Geothermal Energy: the solution, a contributor, a diversion, or part of the problem?

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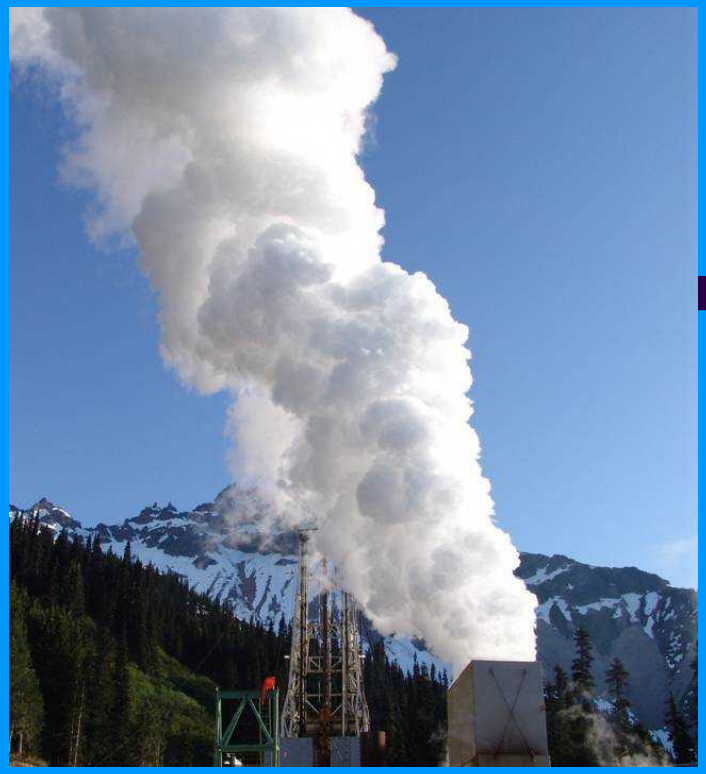


A.J. Mansure

Energy Surety Class 2005

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

"the solution, a contributor, a diversion, or part of the problem?," but what is "the problem"?

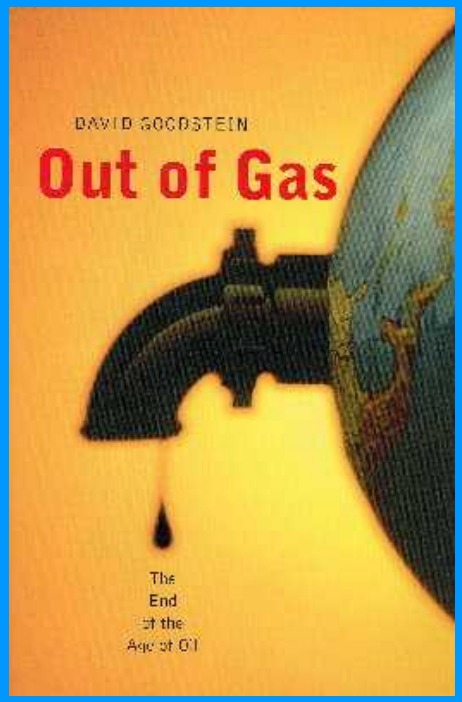
- Emissions (CO^2, acid rain, global warming, etc.)
- Energy Surety
  - Sustainability
  - Reasonable cost

} Sustainable costs or replacement costs

- The problem is we need new energy supplies now:
  - When the growth in oil demand exceeds the growth in non-OPEC production there will be problems – that may be now!

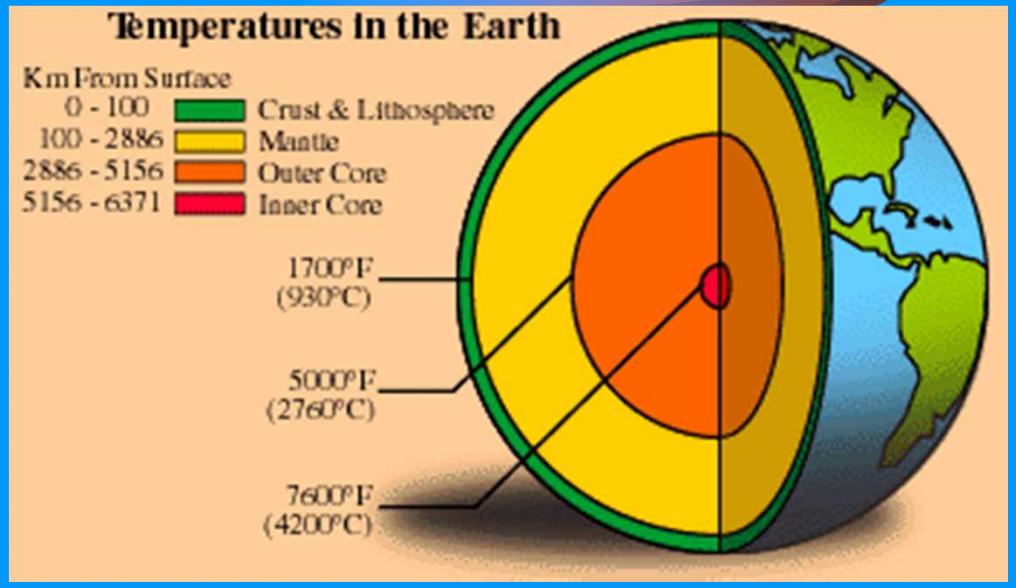
The question isn't what is technically feasible, it is what is economic or is it?

- But, what do we mean by economic?
- And what about ethics
  - Is consuming fossil fuels that should shared with our neighbors and grandkids ethical?"
  - Is burdening future generations with our emissions ethical?



Geothermal Basics

Geothermal energy uses the Earth's natural heat for some useful purpose. Because the center of the Earth is so hot, almost any location could provide energy if we drill deep enough.



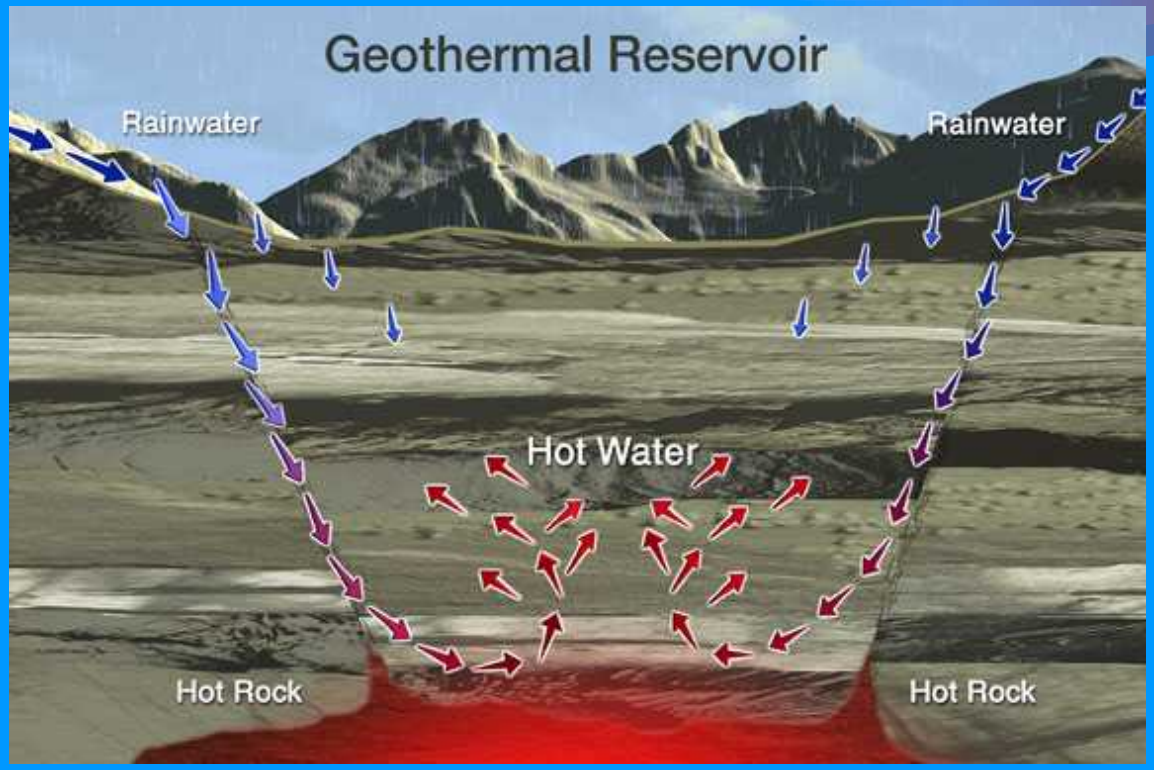
- The trick is having the right combination of heat, water, and permeability at reasonable depth

Vast Geothermal Potential

The energy content of domestic geothermal resources to a depth of 3 km is estimated to be 3 million quads, ***equivalent to a 30,000-year supply of energy for the United States***.

Source: Assessment of Geothermal Resources of the United States--- 1978, Muffler, L.J.P. (ed.), U.S. Geological Survey Circular 790, 1979.

How Geothermal Sites Are Created



Geothermal resources are found where geological activity has brought hot rock near the surface. When hot water and steam is trapped under a layer of impermeable rock, it forms a geothermal reservoir.

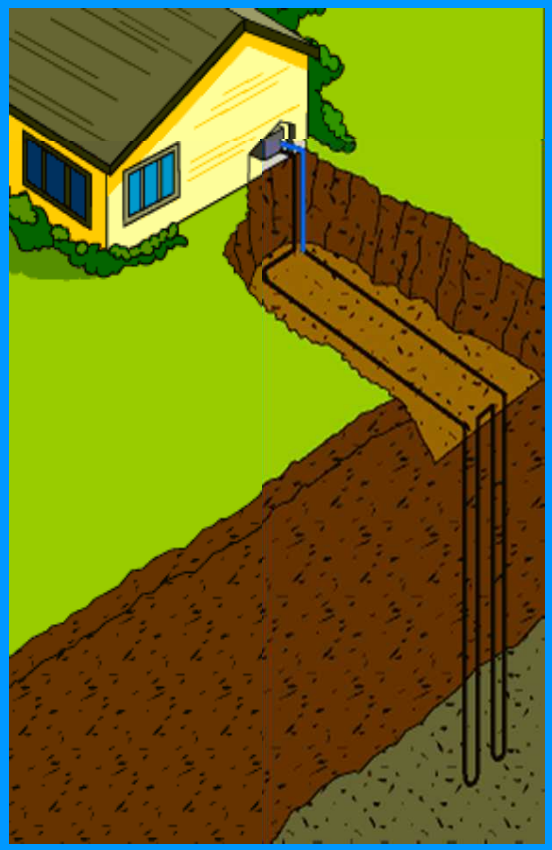
Direct Use Applications

Direct use displaces about 1.6M barrels of oil annually in the United States.

- District Heating
- Process Heat
- Agriculture
- Aquaculture
- Balneology (hot spring and water bathing)

Geo Heat Pumps

Heating Mode



7,500 thermal megawatts geothermal heat pumps, about 750,000 in use today. (Thermal megawatts do not equal electric megawatts.)

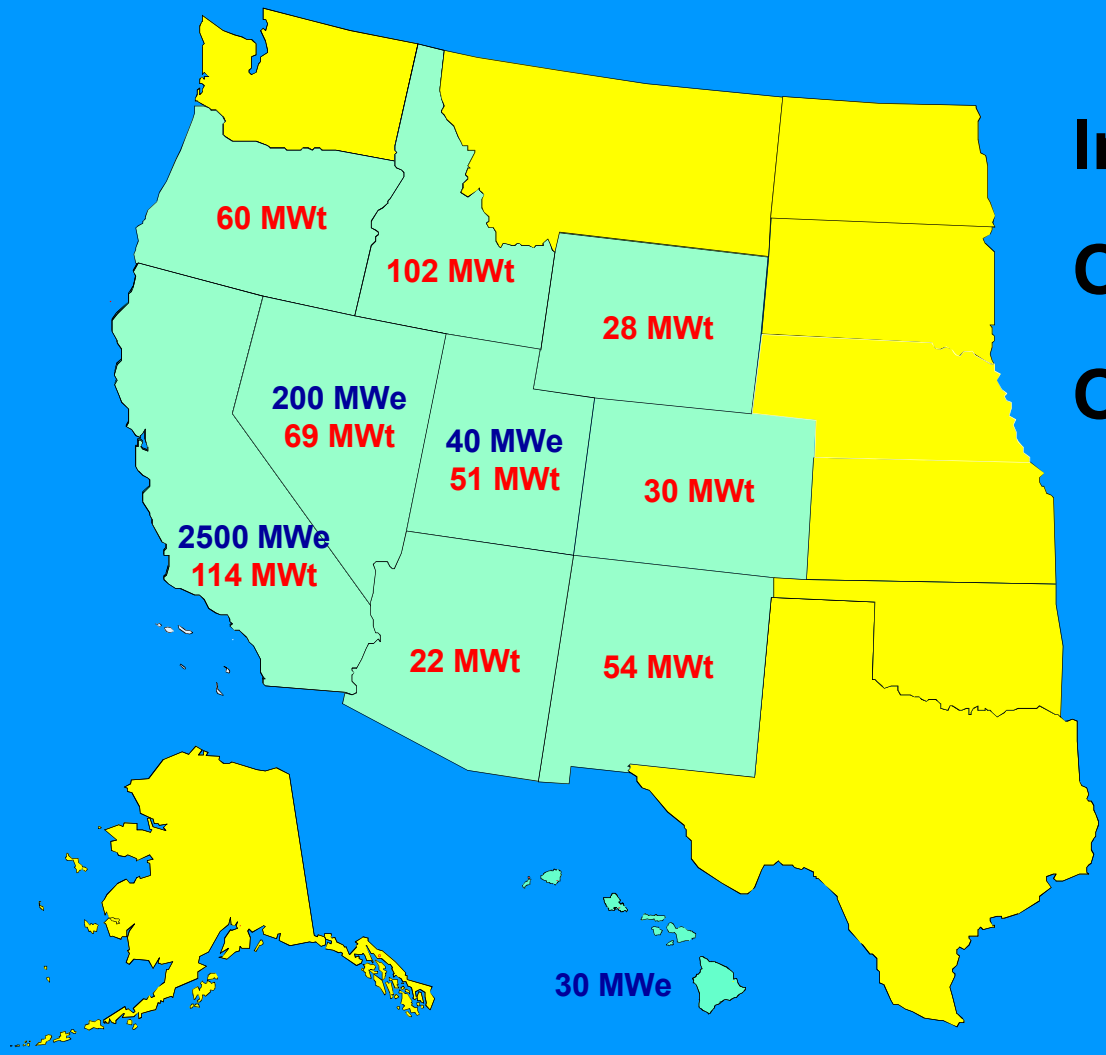
Geothermal heat pumps use the stable temperatures of the ground (often vertical boreholes typically are 100 to 400 feet deep) as a heat source to warm buildings in winter and as a heat sink to cool them in summer. Also called ground-source heat pumps or Geoexchange units.

Electrical Power Production

Geothermal power plants produce almost 5% of California's electricity (12.8 million MWh in 1999)

This hybrid binary/flash power plant provides about 25% of electricity demand on the Big Island of Hawaii

Heat and Power Production



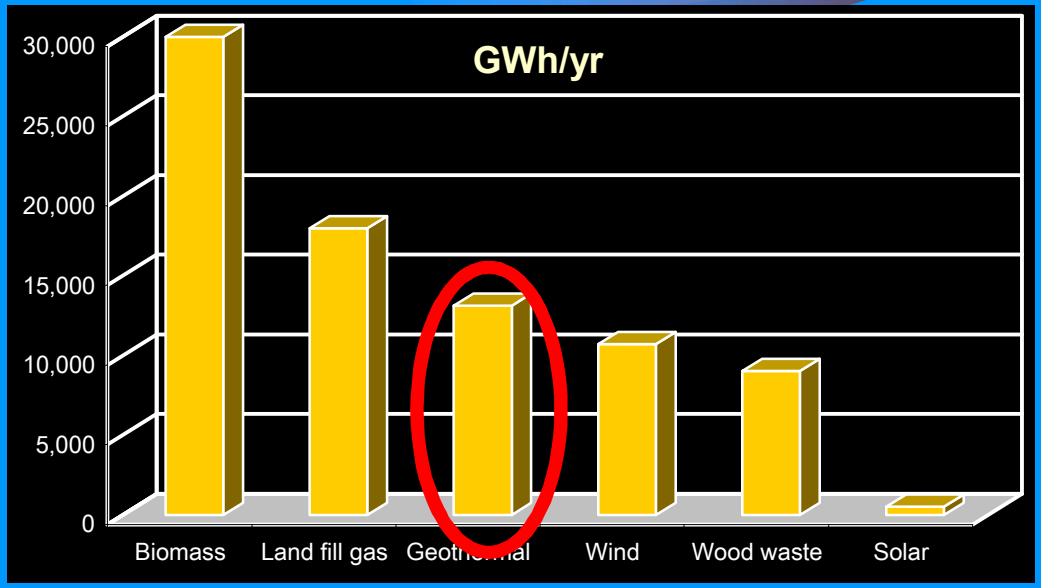
Installed:

Over 2800 MW (electric)

Over 500 MW (heat)

Hydrothermal Systems

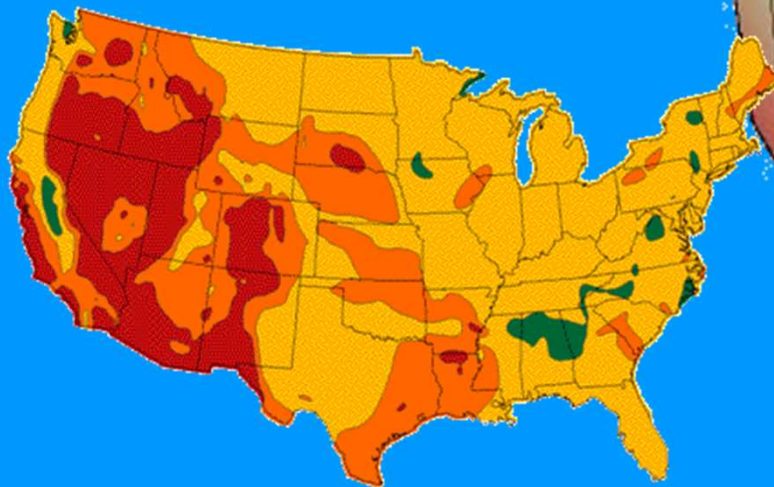
- Existing geothermal plants are hydrothermal systems that naturally provide the needed heat, water, and permeability …making geothermal one of the largest renewable energy sources in the market today…

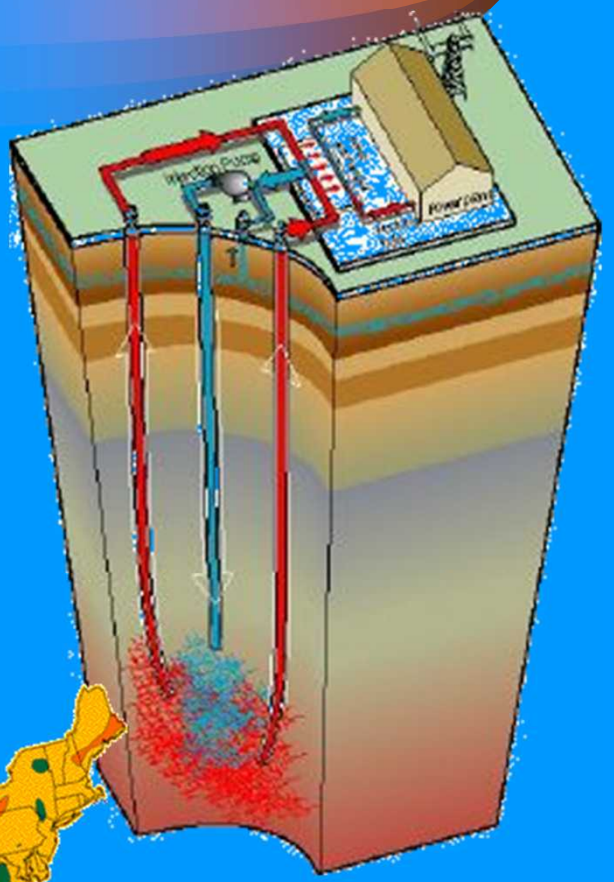


- However, the hydrothermal resource base is limited…

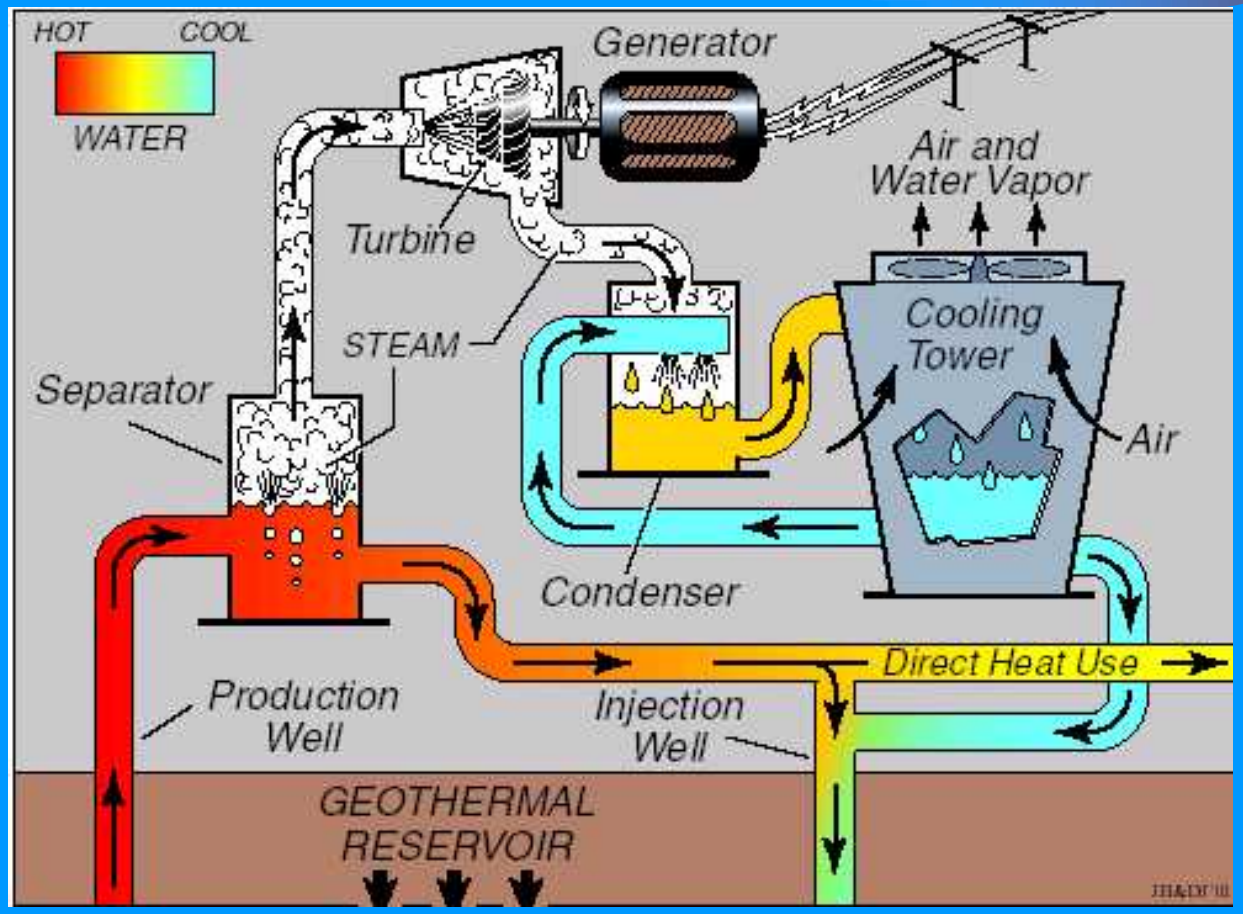
Engineered Geothermal Systems

- To dramatically expand the resource, Geothermal Systems must be Engineered
  - Engineering a geothermal systems involves
    - Deep drilling
    - Permeability enhancement (fracturing)
    - Water injection



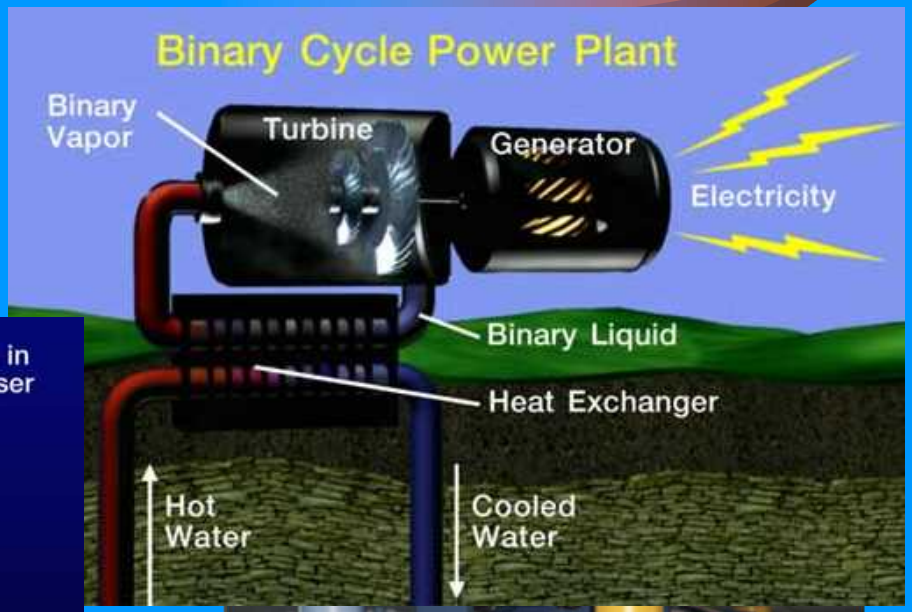


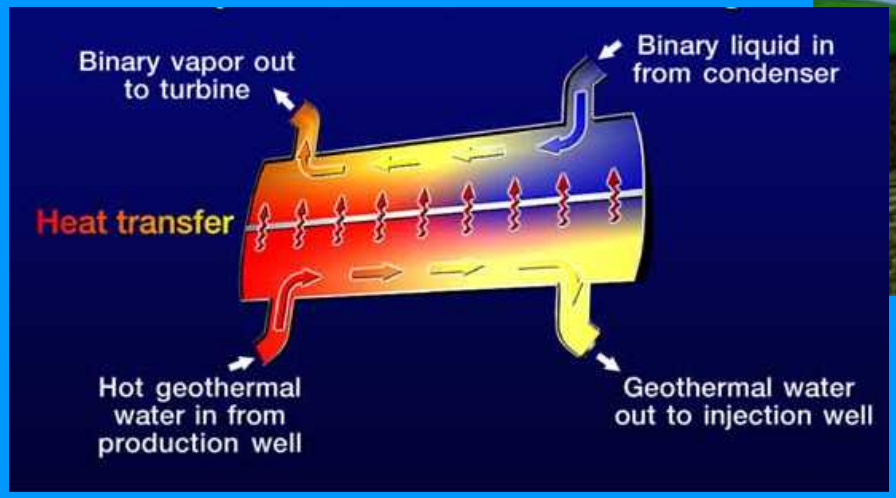
Geothermal Power Plant (flash)



Binary Cycle Geothermal Plant

In a binary cycle plant, hot water is run through a heat exchanger to vaporize a working fluid that powers the turbine generator. The geothermal water is injected back into the reservoir.





This plate-type heat exchanger passes geothermal water over metal plates for heat transfer to the working fluid on the other side.

Attributes of Geothermal Power

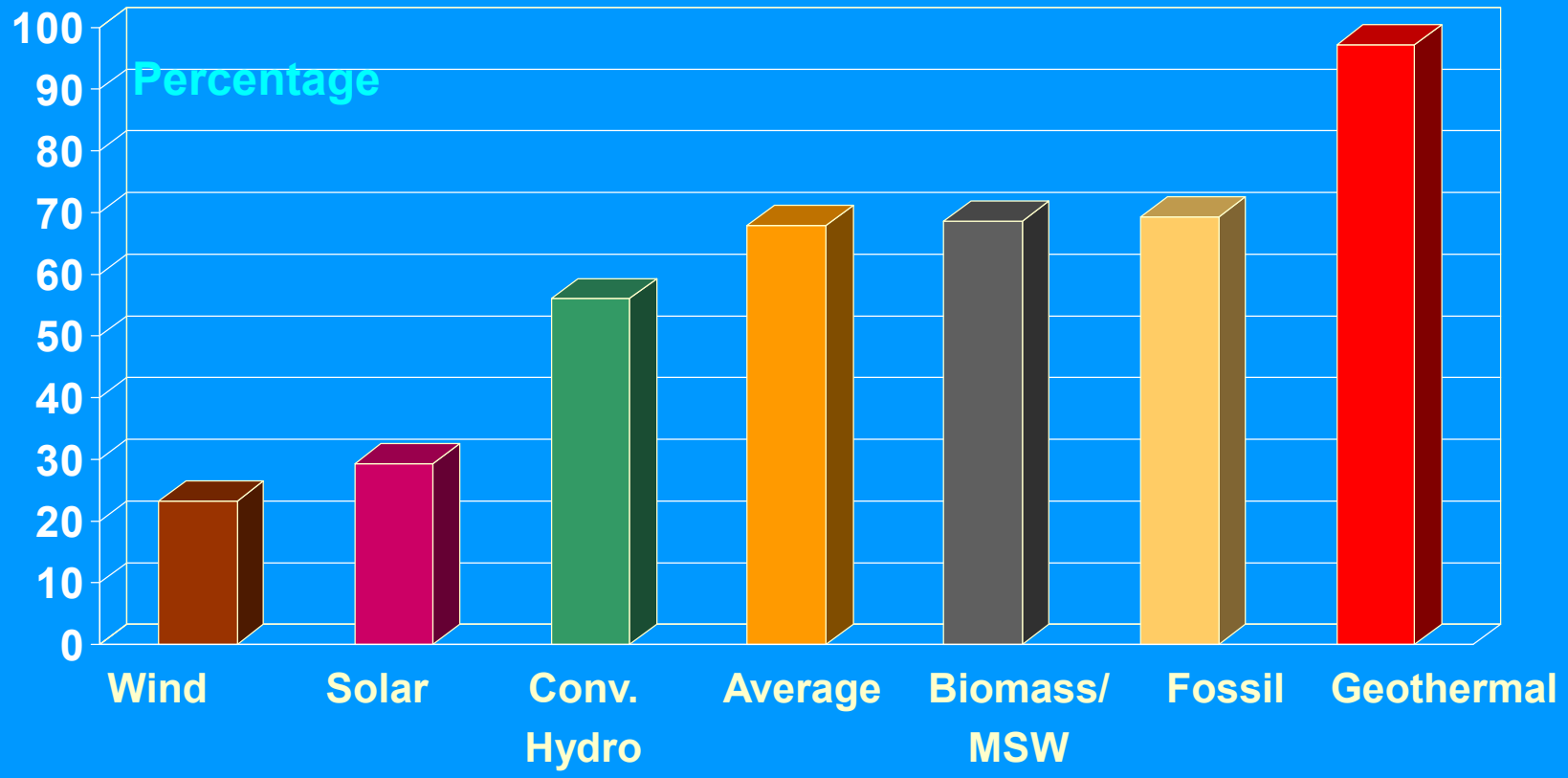
Advantages

- Enormous potential
- High, reliable plant capacity factor
- Greenhouse gas reduction
- Low environmental impact
- Much mature technology

Disadvantages

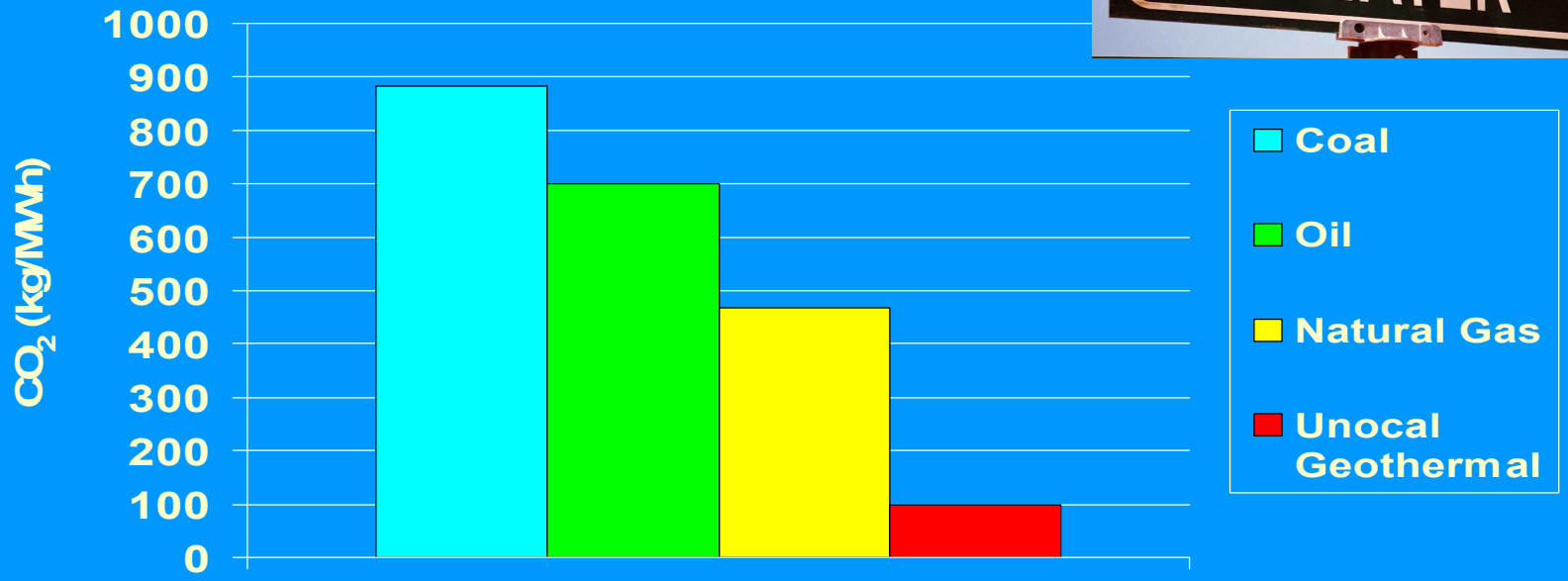
- Expensive drilling
- Regional resource
- Resource uncharacterized
- Threshold plant size
- Plant prefers constant load
- Environmental perception

Capacity Factors



Source: DOE/Energy Information Agency: data for 1996

Power Plant CO^2 Emissions



Fossil fuel data from Goddard and Goddard (1990)
Unocal data includes The Geysers

Major Institutional Issues

- Utility market (no long-term PPAs)
- Deregulation and Renewable Portfolio Standards
- Financial institutions see exploration and drilling as risky; high up-front costs
- Fossil fuels are currently expensive, but higher oil prices drive up geothermal drilling cost because of drilling-service market.
- Public ignorance of geothermal
- Environmental protests

Challenges to Geothermal Development

- Competition with fossil fuels
- Financing
- Long project lead times
- Siting and Permitting
- Obvious sites already taken
- Industry focus overseas
- Large projects at high costs
- Exploration cost and risk

Sandia Focus

Sandia works to reduce the cost of drilling and completing geothermal wells. This is critical for increasing power on-line, because the well field (production and injection) can represent up to 50% of a power project's capital cost.

Geothermal drilling is expensive, compared to oil and gas drilling, because the rocks are hot, hard, abrasive, and fractured, and often contain corrosive fluid. The number of geothermal wells drilled each year is small, so there is little incentive for industry to develop geothermal drilling technology.

Sandia expertise

- Improved drill bits – faster penetration, longer life
- Downhole measurements – monitor drilling process, evaluate reservoir
- Rig instrumentation – identify operating problems
- Lost circulation analysis and treatment – mitigate LC by catching it early
- Slimhole drilling – cheaper exploration with smaller-diameter wells
- Systems analysis – make sure we're solving the right problems
- Field operations – try out new technology in real drilling situations
- Program management – integrate the research program
- Work with industry – partnerships, contracts, and cooperative agreements with 50+ companies

Why is geothermal drilling so expensive?

- Hard, hot, fractured rocks – bits and tools have shorter lives
- Formation fluids are often corrosive
- Need high-temperature tools and electronics – different from oil & gas drilling
- Lost circulation – drilling fluid lost into the fractures in the rock; expensive to fix
- Small geothermal market – little incentive for equipment manufacturers to build drilling tools exclusively for geothermal
- Nearly every well is different

But how do we make it cheaper?

Improve performance, reduce trouble

- Better performance includes bits with higher penetration rate and longer life, or longer-lived and more robust downhole electronics.
- Reducing trouble focuses on minimizing or eliminating “flat time”, which is all the time that the hole isn’t advancing. Flat time for many geothermal wells is 65-80% of total time the rig is over the hole.

*Geothermal Power in 24 Countries**

- ***Meets the Needs of 60 Million People***
- **25% in the Philippines, Iceland, and El Salvador.**
- **30% in Tibet.**

This small binary power plant is in Fang, Thailand.

*** Australia, China, Costa Rica, El Salvador, Ethiopia, France, Guatemala, Iceland, Indonesia, Italy, Japan, Kenya, Mexico, New Zealand, Nicaragua, Philippines, Portugal, Russia, Taiwan, Thailand, Tibet, Turkey, United States, and Zambia**

Geothermal score card

- Low land usage
- Minimal water usage
- Minimal emissions
- Minimal green house gases emissions
- Minimal waste
- Easy reclamation
- Risks & impacts understood
- Low resource demand
- High availability **24-7-365**
- Good option for developing countries
- High Surety
  (reliability, security, safety, & sustainability)
- Other considerations
  - Time to implement
  - Energy return on energy investment

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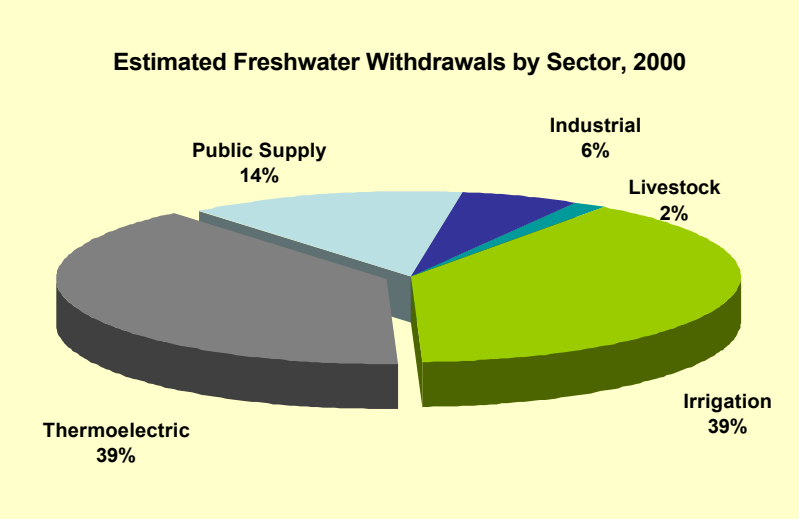

- Half the world's population will face severe water shortage within 50 years
- Water used to produce electricity, roughly equals that consumed by domestic use.

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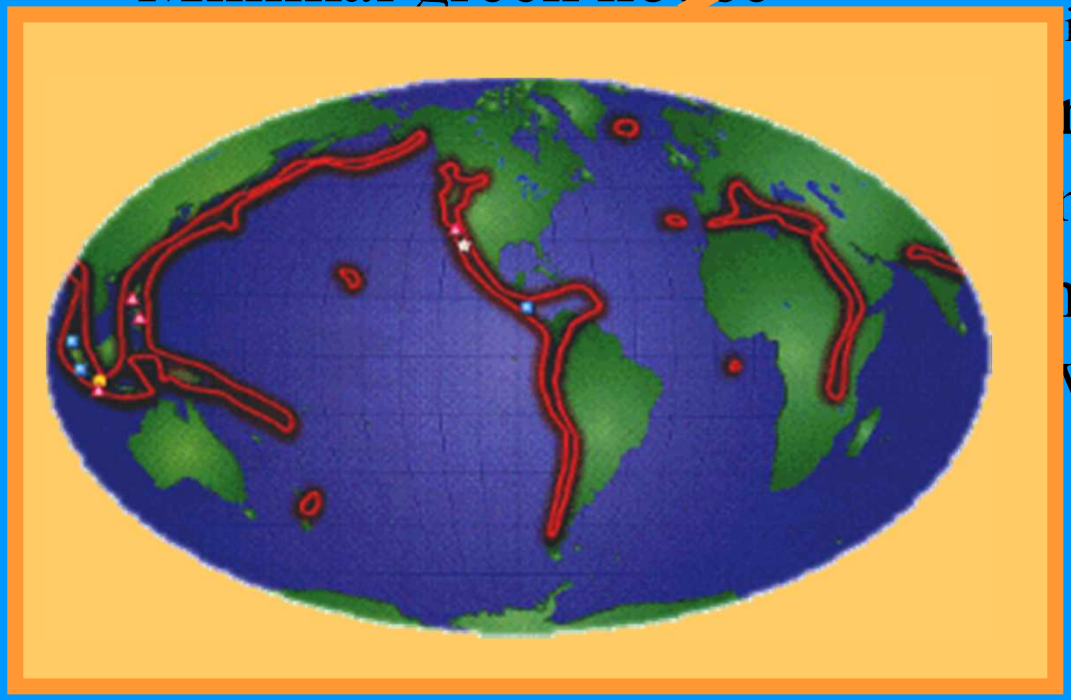

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- You've heard oil production won't peak until ~2030
- But before that, demand will exceed supply
- And before that demand growth will exceed non-OPEC growth
  - That is probably upon us now

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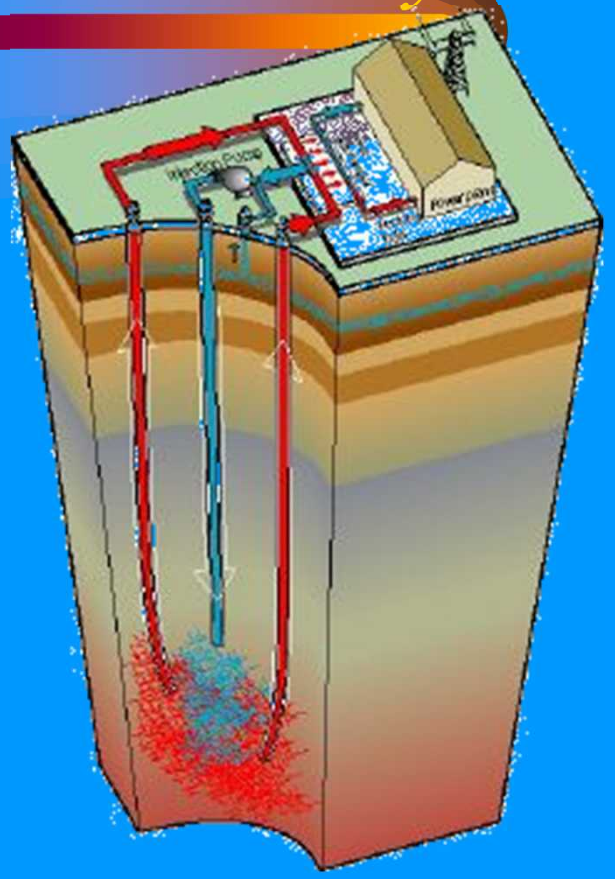
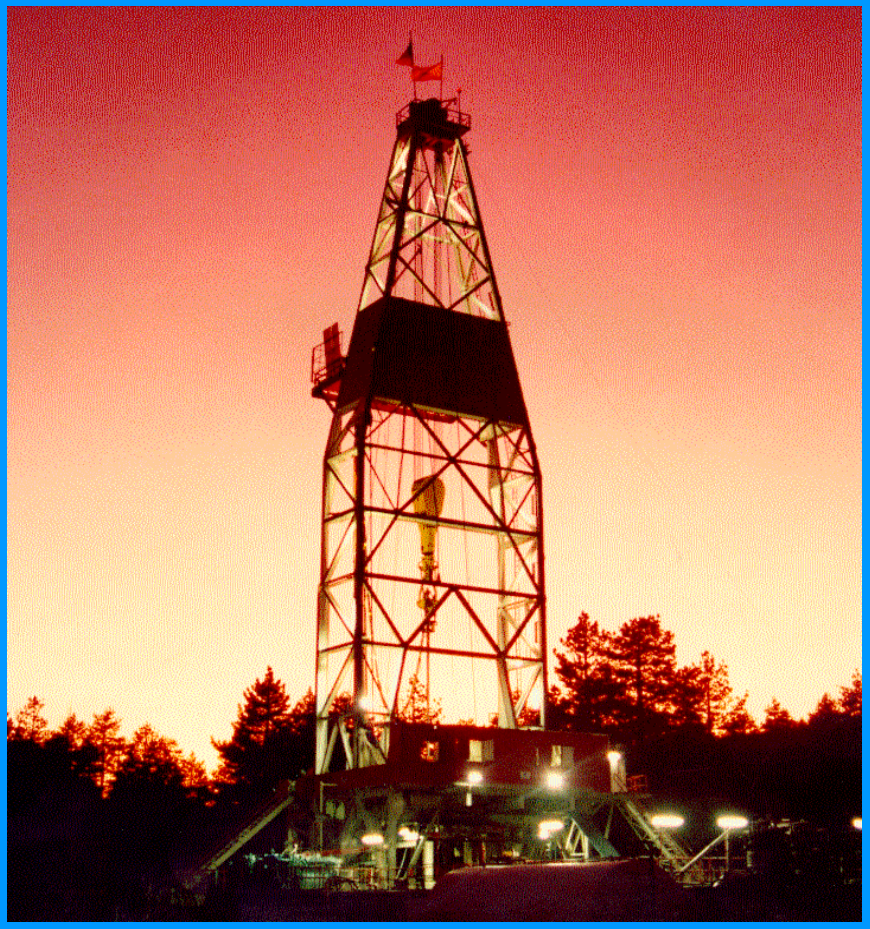
- Ethanol 1.3 gal per gal
- EGS should be > 300 kW-hr per kW-hr

Engineered Geothermal Systems: from concept to reality



- Increase flow through reservoir without premature cool water break through
- Reduce water leakage
- Reduce drilling costs
- Demonstrate the technology

Geothermal Energy: the solution, a contributor, a diversion, or part of the problem?



So what is the answer?

Geothermal Energy: the solution, a contributor, a diversion, or part of the problem?

To be “the” solution geothermal would have to grow over 15% per year. Unlikely, given current budgets and what must be done to demonstrate economic Engineered Geothermal Systems.

Geothermal Energy: the solution, a contributor, a diversion, or part of the problem?

We are already that.

Geothermal Energy: the solution, a contributor, a diversion, or part of the problem?

There aren't false expectations that geothermal is the whole solution.

Geothermal Energy: the solution, a contributor, a diversion, or part of the problem?

Geothermal has a proven to be environmental and developing country friendly.

So what is wrong?

- We don't want to pay replacement costs for energy.
- Too often we make uninformed energy decisions based on emotion: "Will supporting this position make me feel good?"
- The history of geothermal energy shows that emotion does not lead to wise energy choices.
- Ignorance doesn't solve the problem; it is no excuse.
- We are called to debate for informed, rational ethical energy decisions.

Geothermal Energy: the solution, a contributor, a diversion, or part of the problem?

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