Australian Government
Geoscience Australia

# Electricity Generation from Geothermal Energy in Australia

Geothermal energy is the heat contained within the Earth and it can be used to generate electricity by utilising two main types of geothermal resources. Hydrothermal resources use naturally-occurring hot water or steam circulating through permeable rock, and Hot Rock resources produce super-heated water or steam by artificially circulating fluid through the rock. Electricity generation from geothermal energy in Australia is currently limited to an 80kW net power plant at Birdsville in south west Queensland. However this is likely to change in the future as Hot Rock power plants become increasingly commercially viable.

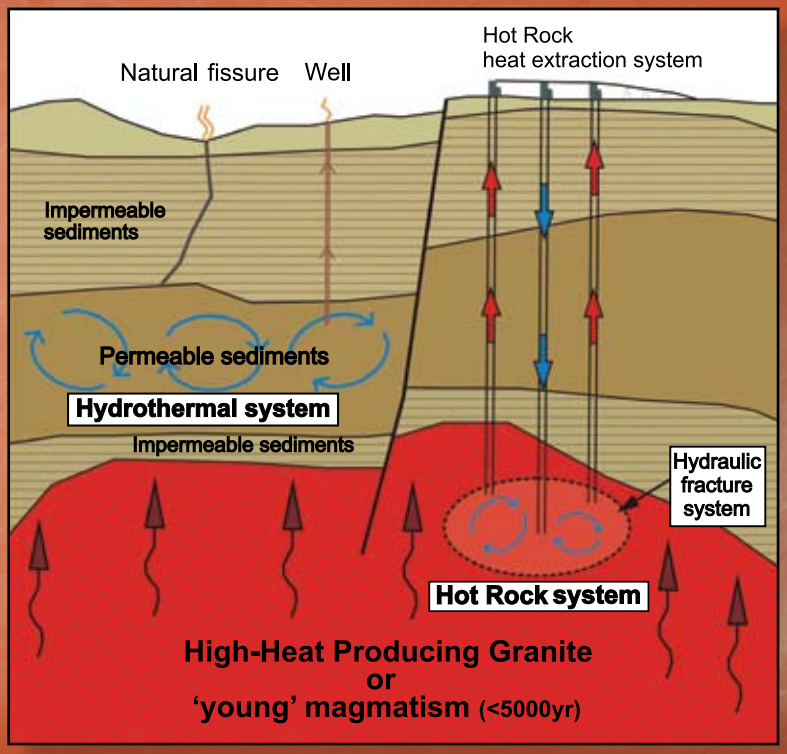


**Figure 1: Geological settings of hydrothermal and Hot Rock geothermal systems in Australia.**

## Geothermal Systems

A geothermal system consists of three elements: a heat source, permeable rock, and a fluid to transport heat to the surface. The heat source is the only fundamental requirement because permeable rock reservoirs can be artificially created and fluids can be introduced. There are two main types of geothermal systems that can be used to generate electricity.

**Hydrothermal systems** have fluids circulating through rock pores or fractures (as a liquid or vapour) in areas where high heat-flow is present. These systems are often found near active tectonic plate boundaries where volcanic activity has occurred, such as in Iceland, New Zealand and the Philippines. Hydrothermal systems can also form above areas of hot basement rocks (see Figure 1), and it is this type of system that is found in Australia. High-temperature hydrothermal systems are often exploited for electricity generation, while low-temperature hydrothermal systems are more suited to direct-use applications (see Geoscience Australia's Factsheet "Direct-use of Geothermal Energy: Opportunities for Australia").

**Hot Rock systems** do not have fluids naturally circulating through the rock and in most cases, the rock needs to be fractured to achieve the fluid flow required for heat transfer. Hot Rock systems are normally associated with granites that contain anomalously high concentrations of the naturally radioactive elements uranium (U), thorium (Th) and potassium (K). Although enriched in these elements compared to other rocks, element concentrations are still relatively low (commonly ~0.002% U, ~0.01% Th and ~4% K). The radioactive decay of these elements over millions of years generates heat, which is trapped when the granites become buried by insulating sediments. The thicker the insulating layer, the hotter the temperatures, for example, granites at 3 kilometres depth overlain by insulating sediments can be hotter than 200°C [i].

Hot rocks at these depths generally have low porosity and permeability, and require fluid pathways to be enhanced. Permeability is artificially increased by pumping water down a bore under high pressure to reopen existing fractures in the granite. When the hydraulic pressure is reduced, the voids do not fit back together perfectly, which increases permeability and allows fluids to be circulated through the rock.

The Hot Rock system is a closed-loop system that requires at least one fluid injection well and one production or recovery well. Liquid is pumped down the injection well and travels through the rock fracture network to be heated by the hot rocks. The superheated fluid then returns to the surface in the production well(s), transfers its heat to a secondary fluid or working fluid (see Figure 3), and is then recirculated and pumped down the injection well (Figure 1). There are currently no Hot Rock systems generating electricity on a commercial scale anywhere in the world, however the Landau Project in Germany is scheduled to be on-line in late 2007.

## Potential advantages of Geothermal Power Generation in Australia

- Baseload and peaking capability: Geothermal power-plants can operate 24 hours a day, 365 days a year and are unaffected by climatic factors.
- Low $CO_2$ emissions: Binary geothermal power plants (overleaf) could be zero-emission (no $CO_2$ or oxides of nitrogen and sulphur).
- High availability factors: Binary power plants can usually produce electricity for 95% of the time.
- Low environmental impacts: No acid rain, mine spoils, open pits, oil spills, radioactive wastes, or damming of rivers. Binary power plants occupy small land areas.
- Increased energy security: Geothermal is an indigenous supply of energy, providing energy supply and pricing security.

GEOCAT # 65455

## Geothermal Power Generation Systems

The type of electricity generation power plant used depends on the volume of fluid available and its temperature. Where a lot of high temperature water or vapour is available, steam power plants are used (Figure 2). Australia does not have the wet, high-temperature geothermal environments found in volcanically active countries. Consequently, Australia's hydrothermal systems are neither hot enough or under enough pressure to produce large amounts of steam. As Hot Rock systems use a closed loop to conserve water and energy, most Australian geothermal resources will be exploited using binary power generation systems (Figure 3).

In binary power plants, a heat exchanger is used to transfer energy from the geothermally-heated fluid to a secondary fluid (called the 'working fluid', e.g. iso-pentane or ammonia) that has a lower boiling point and higher vapour pressure than steam at the same temperature. The working fluid is vaporised as it passes through the heat exchanger, and then expanded through a turbine to generate electricity. It is then cooled and condensed to begin the cycle again (Figure 3). Advances in binary-plant technology have enabled lower temperature geothermal resources to be exploited for electricity generation (as low as 85°C)[ii]. However, issues such as low cycle conversion efficiencies (5 to 9% for resources less than 100°C) and the requirement for larger heat-exchangers, impose economic and practical limits on exploiting low-temperature geothermal resources for electricity generation [iii].

## Existing Geothermal Power in Australia

The only existing geothermal power generation in Australia is a small, 80kW net binary-cycle plant at Birdsville in south west Queensland. This power plant utilises a low-temperature hydrothermal-type geothermal resource, accessing 98°C groundwater from a 1,230 metre-deep artesian bore that taps a confined aquifer in the underlying Great Artesian Basin. The Great Artesian Basin spans 22% of the Australian continent and has groundwater temperatures ranging from 30°C to 100°C at well heads [iv].

## Future Electricity Generation in Australia using Geothermal Energy

Australia has an abundance of high-heat producing basement rocks buried under sediments. By the end of August 2007, 29 companies had applied for geothermal exploration licenses in Australia, and five companies had begun drilling potential sites in South Australia. These are:

- Geodynamics Limited (Habanero project near Innamincka);
- Petratherm (Paralana and Callabonna projects);
- Green Rock Energy Limited (Blanche project);
- Geothermal Resources (Lake Frome project); and
- Scopenergy Limited (project near Millicent and Beachport).

Geodynamics Limited is aiming to have a 40MW commercial-scale demonstration plant providing electricity to the National Electricity Grid by the end of 2010[v].

## References


[i] Geodynamics Limited website: http://www.geodynamics.com.au/IRM/content/home.html

[ii] Maghiar, T. and Antal, C., (2001) Power generation from low-enthalpy geothermal resources. GHC Bulletin., Vol 22(2), pp35-37.

[iii] Hettiarachchi, H.D.M., Golubovic, M., Worek, W.M. and Ikegami, Y., (2007) Optimum design criteria for an Organic Rankine cycle using low-temperature geothermal heat sources. Energy, Vol. 32, pp1698-1706.

[iv] Habermehl, R. & Pestov, I., (2002) Geothermal resources of the Great Artesian Basin, Australia. GHC Bulletin, Vol 23(2), pp20-26.

[v] Geodynamics Limited Company Prospectus, Released 14th March 2007.


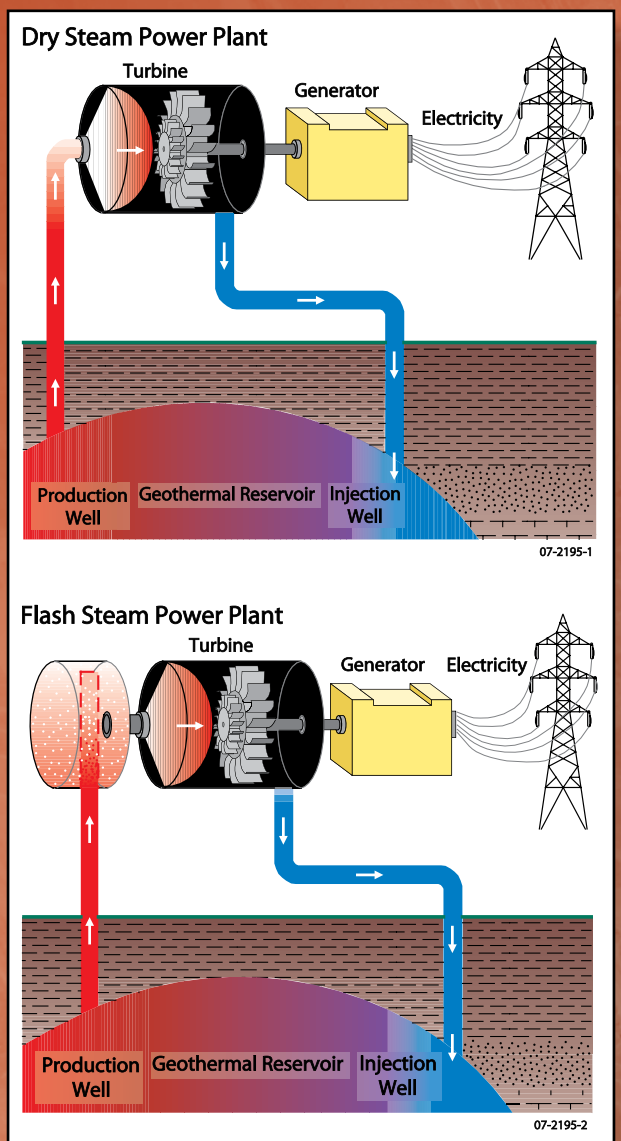


**Figure 2: Schematic diagrams indicating the designs of a dry-steam power plant (top) and a flash-steam power plant (bottom).**

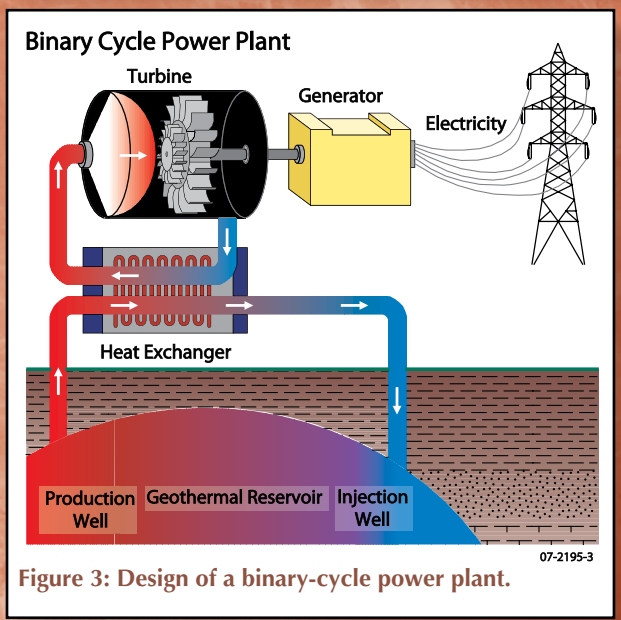


**Figure 3: Design of a binary-cycle power plant.**

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