Geothermal guideline 3

Types of geothermal production systems in Rotorua

This guideline, developed by Bay of Plenty Regional Council, outlines some of the advantages and disadvantages of the different production systems available for using geothermal.

Geothermal use in Rotorua

Rotorua Geothermal System (Ngā Wai Ariki o Rotorua) has been used by Māori for sustainable customary practices for hundreds of years. More recently, geothermal wells have been more widely used to extract heat or water from the geothermal aquifer for domestic, commercial and municipal uses.

Overuse of geothermal in the past has changed the geothermal aquifer and destroyed or damaged precious geothermal surface features (ngāwhā), such as geysers and hot springs. Geothermal use is now carefully managed under the Regional Plan. Under the Plan, all geothermal takes (except those for customary practices) require a resource consent.

Managing the effects of use

Even with good practices (e.g., reinjection), most geothermal takes can affect the geothermal aquifer and surface features. This is because they all remove water and/or heat from the aquifer. While individual takes may be small, together their effects can be large. The effects will depend mostly on the size and depth of the take, the local geothermal aquifer conditions, and the distance between the take and surface features or other users. The type of production system is also an important consideration.

Choosing the right geothermal production system

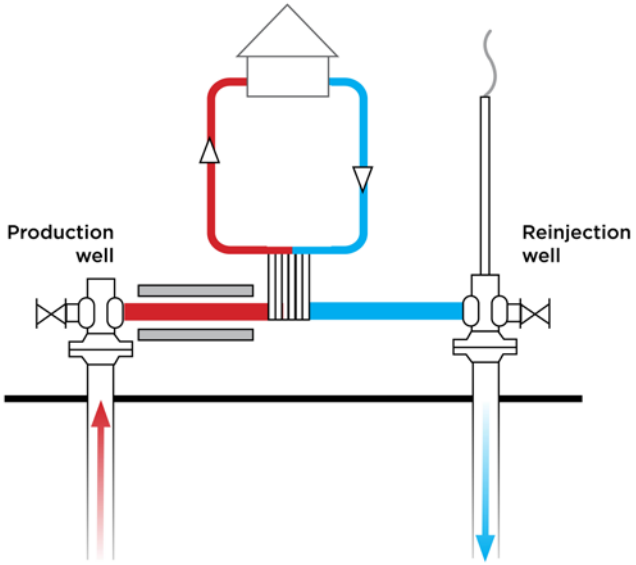
Some of the things to consider when replacing or choosing a new geothermal production system include:

- How much geothermal heat and water do you need for an efficient use?
- What are the potential effects on the geothermal aquifer and nearby surface features?
- Are there effects on nearby geothermal takes?
- What are the potential effects on surface features if you are taking directly from them, like such as pumping a hot spring or ngāwhā?
- What are the costs (drilling geothermal wells, infrastructure, maintenance of your wells)?
- Are there spatial constraints on your site?
- Are you located within the Geothermal Mass Abstraction Exclusion Zone?

Production reinjection (doublet systems)

Geothermal water is extracted from the geothermal aquifer and brought to the surface using a production well. The heat from the water is extracted using a heat exchanger. The cooler water is reinjected back into the same aquifer via a reinjection well. In Rotorua, the typical thermal energy output from this kind of system can range from a few tens of kW_{th} to more than 1.2 MW_{th}, with an average of a few hundred kW_{th}. For reference, one MW_{th} is enough to heat more than one hundred homes, a large hotel or an outdoor Olympic-size swimming pool.

Figure 1: Schematic diagram of a geothermal production reinjection well



PRODUCTION REINJECTION (DOUBLET SYSTEMS)

Main advantages

- Can withdraw enough energy to service larger users (e.g. large hotels) from a relatively small area
- Performance is well understood and predictable
- Retaining existing reliable systems, rather than transitioning to a new type of system, may be cost effective
- Can be regulated to match heat demand using pumps, providing flexibility to meet low heat demand
- Can provide for mixed uses (use for space heating and for mineral pools)

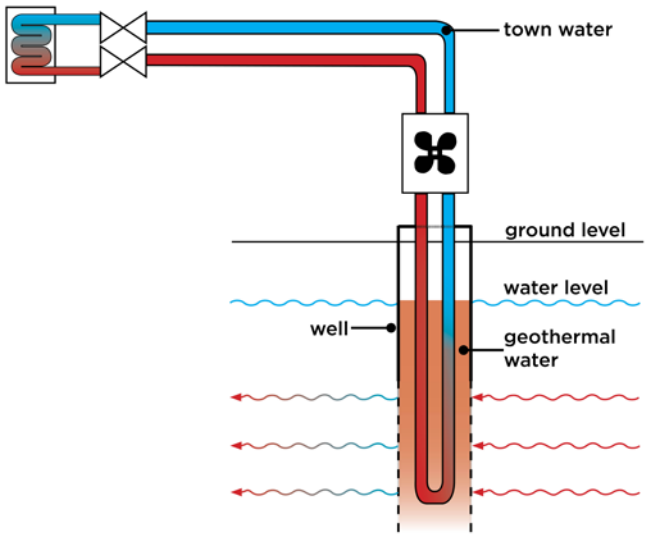
Main disadvantages

- Technically difficult to regulate thermal output so can be inefficient and not well suited to small heat takes (i.e. less than 100 kWth)
- Requires managing the discharge of the geothermal water after use (e.g. the drilling and maintenance of a reinjection well)
- Potentially greater effects on the geothermal aquifer, both locally and system-wide, than a down hole heat exchanger (DHX)
- Very high adverse effects where there is no reinjection
- Higher costs to establish and maintain
- Higher safety risk if not well operated and maintained
- More maintenance intensive compared to DHXs
- More difficult to monitor usage, which is a standard requirement for consenting

Conventional down hole heat exchanger (DHX)

Town supply water is pumped down into a well through a closed loop system. Heat is then transmitted to this piped water from the surrounding geothermal aquifer and the hot rocks. Geothermal energy is produced from the geothermal aquifer without bringing geothermal water to the surface (unlike a doublet system. Typical output for a conventional DHX in Rotorua is < 50 kWth, but it can reach higher outputs depending on aquifer and operating conditions.

Figure 2: Schematic diagram of a geothermal down hole heat exchanger



CONVENTIONAL DOWN HOLE HEAT EXCHANGER (DHX)	
Main advantages	**Main disadvantages**
• The area over which local effects are felt (e.g. localised cooling) is generally smaller than a doublet system, reducing effects on surface features or nearby users • Cumulatively has a much smaller system wide effect on the geothermal aquifer • Promotes efficient use as can more easily be moderated to match changing heat demand (i.e. seasonal changes) • No geothermal water discharge to manage • Easy to monitor usage, which is a standard requirement for consenting • Can be potentially retrofitted to a conventional well, thus not requiring drilling a new well • Requires a single well for small users, reducing drilling, and maintenance costs and risks • Potential alternative for sites where reinjection is not feasible	• Uncertainty of heat output until well construction and testing is completed • Multiple wells may be needed to meet the heat demand for medium to larger users, increasing costs and the area over which effects are felt • Not suitable for takes extracting geothermal water for mineral bathing or spa treatments • Can adversely affect geothermal aquifer pressure, particularly if producing from boiling zones • Potentially low economic viability, due to similar costs to build the geothermal system but a lower thermal output

Enhanced down hole heat exchanger (DHX)

Like a conventional DHX, but modified to increase the thermal output from the well. Normally requires a slightly larger well and the use of a promoter tube or perforated casing to enhance convection of geothermal water around the closed loop. This significantly improves the heat transfer from the geothermal aquifer water and hot rock to the closed loop system.

Figure 3: Schematic diagram of an enhanced geothermal down hole heat exchanger (without promotor tube)

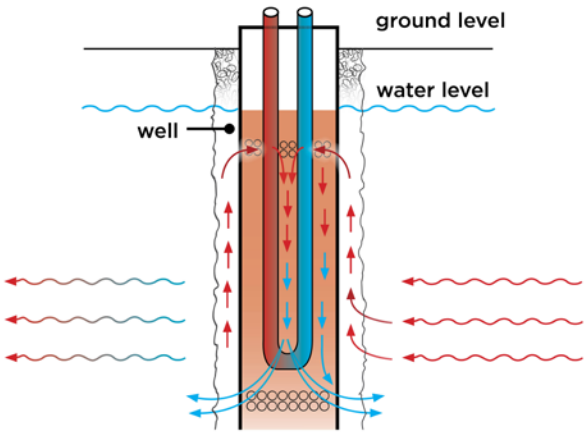
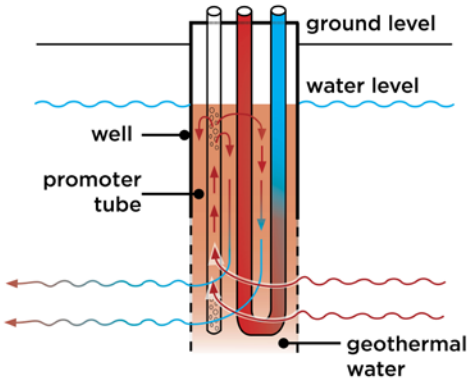


Figure 4: Schematic diagram of an enhanced geothermal down hole heat exchanger (with promotor tube)



ENHANCED DOWN HOLE HEAT EXCHANGER (DHX)	
Main advantages	**Main disadvantages**
• Capacity to generate a much higher thermal output than a conventional DHX, of the magnitude of a small to medium doublet system (up to a few hundred kWth) • Same other advantages of a conventional DHX	• Has potential to create a much larger effect in the aquifer than a conventional DHX, due to its higher thermal output and the generation of a localised convection cell within the aquifer • Same disadvantages as a conventional DHX (except those relating to thermal output)

Surface takes

Geothermal water is pumped or diverted from a geothermal surface feature, typically a hot spring or a hot pool. Like a production-reinjection system, the water can be used directly for bathing or for heat extraction via a heat exchanger at the surface. In some cases, geothermal energy is transferred to town water through piping placed in the surface feature, using the same principles as a DHX.

SURFACE TAKES	
Main advantages	**Main disadvantages**
• Negligible to no effect on the geothermal aquifer where the take is equal to or less than the natural discharge of the surface feature • Suitable for small takes, including takes using geothermal water for mineral bathing or spa treatment • Minimal infrastructure required, cost effective and very low economic risk • Low maintenance	• Diversion and modification can affect downstream surface features • Thermal output is likely insufficient for most users • Vulnerable to natural changes of the surface features • Pumping of a surface feature can affect its natural character and have local effects on the geothermal aquifer (e.g., similar effects to a well) • Requires access around geothermal surface features, which can be hazardous

You may also like to refer to our other geothermal guidelines

- Keeping your geothermal well fit for purpose and safe
- Managing geothermal discharges in Rotorua
- Efficiency of the Rotorua Geothermal System

For more information visit our website
www.boprc.govt.nz/geothermal
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