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THE CLEAN DEVELOPMENT MECHANISM AND ITS IMPACT ON GEOTHERMAL ENERGY PROJECTS

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ABSTRACT

The Kyoto Protocol is a legally binding treaty under the United Nations Framework Convention on Climate Change (UNFCCC) which was adopted in 1997 to meet the objective of the UNFCCC, which is to stabilize greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent anthropogenic interference with the climate system. Kyoto protocol has three flexibility mechanisms, the Clean Development Mechanism (CDM), Joint Implementation (JI) and Emission Trading (ET). The Clean Development Mechanism (CDM), is an emission reduction mechanism between developed and developing countries. The first commitment period of the Protocol was between 2008 and 2012, while the second commitment period is between 2013 and 2020. The CDM Executive Board has developed a voluntary tool to highlight the sustainable development co-benefits. Approximately 8,000 projects had been registered under the mechanism representing emissions from different sectors, and different scales by September 2016. About 32 geothermal projects had been registered compared to other renewables such as wind and hydro which had registered 2,397 and 1,427 projects respectively by September 2016. The rate of registration reflects the rate of deployment of the renewable energy sources. So far, the registered geothermal energy projects are large scale electricity based from high temperature hydrothermal systems and one low temperature geothermal heat application for district heating in China, all of which should be contributing a total of 12 million tCO_2e/year compared to 3.1 million tCO_2e/year in October 2011. These projects are at different monitoring, reporting and verification stages and the above estimates are based on submissions in project design documents and could have significantly changed or expired. Development from geothermal energy has lower emissions per kilowatt hour (kWh) than fossil fuels. Carbon dioxide emissions from geothermal energy range from 4 g CO_2/kWh to 740 g CO_2/kWh with a weighted average of 122 g CO_2/kWh and depend on the chemistry of the reservoir and choice of technology. Despite the collapse of the carbon markets, new opportunities exist in carbon trading through the voluntary carbon markets, new market mechanisms focusing on sectoral approaches, and the cooperative mechanisms and Intended Nationally Determined Contributions (INDCs) under the Paris Agreement. Geothermal energy has the potential of contributing to global emission reduction by increasing its global share in renewables and other sources.

1. INTRODUCTION

1.1 What is the Clean Development Mechanism?

The Kyoto Protocol is a legally binding treaty under the United Nations Framework Convention on Climate Change (UNFCCC) which was adopted in 1997 to meet the ultimate objective of the UNFCCC which is to "stabilize GHG concentrations in the atmosphere at a level that would prevent anthropogenic interference with the climate system", through quantified emission targets within a specified time frame (UNFCCC, 2016a). The Protocol entered into force on 16th of February 2005 with a first commitment period running from 2008 to 2012, and a second commitment period from 2013 to 2020, and is expected to be replaced by the 2015 Paris Agreement in 2020 upon entry into force.

The Kyoto protocol has three flexibility mechanisms, the Clean Development Mechanism (CDM), Joint Implementation (JI) and Emission Trading (ET). The Clean Development Mechanism is the only mechanism open for participation by parties from both industrialized and developing countries. The objectives of the CDM are i) to help Annex I Parties to meet their emissions targets and ii) to assist non-Annex I Parties in achieving sustainable development and in avoiding future emissions (UN, 1998). The Clean Development Mechanism (CDM) generates Certified Emission Reduction Units (CERs) that are tradable. These saleable credits can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol (UN, 1998).

There are over 30 greenhouse gases (GHG), however, the first commitment period of the Kyoto Protocol 2008 - 2012 focused on six, namely, Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxides (N_2O), Perfluorocarbons (C_xF_x), Hydrofluorocarbons (HFCs), Sulphur hexaflouride (SF_6). Nitrogen trifluoride (NF3) was included as the seventh GHG in the second commitment period of the Kyoto Protocal 2013 - 2020. The GHG relevant to geothermal energy projects are Carbon Dioxide (CO_2), Methane (CH_4).

1.2 Distribution of Clean Development Mechanism projects

Table 1 shows distribution of CDM projects by regions with Asia Pacific Countries having 80% of the projects. There is inequitable geographic and sectoral distribution of CDM project activities with lower registration in some regions mainly due to insufficient access to project finance and risk management tools, weak institutional and administrative capacity relating to the development of CDM project activities, complexity of processes and methodologies and uncertainty on the role of CDM in post 2012. According to UNFCCC (2016b), 75% of the registered projects are from renewable energy sources, and about 11% from waste handling and disposal and some 4% from industrial activities.

TABLE 1: Distribution of CDM projects by region (UNEP DTU, 2016)

	Number of projects	**Percentage**
Latin America	1100	13%
Asia Pacific	6924	81.1%
Africa	254	2.9%
Europe and Central Asia	85	1.0%
Middle East	110	1.3%
Total	**8464**	**100%**

About 13% of the projects are located in Latin American Countries and distributed as indicated in Figure 1 with more than half of the projects in Brazil (35%) and Mexico (18%) (UNEP DTU, 2016).

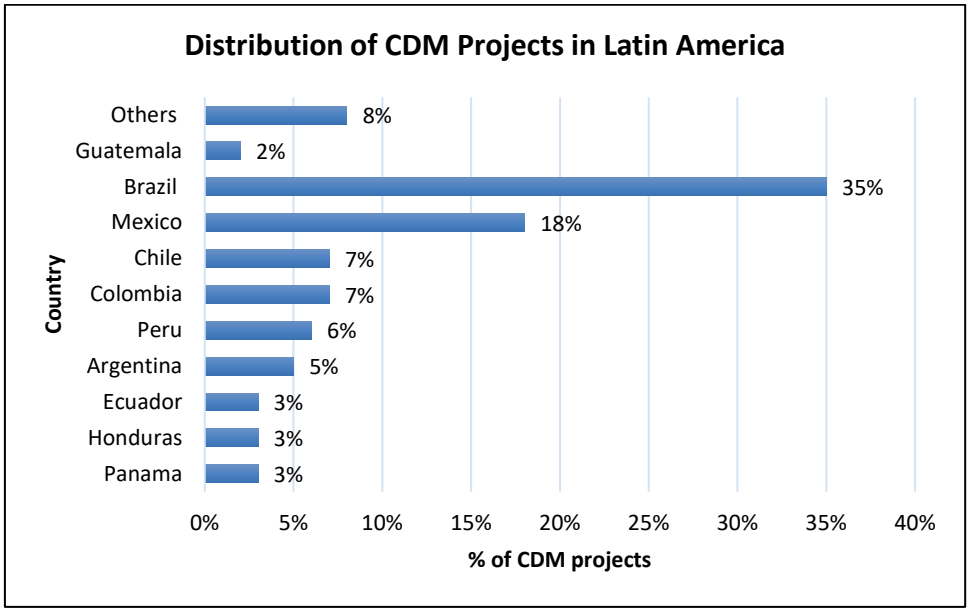

FIGURE 1: Distribution of CDM projects in Latin America (UNEP DTU, 2016)

2. GEOTHERMAL ENERGY

2.1 Carbon dioxide from geothermal energy

Carbon dioxide (CO_2) occurs naturally in most geothermal systems, however, development from geothermal energy has lower emissions per kilowatt hour (kWh) than fossil fuels (Ármannsson et al., 2005) as shown in Figure 2. The possible role and contribution of the projected geothermal energy deployment in mitigation of climate change have been scoped and documented for the Intergovernmental Panel on Climate Change (IPCC) by Goldstein et al. (2011). Other authors that have extensively studied CO_2emissions from geothermal energy include Bertani and Thain (2002); Fridleifsson et al. (2008); Alfredsson et al. (2010); Goldstein et al. (2011); Ogola et al. (2011); Ogola et al. (2012), among others.

The geothermal data derived from Bertani and Thain (2002) refer to CO_2 emissions from high temperature wells. The authors estimated CO_2 emissions from geothermal energy to range from 4 g CO_2/kWh to 740 g CO2/kWh with a weighted average of 122 g CO_2/kWh.

Emissions from geothermal power plants are mostly determined by the chemical characteristics and the choice of technology (Hammons, 2004). Carbon dioxide constitutes 90% of non-condensable gases (NCGs) in most high temperature geothermal systems and is also released naturally prior to geothermal development (Fridleifsson et al., 2008).

Management of CO_2 in most geothermal power plants is through reinjection (Huttrer, 2001). Despite this some leakages from the wells and cooling towers are still experienced. Carbon dioxide emissions from low temperature geothermal resources are usually lower than from high temperature resources. The observed range of CO_2 from these resources is 0–1 g CO_2/kWh (<1 CO_2 g/kWh) and considered negligible (Fridleifsson et al., 2008).

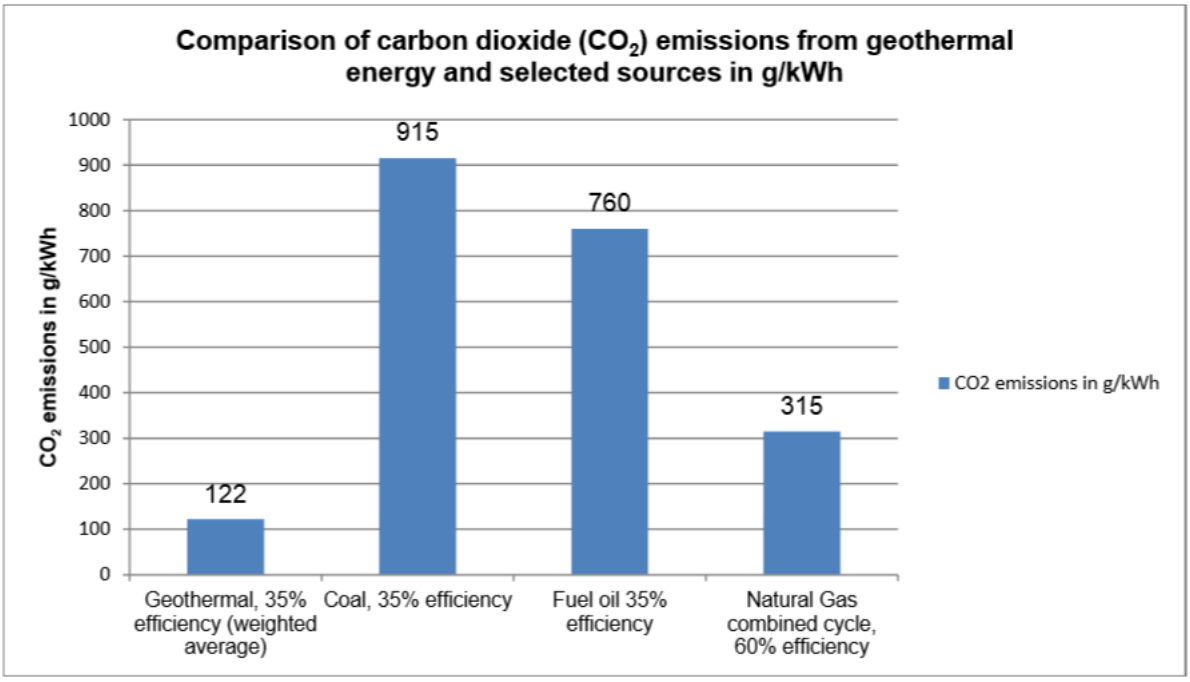

FIGURE 2: Comparison of carbon dioxide emissions from geothermal energy and selected sources in g/kWh (Figure from (Ogola, 2011), data derived from Bertani and Thain (2002))

3. GEOTHERMAL ENERGY, OTHER RENEWABLES AND THE CLEAN DEVELOPMENT MECHANISM

3.1 Geothermal energy and the Clean Development Mechanism

Due to considerably low CO_2 emissions of geothermal in comparison to other forms of energy, geothermal projects are considered as Clean Development Mechanism (CDM) projects under Consolidated baseline methodology for grid-connected electricity generation from renewable sources ACM0002 (Ogola 2011) and AM0072 fossil fuel displacement by geothermal resources for space heating. The emission reductions resulting from a CDM project must be verified before certification using methodologies and procedures set by the CDM Executive Board.

Table 2 shows the number of geothermal CDM projects by country. Twenty one out of the thirty two projects are in Asia with Indonesia having the highest number, followed by the Philippines and Kenya which have four each. Currently Indonesia is the world's third largest geothermal electricity producer after Philippines. Mexico and Kenya take the fourth and eight positions respectively. Generally, the distribution of CDM projects corresponds to geothermal energy development in various developing countries.

TABLE 2: Distribution of registered geothermal energy CDM projects by country (Information summarised from UNFCCC CDM website 2 September 2016)

Country	No. of CDM geothermal projects
El Salvador	2
Nicaragua	1
Guatemala	1
Honduras	1
Chile	1
Mexico	1
Kenya	4
China	2
Papua New Guinea	1
Philippines	4
Indonesia	13
Malaysia	1
Total	**32**

So far, the registered geothermal energy projects are large scale electricity based from high temperature hydrothermal systems and one low temperature geothermal heat application for district heating in China currently contributing a total of 12 million tCO_2e/year (UNFCCC, 2016c) compared to 3.1 million October 2011 tCO_2e/year (Ogola, 2011). The number of registered geothermal CDM projects saw significant growth between October 2011 and January 2013 as most of the projects were registered in 2012. This paper does not go into detail of finding out the current status of the above projects, in terms of actual emission reduction contribution as this varies with different monitoring periods as well as crediting periods.

No significant increase in CDM geothermal energy project has been witnessed since 2013 possibly from the crush of Certified Emission Reduction price in the spot market and the exclusion of non-Least Developed Countries from the European Emission Trading Scheme (EU-ETS) as most are from non-LDCs.

3.2 Comparison between geothermal energy and other renewable energy CDM projects

Table 3 shows renewable energy projects in by installed capacity in giga watts hours in 2010. Despite hydro having the largest contribution in terms of installed capacity, wind projects have the highest number of registered CDM projects as shown in Table 4 below. The difference could be as a result of year of installation of the current hydropower projects, most of which came online before the first commitment period of the Kyoto Protocol (2008-2012) and also reflects the accelerated rate of deployment of wind energy sources.

Table 4 shows the number of geothermal energy CDM projects compared to other renewables. The low number of registered geothermal CDM projects compared to other renewable energy projects is a reflection of the trend in geothermal development and geographical distribution of the resources, long lead time, high risks and costs of exploratory drilling, and preference to finance other renewables due to low risks and uncertainty in comparison to geothermal energy (Ogola et al., 2011).

TABLE 3: Renewable energy by installed capacity in 2010 (WEC, 2013)

	Installed capacity	
	GW	%
Hydro	778	74
Biomass	71	6.5
Wind	191	17.5
Geothermal	**11**	**1.0**
Solar	39	3.6
Total	1,090	100

TABLE 4: Selected renewable energy CDM projects compared to geothermal energy (UNFCCC CDM Registry, 2016)

	Energy	**No. registered CDM projects**
1.	Wind	2397
2.	Hydro	1427
3.	Solar	302
4.	Tidal	3
5.	Biomass	5
6.	**Geothermal**	**32**

4. CLEAN DEVELOPMENT MECHANISM AND SUSTAINABLE DEVELOPMENT

4.1 Clean Development Mechanism and sustainable development

The concept of sustainable development became popular with the report 'Our Common Future' by the World Commission on Environment and Development (WCED, 1987) later known as the Brundtland Report. Meaningful environmental, economic and social benefits can be made through geothermal energy development with possible implications for the 17 Sustainable Development Goals (SDGs) termed 2030 Development Agenda which was adopted 25 September 2015 by the UN General Assembly in New York to build on the 15 Millennium Development Goals which ended in 2015.

The twin objective of CDM is to offset emissions from greenhouse gases and promote sustainable development. Unfortunately, sustainable development criterion as required in the project design document (PDD) is not monitored like the GHG emissions to verify that they are real and measurable. One of the requirements is that a project does an environmental impact assessment and conduct extensive stakeholder engagement.

For a long time, there was no single, authoritative and universally accepted sustainable development approach or methodology applicable to any CDM project regardless of project type and location when it comes to practical and concrete assessments of sustainability impacts. The sustainable development monitoring component of CDM projects has been the responsibility of the Designated National Authorities who are the focal points for UNFCCC in a country. However, in 2012, a sustainable development tool for CDM projects was approved in Doha and is described below.

4.2 Sustainable Development tool for CDM

The CDM Executive Board developed a voluntary tool to highlight the co-benefits brought about by CDM projects and PoAs, commonly referred to as the SD tool. The SD Tool is designed to produce a sustainable development co-benefits (SDC) description report using a set of indicators:

- *Environment*: air, land, water, natural resources;
- *Social*: jobs, health and safety, education, welfare; and
- *Economic*: growth, energy, tech transfer, balance of payment.

The SD tool therefore provides a structured, consistent, comparable and robust manner of highlighting the sustainable development co-benefits of CDM project activities and Programme of Activities (PoAs) and has been applied to the 35 MW Olkaria II Geothermal Expansion CDM project (commonly known as Olkaria II Unit III).

4.3 Application of CDM SD tool in Olkaria II Unit 3 CDM Project

Application of the SD Tool for CDM project is voluntary but also necessary for reporting back sustainable development achievement of the project before and after the project (ex-post and ex-ante).

The 35 MW Olkaria II Geothermal Expansion CDM project provided additional funds for improving local livelihoods under the community development carbon fund (CDCF) managed by the World Bank. The CDCF supported projects that combined community development attributes with emission reductions to create “development plus carbon” where one dollar of every ton of carbon traded is ploughed back into the host community by the project developer (Ebinger and Walter, 2011).

To date, 4 community benefit projects with positive implications for health, education, access to water among other key elements of the Sustainable Development Goals (SDGs) have been completed with payment from CDM proceeds. Subsequent payments based on CDCF, emission reduction purchase agreement (ERPA) are expected to enhance the existing projects and start others (Ogola, 2015).

5. FUTURE OF GEOTHERMAL ENERGY IN MARKET BASED MECHANISMS

The second commitment period of the Kyoto Protocol is expected to end in 2020, when the 2015 Paris Agreement comes into effect upon successful ratification. Despite this, the second commitment period (2013 -2020) of the Kyoto Protocol has been less active than the first (2008-2012) and even saw some developing countries opting out of the Protocol. The CER prices dropped 95% in past few years with the Current price remaining at approximately ~0.10 Euros/CER. As a result, project developers that had no emission reduction purchase agreements (ERPA) face significant challenges to sell issued CERs.

By 2011, only 11 geothermal energy projects had been registered and only 32 geothermal energy projects have been registered by September 2016, when the incentives for doing new CDM projects had gone down. Several geothermal potential countries which are non- Least Developed Country (non-LDC) are not eligible to trade certified emission reductions (CERs) in the European Union –Emission Trading Scheme (EU-ETS) in the second commitment period of the Kyoto Protocol. EU-ETS is the biggest buyer of CERs.

How can geothermal energy benefit from the new market mechanism and the outcome of the 2015 Paris Agreement?

5.1 Opportunities in other market based mechanism

New Market Mechanisms also emerged in the second commitment period focusing on closing ambition gap between 2013 and 2020, when the 2015 Paris Agreement comes into effect. These have mostly focused on sectoral or sub-sector approaches to mitigation compared to project based approaches and include:

Nationally Appropriate Mitigation Action (NAMAs): Kenya developed the first geothermal NAMA focusing on removing barriers to acceleration of geothermal energy development, through risk mitigation instruments, technical assistance and capacity building. The NAMA was not funded and therefore not implemented but had a lot of lessons learned from it.

Tax and Emission Trading Schemes: several countries developing (especially non- least developed countries) are developing domestic emission trading schemes and tax (e.g. Mexico, China, South Africa, Korea) which can enhance domestic trading by assigning allowances for geothermal energy projects.

Bilateral agreements such as the Japanese Joint Credit Mechanism: The JCM crediting period started in 2015 and was to end in 2020 but now extended to 2030. The JCM provides an alternative CER market after 2012 especially for non-LDCs and is supposed to be easier than CDM in registration and monitoring requirements. Geothermal energy projects can qualify for JCM depending on successful agreement by the relevant Japanese institution and for countries which have an agreement with Japan on JCM. Pilot project design document for geothermal energy project was started in Kenya but not concluded.

Voluntary carbon markets: Options exist in unregulated markets, commonly referred to as voluntary carbon markets. Just like the CDM registries, the VCM registries issue, hold, transfer and retire carbon credits often referred to as Verified (or Voluntary) Emissions Reduction (VER). VERs can vary in quality based the standard and sustainable development impact. The best standards that are relevant to renewable energy projects are the Gold Standard (GS) and Voluntary Carbon Standards (VCS). VCS and GS are Kyoto compatible. Geothermal projects that have applied these schemes as seen in the voluntary carbon market Markit Registry include (Markit Group, 2016):

- Wayang Windu Phase 2 Geothermal Project, Indonesia (VCS);
- Capacity Upgrade Gunung Salak Geothermal Power Project, Indonesia (VCS); and
- Dora II 9.5 MW geothermal energy project (GS).

Article 3 of the Paris Agreement, Intended Nationally Determined Contributions (INDCs): to enhance the implementation of the Convention, including its objective of strengthening the global response to the threat of climate change, the Paris Agreement adopts intended nationally determined contributions (to be referred to as Nationally Determined Contributions (NDC) after submission or ratification by a country. It requires countries to communicate their national plans in reducing emissions in support of the long term global mitigation goal of realising 2 degrees or 1.5 degree temperature increase above pre-industrial time by 2100. Geothermal energy can contribute to NDCs as discussed by Ogola (2016).

Article 6 of the Paris Agreement on Cooperative approaches: This article underscores the importance of using of internationally transferred mitigation outcomes (ITMO) towards Parties achieving the NDC objectives for both mitigation and adaptation actions and to promote sustainable development and environmental integrity. Emission reductions resulting from the ITMO shall not be used to demonstrate achievement of the host- country's NDC if used by another party to demonstrate achievement of its NDC (to avoid double counting). Discussions are still going on the approach and methodology to be used under cooperative approaches but it is possible that a lot will be borrowed from Clean Development Mechanism and Joint Implementation projects. Opportunities for geothermal energy exist under such mechanism. Article 6 also underscores the importance of sustainable development, by introducing a sustainable development mechanism.

6. CONCLUSION

Carbon Dioxide emissions from geothermal energy are relatively low compared to other sources. Despite the fact that Geothermal energy did not significantly benefit from CDM like other renewable, several opportunities still exist for geothermal energy in up-coming voluntary carbon markets, and nationally determined contributions (INDC) and cooperative mechanism under the Paris Agreement. Lessons learned from CDM and JI may form a basis for the new market mechanisms that will be developed under the cooperative mechanisms of the Paris Agreement. Negotiations to develop the modalities and procedures of this mechanism as well as sustainable development mechanisms are still being negotiated. Voluntary Carbon Markets attract low volumes compared to CDM/CER markets but offer an opportunity under Gold Standard and Voluntary Carbon Standards based on experience from the Indonesian geothermal energy projects. Ability to generate more revenue from the carbon markets, depend on sustainable development aspects of the projects, hence deliberate effort to achieve this is required. Institutions undertaking geothermal development should look for relevant market based mechanism to increase its contribution in global emission reduction using methodologies that are recognized, and can be monitored, verified and reported.

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