Mind the Gaps

Andrew Lapthorn*[1], Shreejan Pandey[2], Marion Sorez[3]

[1] Department of Electrical and Computer Engineering, University of Canterbury

[2] Formerly Electric Power Engineering Centre (EPECentre), University of Canterbury

[3] Electricity Engineers' Association

*Presenting

EEA Conference & Exhibition 2016, 22 – 24 June, Wellington

Abstract

The word "diversity" is well adopted and celebrated by globally successful companies including Google and Apple who claim that diversity inspires innovation. The New Zealand electricity supply industry supports a number of initiatives that aims to address gender diversity, and increase the number of high achieving electrical engineering graduates. However, the desire to enhance workforce capability by encouraging diversity in New Zealand's electricity industry is not yet fully realised. The gender imbalance is a noticeable issue across all sectors, and anecdotal evidence suggests that there is a void of young engineers to acquire knowledge from experienced senior professionals and smoothly transition into senior roles.

Understanding the demographic profile of electrical engineers derived from census data helps to identify any gaps that need to be addressed. Tertiary enrolment demographic trends for the Electrical and Electronic Engineering (EEE) degree specialisation can be referred to as a proxy for what the future demographic profile of the electricity industry may look like.

This paper analyses and discusses the demographic trends of professional electrical engineers and tertiary students who have completed electrical and electronic related qualifications at universities and polytechnics. Targeted areas that require attention and investment are identified and discussed.

1. Introduction

The New Zealand electricity supply industry has long recognised the need for more electrical engineering graduates, and female electrical engineers to join the industry. The 'Smart People for a Sustainable Future' session at the 2013 EEA conference discussed the need for additional engineering graduates and gender diversity, and highlighted the scale of industry concern.

Previous research has provided some statistics that help to, in part; understand some of the reasons behind the noticeable low-diversity in the electricity supply industry. The following findings suggest that engineering studies struggle to attract new enrolments and women compared to other fields of study. This seems to be particularly true for electrical engineering, for which the difficulty to engage students may start as early as secondary school levels:

1. New Zealand's tertiary enrolments in the field of engineering as a proportion to total enrolments began to fall in the late 1990s with a 0.2 % growth in enrolment between 1997 and 2000. In the same period, enrolment in the fields of health and computer science grew by 15.7% and 64.1% respectively [1].

2. Approximately 50% of the enrolled NCEA Physics students are either not achieving or choosing to not participate in NCEA 3.6 "Demonstrate understanding of electrical systems" examination [2] .

3. The Institute of Professional Engineers New Zealand (IPENZ) "*Women in Engineering Snapshot: 2013"* has brought to view that at 13%, the Electrical and Electronic Engineering discipline represents the lowest proportion of women enrolled in their engineering studies by field of study. Engineers as a whole represent the lowest proportion (13%) of women in their respective profession when compared to architects (27%), scientists (33%), medical doctors (40%), lawyers (40%) and accountants (40%) [3].

Age and ethnicity trends for engineering and more specifically the electrical engineering sector are less known. It is essential to delve into the statistics of those in the electrical engineering profession to fully understand how the demographic profile has evolved over the past decade. Understanding tertiary student demographic trends for electrical and electronic related qualifications help to ascertain what the future demographic profile of the electricity industry may look like. Thus, identifying key areas that need to be addressed to increase diversity and create a well-informed succession plan for the electricity supply industry.

This paper analyses data obtained from the 1991, 1996, 2001, 2006, and 2013 censuses to present the number of engineering professionals on individuals' self-declare "electrical engineer" occupation classification by their gender, ethnicity, and age profiles.

Electrical and electronic related tertiary qualification completion records are obtained from Education Counts, Ministry of Education and analysed by the number of students who completed their qualifications at universities and polytechnics, gender, ethnicity, and age profiles between 2004 and 2014.

Finally diversity gaps in the electricity supply industry are compared to demographic trends in the tertiary sector and key concerns are highlighted.

2. Electricity Industry Demographics

In this section, demographics such as gender and ethnic diversity and age profile of the electrical engineering profession are examined and compared with the engineering profession as a whole. The data has been sourced from the last five New Zealand Censuses (1991 through to 2013). Tables of the data analysed are presented in Appendix A.

2.1 Number of Engineers

The number of engineers and engineering technicians for both electrical and all engineering professions is presented in Figure 1. The general trend is reasonably flat up until 2006 where an increase in professional engineers is seen for both electrical and all engineering fields. The total

number of electrical engineers has increased from 1434 to 2049 between 1991 and 2013, a 30% increase, compared with a 36% increase in all engineering disciplines over the same period. Electrical engineering technicians have increased by 27% compared with only a 6% increase for all technicians. Overall, electrical engineering makes up a small percentage of total engineering 11% in 1991 falling to 10% in 2013. It is also worth noting that there was a reasonably significant fall in the number of engineers in 2001 across the board which has since recovered.

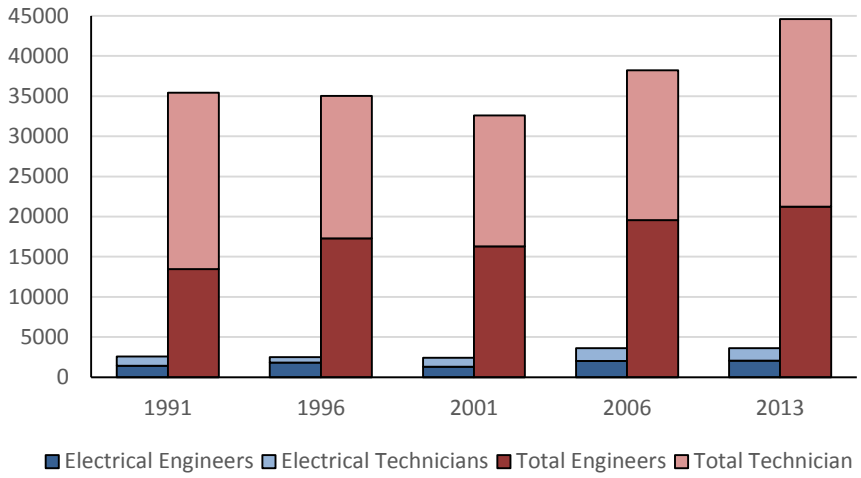

Figure 1: Total number of engineers and technicians

2.2 Gender Diversity

To those working in the engineering field it comes as no surprise that it is a largely male dominated profession. Figure 2 presents the gender diversity as a percentage for both electrical engineering and all engineering. Throughout the study period, both electrical and all engineering types have been in excess of 90% male dominated with electrical engineering consistently worse than engineering as a whole. What is encouraging though is that the percentage of female engineers is increasing between each census period. The female increase rate between 2006 and 2013 is similar for both groups but if electrical engineering wants to close the gender gap compared to all engineering professions, this rate will need to be much higher.

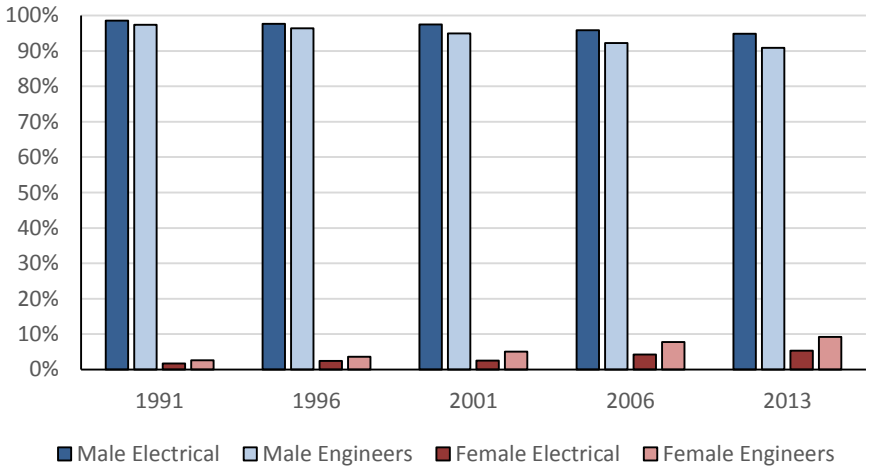

Figure 2: Percentage gender diversity of electrical engineering vs all engineering

2.3 Ethnic Diversity

Figure 3 presents the ethnic diversity of electrical engineering, all engineering and all occupations. It is worth noting that the census data allows for multiple options to be checked for ethnicity such that the percentages do not add up to 100%. This data shows that the ethnic diversity for electrical engineering is similar to that of all engineering types with the exception of an under representation of Asian ethnicity. Māori and Pacific Islanders are also under-represented in engineering as a whole when compared with all occupations.

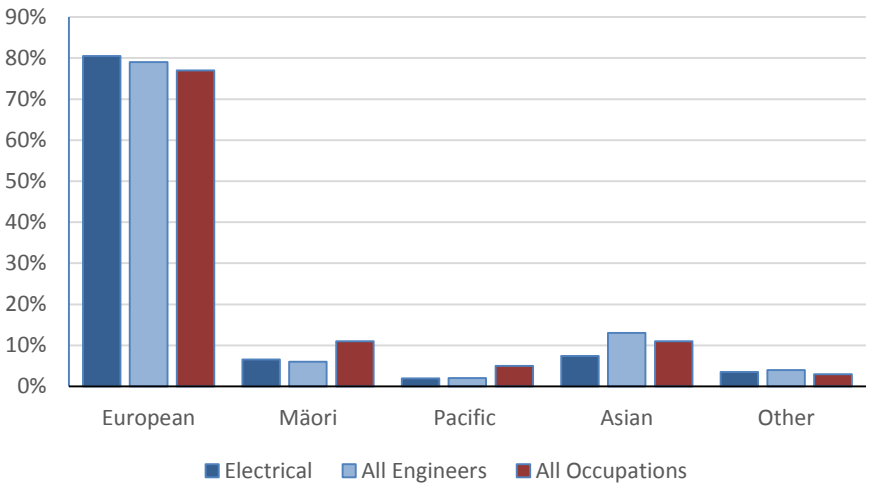

Figure 3: Percentage ethnic diversity of electrical engineers vs all engineering and all occupations (2013)

2.4 Age Profile

Figure 4 shows the age profile for electrical engineering for 1991, 2001 and 2013. There are two things worth noting. Firstly, in 2001 there was a significant drop in the 20-30 year age bracket compared with 1991 which has since recovered in 2013. This has led to a reduction in the 35-45 year age bracket. Secondly, there is a significant increase in numbers for the 45 and over age group in 2013 when compared with the earlier data. This is reflected in the average age increasing from 38.6 years in 1991 to 43.1 years in 2013. There now appears to be a good number of younger engineers coming into the industry to help with the upcoming expected retirements.

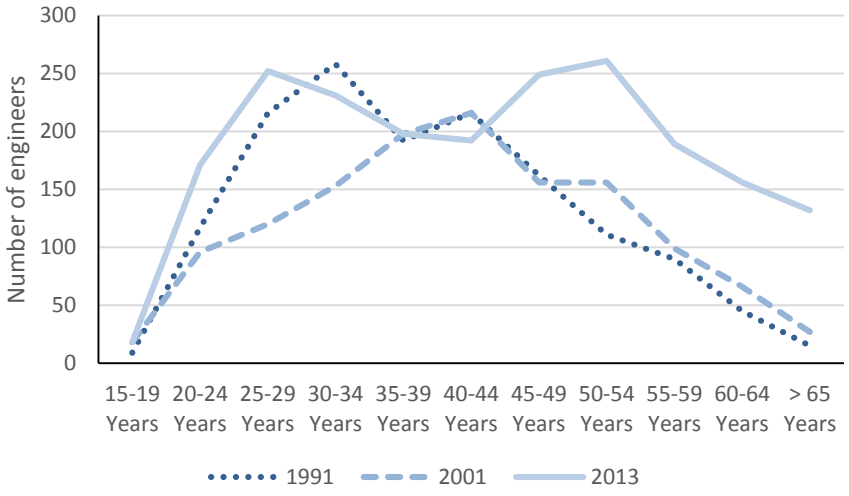

Figure 4: Evolution of the age profile of electrical engineers (1991, 2001 and 2013)

Figure 5 shows the comparison between the age profile of electrical engineers and that of all engineering disciplines as a percentage for 2013. When comparing the two age profiles, it is apparent that they both have a very similar profile for the younger and older age groups (up to 30 years and over 55 years age groups). The total engineering population appears to have a more consistent percentage of engineers over the middle years (30 to 50 years) of about 11% for each relevant group (30-34, 35-39, 40-44, 45-49) whereas the electrical engineering group has a noticeable dip around the 40 year mark and a bulge at the 50-55 year mark. This would suggest there may be a slight shortfall of experienced senior electrical engineers in around a decade's time when compared with engineering as a whole. The average age of electrical engineers has been very similar to that of all engineers throughout each census.

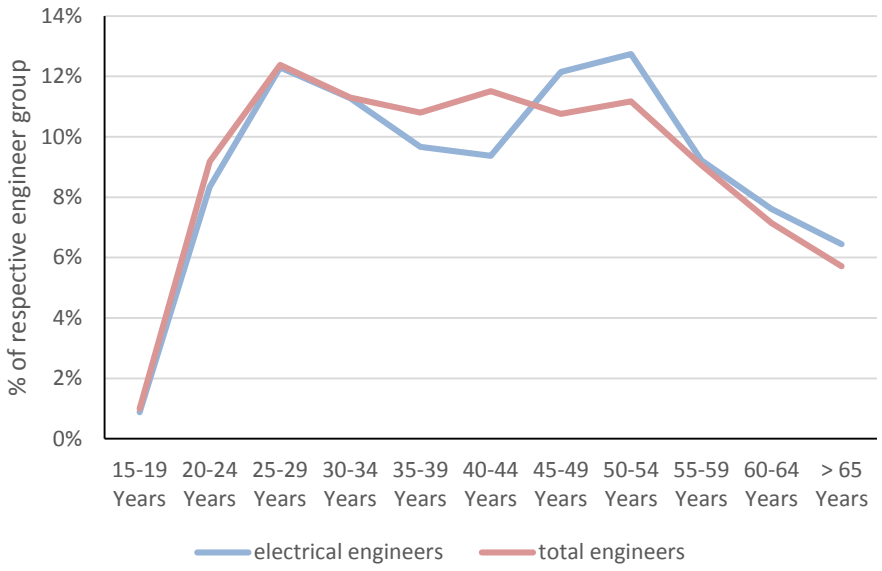

Figure 5: Age profile of electrical engineers vs. total engineers in 2013

3. Engineering Student Demographics

The Ministry of Education collects data on individual's completed qualifications from tertiary institutions. Tertiary institutions use the New Zealand Standard Classification of Education (NZSCED) code to report completed qualifications. The NZCED is a subject-based classification system for courses and qualifications at universities, polytechnics, wānanga and private training establishments in receipt of Government funding [4]. This study covers electrical and electronic related qualifications at all New Zealand Qualifications Authority (NZQA) levels including certificate, diploma, undergraduate and postgraduate degrees.

Detailed codes defining "computer engineering" and "communication technologies" are not considered to keep the focus of the study within the Electrical and Electronic Engineering discipline. Qualifications offered by private tertiary institutions are not considered in the analysis because of the assumption that in the electricity industry, by and large, professional engineers have university qualifications and technicians have polytechnic qualifications.

Figure 6 shows that over the past 10 years, discounting the anomaly in 2007, the number of electrical and electronic engineering related university qualifications completed increased from 255 in 2004 to

375 in 2012, an increase of 47%, before decreasing to 325 in 2014. The number of completed electrical and electronic engineering related polytechnic qualifications increased from 400 in 2004 to 1,105 in 2009 (an increase of 176 per cent) before levelling off in years 2010/11 then increasing to a peak of 1,155 in 2013. The paper titled *Zen and the Art of Engineering Education* asserts a reason for the rise of completed qualifications at polytechnics. Following the introduction of the National Certificates of Educational Achievement (NCEA) a dip in Year 13 Physics and Calculus enrolment numbers at secondary schools were observed leading to a drop in the number of completed electrical and electronic engineering related Bachelors and Honours level engineering qualifications at universities in years to follow. The paper asserts that the drop in Yr 13 Physics and Calculus enrolments led to a rise in vocational studies and a rise in completed Certificates and Diplomas at polytechnics [2].

3.1 Gender Diversity

Section 2 discussed the traditionally low number of women in the electricity industry and engineering profession as a whole. In the tertiary sector, the share of women completing electrical and electronic engineering related qualifications from universities has been between 8.5% in 2008 and 16% in 2013. The highest share of women is observed in recent years of 2013 (16%) and 2014 (15%). This is a much higher share than is traditionally seen in industry. The share of women completing electrical and electronic related qualifications at polytechnics has been 4% or less between 2004 and 2014. The lowest share of women is observed in 2009 (1%), and the highest share of 4% observed in years 2007, 2012 and 2014.

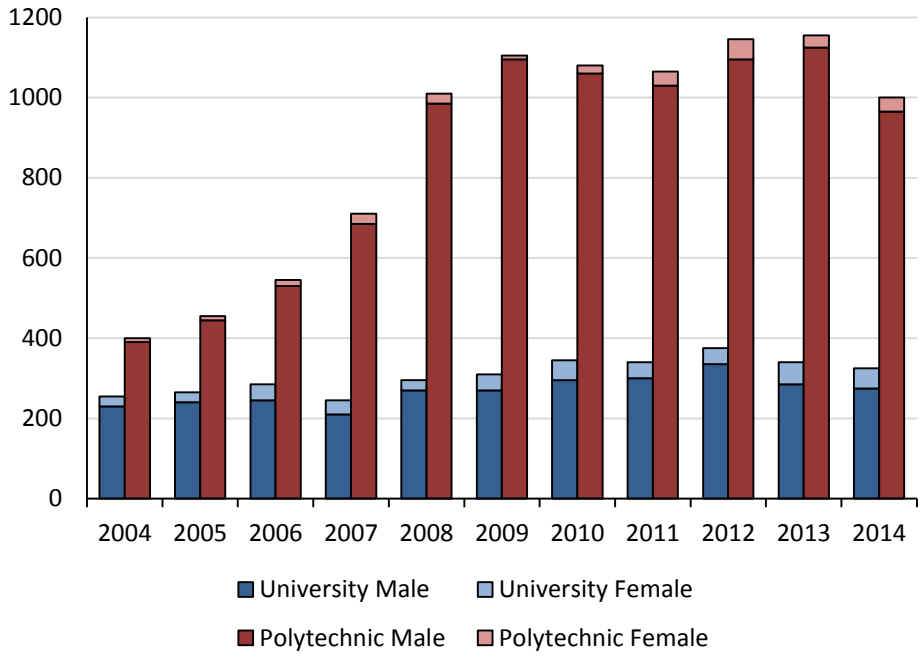

Figure 6: Number of university and polytechnic students with electrical and electronics related qualification by gender

3.2 Ethnic Diversity

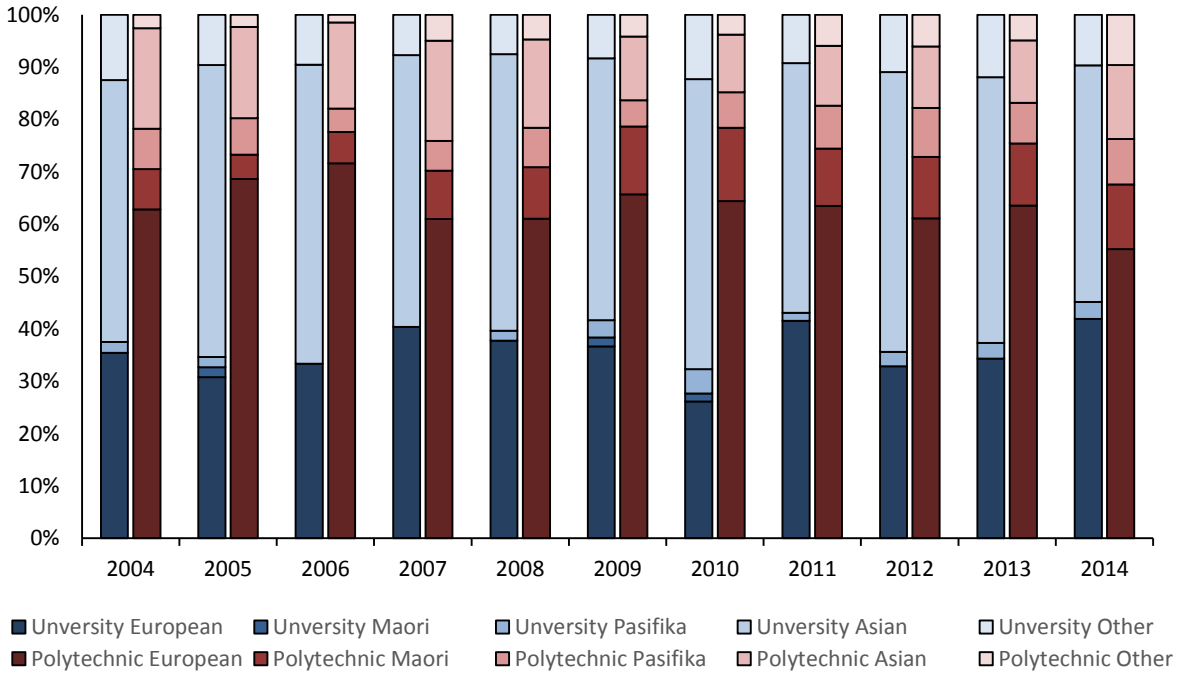

Figure 7: Ethinicity share of university and polytechnic students with electrical and electronic related qualifications

The ethnicity share of students in Figure 7 shows that Asian, followed by European ethnicities have made up the majority share of electrical and electronic related university students over the past ten years. Between 2004 and 2014, Māori followed by Pasifika are either not represented (in years 2006 and 2007) or make up a minority share of less than 2% and less than 5% for Māori and Pasifika respectively. At 45%, the lowest share of university Asian ethnicity in ten years was observed in 2014. Delving further into the Asian data, Figure 8 reveals that domestic students make a greater share of the Asian electrical and electronic related student profile at universities. Chinese (20% - 63%) followed by Indian (18% - 40%) make up the majority share of domestic Asian students over the seven-year period between 2007 and 2014. Chinese students make up the majority of international students with a share of 33% (in 2010) - 86% (in 2008) over the seven-year period.

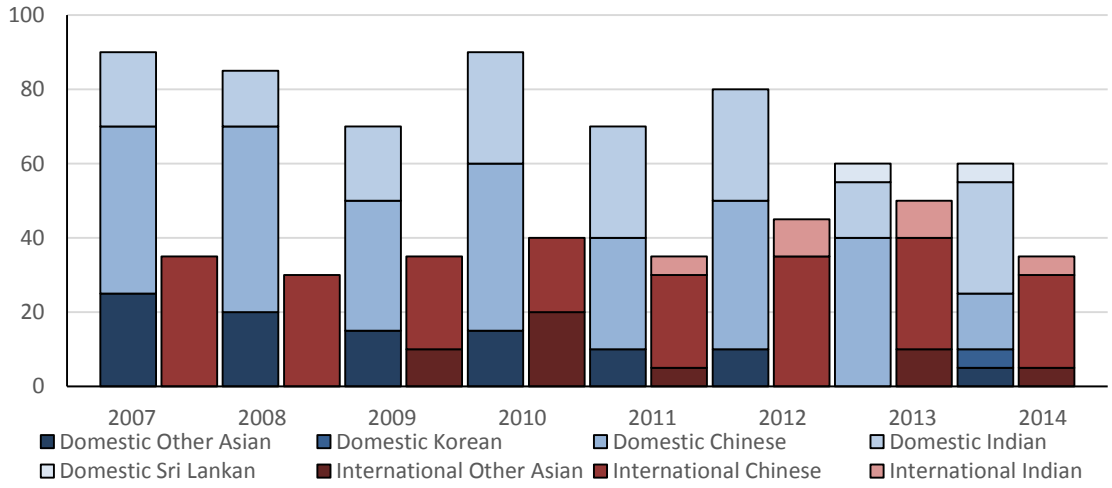

Figure 8: University Asian students with electrical and electronic qualifications

Polytechnic qualifications completed over the past ten years include a 55% (in 2010) to 72% (in 2006) majority share of Europeans, a greater representation of Māori (5% - 14%) and Pasifika (4% - 9%), and fewer Asian (11% - 19%) when compared to university data. Domestic Chinese and Indian make up the majority (above 70%) of the polytechnic Asian students. Indian (25%-60%) followed by Chinese (20%-60%) makes up the majority of the international Asian ethnic group.

3.3 Age Group

The age groups for students who completed electrical and electronic engineering related qualifications are shown in Figure 9. The age brackets are grouped in three categories 18 – 24, 25 -39, and 40+. The Ministry of Education defines "mature students" as people aged 25 years and above, and individuals aged 40+ are considered to be in their middle adulthood or later stage of life.

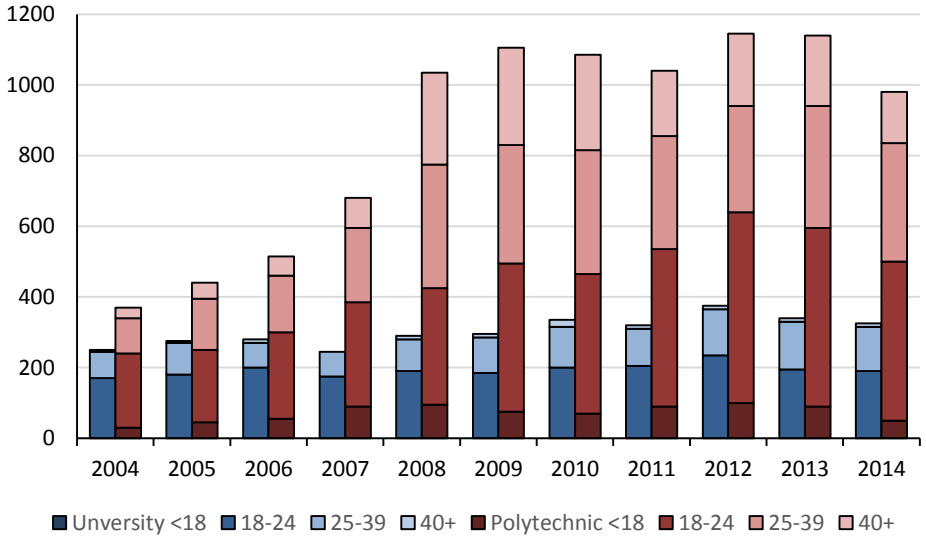

Figure 9: Number of university and polytechnic students with electrical and electronics related qualification by age group

University students aged between 18 and 24 have consistently made up the majority, 57% (in 2013) at lowest to 71% at highest (in years 2006/7) share of completed qualifications between 2004 and 2014. A low of 170 (in 2004) and a high of 235 (in 2012) are observed for students aged 18 - 24. A rise in students aged 25-39 is observed in recent (2009 to 2014) years with a high of 135 completions (in 2013).

Compared to university, a greater share of mature students aged 25-39, and 40+ are achieving their polytechnic electrical and electronic related qualifications. The 40+ age bracket share peaked at 275 (in 2009), and has been reducing since 2012 to 145 (in 2014).

4. Domestic and International Students

Students completing their electrical and electronic related qualifications are by and large domestic. The lowest share of international students completing their university qualifications between 2004 and 2014 was observed in 2011. Since then, international share has risen from 21% (in 2011) to 33% (in 2014). Asian students (mostly Chinese) make up the majority share of the international students completing their qualifications at universities.

Due to the rise of domestic students and a drop of international students at polytechnics between 2007 and 2009, the international share reduced from 16% (in 2006) to 4% (in 2009) before rising to 11% (in 2014) as a result of a reduction in domestic and a rise in international completions. Asians (predominantly Indian and Chinese) make up the majority of international completions at Polytechnics.

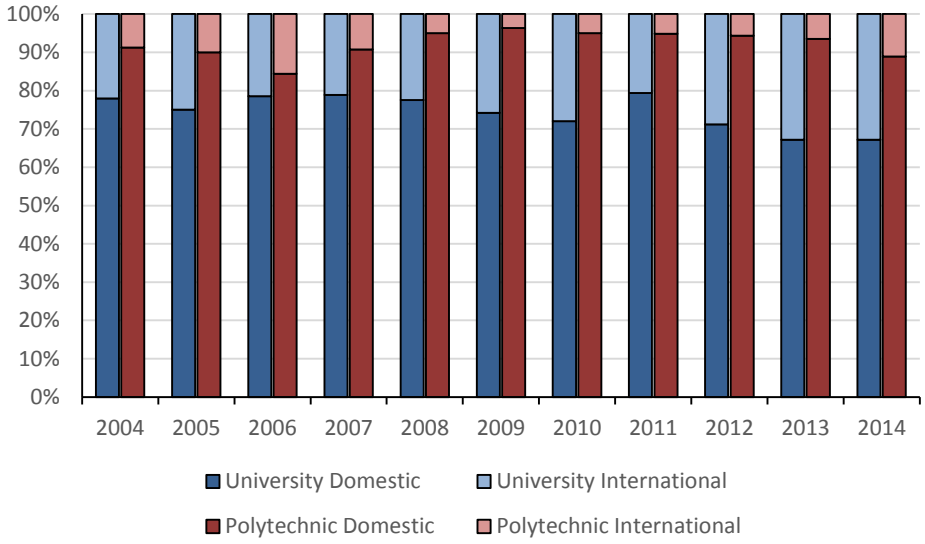

Figure 100: Domestic and international university share of students with electrical and electronic related qualifications from universities and polytechnics

5. Discussion

The electrical engineer population was at its lowest in 2001 with about 1,300 electrical engineers. Since 2006, this population has stabilised around 2,000 people. The total engineer population has stabilised too with about 21,200 engineers. There seems to be sufficient number of tertiary students to sustain the current number of young professionals in the electrical sector.

The age profile of the electrical engineer population has a distinctive two-hump camel back shape that has been accentuated over the years and is slightly more obvious than for the total engineer population. The two distinctive peaks in the electrical engineering workforce are for engineers aged 25-29 years old and aged 50-54 years old. This may cause an issue with resourcing and the transfer of knowledge and skills in ten years when the electricity industry can expect a high number of engineers currently aged 50+ to retire. The industry should initiating programmes to upskill younger engineers in order to retain the knowledge and skill base.

All female engineers are on average 8 years younger (35 years old) than their male counterparts (43 years old). Female engineers (electrical or not) historically haven't been represented in senior roles in the industry (few over 40, almost none over 50), but the 2013 census shows a higher percentage of female electrical engineers in their late 40s and early 50s compared to previous censuses. This is a positive change for the electrical industry. However, the discrepancy between the proportion of female electrical engineers (5%) to all female engineers (9%) and the rate of which they are increasing is a cause for concern if the electrical industry wants to align with engineering as a whole and more needs to do be done to encourage females to pursue a career in electrical engineering. The good news

is that the highest share of females pursing university studies in electrical and electronic qualification is observed in recent years (16% in 2013 and 15% in 2014). Similarly, at polytechnics the highest share (4%) of females completing their electrical and electronic qualification is observed in years 2007, 2012 and 2014.

A considerable discrepancy between the industry and tertiary ethnicity profile is observed. A high proportion of Asian students completing their electrical and electronic university qualifications are not reflected by the ethnic profile of professional electrical engineers. Initially, the authors speculated that the Asian phenomenon may have been skewed by international students but delving further into the data suggests that 50% - 70% of Asian students are domestic. There may be other reasons for this discrepancy. The low representation of Māori and Pasifika in electrical engineering profession is consistent with the low number of Māori and Pasifika students completing their tertiary qualifications. However, the proportion of Māori and Pasifika within the electrical engineer population is similar to the engineering profession as a whole. There is an opportunity for the electricity industry to encourage engineering as a career option to Māori and Pasifika.

6. Conclusion

In conclusion, the average electrical engineer is a 43-year-old white male. This is not surprising to those working in the electricity industry. What was of note is the following:

- Female numbers while low, are increasing in the tertiary sector and the electrical profession but not as fast as engineering as a whole,
- There is a low proportion of Māori and Pasifika representation compared to the wider population of New Zealand,
- For some reason there is a poor conversion rate between domestic Asian graduates and professionals in the industry. Where are they going?

7. References

[1] R. G. Craig, *The declining enrolment of New Zealanders in Bachelor of Engineering programmes,* vol. 3, Auckland: Massey University Albany Campus, 2002, pp. 69-77.

[2] A. L. Y. I. A. M. Shreejan Pandey, “Zen and the Art of Engineering Education,” in *EEA Conference 2014*, Auckland, 2014.

[3] The Institution of Professional Engineers New Zealand Inc, “Women in Engineering: Snapshot 2013,” The Institution of Professional Engineers New Zealand Inc, Wellington, 2013.

[4] Education Counts, “New Zealand Standard Classification of Education (NZSCED),” Education Counts, December 2014. [Online]. Available: https://www.educationcounts.govt.nz/data-services/collecting-information/code-sets-and-classifications/new_zealand_standard_classification_of_education_nzsced. [Accessed 25 May 2016].

Appendix A - Industry Demographic Data

Table I: Total number of engineers and technicians

Population	1991	1996	2001	2006	2013
Total electrical engineers	1434	1830	1302	2040	2049
Male electrical engineers	1413	1788	1269	1956	1944
Female electrical engineers	24	45	33	87	108
Total electrical technicians	1164	654	1110	1569	1587
Male electrical technician	1134	645	1086	1518	1542
Female electrical technician	30	9	24	45	45
Total engineers	13443	17274	16305	19551	21219
Male engineers	13098	16653	15474	18033	19290
Female engineers	345	618	822	1518	1962
Total technician	21981	17760	16299	18675	23388
Male technician	20109	15591	13263	16371	19863
Female technician	1869	2163	1614	2310	3525

Table II: Average age of electrical engineers and all engineers by gender (1991, 1996, 2001, 2006, 2013)

Average age	1991	1996	2001	2006	2013
Total electrical engineers	38.6	38.9	41.4	41.4	43.1
Male electrical engineers	38.7	39.2	41.6	-	43.4
Female electrical engineers	39.4	26.4	28.2	-	35.2
Total engineers	38.6	38.8	40.5	41.3	42.3
Male engineers	38.9	39.1	41	-	42.9
Female engineers	29.3	30.1	36.3	-	35.5