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Supporting Kenya's Transition towards Clean Energy Through Geothermal Development

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ABSTRACT
Clean technologies such as hydropower, geothermal, wind and solar are driving the African Development Bank's (AfDB) energy strategy in Africa. The implementation of that strategy needs substantial financial leveraging from different sources, including climate finance and private-sector investments. In that context, the AfDB is blending sovereign guaranteed concessional loans with climate finance funds to leverage private-sector investments in clean technologies.

In this paper, we will discuss the example of geothermal technology in Kenya, where the AfDB is supporting the Geothermal Development Company (GDC) in the development of the Menengai geothermal field for steam production. The AfDB's intervention is expected to unlock private-sector participation in the transformation of steam into power.

1. INTRODUCTION

Africa's contribution to global carbon emissions is relatively low (4 percent of global greenhouse gas emissions), but the continent suffers high vulnerability to climate change impacts. At the same time, Africa has massive clean-energy potential. The hydropower potential alone stands at around 45 GW, nearly one-tenth of the world's total. The geothermal potential in the African Rift Valley is estimated at more than 15 GW. Finally, wind and solar potential is also huge, but needs to be exploited at scale to be economically viable.

In that context, the AfDB is developing a new energy strategy focused on the development of the continent's clean-energy potential. In fact, the AfDB's strategy has two pillars: (i) ensuring access to modern energy; and (ii) promoting clean energy. Access to energy is essential to reducing poverty. To meet the needs of the continent, large additions to power generation capacity, among other things, will be required. A transition to a low-carbon growth path using clean energy technologies is also essential to ensure sustainable development. A key role for the Bank is to leverage financing from different sources, including climate finance funds, and provide reassurance to private-sector investors by mitigating risks and removing barriers to potential investments. The perceived risks in these projects are high due to the relative long-term maturity of such investments, the availability of the resource and the sometimes new or expensive technology involved.

In Kenya, various candidate generation sources have been considered in the Least Cost Power Development Plan (LCPDP). The optimal development program is dominated by geothermal, coal, and wind power generation as well as power imports from hydropower generation sources in Ethiopia. Geothermal power generation, whose potential is estimated at around 10 GW in Kenya alone, is the Government of Kenya's preferred choice for the future due to the fact that it is an indigenous, reliable and least-cost source. Developing Kenya's geothermal potential will also provide baseload generation capacity and will make it possible to develop the country's huge wind energy potential (which needs to be backed up by baseload power). In that context, the Government of Kenya has developed an ambitious program to develop geothermal generation, aiming to meet the country's rapidly increasing demand for power while diversifying sources of power supply.

2. MENENGAI GEOTHERMAL PROGRAM

The Menengai steam field development project is part of the Government of Kenya's larger program for developing the country's huge geothermal potential. It is estimated that the Menengai geothermal resource has the potential to generate up to 1,600 MW of power. The program has been split into four projects of 400 MW each. The Menengai I geothermal project involves the drilling of an estimated 120 wells to achieve the 400 MW steam production capacity. The power generation facilities will be constructed by the private sector. The clean-energy project is expected to result in approximately 2 million tonnes of reduction in CO_2 emissions per year.

2.1 Geothermal Steam Development Program

The steam development program includes two phases: (i) the steam resource development through drilling activities; and (ii) the steam-gathering system development to collect the steam produced by the wells and convey it to the power plants.

Phase (i) aims at developing the steam resource through drilling. It involves the following components: (A) civil works for the construction of a road system, drilling pads, and a water supply system; (B) equipment - drilling rigs and materials; (C) well drilling and testing; (D) transaction advisory, training and management, and supervision services; and (E) environmental and social management. The cost estimates for Phase (i) are summarized in Table 1.

Table 1: Menengai Steam Resource Development Cost Estimates

Component	USD million
(A) Site civil works	7.5
(B) Equipment	148.5
(C) Drilling activities	267.7
(D) Consultancy services	17.4

(E) Environmental and social	0.8
Contingencies	***44.2***
Total Project Cost	**486.1**

Phase (i) will mitigate the risks associated with the drilling phase and thus facilitate other financiers' participation in the development of phase (ii) as well as the private sector's participation for the construction of the power plants.

Phase (ii) involves the construction of the steam-gathering system required for the operation of the field. The cost of this phase is estimated at around USD 160 million.

2.3 Private Sector Participation

Over the years, the Government of Kenya has introduced key sector reforms that include the unbundling of the Kenya Power and Lighting Company (KPLC) in the 1990s, the establishment of the Energy Regulatory Commission (ERC), the development of a feed-in tariffs policy, and the creation of the GDC. This has been instrumental in encouraging private-sector participation. There are currently five independent power producers (IPP), four thermal and one geothermal, with effective grid capacity of 347 MW (26% of total power generation). IPPs are expected to play a greater role in the future. There are ongoing Power Purchase Agreement (PPA) negotiations with four new potential IPPs.

The Government of Kenya and the GDC are pursuing a financial resource mobilization strategy that will focus on engaging the private sector to invest in the geothermal power generation through a build, own, and operate (BOO) structure. The GDC will be responsible for the steam production and will sell the steam to private operators. A steam sales agreement will be negotiated and signed by both parties.

The approach the GDC has adopted allows public resources to be used to explore and establish the steam-gathering network, thus mitigating and addressing many risks that private investors might be unwilling to take. Once the GDC lays down the steam-gathering infrastructure, it will unlock generation investment decisions for private capital and attract much needed funding into the sector. It is estimated that the power generation component of Menengai I will cost approximately USD 900 million.

3. RISK ASSESSMENT

The Menengai I geothermal project involves some degree of risk. The main risks and the associated mitigation measures are discussed below:

- ***Resource risk:*** The geothermal resource in Menengai could prove insufficient to support the planned 400 MW development. This could result in a scale-down of the project size and/or a shortfall in steam supply and/or cost or schedule overruns as efforts are made to resolve the resource shortfall. This risk is, however, mitigated by the results of the first four wells (as of August 2011), which demonstrated the presence of an exploitable geothermal resource that is expected to meet the 400 MW generation capacity needs.
- ***Drilling risk:*** There is a possibility that the GDC will hit dry wells during the exploration and appraisal drilling campaigns. This will directly result in delays in achieving the intended generation, as well as cost overruns. This risk is mitigated by the exploration studies as well as the experience and expertise of the GDC, which has successfully explored and drilled in several locations in Kenya. This track record gives comfort to financiers and potential private investors. Furthermore, the training to be provided to the GDC under this project will also greatly assist in addressing this risk.
- ***Operation and maintenance risk:*** Once developed, there is a risk that the field will not be maintained and operated according to industry standards. Possible outcomes in this case include chemical scaling from geothermal fluids, delays in drilling and connecting make-up wells or failures in the reinjection system. This risk is mitigated by the GDC's expertise and past experience. The GDC recruited its core team from Kengen, Kenya's historic generation company, which was responsible for the operation and maintenance of existing geothermal power plants in the country (the first geothermal plant was commissioned in 1981). Capacity building will also be provided to the GDC under the project.
- ***Implementation delays and cost overruns:*** Longer-than-anticipated drilling times per well and/or a need to drill more wells than anticipated would result in implementation delays and associated cost overruns. Sensitivity analysis suggests that the project financial performance can withstand implementation delays of up to six months and still retain its financial viability. However, a capex cost overrun is a sensitive parameter, and tests indicate that a 10% increase would result in the project being just marginally viable. The establishment of a competent Project Implementation Team (PIT) supported by a project management consultant will greatly mitigate the risk of delays and cost overruns. Furthermore, the drilling cost estimates are conservative, and adequate contingencies have been put in place for the operations.

4. FINANCIAL AND ECONOMIC VIABILITY

The power plants fueled by the steam produced by Menengai I are expected to produce on average 5,990 GWh annually over 35 years. The price of steam produced by Menengai I and sold by the GDC to an off-taker is assumed to be USD 3.50 cents/kWh. The operating costs are based on the GDC's estimates for similar projects. A financial model has been developed by the GDC with the assistance of the AfDB to assist in the financial and economic analysis of the project.

The results of the financial and economic analysis indicate that the project is viable on those bases. The levelized cost of electricity generation stands at USD 6.83 cents/KWh. This compares favourably to the gazetted feed-in tariff for geothermal energy of USD 8.98 cents/KWh for generation plants of up to 70 MW. The project FIRR is estimated at 9.5%, while the FNPV at the company's weighted average cost of capital (discount rate of 11%) is USD 90.2 million. The project is therefore able to fully cover all the

investment costs related to exploration, drilling, construction of the steam-gathering infrastructure, and operating and maintenance costs. The economic net present value, discounted by the economic opportunity cost of capital of 12%, is highly positive, with an estimated NPV of USD 388.8 million and an EIRR of 17.6%.

Sensitivity tests were also performed linking the identified risks to the project's financial and economic viability. Unfavourable variations considered included changes to the base case scenario with respect to investment cost, operating and maintenance costs, individual well energy capacity, drilling success rate, and the price of steam. The financial and economic results of these tests are robust.

6. THE ROLE OF THE AFRICAN DEVELOPMENT BANK

The AfDB has played a major role in structuring and mobilizing the required financing and removing barriers for the implementation of the project. The provision of concessional financing by the Bank has leveraged significant financing from other development partners under the umbrella of the Scale-up Renewable Energy Program (SREP), which is a component of the Climate Investment Funds (CIF). SREP's overall objective is to support investments in energy efficiency, renewable energy, and access to modern sustainable energy in a small number of low-income countries. According to the program's investment plan, approved in September 2011, SREP will allocate USD 40 million to the Menengai I project, out of which USD 25 million has been channeled through the AfDB to finance part of Phase (i) related to the drilling activities and the remaining USD 15 million will be channeled through the World Bank to finance Phase (ii) related to the construction of the steam gathering system.

The Bank's financing being concessional, it is expected to overcome barriers to encourage private-sector participation and develop Kenya's full geothermal potential. Moreover, the relatively cheap geothermal energy is likely to make Kenya a preferred destination for investors, bringing with it attendant benefits such as increased fiscal revenue and improved economic development in the country and the region. Geothermal being a clean energy source, it is expected that the project will help avoid close to 2 million tons of CO_2 per annum once power is generated from steam.

7. CONCLUSION

The Menengai I geothermal project is a transformative project in the sense that it focuses on gradually changing the base source of electricity in Kenya from hydropower to geothermal power, also a renewable energy source but more sustainable than the drought-prone hydro-based system in the region. The project is also sustainable from a financial and economic point of view, with low operating costs due to low marginal costs for indigenous fuel. Furthermore, geothermal power generation is characterized by high availability and low environmental impacts.

In this paper, we have demonstrated how the blending of concessional resources with climate change finance and private sector investments can help achieve a transformative impact such as in Menengai I.

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