Heating Up

By Mark Fischetti

More than 30 states have passed or are considering "renewable energy portfolio standards" that require utility companies to generate some portion of their electricity from renewable sources. Geothermal power plants, which tap hot subterranean water or steam, are high on many lists.

Most utilities have not pursued geothermal energy primarily because up-front costs, including exploratory drilling, can be high. (Geothermal taps deep reservoirs, not groundwater, which collects much closer to the surface.) But once in operation, the plants consume no fuel and create few if any emissions. "When looking at the true costs over a plant's lifetime, geothermal is on par with or better than a coal plant," the least expensive conventional option, notes Gerald Nix, geothermal technology manager at the National Renewable Energy Laboratory in Golden, Colo.

Furthermore, an extensive study recently released by the Massachusetts Institute of Technology shows that the heat available underground is surprisingly plentiful nationwide. "Geothermal has been dramatically underutilized," Nix concurs.

Several different power plant designs have been operating for years in select places, depending on how hot the water is. So-called flash plants are most common [*see main illustration on opposite page*]. In the future, however, "binary plants will predominate," Nix says. Binary designs, which use the water to vaporize a second fluid, can operate with lower-temperature water, making geothermal viable in more places.

Some critics worry that the reservoirs could slowly be depleted because some of the water can be lost during flash conversion to steam as well as when that steam is subsequently cooled. But the inner earth will naturally replenish reservoirs unless water is drawn too fast. And binary plants send virtually all the extracted water back into the reservoir, although they may cost more to run than flash plants.

Looking ahead, utilities could even use "enhanced" recovery methods to get steam from hot, dry rock [*see illustration on this page*]. Homeowners, too, could tap their own backyards. At a mere 10 feet deep, the ground remains a constant 50 to 60 degrees Fahrenheit year-round. Fluid-filled pipes laid there can feed a home heat pump that provides cooling in summer and heating in winter. "When you are building a new house, the heat-pump system does tend to cost more than a conventional furnace," Nix notes. But it doesn't consume fuel, other than a small amount of electricity. "In four or five years you break even and start saving money," he says.

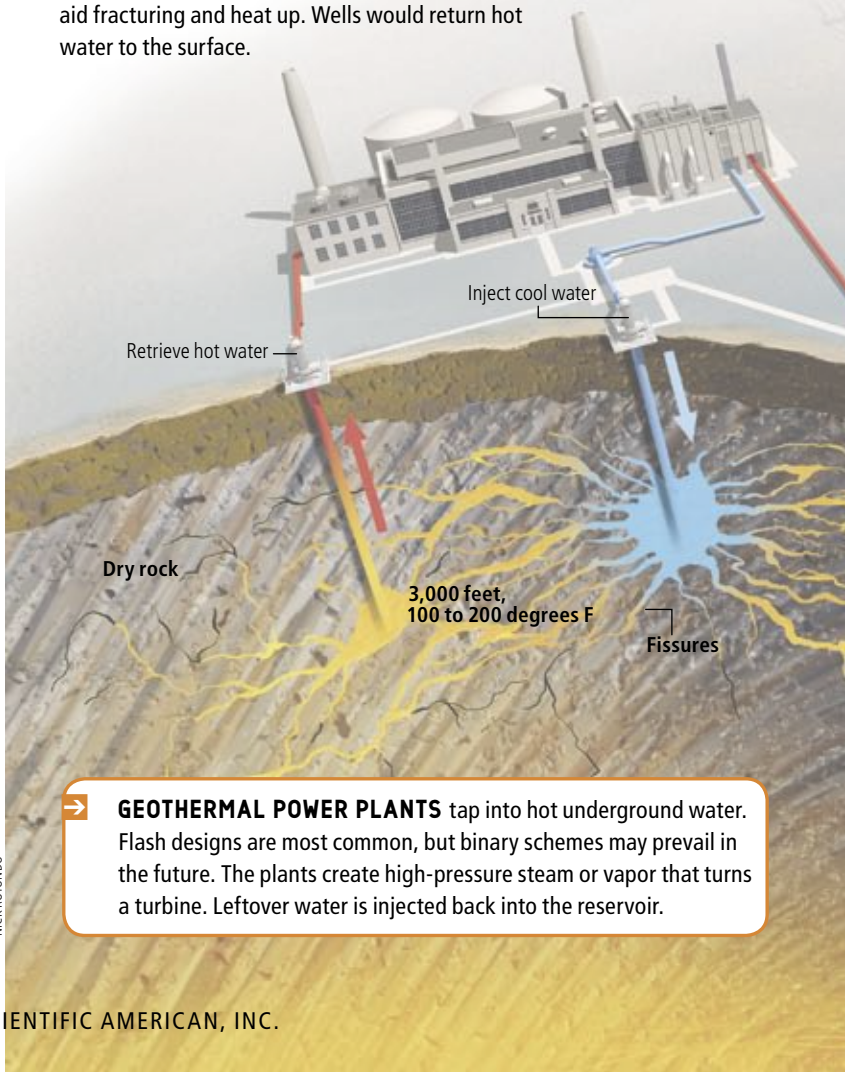
DID YOU KNOW ...

LARGE BUT SMALL: Twenty-four countries have geothermal power plants, with an overall combined electric generating capacity of 8,900 megawatts. The U.S. boasts the largest share, at 2,850 MW (2,490 MW in California), although the total accounts for only 0.36 percent of the nation's electricity supply. Since 2000 geothermal generation has tripled in France, Kenya and Russia.

OLD FAITHFUL: The Geysers, 72 miles north of San Francisco, is the world's largest geothermal power complex. Begun in 1960, it currently operates 21 plants with a combined capacity of 750 megawatts. The city of Santa Rosa now conveniently pipes treated wastewater there; it is injected into the underground reservoir, prolonging the reservoir's useful lifetime.

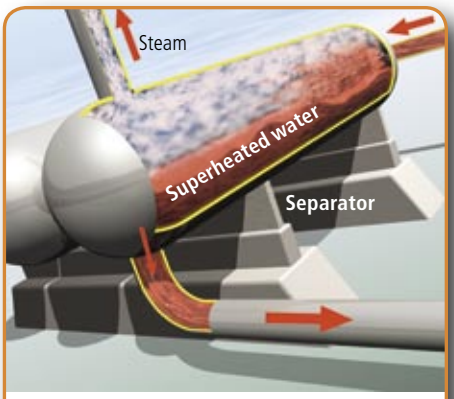
NOT ALL CLEAN: Some deep waters contain condensed gases such as carbon dioxide or hydrogen sulfide and minerals such as zinc. These impurities must be captured or treated at flash plants. Binary plants send the compounds back to the reservoir.

ENHANCED PLANT of the future would inject cool, pressurized water into dry fissures, where it would aid fracturing and heat up. Wells would return hot water to the surface.

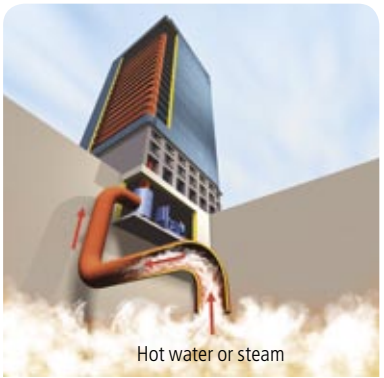


GEOTHERMAL POWER PLANTS tap into hot underground water. Flash designs are most common, but binary schemes may prevail in the future. The plants create high-pressure steam or vapor that turns a turbine. Leftover water is injected back into the reservoir.

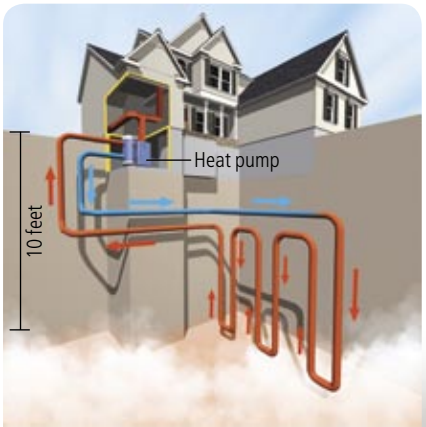
NICK ROTONDO



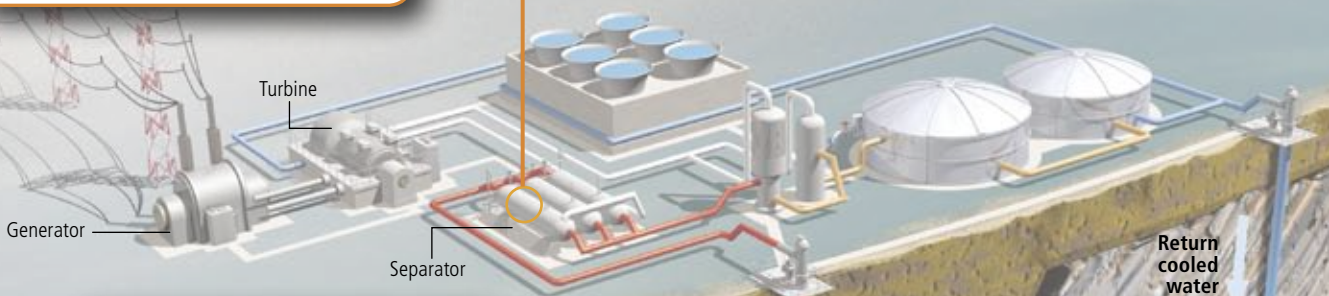
FLASH PLANT
Superheated water under naturally high pressure enters a separator at lower pressure. The pressure drop causes some of the fluid to vaporize, or flash, into steam. Remaining water enters a second chamber at even lower pressure, where it flash-boils, too.

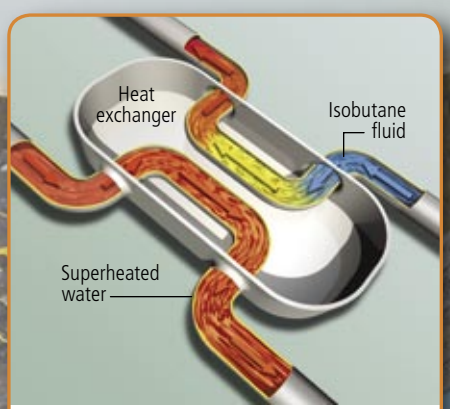


BUILDINGS can be heated directly with piped-in hot water or steam that rises close to the surface in select spots.



HOUSE heat pump circulates fluid through shallow ground pipes or wells, which stay at 50 to 60 degrees Fahrenheit year-round. In summer the relatively cool fluid draws heat from inside the house. In winter the relatively warm fluid carries heat into the house.





BINARY PLANT
Superheated water enters a heat exchanger, where it heats a separate loop of fluid that has a lower boiling point, such as isobutane. That fluid boils, creating high-pressure vapor.

Return cooled water
Caprock
Retrieve hot water
Basement rock
Magma
5,000 feet

If temperature above 300 degrees F, use flash plant; if below 300 degrees F, use binary plant

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