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GEOTHERMAL ENERGY IN THE WORLD FROM AN ENERGY PERSPECTIVE

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ABSTRACT

This paper gives an overview of the energy utilization in the world and the operations of UNU Geothermal Training Programme in Iceland are presented, with emphasis on East Africa. Utilization of geothermal energy in Africa is reviewed and examples are presented from the region, as well as from Iceland where geothermal energy plays a larger role than in any other country in the world.

Based on the World Energy Council report, published in 2013, on the current world energy status and future energy scenarios, the primary energy consumption in the world was assessed as 546 EJ in 2010, with about 80% coming from fossil fuels, and only 15% from renewable energy sources. Different scenarios proposed by WEC for development to 2050 are discussed with emphasis on the potential contribution of the renewables and their prospects. The current share of renewables in energy production is mainly from biomass and hydro, but in a future envisioned through depleting resources of fossil fuels and environmentally acceptable energy sources, geothermal energy with its large technical potential is expected to play an important role. Africa is currently an energy depleted region, but in the WEC report an annual growth rate of 5% is predicted in the next decades, considerably higher than for other regions which is good news for Africa.

High-temperature geothermal resources within the Great East African Rift Valley have the potential to provide East Africa with the some of the energy it needs for development, and even become one of the main source for electrical production. Kenya is now producing about 590 MWe of electricity from geothermal (end of 2014), and has set itself a very ambitious goal of having reached 5000 MWe from geothermal resources on-line in the year 2030, through its Kenya Vision 2030. This is an example for the other East African countries to follow.

1. INTRODUCTION

Geothermal energy is one of the renewable energy sources that can be expected to play an important role in an energy future where the emphasis is no longer on fossil fuels, but on energy resources that are at least semi-renewable and environmentally acceptable on a long-term basis, especially with regard to emission of greenhouse gases and other pollutants. For developing countries which are endowed with good geothermal resources, it is a reliable local energy source that can at least to some extent be used to replace energy production based on imported (usually) fossil fuels. The technology is proven and cost-effective. For developing countries that have good resources and have acquired the necessary local expertise it has become very important. A good example is Kenya, as well as the Philippines, El Salvador and Costa Rica, where geothermal energy has become one of the important energy sources providing for 10-25% of the electricity production. Iceland should also be mentioned as the only country where geothermal energy supplies more than 60% of the primary energy used, both through direct use for heating, bathing, etc., and through production of electricity.

Geothermal systems can be classified into a few different types, but with reference to variable geological conditions each one is in principle unique, so good knowledge is needed through exploration. Furthermore, development of a geothermal system for electrical production is a capital intensive undertaking, and thus requires financial strength, or at least access to good financing. Thus, for developing geothermal resources, good training and expertise are needed for the exploration and development work, and strong financial backup for the project.

Here, the role of geothermal energy in the world's energy mix is presented with some emphasis on E-Africa, and examples are given on its use in Africa and Iceland. An introduction to United Nations University Geothermal Training Programme is also given.

2. THE UNU GEOTHERMAL TRAINING PROGRAMME

United Nations University Geothermal Training Programme (UNU-GTP) has operated in Iceland since 1979 offering six-month annual courses for professionals from developing countries. From being one of four geothermal schools established in the 1970s, UNU-GTP is now the only international graduate Programme offering specialized geothermal training in all main fields of geothermal exploration and development. The aim is to assist developing countries with geothermal potential in capacity building in order to make the countries self-sufficient in expertise for geothermal development. This is done through giving university graduates engaged in geothermal work intensive on-the-job training. The training is conducted in English and is tailor-made to suit the needs of the home country. UNU Fellows generally receive scholarships financed mainly by the Government of Iceland. Since 2000, cooperation between UNU-GTP and the University of Iceland (UI) has opened up the possibility for some UNU Fellows to extend their studies to MSc level, with the six months training adopted as an integral part (30 out of 120 ECTS). A similar contract was made with Reykjavík University (RU) in 2013. In 2008, the cooperation with UI was expanded to include PhD studies, with the first PhD Fellows accepted in the academic year 2008-2009 and the first one graduating in 2013.

As a contribution to the UN Millennium Development Goals and through the funding of the Icelandic Government, UNU-GTP has expanded its activities to giving annual workshops/short courses in Africa (started in Kenya in 2005), Central America (started in El Salvador in 2006), and Asia (given in China in May 2008). The courses are organised in cooperation with local energy agencies responsible for geothermal development (in Kenya these are KenGen and GDC). A part of the objective is to increase geothermal cooperation within the region, and to reach out to countries with a potential and interest in geothermal development which have not yet received quality training. The courses have made it possible for UNU-GTP to reach out to an increasing number of geothermal scientists and engineers. More recently, this has also been an important factor contributing to UNU-GTP being able to offer customer-designed courses, lasting from one to 12 weeks, modelled to the demands of a paying customer. This has become an important part of UNU-GTP's operations in the last 4-5 years, serving several customers on 4 different continents.

East-Africa has always been a major cooperating partner of UNU-GTP. Amongst the 583 graduates of UNU-GTP (1979-2014), 210 or 36% have come from sixteen African countries. Most of these come from East Africa. By far the largest number has come from Kenya (100). This is followed by Ethiopia (34), Uganda (16), Djibouti and Rwanda (11). Former UNU Fellows lead the geothermal research and development in most of these countries. The political and economic situation in some of the countries has, however, delayed geothermal development, with some of its professionals trained at the UNU-GTP having left their jobs in the geothermal sector and even immigrated to other countries. Half or twenty out of the forty UNU MSc-Fellows who have graduated from the MSc programme (at the end of 2014) are from Africa, 13 from Kenya, 2 from Eritrea and Ethiopia, and 1 from each of Djibouti, Rwanda and

Uganda. Currently, 11 Africans are pursuing their MSc studies in Iceland, coming from Ethiopia, Kenya, Malawi, Tanzania and Rwanda. Finally, the first three UNU PhD-Fellows are Kenyans, with the first one defending her thesis in February 2013, the first African to do so in Iceland. Kenya has been the leading country in E-Africa in geothermal research and development, and many of its specialists have been trained in Iceland. Figure 1 shows the group of UNU Fellows that attended 6-month training in Iceland in 2013, which is the biggest group to date, 34 UNU Fellows, including 12 Kenyans.

FIGURE 1: The group of UNU Fellows that attended the 6 months training in Iceland in 2013, at Hjalteyri geothermal wellsite, N-Iceland

For more information on UNU-GTP, see e.g. Georgsson et al., 2014a and b; and Georgsson, 2014a) or its web page (www.unugtp.is).

3. THE ROLE AND POTENTIAL OF GEOTHERMAL ENERGY TODAY

Geothermal energy is a resource that has been used by mankind for washing and healing through its history. In the 20th century, geothermal gradually came on-line as an energy source for electricity production and to be used directly, besides bathing or washing, for heating of houses, greenhouse heating, aquaculture etc. According to energy reviews based on surveys for 2009, presented in combination with the World Geothermal Conference 2010, geothermal resources have been identified in over 90 countries while quantified utilization is recorded in 78 countries. Electricity is produced from geothermal energy in 24 countries. In 2009, the worldwide use of geothermal energy was estimated to be about 67 TWh/a of electricity (Bertani, 2010), and direct use 122 TWh/a (Lund et al., 2010).

In the modern world, access to clean energy at affordable prices is a key issue to improve the standard of living. However, at present, two billion people, a third of the world´s population, have no access to modern energy services, and in addition the world population may be expected to double by the year 2100. Furthermore, the world energy consumption is expected to double in the new century. So the task in providing clean energy to people in the coming century is enormous (Fridleifsson, 2003).

Today´s energy consumption relies on fossil fuels. Table 1 shows the use of primary energy in 2010 based on a recent report by the World Energy Council (WEC, 2013). The total use of primary energy is assessed to have been about 546 EJ in 2010, with 80% of it coming from fossil fuels. With rising oil prices and with environmental concerns expected to play a bigger role, through necessary reduction in emissions of greenhouse gasses, renewable energy sources are expected to play an increasingly bigger role in the 21st century. The technical potential of the renewable energy sources is certainly large enough (WEA, 2004).

TABLE 1: World primary energy consumption in 2010 (WEC, 2013)

Energy source	Primary energy (EJ)	Share, (%)
Fossil fuel	**435**	**79.6**
Oil	172	31.5
Gas	114	20.9
Coal	149	27.2
Renewables	**81**	**14.8**
Biomass	66	12.1
Hydro	13	2.3
Other renewables	2.2	0.4
Nuclear	**30**	**5.5**

In its report, WEC (2013) puts forward two innovative scenarios for the energy utilization development until 2050. One of these is named *Jazz* where it is assumed that the forces of the market or consumer prices will be decisive in the development. The other is named *Symphony,* where it is assumed that focus will be on environmental sustainability, and thus politics will have a major say in the development.

According to *Jazz* total use is predicted to increase to 879 EJ in 2050, which is an increase of 60%. Fossil fuels are expected to be still dominating with 77% of the production while the share of the renewables is predicted to become about 20%. *Symphony* is a considerably different scenario. The total use is predicted to be 696 EJ which is an increase of only 28%. The share of renewables is predicted to reach about 30%. Fossil fuels are still responsible for the majority of the energy production, with their share, however, lowering to about 59%. Also on a positive note is the prediction of a considerably improved energy efficiency.

Table 2 shows the production of electric energy in 2010 and how it is predicted to develop to 2050, according to the two different scenarios (WEC, 2013). The share of the renewables is expected to increase even more. According to the table, other renewables, which include wind, geothermal, solar and tidal energy are only contributing 4% of the total electrical energy production in 2010. In 2050, in *Jazz* this is expected to increase to about 20% and in *Symphony* to about 32%. So the future of the other renewables appears bright.

TABLE 2: Electrical production vs. energy source 2010-2050 (WEC, 2013)

Energy source	2010		2050 - Jazz		2050 – Symphony	
	TWh	%	TWh	%	TWh	%
Coal	8,666	40	20,279	38	8,483	18
Gas	4,777	22	13,427	25	9,517	20
Hydro	3,491	16	5,789	11	7,701	16
Nuclear	2,783	13	3,279	6	6,950	15
Oil	980	5	0	0	0	0
Oth. renewabl.	**798**	**4**	**10,894**	**20**	**15,266**	**32**
Total	**21,476**		**53,647**		**47,918**	

Table 3 shows the similar information but here the distribution is on regional scale. The uppermost line shows the values for Sub-Saharan Africa and it illustrates clearly how this region is starved of electrical energy. Africa is a dark continent in more than one way. The good news, however, are that the annual growth rate for Africa for this period is predicted to be very good, about 5%, which is higher than for all other regions, and considerably higher than for most. This is good news for Africa.

TABLE 3: Electrical production vs. regions 2010-2050 (WEC, 2013)

	2010		**2050 - Jazz**		**2050 – Sym.**	
	TWh	**%**	**TWh**	**AGR %**	**TWh**	**AGR %**
Sub-Saharan Africa	**414**	**1.9**	**3087**	**5.2**	**2836**	**4.9**
Mid. East & N-Africa	1150	5.3	3644	2.9	3314	2.7
Lat. America & Carib	1147	5.3	3701	3.0	3221	2.6
N-America	5214	24.3	8024	1.1	8057	1.1
Europe	5104	23.8	8439	1.3	7961	1.1
S- & Central Asia	1331	6.2	8429	4.7	6560	4.1
E-Asia	6121	28.5	14298	2.1	12571	1.8
SE-Asia & Pacific	996	4.6	4024	3.6	3398	3.1
Total	**21,477**		**53,646**		**47,918**	

The use of geothermal energy has increased steadily during the last few decades, and until the start of this century it was seated as number three of the renewables with regards to electricity production. However, more recently wind energy has surpassed geothermal and has now left it far behind. The total electricity production from renewable energy sources (Table 4) was assessed as 4,289 TWh in 2010 (WEC, 2013). Of this, 81% came from hydropower, 7.9% from biomass, 8.3% from wind, 1.6% from geothermal, while solar contributed to 0.8%. With its huge technical potential, geothermal energy is definitely one of the energy resources contributing to a greener future.

TABLE 4: Electricity from renewables in 2010 (WEC, 2013)

	Installed capacity		**Production/a**		**Capacity factor**
	GW	%	TWh/a	%	%
Hydro	778	74	3,491	81	39
Biomass	71	6.5	337	7.9	54
Wind	191	17.5	358	8.3	21
Geothermal	**11**	**1.0**	**69**	**1.6**	**72**
Solar	39	3.6	34	0.8	10
Total	**1,090**	**100**	**4,289**	**100**	**37**

A comparison of energy costs between countries is difficult, because of differences in taxation and subsidies. According to the World Energy Association survey (WEA, 2004), the renewables are definitely competitive, showing the electrical energy cost to be 2-10 UScents/kWh for geothermal and hydro, 4-8 UScents/kWh for wind, 3-12 UScents/kWh for biomass, but higher for solar energy. These are not new numbers but still representative. The investment cost is also assessed to be quite similar for the different energy sources, 1000-3500 USD/kW for hydro, 500-6000 USD/kW for biomass, 800-3000 USD/kW for geothermal and 850-1700 USD/kW for wind. The advantage of geothermal energy compared to other renewables is the high capacity factor, being independent of weather conditions contrary to solar energy, wind energy, or hydropower. The reliability of geothermal plants means that usually they can be operated at capacity factors in excess of 90%. This is partly illustrated in Table 4.

In 2009, electricity was produced from geothermal energy in 24 countries, increasing by 18% from 2004 to 2009 (Bertani, 2010). Table 5 lists the top ten countries producing geothermal electricity in the world in 2009, and those employing direct use of geothermal energy (in GWh/year). The largest electricity producer is the USA, with almost 16,600 GWh/a, but this still amounts only to half a percent of their total electricity production. It is different for most of the other countries listed there, with geothermal playing an important role in their electricity production. That certainly applies to the second country on the list, the Philippines, where the production of more than 10,000 GWh/a means that geothermal supplied 17% of the electricity produced. Same applies to Kenya, the only African country seen in the table, the total production of 1430 GWh/a only put the country in 9th place with regard to total production but it still amounted to 17% of the total production. Here, we should even see a big jump in the new data being prepared for the World Geothermal Congress 2015. The highest value though, is seen for Iceland where a production of 4597 GWh/a means that geothermal supplied about 25% of the produced electricity. For direct use, China heads the list with USA and Sweden in second and third place, through rapidly increasing use of ground source heat pumps, followed by Turkey, Japan, Norway (new on the list, also through use of ground source heat pumps) and Iceland (Lund et al., 2010). With direct use of geothermal energy still insignificant in Africa it is not surprising that no African country is seen among the top ten countries in direct use of geothermal energy.

TABLE 5: Top ten countries in electricity production from geothermal energy in 2009 (Bertani, 2010), and those with direct use (Lund et al., 2010)

Geothermal electricity production			**Geothermal direct use**	
Country	**GWh/a**	**% nat. produc.**	**Country**	**GWh/a**
USA	16,603	0.5?	China	20,932
Philippines	10,311	17	USA	15,710
Indonesia	9,600	3?	Sweden	12,585
Mexico	7,047	3	Turkey	10,247
Italy	5,520	2	Japan	7,139
Iceland	4,597	25	Norway	7,001
New Zealand	4,055	10	Iceland	6,768
Japan	3,064	0.3?	France	3,592
Kenya	**1,430**	**17**	Germany	3,546
El Salvador	1,422	25	Netherlands	2,972

Focussing on energy use in the East African region, Tables 6-7 show interesting numbers, still indicative despite the data not being quite new. They are based on statistics from the IEA, published in 2005. Table 6 shows the primary energy consumption in four of the East African countries in 2001-2003. It shows well how important biomass and waste are in the region, accounting for 70-90% of the total consumption in the respective countries, and how small the share of the other renewable energy sources is. Fossil fuel supplies energy for some of the electricity and of course the transport sector.

TABLE 6: Primary energy consumption in East Africa in 2001-2003 (IEA, 2005)

	Fossil	**Hydro**	**Geoth./ sol./wind**	**Waste/ biomass**
Kenya	16%	2%	2%	80%
Eritrea	29%			71%
Ethiopia	7%	1%		92%
Djibouti				
Tanzania	8%	2%		90%
Uganda				
Total	**10%**	**1%**	**1%**	**88%**

Finally, Table 7 demonstrates the huge difference in electricity production per capita between the East African countries, varying from 22 to 255 kWh/capita (in 2004) compared to the average value for the OECD countries, about 8000 kWh/capita. It certainly shows the need for improvement in the region, if living standards are to be improved significantly. See also Georgsson (2014b).

TABLE 7: Energy consumption in E-Africa, 2001-2003 in kWh/capita (IEA, 2005)

	Population	**GNI $/capita**	**Energy kWh/capita**
Kenya	32 million	390	117
Eritrea	4.4 million	190	42
Ethiopia	69 million	90	22
Djibouti	0.7 million	910	255
Tanzania	36 million	290	59
Uganda	25 million	240	64
OECD			**8,056**

4. UTILIZATION OF GEOTHERMAL ENERGY IN AFRICA

As seen in Section 3, the East African countries have similar energy production and consumption characteristics. Traditional biomass represents by far the largest category of energy produced (Table 6). The extensive use of combustible waste and biomass causes deforestation and contributes to environmental degradation. All the East African countries import petroleum products, mainly for transport and some for electricity production, which is not desirable in times of environmental awareness and high oil prices. Instead local renewable energy sources should be preferred, at least as far as conventional resources allow. For the countries surrounding the East African Rift System (EARS) (Figure 2) with its volcano-tectonic activity, their high-temperature geothermal resources have the potential to play a much bigger role and even become one of the most important resources for electricity production. Renewable energy sources (hydro, geothermal, wind, solar, etc.) have only represented a small portion of the total primary energy production, averaging 2% for hydropower, wind, geothermal and solar production combined (Teklemariam, 2008).

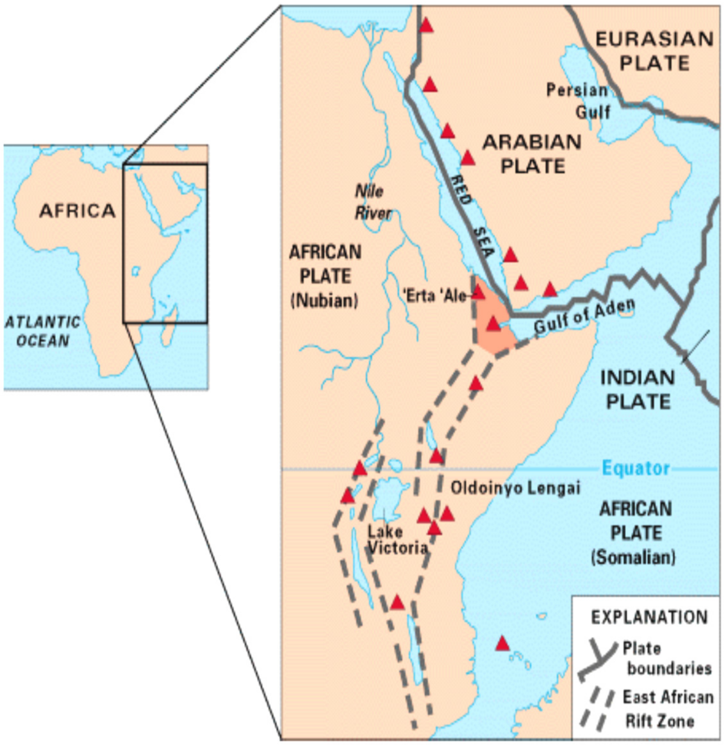

FIGURE 2: The Great East African Rift System (Teklemariam, 2008)

Geothermal can also be expected to play an important role in the countries of North Africa. However, the geothermal resources in this part of Africa are of the low-temperature type, and thus the practical utilization is mainly limited to direct uses, i.e. space heating, agriculture, aquaculture, recreation, etc., Electrical production through binary stations might though be possible at a few locations.

FIGURE 3: The new Olkaria IV power station in Kenya, opened in Mid 2014, with an installed capacity of 140 MWe from 2 turbines

With the technology of today, East Africa has high potential to generate energy from geothermal power. Despite that, Kenya is still the only country harnessing this resource to a significant extent. It has the richest potential, with geothermal potential having been evaluated to be able to supply more than 7000 MWe (Simiyu, 2010). But more importantly, Kenya has put forward a very ambitious plan to reach a total of 2000 MW of geothermal power on-line in 2018 and the even more ambitious 5000 MWe in 2030 (Simiyu, 2010; GoK, 2014). Since the early 1980s, Kenya has slowly been increasing its total geothermal power generation from 15 MWe to 202 MWe at the Olkaria geothermal area in 2010. The year 2014 has seen a major increase in KenGen's geothermal electrical production in Olkaria with two additional 140 MWe power plants coming on-line (Figure 3 shows the new Olkaria IV power plant), which together with smaller units (wellhead generators and enlargement of the ORPower4 power plant) has taken Kenya's production capacity to 580-590 MWe at the end of 2014. This is a dramatic rise and prove of Kenya's great determination in reaching set goals. GDC is also drilling with 4 rigs in Menengai geothermal area, and after some disappoints in the early phases seems to be getting promising results in 2014, with e.g. the new directional well MN-1A being evaluated to be able to sustain 25-30 MWe.

FIGURE 4: Roses grown in a greenhouse heated with geothermal at the Oserian farm, Kenya

It should also be mentioned that at Lake Naivasha, Kenya, geothermal water and carbon dioxide from geothermal fluids are used in an extensive complex of greenhouses for growing roses (Figure 4). Using geothermal heating to improve the quality of the products started in 2003. The Oserian farm is now (2014) the biggest geothermal greenhouse farm in the world, with 50 ha. of greenhouses being heated with geothermal to produce high quality cut flowers (Lagat, 2010).

Olkaria is also the location of a new geothermal spa (Figure 5), built by KenGen in the tradition of the Blue Lagoon in Iceland (Mangi, 2013). There is not much spa or public bathing tradition in Kenya, but this may create a new interest in this and will certainly be popular among tourists in the Naivasha area.

FIGURE 5: The new geothermal spa in Olkaria, Kenya

In Ethiopia, the Aluto-Langano pilot power plant, built in 1998 for producing 7.2 MWe on-line, had major problem in operation for its first years, with only partial production for a few months after its opening. Mechanical problems in the plant and limited steam supply were a difficult problem to overcome. This led to no or low production for long periods of time (Teklemariam, 2008). After restoration, the plant is now running smoothly and producing 3 MWe, which is what the current steam production allows. Drilling has also started to get more steam, not only to get the pilot plant to full production capacity, but also for an extended plant, scheduled to produce 70 MWe of electricity. Furthermore, Reykjavik Geothermal has announced large production plans for the Corbetti geothermal field, with drilling scheduled to start in early 2015.

Geothermal exploration and research have recently been undertaken in Djibouti, Uganda, Tanzania, Eritrea, Zambia, Malawi, and most recently in Rwanda. The ambitious exploration drillings in Karisimbi in Rwanda, unfortunately were not successful, with the two deep exploration wells not confirming the existence of a geothermal reservoir. This is a lesson to learn from for the countries bordering the western part of the EARS, emphasizing that much more exploration is needed there. The big question with the western rift is whether its potential is manly confined to intermediate- and low-temperature activity, which would see its possibilities for electrical production limited quite much.

The status of exploration and utilization of geothermal energy resources in the East African region for the last three decades has been summarized by Teklemariam (2008):

- The region has a large untapped geothermal resource potential;
- The geothermal resources are an indigenous, reliable, environmentally clean and economically viable, renewable energy resource;
- Development of geothermal resources is constrained by
  1. the risks that are associated with resource exploration and development;
  2. the financial risks that are associated with investment in power development projects; and
  3. lack of appropriate investment and institutional settings in many East African countries;
- Diversified use of geothermal energy augments energy supply from hydropower plants and improves the generation mix. It avoids vulnerability to drought and oil price fluctuations.

To light up East Africa by geothermal electricity, investors and financial assistance from international agencies are necessary, and the human capacity to deal with the exploration and development needs to be built up further.

FIGURE 6: A geothermal green house in Tunisia,
the hot water flows through plastic pipes at the ground surface

In North Africa, low-temperature waters for direct use have been utilized successfully in Tunisia where hot water intended for irrigation is cooled down in greenhouses thus allowing production of quality products, such as cucumbers and melons, mainly for export to Europe (Figure 6). In 2014, the total area heated in geothermal green-houses in Tunisia had reached 244 ha, making it one of the largest producers in the world from geothermally heated greenhouses. Extensive use of geothermal water for bathing can be added to this as an important cultural habit with roots stretching back some thousands of years. Direct use of geothermal energy is also recorded for Algeria, and Morocco has been exploring for geothermal resources, but Tunisia provides the example for the other countries of North Africa to follow (Ben Mohamed, 2014).

5. EXAMPLES OF USES OF GETHERMAL ENERGY IN ICELAND

Iceland is a unique country with regard to utilization of geothermal energy, with more than two thirds (68%) of its primary energy consumption in 2013 coming from geothermal energy (Ragnarsson, 2014). Direct use plays the most important role here with 90% of houses in the country heated by geothermal energy, 12 months of the year. Other uses include greenhouses, fish farming, industry, snow melting, swimming pools, etc., but even so only a fraction of the potential is used. Electrical production from geothermal power plants has increased rapidly in the recent years, amounting to about 29% of the total electrical production in 2013. In 2014, the total installed capacity was about 665 MWe (Figure 7).

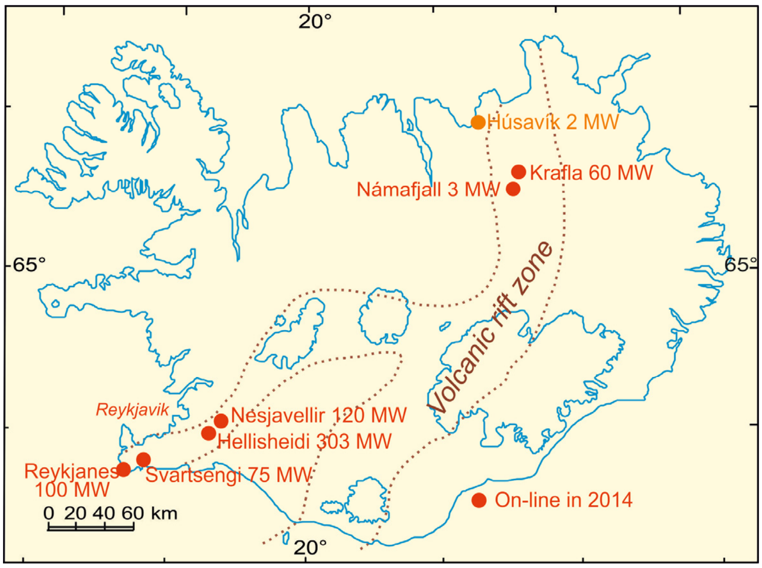

FIGURE 7: Geothermal power plants in Iceland in 2014

FIGURE 8: UNU Fellows bathing in the Blue Lagoon in 2003

It can be said that geothermal energy is a way of life in Iceland. Reykjavik Energy supplies the capital, Reykjavik, and its surroundings, in total just over 200,000 people, with hot water for heating through 12 months of the year, making it the largest geothermal municipal heating service in the world. Geothermal swimming pools are found in almost every village and small town in Iceland. The most famous bathing place is, however, the Blue Lagoon (Figure 8), a by-product of the Svartsengi power plant and located in a hostile lava field, 5-10 km from the nearest towns. It has become a landmark for Iceland and a must for any tourist to visit.

To this can be added benefits such as snow-melting of pavements around houses, not forgetting the use of geothermal water for heating of greenhouses and for fish farming.

6. THE GEOTHERMAL FUTURE

In a future where the emphasis is no longer on fossil fuels but on renewable and environmentally acceptable energy resources, geothermal energy is bound to have an important role. For developing countries which are endowed with good geothermal resources, it is a reliable local energy source that can, at least to some extent, be used to replace energy production based on imported (usually) fossil fuels. The technology is proven and cost-effective, and the technical potential is huge. The World Energy Council (2013) assumes 6% annual increase in use of geothermal energy to 2050 but geothermal has the potential to go beyond that.

Geothermal energy is now on the threshold of becoming a major player in the energy market in East Africa. Kenya has set itself very ambitious goals to reach in the coming decade, by declaring that geothermal is to become their main source of additional electricity in the near future through Kenya Vision 2030. From the current production of 580-590 MWe at the end of 2014, the long-term plans are now to reach at least 2000 MWe on-line from geothermal by the year 2018, and 5000 MWe by the year 2030.

Other countries in the region are slowly following in Kenya’s footsteps. Ethiopia, Djibouti, Tanzania, Eritrea, Uganda and Rwanda are taking significant steps through new projects, partially in cooperation with foreign companies or investors, in exploration and development of their geothermal sources. The time has, however, come to take it one step further, to the energy production. That should be the hallmark of the next decade in East Africa.

The UNU-GTP looks forward to see geothermal turn on the lights in the East African countries, and is determined to provide the training opportunities which the region needs, both in Iceland and hopefully also through a future UNU-GTP training centre in Kenya in cooperation with the Geothermal Developing Company (GDC) and Kenya Electricity Generating Co. (KenGen).

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