Government of South Australia
Primary Industries and Resources SA

FACT SHEET

ISSUE 1

Petroleum and Geothermal Group - Minerals and Energy Resources

Radon and Naturally Occurring Radioactive Materials (NORM) associated with Hot Rock Geothermal Systems.

Many Hot Rock geothermal systems planned in Australia will extract energy by circulating water within granites that are heated by natural radioactive decay. Will this create any radiation hazards above ground? A report from David Battye and Peter Ashman at the University of Adelaide, commissioned by PIRSA, has the answer.

Exposure to radiation from Naturally Occurring Radioactive Materials (NORM) in Hot Rock geothermal systems may occur by:

- **Exposure to radon gas if water and steam are emitted to atmosphere**
- **Exposure to gamma radiation from solid deposits that may form in the above-ground systems.**

Radon Gas

If the Hot Rock geothermal power plant is operated in an entirely closed loop configuration (that is, all fluids and gases are circulated and then re-injected) then there would be little to no risk of radon exposure.

For an open loop situation the levels are probably still below the 'action level' for workplaces in Australia, which is 1000 Bq/m^3, but depend on the time spent by water in the granite, the emission point height above ground and wind speed. The action level determines when intervention or radiation protection is necessary. Some modelling was done to look into the radon activity down-wind of an emission point with respect to key factors.

Figure 1 shows the result of this indicative modelling – for an emission point five metres high or higher, the radon activity would be below the action level for workplaces, and for wind speeds greater than about 2 km/h the radon activity would even be below the action level for dwellings which is 200 Bq/m^3.

Thorough monitoring should take place to ensure that the exposure is known and there is no risk, or that the risk is managed appropriately.

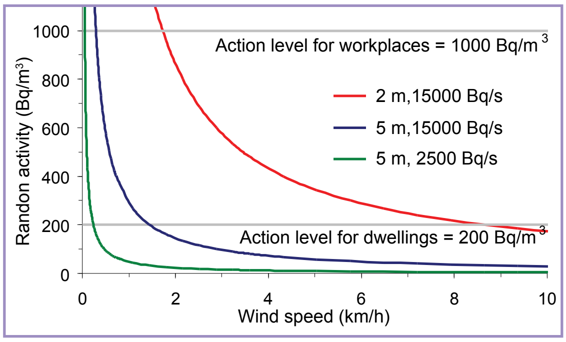

Figure 1 Maximum downwind, ground-level radon activity versus wind speed. Curve labels designate emission point height and emission rate.

Emission rates in Figure 1 are based on two scenarios:

- *Water contains 500 Bq/L radon and flows at 30 L/s from a production well, causing a radon emission rate to atmosphere of 15000 Bq/s. This scenario represents a situation where water is stagnant in the hot rock fractures for several days preceding the flow, allowing radon to accumulate.*
- *Radon enters fractures within 1 km^3 of hot fractured rock and is emitted to atmosphere at the same rate (2500 Bq/s). This scenario represents open-loop circulation testing.*

Solid Deposits

The other potential source of radiation exposure is from solid deposits in surface equipment. Depending on the geochemistry of the circulating water and the power plant conditions, solids may precipitate from the water to form scales and sludges. Experience from the oil and gas industry shows that NORM are often present in these deposits, mainly in the form of radium. Radium emits gamma radiation which is able to penetrate the walls of pipes and other equipment containing the solids, causing exposure to nearby workers.

Water in oil and gas reservoirs is usually very saline, which has the effect of stabilising high levels of radium in solution. Hot Rock waters typically have moderate salinity, therefore relatively lower dissolved radium is expected. The composition of the solid deposits is also important. Barium and strontium sulphates absorb more radium from water than other minerals and are primarily responsible for the radioactivity of deposits in the oil and gas industry. It is not yet known if these components will precipitate from Hot Rock waters and the occurrence of radium-bearing solid deposits therefore cannot be ruled out. Considering the relative levels of dissolved radium, it is likely that such deposits would be less radioactive than those found in the oil and gas industry. In addition to gamma radiation concerns, any NORM that may be present in solid deposits could be hazardous if inhaled as a fine dust, so precautions will be necessary during equipment cleaning operations.

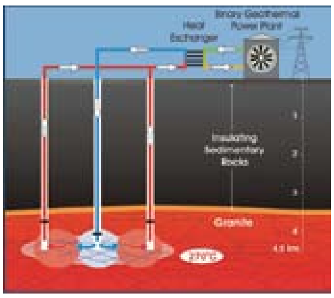

Figure 2 A Hot Rock Geothermal system or EGS where 270ºC granites are the target.
Photo courtesy of Geodynamics Limited.

Glossary

Hot Rock Geothermal System: An unconventional source of geothermal energy, as conventional systems generally use heat generated by volcanic activity. Hot Rock geothermal systems rely on the heat produced by the natural radioactive decay of isotopes within granite, specifically potassium, uranium and thorium. Typically these systems need to be 'enhanced' or 'engineered' to allow water to flow through fractures in the rock and be heated, so these systems are also called Enhanced or Engineered Geothermal Systems (EGS) – see Figure 2. The water is injected in one well, passes through the fractures, and up out of another well where it is then passed through the power plant with the steam running turbines to create electricity. The temperature of the rock increases with depth, and so to get high enough temperatures the wells can be around 3 km to 5 km deep.