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Geothermal Energy and the Millennium Development Goals of the United Nations

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ABSTRACT

The Millennium Development Goals (MDGs) provide concrete, time-bound objectives for dramatically reducing extreme poverty in its many dimensions by 2015 – income poverty, hunger, disease, exclusion, and lack of infrastructure and shelter – while promoting gender equality, education, health, and environmental sustainability. Most of the implementation of the MDGs will be in the developing and transitional countries, but with the support of the industrialised countries and the international community. Almost 70% of the countries with quantified records of geothermal utilisation are categorised as developing and transitional countries. Geothermal energy already contributes significantly to the electricity production of several countries in Central America, Asia and Africa. The direct use of geothermal resources can also replace fossil fuels significantly in densely populated areas where space heating is needed. Many industrialised and developing countries have significant experience in the development and operations of geothermal installations for direct use and/or electricity production. It is important that they open their doors to newcomers in the field. Strong international cooperation is needed in the transfer of technology and the financing of geothermal development in order to meet the MDGs and the threats of global warming.

1. INTRODUCTION

At the United Nations Millennium Summit in September 2000, the largest gathering of world leaders in history adopted the Millennium Declaration from which the Millennium Development Goals (MDGs) were later extracted. In 2002, government leaders, heads of industry, civil society and representatives of United Nations organisations met in Johannesburg at the World Summit for Sustainable Development (WSSD). This conference brought energy and environmental issues to the centre of the global debate. The MDGs provide concrete, time-bound objectives for dramatically reducing extreme poverty in its many dimensions by 2015 – income poverty, hunger, disease, exclusion, and lack of infrastructure and shelter – while promoting gender equality, education, health, and environmental sustainability. These were reaffirmed by world leaders at the United Nations World Summit in 2005 in New York (United Nations, 2005).

The eight Millennium Development Goals are:

1. Eradicate extreme poverty and hunger.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.
6. Combat HIV/AIDS, malaria and other diseases.
7. Ensure environmental sustainability.
8. Develop a global partnership for development.

Most of these goals and targets were set to be achieved by the year 2015 on the basis of the global situation during the 1990s. It was during that decade that a number of global conferences had taken place and the main objectives of the development agenda had been defined. The baseline for the assessment of progress is therefore 1990 for most of the MDG targets. The MDGs provide countries around the world a framework for development, and time-bound targets by which progress can be measured (United Nations, 2006).

2. ENERGY AND MILLENNIUM DEVELOPMENT GOALS

A key paper on energy and the MDGs is a report entitled "Energy Services for the Millennium Development Goals", prepared by experts from Columbia University, ESMAP, UNDP and the World Bank (Modi, 2005). Energy services refer to services that energy and energy appliances provide. Such services include lighting, heating for cooking and space heating, power for transport, water pumping, grinding, and numerous other services that fuels, electricity, and mechanical power make possible. The core message of the report is that energy services are essential to both social and economic development and that much wider and greater access to energy services is critical in achieving all of the MDGs.

Even though no MDG refers to energy explicitly, improved energy services – including modern cooking fuels, improved cook stoves, increased sustainable biomass production, and expanded access to electricity and mechanical power – are necessary for meeting the goals (Modi, 2005). From the point of view of the user, what matters is the energy service, not the sources. Whether in business, home or community life, what matters are the reliability, affordability, and accessibility of the energy service. Therefore, it is essential to have a clear understanding of which energy services are needed to support the MDGs, and to examine the role that different energy carriers can play in providing these services in the most practical and affordable fashion to support human development at large (Modi, 2005). The report does not go into the specific roles of the different energy carriers.

3. WORLD ENERGY SITUATION AND POPULATION

Amongst the top priorities for the majority of the world´s population is access to sufficient affordable energy. There is a very limited equity in the energy use in the different parts of the world. Some 70% of the world´s population lives at per capita energy consumption level one-quarter of that of W-Europe, and one-sixth of that of the USA. Over two billion people, a third of the world´s population, have no access to modern energy services. A key issue to improve the standard of living of the poor is to make clean energy available to them at prices they can cope with. World population is expected to double by the end of the 21st century. To provide sufficient commercial energy (not to mention clean energy) to the people of all continents is an enormous task.

Population growth is, of course, a central issue in studies of how to meet the energy requirements of the world. Figure 1 (reproduced from Nakicenovic et al., 1998) shows the historical development from 1850 to 1990 and World Bank projection to 2100 (Bos et al., 1992), (top) rural-urban and (bottom) by macroregion, in billion people. Urbanization trends are based on UN (1994) and Berry (1990).

As stated by Nakicenovic et al. (1998), the good news in the 1992 World Bank and other global projections is that population growth is slowing down. The next doubling of the world´s population is expected to take much longer than the last one which took only 40 years. The population is expected to rise from the present 6 billion to approximately 10.4 billion by 2100 according to the 1998 UN long-range projection. Virtually all of the population growth is expected in the South. By 2100, the population of the USA, Canada and the whole of Europe combined drops to less than 10% of the world total, according to central studies of the World Bank, IIASA and the UN.

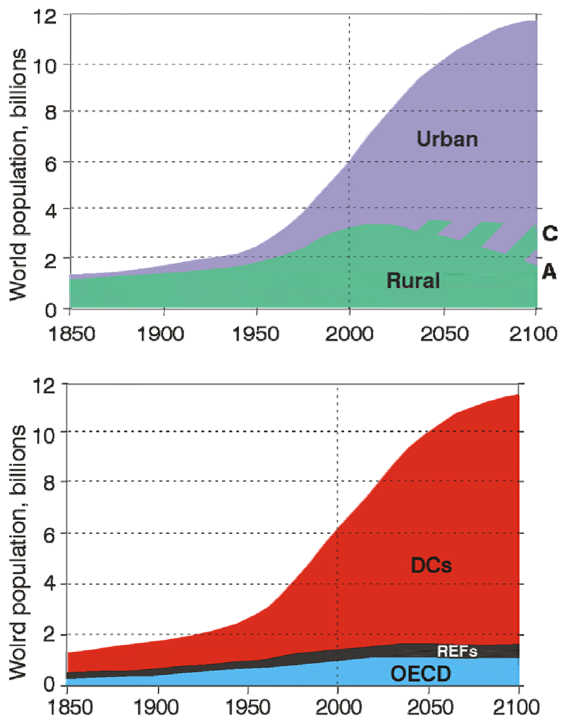

Figure 1: World population showing historical development from 1850-1990 and World Bank projection to 2100 (Bos et al. 1992), (top) rural-urban and (bottom) by macroregion, in billion people. Urbanization trends are based on UN (1994) and Berry (1990).

By the year 2100, the presently categorised developing countries can be expected to account for about 80% of the global energy demand (WEC, 1993). Even then energy per capita availability in the developing countries is likely to be far less than in the rest of the world - perhaps only 50-60% of that in the OECD area by then. The WEC (1993) study suggests that by the end of next century close to three-quarters of the world´s population is likely to be urbanised and the interim pressures on housing, sanitation, air and water quality, health care and congestion are likely to be intense. Energy systems geared to providing the comforts, motive power and mobility that people seek from energy may have lead to some profound changes. The challenge to city transportation systems over that time frame is likely to have called forth some imaginative responses (WEC, 1993).

4. GEOTHERMAL ENERGY UTILISATION

Geothermal resources have been identified in some 90 countries and there are quantified records of geothermal utilisation in 72 countries. Electricity is produced by geothermal in 23 countries. Five of these countries obtain 15-22% of their national electricity from geothermal. In 2004, the worldwide use of geothermal energy was about 57 TWh/a of electricity (Bertani, 2005), and 76 TWh/a for direct use (Lund et al., 2005). Figure 2 shows the installed capacity and the energy produced by geothermal on the different continents.

The electricity production increased by 16% from 1999 to 2004 (annual growth rate of 3%). The direct use increased by 43% from 1999 to 2004 (annual growth rate of 7.5%). Only a small fraction of the geothermal potential has been developed so far, and there is ample space for an accelerated use of geothermal energy both for direct applications and electricity generation.

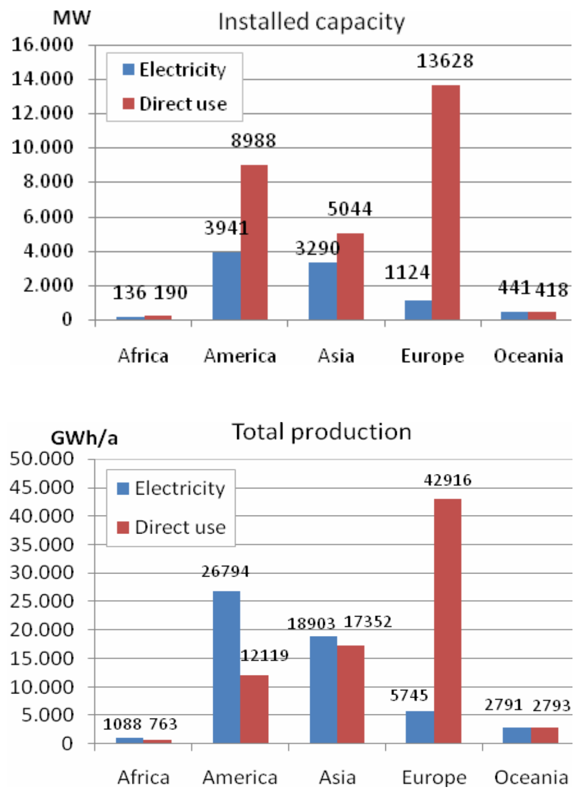

Figure 2: Installed capacity (top) and energy production (bottom) for geothermal electricity generation and direct use in the different continents. Data from Bertani (2005) and Lund et al. (2005).

Table 1 lists the top fifteen countries in geothermal electricity production and in geothermal direct use in the world in 2004 (in GWh/year).

It is of great interest to note that among the top fifteen countries in electricity production with geothermal, there are ten developing countries. Among the top fifteen countries in direct use of geothermal, there are five developing and transitional countries.

Geothermal electricity production		Geothermal direct use	
	GWh/a		GWh/a
USA	17,917	China	12,605
Philippines	9,253	Sweden	10,000
Mexico	6,282	USA	8,678
Indonesia	6,085	Turkey	6,900
Italy	5,340	Iceland	6,806
Japan	3,467	Japan	2,862
New Zealand	2,774	Hungary	2,206
Iceland	1,483	Italy	2,098
Costa Rica	1,145	New Zealand	1,968
Kenya	1,088	Brazil	1,840
El Salvador	967	Georgia	1,752
Nicaragua	271	Russia	1,707
Guatemala	212	France	1,443
Turkey	105	Denmark	1,222
Guadeloupe (France)	102	Switzerland	1,175

Table 1: Top fifteen countries in geothermal use in 2004. Data on electricity from Bertani (2005) and on direct use from Lund et al. (2005).

5. GEOTHERMAL ENERGY AND THE MDGS

Of the 72 countries with quantified records of geothermal utilisation, 41 are categorised as developing and transitional countries. Most of the 20 or so countries where geothermal resources have been identified but not quantified are in the same category. Most of the implementation of the MDGs will be in the developing and transitional countries, but with the support of the industrialised countries and the international community. The last two goals, to "Ensure environmental sustainability" and to "Develop a global partnership for development" will, however, have to be implemented in every country.

Geothermal energy is benign to the environment and improves the health and well being of the people. Geothermal energy has been produced commercially for about ninety years, and for four decades on the scale of hundreds of MW both for electricity generation and direct use. It has been developed successfully for the use of individual families, villages, towns, as well as large municipal district heating systems and national electric grids.

It is not the purpose of the present paper to go into details on how geothermal energy development fits the MDGs. Only a few examples will be mentioned.

6. ELECTRICITY GENERATION

In the electricity sector, the geographical distribution of suitable geothermal fields is restricted and mainly confined to countries or regions on active plate boundaries or with active volcanoes. Figure 3 shows the top fourteen countries with the highest percentage share of geothermal in their national electricity production. Special attention is drawn to the fact that El Salvador, Costa Rica and Nicaragua are among the six top countries in Figure 5, and that Guatemala is in eleventh place. Central America is one of the world´s richest regions in geothermal resources. Geothermal power stations provide about 12% of the total electricity generation of the four countries Costa Rica, El Salvador, Guatemala and Nicaragua, according to data provided from the countries at the World Geothermal Congress in 2005 (Bertani, 2005). The electricity generated in the geothermal fields is in all cases replacing electricity generated by imported oil. Hydro stations provide 48% of the electricity for the four countries, and wind energy 1%. With an interconnected grid, it would be easy to provide all the electricity for the four countries by renewable energy. The geothermal potential for electricity generation in Central America has been estimated some 4,000 MWe (Lippmann 2002), and less than 500 MWe have been harnessed so far. With the large untapped geothermal resources and the significant experience in geothermal as well as hydro development in the region, Central America may become an international example of how to reduce the overall emissions of greenhouse gases in a large region. Similar development can be foreseen in the East African Rift Valley, as well as in several other countries and regions rich in high-temperature geothermal resources.

This clearly demonstrates how significant geothermal energy can be in the electricity production of countries and regions rich in high-temperature fields which are associated with volcanic activity. There are examples from many developing countries of rural electrification and the provision of safe drinking water as well as schools and medical centres in connection with the development of geothermal resources. Thus the projects are in line with the MDGs.

Kenya is the first country in Africa to utilise its rich geothermal resources and can in the foreseeable future produce most of its electricity with hydro and geothermal. Several other countries in the East African Rift Valley can follow suit. Indonesia is probably the world´s richest country in geothermal resources and can in the future replace a considerable part of its fossil fuelled electricity by geothermal.

7. DIRECT UTILISATION

The main types of direct use of geothermal energy in the world are space heating 52% (thereof 32% using heat pumps), bathing and swimming (including balneology) 30%, horticulture (greenhouses and soil heating) 8%, industry 4%, and fish farming 4% (Lund et al., 2005). Figure 4 shows the direct applications of geothermal worldwide by percentage of total energy use. The main growth in the direct use sector has during the last decade been in the geothermal (ground-source) heat pumps. This is due, in part, to the ability of geothermal heat pumps to utilise groundwater or ground-coupled temperatures anywhere in the world.

In many developing and transitional countries, the main use of geothermal has been for washing and bathing, greenhouses and fish ponds (aquaculture). These activities improve significantly the quality of life of the people. Additionally, tourism is often a significant source of income at geothermal locations.

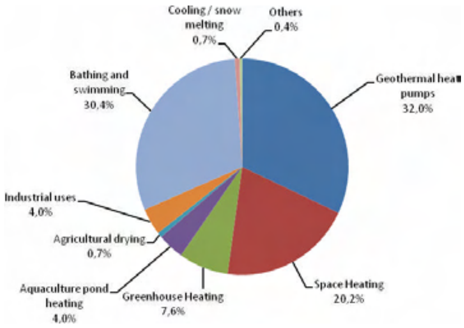

Figure 4: Direct applications of geothermal worldwide by percentage of total energy use (Lund et al. 2005).

The largest potential in the direct use sector is space heating and water heating, as these constitute a significant part of the energy budget in large parts of the world. In industrialised countries, 35 to 40% of the total primary energy consumption is used in buildings. In Europe, 30% of energy use is for space and water heating alone, representing 75% of total building energy use. The largest potential for direct use of geothermal is in China. Due to the geological conditions, there are widespread low-temperature geothermal resources in most provinces of China which are already widely used for space heating, balneology, fish farming and greenhouses during the cold winter months and for tap water also in the summer.

Until recently, almost all of the installations of the ground source heat pumps have been in North America and Europe, increasing from 26 countries in 2000 to 33 countries in 2005 (Lund et al., 2005). China is, however, the most significant newcomer in the application of heat pumps for space heating. According to data from the Geothermal China Energy Society in February 2007 (Zheng Keyan, personal communication), space heating with ground source heat pumps expanded from 8 million m^2 in 2004 to 20 million m^2 in 2006. Conventional geothermal space heating in the country had grown from 13 million m^2 in 2004 to 17 million m^2 in 2006. This reflects the new policy of the Chinese government to replace fossil fuels where possible with clean, renewable energy. The “Law of Renewable Energy of China” came into implementation in 2006.

The only commercial application of geothermal energy for direct use in Kenya is a flower farm near the Olkaria geothermal power station where greenhouses are heated during the night and kept dry by geothermal heat (Mwangi, 2005). Some 60,000 people work at the flower farms in the region and it is estimated that some 300,000 people have their livelihood from this. The flower companies, which export cut flowers (mainly roses) by air to Europe, provide the staff and their families with good housing, water, electricity, schools and medical centres.

Another interesting example of the benefits of geothermal development in Africa is in Tunisia where greenhouses replace cooling towers to cool irrigation water from 2-3 km deep wells in the Sahara desert (Mohamed, 2005). Due to the Earth´s thermal gradient, the temperature of the water from the wells is up to 75°C and needs to be cooled to 30°C to be used for irrigation. Some 110 hectares of greenhouses have been built in the oasis. The main products are tomatoes and melons which are exported to Europe. This has created a lot of jobs for men and women. Here the geothermal energy development is a by-product of the irrigation project.

8. DISCUSSION

One of the major concerns of mankind today is the ever increasing emission of greenhouse gases into the atmosphere and the threat of global warming. It is internationally accepted that a continuation of the present way of producing most of our energy by burning fossil fuels will bring on significant climate changes, global warming, rises in sea level, floods, draughts, deforestation, and extreme weather conditions. And the sad fact is that the poorest people in the world, who have done nothing to bring on the changes, will suffer most. One of the key solutions to avoid these difficulties is to reduce the use of fossil fuels and increase the sustainable use of renewable energy sources. Geothermal energy can play an important role in this aspect in many parts of the world.

More and more countries are seriously considering how they can use their indigenous renewable energy resources. The recent decision of the Commission of the European Union to reduce greenhouse gas emissions by 20% by 2020 compared to 1990 in the member countries implies a significant acceleration in the use of renewable energy resources. Most of the EU countries have already considerable geothermal installations. The same applies to the USA where the use of ground source heat pumps is widespread both for space heating and cooling.

Capacity building and transfer of technology are key issues in the sustainable development of geothermal resources. Many industrialised and developing countries have significant experience in the development and operations of geothermal installations for direct use and/or electricity production. It is important that they open their doors to newcomers in the field. We need strong international cooperation in the transfer of technology and the financing of geothermal development in order to meet the Millennium Development Goals and the threats of global warming.

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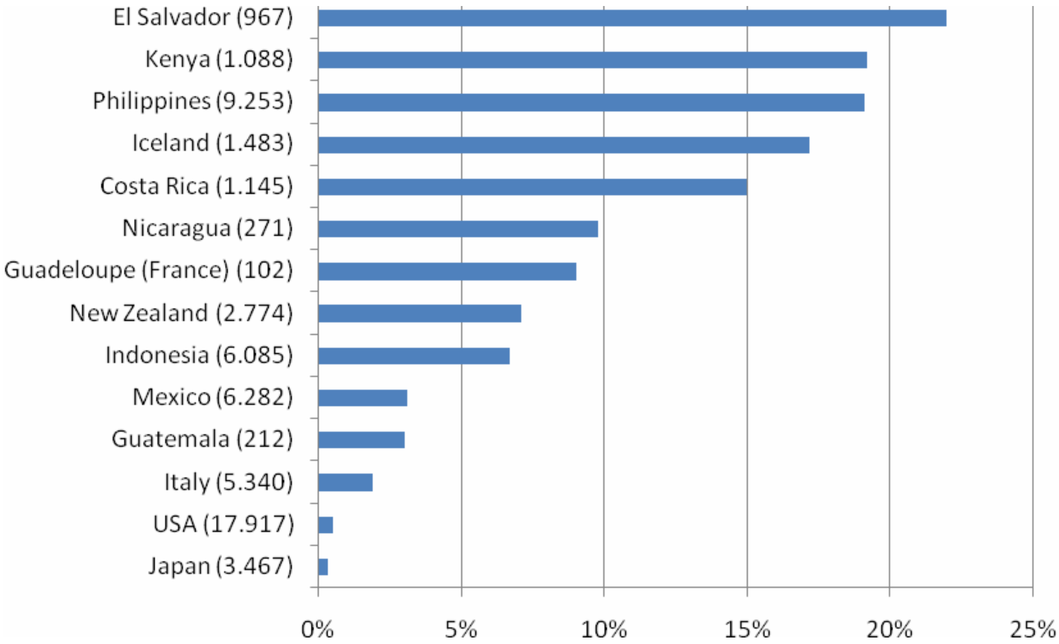

Figure 3: Top fourteen countries with highest % share of geothermal in their national electricity production. Numbers in parenthesis give the annual geothermal electricity production in GWh (data from Bertani, 2005).