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JICA's Global Geothermal Development Assistance: Toward a Carbon-Neutral Society

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ABSTRACT

The purpose of this paper is to explain the main ideas behind JICA's assistance in developing geothermal resources globally. This paper discusses the main challenges that JICA's assistance addresses with respect to geothermal development: (a) managing high resource development risks and (b) strengthening policy and institutional support to stimulate private investment.

Public institutions have an important role to play especially in the early phases of a country's geothermal development. They are in the position of taking more up-front risks, diversify risks, and accumulate data on geothermal resources. If governments can take some or all part of geothermal resources development risks, it can positively impact all stakeholders especially on private investment.

Geothermal development requires diverse and deep understanding of public officers that need to be trained in theory and in practice over a long period of time. Therefore, geothermal development organizations must have long-term plans for developing their staffs' capacities. Having said that, a capacity development required to promote private investment is different from the conventional technology-oriented approach, and contents of training programs must be strategically changed.

In this paper, JICA's energy policy as well as its philosophy for geothermal development will be discussed. Then, a brief history of JICA's approximately six decades of global assistance and on-going and planned geothermal projects will be explained with some case studies. Finally, we would like to introduce additional value to geothermal use such as production of green hydrogen as there has been a renewed focus to achieve a carbon-neutral society.

1. INTRODUCTION < GEOTHERMAL DEVELOPMENT IN JICA'S PARTNER COUNTRIES IN THE LAST DECADE >

Geothermal energy is known as a stable, reliable renewable energy resource but it has some obstacles in development, originating from high uncertainty of its underground resource and high CAPEX. Because it requires high investment to reduce uncertainty at early exploration stage and takes long period of uncertainty stages, it could be a difficult technology for private investment which requires to assure its return and short time recovery of its investment (World bank 2012).

In the last 10 years, these barriers were well focused, and many efforts were made by international cooperation like establishment of risk-mitigation schemes, such as GRMF in Africa, GDF in Latin America, some mechanism in particular country in Indonesia, Turkey etc., (GRMF and GDF). Now, some results of these efforts can be seen. First, some countries achieved dramatic growth in geothermal development, for example, in Turkey, it was 82MW of capacity in 2010 and grow up to 1663MW in 2020 (Orhan et al., 2020). In contrast, in Latin America, only Honduras achieved its first geothermal development, and in other countries only extension projects or development by well experienced public companies. Also in Africa, many surface studies were conducted with help of GRMF, but most of them remained undeveloped.

We can identify some differences between these countries that existence of strong commitment of governments to geothermal development. For example, in Turkey, Feed in Tariff must play important role in its geothermal development in addition to long term governmental investment in exploration drilling. In Latin America, continuous development by public companies in Costa Rica and El Salvador proceeded some geothermal field developments. However, in South America rich in many renewable resources including geothermal, no specific attention has been paid to geothermal energy and geothermal has been exposed to hard price competition with other renewable energy like solar and wind, resulting no geothermal as of now expect specific private project.

It is believed that geothermal energy keeps important roles comparing with other renewable energy, such as its stability compared with intermittent energy, independency of fossil fuel which is not only source of energy but also source of back up energy for intermittent resource, and independency of climate condition, in addition to its low CO2 emission rate which is common to all renewable energy. These advantages could be positively evaluated more in recent years, corresponding to awareness of global climate change, and energy security factor after invasion of Ukraine. However, it is still difficult to evaluate these important advantages in price etc., comparing with its disadvantage such as generation cost, high CAPEX etc. Hence, it is also still hard to attract relevant institutes, authorities, decision makers which take priority in price competitiveness in the electricity market. Under this circumstance, JICA cooperation could have important roles to promote geothermal energy to governmental institutes..

2. PHILOSOPHY OF JICA COOPERATION FOR GEOTHERMAL DEVELOPMENT

JICA is a bilateral agency in charge of administrating Japan's Official Development Assistance (ODA). JICA has three main instruments for its cooperation: (a) Technical Cooperation (b) Finance and Investment Cooperation, and (c) Grants. JICA combines these three instruments and tailors them to the needs of individual client countries. JICA has started assistance in geothermal development in early 70' in Asia, Latin America as well as in Africa. JICA's strength is that it can support our partner countries in the whole value chain of geothermal development from upstream to downstream as follows.

A. Policy development/ nationwide survey stage

At the early stage of geothermal development, JICA provided technical assistances in establishment of master plan of geothermal development, including identification and prioritization of potential sites, policy to promote geothermal development. This assistance also emphasizes public involvement and governmental commitment. Further assistances were designed based on this result.

B. Exploration stage/ from surface survey to exploration drilling

Subsection headings should be capitalized on the first letter. Avoid using subsections deeper than subsubsections.

C. Additional drilling/Construction stage

At these stages, JICA mainly provides finance cooperation for construction of geothermal power plant construction as well as steam gathering system. JICA has directly contributed around 1500MW of geothermal power plants construction and field development in 6 countries.

D. Training program in Japan

In addition to the specific support at each stage, JICA also has the following training programs in Japan exclusively designed for geothermal development.

Intensive training for geothermal resource engineers: This training program started in 2016, taking 4 to 6 months in Kyushu University with an emphasis on practical training for geologist, geochemist, geophysicist and reservoir engineer. Every participant brings own specific issues related with geothermal resource development and/or management then find out solutions through this training.

Geothermal Drilling Operation and Maintenance: This training aims to provide fundamental knowledge for drilling personnel who works at drilling sites at a particular position of drilling rig operation. Some of our partner countries purchased and poses their own drilling rig. Since cost of geothermal drilling is critical aspect of total CAPEX of geothermal development, training for drilling operation is expected to contribute reduction in drilling cost.

Acceleration/Promotion of Geothermal Energy Investment Opportunities: This course aims to discuss how we can involve more investments in geothermal sector not only by public sector but also by private sector. During this course, three parties are invited. Expected participants of the course are from governmental authorities who could be a representative of host country of future investments. Some speakers are expected from private companies as sponsor side, in addition to DFI as financers' view points. They will discuss legal, regulations, commercial, technical and finance aspects.

Scholarship program: Since 2014, JICA established Kizuna Program to provide opportunities of Master and Ph. D courses in Japanese universities for mineral resources industry including geothermal sector. Through this program, 42 engineers have been received from geothermal sector all over the world.

3. HISTORY OF JICA COOPERATION IN GEOTHERMAL DEVELOPMENT

Figure. 1 shows footprint of JICA cooperation in geothermal sector which started early in 70' in Latin America for their surface study. Similar cooperation was extended to Asia, Middle East and African countries until 90s.

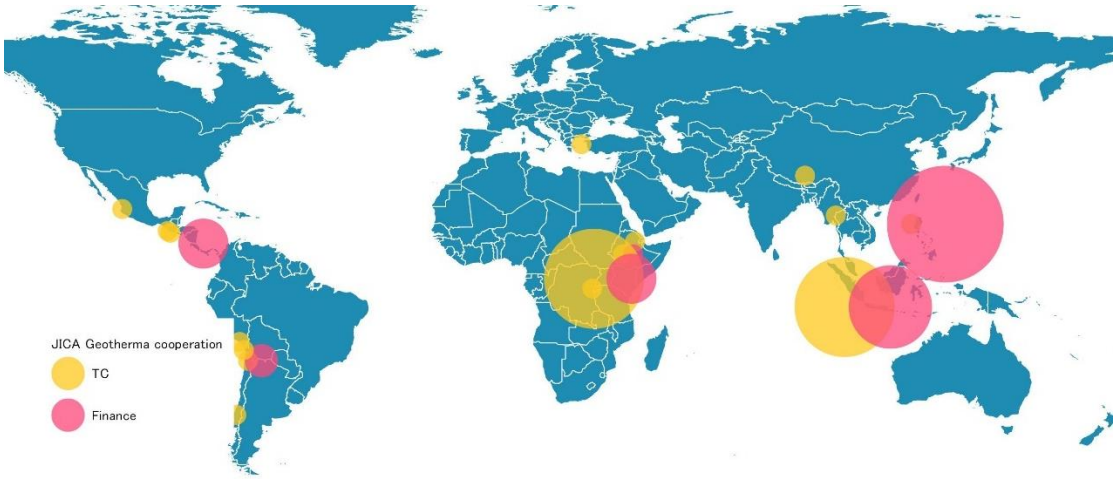

Figure. 1 Location and scale of JICA cooperation in geothermal sector

Finance cooperation was provided to geothermal power plant construction starting from Philippines, and Costa Rica in 80s, then extended to Indonesia and Kenya after 2000. Now, 1st geothermal power plant construction in Bolivia is also supported by JICA Finance cooperation. As of 2023, JICA supported geothermal power plant construction of 1450MW in total, and more than 150MW are still under procurement.

As discussed in the previous section, public involvement must be required to promote geothermal development, both for private and public projects. After ESMAP 2012, it was well identified that de-risking of early exploration drilling is essential to promote more private investment. With this understanding, many de-risking funds were established as well as PPP scheme for geothermal in which public company takes all resource risk as resource developer.

Recent years, JICA's technical cooperation is also addressed to this point. Through cooperation to Master Plan formulation for geothermal development, public role was clearly identified, like in Indonesia, Peru, Kenya, Ethiopia and Rwanda. Specific technical transfer is being also provided to specialized public company such as GDC in Kenya, ODDEG in Djibouti to promote more governmental drilling and reduction of resource risk by government. Regarding de-risking fund, in Indonesia JICA is supporting from its design stage up to its first pilot project. Abovementioned three training programs are also designed in line with this situation.

4. CASE STUDIES

A. Cooperation to Indonesia geothermal sector

Indonesia geothermal potential is huge, and it has long geothermal development history. JICA has started its cooperation to geothermal sector in Indonesia in 70s. First focus was to accelerate more public projects, supporting their Feasibility studies. However, due to huge number of geothermal sites and their large-scale resources, it must require more private investment as well as public ones.

In 2007, through JICA support to "Master Plan Study for Geothermal Power Development", priority and promising sites were identified and 9500MW development plan by 2025 was established. After this cooperation, JICA's approach grew up in step-wised manner scaling up its application from policy, regulation, establishment of investment environment, etc. As first step after master planning and to materialize this plan, technical transfer was provided to Geological Agency of Ministry of Energy and Mineral Resources, in charge of exploration survey and provision of information to establish WKP for tender for private investors. This project, "Capacity Building for Enhancement of the Geothermal Exploration Technologies", was completed in 2013. After that, not only for pure geoscientific-technical strengthening, but for institutional aspects another technical transfer was provided through the "Project to Develop Medium- and Long-Term Geothermal Development Policy" which supported operation of de-risking mechanism in early drilling stage so called, Geothermal Sector Infrastructure Financing Fund (PISP). After establishment of the fund, first pilot projects are being evaluated to apply in which JICA still continues to provide support as second phase of the project. While extensive efforts were accumulated to promote more developer and still on the way, Finance cooperation was provided to assure construction of geothermal power plants, adding 185MW in total and 55MW is still under construction. Figure. 2 shows the whole picture of JICA support to geothermal sector in Indonesia.

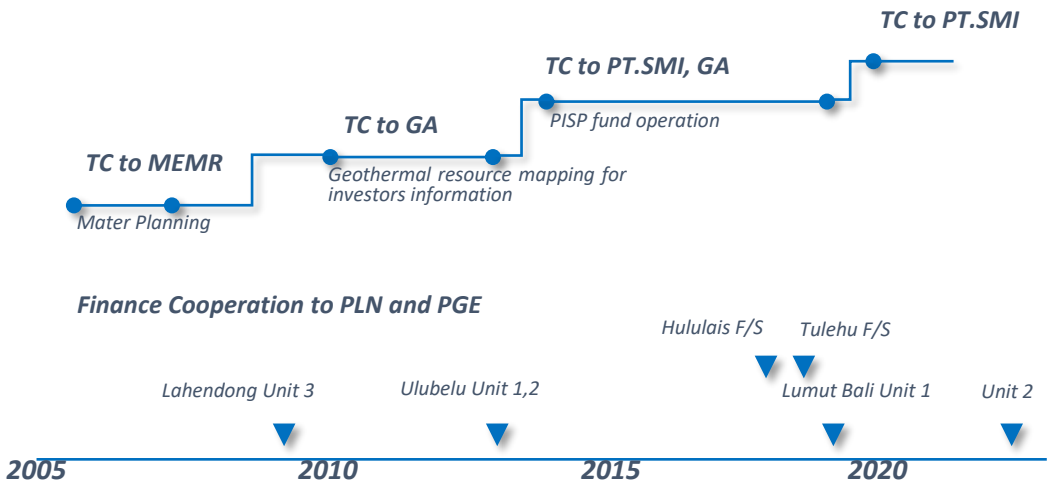

Figure. 2 JICA cooperation to geothermal sector in Indonesia

B. Cooperation to Kenya Geothermal sector

In Kenya, JICA has covered entire stage of its geothermal development. JICA's geothermal assistance in Kenya could be classified in the following three pillars.

Pillar 1. Cooperation in Field development/ Cooperation to GDC

In 2009, the Kenyan government established Geothermal Development Company GDC for acceleration of geothermal development. GDC's role is to take upfront risks associated with geothermal resource exploration and field development. In 2013, JICA and GDC started a technical cooperation project, "The Project for Capacity Strengthening for Geothermal Development in Kenya", in which JICA experts trained GDC staffs on-the-job in geothermal fields, mainly in Menengai field. The project sent 109 international experts to Kenya (mostly from Japan and the Philippines) and trained a total of around 500 GDC personnel. 71 GDC staffs also received

training in Japan. The project completed in 2020. In parallel to this project, JICA and GDC also started another technical cooperation, the "Project for Reviewing GDC's Geothermal Development Strategy in Kenya", which re-evaluated five geothermal prospects: Arus, Baringo, Korosi, Chepchuk, Paka, and Silali and was completed in 2017. In 2022, following above-mentioned two projects, JICA started with GDC new technical cooperation, "the project for Capacity Strengthening for Geothermal Steam Supply and Management". This on-going project aims to strengthen GDC's capacity at a more enhanced level. The project includes a re-evaluation of Menengai reservoir through interference test, reviewing on-going new field developments in Baringo-Silali area, and capacity improvement of steam supply transaction, etc. Through these series of projects, more private investments are expected in Kenya geothermal sectors.

Pillar 2. Cooperation in Construction and O&M/ Cooperation to KenGen

Because KenGen has already had more than 40 years of experience in geothermal development since it started first geothermal power plant in 1981, JICA mainly focuses on more advanced stages with KenGen. So far, three ODA loans agreements have been signed between JICA and the Kenyan government for geothermal power plant constructions which are to be executed by KenGen. The first loan was signed in 2010 for Olkaria I Additional Units, of 140 MW, and another Unit 6 of 83 MW was also constructed with this loan. In 2016, a second loan was signed for Olkaria V of 172 MW, and the third loan was signed in 2018, for rehabilitation of Olkaria I Units 1, 2, and 3, which current total capacity is 45 MW, and will be upgraded to a total net capacity of 51 MW after rehabilitation. In total, 395MW was constructed with ODA Loan which counts more than 40% of total installed capacity of geothermal power plant in Kenya.

In addition to assistance to construction stage, JICA and KenGen started a technical cooperation called "Project for Strengthening Operation and Maintenance Capacity of Olkaria Geothermal Power Stations using IoT Technology". The project will be an initial step for Olkaria geothermal field to evolve into an Internet of Things (IoT) system. With the installation of the IT infrastructure, it will be able to collect and store appropriate data in real-time related to O&M of power plants as well as geothermal reservoir. After this project, it is expected that KenGen will establish efficient maintenance and repair program.

Pillar 3. Cooperation in research and education/ Cooperation to JKUAT

The third pillar is with a perspective of sustainable geothermal development in Kenya, to bring up the next generation to properly maintain their existing geothermal power plants and fields. In this regard, JICA with Jomo Kenyatta University of Agriculture (JKUAT) started new research cooperation project, including many geoscientific research in existing geothermal fields as well as detailed research to specific issues in Olkaria. Through this project, JICA expects to establish a base for geothermal education in Kenya and to promote this field of study among the next younger generations.

5. ADDITIONAL VALUE OF GEOTHERMAL

***Direct use:** JICA mainly focused on cooperation to high enthalpy geothermal resource for electricity generation. It is known that exploration risk and its high investment cost are the same for low enthalpy, direct use purpose and high enthalpy for electricity use, and return on heat supply is comparably low in our partner countries where there is no much demand for heating unlike Europe countries, China etc., where high demand is expected for space heating. Hence, geothermal direct use remains as complementary project of electricity generation such as sub-projects for social consideration, community relations etc. To clarify value of geothermal for direct use, more specific detail study might be necessary in each country, such as full value- chain business model covering from exploration of geothermal heat to sales products /heat using industry.*

***Additional Value:** As discussed in the first section, geothermal energy is not competitive in generation cost comparing with other renewable energy sources, and the cheapest solar energy was installed dramatically all over the world in the last decade. However, it was identified sarcastically after installation of cheap and huge scale but intermittent solar energy, that renewable energy at peak time (mainly at evening and morning time) has more value and geothermal can enter this time as a 24/7 available renewable energy resource (Thomsen 2022). This is not new value of geothermal energy, but finally we can see more quantitative and specific evaluation in price, appearing in large electricity market which has already involved large scale renewable energies. This situation might happen to our partner countries in the next decade and JICA's cooperation could help them to evaluate its value appropriately with the past experiences.*

***Green Hydrogen:** In the last 10 years, global climate change is being taken more seriously year by year, considerations in power sector also clearly such as phase out of coal power mentioned in 2021 COP 26. In coming 10 years, alternative energy sources and fuels will be the big issue and more practical discussion will be required for alternative fuel such as green hydrogen. Under this circumstance, what kind of roles can geothermal play? In Japan, hydrogen production is being tested with geothermal power, then (Obayashi 2021), and also in New Zealand, the larger scale of hydrogen production has started using around 1.25MW of geothermal power (Tuaropaki 2021, Obayashi 2021). They will evaluate advantage of stability and 24/7 availability of geothermal for hydrogen production.Since cheap renewable energy can be considered as first option for green hydrogen production, high potentiality is expected in solar and wind rich countries (IEA 2019). However, in some pilot projects, it was already identified that capacity factor of energy source is also key point to maximize high investment on electrolyzer. Even though, electricity cost of geothermal is less competitive with other renewable energy, its advantage will be well evaluated in some green hydrogen pilot projects like in Kenya, Indonesia etc., in addition to New Zealand and Japan.*

6. CONCLUSION:

The paper discussed the importance of strong government commitment in successful geothermal development, where risk diversification and up-front investment are essential. It also argued the importance of developing capacity of government institutions in charge of geothermal development. In this regard, Geothermal development requires diverse and deep understanding of public officers that need to be trained in practice over a long period of time. In addition, concessional financing for geothermal development is effective because more than half of the geothermal power's generation cost is composed of capital cost. Based on

these ideas, the paper introduced some cases in which JICA is combining financial assistance with improvement of government policy and capacity to support its partner countries to develop their rich geothermal resources potential.

And most importantly, clear and solid value of geothermal energy is not changed; it should be clean and stable energy. With increase of intermittent renewable energy for electricity supply, green hydrogen production etc., geothermal value is expected to be re-evaluated. Once its value is well understood, governmental role will appear at surface again. From this perspective, JICA keeps conversation with our partner countries and its cooperation to geothermal sector providing TaylorMade support to situation of each country

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