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Geothermal Energy Direct-Use in Dieng Geothermal Field: Existing and Potential Development

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ABSTRACT

Dieng geothermal field, located in the Dieng Plateau area in Central Java, is currently installed with a geothermal power plant with capacity of 60 MW, which has been operated since 2002. Located at around 2,000 masl, the geothermal power plant is surrounded by a local community that lives from agriculture and tourism. The main agricultural commodity in the area is potato, while tourism objects are volcano craters, thermal manifestations, caves, and temples.

This study initiated by mapping various existing direct applications of geothermal energy in Dieng geothermal field, especially those related to tourism, health and agriculture. The summary results are then compared with direct-use applications in other geothermal prospect areas, both in Indonesia and abroad. The final goal of this study is to identify other direct-use applications opportunities that are feasible to be applied in this area to improve the local community welfare.

1. INTRODUCTION

Indonesia is formed due to subduction zones of three main active tectonic plates namely the Eurasian Plate, Pacific Plate, and Indo-Australian Plate. This position has made Indonesia has many active volcanoes. The volcanoes in Indonesia are among the most active of the Pacific Ring of Fire. Thus, has made Indonesia warned of geohazards yet abundant with resources, among it is geothermal. The utilization of geothermal area could be direct-use and indirect-use. Dieng geothermal field is one of geothermal big resources in Indonesia. It is located in the Dieng Plateau which is approximately 90 km south of Semarang and 26 km north of Wonosobo. Administratively, it is located in two districts of the regency, Wonosobo Regency and Banjarnegara Regency (Figure 1). Geographically, Dieng geothermal field is situated in a volcanic complex with coordinate 7° 09' 52.3587" - 7° 14' 44.8742" South Latitude and 109° 52' 3.3954" - 109° 55' 52.3493" East Longitude. The ambient temperatures are ranged from 12 - 20°C in the daytime and 6-10 ° C at night. In the dry season (July and August), temperatures can reach 0°C in the morning. Currently, the main indirect use of geothermal is to generate the electricity. This field is operated by PT. Geo Dipa Energi and produces about 60 MW. The field is planned to increase its capacities to 180 MW as its resources is more than those covered from drilling wells.

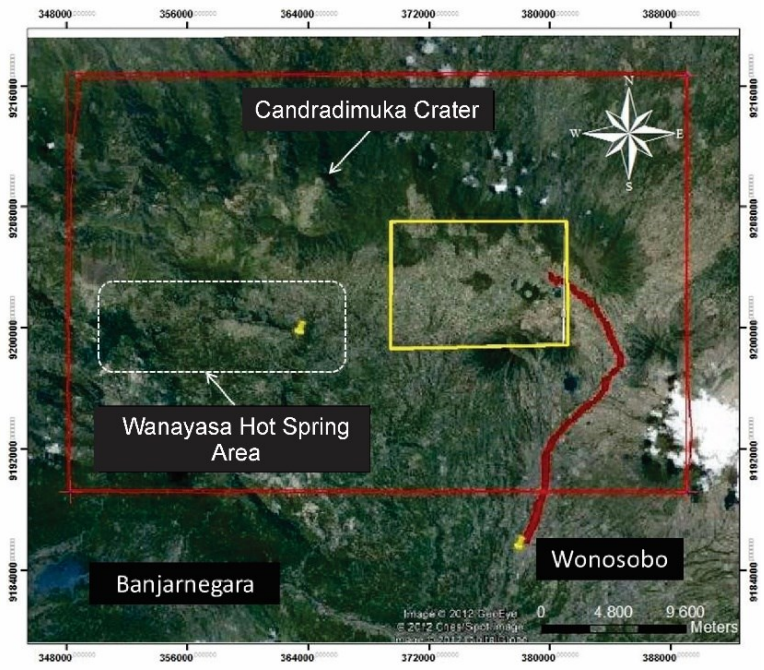

Figure 1. The yellow box shows the location of Dieng geothermal area.

Apart from electricity generation, geothermal in Dieng plateau is also utilized for direct-use as tourism destination, such as Sikidang Crater. However, comparing to other places in Indonesia or the world, this direct-use utilization is far from optimum. The optimization of direct-use utility will improve the local community welfare. There are a lot of other potential that can be used to attract tourists or even used for other direct-use application. Therefore, this paper discussed the existing geothermal direct-use in Dieng and identified the potential development that can be learned from other places around the world. The potential development also will be assessed further to mapping the challenges and opportunities so we can meet the best way to develop the direct-use utilization in Dieng geothermal area.

1.1 Research Objectives

With regards increase the local community welfare, this study aims to:

a. Map the existing direct-use in Dieng, which are mostly used for tourism.
b. Identify the potential geothermal direct-use in New Zealand, Japan, Iceland, and United States of America that can be applied in Dieng to optimize and speed up the development.
c. Map the challenges and opportunity of potential application from other countries for further development in Dieng.

1.2 Research Methodology

Literature review was conducted from various studies, publications, and published papers from seminars or journals regarding the direct-use utilization from various countries and Dieng. The significant potentials that can be applied from various countries were identified and summarized to provide the best suitable direct-use program that can be applied in Indonesia (Figure 2).

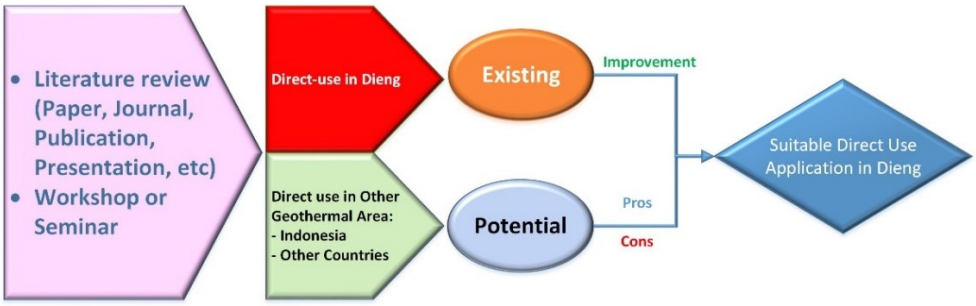

Figure 2. Research methodology on this study.

1.3 Limitations

This study was conducted as a desktop study from various literatures, reports, and papers without further confirmation and trial phase from the community or investors in Indonesia. Therefore, local community and investors might have other consideration regarding what are the suitable direct-use for them to be developed in Dieng that are not covered in this study.

2. GEOTHERMAL DIRECT-USE UTILIZATION

Indonesia began developing geothermal direct utilization (non-electricity) since more than 10 years ago. The most common and traditional use is for balneology, heated swimming pool, and hot springs. Direct utilization is a utilization form of heat energy for various purposes such as heating swimming pools, drying agricultural, plantation products, heating fish cultivation, and utilizing heat for other purposes. These direct-use utilizations are able to keep growing and vary depending on the innovations made.

Direct-use is applied on different stages of scales, ranging from heating and cooling households, large industrial, and institutional building stop. It also can be classified into different commercial uses, for example aquaculture, resorts/ spas, and greenhouses. Geothermal direct-use utilization is very suitable for Indonesia community's needs, especially for industrial use, agricultural lands, bathing, and spa resorts, which all require heat. Direct heat use is one of the oldest, most versatile and also the most common form of utilization of geothermal energy (Porkhial & Yousefi, 2015).

The direct-use utilization of geothermal energy has significant benefits for local community, especially in economics, environmental, and social aspects. It will reduce the electricity demands as the electric-driven tools will be replaced by the direct-use utilities. Using direct geothermal energy will not generate electricity directly, but it will increase the efficiency of energy by using only one energy conversion compared with several energy conversion in electricity generator usage, so the community will feel the impacts at the moment. Geothermal direct-use would not emit carbon, therefore it will help decreasing Indonesia's carbon footprint. In direct-use applications, a shallow well was drilled into a geothermal reservoir to provide a steady flow of hot water. The water was normally pumped to the surface and flows through a mechanical piping system which using a heat exchanger to deliver the heat directly for its intended use. A disposal system then either injected the cooled water back into the subsurface or disposed it on the surface (MNDP-RI, 2014).

Geothermal direct-use utilization is represented in Lindal Diagram. Through this diagram, the utilizations of geothermal energy were classified based on the temperature sequence, so we could get the brief overview about the best geothermal fluid utilization according to the suitable temperature. Based on Lindal Diagram, the limit utilization of direct-use geothermal heat is 200°C, because more than 200°C is classified as high enthalpy and utilize for electricity generation. The Lindal diagram could be seen on below picture (Figure 3).

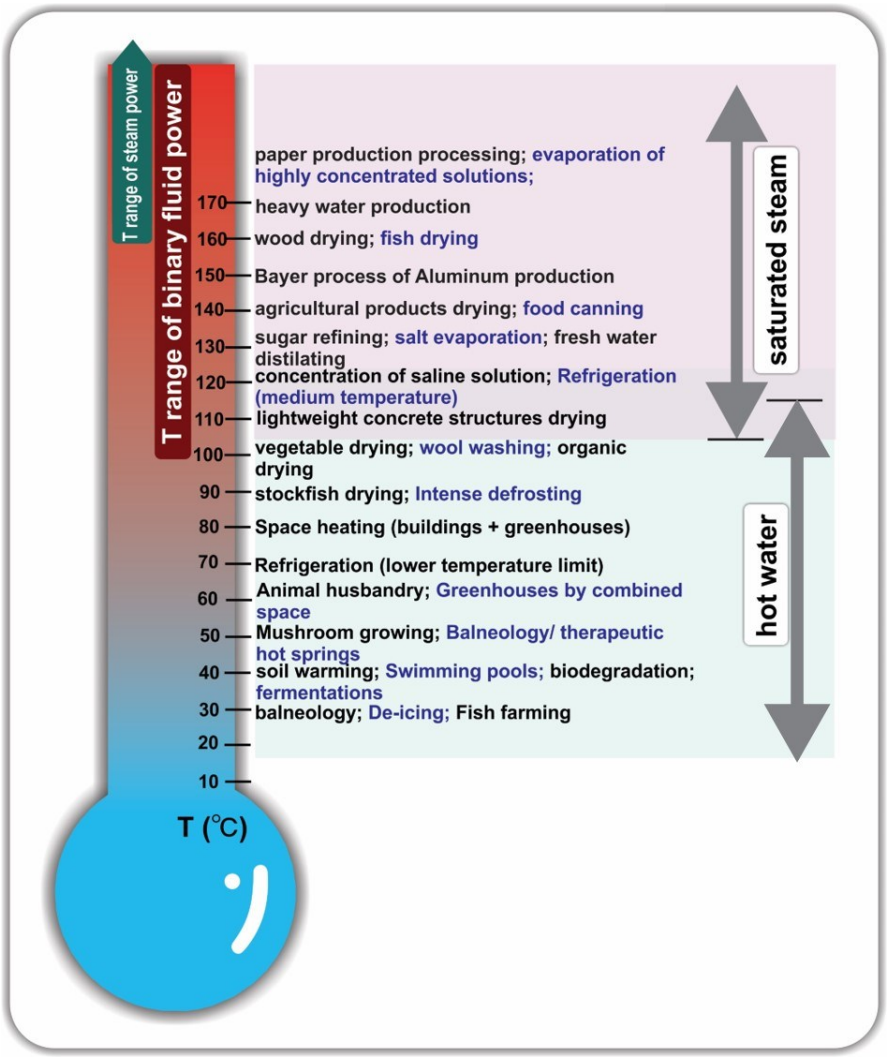

Figure 3. The Lindal Diagram modified from (Gudmundsson & Lund, 1985))

3. EXISTING DIRECT—USE IN DIENG GEOTHERMAL AREA

Dieng geothermal area is surrounded on the hills and mountainous area. The soil is very fertile and suitable for agriculture and plantation. Currently, most of direct-use utilizations in Dieng are only for tourism and without proper regulation. It was handled by the private or free without management. This section would discuss about the geothermal direct-use in Dieng:

3.1 Sileri Crater

Sileri Crater is one of the active surface manifestations in Dieng. This crater is one of the main manifestations that is connected directly to Dieng geothermal system. This crater was one of tourism object it exploded in 2017, a total of 10 tourists were injured. The location has been restricted for public opening since then. Currently, near the location there is a hot spring area that open for tourism (it is called D'Qiano Waterpark). This place gives a new atmosphere in the Dieng plateau area. A swimming pool with warm water as well as several water games for children complete here. In addition to a swimming pool, D'Qiano also has a fairly comfortable and nice lodging in the Dieng area (Figure 4).

D'Qiano water park is a very suitable place for those of you who want to unwind after exploring the natural beauty of Dieng. Tourists can soak in a natural hot spring pool while enjoying the extraordinary surrounding scenery. This area is perfect for all groups of children, adults, and elderly. D'Qiano water park is also equipped with various facilities including a game pool, main pool, restaurant, relaxing area, changing rooms, etc.

Figure 4 (left) Sileri crater (google); (right) D'Qiano Waterpark (google)

3.2 Sikidang Crater

Sikidang Crater is a volcanic craters area with crater hole in a low relief terrain, so that the craters could be seen directly from the crater rim. These craters are still very active, issuing bursts of water, mud and white smoke with the distinctive scent of the volcano. There are several crater holes with a diameter of 10-20 meters. The attraction of the natural craters in Sikidang could be very interesting because of the large number of small natural craters found on site, coupled with the existence of large craters that can be seen up close. Sikidang Crater provides the beauty of natural phenomena, one of it is alternating hot and moving mudflows that resemble deer leaps. Access to Sikidang Crater was very easy because of the availability of transportation facilities and infrastructure. Around the surrounding area, there was a fairly complete complementary for a tourism area, eg: food stalls, handicraft sellers, and Dieng traditional souvenirs. But it was not as organized as it should be, so it caused some of visitors to feel uncomfortable. Around the crater area the management of the tourism object has built tourism support facilities (eg: parking lots, toilets, gazebos (rest areas) and others).

The economic impact created around Sikidang Crater was creating job opportunities, residents not only earned a living as farmers, but also had side jobs as traders or entrepreneurs in the Dieng tourist attraction area. This could increase the income of local residents who were around the area of tourist attractions. Residents not only earn income from selling their agricultural produce, but also from selling in the Dieng tourist attraction area whether it's as a street vendor or handicraft food, also from the results of his business in the form of homestay or food stalls (Figure 5).

3.3 Dieng Plateu Theater

Dieng Plateau Theater provides knowledge about the Dieng Plateau. The main activity that could be done during a visit to Dieng Plateu Theater was watching a documentary film. The film that was screened at Deing Plateu included: discussing the origin of the Dieng Plateau, geographical location, history, culture, potential in Dieng, access to Dieng, customs, arts and culture and the beliefs of local communities: the origin of children dreadlocks boy (Figure 5).

During 23-minutes duration of the film, visitors would be introduced to the Dieng Plateau and the people who live in this area. So, when sightseeing the natural beauty of the Dieng Plateau and visiting tourist attractions, visitors already had the stock of knowledge about this region. The visiting experience carried out will also be more memorable. Unfortunately, Dieng Plateau Theater is located some distance away and hidden. Coming from the direction of Wonosobo, visitors will first pass several tourist attractions, such as the Arjuna Temple Complex, Pengilon Lake, and Warna Lake before finally arriving at this place. But from Dieng Plateu we can enjoy the view of a row of mountains and others.

Figure 5. (left) Sikidang Crater (Travel, 2019); (right) Dieng Plateu Theater (Travel, 2019)

3.4 Warna Lake

This lake is called the Warna (color) Lake, because of the fact about the change in the color of the lake that changes. At any time, it can be green, yellow, purple, or even the color of the rainbow. Scientifically this was explained as a result of the high sulfur content in lake water. When the sun was shining on water with high sulfur content, the water would reflect varying colors. Aloof solitude between the hills at an altitude of more than 2,000 meters above sea level, did not make the Warna Lake empty of visitors. Among the attractions in the Dieng Plateau, the color lake is classified as the most visited. Beside of it, the activities that could be done on Warna Lake area, such as: Trekking, sightseeing the flower garden, enjoying the lake landscape, Dieng view stone, and Semar cave (Figure 6).

3.5 Mardada Lake

This lake is the largest lake in the tourist area of the Dieng Plateau, approximately 25 hectares with a depth of 2-10 meters. Set against a green hillside slope, and mushroom bed-like hills typical of Dieng. Canoes were provided for tourists to be rented around the lake and fishing facilities were also provided (Figure 6).

Besides this lake is the largest lake, this lake did not have a spring. All the water that inundated the lake was a rainwater basin. Because the lake whose water was a rainwater reservoir, in the dry season, this lake would dry. The middle part of the lake would be seen clearly. The lake is surrounded by two hills, Pangonan hill and Semurup hill, which is actually called Summer Up because the land of this hill is red and often burnt, but there was a pronunciation error by the surrounding community.

The extent of this lake was the reason given the name "merdada". "Merdada" refers to "dada", which means broad. This lake water was an important water source for local farmers. Potato fields that were abundant around the lake are very dependent on the water discharge in this lake. The Merdada Lake tourism object had very beautiful scenery. The lake in front of the eyes with clear water and surrounded by natural green hills made the atmosphere in this lake looked beautiful and cool.

Figure 6. (top left) Warna Lake (Travel, 2019); (top right) Mardada Lake (Tour, 2019); (bottom) The Dreadlocks Shaving Ritual in the Abode of the Gods in Arjuna Temple Complex (Kaya, 2019)

3.6 Arjuna Temples Complex

Dieng Plateau has a vast temple area. It is estimated, the temples in this area occupy an area of 90 hectares. However, only a small portion of the temples have been restored. Of the many temples in the Dieng Plateau, the Arjuna Temple Complex is the widest. Located in Dieng Kulon Village, Batur District, Banjarnegara Regency, the Arjuna Temple Complex has an area of around 1 hectare. In this complex, there are five temple buildings, namely Arjuna Temple, Semar Temple, Srikandi Temple, Puntadewa Temple, and Sembadra Temple. Besides Semar Temple, the other four temples are the main temples which are used as a place of prayer (Figure 6).

Besides the four main temples in this complex, only Arjuna Temple has a facilities temple, the Semar Temple. Facility temple is a temple that is used as a gathering place or waiting for devotees before entering the main temple. Arjuna Temple, as the main temple in this complex is also thought to be the oldest temple, estimated to have been built in the 8th century AD by the Sanjaya Dynasty of Ancient Mataram. In addition to the five temples, located about 200 meters west of the Arjuna Temple Complex, there is the Setyaki Temple. The Setyaki Temple consists of two buildings, but only one building is standing - and even that is incomplete because the top of the temple has not been installed. Meanwhile, one other building is only a building base. Setyaki Temple is also a temple that was built to worship Lord Shiva. Looking at niches and building styles, Candi Setyaki is estimated to have been built in the same period as Arjuna Temple.

Arjuna Temple Complex is usually used as a place for Galungan implementation. In addition, this complex is sometimes also used as a place to carry out “ruwatan” gimbal children. The entrance ticket to this temple complex is IDR 10,000. With these tickets, visitors can visit the Arjuna Temple Complex, Sendang Sedayu, Medium Maerokoco, Dharmasala, and Sikidang Crater.

4. DIRECT-USE UTILIZATION IN OTHER GEOTHERMAL AREA

This study aimed to looking for the best suitable application of direct-use in Dieng, so firstly this section would discuss about direct-use utilization in other geothermal area.

4.1 Indonesia

Lahendong

Lahendong Geothermal Field Tomohon, where the Lahendong geothermal field is located, is a city in North Sulawesi Province with great potential coconut plantation. The productive plantation area is 767.5 ha and total coconut production in 2004 was 729.1 tons. Pertamina Geothermal Energy has plans for utilize excess steam or salt water from the separator in Lahendong for commercial copra production. Pilot plant for drying coconut meat (copra) built by Pertamina, and operational experiments provide good results.

Lahendong is a village in the southern part of Tomohon. In this Lahendong there are pine trees that growing and become pine forest for tourism destination. Lahendong hot water bathing pool is made by the local community to take the advantage of the beauty from the dense pine forest and its location that has hot springs containing sulfur. Lahendong is not far from Lake Linow, the lake that can change color due to the high sulfur content. The development of Lake Linow as an eco-tourism spot by a local private company since 2009 is beneficial for the proposed geothermal education park as it provides well maintained public facilities including a café, parking ground, rest rooms, and walking tracks (currently limited on the eastern bank of the lake) (Utami et al, 2011). The other direct-use utilization in Lahendong was to utilize and evaporate palm sugar. Brown sugar plant is one of agriculture commodity in Minahasa Regency. In collaboration with PT. Pertamina Geothermal Energi Lahendong, the local community set up a palm sugar processing factory with geothermal energy utilization (Figure 7).

Kamojang

Kamojang is one of few places that has successfully developed geothermal power generation as well as multiply its benefits thus impacted in an increase in the local economic growth. Kamojang crater is a crater that occurs because of the earth's steam blast, and also a kind of geothermal surface manifestation. different from the crater that exist because of the former volcanic eruption. Direct—use in Kamojang is used to develop mushroom nursery (Adityatama et al, 2019). By using the heat from hot geothermal water combined with glass house or greenhouse structure method, it can be utilized to condition the desired temperature for nursery.

Figure 7. Palm sugar processing factory in Lahendong (Anam), 2019)

4.2 United States of America

Milgro Newcastle Greenhouse. Newcastle, Utah

The Milgro facility is located just west of the town of Newcastle, UT, approximately 37 miles west of Cedar City in southern Utah. The elevation of approximately 5,000 ft results in substantial heating requirements and below zero temperatures are commonly encountered in the winter. Milgro is the largest potted plant grower in the U.S. and in addition to its 1,000,000-sq ft geothermally-heated facility in Newcastle, it also maintains substantial conventionally-heated operations near Los Angeles.)

The Newcastle area has long been recognized as rich in geothermal resources. Prior to the initial development of the Milgro facility, there were three other geothermally-heated greenhouses in the immediate area (all except one now owned by Milgro). There are currently numerous wells in the area producing water in the 190 ºF to 205 ºF range. Wells individually produce flows up to 1500 gpm.

Using a figure of 23 acres, the peak geothermal heating load is approximately 51 million Btu/hr (14.9 MWt) based on an outside design temperature of 0 ºF. The annual use is approximately 93 billion Btu; assuming, that 75% of the sunlight hours, the sun meets the load. Geothermal fluids in Utah are regulated as "a special kind of underground resource." The use of or injection of the fluid constitutes a beneficial use of the waters of the state and as such water rights are required from the State Division of Water Rights. In addition, rights to a geothermal resource or fluids are based upon the principle of "correlative rights" conveying the right of each landowner to produce his equitable share of underlying resources. Well construction and permitting is regulated by the Division of Water Resources of the Department of Natural Resources. Because all of the facilities fluids are injected no special environmental permits associated with disposal are required (NREL-USA, 2013).

Residential Downhole Heat Exchanger, Klamath Falls Oregon

Klamath Falls, Oregon is located on the western edge of the Basin and Range physiographic province on the east flank of the Cascades approximately 30 miles north of the California border. It is located in a graben structure about 10 miles wide flanked by horst blocks rising over 1,500 feet with steeply dipping normal faults trending in a northwest-southeast direction. Upper Klamath Lake, a shallow body of water about 35 miles long, dominates the graben.

Geothermal wells and springs are widespread in the Klamath Falls area. The springs were prevalent over 100 years ago and were used by the Indians and early European settlers. However, due to pumping from wells, all of the springs no longer flow on the surface. Today more than 500 hot water wells have been drilled in the area, most of which are located along the eastern edge of the graben taping into the upflow zones along the fault system. Hot water, heated at depth, migrates up along these fracture zones and then flows southwesterly in permeable zones of volcanic cinders and fractured lava flows. Wells were drilled in the area, starting around 1930, to provide space heating for local residences using downhole heat exchangers (DHE). These DHEs consist of a closed loop of pipe in the well with city water in them extracting heat from the well water. The DHE conserve the resource by extracting only heat from the well water and can provide space heating and domestic hot water to individual homes, several homes or even schools and businesses in the area. A typical residential well can provide up to about 250,000 Btu/hr (0.1 MWt) of energy, and installations with multiple DHE, such as for schools, provide about 10 times this amount of energy. Well depths in the city vary from 100 to 1,800 feet, with 300 feet being the average. Temperatures vary from 120 to 220 ºF, with 140 ºF and above considered desirable for providing sufficient energy using a DHE.

The DHE example selected from Klamath Falls serves two residences from a single well. The system design is fairly simple, but typical of others in the city that provides both space and domestic hot water heating. The well is 200 feet deep, with a temperature of 196 ºF at the top, and 204 ºF at the bottom (when drilled). The static water level is 75 below the casing top. The well was drilled in 1954. (Department of Energy National Renewable Energy Laboratories, 2005)

The space heating system consists of baseboard hot water radiators on a two-pipe system with flow control valves on each heating unit. A motorized valve on the return leg of the heating loop controls the flow via a thermostat. Recently, a solid state controller hooked to a storage battery was installed in case of a power failure. A 10-gallon expansion tank is connected to the high point in the heating system, and pressure reducing and relief valves are part of the cold water supply line used to initially fill the heating loop. City water is also provided to the domestic hot water loops in an open system. There is no storage tank for the domestic hot water, and there is also no circulation pump on the space heating loop, as the circulation is produced by normal thermal syphoning.

The estimated utilization of the system for both houses is about 164 million Btu/yr (48,000 kWh). The maximum capacity of the well is probably 10 times this utilization, but obviously it has not been plumbed or tested to this amount, which depends upon the aquifer flow and efficiency of the vertical convection cell.

Initially, to prevent corrosion of the DHEs at the water-air interface, several pounds of paraffin were placed in the well. This was considered a pollutant to the groundwater; thus in 1974, after the DHEs were replaced, a steel plate was welded to the top of the water to limit air (oxygen) entering the wellbore. This is the recommended procedure today.

Drilling a geothermal well with less than 250 ºF temperature is under the jurisdiction of the Oregon Department of Water Resources (DWR). Wells that exceed this value are under the jurisdiction of the Department of Geology and Mineral Industries (DOGAMI). A drilling log must be filed by the driller to the state (DWR) once the well is completed. The well casing must also be sealed from the surface down to competent formation or to 21 feet below the surface. The City of Klamath Falls passed an ordinance in 1990 to prevent the dumping of geothermal water in the storm sewer or waterways – all water must be reinjected into the same aquifer. Since only heat is removed from a well using DHE, this ordinance does not apply.

4.3 Japan

The Beppu geothermal area is situated at the eastern edge of the Beppu–Shimabara graben that crosses from northeast to southwest on Kyushu Island in Japan. Geologically, Beppu is one of the largest water-dominated geothermal systems in Japan, and it extends up from the Mt. Tsurumi–Mt. Garan volcanic center to the east coast of Beppu city, which is fed by geothermal fluid beneath the volcanic center of Mt. Tsurumi and Mt. Garan. The city of Beppu is a hot spring area with the largest water discharge in Japan. The discharge of hot water coming out in the Beppu spring is ranked second in the world after Yellowstone National Park in the United States.

Beppu is one of the largest hot spring resorts in Japan, popular mostly for its onsen (hot spring bathing) and fumaroles. The extreme hot springs called Jigoku (Japanese for 'hell') are very popular tourist attractions. These Jigoku are 10 small geoparks with boiling, bubbling and steaming attractions, including geysers, mud pools and hot springs for foot baths, which are very popular on cold days. Eggs, vegetables and dumplings are cooked over hissing steam vents or in the boiling ponds. And of course, some culinary experiences should not to be missed. (Beppu Hot Springs: Taguchi, Shichiro)

In order to cater for the large numbers of hot spring tourists, mostly national parks and other areas with geothermal attractions have excellent access roads, information centers, traditional onsen Ryokan (Japanese hot spring resorts), mountain lodges and lakeside inns, historical and cultural sites with shrines and tombs as well as museums and cultural exhibitions themed around the onsen experience. A large service industry with ample retail opportunities for hot spring tourists is the main source of many local economies in Japan (e.g. Yufuin, Kyushu; Matsuyama, Shikoku; Kusatsu, Honshu; Toya, Hokkaido). Besides the utilization for onsen experience, we would found the utilization of geothermal for fish farming and heat exchanger to the local community (Figure 8).

A large number of national parks in Japan include geothermal areas, usually with close links to volcanic activity. Statistics from 2001 reveal a total number of active hot springs in Japan as high as 26,796 (Nipponia, 2003) and in the year 2005 the total visitor numbers to hot spring destinations in Japan was 151 million people (BCTI, 2019).

Figure 8. Geothermal utilization in Japan as tourism, fish farming, and household heat exchanger.

4.4 New Zealand

The Whakarewarewaarea in the southern area of the Rotorua Geothermal Field and contains 500 hot springs, 65 geyser vents, colorful sinter terraces and vegetation unique to geothermal areas. Whakarewarewa is an iconic center of Māori culture and of geothermal features in the New Zealand. Residents at Whakarewarewa over the decades have witnessed an evolution in geothermal and cultural tourism. The Tuhourangi / Ngāti Wāhiao people have a proud heritage which they share with visitors from around the world. The Whakarewarewa Thermal Village Tours continues to grow, with profits supporting growth within the village environment. The Whakarewarewa thermal area occurs in the southern part of the Rotorua Geothermal Field, inside the margin of the Rotorua Caldera and beneath Pohaturoa rhyolite dome (Lloyd, 1975).

Whakarewarewa Valley is an active geothermal area with hot pools, boiling mud, and geysers (Figure 9). Māori people have lived here for centuries, co-existing in harmony with the geothermal forces that lay beneath their feet. Their facilities were Māori cultural performance, nature walks, traditional food, overnight marae stay, and hot water beach campground. Established in 1901 as an experiment to test the suitability of different native and exotic forest species for commercial planting, Whakarewarewa is home to a large number of native plant species as well as giant Californian Redwoods. Today it is known as a walking, running, horse riding and mountain biking destination. Hundreds of jobs could be created in Rotorua, and millions of dollars of private investment sparked, following a multi-million-dollar cash injection from the Government.

People who ride (locals and visitors) in Rotorua's Whakarewarewa forest contribute between $30m and $50m in spending annually to the local economy, creating 200 to 350 jobs. Tourism spending is estimated at $310 million annually in the District and, when flow-on effects are considered, generates approximately $463 million in benefits to the District economy.

Figure 9. Whakarewarewa: New Zealand's Living Iconic Maori Village (whakarewarewa.com)

5. POTENTIAL AND CHALLENGES OF DIRECT-USE APPLICATION IN DIENG

Various direct-use utilization in other area has been explained above, but the best suitable application should be chosen to support the economics and local welfare in Dieng geothermal area. The geothermal fluids temperature of Dieng well output is above 120°C. The soil in Dieng is very fertile. Hence, combining agriculture and geothermal direct-use would be a good pair to improve the local welfare. Table 1 was the summary of potential (pros) and chellenge (cons) of every direct-use utilizations in Dieng. These are the explanation of suitable application in Dieng:

5.1 Potential

Tourism

Most of tourism in Dieng are organized by private sectors which independently established and scattered. It could be upgraded into better tourism if it is more integrated and managed properly. The distance among the craters or the lake is near to each other. But with different management. Whakarewarewa thermal village in New Zealand and Blue Lagoon in Iceland were two of interagated tourism and cultural village (Gudmundsóttir et al, 2010 & Neilson et al, 2010). The first step could be started on Arjuno Temples Complex. Recently, through the ticket that had bought when entered Arjuno Temples Complex, we could visit Arjuna Temple Complex, Sendang Sedayu, Medium Maerokoco, Dharmasala, and Sikidang Crater, but without proper sequence and management. It would be a great potential if it could be combined with the Dieng Plateu Theater and presented with the urban legend. But it would be nothing if it is not managed well.

Green House

Applications that need to be prioritized in the development of direct-use of geothermal energy in Dieng are household industries, for example geothermal energy can be used for heating, evaporation, drying, distillation, sterilization, washing, ice melting and salt extraction. (Poernomo et al., 2015). In agricultural sector, it can be used to warm rooms and land such as building greenhouses for vegetables, fruits, and ornamental plants to keep growing without having to adjust to the season. A greenhouse in Dieng is an interesting proposition, especially considering the success story in Lahendong.

Potential that are found in Dieng areas are extreme temperatures (temperatures ranging from 12-20 ° C in the middle and 6-10 ° C at night) that can damage vegetables and inhibit the growth of existing vegetables. The fertilizers obtained must be obtained from outside the plant with a high price and poor management of the crop causes losses to the farmers. (Layman et al., 2017)

The existence of a mass of cold and dry air from the continent of Australia causes temperatures in Dieng to be extreme. This flow is also called the flow of Australian cold monsoons. One of them is that we can make a green house by utilizing heat directly by flowing

hot water in a place that is placed on the floor or along the wall or a combination of the following two methods. With this extreme temperature makes the use of greenhouses less than maximum, so that the utilization of this greenhouse requires special treatment for the pipes that will be used in the greenhouse. For example, the treatment used in pipes is coating, to make the temperature of the pipe stable (not freezing).

Heat Exchanger

The weather in Dieng could be very extreme. In certain months, the temperature could reach less than 0℃. There was still no innovation to channelize the heat from the geothermal source to the rural community, especially for health facilities. It would be very advantageous if the geothermal generates the heat through heat exchanger as applied as in Rotorua Hospital (New Zealand), Taupo Hospital (New Zealand), and Beppu (Japan). The community would feel the benefits of the direct-use in geothermal. The heat exchanger needed 130-160 ℃ (wellhead temperature of the well) (Steins & Zarrouk, 2011), while in Dieng, the temperature of the brine could reach >200℃. Therefore it would be a big potential to be conducted in Dieng. Procurement of heat exchanger for hospital or daily household would be a concern because of the unit price of each heat exchanger is quite high. Coupled with support from related facilities that must be adequate as well, so that without detailed and massive planning, the economics of the heat exchanger becomes very small.

Plastics Recycle Factory

One of the direct-use utilization that had been proposed by Geo Dipa Energi (GDE) was as plastics recycle mini factories. This concept would use mini well-head generator to operate the plastics recycle machines. It would be one of corporate social responsibility program of GDE. Through this program, would be very much expected to improve the welfare of the rural society too. The weakness of this program was the community could not feel the direct impact of the money, because it should need further processes to utilize the plastics into economic goods.

Table 1. The assessment of possible direct use utilization in Dieng.

Direct-use Application	Assessment Rating	Possibility Value (Possible/ to be Considered/ Impossible)
Tourism	Pros: Improve the welfare community, just need a little polishing to the existence tourism	Possible
	Cons: • Hold by private • issue with the land use to integrate each other	
Greenhouses	Pros: • Potato and agriculture commodity could be improved • Gaining community income	Possible
	Cons: • Educating the local community how to develop it • Building infrastructure near the source of the heat • Requires certain land for the green house establishment	
Heat Exchanger	Pros: The extreme weather could reach below 0 ℃ and useful for the public facility area	To be considered
	Cons: Expensive setup of utilization	
Plastic Recycle Machines	Pros: Support the world environmental campaign	To be considered
	Cons: Expensive setup of utilization	

5.2 Challenges

1. The permitting and concession process to local government might take longer time due to various different facilities to be installed, thus may require different permitting process from more than one office or instances in province or district level.
2. There is no official government regulation so the local government local governments can allocate a special budget for direct use.
3. Geothermal company as the first party of commercial user of geothermal may hesitate in allocate money or human resource to build this kind of facility due to high commercial demand of the programs.
4. Looking for a suitable location near surface thermal manifestations with sufficient space and access to build the facility complex might be problematic Access road upgrade might need to be commenced earlier to support this facility.

5. The integrated direct-use utilization will need large area. Usually the surface thermal features in Indonesia are still inside local community land (private property). Based on author experiences, negotiations process for land acquisition with traditional or local landowner can become complicated matter as the owner want a high compensation because they will perceive that their land contains a very valuable resource.

6. DISCUSSIONS

Several discussions result from this study are as follows:

1. Dieng geothermal area has some direct-use utilization, especially for tourism. But it still needs improvements because it was handled locally and did not manage properly.
2. The government must make special regulations that regulate direct use so that implementation can be easier, especially for geothermal fields. Direct use can be a good bridge between companies and the community so that people can be educated and experience the benefits of geothermal directly.
3. There are still plenty of room to assess the potential of direct-use in Dieng itself. The potential direct-use that applicable into Dieng, beside tourism, are greenhouse, heat exchanger, and plastics recycle machine.
4. This study attempts to propose early concept of an integrated geothermal direct-use facility is expected to increase the local community welfare, be able increase local community acceptance to geothermal development, and at the end of the day will support the completion of the project in timely manner.
5. Need further assessment which is completely taken from the survey and community for the suitable direct-use utilization in Dieng.

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