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MEASURING THE POTENTIAL BENEFITS OF GEOTHERMAL COOLING AND HEATING APPLICATIONS IN INDONESIA

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ABSTRACT

The Government's power capacity target, through the 2025 National Geothermal Development Roadmap, may have led to a predominant focus on geothermal power generation development and have simply kept direct geothermal utilization in Indonesia to remain ever marginal. Moreover, power generation issues and development bottlenecks remain largely unresolved. Prior to a thorough feasibility study, a preliminary review was done in order to measure the opportunity to utilize geothermal energy for various cooling and heating purposes in Indonesia, in which the cooling and heating activities are cited to be the major contributors to the ever-growing electricity demand. Therefore, such applications from geothermal could be a potential alternative to the current lagging geothermal power generation development.

Keywords: *Demand-Side Management, Electricity Consumption and Emission Reduction, Energy-Cost Savings.*

INTRODUCTION

Background

Direct geothermal applications offer solutions we simply cannot ignore, in terms to meet the significant energy demand for cooling & heating in Indonesia and also since the long lagging geothermal power generation over the last decade.

The geothermal power generation development bottlenecks encountered over the years has remained largely unresolved, meanwhile direct geothermal utilization industry in Indonesia has been ever marginal despite the incredible growth of direct-use market worldwide. Although we agree that milestone dates and numbers should be merely considered as indicative urgency figures rather than absolutes, the under-achieved target projected in The 2025 National Roadmap should have had us to change our approach towards this ambitious exclusive power generation campaign.

Despite the fact that there are still plenty high-entalpy undertapped hydrothermal resources to be exploited, we could face more major setbacks if we keep only focusing on the aggressive efforts of geothermal power generation development—supply side management—instead to carry out a more likely demand-side management approach. The regarding approach, in terms of the energy security and elecricity provision issues, has become more crucial, as the adverse impacts (such as periodical black outs,etc) occured more often lately.

Thus, geothermal could have a substantial role in the respective demand-side management campaign through their cooling and heating applications, in which it offers opportunity to shift momentous amount of electricity load and provide significant energy efficiency. The cooling and heating activities are the major contributors to the ever-hiking electricity load in Indonesia, particularly in the the dense-populated urban areas and large commercial or industrial areas. Accordingly, geothermal has a long proven record in providing energy for such cooling and heating purposes, which has been applied by the cold and mild climated countries since the early 1990's,.e.g. the United States and most of the European Countries. The recent studies and successes stories regarding to the implementation of geothermal cooling & heating applicatons in tropical and hot-humid climate countries, i.e. El Savador, India, Thailand, Vietnam, Singapore, etc, never seems to have risen our awareness regarding to this opportunity.

Moreover, despite the numerous worldwide studies related of geothermal cooling and heating and the particular recent studies in tropical-humid nearby countries, studies that reviews geothermal cooling and heating applications particularly in Indonesia are extremely limited. Since the adjustment of such required tecnology are strictly area-specific, there is no such thing as a perfectly ideal implementation model to copy to—even from a similar tropical climate nearby country—and to be applied perfectly in Indonesia. Besides the tropical climate and the vast geothermal resources, Indonesia is known to have a wide range of characteristics (geological settings and physical environments) along with specific encountering issues. Therefore, regarding to the particular reasons, there are still plenty of aspects and considerations to be evaluated further in this study, in which may come to light.

Study Objectives and Approach

Prior to further feasibility studies and demonstration projects, it is necessary to measure the specific potential benefits and advantageous features that is potentially obtained from a mass application of cooling and heating of geothermal energy in Indonesia. Therefore, this preliminary study has identified a number of common advantages benefited from geothermal cooling and heating applications experienced worldwide. Many of these benefits should fit perfectly with Indonesia's characteristics and could overcome the current encountered issues. Furthermore, the entire presumed benefits and advantageous features are eventually valuated hypothetically to provide solid hypothetical footings to realise the technology's full potential. Thus, this paper is also intended to improve our awareness towards the application of such geothermal application in Indonesia following to this study.

This study is organised into three major parts. It starts with the overview of worldwide geothermal cooling and heating development, focusing on the key development drivers and the available technology in the global market. Following is the review of primary aspect of consideration in selecting the most suitable arrangement of application. It finally continues with the identification of features of such applications experienced commonly worldwide that Indonesia could potentially take benefit from, and designed to be the key footings for further desicion making and implementation studies.

Worldwide Geothermal Cooling and Heating Status

For heating and cooling preferences, geothermal resources spans a wider range of temperature levels that can cover several types of demand for various applications such as space and district cooling/heating, domestic and residential air conditioning, spa and swimming pool heating, agriculture soil temperature conditioning, aquaculture water temperature conditioning, and industrial process heating/cooling. It is recently found out that even geothermal resources at temperatures of 20^{o}C to 30^{o}C (e.g. flood water in abandoned mines) may be useful to meet space cooling/heating demand. Moreover, similar to geothermal power generation, geothermal cooling and heating typically provides base-load generation, since it is generally immune from weather effects and does not show seasonal variation.

Regarding to large range of applications for the cooling and heating purposes that geothermal energy offers, geothermal cooling and heating applications has became one of the fastest growing applications of the renewable energy market in the world. There is a lot of heated debate over what climates are optimal for such technology, but in fact successful installations of geothermal heat pump technology are found all over the world, from the chilly Alaska to the scorched Southwest, and from tropical islands to the Middle East.

Table 1: Worldwide utilization status of direct geothermal heat (Lund, 2007)

Country	Production PJ/yr	Capacity GW	Capacity Factor	Dominant applications
China	45.38	3.69	39%	bathing
Sweden	43.2	4.2	33%	heat pumps
USA	31.24	7.82	13%	heat pumps
Turkey	24.84	1.5	53%	district heating
Iceland	24.5	1.84	42%	district heating
Japan	10.3	0.82	40%	bathing (onsens)
Hungary	7.94	0.69	36%	spas/greenhouses
Italy	7.55	0.61	39%	spas/space heating
New Zealand	7.09	0.31	73%	industrial process
63 others	71	6.8		
Total	273	28	31%	space heating

However, most of this substantial growth has occurred in the United States and Europe, though interest is developing in other countries such as Japan and Turkey. Tropical countries—such as Thailand, Vietnam, Singapore, India and El Savador—in which we might have believed that those countries are to be least linked to these applications, has taken serious considerations for mass application in their countries. The increase awareness of these tropical countries towards the potential benefits has been confirmed by a series of feasibility studies and demonstration projects carried out intensively in the recent years. Although it is often cited that geothermal heating and cooling applications are not relevant for the tropical countries, the recent conducted studies in the respective tropical countries have shown suprising opposite results, in which mostly led to recommend geothermal cooling and heating application to proceed for further implementation.

The extensive growth of the two main available technologies associated to the cooling and heating purposes—the Geothermal Heat Pump (GHP) System and District Cooling/Heating System—confirmed such rapid scale of growth. For instance, more than 1 million geothermal heat pumps (with a total capacity to generate approximately 8,600 MW of heat) along with 21 geothermal district heating system locations, has been operated just in the United States. It was also reported that the worldwide energy use of Geothermal Heat Pump (GHP) increased 3.6 times in five years, reaching to 87,503 TJ/year in 2005, with an average annual increases of 10% in about 30 countries over the past 10 years (Lund, 2005). Furthermore, The International Energy Agency (IEA, 2011) reported the worldwide heating (only) application status and projections. Air conditioning by the ground source heat pumps was reported to lead the utilization share (49% of total geothermal heating application), spa and swimming pool heating was following behind (about 25%), for instance in China, where it makes up 23.9 PJ out of the 46.3 PJ of geothermal heat used annually (excluding ground source heat pumps). The next-largest geothermal heating application usage is for district heating (about 12%), while all other applications combined make up less than 15% of the total. In the other hand, information related to total worldwide cooling (only) application are extremely limited.

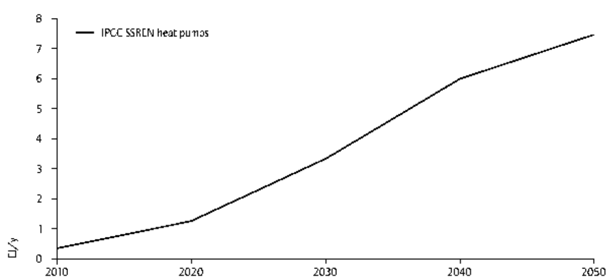

Figure 1: IPCC projection of global geothermal heat produced by geothermal heat pump up to 2050.

Regardless of the fact that every country has their own key country-specific drivers—as the reason behind their vast growing development of geothermal heating and cooling—still there are common advantages that could be summarized altogether.e.g.

- Significant Cost Savings
- Better Operational Lifetime
- Simple Technology Transfer
- Accessibility to Incentives and Promotions
- Additional transmission lines are unnecessary
- Reduce electricity & energy consumption
- A less capital alternative
- Potential Wider Market: Segments & Location
- Encourage Domestic Economy
- Significant Carbon Emission Reduction

The country-specific drivers usually come along with their typical technical arrangements and/or additional features, in order to meet their characteristics or to overcome a particular encountered issue. For instance, in the the Unites States, most units are sized for the peak cooling load and are oversized for heating (except in the northernstates). Lund (2005) also reported the application in most of European countries usually operate mainly in the heating mode, in which air conditioning (HVAC) are rarely required. However, cooling preferences has gained the importance for application since commercial applications requiring cooling are increasing and the ongoing proliferation of the technology into southern Europe. Meanwhile in UK, it took time to discover why the adoption of this technology did not turn out as effective as their initial expectations or either to identify the appropriate technology to be used in UK housing stock and to overcome issues that are unique to the UK.

In addition to the conventional technical arrangements, recently several countries has applied and further developed non-conventional hybrid Geothermal Heat Pump (GHP) systems in order to achieve a more favorable system performance towards the related country specific characteristics. For instance, Sagia et al (2012) studied a typical cooling dominated hybrid Geothermal Heat Pump (GHP) system using a cooling tower as a supplemental heat rejecter in Greece. Such system can also be found in Hong Kong, a subtropical area. Man et al. (2010) pointed out that the hybrid Geothermal Heat Pump (GHP) system is a good option to reduce the accumulated heat under the ground in a cooling dominating area. Yik et al. (2001) investigated three kinds of surface water cooled systems, which used sea water as the cooling medium, in Hong Kong. Their results showed that the water systems would significantly bring down the electricity consumption for air-conditioning buildings in Hong Kong.

Applications in Tropical Countries

In warmer to hot climates, geothermal cooling and heating application is dominated by cooling and industrial process heating. Furthermore, the cooling and heating applications of geothermal energy in tropical countries, Bi et al. (2009) investigated the application of Geothermal Heat Pump (GHP) systems in different temperature zones in China. They reported that in the tropical zone (Qionghai) and subtropical zone (Guangzhou), Geothermal Heat Pump (GHP) systems could be possibly applied for both cooling in the summer and heating domestic water in these districts throughout the year.

Moreover, one of Indonesia's nearby countries, Singapore, has carried out their first attempt to study the potential applicability of subsurface cooling in their country very recently. Singapore itself, perhaps could be a good model for dense populated capital city of tropical areas, such as Jakarta, to reduce the Urban Heat Island (UHI) Effects. Both Singapore and Jakarta face a pretty much similar issue, which is that the air conditioning activities, as the dominant energy consumming end-use appliance in buildings, have the biggest share in the Peak Loads. Liu, et.al (2013) reported that since the Geothermal Heat Pump (GHP) system had shown a good performance in reducing the energy cost, especially water usage in Singapore, it would have been a competitive alternative to the current existing system. Elsewhere, tropical countries such as Vietnam and Thailand has started to consider seriously at the possibility of the geothermal heat pump application. This has been shown by a number of studies conducted related to this topic and latest breakthrough by Thailand, in which has carried out an experimental installation of GHP system in their country (Yasukawa, et al. 2009).

Although cooling activities are extensive in tropical areas, subsurface temperature may always be higher than atmospheric one because of geothermal gradient. Therefore the subsurface would be less effective to be a "cold heat source" and there limited advantages of subsurface heat exchange. High Coefficient Of Performance (COP) may not be expected in such cases. However, it could be summarized that Geothermal Heat Pump (GHP) use in tropical regions is still believed to be effective especially if 1) there are high heating activities concur with the extensive cooling activities, which is pretty much practical in dense populated urban areas and 2) there is a nearby sufficient water resource to be coupled with, and to act as a cold heat source.i.e. deep lake water, sea water, etc. Nevertheless, in these tropical areas, Geothermal Heat Pump (GHP) always has higher performance than an air-source heat pump such as conventional air-conditioner because of its high heat exchange rate. Other research conducted by IEA concluded that Geothermal heat use may be most relevant in colder countries, but in warmer and hot climates, geothermal heat can be made useful in agricultural and industrial applications, and for space cooling using heat in excess as the driving energy for absorption chillers.

Therefore, from the respective studies of the worldwide application, Indonesia are once again trailing behind these countries, in terms of the opportunity searching from this wide-growing market. It is not that such cooling and heating applications are completely unlikely or rather unnecessary for Indonesia (due to the tropical climate) or either that Indonesia do not own such required resources to be able to apply the respective purposes—but it is rather that Indonesia have been complacent towards the abundant energy source available in their country throughout decades. This happens to have set a wide-applied code of conduct that put the economical aspects as if to be always the final—go no go—consideration for any kind of investment/development desicion making.

TECHNICAL ASPECT REVIEW

The amount of benefits and the effectiveness of implementation from such kind of application, in a particular country, strictly depend on the selection of an adopted system. An appropriate selection will result to an effective performance of the system, which further leads to, for instance, a momentous energy saving or perhaps a substantial emission reduction.

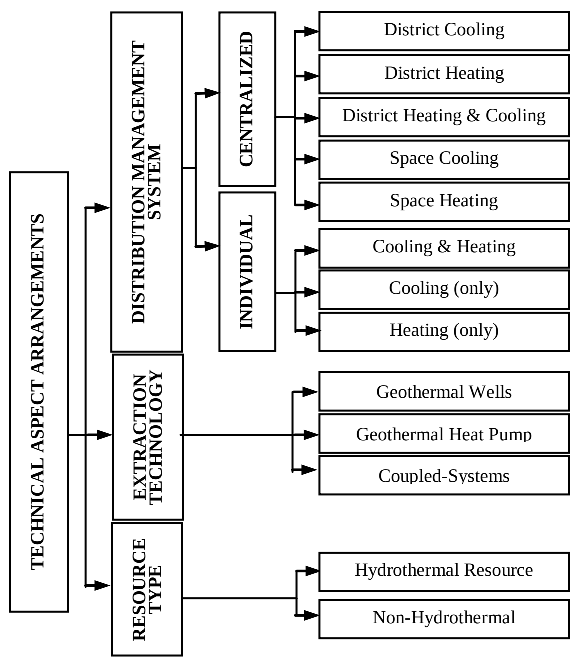

Figure 2: Primary aspects of consideration for system Selection adoption

Lesson learned from the very much-distinctive climates of European countries to the far more climate-relevant circumstance of Singapore, shows that each country experienced different level of adjustments and typical arrangements during their adaption of practices. Thus, it has resulted to numerous permutations of primary technical aspect (arrangements) available to look over. Therefore, the goal of this paper is not to provide suggested specifications and designs to be applied in Indonesia, but to briefly discuss the key considerations prior to the system selection process.

Distribution Management System

There are two general distribution modes to transport the geothermal heating & cooling energy, .i.e. centralized distribution system and individual distribution system. The centralized distribution system are associated to circumstances that requires an accumulative amount of cooling & heating energy to be transported from a central geothermal energy source, in which to be distributed to a large extent of area (space) or multiple users (district). A central energy management is also the characteristics of this centralized mode. The second type of distribution is here named as Individual distribution system, since such systems are associated with circumstances that let an individual user to produce their own geothermal energy required for their small-singular user-scale heating and/or cooling application. Thus, several additional apects must be considered in the distribution mode selection, e.g. regulatory framework, demographical aspects, business and financial aspects.

Centralized Distribution System

The centralized distribution system may perhaps be an obvious selection for public welfare-related purposes and infrastructures with a large extent of area such as snow melting for areas (cold climate countries), central hot water provisions, cooling & heating for integrated airport area and soil & air temperature conditioning for large scale plantation area. The developer and operator to manage the distribution process could be either from government or private parties.

Centralized energy distribution system has various advantages compared to the individual energy distribution systems. In terms of technical aspects, centralized energy distribution system provides a slightly higher energy efficiency along with a better emmition control. Though, centralized distribution systems is a long-term commitment that often fits poorly with a focus on short-term returns on investment.

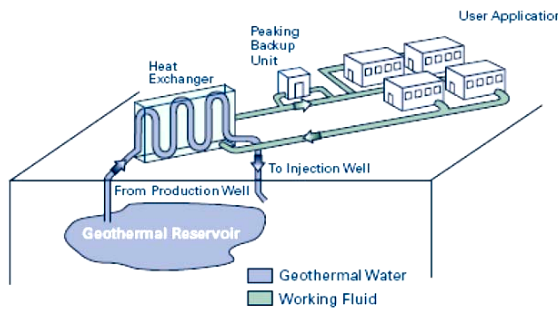

Figure 3: Illustrative picture of a central managed heat energy distribution to several users.

Centralized networks require a substantially higher initial capital expenditure and financing, since this mode will require additional distribution facilities (.e.g. Heat Collecting Station, Sub Station and Pipeline Networks) and a significantly larger production effort in order to be able to obtain such accumulated value of energy (.e.g. Deeper well or extra trenching and extra extension loop). Only if considered as long-term investments will these translate into profitable operations for the developers and operators of district energy management systems. Centralized network is less attractive for areas with low population densities, as the investment per household is considerably higher. Also it is less attractive in areas of many small buildings; e.g. detached houses than in areas with a few much larger buildings; e.g. blocks of flats, because each connection to a single-family house is quite expensive.

Accordingly, "District" and "Space" are familiar terms largely associated with the centralized energy distribution system, in which both terms represent a large amount of energy provisions for a large extent of area. The difference is that the "district" term corresponds to multiple users (usually indicated by multiple metering), while the "space" term corresponds to a single user/purpose, indicated by a single metering. These "space" applications are long practiced throughout the world in locations such as Reykjavík, Iceland, Boise, Idaho, and Klamath Falls, Oregon is known as district heating. The followings are common known categories that corresponds to central energy distribution:

(i) District Geothermal Cooling: these applications are associated to excessive cooling activity and demands. This system will probably be the major geothermal cooling & heating application in Indonesia, in which will potentially cover domestic/residential areas, airports, malls, office complex, industrial areas and other large commercial areas.

(ii) District Geothermal Heating and Cooling: This application will be suitable for areas where heating and cooling both have high energy demand. In Indonesia, location where high heating activities could slightly match the excessive cooling demands may be found in dense commercial areas, in which many hotels are also situated .e.g. sauna, warm private pool, Jacuzzi, water heating, pre-heating for laundry. Moreover, higher economic benefits can be achieved by a simultaneous heating and cooling application, as the resulting load factor is higher than with heating alone, and the unit energy costs are less.

(iii) District Geothermal Heating and Space Geothermal Heating: these applications are associated to (only) excessive heating activity, in which such circumstances is rather unlikely to be found in the tropical humid climate of Indonesia.

(iv) Space Geothermal Cooling: these applications are associated to excessive cooling activity and demands. Large plantation areas with severe drought issues and limited of electricity supply will be a potential target. The regarding energy will be used to cool (conditioning) and moist the soils. Successive stories are found from several African for such application.

Accordingly, particular to the circumstances of Indonesia, it is highly reccomended to set up a central cooling or heat "plant", as found in Czech and Iceland. A Central Plant will offer and attract much more future connection of new cooling or heating appliances, in which is hard to identify entirely at the present. For instance, the blooming innovatives of geothermal heat applications such as sea water desalination plants and preheating for high-temperature process heat, could be tapped reasonably tapped from suc central plant in the future.

Individual Distribution System

The geothermal heating and cooling systems are also found to be installed in a decentralized manner, to fit individual needs. Moreover, costly heat distribution will be avoided by applying individual distribution system. The application of such mode is also to be known for the opportunity to get numerous Intangible features, .i.e. encouraging local economy, in which it is also expected that it would create an intensive price competition and further leads to a faster technology improvement.

Important to be considered is that the individual distribution system are largely associated to a more free liberalized market, in which means a regulatory framework, institutional structures and technical supports, should be established promptly (more earlier) in terms to have good control to the development.

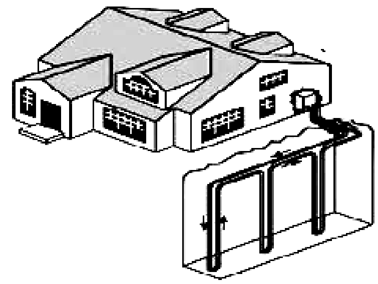

Figure 4: Illustrative picture of a individual managed heat energy distribution for a single residential building.

Despite having a longer time to reach an established market state, once reached, the development of the market would experience substantial rate of growth, in which would explain why geothermal heat pump technology—largely associated with individual distributed systems— has become one of the fastest growing global market. However, centralized distribution systems will be a safe option for early stage development for future geothermal cooling and heating application campaign in Indonesia, considering the instantaneous-demanding viewpoints that became more common lately. Also, centralized systems would be much more preferable nowadays, in terms of the impact control (safety, quality and environmental issues).

<u>Energy Extraction Technology Review</u>

In spite of the wide range of cooling and heating applications that geothermal energy offers and the variety of physical conditions along with different issues to overcome, we could still divide the extraction technology system for geothermal cooling and heating application into primary system categories: Geothermal Heat Pump Systems and Geothermal Well systems.

Geothermal Heat Pump Systems (GHP)

Although geothermal heat pump is most-effective in locations with large seasonal variations in temperature, a review of the geothermal heat pump technology will still be important even to tropical humid countries like us. There are plenty features of these kind of systems that we could take account into, in terms to formulate and design the best system arrangement to be adopted in Indonesia.

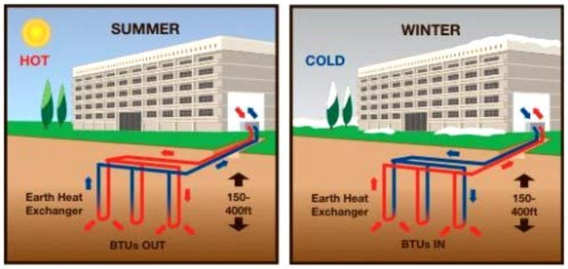

Figure 5: Energy provisions during summer and winter by Geothermal Heat Pump Systems

Having been designed initially for the residential sector, the geothermal heat pump system has variety of names called worldwide—earth-source heat pumps, geoexchange systems, ground-coupled heat pumps, ground-source heat pumps, and water-source heat pumps—GHPs can make use of the stable ground temperatures near the surface of the Earth to provide both heating and cooling to buildings. The surrounding soil, groundwater, seawater or an available nearby water resource is used as a heat source in winter and a heat sink in summer (cold & mild climate).

The geothermal heat pump system (GHP) takes advantage of the relatively constant temperature of the Earth, using it as a source and sink of heat for both heating and cooling. When cooling, heat is extracted from the conditioned space and dissipated into the Earth; when heating, heat is extracted from the Earth and pumped into the conditioned space.

Furthermore, a ground-source heat pump (GSHP) system has three major components:

(1) Heat Pump: The heat pump transfers the heat between the heating/cooling distribution system and the earth connection. It is the basic building block of the GSHP system.

(2) Earth Connection, and

The earth connection is where heat transfer between the GHP system and the soil occurs. GHP's comprise a wide variety of systems that use the ground, ground water, or surface water as a heat source and sink.

Moreover, following are the general categories of earth connection systems:

- Ground-Coupled Heat Pumps - use the ground as a heat source and sink, either with vertical or horizontal ground heat exchangers.

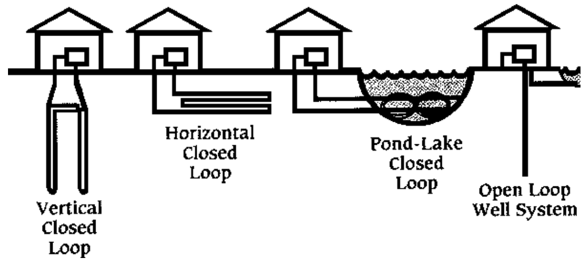

Figure 6: Common types of geothermal heat pump installations

Water Source-Coupled Heat Pumps - use underground (aquifer) water, surface water bodies (lakes, ponds, etc.) even sea water as a heat source and sink; Particular to resources in Indonesia, the abundant seawater and deep lake water resources could be an advantage. The net SPF (seasonal performance factor) of the system for all-year-round operation, considers the electricity consumed by the geothermal and water-resource supplying submersible pumps, the water circulating pumps in the heat pumps and building loops, and the fans of the air handling units and the fan coils.

(3) Heating/Cooling Distribution system.

The heating/cooling distribution system delivers heating or cooling from the heat pump to the building. It usually takes the form of an air duct distribution system, although water loop systems, which heat or cool floors and ceilings are also used.

Particular studies related to geothermal heat pump application in Indonesia, has never been conducted thus far. However, many practitioners believe that with several modifications to the extension loop modifications and adjustments towards the earth connection aspects, the application of geothermal heat pump in may perhaps be effective for several particular areas in Indonesia. For a starter, the geothermal heat pump system could be applied in locations where copious natural flowing brines occurs (.i.e. geothermal power plant vicinity, and downstream of hydrothermal areas) in which the the loops could be outspread simply in a channel of such flowing brines. The particular modified system would certainly not require expensive antifreeze-solutions as the United States, for instance, critically require.

Geothermal Wells

The 'geothermal well' terminology in this paper may turn out to be rather puzzling since in the geothermal heat pump system, the concerning term is also often been used to name the standing column wells that serve a groundwater-coupled heat pump system. Such ground-water coupled system consists of a vertical borehole that is filled with groundwater up to the level of the water table (i.e., similar construction to a domestic water well). Water is circulated from the well through the heat pump in an open loop pipe.

However, the geothermal well in this study refers to wells that corresponds to conventional hydrothermal wells or either enhanced geothermal system (EGS) wells, in which would not require such additional loop media of a heat pump system. Moreover, the geothermal wells are also largely associated to centralized distribution systems (district and space energy provisions) or individual distributed system that requires a large amount of heating/cooling (higher resource temperature and/or higher mass-rates). Therefore, the corresponding wells could be present as a single well, doublet system, multiple wells, depends on the required energy needed.

For instance, in1982, the city of Klamath Falls in The United States, built a geothermal district heating system to service downtown government buildings (Figure 7). The two production wells were located in an area of many private wells used for heating homes with down-hole heat exchangers (DHE).

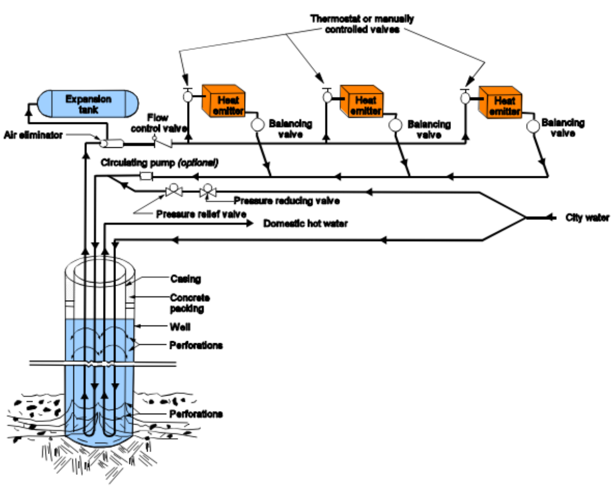

Figure 7: a simplified scheme of energy provisions required for district heating in Klamath Falls.

Particular to the potential application in Indonesia, hydrothermal resources and the high anomaly gradient temperatures of non-volcanic associated areas are both abundant throughout the country, in which the geothermal wells are supposed to be applicable anywhere.

Available Resource Type

Application in Locations with Hydrothermal Resources

Hydrothermal resources can be used for a variety of cooling and heating applications including district/space heating, agribusiness, horticulture, industrial and commercial uses. Additionally, spent fluids from geothermal electric plants can be subsequently used for direct-use applications in a so-called “cascaded” operation.

Hydrothermal resources, which range in temperature between about 70°F and 300°F, are typically accessed by drilling wells usually less than 500-feet deep. Deeper and hotter resources are used in electricity power generation. In a typical direct-use application, the well brings the heated water to the surface; a mechanical system—piping, heat exchanger and controls—delivers the heat to the space or process; and a disposal system either injects the cooled geothermal fluid underground or disposes of it on the surface.

Beside the brine or condensate water from the geothermal power generation activities, low-to moderate-temperature hydrothermal resources exist naturally throughout the eastern part of Indonesia and the outflow zones of high entalphy hydrothermal systems. In indonesia, the regarding outflow zones are usually located in the margin of a high entalphy hydrothermal system, in which occur high tourism activities—cottages, hotels, villas areas, plantation, aquaculture, farms and commercial areas—that also have extensive cooling and heating activities. This means, there are also a tremendous potential for new direct-use applications in these type of areas.

The application of geothermal cooling and heating in hydrothermal areas would require lower investment cost compared with locations with no natural hot water or temperature anomaly occurs. The lower capital cost is largely associated to lesser efforts carried out to obtain heat resource of a same temperature value required for a particular process or application. i.e. shallower well drilling depth, shorter length of extension loops, etc. Nevertheless, the application in hydrothermal areas would have extra technical issues to address. These technical issues will comprise production problems in related to the brine characteristics—scaling, corrossion, etc— and issues related to brine quality and supply—flow rate, temperature and pressure decline. The smaller market segment and application scale in hydrothermal areas is also an aspect to consider in terms of the investment returns and projected revenues.

Application in Non-Hydrothermal Resources

So far, utilisation of geothermal energy has been concentrated in areas of naturally occurring water or steam, and sufficient rock permeability. However, the vast majority of geothermal energy within drilling reach – which can be up to 5 km, given current technology and economics – is in relatively dry and low-permeability sub-surfaces.

However, the larger demand of heating and cooling in Indonesia, as also experienced by the leading geothermal heating & cooling countries, are available in non-hydrothermal associated areas, in which normal gradient anomaly occurs. The less preferrable temperature resource is pretty much believed to be easily offseted (compensated) by such far more larger potential market, .i.e. dense populated cities, capital cities, etc. It is also to be awared higher gradient anomaly presence in the Hot rock resources are believed to offer potential in Sumatra, Kalimantan and Papua. Technologies that allow energy to be tapped from the regarding subsurface conditions are experience to become commercially viable. The best-known such technology is enhanced geothermal systems (EGS).

<u>IDENTIFYING THE POTENTIAL BENEFITS FOR INDONESIA</u>

<u>Electricity Consumption Reduction</u>

Particular to heating applications by geothermal energy, comparisons are mostly made towards fossil fuel or gas energy heating source rather than to the un-efficient electric heaters. As a result, the energy savings-associated to fossil fuel/gas replacements, has always became the main talking point when it comes to geothermal heating. Meanwhile, particular to geothermal cooling, the comparisons are mostly done towards the conventional air-conditioners, in which the power consumption reduction are the main talking point. Moreover, leading countries of geothermal heating and cooling, in the likes of the United States and European Countries, have a larger demand of heating rather than cooling. In the heating mode, although heat pumps use less energy, they use higher electrical energy, in which is several times more expensive than natural gas. Contrarily, in the cooling mode heat pump use lesser electrical energy. Thus, such tradeoff could perhaps explain why literatures, from the leading countries in geothermal heating and cooling, that discuss about power reduction comparisons are somehow limited.

In countries with excessive demands of cooling, in the likes of Indonesia, Thailand, Vietnam, Singapore, India, Middle East Countries, etc. The reduction of power consumption is the major advantageous feature instead.

Moreover, experienced from the implementation of geothermal coolings in Mumbai, India, it has been reported that they managed to obtain substantial electricity consumption reduction to around 60-80% cutted from the previous conventional use. The cooling application elsewhere also shows a similar value of power use reduction, in which supposed to have a signifantly lower energy bills. Geothermal cooling and heating systems are most-effective if applied for new constructed buildings or considered as a direct replacement to the conventional existing cooling or heating system. But if considered only to be an addition to the existing cooling system, the expected electricity consumption reduction will be slightly lower.

The Demand-Side Management

The adverse impacts resulted by the current gaping gap of electricity, such as the periodical and spontaneous black outs has been occured more often lately. The growth of electricity demand has not been able to be matched by the power generation development. Therefore we could face more major setbacks if we keep only focusing on the aggressive efforts of geothermal power generation development—supply side management—instead to carry out a more likely demand-side management approach. The regarding demand side management approach, mainly focus in energy efficiency and electricity use reduction. The respective ability of geothermal cooling and heating to provide a momentous number power consumption reduction, is in line to the regarding demand-side management campaign. Moreover, by such implementation of geothermal cooling and heating, there will be an opportunity to shift the peak load periods, in which supposed to result a lower electricity generation price. Also important to consider is the secondary benefits resulted by the power use reduction, is that the slightly reduced urgency in power generation development, would also offer:

- Lesser investations for transmission lines
- Lesser electricity subsidies to burden (.e.g. margins in the feed-in-tariff)

Further obtained from this study, a hypothetical number of <u>1200-1600 MW</u> with an annual increase of 4% power load shifted by mass application of geothermal heating and cooling in Indonesia, majorly contributed from dense-populated cities, e.g. Jabodetabek, Surabaya, Medan, Denpasar, Bandung, Jogjakarta, Ujung Pandang, Balikpapan, Duri, Jayapura and Halmahera.

Cost Savings

The upfront costs of geothermal will be more than conventional cooling and heating systems, but the savings are very substantial. There should be hardly any operating and maintenance costs throughout the lifetime of the geothermal system. And, as energy prices continue to rise, the investment return gets better and better. Assuming that the specific system is suited to the climate and usage patterns, and that the system is properly installed and maintained, the higher installation costs are quickly offset by the savings in energy costs.

According to the U.S. Environmental Protection Agency, such geothermal systems save homeowners 30–70 percent in heating costs, and 20 –50 percent in cooling costs, compared to conventional systems. The cooling applications by geothermal in the harsh scorching climate of India has also experience savings around 40-70 percent. Moreover, it supposed to be an extremely easy task to find such identical saving experiences elsewhere around the world.

If heating is the dominant energy requirement—cold and mild climates—then low electricity prices and high gas or oil prices will make the geothermal system more attractive than the corresponding combustion systems. If cooling is dominant—subtropical and tropical climates—then high electricity prices will favour such geothermal systems over conventional air conditioning, which is less efficient. Moreover, if both heating and cooling requirements are high, then geothermal systems are ideal where electricity prices are low year round, but high peak load charges are levied during summertime.

Particular to the potential applications in Indonesia, the specific electricity tariff in Indonesia for each different segments of users, has made the potential obtained cost savings in Indonesia ranges widely. At some point in the future, geothermal cooling and heating costs in Indonesia could actually be substantially lower since antifreeze solutions are un-necessary and the material used should not be as complicated as required in locations where high seasonal changes occur.

Potential Wider Market

The general direct geothermal use market in Indonesia has never experienced a great spell of development. Cited to be source of the bottlenecks, the pricing and security of investment for direct geothermal use issues, remain least prioritized in the geothermal development campaign.

Table 2: Geothermal heating and cooling applications brings potential wider market segment

	Target & Locations	Geothermal Areas				Non-geothermal Areas						
						Rural Areas				Remote Areas		
		C SR Programs	Small Scale Industries	Tourism & Resort Areas	Power Developers	Large Commercial Areas	Public & Residential Areas	Industrial Areas	Government Facilities	Small Scale Industries	Large Scale Industries	Tourism & Resort Areas
Direct Use Applications	Current	V	V	-	-	-	-	-	-	-	-	-
	Expected	V	V	V	V	V	V	V	V	V	V	V

Regarding to the experience worldwide, the awareness towards direct geothermal use benefits, for instance in cold climate countries, the benefits of snow melting and building heating are enjoyed by every social segment of people community of their countries. This is contrary to the fact that in Indonesia, direct use development has been fairly limited to Corporate Social Responsibility Response (CSR) of the power generating developers.

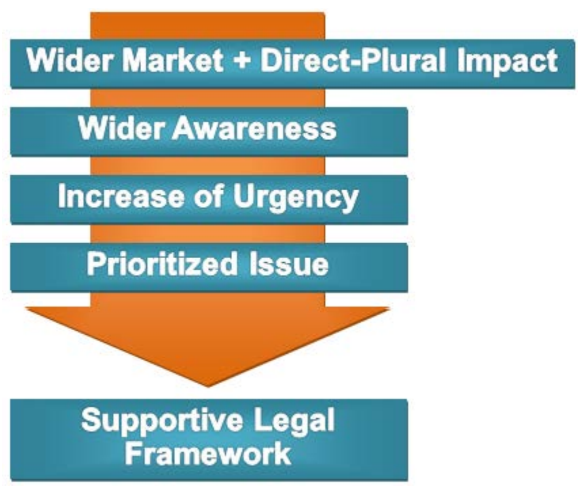

Figure 8: Steps for direct geothermal use to obtain supportive legal framework through geothermal cooling and heating applications

Emmission Reduction

The major comparison left and the main purpose of this paper is to look at the environmental affects of the two systems. Today more than ever it is vital to be earth and environment conscious, protecting the earth from harmful greenhouse gasses, pollution to the air or ground, and assessing the required resources consumed by the various systems.

Using geothermal energy for heating activities obviously replaces fossil fuel use and prevents the emission of greenhouse gases. Meanwhile using geothermal energy for heating activities also replaces freon use of an conventional air conditioning system. However, geothermal heating and cooling technologies still rely on electricity to operate and given the area where the house being tested in this paper was built, the majority of its power comes from coal burning plants that produce greenhouse gasses. Given the efficiency of the system however it still results in a significant reduction in the amount of CO_2 to the environment

Measures for Urban Heat Island Effect

Jakarta, along with a number of capital cities worldwide, are facing a large threat in terms of their environmental conditions, the Urban Heat Island Effect. The freon produced from conventional cooling systems, along with the pollution from vehicles are the main contributors to the respective circumstances. Meanwhile, the air conditioning market is still growing in a significant manner, in which could escalate the impact of the Urban Heat Island Efffect in Jakarta. Again, since air conditioning systems emit large amounts of chlorofluorocarbons, or greenhouse gases, geothermal cooling prevents their emission into the atmosphere.

POTENTIAL BARRIERS

High Upfront Costs

Although having to said brings significantly lower overall life-time costs and more substantial savings that will promptly offset the initial investments, the high upfront cost is one of the—worldwide findings—major drawbacks of the geothermal system when compared to a conventional standard forced air furnace and air conditioning unit. Should applied in Indonesia, the regarding issue may also impact heavier, in which a greater effort will be required to deal with a broader community to be convinced compared to the geothermal power generation campaign. Experienced worldwide that public awareness program conducted early in the planning process, along with the set of incentives and subsidies schemes to support the campaign development, has tremendously encourage the geothermal heating and cooling applications in their countries.

Low Acceptance in Early Development Stages

As experienced worldwide, we should not expect a smooth smart at the early development stages of the implementation of geothermal heating & cooling in Indonesia. The adoption process of such required technologies will perhaps depends on the accomplishment of the public awareness programs. These public awareness campaign should also comprise the strategies to deal with the counter-corresponding energy source, for instance, conventional air-conditioner providers. Therefore, a joint operation team for development that consist the government, counter-corresponding energy company and state-owned company would perhaps to be an alternative option.

Moreover, when it comes to the comparisons of cooling & heating by various renewable energy sources, especially when you bring this topic in the likes of US and European countries, we will find “fierce warfare” of contentious arguments regarding to the best technology option to use. Hence, neutral perspectives suggest several general considerations prior to decision-making, e.g. the location (number of sunny days, wind, climate, space available), energy demand, financial expectations and the applied policy. It even turns out that in order to maximize the delivery of renewable energy, it makes economic sense to couple expensive renewable electricity to ground coupled heat pumps as quickly as possible, for instance, heating ventilation air conditioning (HVAC) by jointly geothermal and seawater or geothermal with photovoltaic arrays. Simple to say that if the electricity can be generated from renewable sources in the first place, then all of the delivered energy is renewable. Nevertheless, many believe that energy efficiency should come before renewable energy campaign.

Low Energy Efficient Infrastructures

An analogy in healthcare is to treat the cause instead of focusing on the symptoms. Both are important and necessary, but it does not make a lot of sense to invest substantially in solar or other alternative energy only to throw it out the window through a poorly designed and constructed building envelope. If you focus on reducing your energy needs first, it makes your investment in renewables more valuable because the same amount of generation will cover a greater percentage of your home’s needs. However, most conditions of buildings in Indonesia are low energy efficient, in which are mostly poor insulated and highly exposed to sun radiation. Afterall, geothermal cooling and heating systems are most-effective applied for new constructions.

DISCUSSIONS & ON-GOING STUDIES

Having reviewed the benefits experienced worldwide, geothermal heating and cooling has a promising market in Indonesia that would potentially provide numerous benefits and advantageous features to the national geothermal development campaign. Thus, obtained from this study, a hypothetical number of 1200-1600 MW with an annual increase of 4% potential power load shifted by mass application of geothermal heating and cooling in Indonesia

Beside an integrated feasibility study regarding to such application, we are now sizing up demonstration projects in four cities, in which we believe could represent the unique characteristics of Indonesia.

Specific Research Category	Nominated Location for Demonstration Project
Dense Populated Thermal Areas	Ciater
Less Populated Thermal Areas	Lahendong Geothermal Area
Dense Populated Non-thermal Areas	Jakarta
Less Populated Non-thermal Areas	Bali

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