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Postgraduate geothermal energy education worldwide and the New Zealand experience

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ABSTRACT

Postgraduate (PG) geothermal energy education is a highly specialised area offered by very few universities around the world. History have witness the demise of several geothermal education programs when their funding was withdrawn.

In this investigation we will give an overview of the global geothermal education programmes. The background, course structure, teaching philosophy, student cohort and funding for the PG geothermal energy course at the University of Auckland is provided. A vision going forward is required given the recent decline in the number of students attending the course and the drop in oil prices which is affecting the global geothermal energy industry.

1. Introduction

Geothermal energy is a clean renewable energy source that has been used for thousands of years. Geothermal energy is simply heat from the ground. It can occur naturally in different geological settings, but is mainly located along tectonic plate boundaries in areas with high volcanic and seismic activities. Geothermal energy can be utilised for electrical power generation as well 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 (Bertani, 2016; Zarrouk and Moon, 2015). Many countries have recognised geothermal energy as a means of helping to achieve energy independence. Geothermal power is known for its high availability compared with other renewables (e.g. wind and solar) (e.g. Zarrouk and Moon, 2014, 2015). Geothermal energy, however, has higher upfront cost and risk associated with exploration drilling and longer development time when compared with other renewable energy resources. 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 Wairakei power plant (Bertani, 2016).

In mid-2008 oil price reached a maximum of $US147/barrel (Fig. 1). Climate change is becoming accepted as a reality and expanding the use of renewable energy has become a mainstream idea. The growing awareness of the potential of geothermal resources and engineered geothermal systems (EGS) led to increasing interest in geothermal technology 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 et al., 2010).

Currently more than 12,635 MWe of electricity are generated from geothermal energy in 26 countries, it accounts to a saving of 1000 million ton of CO_2 emission to the environment per year compared to fossil fuelled power (Bertani, 2016). Fig. 1 shows the worldwide history of geothermal power development since 1950. The forecast for the year 2020 shows a target of 21,443 MWe of possible installed capacity in 51 countries (Bertani, 2016). If this is realised a boom in geothermal developments will trigger significant demand for trained geothermal engineers and scientists.

Not surprisingly Fig. 1 shows that development of geothermal energy is strongly affected by the price of oil. Installed capacity grew very little between 1950 and 1970, when the average price of oil was less than 25 $US/barrel. This was followed by significant increase in installed capacity in the late seventies and early eighties in response to the 1973 and 1980 oil crises. Then growth was moderate between 1985 and 2005 when oil averaged about 20 $US/barrel. While more recently the increase from 2005 up to 2015 has resulted from the surge in oil price. However, the data in Fig. 1 which came from countries forecasts from 2014 (Bertani, 2016) did not consider the drop in oil prices in late 2014, which will likely result in lower investment in geothermal power development and lower installed capacity by 2020 than predicted in Fig. 1. Geothermal power development is also being challenged by the drop in the price of photovoltaic solar energy panels in the past ten years (EIA, 2017). However, geothermal energy development will continue in many countries as a reliable renewable energy source and

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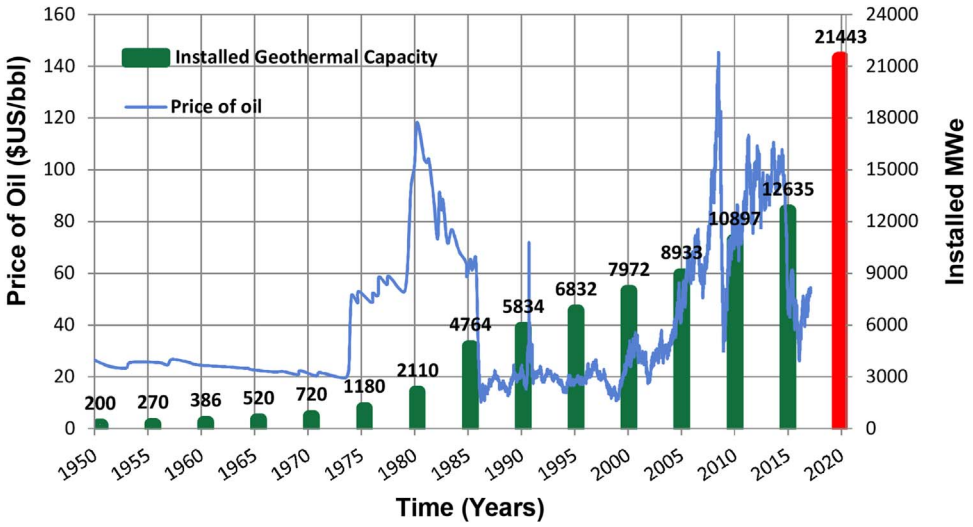

Fig. 1. World geothermal power plant installed capacity in MWe (Bertani, 2016) and the price of Oil (http://www.macrotrends.net/1369/crude-oil-price-history-chart).

as fossil fuel fired thermal and nuclear plants are phased out with time.

In this work, we will give an overview and assessment of the geothermal energy education programmes worldwide, then focus on the Post Graduate Certificate in Geothermal Energy Technology (PGCertGeothermTech) taught at the University of Auckland, New Zealand.

2. Geothermal energy education

Geothermal energy education 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 50 MWe/year as follows: 23.5 geoscientists, 43 engineers and 17 managers. This indicates that for the projected optimistic increase in installed capacity by about 41% between 2015 and 2020 (Bertani, 2016), a major increase of about 14,710 in trained man-power is needed worldwide.

3. Geothermal energy education worldwide

Several papers document the history of geothermal energy education since 1970 (Dickson and Fanelli, 1995, 1998; Hochstein, 2005; Fridleifsson, 2005; Newson, et. al., 2010: Zarrouk, 2012; Georgsson et al., 2015; Zarrouk, 2016). By 2003 the United Nations University (UNU) course in Iceland was the only remaining post graduate level geothermal course (see Table 1). The international (taught in English) courses listed in Table 1 had one main theme in common, that they were designed to bring together graduates from different disciplines in science and engineering and cover all aspects of geothermal energy technology.

Specialized education and training in geothermal energy resources and their application is very challenging because "*the market at national level is normally too small to justify investment and running costs*" (Popovski and Vasilevsks, 2004). Therefore, only international courses can potentially run viably (with some additional support).

History has witnessed the end of several geothermal courses around the world when their external funding stopped (Table 1).

Currently, there are only two "established" geothermal institutions specialising in taught geothermal energy training around the world. These two institutions are the United Nations University Geothermal Training Programme (UNU-GTP) in Iceland (Georgsson et al., 2015) and the Geothermal Institute (GI) at the University of Auckland in New Zealand (Zarrouk, 2016).

The UNU-GTP, Iceland is by far the most active and out reaching geothermal education/training programme in the world. It is the only geothermal course that did not stop since it was started in 1979 (Fridleifsson, 2005; Georgsson et al., 2015). The UNU-GTP receives substantial funding from the Icelandic Government, but it is also financed through funds from international cooperation partners with an estimated total annual budget of $US2.8 million to $US3.0 million) (Private communications with Mr. Lúdvík Georgsson, UNU-GTP). The funding allows for the running of the six months (April-October) geothermal training programme in Iceland and several subsidized/free short courses in Africa (Mwangi, 2003), Asia (Benito and Reyes, 2003), South America (Martínez, 2003; Georgsson et al., 2015) and Europe (Fridleifsson and Geogsson, 2004). The funding also covers scholarships for MSc and PhD in Iceland carried out in cooperation with Icelandic

Table 1
History of post graduate geothermal programmes around the world (updated from Hochstein, 2005 and Zarrouk, 2012).

Institution	Country	Year Started	Year Stopped	Duration (months)	Funding support
International Institute for Geothermal Research, CRN in Pisa,	Italy	1970	1985	9	United Nations Development Program (UNDP).
		1985	1992	8	UNESCO
Kyushu University	Japan	1970	2001	2–4	The government of Japan (JICA)
		2016	Continuing	6	
Auckland University	New Zealand	1978	2002	9	UNDP and MFAT Scholarships (varying number over the years)
		2007	Continuing	4	Employer-funded students Self-supported students
UNU-GTP Reykjavik	Iceland	1979	Continuing	6	The government of Iceland and UNU (until 2007) Employer-funded students