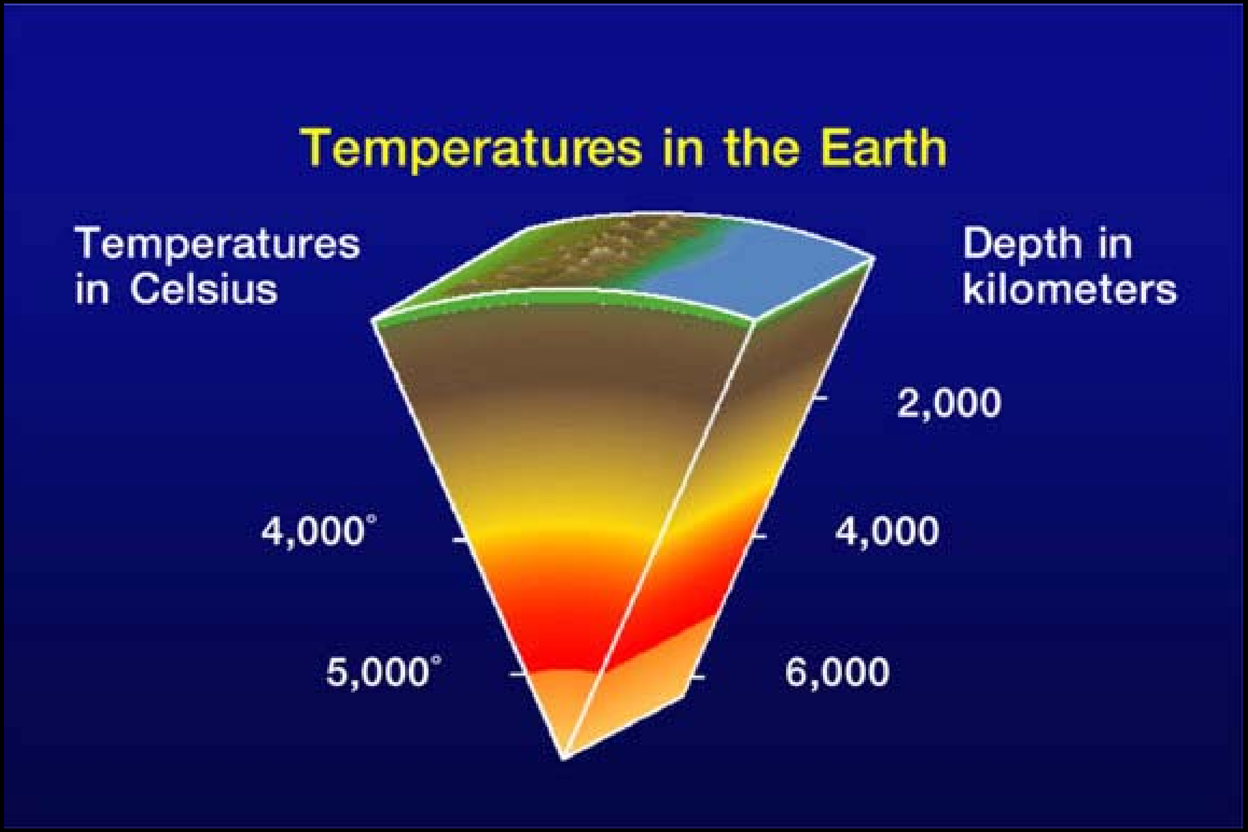
GEOTHERMAL ENERGY

Sustainable Energy Sources

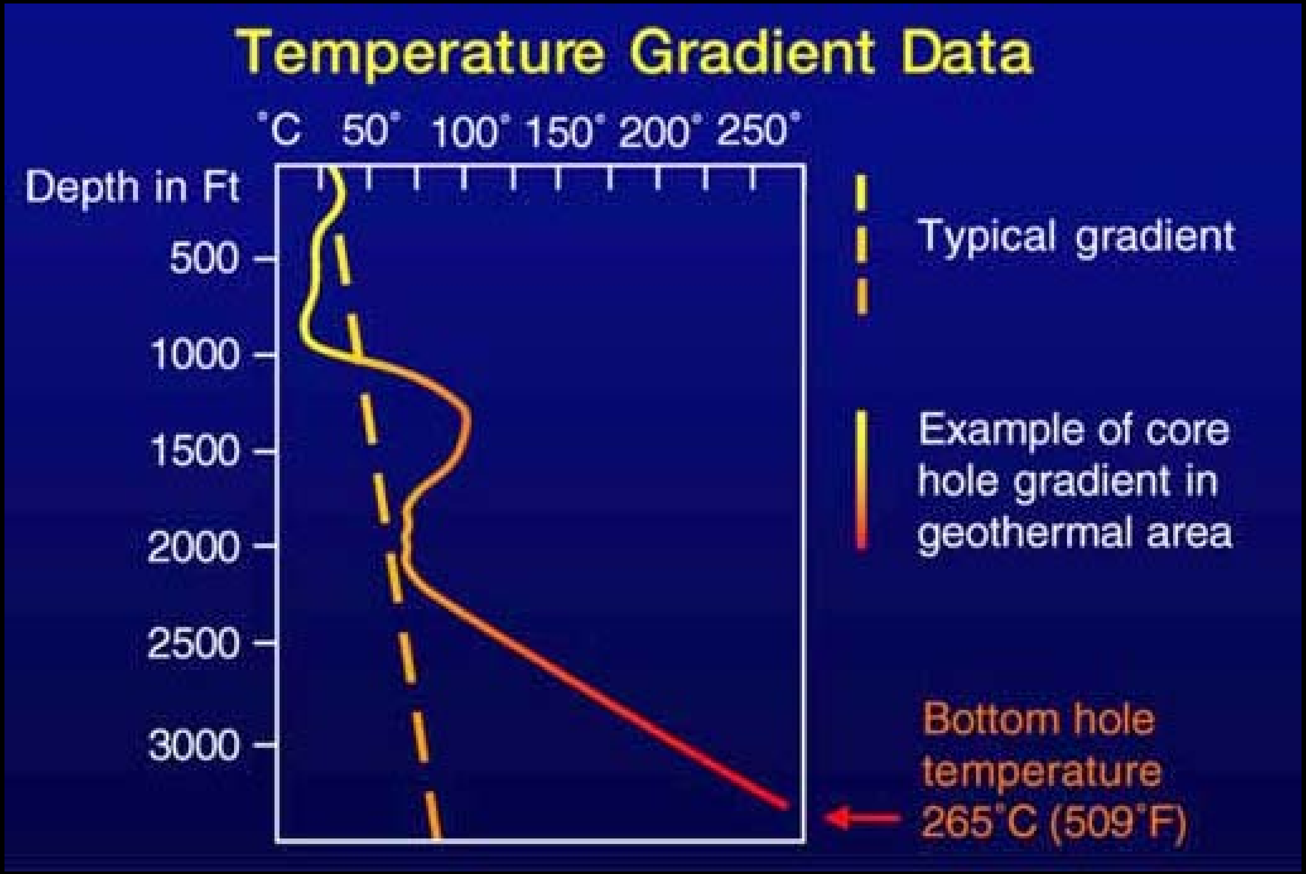
Source: http://geothermal.marin.org/GEOpresentation

Earth's Temperature Profile



Source: http://geothermal.marin.org/GEOpresentation

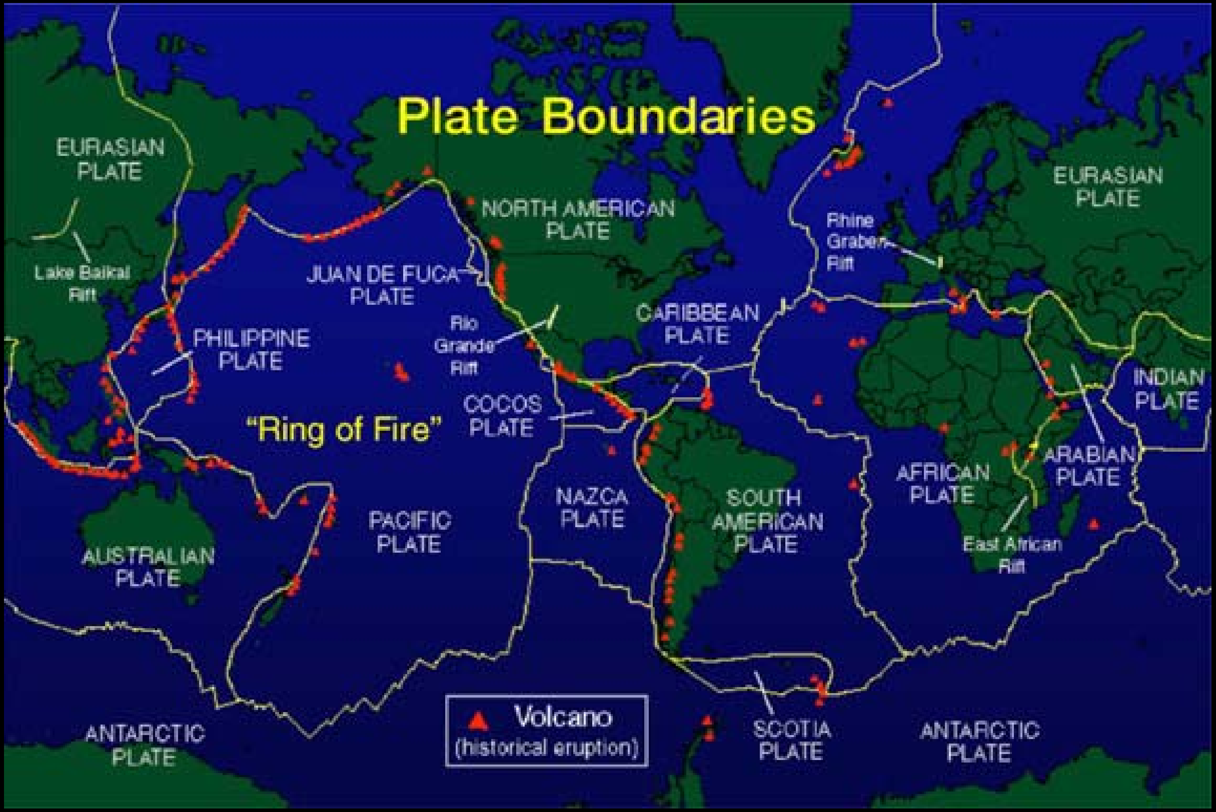
Temperature Gradient



Source: http://geothermal.marin.org/GEOpresentation

Plate Tectonics

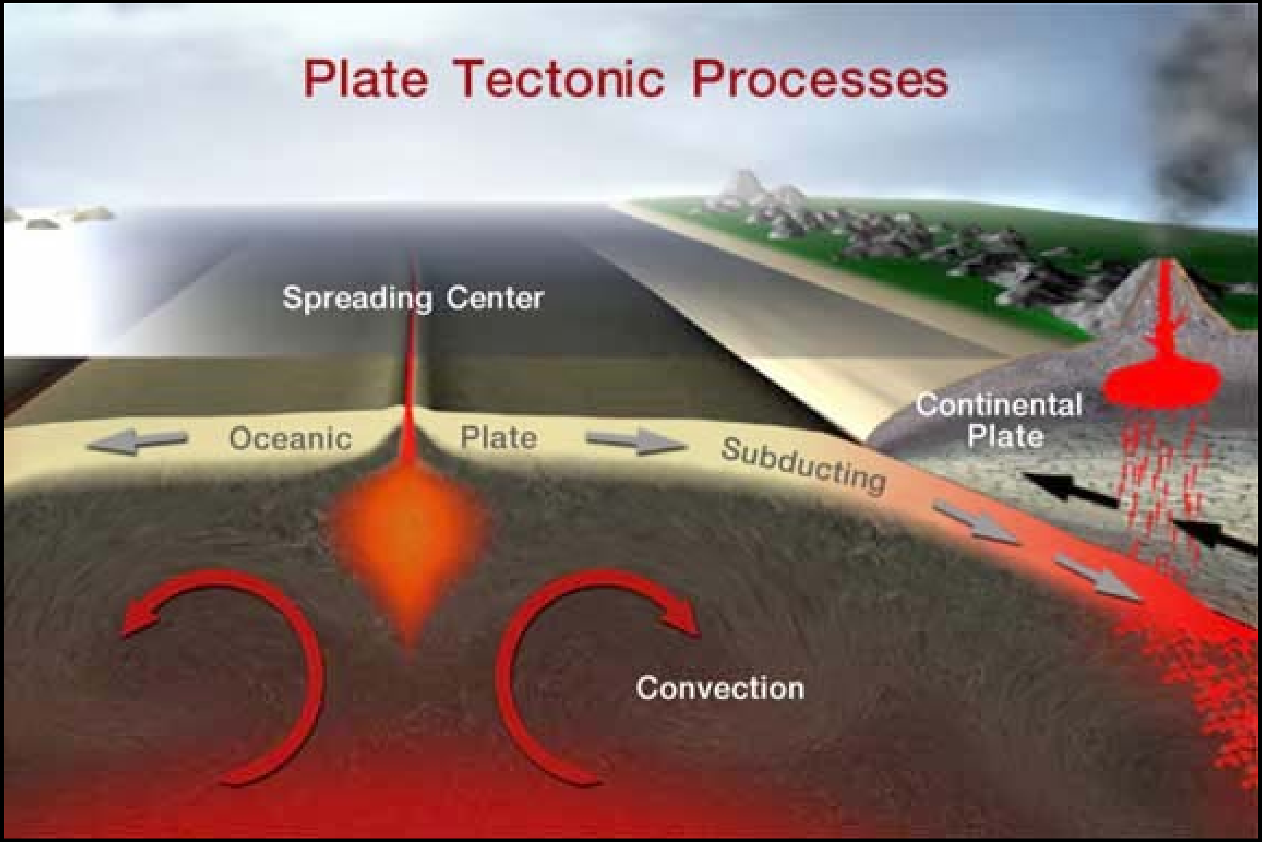
Earth's crust is broken into huge plates that move apart or push together at about the rate our fingernails grow. Convection of semi-molten rock in the upper mantle helps drive plate tectonics.



Source: http://geothermal.marin.org/GEOpresentation

Plate Tectonics

New crust forms along mid-ocean spreading centers and continental rift zones. When plates meet, one can slide beneath another. Plumes of magma rise from the edges of sinking plates.



Source: http://geothermal.marin.org/GEOpresentation

Magma

Thinned or fractured crust allows magma to rise to the surface as lava. Most magma doesn't reach the surface but heats large regions of underground rock.

Source: http://geothermal.marin.org/GEOpresentation

Rain Water Effect

Rainwater can seep down faults and fractured rocks for miles. After being heated, it can return to the surface as steam or hot water.

Source: http://geothermal.marin.org/GEOpresentation

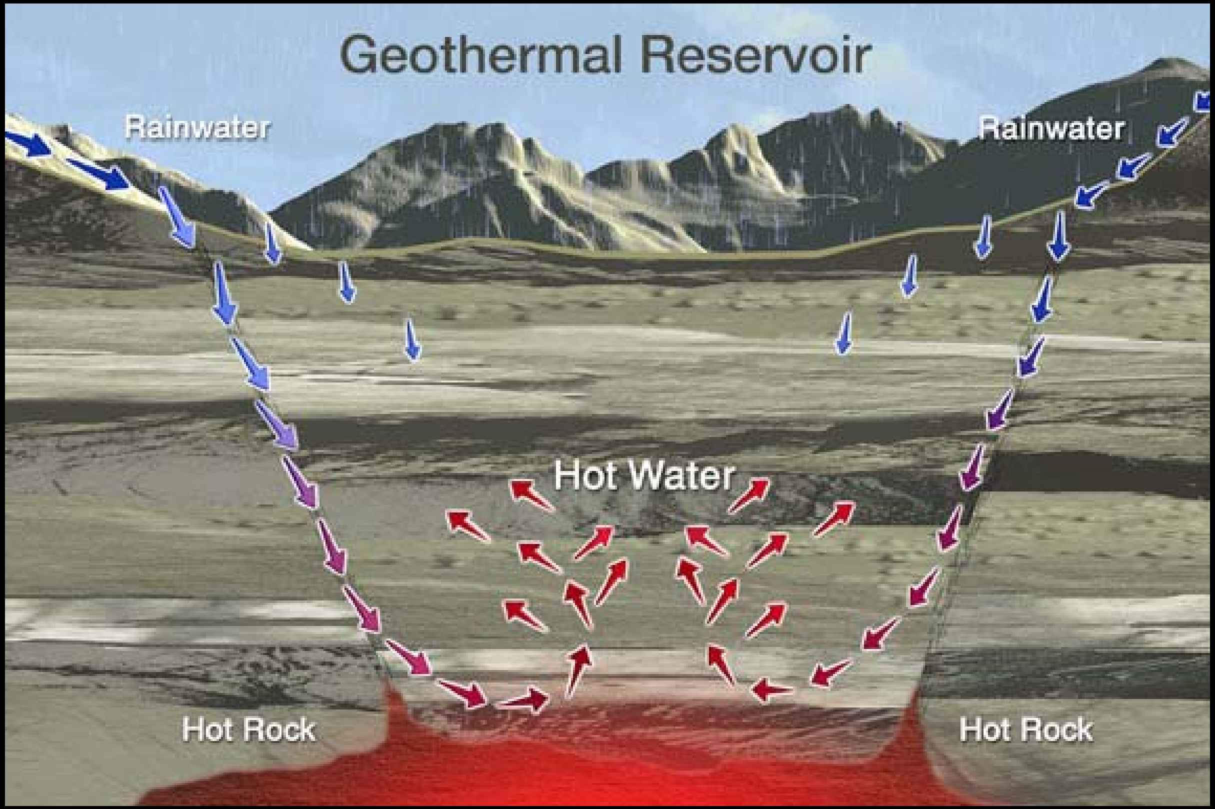
Steaming Ground

This steaming ground is in the Philippines.

Source: http://geothermal.marin.org/GEOpresentation

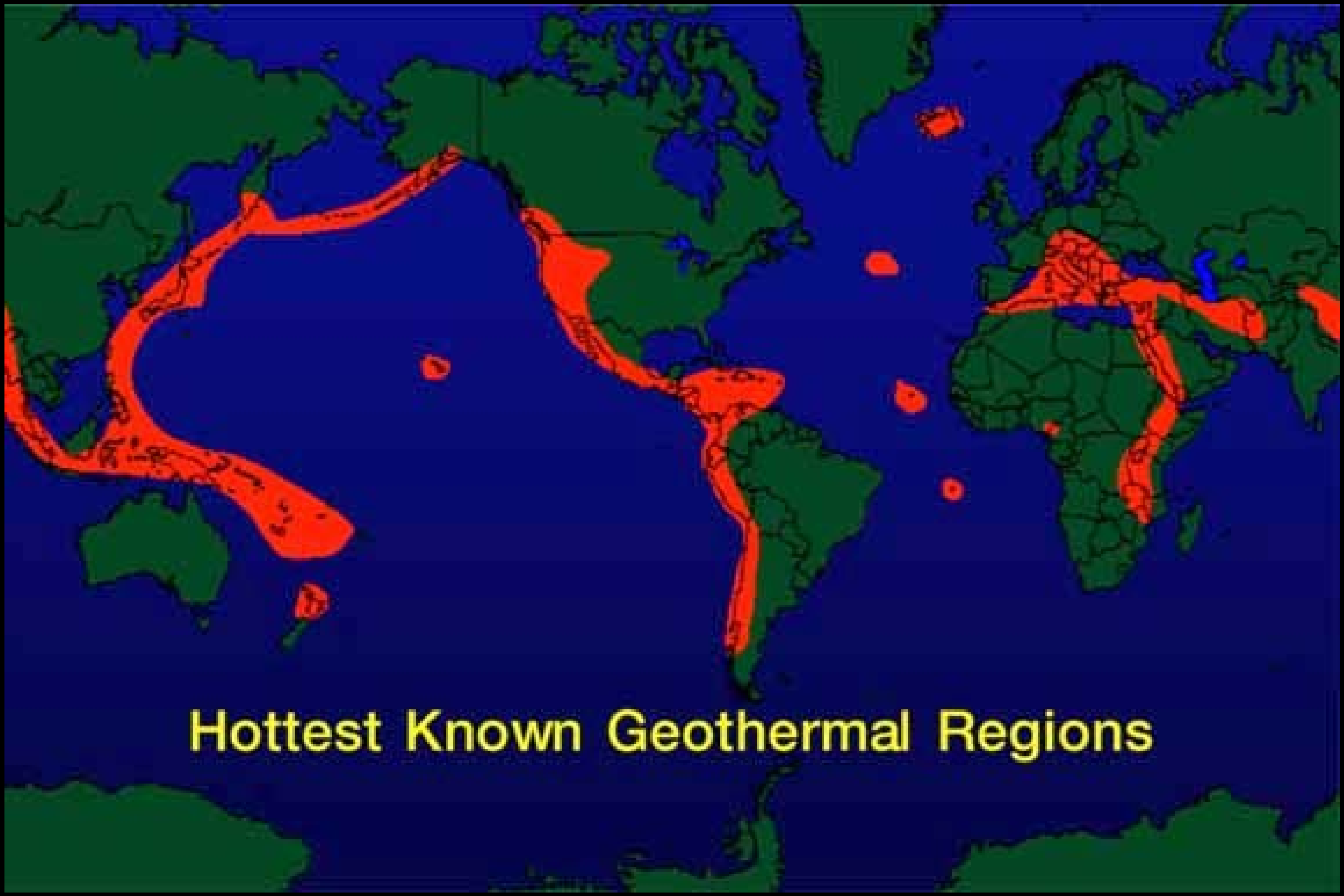
Geothermal Reservoir

When the rising hot water and steam is trapped in permeable and porous rocks under a layer of impermeable rock, it can form a geothermal reservoir. Geothermal reservoirs can reach temperatures of 370°C.



Source: http://geothermal.marin.org/GEOpresentation

GEOTHERMAL ENERGY REGIONS



Source: http://geothermal.marin.org/GEOpresentation

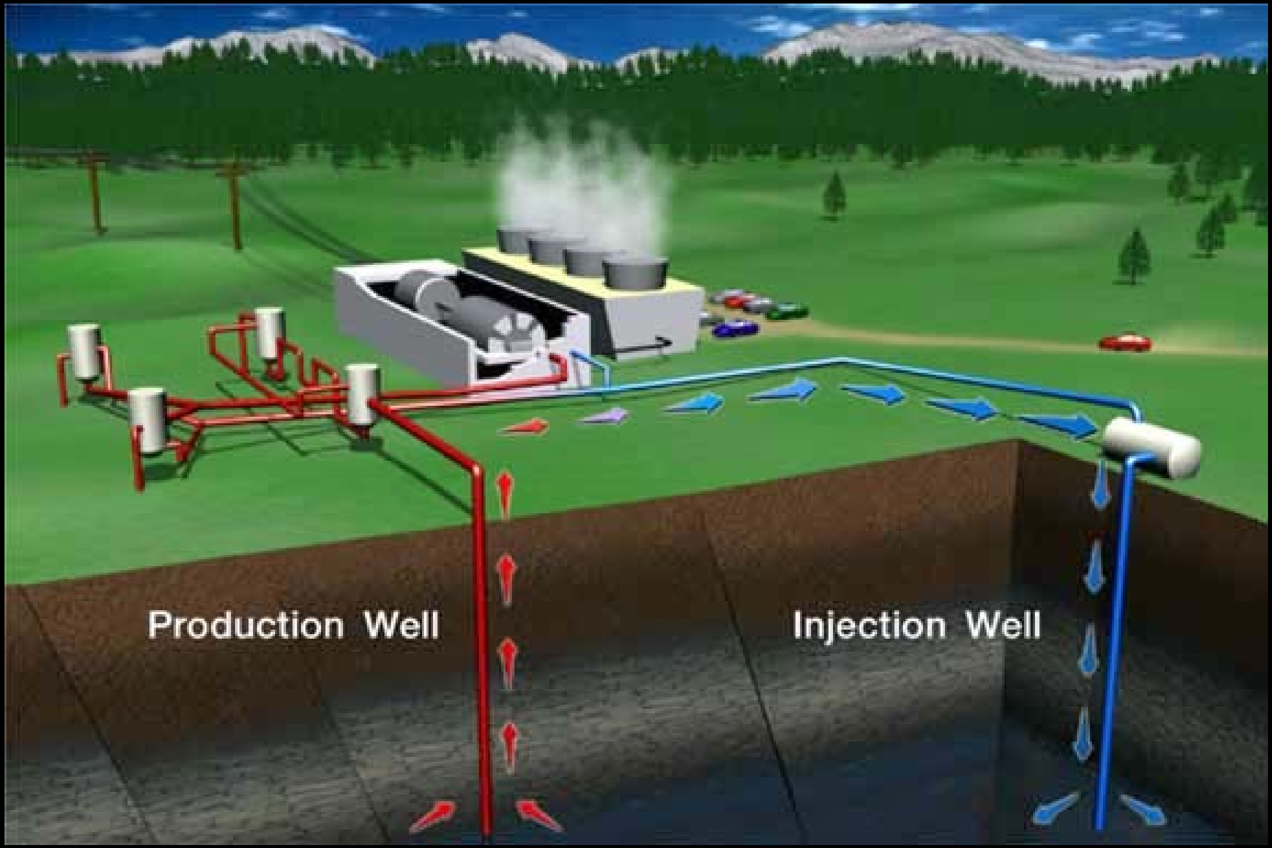
Geothermal Well

This photograph shows a vertical geothermal well test in the Nevada Desert.

Source: http://geothermal.marin.org/GEOpresentation

Geothermal Plant

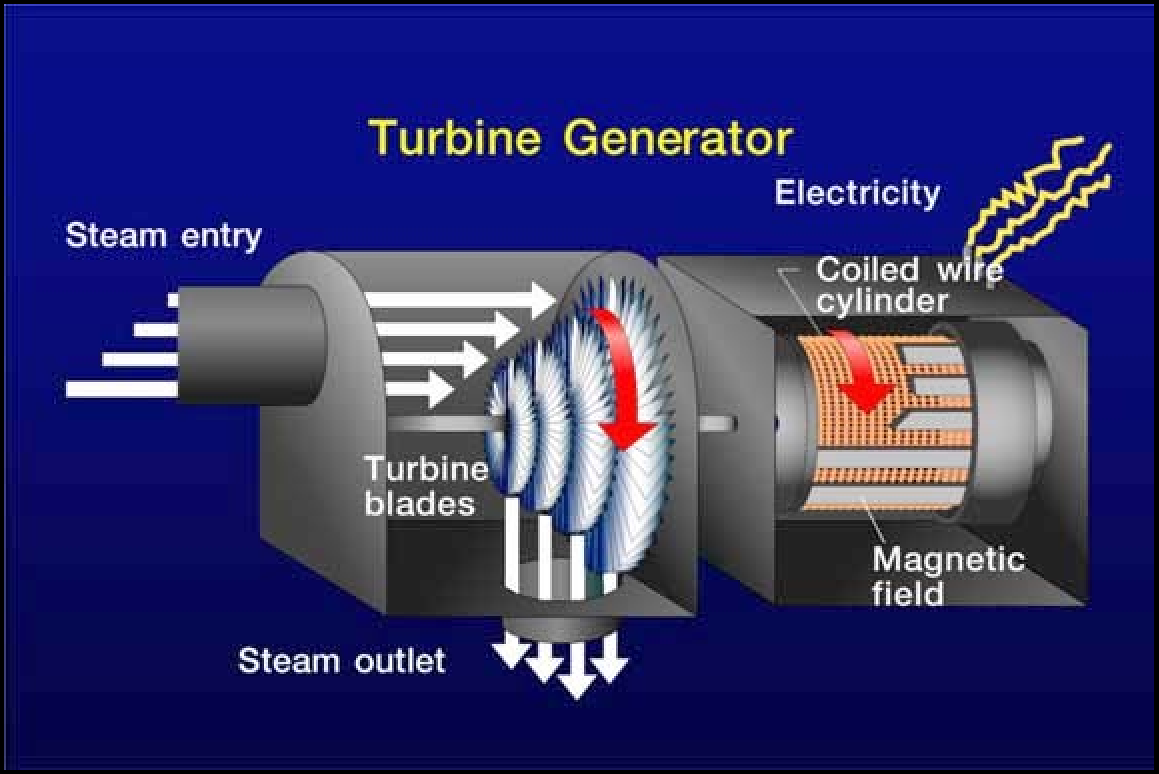
Natural steam from the production wells power the turbine generator. The steam is condensed by evaporation in the cooling tower and pumped down an injection well to sustain production.



Source: http://geothermal.marin.org/GEOpresentation

Turbine Generator

Sustainable electricity production with no fuels are burned.



Source: http://geothermal.marin.org/GEOpresentation

Outdoor Turbine Generator

Turbine generator outdoors at an Imperial Valley geothermal power plant in California.

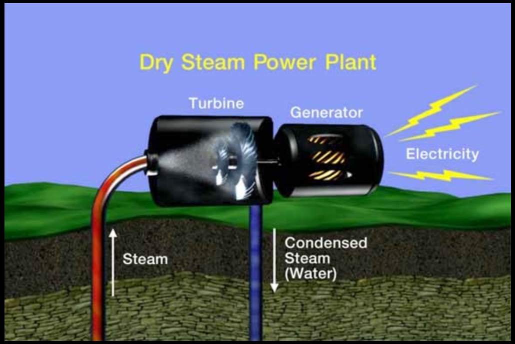
Source: http://geothermal.marin.org/GEOpresentation

Environment

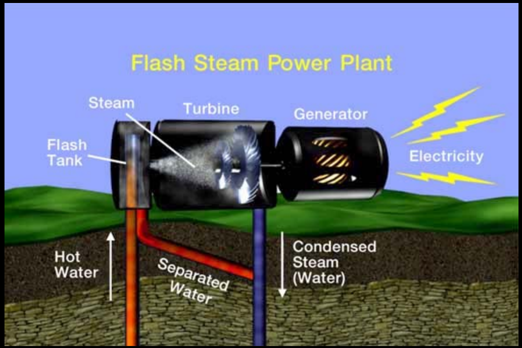
These geothermal plants are operating successfully in a Philippine cornfield, at Mammoth Lakes, Calif., in the Mojave Desert of California, and in a tropical forest, at Mt. Apo, Philippines.

Source: http://geothermal.marin.org/GEOpresentation

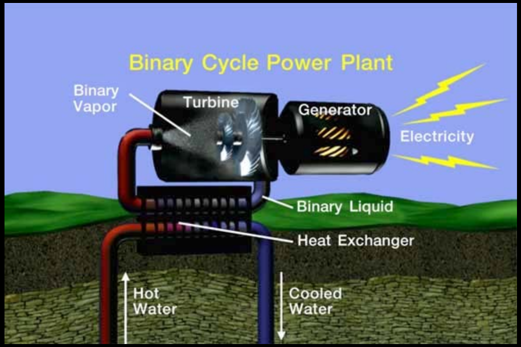
Power Plant Types



Dry Steam: In dry steam power plants, the steam (and no water) shoots up the wells and is passed through a rock catcher and then directly into the turbine. Dry steam fields are rare.



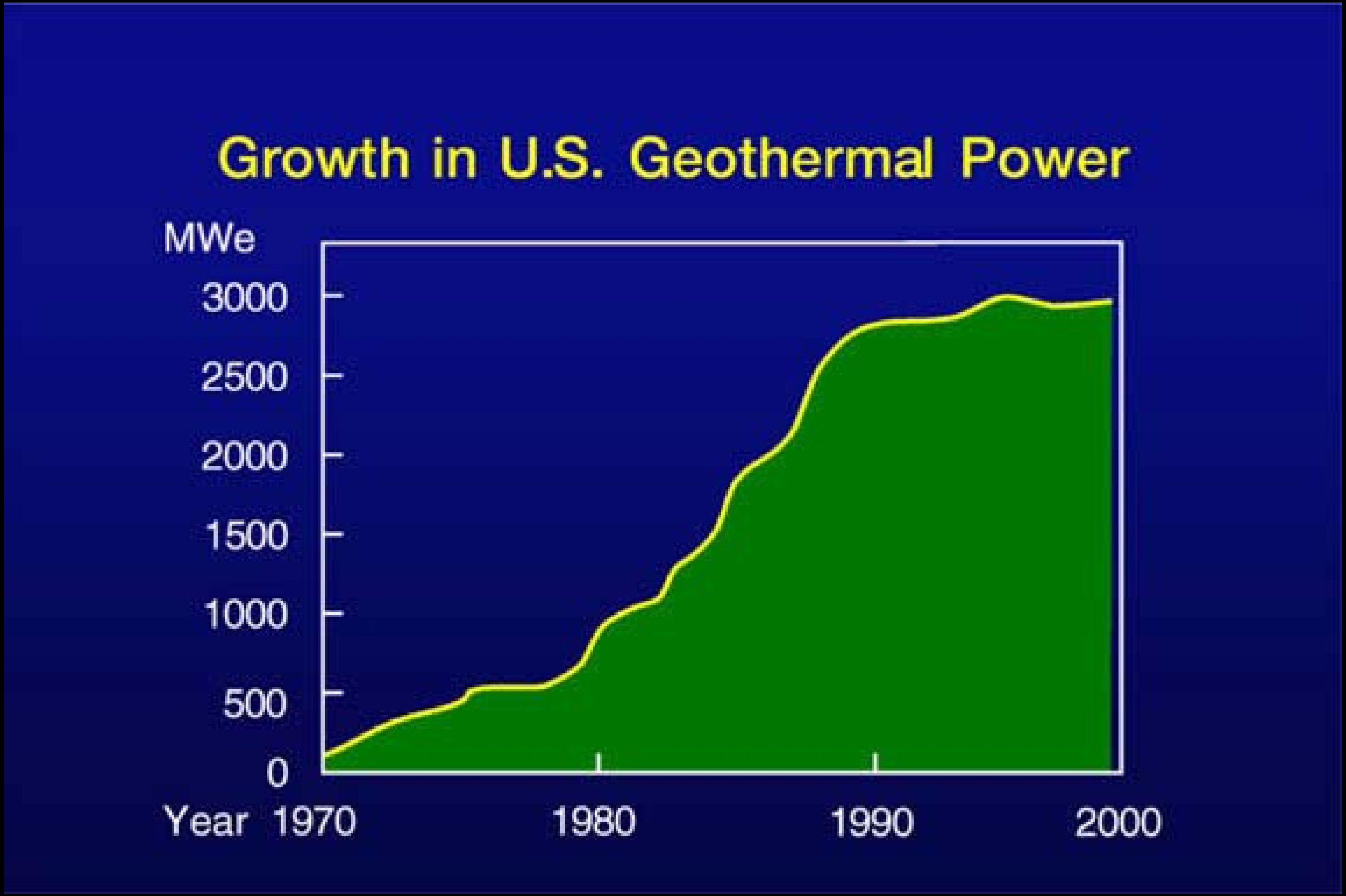
Flash Stream: Flash steam power plants use hot water reservoirs. In flash plants, as hot water is released from the pressure of the deep reservoir in a flash tank, some if it flashes to steam.



Binary Cycle: In a binary cycle power plant, the heat from geothermal water is used to vaporize a "working fluid" in separate adjacent pipes. The vapor, like steam, powers the turbine generator.

Source: http://geothermal.marin.org/GEOpresentation

Geothermal Power



Source: http://geothermal.marin.org/GEOpresentation

Global Geothermal Power

Geothermal power plants are producing over 8,200 MW of electricity in 21 countries

Source: http://geothermal.marin.org/GEOpresentation

Pollution

Reykjavik, Iceland, was taken in 1932, when buildings were all heated by burning of (imported) fossil fuels.

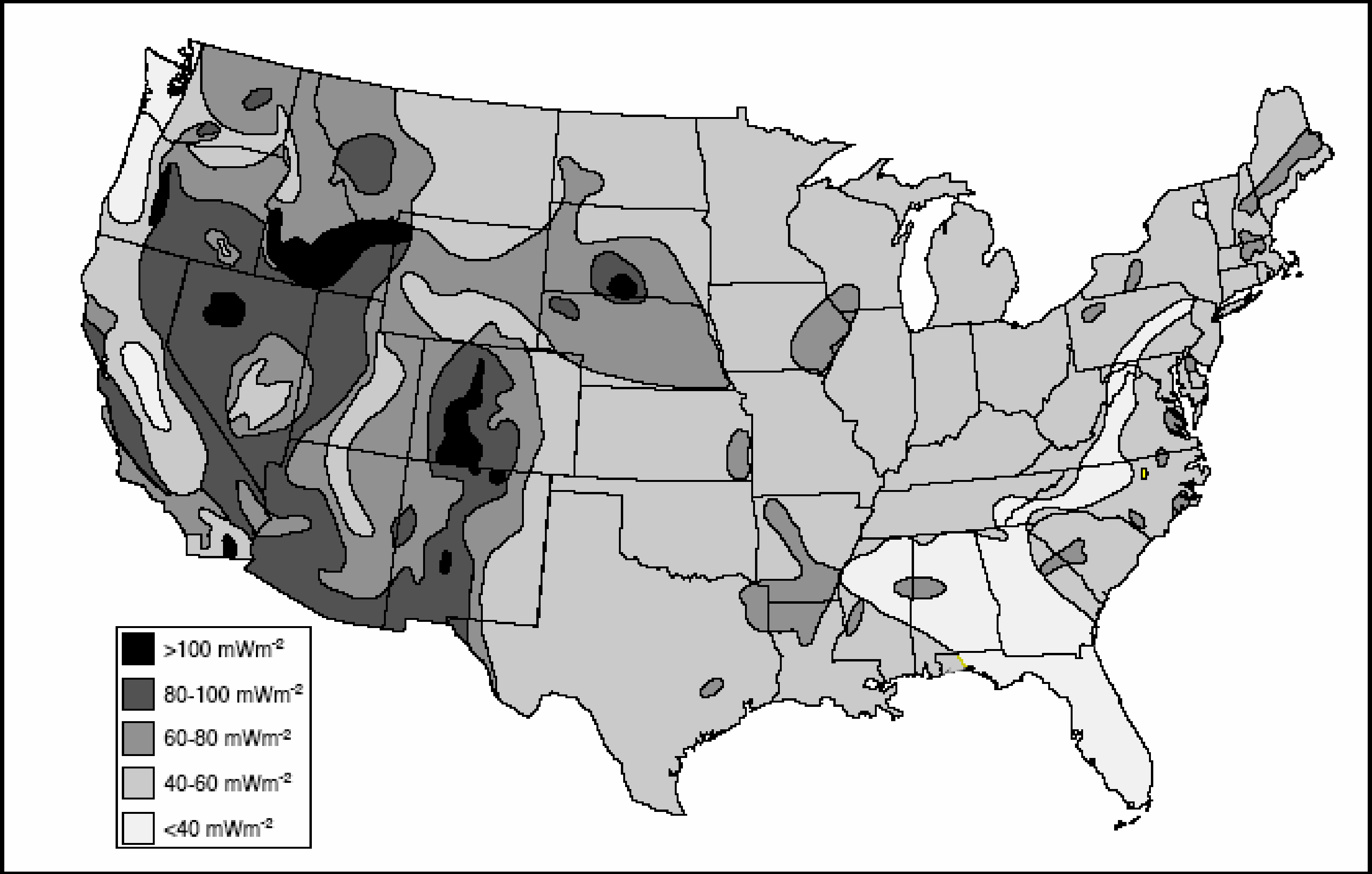
Source: http://geothermal.marin.org/GEOpresentation

Towards Sustainable Energy

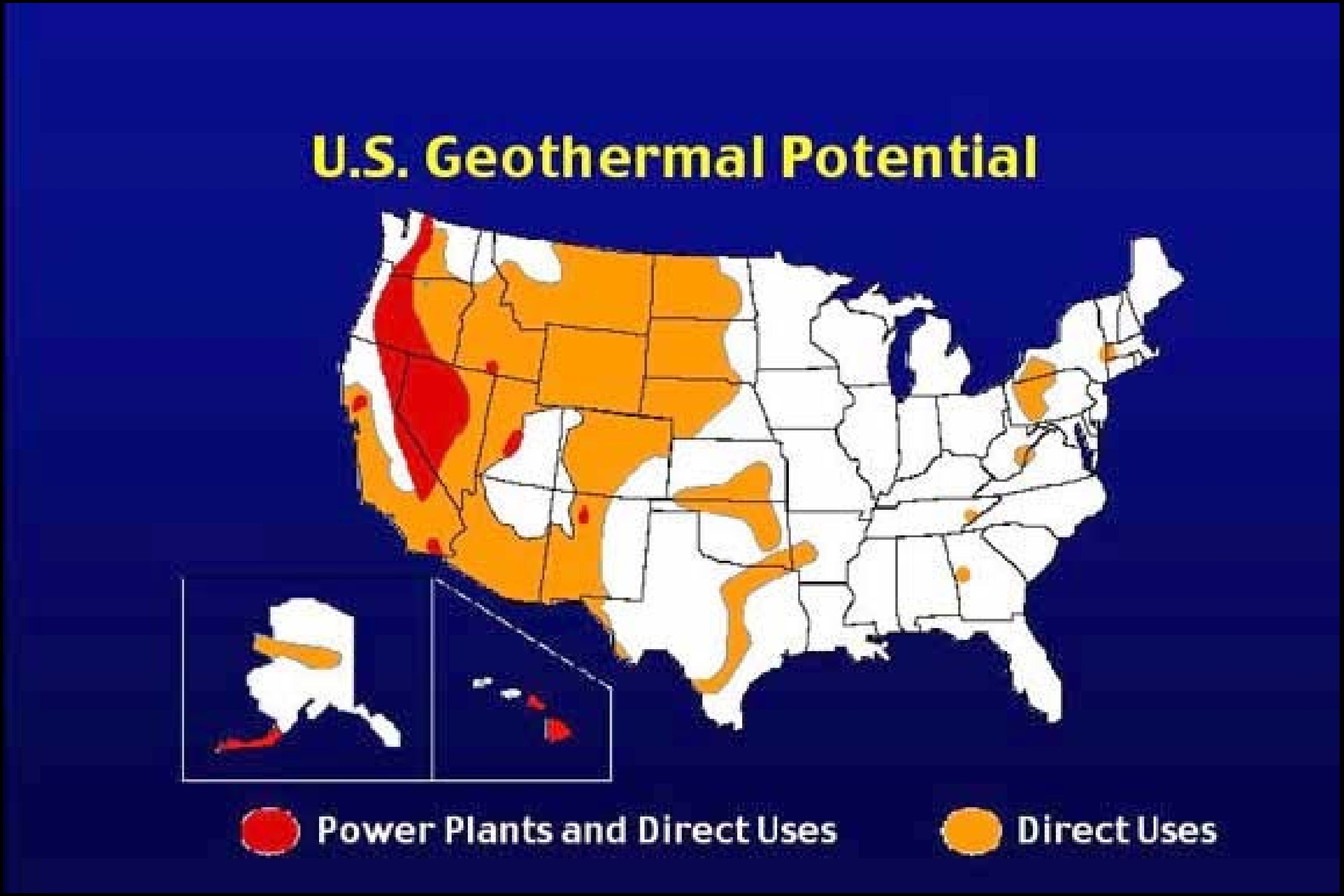
Today, about 95% of the buildings in Reykjavik are heated with geothermal water. Reykjavik is now one of the cleanest cities in the world.

Source: http://geothermal.marin.org/GEOpresentation

Geothermal Resource

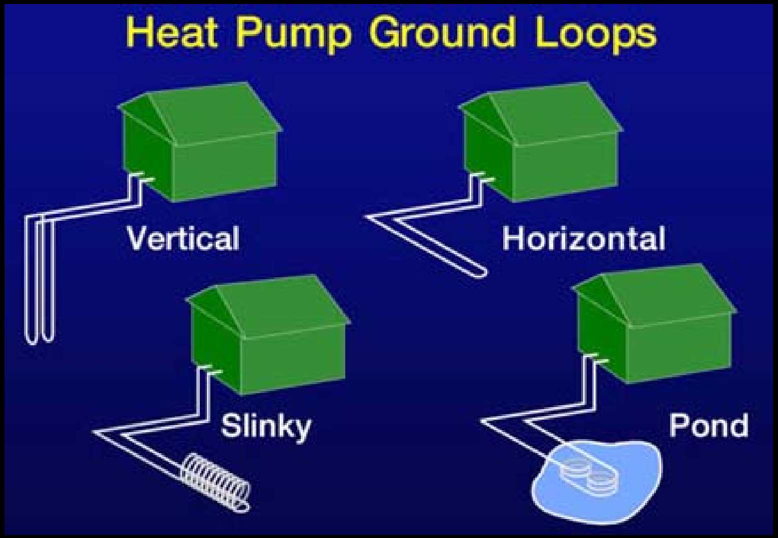


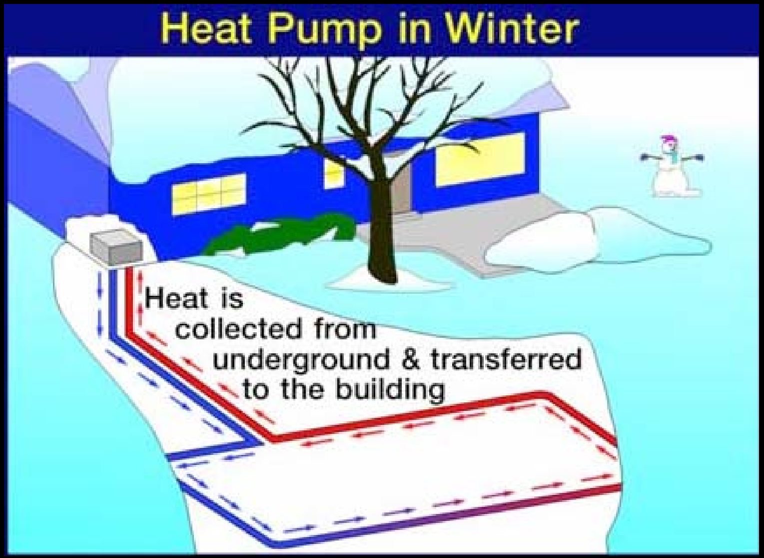
US Geothermal Potential

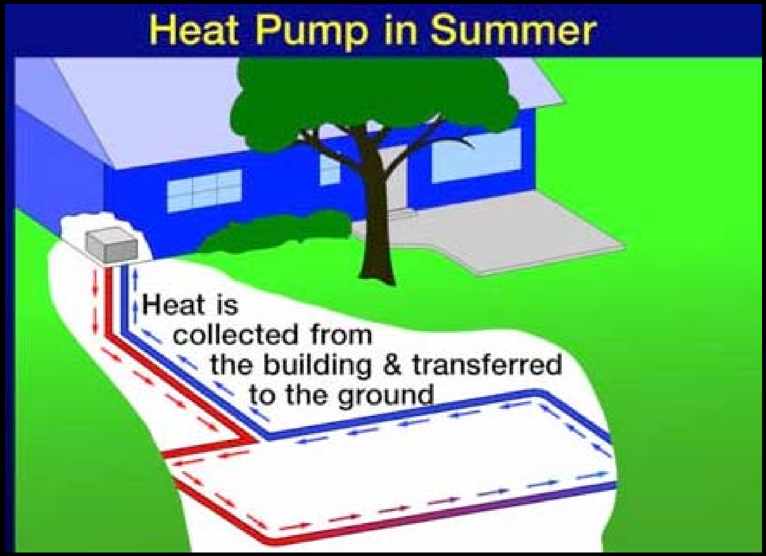


Source: http://geothermal.marin.org/GEOpresentation

Heat Pumps







Source: http://geothermal.marin.org/GEOpresentation

Nuclear Power

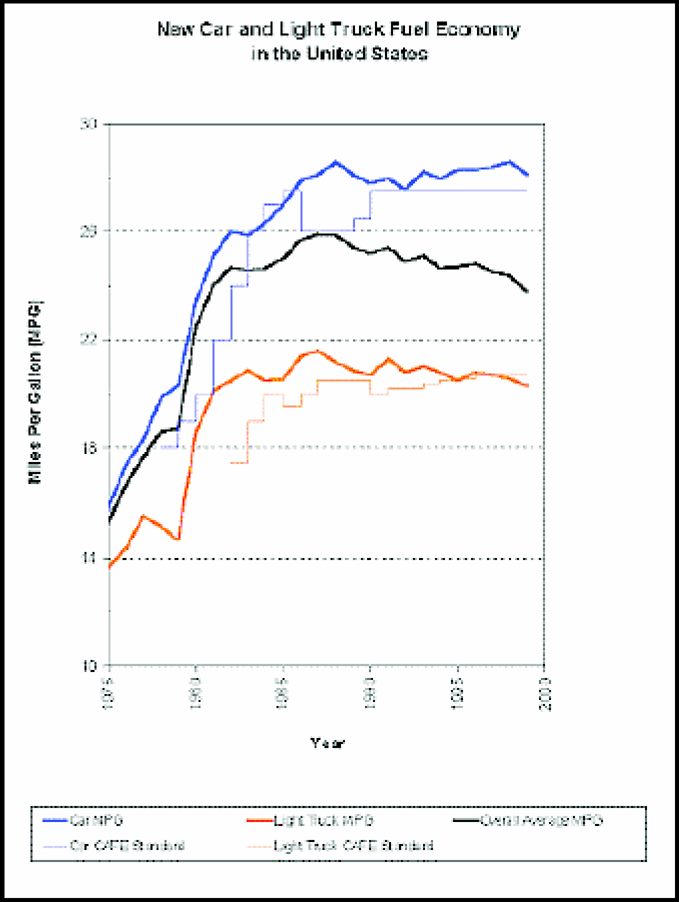
Taxpayer Subsidy: From 1948 to 1998, 59% of R&D funding ($66 billion in constant 1999 dollars) went to nuclear power, 23% to fossil energy ($26 billion), 11% to renewable energy ($12 billion), and 7% to energy efficiency ($8 billion). Despite this massive infusion of federal funds (and billions more in indirect subsidies, such as the Price Anderson limits on nuclear industry liability for accidents), nuclear power has not become a major player in our national energy mix. Today, nuclear power contributes approximately 8% of total U.S. energy supply and 20% of electricity production.

Nuclear Power is not competitive: In the U.S., 27 reactors have been closed after operating for an average of 15 years. This amounts to 37% of the licensed and projected lifetime of U.S. reactors. This empirical trend flies in the face of the industry's claims of reliability and challenges the industry's assertions that the technology, through relicensing and new construction, is a viable strategy for addressing climate change. In 1998, the Washington International Energy Group, an energy industry analyst, released an update to its study: *Nuclear Power Plants and Implications of Early Shutdown for Future Natural Gas Demand*. The report evaluated the performance of nuclear power plants and found that among the 72 reactor sites (each site includes one or more reactors), 34 sites will likely not be able to compete in their deregulated regional market. The owners of six reactors at these sites have already announced permanent shutdowns.

Energy Efficient Home

- Double-pane windows with low-e (emissivity) coating can reduce heating bills by 34 percent in cold climates compared to uncoated, single-pane windows. In hot climates, spectrally selective low-e windows can cut cooling costs by 38 percent.
- For each degree households lower their thermostats in winter, they can save about 3 percent on heating bills. An Energy Star furnace could save $1,700 relative to an old furnace, or $1,000 over the lifetime of a standard new furnace.
- If every household in the U.S. switched to Energy Star light fixtures, we could save 70 billion kilowatt-hours and prevent 100 billion pounds of CO_2 per year -- equivalent to removing 10 million cars from the road.
- Refrigerators in the U.S. alone use the equivalent of the output of more than 20 large nuclear power plants. If all the nation's households used the most efficient refrigerators, electricity savings would eliminate the need for about 10 large power plants.
- Every kilowatt-hour (kWh) of electricity you avoid using saves more than 1-1/2 pounds of CO_2 from being pumped into the atmosphere. If over the next 15 years, Americans bought only Energy Star products, we would shrink our energy bills by more than $100 billion and eliminate as much greenhouse gas pollution as is produced by 17 million cars for each of those 15 years.

Energy Efficiency in Transportation



Improvements in the average fuel economy of new cars and light trucks from around 1975 through the mid-1980s, were significant. The average fuel economy of cars almost doubled in that time period and for trucks it increased by more than than 50 percent. These improvements were due mainly to the Corporate Average Fuel Economy (CAFE) standards enacted in 1975.

Raising the current CAFE standards by 60 percent to 44 MPG for cars and 33 MPG for light trucks by 2012, with further increases after that date, are technically and economically feasible. Raising the CAFE standards as suggested here would save 1.5 million barrels per day (MBD) of gasoline by 2010 and 4.5 MBD by 2020.

Energy Goals

Accessibility to modern energy means that energy must be available at prices which are both affordable (low enough for the poorest people) and sustainable (prices which reflect the real costs of energy production, transmission and distribution to support the financial ability of companies to maintain and develop their energy services);

Availability relates to long-term continuity of energy supply as well as to short term quality of service, because an energy or an electricity shortage can also be disruptive for economic development. This implies that the "right energy mix" relies on a well diversified portfolio of domestic or imported or regionally traded fuels and sources of energy;

Acceptability is an issue for both traditional and modern energy. This covers many issues; deforestation, land degradation or soil acidification at the regional level; indoor or local pollution such as that which exists in Africa and Asia from burning traditional fuels, or in China or South Africa because of poor quality coal briquettes; greenhouse gas emissions and climate change; nuclear security, waste management and proliferation; and the possible negative impact of the building of large dams or large scale modern biomass developments.

Source: WEC

Approaches to Renewable Energy

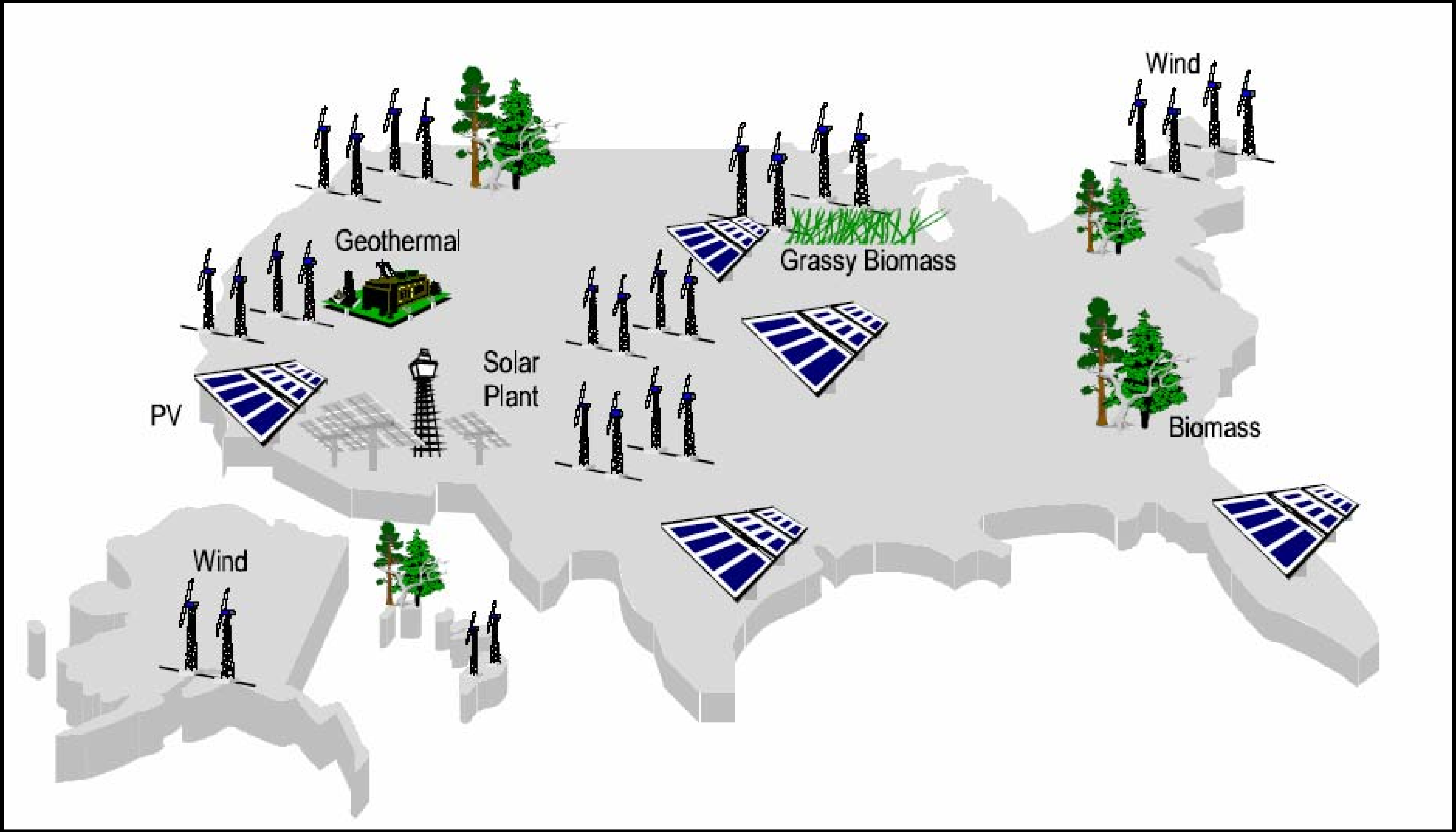
Available Resource: The total annual energy delivered by the source, for example, the total incident solar radiation.

Accessible Resource: The maximum annual energy that could be extracted from the accessible part of the available resource using current technologies.

Practicable Resource: The potential of the source by considering the constraints on using the energy, such as transportation, access to the electricity grid, intermittent supply and public acceptability.

Economic Potential: Economic viability of the practicable resource. Specification of an acceptable energy price taking into account of costs associated with climate change caused by using fossil fuels.

Sustainable Energy Future



Hydrogen Economy

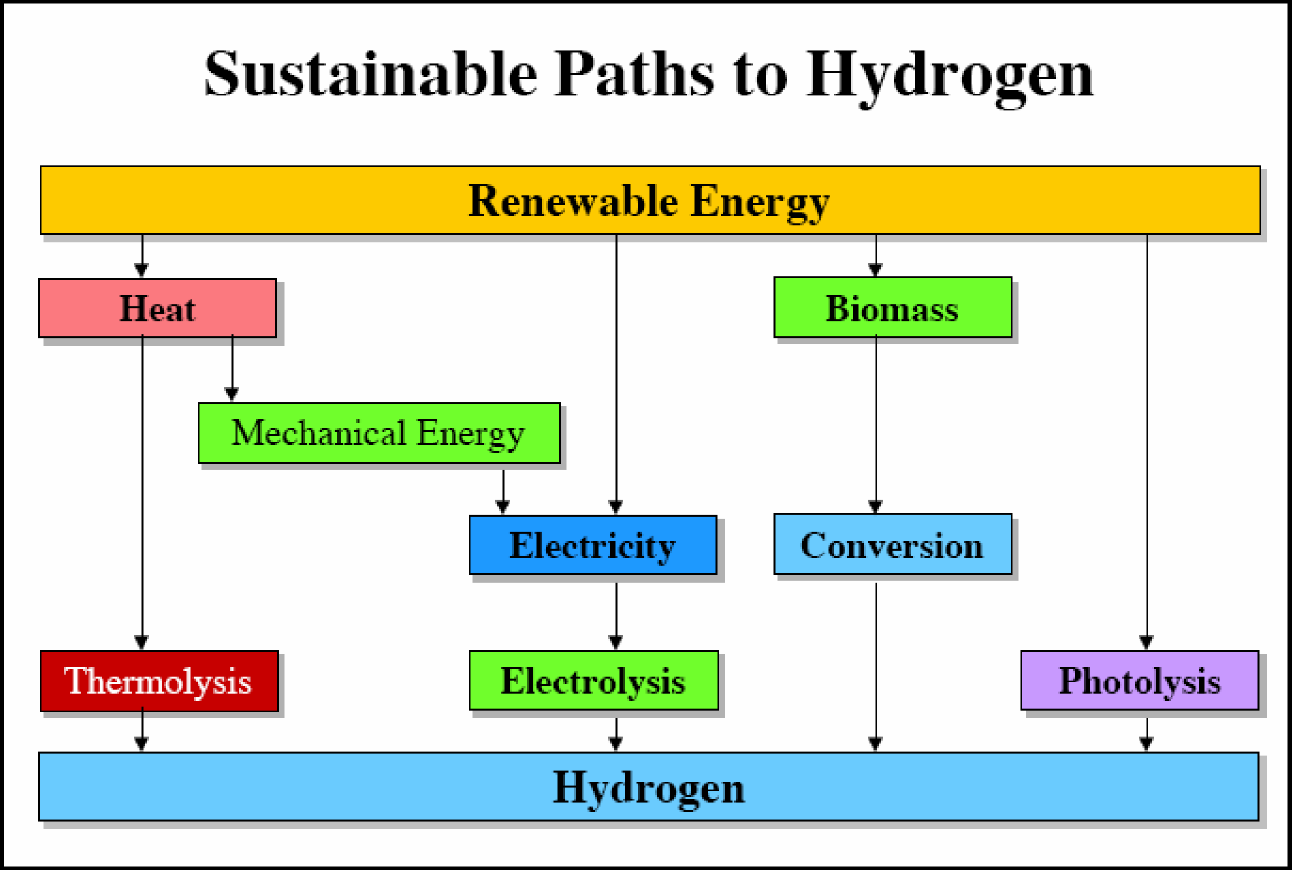
Technological issues:

Manufacturing hydrogen cleanly and at low cost

Finding way to ship it and store it on the vehicles that use it

Reducing the fuel cell price

Hydrogen Production



Source:

D. Brent MacQueen
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SRI International, Menlo Park CA

Energy Security

A strong policy to improve U.S. energy security must pursue reducing demand: for oil, for gas, for electricity. The technologies to do so are at hand. The steps are clear:

- Raise the Corporate Average Fuel Economy (CAFE) standards that govern automobile fuel efficiency
- Strengthen energy efficiency standards for appliances, buildings, and industry; and increase funding for state and utility efficiency programs
- Adopt a renewable portfolio standard requiring 20 percent renewables nationwide by 2020

Our nation can achieve greatly improved energy security if we add the political will.

Source: Union of Concerned Scientists

Climate Change and GHG's

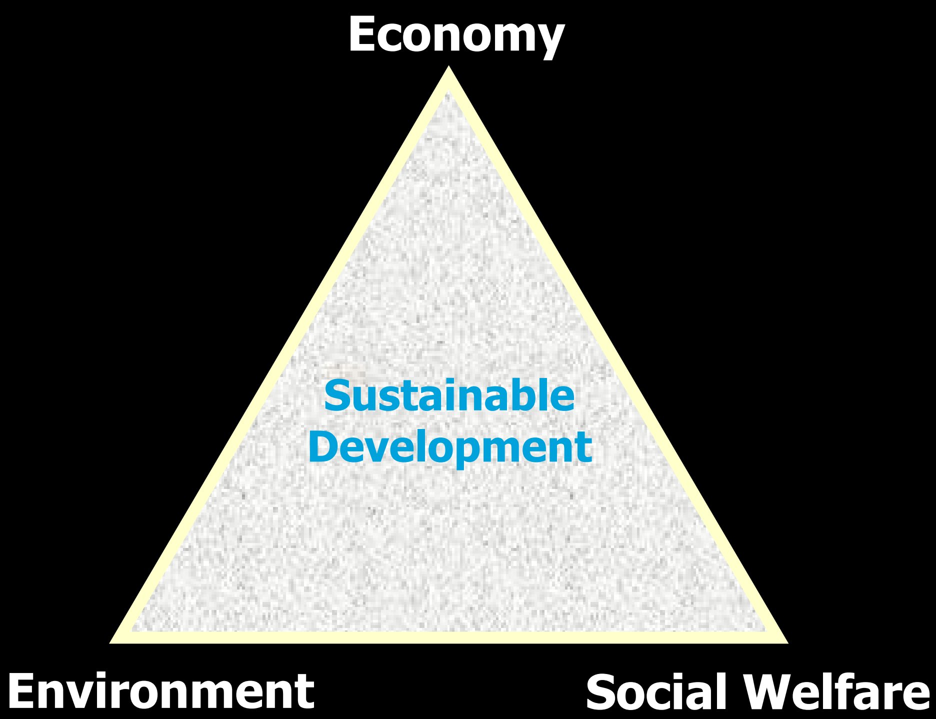
2003 summer in Europe hottest in 500 years

Emissions of greenhouse gases have more than doubled the risk of European heatwaves similar to last year's, according to a study by UK scientists. Many more summers like 2003 are on the way.

Last year's European summer appears to have been the warmest for five hundred years; and by running computer models of climate, these researchers calculated that greenhouse gases from human activities have more than doubled the chances of such heatwaves occurring.

Source: Emissions double heatwave risk - BBC News, December 1, 2004

Energy and Sustainability



Energy has strong relationship with three pillars of sustainable development.

Sustainability requires secure, reliable and affordable supply of energy.

Sustainable energy future is not static - it must be continuously redefined and rebalanced with new technical solutions and technologies.

Sustainability demands that we seek to change present trends.

Change the structure of energy sector, behavior in our societies and economics

Challenge: *To fuel worldwide economic growth with secure and reliable energy supply without despoiling our environment*

Source: IEA statement on sustainable development at the world summit on sustainable development, Johannesburg, 2002