Australian Government
Geoscience Australia

Direct-use of Geothermal Energy: Opportunities for Australia

Geothermal energy is a natural source of heat contained within the Earth, and it can be extracted and used either indirectly to generate electricity, or directly for heating applications.

There are some examples of geothermal direct-use projects in Australia already and there is significant potential for additional domestic, industrial and commercial applications.

Direct-use of geothermal energy for heating applications is an energy efficient alternative to converting the resource to some other form of energy such as electricity.

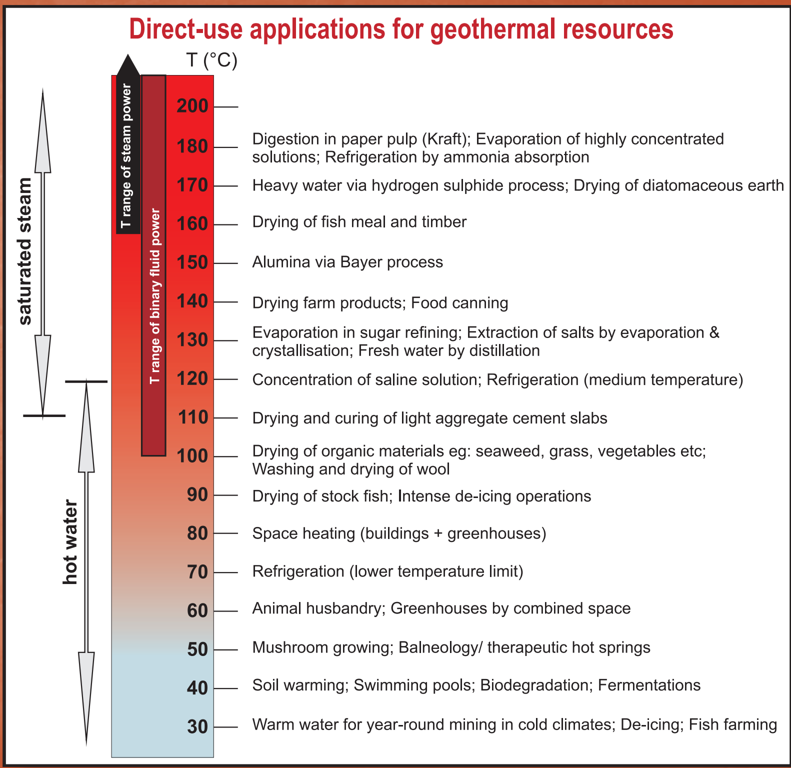

Figure 1: Examples of direct-use applications for geothermal energy (modified from Lindal (1973))[i].

Examples of direct-use applications

The different applications for direct-use of geothermal energy vary according to temperature, as illustrated by the Lindal diagram[i] (Figure 1). Direct-use is typically associated with lower-temperature geothermal resources (those with temperatures less than 150°C), though some applications may require higher temperatures. In Australia, geothermal heat could be used in agriculture for greenhouse heating or crop drying as well as in aquaculture and space heating. It could also be used for industrial processes such as concrete curing, milk pasteurisation, chemical extraction, refrigeration, drying organic materials (seaweed, grass etc), desalination, wool processing and pre-heating of water in coal-fired power stations. Cascading use, whereby the same water is used in successive processes at progressively lower temperatures, is possible within a single geothermal operation. This can improve efficiency and economic feasibility.

Why use geothermal heat directly?

There are economic, environmental and energy efficiency benefits associated with the direct use of geothermal energy, including:

- Lower heating costs by reducing electricity, oil or gas consumption;
- Reduced emissions of CO_2 and oxides of nitrogen and sulphur, by reducing consumption of fossil-fuel-generated electricity;
- Better use of resources, with reduced consumption of a high-grade fuel (such as natural gas) for low-grade heating; and,
- Minimal ongoing costs after installation.

In addition, at the lowest end of the temperature spectrum, ground source heat pumps can be used almost anywhere in the world to provide heating and cooling for buildings[ii].

Where can geothermal heat be used?

Direct-use of geothermal energy normally requires accessing heated groundwater that is naturally circulating through sedimentary strata or fractured rock (a hydrothermal system, see Figure 2). This type of geothermal resource is found wherever sufficient quantities of groundwater come into contact with heated rocks. Hydrothermal systems can be high or low temperature depending on the type of heat source and its proximity to the groundwater. High temperature hydrothermal systems with circulating fluids as hot as 350°C are restricted to locations near active or recent volcanism, such as New Zealand or Iceland, and are usually exploited for electricity generation. Hydrothermal systems with fluids less than 150°C are more widespread and are suited to direct-use applications. Heat sources for low-temperature hydrothermal systems in Australia include high-heat-producing basement rocks, or geologically-recent volcanic systems.

Australia's Great Artesian Basin has large, low-temperature hydrothermal systems, with aquifers containing groundwater that comes to the surface as warm as 98°C. There are likely to be many other locations in Australia where warm groundwater is present and could be used for direct-use applications.

How is geothermal heat extracted?

Heated water or wet steam from a hydrothermal system is extracted through a bore and passed through pipes or coils at the surface to provide energy for a particular process. The cooled fluid is then often recirculated back into the aquifer through a second bore to maintain a sustainable system. In some cases, the warm/hot water may be passed through a heat-exchanger to transfer its heat to what is termed a working fluid, which then delivers the heat to where it is required.

Geothermal Heat Pumps/ Ground Source Heat Pumps

Ground source heat pumps typically circulate fluid through a shallow closed-loop piping system in the earth or a water body (Figure 3), to use the relatively constant temperature of the rocks or water as a heat source or a heat sink. High temperatures are not needed, and these systems can be applied almost anywhere. In winter, cold liquid pumped into the ground absorbs heat from the surrounding rocks, and the warmed liquid that is returned to the surface can be used to heat buildings. Conversely, warm liquid pumped into the ground in summer will lose heat to the relatively cooler surrounding rocks, and can be used to cool buildings. When the temperature contrast between the ground and air temperature is at a maximum, which usually occurs at the height of summer and winter, the ground source heat pumps run most efficiently and provide the greatest potential for cooling or heating (Figure 4).

Although ground source heat pumps are electric-powered, they are used only to move heat, not to produce heat. As a result, they are energy efficient and usually have Coefficients of Performance (a measure of energy efficiency) greater than three. This means that for every unit of electrical energy consumed, three units of energy are delivered in the heating or cooling process.

Existing direct-use applications in Australia

Direct-use of geothermal energy in Australia currently includes building and district heating systems (eg: Portland, Victoria), spa developments (Mornington Peninsula, Victoria and Mataranka, Northern Territory), artesian baths (Moree, Lightning Ridge artesian baths, and Pilliga Hot Artesian bore, inland New South Wales) and swimming pool heating (Challenge Stadium, Western Australia)[iii]. Geothermal heat pumps have been installed in several locations, including at Geoscience Australia's office building in Canberra, the Integrated Energy Management Centre and the Antarctic Centre in Hobart, and the Hobart Aquatic Centre.

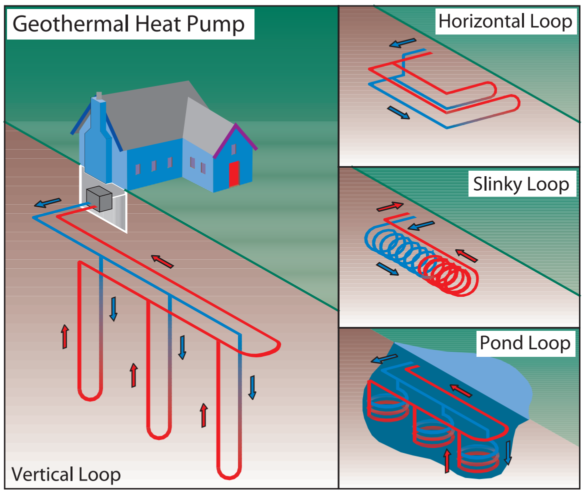

Figure 3: Various closed-loop configurations of Ground Source Heat Pumps (shown in heating mode). Vertical loop systems are usually no deeper than 150 metres.

Global direct-use of geothermal energy

Geothermal energy has been used in direct-use applications for millennia, with ancient civilisations such as the Romans using geothermally-heated waters for bathing and medical purposes. In May 2005, worldwide direct-use of geothermal energy was approximately 273,372 TerraJoules/yr (75,943 GigaWattHours/yr)[iv]. Of this, 32% was attributed to geothermal heat pumps, 30% for bathing and swimming, including balneology, 20% for space and district heating, 7.5% for greenhouse heating, 4% for industrial applications, 4% for aquaculture, and less than 2.5% for snow melting, agricultural drying and other uses[iv]. This equates to annual savings of 170 million barrels of oil, and 24 million tonnes of carbon emissions to the atmosphere [iv].

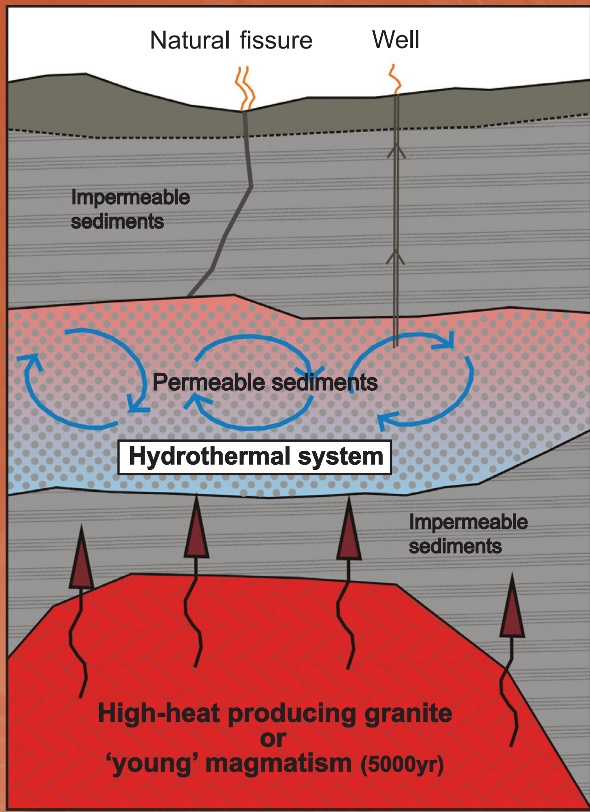

Figure 2: Generalised geological setting of hydrothermal systems in Australia.

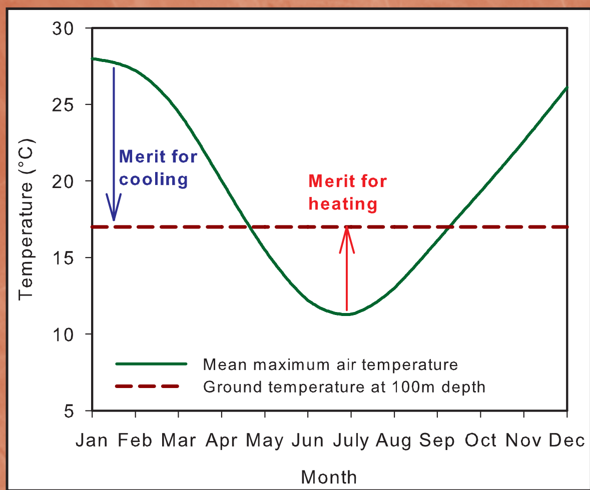

Figure 4: Seasonal air temperature variations in Canberra compared to ground temperature at 100 metres depth (Climate data courtesy of the Bureau of Meteorology, www.bom.gov.au/climate/averages/).

References

[i] Lindal, B., (1973) Industrial and other applications of geothermal energy, In Geothermal Energy: Review of Research and Development, Paris, UNESCO, LC No. 72-97138, pp135-148.

[ii] Fridleifsson, I.B., (2001) Geothermal energy for the benefit of the people. Renewable and Sustainable Energy Reviews., Vol. 6, pp299-312.

[iii] Chopra, P.N., (2005) Status of the Geothermal Industry in Australia, 2000-2005. Proceedings of the World Geothermal Congress 2005, Antalya, Turkey, 24-29 April.

[iv] Lund, J.W., Freeston, D.H., and Boyd, T.L., (2005) Direct application of geothermal energy: 2005 worldwide review. Geothermics, Vol. 34, pp691-727.

07-2191