The Big Three
Sources of "Free" Fuel

William H. Calvin is a professor at the University of Washington in Seattle and the author of 14 books for general readers, including *Global Fever: How to Treat Climate Change* (University of Chicago Press, 2008).

Wind. Solar. Biofuels. Those three are not our only choices for avoiding fossil fuels, just the ones with name familiarity.

The Big Three are less familiar, regularly left off of the lists. They are not pie-in-the-sky but well-researched choices lacking a lobby to speak for them.

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1. Recharging with the nightly excess

About one-fourth of U.S. electricity goes to light bulbs, most of which are energy hogs, producing more heat than light.

Retrofitting incandescent lamps with the new white LED bulbs saves 85% (they're twice as efficient as compact fluorescent lamps and last far longer, with no mercury hazard).

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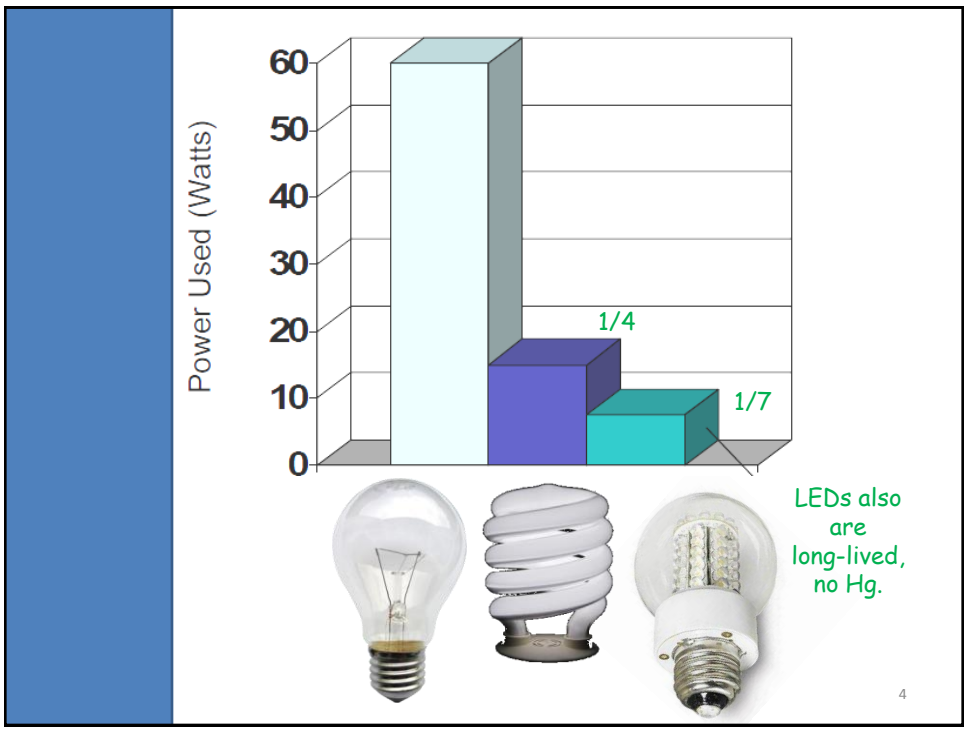

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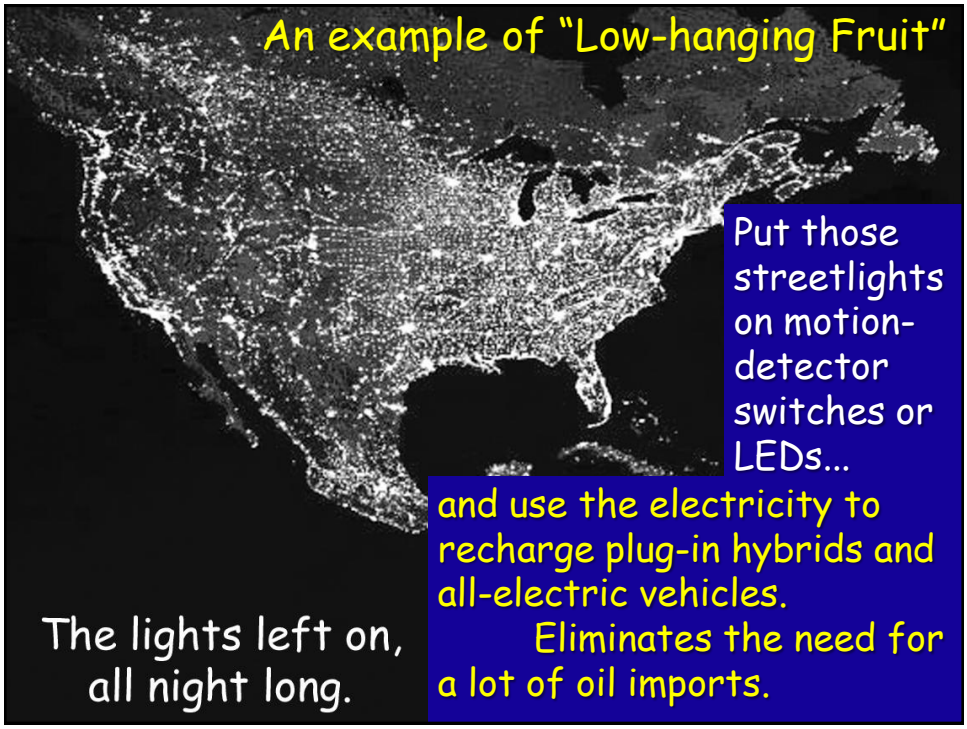

Initially, most of the LED action is in retrofitting street lamps. Until now, there has been little incentive to reduce overnight waste of electricity.

That's because coal- and nuclear-powered plants often produce excess electricity at night and sell it cheaply.

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But with the coming of plug-in hybrid and all-electric cars, we can use the excess for overnight recharging instead—provided, of course, that we vastly reduce the consumption by street lights.

This **combination** will immediately reduce oil imports and CO_2 emissions.

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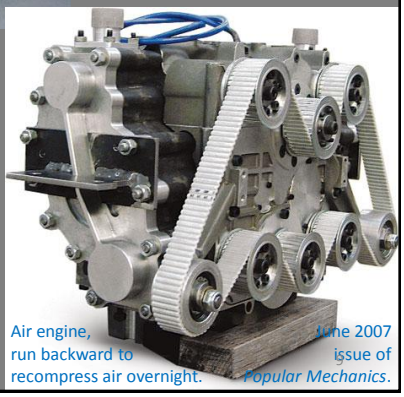
Transportation goes electric

Plug-in hybrid (Prius with extra batteries, recharged overnight in garage)

Air car

(with free air cooling)

India's largest automaker is set to start producing the world's first commercial air-powered vehicle. "Some 6,000 zero-emissions Air Cars are scheduled to hit Indian streets in August of 2008. This six-seat taxi is powered entirely by a tank filled with compressed air."



Air engine, run backward to recompress air overnight. June 2007 issue of *Popular Mechanics*.

With enough electric cars, we will eventually use all of the overnight electricity freed up—but for awhile, this new transportation "fuel" is almost free. It's as clean as the power plant that generates the electricity (even if it is a big coal plant, that's better than all of those idling gasoline engines).

In Switzerland, 99 percent of the electricity comes from hydro and nuclear; 91 percent is clean in France, 32 percent in the U.S.; and in fast-growing China and India, only about 15 percent. (Island nations are even worse, mostly burning imported oil to generate electricity.)

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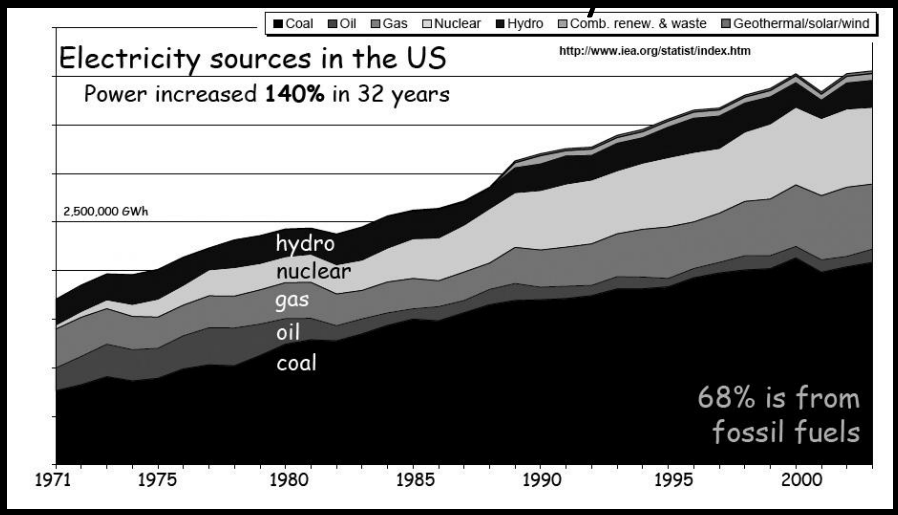
Coal Oil Gas Nuclear Hydro Comb. renew. & waste Geothermal/solar/wind
Electricity sources in the US
http://www.iea.org/statist/index.htm
Power increased 140% in 32 years
2,500,000 GWh
hydro
nuclear
gas
oil
coal
68% is from fossil fuels
1971
1975
1980
1985
1990
1995
2000

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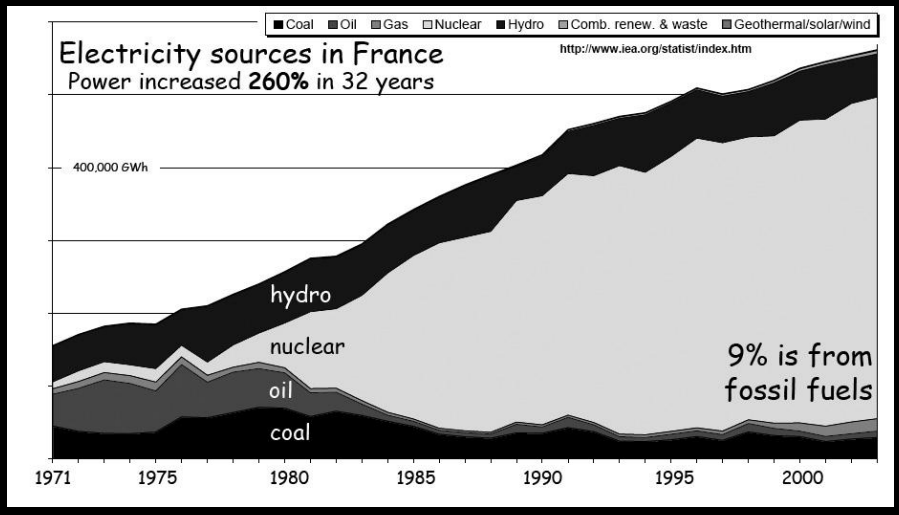
Coal Oil Gas Nuclear Hydro Comb. renew. & waste Geothermal/solar/wind
Electricity sources in France
http://www.iea.org/statist/index.htm
Power increased 260% in 32 years
400,000 GWh
hydro
nuclear
oil
coal
9% is from fossil fuels
1971
1975
1980
1985
1990
1995
2000

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1. Using the heat beneath your feet.

You may think that you know what geothermal energy is all about, but read on. (It's the third type that's so big.)

Besides being huge and having no CO_2 emissions to aggravate the climate, Hot Rock electricity has a very small footprint. No reservoirs, no mines, no smoke, no trucks, and no inherent safety issues or security risks.

Sulfurous fog

A. Near-surface geothermal (all existing)

Chances are that you think that it involves hot springs and sulfurous odors—and indeed it does for most present-day geothermal power plants in Iceland and California. They use near-surface heat to run an old-fashioned steam power plant.

Building more hot-springs plants is an obvious source of new clean energy—but hot springs are a limited resource, easily saturated.

Global Geothermal Capacity & Potential[1]

In Installed Capacity in MW (IGA, Glitnir Research)

Traditional Geothermal	Installed Capacity (MWe 2005)	Potential (MWe)
North America	3,517.	30,000
Asia	3,290.	42,000
Europe	1,124	15,800
Oceania	441	9,000
Central & South America, Carribean	424	38,000
Africa	136	14,000
World Total	**8,933.**	**148,800**

Or perhaps you think that geothermal has something to do with "heat pumps," which are essentially like buried lawn sprinkler pipes—except they are buried a few feet below the surface and don't leak water.

The soil temperature down there stays at about 55°F, which is why cellars are dug to keep stored food cool in the summer while protecting it from freezing in the winter.

Water circulating through a network of buried pipe can be used to cool circulating air in the summer, as well as preheat outside air to 55°F in winter before the furnace further warms it up to room temperature.

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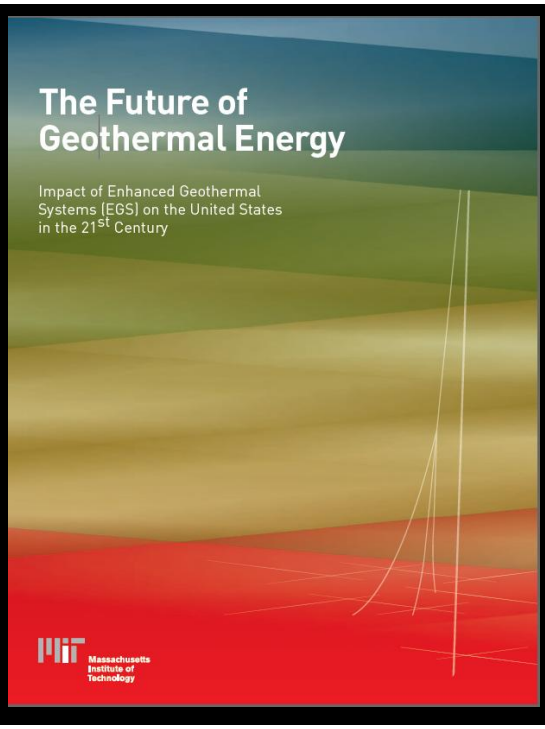
Again, worth expanding—but not the really big opportunity which a panel of experts assembled by MIT said it could expand the U.S. energy supply several thousand times.

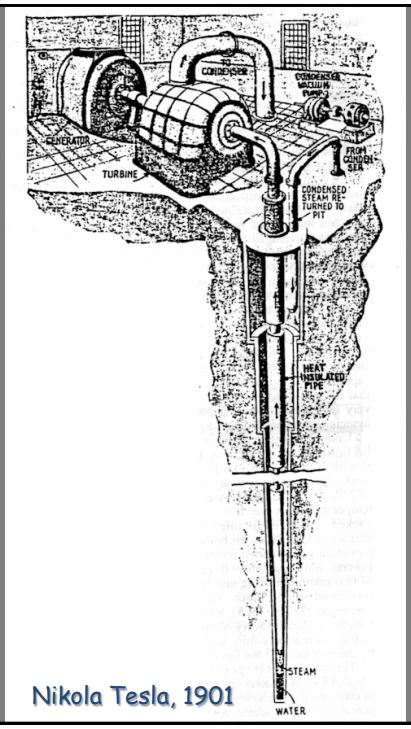
Just google:
"MIT geothermal report"



DEEP GEOTHERMAL

It is variously called deep heat, heat mining, hot rock energy, or enhanced geothermal systems.

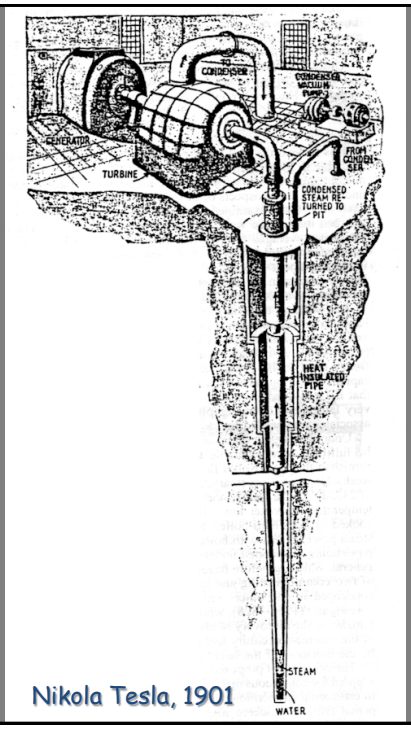
Hot Rock Geothermal



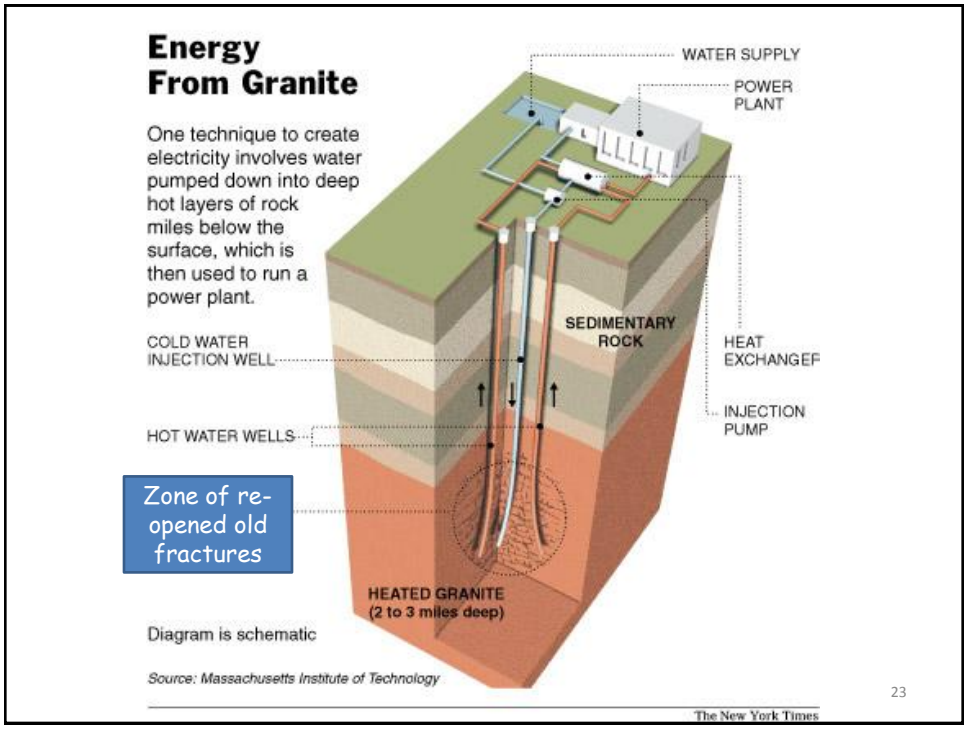
Nikola Tesla, 1901

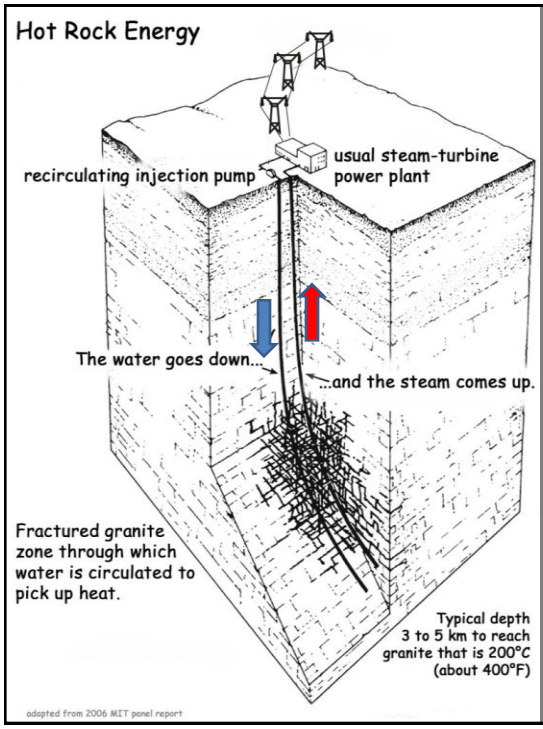
400°F pizza oven

Hot Rock Geothermal

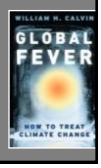


Nikola Tesla, 1901

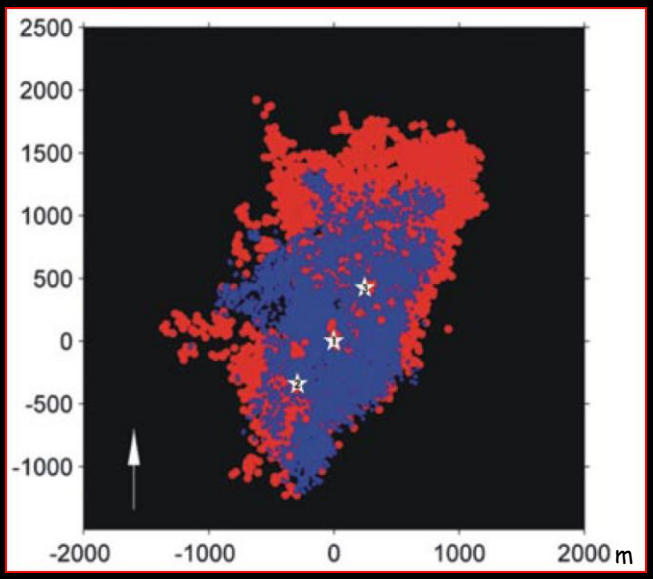




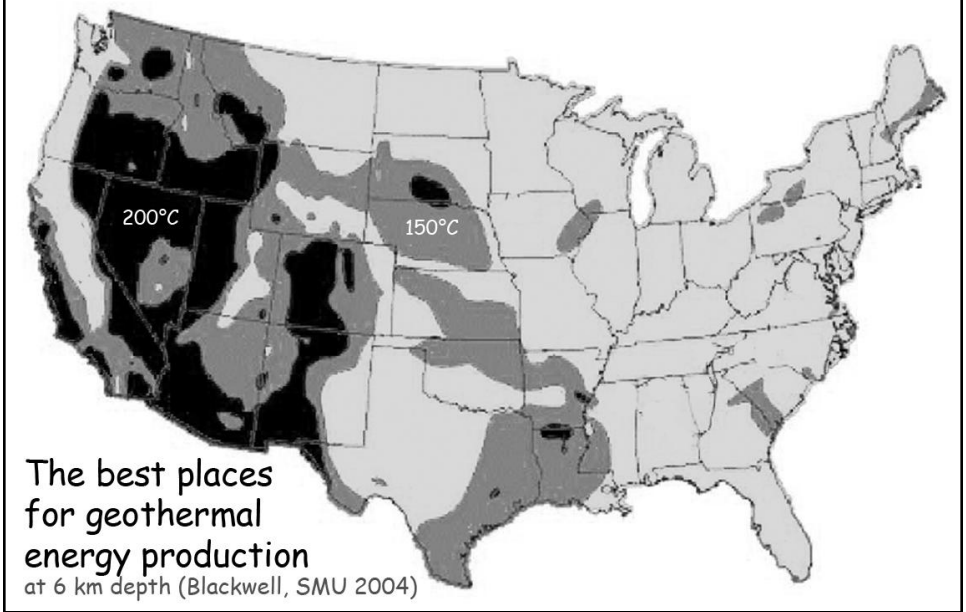
- Deep geothermal ("heat mining") pumps down water, gets steam back up to run steam turbine.
- No pollution, small footprint, steady output.
- Also suitable for developing countries.



Australian geothermal three-well fracture zone is 2x3 km across.

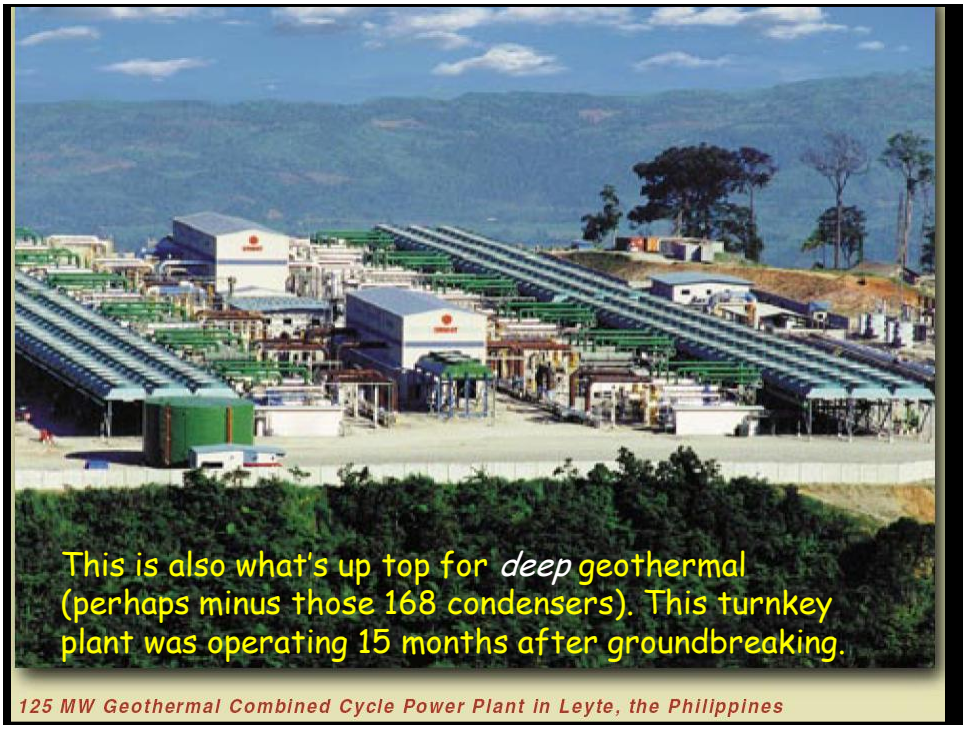


http://www.geodynamics.com.au/irm/Company/ShowPage.aspx?CPID=1638



The best places for geothermal energy production

at 6 km depth (Blackwell, SMU 2004)



125 MW Geothermal Combined Cycle Power Plant in Leyte, the Philippines

Suburb of Basel CH

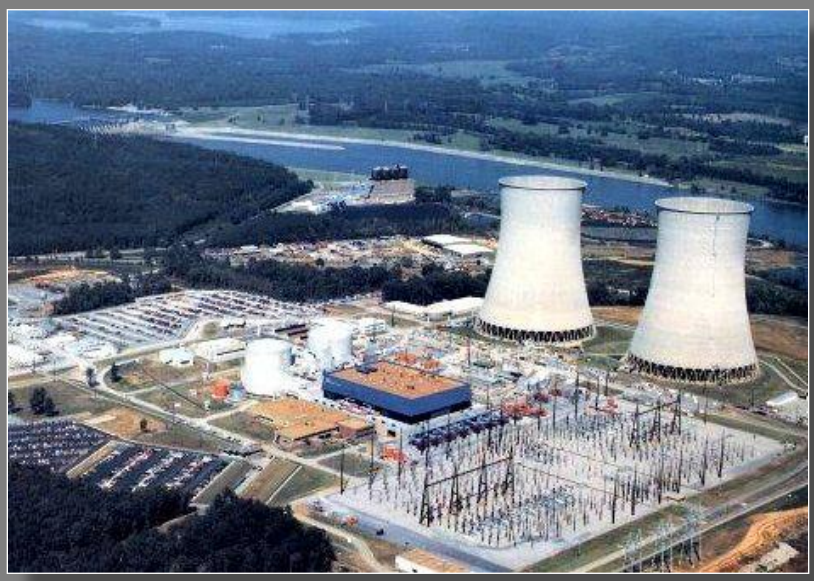
2006

Power plus heating for 29,000 apartments.

In 1972 researchers at the Los Alamos National Labs laid out the modern approach.

But due to lack of R&D support in the U.S., the action in hot rocks has now moved to France, Germany, Switzerland, Japan, and Australia. France is already producing deep geothermal energy on a commercial scale, and Australia has several projects that will be ready in 2010.

Watts Bar nuclear power plant



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2nd generation nuclear

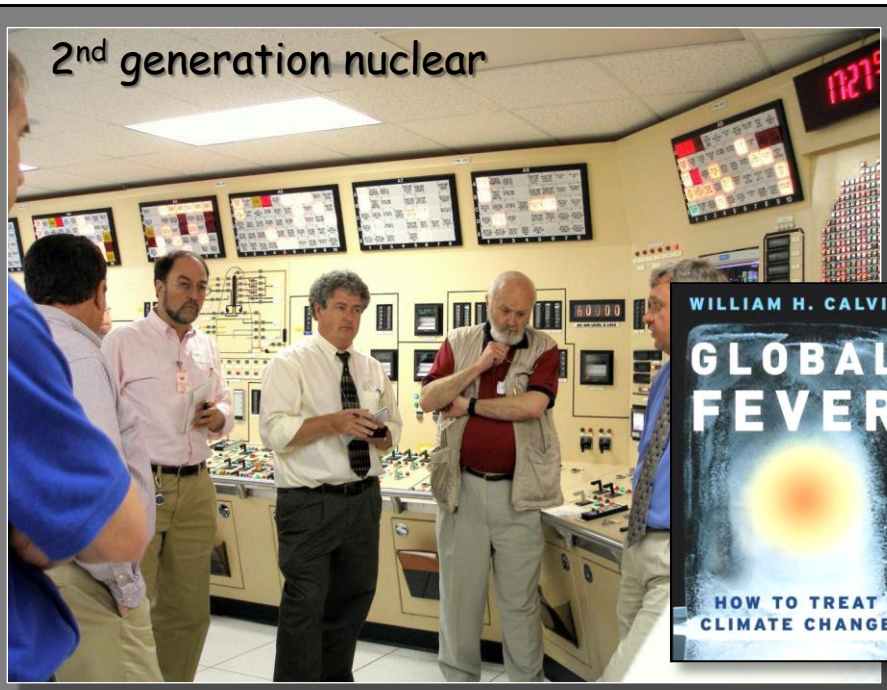

photo: US Nuclear Regulatory Commission staff

On one of my trips [Jim Hansen writes] I read a draft of "Prescription for the Planet" by Tom Blees, which I highly recommend....

Blees makes a powerful case for 4th generation nuclear power, the Integral Fast Reactor (IFR). IFR reactors (a.k.a. fast or breeder reactors) eliminate moderating materials used in thermal reactors, allowing the neutrons to move faster. More energetic splitting of nuclei releases more neutrons. Instead of using up less than 1% of the fissionable material in the ore, a fast reactor burns practically all of the uranium.

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a) The fuel is recycled on-site, incorporating radioactive elements into new fuel rods.

The eventual 'ashes' are not usable as fuel or weapons. The radioactive half-life of the ashes is short, their radioactivity becoming less than that of naturally occurring ore within a few hundred years.

The volume of this waste is relatively small and can be stored easily either on-site or off-site.

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b) The IFR can burn the nuclear 'waste' of current thermal reactors. So we have a supply of fuel that is better than free – we have been struggling with what to do with that 'waste' for years.

We have enough fuel for IFR reactors to last several centuries without further uranium mining. So the argument that nuclear power uses a lot of fossil fuels during uranium mining becomes moot.

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The U.S. domestic stockpile of leftover uranium can produce 10X as much energy as the remaining oil of Saudi Arabia.

And it is free fuel, already mined and paid for.

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c) IFR design can be practically failsafe, relying on physical properties of reactor components to shut down in even the most adverse situations, thus avoiding coolant problems of Chernobyl and Three Mile Island, as well as the earthquake problem.

The terrorist threat can be minimized building the reactor below grade and covering it with reinforced concrete and earth. ("Prescription for the Planet" by Tom Blees, in publication 2008)

Photograph by Jonas Bendiksen

The 650-foot-high Kárahnjúkar Dam blocked the Jökulsá á Dal River in 2006, flooding 22 square miles to generate electricity for a r Alcoa aluminum smelter in the east, where jobs are scarce. The project has polarized Icelanders and raised their environmental consciousness.

1,000 new dams each year

Ranking the Major C-free Candidates
for turning around emissions growth by 2020

		Ability to expand	Public view	Down side	Ups & downs	Foot print	Storage needed	Enough by 2020?
ENERGY	**Hot Rock Energy**	**huge**	Just another well?	Year of small EQs?	**very stable**	**very small**	**none**	•••• to ••
	Nuclear	10X	caution	many	steady	mining	spent fuel	••• to •
	Solar	lots	OK	**few**	night, clouds	multi use	some	••
	Wind	lots	ugly	noise, bird kills	fickle & unstable grid	multi use	some	••
	Biofuels	compete with food	organic fuel	not C-neutral	drought	huge	some	•
	High-rise Hydro	nearly full	nice lakes	dam failure	drought	large	lakes	no
	Coal but capture the CO_2	large	caution	storage burp	steady	67% more coal	huge	no

The Great Use-it-or-lose-it Intelligence Test

The public interest requires doing today those things that men of intelligence and goodwill would wish, five or ten years hence, had been done.

– Edmund Burke

The End

My books and talks may be found at:

WilliamCalvin.com