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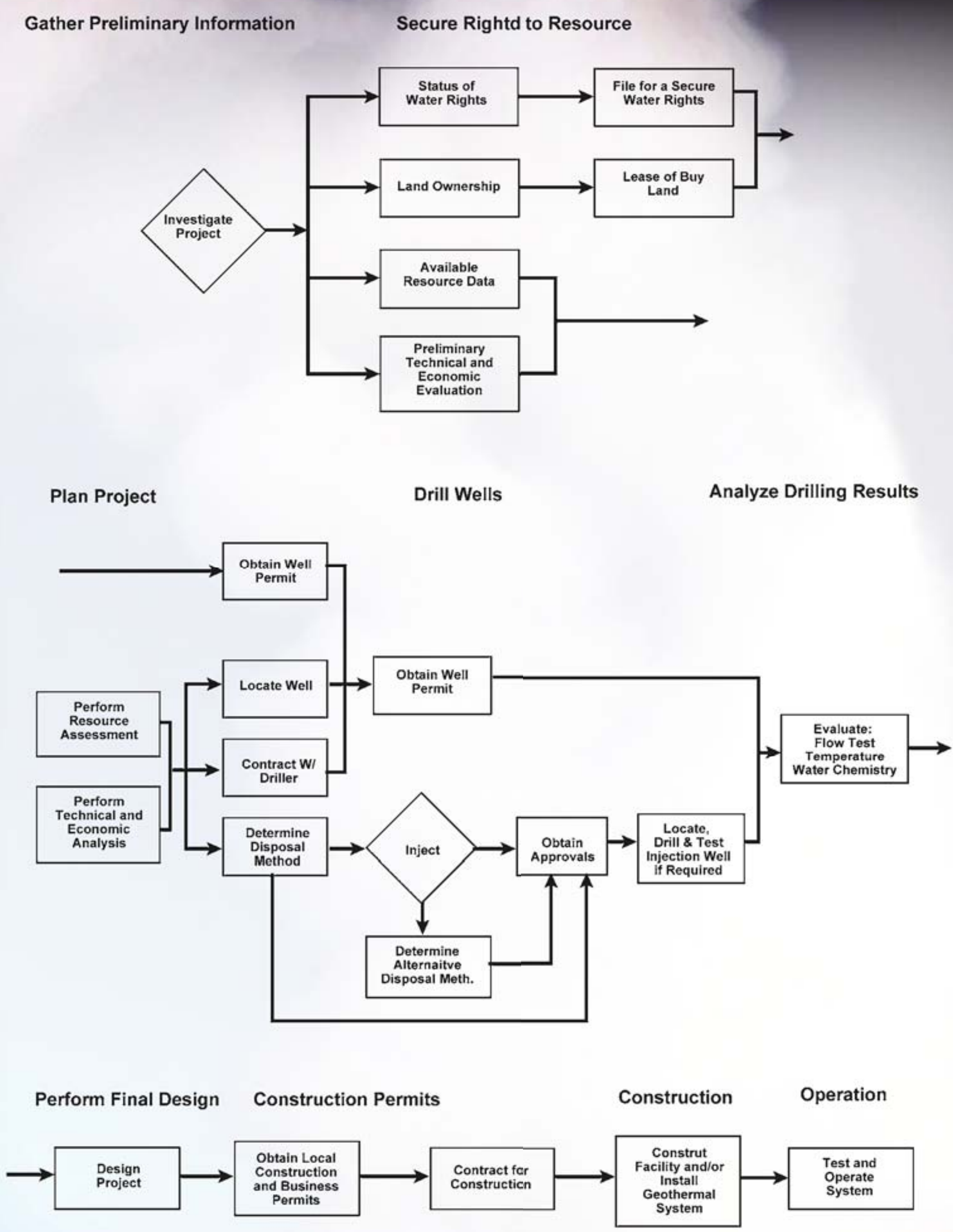

DEVELOPMENT OF DIRECT USE PROJECTS

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A Quarterly Progress and Development Report on the Direct Utilization of Geothermal Resources

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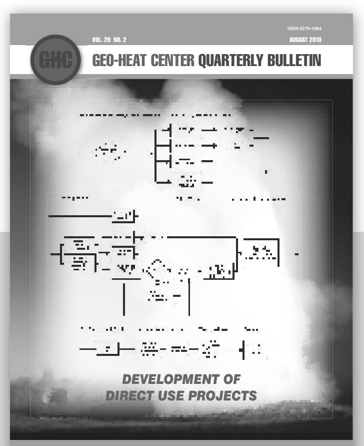

Cover - Direct-use development flow chart

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DEVELOPMENT OF DIRECT-USE PROJECTS

John W. Lund, Geo-Heat Center, Oregon Institute of Technology

INTRODUCTION

A geothermal direct-use project utilizes a natural resource – a flow of geothermal fluid at elevated temperatures, which is capable of providing heat and/or cooling to buildings, greenhouses, aquaculture ponds and industrial process (Lienau, 1998). Geothermal utilization requires a unique blending of skills to located and access a resource, and to concurrently match the varied needs of the user in order to develop a successful project. Each resource development project is unique, and the flow chart (Figure 1) of typical activities can serve as a guideline of logical steps to implement a project. The development of a project should be approached in phases so as to minimize risk and costs. The size of the project determines the amount of exploration and development of the resource that can be economically justified. For heating a single home the risk is high, as outside of gathering data on adjacent hot springs, wells and use, the well becomes the exploration tool and hopefully provides the necessary energy to the project. Larger projects, such as district heating and industrial applications can justified more investigation to better characterize the resource and thus reduce the risk.

The first phase generally involves securing rights to the resource. This includes information on ownership, leasing, agencies involved, water rights, injection requirements, competition with adjacent geothermal users, and any potential royalty payments. The second phase involves interdisciplinary activities of geology, geochemistry, geophysics, drilling and reservoir engineering. These exploration activities are usually expensive and often the economics of a direct-use activity will not support an extensive program. However, a minimum of exploration and resource characteristics that are necessary would include depth to the resource, temperature, flow-rate, drawdown and chemistry of the fluid to provide information to determine if a project is feasible and will meet the needs of the proposed activity.

The preliminary and conceptual design of a direct-use project could start during the reservoir testing and evaluation, however, depending on the risk and financing issues, the phase may have to wait until the reservoir characteristics are confirmed. During the design phase special consideration must be given to the design and selection of equipment such as well pumps, piping, heat exchangers and space heating equipment. The cost of all these pieces of equipment must be considered, along with potential corrosion and scaling problem, to make the project viable.

SELECTING THE POTENTIAL USE OF THE RESOURCE

One of the frequently asked questions the Geo-Heat Center gets is "I have this resource, what can I do with it?" The answer has many parts to it: (1) what is the estimated (or known) temperature and flow rate of the resource, (2) what is the chemistry of the resource, (3) what potential markets do you have for the energy, and what would be the expected income, (4) do you have the experience, or are you willing to hire experienced people to run the project, (5) do you have financing and is the estimated net income enough to justify the investment, and (6) do you own or can you lease the property and the resource, and are there limitations on its use.

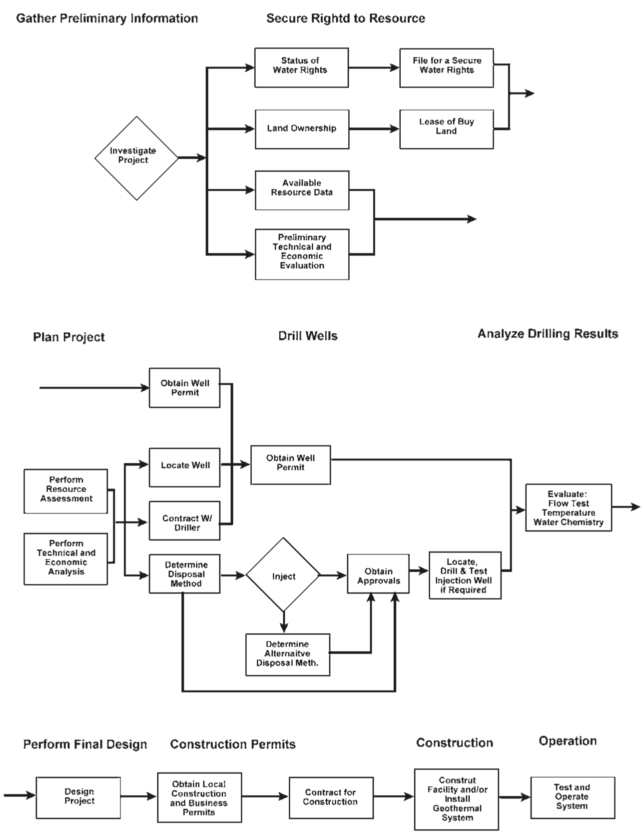

Figure 1: Direct-use development flow chart.

Figures 2 and 3 are examples of charts that can be used to match resource temperature with potential uses, and can be used to narrow the choices. A brief discussion of some of the more common uses is presented below.

Spas and Pools

People have used geothermal and mineral waters for bathing and their health for thousands of years. Balneology, the practice of using natural mineral water for the treatment and cure of disease, also has a long history. A spa originates at a location mainly due to the water from a spring or well. The water, with certain mineral constituents and often warm, give the spa certain unique characteristics that will attract customers. Associated with most spas is the use of muds (peoloids) which either is found at the site or is imported from special locations. Drinking and bathing in the water, and using the muds are thought to give certain health benefits to the user. Swimming pools have desirable temperature at 27˚C; however, this will vary from culture to culture by as much as 5˚C. If the geothermal water is higher in temperature, then some sort of mixing or cooling by aeration or in a holding pond is required to lower the temperature, or it can first be used for space heating, and then cascaded into the pool. If the geothermal water is used directly in the pool, then a flow through process is necessary to replace the "used" water on a regular basis. In many cases, the pool water must be treated with chlorine, thus, it is more economical to use a closed loop for the treated water and have the geothermal water provide heat through a heat exchanger (Lund, 2000).

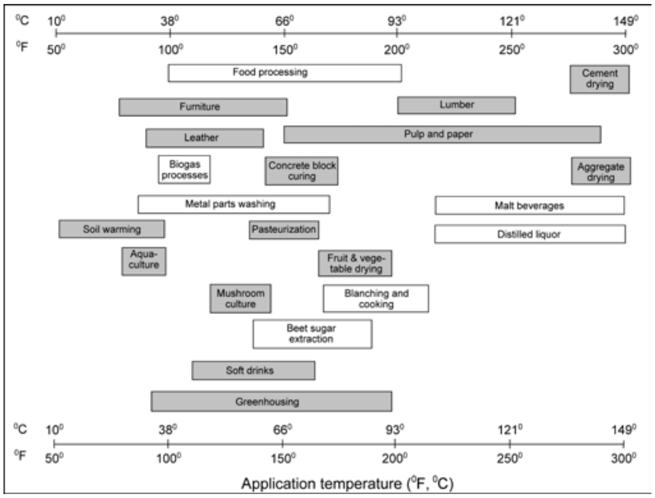

Figure 2: Examples of industrial applications of geothermal energy, with the colored bars indicating those currently using geothermal energy in the world.

Space and District Heating

District heating involves the distribution of heat (hot water or steam) from a central location, through a network of pipes to individual houses or blocks of buildings. The distinction between district heating and space heating systems, is space heating usually involves one geothermal well per structure. An important consideration in district heating projects is the thermal load density, or the heat demand divided by the ground area of the district. A high heat density, generally above 1.2 GJ/hr/ha or a favorability ratio of 2.5 GJ/ha/yr is recommended. Often fossil fuel peaking is used to meet the coldest period, rather than drilling additional wells or pumping more fluids, as geothermal can usually meet 50% of the load 80 to 90% of the time, thus improving the efficiency and economics of the system (Bloomquist, et al. 1987). Geothermal district heating systems are capital intensive. The principal costs are initial investment costs for production and injection wells, downhole and circulation pumps, heat exchangers, pipelines and distribution network, flow meters, valves and control equipment, and building retrofit. The distribution network may be the largest single capital expense, at approximately 35 to 75% of the entire project cost. Operating expenses, however, are in comparison lower and consists of pumping power, system maintenance, control and management. The typical savings to consumers range from approximately 30 to 50% per year of the cost of natural gas (Lienau, 1998).

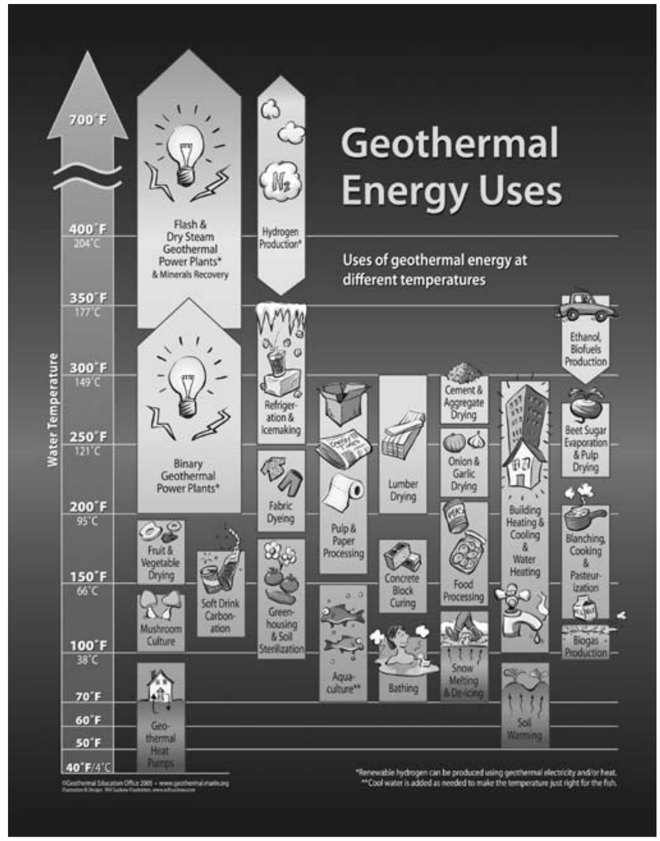

Figure 3: Various geothermal uses, including power generation and direct-use related to their appropriate temperature range (courtesy of Geothermal Education office).

Greenhouses

A number of commercial crops can be raised in greenhouses, making geothermal resources in cold climates particularly attractive. Crops include vegetables, flowers (potted and cut), house plants, and tree seedlings. Greenhouse heating can be accomplished by several methods: finned pipe, unit heater and fan coil units delivering heat though plastic tubes in the ceiling or under benches, radiant floor systems, bare tubing, and a combination of these methods. The use of geothermal energy for heating can reduce operating costs and allow operation in colder climates where commercial greenhouses would not normally be economical. Economics of a geothermal greenhouse operation depends on many variables, such as type of crop, climate, resource temperature, type of structure, market, etc. Peak heating requirements in temperate climate zone are around 1.0 MJ/sq. m, and a 2.0 ha facility would require 20 GJ/yr (5.5 MWt) of installed capacity. With a load factor of 0.50, the annual energy consumption would be around 90 TJ/yr (25 million kWh/yr).

Aquaculture

Aquaculture involves the raising of freshwater or marine organisms in a controlled environment to enhance production rates. The principal species raised are aquatic animals such as catfish, bass, tilapia, sturgeon, shrimp, and tropical fish. The application temperature in fish farming depends on the species involved, ranging from 13 to 30˚C, and the geothermal water can be used in raceways, ponds and tanks. The benefit of a controlled rearing temperature in aquaculture operations can increase growth rated by 50 to 100%, and thus, increasing the number of harvest per year. A typical outdoor pond in a temperature climate zone would require 2.5 MJ/hr/sq. m, and a 2.0 ha facility would require an installed capacity of 50 GJ/yr (14 MWt). With a load factor of 0.60, the annual heating requirement would be 260 TJ/yr (73 million kWh/yr). Water quality and disease control are important in fish farming and thus, need to be considered when using geothermal fluids directly in the ponds.

Industrial

Industrial applications mostly need the higher temperature as compared to space heating, greenhouses and aquaculture projects. Examples of industrial operations that use geothermal energy are: heap leaching operations to extract precious metals in the USA (110˚C), dehydration of vegetables in the USA (130˚C), diatomaceous earth drying in Iceland (180˚C), and pulp and paper processing in New Zealand (205˚C). Drying and dehydration may be the two most important process uses of geothermal energy. A variety of vegetable and fruit products can be considered for dehydration at geothermal temperatures, such as onions, garlic, carrots, pears, apples and dates. Industrial processes also make more efficient use of the geothermal resources as they tend to have high load factors in the range of 0.4 to 0.7. High load factors reduce the cost per unit of energy used as indicated in Figure 4.

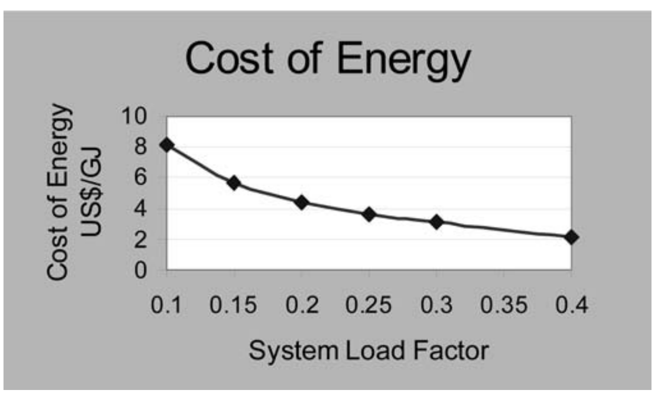

Figure 4: Load factor vs. cost of energy (Rafferty, 2003).

SELECTING THE EQUIPMENT

It is often necessary to isolate the geothermal fluid from the user side to prevent corrosion and scaling. Care must be taken to prevent oxygen from entering the system (geothermal water normally is oxygen free), and dissolved gases and minerals such a boron, arsenic, and hydrogen sulfide must be removed or isolated as they are harmful to plants and animals. On the other hand carbon dioxide, which often occurs in geothermal water, can be extracted and used for carbonated beverages or to enhance growth in greenhouses. The typical equipment for a direct-use system is illustrated in Figure 5, and includes, downhole and circulation pumps, heat exchangers (normally the plate type), transmission and distribution lines (normally insulated pipes), heat extraction equipment, peaking or back-up plants (usually fossil fuel fired) to reduce the use of geothermal fluids and reduce the number of wells required, and fluid disposal systems (injection wells). Geothermal energy can usually meet 80 to 90% of the annual heating or cooling demand, yet only sized for 50% of the peak load.

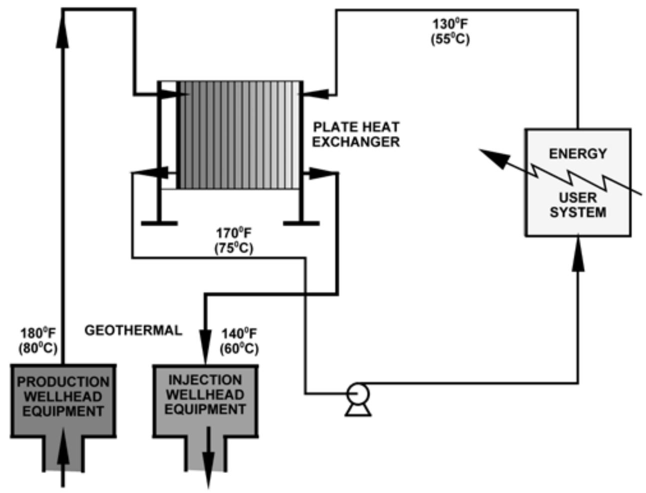

Figure 5: Typical direct use geothermal heating system configuration.

Downhole Pumps

Unless the well is artesian, downhole pumps are needed, especially in large-scale direct utilization system. Downhole pumps may be installed not only to lift fluid to the surface, but also to prevent the release of gas and the resultant scale formation. The two most common types are line shaft pump systems and submersible pump systems. The line shaft pump system consists of a multi-stage downhole centrifugal pump, a surface mounted motor and a long driveshaft assembly extending from the motor to the pump bowls. Most are enclosed, with the shaft rotating within a lubrication column which is centered in the production tubing. This assembly allows the bearings to be lubricated by oil, as hot water may not provide adequate lubrication. A variable-speed (frequency) drive set just below the motor on the surface, can be used to regulate flow instead of just turning the pump on and off. The electric submersible pump system consists of a multistage downhole centrifugal pump, a downhole motor, a seal section (also called a protector) between the pump and motor, and electric cable extending from the motor to the surface electricity supply. Both types of downhole pumps have been used for many years for cold water pumping and more recently in geothermal wells (line shafts have been used on the Oregon Institute of Technology campus in 89˚C water for 55 years). If a line shaft pump is used, special allowances must be made for the thermal expansion of various components and for oil lubrication of the bearings. The line shaft pumps are preferred over the submersible pump in conventional geothermal applications for two main reasons: the line shaft pump cost less, and it has a proven track record. However, for setting depths exceeding about 250 m, a submersible pump is required.

Piping

The fluid state in transmission lines of direct-use projects can be liquid water, steam vapor or a two-phase mixture. These pipelines carry fluids from the wellhead to either a site of application, or a steam-water separator. Thermal expansion of metallic pipelines heated rapidly from ambient to geothermal fluid temperatures (which could vary from 50 to 200˚C) causes stress that must be accommodated by careful engineering design. The cost of transmission lines and the distribution networks in direct-use projects is significant. This is especially true when the geothermal resource is located at great distance from the main load center; however, transmission distances of up to 60 km have proven economical for hot water (i.e., the Akranes project in Iceland–Ragnarsson and Hrolfsson, 1998), where asbestos cement covered with earth has been successful. Carbon steel is now the most widely used material for geothermal transmission lines and distribution networks; especially if the fluid temperature is over 100˚C. Other common types of piping material are fiberglass reinforced plastic (FRP) and asbestos cement (AC). The latter material, used widely in the past, cannot be used in many systems today due to environmental concerns; thus, it is no longer available in many locations. Polyvinyl chloride (PVC) piping is often used for the distribution network and for uninsulated waste disposal lines where temperatures are well below 100˚C. Cross-linked polyethylene pipe (PEX) have become popular in recent years as they can tolerate temperatures up to 100˚C and still take pressures up to 550 kPa. However, PEX pipe is currently only available in sizes less than 5 cm in diameter. Conventional steel piping requires expansion provisions, either bellows arrangements or by loops. A typical piping installation would have fixed points and expansion points about every 100 m. In addition, the piping would have to be placed on rollers or slip plates between points. When hot water metallic pipelines are buried, they can be subjected to external corrosion from groundwater and electrolysis. They must be protected by coatings and wrappings. Concrete tunnels or trenches have been used to protect steel pipes in many geothermal district heating systems. Although expensive (generally over U.S.$300 per meter of length), tunnels and trenches have the advantage of easing future expansion, providing access for maintenance and a corridor for other utilities such as domestic water, waste water, electrical cables, phone lines, etc.

Supply and distribution systems can consist of either a single-pipe or a two-pipe system. The single-pipe is a once-through system where the fluid is disposed of after use. This distribution system is generally preferred when the geothermal energy is abundant and the water is pure enough to be circulated through the distribution system. In a two-pipe system, the fluid is recirculated so the fluid and residual heat are conserved. A two-pipe system must be used when mixing of spent fluids is called for, and when the spent cold fluids need to be injected into the reservoir. Two-pipe distribution systems cost typically 20 to 30 percent more than single-piped systems.

The quantity of thermal insulation of transmission lines and distribution networks will depend on many factors. In addition to minimizing the heat loss of the fluid, the insulation must be waterproof and water tight. Moisture can destroy the value of any thermal insulation and cause rapid external corrosion. Aboveground and overhead pipeline installations can be considered in special cases but considerable insulation is achieved by burying hot water pipelines. For example, burying bare steel pipe results in a reduction in heat loss of about one-third as compared to above ground in still air. If the soil around the buried pipe can be kept dry, then the insulation value can be retained. Carbon steel piping can be insulated with polyurethane foam, rock wool or fiberglass. Below ground, such pipes should be protected with polyvinyl chloride (PVC) jacket; aboveground, aluminum can be used. Generally, 2.5 to 10 cm of insulation is adequate. In two-pipe systems, the supply and return lines are usually insulated; whereas, in single-pipe systems, only the supply line is insulated. At flowing conditions, the temperature loss in insulated pipelines is in the range of 0.1 to 1.0˚C/km, and in uninsulated lines, the loss is 2 to 5˚C/km (in the approximate range of 5 to 15 L/s flow for 15-cm diameter pipe) (Ryan 1981). It is less for larger diameter pipes. For example, less than 2˚C loss is experienced in the new aboveground 29 km long and 80 and 90 cm diameter line (with 10 cm of rock wool insulation) from Nesjavellir to Reykjavik in Iceland. The flow rate is around 560 L/s and takes seven hours to cover the distance. Uninsulated pipe costs about half of insulated pipe, and thus, is used where temperature loss is not critical. Pipe material does not have a significant effect on heat loss; however, the flow rate does. At low flow rates (off peak), the heat loss is higher than as greater flows. Figure 6 shows fluid temperatures, as a function of distance, in a 45-cm diameter pipeline, insulated with 50 cm of urethane foam.

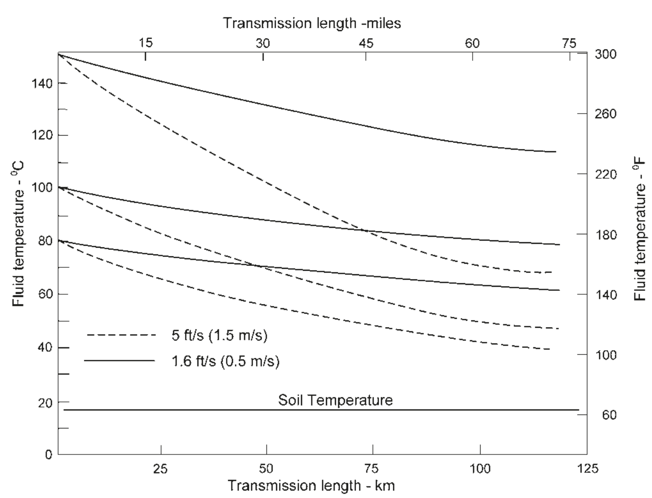

Figure 6: Temperature drop in hot water transmission line.

Steel piping is used in most case, but FRP or PVC can be used in low-temperature applications. Aboveground pipelines have been used extensively in Iceland, where excavation in lava rock is expensive and difficult; however, in the USA, below ground installations are more common to protect the line from vandalism and to eliminate traffic barriers. A detailed discussion of these various installations can be found in Gudmundsson and Lund (1985).

Heat Exchangers

The principal heat exchangers used in geothermal systems are the plate, shell-and-tube, and downhole types. The plate heat exchanger consists of a series of plates with gaskets held in a frame by clamping rods. The counter-current flow and high turbulence achieved in plate heat exchangers provide for efficient thermal exchange in a small volume. In addition, they have the advantage when compared to shell-and-tube exchangers, of occupying less space, can easily be expanded when addition load is added, and cost 40% less. The plates are usually made of stainless steel although titanium is used when the fluids are especially corrosive. Plate heat exchangers are commonly used in geothermal heating situations worldwide. Shell-and-tube heat exchangers may be used for geothermal applications, but are less popular due to problems with fouling, greater approach temperature (difference between incoming and outgoing fluid temperature), and the larger size. Downhole heat exchangers eliminate the problem of disposal of geothermal fluid, since only heat is taken from the well, however, their use is limited to small heating loads such as the heating of individual homes, a small apartment building or business. The exchanger consists of a system of pipes or tubes suspended in the well through which secondary water is pumped or allowed to circulate by natural convection. In order to obtain maximum output, the well must be designed to have an open annulus between the wellbore and casing, and perforations above and below the heat exchanger surface. Natural convection circulates the water down inside the casing, through the lower perforations, up in the annulus and back inside the casing through the upper perforations (Culver and Lund, 1999). The use of a separate pipe or promoter, has proven successful in older wells in New Zealand to increase the vertical circulation (Dunstall and Freeston 1990).

Convectors

Heating of individual rooms and buildings is achieved by passing geothermal water (or a heated secondary fluid) through heat convectors (or emitters) located in each room. The method is similar to that used in conventional space heating systems. Three major types of heat convectors are used for space heating: 1) forced air, 2) natural air flow using hot water or finned tube radiators, and 3) radiant panels. All these can be adapted directly to geothermal energy or converted by retrofitting existing systems.

DIRECT-USE TEMPERATURE REQUIREMENTS

The design of mechanical systems involving heat transfer, such as direct-use geothermal systems, is heavily influenced by temperature. Temperature difference (delta T or ΔT) is particularly important as it frequently governs feasibility, equipment selection and flow requirements for the system. Rafferty (2004) addresses these issues with several "rules of thumb" that are described below. He introduces the material with the following discussion:

Two primary temperature differences govern feasibility, flow requirements and design of direct-use equipment. These are illustrated in a simplified way in Figure 7. The first is the difference between the geothermal temperature entering the system (Tge) and the process temperature (Tp). This difference determines whether of not the application will be feasible. For a direct-use project, the temperature of the geothermal entering the system must be above the temperature of the process in order to transfer heat out of the geothermal water and into the process (aquaculture pond, building, greenhouse, etc). Beyond that, it must be sufficiently above the process to allow the system to be constructed with reasonably sized heat transfer equipment. The greater the temperature difference between the geothermal resource and the process, the lower the cost of heat exchange equipment. The key question is how much above the process temperature does the geothermal need to be for a given application.

The second temperature difference is the one between the geothermal entering the system and leaving the system (Tgo in Figure 7). This determines the geothermal flow rate necessary to meet the heat input requirement of the application. The greater the temperature difference between the entering and leaving temperatures, the lower the geothermal flow required. Obviously, the resource temperature is fixed. The process temperature plays a role as well since the leaving geothermal temperature cannot be lower than the process temperature to which it is providing heat. In addition, the specifics of the application and the heat transfer equipment associated with it also influence the temperature required. There are two broad groups of applications with similar characteristics in terms of heat transfer–aquaculture and pools, greenhouses and building space heating.

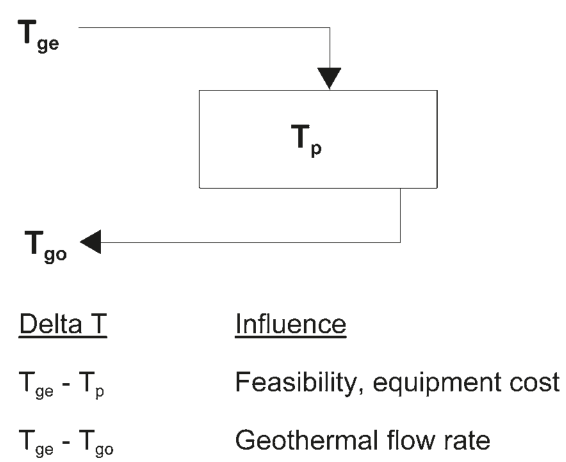

Figure 7: Fundamental direct-use temperature differences (Rafferty, 2004).

Pool and Aquaculture Pond Heating

Pond and pool heating is one of the simplest geothermal applications, as it usually uses the geothermal water directly in the pond/pool to provide the required heat demand. This is illustrated in Figure 8 (Rafferty, 2004), where 50˚C geothermal water is supplied to heat the pool water to 30˚. Thus, the ΔT is 20˚C, and using a flow rate of 10 L/s, the energy supplied would be 837 kW (3.0 GJ/hr) (kW = L/s x ΔT x 4,184). If the supply temperature were instead 40˚C the flow rate would have to be doubled to provide the same amount of energy, and four times at 35˚C, and eight times at 32.5˚C.

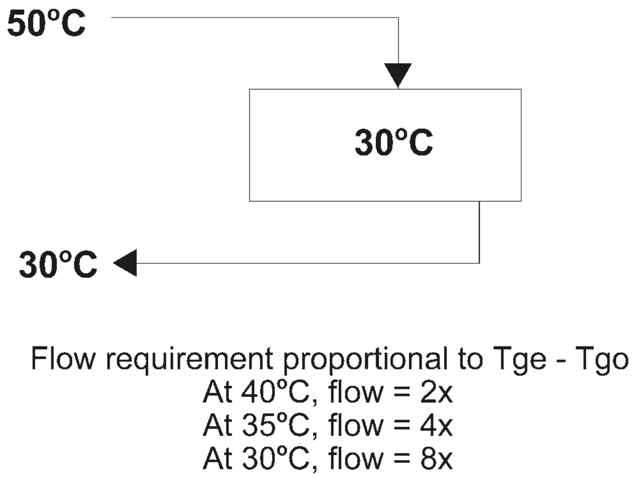

Figure 8: Direct pool/pond heating (modified from Rafferty, 2004).

If the geothermal water cannot be used directly, due to health restrictions, then a heat exchanger is necessary to heat treated water for the pond or pool. Following the "rule of thumb" that the heated water to the pool should be 10˚C above the pool temperature, then according to the previous example 40˚C secondary water would have to be provided to the pool. Using a heat exchanger between the geothermal water and the secondary water an additional ΔT of 5˚C is required to accommodate the heat transfer between the geothermal water and the secondary water. Thus 45˚C geothermal water would be required, and on the return side of the heat exchanger the geothermal reject fluid should be 5˚C above the return temperature of the secondary water. Thus, the rule of thumb is "10-5-5" as listed below in Figure 9.

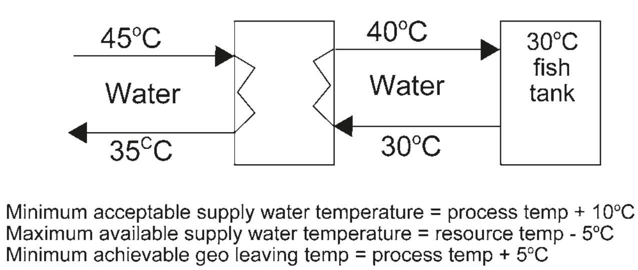

Figure 9. Pond/pool heating with heat exchanger (modified from Rafferty, 2004).

Greenhouse and Building Space Heating

Heating of greenhouses and building often involves the transfer of heat to the air in the structure using a water-to-air heat exchanger called a coil, usually consisting of finned copper tubes (Rafferty, 2004). The simplest version of this application is shown in Figure 10. In order to heat the space, heated air should be delivered at least 15˚C above the space temperature, 20˚C shown in this example. Thus the air should be delivered at 35˚C or above from the water to the coil. The reason for the large difference of 15˚C is to limit the required quantity of air circulated to meet the heating requirements at reasonable levels. Also, as the difference becomes less, the fan and duct sizes become large and the fan power consumption can be excessive. In addition, occupant comfort is important, as when the air supply drops below the 15˚C difference, the temperature of the air approaches human skin temperature, which results in a "drafty" sensation to the occupants, even at the desired air temperature. In addition, the geothermal water delivered to the water-to-air heat exchangers should be at least 10˚C above the require air temperature to limited the size and cost of this heat exchanger – usually a coil type. The same ΔT is required between the leaving geothermal water and the return air temperature. Thus, to supply 20˚C heat to the room, a geothermal resource temperature would have to be at least 45˚C. The "rule of thumb" for this condition is then 15/10/10 as shown in Figure 10.

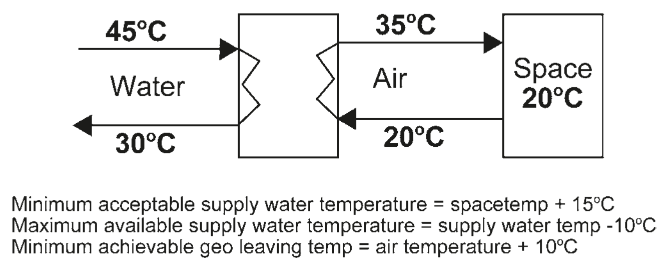

Figure 10. Space heating without isolation heat exchanger (modified from Rafferty, 2004).

The example above assumes that the geothermal water is suitable to flow directly through the water-to-air heat exchanger (coil); however, if hydrogen sulfide is present, then this gas will attack copper and solder in the coil and cause leakage and failure to the unit. Thus, in the case where the geothermal must be isolated from the heating system equipment, a plate heat exchanger is normally placed between the two circuits to protect the heating equipment (Rafferty, 2004). A plate heat exchanger is then added to the left side of the equipment shown in Figure 10 and resulting in the configuration shown in Figure 11. All the temperatures shown in Figure 10 are still valid; the difference is that the plate heat exchangers will require additional temperature input to maintain the space (home) temperature of 20˚C. As in the previous example a ΔT of 5˚C is required between the geothermal supply and the output from the secondary water. Thus, the new geothermal temperature required to meet the needs of the system is 50˚C. The return geothermal water can only be cooled to 35˚C as a result of the intermediate water loop return temperature of 30˚C and the required 5˚C ΔT. This then provides of "rule of thumb: of 15/10/5 as described below Figure 11.

In summary, the following is provided by Rafferty (2004):

"All of the rules of thumb discussed here are exactly that. It is possible in all cases to "bend the rules," and design systems and equipment for temperatures closer than the guidelines provided above. The values provided here are intended for initial evaluation of applications by those not in the practice of designing heating systems on a regular basis. The guidelines cited apply to new systems using commercially manufactured equipment. Homemade heat exchangers or existing equipment selected for water temperatures well above available geothermal temperature would require additional analysis."

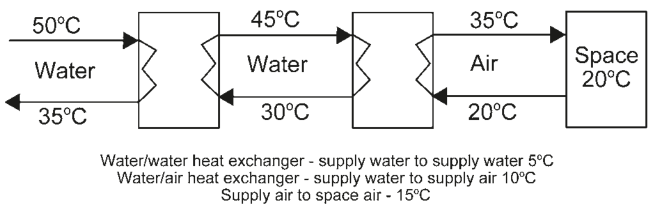

Figure 11. Space heating 15/10/5 rule with geothermal isolation plate heat exchanger (modified from Rafferty, 2004).

CONCLUSIONS

There are many possible uses of geothermal fluids for direct-use; however a number of parameters can limit the choices and need to be determined in advance. First, what are the characteristics of the resource, i.e. temperature, flow rate, chemistry and land availability? Second, what markets are available and do you have the expertise to provide the product, whether it be heat energy, a crop of plants or fish, drying a product (lumber or food), or extracting a mineral from the fluid, and can you get the product to the user economically. Finally what are the capital investments, annual income, and rate of return on investment and/or payback period, and can you raise the funds or find investors.

Another alternative which can be considered to help improve the economics of a project and better utilize the resource is to consider a combined heat and power project. Either project alone may not be feasible; however, together they may, even if the resource has low temperature. See *Geo-Heat Center Bulletin, Vol. 26, No. 2*, (June) 2005 for more details and examples on combined heat and power plants. All GHC Bulletins can be accessed from the website: http://geoheat.oit.edu.

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CANBY'S GEOTHERMAL LAUNDROMAT

Dale Merrick, Canby, California

ABSTRACT

A small community cooperative installs a non-coin operated Laundromat to save money and upgrade equipment. Retrofitted gas-fired 55-lb industrial laundry dryers receive energy from a geothermal district heating system to dry domestic laundry.

PROJECT BACKGROUND

I'SOT, Inc., a non-profit 501 (c) (3) religious organization drilled a 2100 foot geothermal well with the assistance of a DOE grant in 2000. A district heating system was installed in 2003 with the help of a materials-only grant from the CEC and NREL Phase I&II grants that funded permitting, engineering, installation, and monitoring of the project for a 24 month period.

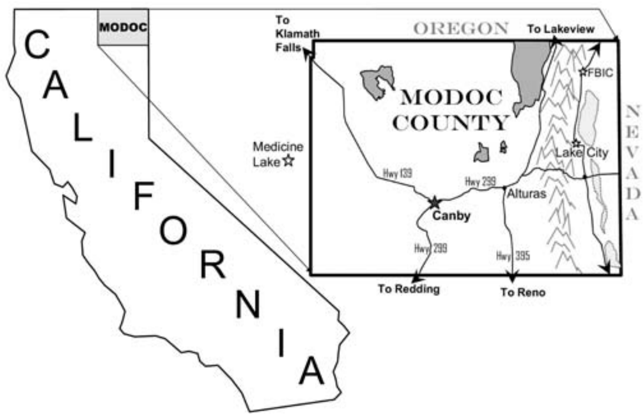

Figure 1: Project Location

The project overcame significant obstacles including:

- Drilling 2,000 feet of clay/tuff formations.
- Low resource flow of 37 gpm with a 250 ft drawdown
- Mercury and arsenic concentrations in excess of EPA standards
- Delayed environmental permitting

Granulated activated carbon was found to be effective for removing mercury, allowing discharge to a local river under an NPDES discharge permit. Average annual discharge to the Pit River since 2004 has been 14.6 gpm.

Today, the district heating system heats approximately 63,000 ft^2 of residential and commercial structures including a 30 ft. x 96 ft. greenhouse. The net 2008 project savings for propane and electricity was approximately $52,500 after all pumping, maintenance and permitting costs were subtracted.

In 2008, the Canby Geothermal Development Project was selected for funding by the California Energy Commission to create the first completely sustainable net-zero energy community in California by fully cascading the use of a geothermal resource and 1) producing green electrical power for California rate payers; and 2) creating up to 120 jobs by implementing geothermal direct-use applications, including greenhouse and aquaculture operations. These long-term goals (3-10 years) will be made possible by drilling a 4,000-ft. geothermal production well, and flow testing it into a current producing well for long-term productivity and power producing potential. A 2,900 ft. pipeline will be installed to connect the currently producing ISO-1 well and newly drilled ISO-2 to discontinue geothermal discharge to a local river while increasing capacity of a district heating system.

A CO-OP LAUNDRY

Historically, the community families in Canby have had a co-op laundry for 40 years and the energy to take care of that need has been propane to heat water for the washers and dry clothes. The five year average propane usage for this task is about 7,050 gallons per year. Figure 2 & 3 show washers and dryers that have been used by community members.

Figure 2: Decommissioned 14 lb. Commercial Washers

Figure 3: Decommissioned Commercial 30 lb. Gas Dryers

Figure 4: New Canby Community Laundromat Location

Typically, I'SOT would buy used laundry equipment from a Laundromat that was upgrading. For many years, inexpensive equipment and the low cost of propane made it a viable way of doing large amounts of domestic laundry. However, in the last few years, propane has more than doubled; going from a 20-year area low of $.80 per gallon to over $2.40 per gallon. Combined with the increased maintenance cost to operate the old machines, I'SOT, Inc. chose to buy all new high efficiency washer/extractors and 55lb gas industrial dryers at an approximate cost of $35,000 and locate them at a new building on the district heating system. Brian Brown Engineering, responsible for the design of the I'SOT geothermal district heating system, drew up the mechanical plans for the building including the retrofitted dryers.

The first equipment selection was the washers. Maytag 21 lb commercial on-premises laundry washer-extractor were selected as they use less than half of the water the old top loading 14 lb washers and extracts that water with 307 g's of force. The first task is to remove excess water from the laundry before requiring the dryers to finish the job. A 50 lb. soft mount washer/extractor was also purchased to handle sleeping bags and large comforters.

Figure 5: New High Efficiency 21 lb Washers

The second equipment selection was the dryers. The relative humidity in Canby for most of the year averages about 15%, so we looked for a dryer with the largest cubic foot per minute (cfm) rating. Figure 6 shows the new dryers. The old 30 lb Loadstar propane dryers moved about 400 cfm of Canby's dry air and had a discharge temperature between 180°-200°F, which was a safety hazard with old kitchen towels.

The selected 55 lb Dexter gas dryers are rated at 910 cfm. After pressure drop going through the filters and coils, the project engineer expected 830 cfm of air flow. Design also required a 140°F airside discharge and 4 gallons per minute (gpm) supply water temperature of 150°F.

Figure 6: New Retrofitted 55 lb. Dryers

THE RETROFIT

After removing the gas unit from the dryer, it was obvious that a larger opening would need to be made to allow the maximum air flow through the coil and rotating drum. Figure 8 shows the small original opening and how much larger it needed to be. A plenum was then mounted over the enlarged opening with a hot water coil as shown in Figure 9. A control valve was installed on the return header which is connected to a controller in the buildings mechanical room. This in turn is monitored by the district heating system's DAS software. The retrofit per dryer averaged about $1,800 including the coil, plenum, control valve, fittings and copper supply and return lines. This cost is largely dependent on the price of copper which has been extremely volatile in the last few years. This equipment was purchased in June 2008. The simple payback for the new equipment and dryer retrofits is under 3 years considering cost of machines ($35,000), retrofits ($9,000), and the current price of propane ($2.33/gal) at an average usage of 7,050 gallons per year.

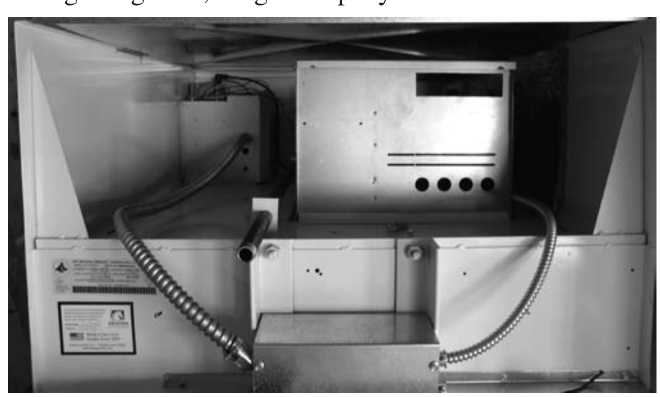

Figure 7: Gas dryer before retrofit

Figure 8: Target Size of New Opening

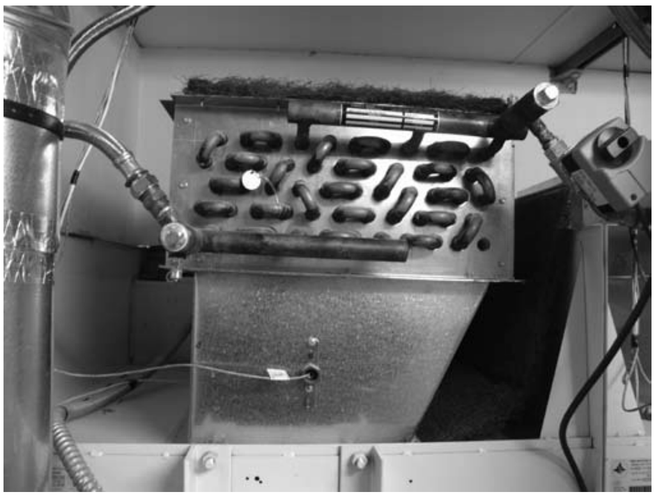

Figure 9: Completed Dryer Retrofit

DRYER PERFORMANCE

Figure 10 below shows dryer and district heating system performance. The upper dialog box shows overall system conditions and the lower dialog box shows the retrofitted dryer performance. Design supply water temperature is 150°F and is manually set to meet that requirement. The supply air temp to the dryers exceeds the design temperature of 140°F. Temperature probes are placed both after the hot water coil and the exhaust duct to monitor dryness of the laundry. If the exhaust temperature exceeds the exhaust temperature set point (EXT T SP), the control valve would close and limit energy to that dryer. At this time, the EXT T SP is set so that drying is maximized. The following year was spent "tweeking" dryer and system parameters to minimize the amount of energy that is sent to the Pit River. Before the dryers were installed, system controls would limit supply loop temperature according to outside temperature, which varies between winter and summer. Typical loop temperature in the winter is between 145°F and 160°F. During the summer, supply loop temperature hovers around 130-135°F. Coordination between users and the system manager will attempt to find the "sweet spot" so that a balance can be struck between drying time and use of the geothermal resource.

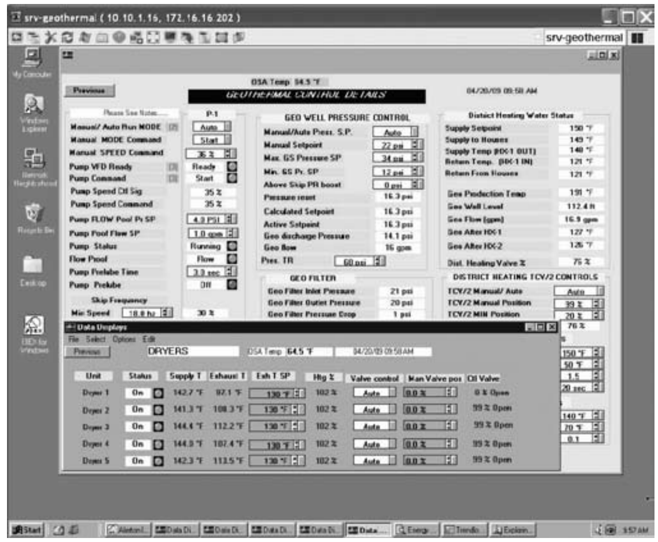

Figure 10: Data Acquisition Screen for Dryers and District Heating System

- The laundry facility has been in use for one month at this writing, so only preliminary observations can be made.
- Users report that drying time is longer with the retrofitted dryers than with the old propane ones but are able to stay within the scheduled time of 1.5 to 2 hours, which is dependent on family size.
- Since the drying temperature is cooler, the laundry is less wrinkled, so less ironing is needed.
- While the dryers were retrofitted with a hot water coil, the dryers "brain" still thinks it is a gas machine. Error codes occasionally come up on the dryers' readout because sensors detect lower drying temperatures with respect to time.

CONCLUSION

The only wrinkle after retrofitting the gas dryers was the error messages that occur because of the hard-wired programming expectations of the dryer's controller. That controller expects higher temperatures than the loop temperature of 150°F can provide. The Canby Geothermal Project's future plans to drill another geothermal well may provide the extra energy needed to satisfy the controller's temperature requirements.

The geothermal savings expected in 2009 for the Canby Geothermal Project is expected to increase from 2008 because 7,050 gallons of propane per year were used to dry clothes in the old dryers. If the cost of propane in 2009 averages only $2.25 per gallon, an additional $15,900 would be saved not counting electrical costs associated with the high efficiency washers. The overall 2009 savings from the project would be estimated to be around $68,500. A subsequent paper on this very new project addition will evaluate the data generated from the project's DAS.

DEVELOPMENT OF GEOTHERMAL ENERGY DIRECT USE IN INDONESIA

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ABSTRACT

As a country with vast potential of high enthalpy geothermal resources, Indonesia has been focusing the development of geothermal energy for electricity generation. On the other hand, Indonesia is also blessed with a huge low-to-medium geothermal resources such as hot springs, natural geothermal wells, etc., which can be applied for direct use applications. Besides the above geothermal resources, direct use applications also utilize energy from un-exploited brine and small capacity production wells. In general, the geothermal resources in Indonesia are located in mountainous areas with agricultural lands (including plantations), forestry, bathing and spa resorts, etc. which need heat for their processes or activities. This is a perfect situation for the geothermal energy direct use to be developed. However, unfortunately at present the direct use of geothermal energy in Indonesia is very low. Agency for the Assessment & Application of Technology (BPPT) has been developing direct use applications since 1999 by utilizing various geothermal resources such as steam from a small well, brine from a separator in an existing power plant, and hot water from natural as well as man-made shallow geothermal wells for mushroom cultivation, copra and cocoa drying, etc.

INTRODUCTION

Indonesia is a country with the largest hydrothermal type geothermal resources in the world, with a potential of more than 17,000 MW. The utilization of geothermal energy in Indonesia is 1,179 MW (4%), and limited to the power generation only (indirect use). The geothermal resources which are generally located in mountainous areas with agricultural lands (including plantations), forestry, bathing and spa resorts, etc. are very potential for various direct use applications. According to the Geothermal Law (Law No. 27 / 2003), geothermal energy must also be developed for direct use, but up to now its implementation in Indonesia is still very low.

The geothermal energy direct use applications can contribute significantly to the government's energy diversification program and fossil fuel substitution, as well as increase the life standard of the local communities. Many local governments have been starting the identification of the direct use potential in their administrative territories. For example, West Java, a province with the largest geothermal resources utilized for power generation, completed the study and reported it on the development plan of direct use in the West Java Province in 2003, and started the implementation in 2006 by adopting the existing mushroom cultivation direct use for the community development program.

PRESENT STATUS

Bathing and Swimming

The most common and traditional usage of geothermal energy in Indonesia is for balneology, bathing and heated swimming pools. Figure 1 shows traditional bathing in Darajat geothermal field, while figure 2 shows a heated swimming pool from a hot spring which is commercially exploited in Cipanas of West Java Province.

Figure 1: Traditional Bathing with Geothermal Hot Water in Darajat Geothermal Field

Figure 2: Hot Water Swimming Pool in Cipanas

At present, there are no accurate data on the total countrywide utilization and capacity because the number of traditional bathing is a lot along the country, so that they are very difficult to collect and quantify. Another example, since more than 10 years ago Pertamina Geothermal Energy has been utilizing the geothermal steam to heat up freshwater for the domestic and office use in Kamojang Geothermal Field, but there is no measurement for the capacity as well as the annual energy use. According to the estimation by Lund et al. (2005), the use for bathing and swimming in Indonesia is 2.3MWt in capacity with an annual energy use of 42.6TJ/yr. However, it is believed that the real number is much more than the above estimation.

Agriculture

Mushroom in Kamojang Field

The utilization of geothermal energy for agriculture in Indonesia was initiated by a geothermal research group of BPPT (Agency for the Assessment and Application of Technology) in 1999. BPPT with the cooperation of Pertamina Geothermal Energy implemented a pilot plant of the geothermal energy direct use for mushroom cultivation in Kamojang Geothermal Field (West Jawa). The facility consists of a steam generator heat exchanger, an autoclave, a freshwater tank, an inoculation room, incubation rooms and production rooms. The schematic diagram of the facility is as shown in figure 3 below. Dry steam from a small capacity well with the temperature of 110-120ºC is directed to a steam generator to heat up freshwater. The heated fresh-steam is used to sterilize the mushroom growing media, or as so called "bag-log", and also for space heating to keep the incubation room warm. The geothermal steam is to substitute the use of fossil fuel (kerosene) which is getting very expensive every year. The mushroom cultivated in this direct use facility is shown in figure 4.

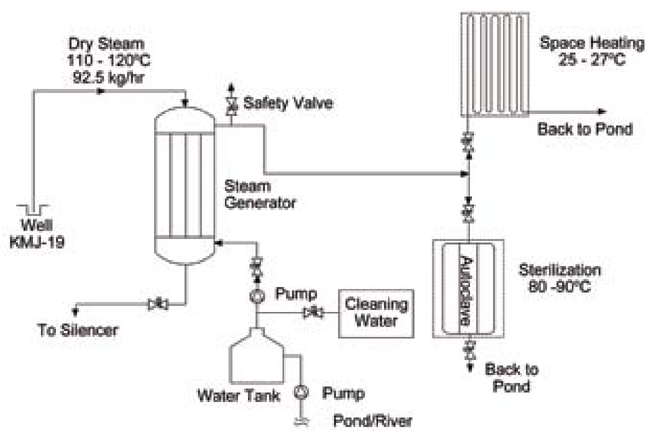

Figure 3: Schematic Diagram of Mushroom Cultivation by Utilizing Steam from Small Production Well

Starting from 2006, the local government of the West Java Province has been adopting this facility as a model for community development program, and expanding the capacity of the facility to 25,000 bag-logs per month. The provincial government provides production houses for the local community, and they are involved in the production process. They can buy the sterilized bag-logs at a lower price, and are allowed to deliver the mushroom directly to the market.

Palm Sugar in Lahendong Field

Lahendong geothermal field is surrounded with a palm sugar plantation which is managed by about 3,500 farmers. A non-governmental organization called Yayasan Masarang with the cooperation of Pertamina Geothermal Energy built a large scale geothermal energy direct use facility for palm sugar production (figure 5) with the capacity of 12 tons/day by utilizing flashed steam from the separated hot water (brine). At present, the facility is running with capacity of 1 ton/day only.

Figure 4: Mushroom Cultivated from Geothermal Direct Use in Kamojang Field

Figure 5: Direct Use for Palm Sugar Production in Lahendong Field

The schematic diagram of the facility is as shown in figure 6. Brine from the separator is directed to a flasher to produce flashed steam of about 4 tons/hour, and it is utilized for the palm sugar processes. Some of the products are exported to the Netherland.

Copra and Cocoa in Way Ratai Field

In 2003 and 2008 BPPT implemented pilot plants of geothermal energy direct use in Way Ratai Geothermal Field (Lampung Province) for coconut meat (copra) and cocoa dryings by utilizing a shallow natural geothermal well and a man-made shallow geothermal well, respectively.

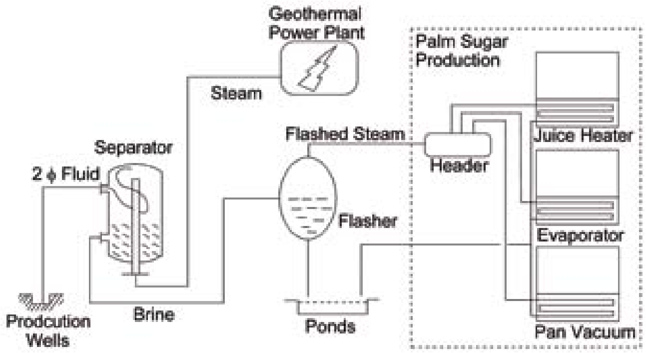

Figure 6: Schematic Diagram of Palm Sugar Production by Utilizing Brine

Way Ratai is an undeveloped geothermal field in Lampung Province, located in a coconut plantation area. There are many natural shallow wells in it with temperature range between 80 – 98ºC. BPPT (Agency for the Assessment and Application of Technology) implemented a pilot plant of the utilization of natural geothermal well for coconut meat drying (copra) in this field in 2003 – 2004, with the capacity of 200 kg coconut meat per batch. The facility consists of a downhole heat exchanger, a drying room, a pump, and a freshwater tank. The schematic diagram of the facility is as shown in figure 7. The downhole heat exchanger is put into a natural geothermal well with the depth of 2m and the temperature of 80 - 95ºC (figure 8), and the freshwater is flowed into it. The freshwater is heated up and directed to the drying room which is kept at the temperature of 50ºC to dry up the coconut meat by natural draft conductive heat exchange. The quality of the copra produced in this facility is much better compared to the conventional one because there is no smoke contamination on it.

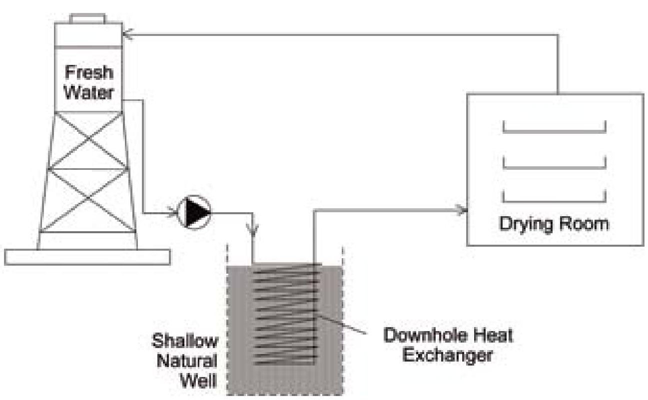

Figure 7: Schematic Diagram of Copra Drying by Utilizing Shallow Natural Well

Close to the location of the above copra drying direct use, BPPT implemented a pilot plant of the utilization of a man-made shallow geothermal well for cocoa drying in the same field in 2008. The well is made artificially from an existing hot water seepage on the ground (figure 9). It has a temperature in a range of 85 - 95 ºC. The schematic diagram of this cocoa dryer facility is the same as the one shown in figure 7, but different in the size of the downhole heat exchanger.

Figure 8: Downhole Heat Exchanger in Natural Geothermal Well

Aquaculture

At present, there is only one place identified as an aquaculture facility that utilizes geothermal fluid in Indonesia. It is a traditional freshwater fishery in Lampung Province, mixing natural geothermal hot water (outflow) with freshwater from a river to grow large catfishes. The farmer reported that the fishes grow better in the geothermal fluid and freshwater mixture.

Figure 9: Artificial Shallow Geothermal Well Hot Water Seepage Before improvement (top) and after improvement (bottom)

Figure 10: Geothermal Direct Use for Large Catfishes Growing in Lampung

Space Heating

As a tropical country, the need of space heating in Indonesia is extremely limited. A small space heating facility was applied in Patuha Geothermal Field, but the detailed information about the exact size and capacity is not available.

Figure 11: Geothermal Direct Use for Space Heating in Patuha Field

FUTURE PROSPECTS

As stated before, the regulation of geothermal energy utilization for direct use is stipulated in the Geothermal Law. The Government of Indonesia cq. the Department of Energy and Mineral Resources is preparing an implementation regulation on the direct use activity in Indonesia. It is predicted that in the near future the development of direct use businesses will grow rapidly, provided that the regulations on it can be settled and come into effect soon.

BPPT has been identifying some geothermal fields which are very prospective for the direct use applications.

Wayang Windu Geothermal Field

Wayang Windu geothermal field operated by Magma Nusantara Limited (MNL) is located in a tea plantation area owned by a state owned company called PTPN8, and surrounded by a national forest. The geothermal fluid produced in the southern field of Wayang Windu is of two-phase, so that a separator is installed to separate the steam from the hot water. The steam is directed to a turbine to generate electricity with the capacity of 110 MWe, while the separated hot water (or so called brine) which still has a high energy content with the temperature of 175 – 180ºC is reinjected into the earth through a brine pipeline. This pipeline is laid down about 500m from the PTPN8's tea drying plant. BPPT with the cooperation of MNL and PTPN8 has finished studying the feasibility of utilizing the brine for tea withering and drying processes in commercial base business, in order to substitute the use of Industrial Diesel Oil (IDO). PTPN8 spends more than 1 million litres of IDO annually. The application of the geothermal direct use is expected to reduce not only a huge fuel cost, but also the CO_2 gas emission.

Figure 12: Wayang Windu Geothermal Power Plant Located in the Area of Tea Plantation

Kamojang Geothermal Field

Learning from the experience of the existing direct use application for mushroom cultivation in Kamojang, the facility is technically and economically feasible to be expanded for commercial based mushroom cultivation business. However, it is necessary to establish a sustainable community based business model before the implementation.

Garut Regency, where Kamojang geothermal field is located, has a product with a globally competitive advantage called grass with fragrant root or java vetiver oil. It is an expensive raw material of perfumes and cosmetics, and exported to European countries with the global share of about 10 – 15%. Recently, the production of the java vetiver oil drops significantly due to a drastic increase in the fuel (kerosene) cost.

An experimental result by a non-governmental organization in Garut concluded that geothermal energy can substitute kerosene for the distillation process with even better quality of vetiver oil product. This shows that geothermal energy direct use for vertiver oil production has a very good prospect to be developed in Kamojang. In order to implement it commercially, it is very important to have a cooperation with Pertamina Geothermal Energy as the owner of geothermal fluids in Kamojang geothermal field.

Figure 13: Grass with Fragrant Root located near Kamojang Geothermal Field

Lahendong Geothermal Field

Tomohon, where Lahendong geothermal field located, is a city in the North Sulawesi Province with a large potential of coconut plantation. The productive plantation area is 767.5 ha and the total coconut production in 2004 was 729.1 tons. Pertamina Geothermal Energy had a plan to utilize the excess steam or brine from the separator in Lahendong for copra production commercially. A pilot plant for coconut meat drying (copra) was built by Pertamina, and its operational experiment gave a good result.

Ulubelu Geothermal Field

Ulubelu is a geothermal field located in Lampung Province. At present, production well drilling activities by Pertamina Geothermal Energy are in progress to develop 220 MW power generation in total. Ulubelu geothermal field is surrounded by a coffee plantation with the productive area of 7680 ha, and coffee production in 2007 was 5200 tons. This indicates that direct use for coffee processing is a very prospective in this field.

Ulumbu and Mataloko Geothermal Fields

Ulumbu and Mataloko geothermal fields are located in East Nusa Tenggara Province. These fields are being developed by PLN, a state owned electricity company. There are many agricultural products yielded from these areas, for example, maize, cassava, onion, etc. These products need heat for their processing treatment, and geothermal fluids (steam or brine) can be prospectively utilized for direct use applications.

CONCLUSIONS

Geothermal resources in Indonesia are generally located in mountainous areas with agricultural lands, forestry, bathing and spa resorts, so that they are very potential for various direct use applications. At present the application of direct uses is mainly for balneology, bathing and swimming pool. Some agricultural applications such as mushroom cultivation, palm sugar production, copra and cocoa drying are also being implemented, but the numbers are very limited compared to the potentials around the country. The future prospect for commercial applications is very bright.

RECOMMENDATIONS

In order to accelerate the development of direct use in Indonesia, it is recommended to implement some actions such as the followings:

- Government regulations on geothermal direct use development must be issued soon. Some aspects which should be included in the regulations are as follows:
- Conditions and requirements to develop direct use in geothermal working areas where geothermal power plants exist.
- Pricing criteria or policy for direct use applications.
- Engineering standard for various applications, basically by grouping into edible and non-edible products, in order to prevent geothermal fluid contamination (for safety reason).
- Establishment of sustainable business model for community based as well as commercial development program.
- Geothermal developers should calculate and decide geothermal fluid potential in their working areas which can be utilized for direct use applications without disturbing the steam production to supply the power plants.
- Identify the direct use potential in Indonesia and prepare an action plan to develop it.
- Study and research to remove barriers, to enhance technology and economics, and to standardize equipment.

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GEOTHERMAL WATER DESALINATION – PRELIMINARY STUDIES

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ABSTRACT

The rate at which geothermal installations become corroded and clogged depends largely on the physico-chemical composition of the geothermal water. A special research program has been developed, in connection with the specific nature of the problem and wide variation in the quality of geothermal waters (whose mineralization ranges from a few to more than 120 g/dm^3). This program is intended to promote the comprehensive utilization of geothermal waters in order to improve the water balance, stimulate the balneological sector and improve the operating conditions of existing systems.

The paper presents possible benefits from the application of water treatment methods. At the same time, the process of desalinating cooled geothermal water may be used in order to produce drinking water.

INTRODUCTION

The use of energy from alternative sources, both in Poland and in the European Union, is hampered by high investment costs, which are largely front-loaded (the cost of drilling the absorption well, among other things), and are much higher than the financial outlay required in the case of conventional energy sources. Taking into account Poland's obligations to increase the share of energy from renewable sources, it is essential to intensify efforts aimed at reducing the aforementioned costs.

The specific nature of the problem and wide variation in the physico-chemical properties of geothermal waters (whose mineralization ranges from a few to more than 120 g/dm^3) has given rise to a research program designed to promote the comprehensive utilization of geothermal waters in order to improve the water balance, stimulate the balneological sector and improve the operating conditions of existing systems.

Reducing the high investment expenditure, which is, inter alia, related to the need to drill the absorption well, the cost of improving absorption capacity, etc., may be of key importance for the initiation of new investment and as a consequence for increasing the share of renewable energy in the domestic market.

The paper presents preliminary observations concerning the feasibility of desalinating geothermal waters, which would contribute to their utilization in many areas, including:

1) An improvement in the management of fresh water resources through the use of desalinated geothermal waters.
2) Limiting corrosion processes and the precipitation of minerals that clog geothermal systems through an attempt to mix raw geothermal water cooled in heat exchangers with "pure water" in inappropriate proportions following the treatment process.
3) The development of the balneotherapy, tourism and leisure sectors.
4) The recovery of mineral compounds with balneological and economic importance (the production of mineral resources).

In Poland, geothermal water resources are associated with the pressure of large regional underground reservoirs. The proper examination and determination of the operating conditions in relevant facilities will not negatively affect the amount of resources, the possibility of sourcing renewable energy or the opportunities for sustainable operation.

THE SALINITY OF GEOTHERMAL WATERS EXTRACTED IN POLAND

The chemical composition of groundwater depends on several factors, including the lithology of the aquifer rocks, the circulation of groundwaters and the water-rock thermodynamic equilibrium. The geothermal water reservoirs that have been made available and are currently exploited in Poland exhibit varied physico-chemical properties. Fresh and weakly mineralised waters with an increased content of specific components are present here as well as brines.

In central Poland, in Mszczonów, weakly mineralised water (below 0.5 g/dm^3) with a temperature of 40.5°C is being extracted from the Mszczonów IG-1 well, from a Lower Cretaceous horizon composed of sandstones interbedded with mudstone and claystone. This is high quality Cl-HCO_3-Na-Ca water. After the extraction of heat using an absorption pump and treatment, the water is used for consumption purposes in the municipal water supply system. Groundwater sourced from a Cenomanian reservoir in Słomniki (south-eastern Poland) is used for similar purposes. This is weakly mineralised (ca. 350 mg/dm^3) HCO_3-Ca-Na-Mg water with a temperature of 16.5°C at the well outlet.

In south-eastern Poland, in Podhale, geothermal waters are extracted from carbonate formations of the Middle Eocene and from Middle Triassic limestones and dolomites. These exhibit relatively low mineralisation — from 2.358 g/dm^3 (Na-Ca-SO_4-Cl hydrogeochemical type) in the Bańska IG-1 well to 3.150 g/dm^3 (SO_4-Cl-Na-Ca) type in the Bańska PGP-1 well (Kępińska 2006). Their temperature at the well outlet ranges from 69 to 86°C.

Geothermal water extracted from Mesozoic formations in the Polish Lowlands (e.g. in Pyrzyce, north-western Poland) has a different composition. Very hard (8,653 mg

$CaCO3/dm^3$) Cl-Na brines with a mineralisation of 123.8 g/dm^3 (Pyrzyce GT-1 well, 1997 analysis) and a temperature of 61°C are present here. The water has a high content of sulphates (1,115 mg/dm^3), iron (16.4 mg/dm^3), manganese (1.5 mg/dm^3) and fluorides (1.2 mg/dm^3) (Kania, 2003).

WATER DESALINATION METHODS

Desalination processes can be classified as follows on the basis of changes in the phase, the type of energy used and the separation technique applied (Sadhukhan et al. 1999; El-Dessouky and Ettouney 2000; Bodzek et al. 1997):

1) On the basis of changes in the phase:
   a) without changing phase — reverse osmosis (RO) and electrodialysis (ED);
   b) involving changes in phase — distillation and freezing out.
2) On the basis of the type of energy used:
   a) heat-based processes — distillation processes;
   b) processes based on mechanical energy — reverse osmosis;
   c) processes based on electrical energy — electrodialysis.
3) On the basis of the separation technique applied:
   a) processes separating water from the solution: distillation processes and reverse osmosis;
   b) processes separating salt from the solution: electrodialysis and ion exchange.

The choice of the most appropriate water desalination process is dependent on the physico-chemical properties of the water, its temperature, gas content and technical aspects related to the energy requirements of individual methods. The following factors are also significant: process efficiency (water recovery level), installation life (mechanical, thermal and chemical resistance of the membrane), the possibility of cleaning modules (membranes) and the need to implement extensive water pre-treatment processes as a result of, inter alia, raw water containing organic substances (macromolecular compounds, biological substances), inorganic compounds (metal hydroxides, calcium salts, silica), suspended particles, colloids (organic and inorganic) that may cause membrane efficiency problems — fouling and scaling.

Desalination processes based on thermal and membrane separation are the most important ones for drinking and domestic water production (Tsiourtrtis 2001; El-Dessouky and Ettouney 2000). Currently, membrane-based water desalination processes predominate due to their lower energy consumption compared to distillation techniques (Bodzek et al. 1997). Reverse osmosis (RO) enables pollutants to be separated at the molecular or ion level. In this process, pressure is applied to a water (solution) to force it through a semipermeable membrane, which separates two solutions with different concentrations. Under pressure, pure (permeate) water molecules pass through the membrane, while molecules of salts and other pollutants (e.g. colloids) and bacteria remain on the raw water side.

Hybrid installations combining thermal and membrane-based technologies are increasingly frequently used to treat salty water. These processes are, among others, the multi-stage flash process (MSF) and multi-effect distillation (MED). Their efficiency does not depend on the quality of the water supplied, which is the case with reverse osmosis (RO).

GEOTHERMAL WATER DESALINATION PROJECT

Water physico-chemical properties have to be determined in detail in order to assess whether it is possible to use geothermal water and to determine the most efficient treatment method. To this end, water has to be tested in situ at two locations: at the wellhead in order to determine the water parameters at the well outlet and in the geothermal installation, after it has been cooled in heat exchangers. During the geothermal water cooling process, several physico-chemical reactions take place, as a result of which the thermodynamic state of the water changes. This may cause the precipitation of the minerals dissolved in the water, which leads to many operational problems in the installation (Kępińska 2006; Kania 2003; Górecki (ed.) 2006). The analysis of the information obtained regarding the specific features of the heating system in question is a precondition for assessing the possibility of treating geothermal water by one of the methods available and using it in various applications other than the most common one.

In-situ studies at selected geothermal facilities in Poland that use water with varying salt content will make it possible to test the process on a semi-industrial scale (with a water desalination installation capacity of around 1 m3/h). The study is to be implemented in two stages. In the first stage, the aim will be to obtain water that meets the requirements for safe drinking water, while at the same time recovering minerals that can be used in balneology or industry. In the second stage, attempts will be made to mix raw geothermal water cooled in heat exchangers with "pure water" following the treatment process in appropriate proportions. The final objective is to achieve a chemical composition of water that will reduce the mineral precipitation processes leading to the clogging of geothermal systems.

The results of studies on the treatment of geothermal waters following the heat recovery process, which often exhibit high salt content and do not constitute drinking water resources, will be used to assess the possibility of improving the local fresh water balance.

PILOT INSTALLATION

A pilot thermal water desalination installation in Poland will be commissioned at the Geothermal Laboratory of the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences. Some of the water extracted from the Bańska IG-1 geothermal well at Bańska Niżna (southern Poland, Podhale Basin), whose total depth it 5,261 metres (the geothermal water level is 2,565 m below ground level), will be desalinated (Fig. 1). The primary objective of the process will be to produce drinking water which is in short supply in the vicinity of the wells. The installation will be supplied with water at a temperature of around 35˚C, after it has been cooled in heat exchangers. The pilot installation must include typical industrial plant components because the pilot research must yield representative results which will constitute guidelines for industrial facilities. For this reason, the minimum installation capacity has been set at 1 m3/hour of desalinated water, which meets the above condition and will enable the extrapolation of results from the pilot installation to an industrial one. The study will take six to twelve months. The use of membrane-based methods is envisaged. The objective of geothermal water desalination will be to obtain water that meets the requirements stipulated in the Regulation of the Minister of Health of 29 March 2007 (Official Journal [Dz. U.] No. 61/2007 item 417) concerning the quality of water intended for human consumption.

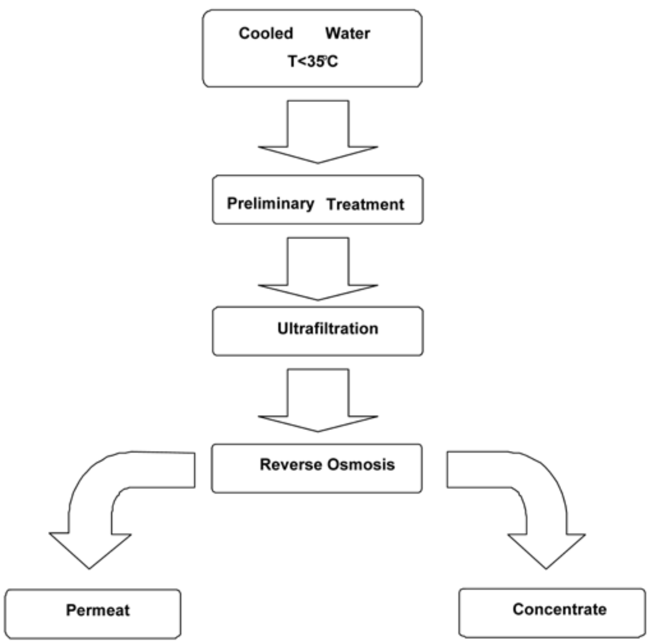

Figure 1: The concept design of the installation geothermal water desalination from the Bańska IG-1 geothermal well.

SUMMARY

The successful implementation of the water desalination research programme presented in this paper would ultimately enable the development of best practices for geothermal water treatment in newly constructed installations and initiate proposals for improving the operation of existing facilities.

In particular, the application of water desalination methods at facilities which operate an open drain system (without reinjection) where the cooled water is released into a surface reservoir, would contribute to more effective use of the water released, including an improvement in the water balance of the area in question.

The comprehensive use of geothermal water may contribute to the development of the alternative energy sector. The improvement of the economic parameters may be of key importance in the stimulation of new investment and as a consequence for increasing the share of renewable energy in the domestic market.

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USING LOW ENTHALPY GEOTHERMAL RESOURCES TO DESALINATE SEA WATER AND ELECTRICITY PRODUCTION ON DESERT AREAS IN MEXICO

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ABSTRACT

It is well known that Mexico has extensive geothermal resources throughout the county, some of them dedicated to the power generation since Mexico has more than 950 MW of geothermal installed capacity. However, at east Pacific Rise along of the Baja Peninsula several geothermal resources are located where a continuous heat and hot water discharge occurs just on the seashore. Most of these systems are located near important tourist and recreational areas where neither potable-water nor power electricity are available.

Mexico's National University (UNAM) through the IMPULSA Program has been working with local scientist and engineers to use these extensive but not well assessed geothermal resources in order to generate electricity or for desalinate using the hot geothermal water. Geological and geophysics studies are being conducted to identify and characterize underground structures governing heat and water movement along with chemical geothermometer behavior.

The aim of this work is to assess the geothermal potential at La Joya, near the City of Ensenada, by using the hot geothermal seawater through new thermal processes, MED (multi effect distillation) and MSF (multi stage flash) mixture, LE-MED (low energy multi effect distillation) in order to use the hot seawater as heat source for desalination with very little energy consumption avoiding the use of steam, as well as reducing the cost of the fresh water produced and at the same time promoting the use of renewable resources in the country. An innovation introduced with this design is the use of hot seawater to heat not only the first one, but all the chambers in the desalination plant, a unique Mexican design. Prototype desalination plant design has already been achieved and the extensive Lab tests shown very promise results.

The IMPULSA project has also designed a power generation system PWG (Pressurized Water Generator) for low enthalpy geothermal resources like the ones at La Joya. The innovation of this system is the use of a high speed turbine and a pressurized water cycle, to avoid the use of large heat exchanger areas.

INTRODUCTION

Baja California, on the northwest part of Mexico and close to the border with the largest economy of the world, has shown a rapid and continued growing in its industrial and tourism activity, triggered a demand for real estate, since thousands of retired Canadians and Americans people are moving south searching for ocean view home sites and warmer weather along the Mexican coast. This baby-boomer phenomena is producing a strong increase of goods and services in the region but, specifically on the fresh water demand, in a zone where this resource is highly stressed and not easy to access or supply.

On the other hand, though, this region with its extreme temperatures, 0ºC in winter up to 45ºC during summer, has been blessed with abundant renewable energy sources. Solar, wind, geothermal, tidal, hydrothermal vents, and other resources are widely spread along the 1,200 miles throughout the Baja Peninsula. That is why, three years ago, the National University of Mexico (UNAM) formed a professional-multidisciplinary research group -IMPULSA IV- to promote and implement technological solutions to the desalination of sea water through the use of renewable energy sources (Alcocer, et al, 2008).

It is well known that in a traditional thermal desalination plant, the main component of cost of desalination of water comes from steam extracted by a power generating plant or power taken from the grid. In the case of Baja California, geothermal heat that rises from geological faults has already increased temperature of water near to the boiling point. In the IMPULSA project a combined analysis of multiple effect distillation plant (MED) and a multi stage flash plant (MSF) was done in order to be able to desalinate sea water using the hot geothermal liquid instead of the traditional steam supply from a thermal plant.

BAJA CALIFORNIA GEOTHERMAL RESOURCES

More than 60 hot spot have been identify along the inland Baja Peninsula, (Torres, 2000) but a dozen or more sites located along the seashore show mass and heat discharges at almost boiling temperatures. Most of these places are good candidates to install a desalination plant coupled with a thermal desalination system in order to take advantage of the geothermal resources where it is expected to lower the energy consumption of the desalination process. Figure 1 shows most of the geothermal resources in Baja Peninsula followed by a brief description of these areas.

Northern Zone

Mexicali Valley

There are at least 20 sites in the northern part of the Baja California Peninsula in which geothermic manifestations have been identified. The most well known and largest area are the Cerro Prieto Geothermal Fields, in the Mexicali County, where the state owned power company, Comision Federal de Electricidad (CFE) has drilled more than 300 wells to extract the steam necessary for power generation. In Cerro Prieto Fields is installed 720 MW of geothermal power capacity that means up to 45% of the electric energy consumed in the cities of Mexicali, Tijuana, Tecate and Rosarito.

A few kilometers from Cerro Prieto there have been at least identified five geothermal sites; all associated with the Pull-apart system between the Imperial and Cerro Prieto faults. However, in none of them has successful temperature been obtained to be able to use them for power generation. For example, the Tulecheck Field, where temperatures of 165ºC has been registered, or in the Airport field at 112ºC or in Guadalupe Victoria up to 230ºC in a well 3,100m deep.

In the western part of the Cucapah Mountains there is a large plain, Laguna Salada (Salted Lagoon) where multiple geothermal and geophysical soundings has been made and three deep exploratory wells were drilled. However, the maximum temperature reported in one of them was only 101ºC. To the south of this plain, it is reported agricultural wells with estimated temperatures up to 230ºC.

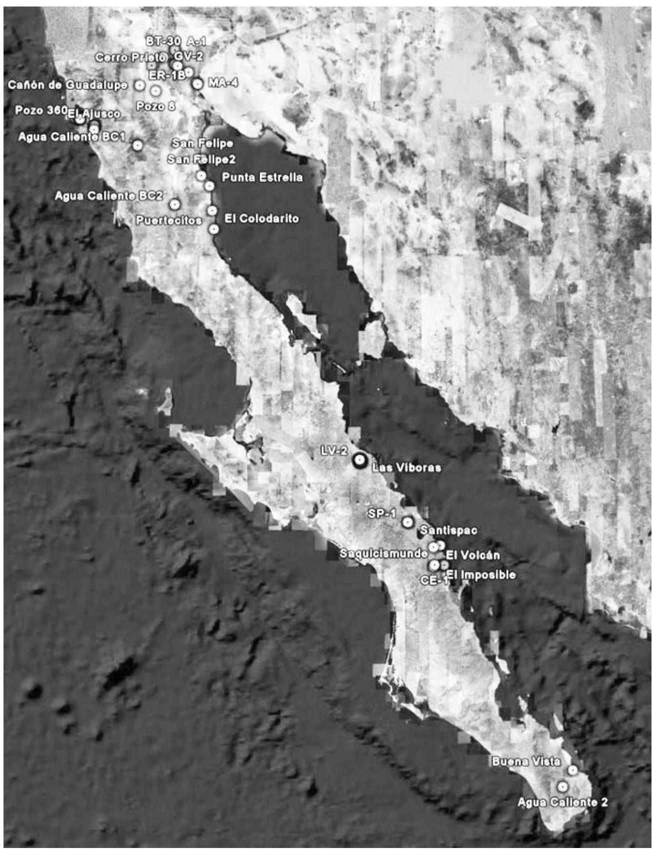

Figure 1: Baja California Geothermal Resources

Ensenada

In the western part of the Baja California Peninsula, south of the city of Ensenada, several geothermal sites have been identified (Alvarez, 1993), springs appearing, hot soil, steam escaping, wells and hot norias, where geothermal potential has been identified from direct measurements of natural discharges and in the wells of the area, particularly in the Maneadero Valley, Punta Banda, Santo Tomas and San Carlos, all associated with the occurrence of Agua Blanca Fault, one of the regional structures predominately oriented NW 48º.

Given that the zone described has been changed into a tourist development, the major part of the usage of thermal water is utilized directly for use in the tourist areas along the coast of the Maneadero Valley. There are various beaches where at low tide it can see hot springs nearly at boiling temperatures that have been measured on the surface, encouraging studies of these sites in order to start projects of desalination of seawater through the use of thermal energy.

Punta Banda - Maneadero

This area is characterized by the intense hydrothermal activity, submarine as well as on the shore of the coast, intense emanations of steam and hot water in the sea bed have recorded temperatures of 102ºC to 110ºC at a depth of 30 meters, as well as at different tourist camps along the coast where some norias have been dug that provide temperatures of 45ºC to 98ºC just at depths of 1.5 meters and in wells dug in the area. The most distinctive sites here are La Joya, Agua Caliente and La Bufadora.

Ejido Uruapan

In this area there are a group of hot springs located on the margins of the arroyo that drops into the Cañon de la Grulla, located some 3 km NE of the Agua Blanca Fault. One slope of this spring has been measured as from 250 liters per minute with temperatures of 50ºC to 65ºC. This water is used by the residents of the Ejido as thermal baths and laundries and they have built pools and pits for the purpose.

Santo Tomas - Ajusco

Along the length of the Santo Tomas Valley and Canyon, some thermal springs have been identifying during the rainy seasons. There are reports of springs with temperatures of about 47ºC and in one of this thermal norias a measured temperatures of 176ºC has been obtained.

San Carlos - Ensenada

To the NE of the Maneadero Valley, on the San Carlos Canyon several hot springs has been reported with temperatures of 47ºC to 50ºC. Even at the City of Ensenada there are springs and norias that have been used for years in the public baths named Acapulco, Lourdes and La Providencia.

Northern Zone of the Peninsula

In the Gulf of California or Sea of Cortez, is the volcanic providence of Puertecitos, where recent tectonic activity and the volcanic and rock activity of the zone have given rise to various thermal springs along the coast (Figure 1). This extreme desert zone in the north of the peninsula of Baja California has been converted into an important tourist area, where there are several areas along the coast in the upper part of the gulf, the majority of which are aimed at recreation and fishing. The main sites are:

San Felipe - Punta Estrella

In the port of San Felipe, around the Machorro Hill area, there are various manifestations of thermal activity located along the coastline, where there is at least one spring with 50ºC and a noria where a temperature of 30ºC has been found at a depth of only 2 m. At this site, apart from the thermal resources, there have been several studies done for the feasibility of installing a solar power plant, owing to the high degree of iridescence in the area, for which many residents of the area have solar panels for energy in their houses. Twenty five kilometers to the south of San Felipe, in Punta Estrella, there is a thermal spring that has given readings of 33ºC.

Puertecitos - El Coloradito

The geothermic area of Puertecitos is located on the east coast of Baja California Peninsula, 76 km south of the port of San Felipe. This area is considered as a place of geothermic interest owing to the presence of recent volcanic action in surrounding areas and for the existence of springs in the inhabited areas along the coast as well, registering temperatures in the range of 55ºC to 77ºC. An exploratory well has been drilled on this site but only got to a depth of 375 m when they started to have problems drilling. The maximum temperature registered there was 44ºC. To the north of Puertecitos, on the coast and some 30km inland there is a hydrothermal manifestation in an area known as Coloradito, where abundant hydrothermal alteration has been observed in the outlying rocks around a spring where 56ºC has been registered.

Central Zone of the Peninsula

Tres Virgenes

This geothermic area is located some 53 kilometers northeast of Santa Rosalia, Baja California Sur (BCS), in a large area remarkable for the hydrothermal activity in the middle of the region of the Tres Virgenes, as the three main volcanoes are known, La Virgin, el Azufre and La Reforma. In this area are numerous thermal zones where several fumaroles and boiling pots are seen, hot springs, mud pots and a large zone of hydrothermal alteration. This area has been widely studied (Lira, 1985) and developed by CFE, the national power company, installing on site a 10 MW power plant, fed by the steam extracted from the deep geothermal wells.

Santispac

Twenty kilometers to the south of town of Mulege, in the central part of the Bahia de Conception, a hot spring has been identified (44ºC) on the beach of the inlet at Santispac, in an area influenced by the fractured region of NW-SE which allows the overflow of hot water to mix with the sea water. Through the use of geo-thermometers it is estimated that the temperatures of formation can be on the order of 180ºC. At this site a slim hole was drilled to a depth of 500 m where the temperature was registered at 85ºC maximum.

San Nicolas - El Volcan

This is an important thermal area with abundant geothermal features. Hot water wells has been found with 65ºC-70-ºC located 70 km to the north of Loreto, BCS, and 9 km southeast of San Nicolás. On this site various hydrothermal activities have been observed, steaming ground and hot water discharges in the arroyo of San Nicolás. A little further south in the area known as Puerto Púlpito there are hot springs on the sand of the beach, unfortunately the sea invading the area makes it difficult to measure actual temperature.

El Imposible - El Centavito

There is a hot water well located in the San Juan Valley, 30 km northeast of Loreto that averages 46ºC. From the chemical analyses of this well, we know that it is sodium-chlorate composed and a temperature between 181ºC and 262ºC has been estimated.

Agua Caliente - Comondu

In this area there is a hot spring (59ºC) located some 25 km to the north of Loreto in the El Caballo Arroyo and 3.5 km from Boca Bataques beach. This spring flows through a fracture parallel to the structural system of the zone, and owing to the presence of recent volcanic action there is an area of high geothermal interest. However, in a slim hole drilled by CFE it only registered 97ºC at 500m depth. The temperatures estimated by geo-thermometers at this site are on the order of 176ºC.

Southern Zone of the Peninsula

Buena Vista

In front of the Bahia de Las Palmas some 60 km NE from San José del Cabo BCS, there is the Hotel Buena Vista where they found a hot water well (58ºC) on the property some 200m from the beach. This hot well was abandoned because they were searching for fresh cold water to be use at the hotel.

Agua Caliente - La Paz

Four kilometers to the west of the town of Agua Caliente, between the towns of Mira Flores and Santiago, in La Paz County, there is a hot spring (50ºC) with water bubbling up over the granite rocks.

Los Cabos

At the southern extreme of the Peninsula of Baja California, is one of the major tourist zones in Mexico, where there is an impressive development of hotels and the service infrastructure has been built in the last 10 years, increasing drastically the need for water and energy in the area. The operator of the municipal water system has a 200 liters/sec desalination plant fed by beach wells. At the beginning they drilled some wells registering temperatures of 35ºC to 72ºC (Lopez, et al., 2006) including a 84ºC well but, they abandoned because were not able to use that hot water in the reverse osmosis process.

HOT WATER TECHNOLOGICAL DEVELOPMENTS

Due the abundance of geothermal resources along the coast of Baja California Peninsula, the IMPULSA group has implemented two programs in order to desalinate sea water.

1. In case of low temperature of geothermal resource (under 140ºC) it can desalinate sea water through a thermal process (LE-MED).

2. In case of hot water resources (>140ºC) it can be used to generate electricity with a PWG system and then that power feed a reverse osmosis plant to desalinate sea water.

LE-MED (Low Energy-Multi Effect Distillation)

The LE-MED system is an original IMPULSA design that comes from the technological mixture of a MED and a MSF thermal desalination plants. The operation basics of traditional MSF and MED plants started pre-heating sea water to its boiling point using steam usually extracted from a thermal power generator, then the pre-heated sea water is evaporated and the steam free of salts is condensate as fresh water. The remaining water leaves the plant as concentrated brine. The new IMPULSA LE-MED does not use steam in the process at all, instead geothermal hot water is used as an energy source to run the system. The main idea with this LE-MED system (Figure 2) is to avoid the use of fossil fuels sources in the scheme of the desalination process. These would significantly reduce the cost per desalinated cubic meter.

We consider this is one of the most relevant themes in the IMPULSA project. It is a rare case in the world that allows a big savings in energy yielding desalination into a sustainable concept. The cost per desalinated cubic meter by this process using geothermal natural heat will depend strongly on the materials required and additional sources of energy for pumping and vacuum.

For the design of the LE-MED IMPULSA plant, several computer programs have been developed in order to assess mass and thermodynamics balance, heat exchange areas, pumping and vacuum power. At this stage IMPULSA project is studying various ways for future incorporation of the problems related with scaling. Later on will come the construction of a laboratory prototype to test the whole system (Figure 3).

The main benefit of this proposal is to avoid the use of steam in the thermal desalination process and in its place, use renewable resources (hot geothermal water) abundant in the Baja California Peninsula, not using the fuel necessary for generating steam for desalination. Savings up to 30 to 40% of the desalinated cubic meter cost has been estimated, corresponding to the cost of the fuel to produce steam by traditional desalination methods (Figure 4).

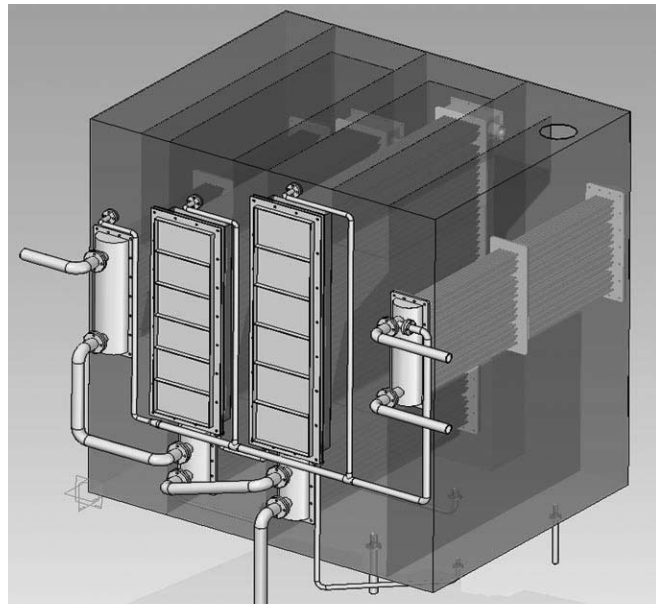

Figure 3: Basic IMPULSA MED-LE Design

The continuous economic results of the project estimate that it can lower the cost up to 30% of m3 desalted with thermal technologies through the use of hot seawater as a source of energy for desalination.

Geothermal Electricity Generation, PWG. (Pressure Water Generation)

The following project proposes the use of the hot geothermal water located in abundance in the Baja California Peninsula, as part of distributed generation for small plants that in many cases won't be connected to the grid. Under this plan the IMPULSA project of UNAM hasdeveloped exploratory surveys to locate, characterize and estimate the potential of hot sources in the Peninsula. The main idea of this project is to generate electricity

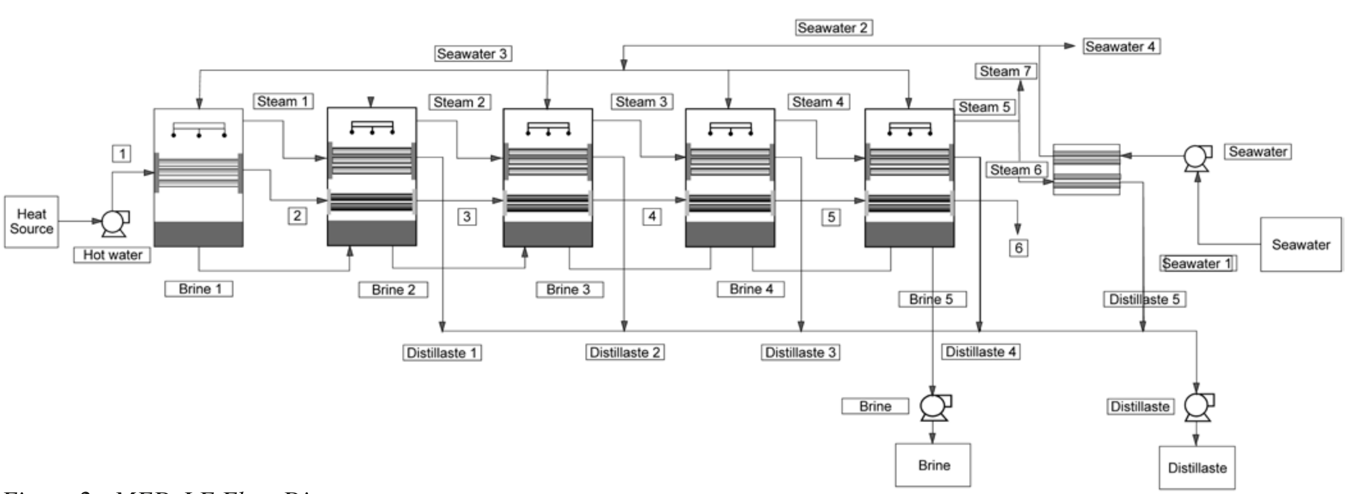

Figure 2: MED-LE Flow Diagram

with the PWG plant, the proposal is the generation of electrical energy by heat transference from a geothermal source into a working compressed liquid (water).

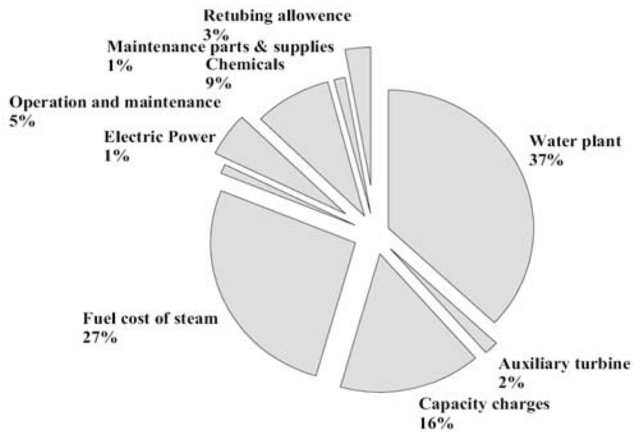

Figure 4: Integrated cost of a thermal desalination project (Semiat, 2000)

The binary geothermal generation technology that is installed in many parts of the world with organic fluids which are basically preheated and evaporated through heat exchangers (shell and tube system) is already well known. The main difference of the proposal with respect to a traditional binary cycle is the elimination of the heat exchange evaporator, proposing a flash system so that the fluid vaporization is done by the pressure lowering, thereby in order to pre heat the working fluid it is possible to use a heat plate exchanger that is easier to maintain and operate. Also the turbine proposed for the PWG is a high speed turbine with a reduced diameter but higher revolutions. This proposal meets these objectives, having the main goal of generating electricity in a more efficient, sustainable and economically competitive way.

The IMPULSA group has developed a new thermodynamic cycle for the efficient use of geothermal low enthalpy resources. In this design the secondary fluid is water at high pressure and a temperature. First the working pressurized fluid is pre heated in the heat plate exchanger, then it is flashed into a separation tank, the steam runs the high speed turbine. Finally the exhausted steam from the turbine is condensate and mixed with the hot water that did not flash in the tank, the mixture is pressurized and the cycle starts again (Figure 5).

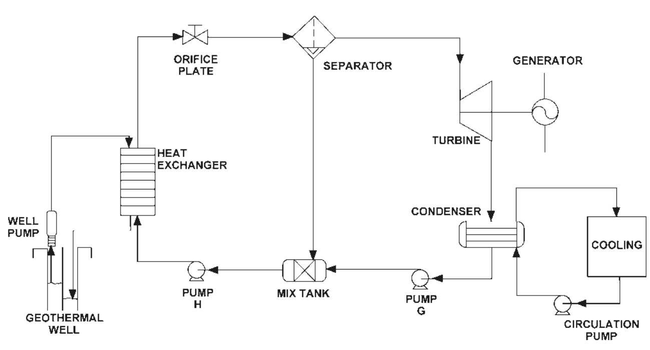

Figure 5: PWG Flow Diagram

The conventional systems of binary generation use great chambers of heat exchange to preheat the working liquids, which are generally organic fluids such as isopentane and isobutane and other heat exchangers to vaporize the fluid and activate the turbine, constants stops, are required for service and maintenance of the shell and tube heat exchangers.

The proposal consists of the installation of plate type heat exchanger that will improve the heat transfer, takes less space and are easy maintenance. The proposed cycle will be water-to-water (pressurized) generating steam by a pressure decrease. The IMPULSA turbine design will be small diameter (10 to 20 cm diameter) and high velocity (30,000 rpm) integrating the most advance turbine design.

PWG system could generate energy at costs of 0.04 to 0.06 US$/kWh, strongly depending of the installation equipment's cost, well drilling and operation and maintenance costs.

LA JOYA, CASE STUDY

The IMPULSA geothermal project "La Joya" is located in northeastern Baja California in the Ensenada County, (Figure 1) where exploratory studies have been developed by the Mexico's National University (mapping superficial manifestations, geochemistry, geology, geophysics, satellite thermal images) (Arango, et al., 2007) as a result of this work, in order to exploit the research site in "La Joya" a hot water beach well site has been selected and programmed to be drilled, the preliminary studies shows that temperatures up to 180°C are feasible in the test site, so we decide to test the two systems described (MED-LE desalination plant and the PWG generator). Also the potential of the zone is described for each system, as follow:

1. For the MED-LE project, IMPULSA has just finished the thermodynamic analysis and the basic constructive design (Figure 3), laboratory design will be prepared for testing in La Joya site. The basic info of the prototype is shown in Table 1.

   We estimate that the desalination potential of La Joya zone is up to 1 m^3/s possible to be generated from a renewable source of energy, the preliminary estimated cost per cubic meter is 0.8 US$/$m^3$ and the cost break down is as follows in Figure 6.
2. The estimated electrical generation potential based on the preliminary exploration data analysis shows that it is up to 30 MW distributed in the zone, including La Joya site (1 MW). The PWG laboratory prototype is under construction, and its power capacity will be 14 electrical kW generated by the experimental La Joya well (1st stage), the basic data from the system is presented in Table 2.

FINAL REMARKS

Intensive use of the coastline geothermal resources in Baja California is one of the big challenges for IMPULSA in Mexico, helping to solve the power and fresh water scarcity on this region of the county. Since it is located in a very arid zone but with abundant natural resources i.e., solar, wind and geothermic as well.

At the same time, an enthusiastic and promising engineering group has been consolidated at the National University; UNAM committed with the use of renewal energies while several research projects of IMPULSA allow post graduate students to finish their Engineering degrees.

Desalination of sea water by using renewable energy is the main goal of the IMPULSA team that, by scientific and technological research, is promoting the use of clean and environmental friendly energy sources, i.e., the PWG and LE-MED prototype developments.

Table 1. Basic Information of the MED-LE Prototype

Laboratory model data	Flow rate (kg/s)	Inlet temp. (˚C)	Outlet temp. (˚C)	Concentration (ppm)
Hot water	1.4	85	46	4,000
Sea water (condenser)	3.6	25	36	35,000
Sea water inletto chambers	0.6	36		35,000
Brine	0.38		41	56,000
Product	0.23		41	10
Recovery rate	37%			
Performance ratio	1.4 (kg/MJ)			
Maximum vacuum pressure	0.78 (bar)			
Auxiliary power consumption	2 (kW)			

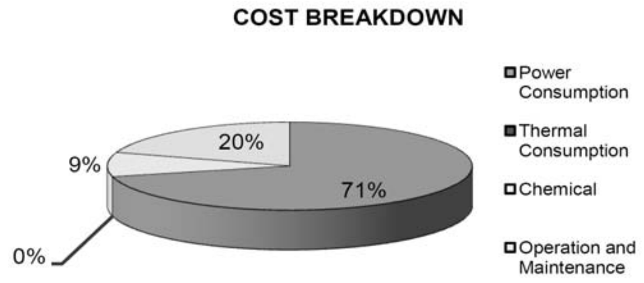

Figure 6: Cost break down

Table 2. Basic Data from the PWG Prototype

Laboratory model data	Flow rate (kg/s)	Inlet temp (˚C)	Outlet temp (˚C)
Geothermal Well	1.4	140	106
Cycle Working Fluid	1	96	136
Cooling fluid	1.5	27	49
Power Output	14 kW		

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MEASURING THE COSTS AND BENEFITS OF NATIONWIDE GEOTHERMAL HEAT PUMP DEPLOYMENT

Alexandria, Virginia - 2 June 2010 - While the technology has existed since the late 1940s, geothermal heat pumps (GHPs), also known as ground-source heat pumps and GeoExchange®, currently account for less than two percent of the total North American heating and cooling market. Only 120,000 units were shipped in the United States in 2008.

But, what if the numbers were higher? What if GHPs were installed wherever they made economic and geographic sense? How would a nationwide deployment of these green heating and cooling systems benefit the country economically, environmentally, and socially? If GHPs were installed as widely as possible:

- How many new green jobs would GHP manufacturers create to meet the increasing demand?
- How many more feet of high-density polyethylene (HDPE) and cross-linked polyethylene (PEXa) pipe would factories produce?
- How many thousands more heat exchangers and tons more geothermal grout would be needed?
- How many greenhouse gases would not be emitted?
- How much business expansion and energy savings would result from such a momentous deployment?

With support from the U.S. Department of Energy through the American Recovery and Reinvestment Act of 2009, Bob Lawrence & Associates, Inc. (BL&A) and the California Geothermal Energy Collaborative (CGEC) are conducting a three-year study to help find the answers to these questions.

Over three years, BL&A and the CGEC will undertake a massive data collection effort focused on the 30 largest metropolitan areas (see Figure 1).

BL&A and the CGEC will collect two types of data: 1) manufacturing and installation cost data, and 2) geological and geographical data.

1) Manufacturing and installation cost data will be sought from GHP manufacturers and their suppliers, contractors, engineers, installers, drillers, and others.
2) Geological and geographical data--including soil types, thermal conductivity, heat flow, hydrological properties, and heating and cooling demand--will be collected and analyzed for the 30 metropolitan areas. The two data sets will then be correlated to identify the relationship between installation cost and location.

Lastly, BL&A and the CGEC will establish criteria for evaluating the economic, environmental, and social benefits of GHP deployment in the 30 areas, and seek to quantify those benefits.

We need you!

Such an enormous data collection effort has never been undertaken. We need your help to succeed. So, in the coming months, when you receive the call from BL&A or the CGEC, please help. We cannot do this without your active participation.

Figure 1. Thirty (30) largest metropolitan areas in the United States (from largest to smallest)

New York-Northern New Jersey-Long Island, NY-NJ-PA
Los Angeles-Long Beach-Santa Ana, CA
Chicago-Naperville-Joliet, IL-IN-WI
Dallas-Fort Worth-Arlington, TX
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD
Houston-Sugar Land-Baytown, TX
Miami-Fort Lauderdale-Pompano Beach, FL
Atlanta-Sandy Springs-Marietta, GA
Washington-Arlington-Alexandria, DC-VA-MD-WV
Boston-Cambridge-Quincy, MA-NH
Detroit-Warren-Livonia, MI
Phoenix-Mesa-Scottsdale, AZ
San Francisco-Oakland-Fremont, CA
Riverside-San Bernardino-Ontario, CA
Seattle-Tacoma-Bellevue, WA
Minneapolis-St. Paul-Bloomington, MN-WI
San Diego-Carlsbad-San Marcos, CA
St. Louis, MO-IL
Tampa-St. Petersburg-Clearwater, FL
Baltimore-Towson, MD
Denver-Aurora, CO
Pittsburgh, PA
Portland-Vancouver-Beaverton, OR-WA
Cincinnati-Middletown, OH-KY-IN
Sacramento--Arden-Arcade--Roseville, CA
Cleveland-Elyria-Mentor, OH
Orlando-Kissimmee, FL
San Antonio, TX
Kansas City, MO-KS
Las Vegas-Paradise, NV

NEW WEBSITE "GHPSRUS.COM" LAUNCHED TO SUPPORT GEOTHERMAL HEATING AND COOLING

Alexandria, Virginia - 6 August 2010 - Bob Lawrence & Associates, Inc. (BL&A) has launched a new website - GHPsRUS.com - to promote the installation of geothermal heat pumps (GHPs) across the United States. "GHPsRUS" is short for "GHPs are U.S." The website URL ishttp://GHPsRUS.com/.

GHPsRUS.com was created to:

- Help collect data from contractors, designers, installers, drillers, and GHP manufacturers and their suppliers; and
- Generate excitement about and serve as an online portal for the GHPsRUS Project.

The GHPsRUS Project seeks to quantify the economic, environmental, and social benefits resulting from a nationwide deployment of GHPs, wherever they make "economic sense." "Economic sense" will be defined vis-à-vis current sources of heating, cooling, and electricity as well as geographic factors.

Economic benefits include jobs created, taxes paid, business expansion, and energy savings. Environmental benefits include a reduction in the emissions of greenhouse gases and air pollutants and a decreased need for new electricity generation. Social benefits include improved quality of life.

GHPsRUS.com features a poll of the month, links to useful websites and reports, press releases, and specific pages for GHP contractors, designers, installers, drillers, and GHP manufacturers and their suppliers.

The GHPsRUS Project is supported by the U.S. Department of Energy through the American Recovery and Reinvestment Act of 2009.

“Be In The Loop” at GHPsRUS.com.

Geothermal heat pumps (GHPs) - among the most efficient heating and cooling technologies available - use the constant temperature of the earth to heat and cool buildings. GHPs move heat between buildings and the earth three to five times more efficiently than other HVAC systems. And, about 70 percent of the energy used in a GHP system is renewable energy from the ground.

While the technology has existed since the late 1940s, GHPs, also known as ground-source heat pumps and GeoExchange®, currently account for less than two percent of the total North American heating and cooling market.

Bob Lawrence & Associates, Inc. (BL&A) is a Washington, D.C.-based government relations firm established in 1986. It features corporate clients and federal government contracts and has significant relationships with several international entities. BL&A has worked with the U.S. Department of Energy since its inception to promote the use of clean renewable energy in the United States and around the world. Visit BL&A on the web athttp://www.bl-a.com/.

GHPsRUS.com

BE IN THE LOOP

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