# GEOTHERMAL ENERGY: DEEP SOURCES IN VICTORIA

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Geothermal energy is heat stored naturally within the rocks of the earth. The higher the temperature of the rock, the more thermal energy is potentially available. In general, temperature increases with depth so deeper rocks store larger amounts of geothermal energy. Water has a higher volumetric heat capacity than most solid minerals, so saturated porous rocks tend to store larger amounts of heat than non-porous rocks. Under the right circumstances, geothermal energy can be economically extracted and put to use either directly (for example, to heat buildings) or by converting it to electrical energy. There are already two geothermal power generators in Australia (a 120 kWe plant at Birdsville, Queensland, and one 1 MWe plant at Innamincka, South Australia) and a range of direct applications of geothermal energy (heated buildings, swimming pools and spas).

The Gippsland and Otway Basins in Victoria represent attractive targets for geothermal energy from a geoscientific viewpoint, although the economic challenges to extracting the energy are profound. Focusing on the geoscience, each basin has regions with elevated surface heat flow (Vic DSDBI 2013), substantial thicknesses of thermally insulating rock layers (Jorand et al. 2009; Driscoll and Beardsmore 2011), and a geological expectation that the basal sedimentary layers will be coarse, porous units, as is generally the case in sedimentary basins. These conditions are attractive for accumulations of extractable geothermal heat at temperatures in excess of 150°C at depths shallower than 4000 m, suitable for electrical power generation using so-called ‘binary plants’.

Binary plants produce electricity by passing a vaporised secondary fluid though a turbine to rotate a generator. The secondary fluid is typically a low boiling point, high vapour pressure hydrocarbon, which is boiled via an exchange of heat from the primary geothermal fluid. Once the heat has been extracted from the primary fluid, that cooled fluid is reinjected back into the rocks whence it came, but at a lateral offset to stop premature cooling of the primary fluid being extracted. After passing through the turbine, the vaporised secondary fluid is recondensed and the cycle is repeated. For primary fluid temperatures lower than about 220°C, binary plants provide more efficient heat to electricity energy conversion than directly driving a turbine from steam released from the primary fluid (Moon and Zarouk 2012).

The principal geological uncertainty in targeting deep geothermal energy in the Otway and Gippsland Basins relates to the depth, location and extent of those probable deep porous units, because current geophysical data are inconclusive. Reflection seismology provides the main geophysical tool for imaging the structure of sedimentary basins. Deep boreholes are almost exclusively sited according to the interpretation of recorded sound waves from a surface source (either explosive or impact) reflected off underground boundaries of contrasting acoustic impedance. This standard technique has been developed and refined by the petroleum exploration sector since its first introduction in the 1920s (Sheriff and Geldart 1995). Under beneficial conditions, sophisticated three-dimensional seismic surveys are now capable of delineating the subsurface geological structure with remarkable accuracy, and can even shed some light on fluid properties within the rocks.

The characteristics of the shallow geological sequences of the Gippsland and Otway Basins are not beneficial for reflection seismology, though. Thick, poorly consolidated calcareous and basaltic units in the Otway Basin, and thick coal sequences in the Gippsland Basin, each attenuate seismic energy to such an extent that seismic signals reflected from beneath these units are often dominated by noise. The result is that the geological structure in some deeper parts of these basins remains very uncertain, constrained more by geological reconstructions of basin formation than by direct imaging through reflection seismology.

Other geophysical techniques are available that are impacted less by the characteristics of the shallow geological units in the two basins. They are of much lower spatial resolution than reflection seismicity, but have the advantage of providing a measureable response to the deeper units of interest for geothermal exploration. If data are carefully collected and interpreted, they could reduce the current uncertainty about the nature and extent of the formations in the deeper sections of the sedimentary piles.

Passive seismic techniques are one such option. Sensitive seismometers might be deployed across the regions of interest to passively record the natural seismicity of their surroundings. Over time, a picture might emerge of the underlying geological structure based on interpretations of sonic travel time differences for the same distant seismic events recorded at different locations; based on small local seismic events occurring on natural fault lines in response to tectonic stresses; and based on the different amplitudes and phases of recorded seismic wavelets.

Magneto-telluric soundings provide another option. This technique is sensitive to the electrical conductivity structure of the underlying rocks, so will only be an option if the electrical properties of the target rocks contrast with their surroundings. Laboratory work might be required to confirm this prior to embarking on a significant field survey.

If porous, saturated rocks do indeed lie at the base of the sedimentary sections of the Gippsland and Otway Basins, at depths less than 4000 m and temperatures greater than 150°C, as prima facie geological evidence suggests is possible, then these represent attractive geological targets for geothermal energy extraction and electrical power generation. Whether this could be achieved economically depends on a range of factors beyond geology – most directly the price that could be realised for the geothermal power relative to the cost of producing it and the cost of alternative power options.

**References**

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