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Geothermal development for supporting the Rural Electrification Program in Indonesia

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Sjafra DWIPA (2002) Geothermal development for supporting the Rural Electrification Program in Indonesia. *Bull. Geol. Surv. Japan,* vol. 53 (2/3), p. 79-86, 3 figs., 4 tables.

Abstract: Indonesia is blessed with abundant geothermal resources. However, only 787 MWe of geothermal energy has been developed as of 2001. To further increase the capacity in Indonesia, we must overcome obstacles like weak cost-competitiveness. Accordingly, a new regulation was issued that shows the government is willing to share the steam development risk and introducing fair competition and more efficient private sector participation. In supporting regional autonomy, the government made stable power supply and rural electrification as its top priorities for expansion of the infrastructure to promote the development of remote islands. The government electrified about 30,394 villages. We look forward to a fruitful cooperation on geothermal development and invite investors for capital investments to keeping momentum of growth.

1. Introduction

Indonesia is made up of more than 17,000 islands with a population of 210 million people distributed in 62,916 villages. Located between the eastern end of the Mediterranean Volcanic Belt and western side of the Circum Pacific Volcanic Belt, this country is blessed with abundant geothermal resources. Trial calculations indicate that forty percent (equivalent to approximately 26,240 MWe $\approx$ 9 Billion BOE) of the geothermal energy in the earth's crust is released in the Indonesian archipelago and neighbouring areas. This country has the biggest geothermal energy potential in the world. Indonesia needs a balanced energy mix to benefit from its clean geothermal energy. The use of renewable geothermal energy would eliminate its dependency on a single source of fossil fuels to generate electricity and meet Indonesia's growing energy demand. Therefore, this is an investment opportunity now to benefit from developing its abundant and indigenous geothermal resources to provide for the countries domestic needs. Using geothermal energy will obviously enable Indonesia to export fuels that are easy to transport for much needed hard currency.

To accelerate geothermal development, a new regulation on the power sector and geothermal development was introduced. The programs on the small-scale geothermal energy development and geothermal research for rural electrification must be carried out to fulfil increasing electricity demand especially in the eastern part of Indonesia.

This paper presents the current geothermal development and overview of bilateral research cooperation in achievement of electricity demands, geothermal regulation and Rural Electrification Program. Before discussion on these subjects, we would like to take the opportunity to explain the classification and geothermal energy potential in Indonesia.

2. Classification a geothermal energy potential

The classification of geothermal energy potential in Indonesia has been established based on the level of confidence, result of integrated scientific survey works (surface and subsurface) and economic-technical considerations. The two general categories are defined as resource and reserve, and further subdivided as shown below (see also Fig. 1 and Table 1):

1. Resource (Unidentified Resource) consists of two classes, i.e.:
   - Speculative Resource
   - Hypothetical Resource
2. Reserve (Identified Resource) consists of three classes, i.e.:
   - Possible Reserve
   - Probable Reserve
   - Proven Reserve

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Keywords: geothermal energy, energy policy, regulation, cooperation, rural electrification, Indonesia

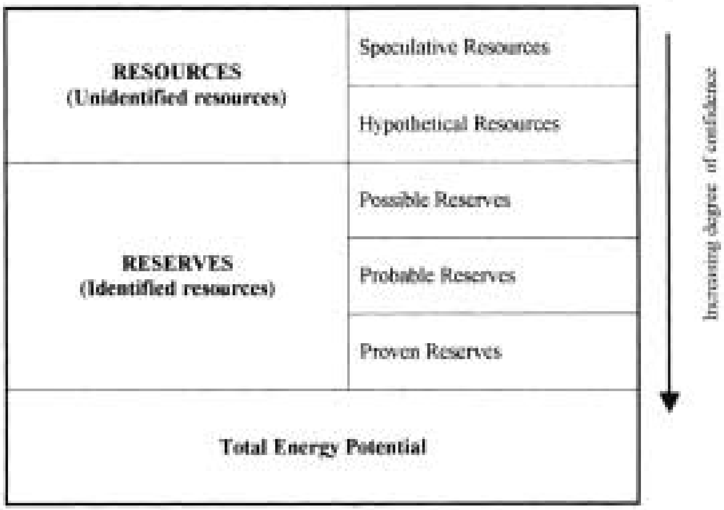

Fig. 1 Geothermal energy potential classification.

Table 1 The energy potential calculation consideration.

Energy Potential Status	Required Condition	Formula for Energy Potential Calculation
Speculative Resource	• Presence of surface thermal features • Associated with volcanic activity	• Assumed that each resource is considered to have an extent of 20 km^2 and the recoverable resource has a power density at 12.5 MWe per km^2
Hypothetical Resource	• Regional studies has been established and used to determine resource size • Fluid geochemistry (geothermometry) anomaly	• Heat Stored Calculation (the parameters for energy potential calculation are mostly using geological thinking)
Possible Reserve	• Geological and geophysical data indicated the presence of a hydrothermal systems This includes remote sensing, surface sampling and shallow temperature gradient • A surface manifestation (hot spring, steaming ground, etc.) or commercial production must be located within a reasonable distance	• Heat Stored Calculation (the parameters for energy potential calculation are based on scientific model estimated from integrated
Probable Reserve	• Deep drilling has established producible fluids • Market conditions forecast atypical power plant that is likely to be needed • Current economics do not justify capital investment at present	• Heat Stored Calculation (the data for calculation are taken from integrated scientific survey works and boreholes)
Proven Reserve	• Engineering and scientific evaluation has confirmed a resource • Commercial wells have been developed • A reservoir model has been developed	• Gomma Formula • Lump parameters

Table 2 Geothermal energy potential of Indonesia.

Location	Resources		Reserve		
	Speculative	Hypothetic	Possible	Probable	Proven
Sumatra	6350	1427	5485	130	145
Java	2725	1501	2553	360	1722
Bali	75	-	226	-	-
Nusa Tenggara	135	181.2	519.6	20	12.5
Sulawesi	1050	330	615.7	110	65
Maluku	300	5	7	-	-
Irian Jaya	50	-	147	-	-
Total	**10580**	**3444.2**	**9546.3**	**620**	**1944.5**
	14024.2		**12109.8**		
	26134				

The calculation of geothermal energy potential uses as stored mass and heat in place method for any given prospect. The total thermal energy potential Q_{Total} is converted into electrical potential in megawatt (MW) by considering recovery and utilization factors. Different equations have been applied to estimate the thermal energy potential in fluids and rocks depending on the reserve or resource sizes. The method of energy potential calculation for any category of reserve and resource is given on Table 1.

Geothermal exploration and research activities carried out in Indonesia have identified about 244 geothermal manifestation areas. However, only 5 % are in detailed exploration and the rest are still in the regional exploration stage. Total geothermal energy potential of 26,240 MWe is calculated from these areas (Table 2). The figure will be updated and issued every year as the level of exploration changes.

3. Current geothermal development

During the last three years, three geothermal power plants became newly operational in Indonesia at Darajat and Wayang Windu (West Java Province) and Lahendong (North Sulawesi Province) (Table 3 and Fig. 2). These installations have rapidly expanded the Indonesian geothermal power capacity. At the present, total geothermal power capacity is 787 MWe as of January 2002. Indonesia now ranks third in geothermal power generation in the world.

We should also draw attention to the sustainability of the older geothermal power plant in Indonesia because its many years of operation have taught us valuable lesson. The Kamojang plant, the first geothermal power plant in Indonesia, has been operating stably for 19 years. Its reliable operation demonstrates the sustainability and renewability of geothermal resources, if the rate of production is suitable for the reservoir size.

Table 3 The installed capacity of geothermal development in Indonesia.

Geothermal Field	Drilling depth (m)	Temp (°C) system	Unit	Capacity (MW)	Installed Capacity
Kamojang, West Java	1000-2200	220-245 dry steam	1,2,3	140	1983 1987
Darajat, West Java	1100-2800	220-245 dry steam	1 2	55 70	1994 1999
G.Salak, West Java	1250-3210	221-312 water dam	1,2,3 4,5,6	110 220	1994, 1998
Wayang Windu, West Java	1200-2000	220-300 two phase	1	110	2000
Dieng, Central Java	1200-2000	220-300 two phase	1,2	60	1998
Sibayak, North Sumatra	1000-1800	220-301 water dam	1, mono block	2	1998
Lahendong, North Sulawesi	500-2000	220-280 two phase	1,2	20	2001

However, the total geothermal power capacity of 787 MWe is only 2 % of the total domestic installed power plant capacity of 37,385 MWe (Table 4). The geothermal power capacity in Indonesia still remains at a relatively low level compared to 2,850 MWe in the USA and 1,861 MWe in the Philippines.

Regional autonomy started on January 1, 2001 gives a significant impact on district infrastructure development. More industries are expected to grow and consequently more energy is needed. Diversification of fuels is necessary to ensure stable and economical priced electric power.

4. Policy and regulatory incentives

The Government of Indonesia (GOI) stresses a

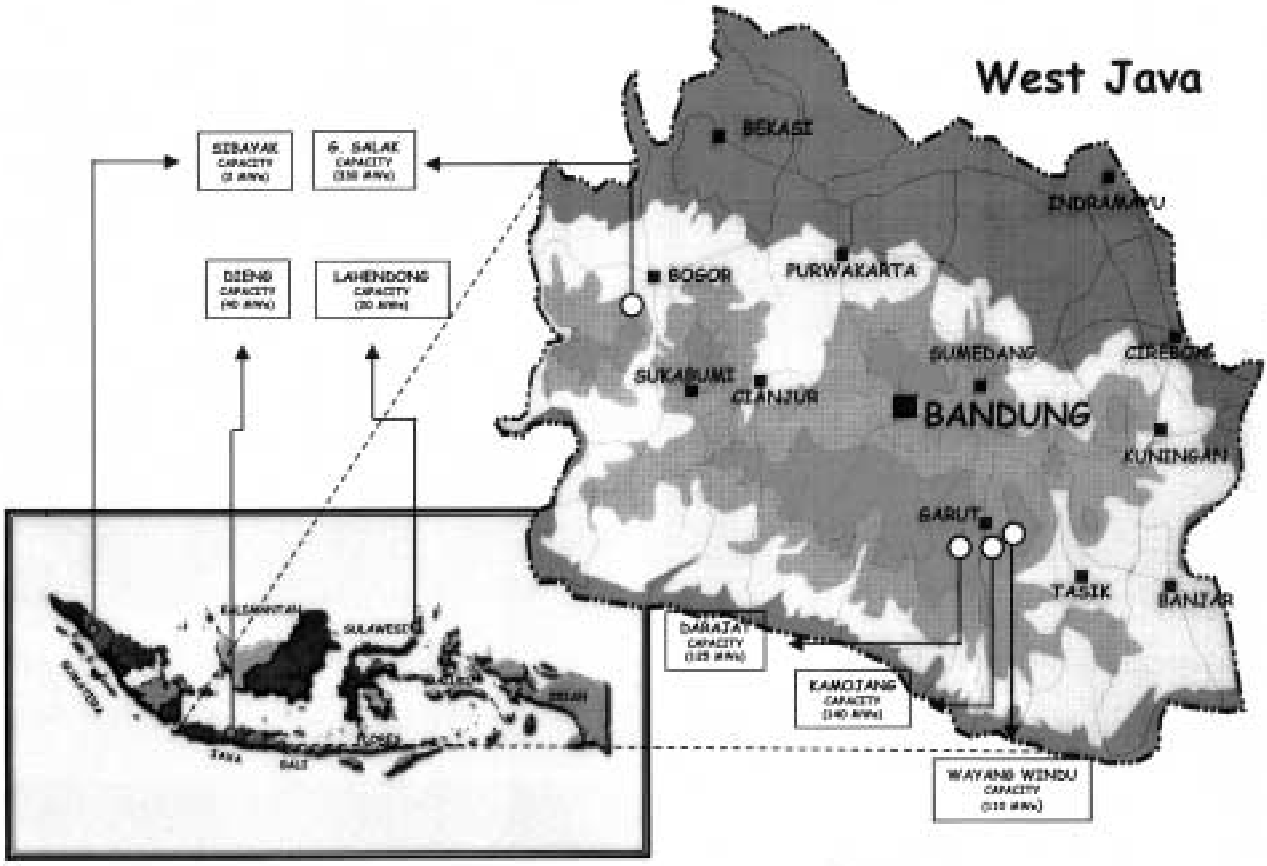

Fig. 2 Installed capacity geothermal development in Indonesia.

Table 4 The installed capacicy ot electricity in Indonesia.

Power Generation Type	Capacity	%
Hydro	3,915 MWe	11
Thermal (Coal Fired)	8,120 MWe	22
Combined Cycle	6,860 MWe	18
Diesel	15,050 MWe	40
Gas Turbin	2,650 MWe	7
Geothermal	790 MWe	2
Total	37,385 MWe	100

guideline for the energy policy, namely *intensification* on survey and exploration of energy resources; *diversification* of energy by reducing its oil utilization and promoting development utilization and customary use of substitute fuel; *conservation* of natural resources with goals of economic and efficient energy utilization; and *indexation* of each energy need with the most appropriate energy resources available in the country.

Under the Law of Environmental Management (Law No. 23/1997), GOI recommends and gives the highest priority to develop renewable energy such as geothermal. This energy is a potentially significant source of environmentally friendly energy. Furthermore to promote the utilization of geothermal energy, GOI has enacted a Presidential Decree No. 76/2000 regarding the utilization of geothermal energy for electricity. The supporting regulation shows that the government will explore and drill two or three exploration wells. Probably an addition production well will have a significant impact on price. It will take over the steam field development risk. Tendering by the government will bring fair competition. The improvement in efficiency, sustainability and productivity of existing should be performed through technology improvement and optimal utilization. Transparency is one of the new government roles promoted to eliminate anti-competitive practices.

5. Rural electrification program

The Indonesian State Electricity Company (PLN) on behalf of GOI has developed the rural electrification program by utilizing diesel power in the areas that have insufficient water for hydropower or lack of other energy resources. This program increased dramatically until the mid 1990's. There are about 62,916 villages all over the country with half (31,394 villages) being electrified by 2000. There are still large demands for electricity in other villages. Therefore, small-scale geothermal power (less than 10 MWe) is one of the energy resources, which are very useful to solve the problem of not having access to electicity in rural areas.

Now, energy is solely evaluated by cost competitiveness; however, this criterion will no longer be meaningful in the 21st century. We must evaluate energy by the cleanliness to the global environment. From this viewpoint, geothermal energy can be regarded as one of the excellent energy sources. The cleanliness of geothermal power in terms of carbon dioxide emissions is ranked third among various energy sources after medium- to small-scale hydro power and nuclear power. The emission of carbon dioxide for nuclear power does not take the waste deposal process into account because it has not been fully established (Uchiyama, 1993). Compared to the present energy composition, geothermal power is the most effective energy to reduce the emissions of carbon dioxide in terms of cost.

Until recent years, economic-driven development has solely dominated the energy production field. However, to solve global environmental problems, political-driven development must replace it. From this viewpoint, geothermal power development could play a worldwide role in the global environmental issue. Therefore future development could be controlled not only by market forces but also by strong political forces. Furthermore, international cooperation will become important when we consider the worldwide geothermal development. From this demand, we have started a five-year bilateral program "Research Cooperation Project on the Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia" (Fig. 3) expected to continue into the future.

6. Research co-operation

A five-year Indonesia-Japan bilateral research cooperation program, "Research Co-operation Project on the Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia" (ESSEI), started in fiscal year 1997. The objectives of this project are to develop a geothermal exploration system that is suitable for tropical remote islands in Indonesia and consequently, contribute to the Rural Electrification Program of the Indonesia government. The implementing organizations are the Volcanological Survey of Indonesia (VSI), New Energy and Industrial Technology Development Organization (NEDO), and Geological Survey of

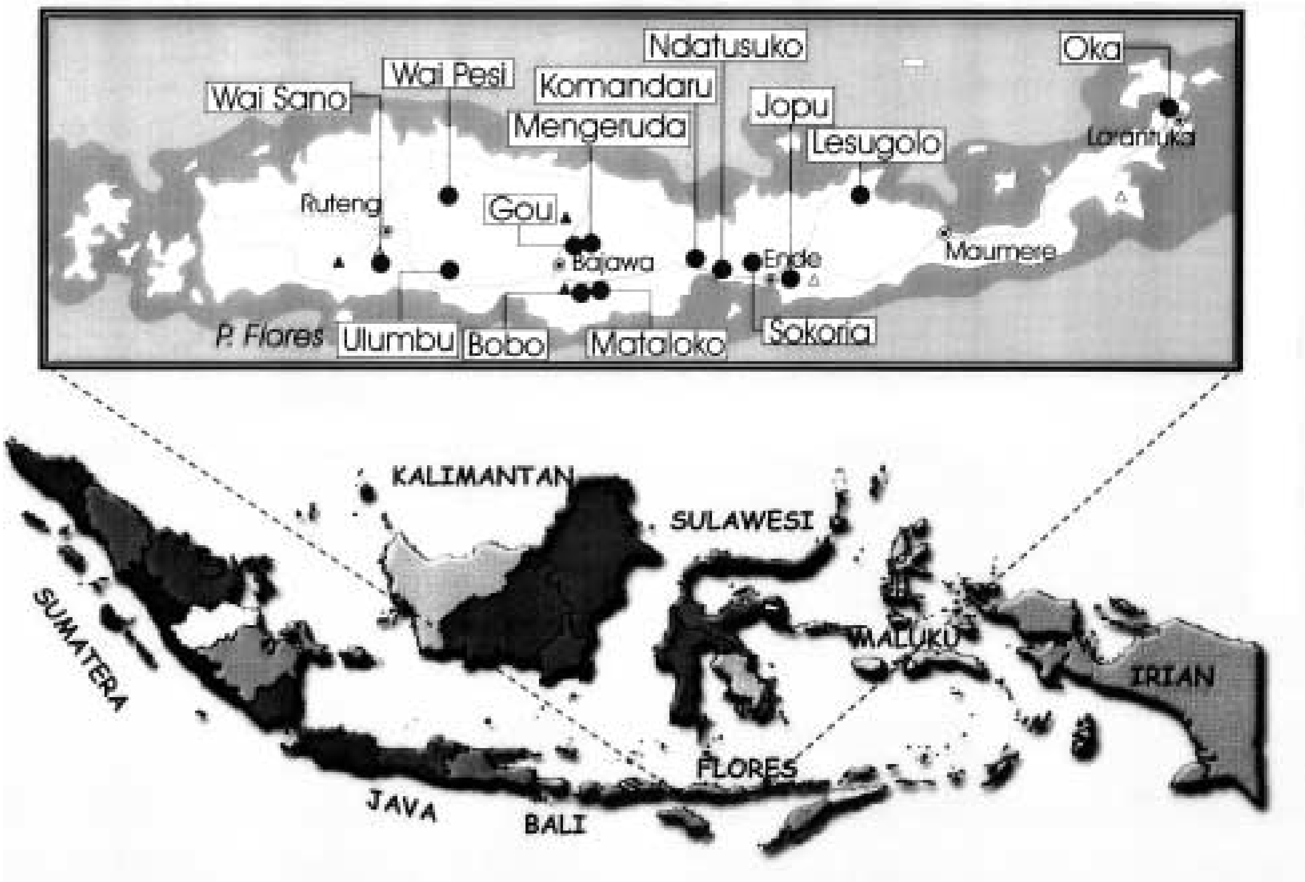

Fig. 3 Geothermal distribution map of Flores Island.

Japan (GSJ).

The Mataloko geothermal field near Bajawa, central Flores, was selected as the study area of the project based on the 1997 reconnaissance surveys (Fig. 3). Intensive investigations including remote sensing, geology, geochemistry, geophysics and reservoir engineering started in fiscal year 1998. The results of the surveys have been published by both Japanese and Indonesia researches (Dwipa and Andan, 1998; Komazawa *et al.,* 2000; Muraoka *et al.,* 2000; Takahashi *et al.,* 2000; Takashima *et al.,* 2000; Uchida *et al.,* 2000; Urai *et al.,* 2000; Yasukawa *et al.,* 2000). An exploration well has encountered a steam zone at a depth of 180 meters, which produce 15 tons of steam per hour. Results of exploration drilling at the Mataloko geothermal field are presented by Sitorus *et al.* (2002) and Sueyoshi *et al.* (2002).

Many organizations are involved in this project regarding the administration, funding, technical investigations and logistics. The Directorate General of the Geology and Mineral Resources (DGGMR) of Indonesia and New Sunshine Project Promotion Headquarters (NSS) of Japan administrate this project. The MOU was signed by three organizations, DGGMR, NEDO and GSJ. The technical investigations are mainly performed by the three organizations. The VSI and GSJ conduct the investigations by their researchers while NEDO has a contract with West Japan Engineering Company Inc. (WestJec) and Mitshubishi Materials Natural Resources Development Corp. (MRC) for the investigation work. The PLN is the main implementing organization for the Rural Electrification Program and will play a role of an adviser to this project as a developer of small-scale geothermal power plants.

To construct a geothermal exploration system suitable for tropical remote islands in Indonesia, geothermal modeling of the area is very important. The NEDO mainly focuses on depth modeling by an exploration drilling survey. On the other hand, GSJ mainly focuses on regional modeling by a survey over a regional assessment area. Another role of GSJ is logistics to NEDO from a viewpoint of scientific research background.

7. Investment opportunities

Flores Island is one of the biggest islands in East Nusatenggara archipelago where distribution of geothermal manifestations is stretched along the islands (Fig. 3). The Directorate of Mineral Resources Inventory of Indonesia (DMRI) inventory data indicates that there are 13 geothermal prospects of high, medium and low enthalpy across the islands, which suggests more than 100 Megawatts generation potential.

The electric power on Flores Island is generated and distributed by PLN. There are isolated small-scale diesel power plants and distribution network not covering all the areas of the island. The current electric power is distributed from existing diesel power plants through a 20 kV line to each area with no interconnection. According to the 1996 data, total power generation is 37.2 GWh with a peak demand of 10.3 MWe. The electricity is distributed to about 200,000 people, which is only about 13 % of the population of the island. Since the electricity demand is increasing by 10 % per year during the last two years, it is expected that the demand increase shall dramatically increase once rural electrification is realised. The GOI, PLN and provincial government consider the rural electrification as the top priority project for expansion of the infrastructure to promote the development of the area. They are also strongly promoting the fast rural electrification of the island with the proposes of stable power supply and utilisation of the idle geothermal resources on Flores Island as well as a CO_2 emission reduction. Accordingly, electricity interconnection shall proceed from the western part of the island to the eastern part through Ruteng, Bajawa, Ende, Maumere and Larantuka. On Flores Island, two promising geothermal areas have been explored at Ulumbu by PLN-GENZL and Mataloko by NEDO-GSJ-VSI.

There are meny investment opportunities in these profects mention above due to government's limited funds. In addition, opportunity in the field of supporting related work such as engineering, testing and other services are also available.

8. Conclusions

In conclusion, we expect geothermal, being a renewable energy resource, to make a significant contribution to the country's energy sector in the future. Considering that most of the utilization of the geothermal energy source is still on high-enthalpy fields, there remains much development. In this respect, we invite the private sector to actively participate in geothermal exploration activities of Indonesia.

The political and structural changes in Indonesia have resulted in a situation much more conducive than ever before to convincing the stakeholders of the value of geothermal industry to the national economy and welfare. Furthermore, the implementation of regional autonomy started on January 1, 2001 will give impetus to geothermal projects that contribute to regional development such as off-grid rural electrification and direct geothermal uses for agribusiness.

To our neighboring Asian counties, we look forward to a fruitful cooperation on technology transfer and information exchange on geothermal exploration, development, exploitation and production of geothermal energy

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インドネシアの地方電化計画を支援する地熱開発

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要　旨

インドネシアは豊富な地熱資源に恵まれている．しかしながら，2001 年までに開発済の地熱エネルギーは 787 メガワットに留まっている．インドネシアの地熱発電量をさらに増加させるには，コスト競争力の弱さなどの障害を克服しなければならない．このことから，政府が地熱蒸気開発リスクを分担し，公正な競争および民間業者の効果的な参画を導入することが，新たに決定された．地方自治の支援策として，政府は離島地域の開発を促進するインフラストラクチャ拡張のための安定的電力供給および地方電化を最優先しており，30,394 の村落が電化された．我々は地熱開発における実り多い協力を期待しており，発展の勢いを保つため投資家の参入を歓迎する．

（要旨翻訳：水垣桂子（地圏資源環境研究部門））