ATSE

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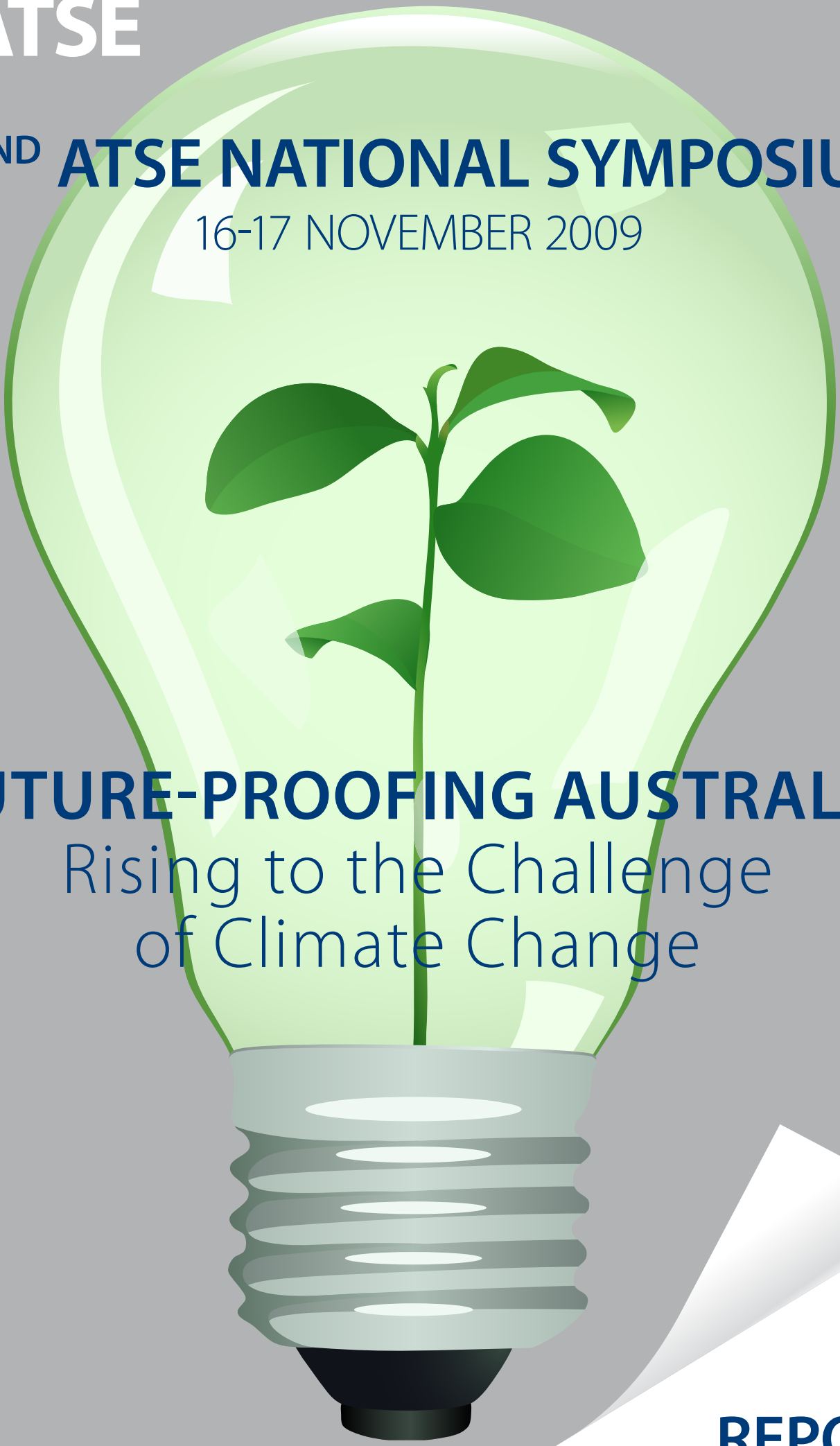

FUTURE-PROOFING AUSTRALIA

Rising to the Challenge of Climate Change

REPORT

The Academy is particularly grateful to the sponsors of this Symposium for their support and to the speakers and delegates for their participation in a key forum to deal with some of the major issues facing Australia today.

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The Academy's 32nd National Symposium **FUTURE-PROOFING AUSTRALIA – Rising to the Challenge of Climate Change** addressed one of the most important topics our nation and the world faces.

The 2009 Symposium, held in Brisbane, continued the Academy's long, successful and distinguished tradition of providing forums for:

- discussing issues relevant to the formulation of public policies;
- conveying expert advice to Governments and the community; and
- promoting the application of scientific and engineering knowledge.

It recognised that Governments are introducing policies for reduction of greenhouse gas emissions and that meeting the targets that are being debated will raise daunting challenges. It focused on the practical potential of current and future low-emission technologies and other greenhouse-gas-abatement strategies.

Four large emissions sectors were addressed – electricity generation, transport, the minerals industry and land management. Options were evaluated in terms of cost, time to implementation, scale-up potential, risks, R&D needs, policy support requirements, public acceptability and commercial opportunity.

National and international representatives of both the private sector and public sector were prominent, along with leading researchers.

All contributed to the final session, which worked to distil the presentations, questions and discussions into a Symposium Communiqué, which is reproduced in this Symposium Report (see page 19) and can be viewed at www.atse.org.au/index.php?sectionid=1019

This **Report of the 32nd ATSE National Symposium** summarises the speaker presentations at the Symposium. Full audio recordings and slide presentations from each speaker, plus this report, are also available online at www.atse.org.au/index.php?sectionid=1019

SESSION 1: SETTING THE SCENE

1. Welcome Address

Professor Robin Batterham AO FREng FAA FTSE
President, ATSE

Climate is chaotic, it is complex and it is open ended. It is not something you can cart off to the laboratory and undertake controlled experiments on. It is very hard to have a debate about climate science without it degenerating into a debate about belief systems, fallibility and what is essentially religion. To me, the vagaries of climate are much more about risk and the perception of risk, how you handle it economically and how to build as much resilience into it as you can. These are the themes our industries should be discussing.

All of these factors are taking place in an increasingly competitive world, in which not everything necessarily lines up and not everybody plays by the same rules.

Governments are introducing policies for reduction of greenhouse gas emissions, and meeting the targets that are being debated is going to raise quite daunting challenges. This symposium will focus on the practical potential of existing and future low-emission technologies and other greenhouse gas abatement strategies. We will give a fair bit of attention to options that are being evaluated in terms of things like cost, time to implementation, scale-up potential, risks, research and development needs, policy support requirements, public acceptability and, of course, commercial opportunity.

It is about risks, perceived risks, and about the opportunities that can balance those risks. It is about what we can do in an opportunistic and acceptable way.

Professor Robin Batterham

2. Climate change and implications for sustainability

Professor David Griggs
Director, Monash Sustainability Institute, Monash University; Previously leader of Secretariat for the Science Working Group of the United Nations Intergovernmental Panel on Climate Change (IPCC)

The fact that climate change exists is unequivocal. And it is not just one line of evidence that points to this. The surface temperatures are increasing; the temperatures throughout the atmosphere are increasing; the water vapour content of the atmosphere is increasing; the heat content of the ocean is increasing; Greenland and Antarctic ice sheets are losing mass; glaciers and snow cover are retreating; the Arctic sea ice extent is decreasing; the area of seasonally frozen ground around the world is decreasing; the mid-latitude wind patterns and storm tracks are shifting towards the poles; we're getting more intense and longer droughts; the frequency of heavy precipitation events is increasing; extreme temperatures are increasing; tropical cyclone intensity is increasing … Do I need to go on? These occurrences are what caused the Intergovernmental Panel on Climate Change to say that global warming in unequivocal.

So what is the world doing about this? We need to look to stabilise the concentration of greenhouse gases in the atmosphere. A lot of governments have said they would like to reduce warming to less than 2°C, so scientifically that means that developed countries would need to reduce their emissions by 25 to 40 per cent by 2020, and 80 to 95 per cent by 2050 – and you would still only have a one-in-four chance of meeting that 2°C target.

Australia's energy demands have been growing rapidly – we are using about 556 per cent per person per capita more energy than in 1960. We have also been using more peak oil than we have been discovering since the 1980s, so there is a huge energy gap that we, as technologists, have to find some way of filling.

The Monash Sustainability Institute aims to provide practical solutions that are dedicated to a sustainable and prosperous low-carbon society through education and collaborative research. We coordinate, develop and apply world-class interdisciplinary research, and bring those together with economists, social scientists and lawyers so that we can look at the whole chain of bringing technology through to implementation. We are doing this to provide individuals and organisations with the knowledge and skills to meet climate change and sustainability goals.

3. Australia's role in shaping global energy futures

Professor Gregory J. McRae
Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, and Executive Director, Morgan Stanley, New York

Energy is absolutely crucial to the economic growth and sustainability of our societies, both globally and locally, and it's very important that we take a long-term view when assessing

the possible solutions to the energy security problems. However, it's also an area with exciting opportunities for science and engineering, with technological innovation, economic growth and possibilities for new businesses.

The real driving forces for change around energy policy seem to be: energy security concerns; the change in public opinion and willingness to pay for some of the energy-efficient options; and local environmental impacts. In countries that are developing rapidly the major political driving force for change to do something about fuels is not CO_2, but is to do with the local air pollution problems. Focusing on local living-standard improvements when it comes to the UN Climate Change Conference in Copenhagen presents a real opportunity to get political driving force to change.

It can be easy to lose sight of the fact that the scale of the problem we are facing is immense, and – if we are to have a significant impact on achieving the CO_2 emission reductions about which governments are talking – tackling the problem calls for long-term, sustained investments in thinking about energy, energy sources and the impact of those sources.

When it comes to new technologies and possible solutions, there are so many debates about one new technology versus another, but we need to look at every possible technology we can get our hands on. There is no silver bullet. We must evaluate all of the options by evaluating impacts during the life cycle of the new technologies – not just CO_2 emissions, but also the effects on water, trade, food prices, infrastructure, land and many other factors.

The business potentials that are emerging (for example, with solar photovoltaic cells, new technologies that look at post-combustion CO_2 removal from flue gas, and geothermal power) are exciting, and there are many energy alternatives emerging. We have choices in terms of the types of fuels and technologies we use, and to manage the problem of climate change we need an integrated approach – we need to look at many alternatives and how to manage the complexity of those alternatives.

4. Future energy technologies and philosophies for UK and Europe

Dr John Loughhead FREng FCGI FRSA
Executive Director, UK Energy Research Centre

The carbon reduction targets that have been set by the UK Government are challenging, and we may even need to adopt more aggressive targets in the future. If we are going to meet the CO_2 emission targets that have been set then the emissions from electricity and transport – the two highest-emitting sectors – have to decrease dramatically. As the carbon reduction targets get more aggressive, the use of coal with carbon capture and storage (CCS) will also have to diminish, the reason being that it is not a zero-CO_2 emission technology, and if you want to meet the targets you can only allow a certain amount of CCS. To meet the most aggressive targets, nuclear and renewables such as wind will have to replace CCS.

The UK and Europe have identified a number of technologies that can possibly fit into a low-carbon future – such as solar photovoltaics, CCS, wind, bio-energy sources, nuclear, tidal and wave energy – but most of these technologies still require substantial development and investment before they are ready and commercially viable; they are not likely to come into use until post-2020. Onshore wind is now considered a commercial technology and is the primary

John Loughhead and Gregory McRae

new energy source for northern Europe. The reliability, maintenance and costs of offshore wind technology are still major limitations for that technology.

Forty-five per cent of carbon emissions now come from existing buildings, with 27 per cent from homes. On average, it takes 40 years to roll out energy-saving measures into existing buildings and, quite simply, we do not have that much time. If we implement all of the measures and appliance technologies that we presently know about we can get a 45 per cent reduction in CO_2 emissions. We need an 80 per cent reduction. We need to implement the savings at six times the rate now, and that is a policy and a social issue more than a technological issue.

With the exception of solar technologies (about which we need more scientific research) we know most of the methodologies and approaches for many of the proposed technologies. Now it's a matter of turning that scientific knowledge into something we can use. The primary need now is for development.

5. Stationary energy technology for climate change mitigation

Dr John Burgess FTSE
Principal, Niche Tasks

ATSE undertook a project last year to look at accelerating the technology response to climate change. We were looking at a portfolio of technologies that would solve the power generation problems given the constraints around targets for CO_2 emissions: five per cent reduction by 2020, and a 70 per cent reduction by 2050.

If we do nothing – if we take the business-as-usual approach – our CO_2 emissions will double by 2050. In the business-as-usual approach it would cost up to $100 billion to replace the power generation infrastructure. But it would cost up to $300 billion for a 70 per cent target in 2050, which is a substantial investment. It would cost $84 billion to reach the five per cent reduction target by 2020. We would need massive increases in the use of technologies such as gas stream, gas turbine, wind, solar PV, solar thermal, CCS and geothermal to reach these targets. The technological, engineering and deployment challenge to meet the targets is significant. I think people who say the five per cent target is wishy-washy do not understand what really needs to be done to hit that target.

The new technology mix needed to reach the 2050 targets calls for massive change in our energy outlook – and this includes nuclear. Martin Ferguson disagreed with our project analysis and said Australia would never have nuclear. But if we do not have nuclear we are going to have to find 10GWe of energy somewhere else.

The Australian Treasury has used global equilibrium economic modelling to predict the future effects of an Emissions Trading Scheme for CO_2. CCS and geothermal play a very big role in Treasury thinking, and it is quite a heroic assumption for technologies that have not yet been proven. CCS's capacity factor needs to string together perfectly with this assumption.

ATSE has received a Learned Academies Special Projects grant to calculate the real option value (that is, the financial viability) of many technologies. Our project calculates the after-tax cash flow and future investment requirements. The results of this report will be used in policy discussions for the forthcoming White Paper.

John Burgess and Adi Paterson

6. Electricity and carbon: South Africa as an example of a resource-based economy

Dr Adrian (Adi) Paterson FTSE FAASA FSAAE
Chief Executive Officer, Australian Nuclear Science and Technology Organisation (ANSTO)

When looking at potential solutions to climate chance, South Africa does not pre-select or rule out any technology options before an evidence-based scenario is generated. We then set primary targets; evaluate the maturity of the options; and test the scenarios – and from that the viable options emerge. It is a very simple, effective and rational process, and one that can be applied to Australian policy thinking.

It is important to apply Socolow and Pacala's wedges approach, which is a clear and coherent way to think about how we deal with mitigating carbon. It is a remarkable piece of policy thinking that has led to a fundamental mind shift in the way policy is made. Technologies described as small wedges – such as methane from animals and afforestation – have limited effects in terms of abatement, but you have to add them all up because then they become useful. These small, but in no way insignificant, technologies should be added to the medium and larger wedges, which includes things like residential efficiency, CCS, taxes, renewables and nuclear. Each technology is important and adds up.

Jamais Cascio spoke truly when he said that *"far too often, discussions of efforts to mitigate the worst effects of global warming bog down under an argument that is simultaneously factual and irrelevant: there's no single solution. Solar power (or wind, or nuclear, or sonofusion) is not going to be sufficient to replace all coal and oil use. Efficiency won't improve fast enough. Sequestration can't bury enough CO_2. These are all true, but only in isolation. The solution that will work comes not as a single bolt from the blue, but from a combination of multiple, varied efforts."*

The bottom line is no rationally thinking or reasonable world economy has decided not to use all of the options that are available to mitigate carbon. All options must be on the agenda.

SESSION 2: POWER GENERATION – LOW CARBON EMISSION FUELS

1. Low emission coal technologies

Professor Kelly Thambimuthu FTSE
Director, Centre for Coal Energy Technology, University of Queensland and Chairman, International Energy Agency, Greenhouse Gas Program

Fossil fuels are likely to dominate the energy outlook for the next 25 years, and the use of coal is likely to increase as a source of energy. About 25 per cent of the increased demand for energy is likely to come from India and China alone, and it is abundantly clear that coal is, and will continue to be, used. The sensible option is to find solutions to find a better way to use it because the world is addicted to coal.

While it is critical to have a whole portfolio of technologies to reach the G8's aspiring goal for an 80 per cent reduction in CO_2 emissions by 2050, coal and gas are still going to dominate in the coming years. So by 2050 we ought to have the capacity to implement CCS for power generation to the level of about 10 to 19 per cent of the electricity supply.

The options for CCS are power generation with post-combustion capture (close to 90 to 95 per cent of the world's infrastructure is based on burning coal in a box and raising


Professor Kelly Thambimuthu

steam, so you need post-combustion flue gas separation technology to retrofit); pre-combustion capture (still a relatively infant, but emerging, power technology); and oxy-fuel combustion (this technology would initially be a variant on conventional boilers, but we don't have proven experience).

Learning by doing is a very important aspect of the approach that we should take to get the new technologies underway, and while CO_2 capture technologies are available, they need to be integrated into power plants so we can learn how to improve efficiency and to get the capital costs down.

2. Geological storage of carbon dioxide

Dr Peter J Cook CBE FTSE
Chief Executive, CO2CRC

Many projections indicate that because of rapidly rising demand from developing countries, we will be using more, not less, fossil fuels in the future. We need to use CCS to minimise the resulting emissions.

CCS is already happening, but not at the scale that it needs to happen. There is a storage project in place in the Otway Basin, where we have safely injected and stored 60,000 tonnes of CO_2 in the ground in the past 18 months or so, and we know we can conduct CCS safely by understanding the geology and knowing we are using the right rocks. CCS is well known, safe, and it works.

All clean energy technology options will cost more, and, quite simply, CCS will cost more than conventional pulverised coal-fired power stations. When looking at the price of emerging low-emission technologies there are no clear winners yet, so this calls for a balanced mitigation portfolio. The IPCC's view is that having CCS in an energy portfolio would make the total cost of mitigation 35 per cent cheaper than a strategy that does not include CCS.

Much of the existing energy generation capacity will still be in existence in 2040, and so we're deluding ourselves if we think we can tackle greenhouse without including CCS in the mix. It is absolutely crucial and we can't assume that renewables can take up the slack. For as long as we choose to use fossil fuels we need a balanced mitigation portfolio that includes deep cuts in CO_2, greater energy efficiency, renewables, fuel switching, nuclear, biosequestration and CCS.

We have to make CCS work otherwise we don't have a solution to the greenhouse problem.

3. The growth and significance of coal seam gas in Queensland

Shalene McClure
Comet Ridge Manager, Santos Ltd

Natural gas is going to play a vital role in meeting Australia's – and the Asia Pacific region's – energy requirements, and Australia is going to have a strategic role as an LNG supplier. Natural gas will meet eastern Australia's new baseload power generation requirements, and will lower the carbon intensity by up to 70 per cent. Using natural gas instead of coal would lower water use by 99 per cent, and that is an enormous saving.

Australia is blessed with enormous gas potential and we believe it will take us into the next century and probably well beyond that. We believe that the natural gas industry is ample and affordable enough to meet both domestic and export requirements. Queensland coal seam gas (CSG) reserves now stand at more than 30 times the total eastern Australian annual demand and the reserves have jumped nearly 20 per cent in only six months. We expect to see LNG tankers leaving Gladstone in 2014 and, in effect, that means Australia will be exporting a clean energy to the world.

There are many challenges and new technologies that Santos is looking at in relation to drilling and completions – such as the need for customised drilling rigs, reducing the footprint by using pad wells, increasing efficiency of remote wells, geomechanical modelling and reservoir uncertainty – but perhaps our major challenge is water handling and disposal. Santos takes water management very seriously, and now has a reverse osmosis system operating and is working on the world's largest CSG water irrigation system. Establishing innovative water-handling solutions is a priority and the last thing we want to do is ruin the absolutely beautiful environment in which we're working.

4. Going nuclear – an industry perspective

Dr Selena Ng
Director, Asia-Pacific Business Development – AREVA

Nuclear power is a proven technology that generates low-carbon electricity. It is affordable, dependable, safe and capable of increasing diversity of energy supply. Nuclear power is therefore an essential part of any global solution to the related and serious challenges of climate change and energy security.


Shalene McClure

A global transition towards a low-carbon economy requires a sharp increase in the use of nuclear power and, together with renewables and CCS, it will play a crucial role. It is important to realise that no one technology can do the job alone – all technologies will be needed if we are to have a chance at successfully mitigating climate change, but it is essential to add nuclear to the power generation mix.

While the capital investment costs of nuclear energy are much higher than coal or gas, when looking at the entire life cycle of nuclear energy it is a cost-effective way of providing baseload electricity due to a low marginal cost of generation and high potential availability factors. Similarly, its sensitivity to fuel costs is limited, so nuclear power can produce electricity at a predictable cost.

Nuclear power is dependable and uranium reserves are widely distributed around the world, so this gives generators a diversified range of suppliers.

Safety is essential, and the entire life cycle of nuclear is highly regulated – from the mining of uranium through to the storage of radioactive waste. Reactor safety is based on the 'defence-in-depth' principle (involving several barriers of confinement) and safety features are designed into reactors. While accidents like Three Mile Island and Chernobyl were disastrous, they sparked the movement for international cooperation in reactor safety and instilled a strong safety culture globally in the nuclear industry.

To successfully launch a nuclear power program, a country needs: political and economic stability; to commit to using nuclear power for exclusively peaceful purposes; and to communicate in an open and transparent manner with the public and neighbouring countries.

Dr Ziggy Switkowski

5. Challenges and opportunities for nuclear power generation in Australia

Dr Ziggy Switkowski FTSE
Chairman, Australian Nuclear Science and Technology Organisation (ANSTO)

The advocacy of nuclear energy in Australia – which has begun carefully, cautiously and timidly – will soon escalate to a position where it becomes a serious part of our strategic thinking about energy security, and also to a point where we realise that it offers the promise of providing most of the answer to the challenges ahead of us. However, we must not diminish the challenges that we still have to overcome in terms of social and political acceptance of nuclear technology.

In Copenhagen, the Prime Minister will learn that: two-thirds of the world gets some of their electricity from nuclear reactors; countries that have paused in the past are reactivating their nuclear programs or debates; and that countries affected by the Chernobyl disaster are increasing their nuclear networks. No economy of Australia's size or larger is without nuclear power.

Australia's energy and climate change strategy is based upon a number of assumptions, such as an accelerated deployment of renewables such as wind and solar, a substitution of coal by gas, and the presumed success of clean coal technologies and CCS. We may be the only country whose total energy strategy is based upon such fragile assumptions.

As we transition to a low-carbon economy, our traditional sources of competitive advantage – abundant and inexpensive fossil fuels – will be overtaken by new generation technologies, such as nuclear power, where we have no presence. Without taking up nuclear, our competitive advantage will disappear. A portfolio that includes nuclear, renewable technologies and a continued fossil fuel platform would meet all of Australia's electricity needs reliably, safely, cleanly and cost-effectively.

My view is that we must design an evolutionary path along which the Australian economy progressively reduces its dependence on fossil fuels, while enhancing its productivity and competitiveness. Assembling a range of novel, niche energy technologies may be interesting and intellectually satisfying, but it is inefficient when better industrial-grade solutions are available. Nuclear power simply must be in the mix, and we should be prepared for it to be most of the answer.

SESSION 3: RENEWABLES

1. Geothermal: evolving sector with investment appeal

Dr Adrian Williams
Australian representative on International Partnership for Geothermal Technology and, previously, CEO Geodynamics

Geothermal energy is an evolving sector that is likely to be one of the most cost-competitive, low-emission technology options. Australia has an abundance of hot fractured rocks and sedimentary aquifers, and so in using it we can exploit the benefits of geothermal energy like the zero emissions, the small footprint, and the developments that are being made with re-injection of water.

Geothermal is not a new technology. It has been around for a long time and is well established and proven globally. All of the core technologies already exist in subsurface areas like drilling, reservoir modelling, and also with power stations. Similarly, all of the legislation is already in place, which means that companies can hold geothermal property and invest in it. We're not facing any regulatory barriers and we have strong public support.

The main challenge that faces geothermal is the lack of experience: we have the ingredients, but we are seriously short of hands-on geothermal experience. That applies to our financial markets and the way they understand the industry; education; and to the way companies implement their projects. From proof-of-concept through to being fully commercially viable, a project can take between seven and 11 years. The pace of development of the industry won't be limited by the availability of a geothermal resource – it will be limited more by people, experience and finance.

We have a suite of new technologies that all promise to have similar costs. At the existing level of experience and deployment it's really hard to argue much one way or the other – it is clear in the outlook that geothermal will be competitive.

2. Challenges and opportunities for renewables generation

Mr Gordon Jardine FTSE FAICD FAIM
Chief Executive, Powerlink Queensland

If you want to develop renewable generation in this country, it's important to realise that you're playing in a market/price-based game, and that you'll be dealing with commercially focused entities called electricity retailers. The legal obligation for meeting the 20 per cent Renewable Energy Target is imposed on the retailers, so they will have the controlling say in how things unfold, and in which technology gets developed and when. The important thing to realise is that if you want to develop a renewables generation facility in this market, you will have to get an offtake agreement for 10 to 15 years with a retailer to qualify for financing.

The Government has stepped in on a number of issues, because with the market/price forces as they are, a number of high-cost and uncompetitive technologies simply would not have a chance. For example, the Government is subsidising the capital costs of solar energy and has made some policy changes to the way generators have to pay for grid extensions – new generators only pay for their share of the transmission capability of the grid extension, rather than 100 per cent of the extension cost, as was the case in the past.

There are some great opportunities for the lower cost renewables that are located close to the power grid.

Stuart Wenham addresses the symposium.

The main challenges that remain are for very high-cost renewables, particularly those located a long way from the existing grid or which don't have a convincing case for grid extension. It will be very difficult for them to secure an offtake agreement with an energy retailer.

So basically, if you have low-cost renewables you're going to be in good shape, but the real key to this exercise is securing an offtake agreement with an energy retailer.

3. Commercialisation of Australian photovoltaic technology

Professor Stuart Wenham FTSE and Dr Zhengrong Shi FTSE
Director, Centre for Voltaic Engineering, UNSW; CEO and Chairman, Suntech Holding Co Ltd, China

Solar voltaic cells convert sunlight directly into electricity. There are no moving parts, no noise, no waste products or pollution and there's no wear-out mechanism. The real challenge for photovoltaics is to bring the cost down to be competitive with other forms of electricity generation. The other challenge is also to do with cost – you have to pay all the cost upfront, but then essentially get your electricity for free for the lifespan of the cells, which can be up to 50 years.

Photovolatic solar cells can be used in a number of applications – on residential rooftops (as both solar panels and as a solar tile building product), above car parks and also at a utility-scale implementation level, where you see hundreds of acres in deserts covered in solar panels, which can generate up to 400MW.

Introducing high-efficiency attributes into technology is only going to work commercially if you can convince industry that it is not going to add to their costs; is going to be a simple, robust technology; and can be implemented with high throughput in mass production with very high yields. This is the challenge for photovoltaics.


Zhenrong Shi

We think we have developed a technology that can reach grid parity in most countries and can compete with fossil-fuel-generated electricity, but ultimately there has to be another solution where further science addresses the efficiency losses that occur during the conversion process. We need to pave the way for photovoltaics to become a baseload power source. The first stage to reaching that goal is going to be subsidy-driven, but from there – once the costs begin to come down a little – photovoltaics could become part of a hybrid power plant, before finally becoming a fully independent baseload power plant. It is a challenge, but I believe we can make it happen.

4. The possible futures for solar thermal power: a business and technology perspective

Mr Peter Meurs
Managing Director, Worley Parsons

There are some great applications for solar thermal power, and one of the big motivators for being interested in solar power in Australia is that, if we want to harness it, there is certainly enough energy here to be converted to power for Australia and all of Asia.

Traditionally there have been a number of challenges that have prevented the uptake of solar thermal energy, including concerns about cost, intermittency, dispatchability and scale. Although it has been around for 20 years, there has not been much money or attention spent on it so, in terms of costs, it is still in a fairly early stage of development. We expect the costs to continue to come down, but solar thermal still requires regulatory support to be cost effective and to compete with other renewables. Intermittency and dispatchability continue to be key barriers in using renewables, but as solar thermal has the benefit of being able to store energy – sometimes up to seven hours with certain systems – it allows for cloud cover and can provide consistent power generation. An area of just 2500 kilometres would be able to power all of Australia, so scale certainly is not a problem in Australia.

Solar thermal is competing against other renewable. It has to match or beat them in some way and that has been a challenge. A good way to do this is by combining concentrating solar thermal with other types of energy plants so they benefit from sharing the hardware, site and network connection. The combination of geothermal power with solar has real application potential in Australia. Geothermal has limitations in very hot weather, but that is when there is excellent solar radiation, so these technologies complement each other.

Worley Parsons is now working on a solar flagship in Port Augusta. Our vision is that we can then extend to a solar gas hybrid power station and then to solar geothermal in the Cooper Basin. We think that the synergies from integration and new thinking are real and being developed now, and that this kind of opportunity exists in Australia for baseload power.

SESSION 4: REDUCING CONSUMPTION

1. Creating a secure, low-carbon future

Mr Revis W. James
Director, Energy Technology Assessment Center,
Electric Power Research Institute (EPRI), USA

At EPRI we have taken a look at CO_2 and how we can actually reduce emissions based on what is feasible – what we could do – based not necessarily on economics, but on technology capability. We have looked across a wide range of opportunities from the supply side, to efficiency, deployment of hydro-electric vehicles, and electro-technologies that will reduce the consumption in the residential and commercial sectors. We have found that when you combine these technologies the potential of emission reduction is sizable – we could conceivably reduce emissions by 58 per cent of the 2005 level.

The thing to realise is that our assumptions are based on a balanced mix of technologies. The value of a varied portfolio is that it allows you to diminish your dependence on any one technology or your susceptibility to barriers in developing or deploying that technology.

In a world with a limited energy portfolio – a business-as-usual approach – there has to be a tremendous reliance on natural gas and renewables and a gigantic reduction in electricity demand. However, in a full portfolio where you allow new technologies to expand, you see an increase in nuclear, wind and CCS and a smaller reduction in electricity demand.

Efficiency, nuclear, renewables and CCS will play a very important role in meeting emission reduction targets and, if we rule things like nuclear and CCS out of the mix, other technologies are going to have to be stretched. We would have to rely a great deal on natural gas and demand reduction to offset the lack of availability of these baseload technologies.

Emission reductions are possible, but it's a question of how much it will cost. A full portfolio, rather than just focusing on a handful of technologies, will be critical. It's going to cost money to bring down CO_2 emissions, but the costs are going to be a lot less if you consider a full portfolio.

2. Reducing energy consumption and carbon intensity – a minerals industry perspective

Dr Grant Thorne FTSE
Group Executive, Technology and Innovation, Rio Tinto

The shape of any global accord to reduce carbon emissions is almost certainly the single most significant uncertainty in our industry. In the Australian mining and metals production industries, energy consumption is increasing. The mining industry consumes about 30 per cent of all electricity generated and, clearly, with greenhouse gas concerns the cost of electricity will only increase.

The drivers for operational practice to date have been profitability. Existing practice reflects rational responses to operational issues. However, with the added complexity and increased importance of energy cost and availability in some quarters, we are being pushed to ever more expensive solutions to our energy issues.

Unfortunately, there is no source of electricity generation without issue. The problems are – variously – carbon

exposure, fuel price risk, resource availability, intermittency or low intensity, public approval, land use, biodiversity … and on and on the list goes. The inherently green technologies will certainly have a place but they lack the muscle to power intensive industry without a prohibitive footprint and cost. They will feature more in the developed world but continue to be diluted by rapid expansion in carbon-based electricity in the developing world.

Australia sits in self-imposed isolation from the nuclear-generating club. International obligations under future climate treaties are bound to have their inevitable consequence for us. Our irrational disregard for proven technology with low carbon footprint is ultimately unsustainable, and nuclear in Australia is 'when', not 'if.'

It is not realistic at this point to discriminate between various low-emission technologies on the basis of price as there are still simply too many uncertainties. The only sensible option is to promote all low-emission technologies and then let the market decide.

On a cautionary note, historically it has taken the mining industry far too long to adopt breakthrough technologies – even with technologies that are critical to performance in our industry. Even the fast adopters took an extraordinarily long time to warm to the use of performance-enhancing technologies. We will not have the luxury of such timeframes in the future to adopt low-emission energy production regimes.

3. Australian transport: prospects for reducing our imported oil dependency and carbon footprint

Dr John Wright FTSE
Advisor, Sustainable Energy Partnerships, CSIRO Energy Transformed Flagship

Greenhouse gas emissions from road transport account for 14 per cent of Australia's total emissions, and this level must come down to around 30MT by 2050. To make just a five per cent reduction in the transport sector will be a major effort, so to reach the 25 per cent target will be a huge task.

There are a number of benefits of technology improvements and there has been a trend to smaller and more fuel-efficient cars, but these benefits take quite some time to come into effect because of Australia's slow fleet turnover – the average age of the passenger vehicle fleet is 9.7 years. There have also been steady improvements in engine efficiency, but vehicle size has grown, which has negated the benefits of efficiency. However, there are a number of ways to decrease our transport carbon footprint, which include encouraging faster fleet turnover; encouraging smaller, more fuel-efficient cars; having a close look at vehicles for business use (because businesses and governments tend to favour larger cars, which have higher fuel consumption); and encouraging less personal vehicle travel.

Projections about the future fuel mix indicate that we need to prepare for quite significant changes. Petrol use will decline, and the use of electricity, ethanol and natural gas will grow significantly. Diesel will be prominent until about 2022 but will decline as substitutes come into the market.

Similarly, there will be big changes with the technology type of vehicles. Internal combustion engine vehicles will decline post-2020, to be replaced with hybrids, plug-in hybrids and vehicle electrification.

Everything is interconnected and, to achieve the overall whole-of-economy targets, this extra electricity generation for transport will have to be by the progressive implementation of low emission technologies – that is absolutely essential if we are to reduce greenhouse gas emissions. We can reduce both our transport carbon footprint and imported fuel reliance – really we have no option – but it will not be simple and we need to do it in an integrated way that fits in with our overall plans for future-proofing Australia.

SESSION 5: SUSTAINABLE BIOCOMMODITIES BASED ON AUSTRALIAN AGRICULTURE

1. A perspective on renewable fuels and materials

Mr John Pierce
Vice-President, Technology, DuPont, Applied BioSciences, USA

There are a variety of drivers associated with the shift towards renewable fuels and materials. These are not limited to climate change, increased global electricity demand and the increasing cost and scarcity of fossil fuels. They also include national security, trade balance and governmental policies. It falls upon us to figure out technology developments, improved efficiencies and alternatives to current uses.

Today's renewable energy market has been created by public policy and government intervention. If it were just left to its own devices it could not compete against incumbent technologies. The chemical industry has been massively innovative and new products must compete with the installed base, very often in fully depreciated facilities. However, the use of biotechnology for the production of fuels, chemicals and other materials is an economic driving force.

Biomass is our only renewable source of carbon-based fuels and chemicals and we need carbon-based fuels and chemicals as far as the eye can see. Biomass (from corn starch, sugarcane sugar, corn mills and yeast conversions to ethanol) takes advantage of all the infrastructure and technology that already exists.

Liquid transport fuels are still going to be the source in the future and there are lots of options for conversion of biomass to fuels – gasification, thermal-chemical approaches, bio-chemical approaches. By using cellulosic biomass you can start to have an impact on the CO_2 emitted and using cellulosic fuels you can get very high energy outputs with very low fossil energy inputs. It is also very accessible, with an estimated 1.3 billion tonnes available in the US without major changes to our agricultural footprint.

We need strong, consistent governmental support to reduce the investment risk and to stimulate the research. This is nothing new. Whenever you start up a brand new industry it is too expensive at the beginning and governments help support it happening. The idea is for governments to help birth appropriate new industries without trying to pick winners and losers, and to do it in such a way that those industries can stand on their own in the future.

2. Building a sustainable future

Dr Donald Chen
Business Director, Hydrocarbons and Energy, Asia Pacific Dow Chemical Company

The chemical industry accounts for about five per cent of the world's total greenhouse gas emissions – it is not a huge chunk, but it is still significant and we need to do something about it. However, though the application of chemical products, in 2005 alone the chemicals industry has been able to save up to about 8.5Gt of CO_2 emissions. The biggest savings were enabled by chemical industry technologies and innovations in insulation, chemical fertiliser and crop protection.

At Dow we believe that energy supply and climate change are the most urgent environmental issues facing society and that we are uniquely positioned to address these issues. Our company has set out a number of goals for reducing CO_2 emissions and we are now pursuing a couple of big projects to enable us to meet these goals. We are looking at other feedstocks, such as sugarcane and soy, to make polyethylene and polyols; we have started the Algenol CO_2 to ethanol pilot project; we are investing in wind turbines; and also building integrated photovoltaic (BIPV) roofing.

Across our portfolio, our products reduce greenhouse gas emissions by more than six times our own emissions on an annual basis. We are one of the largest producers of innovative products that reduce energy use – building insulation applications, solutions for fuel-efficient vehicles, technology to enable wind power and integrated solar systems into building materials.

It was estimated in 2007 that the emissions that were saved as a result of our insulation product Styrofoam were in the region of 65MMt of CO_2 emissions per year – a significant amount. We continue to invest in insulation R&D.

Dow sincerely believes that the chemical industry is and will be part of the solution to world challenges, and that innovation – in technologies, products and processes – is and will be the foundation moving forward.

3. Biorenewables beyond bioethanol – or why cheap bioenergy is a trap

Professor Luuk van der Wielen
Bioseparation Technology Group, Delft University of Technology, The Netherlands

The main driver for looking at biomass in the Netherlands is that much of our country is below sea level. As the climate will change, our country should not just be thinking in terms of mitigation, but also adaptation – we will have to learn how to cope with sea level rise. There are also problems with many multinational companies moving offshore, away from Europe. The third challenge I see is that this is not a simple picture – the economy, environment and energy security are inter-linked. We have found that with a bio-based economy you can connect energy, chemical and climate innovation.

When you start out, there is not a pile of biomass along the road waiting to be picked up. There is not an established industry, so biomass still has to be fine-tuned. The main drivers for biofuels, however, are based around energy security concerns, economic opportunities, rural support and greenhouse gas savings. It is important for continued development of new, relevant bio-based concepts for sustainable production and impact monitoring and control – and to set up a new industry around bio exploration. We also need to accelerate a number of innovations. This should include piloting and venturing, as it is critical for developing relevant technologies, creating new jobs and valorisation.

We have to look into the benefits that industrial biotech brings. These benefits could be outside the regular fields, and this has proven to be the case in areas such as animal testing, and also with the possibility of applying some of our findings to the building industry.

Partnership with companies in our field and also in fields outside the traditional biotech sphere is important in this relatively complex sector, because it reduces costs and shares the risk. There is a lot of research going on world-wide that we would like to partner with and we are targeting biomass-rich areas where we can implement our technologies.

Moving forward in a bio-based economy – in a de-hyped and non-emotional manner – is valuable for policy makers, for scientists, and for industry all together.

4. Sugar bio-refineries
Professor Lars Nielsen
Professor and Chair of Biological Engineering, Australian Institute for Bioengineering and Nanotechnology, University of Queensland

At the University of Queensland we are looking at how we can convert some of the material in sugarcane into cost-effective chemicals. The motivation to do this is coming from the drive to change from a petrochemical-based to a biochemical-based chemical industry. There are increasing costs related to petrochemical raw materials, environmental compliance, and also because of the coming shortage of oil.

There's only one crop right now that satisfies all the criteria for a good feedstock – sugarcane. Half the energy in sugarcane is in the sugar, which is easy to convert into chemicals, and the other half is in bagasse, which you can burn to meet all of your energy requirements. What makes sugarcane so unique is that you have a green, renewable energy source and a water source. It is also the cheapest raw material, and has great environmental benefits.

The particular challenge in Australia, though, is that you need water, and that limits where we can expand sugar production. There are also challenges with turning sugar into fuel, and realistically it is not a good option or sensible dollar-wise because there are cheaper options.

To access new chemicals and new products, you need to go in and engineer the systems with metabolic engineering. We are taking living cells and making them into programmable chemical factories; they are unique, and specific for our particular needs. We are developing a framework that asks not what is possible, but what might be possible in biology.

We are looking at a future where we take design in silico (computer design), synthesise the genome, do some strain tuning like we do in a chemical plant, and then deploy them into industry. Biology is changing so quickly, so I have no hesitation in saying that we will get this kind of engineering where we can make living organisms in the next decade.

SESSION 7: EDUCATING THE GENERATIONS

1. The science and urgency of climate change: why is science failing to get the message across?
Professor Ove Hoegh-Guldberg
Director, Global Change Institute, University of Queensland

The scale of the problem of climate change is immense, and the impacts are arriving faster and more fundamentally than scientists had predicted. Our existing emission trajectory is one that will end up truly disastrously if nothing is done, and time is fast running out for us to take action that will avoid this disaster. The science could not be more urgent or credible, but there has been a failure to communicate the urgency of this message clearly enough to public, the government, our leaders and policy makers.

There are a number of reasons why the message is not getting across, the first of which is that climate change is a complex message, and many politicians are not trained in science or technology. Also, the messages can be very inconvenient, particularly if you have large reserves of coal in your state. It is a big step then to support the science that

says you have to spend a lot more money on digging that coal out and making it safe.

The problem also stems from the fact that politicians do not know how to tell the scientists apart and who to believe. The obvious answer is to establish an index of credibility based upon scientific peer-reviewed papers on climate-related science that have been published in the best journals. We need to educate the politicians on how to pick their experts.

Another problem comes from special interest groups and lobbying. It has been reported that companies who have vested interests in climate change denial are funding lobby groups that have the sole intention of confusing the argument. The media have also muddied understanding by doing what they think is balancing the debate. But actually the debate has moved on scientifically and pitting scientists against unqualified people is very misleading.

Generally, scientists are poor communicators and I think we need to do a better job of communicating the nub of the matter. It is about getting across the messages so we educate the public and our politicians so they know where to go in terms of the best information.

2. The STELR project: the importance of relevance in inspiring students to study science

Dr Alan Finkel AM FTSE
Chancellor, Monash University

We see the need to enhance the level of scientific literacy in the community by teaching students while they're young and helping them to understand the nature and fundamentals of science. We are hopefully achieving that through the Science and Technology Education Leveraging Relevance (STELR) program. We have no lesser aim than to change the nature of science education in Australia.

There has been a major decline in science participation rates over the years, and as a result there are just not enough students filling the pipeline for science, technology, engineering, and mathematics careers. The other problem is the question of scientific literacy in our community. Not everybody has to be a scientist, but we all want the average member of the community to be able to at least participate competently in some of the big debates of the day.

We came to the conclusion that the problem stems from the fact that students feel that science education lacks relevance in their lives. However, a survey found that young people are concerned about water and climate change – the world they are going to grow into – so we are focusing the program on technologies related to these topics. The logical flow was to focus on renewable energy in the STELR program.

STELR provides professional teacher development, classroom kits, curriculum resources, peer networks and career profiles. Our goal is to provide the schools with everything they need to run this course because we do not want the program to fail simply because a teacher cannot get his or her hands on one little element that they need.

We want to get STELR into every secondary school in Australia so that all Australian students will be exposed to it. We do our best to motivate the students not just to be interested in science, but to think about it in terms of a career. It is important to do this within the National Curriculum to make sure we reach all of the kids, and not just the ones who have elected to do a science program as an extracurricular activity.

Sue Meek and Julie Campbell

3. Enquiry-based science education for primary schools and junior and middle high school

Professor Julie Campbell AO FAA
Director, Centre for Research in Vascular Biology, University of Queensland, and Secretary for Education, Australian Academy of Science

The technological world is changing at an incredible rate, and Australia's economy demands high science education to cope with this change. Not only will we need specialist scientists who will keep us at the forefront of scientific development, but many emerging jobs will require high level skills in scientific thinking. We are importing considerable numbers of scientists, doctors and engineers, as we are not training enough of our own.

We need to invest seriously in science education. For Australian students to be motivated to train in scientific professions, research indicates that they have to have a solid background in science education before age 14. It is also becoming increasingly difficult to recruit teachers in this field.

In primary school very little time is spent on teaching science and this is due to the heavy emphasis on literacy and numeracy, and the very small amount of money spent on science teaching resources. To address these problems, the Australian Academy of Science believes that the teaching and learning of science should be made more appealing for both teachers and students.

The Australian Academy of Science has two initiatives that engage students in learning science through inquiry – Primary Connections: Linking Science with Literacy, and Science by Doing. Both programs establish a professional learning community in each school for the teachers, have professional learning resources that teach the teachers and have hard-copy curriculum resource units for the classroom. Both programs are centred on a hands-on approach, discussion, open questioning and higher order thinking.

If we can engage children through all levels of schooling in the wonders of the world, it will encourage them to consider studying science at university and, as a result, we will not have to import Australia's future supply of scientists, doctors and engineers. Just as importantly, it will make the general population more science literate and better able to make informed judgements on contemporary issues that affect them.

SESSION 8: DEVELOPING A COMMUNIQUÉ

KEY MESSAGES FROM THE EARLY CAREER SYMPOSIUM FELLOWS

One thing we have considered is developing an independent, unbiased advisory and funding body whose role is to provide the truth in scientific matters for the community and government. The public could then make decisions based on facts and not media sensationalism. Similarly, we believe that funding decisions for research should be transparent and not influenced by the government of the day. Applied research that does not have any immediate commercial benefit and fundamental research should not be considered the whimsical playthings of a wealthy nation, but should rather be considered scientific necessities to understand our world.

We will need a skill base that can build, commission, run, maintain and decommission nuclear power stations, so we

Jessica Andrewartha, one of the Early Career Symposium Fellows.

need to start planning our education system for that. Some options for encouraging more science and engineering students can include reducing the HECS band for those university subjects, and providing more scholarships. We believe that universities need to be very careful in the way they are modifying courses to make them more appealing to an international market.

A common theme among speakers has been the need for a portfolio of energy resources to significantly reduce our greenhouse emissions. We must adopt an integrated approach, because no one technology is going to provide the solution. We also need to consider the whole lifecycle of our energy options. The way we manage our electricity grids will need to change, particularly as we increase the penetration of intermittent renewables such as solar and wind. There is also a need to consider energy storage.

We need to adopt an aggressive energy efficiency policy, from big business right down to the end consumers. Energy efficiency also needs to be extended to sustainable transport.

We have covered a lot of topics in the past few days, but we believe that one of the missing pieces has been water: you cannot future-proof Australia and rise to the challenge of climate change without considering our water security.

• *All delegates and speakers in attendance contributed to the final session which worked to distil the presentations, questions and discussions into a Symposium Communiqué.*

SYMPOSIUM COMMUNIQUÉ

The topic of the 32nd Symposium conducted by the Australian Academy of Technological Sciences and Engineering (ATSE) in Brisbane, 16 and 17 November, 2009 was FUTURE- PROOFING AUSTRALIA – Rising to the Challenge of Climate Change. The context for the Symposium was the widespread concern about the scale of the challenge posed by climate change policies and the urgent need to identify economic and practical solutions.

200 delegates from across Australia heard and discussed a series of presentations from leading international and national speakers covering future energy technologies, options for reducing carbon emissions, the possible contributions from the agricultural and land management sectors and the need for better community understanding of the issues.

In the final session the delegates discussed and agreed the elements of the following Symposium Communiqué.

The Symposium took as its basic premise that governments around the world had accepted the need to drastically reduce greenhouse gas emissions and that it was necessary in Australia to meet any reduction targets established in the most effective way possible, while identifying opportunities to maximise economic, social and environmental benefits.

Australia has a number of options for future energy generation. A portfolio of measures will be required to minimise the future demand for energy and reduce the carbon emissions from electricity generation and transport requirements. No technology can solve the problem in isolation.

An integrated resource management approach is required to meet the climate change challenge, taking into consideration the whole range of factors including energy and food security, emissions, environment, biodiversity, trade, employment, transport, finance, and the demand on other resources (water and land particularly).

The scale of investment required in low-emission technologies is considerable and urgent. Many countries have already advanced further than Australia, recognising that it is cheaper to invest early rather than waiting until a crisis emerges. The time frame to migrate to a low-carbon economy is considerable.

While uncertainty exists about carbon pricing, energy security is likely to be a major issue as investment will be limited. An emissions trading scheme (ETS) is unlikely to provide sufficient incentive for most of the lower-emission technologies under discussion and development to be established on a commercial scale.

Considerable cost and performance uncertainties exist about many of the technology options available. A current ATSE project is evaluating the various technologies under consideration in a way that accommodates the uncertainties confronted.

Government interventions will be necessary where it is clear that market forces are not working. Energy technology is capital-intensive. Early stage investment is highly risky and may require special incentives to support early entrants into new technology areas. Efforts need to be made to increase investment certainty.

Australia, alone amongst virtually all the world's largest economies, is not considering nuclear energy as part of a future portfolio of low-emission technologies. Meeting baseload generating requirements under stretched emissions targets without nuclear energy will be very difficult, if not impossible. The record of the nuclear industry, its public acceptance internationally and its lower level of uncertainty means this policy needs to be reconsidered.

Australia is at the forefront in some technology areas. But as a small nation, we need to foster partnerships, build collaborative efforts and encourage a free flow of people and investment to remain abreast of emerging opportunities to reduce or avoid emissions.

Forest, crop, livestock, fisheries and land management have significant roles to play developing new forms of biofuels and bioenergy. Agriculture has a strong role to play in sequestering carbon and reducing emissions.

The implications of the challenges arising from action being taken on climate change are not fully understood in the community. There are confusing messages which impede the development of public support for the introduction of 'future-proofing' measures. Efforts to improve this understanding are being made through initiatives being undertaken in schools, but these need to be more widespread through the community.

RECOMMENDATIONS

1. Australia will need to implement a suite of low emission technology options to meet climate change-driven targets and provide energy security.
2. National policy development must address questions of security and sustainability and not focus solely on reducing greenhouse gases.
3. Government must adopt an integrated approach to climate change response to ensure food security, water, competing land uses and other impacts are considered.
4. To increase investment certainty Government must develop unambiguous and consistent policy to attract investors – including the carbon pricing regime and the levels and nature of support for low emission technologies.
5. Continued R&D support is necessary, both in the overall processes and the underlying systems, components and enabling technologies.
6. Government should consider special incentives to encourage and support early entrants into capital-intensive new technology areas.
7. Government, the research community and industry must foster international partnerships and collaborations in low-emissions endeavours.
8. A major priority for the use of proceeds from any ETS should be given to developing low-emissions technologies.
9. Government must address all the relevant factors over the full life cycle of any project in evaluation of new technologies.
10. Government interventions required when market forces are not driving adoption of low-emissions options should not favour any particular technology or distort investment decisions.
11. Government must immediately review its policy on nuclear power, to accommodate it as one of the suite of low-emissions energy technology option, with decisions on investment made on economic, social and environmental grounds.
12. Greater focus should be applied to the role of agriculture both in sequestering carbon and reducing emissions.
13. The nation should foster informed public debate on the issues and consequences of adopting greenhouse gas emissions targets to improve public understanding and acceptance of mitigation measures.

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