

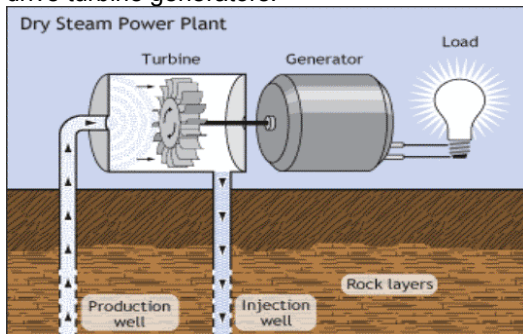
# Can Geothermal Replace Coal for Baseload Power?

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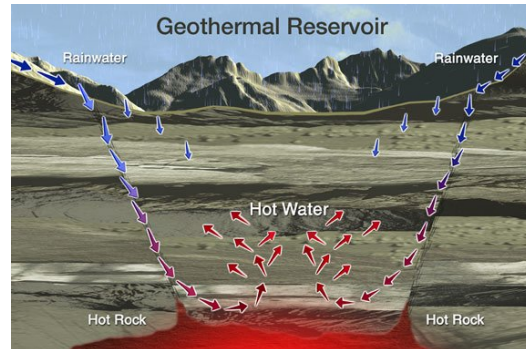
From our home on the earth's cool crust, it's hard to believe that 99.9% of the earth's volume is hot enough to boil water. Atomic decay deep inside of the earth heats it's molten core to a temperature that is hotter than the surface of the [sun](#)<sup>1</sup> To harness this geothermal power, we need only drill through the crust and use that heat to boil water to drive turbine generators.



Geothermal power is a practical reality today. It supplies 26% of electrical power in Iceland and the Philippines and 5% of California's at prices that are competitive with coal. Geothermal power plants require no fuel and produce no pollution, yet they produce steady base load power 24 hours a day. The world's first geothermal power plant, built in Larderello Italy in 1911, is still producing enough power for a million homes today.

Geothermal power generation is a profitable business. [Ormat](#) Technology, for example, has been steadily profitable for decades selling geothermal power worldwide at prices competitive with coal power. Their current market capitalization is over two billion US dollars. Since they have no fuel costs, many of their power sales contracts are for a fixed price per kWh.

Geothermal generation today is done mostly in natural geyser or hot spring areas where nature has placed underground water in contact with hot rocks below and steam flows to the surface. The Geysers area in California



for example, was first developed in 1921. In 1960 it was upgraded to an 11 MW commercial power plant. In 1998 the natural water sources began to dry up so recycled water injection began. Currently the plant is being expanded to 80 MW, enough to power the nearby city of San Francisco. The power from the Geysers plant is currently sold for [only \\$03-.035](#) per kWh. In Mexico the 30 year-old [Cerro Prieto](#) field is being expanded from 620 to 720 MW. The power sells for \$.03/kWh.

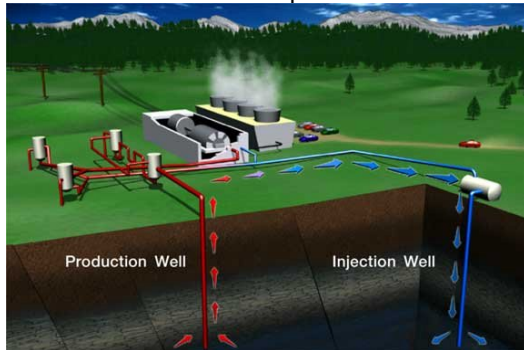
Water re-injection in most modern geothermal plants keeps the water usage very low but many plants today are adding water injection from external sources to greatly expand their power capacity. The technology for doing this has been highly developed by the oil industry. Since the 1950's, oil wells have been rehabilitated by drilling another hole nearby and injecting water to push out the oil. The mixture of oil and water that comes out is very hot. This hot water is now considered a nuisance but if the heat was used to generate power, tens of thousands of megawatts could be generated in Texas alone with a cost payoff in only [three years](#). It is estimated that the geothermal energy produced could [exceed the power in the oil already extracted!](#)

The key to geothermal power generation on a massive scale is developing this water injection technology so that geothermal plants can be routinely built without depending on accidents of nature to produce steam. Enhanced Geothermal Systems ([EGS](#))<sup>2</sup> can be built

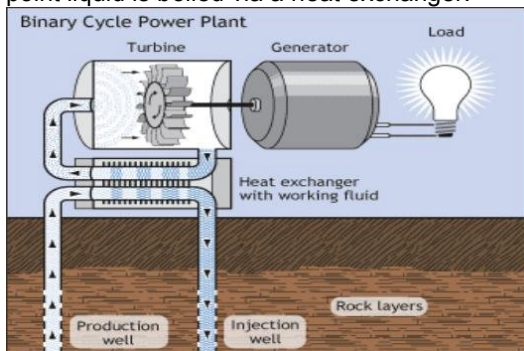
<sup>1</sup> Inside the earth 6,000 degrees C  
<http://www.physorg.com/news62952904.html>

<sup>2</sup> MIT report on EGS  
<http://www.renewableenergyaccess.com/rea/news/story?id=47192>

wherever there are hot rocks covered by an insulating sedimentary layer. Water injection is designed in from the start. Since water is reinjected in a closed loop, the water consumption of an EGS system is much less than for a coal or nuclear plant.



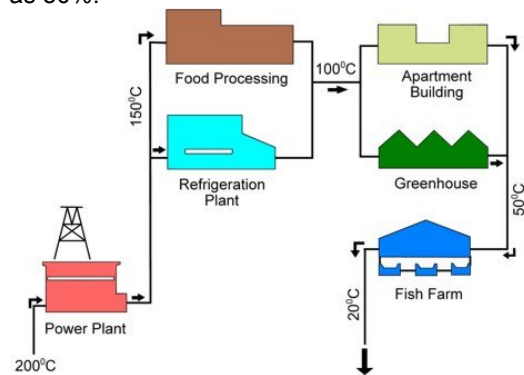
Another exciting development involves power generation from low temperature geothermal resources. In a binary system, a low boiling point liquid is boiled via a heat exchanger.



UTC Power built a practical power plant using a 74°C hot spring in Alaska. The truck transportable [generator](#)<sup>3</sup> they used is significantly cheaper than most ORC generators because it is based on a high-volume air conditioning chiller modified to efficiently run backwards as a generator. Power can be generated anywhere hot water and cooling water (or air) are available. Industrial waste heat can be inexpensively turned into power as can excess heat from district heating systems during warm weather.

Combined Heat and Power (CHP) systems give amazingly high overall efficiencies by using the hot water first for power generation and then passing it to successively lower temperature applications like drying, greenhouse heating, fish farming, bathing, etc. Nothing is wasted. Another new development, the [Kalina](#) cycle, can improve the efficiency of

low temperature power generation by as much as 30%.



Drilling and exploration costs make geothermal power plants expensive to build. However, cost/watt construction costs are a very poor measure of true cost: Coal plants, for example, must be fed an endless stream of trainloads of coal. Energy inflation guarantees an ever-increasing fuel cost. Coal prices have increased 140% since January 2007. Coal also has incalculable [hidden costs](#)<sup>4</sup> from severe storms, acid rain, contamination of [fisheries](#) and increased healthcare costs. In spite of massive subsidies, the *real* cost of coal power is clearly more than geothermal.

### The Hidden Costs of Coal Power

- Health Care Costs (asthma, autism, cancer)
- Global Warming (storms, heat, floods)
- Destruction of Forests & Lakes (acid rain)
- Destruction of Fisheries (mercury)
- Mining Devastation of the Landscape
- Oil use in Mining & Transporting
- Subsidies paid for by your taxes
- Future Cleanup of Toxic Waste Ponds



Wind power is also clean and cheap, but like solar power, it is as unpredictable as the weather. Rain, sunshine and wind vary widely throughout the day and can sometimes drop to a tiny fraction of their long-term average for months at a time. Hydropower is greatly reduced after a dry year. Base-load power is needed to provide a predictable supply that can be supplemented by wind and solar when available. Maintenance shutdowns reduce average availability (*capacity factor*) to 71% for coal and 90% for geothermal.

Wind and sunshine vary on a daily cycle. The capacity factor of wind power averages only

<sup>3</sup> [www.yourownpower.com/Power/grc%20paper.pdf](http://www.yourownpower.com/Power/grc%20paper.pdf)

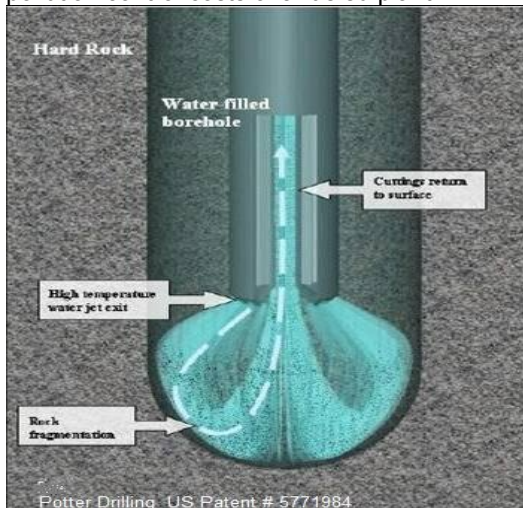
<sup>4</sup> The hidden cost of coal: 2.4% of GDP! p21 [http://assets.panda.org/downloads/coming\\_clean.pdf](http://assets.panda.org/downloads/coming_clean.pdf)

30% and solar averages 18%. In a “normal” year, one megawatt of geothermal capacity will thus generate as many kilowatt-hours as 6 megawatts of solar power in New York or 5 in California. Wind power averages 30% capacity factor so it takes about 3 MW of wind power to generate as many kilowatt-hours as 1 MW of geothermal. On bad weather years the differences are even greater. Cost/watt figures must be used with care in comparing renewable technologies. If you want to keep a 100-watt lamp continually lit with solar power you’ll need a 500-watt solar panel and a storage battery. On rainy days you’ll need a flashlight. The constancy of geothermal power makes it the only renewable energy capable of replacing coal and nuclear for base-load power.

**8 Million kilowatt-hours/year (~ \$500,000 worth) from:**

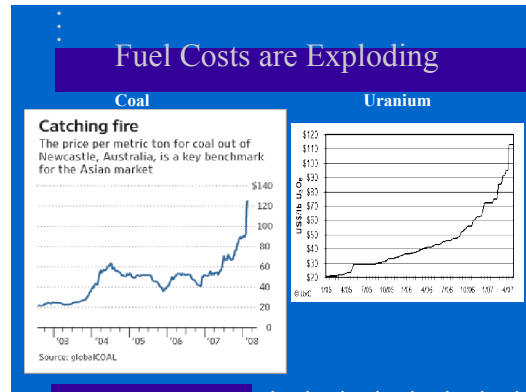
- 1 Megawatt of Geothermal Power
- 1.27 Megawatts of Coal Power
- 3 Megawatts of Wind Power
- 5 Megawatts of Solar Power

In this age of rising fuel costs it is time to rethink the basic idea of building power plants that require fuel. The exploration and drilling costs of a geothermal plant are insignificant compared to the future skyrocketing fuel and pollution control costs of a fueled plant.



New 10X faster deep drilling technologies under development will enable geothermal energy to be used on a scale never before imagined. The risk and time scale of such research is much less than current “clean

coal”<sup>5</sup> and nuclear power<sup>6</sup> projects. The future belongs to the countries that are first to master the use of this free energy that is our gift from the earth.



Australia has vast coal resources, yet the new government has committed to an aggressive effort to develop EGS geothermal power plants. Drilling was just completed on the first wells of a 500 MW EGS power plant<sup>7</sup> in the desert. There are 33 companies with 277 exploration licenses working on projects all over the country. Germany has provided free connection to the grid for remote geothermal projects. This has triggered a gold-rush boom in geothermal projects with over 100 exploration licenses granted so far. In Indonesia, Medco just signed a \$600 million contract to build a 340 MW geothermal plant which will sell power for only \$0468 /kWh

China today has a golden opportunity to take the leadership position in geothermal technology development. The new age of free energy from the earth will someday put the problems of the age of fuel behind us. Geothermal power is quickly coming of age and China could be it’s biggest beneficiary.

<sup>5</sup> Every ton of coal burned creates 3.7 tons of CO2 as 2 oxygen atoms from the air join with each carbon atom. Geosequestration will make clean coal very expensive.

[http://ran.org/campaigns/global\\_finance/resources/the\\_dirty\\_truth\\_about\\_clean\\_coal/](http://ran.org/campaigns/global_finance/resources/the_dirty_truth_about_clean_coal/)

<sup>6</sup> Geothermal heat is nature’s safe atomic power. By leaving the Uranium and Thorium in the rocks safely underground we can just use the heat they produce to boil water. Simple and safe!

<sup>7</sup> <http://www.geodynamics.com.au/IRM/Company/S howPage.aspx?CPID=1405>