, in its 38 mentions of El Niño, found that "El Niño events became more frequent, persis-

tent and intense during the last 20 to 30 years compared to the previous 100 years" (Table SPM-1). Because El Niño is associated with major Australian droughts, this 2001 finding is embedded in Australian mind-sets.

This IPCC 2001 finding must be updated. But the 23-page, 2007 IPCC Synthesis Report SPM does not update it, or even mention El Niño.

However, in 2007, Working Group [WG] I Section 11.7 (p. 898) states:

QUOTE 2: "Significant factors contribute to uncertainty in projected climate change for the (Australia–New Zealand) region. The El Niño–Southern Oscillation (ENSO) significantly influences rainfall, drought and tropical cyclone behaviour in the region and it is uncertain how ENSO will change in the future."



'Well, if it's not another sign of the greenhouse effect, what is it?'

Only three of 15 climate models foreshadow a greenhouse-caused increase in ENSO variability by 2100, five exhibit significant decreases and seven show no significant change (IPCC 2007, WGI, Section 9.5.3.1).

Both are very significant findings for Australia, implying that natural climate changes from ENSO variability may be major forces until 2100. Table SPM.2 of 2007 IPCC WGI shows the "Likelihood of a human contribution to" seven observed trends in the late 20th century was "likely" (above 66 per cent) in two cases and "more likely than not" (above 50 per cent) in five cases. IPCC has no comparable table for natural causes. Why not?

I have neither space nor expertise to summarise varied views in 2007 IPCC WGI. Selected quotes from complex reports may not be adequate. Varied views are in: Executive Summary of 2007 IPCC WGI, Section 11 on "Increased risk of drought in southern areas of Australia is likely"; Section 11.7 p.898 on "No detailed assessment" of MMD AOGCM [climate model] performance over Australia; Section 9.5.3.1 p.709 on "some weakening" of the Walker Circulation over 140 years.

Case studies: flaws in advice on climate-change science

Governments and policymakers claim their climate-change policies are based on science. I provide six recent examples of senior-level advice, all flawed.

Case Study 1: CSIRO and Australian Greenhouse Office Report, 2006.

The May 2006 report of national strategic importance by CSIRO for the Australian Greenhouse Office (AGO/CSIRO) was based on the 2001 IPCC Report, that: "Most of the warming since 1950 is due to human activities that have increased greenhouse gases." (CSIRO/AGO chapter 2, page 7). This much-quoted quote, without probabilities, has no robust provenance. It is not in the scientific text of 2001 SPM, but only in a preface and a bold blue headline. Within nine months of the CSIRO/AGO report, the 2007 IPCC gave more confidence in anthropogenic warming for the globe than in 2001 (QUOTE 1), but perhaps more in changes for Australia from natural causes (QUOTE 2). The IPCC 2001 quotation was still the authorised version for ATSE in March 2007.

Case Study 2: CAETS Statement, Tokyo, October 2007.

At its 2007 Convocation in Tokyo, CAETS used only the first sentence from IPCC QUOTE 1 as scientific basis of its Statement. Omission of the second sentence

wrongly implies 'very likely' applies to member countries, instead of 'likely'. The CAETS statement continued, still as if attributing to IPCC a value judgement with the words 'even worse' – words not found in 2007 IPCC reports. The CAETS statement loses its potential authority because it is not rigorous.

Case Study 3: The Interim Report by Garnaut, February 2008

The February 2008 Interim Report by Garnaut does not mention 'El Niño', 'La Niña', 'ENSO', 'drought' or 'flood' in its review of Australian climate change, the climate equivalent of a 63-page report on Australian cricket not mentioning Don Bradman.

Case Study 4: The ATSE 'Update of Current Understanding and Uncertainties in Climate-Change Science', ATSE *Focus* No 124, 2002

In its 2002 update of its 1995 report, ATSE mentions El Niño only once, with no mention of La Niña, ENSO, drought or flood. It does not mention the Pacific Ocean, Indian Ocean or Antarctica at all. It makes me wonder where Australian 'climates' come from. But ATSE does repeat 'global' 15 times.

Case Study 5: 2007 IPCC Working Group I – Summary for Policymakers

The expert 2007 IPCC WGI managed to produce an 18-page Summary for Policymakers (SPM) of the 'Physical Science Basis' of climate change without ever mentioning El Niño, La Niña, ENSO or flood. But it did repeat 'global' 46 times.

Case Study 6: 2007 IPCC SPM – Synthesis Report, WGII and WGIII

I find it alarming that neither El Niño, La Niña nor ENSO is mentioned in 2007 IPCC Summaries for Policymakers (SPM) of the Synthesis Report or the two other Working Groups, WGII and WGIII. But they did say 'global' to policymakers 206 times.

Responsibility for, and consequences of, science advice

These six case studies are not a childish game of counting words. The implications of existing systemic flaws, even bias, in senior science advice are very serious.

Australian policymakers, communities and media are not being informed by senior Australian scientists or IPCC scientists about natural influences on climate change in Australia, or about a palpable bias towards globalism in the 2007 IPCC Reports.

Australian climate-change policies and costings create flawed governance and higher risks when they omit natural variability of climate. When they use global – not Australian – findings from IPCC, they compound risks and hide uncertainties.

A policy or costing may claim to be based on science, but if it contains one or both flaws articulated here then that claim is false.

Conclusion

After 20 years of greenhouse controversies, and with apologies to JFK:

- ask not what my country's greenhouse industries, like emissions trading, can do for lawyers, scientists and money markets;
- ask what they can do for my country's climates. ◀

DR BRIAN O'BRIEN heads a strategic and environmental consultancy he founded in Perth in 1978, after seven years as the first Director and Chairman of the WA Environmental Protection Authority. He was Professor of Space Science at Rice University in Houston, with many discoveries in solar-terrestrial relations. He has written and spoken extensively on greenhouse. He persuaded the WA Government to fund $1.7 million for the Indian Ocean Climate Initiative in 1997-98. Listed in *Who's Who in the World*, his honours include the NASA Medal for Exceptional Scientific Achievement, and the Centennial Medal.

A case against climate alarmism

The interests of the environmental movement in acquiring more power and influence are reasonably clear

Richard S. Lindzen
lindzen@wind.mit.edu

The notion of a static, unchanging climate is foreign to the history of the earth or any other planet with a fluid envelope. The fact that the developed world went into hysterics over changes in global mean temperature of a few tenths of a degree will astound future generations. Such hysteria simply represents the scientific illiteracy of much of the public, the susceptibility of the public to the substitution of repetition for truth, and the exploitation of these weaknesses by politicians, environmental promoters, and, after 20 years of media drum-beating, many others as well.

Climate is always changing. We have had ice ages and warmer periods when alligators were found in Spitzbergen. Ice ages have occurred in a 100,000-year cycle for the past 700,000 years, and previous warm periods appear to have been warmer than the present, despite CO_2 levels being lower than they are now. More recently, we have had the medieval warm period and the little ice age. During the latter, alpine glaciers advanced, to the chagrin of overrun villages. Since the beginning of the 19th century these glaciers have been retreating. Frankly, we do not fully understand either the advance or the retreat.

For small changes in climate associated with tenths of a degree, there is no need for any external cause. The earth is never exactly in equilibrium. The motions of the massive oceans, where heat is moved between deep layers and the surface, provides variability on time scales from years to centuries. Recent work (Tsonis *et al*, 2007), suggests that this variability is enough to account for all climate change since the 19th century.

Supporting the notion that man has not been the cause of this unexceptional change in temperature is the fact that there is a distinct signature to greenhouse warming: surface warming should be accompanied by warming in the tropics, around an altitude of about nine kilometres, that is about 2.5 times greater than at the surface. Measurements show that warming at these levels is only about three-quarters of what is seen at the surface, implying that only about a third of the surface warming is associated with the greenhouse effect, and, quite possibly, not all of even this really small warming is due to man (Lindzen, 2007, Douglass *et al*, 2007).

This further implies that all models predicting significant warming are greatly overestimating warming. This should not be surprising. According to the UN's Intergovernmental Panel on Climate Change, the greenhouse forcing from man-made greenhouse gases is already about 86 per cent of what one expects from a doubling of CO_2 (with about half coming from methane, nitrous oxide, freons and ozone), and alarming predictions depend on models for which the sensitivity to a doubling for CO_2 is greater than 2°C, which implies that we should already have seen much more warming than we have seen thus far, even if all the warming we have seen so far were due to man.

This contradiction is rendered more acute by the fact that there has been no significant global warming for the past 10 years. Modellers defend this situation by arguing that aerosols have cancelled much of the warming, and that models adequately account for natural unforced internal variability. However, a recent paper (Ramanathan, 2007) points out that aerosols can warm as well as cool, while scientists at the UK's Hadley Centre for Climate Research recently noted that their model did not appropriately deal with natural internal variability, thus demolishing the basis for the IPCC's iconic attribution (Smith *et al*, 2007).

Interestingly (though not unexpectedly), the British paper did not stress this. Rather, it speculated that natural internal variability might step aside in 2009, allowing warming to resume. Resume? Thus, the fact that warming has ceased for the past decade is acknowledged.

Given that the evidence (and I have noted only a few of many pieces of evidence) strongly suggests that anthropogenic warming has been greatly exaggerated, the basis for alarm due to such warming is similarly diminished. However, the really important point is that the case for alarm would still be weak even if anthropogenic global warming were significant.

Polar bears, Arctic summer sea ice, regional droughts and floods, coral bleaching, hurricanes, alpine glaciers, malaria and so on all depend not on some global average of surface temperature, but on a huge number of regional variables, including temperature, humidity, cloud cover, precipitation, and direction and magnitude of wind. The state of the ocean is also often crucial.

Our ability to forecast any of these over periods beyond a few days is minimal. Yet, each catastrophic forecast depends on each of these being in a specific range. The odds of any specific catastrophe actually occurring are almost zero. This was equally true for earlier forecasts famine for the 1980s, global cooling in the 1970s, Y2K and many others.

Regionally, year-to-year fluctuations in temperature are more than four times larger than fluctuations in the global mean. Much of this variation has to be independent of the global mean; otherwise the global mean would vary much more. This is simply to note that factors other than global warming are more important to any specific situation.

This is not to say that disasters will not occur; they always have occurred and this will not change in the future. Fighting global warming with symbolic gestures will certainly not change this. However, history tells us that greater wealth and development can profoundly increase our resilience.

Given the above, one may reasonably ask why there is the current alarm, and, in particular, why the astounding upsurge in alarmism of the past two years. When an issue such as global warming is around for more than 20 years, numerous agendas are developed to exploit the issue.

The interests of the environmental movement in acquiring more power and influence are reasonably clear. So too are the interests of bureaucrats for whom control of CO_2 is a dream come true. After all, CO_2 is a product of breathing itself. Politicians can see the possibility of taxation that will be cheerfully accepted because it is necessary for saving the world. Nations have seen how to exploit this issue in order to gain competitive advantages.

But, by now, things have gone much further. The case of Enron is illustrative in this respect. Before disintegrating in a pyrotechnic display of unscrupulous manipulation, Enron had been one of the most intense lobbyists for Kyoto.

It had hoped to become a trading firm dealing in carbon emission rights. This was no small hope. These rights are likely to amount to over a trillion dollars, and the commissions will run into many billions. Hedge funds are actively examining the possibilities. It is probably no accident that Al Gore, himself, is associated with such activities.

The sale of indulgences is already in full swing with organisations selling offsets to one's carbon footprint while sometimes acknowledging that the offsets are irrelevant. The possibilities for corruption are immense. Archer Daniels Midland (America's largest agribusiness) has successfully lobbied for ethanol requirements for gasoline, and the resulting demand for ethanol is already leading to large increases in corn prices and associated hardship in the developing world (not to mention poorer car performance).

And finally, there are the numerous well-meaning individuals who have allowed propagandists to convince them that in accepting the alarmist view of anthropogenic climate change, they are displaying intelligence and virtue. For them, their psychic welfare is at stake.

With all this at stake, one can readily suspect that there might be a sense of urgency provoked by the possibility that warming may have ceased. For those committed to the more venal agendas, the need to act soon, before the public appreciates the situation, is real indeed. ◀

RICHARD LINDZEN, the Alfred P. Sloan Professor of Atmospheric Sciences, Massachusetts Institute of Technology, is a dynamical meteorologist with interests in the broad topics of climate, planetary waves, monsoon meteorology, plantary atmospheres, and hydrodynamic instability. Professor Lindzen's research involves studies of the role of the tropics in mid-latitude weather and global heat transport, the moisture budget and its role in global change, the origins of ice ages, seasonal effects in atmospheric transport, stratospheric waves, and the observational determination of climate sensitivity. He is a member of the National Academy of Sciences, and the Norwegian Academy of Sciences and Letters, and a fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Sciences, the American Geophysical Union and the American Meteorological Society.

Contributions are welcome

Opinion pieces on topics of national interest will be considered for publication in ATSE *Focus*. Items between 800 and 1500 words are preferred. They must list full name, title/role, organisation (if relevant), city of residence and email address for publication. Please address to editor@atse.org.au

HYDROGEN STILL HAS PLENTY OF RESEARCH CHALLENGES

A review of *Hydrogen Energy: Challenges and Prospects** by D.A.J. Rand FTSE and R.M. Dell, which advances four 'drivers' for the hydrogen economy

By Ian Rae
iandrae@bigpond.com

When the Australian Government published its report *Securing Australia's Energy Future* in 2004, it relegated hydrogen to the 'reserve' category, thus annoying CSIRO researchers and a few from private industry who would liked to have staked their future on this lightest of gases.

In the 'market leader' category were brown coal, geosequestration, photovoltaics, hot dry rocks and solid oxide fuel cells. 'Fast followers' included black coal, natural gas, wind, wave and hybrid electric vehicles. With hydrogen in the third category were tidal and nuclear energy and other fuel cells. This is clearly oversimplified since, as Rand and Dell explain, hydrogen is involved in many of these energy technologies, but its potential is not in the short term, so maybe the government got it right. The major identifiable benefit of deriving energy from hydrogen is the reduction in carbon dioxide (CO_2) emissions.

The authors advance four drivers for the hydrogen economy: national security of energy supplies, climate change (global warming), atmospheric pollution, and electricity generation. These are the reasons why many people view it as "the fulfillment of an environmental dream for the long-range future". These four are "inter-related in a complex fashion in an increasingly complex world". They face a number of obstacles that the authors classify as institutional, technical, regulatory and financial.

Many of the obstacles are related to the huge scale of energy production from coal and gas; renewable forms of energy are expensive and produced only on a small scale. Scale-up issues for a number of technologies are described as daunting. The most serious drawback is that present routes to hydrogen involve fossil fuels either directly (methane) or indirectly (coal-based electricity).

As well, there is no satisfactory technology for hydrogen storage, especially for mobile applications. Producing hydrogen from coal and water – the carbon source used by today's chemical industry is mostly natural gas, with geosequestration of the byproduct CO_2 – is a number-one prospect, but it will not come cheap. The availability of suitable sinks and the cost of separating CO_2 and pumping it around will not be offset by the greater efficiency of electricity generation by combined cycle – gas turbine followed by steam turbine.

The introductory chapter ends with "a note of caution", which urges supporters of the low-carbon economy to think carefully about hydrogen "before you become too enchanted". In fact, the tone of the book is decidedly deflationary of the more optimistic view that a hydrogen economy might be just around the corner.

Rand and Dell go into scientific and technical matters in exhaustive detail, thus making their book at once a fascinating read, a sourcebook of knowledge and a dossier of engineering and scientific challenges.

The litany of chapter headings is a good place to get an overview of this book: hydrogen from fossil fuels and biomass; carbon sequestration; hydrogen from water; hydrogen distribution and storage; fuel cells; hydrogen-fuelled transportation; and hydrogen energy – the future.

There is extensive coverage of chemical reactions with their thermodynamic consequences and, especially (David Rand FTSE is a battery expert), electrochemical ones with their practical (not just theoretical) voltages. Efficiency considerations feature prominently, especially the low efficiency of interconversion of various forms of energy.

The text is accompanied by diagrams and tables. The index is acceptable but not exhaustive. There is a list of references at the end of each chapter, some to publications as late as 2006.

In the transport field, resource conservation and air pollution will best be tackled in the short to medium term, according to the authors, by hybrid vehicles and better diesel than petrol.

Hydrogen will play a minor role until research challenges are met, and even then not before 2050, or beyond; sentiment is not enough to carry us into the new age.

Regarding fuel cell vehicles – "it is important not to disillusion the public by promising too much before (they are) fully practical, commercially available, and

cost-competitive". The internal combustion engine running on liquid fuels has beaten off a number of competitors over the past century and a bit, and its continual improvement makes it a 'moving target' for fuel cell enthusiasts.

The depth of argument by Rand and Dell extends to the observation, repeated several times, that the silence of the all-electric vehicle could make it a hazard to pedestrians. It's probably too early to check on how many people are run down by hybrids in their 'quiet' phase, but I look forward to seeing such a study.

A recent survey showed that we motorists are more concerned about petrol prices, traffic congestion and road rage than we are about greenhouse. Nonetheless, the Australian Government has already heeded the Rand and Dell message and is pushing ahead with its Green Car program and attempting to woo Toyota to manufacture the Prius here.

The numbers are against them. Australians purchased about a million cars in both 2006 and 2007; for 2007 the hybrid sales were 4900 (0.5 per cent of the total). Only two, the Toyota Prius (3176 units sold in 2007) and the Honda Civic Hybrid (750 sales), sell for less than $40,000, and the sort of small cars that people actually buy cost a lot less than that. For the less cost-conscious, what is needed is a hybrid sports utility vehicle (SUV).

Perhaps the most striking feature of the development of hydrogen energy is that it has been the subject not only of romantic speculation but of intensive research for so many years, and yet it still seems to be a distant mirage.

By 2002, Daimler–Chrysler had produced its sixth-generation fuel-cell car – but when was the last time you saw one on the road? The lack of real progress over several decades is true of hydrogen generation (by which method, and centrally or distributed?), fuel cells that will take us behind niche applications, hydrogen storage (think about the massive energy input required to liquefy the stuff) and hydrogen combustion either alone or as part of a fuel mixture.

If you are looking for a challenge and hoping to see hydrogen occupy a serious role in energy generation within your lifetime, make sure you read this book and think carefully about its messages. ◀

PROFESSOR IAN RAE FTSE, a chemist with extensive experience in university teaching, research and administration, was Technical Director of the Academy from 2000–06. He currently co-chairs the Chemicals Technical Options Committee for the Montreal Protocol on substances that deplete the ozone layer, and is a member of the expert committee that reviews persistent organic pollutants for the UN Environment Program. He is chair of the Prescribed Industrial Waste Advisory Committee for EPA Victoria and an adviser to several Commonwealth departments. His report on public reporting of greenhouse gases, commissioned by the Victorian Government, laid the basis for national reporting which begins in 2009.

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ATSE wins grant to reshape health care

ATSE has won one of six new projects awarded to the Learned Academies – to shape new approaches to illness/wellness through applications of converging technologies, such as smart packaging, air and water treatments with neuronal chips, and robotics.

ATSE will also manage a second project – awarded to the National Academies Forum – to analyse the research of historians, political analysts, physicists, environmentalists, legal analysts, economists, cultural critics, anthropologists and others to clarify the political, scientific, environmental and social contexts in which decisions on nuclear energy are made.

Senator Kim Carr, Minister for Innovation, Industry, Science and Research, announced $561,272 over two years for six research projects under the ARC Linkage Learned Academies Special Projects scheme. Average funding of the projects is $93,545.

Senator Carr applauded the Academies for their innovative proposals and for supporting research that is likely to produce long-term benefits for many Australians.

"The Learned Academies are able to provide a unique perspective on research that needs to be done in the natural and applied sciences, technological development and applied technology, the social sciences and the humanities, without being blinded by allegiances to individual universities," Minister Carr said. "Through them, we are able to tap into research that focuses on advancing knowledge across the whole sector or that may not fit easily into other funding schemes."

With a membership of about 2000 eminent Australian researchers in all disciplines, the four Academies provide objective expert advice to Government on important matters of public interest, and contribute significantly to the advancement of Australia's intellectual capacity and international research reputation.

The other four projects are:

- Integration and multiculturalism in Australia (Academy of the Social Sciences in Australia);
- Australia's communication capability of areas of workforce need. (The Australian Academy of the Humanities);
- Technology-enhanced language learning activities and best practice for teaching other languages (The Australian Academy of the Humanities); and
- Nanotechnology research trends/ priorities and health, safety and environmental risk assessment criteria (Australian Academy of Science).

Peter Cullen: a truly great Australian

ATSE Fellows pay tribute to a giant of the water industry

With the death in March of Professor Peter Cullen AO FTSE, Australia lost a giant of the water industry, and the Academy lost a respected Fellow.

Professor Cullen was an Emeritus Professor of the University of Canberra and a Commissioner of the National Water Commission. He was best known for his advocacy of Australia's inland rivers, and his role as a very influential member of the Wentworth Group of Concerned Scientists.

He had worked in the field of natural resource management for more than three decades, winning the Prime Minister's Prize for Environmentalist of the Year in 2001 for his work on the National Action Plan for Salinity and Water Quality.

He graduated in agricultural science from the University of Melbourne and his major professional work was in the areas of nutrient dynamics, lake ecology and environmental flows. He was elected a Fellow in 1991. He was also a former President of FASTS.

A number of ATSE Fellows who worked with Peter Cullen have offered tributes to the man and his work.

Dr Wendy Craik FTSE, Chief Executive Officer of the Murray–Darling Basin Commission

"We were honoured to have worked closely with Professor Cullen over many years, but especially during his time as Chief Executive of the CRC for Freshwater Ecology, to which the Commission was a significant funding partner.

"Professor Cullen's stewardship of the CRC from 1993 to 2002, especially through its Murray–Darling Freshwater Research Centre, paved the way for major commission programs such 'The Living Murray' and the 'Sustainable Rivers Audit'.

"His public advocacy and strong scientific positions created huge public awareness of the Murray's environmental needs and his work undoubtedly contributed to the development of The Living Murray's 'First Step' decision to recover water for the river.

"Professor Cullen's reasoned, intellectual and concerned voice will be greatly missed in all future public discussions of the water resources challenges facing Australia."

Professor Peter Cullen AO FTSE

Dr Roy Green AO FTSE, former President of the Murray–Darling Basin Commission and Chief Executive of CSIRO

"Peter was a dedicated and sincere environmentalist, with a knowledge and understanding of Australia's water systems that will be sorely missed. However, Peter's greatest asset was his ability to convey his message in a clear and concise way to the community generally and, in particular, to those in politics who are so influential in providing the resources to tackle the difficult problems we face.

"I well remember attending a presentation by Peter to Government in which his cogent and forceful arguments had a very strong influence on decisions to provide a step function increase in the funds available for water studies.

"While Peter has many scientific peers, few of us can emulate this ability to communicate so effectively. His achievements will continue to support us in the years ahead, and his memory will stay strong."

Professor John Langford AM FTSE, Director of Uniwater (a joint initiative of Monash University and the University of Melbourne) and former Chair of the CRC for Freshwater Ecology and Executive Director of the Water Services Association of Australia

"I have known Peter Cullen for over 40 years. We were research students together at the University of Melbourne in the 1960s. I was Chairman of the Board of the CRC for Freshwater Ecology for 12 years while he was the Chief Executive.

"He was a great mind and put freshwater ecology

on the map in Australia. More than anything, though, he changed the water debate in this country and our attitudes to our river environment.

"He was a brilliant communicator with a sharp mind – he understood the political process and the media and used this to great effect. His influence in the water debate will be greatly missed at this critical time. I will greatly miss his company and the vigorous discussions we regularly had on water affairs."

Professor Nancy Millis AC MBE FAA FTSE, Emeritus Professor, Department of Microbiology and Immunology at the University of Melbourne, former Chancellor, La Trobe University, Board member of MMBW and later on Melbourne Water and chair of the CRC for Water Quality and Treatment.

"I have known Peter Cullen since his undergraduate days, but later we came in close contact through the Board of Management of the CRC for Freshwater Ecology, which he directed before his retirement.

"I know his contributions will be lasting; they have been incredibly valuable in raising political and regulatory awareness, as well as informing the general public of the value of water as a scarce, but essential, resource for both urban and rural communities. Equally, he urged its careful exploitation, as he recognised that healthy rivers, flood plains and wetlands are vital to the quality and sustainability of the entire aquatic ecosystem.

"He was realistic in his advice and fearless in delivering often unpalatable messages when he was convinced that current practices were unsustainable. Would that there were more like him – his voice will be sadly missed."

Dr John Radcliffe AM FTSE, Commissioner, National Water Commission, former Deputy Chief Executive, CSIRO, Director–General Agriculture, SA

"Peter Cullen had a remarkable career, making a very significant impact on thinking about how we should manage Australia's natural resources. This was reflected most recently in the National Water Commission, where he was lead Commissioner for water-dependent ecosystems.

"As well as his academic appointment at the University of Canberra, his role as Visiting Fellow at CSIRO and as first CEO of the CRC for Freshwater Ecology, he held formal appointments with the NSW, Victorian and South Australian governments. Up to the time of his passing, he continued to be in informal communication with all three governments, providing advice on evolving policy issues.

"He had a remarkable facility for expressing complex issues in simple terms. His visual presentations were a model of simplicity and clarity. With his formal training in agricultural science, he often spoke on the impact of water issues on agriculture, giving the truth as he saw it, albeit the messages were not always palatable to some. But he could be readily persuaded to modify, or further develop, his ideas in the light of new sound science and understanding.

"He was truly a great Australian."

Emeritus Professor Bruce Thom FTSE, Member, Wentworth Group of Concerned Scientists, former Chair, Coastal Council of NSW, Vice-Chancellor, University of NSW

"What prompted the formation of the Wentworth Group of Concerned Scientists in 2002 was a national water crisis. Many in the media and politics were seeking to 'drought-proof' Australia. Peter Cullen immediately became spokesperson for the Group, explaining in simple, yet scientifically sound terms, that droughts should not be seen as 'indignant surprises', but as a frequently recurring part of the Australian environment. Water is a scarce resource and he had incredible capacity to tell us what that meant and what we must do to improve its management.

"Peter Cullen was a listener, thinker and communicator. He took his science into the complex arena of public policy and willingly confronted those interest groups who were unable to see the 'big picture'. He was appalled at ways urban and rural Australia abused water. Environmental crises arising through our exploitation of precious surface and ground waters presented him with challenges that required constant travel, innumerable meetings and speeches, and opportunities to offer solutions.

"Peter had the endearing capacity to make us laugh. His wit and joviality made participation in debates within the Wentworth Group a joy to behold. He is irreplaceable, yet he has left us all a legacy to strive for solutions and not whinge about gloom and doom of past mistakes, present misuse and future threats."

Warm tributes to Professor Cullen were also issued by Senator Kim Carr, Minister for Innovation, Industry, Science and Research; Senator Penny Wong, Minister for Climate Change and Water; Dr Brendan Nelson, Leader of the Opposition; Senator Eric Abetz, Shadow Minister for Innovation, Industry, Science and Research; Senator Barnaby Joyce, National Party; Senator Rachel Siewert, Australian Greens; and Professor Ken Baldwin, President of FASTS.

Several of Peter Cullen's recent talks are available on the Wentworth Group website (www.wentworthgroup.org). ◀

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Ian Gould continues an ATSE tradition at UniSA

Ian Gould

Dr Ian Gould FTSE has been appointed Chancellor of the University of South Australia from 1 July 2008, succeeding Mr David Klingberg AM FTSE, who, in turn, succeeded Dr Basil Hetzel AC FTSE.

Dr Gould had a distinguished executive career in top positions with Rio Tinto, Normandy Mining and Comalco. He is a former President of AusIMM and has served as Chairman of the SA Minerals and Petroleum Expert Group since 2006 and Chairman of the Australian Institute of Marine Science since 2005.

Vice-Chancellor Professor Peter Hoj FTSE said he was delighted with the appointment of Dr Gould, a man of vast experience in governance and leadership, and someone with a comprehensive understanding of the nexus between education, innovation, the community and business.

"In this new appointment, we will have a Chancellor with broad and comprehensive experience across the mining and technology sectors, and someone with a thorough understanding of what is required of graduates in the working world and the role of research in fostering development," Professor Hoj said. "That combination is more than appropriate in a state gearing up for a mining, defence and environmental science boom, and for the SA university that is graduating so many students who will go on to work in these industries."

Dr Gould has in-depth experience in corporate governance, having served as a member or chairman on a range of industry and organisation boards including the CSIRO Minerals Sector Advisory Committee, the South Australian Resources Industry Development Board, the National Parks and Wildlife Committee, the Royal Flying Doctor Service and St Andrew's Hospital.

ATSE Fellows have been instrumental in the university's leadership. Professor Hoj described Dr Hetzel, a former SA Lieutenant Governor, as "an eminent researcher who led breakthrough research into the effects of iodine deficiency, and a man who dedicated his life to health, both locally and, through research and education, globally."

David Klingberg was described as "an engineer and business leader of vast experience, and a man who has shown unstoppable passion and commitment for educational, economic and environmental development in SA and who has provided over 10 years of dedicated service to UniSA."

Dr Gould said: "I am delighted and honoured to be joining UniSA and a little humbled to follow in the footsteps of previous Chancellors, such as the remarkable Dr Basil Hetzel and the extremely dynamic David Klingberg.

"The problems and opportunities of the future lie in education, health, resources, defence, communication and the development of sustainable societies and environments, and UniSA is developing graduates not only with the right skills for those challenges, but the right attitude to apply their knowledge in the working world both ethically and professionally."

Carfrae to deliver Warren Innovation Lecture

Tristram Carfrae FTSE, structural design engineer and Arup Fellow, will present the 2008 Warren Centre Innovation Lecture in Sydney, Melbourne, Brisbane and Adelaide in July. Each year, the Innovation Lecture explores the issues around engineering innovation and the success of Australian technology-based companies.

With a reputation for challenging established ways and exploring better solutions, Mr Carfrae is renowned for taking people along with him on his voyages of exploration and innovation. Responsible for the design of award-winning buildings around the world, he is regarded as one of the world's leading designers of sporting stadia and lightweight long-span structures.

Mr Carfrae is a member of the global Arup Group Board, chair of the Arup Group Buildings Board, and one of nine Arup Fellows (from a global staff of 9000), an accolade honouring those who have significantly contributed to the firm's reputation for excellence in innovation and design.

He will join a distinguished group of ATSE Fellows who have delivered the Warren Centre Innovation Lecture including: Dr Chris Nicol FTSE, Chief Technology Officer, Embedded Systems, NICTA; Dr Don Fry AO FTSE, Chairman of AIMTEK; and Catherine Livingstone AO FTSE, former Chair of CSIRO, former CEO of Cochlear and current Director of Telstra and Macquarie Bank.

Tristram Carfrae

Tom Healy wins Gaudin Award

Tom Healy

Professor Tom Healy AO FAA FTSE, a Professorial Fellow at the University of Melbourne, was awarded the 2007 Antoine M. Gaudin Award by the Society for Mining, Metallurgy and Exploration (USA) for his " innovative contributions to fundamental colloid and surface chemistry and their applications to mineral processing and related areas".

The Antoine M. Gaudin Award, established in 1975, is for scientific or engineering contributions that further understanding of the technology of mineral processing.

Professor Healy has had a long and distinguished career in science and technology, higher education, management and in community service. He held several senior positions at the University of Melbourne and at major universities and industrial research centres in the UK, the US and Japan.

Upon his retirement, in December 1999, from the full-time staff of the University of Melbourne he was appointed Professor Emeritus and Deputy Director of the ongoing ARC Special Research Centre – the Particulate Fluids Processing Centre. He has held senior positions in federal government agencies including membership of the ARC from 1993 to 1996. During that period he was Chair of the Institutional Grants Committee of the ARC, responsible for the core funding of research infrastructure across the Australian higher education sector.

He has been Principal of Colloid Consultants Pty Ltd for more than 20 years, providing technical consultancy to many Australian and international companies in the resources, chemical and manufacturing sectors, and to universities, government agencies, and Australian and UK courts and legal firms.

Rod Tucker joins Broadband panel

Professor Rod Tucker FAA FTSE has been appointed to the Panel of Experts to assess proposals to build the National Broadband Network. The panel will be chaired by the Secretary of the Department of Broadband, Communications and the Digital Economy, Ms Patricia Scott.

Professor Tucker is a Laureate Professor at the University of Melbourne. He is Research Director of the Australian Research Council Special Research Centre for Ultra-Broadband Information Networks (CUBIN), in the University of Melbourne's Department of Electrical and Electronic Engineering.

Professor Tucker has held positions at the University of Queensland, the University of California, Berkeley, Cornell University, Plessey Research, AT&T Bell Laboratories, Hewlett Packard Laboratories and Agilent Technologies.

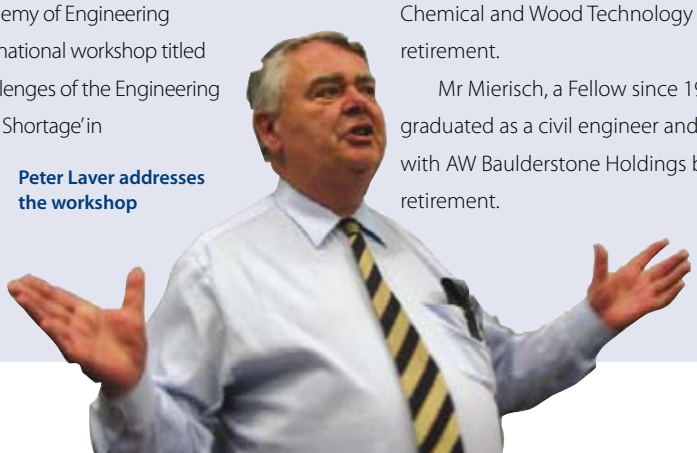
Rod Boswell joins Academy of Science

Professor Rod Boswell FAA FTSE has been elected a Fellow of the Australian Academy of Science. Election to the AAS recognises a career that has significantly advanced, and continues to advance, the world's scientific knowledge.

Professor Boswell, from the Research School of Physical Sciences and Engineering at the Australian National University, was recognised for his distinguished for his work on basic and applied plasma physics.

ATSE joins South African engineering skills debate

ATSE Vice President Peter Laver AM FTSE represented the Academy at a South African Academy of Engineering international workshop titled 'Challenges of the Engineering Skills Shortage' in Pretoria in March, offering an Australian perspective on the topic. Other international speakers at the two-day workshop in Pretoria included Professor David Nethercot OBE FREng, Head of the Department of Civil and Environmental Engineering at Imperial College London (representing the Royal Academy of Engineering) and Professor R. Natarajan from the Indian National Academy of Engineering.



Peter Laver addresses the workshop

Vale Fellows

The Academy notes with regret the recent deaths of Professor Peter Cullen AO FTSE and Professor Chu Pak Lim in March, Dr Ted Hillis AM FTSE in February and Bob Mierisch AM FTSE in December 2007.

Professor Cullen was an Emeritus Professor of the University of Canberra and a Commissioner of the National Water Commission. He was best known for his advocacy of Australia's inland rivers, and his role as a member of the Wentworth Group of Concerned Scientists. (See tributes, page 28.)

Professor Chu's death followed a battle with lung cancer. His contribution to his chosen field was enormous. As a Professor of Electronic Engineering at the University of NSW and, more recently, the City University of Hong Kong, as well as in the commercial setting, his collaborative research extended the limits of knowledge and drove forward technical advancement, particularly in photonics, in which he remained one of the world's true authorities. His career-long involvement as a mentor to students, including the supervision of more than 35 PhD students, has helped produce new generations of innovators. He was elected a Fellow in 1997.

Dr Hillis, a Fellow since 1980, was Chief Research Scientist with CSIRO's Division of Chemical and Wood Technology before his retirement.

Mr Mierisch, a Fellow since 1986, graduated as a civil engineer and worked with AW Baulderstone Holdings before his retirement.

Ian Chessell named SA's chief scientist

Ian Chessell

Former Commonwealth Chief Defence Scientist and head of the Defence Science and Technology Organisation (DSTO) Dr Ian Chessell FTSE will become South Australia's second chief scientist.

Announcing the apointment SA Premier Mike Rann said Dr Chessell would help raise SA's R&D profile and ensure that the state's R&D capabilities "support important and emerging industry sectors, such as agriculture, manufacturing, health, bioscience and resources."

Dr Chessell, a Fellow since 2003, replaces SA's retiring first chief scientist Max Brennan, who was appointed to the part-time position in 2005.

Among a range of senior board appointments, Dr Chessell has been a member of the Prime Minister's Science, Engineering and Innovation Council and the Premier's Science and Research Council in SA and is currently a member of the Premier's Defence SA Advisory Board.

As Chief Scientist, Dr. Chessell will also now co-chair the Premier's Science and Research Council, providing dedicated leadership for strategic development of the SA's science and research sector.

"In this capacity, Dr Chessell's experience and networks in government and applied research, his ability to communicate effectively with scientists and non scientists and his broad knowledge of both research and administration, will prove invaluable", Premier Rann said.

Mike Dureau to head Warren Centre

Professor Michael Dureau FTSE has been appointed Chairman of the Warren Centre, succeeding founding Board member Peter North AM FTSE.

After a successful career in the chemical, water, controls and power industries, Professor Dureau retired as CEO of Alstom Power in 2003, and was then appointed Adjunct Professor of Engineering at Sydney University and Executive Director of the Warren Centre. He was Professional Engineer of the Year in 2000 for Engineers Australia (Sydney Division), received the Centenary Medal for services to the community in power and electrical Engineering, received the 2001 Fluor Daniel Award for sustained achievement in leadership and management and was listed for three years in the Top 100 Influential Engineers.

Mr North stepped down as chairman after a distinguished career in engineering spanning 50 years. He led the successful fundraising committee that raised the original $2 million in foundation funding to establish the Warren Centre in 1982, and was elected Chairman in 1996. In recognition of his contribution to the centre, he was elected to the position of Honorary Life Governor and received the Chancellor's Warren Centre Medal for Outstanding Contribution.

Fellows honoured in materials handling

Dr Greg Tegart AM FTSE and Professor Ian Polmear AO FTSE have both been elected honorary members of Materials Australia for their outstanding service to the materials industry.

Dr Tegart, former Secretary of the Australian Science and Technology Council, is a Professorial Research Fellow at Victoria University, studying issues of technology and society, including nanotechnologies and converging technologies. He led a 2005 ATSE delegation to France and is presently principal investigator in an ATSE study for the Australian Research Council on energy and technology. He is a former ATSE ACT Division Chair and ATSE Councillor.

Professor Polmear was a Professor of Materials Science at Monash University for 24 years and Deputy Vice-Chancellor from 1987 to 1990. He has taken an active role in the development of research in Australia through chairmanship of key committees in organisations such as the ARC, Australian Institute of Nuclear Science and Engineering, CSIRO and the CRCs. He is a former ATSE Victorian Division Chair and ATSE Councillor.

Graham Harris goes to Lancaster

Tasmanian Fellow Dr Graham Harris FTSE has accepted a three-year post, from May, as Director of the Lancaster Environment Centre at Lancaster University in the UK.

With a staff or more than 200, together with the co-located NERC Centre for Ecology and Hydrology laboratory, the centre is home to one of the biggest collections of environmental scientists in Europe. A key task will be to merge three university departments (Environmental Science, Geography and Biological Science) into one unit.

ATSE Fellows at core of NICTA world first

Two ATSE Fellows play key roles at NICTA, which has developed a world-first in semiconductor technology for the wireless home and office of the future.

NICTA, Australia's Information and Communications Technology (ICT) Research Centre of Excellence, recently announced the world's first transceiver integrated on a single chip that operates at 60GHz on the CMOS (complementary metal–oxide–semiconductor) process, the most common semiconductor technology.

This technology breakthrough will enable the wireless transfer of audio and video data at up to five gigabits per second, 10 times the current maximum wireless transfer rate, at one-tenth the cost. The development will enable the truly wireless office and home of the future, as the integrated transceiver is extremely small and can be embedded into devices.

"Our team, which includes 10 PhD students from the University of Melbourne, has overcome some significant challenges in developing this breakthrough technology," said NICTA Chief Executive

Officer Dr David Skellern FTSE. "Developing very-high-frequency radio components in a standard CMOS process and then integrating those components on a single chip has posed challenges in dealing with the inherent limitations of that process for radio circuits.

"Now that NICTA researchers have successfully addressed these challenges, the ICT industry will soon have access to low-cost, low-power and high-broadband chips that will be vital in enabling the digital economy of the future."


Sue Meek

NICTA Chief Technology Officer, Embedded Systems, Dr Chris Nicol FTSE , said the availability of a single-chip, low-cost, very-high-speed wireless technology would transform the home entertainment industry: "For example, consumers will be able to download a high-definition DVD onto their PDAs (personal digital assistants) at a public kiosk in seconds, take it home and play it directly onto their high-definition TV."

Sue Meek to head Academy of Science

Dr Sue Meek FTSE, Australian Gene Technology Regulator, takes over as Executive Secretary of the Australian Academy of Science in May, succeeding Professor Sue Serjeantson.

Dr Meek has 25 years of experience in a variety of capacities at the interface of industry, academia and government. She has held the position of Gene Technology Regulator since 2001, in which she has been responsible for administering and enforcing the national regulatory system for the development and use of gene technology. She has a PhD in marine biology, an MSc in oceanography and BSc (Hons) in microbiology.

Parliamentary science briefings under way in Victoria

The Victorian Parliament Presiding Officers' Science Briefings 2008, organised by ATSE, got under way in March, with a presentation on bushfires.

The program, organised through the offices of the President of the Legislative Council and the Speaker of the Legislative Assembly and coordinated by Dr Michael Manton FTSE, are for parliamentarians and staff. The topics cover policy-relevant issues in science and technology. For 2008 the topics are water recycling (April), education for the future (June), nanotechnology (July), drug-resistant diseases (September) and biofuels (November).

Fellows on WA Science Council

Four ATSE Fellows sit on the Premier's Science and Innovation Council in Western Australia, formed in 2007. They are: Professor Alan Robson AM FTSE, Vice-Chancellor of the University of Western Australia; Dr Bernard Bowen AM FTSE, former Chair of the WA Environmental Protection Authority; Professor Beverley Ronalds FTSE, Chief of CSIRO Petroleum; and Dr Roy Green AO FTSE, former President of the Murray–Darling Basin Commission and Chief Executive of CSIRO.

The Council is chaired by WA Chief Scientist Professor Lyn Beazley, who was a speaker at the 2007 ATSE National Symposium in Perth.

Old Forests, New Management

The 'Old Forests, New Management' conference in Hobart in February attracted a very good international attendance, according to a conference report by Professor Ian Ferguson FTSE

The presentations were organised around major themes regarding old-growth forests, including: their social and historical importance; structure, biodiversity and ecological dynamics; long-term experiments; conservation and reserve management; ecological silviculture; and future management regimes.

Climate change was seen to pose special challenges because models of species distribution generally predict wholesale relocation of tree species in the next century in some places, yet evidence of migratory responses do not match the predicted climate changes.

This conference was supported by the Australian and Tasmanian governments, ATSE and the Australian Academy of Science (AAS), the CRC for Forestry, Forestry Tasmania, the International Union of Forest Research Organizations (IUFRO), the University of Tasmania and Long Term Ecological Research, Australia. In addition, ATSE and AAS nominated this as the ninth conference in the Sir Mark Oliphant 'International Frontiers of Science and Technology' series.

Professor Ferguson's report is at www.atse.org.au/index.php?sectionid=1129.

2008 ATSE CLUNIES ROSS AWARD PRESENTATION DINNER

14 MAY 2008 SOFITEL BRISBANE

PROGRAM HIGHLIGHTS:

- Address by Anna Bligh MP, Premier of Queensland
- Guest Speaker - Dr Andy Thomas, NASA Astronaut
- Celebration of the 2008 ATSE Clunies Ross Awardees
- The opportunity to network with key decision makers from industry, government and academia

BOOKINGS:

To express your interest in attending the Presentation Dinner, please contact the ATSE Office on (03) 9340 1200 or cathrynl@atse.org.au

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ATSE CLUNIESROSS FOUNDATION

Dr Clare Underwood and Dr Tim Silk at UQ's $63 million Queensland Brain Institute

Australia's brain gain

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