Japanese ODA Loan

Ex-ante Evaluation

1. Name of the Project

Country: Plurinational State of Bolivia
Project: Laguna Colorada Geothermal Power Plant Construction Project (Second Stage)
Loan Agreement: March 24, 2017
Loan Amount: 61.485 billion yen
Borrower: Plurinational State of Bolivia

2. Background and Necessity of the Project

(1) Current state and issues of the electric power sector in Bolivia

According to Bolivia's National Committee of Dispatch of Charge (Comité Nacional de Despacho de Carga; CNDC), the maximum power demand in the country's National Electric Power System (Sistema Interconectado Nacional; SIN) was 1,370 MW in 2015 while its power generation capacity was 1,831 MW, which was sufficient to satisfy the domestic demand for electric power. However, according to the "Electricity Plan for the Plurinational State of Bolivia 2025" ("Plan Eléctrico del Estado Plurinacional de Bolivia 2025"), which was established in 2014, the rate of increase in the per-capita average annual power demand will be 11% from 2012 to 2025 and the power generation capacity, which was 1,831 MW as of 2015, is to be expanded to 4,353 MW by 2025 in order to cope with this increased demand. The plan also promotes diversifying the country's power resources by rebalancing the country's current composition of power sources, where thermal power currently accounts for 69%, hydropower for 30%, and renewable energy (biomass, wind, geothermal, etc.) for 1%. The aim is to achieve an energy balance where hydropower accounts for 70%, thermal power for 26% and renewable energy for 4% by 2025.

The development of mineral resources is being actively pursued, especially at sites in the southwestern area of Bolivia such as the San Cristobal mine, one of the most productive spots for zinc and lead ore in the country, and this is raising the demand for electric power year by year. However, as there is no large-scale power plant in the area, electric power is supplied by long distance transmission, which causes problems in terms of efficiency and reliability. An accident involving an existing transmission line would delay the supply of power to the area, which could cause major problems in terms of the mining activities. Approximately 20% of Bolivia's total exports come from mineral resources, and any interruption to the mine development would significantly affect the Bolivian economy. Therefore, stabilization of the power supply is an urgent issue.

On the other hand, Bolivia is a landlocked country, the transportation of fuel for

thermal power generation is expensive, and the country's power generation relies heavily on thermal power. Poor fuel efficiency at the high altitude areas of southwest Bolivia means that constructing a large-scale thermal power station there is difficult.As there is no suitable place for hydroelectric power generation either, it is imperative to develop alternative electric power resources in the southwestern area, particularly in terms of the use of geothermal power, which has great potential in this area.

(2) Development policies for the electric power sector in Bolivia and the priority of the Project

Bolivia's "National Development Plan (2006–2020)" states that diversifying power resources is one of the basic policies of the electric power sector for addressing the country's soaring power demand and it promotes the development of renewable energy under this strategy. Under the "Laguna Colorada Geothermal Power Plant Construction Project (Phase 1 of First Stage)," for which a Japanese ODA loan was provided in July 2014, and the "Laguna Colorada Geothermal Power Plant Construction Project (Second Stage) (hereinafter referred to as the "Project"), 100 MW of electric power is to be produced. This is also included in the "Electricity Plan for the Plurinational State of Bolivia 2025" as part of the development of new power resources to be completed by 2025.

(3) Japan and JICA's policy and operations in the electric power sector in Bolivia

The "Country Assistance Policy for the Plurinational State of Bolivia" (June 2012) stipulates "assistance for sustainable economic growth through poverty reduction" as a basic policy and emphasizes "improvement of productivity through regional development, etc." as a priority issue. The policy promotes the improvement of the country's infrastructure to achieve sustainable economic growth, focusing on electric power and roads in order to improve productivity through regional development and other initiatives. The Project falls under the category of "economic infrastructure" as a development issue in the priority issue of "improvement of productivity through regional development, etc." and it is positioned as part of the energy program. The Ministry of Economy, Trade and Industry conducted a "Study on Economic Partnership Projects in Developing Countries" entitled "Study on Geothermal Power Plant Construction Project in the Laguna Colorada Field, Bolivia" in 2008. JICA has provided support through the "Preparatory Survey on Laguna Colorada Geothermal Development Project" (2009–2010), technical assistance through the "Preparatory Project for Laguna Colorada Geothermal Power Plant Construction Project" (2011–2013), and so on. The Japanese ODA loan agreement for the "Laguna Colorada Geothermal Power Plant Construction Project (Phase 1 of First Stage)" was signed in July 2014.

(4) Other Donors' Activities

In "The Bank's Country Strategy with Bolivia (2011–2015)," the Inter-American

Development Bank (IDB) identifies seven strategic issues for cooperation: transportation, water and sanitation, energy, early childhood development (ECD), health, education, and the strengthening of public governance. For the energy issue, the IDB is implementing initiatives such as the following: the "Misicuni Renewable Energy Hydroelectric Project," the "Cochabamba–La Paz Transmission Line," and the "Program for Rural Electrification with Renewable Energy." For the Project, the bank is planning to co-finance the transmission lines to be laid from the Laguna Colorada Geothermal Power Plant to the junction point for the power system network (230 kV; approximately 170 km) and construction of transformer substations. With regard to the assistance that the Development Bank of Latin America (CAF) provides for Bolivia, 84% of its operations involve finance for the Government of Bolivia. CAF places an emphasis on economic infrastructure and social and environmental development. In the field of energy, CAF implements economic infrastructure initiatives such as the "San Jose Hydroelectric Project" and the "Interconnection Project Tarija to SIN" to increase the capacity of the electric power supply. The assistance provided by CAF does not overlap with that provided under the Project.

(5) Necessity of the Project

As stated above, there is an urgent need to meet the country's soaring demand for power and to provide a stable electric power supply for mine development, which is a major industry in the southwestern area of the country.

The Project supports the promotion of renewable energy development by the Bolivian government and the securing of a stable power supply, and it is consistent with not only Bolivia's development policies but also Japan and JICA's assistance policies. Therefore, it is extremely important and relevant for JICA to execute the Project.

3. Project Description

(1) Project Objective

The objective of the Project is to facilitate the diversification of power resources, meet the soaring demand for electric power and contribute to the mitigation of climate change mainly through the construction of a geothermal power plant in the Potosi Department, which is located in the southwestern part of Bolivia. This will in turn promote the country's economic growth.

(2) Project Site/Target Area: Potosi Department

(3) Project Component(s)

This is the second stage of the Project, which targets the construction of a geothermal power plant and its power transmission and substation facilities with the aim of generating 100 MW in the Potosi Department. This work includes the drilling of wells for the construction of the geothermal power plant and the construction of the plant itself.

1) Preparation, complementary construction work, etc.
2) Drilling of production wells (15) and reinjection wells (6) (including well test analysis)
3) Geothermal power plant construction (50 MW × 2), including FCRS, etc.
4) Construction of power transmission and substation facilities (the former to be co-financed by IDB and the latter to be independently financed by Empresa Nacional de Electricidad (ENDE))
5) Consulting services (supervision of well test analysis, well drilling, assistance for bidding on the construction of the geothermal power plant (including FCRS, etc.), design and surveillance, and training)

(4) Estimated Project Cost (Loan Amount)

90.765 billion yen (ODA loan amount for the second stage: 61.485 billion yen)

(5) Schedule

July 2014–November 2024 (125 months). The Project will be considered completed upon start of operation (November 2023).

(6) Project Implementation Structure

1) Borrower: Plurinational State of Bolivia
2) Executing Agency: Empresa Nacional de Electricidad (ENDE)
3) Operation and Maintenance System: ENDE

(7) Environmental and Social Considerations, Poverty Reduction, and Social Development

1) Environmental and Social Considerations

① Category: A

② Reason for Categorization

Because the Project falls under a sensitive sector (thermal (geothermal) power generation) and is in a sensitive area (national protected area) as specified in the "JBIC Guidelines for Confirmation of Environmental and Social Considerations" (established in April 2002).

③ Environmental Permit

The Environmental Impact Assessment (EIA) report on the Project was approved by the Ministry of the Environment and Water in September 2010. Although ENDE had been renewing its environmental permit in accordance with Article 90 of Law No. 1333 (Environmental Law), the ministry was notified in writing of the commencement of construction in September 2016, resulting in the renewal of the permit being replaced by the annual submission of a monitoring report during the implementation of the Project.

④ Anti-Pollution Measures

The sludge generated by drilling during the construction and operation work will be stored in metal pits, and materials containing toxic substances

will be solidified in cement before they are disposed of at disposal sites. The height of the cooling tower will be adjusted so that the density of hydrogen sulfide contained in the exhaust gas from the cooling tower satisfies international standards. Hot water pumped from underground for power generation will be temporally stored in the reservoir protected against permeation and returned to the storage tank through a reinjection well. Since a study conducted by ENDE has confirmed that the reservoir is not connected to the aquifer, no adverse impact on the ground water is expected.

⑤ Natural Environment

As the Project site is located in the wetland registered in the Ramsar Convention and the Eduardo Avaroa National Reserve, the conducting of development activities in a nature reserve was examined and approved in accordance with Bolivia's domestic laws in 2010. Mitigation measures are to be implemented, such as securing passage for animals crossing the pipelines and prohibiting the removal of vegetation from around the water area. For the construction of transmission lines and substation facilities (which is to be co-financed by the IDB), ENDE will optimize the route and design of the transmission lines and install anti-collision lights on them. This will be done based on research conducted by the IDB into the habits of flamingos to give appropriate consideration to this rare species that inhabits the site. Furthermore, the line towers will be kept low enough to alleviate the risk of deaths from collision.

⑥ Social Environment

As the Project area is state-owned, no land acquisition or resettlement is expected. Once the land for power transmission (ROW) has been finalized, the necessary procedure for the acquisition of land-use rights will be followed in accordance with domestic legislation. It has also been confirmed that the concession for underground resources is state-owned.

⑦ Monitoring, etc.

The contractor will monitor factors such as the air, water, noise, vibration, and eco-system during the construction work and ENDE will monitor these factors after the start of operation. ENDE will also carry out socio-economic monitoring (number of people employed from the local community, etc.).

2) Promotion of Poverty Reduction: None in particular

3) Promotion of Social Development (e.g. Gender Perspective, Measures for Infectious Diseases Including AIDS, Participatory Development, Considerations for Persons with Disabilities, etc.): The contractor will conduct health awareness activities for workers and local residents in order to prevent infections such as HIV.

(8) Collaboration with Other Schemes and Donors

The IDB will co-finance the construction of the transmission lines for connection to the SIN, which is to be implemented as part of the Project.

(9) Other Important Issues

As the Project is an initiative that promotes the utilization of renewable energy, it is expected to contribute to a reduction in greenhouse gas (GHG) emissions. It is estimated that the Project will produce a reduction of 280,000 tons of CO^2 emissions per year.

4. Targeted Outcomes

(1) Quantitative Effects

1) Operation and Effect Indicators

Indicator		Baseline (2014)	Target Value (2025) [2 years after project completion]
Maximum output (MW)		-	99.5
Capacity factor (%)		-	85.0
Operating rate (%)		-	85.4
Auxiliary power ratio (%)		-	3.0
Sending-end output (GWh/year)		-	722.26
Suspension time by cause (hours/year/unit)	Human error	-	0
	Machine failure	-	619
	Plan cancellation	-	660

(2) Qualitative Effects

The diversification of power resources through the incorporation of renewable energy, the lowering of business risks associated with developments in the mine sector brought about by a stable power supply, the mitigation of climate change, and the promotion of economic development

(3) Internal Rate of Return

Based on the conditions indicated below, the Economic Internal Rate of Return (EIRR) for the Project is 14.5% and the Financial Internal Rate of Return (FIRR) is 0.33%.

[EIRR]

Cost: Project costs (excluding tax), operating costs and maintenance costs

Benefits: Replacement of construction and reduction in the maintenance and management costs for a natural gas thermal power plant, exporting of natural gas for thermal power generation, reduction in CO^2 emissions,

and longer operating hours in mine development

Project life: 30 years

[FIRR]

Cost: Project costs (including tax), operating costs and maintenance costs

Benefits: Profits from electricity sales

Project Life: 30 years

5. External Factors and Risk Control

External Factors: It is assumed that the political and economic situation in Bolivia and the area surrounding the Project site will not deteriorate and that no natural disasters will occur.

6. Results of Evaluations and Lessons Learned from Similar Projects

(1) Lessons Learned from Similar Past Projects

In evaluations of the "Northern Negros Geothermal Project" (evaluated in 2009) and the "Tiwi Geothermal Power Plant Complex Rehabilitation Project" (evaluated in 2008) in the Philippines, it was pointed out that securing output was made difficult by a lack of steam as a result of inadequate preliminary analysis of the geothermal fluid reservoir and management in the plant operation stage.

(2) Application of the Lessons in the Project

The Project has already conducted a well test on the drilled wells and supported the transfer to ENDE of evaluation technologies for resource development. It will also provide further technological support through the provision of consulting services to ensure that resource evaluations are conducted appropriately.

7. Plans for Future Evaluation

(1) Indicators to Be Used for Future Evaluation

See "1) Operation and Effect Indicators" under "(1) Quantitative Effects" in "4. Targeted Outcomes" above.

(2) Timing of Future Evaluation: 2 years after project completion