

Ex-Ante Evaluation (for Japanese ODA Loan)

1. Basic Information

Country: The Republic of Kenya

Project: Olkaria I Units 1, 2 and 3 Geothermal Power Plant Rehabilitation Project

Loan Agreement: March 16, 2018

2. Background and Necessity of the Project

(1) Current State and Issues of the Energy Sector in Kenya and the Priority of the Project

The Power Generation and Transmission Master Plan formulated by the Kenyan government in October 2016 (hereinafter referred to as "Master Plan") projects that the annual peak load will increase significantly from 1,656 MW in 2016 to 2,845 MW in 2020 and 10,219 MW in 2035 due to economic growth and the electrification of areas without electricity. On the other hand, the nation's total installed capacity of power plants as of June 2017 is only 2,333 MW. Thermal power generation accounts for about 36 percent (830 MW) of the total installed capacity of power plants, followed by hydroelectric power generation (about 35 percent, 823 MW), geothermal power generation (about 28 percent, 652 MW) and other power generation (about 1 percent, 26 MW). Frequent droughts in recent years and other causes have made power supply by hydroelectric power generation unstable. The consequent increase in hours of planned power outage is one of the obstacles to conducting business in Kenya. Since Kenya's current account deficit is partially attributed to fuel import for thermal power generation, securing stable base-load power sources is a pressing task for the nation.

Several geothermal studies presume that Kenya, located in the Great Rift Valley of East Africa, has geothermal resources with a potential of 10,000 MW (Master Plan 2016). As geothermal power generation is a stable power generation system not affected by weather, the long-term plan (2015 to 2035) of the Master Plan aims to increase the installed capacity of geothermal power plants from 652 MW in 2017 to 2,435 MW by 2035 so that geothermal power generation will account for about 24 percent of the nation's total installed capacity of power plants and 56 percent of its estimated annual power output. To promote the stabilization of power supply in Kenya with the expected increase in its power demand, it has become more necessary than before to maintain and reinforce the power supply capacity of its existing power generation facilities as

well as to construct new ones. In these circumstances, the Olkaria I Units 1, 2 and 3 Geothermal Power Plant Rehabilitation Project (hereinafter referred to as "the Project"), the purpose of which is to rehabilitate the existing power plant constructed in the 1980s, is considered one of the priority projects in the long-term plan (2015 to 2035) and medium-term plan (2015 to 2020) of the Master Plan.

(2) Japan and JICA's Cooperation Policy toward the Energy Sector and the Priority of the Project

Japan's Development Cooperation Policy for Kenya (April 2012) considers economic infrastructure development to be one of its priority fields and emphasizes the focus on the development of infrastructure for geothermal power generation, which is effective in curbing climate change. The Sixth Tokyo International Conference on African Development (TICAD VI) in August 2016 announced the TICAD VI Nairobi Implementation Plan, whose first pillar "Promoting Structural Economic Transformation through Economic Diversification and Industrialization" includes promoting investment in geothermal and other renewable energies. The Project is thus considered one of the projects under the Plan.

JICA Country Analysis Paper for Kenya (April 2012) sets "the development of economic infrastructure" as a priority area, and suggests that improving the country's access to electricity will help its sustainable economic growth. The Project is consistent with this analysis because it emphasizes the need to continue assistance with the development of geothermal resources, in which Japan has technological advantages over other countries. The Project is also expected to contribute to achieving Sustainable Development Goal 7 ("ensure access to affordable, reliable, sustainable and modern energy for all"). Therefore, the provision of an ODA loan for the Project is much needed.

(3) Other Donors' Activities

The World Bank has supported the construction of Olkaria IV and transmission lines as well as the formulation of Kenya's electric power development plan. In the area of geothermal power generation, the World Bank, the European Investment Bank (EIB), the German Reconstruction Credit Institute (KfW), the French Development Agency (AFD) and the African Development Bank (AfDB) provide assistance in the Olkaria geothermal field. Many donors, including the

World Bank, AfDB and AFD, have also assisted with the Last Mile Connectivity Project of the Kenyan Government, which aims to electrify areas without electricity. The United Nations University is accepting many long- and short-term trainees from Kenya Electricity Generating Company Ltd. (hereinafter referred to as "KenGen") in its Geothermal Training Program, helping them improve their skills in geothermal reservoir analysis and other skills. There is no duplication of the projects among the donors.

3. Project Description

(1) Project Objective

The purpose of the Project is to enhance volume and security of electric power supply in Kenya, by rehabilitating the existing Olkaria I Geothermal Power Plant (Units 1 to 3) in the Olkaria geothermal field in Nakuru County in central Kenya, thereby creating a conducive environment for investment and enabling sustainable economic growth in Kenya.

(2) Project Site/Target Area

Olkaria geothermal field in Nakuru County (about 120 km northwest of Nairobi, Kenya's capital city)

(3) Project Components

- a) Rehabilitation of the existing geothermal power plant (improving the gross output of its three 15 MW units to about 17 MW) and its ancillary facilities, including steam pipes and hot water pipelines
- b) Consulting services (such as preliminary design, bidding assistance and construction management)

Under the Project Components, only "a" is financed by ODA loans, while for the other project component, the executing agency has hired consultants at its own expense since December 2015.

(4) Estimated Project Cost

12,124 million yen (ODA Loan Amount: 10,077 million yen)

(5) Schedule

From March 2018 to December 2022 (58 months in total). The project will be deemed as completed on the date on which the facilities begin to be made

available (December 2021).

(6) Project Implementation Structure

- 1) Borrower: The Government of the Republic of Kenya
- 2) Executing Agency: KenGen
- 3) Operating and Maintaining Agency: Same as 2)

(7) Collaboration and Design of Roles with Other Projects and Donors

1) Japan's Cooperation Activities

The ODA loan project named "Olkaria-Lessos-Kisumu Transmission Lines Construction Project" (the loan agreement signed in December 2010) is constructing 220 kV/400 kV transmission lines between Olkaria, Lessos and Kisumu and expanded transformer substations, which will enable power generated by the Olkaria geothermal plants, including the power plant of the Project, to be supplied to western Kenya as well as eastern Kenya.

JICA is currently formulating the Project for Improvement of Geothermal Power Operation through Introducing IoT Technology for the Olkaria Geothermal Power Plants (already approved in 2016). This project plans to provide technical assistance in maintaining and managing the power plants and geothermal wells of Olkaria I (Units 1 to 5), Olkaria II (Units 1 to 3) and Olkaria IV (Units 1 and 2), updating geothermal reservoir modeling and other activities. This project is expected to help enhance the sustainability of the Project as it targets workers, who maintain and manage Olkaria I (Units 1 to 3) to be rehabilitated under the Project and its geothermal wells.

2) Other Donors' Cooperation Activities

None

(8) Environmental and Social Considerations/ Poverty Reduction/ Social Development

1) Environmental and Social Considerations

(1) Category: B

(2) Reason for Categorization:

The Project is not considered to be a geothermal power project with serious adverse environmental impacts as per "Japan International Cooperation Agency Guidelines for Environmental and Social Considerations" (issued in April 2010). The Project does not have any sensitive characteristics as

described in the JICA Guidelines.

(3) Environmental Permits:

The environmental and social impact assessment report for the Project was approved by the National Environment Management Authority (hereinafter referred to as "NEMA") in May 2015. In May 2017, the validity of the report was approved for another two years.

(4) Anti-Pollution Measures:

Noise generated during the rehabilitation work and after the start of operation of the power plant is expected to meet Kenya's domestic noise standards as installation of soundproofing equipment and other measures will mitigate such noise. Although the power plant will release hydrogen sulfide into the air once the operation starts, the amount of hydrogen sulfide released is expected to fall below the WHO guideline value. General and industrial waste generated during the rehabilitation work and after the start of operation of the power plant will be appropriately disposed of by waste disposal operators with a NEMA license pursuant to domestic laws. Geothermal water separated from geothermal steam is expected not to have adverse impacts on the living and natural environments as it will be injected into injection wells.

(5) Natural Environment:

Although the site of the Project is located in Hell's Gate National Park managed by the Kenya Wildlife Service, KenGen has already obtained a license for geothermal power generation in the project site and the rehabilitation work will take place only within the site of the existing power plant. Transport of equipment and materials necessary for the work will have minimal adverse impacts on the natural environment as the existing roads in the national park are planned to be used. New pipelines for geothermal steam and hot water will not be constructed.

(6) Social Environment:

The Project will not involve any acquisition of land or involuntary resettlement. KenGen will continue its CSR activities benefiting residents in the Olkaria geothermal field in health, education, infrastructure development and other areas.

(7) Other/Monitoring:

The air quality, noise/vibration, solid waste and ecosystems, etc. will be monitored by the Contractors and the Executing Agency during the Project

Implementation and by the Executing Agency after the start of operation of the power plant.

2) Cross-Cutting Issues

(1) Project Related to Climate Change Measures:

For the effectiveness of the Project in easing climate change, the rehabilitated geothermal power plant is expected to reduce carbon dioxide emissions by about 193,946 tons per year compared to a diesel power plant with the same output.

(2) Poverty Reduction/Poverty Considerations: None in particular

(3) Measures for Infectious Diseases Including HIV/AIDS: None in particular

(4) Participatory Development: None in particular

(5) Considerations for Person with Disabilities: None in particular

3) Gender Classification:

(1) Gender Classification: Not applicable

(2) Reason for Categorization: There is no way to incorporate gender activities into the Project.

(9) Other Important Issues: None in particular

4. Target Outcomes

(1) Quantitative Effects

1) Outcomes (Operation and Effect Indicators)

Indicator	Baseline (Actual value in 2017)	Target year (2023) [Expected value 2 years after project completion]
Gross Output (MW)	45	50.7
Plant load factor (%)	50.6	81.83
Availability factor (%)	56.64	90.0
Auxiliary power ratio (%)	5.8	8
Outage hours for every cause (hours per year)	Human error	0
	Machine trouble	365
	Maintenance Stop	170
		504

(Note 1) All the indicators are intended for Olkaria I (Units 1 to 3).

(Note 2) The impacts of equipment to be installed by the Project are counted for setting the target auxiliary power ratio.

(Note 3) The actual value in 2017 of maintenance stoppage hours is attributable to the low availability factor. On the other hand, the target value of maintenance stoppage hours is the minimum hours needed for the rehabilitated geothermal power plant to be appropriately operated, maintained and managed.

(2) Qualitative Effects

Increased and stabilized power supply will improve the people's livelihood, develop the economy of the region and improve the investment environment. Use of renewable energy will reduce emissions of air pollutants and carbon dioxide as well as environmental loads.

(3) Internal Rate of Return (IRR)

The economic internal rate of return (EIRR) and financial internal rate of return (FIRR) of the Project are 33.5% and 13.2%, respectively based on the conditions listed below.

[EIRR]

Cost: Project cost (excluding tax) and operating, maintenance and management cost

Benefit: Reduction of the operating, maintenance and management cost for an alternative power source (diesel power generation)

Project Life: 25 years after the start of operation of the rehabilitated power plant

[FIRR]

Cost: Project cost and operating, maintenance and management cost

Benefit: Revenue from power sales

Project Life: 25 years after the start of operation of the rehabilitated power plant

5. Preconditions and External Factors

(1) Preconditions

The security situation of the site of the Project will not deteriorate.

(2) External Factors

None in particular

6. Lessons Learned from Past Projects

(1) Lessons Learned from Past Projects

The ex-post evaluations of ODA projects for the Republic of the Philippines "Tiwi Geothermal Power Plant Rehabilitation Project" (evaluated in 2008) and "Northern Negros Geothermal Development Project" (evaluated in 2009) suggest that insufficient prior analysis of geothermal reservoirs and steam monitoring after the start of operation of the power plants made it difficult for the power plants to use a sufficient amount of steam and thus achieve the expected output, impairing the effectiveness of the projects.

(2) Lessons for the Project

Based on the above lessons, JICA reviewed KenGen's reports on the amount of available steam, and has confirmed that the Project is sustainable in terms of the amount of steam. The executing agency has agreed to continuously monitor the amount of steam. In addition, JICA is planning to provide technical assistance in maintaining and managing the geothermal wells and updating geothermal reservoir modeling, etc., through the Technical Cooperation Project for Improvement of Geothermal Power Operation through Introducing IoT Technology for the Olkaria Geothermal Power Plants.

7. Evaluation Results

The Project is consistent with the development themes and policies of the Government of Kenya, as well as the cooperation policies of the Government of Japan and the analyses by JICA, and will help stabilize the country's tight power supply. The geothermal power plant using low-cost resources will curb the hike of power tariffs, compared to a thermal power plant with the same output, helping the country attain economic stability and reduce its current account deficit. The Project is also expected to reduce emissions of air pollutants and carbon dioxide.

8. Plan for Future Evaluation

(1) Indicators to be Used

As mentioned in 4. (1) to (3)

(2) Timing of the future evaluation

Two years after project completion