Geothermal Direct Use Implementations and Its Potential Developments in North Sulawesi

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ABSTRACT

Indonesia is located in the ring of fire area, associated with an enormous potential for geothermal resources, including North Sulawesi. The government is currently focusing on generating electrical power from geothermal resources. Lahendong geothermal power plant is the first geothermal project in the east of Indonesia, operated since 2001 and generating 20 MWe. Currently, Lahendong is supplying 20 MWe from each of 6 units to the SULUT-GO (North Sulawesi and Gorontalo) electrical network. Also, there is a small-scale power plant using a binary cycle with a capacity of 0.5 MWe. In many locations, North Sulawesi is also known for its Geotourism, such as at Bukit Kasih, Danau Linauw, Bukit Pinus and other hot swimming pools. Geothermal energy is also utilised by Yayasan Masarang in producing palm sugar. Another development is being carried out in drying agricultural foods. With the considerable potential for geothermal direct use to support tourism and agriculture, further developments need to be considered.

1. INTRODUCTION

Indonesia is a country with an enormous geothermal potential compared to other countries. Located in the ring of fire area, Indonesia has approximately 23.9 GW of geothermal potential according to the Geology Agency of Indonesian government (EBTKE, 2020). However, the recent data show that Indonesia had just 2,276 MWe of installed capacity of geothermal power plant by the end of 2021 (Richter, 2022). The Indonesian government plans to achieve 5,799 MWe installed capacity of geothermal plant by the end of 2035 as stated in the RUPTL PLN document (PLN, 2021), which means that approximately 391 MWe of new installed capacity is needed each year. On the other hand, geothermal development is not limited to electricity generation, but also includes direct-use projects.

Direct utilization of geothermal is one of the oldest, versatile and common forms of using geothermal energy (Dickson & Fanelli, 2003). Various categories of common direct-use, worldwide, include geothermal heat pumps, space heating, greenhouse heating, aquaculture pond heating, agricultural drying, bathing, swimming, snow melting etc. Figure 1 illustrates geothermal direct applications worldwide in 2015.

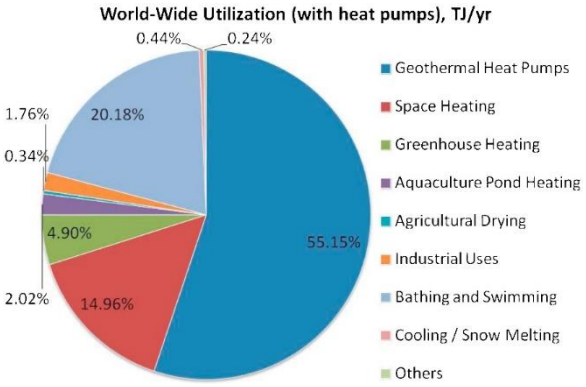

Figure 1: Total energy share of geothermal direct utilization 2015 (Lund & Toth, 2021).

Although Indonesia occupies the position of 2nd highest in the world in terms of installed capacity, direct utilization of geothermal energy is still low compared to other countries. According to Lund and Toth (2021), Indonesia only utilizes 42.60 TJ/year of direct-use geothermal energy, which is mostly for bathing, swimming and balneology. Some geothermal direct uses in Indonesia include mushroom cultivation in Kamojang geothermal field, palm sugar production in Lahendong field, copra and cocoa dryings in Way Ratai Field, a large catfish fishery in Lampung, etc. Besides taking advantage of electricity production from geothermal energy, direct utilization is also needed in Indonesia and requires focusing on the potential of each potential region in Indonesia including North Sulawesi.

Lahendong geothermal power plant is one of the commissioned geothermal power plants of Indonesia, and currently produces a total of 120 MWe to meet the energy demand in North Sulawesi. Moreover, the Kotamobagu geothermal working area (WKP) has been assigned to Pertamina Geothermal Energy for its development. Besides the current geothermal working area, EBTKE also has identified geothermal potential in the Duasudara and Wineru areas (EBTKE, 2017). Along with natural resources such as coconut flesh, clove, nutmeg, palm, and other agriculture products, geothermal direct use can be used to increase public welfare and public awareness about the importance of geothermal energy.

2. OBJECTIVES

This paper aims to:

1. Summarize and discuss the current geothermal direct use applications in North Sulawesi

2. Discuss the options for geothermal direct use in North Sulawesi based on potential usage or commodities in the area.

3. LITERATURE REVIEW

3.1 Current Status of Geothermal Direct-Use in North Sulawesi

2.1.1 Lahendong Geothermal Park

Concern arises due to the importance of educating the public of the role of geothermal in terms of overcoming the energy security issue in Indonesia. To address this problem, the government and people of North Sulawesi are planning to build a park for Geothermal Education at Lahendong that can build the interest and enthusiasm of the children and younger generation to know and love the earth sciences. Thus, Lahendong Geothermal Education Park is proposed as an education park concept that allow visitors to enjoy the scenery of a geothermal area, along with learning the science of geothermal phenomena and appreciate the indigenous folklores, and also appreciate the role of geothermal energy in terms of fulfilling humanity's need for clean, renewable and sustainable energy (Roeroe et al., 2015).

2.1.2 Palm Sugar Producing

A non-governmental organization named Yayasan Masarang, in collaboration with Pertamina Geothermal Energy, established a large-scale direct-use geothermal energy facility (Figure 2) to produce palm sugar. It has a capacity of 12 ton/day and uses the flashed steam from separated brine water (Surana et al., 2010). This facility brings opportunity for the farmers to obtain more income without using firewood and provides extra power compared to the traditional methods. It is not only effective in time and power, but also prevents the negative impacts from burning wood.

Figure 2: Direct Utilisation of Palm Sugar Processing in Lahendong Field (Surana et al., 2010)

Figure 3 shows the schematic diagram of the processing facility. Brine from the separator is directed to the production facility through a flasher to generate the steam. The palm sugar processing in the facility is also illustrated in Figure 4.

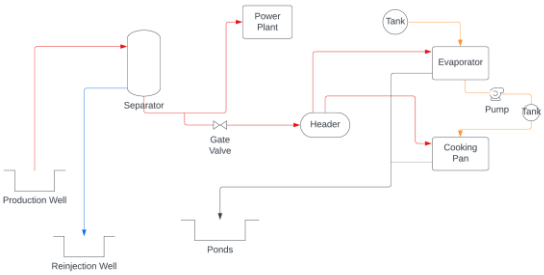

Figure 3: Schematic Diagram of Palm Sugar Production by Utilizing Brine

Figure 4: Production process of Palm Sugar (Masarang, 2023)

2.1.3 Geotourism

Geothermal also provides beautiful scenery through geothermal manifestations. Geothermal manifestations, including fumaroles, mudpools, hot/warm springs, hot pools, hot lakes, silica sinter and rock alteration, can be found in several locations in North Sulawesi.

Figure 5: Geothermal manifestations at Bukit Kasih

These manifestations are being used to attract tourism. Several famous locations in North Sulawesi for enjoying the geothermal scenery are Bukit Kasih, Lahendong Pine Forest, Linauw Lake and Mahwatu. The places cost around Rp.15.000 to Rp.30.000 for a single entry in 2023.

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Figure 6: Geothermal manifestations at Lahendong Pine Forest

Figure 7: Geothermal manifestations at Linauw Lake

Figure 8: Geothermal manifestations at Mahwatu

2.1.4 Bathing and Balneology

North Sulawesi is blessed with low-medium temperature geothermal systems across the land, and thus pumped hot water and pumped warm water from below ground can be easily found. Thus, there are many hot and warm swimming pools in North Sulawesi, such as Po'opo Swimming Pool, Ote-Ote Swimming Pool, and Om Nyong Swimming Pool. Bukit Kasih tourism also provides relaxation by soaking the feet in hot water. Hutan Pinus Lahendong also provides a swimming pool directly fed from the hot spring.

Figure 8: Ote-Ote Swimming Pool

Figure 9: Po'opo Swimming Pool

Figure 10: Om Nyong Swimming Pool (Retrieved from Google)

3.2 Potential Resources from North Sulawesi

North Sulawesi is usually called Nyiur Melambai Island because of the availability of coconut and its derivative products which are significant. Coconut is the main commodity produced from North Sulawesi. There are other products from North Sulawesi, such as clove, nutmeg, coffee, palm and vanilla (BPS, 2022b). Table 1 shows plantation products of North Sulawesi. Moreover, rice production in 2021 from North Sulawesi reached 0.2 mega tonnes with the highest production in Bolaang Mongondow, followed by the Minahasa regency (BPS, 2022a). Corn production also reached 0.3 mega tonnes in 2015, with Bolang Mongondow as the region with highest production followed again by Minahasa (BPS, 2016).

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Table 1: Resources production (in tonnes) of North Sulawesi in 2021 (BPS, 2022b)

Regency/City	Coconut	Clove	Nutmeg	Coffee	Cocoa	Vanilla	Candlenut	Palm
Bolaang Mongondow	30116.40	-	41.04	2971.13	3761.52	-	468.50	10.23
Minahasa	16222.60	110.00	3.80	36.00	-	16.50	2.00	10.00
Kepulauan Sangihe	24017.71	-	4335.50	-	-	-	-	-
Kepulauan Talaud	19195.00	-	4158.00	-	-	-	-	-
Minahasa Selatan	42209.90	4.42	26.84	21.79	-	1.82	-	650.00
Minahasa Utara	41255.50	-	241.52	-	-	-	-	224.99
Bolaang Mongondow Utara	15551.50	0.50	5.05	1.78	424.36	-	-	16.00
Kepulauan Sitaro	3248.88	-	3212.70	-	-	-	-	-
Minahasa Tenggara	37372.18	8.28	44.83	38.43	19.95	41.59	-	57.10
Bolaang Mongondow Selatan	11125.92	17.11	26.82	5.45	426.80	-	4.88	2.00
Bolaang Mongondow Timur	9297.98	12.30	14.85	579.33	402.55	7.00	64.00	87.88
Kota Manado	2736.97	-	-	-	-	-	-	-
Kota Bitung	11689.47	-	62.68	-	-	-	-	1.45
Kota Tomohon	370.86	-	0.53	0.09	-	-	-	54.56
Kota Kotamobagu	692.50	-	7.32	49.24	147.40	1.25	21.21	46.00
Total	265103.37	152.61	12181.48	3703.24	5182.58	68.16	560.59	1160.21

4. PROPOSED DIRECT USE OPTIONS

Based on the potential resources of North Sulawesi, several options are proposed in Table 2.

Table 2: Proposed Direct Utilisation

Facility Name	Sector	Geothermal Fluid Temperature	Reason to Choose this Facility
Rice drying	Agriculture	75°C for air heating (Popovska-Vasilevska, 2003)	Rice needs to be dried first. Since North Sulawesi has an enormous potential for rice especially in Bolaang Mongondow, this facility will be helpful for the local community. WKP Kotamobagu is suitable for developing the facility.
Coconut flesh drying	Agriculture	92 - 95 °C by using Down Hole Heat Exchanger (Suyanto et al., 2010)	Copra is a major commodity in North Sulawesi. Thus, using geothermal fluid to dry the coconut meat helps to boost productivity
Coffee drying	Agriculture	175 °C (Prasetyo et al., 2018)	Coffee is another option to be considered by WKP Kotamobagu due to its potential in the Bolaang Mongondow region.
Cocoa drying	Agriculture	92 - 95 °C by using Down Hole Heat Exchanger	Cocoa drying is also similar to coffee drying, since the potential resources are

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		(Suyanto et al., 2010)	most available from the Bolaang Mongondow region.
Timber drying	Industrial	150 – 180 °C for Shell and Tube Heat Exchanger (Carey, 2018)	Timber is one of the essential products to support human lives. Timber is also a derivative product from coconut and therefore timber drying is one of the possible good options.
Clove drying	Agriculture	Around 140 °C (Budy et al., 2018)	Clove needs around 3 to 5 days to be dried. By applying geothermal fluid to dry the clove, production can be increase since it is independent of the weather
Nutmeg drying	Agriculture	Around 140 °C (Budy et al., 2018)	To increase the quality of nutmeg, a drying method should be applied and by utilizing geothermal fluid, the quality of the nutmeg can also be increased.

5. CONCLUSION

After the discussions above, it can be concluded that geothermal direct use in North Sulawesi has been utilized for industries such as palm sugar production, geotourism, bathing and balneology. Lahendong geothermal park is also a promising idea but is still being developed. Therefore, to increase local wealth and awareness about the role of geothermal, some direct-use facilities are proposed such as rice drying, coconut meat drying, coffee drying, cocoa drying, timber drying, clove drying and nutmeg drying. Further studies need to be done to assess the best direct-use options to meet community demands in North Sulawesi.

REFERENCES

BPS. (2016). *Luas Panen, Produksi dan Rata-Rata Produksi Jagung 2013-2015*. https://sulut.bps.go.id/indicator/53/156/1/luas-panen-produksi-dan-rata-rata-produksi-jagung.html

BPS. (2022a). *Luas Panen, Produksi dan Rata-Rata Produksi Padi 2019-2021*. https://sulut.bps.go.id/indicator/53/114/1/luas-panen-produksi-dan-rata-rata-produksi-padi.html

BPS. (2022b). *Produksi Perkebunan Besar/Rakyat/Negara per Jenis Tanaman (Ton) Tahun 2021*. https://sulut.bps.go.id/indicator/54/147/1/produksi-perkebunan-besar-rakyat-negara-per-jenis-tanaman.html

Budy, A., Gerner, E., & O'Reilly, S. (2018). *Feeling the heat: geothermal energy*. Australian Academy of Science. Retrieved 31 July from https://www.science.org.au/curious/technology-future/feeling-heat-geothermal-energy

Carey, B. (2018). Using Geothermal Energy for Kiln Drying Operations. WoodTECH 2018, Rotorua.

Dickson, M. H., & Fanelli, M. (2003). *Geothermal energy: utilization and technology*. UNESCO.

EBTKE. (2017). *Potensi Panas Bumi Indonesia Jilid 2*. ESDM.

EBTKE. (2020). *Potensi Besar Belum Termanfaatkan, 46 Proyek Panas Bumi Siap Dijalankan*. ESDM. Retrieved 13 May from https://ebtke.esdm.go.id/post/2020/03/27/2518/potensi.besar.belum.termanfaatkan.46.proyek.panas.bumi.siap.dijalankan#:~:text=Saat%20ini%20Direktorat%20Jenderal%20EBTKE%20telah%20menyusun%20road,sebesar%2023%2C9%20Giga%20Watt%20%28GW%29%20hingga%20Desember%202019.

Lund, J. W., & Toth, A. N. (2021). Direct utilization of geothermal energy 2020 worldwide review. *Geothermics*, *90*, 101915. https://doi.org/https://doi.org/10.1016/j.geothermics.2020.101915

Masarang. (2023). *Role of the sugar palm in Masarang projects*. Masarang. Retrieved 12 May from https://masarang.eu/what/sugar-palm-good-alternative-palm-oil/

PLN. (2021). *Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) PT PLN Persero 2021-2030*. PLN. https://web.pln.co.id/statics/uploads/2021/10/ruptl-2021-2030.pdf

Popovska-Vasilevska, S. (2003). Drying of agricultural products with geothermal energy. *International Summer School on Direct Application of Geothermal Energy*, 1-11. https://www.researchgate.net/profile/Sanja-Vasilevska-2/publication/228985886_Drying_of_Agricultural_Products_with_Geothermal_Energy/links/0a85e532bf6d34a55d000000/Drying-of-Agricultural-Products-with-Geothermal-Energy.pdf

Prasetyo, R. M., Wicaksono, A., Biddinika, M. K., & Takahashi, F. (2018). Study of geothermal direct use for coffee drying at Wayang Windu geothermal field. *AIP Conference Proceedings*, *2026*(1). https://doi.org/10.1063/1.5064989

Richter, A. (2022). *ThinkGeoEnergy's Top 10 Geothermal Countries 2021 – installed power generation capacity (MWe)*. Think Geoenergy. Retrieved 1 May from https://www.thinkgeoenergy.com/thinkgeoenergy

ISSN 2703-4275

s-top-10-geothermal-countries-2021-installed-power-generation-capacity-mwe/
Roeroe, H. J., Utami, P., Khazani, & Polii, J. (2015, 19 April). The Problem and Challenges to Development Lahendong Geothermal Education Park. Proceedings World Geothermal Congress, Melbourne.
Surana, T., Atmojo, J. P., Suyanto, & Subandriya, A. (2010). Development of Geothermal Energy Direct Use in Indonesia. Proceedings World Geothermal Congress 2010, Bali.
Suyanto, T. S., Agustina, L., & Subandriya, A. (2010). Development of Direct Use Application by BPPT. Proceedings World Geothermal Congress,

ISSN 2703-4275