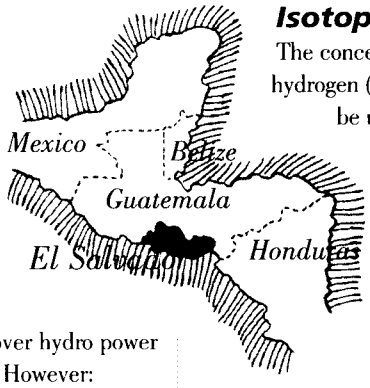
Geothermal Energy - El Salvador

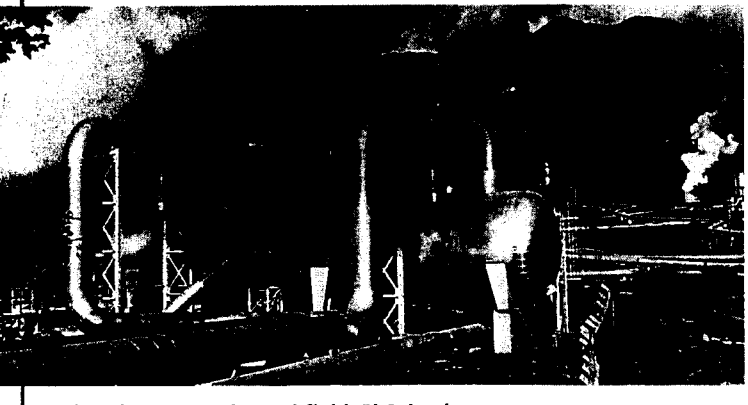
Geothermal energy is one of the most sustainable and environmentally friendly sources for electricity. Its development must, however, be based on reliable information on its occurrence, temperature and flow of fluids deep within the Earth's crust. Nuclear technology provides an accurate and sometimes unique method for determining the origin of geothermal fluids as well as for tracing water movement and heat flows. The Department of Technical Co-operation is sponsoring a programme, with technical support from the Department of Research and Isotopes to assist the Government of El Salvador to expand its geothermal capacity.

Energy from Earth

Where geological conditions are favourable, rainwater seeps through the surface and becomes trapped in vast underground reservoirs so deep below the Earth's surface that it becomes heated to very high temperatures by the magma. This very hot water can be extracted by drilling wells into the reservoir to generate steam which run turbines to produce electric power. Once the system is developed, geothermal energy is relatively cheap, costing about one third that of oil. It has advantages over hydro power which may be susceptible to drought and/or siltation. However:



- If too much water is extracted too quickly, there is a risk that the reservoir replenishment rate will be insufficient to match the extraction rate.
- The extraction of water and steam reduces pressure inside the underground reservoir. This may sometimes induce the inflow of cooler waters which reduces the temperature of the reservoir as well as collapse of the surrounding rock wall.



Ahuachapán geothermal field, El Salvador

- Water and steam are released through the boreholes. The steam is used to drive turbines after which, with the unused water, it must be disposed of. There is a high risk of environmental pollution because this water is both very hot and contains potentially hazardous substances like boron. These risks are avoided by reinjecting the waste water back into the reservoir where it will become reheated and available for re-use. Reinjection wells must be drilled where the returning water will not cool the water in the reservoir and reduce the value of the energy resource. Capital investment costs for drilling production and reinjection wells are high, and therefore an understanding of the water and heat flow at each field is necessary in order to site wells profitably. Isotope techniques are among the most useful tools for tracing such flows. (see box)

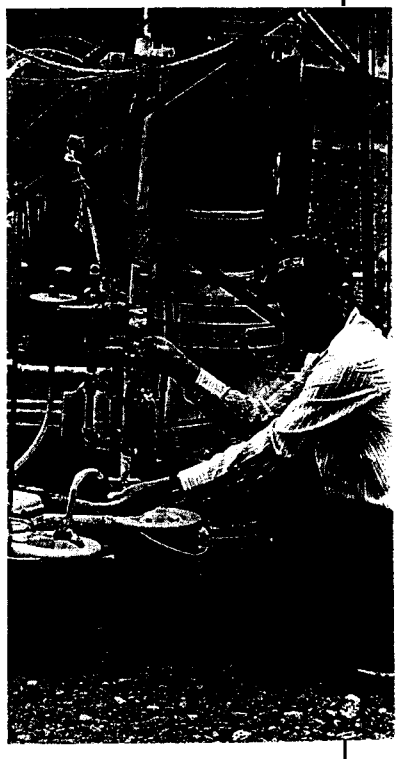
Isotopic identification

The concentration of naturally occurring stable isotopes of hydrogen (^{2}H, called deuterium) and oxygen (^{18}O) in water can be used in geothermal investigations to identify:

Origin of fluids: They indicate the source where fluids have originated and are recharged. The naturally occurring radioactive isotope of hydrogen (^{3}H, tritium) can indicate the presence of cold, young, meteoric water in the geothermal system.

Temperature: Stable isotopes also provide an indication of the temperature at which physical and chemical interactions among water-rock-steam occur in the reservoir. Isotopic and chemical data are used as a geothermometer, helping scientists to decide where to site wells in order to extract fluids at the ideal temperature.

Flow: It is also important to understand the direction where natural and reinjected water flow within a geothermal system. Radioactive isotopes such as iodine-131 (^{131}I) can also be injected into one part of the system and calculations, based on the half life decay of the isotopes at sampling points elsewhere, identify the route and rate of water flow. This helps to understand the field hydrology which is necessary for siting reinjection wells where too rapid a flow through the system would lead to insufficient reheating of the reinjected cool water.



Samples from the wells are sent for chemical and isotopic analysis

Isotopes

Elements consist of atoms of different mass called isotopes. During the evaporation and condensation of water, the concentration of oxygen and hydrogen isotopes that make up the water molecule undergoes small changes, effectively providing an isotopic signature to a body of water. Modern instruments can identify this signature with great accuracy and hence identify the movement of a given body of water.

Geothermal Energy - El Salvador

Model Project

El Salvador is one of the top ten geothermal energy producers in the world. Its current production from geothermal sources meets 14% of national requirements. (Hydro power contributes 46% and the remaining 40% comes from imported fossil fuel.) There is potential to double geothermal production over the next five years. This would make a major contribution to national development, helping to meet the expected demand for electricity as economic recovery continues while reducing oil imports.

Well head at Berlín geothermal field

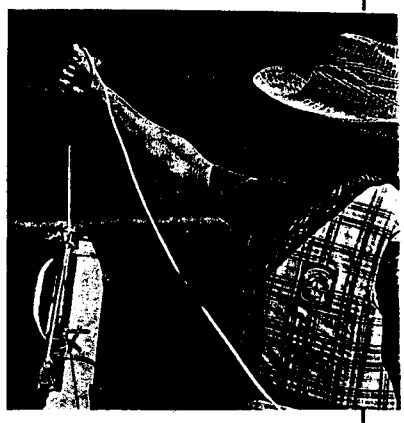
The Ahuachapán geothermal field has been in operation since 1975. It has an installed power plant capacity of 95 MWe with 32 wells drilled up to 3km deep over an area of 6 sq km. The hottest well taps fluid at about 240°C. The Berlín geothermal field began commercial production in 1992 with the installation of two units - 5 MWe power plants. A total of 11 wells have been drilled. At this rate the two fields reduce the cost of imported oil by $9 million per year. The national plan for geothermal electricity development will require drilling of an additional 10 production and injection wells at Ahuachapán, 16 additional wells at Berlín and 5 in San Vicente, a field under exploration.

The disposal of waste water is a major concern. During its eight years of production, the volume of waste water at Ahuachapán has increased to 318 million tons. These waste waters have temperatures of about 115°C and contain toxic substances which pollute the environment if discharged to surface water bodies, thus they are reinjected back to the reservoir.

● **Geothermal fields supported by the Model Project**

The two-year Model Project will integrate isotope hydro-geochemical techniques to develop a hydrological model which is a basis for decision-making in reservoir management, in order to:

- identify suitable sites for drilling.
- reduce pollution from waste water.



Taking water samples for isotope and chemical analysis

Training and Technology Transfer

The Agency is providing direct assistance to the Rio Lempa Executive Hydroelectric Commission in the practical application of isotope techniques.In exploration areas, water and steam samples from all hot and cold springs, rivers and wells are collected and analyzed for chemistry, oxygen-18, deuterium and tritium. This will provide the baseline hydrology and chemistry. New samples from production and injection wells are also regularly collected and analyzed to provide an understanding of the effects of exploitation and injection of waste water. Iodine-131 or Iodine-125 are used to trace water movement and determine the rate of flow from one well to another. A hydrological model will be developed to illustrate quantitatively the directions of fluid flow and the physico-chemical changes taking place as a result of exploitation, like pressure and temperature changes over time, as well as fluid flow. This will involve extensive computer simulation which in turn will provide a powerful management tool for the sustainable use of the geothermal resource.

Collecting water samples form a geothermal well

The Model Project will offer opportunities for improving national capability for isotope and geochemical data interpretation. This will be important for long term development of the country's high geothermal potential. The government and electricity generating authority of El Salvador are demonstrating national commitment to the Model Project by their investment in the development of Ahuachapán and Berlín and to exploration of other geothermal fields. With enhanced national skills in isotope hydrology, El Salvador will be able to offer analytical services to other countries within the region.

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