REALISING AN INNOVATION ECONOMY

A practical roadmap to ease the Australian engineering skills shortage.

An analysis of the engineering skills shortage in Australia. Practical recommendations for the Australian Government to frame a response. By the Australian National Engineering Taskforce (ANET).

"The race we want to win, the race we can win is a race to the top – the race for good jobs that pay well and offer middle-class security. Businesses will create those jobs in countries with the highest-skilled, highest-educated workers, the most advanced transportation and communication, the strongest commitment to research and technology.

The world is shifting to an innovation economy....

But we need to meet the moment. We've got to up our game. We need to remember that we can only do that together. It starts by making education a national mission …

In today's innovation economy, we also need a world-class commitment to science and research, the next generation of high-tech manufacturing…

Because if we want an economy that's built to last, we need more of those young people in science and engineering."

United States President, Barack Obama.

Speech to Osawatomie High School, Kansas

6 December 2011

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Glossary

ANET

The Australian National Engineering Taskforce has been formed by the Association of Professional Engineers, Scientists and Managers Australia (APESMA), Engineers Australia, Consult Australia, the Australian Council of Engineering Deans (ACED) and the Australian Academy of Technological Sciences and Engineering (ATSE). Together these organisations represent the major professional, industrial, commercial and academic interests in the engineering sector. Through this new form of education-industry collaboration, ANET aims to create a national strategy for the development of Australia's current and future engineering workforce.

APESMA

The Association of Professional Engineers, Scientists and Managers Australia is the largest union representing professionals in Australia, with coverage of engineers nationally, performing design, scoping and project management roles across essential industries and services including IT, mining, construction, water, power, road and rail.

ATSE

The Australian Academy of Technological Sciences and Engineering is an independent, non-government organisation dedicated to the promotion of scientific and engineering knowledge to practical purposes in Australia.

Engineers Australia

This is the national professional association for engineers, responsible for the national accreditation of education programs for entry to practice in the three engineering occupations, and for setting standards for experienced practitioners. It works with government, industry and tertiary education providers to promote engineering as a discipline.

ACED

The Australian Council of Engineering Deans has 33 member universities that provide engineering qualifications accredited by Engineers Australia and exists to advance engineering education, research and scholarship on behalf of the Australian higher education system.

Consult Australia

Consult Australia is the association for professional services firms within the built and natural environment; influencing policy, creating value and promoting excellence. It represents member firms' business interests at a commercial, community, industry and government level through collaboration, education, support and advocacy. Consult Australia member firms' services include, but are not limited to: engineering, design; architecture; technology; surveying; legal; and management solutions. This allows Consult Australia to provide a collective, holistic and highly informed voice for industry.

Engineering Occupations

Engineers design, build and maintain infrastructure routinely used by the community – roads, railways, ports, water, electricity, gas and communications. They perform key roles in feasibility scoping, structural and system design, damage control and maintenance – monitoring and addressing safety and quality throughout systems. Engineers develop and test practical solutions to everyday and extraordinary problems. Engineers conceive, design and manufacture innovative products, processes and systems that contribute to the nation's prosperity, security, health, culture and environment.

The three recognised engineering occupations can be categorised by their educational qualifications:

1. Professional engineers who have completed an accredited four year (full time) bachelor or master degree in engineering;

2. Engineering technologists who have completed an accredited three year (full time) bachelor degree in engineering technology;

3. Engineering associates who have completed a two year (full time) accredited associate degree in an engineering area, or a two year (full time) diploma or advanced diploma in an engineering area from university or TAFE college.

Engineers in all three occupations are not recognised as fully qualified for independent practice until they have gained experience during a period of supervised practice. Typically, a professional engineer will take 3 – 5 years to reach the standard for admission to the status of Chartered Professional Engineer eligibility to be entered on to the national register.

The program accreditation standards and practice standards operated by Engineers Australia are internationally benchmarked through the International Engineering Alliance,[1] a system of accords and agreements operated by national accreditation and professional registration bodies in more than 20 countries.

[1] International Engineering Alliance (2009), p1. *Graduate Attributes and Professional Competencies*, International Engineering Alliance, http://www.washingtonard.org/IEA-Grad-Attr-Prof-Competencies-v2.pdf, last accessed February 22, 2011.

Executive Summary

This report to the Federal Government has been prepared by the Australian National Engineering Taskforce (ANET). Specifically the report addresses itself to improving the pipeline of engineers into university, strategies to improve diversity and workforce development and retention. It is intended also to inform the deliberations of the Senate Education, Employment and Workplace Relations Committee's Inquiry "The shortage of engineering and related employment skills".

The scale and consequences of the shortage.

Statistics and industry assessments demonstrate the long-standing and critical shortage of engineering skills in Australia. Local graduates are not meeting domestic demand and there is an acute demand for experienced engineers which an improved supply of graduates will not meet in the immediate future. There is an increasing industry reliance on immigration to meet demand for experienced engineers. The critical nature of the shortage is demonstrated by the fact that ANET members have previously estimated that 20,000 engineers are required each year, with domestic graduations providing supply of less than half this figure. The current reliance on migration is an inadequate response to the shortage.

The consequences of the engineering skills shortage are manifested through project cost over-runs, delays and reduced value for the taxpayer. The shortage also has the potential to endanger public safety.

Critically, a shortage of engineers compromises Australia's ability to meet the challenges we face in transitioning to a low-carbon economy and is driving waste in government infrastructure spending.

This report recommends government action to overcome this crisis and to meet industry needs through:

- Increasing the supply of domestic graduates;
- Improving support for graduates to progress to independent practice;
- Lifting the visibility of the profession;
- Improving the support for the profession, industry and educational providers;
- More effectively harnessing the existing workforce;
- Diversifying the workforce;
- Increasing government's engineering capacity, thereby ensuring government again becomes an informed purchaser and maximises value for money.

Infrastructure procurement models are also examined as contributing to the shortage of engineers, with a range of measures proposed to ensure that procurement is delivering real value for money over the life of projects and facilitating investment in the engineering workforce.

As the first step in acknowledging and undertaking to deal with the engineering skills shortage, it is imperative that the government set a target to ease our reliance on migration to meet our engineering skills needs and build our domestic capacity, for the benefit of our economy, industry, consumers and government.

Recommendation.

1. That the Federal Government adopts a target for an increased number of domestic engineering graduates, with an aim to increasing the available domestic engineering workforce, including targets for graduates at all relevant levels of the Australian Qualification Framework (AQF) from programs provided by both Vocational Education and Training (VET) and higher education.

Governments have felt the consequences of engineering shortages as acutely as any stakeholder, with resultant impacts on the private sector. The diminished engineering capacity of government has eroded their ability to be an informed purchaser and at the same time has made them an increasingly difficult client for the private sector. This is serving to directly affect the value that the government is receiving from its infrastructure spend by driving adversarial behaviours and causing project delays and cost over-runs. While the Federal Government cannot directly control the actions of all governments around the country, it can use the levers which are provided to it through its infrastructure spending to drive change.

Recommendations.

2. That the Federal Government increase its engineering capacity to ensure that it is an informed purchaser of engineering infrastructure, in line with the recommendations of the Building the Education Revolution Implementation Taskforce, and establish a small Procurement Unit, residing within the Department of Finance and Deregulation.
3. That the Federal Government, through its Procurement Unit conducts an audit of its procurement capability across all agencies.
4. That the Federal Government take to the relevant Standing Council of COAG a proposal that all States and Territories conduct their own audit, to ensure that the community is receiving value-

for-money in infrastructure delivery.

5. That, following this audit, the Federal Government put in place a series of requirements for baseline engineering competence and capacity in jurisdictions, including local government, for the management of projects funded by the Federal Government.

Addressing the causes of the shortage – increasing the level of interest among school leavers in engineering careers and improving support for the profession.

The relatively low interest in engineering careers by Australian school students is fed by low public recognition of engineering, a lack of understanding of the engineering profession and its role amongst school students and educators, limited existing marketing programs and the lack of a single engineering advisory body. This 'invisibility' is reflected in a laissez-faire attitude to the regulation of engineering practice. Building on recent industry and government studies and the achievements of existing programs, there is an opportunity to address these deficiencies through a range of measures recommended by this report. These aim to improve the supporting architecture for the profession, increase its visibility and the esteem in which it is held. The engineering profession can play a vital role in demonstrating the practical application of school mathematics and science and to promote opportunities that flow from studying these two key enabling subjects.

Recommendations.

6. That the Federal Government establishes the Office of the Australian Engineer, reporting to the Prime Minister. The responsibilities of this office would be:
    a. To develop a marketing and promotion program for school teachers, students and the wider public on the engineering profession, and the wide variety of important roles that engineers play in Australian society and their presence in leadership roles. Materials should be developed for early school-age that introduces engineering, and targeted materials at all school ages;
    b. To advise the Chief Scientist, State Governments and to work with the Australian Curriculum Assessment and Reporting Authority to increase engagement in practical engineering programs at a school-age;
    c. To assess the effectiveness of current engineering engagement programs for school-aged students, and to oversee the integration of effective programs in the curriculum across Australia;

d. To work with higher education providers and the Federal Government to ensure the implementation of the recommendations of the 2011 ACED report (Godfrey and King, *Curriculum specification and support for engineering education: understanding attrition, academic support, revised competencies, pathways and access*), as well as recently completed recommendations carried in ANET publications;
e. To commission such research as is necessary to support the activities of the office;
f. To advise government on the effectiveness of current funding models for VET and higher education, and to try and ensure that supply is matching demand across industry, and across disciplines;
g. To oversee the development of a national registration scheme for professional engineers, and to ensure such established boards under State legislation perform satisfactory marketing of the benefits of registration in their jurisdictions;
h. To increase diversity in the engineering workforce and attract and retain experienced engineers;
i. To work with Federal Government to ensure that there are informed purchasers in the procurement process and that procurement agencies have the appropriate range of engineering skills internally to receive value for investment from their purchasing decisions.

7. That the Federal Government establishes the Australian National Engineering Workforce Development Council, which is systemic in the context of Federal Government funding for training and fulfils the role of an Industry Skills Council for the profession, while acknowledging its difference from trade-based occupations. Consideration could be given to the aggregation of other related professions into the new body. The current membership of ANET, with representatives from the VET sector and industry would comprise the membership. The Federal Government is to work with the newly established council to ensure that supply is meeting demand, and to assist in establishing dialogue between all stakeholders to ensure that pathways between VET and higher education are both clear and efficient.
8. That the Federal Government support the policy proposals by the Australian Mathematical Sciences Institute to promote the study of mathematics at secondary and tertiary level as being intrinsic to the aim of increasing Australia's engineering skills base.

Addressing the causes of the shortage – using procurement effectively to develop the workforce.

The major role of government in the provision of infrastructure in Australia provides an opportunity for them to lead the development of Australia's engineering workforce. However, the effects of current models of procurement for infrastructure used by government are seen by many stakeholders to be driving increased waste and costs, adversarial behaviour and under-investment in training and development. These models provide no incentive for industry to improve workforce supply or undertake training. The government, in outsourcing construction to the private sector, has also outsourced the responsibility for workforce development, while the skills shortage has applied pressure which diminishes the capacity for industry to conduct appropriate levels of training and workforce development. Increased costs due to shortages are passed on to government. Thus evolves a cycle of under-investment.

The Federal Government can use procurement as a means of driving change and maximising the benefits from projects not only in an immediate sense, but over the longer term.

Recommendations.

9. That the Commonwealth's Procurement Unit conduct a detailed examination of current procurement models in Australia, and assess the merits, suitability, longer term consequences of and relative risks associated with each method across all ranges and scope of projects. This research should inform the development of baseline requirements in procurement for Commonwealth funded projects by providing a portal through which procurement methods are assessed on a project-by-project basis.
10. That for all Commonwealth-funded projects, procurement criteria and incentives should be utilised to support and encourage additional training in successful bidders, including the revival of graduate programs and cadetships.
11. The Commonwealth Procurement Unit should, in consultation with the Australian National Engineering Workforce Development Council, identify models of procurement and procurement criteria which support and provide incentives to the private sector to undertaking additional training. These procurement criteria should provide recognition of firms tendering who are already undertaking substantial training. Training arising from procurement criteria and incentives should be readily and simply identifiable. The models developed should recognise training plans and programs could go beyond the term of the project.
12. Similar to traineeship funding, government should subsidise or provide tax incentives for

industry-sponsored cadetship programs and other workplace-based programs undertaken by engineering students.

13. The Commonwealth Government should consider the introduction of an education and training tax concession for employers that spend more than two per cent of payroll per year on training at a rate of 125 cents for every dollar spent on training.

Addressing the causes of the shortage – increasing the diversity in the workforce.

The engineering workforce can be maximised and expanded through reducing workforce attrition and raising the participation of both women and existing qualified migrants in the profession, bringing the benefits of a more diverse workforce.

A direction is emerging from industry that sees improved workplace flexibility (maternity and paternity leave, part-time and flexible hours) and an awareness that equal opportunity and workforce diversity are enablers of improved productivity and workforce retention. New industry mentoring programs, team-based working and the recent profile given to young female engineers show the way to cultural change. While the private sector will need to drive this cultural change, government can assist through measures to promote engineering studies to women, through less adversarial procurement practices and through utilising the provisions of the *Equal Opportunity for Women in the Workplace Act 1999.* Barriers to the employment of the many qualified migrants not working in engineering must also be addressed.

A broader problem, compounding the issues of access outlined above, is the issue concerning the participation and retention of qualified engineers in the profession and engineering workforce. A significant number of qualified engineers appear to not be employed in engineering occupations. Workplace stress, over-work and the compounding of responsibilities are contributing to driving engineers to early exits from the sector. In addition, the ageing nature of the existing engineering workforce needs to be managed to benefit the future development of the workforce.

Again, government can play a critical role as both a direct employer and as procurer in driving these strategies throughout the sector and thereby increasing engineer retention and participation.

Recommendations.

14. That the Office of the Australian Engineer develop materials for CEOs and governmental leadership which identifies the competence of migrant engineers and the equivalence of their qualifications, whilst also identifying best practice in workplace support.
15. That, following a detailed assessment of the effectiveness of current offerings, an orientation program for migrant engineers be established as part of a national registration scheme, with funding sourced from the Federal Government. The English language requirements of the current migration program for engineers should be assessed with industry to ensure current requirements are adequate.
16. That in developing a marketing and promotion program for teachers, students and the wider public on the engineering profession, the Office of the Australian Engineer ensure adequate representation of women and the role they play in the engineering workforce currently, what role they might play as part of solution to our skills shortage and that consideration be given to appointing an ambassador for young women in engineering.
17. That within the marketing campaign for the engineering profession, a specific effort be made to target retired engineers and qualified engineers not working as engineers to try and attract them back into the profession. A large study of employment paths of individuals with both Australian and overseas engineering qualifications should be undertaken to supplement evidence from census data.
18. That a grants program for engineering bridging courses be developed for industry to allow re-entry to the workforce for departed engineers. Eligibility and course criteria can be developed with the assistance of the Office of the Australian Engineer.
19. That the Federal Government establish grants program for engineering mentoring programs in the public service across all jurisdictions, which would represent a wage subsidy for two years to enable the employment of graduates and retention of experienced engineers for the purpose of mentoring new entrants.
20. That as part of the effort to ensure all Australian governments are informed purchasers, particular effort should be made to ensure all jurisdictions have in place adequate administrative support, transition to retirement plans, workplace flexibility and mentoring by older engineers for new employees.
21. That Government procurement officers be trained to consider compliance with the *Equal Opportunity for Women in the Workplace Act 1999* as a condition to the awarding of contracts for the purchase of goods and services.

22. That Government officers be trained to consider compliance with the *Equal Opportunity for Women in the Workplace Act 1999* for eligibility for grants under industry assistance programs.

1. Introduction.

Engineers play a vital role in Australian society and are drivers of our economic prosperity. They design, build and maintain infrastructure routinely used by the community – roads, railways, ports, water, electricity and gas, and perform key roles in feasibility scoping, structural design, damage control and maintenance – monitoring and addressing safety and quality throughout systems. In industry, our engineers work to ensure that manufacturing, mining and agriculture is world competitive through creatively designed and efficiently produced goods, systems and processes. In so doing, engineers drive innovation and national wealth creation.

The shortage of qualified engineers in Australia is well documented and has been substantially dealt with in previous ANET publications. It is deep, shared across many sectors and has serious consequences.

The Australian National Engineering Taskforce (ANET) brings together the major organisations representing the engineering sector in Australia. It has been formed by the Association of Professional Engineers, Scientists and Managers Australia (APESMA), Engineers Australia, Consult Australia (formerly the Association of Consulting Engineers Australia), The Australian Council of Engineering Deans (ACED) and the Australian Academy of Technological Sciences and Engineering (ATSE). Together these organisations represent the major professional, industrial, commercial and academic interests in the engineering sector. Through this new form of education-industry-profession collaboration, ANET aims to create a national strategy for the development of Australia's current and future engineering workforce. Whilst the ideas and recommendations in this submission have the broad support of the ANET Steering Committee, they may not represent all the views and positions of all ANET members. ANET members are making submissions to the Senate inquiry in their own right.

At the outset, it is appropriate to acknowledge the important work of ANET partners in driving practical solutions to the skills shortage in engineering. These new developments must be noted as taking Australia in the right direction - the number of women in engineering has increased, there are more people studying engineering than ever before and attrition rates from both education and employment are reducing . Yet substantial room for improvement remains.

ANET acknowledges the support of the Federal Government in commissioning this important research through the Department of Education, Employment and Workplace Relations (DEEWR), and for their ongoing support of ANET.

Providing a long-term solution to the engineering skills shortage must be a public policy imperative if we are to succeed in developing a diverse, modern, global economy, to innovate and to put in place the foundations for an Australia which goes beyond a reliance on the mining sector and the economic success of our neighbours.

The series of recommendations within this report seek to bring shape and practicality to a range of solutions which would see an increase in the number of engineers in Australia, through improving the pipeline of engineers into university, improving diversity in engineering and encouraging workforce development and retention - while enabling the achievement of recommendations made in other ANET reports and those of ANET partners. Without an adequate supply of engineers in both the public and private sectors, we will see continued waste in infrastructure spending and a cycle of under-investment in the profession, which has been one of the driving forces behind engineering shortages and continues to exacerbate it. No series of solutions can ignore the positive role government and large industry procurement practices can play in overcoming these challenges.

We must improve the supply of engineers. This means more schoolchildren studying the enabling subjects for an engineering qualification, more female engineers and better utilisation of our available workforce.

For a viable long-term solution and to maximise the benefit for all Australians, we must also lessen our dependence on migration. Engineers are increasingly a global workforce and with a world economic recovery being inevitable in the medium term, Australia faces the prospect of becoming a far less attractive destination for these skilled workers. To overcome this emerging problem, we must increase both the visibility and understanding of engineering throughout the community, and in particular with educationalists and schoolchildren. It is time to lift the status of the profession, celebrate its achievements and put in place important government action and infrastructure to support and promote it. It is time to bring visibility to a profession on which Australia relies on day-to-day basis, the excellence of which has helped to build the nation we are all proud of.

The recommendations outlined are not cost-free, nor do they represent a massive imposition on the Australian taxpayer. Over time, with a larger engineering workforce driving innovation and delivering infrastructure on time and on budget, the benefits of our proposals will well outweigh the cost to the taxpayer, a fact that we feel sure will be borne out by any economic modelling of our proposal which takes into account the consequences of the billions of dollars wasted each year through inadequate scoping and design of projects and wastage from contract disputes.

2. The scale of the shortage.

The reality of the Australian engineering skills shortage is clearly demonstrated by recent statistics and major industry studies.

There is an inadequate supply of graduates to meet current and future needs, a shortage of experience engineers and an insufficient number of high school students choosing to undertake the necessary studies to enable an engineering education, or identifying engineering as their chosen future profession.

Skills Australia has reported shortages across nearly every discipline of engineering[2]. Engineer shortages were the worst among all the occupations surveyed with 59 per cent of vacancies unfilled, the highest of any profession. Research conducted by ANET partners provides further evidence to underline the severity of the shortage.

Engineers Australia have reported in their statistical overview of the profession that the flow of domestic engineers cannot and will not meet the growth in demand for engineers across most disciplines, and that when "examined carefully, the difficulties in some areas are extreme"[3]. The latest statistical report also reveals that in 2010, "over 52 per cent of the Australian engineering labour force was born overseas compared to 36 per cent for comparable non-engineering skills and 27 per cent in the overall labour force"[4].

It further identifies that the 6,712 permanent visas granted to immigrant engineers outstripped the number of Australian bachelor level graduates by approximately 14 per cent in 2009-10[5]. We produce approximately half of engineering needs domestically. There were 2,408 temporary 457 visas granted in that same year, bringing total immigration of engineers for that year to more than 9,000, more or less static when compared to the year before, but a more than seven-fold increase from 2000-01.[6]

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[2] DEEWR (2011). *Skills Shortages List.* DEEWR, Canberra ACT. http://www.deewr.gov.au/Employment/LMI/SkillShortages/Documents/SSL_AUS.pdf last accessed January 25.
[3] Andre Kaspura (2011), p71. *The Engineering Profession. A Statistical Overview, Eighth Edition, 2011.* Engineers Australia, Barton, ACT 2600.
[4] Engineers Australia. *Engineering graduates still well short of meeting demand.* http://www.engineersaustralia.org.au/news/engineering-graduates-still-well-short-meeting-demand last accessed January 25, 2012.
[5] Kaspura (2011), p55. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[6] Birrell, Sheridan and Rapson cited in Kaspura, (2011), p58. *The Engineering Profession. A Statistical Overview, Eight Edition*.

The importation of labour has historically been a feature of Australia's response to skills shortages in engineering. In an age of unprecedented globalisation and labour mobility, it does not represent a satisfactory or enduring solution.

Despite this massive increase in immigration in recent years, the shortage of engineers is being acutely felt across both the private and public sector.

APESMA has found that 91 per cent of their membership agreed that there were not enough engineers within the workforce[7] and that there is inadequate planning to meet future demand. Consult Australia's 2011 Skills Survey found that 90 per cent of large firms are experiencing skill shortages with two-thirds supplementing their workforce with overseas-based staff and 75 per cent finding that employees are being poached[8].

Figures quantifying the number of engineers which are required in Australia to meet our shortage vary. APESMA has identified that Australia needs to develop 70,000 experienced engineers over the next five years[9], while Engineers Australia has in the past used the 20,000 per year figure to quantify the number of engineers required to meet current annual demand[10]. Even the level cited by the latter is in excess of the current supply figure of approximately 18,600 (comprised of 9,120[11] through immigration programs and approximately 9,500 graduating professional engineers, engineering technologists and engineering associates[12]), an increasing number of whom are gaining qualifications to enter practice.

It is important to note that overseas students are a key driver of the growth in commencement in engineering study, and indeed "is the major part of overall growth in commencements"[13].

What is known is that this shortage is directly affecting business and government with current and potential future consequences. Supply is far from what is required to meet demand and places increasing pressure to meet our domestic shortfalls through migration programs.

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[7] APESMA. *Membership survey on engineering shortages.* November 2011.
[8] Consult Australia (2011), p4. *The Consult Australia 2011 Skills Survey: An analysis of skills in the consulting industry for the built and natural environment.* Sydney, NSW.
[9] APESMA (2011), p5. *Submission to the Public Accounts and Estimates Committee.* APESMA, South Melbourne, Victoria.
[10] Adelaide Now. *Education to tackle shortage of 20,000 engineers in Australia.* http://www.adelaidenow.com.au/news/south-australia/education-to-tackle-shortage-of-20000-engineers-in-australia/story-e6frea83-1225907964866 last accessed 8 January 2012.
[11] Birrell, Sheridan and Rapson cited in Kaspura, (2011), p58. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[12] Kaspura (2011), 46. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[13] Ibid, p35.

In 2010, unemployment in the engineering workforce reduced by 1,000, with demand increasing and supply contracting by that same figure, stretching an already stretched workforce. There was a marked drop in temporary migration in this period, at the same time that the permanent intake reached record levels of 6,712. Temporary migration intake appears therefore to be elastic[14].

There is a real need to focus our effort on increasing the supply of locally-graduating domestic engineers. To continue to rely on immigration programs as a means of meeting our critical infrastructure challenges is a one-dimensional solution. In the context of evidence of a shortage of engineers in the developed world, it relies heavily on Australia's economy continuing to outperform and thus stay an attractive destination. Temporary immigration is also an expensive option for employers. A target needs to be adopted by the Federal Government which would see an end to the over-reliance on immigration, and ensure an adequate supply of local engineering graduates. This is made even more pressing by the ageing nature of the engineering workforce, with the majority of large firms expecting up to five per cent of their workforce to retire in the next 12 months[15].

A realistic target may be to reduce the reliance on immigrant engineers within ten years, by modestly increasing domestic supply such that it increases at a rate above assumed demand in coming years and above the levels which are currently being experienced due to a continuation of a strong economic and investment environment in Australia.

One of the key focuses of this target should be the revitalisation of the paraprofessional qualifications at AQF level 6, Advanced Diplomas and Associate Degrees. These qualifications provide entry to Engineering Associate occupations and the opportunity for graduates to progress to further studies and become engineering technologists and professional engineers. The numbers in Associate Degrees are increasing, whilst Advanced Diploma enrolments are decreasing. This approach would see an improvement in the supply of "technically-trained engineering staff as well as increase the number of engineers (through HE pathways) in the longer term"[16]. Equally, the education and employment of 3-year graduates to enter engineering technologist occupations should be encouraged.

Importantly, this approach would change the mix of the engineering workforce, and could serve to ease the burden on our workforce of professional engineers, through the sharing of tasks, the relief

[14] Kaspura (2011), p72. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[15] Consult Australia (2011), p16. *The Consult Australia 2011 Skills Survey: An analysis of skills in the consulting industry for the built and natural environment.*
[16] ANET (2011), p11. *Engineering Skills & Workforce Capacity.* ANET, Sydney, NSW.

of administrative burdens and the provision of necessary support in the discharge of their duties. This also would assist in aligning the mix of our workforce with that of many of our trading partners.

Assuming current long-term (ten year) growth rates of 4.8 per cent of supply of engineers, which is only currently meeting demand growth of that same level[17], the domestic supply of engineers would have to increase above the current demand growth for engineers over ten years to appropriately reduce reliance on immigration. Increasing the growth of domestic graduates, both from the higher education and VET sectors to 20,000 by 2022 would see an easing of the need for overseas labour.[18] We propose that the growth in domestic completions represented by this target should be apportioned between higher education and VET level qualifications, to maximise all avenues for domestic skills growth and to improve the diversity within the Australian engineering workforce, and to provide immediate support for the current engineering workforce.

Recommendation.

1. That the Federal Government adopts a target for an increased number of domestic engineering graduates, with an aim to increasing the available domestic engineering workforce, including targets for graduates at all relevant levels of the Australian Qualification Framework (AQF) from programs provided by both Vocational Education and Training (VET) and higher education.

[17] Kaspura (2011), p20, *The Engineering Profession. A Statistical Overview, Eight Edition*.
[18] Assumes average growth rate in demand for engineers remains stable at 4.8 , per cent with growth in engineering graduations increasing to 7.8 per cent annualised, from a base of 9,500.

3. Consequences of the shortage.

The lack of appropriately qualified engineers can have severe impacts on Australia's economy, on the provision of services and the wider public. It can create cost over-runs, project delays and has the potential to endanger public safety. Such is the critical nature of the role that the profession plays in Australian society.

One of Australia's key public policy imperatives is the transition to a low-carbon economy. Engineers are the enabling profession for industry in this transition and the shortage will compromise and delay the nation's efforts in this regard.

The costs of the shortage of engineering services are being felt acutely by consumers of engineering services. Blake Dawson in their 2008 Report *Scope for Improvement* found that "83% of respondents felt the skills shortage in Australia had an adverse impact on their ability to find skilled resources and expertise to develop scope documents properly"[19]. Scoping is the critical project stage which identifies and details work that needs to be accomplished to deliver a project to the client's specifications. It lays the foundations for project delivery.

Blake Dawson's explanation of project scoping includes:

- "the identification of the fundamental objectives of the project"
- "the development of the principal's project requirements" … "to achieve those objectives, with due regard to stakeholder and end user requirements, any project interface requirements and any other specific project risks and circumstances"
- "the selection of the most appropriate contractual model and risk profile to deliver the principal's project requirements"
- "the translation of those requirements into appropriate contractual scope documents for the project"[20].

Inadequate scoping in Australian construction and infrastructure projects can have severe consequences. 52 per cent of respondents (drawn from across sectors, public and private) to Blake Dawson in 2008, "felt their project was not sufficiently and accurately scoped prior to going to market"[21], an increase of ten per cent from the same survey in 2006[22]. This caused "cost overruns

[19] Blake Dawson (2008), p7. *Scope for Improvement. A report on scoping practices in Australian construction and infrastructure projects.* Blake Dawson, Australia.
[20] Ibid, p4.
[21] Ibid, p7.
[22] Ibid.

(61%), delayed completion (58%) and disputes (30%)", with "26% of the $1billion+ projects surveyed being more than $200 million over budget"[23].

A lack of engineering capacity in the public sector is also contributing to difficulty in project delivery and delivering poor value for the taxpayer. The *Building the Education Revolution Implementation Taskforce Final Report* (BER Taskforce) identified only the Queensland Government as "an informed buyer of capital works projects"[24]. They stated that "there is a correlation between states capacity to leverage existing public works capacity and their overall value for money outcomes"[25], specifically outline a decline in engineering capacity in the public sector and identify that the "rebuilding of capacity in several roads agencies may represent a cautionary tale… and may therefore be an indication that a significant level of in-house expertise is beneficial in ensuring that governments get value for money over the life of an asset".[26] The work of the Western Australian Government towards increasing its informed purchaser status through the establishment of the Centre for Excellence and Innovation in Infrastructure Delivery in 2007 to "improve collaboration, share knowledge and drive reform across a broad spectrum of activities associated with public works, infrastructure delivery and strategic asset management"[27] should also be commended in this context.

APESMA's recent survey of its membership provides evidence that a shortage of qualified engineers is impacting on project cost and delivery, and therefore value for both business and the Australian taxpayer. More than 80 per cent of their membership, surveyed across the private and public sector, agreed that the shortage of engineers contributes to higher project costs and prices charged by contractors. Comments included "Part of my job is to check design and I'm picking up fatal flaws in the plans, flaws that can kill people- this is mistakes mostly done by consultants but managed by in-house project managers that don't have the background knowledge to do that type of work", "we get project overruns because drawings etcetera are at such a standard you're paying for significant contract "variations" or "stuff ups"". Nearly 80 per cent of respondents saw this situation as unsustainable, with the long term consequences being "if we become an uninformed purchaser and the project manager doesn't recognise this, then we'll start building things that could have some fatal flaws in it - plus we won't have the people that even recognise the flaws" and "higher prices,

[23] Ibid.
[24] Building the Education Revolution Implementation Taskforce (2011), p 53. *Final Report.* Commonwealth of Australia, ACT.
[25] Ibid.
[26] Ibid., p58.
[27] Centre for Excellence and Innovation in Infrastructure Delivery. http://www.ceiid.wa.gov.au/. Last accessed January 4, 2012.

lower level services, further degradation of assets leading to replacements that cost much more than proper maintenance programs"[28].

Diminished engineering capacity in Australia has the potential to have serious effects on the wellbeing of its citizens. As well as ultimately bearing the costs of projects being delivered late and over budget, there are potentially serious risks to public safety from diminished capacity. The consequences of engineering failure can be devastating, and as outlined previously, a lack of capacity is causing poor scoping and design of projects, as identified by APESMA, the BER Taskforce and Blake Dawson. Appropriately qualified and experienced engineers, in adequate supply, are vital to ensuring that tragedies such as those seen in the HMAS Westralia Fire and the Sea King helicopter crash are avoided. Equally, "the Thredbo landslide, Longford Plant explosion, Lane Cove Tunnel collapse and Canberra Hospital implosion all result from engineering issues"[29]. A lack of engineering capacity is placing increased demand on scarce resources, increasing the likelihood of engineering failure.

As identified in the report of the BER Taskforce, the public sector can play a vital leadership role. The Federal Government, in particular, is well placed to demonstrate best practice in that it directly funds infrastructure to be delivered by the States through Specific Purpose Payments and directly through other programs. Ensuring that there is adequate capacity at both a Commonwealth and State level to be certain that the public is receiving value for money is vital. Specifically, the BER Taskforce has recommended that within the Department of Infrastructure and Transport there "is scope to strengthen" it "to ensure that it can provide leadership for project procurement in public works on a national basis"[30]. Local Government is also in receipt of large amounts of Federal Government funding for local roads, and in untied grants through *Financial Assistance Grants* and the *Roads to Recovery* program. Measures should also be taken to ensure that there is adequate engineering capacity in local government to make sure of value for money for the Federal Government and taxpayer.

The United Kingdom's *Government Office for Science* correctly states that "the effective use of science and engineering advice (allied to other evidence) in policy making is important. Decisions that don't take into account science and engineering are not robust, and policies that take account

[28] APESMA. *Membership survey on engineering shortages.*
[29] National Engineering Registration Board (2011), p14. *The Regulation of Engineers. Finding the right approach for a national economy.* Engineers Australia, Barton, ACT.
[30] Building the Education Revolution Implementation Taskforce (2011), p 59. *Final Report.*

of sound evidence are more likely to succeed than those that do not"[31], and "conducts a series of Science and Engineering Assurance reviews of major government departments"[32]. The importance of an internal engineering capacity is again emphasised. Value can only be delivered for government when it can be assured it is properly assessing policy with an engineering matrix, and purchasing with that same developed set of skills.

While the Federal Government cannot provide a systemic solution across all States and Territories in strengthening engineering capacity in the public sector, it can demonstrate best practice and use its financial levers to drive change. In the case of Building the Education Revolution, it was the Federal Government which initiated and funded this major infrastructure program across Australia. All care must be taken to ensure that value for money and excellence in project delivery are being achieved. This is the case across the whole of the Federal Government infrastructure spend. Public sector employment is also the most direct way that government can play a role in the labour market and demonstrate best practice in employment. Enhanced public sector capacity would also assist the private sector by allowing them to deal with informed purchasers, thereby minimising delays, adversarial relationships and cost overruns.

Recommendations.

2. That the Federal Government increase its engineering capacity to ensure that it is an informed purchaser of engineering infrastructure, in line with the recommendations of the Building the Education Revolution Implementation Taskforce, and establish a small Procurement Unit, residing within the Department of Finance and Deregulation.
3. That the Federal Government, through its Procurement Unit conducts an audit of its procurement capability across all agencies.
4. That the Federal Government take to the relevant Standing Council of COAG a proposal that all States and Territories conduct their own audit, to ensure that the community is receiving value-for-money in infrastructure delivery.
5. That, following this audit, the Federal Government put in place a series of requirements for baseline engineering competence and capacity in jurisdictions, including local government, for the management of projects funded by the Federal Government.

[31] Government Office for Science. *Reviewing science and engineering.* http://www.bis.gov.uk/go-science/science-in-government/reviewing-science-and-engineering last accessed 11 January 2012.
[32] Ibid.

4. Addressing the causes of the shortage – increasing the level of interest among school leavers in engineering careers and improving support for the profession.

There has been a great deal of attention paid to the fact that the numbers of students undertaking science and mathematics - the enabling subjects for an engineering career - has declined in recent years.

Recent years has witnessed an expansion in school retention to Year 12. Engineers Australia has documented the continuation of this rise, with completion rates rising from 74.6 per cent to 78 per cent between 2008 and 2010, resulting in continued growth in the Year 12 population moving into tertiary studies[33]. This shift has been the result of a major policy push by both the Federal and State Governments since the 1980s.

Despite this overall growth in the feeder population for tertiary studies, there has been a decline in science and maths studies within this population. There have been reports that the number of students participating in science at a Year 12 level has dropped from 90 per cent in the early 1990s to approximately 50 per cent currently[34]. The Victorian Government is reporting a decline in enrolments in VCE specialist mathematics of approximately 15 per cent over the last five years[35]. "The proportion of Year 12 students studying appropriate enabling subjects in mathematics and science has continued to decline at the same time that skill shortages in engineering have emerged"[36]. Just as worrying is the decline in the study of chemistry and physics – with the proportion of Year 12 students studying these subjects having declined to 18 per cent in chemistry and below 15 per cent for physics in 2007, although now stable at these low levels[37].

Further, a recent major report profiling the mathematics discipline confirms that "the proportion of Year 12 students enrolled in calculus-based mathematics subjects has been declining over the past 15 years. These subjects, often referred as intermediate or advanced, serve as prerequisites to most

[33] Kaspura (2011), p28, *The Engineering Profession. A Statistical Overview, Eight Edition*.
[34] The Australia newspaper, 12 January 2012. *Year 12 students ditching 'boring' science in droves.* http://www.theaustralian.com.au/news/health-science/year-12-students-ditching-boring-science-in-droves/story-e6frg8y6-1226227095267. Last accessed January 25, 2012.
[35] The Age newspaper. 30/08/2011. *Schools bid for specialty maths, science teachers. Schools bid for specialty maths, science teachers.* http://www.theage.com.au/national/education/schools-bid-for-specialty-maths-science-teachers-20110829-1jif2.html. Last accessed January 25, 2012.
[36] L Dawes and G Rasmussen (2007), p13. *Activity and engagement – key in connecting engineering with secondary school students.* In Australian Journal of Engineering Education. http://www.engineersmedia.com.au/journals/aaee/pdf/AJEE_13_1_Dawes.pdf. Last accessed 25 January 2012.
[37] Kaspura (2011), p30, *The Engineering Profession. A Statistical Overview, Eight Edition*.

university science and engineering courses"[38]. Over the period 1995-2010, Australian advanced mathematics students have declined from 14.1 to 10.1 per cent of all Year 12 students, with intermediate declining from 27.2 to 19.6 per cent over the same period[39]. It also reports that while elementary mathematics studies continues to grow, this has been at the expense of the more demanding and enabling subjects[40].

In addition, mathematics studies faces the further crisis in that a significant number of secondary school students do not have access to high quality mathematical expertise at the crucial time where they are making decisions about tertiary level study. A recent profile of the discipline reveals that, not only are mathematics teaching position amongst the most difficult to fill, only 68 per cent of Year 11 and 12 mathematics teachers have received three or more years of tertiary education in mathematics[41]. Studies also show that Australia's science and maths teaching population is well below the international average for maths and science teaching[42]. The ageing of the existing secondary teacher population[43], combined with falling graduation rates, has the potential to compound this problem into the future unless remedial action is taken.

The effect of this decline at the secondary level is directly reflected in the engineering population at tertiary institutions. A comparison of Australia's engineering (including manufacturing and construction) higher education graduates with the OECD mean percentage reveals that Australia is producing approximately a half the proportion of graduates as the OECD mean – 7.3 per cent compared to 13.1 per cent of three year full time equivalent courses and 10.8 per cent compared to 17.2 per cent of two year full time equivalent courses[44].

It cannot be stressed enough that increasing levels of tertiary enrolments in engineering is directly dependent on successfully increasing the demand for study in these two critical areas of knowledge amongst the school age cohort. As a recent report profiling the declining state of mathematical

[38] Professor Geoff Prince (2012), p1. *Discipline Profile of the Mathematical Sciences*, Paper prepared for the maths for the Future: Keep Australia Competitive Conference, 7-8 February 2012, ANU Canberra.
[39] Ibid.
[40] Ibid.
[41] Ibid., p2.
[42] John Ainley, Julie Kos, Marina Nicholas (2008). *Participation in Science, Mathematics and Technology in Australian Education*, ACER, Camberwell, Vic.
[43] Ibid.
[44] Professor Geoff Prince (2012), p5. *Discipline Profile of the Mathematical Sciences*.

studies at school level concludes "the declining interest in advanced mathematics courses at Year 12 poses an immense challenge to securing Australia's future skills base"[45].

There seems to be ample evidence that there is a lack of awareness of what potential future occupational choices may be made available through the study of mathematics and science, or that the consequence of not studying these subjects can be extremely limiting. "The choice to continue with science, mathematics or technology in their final years of schooling has consequences for their subsequent tertiary options and career opportunities. For most students however, the relationship between mathematics, tertiary study and career remains largely unimportant and poorly understood[46]", with science seen as "irrelevant to student's lives[47]" and engineering invisible. The Australian Mathematical Sciences Institute has recently stated that despite the fact that mathematical and statistical skills are in high demand across all sectors of the economy, "many students are unaware that closing the door on mathematics at school will limit their future career options"[48].

Engineering is one such career which can be limited by a failure to study mathematics and science at an appropriate level and by this lack of knowledge about the relevance of engineering, science and mathematics to the lives of students.

The results of a survey recently conducted for ANET shows that awareness of study options in engineering was higher among boys than girls, at just over 50 per cent of those surveyed. English is rated highest as the enabling subject for engineering careers, while at the same time, there is a lack of awareness of the range of roles that engineers perform, and a perception of the profession built around construction. Students identify pay (79 per cent) and stability (51 per cent) as the key determinants in career choices, and rank engineering higher as well paid and stable at 83 per cent and 79 per cent respectively. However, it is not perceived as well on a measure of creativity. The profession has consistently better perceptions amongst males than females in this survey. 59 per cent of males agree engineers work in exciting jobs while only 34 per cent of females agree with this statement. Approximately 21 per cent of the total sample consider it to be either

[45] Professor Geoff Prince (2012), p. ii., *Discipline Profile of the Mathematical Sciences*, Paper prepared for the maths for the Future: Keep Australia Competitive Conference, 7-8 February 2012, ANU Canberra.
[46] Mohan Chinnappan, Stephen Dinham, Anthony Herrington, Dale Scott (2007), p5. *Year 12 Students and Higher Mathematics: Emerging Issues.* Australian Association for Research in Education. http://www.aare.edu.au/07pap/chi07180.pdf. Last accessed 25 January 2012.
[47] Australian Science Teachers Association 2006. *Submission to Skills audit, Science, Engineering and Technology skills.* http://www.asta.edu.au/media/policy/skillaudit. Last accessed 25 January 2012.
[48] Australian Mathematical Sciences Institute (2012), *Solutions to the mathematics skills shortage*, Media Release, 1 February 2012.

challenging/interesting, a possible choice, a good career and a further (12 per cent) are not sure. This means a third of the population are either interested or unsure about a career in an engineering occupation. Expanding the conversion of this interest in entry into a commencement of study is a challenge, and would be assisted by showcasing the full range of career options in the profession to this cohort[49].

Of concern are results of a survey of career guidance counsellors which showed that 83 per cent of respondents stating that school leavers do not know what an engineer does. Further, 81 per cent do not believe that the role of engineers and the nature of their careers are adequately explained to Australian school leavers, with studying engineering perceived as being 'too hard'[50].

These concerns and lack of understanding exist despite the evidence that engineering remains a rewarding career choice.

There is no doubt that most of the more than 140,000[51] engineers working in engineering in Australia have found their career rewarding, engaging and comparatively well paid, with the median total package for professional engineers amounting to $132,000 per annum, well above many professions with comparable periods of study for qualification, with wage growth exceeding both the Consumer Price Index and Average Weekly Ordinary Time Earnings[52].

Median graduate salaries for engineering and related technologies are ranked highest amongst all professions in recent years. Graduates enjoy 90 per cent placement in employment related to their long-term career goals and salaries have grown by more than a third, on average, over the last three years[5354]. The unemployment rate amongst engineers was 3.7 per cent in 2010, well below the national average[55].

These factors and the vital nature of the work that engineers perform, should make it an attractive career option for school-aged children. However, the disconnect between science, mathematics and their future seems also to extend to engineering and a knowledge of what engineers actually do, as borne out by the previously cited research. While the study of advanced or intermediate

[49] Alex Frankel and Associates (2012). *Research into young people's attitudes towards engineering.* Melbourne, Vic.
[50] Survey of school career counsellors, conducted December 2011.
[51] Kaspura (2011), p8. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[52] APESMA, Engineers Australia, (2011), p13. *Professional Engineer Remuneration Survey Report.* Melbourne.
[53] Graduate Careers Australia (2011), p4, p12. *Beyond Graduation 2010, The report of the Beyond Graduation Survey.* Graduate Careers Australia, Melbourne, Vic.
[54] Graduate Careers Australia (2011), p9,. *December 2011 Grad Stats. Employment and salary outcomes of recent higher education graduates.* Graduate Careers Australia, Melbourne, Vic.
[55] Kaspura (2011), p20. *The Engineering Profession. A Statistical Overview, Eight Edition*.

mathematics and enabling sciences may have stabilised, it has stabilised at a critically low level. Only an overall increase in Year 12 retention has seen the feeder population for universities increase[56].

Studies have borne out that "though we all are surrounded by the products of engineering in our everyday lives, students and the general public don't understand what engineers do"[57]. This lack of understanding and therefore the standing of the profession in the public mind are fundamental to overcoming the problem of attracting more students into engineering as a career. It is systemic, and borne out by a raft of studies conducted around the world[58]. In 2008, the President of the Australian Council of Engineering Deans advocated for "actions and initiatives to increase the public understanding and awareness of innovation, and the role engineering plays within it"[59].

It would seem that this could extend to many of those who are providing career guidance in our schools, who in unprompted responses request further information on all aspects of engineering as a career[60]. Responses from these career guidance counsellors overwhelmingly suggest the benefits of a new marketing campaign for the profession, ranging from school visits by new graduates to the use of social media, electronic advertising campaigns, publications, DVDs and the integration of real engineering practice into the curriculum.

Such a marketing campaign should also include teachers in its target population, especially those who teach maths and science, to ensure a wider understanding of engineering principles and applications. We have referred earlier to the reports detailing the academic limitations of many of Australia's existing secondary mathematics teaching population. It should also be understood that the training of many maths and science teachers has been largely theoretical and therefore often leads to a limited appreciation of the connection between maths, science and the real world. Increasing the awareness of the reality of engineering amongst these key communicators to the school age population is critical.

In this environment, industry has made an attempt to fill the gap. Engineers Australia's 'Make it so' campaign, and their ongoing commitment to raising the status and awareness of the profession in

[56] Ibid, p27,28.
[57] Cunningham et al, 2005,cited in L Dawes and G Rasmussen (2007), p14. *Activity and engagement – key in connecting engineering with secondary school students.* http://www.engineersmedia.com.au/journals/aaee/pdf/AJEE_13_1_Dawes.pdf last accessed 25 January 2012.
[58] Ibid, p14.
[59] Prof. Elizabeth Taylor (2008), p1. *Submission to the National Innovation Review.* Australian Council of Engineering Deans, Rockhampton, Qld.
[60] Survey of school career counsellors, conducted December 2011.

Australia is to be commended. However, to expect the profession to self-fund a response to an issue of national significance in an ongoing sense is not sustainable.

This engineering studies promotional campaign detailed above is not proposed in isolation to other proposals to increases the enrolment in engineering's enabling studies at the secondary level. We note the proposal to appoint a national mathematics advisor to government, to advise, coordinate, promote and report on the implementation of the national mathematics strategy proposed by the Australian Mathematical Sciences Institute. These proposals have merit in supporting a re-invigorated effort to promote mathematics in Australian secondary and tertiary education. This report supports the adoption of these measures by government as they are complementary to the recommendations made in this report.

Engagement of school-aged students.

A consistent theme of much of the work performed by an alarmed profession in Australia has been the identification of the need for the sector themselves to take responsibility to "increase the level of engagement with the school sector"[61]. As previously identified herein this level of engagement remains inadequate, and is subject to further recommendation by the Australian Academy of Science in their recent report to the Office of the Chief Scientist[62]. This report identifies one of the major deficiencies of the teaching of science in schools as being conducted primarily involving the "transmission model"[63], whereby " 73% of science students indicated that they spend every lesson copying notes from the teacher"[64]. As is further explored later, engineering brings science to reality, and has the capacity to engage and involve students throughout their school years in a practical and meaningful way. The aim to "make school mathematics and science more relevant to daily life"[65] is the key recommendation of research conducted by Universities Australia for the Office of the Chief Scientist to increase the interest in science and mathematics.

There are a number of programs run throughout Australia which aim to bring 'science to life' in the classroom, as well as programs which engage students in the real and practical outcomes of engineering work.

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[61] Robin King (2008), p21. *Engineers for the Future addressing the supply and quality of Australian engineering graduates for the 21st century.* Australian Council of Engineering Deans, Epping NSW.
[62] Denis Goodrum, Amelia Druhan and Joanna Abbs (2011), pii. *The Status and Quality of Year 11 and 12 Science in Australian Schools.* Australian Academy of Science, Canberra ACT.
[63] Ibid.
[64] Ibid.
[65] Universities Australia (2012), p2. *STEM and non-STEM First Year Students.* Universities Australia, Canberra, ACT.

The Engineering Link Group "offers several programs for secondary school students and teachers, aimed at allowing them to explore and better understand the exciting career opportunities available to them. These are:

- Engineering Link Project (ELP)
- Enterprise Management Project (EMP)
- Linking Engineers and Scientists with Teachers (LEaST)
- International Engineering Experiences for Students and Teachers"[66]

Robogirls, founded by 2012 Young Australia of the Year winner, Marita Cheng with a group of her peers, "revolves around introducing girls to engineering via interactive workshops conducted within schools by visiting university student volunteers. In these workshops, girls construct and program LEGO NXT robotics kits, which include a central CPU brick that is programmed using a simple, visual interface to use components such as light sensors, colour sensors, sound sensors, motors and sound outputs. In addition, the Robogirls volunteers talk with the girls about different types of engineering and how engineers impact our daily lives"[67].

EngQuest, an initiative of Engineers Australia, "provides an exciting way for students to participate in free, fun, educational engineering activities involving mathematics, science and technology. EngQuest is non-competitive, with every student recognised for their participation and hard work with a certificate and a gift"[68].

Re-Engineering Australia aims "to establish a series of stepping stone activities, starting at the earliest ages, forming a pathway of encouragement which school students can progress, with each step adding to their interest and understanding of Maths, Science & Engineering activities, trades and professions. In doing so, we hope to inspire younger generations to consider technology based industries as a fulfilling career path"[69].

[66] The Engineering Link Group. *Your Portal to a career in engineering.* http://www.telg.com.au, last accessed 14 January 2012.
[67] Engineering Source. *The Program behind the Young Australian of the Year.* *http://designbuildsource.com.au/program-young-australian-year* last accessed January 27, 2012.
[68] EngQuest. *Welcome to Engquest.* http://www.engquest.org.au/teachers-entry.cfm, last accessed 14 January 2012.
[69] Re-engineering Australia foundation. *Our Goals.* http://www.rea.org.au/about/goals/ last accessed 14 January 2012.

The SQUEAK program, by the Queensland University of Technology "involves building relationships with secondary schools motivating and providing role models for engineers of the future… Final Year engineering students visit high schools with activity kits where they engage with the class for the subject period"[70].

Build A Bridge... & get over it!, is a partnership between COMPACT, the Riverina Eastern Region Organisation of Councils (REROC), TAFE NSW Riverina Institute, Leeton Campus, IPWEA & RTA NSW[71]. This program involves a camp designed to promote civil engineering as a career option using practical hands-on experiences.

The Science and Engineering Challenge, led by the University of Newcastle with a range of supporters including Engineers Australia, governments and Rotary is a national "outreach program conducted nationally by the University of Newcastle. It is designed to inspire students to study science and engineering at a senior level"[72].

All of these programs have merit, especially in that they are all seeking to engage students with engineering at a school age. However, none are subject to external assessment as to their efficacy, and it is unclear as to how they link to the current curriculum.

One program, run by ATSE, Science and Technology Education Leveraging Relevance (STELR), does operate within curriculum, and is being piloted across more than 200 schools in Australia. The STELR Program is "a hands-on, inquiry-based, in-curriculum program designed for Year 9 or Year 10 students, on the theme of global warming and renewable energy. A range of directed and student-designed practical investigations are an integral part of the program", and "is distinctive amongst state and national programs in that it is an excellent vehicle for fulfilling the aims of the Australian Curriculum: Science"[73].

It is obvious from this review that engaging school students more directly in engineering activities throughout their study must be better coordinated and integrated. Practice to date by government relying on industry and educational providers to deliver engagement at a school level has meant that these programs remain relatively uncoordinated, with excess reliance on teachers and industry to

[70] Queensland Government (2008), p18. *A directory of science, engineering and technology programs in Queensland schools.* Queensland Government, Brisbane, Qld.
[71] Compact. *Build a Bridge… & get over It.* http://www.compact.org.au/services/adopt-a-school/ last accessed 15 January 2012.
[72] The University of Newcastle. Faculty of engineering and built environment. *Science and Engineering Challenge*. http://www.newcastle.edu.au/faculty/engineering/community-engagement/challenge/ last accessed 16 February 2012.
[73] STELR. *About STELR.* http://www.stelr.org.au/about-stelr/ last accessed 27 January 2012.

seek out and deliver solutions to engage students in engineering in a real and meaningful way. The Commonwealth Government, as the primary source of funding for higher education and a significant source of funding for school-aged education[74], should take a more active and direct interest in school-age engagement in engineering if the outcomes desired are to be achieved. It is only through active engagement by the Federal Government that we will see an increase in the uptake of engineering at an undergraduate level and ultimately see an end to the engineering skill shortage.

Increasing the engagement of post-secondary students and completion rates.

For ACED and participating universities, Elizabeth Godfrey and Robin King have recently authored an important work, *Curriculum specification and support for engineering education: understanding attrition, academic support, revised competencies, pathways and access* funded by the Australian Learning and Teaching Council. From cohort studies, and taking into account student transfers between universities, they identified the current rate of graduation from engineering bachelor degrees is approximately 65 per cent, which indicates that while there has been significant progress in addressing what were previously counted as unsustainably high attrition rates "there remains considerable scope for reducing attrition"[75]. Despite this graduation rate improvement, graduations from engineering and related technologies have fallen as a share of all domestic completions, as other disciplines such as health sciences have grown.

The shift to a student demand model for higher education places requires that greater emphasis must be placed on the marketing to students the merits of engineering as a career. As previously advocated by ANET, the funding of universities needs further examination, such as through university funding compacts, "to ensure ongoing support for industry to increase internships and mentor relationships with universities"[76]. This is especially critical as the supply of internships, a compulsory component of most engineering degree program is "variable, and programmes for matching employers with candidates remain dependent on individual universities"[77].

[74] Marilyn Harrington (2011), pp1-2. *Australian Government funding for schools explained.* Parliamentary Library, Australian Parliament House, ACT.
[75] Godfrey and King (2011), p. xii. *Curriculum specification and support for engineering education: understanding attrition, academic support, revised competencies, pathways and access.* Australian Learning and Teaching Council, Strawberry Hills NSW.
[76] ANET (2011), p21. *Scoping Our Future. Addressing Australia's Engineering Skills Shortage.* ANET, Sydney, NSW.
[77] Ibid.

The fluctuating nature over time of discipline specific engineering skills shortages, with the shortage across some disciplines being particularly acute, means that student driven demand model may not of itself accurately meet industry need. Real attention must be paid to the supply of engineers across all disciplines, and measures put in place to ensure that the supply of engineering graduates from higher education and the VET sector meets industry demand.

The ANET funded work performed by Godfrey and King deals in some detail with pathways between the VET sector and higher education, and their extension of this with David Dowling for ANET should also be regarded as of great import. These studies provide a series of practical solutions to improving pathways and partnerships which will "promulgate this rich network of opportunities, and ensure that they enable as many students as possible to attain their educational goals and join the engineering workforce[78]". Key amongst the recommendations is the proposal to establish dialogue between the "engineering related Industry Skills Councils and Skills Australia, VET and higher education and Engineers Australia, and employers"[79] to ensure supply is meeting industry demand and "provide efficient pathways for students aspiring to articulate to higher level qualifications"[80]. This is a task of some magnitude, and the ACED are to be commended for undertaking it. It is a task however, made more complex by the nature of the way engineering awards in VET are covered by a number of Industry Skills Councils.

Currently, there is no dedicated Industry Skills Council for engineering. Industry Skills Councils (ISC) play a critical role in Australia's training system, specifically:

- "providing integrated industry intelligence and advice to Skills Australia, government and enterprises on workforce development and skills needs
- actively supporting the development, implementation and continuous improvement of high quality training and workforce development products and services including training packages
- providing independent skills and training advice to enterprises, including matching identified training needs with appropriate training solutions; working with enterprises, employment service providers, Registered Training Organisations and government to allocate training places under the Productivity Places Program

[78] Godfrey and King (2011), p. xiv. *Curriculum specification and support for engineering education: understanding attrition, academic support, revised competencies, pathways and access.*
[79] Ibid, p. xvii.
[80] Ibid.

- engaging with State and Territory Governments, State and Territory industry advisory bodies and peak representative bodies in their area of industry coverage.[81]"

ANET partners have sought to have dialogue with relevant ISCs to gain access to the Federal Government's National Workforce Development Fund, a program designed to provide "$558 million over four years to industry to support training and workforce development in areas of current and future skills need"[82].

Yet while engineering is well represented on the Priority Occupations List, no ISC is taking direct responsibility for this key area of training. One of the key responses of the Federal Government to developing industry-led responses to addressing areas of critical skills shortage therefore remains inadequately supported by an appropriately resourced and dedicated coordinating advisory body which fulfils the same roles as an ISC for the engineering profession, while accounting for the reality that, unlike other occupations for which there is an ISC, engineering is a profession, rather than a trade.

Lifting the status of the profession.

Successive governments have engaged in marketing campaigns relating to professions they see as in critical need, such as nursing and teaching. "They have sought to raise the status of these professions, while at the same time investing in better wages and conditions to attract more people into them"[83]. Given the critical shortage of engineers in Australia there is now an imperative for Government to undertake similar measures to lift the status of the profession amongst the community and to effectively market it to school aged students.

Governments have established Offices of the Government Architect, and we have seen the establishment of the Office of Chief Scientist in a number of jurisdictions. The establishment of improved over-arching coordination of engagement with engineering during education is vitally important to ensure that the Federal Government derives real value-for-investment from its funding of government and non-government schools. The lack of established dedicated infrastructure in Australia leaves approaches to engagement in the hands of State Governments, many of whom then devolve much decision-making to schools. The establishment of a national curriculum and the

[81] Industry Skills Councils. *About Us.* http://www.isc.org.au/about.php last accessed 15 January 2012.
[82] Department of Education, Employment and Workplace Relations. *National Workforce Development Fund Home*. http://www.deewr.gov.au/Skills/Programs/SkillTraining/nwdf/Pages/default.aspx last accessed 15 January 2012.
[83] APESMA (2011), p6. *Submission to the Public Accounts and Estimates Committee.* APESMA, South Melbourne, Victoria.

Australian Curriculum Assessment and Reporting Authority as the enabling authority presents an opportunity for improved coordination. What this authority lacks is an appropriate mechanism for the delivery of advice and the sharing of best-practice in engineering engagement with school-age students.

Australia has a laissez-faire regulatory environment for its engineers, treating the profession in marked difference in this regard to many of its international trading partners. The value assigned to the profession by the public and government is also lower than would be optimal to drive increasing interest in engineering careers. The "Chinese Academy of Engineering (CAE) and the Engineering Academy of Japan (EAJ)—carry enormous authority. The President of the CAE bears the same rank as a Government minister"[84]. This was a consistent theme of responses to APESMA's survey of its membership, with responses to questions relating to the retention of engineers eliciting many responses advocating for "greater recognition to their profession"[85].

Substantial numbers of our trading partners have a registration scheme for engineers, or protect the use of the term. "Japan, Malaysia, Korea, the United States, China and Singapore, have statutory registration systems for engineers"[86], while in Australia, only Queensland has a mandatory, statutory registration system for engineers, with de-facto and limited systems existing in a number of other jurisdictions[87].

Registration systems assign value to the profession, and put in place infrastructure to allow for regional boards which can promote the profession and safeguard standards. In light of the previously outlined potentially catastrophic consequences of engineering failure, an important foundation in the building of a sustainable domestic engineering workforce must be a national registration scheme, which is largely funded by contributions made by the profession or employers. The boards established in jurisdictions to ensure the competence of engineers and to administer registration can play a vital role in marketing the profession at a jurisdictional level. The economic benefits of the establishment of such a scheme through the prevention of engineering failures and enhancing mobility are borne out by a detailed analysis conducted by ACIL Tasman[88]. It is

[84] Innovation, Universities, Science and Skills Committee, 2009. House of Commons, United Kingdom. *Engineering: turning ideas into reality.* http://www.publications.parliament.uk/pa/cm200809/cmselect/cmdius/50/5008.htm#n287 last accessed January 17, 2012.
[85] APESMA. *Membership survey on engineering shortages*.
[86] National Engineering Registration Board (2011), p17. *The Regulation of Engineers. Finding the right approach for a national economy.*
[87] Ibid., pp8-10.
[88] ACIL Tasman (2011). *The Economic Basis of the Case for National Registration of Engineers in Australia.* Canberra, ACT.

understood that the regulation of engineers is a matter which is under consideration by the Council of Australian Governments (COAG), and that there is significant jurisdictional support around Australia for a move to a national system of registration.

The continuing professional development which would be enforces under such a scheme would also serve to ensure that engineers are continually exposed to the latest practices and are in the best position possible to drive innovation.

The Office of the Chief Scientist.

The Office of the Chief Scientist was established by the Federal Government to provide "high-level independent advice to the Prime Minister and other Ministers on matters relating to science, technology and innovation"[89]. The Chief Scientist also functions as Executive Officer of the Prime Minister's Science, Engineering and Innovation Council, which has been established "as the Government's principal source of independent advice on issues in science, engineering and innovation and relevant aspects of education and training"[90]. Chief Scientists also exist at a State level throughout Australia. Of note however, is the establishment in New South Wales of the Office of the Chief Scientist and Engineer.

There is no doubt this is an important role, and much of the recently commissioned research by the Commonwealth Chief Scientist centred around the engagement of school-aged children in science is welcome, important, and cited throughout this document.

However there are crucial differences between science and engineering which need to be recognised. What is important is the notion that engineering brings science to life, and as such is able to give practical demonstration of the importance of science, and of its application for students through school years.

The British Parliament's House of Commons- Innovation, Universities, Science and Skills Committee report - entitled '*Engineering: turning ideas into reality*' - states this case succinctly by concluding "notwithstanding niche research areas, science and engineering are disciplines that differ fundamentally, particularly in their goals: scientists set out to find out how things work whereas

[89] Australia's Chief Scientist. *About.* http://www.chiefscientist.gov.au/about/ last accessed 17 January 2012.
[90] Ibid. *PMSEIC explained.* http://www.chiefscientist.gov.au/2009/10/the-prime-minister%e2%80%99s-science-engineering-and-innovations-council-pmseic-explained/ last accessed 17 January 2012.

engineers typically are more interested in whether they can turn ideas into reality. In a policy situation the distinction is obvious"[91].

It is not only an important distinction for the engagement of students in science and mathematics, it is an important distinction for the provision of advice to government on procurement and bringing practical relief to real policy problems such as climate change. Simply put, a scientist can advise on issues relating to science, while an engineer can deliver tangible solutions in forms as manufactured products, systems and infrastructure.

This is where much of government activity is concerned, while demonstrated implementation of science through the practicality of engineering can serve to provide engagement for school – aged students.

[91] Innovation, Universities, Science and Skills Committee, 2009. *Engineering: turning ideas into reality.*

Recommendations.

6. That the Federal Government establishes the Office of the Australian Engineer, reporting to the Prime Minister. The responsibilities of this office would be:
   a. To develop a marketing and promotion program for school teachers, students and the wider public on the engineering profession, and the wide variety of important roles that engineers play in Australian society and their presence in leadership roles. Materials should be developed for early school-age that introduces engineering, and targeted materials at all school ages;
   b. To advise the Chief Scientist, State Governments and to work with the Australian Curriculum Assessment and Reporting Authority to increase engagement in practical engineering programs at a school-age;
   c. To assess the effectiveness of current engineering engagement programs for school-aged students, and to oversee the integration of effective programs in the curriculum across Australia;
   d. To work with higher education providers and the Federal Government to ensure the implementation of the recommendations of the ACED report (Godfrey and King (2011), *Curriculum specification and support for engineering education: understanding attrition, academic support, revised competencies, pathways and access*), as well as recently completed recommendations carried in ANET publications*;*
   e. To commission such research as is necessary to support the activities of the office;
   f. To advise government on the effectiveness of current funding models for VET and higher education, and to try and ensure that supply is matching demand across industry, and across disciplines;
   g. To oversee the development of a national registration scheme for professional engineers, and to ensure such established boards under State legislation perform satisfactory marketing of the benefits of registration in their jurisdictions;
   h. To increase diversity in the engineering workforce and attract and retain experienced engineers;
   i. To work with Federal Government to ensure that there are informed purchasers in the procurement process and that procurement agencies have the appropriate range of engineering skills internally to receive value for investment from their purchasing decisions.
7. That the Federal Government establishes the Australian National Engineering Workforce Development Council, which is systemic in the context of Federal Government funding for

training and fulfils the role of an Industry Skills Council for the profession, while acknowledging its difference from trade-based occupations. Consideration could be given to the aggregation of other related professions into the new body. The current membership of ANET, with representatives from the VET sector and industry would comprise the membership. The Federal Government is to work with the newly established council to ensure that supply is meeting demand, and to assist in establishing dialogue between all stakeholders to ensure that pathways between VET and higher education are both clear and efficient.

8. That the Federal Government support the policy proposals made by the Australian Mathematical Sciences Institute to promote the study of mathematics at secondary and tertiary levels as being intrinsic to the aim of increasing Australia's engineering skills base.

5. Addressing the causes of the shortage – using procurement effectively to develop the workforce.

Recent natural disasters in Australia have seen our need for infrastructure investment grow exponentially. Infrastructure Partnerships Australia estimates a backlog of $770 billion in infrastructure investment, while the Federal Government is bearing a bill of $5.6 billion to repair damage incurred due to recent natural disasters[92]. With such wide needs for infrastructure in Australia, coupled with the billions identified for investment by the Federal Government in coming years, ensuring that procurement of infrastructure is done in a manner which ensures value for money, not only immediately, but in the longer-term, is vital. While engineers perform work across the full gamut of Australian society, herein we focus on the work of engineers as it relates to the built environment.

The UK House of Commons Committee stated, "government needs to be an intelligent customer for the engineering advice it receives" [93]. However there is ample evidence that increasingly, the value government has derived from infrastructure investment has been diminished due to a reliance on models for infrastructure delivery that effectively outsource most of the functions previously performed in-house.

This has eroded government's ability to be an informed purchaser and placed much of the responsibility for training and development of the workforce in the hands of the private sector, which is, in turn, constrained by the skills shortage in their ability to deliver training and development and grow their workforce. These providers compete on price, and as such, increased costs due to demand for engineering services are passed on to the government as higher prices. In turn, industry suffers from the poor scope and design of projects and cannot discharge contract requirements adequately. In this way, a cycle of underinvestment has evolved.

Procurement models and project delivery.

In contrast to past practices where government undertook much of the delivery of infrastructure itself, the last several decades has seen an evolution to a model which is largely contracted work arrangements that seek to shift risk and responsibility to the private sector. As such, current procurement practice is not delivering optimal results for the taxpayer, government or industry. It is

[92] Blake Dawson (2011), p5. *Scope for improvement. Project risk – Getting the right balance and outcomes.* http://www.constructors.com.au/publications/sfi_2011/14623-PUB%20Scope%20for%20Improvement%202010%20-%20REPORT%20(web).pdf last access February 29, 2012.
[93] Innovation, Universities, Science and Skills Committee, 2009. *Engineering: turning ideas into reality.*

also not driving investment in the workforce which is needed to ensure the government can become an informed purchaser and to provide for adequate investment by the private sector in workforce development.

The share of the risk that has been shifted is now seen by many to be inappropriate, especially when it is considered that what is being procured is public infrastructure for which the government will be held accountable, regardless of who may actually deliver the project. The most recent research published by Blake Dawson, in *Scope for Improvement 2011-Project Risk – Getting the right balance and outcomes* has found that, whilst improving, 58 per cent of contractors felt that they bore the burden of risk, with 43 per cent feeling that allocation was inappropriate[94].

There has been widespread criticism of the manner in which procurement has occurred in Australia, with inefficiency and an erosion of relationships between client and provider identified as key consequences. "Over the last twenty years, there has been an increasing level of dissatisfaction amongst many of those involved within the Australian construction industry regarding the adversarial and inefficient environment in which construction projects are often undertaken"[95]. "Many existing contractual relationships, particularly traditional forms lead to adversarial behaviour between parties and this has a negative effect on project outcomes"[96].

Optimal models for procurement should be explored, which in addition to the measures outlined previously to ensure informed purchaser capacity at governmental level, will foster a collaborative approach and deliver outcomes from projects for the wider community and government over the longer term through the development of a diverse and sustainable workforce. Trust, goodwill, early involvement of head contractors and sensible risk allocation are the hallmarks of a good procurement process, as outlined by the CRC for Construction Innovation in its *Guide to Leading Practice for Dispute Resolution*, which estimates wastage from disputes in the construction industry "at approximately $7 billion per annum"[97].

The common, currently used models for procurement of projects in Australia include:

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[94] Blake Dawson (2011), p7. *Scope for improvement. Project risk – Getting the right balance and outcomes.*
[95] CC McDonald, Chief Engineer (2005), p1. *What are the important differences between partnering and alliance procurement models and why are the terms so seldom confused?* http://cms.3rdgen.info/3rdgen_sites/107/resource/MacDonald-AIPMOct05.pdf last accessed February 27 2012.
[96] Australian Constructors Association (1999), p6. *Relationship Contracting. Optimising Project Outcomes.* http://www.constructors.com.au/publications/rc_general/Relationship%20Contracting%20Optimising%20Project%20Outcomes.pdf last accessed January 27 2012.
[97] Cooperative Research Centre for Construction Innovation (2009), p7. *Guide to Leading Practice for Dispute Resolution*. Cooperative Research Centre for Construction, Brisbane Qld.

- Construct, and design and construct. The project is let for a fixed price for delivery by a set date. Has evolved from a procurement model which saw the design of projects conducted by the client to more commonly complete outsourcing of both the design and construct functions. This has been a key contributor to the loss of engineering design and scope capacity within public sector agencies, and is widely identified as contributing to the adversarial relationship which has developed in infrastructure delivery in Australia[98];

- Public Private Partnerships (PPP). Have been used widely across many jurisdictions, with mixed results, ranging from widely held success to embarrassing failure[99]. Essentially it involves a contract between the government and the private sector "to deliver infrastructure and related services over the long-term"[100] that will then operate and maintain it to an agreed standard over a contractual period;

- Relationship contracting and the Alliance Model. This is rapidly emerging as a preferred model for delivery for many agencies, with greater emphasis on early and ongoing involvement of the client in working with the contractor[101] "The participants – the client and the members of the contracting consortia – assume collective responsibility for delivering the project and collective ownership of all associated risks – and they collectively share in the pain or gain based on predetermined targets to which they have jointly agreed"[102].

The Queensland Government has identified traditional procurement methods as being unsuitable for complex and risky projects and identifies a trend towards 'adversarial behaviours'. Importantly, the alliance "model has also been seen to provide an opportunity for providing hands-on experience and development for their younger engineers"[103]. The Australian Contractors Association identifies the key benefits of relationship contracting as "enhanced business relationships and improved behaviour of the parties to the contract, especially where the contract experiences practical and/or financial difficulties"[104]. The alliance model has a capacity for greater involvement of the public

[98] Building the Education Revolution Implementation Taskforce (2011), p58. *Final Report.* Commonwealth of Australia, ACT.
[99] Ibid, pp 58,59.
[100] Centre for Excellence and Innovation in Infrastructure delivery (2010), p36. *Infrastructure options procurement guide.* Government of Western Australia, Perth WA.
[101] Building the Education Revolution Implementation Taskforce (2011), p58.
[102] Global Water Intelligence. *Coming to terms with Australia's 'alliance' contract process.* http://www.globalwaterintel.com/archive/6/8/general/coming-to-terms-with-australias-alliance-contract-process.html. Last accessed January 20, 2012.
[103] Building the Education Revolution Implementation Taskforce (2011), p58. *Final Report.*
[104] Australian Constructors Association (1999), p15. *Relationship Contracting. Optimising Project Outcomes.*

sector throughout a project, reduces risk and has the capacity to improve the development of the engineering workforce.

Blake Dawson also identified the alliance model as optimal in the delivery of projects, with 67 per cent of respondents believing that this method saw projects "delivered on time/budget/to required quality"[105]. This is in contrast to 48 per cent overall for all models of procurement, and just 38 per cent for public private partnerships[106]. Moves by some jurisdictions towards 'competitive alliancing', where teams are embedded in processes for long periods prior to a final 'winner' being determined are to be discouraged. This simply provides for higher bid costs and discourages industry from future project involvement.

It should be noted, that at the instigation of partners in ANET, Consult Australia and APESMA recently approached Senators and requested consideration of an inquiry being conducted into matters related to procurement and delivery of infrastructure and the relationship with the effectiveness of that due to the shortage of engineers and the nexus between infrastructure delivery and the shortage, which this report is expected to inform the considerations of. Key issues under consideration, which are relevant to workforce development, are those which go to examining procurement models which foster collaboration and skills development.

It should also be noted that the Victorian Parliament's Public Accounts and Estimates Committee is currently conducting an "inquiry into effective decision making for the successful delivery of significant infrastructure projects", with terms of reference which include " the competencies and skills that public sector managers require for the effective evaluation, decision making and oversight of significant infrastructure projects and protection of the public interest" and "the extent to which Government policies such as the National Public Private Partnership Policy and Guidelines and the Partnerships Victoria Requirements specify these requisite competencies and skills, and support the Department of Treasury and Finance's application of these across the public sector", "strategies in place within the public sector for the development of such requisite competencies and skills" and an examination of "relevant infrastructure delivery strategies and practices"… "in relation to enhancing (the) public sector"[107].

[105] Blake Dawson (2011), p21. *Scope for improvement. Project risk – Getting the right balance and outcomes.*
[106] Ibid.
[107] Victorian Parliament Public Accounts and Estimates Committee. *Inquiry into effective decision making for the successful delivery of significant infrastructure project*. http://www.parliament.vic.gov.au/paec/inquiries/article/1500 last accessed 11 January 2012.

Issues relating to procurement and skills development, within both the private and public sector, are topical. Government is recognising the need for value and enhancing their internal capacity while industry has suffered due to the risk shifting under many current procurement practices.

Leveraging infrastructure procurement for workforce development.

With the shortage of engineers felt across the public and private sector and increased contracting-out of public infrastructure delivery, the responsibility for training of the workforce is falling on the private sector. Procurement processes however gives no support to the private sector for this training function. Commonwealth Procurement Guidelines state that "value for money is the core principle underpinning Australia Government procurement ... and requires a comparative analysis of all relevant costs and benefits of each proposal throughout the whole procurement cycle.[108]" However it is clear that these guidelines provide no incentive for private contractors to improve workforce supply or training, an issue exacerbated due to the existing limited availability of engineers and the constraints it places on the private sector.

This may be an effective way to derive short-term value, but over the longer term it results in an under-investment in skills and training and resultant increases in costs and problems in project delivery. This is seen in falling industry investment in training and professional development, with just 29 per cent of firms surveyed by Consult Australia spending more than three per cent of payroll expenditure on training and professional development, with 63 per cent of firms reporting spends between one and 2.9 per cent[109]. In 2009, the *Victorian Skills Summit* recommended consideration of "the application of a 'training levy' that will apply to all civil construction contract works… for the sole purpose of financing industry oriented and focused training initiatives"[110].

The Queensland Government has mandated apprentice, trainee and cadet commitment across building or construction projects through their *Building and Construction Contracts – Structured Training Policy,* while levies also exist in other jurisdictions. This is not the first document to identify the failings of current procurement practices in delivering workforce development, nor does it propose the first set of solutions.

[108] Australian Government, Department of Finance and Deregulation, Commonwealth Procurement Guidelines – December 2008. http://www.finance.gov.au/procurement/procurement-policy-and-guidance/CPG/division-1.html#value Last accessed 7 February 2012

[109] Consult Australia (2011), p14. *The Consult Australia 2011 Skills Survey: An analysis of skills in the consulting industry for the built and natural environment.* Sydney, NSW.

[110] Victorian Civil Construction Industry Alliance (2009), p11. *Victorian Skills Summit, 2009.* Melbourne, Victoria.

We do not propose that a training levy is a model for the future. Levies do not necessarily deliver value for money, do not encourage innovative solutions for training delivery by the private sector and historically tend to focus on construction-industry trades.

If engineers bring science to reality, then construction workers deliver that reality. Thus, it is critically important that there is investment in engineering training and education, especially as the work of engineers serves to ensure the safety of all of those who perform work in the completion of the project. There remains a capacity to harness the Commonwealth's infrastructure investment to ensure that projects are not only delivering in an immediate sense, but also contributing to necessary skills development to ensure a sustainable infrastructure provision market, of which engineers are the key component.

Current practice in procurement is not encouraging skills development, and the private sector is limited in what it can do within the constraints of a stretched workforce driven by the skills shortage. Further, adversarial behaviours are the enemy of innovation as it impairs the sharing of knowledge, erodes confidence and impedes the use of new practices. The 'patchy', project-by-project nature of work delivered through current procurement practices provide a disincentive to long-term workforce planning, and recent government decisions in this regard to provide for longer term planning of infrastructure delivery is to be commended.

If the government again becomes an informed purchaser, it will still continue to rely on the private sector for delivery. Therefore to protect taxpayer's interests, the government must take an ongoing interest in the capacity of the private sector to deliver and as such must always have a role in training and in continued learning and professional development throughout the careers of engineers.

Cadetships involve the employers supporting the student through university. During university they work for the employer receiving practical experience. After completion of their qualifying degree studies, they participate in a structured graduate program. This has multiple benefits including encouraging students into engineering courses, through reducing dropout rates at university and ensuring structured development of the engineer after completion of their degree.

As part of assessing the merit of a bid for a government project, 'value for money' is of course the most important determinant of success. As outlined herein however, that is now resulting in an under-investment in education and training. Over the longer-term, it is adding to cost by diminishing the pool of available labour and increasing project costs and project over-runs through a lack of capacity in the public sector. We have previously made suggestions as to how the public

sector can improve its 'informed purchaser' capacity. With the public sector increasingly relying on the private sector for delivery, it too should play its part, but only with an appropriate level of incentive and reward, in recognition of the important role that it has and will continue to have in both infrastructure delivery and in workforce development.

To encourage greater investment in training by employers, government implementation of an education and training tax concession is encouraged. The model proposed by ANET is that when expenditure on education and training activities exceeds two per cent of payroll per year, employers are rewarded with a concession rate of 125 per cent of every dollar that exceeded the two per cent threshold.

A concession rate of 125 per cent will ensure that indirect costs associated with training, such as time spent at training courses, does not act as a disincentive to training.

The target of two per cent is recommended as it is the level that the Department of Immigration and Citizenship requires businesses to meet before being authorised to sponsor foreign workers on temporary resident work visas. The two per cent target also recognises that employers have an ordinary obligation to invest in their staff. The concession eligibility criteria must be broad reaching, and simple for businesses to administer.

Recommendations.

9. That the Commonwealth's Procurement Unit conduct a detailed examination of current procurement models in Australia, and assess the merits, suitability, longer term consequences of and relative risks associated with each method across all ranges and scope of projects. This research should inform the development of baseline requirements in procurement for Commonwealth funded projects by providing a portal through which procurement methods are assessed on a project-by-project basis.
10. That for all Commonwealth-funded projects, procurement criteria and incentives should be utilised to support and encourage additional training in successful bidders, including the revival of graduate programs and cadetships.
11. The Commonwealth Procurement Unit should, in consultation with the Australian National Engineering Workforce Development Council, identify models of procurement and procurement criteria which support and provide incentives to the private sector to undertaking additional training. These procurement criteria should provide recognition of firms tendering who are already undertaking substantial training. Training arising from procurement criteria and incentives should be readily and simply identifiable. The models developed should recognise training plans and programs could go beyond the term of the project.
12. Similar to traineeship funding, government should subsidise or provide tax incentives for industry-sponsored cadetship programs and other workplace-based programs undertaken by engineering students.
13. The Commonwealth Government should consider the introduction of an education and training tax concession for employers that spend more than two per cent of payroll per year on training at a rate of 125 cents for every dollar spent on training.

6. Addressing the causes of the shortage – increasing the diversity in the workforce.

The engineering workforce lacks appropriate levels of diversity, with few women engineers and a marked under-representation of migrant engineers as against their share of the engineering workforce in Australia. This represents a real opportunity to expand the engineering workforce.

Large numbers of qualified engineers apparently do not work as engineers, with just over 57 per cent of the engineering workforce actually employed in an engineering capacity. Unemployment is higher among migrant engineers at 4.3 per cent, as against 1.8 per cent for the Australian born workforce[111] and just over 50 per cent of the overseas-born workforce is employed in engineering occupations[112]. While women represent 16 per cent of new graduates, they still comprise only ten per cent of the overall engineering labour force[113].

This reveals real untapped capacity to expand the existing engineering workforce, while at the same time increasing the diversity of the engineering workforce by increasing the number of women engineers and improving the way we use the existing resource of migrant engineers and those who have left or are leaving the profession.

Migrant engineers. Maximising the benefits.

A submission to a recent parliamentary inquiry into migration and visas stated that "migrant engineers are a vital element in generating new ideas and approaches to engineering, and for providing skills where there are shortages"[114]. The international nature of the engineering workforce and the great mobility across jurisdictions does much to foster international and domestic innovation. There is a large pool of migrant engineers which Australia needs to access to provide immediate relief to our engineering skills shortage[115]. Changes to our immigration program which aim to ensure professional competence and sufficient English language skills to allow for employment clearly are not providing the set of foundations needed to allow migrant engineers to find appropriate employment within the engineering workforce.

[111] Kaspura (2011), p6. *The Engineering Profession. A Statistical Overview, Eight Edition*
[112] Ibid., p10.
[113] Ibid., p46.
[114] Kathryn Hurford, Kim Rickard (2007), p1. *Submission to the Joint Standing Committee on Migration Inquiry into Temporary Business (Long Stay) 457 Visas.* http://www.aph.gov.au/house/committee/mig/457visas/subs/sub054.pdf last accessed 21 January 2012.
[115] Ibid.

For overseas engineers seeking to migrate to Australia permanently, Engineers Australia is the assessment authority responsible for assessing and ensuring the competence of the applicant to perform engineering duties in Australia. In this respect, Engineers Australia assesses whether or not the applicants overseas engineering qualifications can be recognised as equivalent to Australian engineering standards[116]. Engineers Australia is appointed to this role by the Department of Immigration and Citizenship [117].

Previous comments by ANET member bodies and by stakeholders have outlined some of the difficulties faced by migrant engineers broadly as being that:

- Employer doubts as to the appropriateness of their qualification;
- A lack of cultural familiarity and a difficulty adjusting to the Australian regulatory environment;
- Difficulties with the job application process and to present relevant local experience;
- Cultural barriers.

Comments in the recent survey conducted by APESMA provided further illustration of the nature of the problems for foreign born engineers assimilating into an Australian work environment. "Maybe the government can subsidise an employer for employing and training up a foreign engineer (there's a difficulty with communication and cultural differences - in the way things are presented, a different way of structuring reports and replies to questions)"[118]. Assimilation to the Australian engineering environment, from the job market to the regulatory environment are pressing issues, as are addressing scepticism about the adequacy of a person's qualifications.

Given the historical dependence of Australia on an imported engineering workforce, and the important role they have played in the delivery of a number of critical infrastructure projects, the fears of team members and employers should be able to be satisfactorily addressed. More needs to be done to communicate with employers the effort undertaken to ensure the competence of migrant engineers, and more needs to be done to provide support to migrant engineers in understanding the Australian regulatory environment, workplace practices and ensuring they have the basic skills needed to discharge their duties.

[116] National Engineering Registration Board (2011), p8, p11. *The Regulation of Engineers. Finding the right approach for a national economy.*
[117] Kaspura (2011), p55. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[118] APESMA (2011). *Membership survey on departing engineers.* Conducted December 2011.

Engineers Australia identifies "A lack of communication skill is typically the greatest impediment to foreign engineers entering the workforce in Australia" and that their "orientation programs address this skill"[119]. Such orientation programs are not mandatory however, and as baseline, many employers feel that minimum English language requirements for independent migration as an engineer is too low. An International English Language Testing System (IELTS) level of 7.0 is "expected of professional engineers who seek to gain employment or offer professional services as a consultant in Australia, though this is not specifically tested"[120]. That is above the minimum IELTS score that is the legal minimum required for independent migration.

There are a variety of orientation and support programs offered for migrant engineers, from mentoring programs to employment skills training, sometimes incorporating work placement across the VET and community education system. These are not systemic, and they do not seem to have external assessment of efficacy. Engineers Australia does record much greater success in job placement for individuals who participate in their programs. Gaining greater promotion and integration of such programs could easily be facilitated through a national, mandatory, statutory registration scheme for engineers.

Making the engineering profession more attractive to more women.

The Federal Government recently reported that "almost 4.8 million women were in some form of paid employment in January 2008, with a labour force participation rate of 58 per cent"[121].

The under-representation of women in the engineering workforce represents both a problem and an opportunity in addressing the engineering skills shortage over time. While progress is being made and an increased number of female graduates are being seen, this is an area of supply which presents itself as needing urgent action, especially as the problem seems to be both one of supply and demand. Unemployment amongst female engineers is almost double that for the male cohort[122], while there is insufficient interest in engineering careers amongst women, and "without additional and significant growth in female applications, little change is likely"[123]. The previously outlined results of the school-aged survey conducted for ANET underlines the gender gap in interest in engineering careers.

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[119] Michael Bevan (2008), p3. *EMF IRPE Benefits List – Amended June 2008*. Engineers Australia, Barton, ACT.
[120] Ibid., p4.
[121] Department of Foreign Affairs and Trade. *Women – toward equality.* Australian Government. http://www.dfat.gov.au/facts/women.html. Last accessed 22 January 2012.
[122] Kaspura (2011), p8. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[123] Ibid., p 27.

Unfortunately, many of the perceptions of engineering as being male-dominated as a profession are reflective of reality, so a longer-term approach is needed. The work of ANET partners in this regard is also to be commended, and in particular their efforts to promote flexibility in the workplace and to promote role models. However, such is the nature of this problem that the government should be expected to play a role, much as they have in the past in increasing diversity in occupations such as policing and teaching. What is required is further cultural change in industry which adapts in recognition that "businesses with a diverse workforce have higher retention levels and greater profitability"[124].

Male Champions of Change is an initiative "of corporate and institutional leaders convened by Elizabeth Broderick, Sex Discrimination Commissioner"[125]. In the recent publication *Our experience in elevating the representation of women in leadership. A letter from business leaders*, they identify that CEO commitment and leadership is key to bringing about cultural change. They identify a phased approach, evolving from support mechanisms for women in the workplace, to the adoption of diversity councils and the eventual entrenchment of diversity as a cultural norm[126]. The "'anytime/anywhere' business culture and the 'double burden' on women who are likely to take up more family commitments outside of work hours"[127] are cited as the biggest obstacles to women progressing in the workplace. Progress has been made in the engineering workforce in this regard. Engineers Australia's 2008 survey showed across-the-board improvement in workplace flexibility, with access to carer's leave and maternity leave increasing markedly from 1999, and a notable increase also in the part-time work, flexible hours and job sharing[128].

However, APESMA's *The State of Play* identifies that women typically earn 8.5 per cent less than their male counterparts at times when they are considering commencing family obligations[129], while 71.6 per cent of engineers "said that taking maternity/parental leave (including unpaid leave) was likely to be detrimental to their career", and "nearly 60 per cent… agreed that in their occupation,

[124] Cited by Engineers Australia Women in Engineering National Committee (2011). *Women in Engineering National Committee Position Statement.* http://www.engineersaustralia.org.au/sites/default/files/shado/Learned%20Groups/Interest%20Groups/Women%20in%20Engineering/WIENC_gender%20equality%20position%20statement_final.pdf Last accessed 22 January 2012.
[125] Australian Human Rights Commission (2011), 'Dear Colleague'. *Our experience in elevating the representation of women in leadership. A letter from business leaders.* Australian Human Rights Commission, Sydney NSW.
[126] Ibid., p5.
[127] Ibid., p26.
[128] Engineers Australia Women in Engineering National Committee (2008), p3. *Valuing the difference. An update on the progress of women in the engineering profession.* Engineers Australia, Barton, ACT.
[129] APESMA (2010), p4. *Women in the Professions: The State of Play 2009-10. Executive Summary.* APESMA, Melbourne Vic.

women have to prove themselves where men are assumed capable" [130]. While the situation may be improving in relation to the offer of flexible workplace practices, there still needs to be significant work undertaken to change the culture of engineering workplaces.

It is apparent workplace flexibility is widely considered to be the key in the development of a diverse workforce and to improving Australian productivity. There have been attempts by government to entrench rights to reasonable requests for flexibility[131][132], in an effort to ensure that workforce diversity becomes both the norm and a focus. Working in teams is a foundation for this approach, as where there is reliance on one individual, there is little scope for that individual to have flexibility in the workplace, especially given the demanding roles which many engineers perform.

Appropriate mentoring arrangements are the key to fostering engineering talent more broadly, but especially with women entering the workforce. The window for our ageing engineering workforce to properly mentor young talent will not be open for ever. The most recent work of Godfrey and King contains a number of recommendations in this regard which again warrant consideration and implementation. Careful consideration must also be given to who plays the role of mentor with young women. Male mentors may in many cases be more appropriate and such relationships can also contribute directly to cultural change.

Current procurement practices which have encouraged adversarial relationships do not foster flexible work practices. Changes to procurement practices again must play a part in any systemic solution to the shortage of women in engineering, as an environment where staff are involved in constant problem mitigation and dispute resolution cannot serve to encourage workforce diversity. Recognition of efforts to improve workforce diversity by industry should also be encouraged through procurement practices, where the Commonwealth Government can again exercise leverage. This is achievable through existing provisions under the *Equal Opportunity for Women in the Workplace Act 1999* and further strengthening of the Act that is expected to be implemented in 2012[133].

The awarding of the Y*oung Australian of the Year* to female engineer Marita Cheng presents a great opportunity to continue to lift the status and profile of the profession among school-aged girls. By gaining the award, she has already provided real demonstration of the Federal Government's

[130] Ibid., p7.
[131] Government of Victoria (2008). *Equal Opportunity Amendment (Family) Responsibilities Act 2008 (Vic).* Victorian Parliament, Melbourne.
[132] Commonwealth Government (2009). *Fair Work Act, 2009.* Commonwealth Parliament, ACT.
[133] Australian Government, Equal Opportunity for Women in the Workplace Agency. http://www.eowa.gov.au/reporting_and_compliance/Complying_with_the_Act/Sanctions_for_not_Complying.asp last accessed 27 February, 2012.

commitment to the field and acknowledgement of the efforts of many individuals, and especially her, in increasing female interest in engineering careers.

Both the private and public sector must work in unison to address this problem, and be properly supported and encouraged to deliver outcomes over the longer term. Continuing to increase the supply of female engineering graduates, while at the same time addressing the cultural issues within engineering workplaces are key elements of a successful approach, and will ultimately succeed in addressing both supply and demand.

Increasing participation and retention by the engineering workforce.

The ABS reported that in 2006 Australia had over 305,000 qualified engineers (encompassing undergraduate, graduate and post graduate qualifications), with approximately 250,000 of these in the engineering workforce (with only 2.9 per cent of these unemployed)[134]. This is conservative as it excludes engineers with MBAs[135].

Just 142,822 or 57 per cent of the engineering workforce are reported to be employed in engineering occupations, with nearly 67,000 either unemployed or not employed "in a manner commensurate with their training and could not be said to be productively used" [136]. So, within the available cohort of qualified Australian engineers, there are significant resources that could be immediately brought to bear to ease the skills shortage in engineering.

For those qualified engineers who are not working in the profession, many of the measures already outlined herein could have effect on their future choices and may see them again consider engineering as a viable career option, with the profession given greater visibility and worth, and with a greater provision of support and focus by government.

Significant effort has been placed on similar measures and incentives for return by State Governments in recruiting teachers and nurses back into those professions to address similar skills shortages, with some success, albeit success drawn from a workforce which in some cases had left involuntarily. The shortage of engineers seems to be exacerbating the workload of engineers and driving them into retirement, with a survey recently conducted by APESMA showing 80 per cent of

[134] Kaspura (2011), p6. *The Engineering Profession. A Statistical Overview, Eight Edition*.
[135] Ibid., p3.
[136] Ibid., p6, p9.

respondents believed that engineers were leaving their workplace due to increased administrative and managerial tasks[137].

Increased flexibility in the workplace again may provide a solution to these problems with more than 60 per cent of respondents saying in response to a survey "that the opportunity to work the same role but on a more flexible basis would be a reason to stay. In the same vein, over half said that working in a similar role but with reduced hours and less responsibility would see them working beyond the traditional retirement date"[138]. Again, a stretched workforce and the consequences which flow from that are contributing further to the skills shortage as people make the decision that their work-life balance has become skewed as they get closer to retirement, while industry cannot adequately respond to these issues in the context of severe skills shortage.

Flexibility in the workplace bears dividends for employers and employees, delivering improved morale, longevity, loyalty, job satisfaction and making the employer a destination of choice[139]. However, herein lays a difficulty within the engineering profession. It is strained due to the skills shortage, with longer average working hours than other professions, and with commensurate recruitment difficulties[140]. These stresses means the profession will struggle to facilitate the entrenchment of flexible workplace practices in the immediate future. Any improvement in this regard will take place over time, and should be an ongoing focus of dialogue between government and industry. An opportunity to support this may exist through a renewed focus on VET level qualifications to improve the mix of skills within the engineering workforce. This would help alleviate the strain on professional engineers, while encouraging industry and government to plan their workforce more carefully, with retirement plans an integral part of this effort.

The ageing nature of the engineering workforce is an issue across the private and public sector, as outlined earlier. However, a more pressing one for the public sector, with the average age of engineers in that sector at 45.3 years - more than six years higher than that of the private sector.[141] This has the capacity to further erode the informed purchaser capacity of the public sector if the ageing nature of the workforce is not addressed through previously outlined measures.

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[137] APESMA (2011). *Membership Survey on engineering shortages*.

[138] Catriona Byrne (2010). *Flexible mindset required to solve the ageing workforce puzzle.* Workplace flexibility. http://www.workplaceflexibility.com.au/flexible_mindset_required_to_solve_the_ageing_workforce_puzzle.html last accessed January 29, 2012.

[139] Workplace flexibility. *Why implement workplace flexibility?* http://www.workplaceflexibility.com.au/why_implement_workplace_flexibility.html last accessed January 29, 2012.

[140] Graduate Careers Australia (2011), p4. *Beyond Graduation 2010.*

[141] Kaspura (2011), p63. *The Engineering Profession. A Statistical Overview, Eight Edition*.

In facilitating the mentoring of inexperienced engineers, there are particular pressures on asset owners driven by the required delivery of a 'productivity dividend' year-on-year, whereby they are required to reduce operational costs by a set percentage. The pressures applied to asset-owners in this regard are manifested by increased workloads for staff, the limitation of recruitment and represents a barrier to enabling proper mentoring programs[142].

Australia will need to harness the skills of these experienced employees in training and developing the wider engineering workforce before they enter retirement. Workplace flexibility, transition to retirement plans, mentoring roles and careful workplace planning have the potential to successfully manage this issue and provide benefit to the goal of expanding Australia's engineering skill base.

ANET members, in consulting with their membership, have identified that engineering as a field evolves quickly. As innovators and drivers of technological change, a brief period out of the workforce can result in a loss of knowledge which could impair re-entry to the workforce. This is a barrier which could easily be overcome and provide a 'bridge' back to employment for many engineers who have departed the workforce.

[142] Australian Public Service Commission (2008). *State of the Service Report.* http://www.apsc.gov.au/stateoftheservice/0708/six.htm last accessed 22 February 2012.

Recommendations.

14. That the Office of the Australian Engineer develop materials for CEOs and governmental leadership which identifies the competence of migrant engineers and the equivalence of their qualifications, whilst also identifying best practice in workplace support.
15. That, following a detailed assessment of the effectiveness of current offerings, an orientation program for migrant engineers be established as part of a national registration scheme, with funding sourced from the Federal Government. The English language requirements of the current migration program for engineers should be assessed with industry to ensure current requirements are adequate.
16. That in developing a marketing and promotion program for teachers, students and the wider public on the engineering profession, the Office of the Australian Engineer ensure adequate representation of women and the role they play in the engineering workforce currently, what role they might play as part of solution to our skills shortage and that consideration be given to appointing an ambassador for young women in engineering.
17. That within the marketing campaign for the engineering profession, a specific effort be made to target retired engineers and qualified engineers not working as engineers to try and attract them back into the profession. A large study of employment paths of individuals with both Australian and overseas engineering qualifications should be undertaken to supplement evidence from census data.
18. That a grants program for engineering bridging courses be developed for industry to allow re-entry to the workforce for departed engineers. Eligibility and course criteria can be developed with the assistance of the Office of the Australian Engineer.
19. That the Federal Government establish grants program for engineering mentoring programs in the public service across all jurisdictions, which would represent a wage subsidy for two years to enable the employment of graduates and retention of experienced engineers for the purpose of mentoring new entrants.
20. That as part of the effort to ensure all Australian governments are informed purchasers, particular effort should be made to ensure all jurisdictions have in place adequate administrative support, transition to retirement plans, workplace flexibility and mentoring by older engineers for new employees.
21. That Government procurement officers be trained to consider compliance with the *Equal Opportunity for Women in the Workplace Act 1999* as a condition to the awarding of contracts for the purchase of goods and services.

22. That Government officers be trained to consider compliance with the *Equal Opportunity for Women in the Workplace Act 1999* for eligibility for grants under industry assistance programs.

7. Conclusion.

Contained within this document are practical solutions to what has become an enduring problem. With a renewed focus on building an innovation economy and increasing educational attainment, we cannot afford to ignore the most important – and practical – innovators of them all - Australia's engineers.

These recommendations are shared solutions from industry, the profession, educationalists and the labour movement. We look forward to continuing to work with governments throughout Australia to deliver a systemic solution to the engineering skills shortage in Australia to ensure we are equipped to build a modern Australia, ready to take its place in the world not just as the lucky country, but the clever country.

8. Consultations.

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