

Geothermal and Tidal Power

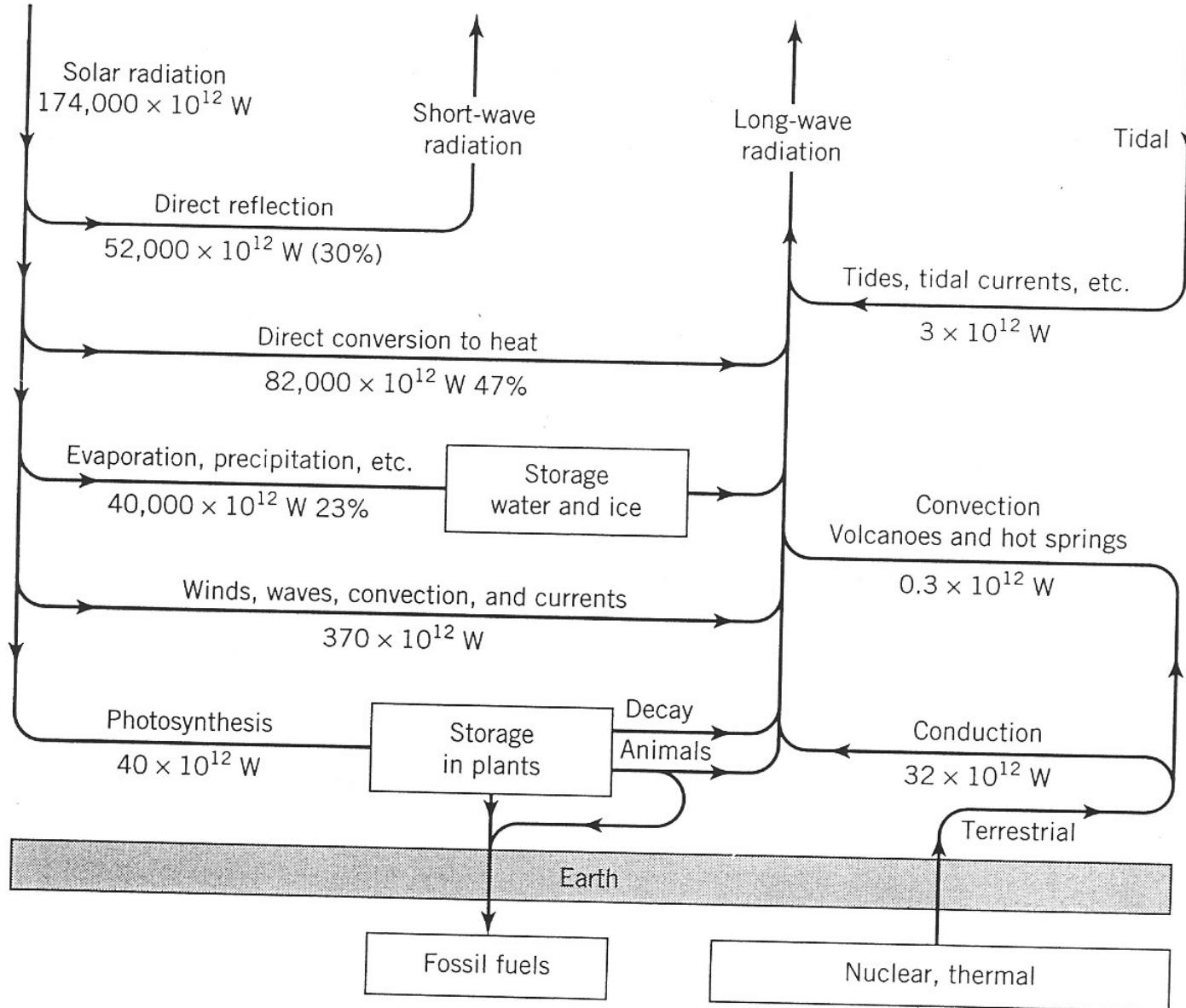
Non-Solar Energy Flows.

Original slides provided by Dr. Daniel Holland

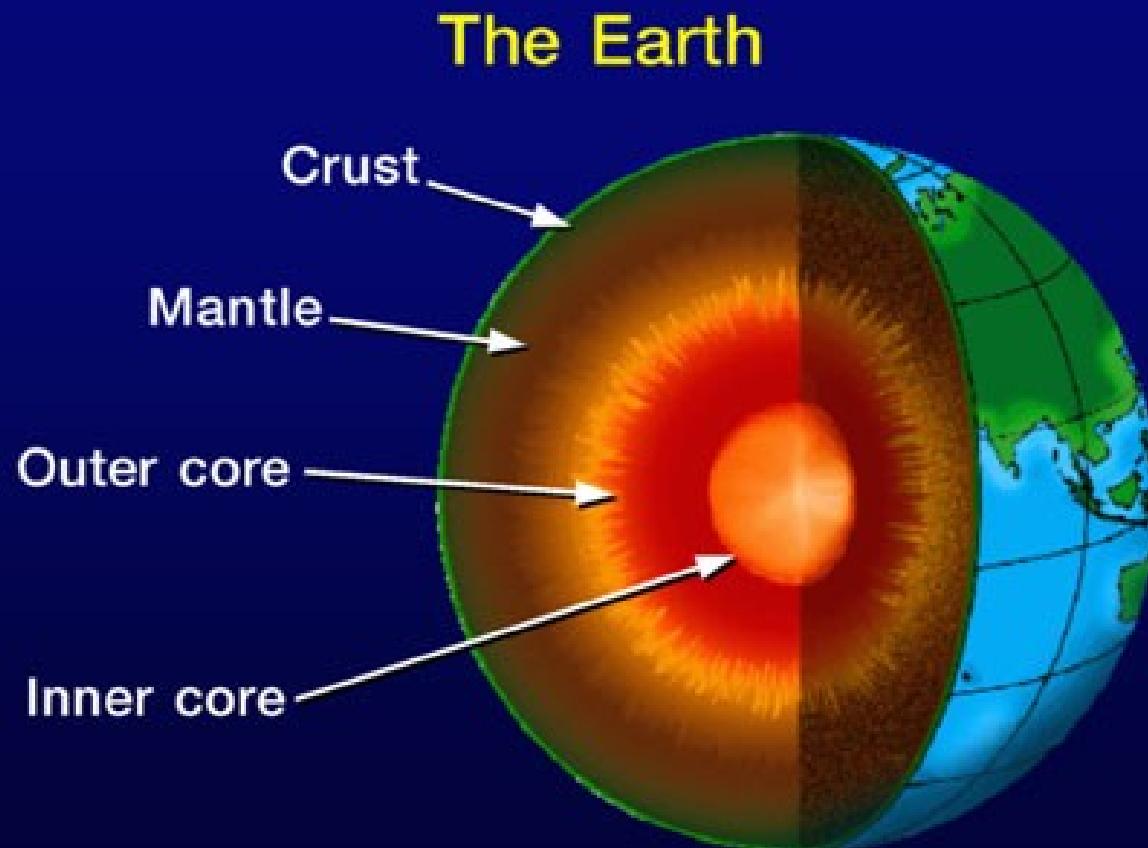
Geothermal

- Produced by heat from the earth's interior.
- One of two energy flows not coming from the sun. (the other is tidal.)

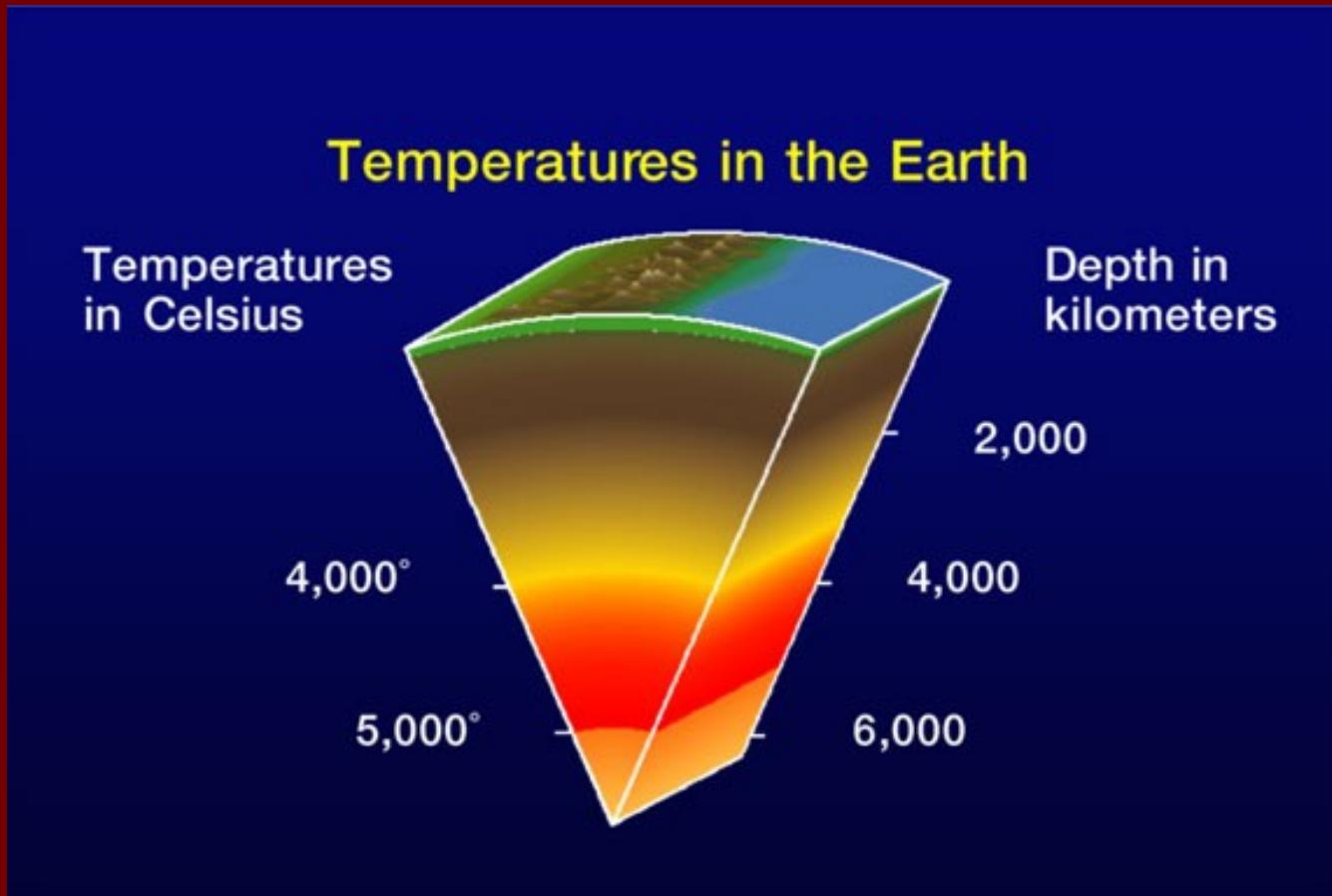
[Audio link](#)



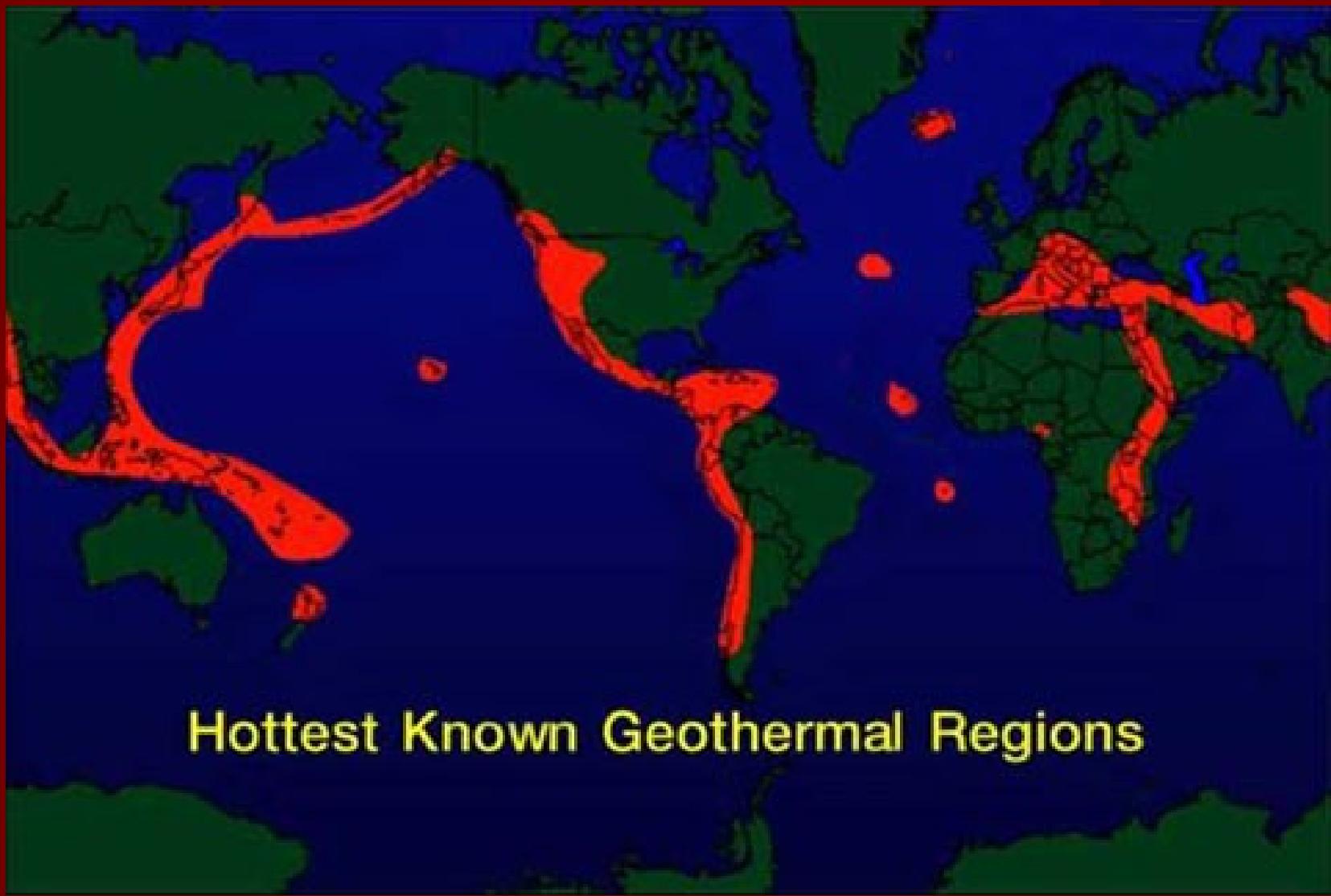
Interior of Earth



- Normal thermal gradient is $30^{\circ}\text{C}/\text{km}$ of depth.
- In general, the deeper we go into the earth, the hotter it gets.



- Drill holes of 20,000 ft (6100m) are possible. This gives a temperature increase of 190°C (463 K). Plenty hot for electric generation.
- $e_c = 1 - T_c/T_h = 1 - 300/463 = 0.35$
- Locations with larger thermal gradient work with shallower holes.
- Can also use shallower hole for space heating.

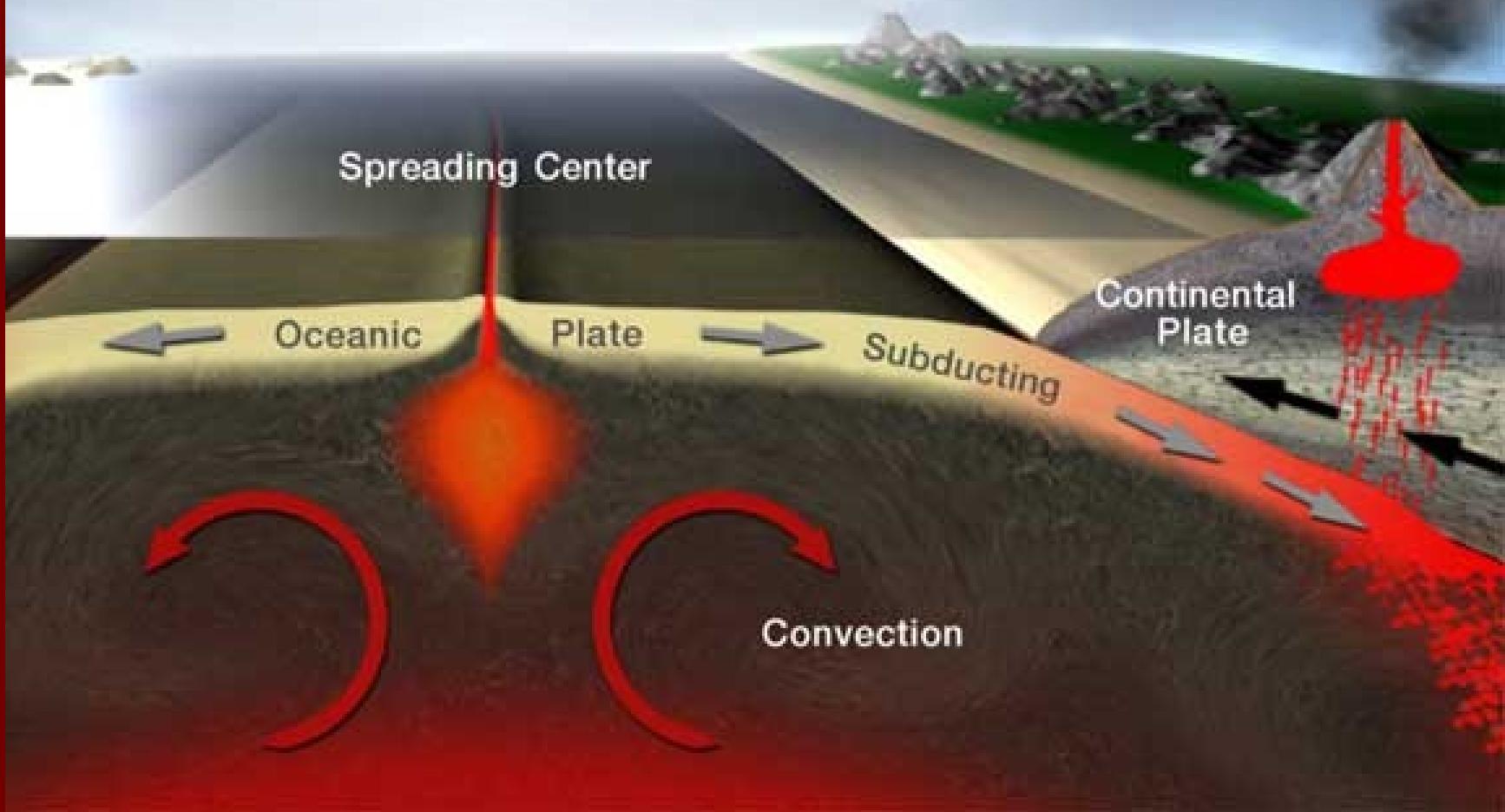


Hottest Known Geothermal Regions

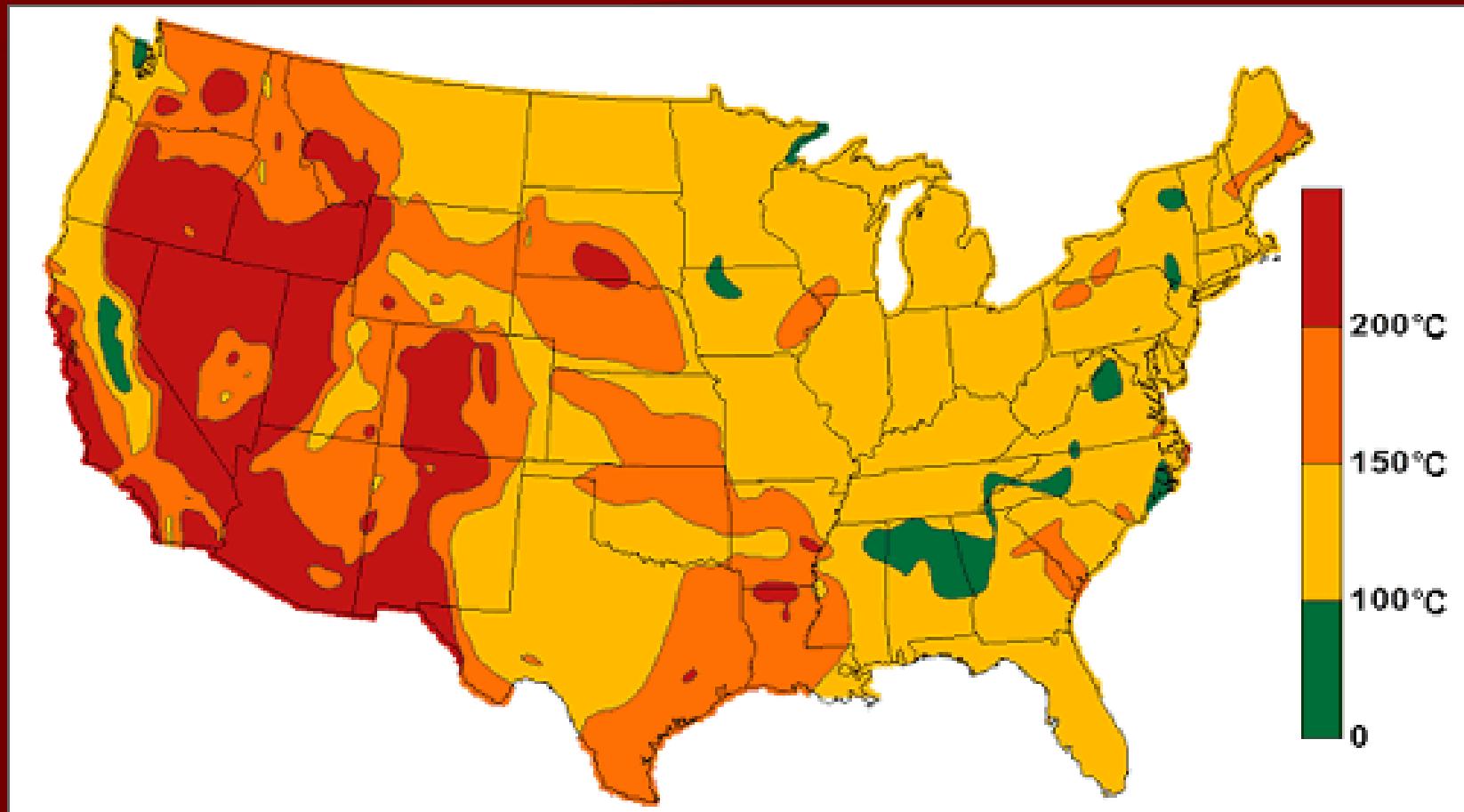
Good Geothermal Regions Associated with Plate Boundaries



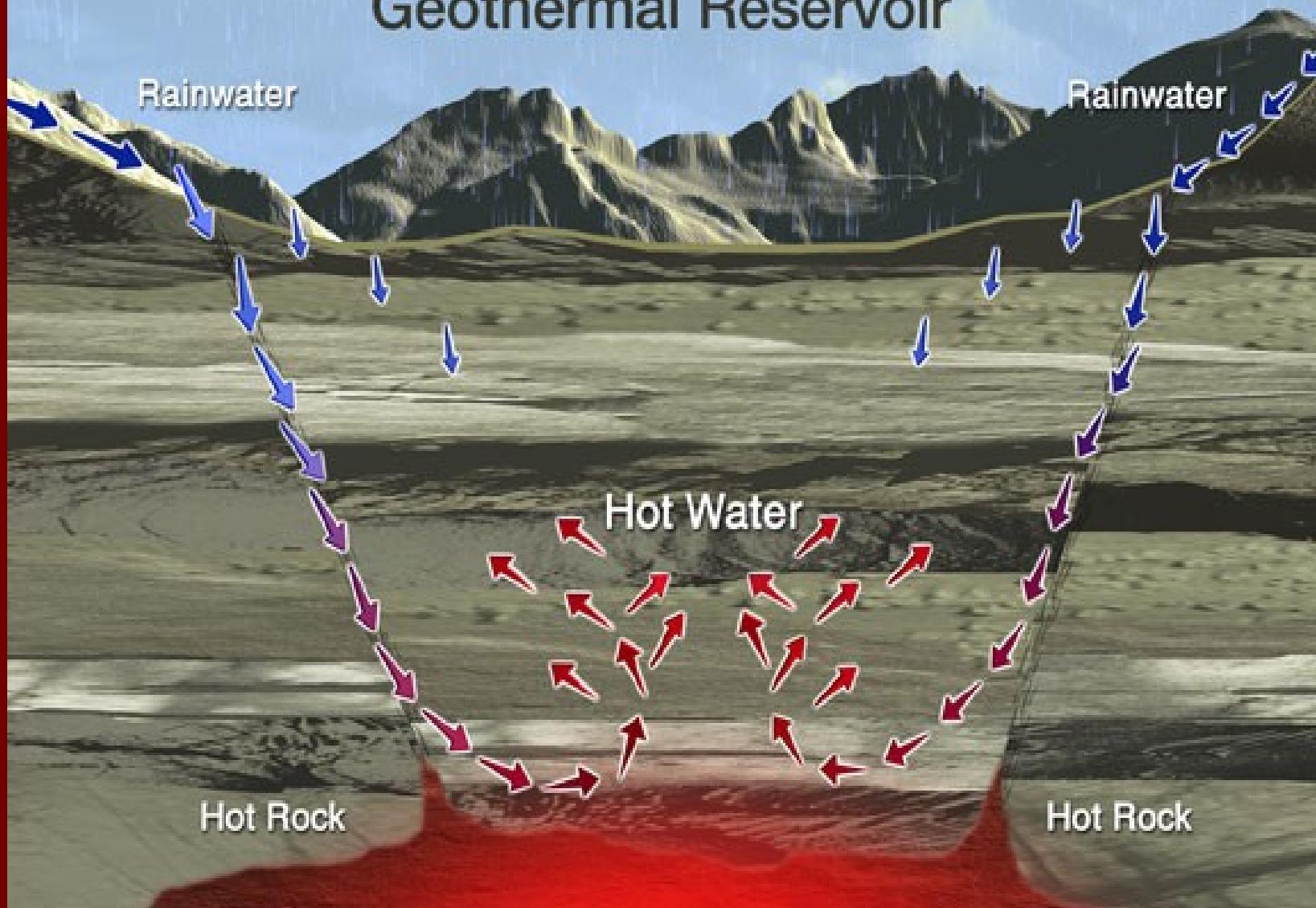
Plate Tectonic Processes



Temperature at a depth of 6 km

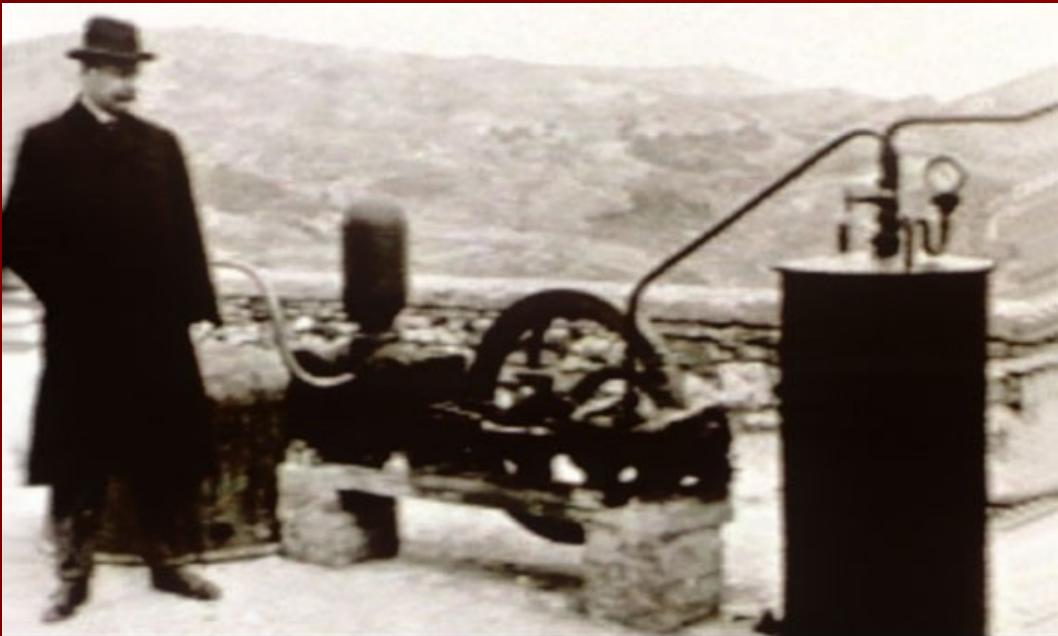


Geothermal Reservoir



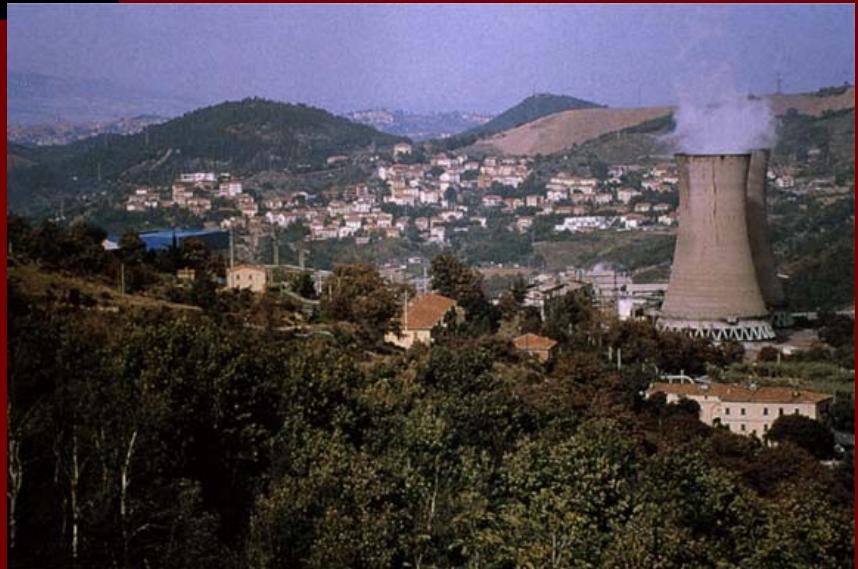
Sometimes the hot water comes back to the surface on its own



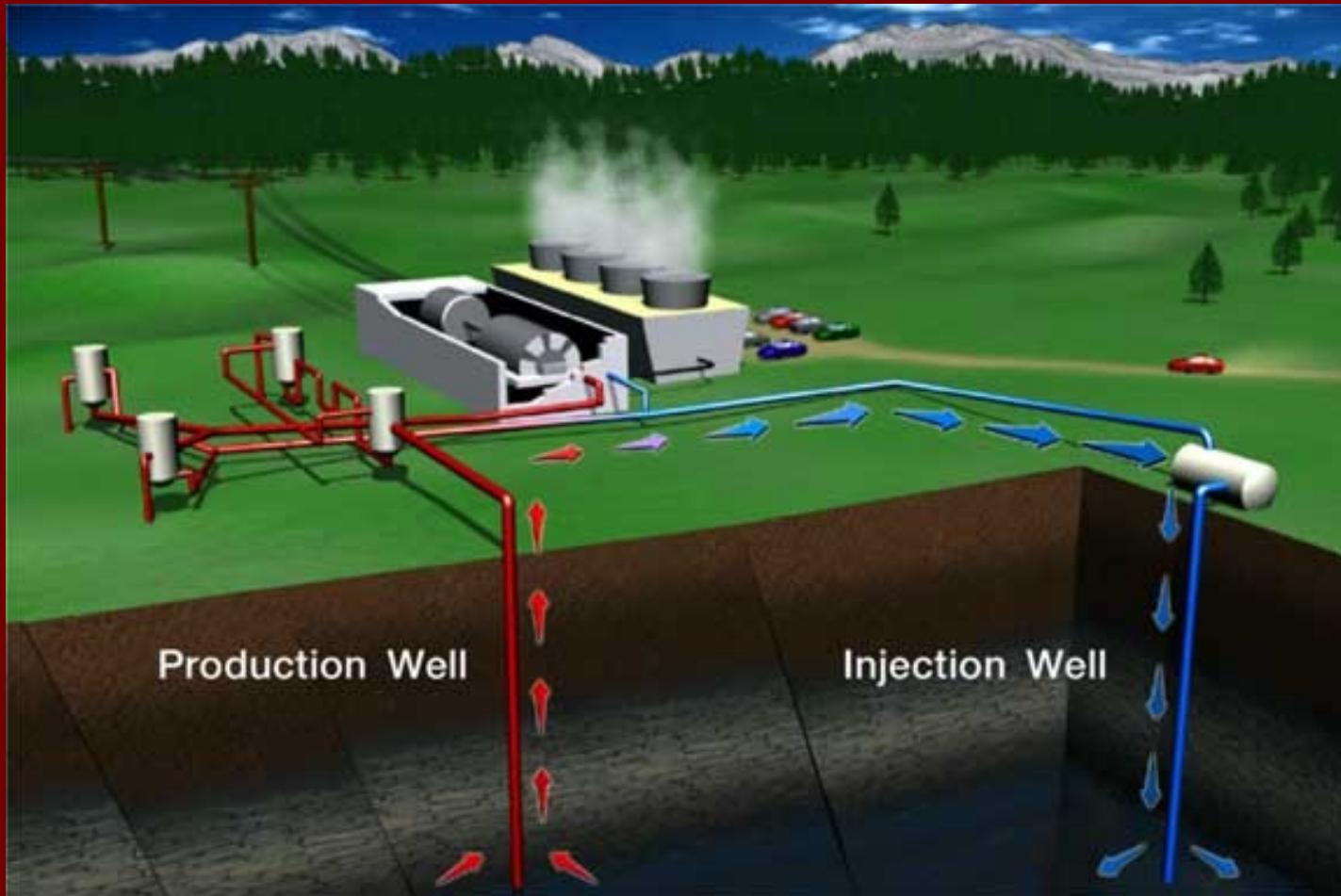


First Geothermal Power Plant, 1904, Larderello, Italy

Larderello is still producing geothermal electricity 100 years later.



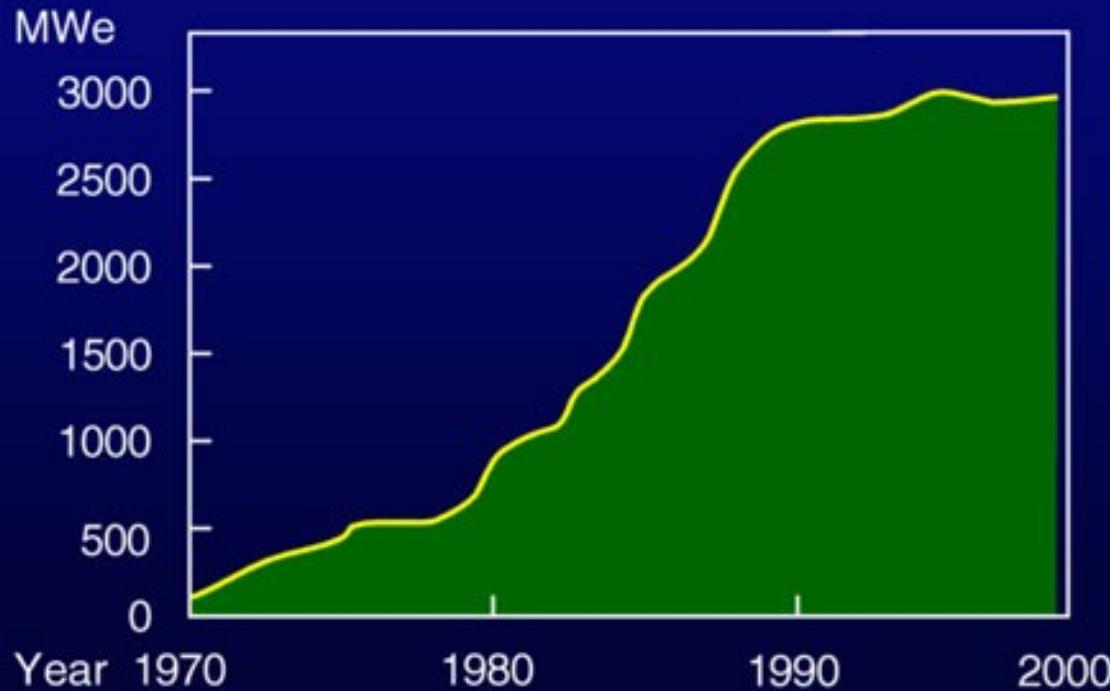
Typical geothermal electric production



Geysers Plant in California (one of twenty plants there)



Growth in U.S. Geothermal Power

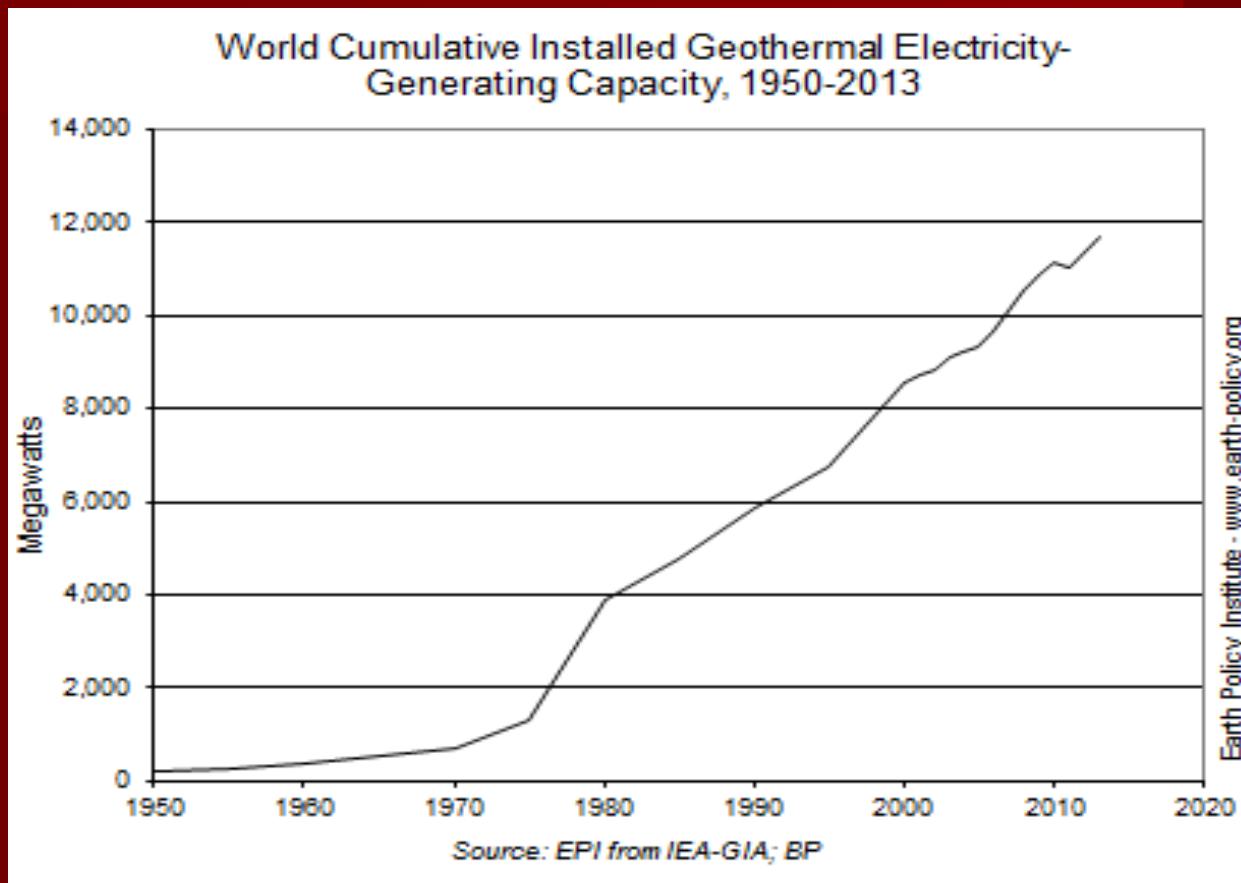


Most growth between 1980 and 1990
when PURPA required power
companies to buy energy from
independent producers.

U.S. Geothermal Power

Over 2,800 megawatts of electricity from geothermal power plants are supplying about 4 million people in the U.S.

World-wide geothermal generating capacity now exceeds 11000 MW.

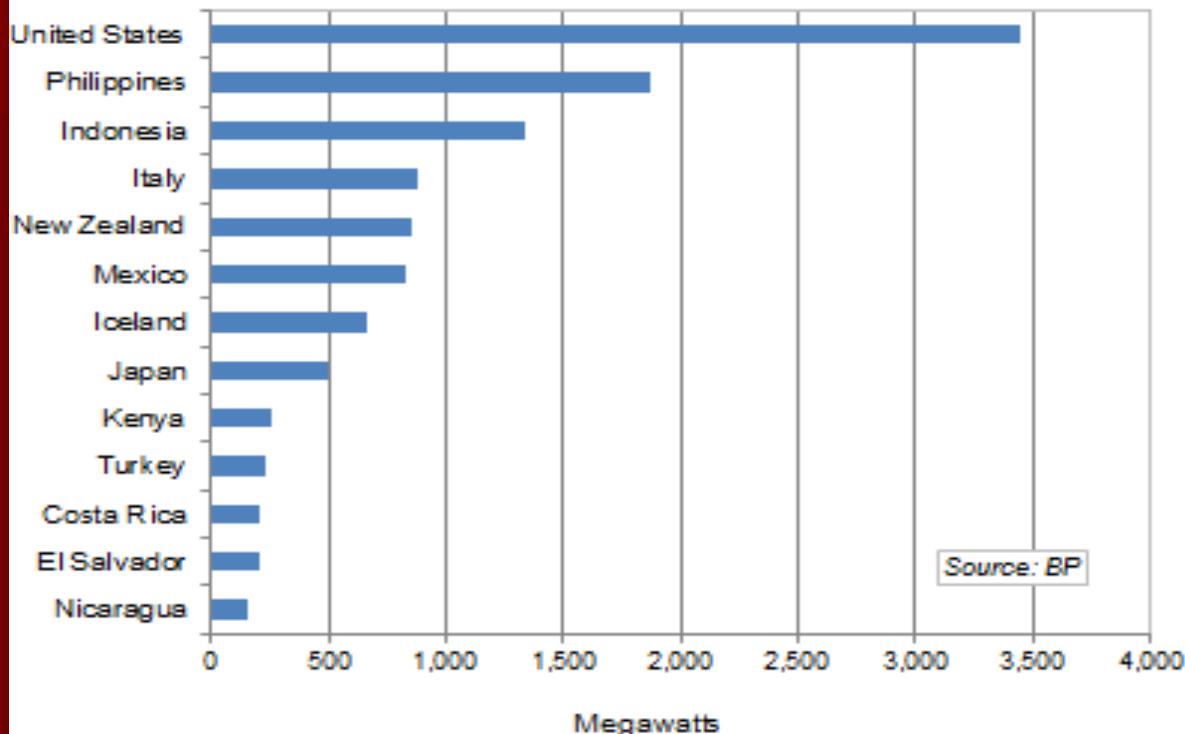


<http://cleantechica.com/2014/09/11/geothermal-power-experiencing-quiet-solid-growth/>



Geothermal Power Plants

Geothermal Electricity-Generating Capacity in Leading Countries, 2013



<http://cleantechica.com/2014/09/11/geothermal-power-experiencing-quiet-solid-growth/>

Table 18.1 GEOTHERMAL POWER PLANTS

Site	Installed Capacity (MWe)	
	1990	2003
United States	2775	2200
Philippines	890	1931
Mexico	700	953
Italy	545	790
Indonesia	145	807
Japan	215	561
New Zealand	283	421
Iceland	45	200
El Salvador	95	162
Costa Rica	0	161
Kenya	45	127

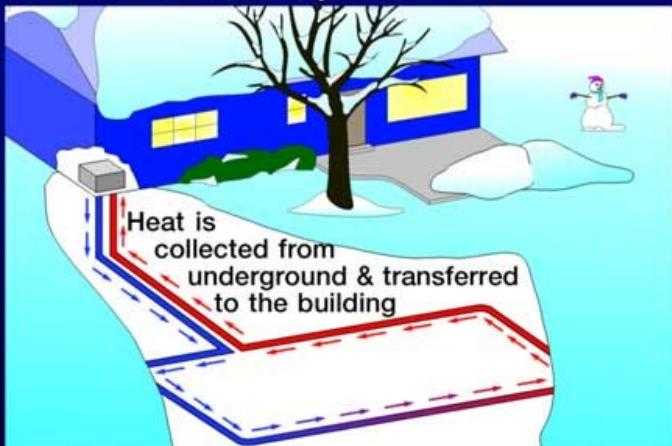
Source: International Geothermal Association.

Benefits of Geothermal Power

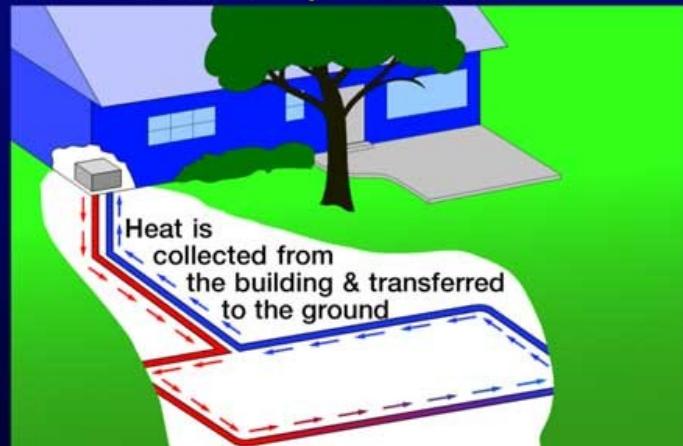
- Provides clean and safe energy using little land
- Is renewable and sustainable
- Generates continuous, reliable “baseload” power
- Conserves fossil fuels and contributes to diversity in energy sources
- Avoids importing and benefits local economies
- Offers modular, incremental development and village power to remote sites

Geothermal Energy For Home Heating

Heat Pump in Winter



Heat Pump in Summer



Benefits of Geothermal Heat Pumps

- Can be used almost everywhere worldwide
- Are energy- and cost-efficient
- Conserve fossil fuel resources
- Provide clean heating and cooling --
no emissions from burning fuels

Tidal Power

- Energy that comes from the gravitational attraction of the moon and sun on the earth's oceans



Gravitational Pull of Sun and Moon



Earth



Gravitational Pull of Sun



Earth

Gravitational Pull of Moon



First Quarter



Gravitational Pull of Sun and Moon



Full Moon



Gravitational Pull of Sun



Gravitational Pull of Moon



Third Quarter



New Moon

Spring Tide
New Moon

Neap Tide
First Quarter

Spring Tide
Full Moon

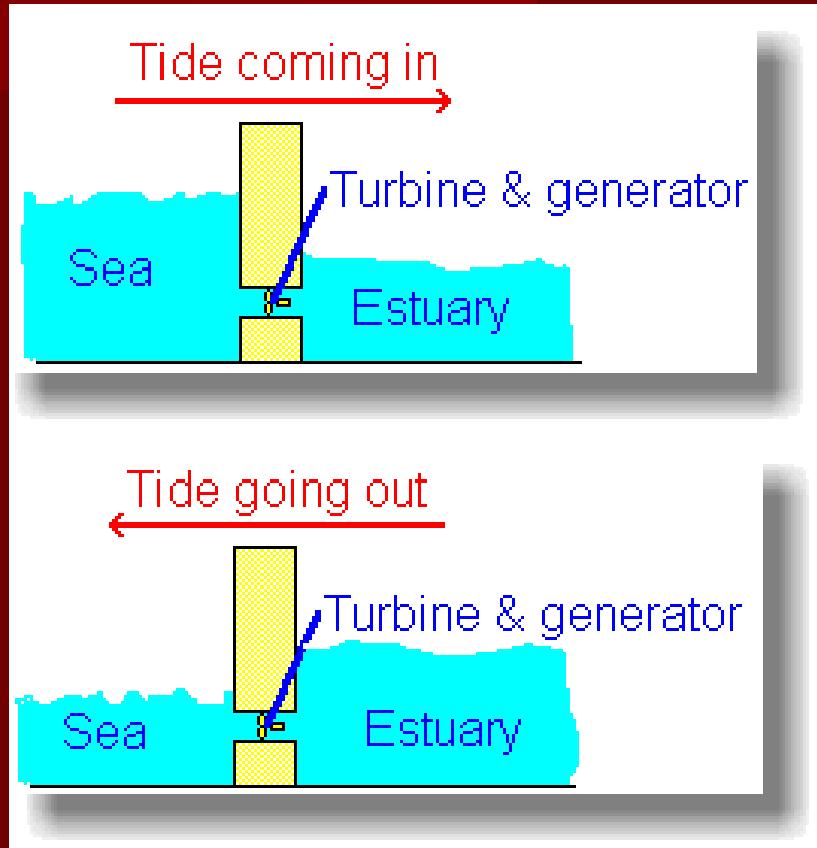
Neap Tide
Third Quarter

Two general approaches

- 1) Use a “two way” dam on a large estuary. Similar to low head hydroelectric.
- 2) Use turbines somewhat similar to windmills.



The largest tidal power station in the world is in the Rance estuary in northern France. It was built in 1966.

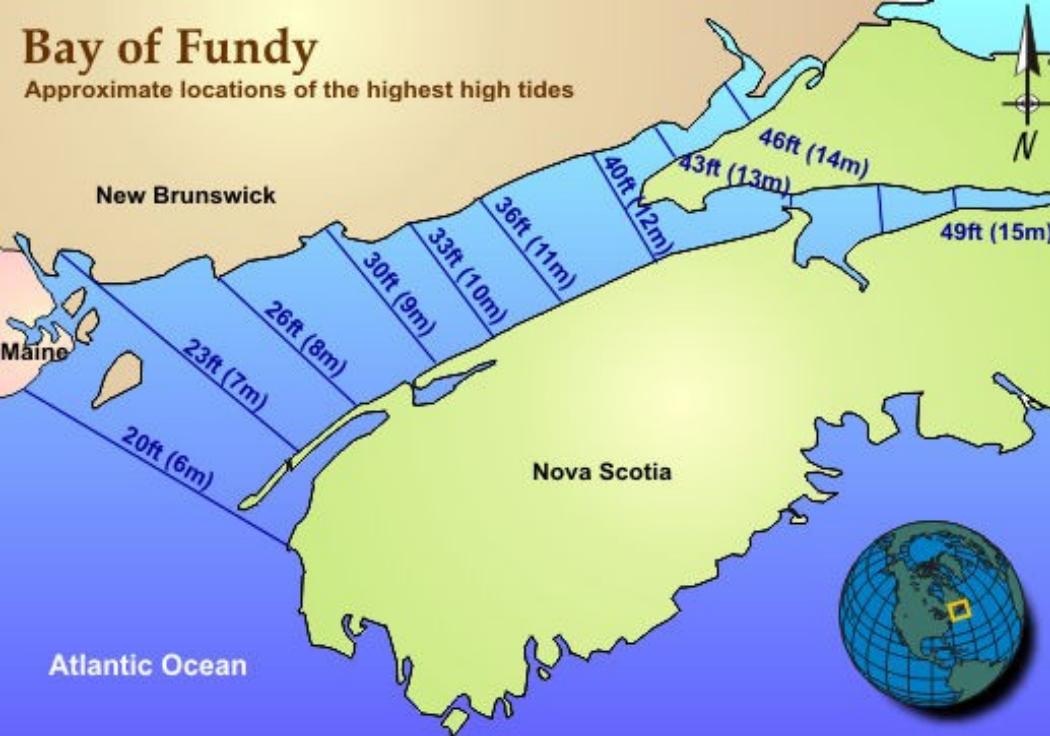


Man-made tidal lagoons

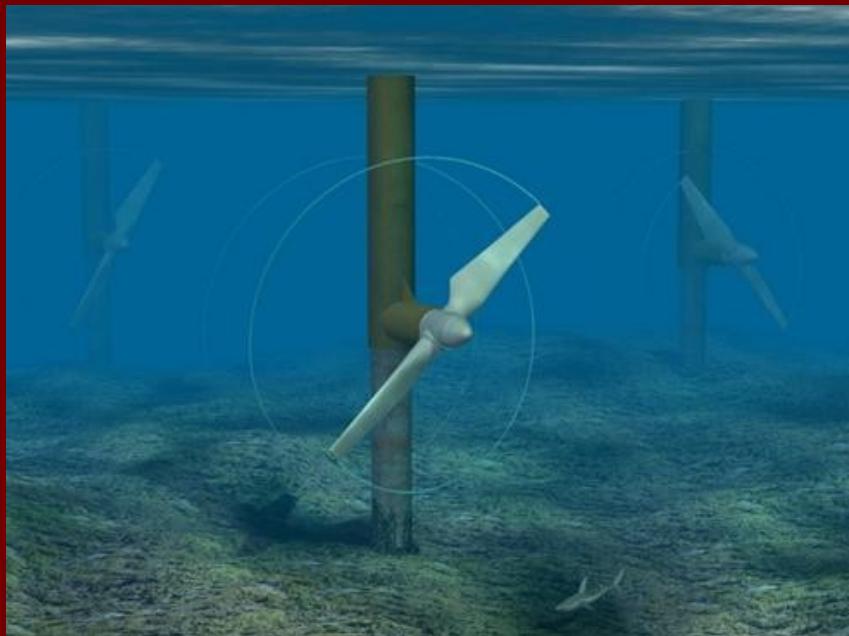


- A major drawback of tidal power stations is that they can only generate when the tide is flowing in or out - in other words, only for 10 hours each day. However, tides are totally predictable, so we can plan to have other power stations generating at those times when the tidal station is out of action.

World's largest tidal variations: Bay of Fundy



Watermills



© MCT Ltd 2003



Offshore Wave Energy 750 kW Pelamis machines

