SUBMISSION TO SENATE STANDING COMMITTEE ON EDUCATION, EMPLOYMENT, AND WORKPLACE RELATIONS

Inquiry into the shortage of engineering and related employment skills

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CONTENTS

SUMMARY

1. Based on surveys conducted by Engineers Australia there is evidence of a shortage of engineers in Australia. The findings of these surveys support the considerable amount of anecdotal evidence that such a shortage exists.

2. However, the evidence provided by salary movements does not appear to support the view that there is such a shortage. Despite this, the high level of permanent immigration of overseas qualified engineers would appear to provide evidence of a real shortage.

3. In spite of the much improved public information concerning engineers there is still a considerable misunderstanding of the nature of engineering and the roles of engineers. These misconceptions may be among the reasons that young people have been less inclined to opt for a career in engineering than was once the case.

4. The number of persons completing first (bachelor) degrees in engineering has not increased in the period 1995 to 2009. Furthermore the proportion of the relevant age group completing engineering degrees has declined.

5. Relative to population Australia graduates fewer engineers than all but two of the OECD countries. The Australian graduation rate is less than half the OECD median.

6. The number of civil engineering graduates is now no higher than it was in the late 1970's and relative to population it is very much lower. In 1977 forty per cent of engineering graduates were civil engineers; now the proportion is seventeen per cent.

7. The current level of immigration can only be described as spectacular. While a high level of immigration of engineers no doubt avoids a severe shortage it also limits any pressure to increase engineers' salaries. An increase in salary levels would be one way to encourage young people to undertake the onerous studies involved in acquiring an engineering education.

8. The analysis of engineering supply and demand is hampered by the inadequacy of the available data. Analysts would be considerably assisted by the existence of a data base equivalent to that maintained by the National Science Foundation of the United States.

1. Introduction

Worldwide, a total of 1,985,714 persons graduated in engineering with bachelor degrees in 2008. This was roughly twice the number which graduated only six years earlier. In 2008, 1,066,439 persons graduated in the natural sciences, that is the physical and biological sciences. Six years earlier the number of graduates in the natural sciences was 699,110 These figure reflect the emphasis that the countries of the world have placed on engineering education .Australia appears to have a different approach.

While in 2008, 5,290 Australians completed engineering degrees, 0.3 % of the world total, 11,104 persons or 1% of the world's total, completed first degrees in science. The nations of the world now graduate two engineers for every scientist while Australia graduates two scientists for every engineer. Relative to population Australia's engineering graduations are almost the lowest in the OECD, we graduate more natural scientists than any other country with one or two exceptions.

The comparatively low rate of engineering graduations in Australia has been evident for many years. Data published in a publication sponsored by the then Association of Professional Engineers, Australia (Rice, M.R., 1969) indicated that, even then, many other countries exceeded Australia's output of professional engineers. In view of the long and persistent history of a low level of engineering graduations in this country it should be no surprise that eventually there would be an inadequacy of the supply of engineers.

Modelling undertaken as early as 1991 indicated that there would be a diminishment of the rate of growth of the Australian engineering profession in the first decade or two of this century unless graduations were markedly increased. Even with substantial immigration the growth rate of the profession would inevitably decline to a much lower level that has prevailed over the last 50 years. The warnings arising from this work were ignored.

2. Evidence of a shortage of engineers

Engineers Australia's report on the current state of the engineering profession (Engineers Australia, 2011) includes a discussion of the findings from surveys of employers regarding the difficulty of recruiting engineers. The surveys demonstrate continuing difficulties in recruiting engineers particularly those with several years' experience.

The web site of one particular employment agency carries a large number of advertisements for professional engineers. The total number of these advertisements declined at the time of the financial crisis but there was a recovery in recent years. Currently the number of jobs for engineers advertised on this site is nearly 20,000 while the total number of jobs for engineering managers is nearly 9,000. These are dramatically large numbers considering that my estimate of the current total number of persons under 65 years of age with professional engineering qualifications is approximately 200,000. In fact, bearing in mind that the ABS estimate of the proportion of that number that is actually employed in engineering roles is less than two-thirds, the level of advertising is even more remarkable. It is difficult to accept that this level of advertising is not a clear demonstration of a shortage of engineers in Australia.

It might have been thought that, if there is, in fact, a substantial shortage of engineers, there would have been an increase in the salary levels of engineers relative to some such measure as adult male wages. It might be also have been assumed that the ratio of engineers' salaries to average weekly earnings might provide an indication of real movements in engineers' income relative to that of the community would provide evidence of a shortage. However, I have found that the belief that there is a shortage of engineers in general and of civil engineers in particular does not seem to be supported by the current trends in salaries for young engineers. Whether this is the attributable to an exaggeration of the evidence of an apparent shortage of engineers or reflects the "stickiness" of wages is a matter for further investigation. I am inclined to believe the latter is the case.

The data of table 1 confirm that the relativity of private sector salaries for young engineers has depreciated over the last ten years, the relativities for public sector engineers of equivalent experience has, for all practical purposes remained unchanged.

Table 1 — Ratio of base salary to average weekly earnings for engineers of all specialisations with 1 to 3 years' experience.

Period	Private sector	Public sector	All sectors
June 2000	1.02	0.99	1.01
June 2005	0.90	0.91	0.91
June 2010	0.95	1.01	0.99

Source : Derived from data in various editions of "Professional Engineer Remuneration Survey Report", Association of Professional Engineers, Scientists and Managers, Australia.

Because of the decline of the relative salaries of young engineers between 2000 and 2005, there is the appearance of a subsequent improvement of the salary position of these engineers, but it is clear that the changes since 2005 have, in the case of public sector engineers only, have served to restore the status quo of 2000. If true, the decline is difficult to explain. While there was a slowdown in the economy in late 2000 – 2001 with consequent unemployment of engineers, it would be surprising if its effects on engineering employment persisted until 2005.

Table 2 relates specifically to civil engineers, the group commonly regarded as being in shortest supply in Australia. Two things are apparent from the data in the table. First, there has been little improvement in the relative salary position of the young civil engineers in the private sector over the ten year period and that of the public sector engineers has worsened. Of course there has been some improvement over the period since 2005 but the general picture over the longer term indicates that nothing much has changed.

Table 2 — Ratio of base salary to average weekly earnings for civil engineers with 1 to 3 years' experience.

Period	Private sector	Public sector
June 2000	0.93	0.99
June 2005	0.89	0.89
June 2010	0.95	0.93

Source : As for Table 1

Second, the supposed greater shortage of civil engineers have has not resulted in a dramatic improvement in the salary relativity between civil engineers and engineers in general. The salaries of young civil engineers appear to be no more attractive than they have been in the recent past.

If the widely publicised shortages are real, despite the operation of the laws of supply and demand there has been no response to these shortages as economists would have us expect. This requires explanation.

3 Misconceptions concerning the engineering profession.

There are a few common misperceptions of the engineering profession and its roles. These should be kept in mind in considering possible causes of shortages of engineers.

A study published by in the UK (The Royal Academy of Engineering , 2007) summarised an analysis of a survey of public attitudes to the engineering profession. Included in the findings of the study were the following :

- "A limited ... awareness and understanding of engineers and engineering was identified."
- "Overall awareness and knowledge was found to relate to demographic characteristics, such as social class, education., gender and age. Younger people in particular were found to have a much more limited understanding of engineering in comparison to other groups. ..."
- "Understanding of engineering and the work of engineers was limited to construction and fixing things"
- "Confusion around engineering was in part seen as stemming from the wide and often misleading use of the term 'engineering'."

These findings would be applicable to Australia although perhaps not to the same extent. However, the image of the engineer as a manual worker acting as a fixer or constructor is clearly uppermost in the minds of many as is evident from the repeated use of the hackneyed photographs of helmeted engineers in the newspapers. These illustrations are not helpful in presenting the true image of engineering to the uninformed. The problem is exacerbated by the continual reference to the so-called "engineers" who service aircraft. There is little or no appreciation of the role of the professional engineer in the design of advanced devices and machines let alone in research and development. It is a little acknowledged fact that there would be no research and development in the manufacturing sectors of advanced industrial countries without engineers; scientists are not educated or trained to design and develop sophisticated industrial products such as computer equipment, cars, aircraft and photographic equipment. There are very few physicists and chemists working in manufacturing industry of other countries and even fewer in the R&D function in that sector. For example there are only about 1,000 physicists in the American manufacturing sector. Since there are approximately 600,000 researchers in that sector and not all physicists are involved in R&D their contribution is negligible. There are however 750,000 engineers employed in the manufacturing sector.

One of the greatest and most persistent misconceptions is the belief that space flight is a product of science. This belief is exemplified in the unrelenting use of the term "rocket science". There is no such thing as rocket science. From the time of the earliest NASA space missions, spacecraft and their operation have been the responsibility of engineers rather than scientists.

These misconceptions are among the factors that affect the thoughts of young school students when they consider their future career options. Clearly, until such misconceptions are overcome the achievement of significantly greater enrolments in professional engineering courses will be more difficult than it otherwise would be.

The problem of the community's misperception of engineers and engineering has often been cited as one for the engineering profession itself to rectify. However, since Australian society's misunderstanding of the profession's nature is not of the profession's making , why should it be up to the profession alone to accept the responsibility and the burden of the task? Furthermore, since the benefits that would accrue from a truer community perception of engineers and their work would flow to the community, there is every reason for the community to accept that onus.

Recommendation 1.

The Committee give consideration to the establishment of a means of communicating to young people and the wider community the nature of the roles of engineers and the work of the engineering profession. It would also be helpful if consideration was given to the replacement of the title of Licensed Aircraft Maintenance Engineer by the internationally recognised title of Licensed Aircraft Maintenance Technician.

4. Course completions in engineering 1995 – 2009

4.1 Introduction

The data in this section relate degrees in engineering whereas the data published by the Department of Education, Employment and Workplace Relations (DEEWR) which purport to relate to engineering in fact relate to a field of education described as “Engineering and Related Technologies”. In the main the “related technologies” have no relation to engineering as it is normally understood. For instance some of these technologies relate to such activities as air traffic control and marine operations which certainly have nothing to do with engineering. As a consequence of the inclusion of the graduates in the Related Technologies in the statistics published by DEEWR results in a misleading inflation of the graduation data. The correction of the data to exclude the unrelated technologies results in an apparent discrepancy between the information published by DEEWR and that published in the report published by Engineers Australia regarding the state of Australian professional engineering workforce.

4.2 Number of course completions 1995 – 2009

Until 2009 the number of course completions in engineering degrees at bachelor degree level has shown little variation from the level attained in 1995. The number of such degrees awarded in each of the years over the period 1995 to 2009 is tabulated at Appendix A. It may be seen from the tabulation that the number of engineering degrees peaked at 5,550 in 1998. The lowest number of engineering degrees awarded since 1995 occurred in 2005 when 4,553 degrees were awarded.

The number of course completions in 1998 was equivalent 294 per million population. From that time the ratio of engineering degrees to population declined to a minimum of 222 in 2005. Since that time the ratio has recovered to 244 in 2009. Consequently the ratio is still 17% below the level achieved in 1998.

Data relating to commencements in professional engineering courses at bachelor degree are unavailable . However, the data relating to university commencements in the field of Engineering and Related Technologies (E&RT) between 2000 and 2010 are available. These data may be used to give an indication of the likely future level of completions in courses that would lead to degrees recognised by the Institution of Engineers, Australia as professional engineering qualifications. Course commencements in E&RT have increased by 20% since 2000. It may be assumed that completions in professional engineering degrees will increase by approximately the same amount. Therefore it is possible that the number of degrees awarded to engineering students in 2014 would be 6,300 which would be equivalent to approximately 288 engineering graduates per million population. That would be still lower than the level attained in 1998.

It is instructive to examine one of the possible influences on the level of graduations in engineering over the last 15 years. In 1995 the proportion of Australian males in the relevant age group who completed engineering degrees was 3.2%. By 2000 this participation rate had increased to 3.6% but in the next 5 years it had declined to 2.6%. The reason for this abrupt decline are unknown. By 2009 there had been a slight increase to 2.8%. Because of the growth in the size of the relevant cohort, the number of graduates had increased to a level a little higher than that for 1998.

In the case of females the pattern has been somewhat similar. The participation rate was 0.5% in 1995 and then increased to 0.6% in 2000. By 2005 the percentage of the female cohort who completed engineering degrees had fallen to 0.5%.

If in fact 6,300 engineers graduate in 2014, the participation rate for males would be no higher than 3.6% and for females 0.6%. This estimate is based on the assumption that the proportion of engineering graduates who are female would continue to be the current 14%.

It is clear from the foregoing that has been no increase in popularity of engineering as a career option since end of last century. The contrast with other countries is notable. The world total of students completing first degrees in engineering increased from a little over 1 million in 2000 to approximately 2 million in 2008 (National Science Board, 2002 and 2012). This represented a growth rate of 8.7% per annum. In the case of the European Union alone a similar growth rate of 8.5% per annum was achieved between 2002 and 2008. Setting aside the case of the United Kingdom it could be fairly said that Australia is in an almost unique position in terms of its failure to increase the rate of graduations in engineering over time.

4.3 The number of first degrees in engineering for OECD countries relative to population

Appendix B summarises the most recent available data on the number of course completions in engineering pro-rated to population for OECD countries. The data have been derived from data regarding graduations published by the National Science Foundation of the United States (National Science Board, 2012) with one exception. The data for Australia are derived from the tabulations provided to Engineers Australia by the Australian Department of Education, Employment and Workplace Relations. The population data employed in undertaking the estimates are taken from an OECD source (OECD, 2011).

The reason that the Australian data tabulated in the National Science Foundation publication have been ignored is that those data are clearly incorrect. From my acquaintance with the educational statistics of a number of the other countries I have no reason to doubt the other data with the possible exception of the information relating to New Zealand.

In a note to the Table I have referred to a second ratio for Australia. This was intended to indicate the effect of the high proportion of engineering students who are not Australians. The lower figure of 244 engineering graduates per million population relates to domestic (Australian) graduates alone. The higher figure of 400 graduates per million population relates to all graduates both domestic and foreign.

It is evident that, relative to population, Australia graduates fewer of its citizens in engineering that any other OECD country with the exception of Luxemburg and the United States. The Australian figure of 244 engineering graduates per million is less than half the median figure for OECD countries and 40% of the mean. It is less than one sixth of that for Korea and Finland.

As against Australia's relatively poor performance in engineering graduations, only Finland and New Zealand outperform Australia in terms of the number of graduates in the natural sciences relative to population. In earlier years Australia had led the world in terms of this ratio.

4.4 The case of civil engineering

As early as 2005 there had been complaints about the difficulties created for the consulting engineering industry by a shortage of civil engineers (Charles, T., 2005). It is clear from more recent repeated complaints by employers publicised in the daily press and the findings of surveys conducted by Engineers Australia that the situation has, if anything worsened (Engineers Australia, 2011).

Over 24% of job vacancies for engineers on the web site of one particular employment agency were for civil engineers. The number of vacancies for civil engineering managers was 22% of the vacancies for all engineering managers. Therefore the total number of advertised civil engineering jobs was approximately 6,700. There were only 936 new Australian graduates in civil engineering in 2009 (Engineers Australia, 2011).

I have estimated that, in 2004, 47 % of civil engineers in the public sector were at least 48 years of age. I also estimated that 28% of civil engineers in the private sector were at least 48 years of age (Rice, M. R., 2005). Using the same approach as was previously employed, I estimate that currently, 53% of public sector civil engineers and 37% of private sector civil engineers are at least 48 years of age. These results would appear to indicate that the civil engineer workforces of both the private and the public sectors are aging. The implications for future rates of retirement should give cause for concern.

It is also noteworthy that the ageing of the private sector civil engineer workforce is following the path that has been followed by its public sector equivalent. In 1999 the proportion of public sector civil engineers was about the level now demonstrated by the private sector, that is 37%.

An examination of the historical pattern of graduations of domestic (Australian) civil engineers gives an indication as to why employers are reporting difficulties in recruiting adequate numbers of civil engineers. Appendix C summarises the available data. It is evident that, despite population growth, the number of civil engineering graduates is no higher now than it was in the 1970's and that there has been a loss of interest in undertaking civil engineering studies. In 1977 there 1,035 graduates (mostly male)in civil engineering. In 2009 there 936 such graduates of whom 793 were male. Whereas 40.3% of engineering graduates were civil engineers in 1977 only 17.4% of 2009 graduates were civil engineers.

The data relating to the ageing of the civil engineering workforce indicate that, in the near future the losses from that labour force due to age retirements, premature retirements as a result of disabilities as well as deaths will increase. In the absence of a substantial increase in the number of civil engineering graduates or in the absence of a substantially increased number of immigrants with the appropriate qualifications it is obvious that the magnitude of the civil engineering workforce might begin to decline.

5. Immigration of engineers

5.1 The level of immigration of engineers

A report prepared by Engineers Australia (Engineers Australia, 2011) summarises the level of immigration of engineers to Australia in the period 2000-2009. In that period 34,865 foreign engineers settled in Australia. The average over the 10 year period was therefore 3,487 per annum. In the same period the average number of Australians completing first degrees in engineering was 5,109. Therefore 41% of the gross additions to the Australian engineering workforce were foreign born.

Over the same period the annual number of immigrant engineers has progressively increased from 1,271 to 6,712. Hence of the 12,096 gross additions to the Australian professional engineering workforce in 2009-2010, over 55% were permanent settlers.

Even if one does not accept that there is a shortage of engineers in Australia, it has to be accepted that, in the absence of immigrant engineers, there would have been a considerable shortage by now.

5.2 Emigration of engineers

In the time available I have been unable to obtain recent data on the rate of emigration of engineers from Australia. In earlier years such information had been readily available. In the late 1980's and early 1990's losses due emigration averaged about 14% of new arrivals. About 0.5% of the total number of engineers in Australia were emigrating at that time.

5.3 The consequences of high levels of immigration of engineers

Increasingly, Australia's engineering workforce includes a substantial component of foreign born engineers. A study published by Engineers Australia (Engineers Australia, 2011) points out that between 2001and 2010 the proportion of the engineering workforce that is overseas born has increased from 41.8% to 52.6%. If the immigration of engineers continues at the current exceptionally high level this proportion will increase. This increase will not only be the result of the fact that immigration is exceeding Australian graduations. Since engineers close to retiring age include a substantially smaller proportion of those who were foreign born, the losses due to retirement and premature deaths will automatically reduce the representation of Australians in the engineering population. The gains to the workforce and the losses will both serve to reduce the Australian proportion. A rough estimate indicates that, given a continued high level of immigration of engineers, it would not be inconceivable that within 10 years the proportion of Australian born engineers could decline to 40% or less.

The United States has undergone a protracted period of immigration of engineers in comparatively large numbers. As a result that country's professional engineering workforce now has a large component of foreign born engineers. In 1995, 17% of American working engineers were foreign born (National Science Foundation, 1999). By 2010, 33% of all engineers in America were not born in the United States (United States Census Bureau, 2011). In the later year over 101,000 engineers were unemployed and many more were no longer working as engineers. According to one recent study (Center for Immigration Studies, 2012) "Relatively low pay and perhaps a strong bias on the part of some employers to hire foreign workers seems(sic) to have pushed many engineers out of their profession."

6. The anomaly between National Science Foundation and Department of Education data

The National Science Foundation (NSF) of the United States publishes a biennial report on the state of science and engineering in that country. The report, which is entitled "Science and Engineering Indicators" includes comprehensive tabulations of, inter alia, engineering and science educational outcomes in many countries. One of these tabulations provides data concerning the number of first (bachelor) degrees in a number of science and engineering fields for a large number of countries. Based on my knowledge of the details of the engineering education outcomes of a number of countries the very great majority if not all of the data is, in my opinion, reliable. However, recent editions of the publication have tabulated erroneous data concerning the number of graduations in Australia.

For example, Appendix table 2-32 of the 2012 edition of "Science and Engineering Indicators" states that in 2008, 177,155 persons were awarded bachelor degrees in Australia and 12,489 persons were awarded bachelor degrees in "engineering". Data published by the Department of Education, Employment and Workplace Relations (DEEWR) indicate that, in 2008, 143,151 persons were awarded bachelor degrees and 8,661 persons were awarded bachelor degrees in Engineering and Related Technologies, which is not engineering as such.

One of these anomalies first occurred in the 2004 edition of "Science and Engineering Indicators" and it related to engineering course completions only. Before that edition there was little conflict between the data provided by DEEWR and the data published by NSF.

The conflict between the two sources requires explanation and resolution in view of the falsely optimistic picture of the Australian situation which the NSF's data portray .

Recommendation 2.

That the Committee give consideration to requesting that the Department of Education, Employment and Workplace Relations find a means of eliminating the anomaly between the data published by the National Science Foundation and that published by DEEWR.

7. Attracting more Australian students to undertake engineering studies

The inadequacy of Australia's engineering educational efforts is graphically illustrated by the need for Australia to import large numbers of migrant engineers. Without those engineers this country would suffer from a greater shortage than that which might currently exist. In the absence of an increase in the level of graduations of engineers the need for immigrant engineers will persist and possibly intensify. This is because reliance on immigrant engineers has its drawbacks in the longer term.

While I do not have access to current data relating to the age distribution of immigrant engineers, in earlier years the median age of immigrant engineers was 31. Even if there are no language problems an immigrant engineer has to acquire knowledge and facility in the use of Australian standards and engineering procedures. This takes time. A high proportion of engineers cease to practice their profession in their mid 40's principally because they become managers. Consequently the useful working life of an immigrant engineer will be truncated in comparison with that of an Australia graduate who enters the labour market at the age of 22 or 23.

Surely these considerations indicate the fatuity of continuing to rely on immigration to solve the problem of providing an adequate supply of engineers. It follows that, at the national level there should be an attempt to emulate the efforts of other countries in seeking to increase engineering graduations. The question is : how is this to be done?

Clearly there is reluctance on the part of young Australians to embark on engineering studies. This disinclination must be overcome and therefore the reasons for it need to be overcome. In 1980, Sir Montague Finniston chaired a committee appointed by the British government to review, inter alia, the need for engineers in British industry. In his report (Finniston, 1980) Finniston identified problems relating to the image of engineers in Britain. Much of what was discussed in the report regarding the image of engineers is applicable to Australia. It is noteworthy that thirty years later, the Royal Academy of Engineering saw fit to undertake a review of public perceptions of engineering which revealed that little change had occurred since the time of the Finniston report.

Be that as it may, there would be considerable benefit if public perceptions of engineers and the roles that they perform were improved. This would particularly helpful in attracting more young women into engineering. At the moment about 14% of new engineering graduates are women although their distribution between specialties varies somewhat. Mechanical , electronic and civil engineering are not as favoured by women as chemical, materials and environmental engineering. In some countries much higher proportions of engineering graduates are women . In some cases as many as 30% of engineering graduates are female. Any attempt to improve the community's perception should take account of the need to acquaint women with the true nature of the unpopular specialities.

It has frequently been said that bodies such as Engineers Australia should do more to attract young people and women in particular into engineering. However, since the problem is a community one why should the cost of its rectification fall upon the profession? An effective program to change community perceptions would not be cheap and the entire cost should not be borne by the engineers.

8. The need for reliable data sources

It has always been difficult to obtain reliable and precise data concerning the Australian engineering profession and its members. One example is the Australian Census. The census seeks information concerning the educational qualifications of Australians but the data regarding such things as the number of qualified engineers suffers from a failure to clearly identify the basic qualifications of engineering professionals. No doubt this applies to other occupational groups as well.

The relevant census question requires respondents to identify their highest qualification. Since about 25% of engineers have post-graduate qualifications in other fields than engineering they may not be counted as persons who are qualified engineers but as persons with some such qualification as business management.

Another problem with the census is the question regarding occupation. Some may self identify as engineers when in fact their occupation is in one of metal trades. Alternatively some engineers will identify themselves as “managers” or “consultants” when in fact their occupations are essentially engineering occupations. These problems have been repeatedly pointed out to the Australian Bureau of Statistics over the last 15 years but the Bureau has not seen fit to introduce comparatively simple modifications to the census questionnaire to overcome the problems. Until the census questionnaire is redesigned so that it provides relevant educational and occupational data there will be no satisfactory means of determining the number of engineers in Australia.

Another problem concerns the data regarding students that is published by DEEWR. In 2001 the Field of Study classification of Engineering, Surveying was replaced by the Field of Education classification entitled “Engineering and Related Technologies”. The so-called Related Technologies are not at all related to engineering. The new classification includes such as categories as “bicycle repairing” under the sub-classification Aerospace Engineering and Technology. It appears that the new Field of Education was developed in complete ignorance of the nature of engineering. If it is to be a useful source of information regarding higher education outcomes the definition of this particular Field needs to be completely revised to rid it of references such things as textile making, footwear making , fitting and turning and the like.

Recommendation 3.

That the Committee give consideration to requesting DEEWR and the Australian Bureau of Statistics to revise the definition of the field of education described as “Engineering and Related Technologies” to correctly reflect the nature of the specialisations of professional engineering.

9. Conclusion

Because of the failure to ensure that the annual number of Australian engineers graduates is commensurate with the needs of a developed industrial country, Australia continues to be dependent on importing engineers to meet the demand that not only exists but will inevitably increase. There is hardly a developed country that is not only graduating more engineers relative to population than Australia but is continuing to increase the annual number of engineering graduates. The engineer populations of these countries have continually increased over many years and will continue to do so without the need to import engineers from other countries.

China is on the same path. That country has increased the number of engineering graduates at what can only be described as a spectacular rate. I estimate that in 2012 China will graduate 970,000 engineers. That number will represent approximately 40% of engineers graduating throughout the world.

Australia has not increased the number of engineering graduations until very recently and the increase has not been spectacular. Unless the level of graduations is markedly increased the rate of growth of the Australian professional engineering workforce will eventually decline to a very low level even with high levels of immigration. Over the last 50 years the magnitude of the Australian engineering workforce has increased at an average annual rate of 5%. However, even with the recent large influx of migrant engineers the rate of growth has begun to diminish.

Increasing the number of Australian engineering graduates will undoubtedly present great difficulties. First, it will be necessary to increase the educational facilities and academic staff to handle any such increase. There would be some capacity in the engineering faculties to increase the number of Australian engineering students if foreign students were excluded from our engineering schools, if that were possible. Such an outcome would, however, be very unlikely. Second, it would be necessary to increase the number of young people wishing to undertake engineering education with a view to embark on an engineering career. Anecdotal evidence indicates that many students view the demands of an engineering education as being too great in terms of time taken, the fees and the contact hours and the unfashionability of engineering. Overcoming this problem would probably present great difficulties.

10. Summary of recommendations

Recommendation 1.

The Committee give consideration to the establishment of a means of communicating to young people and the wider community the nature of the roles of engineers and the work of the engineering profession. It would be helpful if consideration was given to the replacement of the title of Licensed Aircraft Maintenance Engineer by the internationally recognised title of Licensed Aircraft Maintenance Technician.

Recommendation 2.

That the Committee give consideration to the requesting the Department of Education, Employment and Workplace Relations to find a means of eliminating the anomaly between the data published by the National Science Foundation and that published by DEEWR.

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That the Committee give consideration to requesting DEEWR and the Australian bureau of Statistics to revise the definition of the field of education described as "Engineering and Related Technologies" to correctly reflect the nature of the specialisations of professional engineering.

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APPENDIX A

ANNUAL NUMBER OF FIRST DEGREES IN ENGINEERING

Year	Number of degrees
1986	2790
1987	2840
1988	2894
1989	3243
1990	3218
1991	3389
1992	3846
1993	4395
1994	4825
1995	5300
1996	5287
1997	5504
1998	5550
1999	5263
2000	5209
2001	5266
2002	4944
2003	5103
2004	5250
2005	4553
2006	5029
2007	5061
2008	5290
2009	5384

Sources : 1. 1986 – 2000 — DEEWR reports on student numbers various years.
2. 2001 – 2009 — Table 6.4 “The Engineering Profession — A Statistical Overview”, Engineers Australia, 2011

APPENDIX B

FIRST DEGREES IN ENGINEERING RELATIVE TO POPULATION
OECD COUNTRIES

Country	Number of graduates per million population
Finland	1637
Korea	1589
Slovak Republic	1085
Czech Republic	1010
Poland	936
Sweden	819
Japan	747
Israel	745
Denmark	720
Iceland	708
France	650
Ireland	627
Spain	618
Estonia	588
Italy	578
Portugal	550
New Zealand	507
Belgium	504
Mexico	496
Germany	489
Norway	487
Austria	457
Chile	432
Netherlands	418
Slovenia	413
Hungary	410
Canada	408
Switzerland	405
Greece	353
United Kingdom	329
Turkey	318
Australia	**244**
United States	227
Luxemburg	27

APPENDIX B (cont.)

Note : The data for Australia relate to domestic students only. When overseas students are included the number of graduates per million increases to 400.

Source : Derived from the data in Appendix Table 2 – 32 of “Science and Engineering Indicators 2012” (NSB 12 – 01), National Science Board, Arlington.

APPENDIX C

ANNUAL NUMBER OF BACHELOR DEGREES IN CIVIL ENGINEERING
(1977 to 2009)

Year	Number of bachelor degrees
1977	1035
1978	1048
1979	934
1980	711
1981	503
1982	595
1983	602
1984	684
1985	731
1986	824
1987	822
1988	...
1089	...
1990	*630*
1991	*690*
1992	*710*
1993	*810*
1994	*840*
1996	*900*
1996	*840*
1997	*910*
1998	*940*
1999	...
2000	...
2001	885
2002	794
2003	796
2004	718
2005	582
2006	616
2007	733
2008	919
2009	936

Note : The data for the period 1990 to 1998 are my estimates.

APPENDIX C (cont.)

Sources : 1. The data for the period 1977 to 1998 are taken from "Up to the Task? — The Future of the Civil Engineering Work Force", M. R. Rice, Melbourne, 2005

2. The data for the period 2001 to 2009 are taken from "The Engineering Profession — A Statistical Overview", Engineers Australia, 2011