The Electric Power Engineering Centre's Success: Past, Present, and Future

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Abstract

The Electric Power Engineering Centre (EPECentre) at the University of Canterbury was established in 2002 to carry out the purpose of the Power Engineering Excellence Trust (PEET); to promote and support the education of power engineers and the study of power engineering as a field of excellence in New Zealand. Since then it has become active in a number of power engineering related research areas. This paper looks at the success of the EPECentre in growing the number of students enrolling in power engineer related courses, and ultimately graduating to become electric power engineers. It concludes that there has been a near doubling in the number of students undertaking electric power engineering as a speciality discipline in their fourth year of the engineering honours degree since 2002. However, that trend has reversed in 2011, highlighting the importance of continued support of PEET and the EPECentre by the power industry. Moreover, the paper also concludes that global shortages of electric power engineer graduates, combined with large infrastructure projects locally and globally, will put pressure on New Zealand for its graduates, as well as on engineering salaries. This emphasises the need for support of PEET and the EPECentre now, more than ever. The success factors for such university-industry collaborations are reviewed, and a plan discussed to re-engage with member organisations, past and present. In addition, a plan for ways in which to enhance and broaden EPE student education is touched on, which will benefit from an increase in the research focus of the EPECentre on contemporary and future areas of relevance to the industry.

1. Introduction

In writing this paper, the authors reviewed two papers of particular interest, one stating that '*The electric utility industry is facing the most difficult challenge in its long history*', and '*…the problem of developing and hiring the necessary new engineering and management talent to see the industry through this period is very serious.*' The second paper points to some disturbing trends, stating that '*the area of electric power engineering education may again be facing a future decline on a national basis.*' Yet this is at a time when '*We need to develop national energy policies and programs to eliminate waste, conserve energy and to protect the environment…*' and '*We also need to produce the energy that we will need in the future*'. These papers were written in 1968 and 1978 respectively – (Kersting 1968) and (Morgan 1978) – yet if we jump forward to 2002 and 2012 we find a very similar picture. In some respects, the issues we face now are a result of the success of measures taken to deal with the power engineering talent shortage 40 to 50 years ago; many new engineers were trained and hired, but are now retiring, leaving a shortage of engineers at a time when the industry is undertaking major new infrastructure projects.

To deal with this shortage, and a major decline in the number of students undertaking electric power engineering (EPE), which reached an 'all time low' in 2002, the Electric Power Engineering Centre (EPECentre) was established ten years ago. This was to primarily fulfil the purpose of the Power Engineering Excellence Trust (PEET): to promote and support the education of power engineers and the study of power engineering as a field of excellence in New Zealand. PEET is a trust, funded through industry members. In this paper we examine the success of the EPECentre in achieving this goal, evidence from around the world that supports a growing call to improve education in power engineering, and based on this, where the EPECentre will be focusing for the next 10 years.

The paper begins by examining global challenges from a retiring workforce, falling numbers of graduates in technology, and electric power engineering, but increasing demand for electric power engineers through infrastructure projects. The paper points out that these global trends will affect New Zealand, through the global labour market. The paper then examines the success of the EPECentre in increasing the number of graduates in electric power engineering, and asks whether the EPECentre is continuing to be successful. Finally, the paper discusses ways in which the EPECentre can be even more successful in assisting to train graduates in EPE for the New Zealand industry.

2. Global Trends

When the EPECentre was established in 2002, it was clear that there was a proportion of the electric power engineering workforce that was close to retirement. That pattern has continued, and, according to Statistics NZ (Bascand 2012) and (Ashley-Jones 2009), the population nearing retirement has grown in that time, and the retirement rate is increasing.

The picture is similar in other parts of the world, with measures being taken to deal with this. For example, in the USA, in 2008 the National Association of Electrical Distributors launched a marketing campaign titled "Power Up Your Career" to attract young adults to careers in electrical distribution, citing the reason that '*Recruiting is a critical issue for electrical distribution. As the pre-Boomers and Baby Boomers retire, forecasts call for the*

United States to have over 10 million more jobs than workers to fill them by the end of the decade' (NAED 2008).

Edward (2009) also points to low birth-rates in the industrialised world and a high proportion of baby boomers retiring, particularly in western Europe and parts of Asia, and makes the point that '*...between 2010 and 2020, some technology-based industries will be seeking to replace 100% of their workforces.*', and that '*...66% of the jobs to be filled during the next decade will be vacancies created by boomer retirements.*' To make matters worse, Edward (2009) points to a cultural bias against gaining education required for science and technology jobs, '*...but not against technology itself.*' In Japan this is termed '*the flight from science*', and is even being experienced in the tech-driven German economy.

In the UK, Lunn (2007) reports that the number of engineering graduates has been falling for the past decade, but that demand for graduates is strong due to the upgrade of the UK's electricity grid. For example, '*in 1995 there were 23,000 undergraduates on engineering courses, but by 2004 this figure had dropped to 19,500.*'

Closer to home, the Australian Power Institute was formed in 2004, highlighting the demand for power engineers, with Australia too coping with an ageing engineering workforce (Alcerreca 2007). Further, the University of Sydney has started, from 2007, a new program in power engineering, with the chair funded by Energy Australia. The programme is designed with key industrial partners, and also includes aspects of information technology. Alcerreca (2007) states that '*Electrical power engineering has been and will remain a key discipline for the future*.' This is based on the retiring workforce, the '*...insatiable demand for power and major improvements to the power infrastructure around Sydney planned over the next decade.*', and the increasing demand for suitably trained electrical power engineers.

This review of the global outlook is important to New Zealand because we live in an increasingly mobile world, with a resulting mobile work force. This means that New Zealand has available to it graduates from around the world, as well as from New Zealand. However, it also means that New Zealand graduates have opportunities available to them from around the world, which, as we have seen, are plentiful. So the New Zealand power engineering industry will be subject to both global talent shortages, and the on-going need for power engineers around the world, to cope with global retirements and increasing infrastructure projects. The eventual implication to New Zealand companies in the power industry will be escalating graduate salaries, and a flow on to escalating engineering salaries. Maintaining, and retaining, the power engineering graduates from within New Zealand is therefore of critical importance to the New Zealand power industry.

3. Has the EPECentre Achieved its Objective?

3.1 Charting the EPECentre's Success

From the previous section, it is clear that training engineers for the New Zealand industry is critical. The New Zealand power industry recognised this over ten years ago, and, as previously mentioned, established the EPECentre to carry out PEET's purpose, mainly through organising events, such as power system field trips and the careers conventions, and administering scholarships provided by PEET (Lawrence and Bodger 2008). In this respect the EPECentre has fulfilled PEETs purpose, but are there more power engineering graduates available to the industry? To test this we gathered data on enrolments in each year of the

three types of the electrical and computer engineering (ECE) degree: electrical engineering (EE), computer engineering (CE), and mechatronics (MT). As a baseline, we examined the number of students enrolled in the first professional year in electrical engineering – the precursor to the power engineering specialisation in later years - shown in Figure 1.

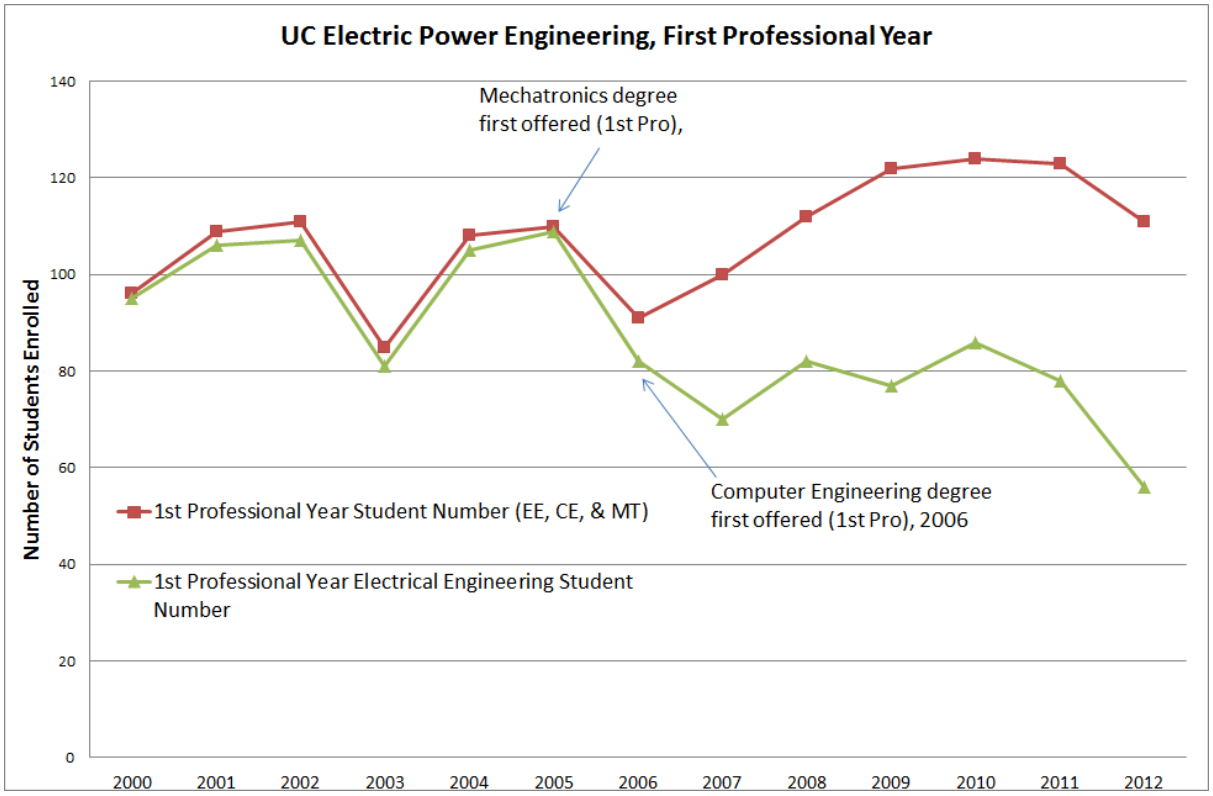

Figure 1: University of Canterbury first professional year electrical and computer engineering enrolments.

Figure 1 shows that the number of students entering the Electrical Engineering degree (and therefore those eligible to continue to electric power engineering) declined with the introduction of both the Mechatronics degree and the Computer Engineering degree. However, the total intake, to all degree streams, rose, suggesting more successful targeting of the degree programme to students. Indeed, the offering of a separate computer engineering degree has been a world-wide trend in what was electrical and electronic engineering degree programmes.

Despite this reduction in students opting for EE in their first professional year, there has been a steady increase in the number and percentage of students undertaking power systems courses in their final, 3rd professional, year since 2002, as illustrated in Figure 2. Actual data on enrolment numbers prior to 2000 was not available for this analysis, however it is recognised that enrolments in electric power engineering were at a minimum in 2002. This is when the EPECentre was established, which also coincides with the beginning of the steady increase in enrolled students. To obtain an indication of the year-on-year increase in students undertaking EPE related courses, we fitted a linear trend to these enrolment numbers. A least squares fit was used to reduce sensitivity to the start and end points. The results are given in Table 1.

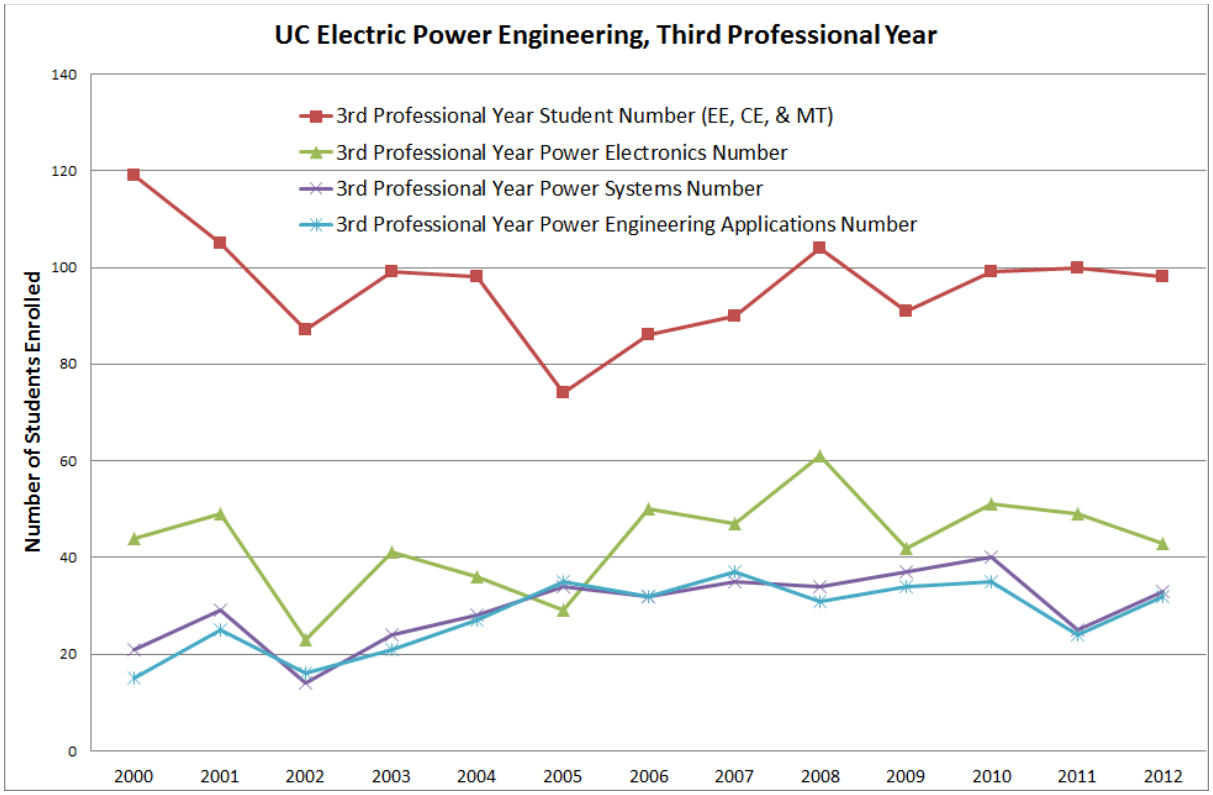

Figure 2: Number of students taking power engineering related courses.

Table 1: Annual changes in the number of students enrolled in power engineering courses.

	Annual Increase	
Final Year Paper	2000 to 2010	2000 to 2012
Power Systems	4.7%	3.0%
Power Engineering Applications	5.0%	3.3%
Power Electronics	2.6%	1.9%
Students enrolled in EE, CE, and MT	-1.4%	-0.6%

In cumulative terms, enrolled student numbers in 2010 have increased to 1.6 times that of the 2000 level in both power systems and power engineering applications, and 1.3 times for power electronics. That is despite a decline in the total number of students enrolled in EE, to 0.9 times that of the 2000 level by 2010. It is clear from these results that there is a coincidence between the establishment of the EPECentre in 2002 and the beginning of a rise in students enrolling in electrical power engineering courses. Since most 3rd professional year students also graduate, we can conclude that there has been a rise in the number of electric power engineering graduates, coincidental with the EPECentre.

It is possible that this rise may also be attributable to the introduction of the 2nd professional year power systems course in 2003, and a generally larger focus on, and marketing of, electric power engineering to students. While it is not possible to definitively point to the EPECentre itself as the cause of the rise, it is, nevertheless, clear that there was a greater

emphasis on power engineering from 2002, with greater resource available in terms of PEET scholarships, support for field trips, etc).

3.2 Early Warning Indicators

Despite the early and sustained rises in power engineering enrolments, there are two concerning indicators in the latter two years investigated. First, there is a prominent dip in students enrolled in power systems and power engineering applications in 2011. Coincidentally there was also a prominent dip in students enrolled in the 2nd professional year power systems course in 2010, and a less prominent dip in 1st professional year in 2009. It is possible that an event in 2009, that 1st professional year students were subject to, may have propagated through to the final year, two years later. It is also highly likely that the major earthquake on 22 February 2011 influenced final year student's enrolment choices away from electric power engineering in 2011. Secondly, the latter two years indicate a reversal in the previously uninterrupted upward trend since 2002; while 2012 has shown some recovery, it is not back to the 2010 level. Finally, 2012 1st pro enrolments in EE are well down on previous years. The earthquake may have something to do with this also – Civil Engineering enrolments are at record highs – and it has been reported that Electrical Engineering enrolments are down nationally. This may mean a reduction in power engineering graduate numbers in 2014. Combined with this, however, is the concerning reduction in PEET membership over the last three years. This ultimately means less money available for EPE scholarships, and more concerning, a waning in industry's interest in, or recognition of, the importance of training graduates – which may lead to a propagation of the cycle of shortages.

3.3 Benchmarks and Perspectives

As a bench mark for how the University of Canterbury is performing in producing electric power engineering graduates, we investigate the ratio of electric power engineers to general electrical, electronic, and computer engineering professionals. We used the IEEE membership statistics as a proxy for the number of electrical engineering professionals, and for the number of electrical power engineering professionals. From the 2000 Annual Statistics of the IEEE to the 2009 Annual Statistics of the IEEE, the total membership of the IEEE varies from 360,000 to 395,000. The proportion of this number who are members of the power engineering society or power electronics society varies between 7.4% and 8.2% over this time. The percentage of power engineering enrolments in the final year of the ECE degree at the University of Canterbury is about 40% of the number enrolled in all of EE, CE, and MT. Compared to the general population statistics (based on the IEEE analysis), the University of Canterbury is 'punching well above its weight' in educating power engineering students.

To give some perspective to the number of EPE graduates produced by the University of Canterbury, which is about 35-40 per annum currently, the number of EPE undergraduate degrees conferred annually in the United States was slightly above 1,000 each year in about 2000 (Heydt and Vittal 2003). This is a ratio of 1:29 – 25, as compared to a population ratio of about 1:74. New Zealand, or more specifically the University of Canterbury, has produced nearly 3 times the number of EPE graduates per head of population.

3.4 Electric Power Engineering as a Differentiator

Clearly the University of Canterbury – industry collaboration, in the form of the EPECentre, has done well in increasing the number of graduates in EPE. EPE has historically been a

point of difference for the University of Canterbury, especially with the strong leadership brought about by the late Professor Arrillaga – world renowned for his research into HVdc transmission and power quality. It would seem to be sensible to continue to promote EPE, and offer it as a point of difference of the University of Canterbury. The next section investigates future initiatives to strengthen EPE education and research, as well as the University of Canterbury-industry collaboration through the PEET.

4. The Future: Building on the Past EPECentre Success to Train Better Graduates

There are two areas of concern when planning future EPECentre strategy and activities. The first is the decline in enrolments in EPE and EE, as identified in the previous section, combined with declining PEET membership. The second is that the analysis in the previous section focused on graduate numbers, whereas it is important to ensure quality graduates (although the EPECentre Establishment Application does focus on the quality of graduates and excellence in EPE education). A number of industry executives from around the world point to pitfalls in just hiring graduates to fill numbers. They recommend competing for smart, qualified people instead of 'warm bodies', and competing within the industry for the best (Eilerston 2010). Given the success of the EPECentre to date, but also the challenges currently facing it and the industry, this section discusses the focus for the EPECentre over the next ten years. It first reviews some lessons learned from other university-industry collaborations from around the world, and summarises the relevant conditions required for successful partnerships, as well as lessons related to engineering education. It follows this with a summary of how the EPECentre has met many of these to date, and finishes with discussion on new initiatives and approaches for the EPECentre.

4.1 University-Industry Collaborations and Engineering Education

In the IEEE Power and Energy Magazine article, "Got Power", Schifo (2005) suggests that companies need a comprehensive industry wide recruitment strategy to deal with the talent shortage, which should be a collaborative approach; rather than one company winning over another (by recruiting their staff) '*...a collaborative model would allow a win-win scenario to evolve, as stakeholders join forces on the basis of their common ground.*' This would also help to bring about a consistent message to the decision makers. Finally Schifo (2005) argues that leadership is required at the senior level, '*...to provide appropriate sponsorship and motive force for a change initiative around a coordinated recruitment effort.*', and at an operational level '*...for effective execution of the tactics that are aligned with strategy.*'

This is echoed by some of the conclusions made by Thune (2011), who based these on an empirical study of cross-sector collaboration between four regional universities and energy firms in Norway, and lists the following pre-conditions for successful partnerships:

- Prior relationships and networks (although these do not necessarily have an impact on results of particular partnerships);
- Geographical proximity (which eases communications, and gives more efficiency to the collaboration); and
- Organisational factors, including institutionalisation of the collaborations in partner organisations, formal organisational and top leadership commitment, and engagement and commitment of key people.

Thune (2011) then suggests a number of 'success factors' that can be used to gauge the success of university-industry collaboration:

- Subjective assessment made by participants in the partnerships;
- Systematic empirical data on particular performance indicators; and
- Partnership continuity over time.

Thune (2011) notes that the perceptions of different participants are, however, likely to be quite different.

Finally, Walther et al. (2011) offer an interesting perspective on the education of engineering professionals. They ask the question '*What are the influences that contribute to engineering students' professional formation?*', and introduce the idea that '*Engineering education is a complex system where a range of influences outside the realm of explicit instruction contribute to the development of students as professional engineers*.' They introduce the term '*Accidental Competency*' (giving the example of preparing for exams under pressure as an 'accidental competency' that will be useful in the workplace, in dealing with deadlines), and that '*...learning is influenced by factors from the wider educational context*', suggesting the need '*...to explore broader perspectives of student learning as emergent from the social learning environment*'.

They also point out that engineering and technology are likely to play a major role in addressing challenges on a global, economic, environmental, and social level, citing several sources to back up this claim. They assert that this changes the expectations of engineers from one of '*...transmitting technical content knowledge to the urgent need for educating for broader competencies which concern students' attitudes and values*.'

4.2 The EPECentre in the Context of University-Industry Collaboration

It is interesting to look at the establishment and management of the EPECentre in the context of the previous discussion, as many of the strategies and preconditions have been met by the industry, PEET, and the EPECentre, including:

- An industry wide collaborative approach, where stakeholders join forces on the basis of their common ground, that being to ensure an adequate supply of appropriately trained electric power engineers; Trustees of PEET are from key companies in the industry, representative of all sectors.
- Leadership provided by industry at the senior level; Trustees of PEET have always been senior executives from the power industry.
- Engagement and commitment of key people from within a number of member organisations at an operational level, with institutionalisation of the collaborations in partner organisations. A number of the member organisations have dedicated a proportion of staff time to work with the PEET and EPECentre.

Much of this has been built on prior relationships and networks, and with New Zealand being a small country, geographical proximity is not a major issue. These strategies and pre-conditions have been enhanced by the operation of the EPECentre, employing a young and enthusiastic manager who related well to students (being a recent graduate himself), with the

director being the chair of EPE, passionate about the EPE programme at UC, and with very good prior relationships and networks.

4.3 The Future of the EPECentre

We have discussed that prior relationships and organisational commitment are important to university-industry collaboration. However, organisations do not remain stationary, and the people with these relationships and commitments do change organisations, or they themselves retire or move to other industries. This is exactly one of the challenges currently facing the EPECentre, and very likely one of the factors behind declining PEET membership. However, the EPECentre is fortunate to have some on-going strong and senior level support from member organisations. Nevertheless, we wish to counter the decline in membership, and establish and build strong relationships again with the key companies in the industry. To do this, the EPECentre will be embarking on:

- a series of meetings with both members and recently 'retired' member companies, to (a) establish new and build stronger relationships, and (b) understand employers' / industry's needs for graduate electric power engineers, and summarise and feed this back to the EPE programme.
- Continue to market the EPECentre to members and non-members, including arranging key events such as field trips and careers conventions.
- Devise and conduct an, or access existing, efficient survey of students for their motivations for making the choices they make.

With field trips, and other activities, taking place in the EPECentre, the opportunities for 'accidental competencies' and interesting and innovative learning is high. These activities are considered essential to the training of graduates, and will continue. The EPECentre will seek further opportunities to provide 'accidental competencies' and enhancement of student learning. One such area is an increased focus on research, in contemporary and future issues facing the electric power industry, undertaken in close collaboration with industry partners.

We believe that a successful EPE research organisation within the University, closely associated with the EPE degree programme, and with industry, will not only deliver research to industry, but will act as a 'beacon' to new students, encouraging them into power engineering, and enhancing their training by exposing them to research of relevance to industry. In turn, this will help fulfil the purpose of PEET. Consistent with this, the EPECentre has recently completed a proposal for a major six year research project in the area of renewable energy and smart grids.

5. Conclusion

Reviewing the relevant literature and case studies of university-industry collaboration to deal with low graduate numbers, strikes a chord with the EPECentre. In its first ten years it has, together with industry, done many things right in promoting education in EPE. Not surprisingly, its efforts have been rewarded with a near doubling in the number of graduates. Unfortunately, due to staff changes in member organisations, the effect of the Christchurch earthquakes, and University of Canterbury ECE staff changes, this growth has not been maintained. Moreover, global issues will increase the demand for New Zealand graduates, and place upwards pressure on engineering salaries. Nevertheless, the number of graduates is

still healthy, and the EPECentre's focus for the future is: (a) on re-building relationships with industry members who have been lost, while maintaining existing relationships; (b) in maintaining and improving the quality of the EPE degree programme; and (c) increasing research in contemporary EPE areas, and areas of concern in the future. These three areas: industry relationships, education in EPE, and industry research, have always been important focuses for the EPECentre, and will continue to be so in the future.

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