Academic Importan Plays To Energy

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Academic Importan Plays To Energy

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ABSTRAK

Seiring peningkatan jumlah penduduk dan pertumbuhan ekonomi maka permintaan kebutuhan energi meningkat pula. Dimana pemenuhannya dengan membangun fasilitas pembangkit listrik oleh pemerintah dari berbagai sumber daya energi yang ada. Salah satu energi yang bersih, terbaharukan dan kaya akan sumbernya adalah energy panas bumi (28000MW). Pemerintah Indonesia mengadakan percepatan pembangunan dibidang energi dengan memprioritaskan pembangunan energi panas bumi. Potensi energi panas bumi di Sulawesi terdapat di Sulut (Lahendong-Tompaso field 250MW, Kotamobagu field 180MW) dan Gorontalo (20 MW). Energi panas bumi berasal dari bawah permukaan bumi. Fluida panas bumi di ekslpoitasi dengan mengebor sekitar 2 - 3 km ke bawah permukaan tanah mencapai reservoir panas bumi. Fluida panas bumi yang didapat diekstrak dimana tekanannya menggerakan turbin dan uap air yang terkondensasi di injeksikan kembali ke dalam tanah. Seluruh proses dari awal sampai mendapatkan listrik menggunakan ilmu dan teknologi yang implementasinya berlangsung terus selama kegiatan itu ada. Hal ini dimaksudkan untuk meminimalisasi dampak negatif dan mengelola keberlangsungan sumber daya panas bumi tersebut. Kegiatan yang sangat penting ini tidak lepas dari peran ilmuan yang saling bersinergi dengan pihak pemerintah serta pelaksana/pengelola energi panas bumi.

Kata-kata kunci; Academic Plays, Geothermal Energy, Sulawesi

Overview Energy in Indonesia

The Indonesian archipelago consists of five major islands namely: Sumatra, Java, Kalimantan, Sulawesi and Irian Jaya, and 17,504 islands which are stretched from the west to the east for a length of around 5,000 km. The archipelago is on a crossroad between two oceans, the Pacific and the Indian, and bridges two continents, Asia and Australia. The total area is 1,890,754 km2 with 255,973,838 people population in the year of May 2015. The energy demand in Indonesia is mainly supplied by oil reserves and coal which currently cover 43% and 34.5% of national energy demands. Energy consumption in Indonesia has grown rapidly (annually 7%).

At the end of 2013, total installed generation capacity in Indonesia stood at 47.3 GW. Around 70% of this generation capacity is owned by PLN, while 21% is operated by independent power producers (IPPs) and 4% is operated by private power utilities (PPUs). Other 5% is operated by Operation License non fuel. According to the PLN ten-year power development plan towards 2022, the TSO aims to achieve 84.9 GW of installed capacity by 2020 and 96.3 GW of installed capacity by 2022. The Java-Bali system has the largest installed capacity - 77% of total installed capacity of the country in 2013, followed by Sumatra (14%), **Southern Sulawesi (4%)**, South and Central Kalimantan (1%), East Kalimantan (1%), **Northern Sulawesi (1%)**, West Kalimantan (1%) and West Nusa Tenggara (0.5%). In order to satisfy the domestic energy demand, the Indonesian government has accelerated developing power generation by geothermal energy. To support strategic planning of Mineral Resource and Energy Department year 2010-2014, Geology board is one of the sub-sectors of Mineral Resource and Energy Department give priority on several programs, which is energy resource development, related to geothermal renewal energy utilizing.

The geothermal energy is one of the clean and renewable energy resources and also plays an important role in alternative energy resources. Thus, many countries have been attracted by geothermal. The installed capacity of power generation by the geothermal energy has reached to 10,898 MWe in the world (Bertani, 2012). Indonesia 1337 MW is the third largest country of the geothermal use after USA 2544 MW and the Philippine 1934 MW. The geothermal resources in Indonesia are estimated to be 28,000 MW (Y Kamah, 2014), spreading on the islands of Java, Sumatra, Bali, Nusatenggara, Sulawesi and Halmahera. Figure 1 shows the promising resource potential of geothermal field in Indonesia about 9,096 MW from 51 fields separate as Sumatera 4520 MW, Jawa-Bali 3635 MW, Nusa Tenggara 146 MW, Sulawesi 755 MW, and Maluku 40 MW.

The Indonesian archipelago is located along the plate boundaries of convergent margins between the Eurasian and the Australian plates in western areas (Sumatra, Java and Nusatenggara Islands) and the Eurasian and Pacific plates in the eastern areas (Sulawesi and Halmahera Islands). These convergent systems formed 200 active volcanoes as shown in Figure 2. Indonesian geothermal systems occur in areas with Quaternary volcanism and active volcanoes along well-defined volcanic arcs and are associated with surface manifestations such as hot water at boiling temperature. There are five volcanic arc segments (Sunda arc, Java arc, Inner Banda arc, Halmahera arc and Sangihe arc) in Indonesia that defines regions of interest for geothermal exploration as shown in Figure 2.

Figure 1 Map showing the resource potential in promising geothermal fields Indonesia
(Y Kamah, 2014).

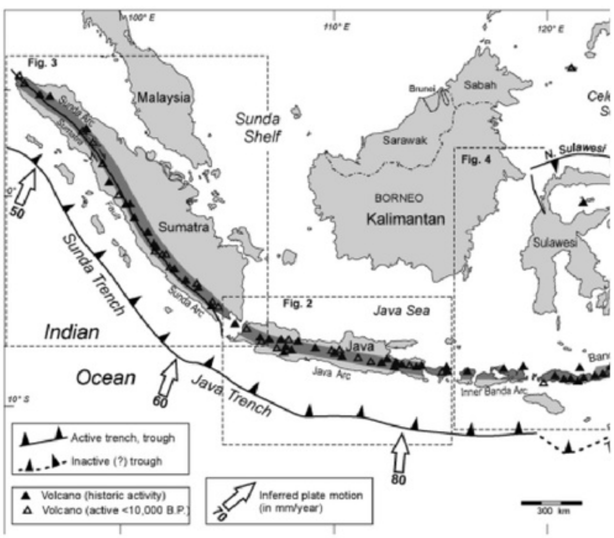

Figure 2 Plate tectonic structures and active volcanic arcs in Indonesia
(Hochstein and Sudarman, 2008).

Especially for Sulawesi island, the distribution map of geothermal energy shows in Figure 3 as below:

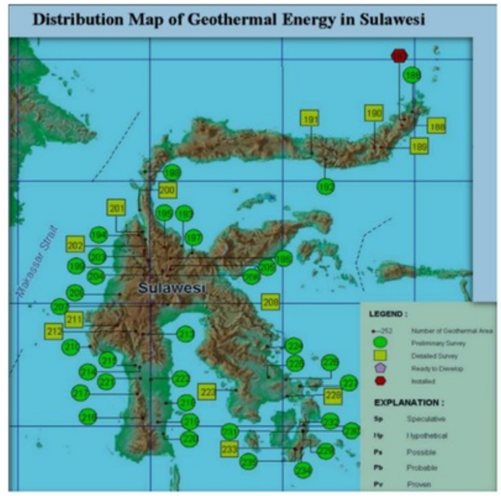

Figure 3 North Sulawesi Regional Planning and Development Agency.

Geothermal fields in North Sulawesi

In the eastern part of Indonesia, the island of Sulawesi has been shaped and deformed as a result of collision with the Sula platform, a sliver of continental material from the northern margin of Australia-New Guinea as shown in Figure 4. The collision has a resulted in rotation of the north volcanic arm of Sulawesi and the development of the accretionary wedge of the North Sulawesi (Silver et al., 1983). At this time the promising geothermal prospects are documented in northern Sulawesi, such as Lahendong, Tompaso and Kotamobagu. The locations of the geothermal prospects in North Sulawesi are shown in Figure 6.

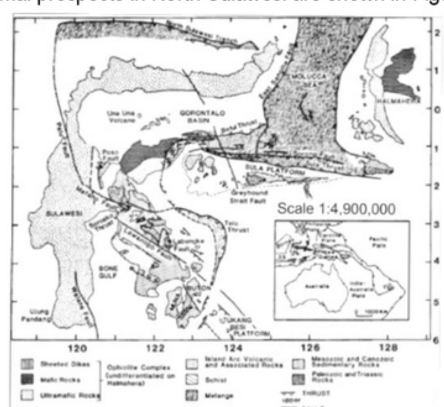

Figure 4 North Sulawesi has been shaped by collisions as a result of rotation of north volcanic arm of Sulawesi and the development of the accretionary wedge of the North Sulawesi (Silver et al., 1983).

Two calderas are present in North Sulawesi in the geothermal prospects. They are Moat and Tondano caldera's as shown in Figure 5 (Kavalieris et al., 1992). The Lahendong and Tompaso geothermal prospects are located in the area of Tondano caldera, and the Kotamobagu geothermal prospect is located in the area of Moat caldera. Hydrothermal system in a caldera is one of the geothermal resources, which has been proved to produce steam for power generation in some geothermal fields in the world such as Latera, Baca, Onikobe, and Wairakei.

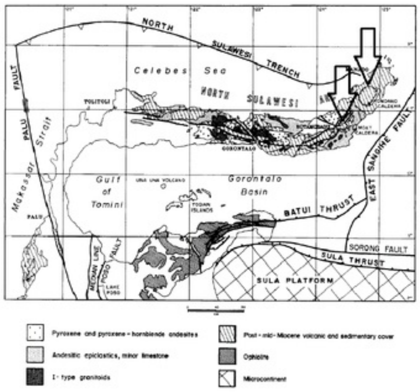

Figure 5 Location of calderas as shown in the regional geological setting in North Sulawesi.

Figure 6 Three geothermal prospects in North Sulawesi: Lahendong, Tompaso and Kotamobagu fields.

The Lahendong geothermal field is located about 30 km south of Manado (the capital city of North Sulawesi province) as shown in Figure 6. The exploration activity in this field was started in 1976. During that period, geological, geochemical and geophysical surveys were carried out by the Volcanological Survey of Indonesia.

The Lahendong geothermal field is located in a depression of the Pangolombian caldera. This condition is most respected for geothermal systems in Lahendong. Thermal manifestations are mainly controlled with NW-SE and NE-SW trending faults and are believed to be control the permeability of the Lahendong system. The Lahendong geothermal field is of hot water dominated system and consists of two reservoirs; the southern and northern reservoirs. The southern one has temperatures of 300 to 350°C and the northern one has lower temperatures between 250 to 280°C (Koestono et al., 2010).

The Tompaso geothermal field is located about 60 km south of Manado city as shown in Figure 6. This field is included within the Lahendong concession. The Tompaso geothermal field is located in a relatively flat depression with an average elevation of 750 m a.s.l. The active volcano Mt. Soputan is inferred to affect the deep hydrology of Tompaso. The regional faults produce a high permeability zone trending NE-SW through the area. The Tompaso geothermal prospect is of hot water dominated system with reservoir temperature 260°C.

Geothermal resources of Lahendong-Tompaso field is 250 MW (Y Kamah, 2014). Now, the total install capacity in Lahendong-Tompaso field are 80 MW.

The Kotamobagu geothermal prospect is located in North Sulawesi Province, Indonesia, approximately 200 km southwest of Manado City, the capital of the province (Figure 7). The concession of the Kotamobagu geothermal field is owned by Pertamina geothermal Energy Co. The field has been proved to be one of the geothermal prospects in Indonesia (Hochstein and Sudarman, 2008).

In 2005, Pertamina Geothermal Energy Co. conducted the reconnaissance and feasibility studies at the Kotamobagu field, and concluded that the field has a high potential for power generation. Pertamina Geothermal Energy Co. also conducted a research on environmental impacts upon development and issued a document related to the environmental impact in 2009, which is one of the requirements by Indonesian government for starting the geothermal development project in Kotamobagu.

Figure 7 Topography map of the Kotamobagu geothermal field.

The Kotamobagu geothermal field is of hot water dominated system with reservoir temperature estimated to be about 230-280°C. The geothermal resource at Kotamobagu is 180 MW (Y Kamah, 2014).

In 2011, two wells (KTB-B1 & KTB-B2) were drilled at Liberia village on the southern slope of Mt. Muayat, Kotamobagu. Production tests of these wells were not successful because of low temperature, of 160°C at the well bottom for both wells.

Geothermal Fluid

Geothermal fields are the areas where the temperature of the groundwater above normal values and where the water can be exploited for various purposes such as space heating and power generation (above 150°C). The heat sources are from the magmatic intrusions at depths of 7 to 15 km or, where the Earth's crust is thinner, the mantle itself (Barbier et al., 1983). The heat is transferred to sub-surface regions firstly by conduction and then by groundwater convection. Impermeable rocks cover the permeable formations containing the hot water, called the geothermal reservoir, and are preventing or limiting the heat losses and maintaining the hot fluid under pressure (Barbier et al., 1983).

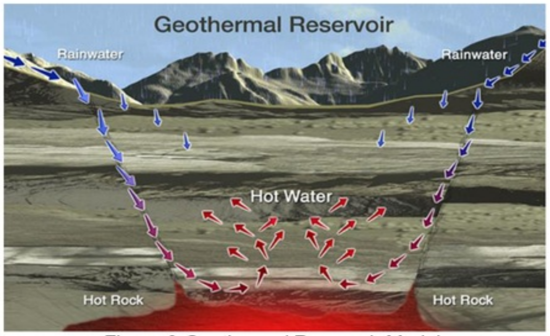

Figure 8 Geothermal Reservoir Model.

Geothermal Power Plants

Geothermal energy is also used to generate electricity. Hydrothermal systems which use hot water or steam from underground convert energy from Earth's heat into electricity. There are three main kinds of hydrothermal systems in use: dry-steam power plants, flash-steam power plants, and binary cycle power plants. All three of these systems harness the power of hydrothermal fluid—that is, water or steam—that is naturally heated within Earth. Dry-steam power plants take steam inside Earth and use it to drive a turbine. Geothermal reservoirs filled with steam exist inside Earth. First, a well is drilled to reach the steam. The steam rises through the well. As it rises, it spins the rotors of the turbine. The turbine is connected to a generator. Electricity produced by the generator can be carried by wires to wherever people need it. Dry-steam power plants were the first type of geothermal power plant. Flash-steam power plants are similar to dry-steam power plants. Instead of using natural steam, however, they use naturally hot—very hot—water. The temperature of the water used in flash-steam power plants ranges from 300°F to 700°F (150°C to 370°C). Underground, there is great pressure that keeps the water in liquid form at temperatures far higher than its usual boiling point. The hot water comes up to the surface through a well. At the surface, it is sprayed into a tank. The tank is kept at much lower pressure than the geothermal fluid. When the very hot water hits the tank, it vaporizes (turns to steam) in a "flash" of energy. The flash of energy turns the rotors of a turbine, which is connected to an electrical generator. Some flash-steam power plants use more than one tank. If there is still hot water in the first tank, it can be flashed again in the second tank, taking advantage of all the heat energy. When the steam cools down, it changes back into water. The water can be forced back into the ground to be used again. Flash-steam power plants are the most common type of geothermal plants in use today. Binary-cycle power plants are more complicated. The water they use is considered moderately hot—below 400°F (200ºC). In these power plants, the hot water does not directly turn the turbine. Instead, as the water comes above ground from a well, it enters a heat exchanger. The heat exchanger transfers the geothermal heat to a different fluid that has a lower boiling point. This second fluid then flashes into vapor, which turns the turbine. After it turns the turbine, the second fluid flows back into the heat exchanger.

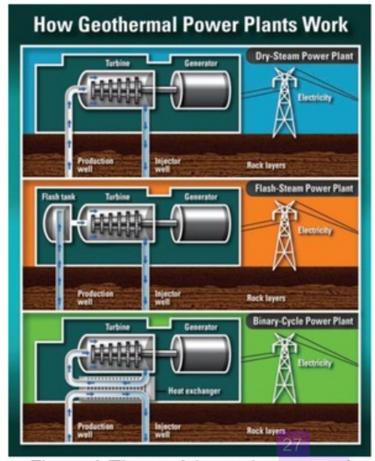

Figure 9 Three of the major types of geothermal power plants.

In Indonesia the majority of geothermal projects utilize single flash power plant technology. This technology is best suited for high temperature geothermal liquid (above 150 degrees Celsius) which is found beneath the surface of Sulawesi. A flash system works by pumping fluid from below the earth's surface by a system of high pressure into a tank at the surface. The tank at the surface is at a much lower pressure which causes the fluid to vaporize. This vaporized fluid drives the turbine which generates electricity. The fluid changes back into liquid and is re-injected into the ground.

Schematic diagram of geothermal energy utilization shows in Figure 10.

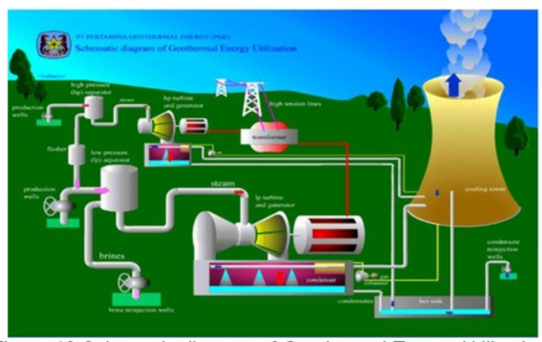

Figure 10 Schematic diagram of Geothermal Energy Utilization, PT PGE.

Mitigate and Reducing Environmental Impacts of Geothermal Energy Development

Although Geothermal Energy is good solution as green energy but the other hand givens environment impacts. The environment impacts of geothermal energy need to mitigate for consistently usage. Environmental impacts possible occur by exploitation geothermal energy as follows:

1. Geothermal Emission
    - Impact of Hydrogen Sulfide (H_2S)
      Odor, heavy gas, toxic
    - Carbon Dioxide (CO_2)
      Main non-condensable gas, heavy gas
2. Water Quality Issues
    - Waste water disposal (discharge to river, evaporation pond).
    - Liquid wastes produced at geothermal facilities include:
      - Spent geothermal fluids.

- Petroleum products such as fuels and lubricants.
- Drilling mud additives.

3. Geologic Hazards
   - Induced seismicity.
   - Subsidence and convergence.
   - Hydrothermal Eruption
   - Thermal Effluents
   - Natural Features
   - Degradation of thermal features
4. Noise
5. Land use
6. Temperature drop of reservoir due to reinjection

We can effort for mitigate or reduce the environment impacts caused by geothermal development as several methods consist of:

1. Air Emissions

   Geothermal fluids contain dissolved gases which are released into the atmosphere. The main gases both carbon dioxide and hydrogen sulfide is toxic. These gases are recognized hazard for people working at geothermal stations or bore fields. Emergency number of hazards attributed hydrogen sulfide poisoning, often in motel rooms or hoot-pool enclosures shown as below:

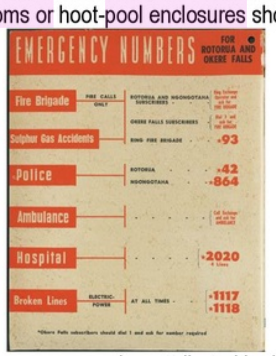

Figure 11. Emergency number attributed hydrogen sulfide poisoning.

   It's important for mitigate air emission especially toxic gases or anticipate before occurs. Intensive Research should did for use carefully to arrange plan and action since beginning drilling well, erection power plant and network site involved geothermal energy development and distribution.

   Work must be follows Standard of Operational (SOP) each kind of work involved geothermal development. The toxic gas from geothermal power plant must be evacuated and treatment into lower contains level which one safety for discharge to atmosphere.

2. Waste Water Disposal

   Geothermal fluids contain level of arsenic, mercury, lithium, and boron because of the ground contact between hot fluid and rocks. If the fluid discharge into river or lakes will affect damage aquatic life and the water can use for drinking and irrigation. Levels of arsenic in the Waikato River almost exceed the World Health Organization standard for drinking water of 0.01 parts per million. Significant arsenic comes from geothermal waste water discharged from the Wairakei Power Station.

Figure 12. Arsenic in the Waikato River

   Mitigate arsenic by:

   The arsenic before release to the river or lakes must be treatment for decreasing contains level of arsenic until below standard of WHO for available discharge into natural. The treatment did in pool disposal by colorful mineral precipitates like bright red realgar and yellow green orpiment which is removal arsenic from the water.

3. Subsidence

   Exploitation geothermal fluids can reduce the pressure in ground reservoirs and cause the land to sink. The largest subsidence occurs on record is at Wairakei where the center of the subsidence is sinking at a rate 300-450mm/year. In 2005 the level of ground was 14 meters lower than it was before the power station was built.

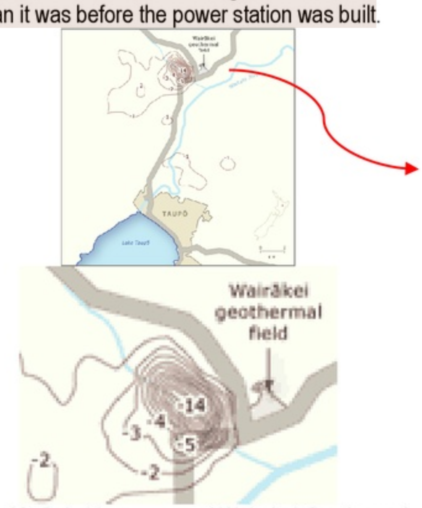

Figure 13. Subsidence around Wairakei Geothermal Field

   Mitigate of subsidence by:

   Step by step increased in capacity for get sustainable result of energy production, and start for 50% of the predict value of geothermal potency. To prohibited for extremely exploitation such 90-100% production of capacity geothermal reservoir.

   To manage the environmental on natural recharge area with the plantation of tree or forestation.

4. Induced Seismicity

   Reinjection of water into ground on reservoir caused to accelerate earthquakes. Need to mitigate this affect since the first or before erection the power plant such as:

   Observe and investigate geology completely for identify possible occurs hazards of earthquakes in further by reinjection. Result of investigated will be used for evaluation good position where as production well and reinjection well located with considered sustainable production management.

   Installed the micro seismic device around geothermal field for monitoring accelerate of earthquakes by reinjection and natural earthquakes.

   Monitoring by measures of level use several bench mark around geothermal field by time for evaluating have significant subsidence occurs in further.

5. Natural Features

Almost all geothermal resources currently develop for generate electricity are located in the vicinity of natural geothermal surface features. The natural features recovery has degradation thermal and volume. Sometimes disappears after the geothermal power plant operation for a long time. Wairakei geyser is famous geyser in the world with rising until 42 meter. Geyser Valley continued to deteriorate, and in 1973 it was shut down as a tourist spectacle.

Figure 14. Geyser Valley in 1950

In several countries have some regulation which is to governing about protected and preserve national parks. Like U.S. and Japan laws and regulations protect and preserve national parks and their significant thermal features.

6. Noise

The highest noise levels impact attributed well drilling, stimulation, and testing phases when noise levels ranging from about 80 to 115 decibels A-weighted (dBA) may occur at the plant fence boundary. During normal operational of a geothermal power plant, noise levels are in the 71-83 decibel range at a distance of 900 m.

Noise levels drop rapidly with distance from the source, so that if a plant is sited big area of geothermal field, boundary noise should not be objectionable. Noise levels could be reducing further by the addition of mufflers or other soundproofing.

7. Landscape Impacts and Land Use

Land footprints for hydrothermal power plants vary considerable according site because the properties of the geothermal reservoir fluid and the best options for waste stream discharge are highly site-specific. A comparison of land uses for typical geothermal flash and binary plants with those of coal and solar photovoltaic plants is presented in table 1 below here:

Table 1. Comparison of land requirements for typical power generation options.

Technology	Land use (m²/MW)	Land use (m²/GWh)
110 MW geothermal flash plant (excluding well)	1.260	160
20 MW geothermal binary plant (excluding well)	1.415	170
49 MW geothermal FC-RC plant(A) (excluding well)	2.290	290
56 MW geothermal flash plant (including wells, (B) pipes, etc.)	7.460	900
2.258 MW coal plant (including strip mining)	40.000	5.700
670 MW nuclear plant (plant site only)	10.000	1.200
47 MW (avg) solar thermal plant (Mojave Desert, CA)	28.000	3.200
10MW(avg) solar PV plant (C) (Southwestern US)	66.000	7.500

(A) Typical Flash-Crystallizer/Reactor-Clarifier plant at Salton Sea, California.

(B) Wells are directionally drilled from a few well pads.

(C) New Land would not be needed if, for example rooftop panels were deployed in an urban setting.

The power plant is built near the geothermal reservoir because the long transmission lines degrade the pressure and temperature of the geo-fluid. With directional drilling techniques, multiple wells can be drilled from a single pad to minimize the total wellhead area.

Drilling well

Pipeline

Figure 13. Land use at Lahendong Geothermal Power Plant, Indonesia.

Land is open among of pipeline we can use for productive farmland.

Figure 14. Imperial Valley Power Plant Next to Productive Farmland

Source: Geothermal Education Office.

Figure 15. Kamojang Power Plant, Jawa-Barat, Indonesia.

The power plant attends on among of plantation/ tree.

Environmental Impacts as affect from geothermal development it's important for mitigate and reducing for consistently energy consumption. Science and technology can be applied for mitigate and reducing risk that mention caused by environmental impact of geothermal development.

Academic Important Plays to Geothermal Energy

In order to promote development of geothermal energy in Indonesia, scientific and engineering activities are required which scientist is full needed such as:

1) Feasibility study, preliminary study on the candidate field for evaluating its geothermal potential.
2) Environmental impacts analysis document, which is one of the requirements by Indonesia government for starting geothermal development project.
3) Exploration, detailed survey and scientific study to collect the geological, geophysical geochemical data, and develop conceptual model.
4) Developing, and managing the power generation, such as:
    a. Drilling wells (production, injection and monitoring wells).
    b. Piping and installing the geothermal field.
    c. Installing the power plant.
    d. Test and commissioning.
    e. Exploitation and monitoring.
5) Managing and assessment reservoir and environment.

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