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The History of the Earliest Geothermal Power Plants in Indonesia

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ABSTRACT

Currently, the installed capacity of geothermal power plants in Indonesia has reached 1332 MW. The development of geothermal power plants started on November 27th 1978 when a back-pressure unit with capacity of 250 kW was inaugurated in the Kamojang field. This unit was a pilot project and served the electricity needs of the field.

On May 14th 1981, another back-pressure unit with capacity of 2000 kW was inaugurated, by the Minister of Mining and Energy of Indonesia, in the Dieng field. This unit became the second geothermal power plant installed in Indonesia. This unit was operated to serve the electricity needs of a local water pump station and a field office. In late 1995, the 2 MW unit was moved to the Sibayak field and there operated commercially until middle of 1996. In middle of 2010, the unit retired after 30 years of service. The unit has an important role in the history of geothermal power plant development in Indonesia.

1. INTRODUCTION

Geothermal exploration began in Indonesia at Kawah Kamojang, 42 km southeast of Bandung, in Java. First geothermal studies began in 1919 by volcanological society of Netherlands East Indies. This investigation resulted in the drilling of 5 shallow wells in the Kamojang area of West Java from 1926 to 1928. These wells were never utilized and the project was abandoned until 1971.

In 1971, a new team joined the volcanological society of Indonesia (VSI), Geothermal Energy of New Zealand Ltd (GENZL) and Pertamina and studied the Kamojang field and recommended further exploration. After this study an aid program was signed with New Zealand in 1973. This program included exploration, drilling and construction of power facilities to be managed by GENZL. The first exploration well drilled in this program was successful with dry steam flow in 1974.

During 1965 to 1968 UNESCO and France undertook geothermal surveys on Java. In 1970, Muffler, a U.S geological survey expert, surveyed the geothermal potential of the Dieng Mountains, as reported in a paper by Donald Finn. The Indonesia government also secured the services of an expert from the United Nations who prepared an evaluation of the country's overall potential.

Currently, Indonesia maintains the world's fourth largest generation of electricity from geothermal energy with total installed capacity of 1332 MW. The electricity produced comes from twenty four units of power plants located at eight different geothermal fields. The largest unit, a single turbine, has capacity of 121 MW and the smallest operating today is 5 MW. All units are single flash with a condensing system. These plants are owned by eight geothermal energy companies. In the next three years six units with total capacity of 300 MW will be developed, adding to the installed capacity of geothermal power plants in Indonesia. This large number of the geothermal power plants' installed capacity started with a back pressure unit modular just for utilizing the steam from the earliest wellbore.

2. KAMOJANG POWER PLANT 250 KW

Kamojang geothermal filed is located at West Java province, about 60 km from Bandung city as shown in Figure 1. This field is operated by PT Pertamina Geothermal Energy, a subsidiary company of PT Pertamina (Persero), the Indonesian state owned oil and gas enterprises previously known as Pertamina. Kamojang field is a dry steam resource. In 1978, a 250 kW geothermal power plant was installed to serve the field load. This unit was inaugurated on 27 November 1978 by the Minister of Energy and Mining of Indonesia which was at that time Prof Dr. Subroto. The plant, a mobile wellhead unit, was designed by a geothermal power company in USA. With the installation of this unit, Indonesia at that time became the fourteenth top country in the world to use geothermal energy for the electricity generation.

The small scale modular power plant called monoblok was a back pressure unit. The monoblok consisted of turbine, gear box and generator with electric control panel and air cooled lube oil system, all in one container. The turbine had 4 stage blades with revolution of 3100 RPM. The gear box reduced the revolution from 3100 to 1500 rpm to meet the generator's revolution. To generate electricity of 250 kW the monoblok needed steam flow rate of about 29 ton/hr, turbine inlet pressure of 50 PSIG and an exhaust to the atmosphere through a diffuser silencer which pulls a slight vacuum to improve performance.

One of the functions performed by early operation of the monoblok at a new location was to indicate maintenance problems caused by the geothermal steam at that location. After two years of continuous service at Kamojang, the monoblok was shut down for inspection and servicing. There was some erosion evident in the first stage nozzles and considerable scaling on all of the diaphragms blades. There was also light deposition on all rotating blades. The deposits were primarily silica with some calcium sulfate and boron as Gary Shulman reported in his paper.

To overcome this problem a cycloform scrubber and steam cleaner was installed at Kamojang to clean the steam before entering the monoblok. This unit was placed in service after the monoblok was inspected and cleaned in September 1980. After operating for eight years the plant retired in 1986. During 1983 to 1986, the electricity generated by the monoblok was 2.29 GWh. Figure 2 shows the plant in recent day where the monoblok became a monument. In 1983, a commercial unit with capacity of 30 MW was developed at Kamojang by PT Perusahaan Listrik Negara (PLN), the Indonesian state owned electricity enterprises. That moment brought Indonesia to a new era of electricity generation from geothermal energy.

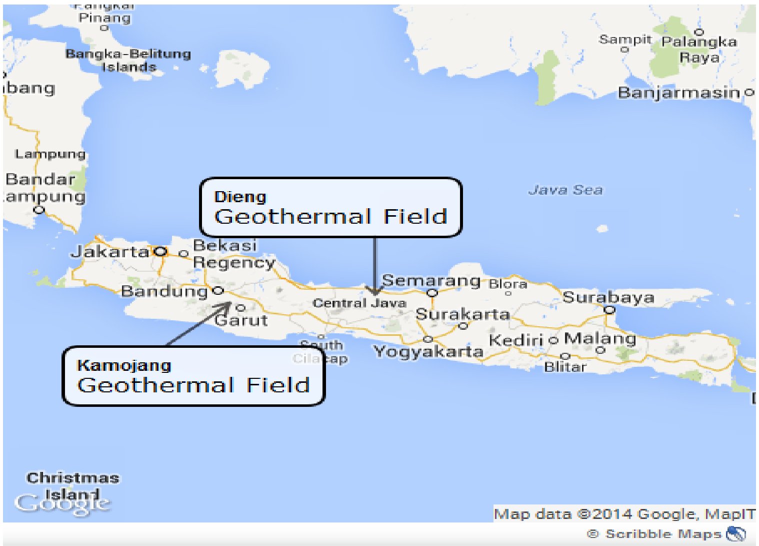

Figure 1: A map of Java Island (courtesy of Google Map).

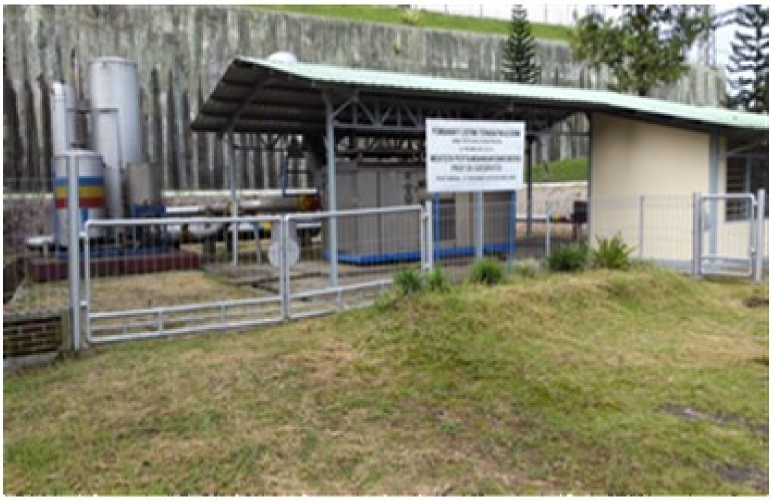

Figure 2: monoblok 250 kW at Kamojang Field in recent day.

3. DIENG-SIBAYAK POWER PLANT 2000 KW

Dieng field located at Dieng plateau with elevation about 2000 meters above sea level has resources dominated by high temperature water. Dieng is about 180 km from Semarang city as shown in Figure 1. In 1979, Pertima had already drilled two geothermal wells at the Dieng field. The second well was a good steam producer. To utilize the steam from the second well in 1981, a back pressure geothermal power plant with capacity of 2000 kW was installed. This unit, also called monoblok, is shown in Figure 3.

The monoblok was inaugurated on May 14th 1981. This power plant, built by a geothermal power company in USA, was a mobile wellhead unit. With the installation of this unit, Indonesia at that time became the fourteenth top country in the world to use geothermal energy for the generation of electricity.

Figure 3: monoblok 250 kW at Dieng field in early year of operation.

The monoblok served a water pump station and a near village that for the first time had electricity and a field's office. From cluster DNG 2 the electricity delivered to the office, using underground cable of about 2 km, was about 1.2 MW. The monoblok was also connected to PLN's grids of 20 kV. In daily operation, two operators run this unit with three group shifts.

The monoblok contained a turbine, gear box and generator, electrical control panel and air cooled lube oil system. With output of 2000 kW, the unit had steam consumption of 36 ton/hr, turbine inlet pressure of 100 PSIG and an exhaust to atmosphere through a diffuser silencer which pulls a slight vacuum to improve performance. Figure 5 shows the turbine, gear box and generator of the monoblok.

The generator, manufactured by Kato, had four poles brushless and speed input of 1500 rpm. The turbine, manufactured by Westinghouse, had speed of 6543 rpm. The gear box, manufactured by Turbodyne, had with four poles brushless and speed input and output of 6543 and 1500 rpm, respectively. A cycloform scrubber and steam cleaner was installed, like at Kamojang field, to clean the steam before entering to the monoblok.

When the development of Dieng field was handed over from Pertamina to Himpurna California Energy in 1995, the unit was dismantled and moved to Sibayak field in North Sumatera. This field is located about 60 km from Medan city as shown in Figure 4. In August 1996 the unit had been reinstalled completely and was ready for commercial operation under a power purchase agreement with PLN. The generator voltage output eas 380 V and the step up to 20 kV was by two unit transformers, each with capacity of 1250 kVA. Figure 6 shows the picture of the monoblok 2000 kW at Sibayak field in 2010.

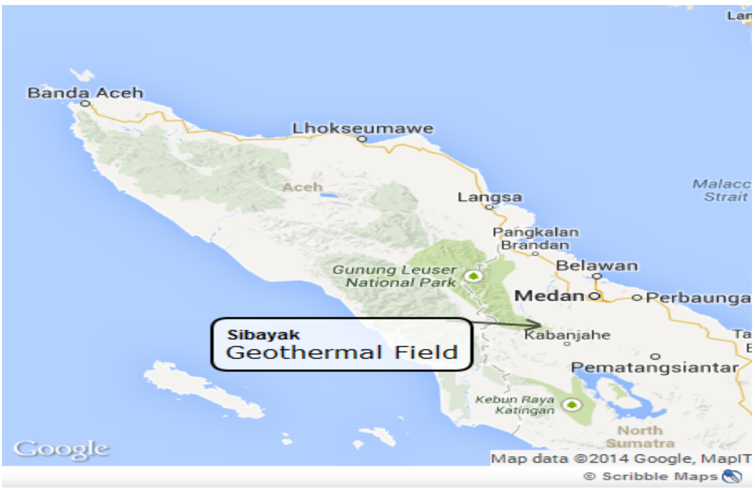

Figure 4: A map of North Sumatera (courtesy of Google Map).

The electricity from this unit delivered 20 kV to the grid system to serve the Karo regency. With small scale tariff regulation, the electricity from this unit had gained the highest tariff compared to the other geothermal unit at that time. The electricity was delivered through a 20 kV grid along a 20 km route to the substation PLN. The grid was mostly located at the edge of a protected forest with the big trees and when windy and rainy weather occurred, branches of the trees dropped on the grid causing disturbances. This caused the grid to trip due to short circuit and resulted often in shutdown of the monoblok.

Figure 5: A turbine, gear box and generator.

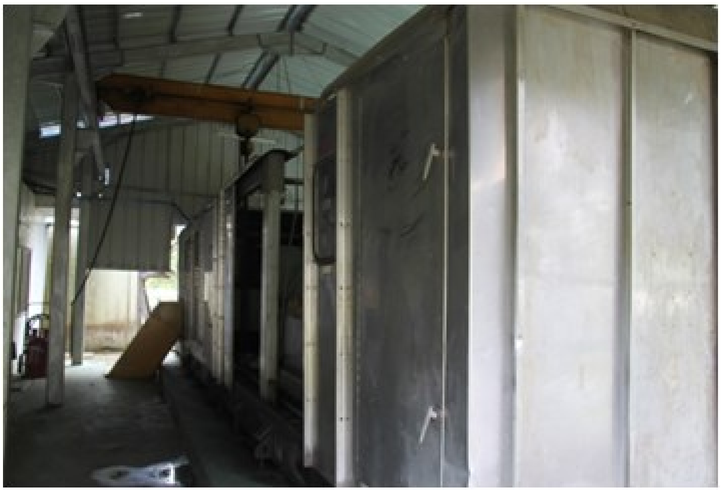

Figure 6: Dieng-Sibayak monoblok 2000 kW.

At the end of 2009, the rotor blades had severe corrosion problems and some parts could not be repaired by welding. The corrosion rate on the turbine material was high with 100um for 400 operation hours. Also, the stator blades had severe corrosion problems as well as scaling problems. Figure 7 shows the damaged turbine rotor drum and Figure 8 shows the turbine rotor with some damaged blades.

The lubrication system, with a lube oil reservoir inside the skid of the monoblok, was corroded and needed replacement. Replacing the skid meant replacing the lower skid mounted to the container. Installing external oil purifying mechanism would not have solved the problem. After rewinding the generator, high vibration was encountered that needed to be repaired to meet the recommended vibration level. Also, the monoblok's pedestal also had cracks and needed reconditioning. The cracks in the pedestal also gave contribution to the high vibration problem of the monoblok.

Figure 7: The turbine rotor drum was damaged.

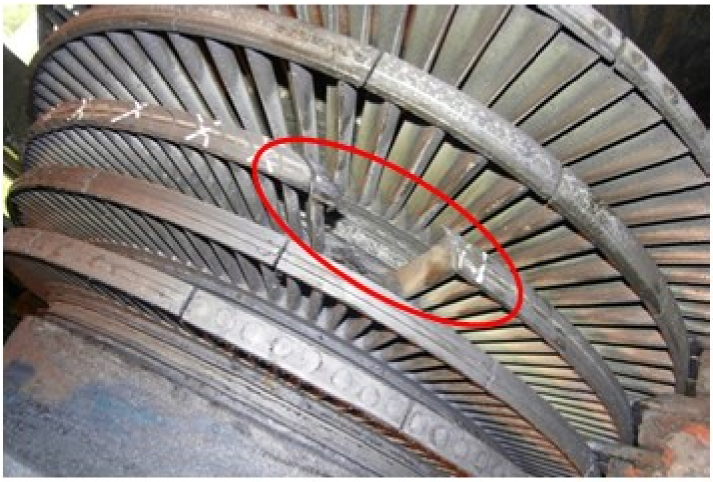

Figure 8: Some rotor blades were damaged

During the commercial operation period from 1996 to 2009, the monoblok had been operating on average six months in a year with total electricity generation of about 43 GWh. Considering the low reliability, the inefficient of steam consumption and the amount of recondition needed, the company decided to terminate the operation of the monoblok in 2010.

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