AAEE 2012 CONFERENCE
Melbourne, Australia
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The Challenges of Running Specialised Taught Courses: The Geothermal Postgraduate Course, University of Auckland

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BACKGROUND

Geothermal energy training is a very specialised area with only two established postgraduate (PG) courses available worldwide. The two-semester geothermal PG Diploma course at the University of Auckland ran from 1979 till 2002 when the government funding ceased. The course was restarted in 2007 as a one-semester PG Certificate in response to the increasing demand for trained engineers and scientists with the boom in geothermal exploration and development in many countries around the world. The course is very applied and is designed to bring together graduates from different disciplines in science and engineering.

Running this course has many challenges such as the diverse technical skills needed to teach this course, which are not all available within the University. The course is expensive to run due to the high cost of the two-week long field studies. At the same time student numbers have to be limited for this level of applied teaching. The students are mostly international with different academic backgrounds, ages and ethnicities.

PURPOSE

The purpose of this investigation is to find the optimum teaching and learning environment and course structure that achieve a balance between field work and class room based education (taking account of the changes in course funding and increased demand from industry for graduates).

DESIGN/METHOD

Given the diversity of the student backgrounds, the first two weeks of the course are dedicated to the principles of geothermal energy, aiming to bring the students to a common level of knowledge. The curriculum then rapidly builds up a base level of fundamentals and information in preparation for the field study for both the engineering and earth science streams of the course. The block structure of the PGCert and the short duration of the modules allow the students to undertake the program in two short periods away from their regular employment spread over two calendar years. The course coordinator and main academic staff carry out most of the teaching, field work and are strongly involved in the selection of material covered by the external lecturers and industry experts. This reduces the course overhead in terms of number of full time academic staff and prevents repetition of material covered by multiple lecturers, which also ensures a consistent course structure.

Running this course requires strong links with the geothermal industry for access to commercial sites, data and facilities. However, the course is not entirely structured as a field-based course as in some applied science programs.

RESULTS

The success of the course is evident from the student feedback (course reviews), the input from the employers of the students and the increasing number of applicants each year.

The student projects at the end of the course are commonly published in scientific journals and refereed conference proceedings. Several students undertake further studies to Masters and PhD level upon completing the PGCert course. The PGCert is also popular with PhD students undertaking geothermal research at other universities in New Zealand and internationally.

CONCLUSIONS

The main academic staff teaching such a course should have extensive industry/field experience with ongoing involvement along with a strong academic background for research based teaching.

The PGCert provides training for engineers and scientists involved in geothermal development and at the same time, delivers a constant stream of Masters and PhD research students.

KEYWORDS

Geothermal training, geothermal research, field-based education.

Introduction

Geothermal energy development is booming worldwide, requiring significant increases in trained man-power. Geothermal energy is simply heat from the earth. It can occur in different geological settings, but is located mainly along tectonic plate boundaries. This energy can be utilised for electrical power generation or as a heat source for direct use applications (for example space heating, aquiculture, green houses, industrial processes). Power generation from geothermal energy has been proven to offer reliable base load at low cost. Many countries have now recognised geothermal energy as a means of helping to achieve energy independence.

In 2003 the price of oil was around $20/barrel, but by mid-2008 oil reached a maximum of $147/barrel. Climate change is becoming accepted as a reality and expanding the use of renewable energy had become a mainstream idea. The growing awareness of the potential of geothermal resources and engineered geothermal systems (EGS) led to the creation of an Australian geothermal industry. This was strongly supported by a government looking to encourage environmentally responsible power generation and energy use. The emerging Australian geothermal energy industry is expected to provide between 1000 to 2200 MWe of base-load electricity by 2020 (MMA, 2008). Similarly there has been an increasing interest in engineered geothermal systems in the United States (MIT, 2006). The interest in the potential of conventional geothermal energy on every continent has continued despite the world financial problems of 2008 (Newson; O’Sullivan and Zarrouk, 2010).

Geothermal power production was started in Italy in 1913 to power the local railway network. New Zealand was the second country to produce electricity from geothermal energy in 1958 with the commissioning of the Wairkei project (Bertani, 2012). Currently more than 11,000 MWe of electricity is generated from geothermal energy in 24 countries. Figure 1 shows the worldwide history of geothermal power development. The forecast for the year 2015 shows a target of 18,500 MWe of installed capacity in 35 countries (Bertani, 2012). This recent boom in geothermal developments has triggered significant demand for trained engineers and scientists.

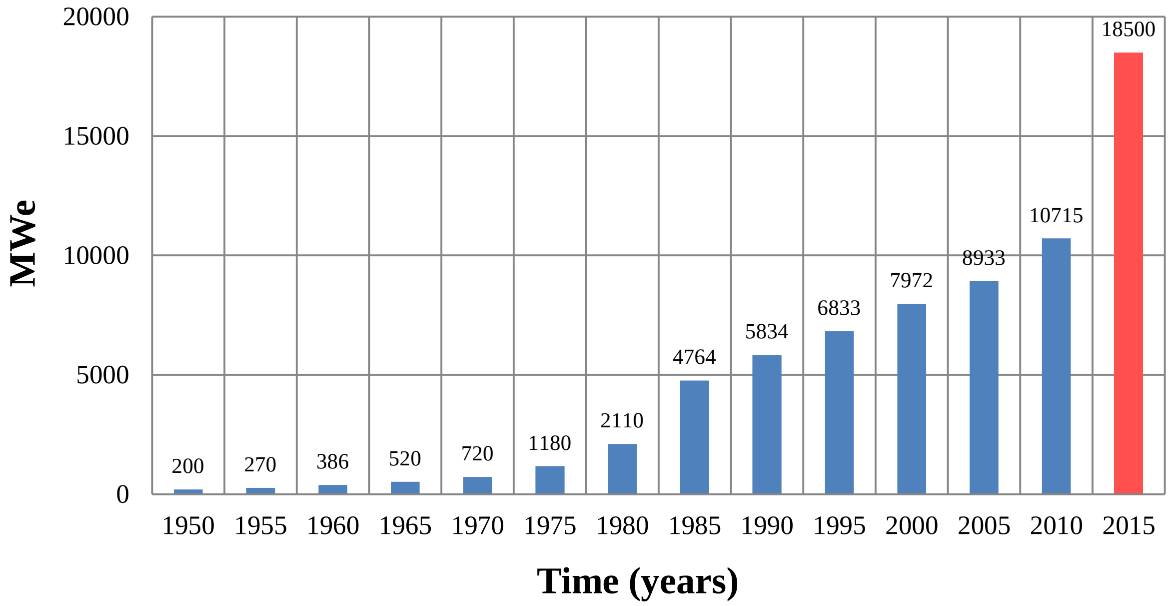

Figure 1: World geothermal power plant installed capacity (data from Bertani, 2012)

Interestingly Figure 1 shows that development of geothermal energy is strongly affected by oil prices. Note the major increase in installed capacity in the late seventies and early eighties was in response to the 1973 oil crises, while more recently the increase from 2008 up to now has resulted from oil price fluctuations.

Geothermal Energy Training

Geothermal energy training is a very specialized discipline with only a few courses currently running around the world. It is concerned with understanding the natural setting of the geothermal systems and the technology applied to harness and utilise this energy. Geothermal developments are very man-power intensive. SKM (2005) gave estimates of the man-power requirements for an expansion of the geothermal capacity in New Zealand by 50MWe/year as follows: 23.5 geoscientists, 43 engineers and 17 managers. This indicates that for the projected increase in installed capacity from 628 MWe in 2010 to 1240 MWe in 2015 (Bertani, 2012), a major increase in trained man-power is needed.

Geothermal energy training worldwide

Several papers document the history of geothermal training up to 2010 (Dickson and Fanelli, 1995; Dickson and Fanelli, 1998; Hochstein, 2005; Fridleifsson, 2005; Newson, O'Sullivan and Zarrouk, 2010). By 2003 the Iceland course sponsored by the United Nations University (UNU) was the only remaining graduate level geothermal course (see Table 1). The courses listed in Table 1 had one main theme in common, that they were designed to bring together graduates from different disciplines and cover all aspects of geothermal energy.

Table 1: History of geothermal energy training worldwide up to 2003

(Data from Hochstein, 2005)

Institution	Country	Year Started	Year Stopped	Duration
Pisa	Italy	1970	1992	6 months
Kyushu	Japan	1970	2001	2 then 4 months
Auckland	New Zealand	1978	2002	1 year
Reykjavik	Iceland	1979	Now	6 months

Geothermal energy training in New Zealand

Geothermal energy training is very important for supporting New Zealand's local and technology export industries. New Zealand has a wealth of geothermal natural resources and expertise. The geothermal systems are valued both for their natural beauty, direct use applications and for power generation. New Zealand currently generates around 70% of its electricity from renewable resources, including about 14% from geothermal energy. Most of the high temperature geothermal systems are located in the central North Island, a three hour drive from Auckland, New Zealand's largest city.

The Geothermal Institute (GI) at the University of Auckland ran a very successful year-long post graduate diploma (PGDip) in geothermal energy technology from 1979 to 2002 (Hochstein, 2005; Newson, O'Sullivan and Zarrouk, 2010). The GI had 1300 alumni from more than 50 countries most of whom are now in senior positions in their home countries. They still maintain a close relation with the New Zealand geothermal industry (providing links and potential contracts). The GI also trained most New Zealand geothermal experts and kept New Zealand at the forefront of geothermal research, knowledge and practice worldwide.

Unfortunately support from the New Zealand government for the PGDip course was withdrawn at the end of 2002 (Newson, O'Sullivan and Zarrouk, 2010). This was despite the growing concern among professionals in the geothermal industry over the loss of momentum in geothermal research and training in New Zealand, and a potential shortage of geothermal professionals (SKM, 2005).

The GI was fully funded by the United Nations from 1978 and later by the New Zealand government up to 2002. It had seven fulltime academic staff (three in geothermal engineering and four geoscientists) plus three administration staff (manager, secretary and technician) and ran the one-year (two-semesters) PGDip with an average of 25-30 students/year. There were also several Masters and PhD students undertaking geothermal research in both earth science and engineering.

Most (>85%) of the students attending the course were funded by New Zealand government scholarships. The income from the student enrolment could not support the continuation of running the PGDip course. Therefore, in 2003 when the New Zealand government stopped funding the scholarship program and the staff salaries, the course was abandoned by the university and most of the academic staff were made redundant. The fate of the GI is not different from that of the geothermal courses at Pisa, Italy and Kyushu, Japan (Table 1), where the courses were also fully reliant on government/external funding or a scholarship programmes. This can serve as an example for similar programmes because as governments change their education funding or aid programs, it puts academic courses at risk. With that in mind, when restarting the new post graduate certificate (PGCert) in geothermal energy technology in 2007 significant emphasis was given to making the course self-sustaining.

The geothermal PGCert (2007 till now)

This paper describes a new PGCert course created in responce to the need described above while recognising the challenges faced by similar courses in the past. It is argued that a sustainable geothermal PGCert course must be designed with a strong cross-disciplinary focus and a balance between class work and field work.

In 2007 the one-semester (60 points) PGCert course was started with initiative from the academic staff of the Department of Engineering Science with the help of three scholarships (for two years) from Contact Energy Ltd. and one from MBCentury Ltd. These scholarships helped restart the course with student numbers increasing each year as shown in Figure 2.

Figure 2 shows the increase in student numbers since 2007. Note the anomalous increase in student numbers in 2009. This was due to an influx of New Zealand and Australian students as a result of the financial problems and poor employment prospects in late 2008.

Understanding the challenges of running the course and the lessons learned from the GI PGDip helped us to structure the PGCert course to ensure sustainability with minimum risk:

- The course was reduced to a one-semester (19 week) course, which made it easier and cheaper for employers to send their staff to New Zealand.
- The course was divided into separate blocks of about six weeks. This meant that students can do the PGCert over two years in six week long blocks plus a one month short project. This was very attractive to some company-sponsored students.
- For the first four years, the course was run by two part time (50 %) academic staff. Currently one full time academic staff (the author) runs the course, with most other lecturers either donating their time or on short-term contracts.

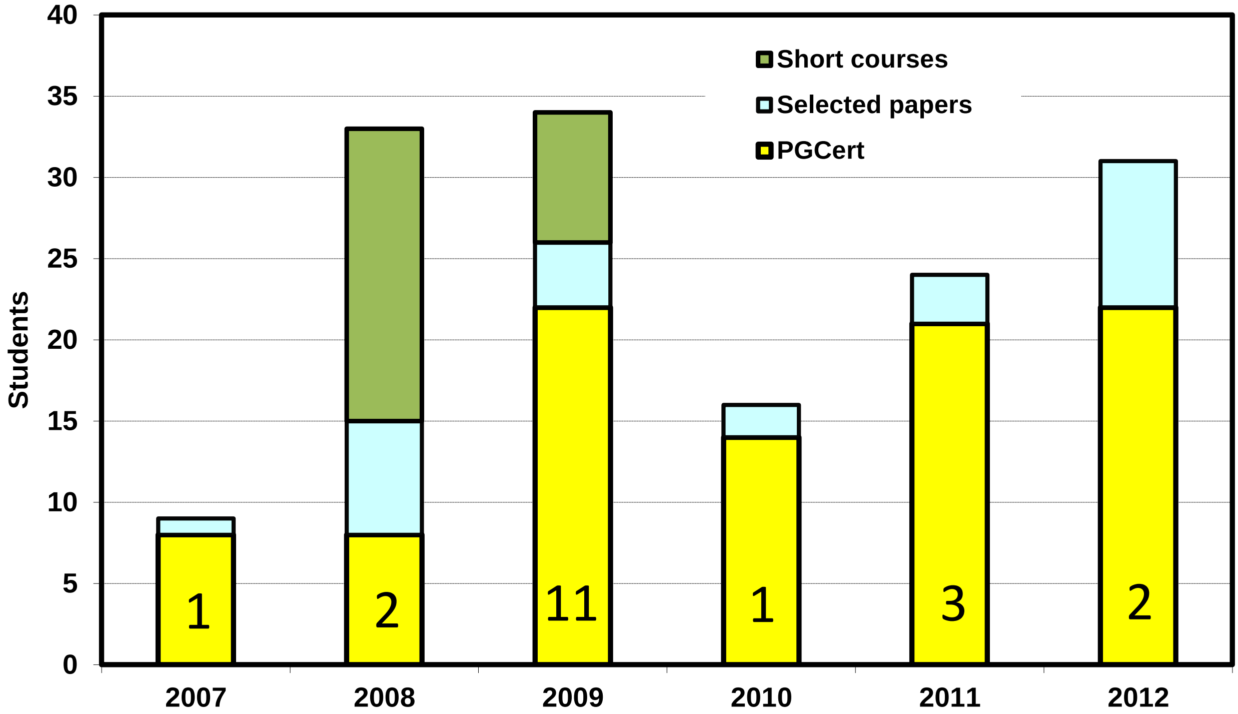

Figure 2: Students enrolment in the PGCert, selected papers and short courses. The numbers indicates the portion of domestic students attending the full PGCert course each year.

In the first three years of running the PGCert course some of the papers were used as open entry short courses (see Figure 2). This was aimed at increasing student numbers and improving the course finances. This proved to be not a good idea as some students doing a short course with no means of assessment at the end did not take the course as seriously as student doing an academic course. Also having students joining the course half way through the program can disturb the harmony of the class.

The PGCert program is mainly aimed at training engineering and science graduates for work in the geothermal industry. This involves the use of a proven technology in a mature and well-established industry and the students are directed to the relevant literature. However, most of the course material is provided for the students to save time due to the block structure of the course and to avoid some of the confusing information found on the internet and in some of the literature.

The teaching has a strong research base and many of the student projects are published in journals and conference proceedings and are available as a resource for future students. The projects are all industry focused and are concerned with how to develop and improve current exploration and utilisation techniques. The course is also popular with Masters and PhD students undertaking research in all aspects of geothermal energy. The PGCert graduates are highly sought after by the geothermal industry both in New Zealand and overseas.

The PGCert course is very lecture intensive with 4 hours of lectures and 2 hours of tutorials every day. It also involves several field trips which are highlights of the course. The coures is demanding as students only take one week off during the mid-semester break and have to do field work during some of the weekends.

The students are mostly (> 80%) international students from different academic backgrounds (science or engineering), age (22 to 62 years old), ethnical and gender diversity (Figure 3).

This diversity requires great effort to develop positive relationships (trust) with mutual respect between the lecturers and the students.

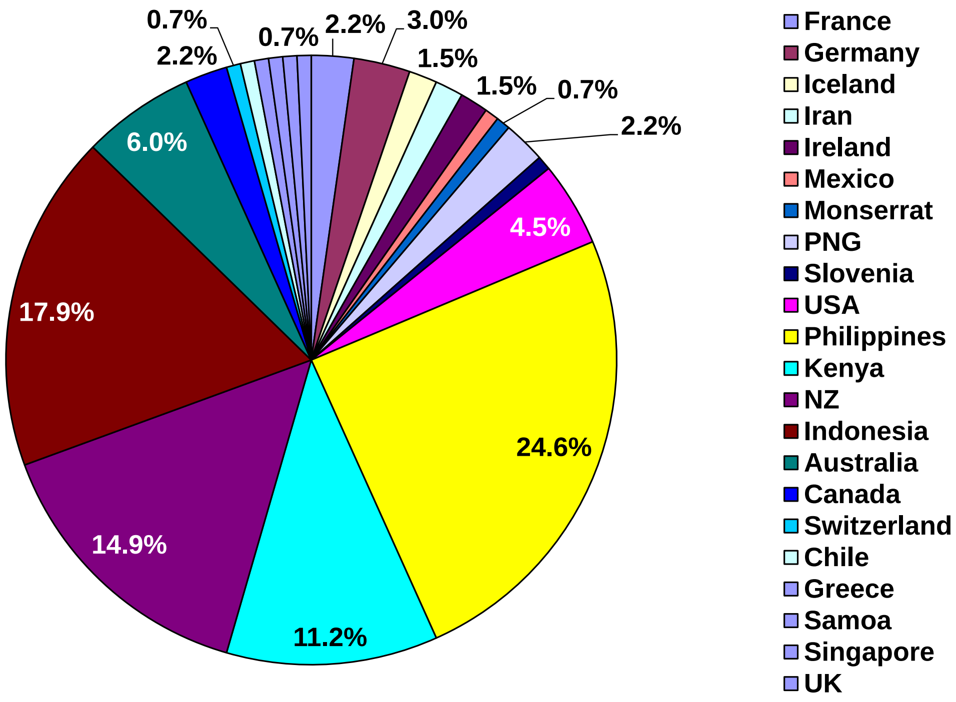

Figure 3: Students distribution by country for the past six years (2007-2012).

Given the diversity of student backgrounds, the first two weeks of the course are dedicated to the principles of geothermal energy, aiming to bridge the knowledge gap and to bring the students to a common level of knowledge. All students do two compulsory papers, geothermal resources and their use (GEOTHERM 601) and geothermal energy technology (GEOTHERM 601). This is when the engineers learn more about earth science (geology, geochemistry, geophysics) while the earth scientists learn the engineering fundamentals (thermodynamics, fluid mechanics, heat transfer). This also serves as a refresher for returning students who have been away from university/academia for some time.

In the second part of the course, the students have the option to learn more about either geothermal engineering (GEOTHERM 620) or geothermal exploration (GEOTHERM 603). The students then carry out an industry-based project (GEOTHERM 689) to apply, in a practical setting, the knowledge they have gained through course work.

There are also several day trips to visit geothermal companies and sites of geological or geothermal interest. The field trips help to cement the theory with practice. The students also receive several lectures from experts in the geothermal industry during the field trips.

By the end of the course the students have been through five different geothermal power stations, three geothermal drilling rig sites, four steam fields, eight direct use geothermal energy developments, five different geothermal systems and have had twelve lectures from geothermal experts in the industry.

The success of the PGCert course and the strong support from the New Zealand geothermal industry prompted the New Zealand government to re-establish a scholarship programme in 2011 as part of New Zealand government aid (NZAID) programme with up to $NZ 1.3M/year for three years. These scholarships are very welcomed. However, lessons have been learnt from the PGDip course and the demise of the GI in 2002. So it is important to make sure that the PGCert course is not fully reliant on scholarships**.** This is done by diverting some of the funding to sponsor Masters and PhD students and maintaining a constant stream of self-funded students to the PGCert to insure the course sustainability.

Field-based versus class-based teaching

Field-based education is very common in applied sciences (mainly in geology, biology and environmental sciences) and is also applied to some business and engineering courses. Many universities have established undergraduate and postgraduate courses that are run fully in the field and many of these universities have permanent field stations dedicated to this type of applied education (Douglas, Suttner and Ripley, 2009) or run field camps (Puckette and Suneson, 2009).

The PGCert combines both field-based and class-based teaching. The field trips (25 % of the course time) are integrated with the academic teaching to build student confidence in understanding the framework of geothermal fields: assessment, development, and utilization.

There are two one-week long field trips to the Taupo volcanic zone (TVZ) of New Zealand. Fieldwork in the first field trip, during the GEOTHERM 601 and GEOTHERM 602 courses in the first part of the semester, is designed to give an overview of geothermal energy. This is to ensure that all students learn a basic level of geothermal geology and engineering and field techniques like mapping, sampling, carrying out geothermal field surveys and understanding the purpose of various utilisation systems.

The second field trip during GEOTHERM 603 and GEOTHERM 620 in the second part of the semester addresses problems of increasing complexity and students are required to work together when taking measurements and share data for their field trip reports. The field exercises provide the basis for cementing the concepts and problem solving techniques introduced in the lectures. The field trips also increase the professional relationship between students. Students have to complete a 1500-2000 word technical report after each field trip recording their observations and applying the techniques they learned during the lectures.

There are also several day trips to visit geothermal companies and sites of geological or engineering interest.

Running the field trips normally requires significant investment due to the high costs associated with travel, food, accommodation and for access to some sites, which may be covered by the students in addition to their tuition fees. The regulations at the University of Auckland do not permit charging the students additional fees on top of the standard course fees. This puts significant pressure on the course budget and viability. At the same time it is not possible to increase student numbers as most geothermal companies/operators put a maximum limit of 30-35 students and staff during site visits at a time. It is also not possible to run these field trips multiple times a year due the logistics, cost and limited staff. Therefore, student numbers are restricted to 25-30 a year.

Student safety during the field trips is a top priority. Much effort goes into planning these field trips, working with the geothermal industry to ensure safety. Key hazards are cold weather, hot steam and water, unstable and thin ground, potential for toxic fumes and heavy machinery. I develop a health and safety plan for each field trip.

Teaching philosophy

The main teaching philosophy, which I feel to be unique to the course, is the crosslink and overlap between the two main disciplines in the geothermal industry: engineering and earth science. This is implemented by having all students do the first part of the course. The students also learn a lot from interactions with each other during the field trips and during the feasibility study. The students carry out a group assessment of a geothermal resource they visit during the field trip, with field data provided by the industry or from the public domain.

The course content draws on recent advances in geothermal energy technology and uses experts from academia and industry as lecturers and field demonstrators. Managing a large number of experts to ensure a consistently structured course is one of the main challenges of running the course. As the course coordinator, I invite and/or contract the different industry experts to cover most of the geoscience component of the course. However, I am also involved in the course material selection and insure that the delivery of the course follows our academic structure. This means imparting a sound knowledge of the principles of geology, geochemistry and geophysics, which require on-going development and involvement in geoscience research.

As PGCert is a very technical course with long lecture hours, there is an impact on student attention level throughout the lectures: it normally drops with time. I regain student attention through the use of short technical movies, relevant stories from my field experience or interesting incidents that took place in the industry. I get the students to comment and possibly tell a similar story from their experience. I also use models of equipment, rock samples and damaged/broken parts of equipment (turbine blades, heat exchangers, drilling bits etc.) as a tool to regain attention and engagement.

The course receives strong support from the New Zealand geothermal industry for two main reasons. Firstly, the course provides the New Zealand industry with links and potential clients in many countries as most of our former graduates are now leaders in the geothermal industry worldwide. Secondly, the graduates of the PGCert are highly sought for the applied skills they learn through the course.

Student evaluation of PGCert courses has been always very positive, scoring an average of 9.1/10 with a minimum of 8.5/10 across all the courses. Since starting the PGCert in 2007, 147 students from 22 countries have attended the course (see Figures 2 & 3).

The course undergoes continuous development with the taught material being kept up to date with recent industry developments and research. The course structure is also undergoing constant change to keep up with industry demands.

Conclusions

A sustainable geothermal PGCert training course was designed with a strong cross-disciplinary focus and a balance between class work and field work.

Geothermal energy development is booming worldwide, requiring a significant increase in trained man-power.

Geothermal energy training is very specialised with only a few courses currently running around the world. It involves an integrated approach between field-based and class-based education.

History has witnessed the demise of several geothermal training programmes around the world as their funding has been withdrawn.

Learning from past experience, the new geothermal PGCert course is structured in a way to ensure its sustainability, by reducing the number of full-time academic staff while contracting most of the remaining lecturers and experts from the industry.

To ensure a consistent and structured delivery of the different courses, a strong cross-disciplinary understanding together with research and field experience, is needed when organising such a course.

References

Bertani, R. (2012). Geothermal power generation in the world 2005-2010 update report. *Geothermics*, 41, 1-29.

Dickson, M. H. & Fanelli, M. (1998). Geothermal Training Centres in the World. GHC Bulletin, December, 1998.

Dickson, M. H. & Fanelli, M. (1995). Geothermal Training at the International Institute for Geothermal Research in Pisa: Twenty-five years of activity, Proceedings, World Geothermal Congress 1995, Italy, pp. 2935-2937.

Douglas, B.J., Suttner, L.J. & Ripley, E. (2009). Indiana university geological field programmes based in Montana G429 and other field courses, a balance of tradition and innovation. In W.J. Steven, D. W. Mogk & E. J. Pyle (Ed) Field Geology Education (pp. 1-14). The Geological Society of America, Special paper 461.

Fridleifsson, I. B. (2005). Twenty-five years of geothermal training in Iceland, Proceedings, World Geothermal Congress 2005, Antalya, Turkey.

Hochstein, M. P. (2005). 25 years Geothermal Institute, Proceedings, World Geothermal Congress 2005, Antalya, Turkey.

Massachusetts Institute of Technology (2006). The Future of Geothermal Energy. Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century. An assessment by an MIT-led interdisciplinary panel, prepared under Idaho National Laboratory Subcontract No 63 00019 for the US Department of Energy. Available at http://www.geothermal.inel.gov.

McLennan Magasanik Associates Pty Ltd. (2008). Installed capacity and generation from geothermal sources by 2020. Report to the Australian Geothermal Energy. Association, August 2008. Available at http://www.infrastructureaustralia.gov.au/public_submissions/published/files/374_agea_SUB3.pdf

Newson, J., O'Sullivan, M.J. & Zarrouk S.J. (2010). Postgraduate Geothermal Training in New Zealand. World Geothermal Congress. Bali, Indonesia.

Puckette J. O. & Suneson N. H. (2009). Field camp: Using traditional methods to train the next generation of Petroleum Geologists. In W.J. Steven, D. W. Mogk & E. J. Pyle (Ed) Field Geology Education (pp. 25-34). The Geological Society of America, Special paper 461.

Sinclair Knight Merz (2005). Review of Current and Future Personnel Capability Requirements of the NZ Geothermal Industry. Report prepared for NZ Geothermal Association. Available at http://www.nzgeothermal.org.nz/publications/Reports/NZGA_Geothermal_Capability_Review.pdf

Acknowledgements

I like to thank my wife Maryam for her valuable help, support and input when writing this manuscript. I also like to thank Professor Mike O'Sullivan and Dr. Adrian Croucher for their help in reviewing the final manuscript.

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