**Japanese ODA Loan**

# Ex-ante Evaluation

## 1. Name of the Project

Country: Plurinational State of Bolivia
Project: Laguna Colorada Geothermal Power Plant Construction Project (Phase 1 of First Stage)
Loan Agreement: July 2, 2014
Loan Amount: 2.495 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 the Monthly Journal of the Results of Operation of National Electric Power System (Sistema Interconectado Nacional, SIN) and of the Wholesale Electric Market, issued in March, 2014 by National Committee of Dispatch of Charge (Comité Nacional de Despacho de Carga, CNDC), while the maximum power demand in Bolivia's SIN was 1,202MW in 2013, the power generation capacity is currently 1,469MW, which is sufficient to satisfy the domestic demand for electric power. However, according to the CNDC's Optimal Plan of Expansion of SIN 2012-2022, the demand for power is expected to increase by an average of 7% per year up to 2020, and it is targeted to increase the power generation capacity by approximately 1,696MW, extend transmission lines by approximately 2,946Km, and improve the facilities of transformer substations by 2020.

Development of mineral resources is active, especially in the southeastern area of Bolivia including the San Cristobal mine in which a Japanese company owns interest, one of the most productive spots in the country, 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 efficiency and reliability. An accident of an existing transmission line would delay the power supply to the area, which could cause a major trouble in the mining activities. Approximately 20% of Bolivia's total exports are from mineral resources, and any interruption in mine development would significantly affect the Bolivian economy. Therefore, stabilization of power supply is an urgent issue.

On the other hand, Bolivia is a landlocked country, and fuel transportation cost for thermal power generation is expensive. The poor fuel efficiency at high altitude makes construction of a large-scale thermal power station difficult in the area. As there is no suitable place for hydroelectric power generation either, it is imperative to develop alternative electric power resources in the southwestern area.

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

Bolivia's "National Development Plan (2006-2011)" says "securing sovereignty and independence of energy" is one of the basic policies of the electric power sector and promotes development of renewable energy under this strategy. "Laguna Colorada Geothermal Power

Plant Construction Project" is prioritized by the Bolivian government and positioned as part of new electric power development planned to produce about 1,696 MW of electric power by 2020 in "National Electric Power System Development Plan 2012-2022". "Laguna Colorada Geothermal Power Plant Construction Project (Phase 1 of First Stage)" (to be referred to as "the Project" hereinafter) has been planned to cover 50MW of this plan.

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

The Country Assistance Policy for Plurinational State of Bolivia established by the Government of Japan in June 2012 indicates "assistance for sustainable economic growth through poverty reduction" as a basic policy and emphasizes "improvement of productivity through regional development, etc." as one of the priority issues. The Policy states promotion of improvement of infrastructure for the country's sustainable economic growth focusing on electric power and roads in order to improve productivity. The Project falls under "economic infrastructure" as a development issue in the priority issue of "improvement of productivity through regional development, etc." and is also positioned as a part of the "electric power program". The Ministry of Economy, Trade and Industry conducted a Study on Economic Partnership Projects in Developing Countries titled as "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), the technical assistance of "Preparatory Project for Laguna Colorada Geothermal Power Plant Construction Project" (2011-2013) and so on.

(4) Other Donors' Activities

THE BANK'S COUNTRY STRATEGY WITH BOLIVIA (2011-2015) of the Inter-American Development Bank (IDB) identifies seven strategic issues of cooperation: transportation, water and sanitation, energy, early childhood development (ECD), health, education, and the strengthening of public governance. In the energy issue, IDB implements "Misicuni Renewable Energy Hydroelectric Project", "Cochabamba - La Paz Transmission Line", "Program for Rural Electrification with Renewable Energy", etc. Concerning the Project, the Bank is considering co-finance for transmission lines from Laguna Colorada Geothermal Power Plant to the junction point to the power system network (230kV, approximately 170Km) and construction of transformer substations. Regarding the assistance of Development Bank of Latin America (CAF) for Bolivia, 84% of its operation is finance for the Government of Bolivia. CAF places an emphasis on economic infrastructure and Social and Environmental Development. In the energy issue, CAF implements "San Jose Hydroelectric Project", "Interconnection Project Tarija to SIN", etc. to increase the capacity of electric power supply.

(5) Necessity of the Project

As stated above, it is urgently required to stabilize electric power throughout Bolivia as well as electric power supply needed for mine development, which is a major industry in the southwestern area of the country.

The Project supports for renewable energy development promoted by the Bolivian

government and for securing of stable power supply, and is consistent with Bolivia's development policies as well as Japan and JICA's assistance policies. Therefore, it is highly necessary and relevant for JICA to execute the Project.

## 3. Project Description

(1) Project Objective

The objective of the Project is to satisfy Bolivia's demand for electric power expected to increase in the future, stabilize power supply by constructing a geothermal power plant in Potosi Department, thereby promote the country's economic growth and development of renewable energy and contribute to mitigation of climate change.

(2) Project Site/Target Area: Potosi Department

(3) Project Component(s)

Construction of a 50MW geothermal power plant (as the first stage) and drilling of production wells. There are the Phase 1 of the Project to construct a geothermal power plant and improve transmission lines and substations in Potosi Department. Applicable to ODA Loan are as follows. Concerning improvement of transmission lines and substations facilities, the IDB is currently considering co-finance.

① Drilling of production wells (4), reinjection wells (2) and reinjection well for condensate (1) (including well test analysis) (Applicable to ODA Loan)

② Construction of geothermal power plant (50MW x1), including FCRS, etc. (Applicable to ODA Loan)

③ Consulting services (supervising of well test analysis, assistance for the bidding on construction of geothermal power plant including FCRS, etc., design and surveillance, training) (*Applicable to ODA Loan are the areas financed by JICA only)

* Method of Procurement: International competitive bidding
  Consulting services: Short list

(4) Estimated Project Cost (Loan Amount)

27.823 billion yen (ODA Loan Amount: 2.495 billion yen)

(5) Schedule

July 2014 - August 2020 (74 months). The Project will be considered completed upon start of operation (August 2020).

(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/Social Development

1) Environmental and Social Considerations

① Category: A

② Reason for Categorization

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

③ Environmental Permit

The Environmental Impact Assessment (EIA) report concerning the Project was approved by the Ministry of the Environment and Water, of Bolivia in September 2010. However, because of time passage from the approval, the report will be updated before the construction is started and submitted to the Ministry of the Environment and Water by ENDE.

④ Anti-Pollution Measures

Sludge generated from drilling during construction and operation will be stored in metal pits, and materials containing toxic substances will be solidified with cement before disposed at disposal sites. The height of the cooling tower will be changed so that the density of hydrogen sulfide contained in exhaust gas from the cooling tower will satisfy the international standard. 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 reinjection well. Therefore, no adverse impact to ground water is expected. ENDE is implementing a study for subterranean water. With the results of the study, ENDE will consider to implement the adequate mitigation plan if it is necessary.

⑤ Natural Environment

As the the Project site is located in the wetland registered in the Ramsar Convention and Eduardo Avaroa National Reserve, developing activities in a nature reserve was examined and approved in accordance with Bolivia's domestic laws in 2010. To take mitigation measures, it is planned to secure passages for animals crossing with pipelines and prohibit removal of vegetation from around the water. Concerning construction of transmission lines and substations facilities (co-finance considered by the IDB), ENDE will study design of transmission lines (optimization of routes and design) based on the research on the habits of flamingos conducted by the IDB and consider mitigation measures.

⑥ Social Environment

As the Project area is state-owned, no land acquisition or resettlement is expected. It has also been confirmed that the concession of underground resources is state-owned.

⑦ Monitoring etc.

Concerning the Project, ENDE will monitor soil, industrial wastewater, domestic wastewater, surface water, ground water, amount of waste, air, noise, vibration, eco-system, topography, the water level of nearby Laguna Colorada Lake and impact to the residents based on the environmental monitoring plan.

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 the Persons with Disabilities, etc.): The contractor will conduct health awareness enlightenment activities for workers and local residents in order to mitigate infections such as HIV.

(8) Collaboration with Other Schemes and Donors

The IDB is considering co-finance for construction of transmission lines and substations for connection to SIN.

(9) Other Important Issues

None

## 4. Targeted Outcomes

(1) Quantitative Effects

1) Operation and Effect Indicators

| Indicator | | Baseline (2014) | Target Value (2022) [2 years after project completion] |
|---|---|---|---|
| Maximum output (MW) | | ― | 49.75 |
| Capacity factor (%) | | ― | 85.0 |
| Operating rate (%) | | ― | 85.4 |
| Auxiliary power ratio (%) | | ― | 9.0 |
| Sending-end output (GWh/year) | | ― | 338.8 |
| Suspension time by cause (hours/year/unit) | Human error | ― | 0 |
| | Machine failure | ― | 619 |
| | Plan cancellation | ― | 660 |
| Reduction of $CO_2$ emission (ton/year) | | ― | ($CO_2$ equivalent) 248,303 |

2) Internal Rate of Return

Based on the conditions indicated below, the Economic Internal Rate of Return (EIRR) of the Project is 14.2%, and the Financial Internal Rate of Return (FIRR) is 1.20%.

【EIRR】

Cost: Project cost (excluding tax), operation and maintenance expenses

Benefits: Limited to cases of exporting natural gas to be consumed by thermal power generated by alternative natural gas

Project life: 30 years

【FIRR】

Cost: Project cost, Operation and maintenance expenses of the power plant (including utility costs and personnel management), sales costs such as transmission expenses

Benefits: Profits from electricity sales

Project Life: 30 years

(2) Qualitative Effects

Improvement of living standards and promotion of development in the mine sector brought about by stable power supply, economic growth by industrial promotion, diversification of power resources through incorporation of renewable energy, mitigation of climate change

## 5. External Factors and Risk Control

Deterioration in political and economic conditions in Bolivia and surrounding area of project site, and natural desaster.

## 6. Results of Evaluations and Lessons Learned from the Similar Projects

In case of Northern Negros Geothermal Project and Tiwi Geothermal Power Plant Complex Rehabilitation Project in the Philippines, it became difficult to secure output due to the lack of steam caused by the insufficiency of the preliminary analysis of geothermal fluid reservoir and the management at the stage of plant operation. Laguna Colorada Geothermal Power Plant Construction Project (Phase 1 of First Stage) has already conducted well test on drilled wells, and also supported technology transfer of resource development to the executing agency and planned to continue assistance in order to strengthen the organizational capacity of ENDE.

## 7. Plans for Future Evaluation

(1) Indicators to be used for Future Evaluation

See the above 4. Targeted Outcomes (1) Quantitative Effects 1) Operation and Effect Indicators.

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