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UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS AND GEOTHERMAL DEVELOPMENT

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ABSTRACT

Fulfilling future global energy needs, reducing energy poverty, increasing scarcity of fossil fuels and combating climate change push for a new energy paradigm called sustainable energy development. Several UN initiatives such as the SE4ALL and the UN Sustainable development goals (SDG) aim at global sustainability but at the same time acknowledge the central role sustainable energy development has in that context. This paper briefly reviews the importance of geothermal development in the quest to fulfil the SDG´s before 2030.

1. INTRODUCTION

According to SE4ALL (http://www.se4all.org) over 1 billion individuals do not have access to high-quality fuels, and more than 2.9 billion do not have access to energy that enables clean cooking. Providing these households with affordable and reliable access to energy services still remains a major challenge (Spalding-Fecher et al., 2005). In addition to significant energy poverty in many countries energy demand is expected to increase 33% worldwide by 2040 (IEA, 2015).

Fulfilling growing energy needs, enabling access to the billions of individuals without access to high-quality fuels, and reducing emissions of greenhouse gases (GHGs) requires a radical departure away from the fossil fuel-focused business-as-usual scenarios. What needs to replace past emphasis is an energy paradigm that will encourage transforming our current energy systems towards relying on sustainable low-carbon energy resources. This new energy paradigm has been called sustainable energy development (SED), defined as "the provision of adequate energy services at affordable cost in a secure and environmentally benign manner, in conformity with social and economic development needs" (IAEA/IEA, 2001).

Several international initiatives have been launched to facilitate SED. Examples include the SE4ALL initiative and the Sustainable Development Goals. The sustainable energy for all initiative (SE4ALL), launched in 2011 has three objectives: i) Ensure universal access to modern energy services ii) Double the global rate of improvement in energy efficiency; and iii) Double the share of renewable energy in the global energy mix. Realizing the importance of SED for reaching global sustainability the first SE4ALL Forum in 2014 illustrated support for including energy as part of the Sustainable Development Goals (SDGs) that were to replace the Millennium Development Goals. This initiative succeeded, resulting in SDG Goal 7 that calls for "secure access to affordable, reliable, sustainable and modern energy for all" by 2030.

2. UN MILLENNIUM GOALS AND THE UN SUSTAINABLE DEVELOPMENT GOALS

2.1 UN Millennium Goals

In 2000, the Millennium Summit was held, where the United Nations Millennium Declaration was adopted. Derived from the Millennium Declaration the eight Millennium Development Goals (MDG) were derived (http://www.un.org/millenniumgoals/) to be reached by 2015. The aim of defining the MDGs was to encourage development by improving social and economic conditions in the world's poorest countries, shifting the focus within the discourse on sustainable development towards poverty, human rights, and protection of vulnerable populations. The eight MDGs were as follows:

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

Energy was not an explicit part of the MDGs, but the provision of modern energy services during their development was recognized as a critical foundation for reaching these goal (Modi et al., 2005; Ogola et al., 2011).

2.2 Sustainable development goals (SDG)

Following the Rio+20 summit in Rio in 2012, the 17 SDG´s were agreed to in 2015 to replace the MDG´s (https://sustainabledevelopment.un.org). The overall objective of the SDG´s is "to end **p**overty, **p**rotect the **p**lanet, and ensure **p**rosperity **for all"** as part of a new sustainable development agenda. Each goal has specific targets to be achieved by 2030. The 17 goals are shown in Table 1.

3. THE IMPORTANCE OF GEOTHERMAL DEVELOPMENT FOR THE SUSTAINABLE DEVELOPMENT GOALS

It is widely acknowledged that the development of geothermal resources, if done properly, can support the movement towards sustainable development (Davídsdóttir, 2012; Shortall et al., 2015) and therefore is likely to support the attainment of the 17 SDG´s. Below we review a few arguments supporting this statement by looking at selected SDG´s, focusing mostly on Goal 7.

3.1 Goal 7: Access to affordable, reliable, sustainable and modern energy for all

GOAL 7 of the SDG´s aims to "ensure access to affordable, reliable, sustainable and modern energy for all." Three targets are to be reached under this goal; i) Ensure universal access to affordable, reliable and modern energy services; ii) Increase substantially the share of renewable energy in the global energy mix; and iii) Double the global rate of improvement in energy efficiency.

Enhanced **access** to high-quality energy services is key to economic and social development. Several characteristics of geothermal energy are particularly important in this context; location often in remote rural areas, ability to be harnessed in small centralized units, reliability in supply and relative independence from climatic and sociopolitical events. These features enable unconnected remote and rural areas to gain access to **reliable**, high-quality energy (Shortall et al., 2015).

TABLE 1: The SDG´s (https://sustainabledevelopment.un.org)

Goal 1: End poverty in all its forms everywhere
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3: Ensure healthy lives and promote well-being for all at all ages
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5: Achieve gender equality and empower all women and girls
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5: Achieve gender equality and empower all women and girls
Goal 6: Ensure availability and sustainable management of water and sanitation for all
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10: Reduce inequality within and among countries
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12: Ensure sustainable consumption and production patterns
Goal 13: Take urgent action to combat climate change and its impacts
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development

Affordability is also important in this context, as access is necessary but not sufficient since the targeted population must be able to afford the energy. Fluctuating energy prices derived from fossil fuels, in particular in winter in cold climates due to increased heading demand and in summers in other areas due to air conditioning can create significant burden on low-income households. As geothermal energy is a local, climate independent energy source, it is not subject to such fluctuations. Comparing levelized cost analyses for electricity generation from geothermal resources also reveals that it is largely competitive with electricity generation using coal or fuel oil (Black & Veatch, 2008), and with most other renewable energy resources except wind. Furthermore the direct use of geothermal resources for various applications such as heating houses or horticulture is also fully cost competitive (Goldemberg and Johansson, 2004). The combined effect of these characteristics is that geothermal energy can be fully cost-competitive and less subject to energy price fluctuations, making it a desirable choice when possible.

As geothermal energy is considered a **renewable** energy resource, and is in most cases produced and used domestically, investment in geothermal energy reduces import dependency, increases energy security and enhances the fractional share of renewable energy of total primary energy use.

Energy use per GDP captures the general relationship of energy consumption to population and economic growth. At higher levels of the income scale, it is desirable to e.g. reduce the energy required to produce a unit of GDP (Goldemberg and Johansson, 2004). Increased use of geothermal power can contribute to this goal by increased ‘direct use’ of geothermal heat or in combined applications of electricity generation and direct use of waste heat. ‘Direct use’ is far more efficient

than electricity generation from geothermal power and places less demanding temperature requirements on the heat resource. As a result, direct use is economic at many more sites than geothermal electricity generation. 'Heat' for direct use may come from cogeneration via a geothermal electrical plant or from smaller wells or heat exchangers such as geothermal heat pumps. In areas where natural hot springs are available, the warm water can be directly pumped into the district heating system, to industrial or other economic applications. However, in areas where the ground is dry, but still warm, it is possible to use heat exchangers to capture the heat. In 'cold' areas, this is also possible with the use of geothermal heat pumps, using the natural heat gradient of the Earth. Therefore, it is possible in nearly all areas to capture heat more cost-effectively and cleanly than by conventional furnaces (Lund, 2006).

While direct uses of geothermal energy are efficient, the efficiency of indirect use for electricity generation, varies depending on the temperature of the geothermal resource and the type of plant technology used. Overall, the thermal efficiency of geothermal electric plants is relatively low, ranging from 9% to 23%. Exhaust heat is wasted, unless cogeneration occurs and the hot water is used directly and locally, for example, in greenhouses, industrial applications, aquaculture, or district heating (Fridleifsson et al., 2008). As a result, it is vital, if geothermal power is used indirectly for electricity generation to ensure that the waste fluids are utilized at cascading levels of lower heat or re-injected (Shortall et al., 2015).

It is clear from this short review that the development of geothermal energy resources can significantly contribute to SDG Goal 7.

3.2 Goals 1 – 5: Human development

Goals 1 through 5 all focus on human development. Goal 1 aims to end poverty in all forms everywhere, Goal 2 to end hunger and acheive food security, Goal 3 to ensure healty lives, Goal 4 to ensure quality education and Goal 5 to empower women. The development of geothermal energy can contribute to all these goals as it will enable access to high quality energy as well as access to heat. High quality energy services facilitate economic growth through increased productivity and employment opportunities (Modi et al., 2005). As geothermal energy is often available in remote rural areas that do not previously have access to high quality energy the derived impact can be significant. For example, Ogola et al. (2011) illustrate that the use of geothermal energy, where possible, in areas that suffer from food insecurity and poverty can drastically reduce poverty and hunger. This can be achieved by, for example, provision of electricity for water pumping, irrigation and food preservation as well as cooking, lighting, use of greenhouses for commercial production as well as for hunger relief. Farmers may also have the possibility to grow multiple harvests, and postharvest losses will be reduced through better preservation and the possibility of chilling and/or freezing (Ogola et al., 2011).

At both local and national scales anywhere in the world, lack of reliable and affordable electricity supply is an impediment to income-generating industrial, commercial, and service activities. As geothermal energy is best harnessed locally, and can be used in small-decentralized units, it can provide a local source for heat and electricity, at an affordable price for locally owned businesses and thereby create local employment opportunities. Also microenterprises relying on cascading use of the geothermal resource such as high-value aloe production or honey/wax production as well as tourism will contribute to a shift from economic dependency on livestock only and lead to income diversification and reduced poverty (Ogola et al., 2011; Ogola et al., 2012).

A close link exists between the quality of health services and the availability of quality energy services. This is due to that electricity is essential for many medical instruments, illumination, medical record keeping, communication facilities for reporting medically significant events, medical training, and high heat is needed for sterilization of equipment (Ogola et al., 2011; Modi et al., 2005). Increasing evidence exists that the burning of solid biomass fuels for cooking in indoor environments, especially using traditional stoves in inadequately ventilated spaces, can lead to an increased incidence

of respiratory diseases. World Health Organization (WHO) estimates that the impact of indoor air pollution on morbidity and premature death of women and children is the number one public health issue in many developing countries, particularly for the poorest segments of the population. Once again, women and small children are likely to share a disproportionate burden (Modi et al., 2005). In addition to poor ventilation and use of low-quality fuels for cooking, lack of adequate nutrition, low immunization coverage, poor sanitation, and inadequate health facilities in addition to poverty are the main issues that need to be tackled when combating child mortality and malnutrition levels in many developing countries (Modi et al., 2005). Clearly, the availability of nutritious cooked food, space heating, and boiled water contribute to better health, all of which can be attained by access to high quality energy such as electricity and heat derived from geothermal power (Ogola et al., 2011). Unlike hydropower, which through its stagnant reservoirs creates a breeding ground for mosquitoes, utilization of geothermal energy does not increase the incidence of malaria, skin diseases, and other waterborne diseases. Also, with access to electricity, doctors will have electricity they need to treat patients at night and enable the use of equipment that is needed, for example, for sterilization, refrigeration, and operating rooms (Ogola et al., 2011).

Access to high-quality energy helps create a child-friendly atmosphere (Modi et al., 2005). Particularly for school-age girls, improved access to modern energy services can free time for going to school and for after-school study at night. Energy scarcity creates time pressure on children to collect fuel, to fetch water, and to participate in agricultural work and thereby contributes to low school enrolment (Modi et al., 2005).

3.3 Goal 13: Climate change

Goal 13 urges countries to act swiftly on climate change. Development of geothermal energy contributes significantly to mitigation of greenhouse gas emissions as greenhouse gas emissions per kilowatt-hour of electricity derived from high-temperature geothermal fields are significantly lower than derived from fossil fuel resources. Fridleifsson et al. (2008) illustrate that emissions of GHG measured in grams per kilowatt hour range from 4 to 740 g, with a weighted average of 122 g kWh^{-1}. Comparable emissions for coal fired power plants are 740-910 g kWh^{-1} and for natural gas combined cycle 410 – 650 g kWh^{-1} (Schlömer et al., 2014). In addition to significant impact on mitigation the development of geothermal energy contributes as well to climate change adaptation (Ogola et al., 2012).

4. CONCLUSION

It is clear from this short review that the development of geothermal energy can significantly contribute to the attainment of SDG Goal 7. Furthermore it is clear that without rapid progress on SDG 7, it will be very difficult to deliver on the other SDGs by 2030. Geothermal energy, if developed based on the principles of SED is very important in this context. It contributes directly through impact on SED, social and economic development as well as climate change and indirectly through attainment of SDG goal 7 that is a prerequisite for progress on the other SDG´s.

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