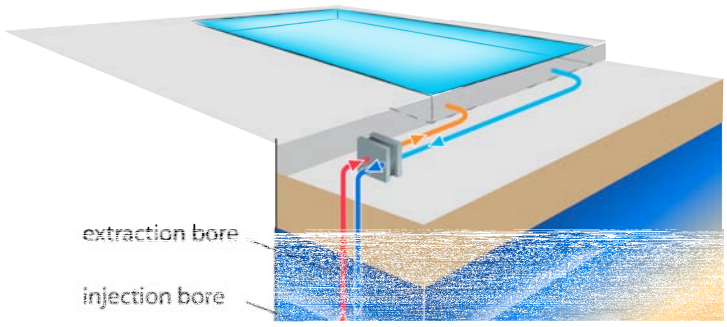
Comparing energy sources

How much geothermal energy is there, and how does it compare with coal as a source of energy?

There are two ways to calculate the potential geothermal heat energy of the Perth basin, using the relationship $Q = m\ c\ \Delta T$.



Scenario 1

The first scenario considers geothermal energy as non-sustainable. That is, hot water is removed without re-injection. Water is brought to the surface, heat is extracted and the cooled water used for other purposes, such as watering gardens.

Scenario 2

Scenario 2 considers geothermal energy a sustainable energy source. In this case, hot water is pumped to the surface, heat is extracted and the cooled water is re-injected into the aquifer. Water is returned to the aquifer at a different location and is reheated over a period of time by conduction of heat from rock. In this way a large proportion of the energy from the rock and water system in the aquifer is accessed in an *ideal* situation.

To calculate the potential energy for each scenario the following data may be used.

PERTH BASIN SCENARIO 1 NON-SUSTAINABLE GEOTHERMAL ENERGY	
area of the Perth basin	72 000 km^2
average thickness of the aquifer	1500 m
water content of the aquifer (by volume)	20%
density of water	1000 kg m^{-3}
average temperature of extracted water	75 °C
temperature of water after use	30 °C
specific heat of water	4200 J kg^{-1} K^{-1}

PERTH BASIN SCENARIO 2 SUSTAINABLE GEOTHERMAL ENERGY	
area of the Perth basin	72 000 km^2
average thickness of the aquifer	1500 m
the whole volume of the aquifer (rock and water) is used	100%
density of rock and water	2580 kg m^{-3}
average temperature of extracted water	75 °C
temperature of water after use	30 °C
specific heat of rock and water	1039 J kg^{-1} K^{-1}

The potential geothermal energy stored in the Perth basin can be compared with the potential energy of reserves of coal in the Collie coalfields.

COLLIE COALFIELDS	
Mass of coal reserves	600 x 10^6 tonnes
Average thermal capacity of the coal (energy produced by burning coal)	2.7 x 10^7 J kg^{-1}

Note: Data in this calculation exercise have been simplified for educational purposes and should not be used for any commercial estimate or modelling.

Part 1

1. Using data provided in scenario 1, calculate the potential geothermal energy available in the Perth Basin aquifer.

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2. Using the data provided in scenario 2, calculate the potential geothermal energy stored in the Perth Basin aquifer.

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3. Using the data provided for coal, calculate the potential energy available in the Collie coalfields.

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4. In the 2008/2009 financial year, Western Australia used 946 PJ of energy (1 PJ = $1x10^{15}$ J). How long would each of these reserves last, at this rate of use?

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5. Compare the quantities of energy calculated for each of the above situations and comment on the results.

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6. What is the biggest difference between energy supply from the Collie coalfields and the Perth Basin aquifer?

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7. What is the advantage of returning cooled water to the aquifer?

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8. Can geothermal energy be considered a sustainable source of energy? Explain your answer, including any special conditions.

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Part 2: other renewable energy sources

Wave energy

Research is underway to use wave energy as a significant contributor to base load requirements of Australia. Base load is the minimum amount of power that a utility or distribution company must make available to its customers, or the amount of power required to meet minimum demand, based on reasonable expectations of customer requirements. Base load values typically vary from hour to hour in most commercial and industrial areas.

It has been estimated that the coastline from Geraldton in Western Australia to Eden in New South Wales could provide sufficient wave activity to generate 170 000 MW of electricity, which is at least 35% of Australia's power requirements.

9. What factors should be considered when comparing wave energy with geothermal energy as a viable energy resource for the future?

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10. Which of these two sources would you advise as a solution to the future energy needs of WA ? Explain your answer.

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Solar energy (photovoltaic)

With extended periods of sunlight throughout the year, Australia is an ideal place for rolling out photovoltaic technology to provide a sustainable source of energy. As an example, 363 solar panels installed on the roof of the library at Western Australia's Murdoch University are capable of producing 56 kW, which is enough power to run 45 houses or a small housing estate.

11. Estimate the number of individual solar voltaic panels, similar to those installed on the roof at Murdoch University, that would be required to supply energy to run all domestic households in Australia.

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12. Estimate the power produced by all the domestic houses in Australia if panels similar to those installed on the roof of Murdoch Library are used.

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Wind energy

At the end of 2009 there were 33 wind farms Australia wide, producing a total of 1877 MW. Farms in South Australia and Victoria lead the way in providing alternative methods of energy generation, as well as reducing greenhouse gas emissions.

Albany, on the south coast of Western Australia, is an ideal place to make use of winds that blow consistently all year round. The 12 turbine generators are rated at 1800 kW each and can operate safely in winds between 7 and 130 km h^{-1}. The turbines are spread along 3 km of coastline.

Wind farms are restricted to areas where there are reliable winds, so coastal regions of Western Australia from Geraldton to Esperance are suitable sites. The total output from wind energy in Western Australia is about 200 MW.

13. What percentage of Australia's energy generated by wind is produced in Western Australia?

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14. What length of coastline suitable for producing wind energy would be required so the installation of wind turbines would generate adequate power to meet Western Australia's requirements? (Hint: see data from Question 4.)

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15. How many 1800 kW wind turbines would be required to meet Western Australia's requirements?

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Part 3

16. On the basis of these calculations and other considerations, how viable is geothermal energy as a future energy source, compared to the other sources considered here?

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Acknowledgements

- Engineering Toolbox (http://www.engineeringtoolbox.com)
- Green Rock Energy Limited, 6/38 Colin Street, West Perth WA 6005
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