ENGINEERING OUR FUTURE

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Abstract
To be prosperous in terms of having a sustainable social, economic and physical environment, equitably shared by all Australians, we as a nation must overcome a number of challenges. These challenges are complex at a global and local level.
At a global level, climate change is first on the agenda because it impacts on so many things: water, food production, infrastructure stability, rising sea levels displacing many people, and enhanced severe weather activity that can be life threatening.

As well, the world economy is changing dramatically and we have an increasingly inter-dependant global economic order. The world's population is increasing and access to resources is diminishing and the divide between the rich and poor is growing wider.

Knowledge intensive production and services have become dominant over other kinds of work in the western world, and technology is changing at an ever-expanding rate.
Many commentators believe that life in the 21st Century is shaped primarily by what happens at the global level, rather than locally or nationally. But we also need to believe that what we do at a local or national level can have an effect at a global level.

Many of the solutions to the challenges will need significant involvement by the engineering profession, with key solutions being found in the areas of energy, water, infrastructure, and skills. Engineers must think in terms of the sustainable use of resources, creating a clean and low carbon emission environment, measures to cope with the impacts of climate change, as well as providing opportunities of all Australians to have continuing access to the basic infrastructure and services that many of us take for granted. Focussing solutions in these areas can make a significant difference to our future.

Key Words: Sustainability, climate change, water, energy, infrastructure, engineering skills, engineering responsibilities.

Introduction

To be prosperous in terms of having a sustainable social, economic and physical environment, equitably shared by all Australians, we as a nation must overcome a number of challenges. These challenges are complex at a global and local level.
At a global level, climate change would be first on the agenda because it impacts on so many things: water, food production, infrastructure stability, rising sea levels displacing many people, and enhanced severe weather activity that can be life threatening.
As well, the world economy is changing dramatically with the rise of China and India and this will bring about a substantial geopolitical transformation. We also have an increasingly inter-dependant global economic order where flows of money and information are world wide. The current turbulence of the interconnected financial markets defies explanation, and as we have seen, being part of the global economy leaves Australia vulnerable to any significant changes in the economic or political circumstances of countries who are major trading partners.
The world's population is increasing and access to resources is diminishing. We are seeing world food shortages and the divide between the rich and poor is growing wider.
While the western world has experienced rising prosperity, it has also fostered rampant consumerism, with more and more money spent on better products that are available to fewer and fewer people.
Knowledge intensive production and services have become dominant over other kinds of work, and technology is changing at an ever-expanding rate. 10 years ago, who would

have thought that Australia would have more mobile telephones than people!
Given the rapid, even accelerating, pace of change, the world of tomorrow will be vastly different world from the world of today. Many commentators believe that life in the 21st Century is shaped primarily by what happens at the global level, rather than locally or nationally.
But we also need to believe that what we do at a local or national level can have an effect at a global level.

Engineering the solutions
The conference theme – "Global challenges – Local Solutions" is ideally suited to the engineering profession.
Many of the solutions to the challenges will need significant involvement by the engineering profession, particularly at a local government level, with solutions being found in the areas of energy, water, infrastructure and skills.
Engineers must think in terms of the sustainable use of resources, creating a clean and low carbon emission environment, measures to cope with the impacts of climate change, security and safety issues, as well as providing opportunities of all Australians to participate in society and have continuing access to the basic infrastructure and services that many of us take for granted. Focussing solutions in these areas can make a significant difference to our future.
When they think of engineering, most people think of our infrastructure: roads, rail, buildings, water and sewerage. But engineering is much more than that. Engineering is fundamentally about problem-solving. Engineering turns ideas and concepts into reality. It creates and shapes the physical world in which we live and determines the way in which that world functions. It provides a bridge between science and technology and between technology and commerce. Engineering is at the heart of modern economies and contemporary life.
Also at the heart of contemporary life is local government, which contributes enormously in economically difficult times, with money being spent locally flowing directly to the community.
While local governments do not have the resources to provide all the community's need and wants, creative and innovative engineers can and do make a substantial positive contribution to raise the living standard of other Australians and take the country to a much higher level in terms of prosperity and quality of life. Local government engineers are the face of the profession to the community.
Engineers have a central role to play in understanding nature. Weather, tides, earthquakes, tsunami and volcanic eruptions are already better understood as a result of complex engineering systems for data gathering, analysis, interpretation, and forecasting ,and the future may result in engineered interventions to influence and even, to a degree, control these forces.
The concept of sustainability will influence almost all engineering developments and the potential effects on the environment, long term and short term, proximate and remote, will be integrated routinely into engineering design and planning.

I would like to discuss four of the major challenges facing Australia and describe the implications for engineers and engineering. The first is climate change and energy.

Climate Change and Energy
There is increasing global concern about climate change and since the publication of the Stern Review, and the Garnaut reports, this concern has gathered pace in Australia. The Intergovernmental Panel on Climate Change Fourth Assessment Report has provided the strongest evidence yet to demonstrate that climate change is unequivocal and due to increasing concentrations of greenhouse gases in the atmosphere. Resistance to the IPCC`s conclusions by climate change sceptics typically say that pre-emptive action ahead of <u>being 100% certain</u> will incur unnecessary costs or unnecessarily curtail development. The IPCC takes the view that their conclusions are '<u>very</u>' likely. That is, they are likely with more than 90% probability, which in most business risk analysis is treated as a near certainty. The IPCC has warned that current climate change mitigation policies are far from adequate and will not curtail growth in greenhouse emissions to the degree necessary to stabilise the global climate.

Climate change is a global phenomenon with consequences for all countries. Trading off climate stabilisation action in favour of short term economic growth misses the point.
Engineers Australia believes that the correct trade-off was between the costs of climate change impacts and the costs of climate change stabilisation action.
According to Stern, climate change costs are likely to lead to a reduction in the size of the global economy of between 5 and 20% depending on whether only narrowly defined economic costs were included or broader considerations applied. In contrast, the costs of climate change action were estimated to reduce global GDP by about 1%. Similar comparisons emerged from the IPCC deliberations on climate change mitigation.
As Stern said, if you believe that future generations do not matter, you will not care much about climate change. Whatever beliefs or systems of government there are in the world, this view must be unacceptable.
Engineers Australia has taken the view that Australia must act swiftly and proactively in line with global expectations to address climate change as an economic, social and environmental risk. Many of the solutions in this area will come from local governments.
In terms of energy, Australia's demand for electricity is predicted to increase by 62% over the coming 25 years. Therefore, addressing climate change means addressing energy sustainability.
Australia faces difficult decisions ahead in balancing the obvious attractions of cheap and plentiful coal supplies with the need to reduce greenhouse gas emissions.
Research shows that diversified portfolio solutions are needed to make our energy use sustainable and that no single technology will be able to deliver the cuts in emissions needed.
For instance, it is estimated that energy efficiency initiatives could be responsible for about half of the forecast reduction in Australian emissions up to 2020. Therefore, these must be pursued vigorously. As well, reductions in greenhouse gases will come from the adoption of renewable energy, which is encouraged by the Mandatory Renewable Energy Target.
We believe that the introduction of a carbon trading scheme is an essential part of the mix as it makes emitters in the energy sector bear the costs of their actions. While there has been concerns expressed about the increased costs that will be passed on to consumer, this will assist in driving energy efficiency in the home.
Engineers Australia believes that the Federal Budget's $4.5 billion Clean Energy Initiative will complement the Carbon Pollution Reduction Scheme (if it ever receives the Senate's approval) and the expansion of the renewable energy target. Direct action and leadership is needed to overcome the reluctance of private investors to be the first to adopt emerging renewable energy and carbon capture technologies.
We believe that by establishing Renewables Australia as an independent innovation agency, the Government is setting Australia firmly on a diversified technology course.
"Wind generation has demonstrated its potential already and geothermal energy has made a promising start. With solar energy, scientists and engineers have made huge advances in laboratory demonstrations and small scale applications.
The Budget's $1.5 billion Solar Flagship Program will provide a major boost to the potential of a range of solar technologies at commercial scale in the National Grid. Success will convince the doubters and show the way for private investors. The program will build critically needed skills that future projects can take advantage of to open up new export opportunities for the implementation of solar technologies overseas.
Carbon capture and storage is also a vital component of the mix of new generating technologies needed by Australia and the world to move to a low carbon future.
Engineers Australia's role has been, and will continue to be, in leading capacity building to innovate for more sustainable, eco-efficient and less polluting outcomes in engineering practice. The role of engineers will be in developing energy efficient power plants, developing and improving renewable energy options in solar, wind and thermal rock technology, and ensuring that energy efficient products and processes are introduced.
Engineers will be at the forefront in designing systems that create green buildings. For instance, some of the sustainability features might include light harvesting devices, solar hot water collectors, photovoltaic cells, chilled

water cooling systems, shading screens, and co-generation plant.
Engineers have a role as consumers. We can reduce our demands for energy in a myriad of ways, which in turn reduces energy consumption and reduces greenhouse gases. For instance, buying green energy, changing light bulbs to energy efficient ones, buying products with high energy efficiency ratings, and encouraging others to do the same. Did you know that the average home has roughly two TVs, a VCR, a DVD player and three telephones. If these items were replaced with ENERGY STAR models, it would save over 25 billion pounds of greenhouse gas emissions, the equivalent to taking over 3 million cars off the road. (ENERGY STAR is an international standard for energy efficient office equipment including computers, printers and photocopiers, and home electronics such as TVs, audio products and DVD players)
Combating climate change and reducing energy consumption globally requires a combination of actions at the local, national and global levels.
I would like to turn now to another topic that has a global and local impact, and that is water.

Water
Over time, the early effects of climate change in the form of several unusually severe droughts have posed serious challenges for water resources. This graph shows the increases and decreases in rainfall over the last 30 years. The decreases (in brown) are in the most populous areas of Australia.
Reservoirs in cities have experienced water levels sufficiently low to convince authorities to impose strict water restrictions, in many cases for prolonged periods. For many of you, this situation is all too familiar. At the same time, our past approach to managing irrigation has resulted in environmental degradation threatening the livelihood of rural producers and country towns.
Many of Australia's water problems result from outmoded water management methodologies, dating from times when water was in abundant supply. Reservoirs created an impression of plentiful water, and cheap water prices reflected long gone development objectives. Once used, waste water was seen as a problem to be disposed as quickly and inexpensively as possible. Storm water run-off flows into drains, creeks, and rivers, and ultimately the ocean, unable to be captured and stored. The result has now been acknowledged by governments, water managers and the community as an appalling waste of large proportions of potentially high quality water.
We have seen substantial moves in water reform in recent times, with a shift in emphasis to the effectiveness of water use and significantly changed water management practices.
With predictions of even greater climate variability, and faced with population growth, especially in urban areas, we must act to prevent water shortages and provide certainty of supply.
The solutions that are being proposed require a contribution from us all, but local government engineers have a very big role to play.
We are seeing government policy makers set water prices so they reflect the costs of collection and distribution infrastructure, and in time, the scarcity value of water. They are also implementing long-term water saving rules.
On the macro level, engineers are involved in upgrading of water infrastructure and the design, construction and maintenance of desalination plants.
On a smaller scale, the whole community is able to take local actions to contribute to global outcomes. One of the most successful programs has been to educate our children to turn off the tap when they brush their teeth. Such simple measures can have an enormous effect over time.
We can all take measures to reduce our water usage and take on board activities to implement grey water recycling and rainwater collection within our homes. And reducing demand doesn't mean that we have to go without gardens if we use drought resistant plants and design the garden with low water usage in mind.

Infrastructure
Infrastructure is a topic that is dear to the hearts of engineers, but sustainable infrastructure is essential to us all. This is the third issue I'd like to discuss.
It has become common place to adopt the word "sustainable" as an adjective liberally

sprinkled throughout the presentations on all manner of issues relating to development and to the exploitation of natural resources. It is equally common place to find little connection between the use of the term sustainability and what is proposed in the policies and/or programs that are the subject of the presentation.

There is increasing recognition in many communities that sustainable development is too important for our future to be dealt with in this way. Slowly but surely more robust approaches to sustainability are being discussed and considered to guide the development policies. This is particularly true for Australian cities, as about 80% of the population live in cities, with most in the capital cities. Included in the sustainability debate are issues such as water shortages and management, congested transport and demand placed on energy and urban services.

Most matters relating to the development and management of urban areas are the responsibility of the State, Territory and local governments and leadership from these levels of government is imperative.

Engineers Australia has been a proponent of sustainable development policies for over 20 years, particularly in terms of infrastructure. Throughout this period Engineers Australia had accepted the Brundtland definition of sustainable development; that is - development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Professional organisations, like Engineers Australia, are well placed to contribute to the development of the shift needed for sustainable development to become part of everyday life, by influencing the way in which communities and individuals make decisions that contribute to the realization of broad social goals.

Governments need to set policies and frameworks but these need to be influenced by underlying sustainability concepts and principles. Engineers have the opportunity to influence the character of the thousands of everyday decisions that flow from these sustainability concepts and principles. This they do through their involvement in the design and construction of all aspects of infrastructure, from roads, bridges, buildings to communications networks, as well as in the service delivery of utilities (public or otherwise) such as power, water, waste management, etc.

The community also has a part to play in terms of their involvement in the local planning processes and in terms of the decisions they make with regard to their own residences. Even small things like catching a bus or walking instead of driving will reduce traffic congestion. Making changes to the way we live, for instance ways of reducing energy use, recycling our waste, using less water, planting more trees, growing our own vegetables and generally reducing our impact on the environment can all assist to create a sustainable future. Government policies must strongly support and encourage such choices.

Education and skills

The education and skills of the population determines a country's ability to absorb and adapt new technologies, which in turn enhances economic and social growth. As the world moves further into the knowledge economy, a strong skills base will continue to be of utmost importance if we are to participate in the global economy in a meaningful way. A strong skills base requires a strong and high quality education system that is accessible by all the population. Data collected by international agencies such as the World Bank and the OECD show that rates of educational participation are rising across the world. Literacy standards are rising and life long learning practices are spreading. We need to make sure that Australia's literacy levels remain among the world's highest.

But in a country where technology drives our whole way of life, we must also ensure that our education system is focussed on producing the skills that society needs. The final issue I would like to focus on is the skills shortage, and more specifically, the skills shortage in engineering.

It may seem that in the midst of a world financial crisis and growing unemployment that we shouldn't be considering skills shortages. But all evidence suggests that there is still a continuing shortage of qualified professionals. Some areas, such as mining, have seen a reduction in demand, but there

has been a corresponding increases in demand in infrastructure. We expect that this will continue into the future, particularly given the budget announcements of $8.5 billion for roads, rails and ports; $3.6 billion for clean energy infrastructure; $2.6 billion for education infrastructure; $2.6 billion for local infrastructure; and $3.2 billion for health and hospital infrastructure, which complement previously announced provisions for a fast broadband network and other infrastructure initiatives.

But will we have enough engineers to deliver this ambitious nation building program?

There is a declining number of students studying the enabling subjects for engineering – physics, chemistry and mathematics. In primary school, technology related subjects are often not taught or are taught on an ad hoc basis. At secondary level, there is a disturbing trend for students to lose interest in science and mathematics. Fewer students are studying general sciences and intermediate mathematics than in the past and the flow on effects to tertiary level have been inevitable

For the 10 years to 2006, the annual input and output of Australian domestic students in engineering remained almost static, with a large gap between the number of commencements and the number of completions. This has only marginally improved in recent times. Internationally, the number of Australian engineering graduates per million lags behind most of the other OECD countries. In the decade that our Australian engineering graduate numbers remained static at about 5,000, the number of full-fee paying overseas students graduating from Australian universities trebled to 3,000 per year. We estimate that the current shortage of engineers in Australia is over 20,000.

Increasing the pool of engineers can be done in two main ways: by training Australians, or by buying skills 'off the shelf' from overseas - either through the skilled migration system, or by having the work done off-shore.

Off-shore permanent migration of engineers has increased notably since 2000, as has on-shore permanent immigration - that is, international students studying in Australia who are then able to apply for permanent migration. More recently there has been a massive increase in 457 temporary visas for engineers. The total immigration of engineers in 2006-07 is 6090 – more than the graduation figures for domestic students.

But we may not be able to rely on skilled migrants to solve our skills shortage problems into the future. Until recently, only traditional immigrant countries like Australia, New Zealand, Canada and the United States competed for immigrants. Now, European and Asian nations are also entering the competition. As the world economy continues to improve, this focus on skilled migration will only increase as more countries experience labour shortages and population pressures.

If local training doesn't increase and the competition to attract skilled migrants continues to heat up, Australia may not be able to attract enough migrants to meet our skills needs.

But relying on skilled migrants to solve our skills shortage problems into the future is not the solution. Growing our own skilled engineers and technologists, through investment in education and training, provides longer-term benefits for Australia.

There is a need to mobilise schools to improve the science, engineering, technology and mathematical literacy of students. Strategies are needed to ensure that all students gain a broad base in the enabling sciences. This must be given a high priority across Australia, in all education systems and in every school.

Primary school curriculum should be designed to present science and engineering concepts in ways that will excite, interest and motivate our young children to pursue secondary and tertiary studies and then careers in engineering and technology.

Initiatives to address the decline in the number of secondary students studying chemistry, physics and advanced mathematics need to be implemented. These could include establishing an engineering component in secondary curricula, where it doesn't currently exist. Evidence is that these subjects are not only successful in raising the profile of engineering among school students, but also ensure that students considering further study in engineering have the relevant skills, education standard and background in mathematics and science to succeed at university.

Long term planning also needs to be undertaken to ensure that there are enough

teachers with the capacity to teach maths and science in all schools, primary and secondary. Professional development requirements focused on science, engineering, and maths education should be in place for all teachers and be a part of their normal career development. Government, industry, the community, professional associations and educators, including both schools and universities, need to be better connected to support the professional development of teachers and the education of our young people to meet our national skills needs.

Conclusion

These four issues – climate change and energy, water, infrastructure, and skills – affect all of us directly and indirectly, in our private lives and in our workplace. With them come a number of tensions that we must consider:

- Sustaining our current environment, reducing greenhouse gas emissions and accounting for the true cost of development vs the perceived negative effect on national and global economic growth
- Meeting our obligations on the world stage, setting an example, adopting policies for the long-term global good vs the knowledge that, compared to much more populous nations, the physical impact of some of our measure will be minor.
- Adopting a user pays approach to the provision of utilities such as water, energy and telecommunications to encourage demand reduction vs delivery of life's basic services as a fundamental right of a citizen
- Rapid uptake of technology by the minority vs unaffordability for the majority
- Provision of education at all levels as a public good vs privileged access to education as a private asset

Charting our course for the future is not just someone else's problem – we all have a role to play. It requires leadership, from people in government, business, industry and the wider community.

We in the engineering profession have a contribution – and an obligation – to provide leadership on a range of issues:

- To understand and explain the impacts of technology on our modern lives
- To advocate and influence governments at all levels
- To create infrastructure that is sustainable by design
- To solve problems associated with technology, especially in regard to climate change, energy, water and infrastructure
- To support educators at all levels to inspire young Australians to take up careers in engineering and technology
- To invent, innovate and turn dreams into reality

It will be engineers at a local level who will be at the forefront of making Australia prosperous in terms of having a sustainable social, economic and physical environment, equitably shared by all Australians.