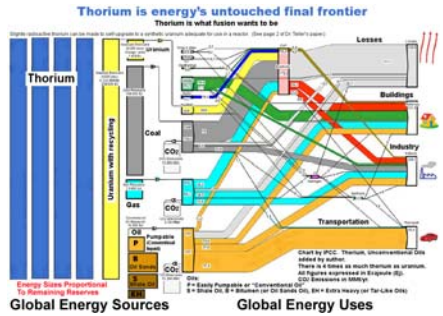
Using Chinese nuclear technology to end the era of Global Warming.

A suggestion by James P. Holm, P.E.

- **Global Energy, China's New Nuclear.**



- **Ending The Era Of Global Warming.**

carbon
capture

- **Appendix Flash**

The Complete Energy Picture

Thorium is energy's untouched final frontier

Thorium is what fusion wants to be

Slightly radioactive thorium can be made to self-upgrade to a synthetic uranium adequate for use in a reactor. (See page 2 of Dr. Teller's paper.)

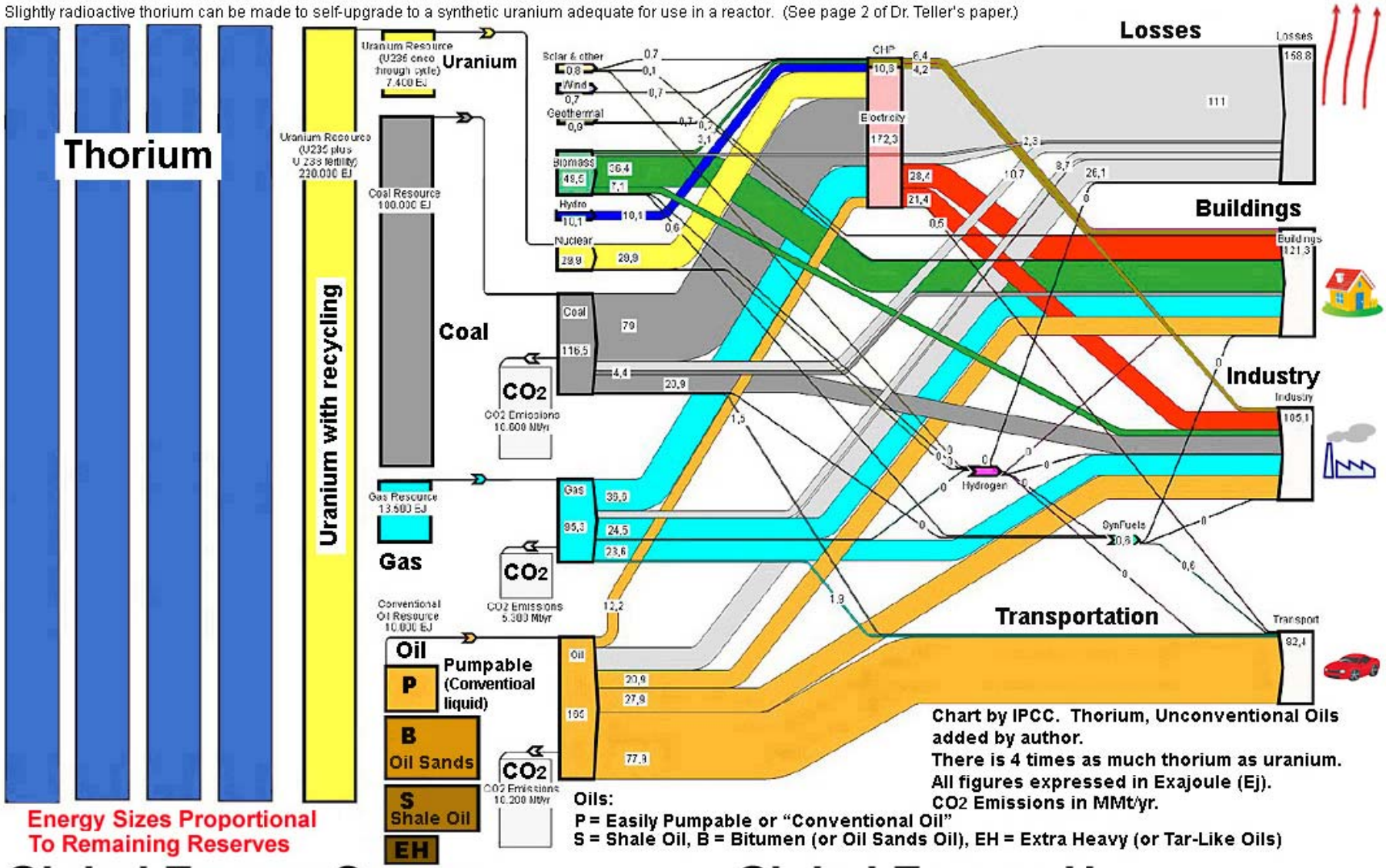


Chart by IPCC. Thorium, Unconventional Oils added by author.
There is 4 times as much thorium as uranium.
All figures expressed in Exajoule (Ej).
CO_2 Emissions in MMt/yr.

Oils:
P = Easily Pumpable or "Conventional Oil"
S = Shale Oil, B = Bitumen (or Oil Sands Oil), EH = Extra Heavy (or Tar-Like Oils)

Energy Sizes Proportional To Remaining Reserves

Global Energy Sources

Global Energy Uses

3 Chemical Fuels (Combustion):

- Coal
- Oil
- Natural Gas

3 Nuclear Fuels (Fission):

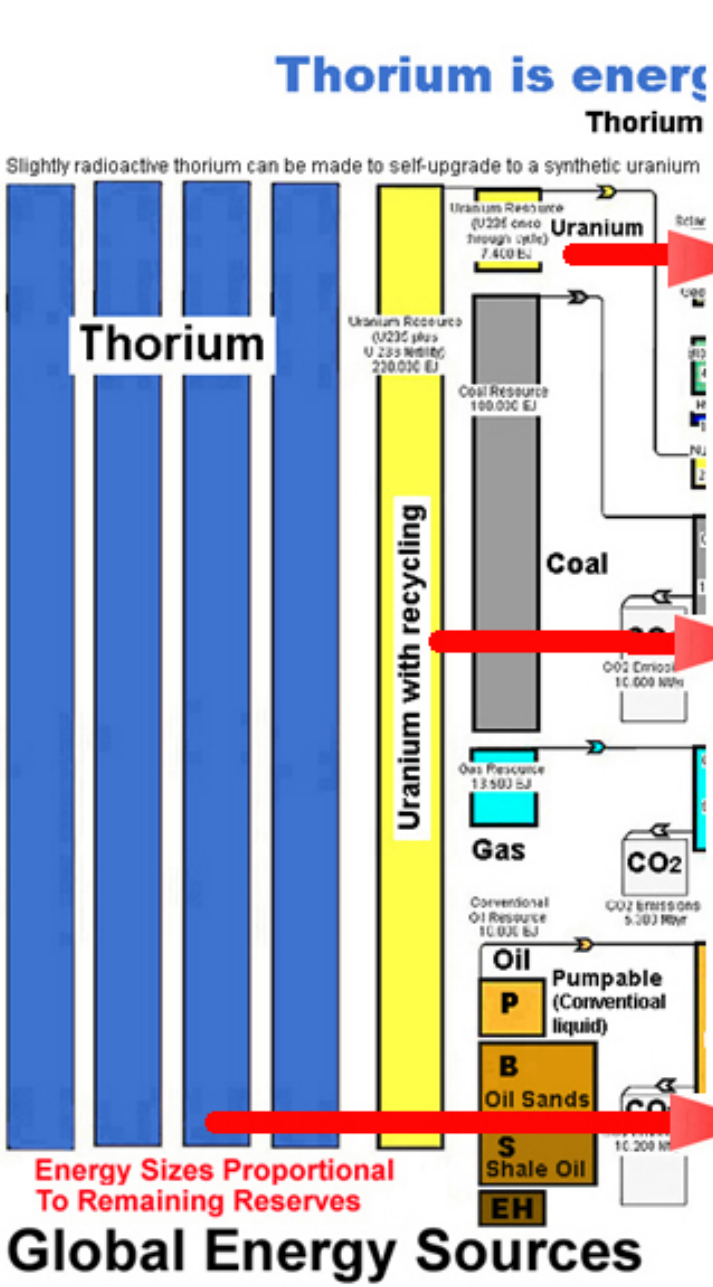
- Uranium-235
- Uranium-238
- Thorium-232

Thorium?
Liquid Reactors?

"Come for the thorium, stay for the reactor."

- **The Manhattan Project identified 3 viable energy paths: Uranium, Plutonium, and Thorium.**
- **Thorium had near-zero military potential and was subsequently abandoned and forgotten.**
- **80% of thorium's nuclear waste is safe in 10 years, the remainder, 300 years.**
- ***Regardless of the nuclear fuel used*, a fluid fuel molten salt reactor produces only several percent the nuclear waste produced by a solid fuel reactor.**
- **Molten salt resembles lava – fluid when hot, rock-like when cold. This means if it leaks out, it turns solid and won't sink into the environment like radioactive reactor water does.**

How the three different nuclear fuels work



“Fire-places” make using our chemical fuels safe.

Furnace

Hot Water Heater

Car Engine

Reactors are fireplaces for nuclear fuels.

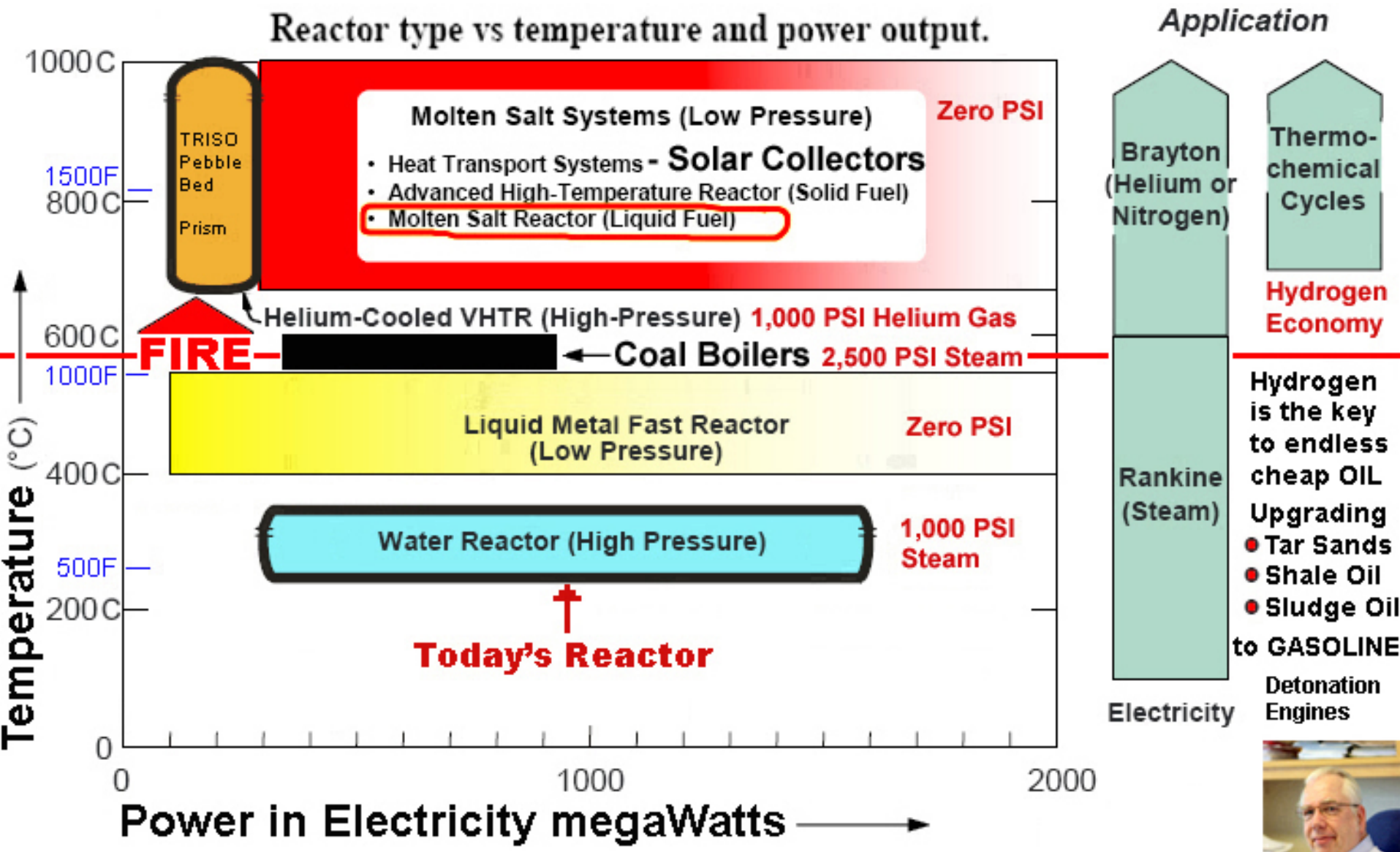


Chart by Dr. Charles W. Forsberg, MIT & ORNL, (pictured),
Coal, specific pressures by author.

Hotter reactors and the countries working on them:
Canada, China, Finland, France, Japan, Korea, Russia, South Africa, UK, USA.

	neutron spectrum (fast/ thermal)	coolant	temperature (°C)	pressure*	fuel	fuel cycle	size(s) (MWe)	uses
Gas-cooled fast reactors	fast	helium	850	high	U-238 +	closed, on site	1200	electricity & hydrogen
Lead-cooled fast reactors	fast	lead or Pb-Bi	480-800	low	U-238 +	closed, regional	20-180** 300-1200 600-1000	electricity & hydrogen
Molten salt fast reactors	fast	fluoride salts	700-800	low	UF in salt	closed	1000	electricity & hydrogen
Molten salt reactor - Advanced High-temperature reactors	thermal	fluoride salts	750-1000		UO_2 particles in prism	open	1000-1500	hydrogen
Sodium-cooled fast reactors	fast	sodium	550	low	U-238 & MOX	closed	30-150 300-1500 1000-2000	electricity
Supercritical water-cooled reactors	thermal or fast	water	510-625	very high	UO_2	open (thermal) closed (fast)	300-700 1000-1500	electricity
Very high temperature gas reactors	thermal	helium	900-1000	high	UO_2 prism or pebbles	open	250-300	hydrogen & electricity

** high = 7-15 Mpa*

+ = with some U-235 or Pu-239

*** 'battery' model with long cassette core life (15-20 yr) or replaceable reactor module.*

The United States has become ossified around the first nuclear technology.
China is using 4 different nuclear technologies.

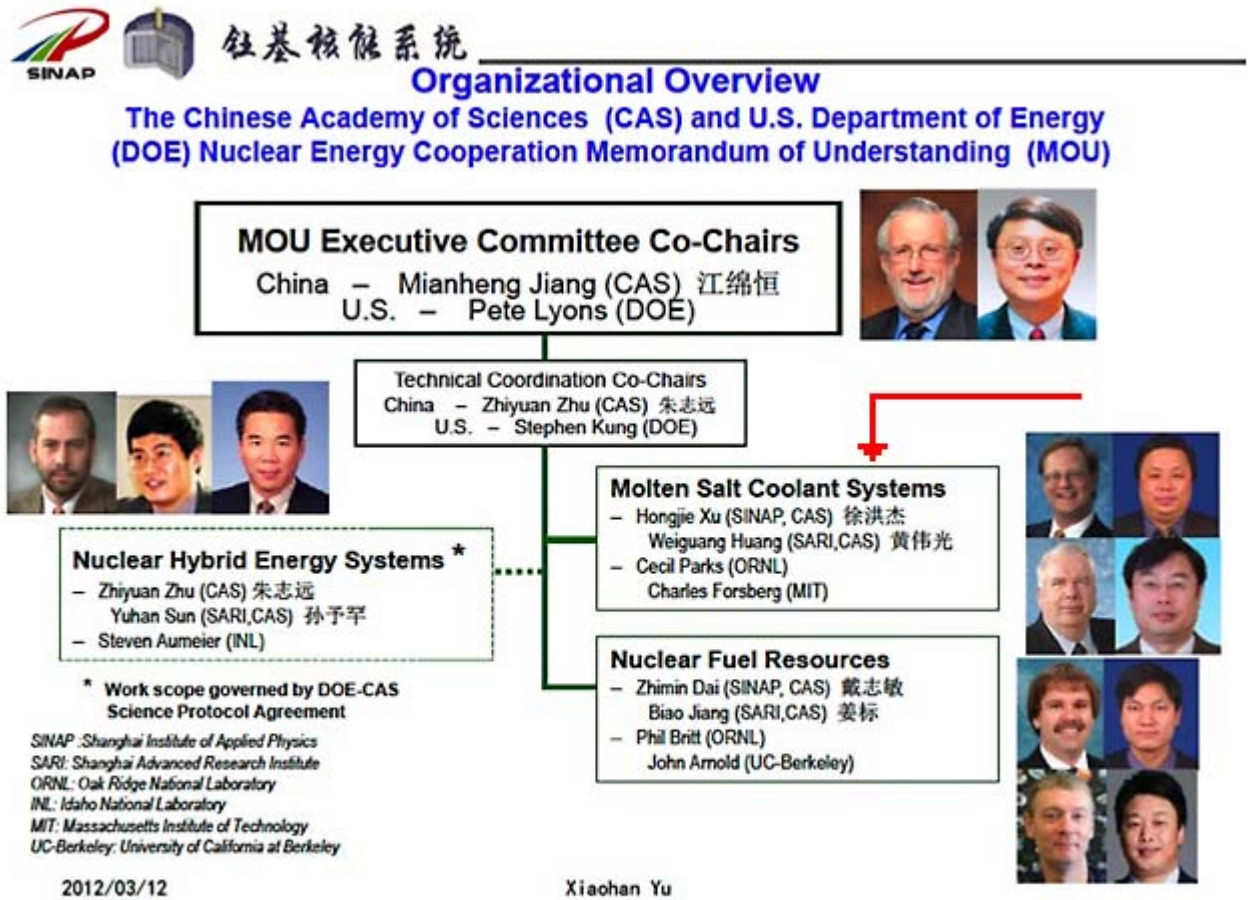
Dr. Jiang Mianheng

Pebble Bed (U + Th)

Molten Salt (Thorium)

Fast Breeder (U or Pu)

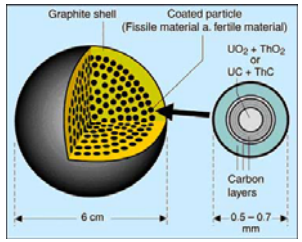
Conventional Uranium



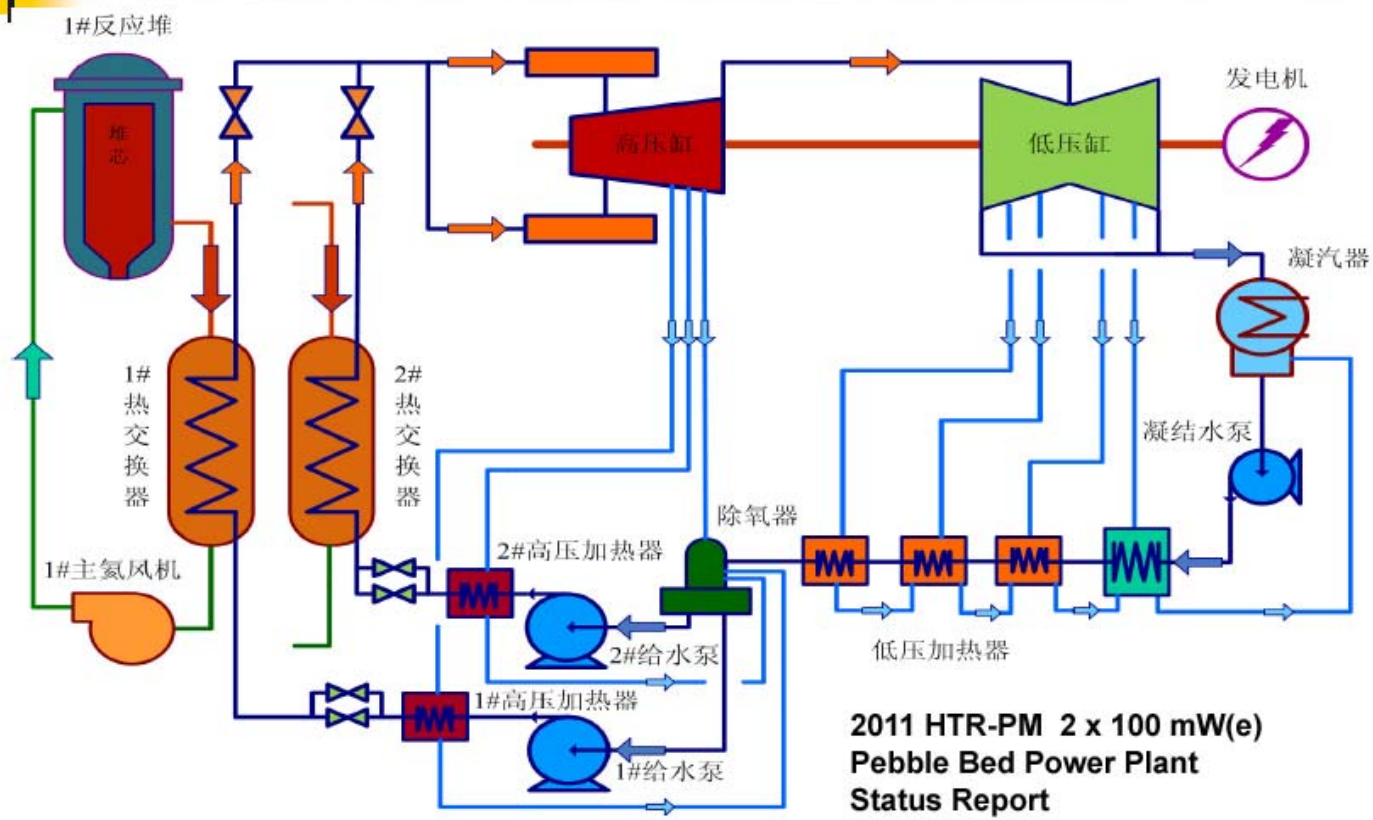
The names, faces and structure of the U.S. Department of Energy's nuclear collaboration with the Chinese Acaden of Sciences.

Photos and chart: Jiang/Clinton, from David Scull via Wikimedia. All others from page 27 of Chinese Academy of Science's March 12 presentation on thorium molten salt reactors, "TMSR Project of CAS."

Example:
40 Pebble-Bed reactor electricity generation complex at Rongcheng



Flow diagram of power conversion



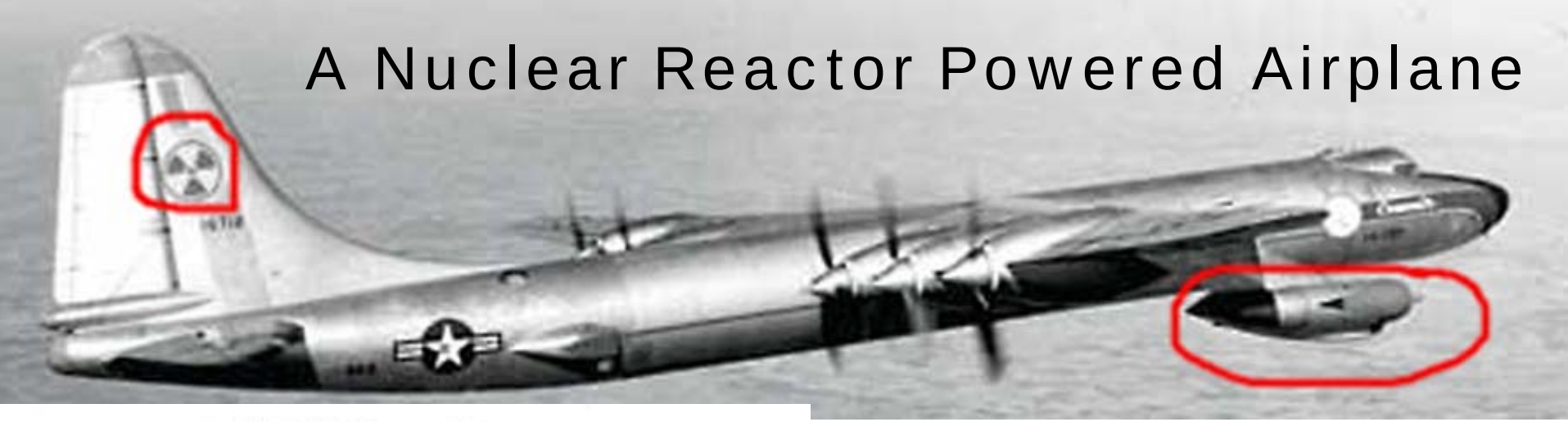
If I read this diagram correctly, we are looking at the world's first dual reactor steam turbine.

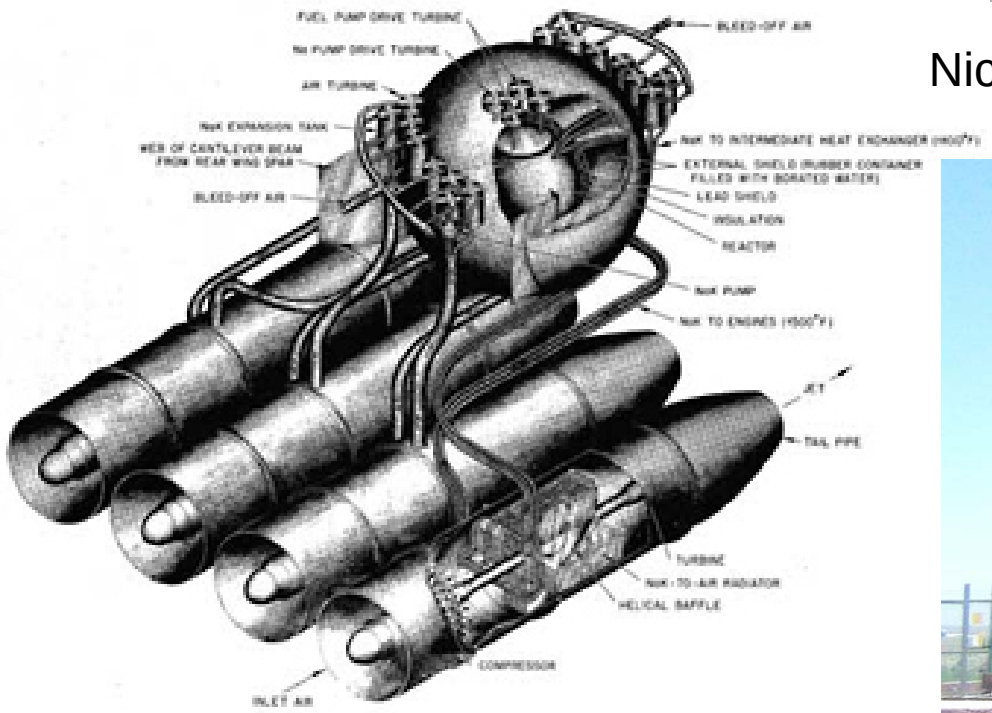
It's like the world's first two cylinder engine. Think about what having two cylinders instead of one did for railroad locomotives.

The power implications are significant.

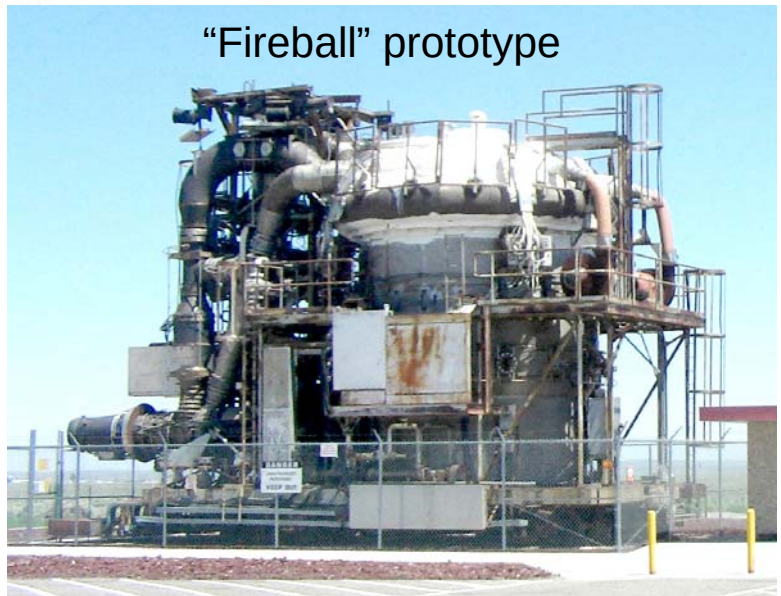
Long ago and far away over the Air Force's super secret Area 51 airbase . . . .

A Nuclear Reactor Powered Airplane





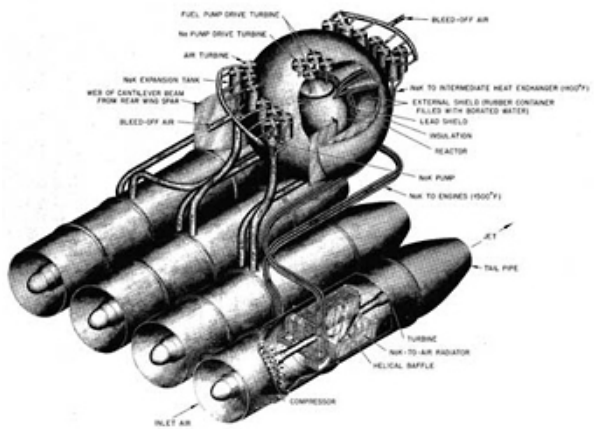
Nicknamed “Fireball”

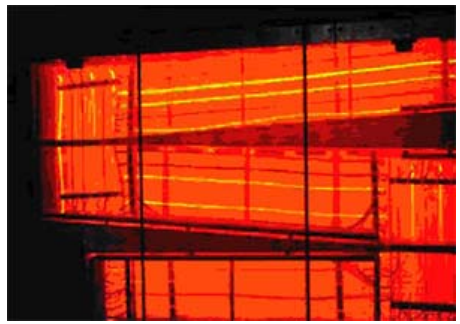


Marilyn and I saw this prototype next to the visitor’s parking lot at Idaho National Laboratories in 2011.

Jet engines need fire-hot heat
so we invented a fire-hot reactor.

Far safer unpressurized radiation – like in every hospital.



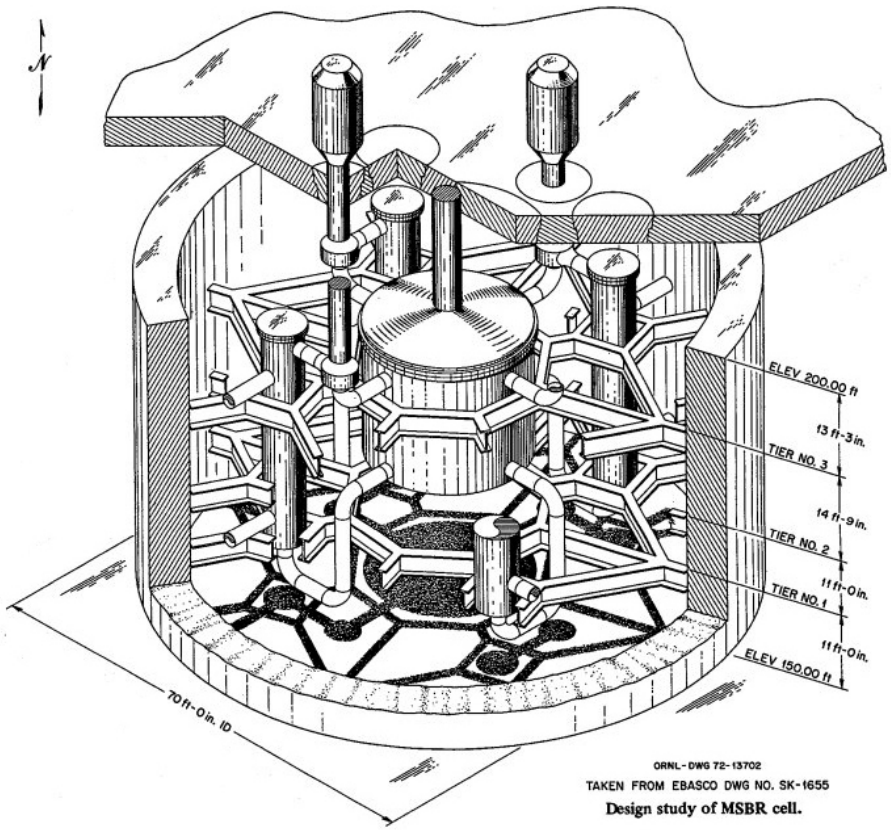


The externally fired gas turbine process

This modified drawing based on Figure 3 of externally fired gas turbine paper.

This led to the design of the 1,000 megaWatt (e) EBASCO power plant molten salt reactor.

(Then President Nixon defunded the project because it had no nuclear weapons potential.)



EBASCO Molten Salt Reactor + Confinement Cell

2,500 megaWatts (thermal) to produce 1,000 megaWatts (electrical)

70’ Diameter, 50’ High, 3’ thick confinement wall

HOME

HELP

TID-26156

RECEIVED BY TIC JUL 24 1972

1000 MW(e) MOLTEN SALT BREEDER REACTOR

CONCEPTUAL DESIGN STUDY

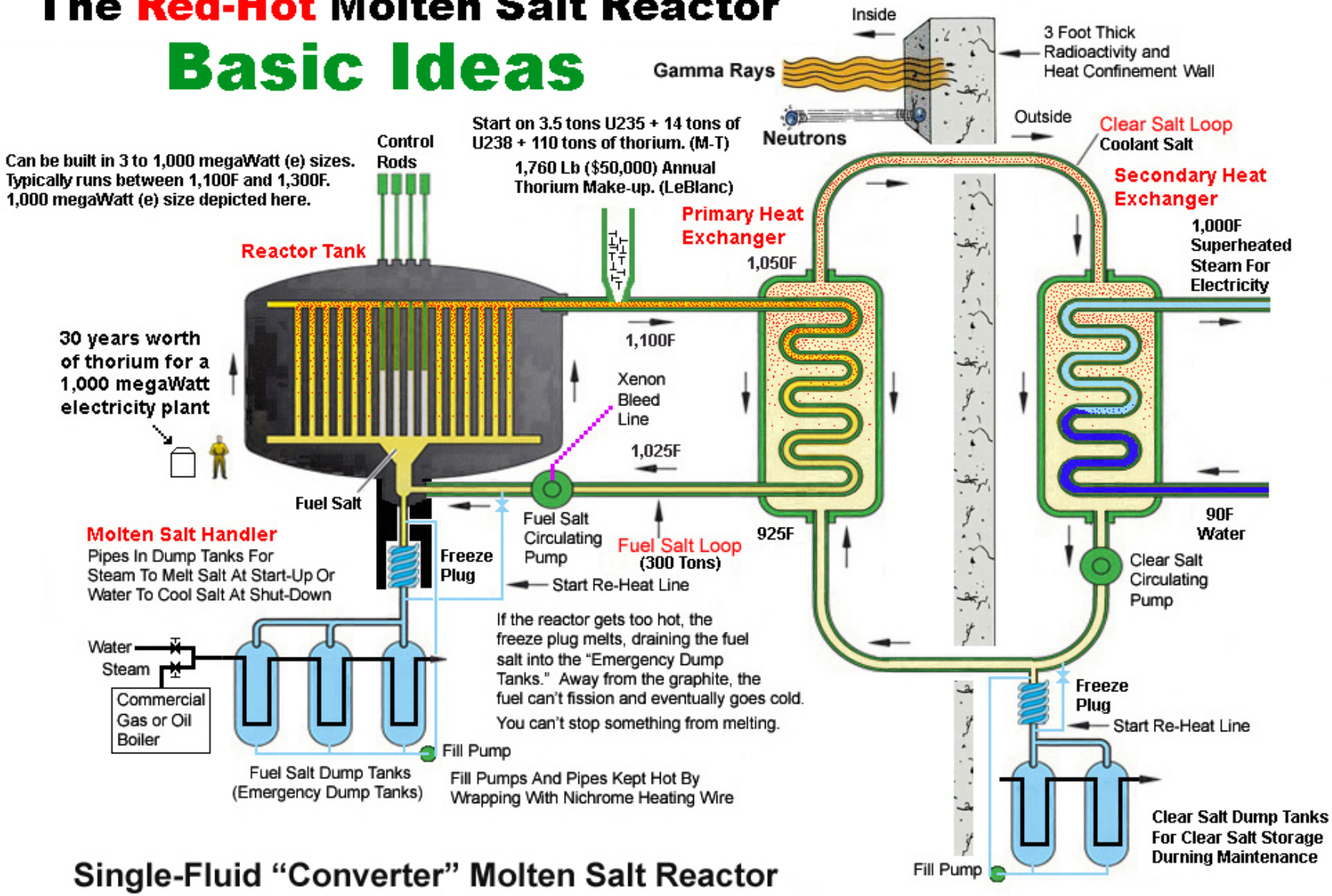
FINAL REPORT – TASK I

SUBCONTRACT NO. 3560
WITH
UNION CARBIDE CORPORATION
NUCLEAR DIVISION
OAK RIDGE NATIONAL LABORATORY
OAK RIDGE, TENNESSEE
UNDER
U.S. ATOMIC ENERGY COMMISSION
CONTRACT NO. W-7405-eng-26

This 300 page pdf report is freely downloadable. Just Google TID-26156

The Red-Hot Molten Salt Reactor

Basic Ideas



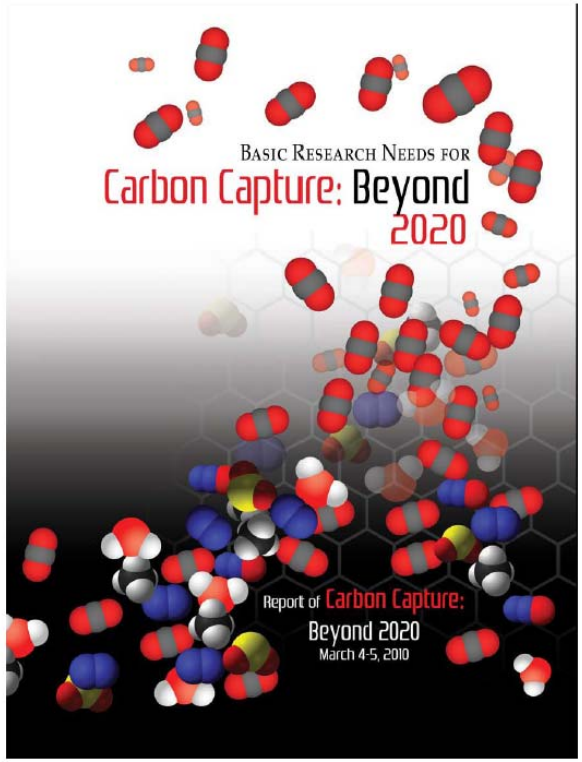
Single-Fluid "Converter" Molten Salt Reactor

Takes dissolved thorium in, converts it to a synthetic uranium, and then burns that down to almost nothing leaving almost no nuclear waste. The tiny amount of waste remains dissolved in the salt.
Goes 30 years between salt cleanings - a simple precipitation process - the salt, FLiBe, lasts forever.
Thorium heat can be 2,000 times cheaper than coal heat.

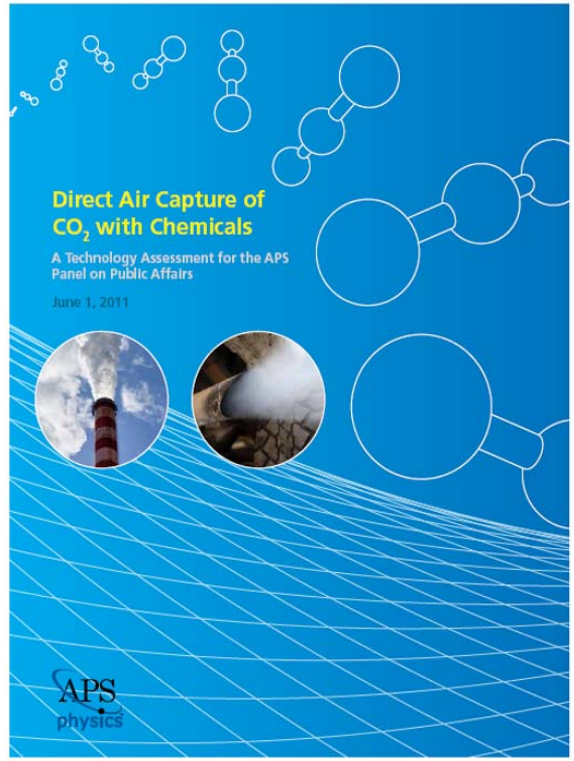
Next:

Ending The Era Of Global Warming.

carbon capture



Lawrence Berkeley National Labs
Oak Ridge National Laboratory
March 4-5, 2010 200 pages



American Physical Society
June 1, 2011 100 pages

Planet Earth's CO_2 level has never been higher than 280 ppm for the last ½ billion years.

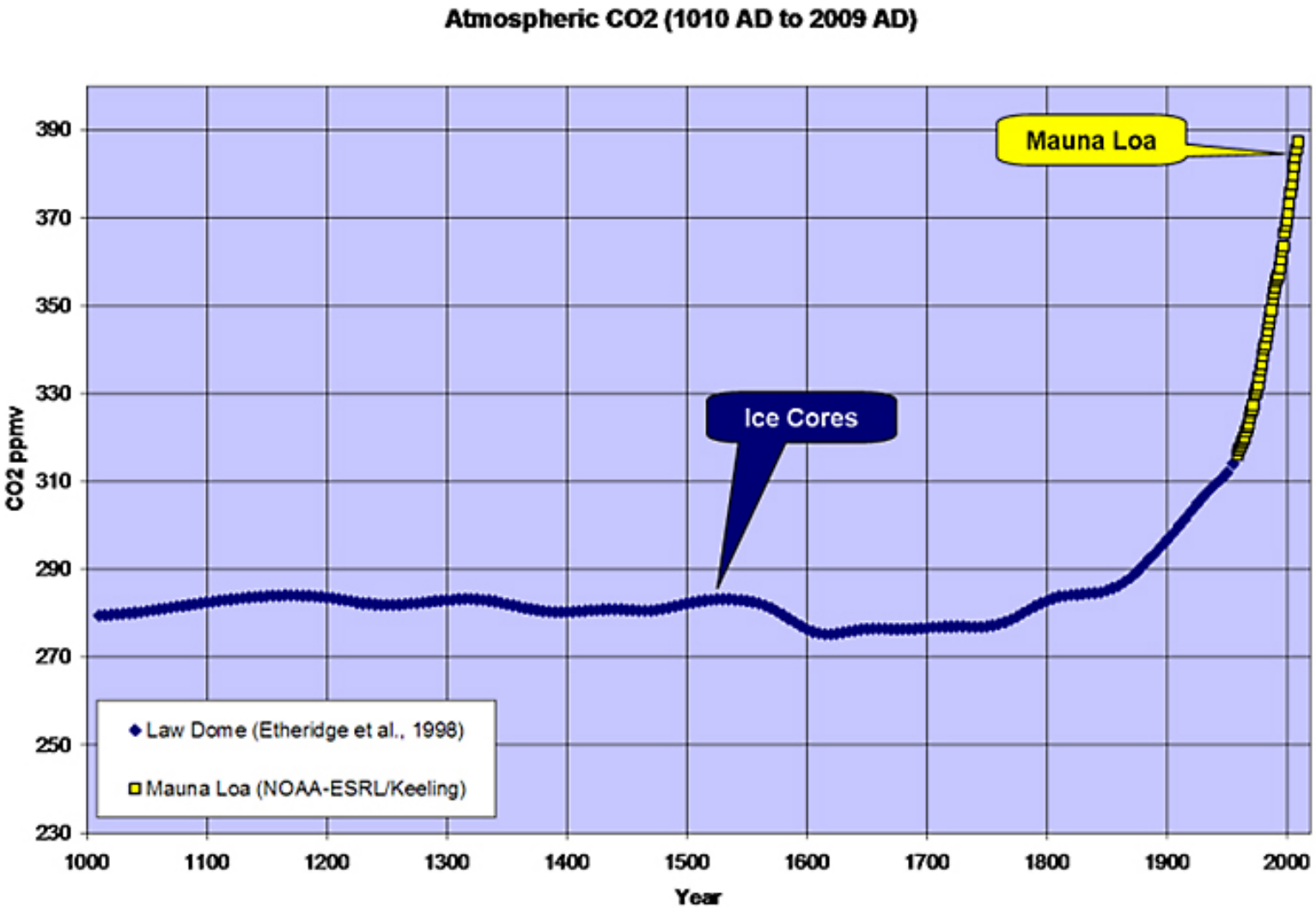
Now, at 390 ppm, man has taken Planet Earth's atmosphere deep into unknown territory.

"Fracking Frenzy" is just going to make everything worse.

Earth System Research Laboratory

Global Monitoring Division

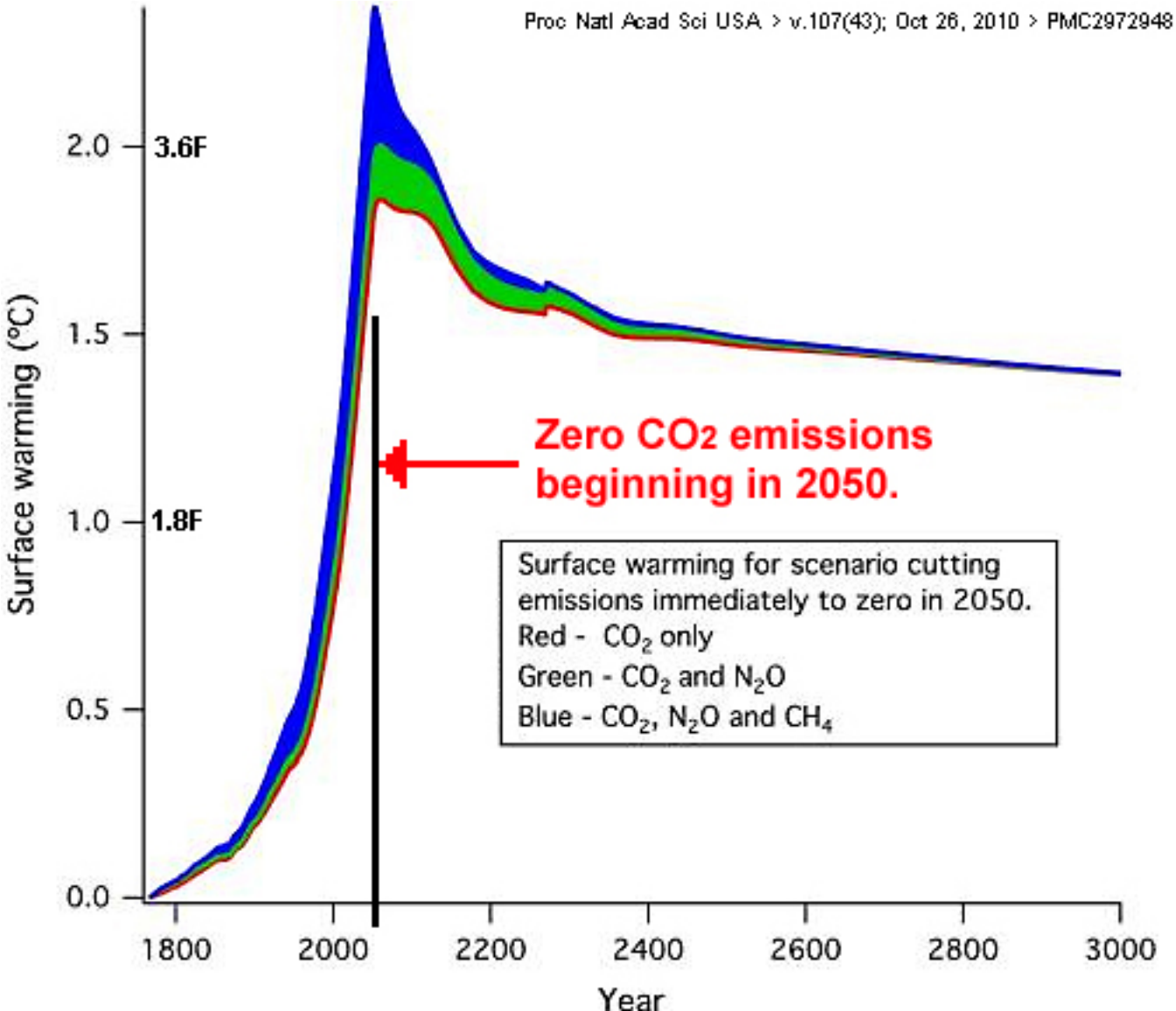
Welcome to Mauna Loa Observatory!



Direct CO2 measurements from ice cores and Mauna Loa Observatory.

MLO and Ice Cores 1000-2009

Even if we stopped all burning now, Global Warming would persist for over 1,000 years.



1. Experts say no matter how hard we try, we will never end more than about half of all CO2 emissions. Combustion will remain a principal component of the global energy system for centuries to come.
2. They also say about 350 BILLION tons of OLD CO2 must be removed from the air immediately to avoid the worst of Global Warming's Climate Changes.

So, HOW DO WE REMOVE GLOBAL WARMING FROM AIR?

(Right) Mono Lake in California.

It has been well-known for a long time that alkaline lakes absorb CO_2 from the air.

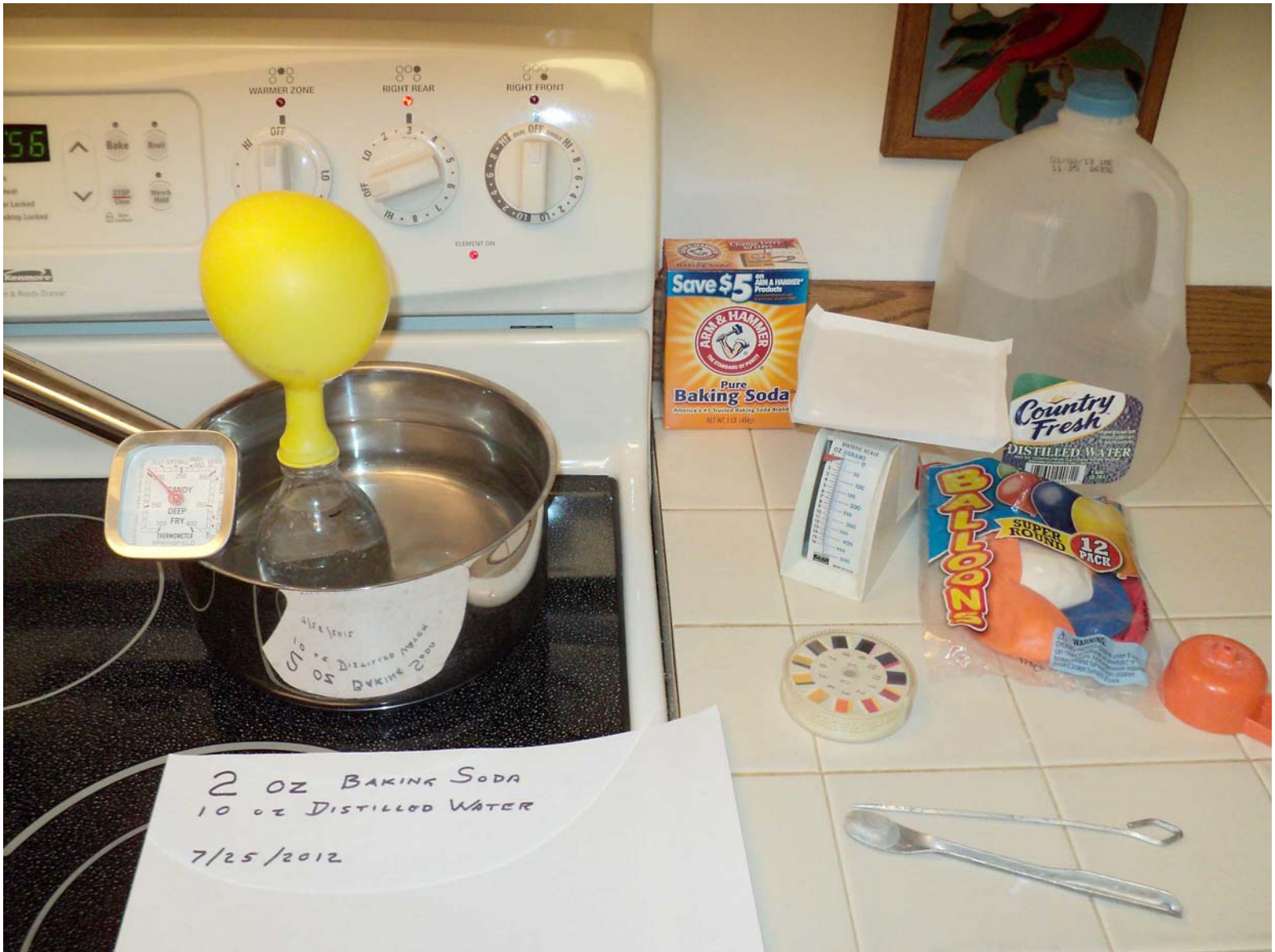
This means that ambient temperatures and simple, cheap, and abundant natural chemicals are involved.

It should be possible to build canals with the alkaline chemistry of Mono Lake, use air bubblers to contact the CO_2, extract the CO_2 from the water, and then return the water to the canals to absorb more CO_2.

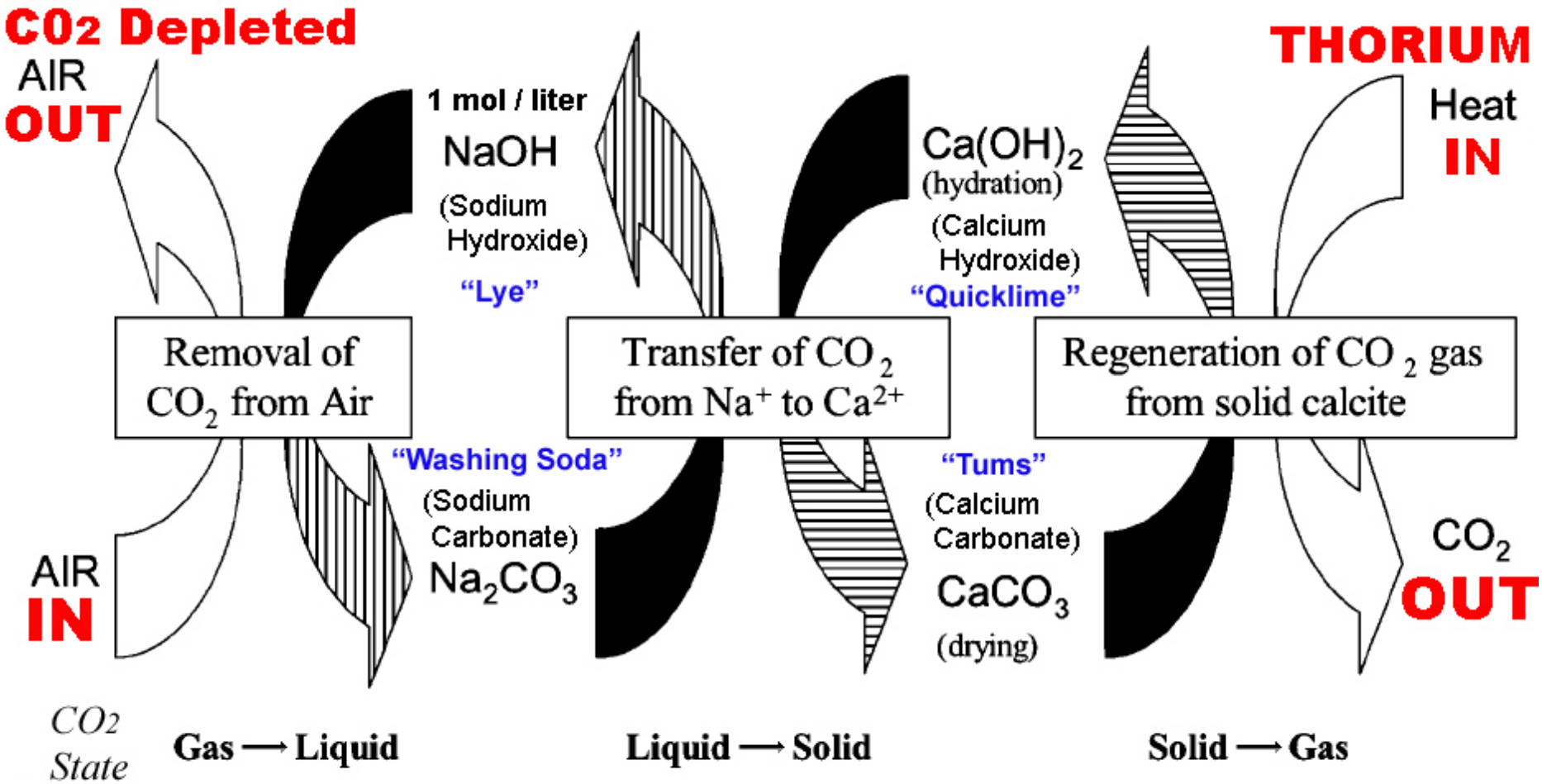
This process is known as:
"Direct Air Carbon Capture."

An alkaline lake absorbs CO_2 at an estimated rate of ~450 ton per acre per yr

My cell biologist wife helped. Baking soda was tried.
David Nicholson was unable to confirm the idea.
There are several paths and for now I'm sticking to the "Official Chemistry."



Modeled after a process common in the paper industry, this is perhaps the most accepted chemical process for removing CO_2 from the air.

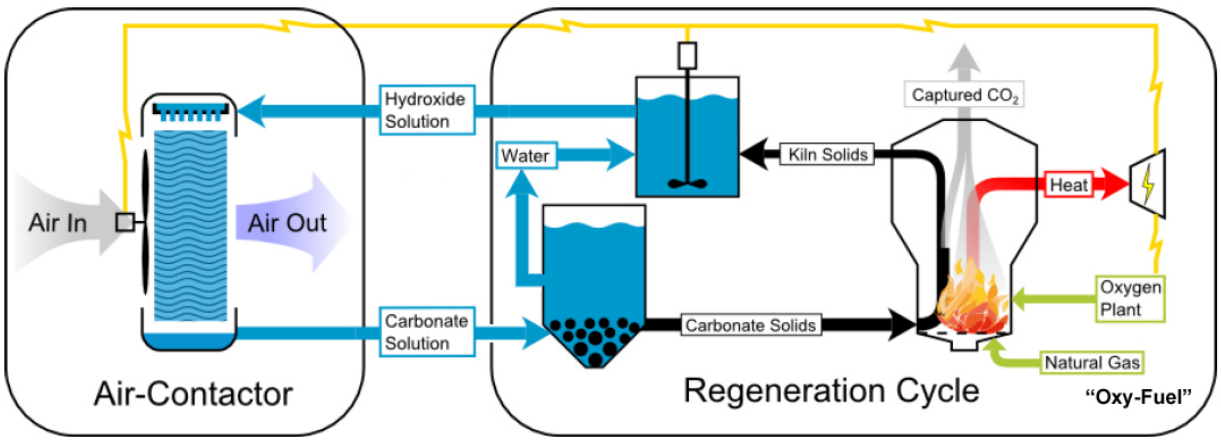


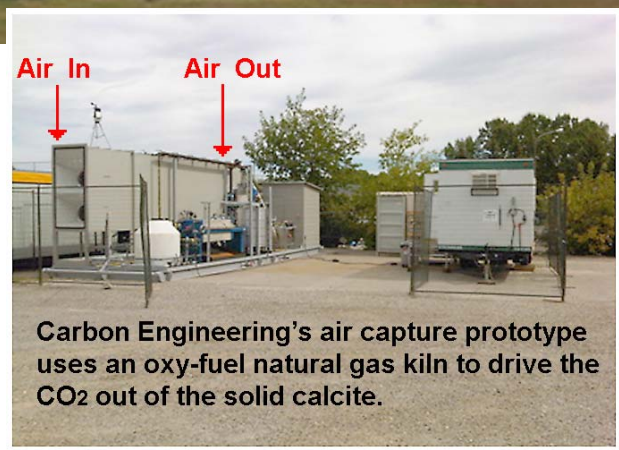
Schematic overview of air capture process.

Frank S Zeman, ENVIRONMENTAL SCIENCE & TECHNOLOGY / VOL.41, NO. 21, 2007, p 7558 - 7563

To drive the CO_2 out of the solid calcite (Tums) you need a 900°C (1,650°F) kiln.

Companies have been formed to develop Direct Air Capture of CO_2 systems. Unfortunately, the capture process uses fire. They advocate oxy-fuel natural gas which produces pure CO_2 emissions which is then added to the captured CO_2 stream. This restricts their systems to tiny amounts of heat and thus little CO_2.





The CE Outdoor Contactor work-site.

Much more at: http://www.CarbonEngineering.com Dr. David Keith

Using nuclear's muscle

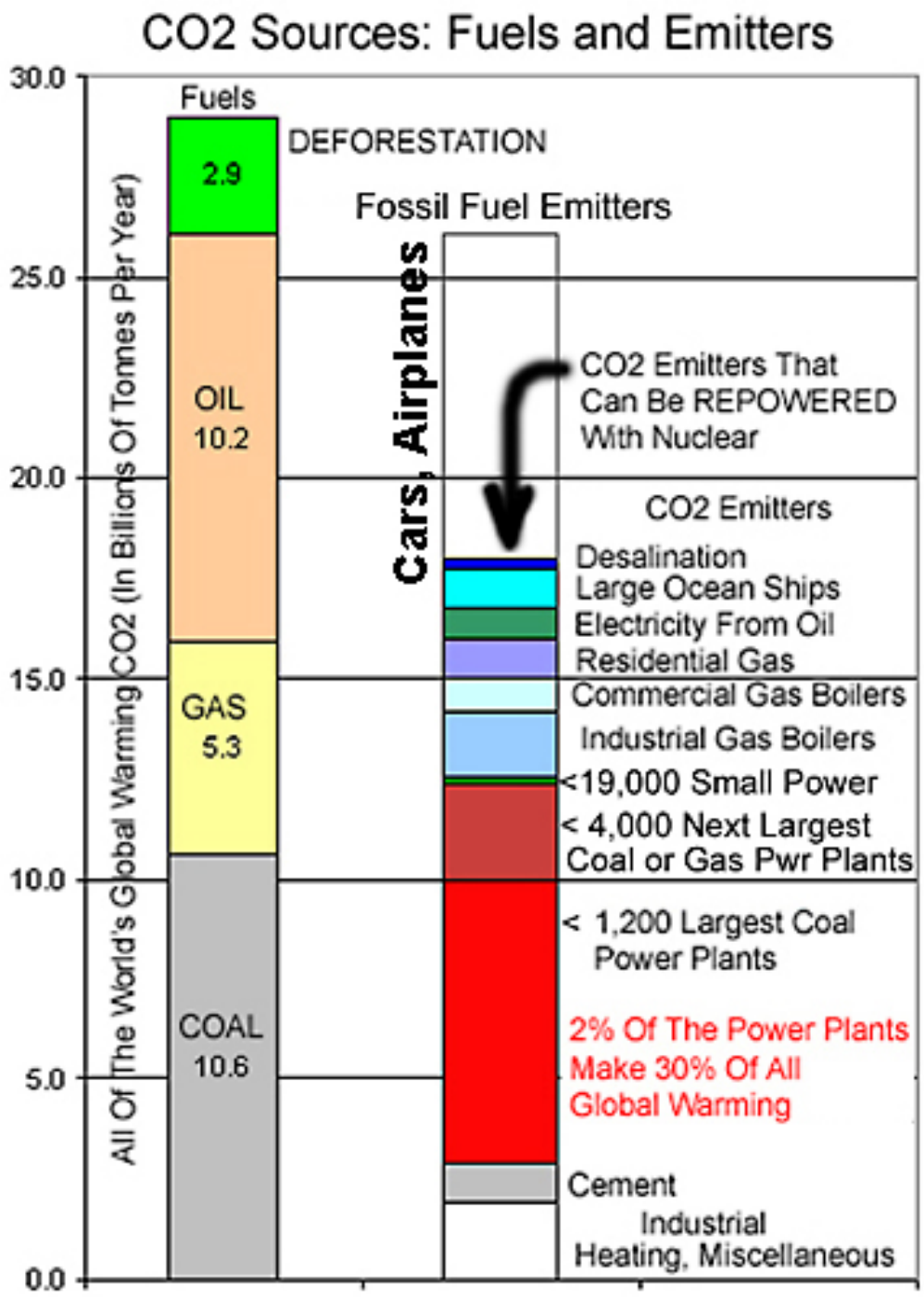
First: **Fire-hot molten salt reactors can be used to convert the world's 1,200 largest power plants from coal or gas to nuclear – an immediate 30% reduction in total Global CO_2 emissions.**

Side benefit: – The power plant's $ 120 million per gW-year coal is replaced with $ 50 thousand per gW-year thorium. Substantial lowering of your electric bill's fuel-charge.

Second: **By *over-sizing the reactors*, the power plants would have sufficient additional heat and power to also remove a large amount of Global Warming from the air.**

We simply overwhelm man's ability to make Global Warming.

By recycling existing large coal burning power plants we make ending Global Warming quick and affordable along with substantially reducing your electricity bill.



Taichung, Taiwan.

The world's largest single source of Global Warming. The world's largest mega-coal power plant.

China	**395**
US	**286**
India	**64**
Russia	**56**
Japan	**45**
Germany	**41**
UK	**22**

← The 1,200 mega-coal power plants that are the master key to ending Global Warming

Old coal burning power plants have the "Right Stuff" for scrubbing CO_2 out of the air.

Large coal storage yard for CO_2 canals.
Ample adjacent land.
Cooling water access.
Local, state, and federal permits.
Proven team of skilled trades workers.
Strong local support.
Already paid for.
Basic site construction completed.
Hazardous waste storage in place.
Railroad access.
Road access.
Electric switchyard in place, grid access.
Computer and telecommunications in place.
Sewage and wastewater in place.
Electricity + CO_2 capture doubles the value of the plant.

Big Bend, 4 x 450 mW, Apollo Beach, FL

Big Bend is on navigable water.

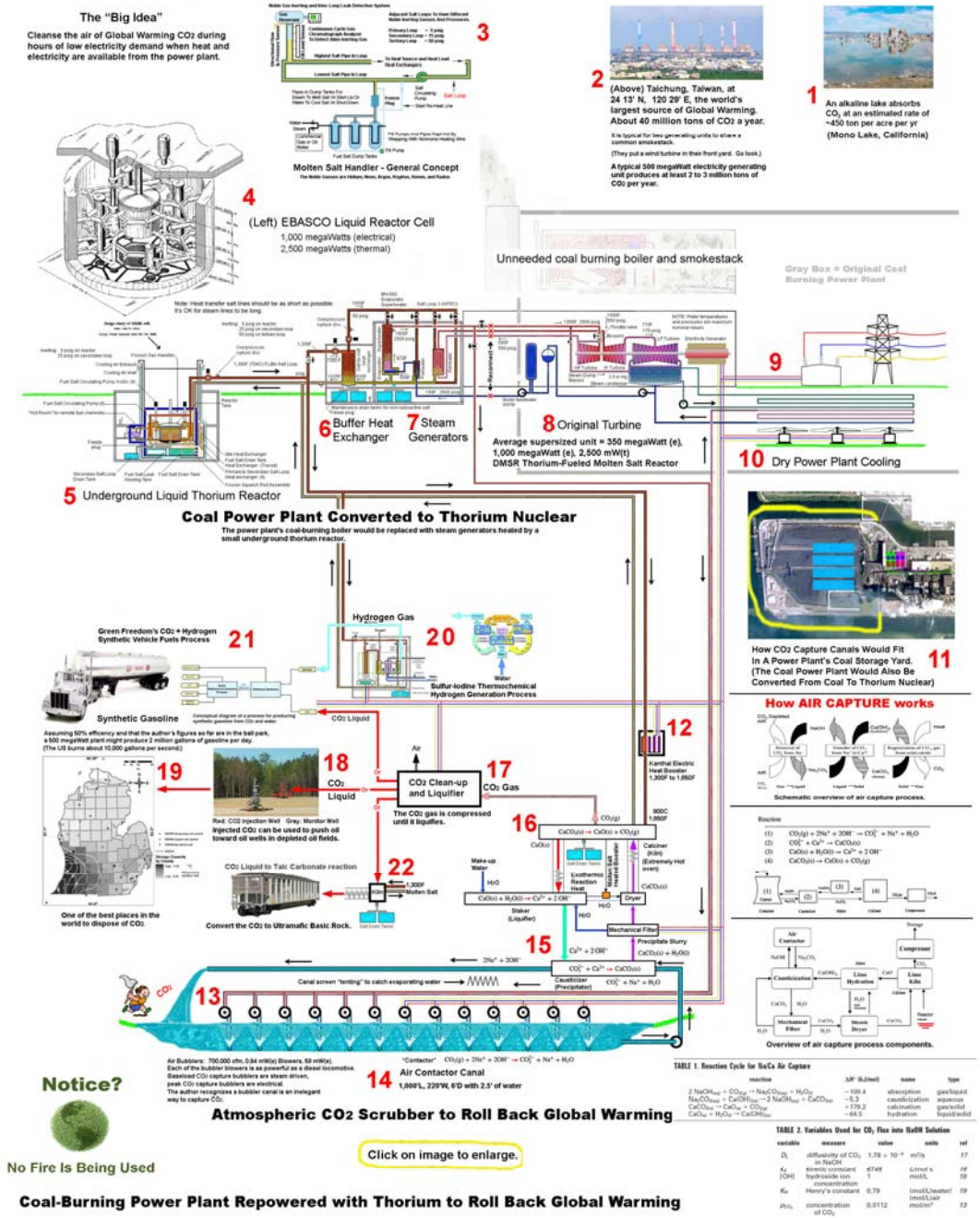
Lacks connection to the national CO_2 transmission pipeline.

What would an old coal power plant with added direct air CO_2 capture look like?

(Using Big Bend as an example.)

8. Original coal power plant.
5. New underground reactor.
7. New steam generators.
14. CO_2 scrubber canal.
13. Air bubblers.
15. Liquid-to-solid CO_2 converter.
16. Solid-to-gas CO_2 kiln.
17. CO_2 gas liquefier.
18. CO_2 disposal well.
21. CO_2 to vehicle fuels refinery.
22. CO_2 to ultramafic rock.

11. Scrubber canals in Big Bend's now-unneeded coal storage yard.



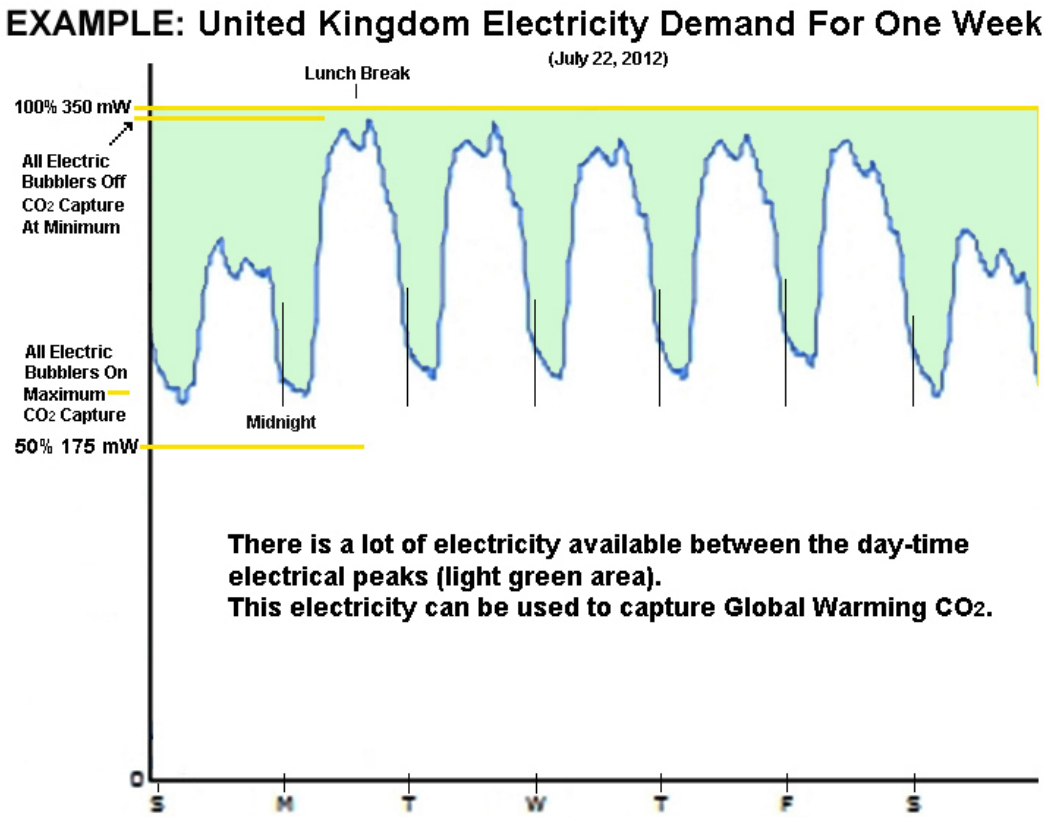
Would it continue to make as much electricity?

Yes. The green area indicates off-peak electricity is available.

There are two types of air bubblers: Steam turbine and Electric motor. The steam bubblers run all the time. The electric bubblers run only when there is available electricity.

Enormous amounts of air must be moved if the entire atmosphere is to be scrubbed of Global Warming CO_2.

Each 700,000 CFM (cubic feet per minute) bubbler takes as much power as a railroad locomotive. 100 bubblers on one reactor is not unthinkable.

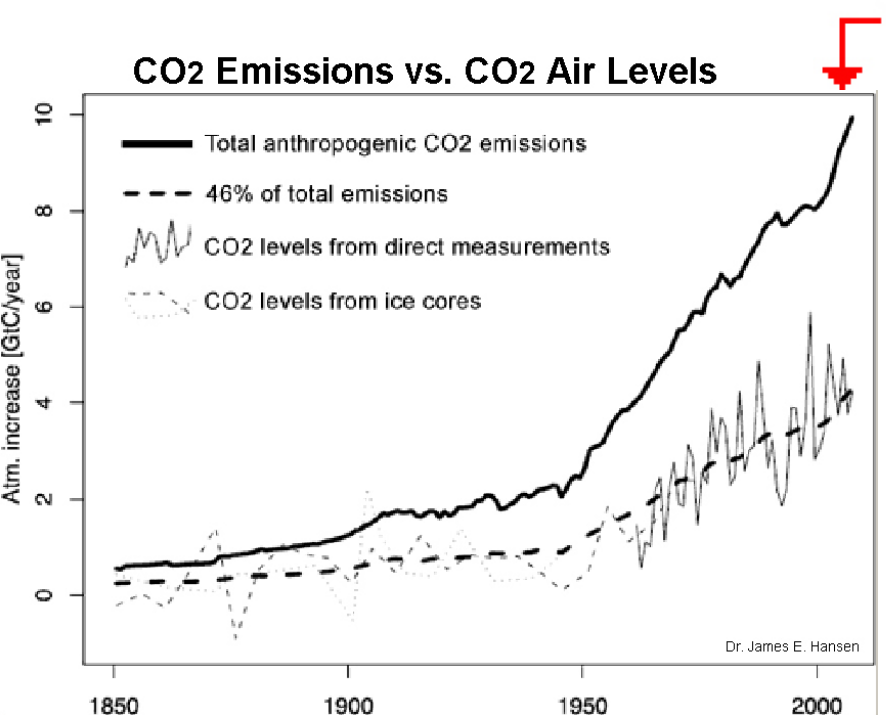


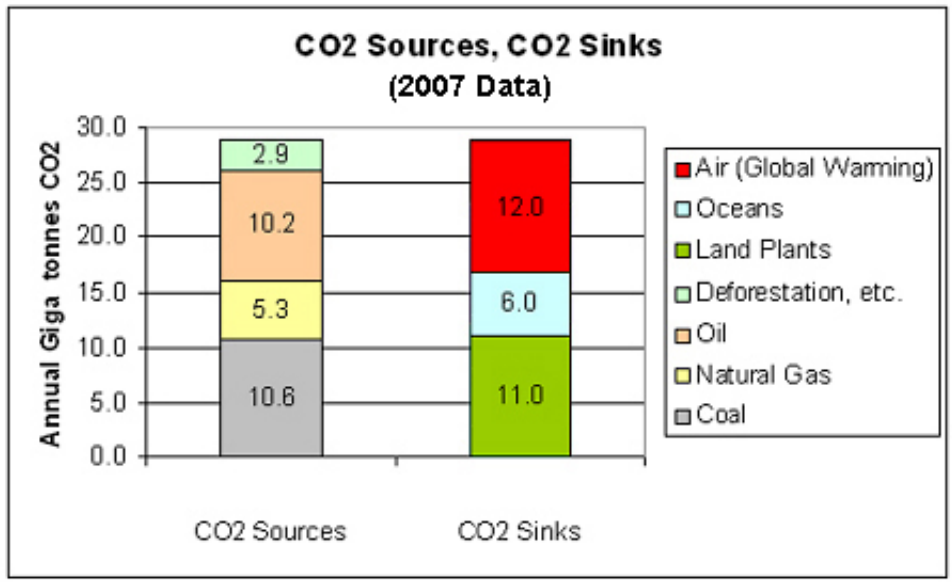
What kind of results can we expect?

Man produced 35 billion tons of CO_2 in 2011.
About 46% or 16 billion tons of CO_2 will end up in the air.

This suggestion would:

- **Immediately end 10 billion tons of Global Warming emissions by converting 1,200 large power plants from coal to thorium.**
- **11.5 billion tons of CO_2 would be removed from the air per year by air capture equipment added to 1,200 large existing power plants.**
- **Purpose built air capture facilities on new sites adjacent to existing sites are an option for removing even more CO_2.**





What was presented:

- **Global Energy, China's New Nuclear.**
- **Ending The Era Of Global Warming.**

Thank you for your interest.

www.coal2nuclear.com

References

1) "**Direct Air Capture of CO2 with Chemicals**" - A Technology Assessment for the APS Panel on Public Affairs - June 1, 2011 (100 pages, a darn good overview. Read pages 29 to 44.) [45.052]

2) Baciocchi, R., Sorti, G., and Marzotti, M., ***"Process design and energy requirements for the capture of carbon dioxide from air."*** Chemical Engineering and Processing, 2006. 45: p. 1047-1058. [45.026]

3) **"BASIC RESEARCH NEEDS FOR CARBON CAPTURE: BEYOND 2020"** Co-chairs: Paul Alivisatos, Lawrence Berkeley National Laboratory, Michelle Buchanan, Oak Ridge National Laboratory (196 pages.)

4) "**CLIMATE STRATEGY WITH CO2 CAPTURE FROM THE AIR**" David W. Keith, Minh Ha-Duong and Joshuah K. Stolaroff, *Climatic Change,* (2006), 74:17-45, DOI: 10.1007/s10584-005-9026-x [45.037]

5) "**Energy and Material Balance of CO2 Capture from Ambient Air**" Frank Zeman, *Columbia University, Department of Earth and Environmental Engineering, 918 Mudd MC 4711, 500 West 120th Street, New York, New York 10027* [45.049]

6) "**Capture of carbon dioxide from ambient air**" K.S. Lackner Columbia University, New York, and NY GRT LLC, Tucson, AZ, USA

7) "**Absorption of Carbon Dioxide in a Bubble-Column Scrubber**" Pao-Chi Chen *Graduate School of Engineering Technology Department of Chemical and Materials Engineering Lunghwa University of Science and Technology Taiwan*

8) "**An Investigation into the Feasibility of Capturing Carbon Dioxide Directly from the Atmosphere**" Frank S. Zeman, *Earth and Environmental Engineering,* Columbia University New York, NY 10027

9) "**Capturing carbon dioxide directly from the atmosphere."** Zeman, F. S.; Lackner, K.S., *World Resour*. Rev. 2004, 16,157-172.

Appendix

A US-China fast-neutron company

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Enter term or ADAMS # SEARCH

REPORT A SAFETY CONCERN

NUCLEAR REACTORS | NUCLEAR MATERIALS | RADIOACTIVE WASTE | NUCLEAR SECURITY | PUBLIC MEETINGS & INVOLVEMENT | NRC LIBRARY | ABOUT NRC

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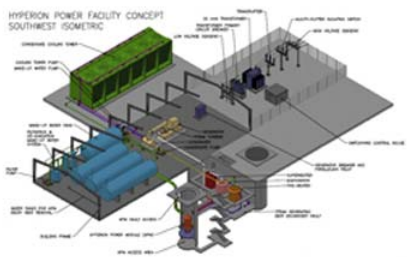
- NGNP
- NuScale
- B&W mPower™
- Clinch River - TVA

Spotlight
CHOOSE A SECTION

Home > Nuclear Reactors > Advanced Reactors > **Hyperion**

Hyperion Power Module (HPM)

Designer:	Hyperion Power Generation, Inc.
Reactor Power:	70 MWt
Electrical Output:	25 MWe
Outlet Conditions:	500C
Coolant:	Lead-bismuth eutectic, primary and secondary loops
Fuel Design:	Stainless steel clad uranium nitride
Refueling:	Entire reactor module replaced every 7 to 10 years



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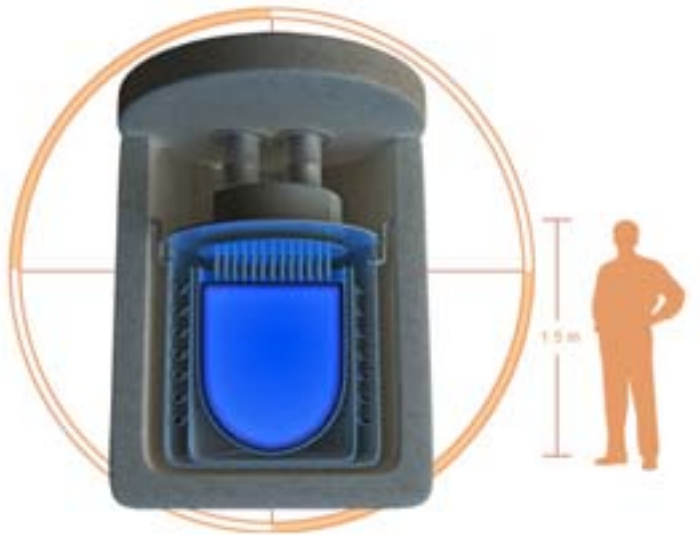


"Let a thousand reactors bloom."

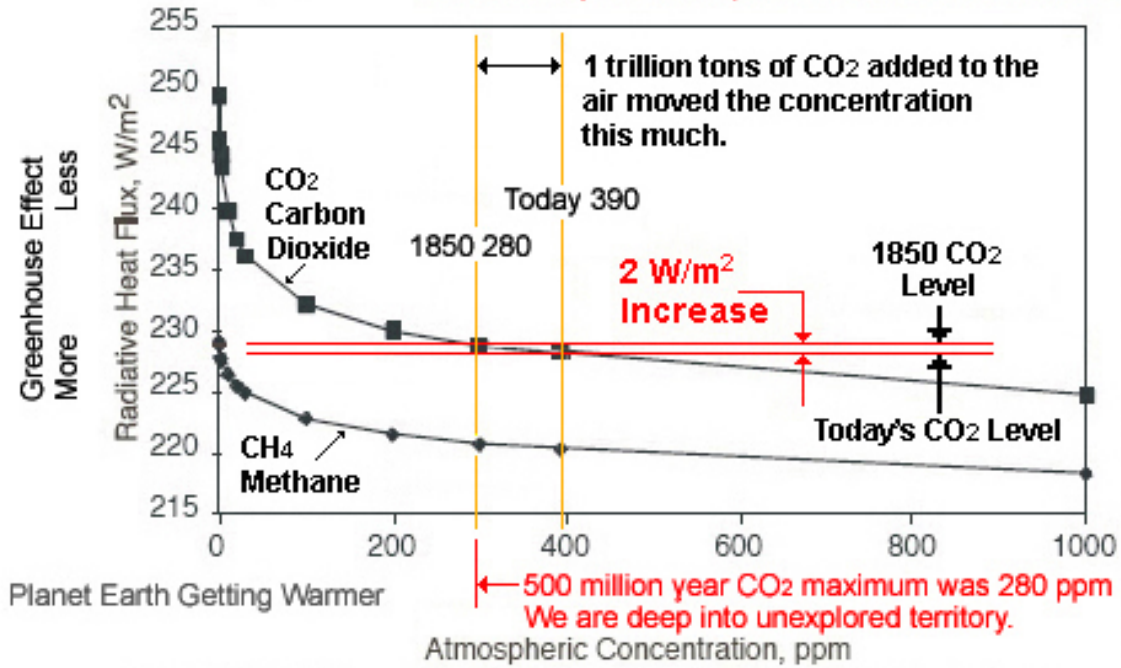
10-year exchangeable nuclear module.

How The Global Warming Machine Works

Planet Earth's average temperature is 59F.

If there were no CO_2 in the air, Planet Earth would be at 0 degrees F.

If we develop a second pair of lines for Methane we are in for big trouble fast.



Radiative impacts of atmospheric methane and CO_2 concentrations: the outgoing longwave radiation flux over midlatitude winter conditions, from the Modtran model (Rothman, 1992), with a web interface at http://geosci.uchicago.edu/~archer/cgimodels/radiation.html. The sensitivities to methane and CO_2 are fundamentally similar, but because methane is present at lower concentration, the atmosphere is at a steeper part of the curve where a single molecule of methane would have approximately twenty times the radiative impact of a single molecule of CO_2. The leveling off of this curve is due to saturation of absorption bands.

Planet Earth has an area of 510,072,000 sq kilometers or 510,072,000,000,000 sq meters.

2 watts per sq meter would be 1,020,144,000,000,000 watts or 3,468,000,000,000,000 BTUs or 3.468 Quads.

Planet Earth is picking up an extra 3.5 Quads every hour or 84 extra Quads every day.

Or 30,660 Quads of extra heat is added to Planet Earth every year.

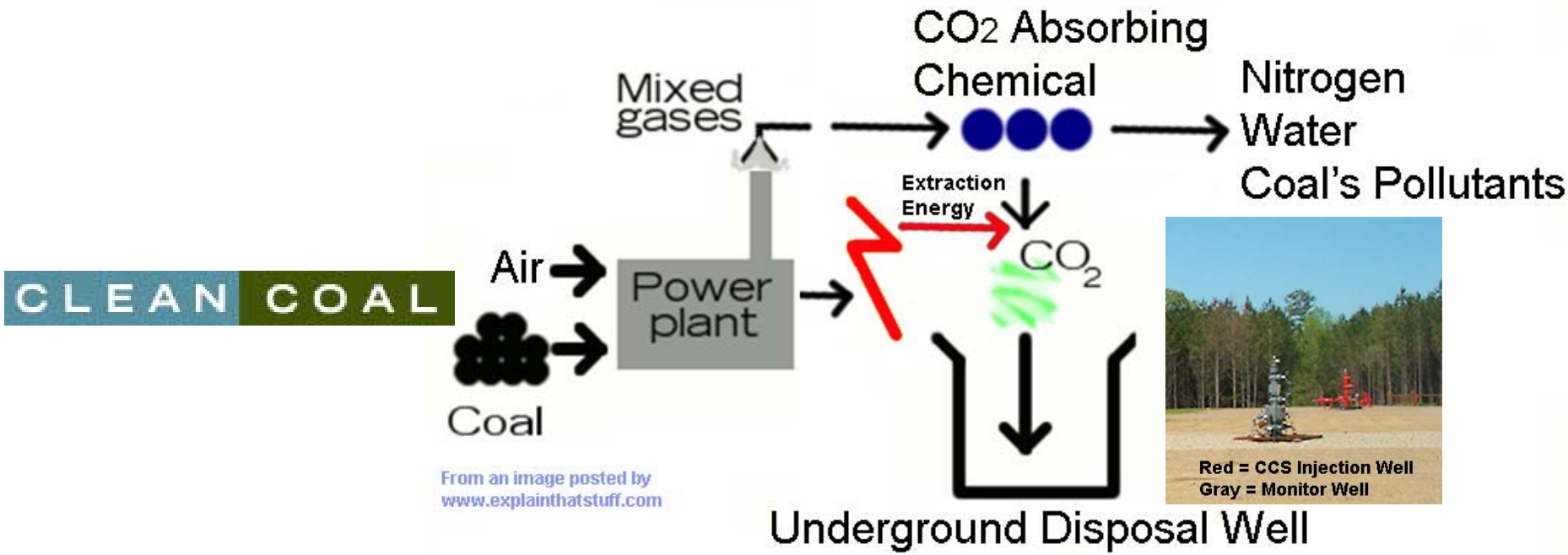
The United States produces about 100 Quads of heat every year, all mankind about 450.

(1 watt-hour = 3.4 BTUs.)

*** World CO_2 emissions were almost 35 billion tons in 2011.**

carbon capture journal

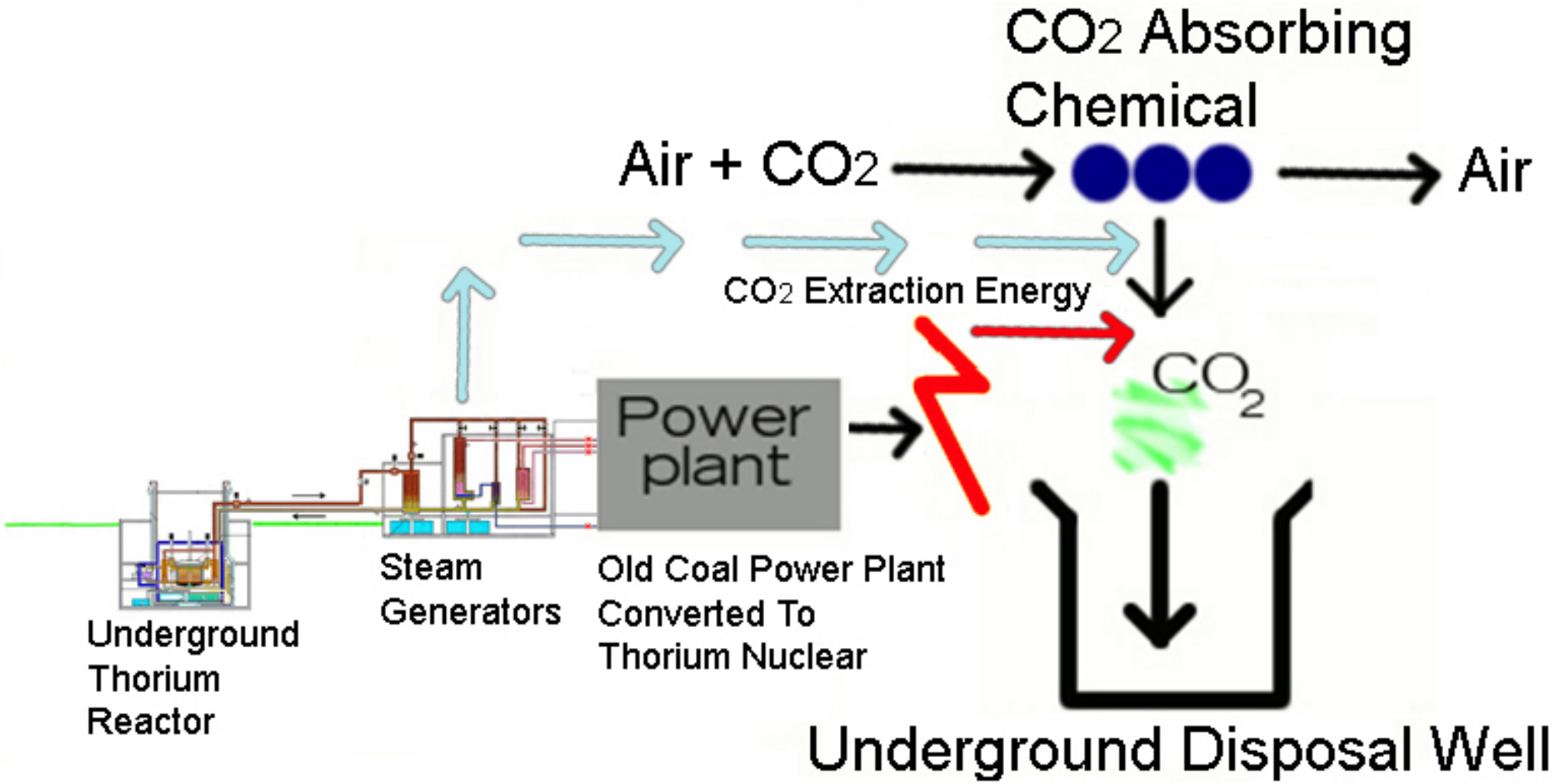
GLOBAL CCS INSTITUTE



CLEAN COAL

How Carbon Capture and Storage (CCS) works

Air Capture of CO_2



How Air Capture of CO_2 would work

Yields, Costs, and Concerns

- **RESULTS:** 700,000 cubic feet per minute (cfm), 30" head (at the bottom of 30" of water) bubblers = 6,559 grams of CO2 per minute per bubbler (at 50% efficiency). (as per Frank Zeman)
  Base: 383 blowers = 2,512,097 grams, 5,526 pounds of CO2 per minute, times 60 = 331,560 pounds or 166 tons per hour. Times 8,760 hours per year = 1,452,233 tons per year.
  Peak: 45 blowers = 295,155 grams, 649 pounds of CO2 per minute, times 60 = 38,940 pounds or 19.5 tons per hour. Times 8,760 hours per year = 170,820 tons per year.
  Total: 1,623,053 tons per year. At $22 dollars per ton, that comes to about 36 million dollars per year. Heat from thorium can be 2,000 times cheaper than heat from coal.

- Oops, I'll have to trade off a few steam powered blowers for some more extraction heat. This is based on Dr. Frank Zeman's 50% efficiency estimate. If the bubblers can be made to be 80% efficient as some suggest, then the air capture tonnage would be in the range of 2.5 million tons per year per reactor.

- Using Dr. Zeman's comment that 442 kiloJoules is required to process one mole (44g) of CO2 from air to pure extracted gas (**123 watt-hours thermal per 1.55 oz**).

- This translates to 12,601 oz of CO2 per megaWatt-hour thermal or 787 pounds per mW-h (t).

- Since the reactor puts out 2,500 mW(t), that would come to 1,969,000 lb/hr or 985 tons per hr, times 8,670 hours/year = 8.5 million tons of CO2 per year - an absurdly large figure.

- According to Dr. LeBlanc, at $100 per kg of Uranium, this might come to about $3 million. $3 million divided by 8.5 million tons of CO2 comes to $0.35 per ton - an absurdly small figure.

- How much will the chemicals cost and how fast will they be used up?

Costs

- 350 mW(e) Power Plant Costs

- Air CO2 Capture Plant Costs

Process chemical energy levels and plant equipment diagram

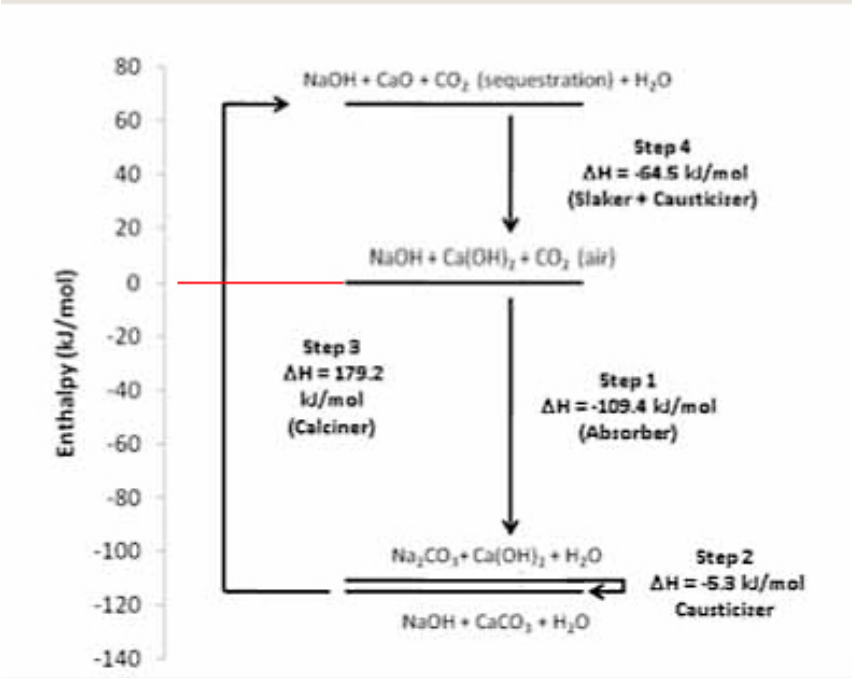


Figure 2.B5.1a. Enthalpy level diagram for CO_2 absorption and regeneration by sodium hydroxide (NaOH). Note that each level has the same set of atoms. In the system studied here, some molecules do not participate in specific physical processes; for example, ideally, NaOH is not transported to the calciner, nor does $Ca(OH)_2$ participate in the absorption.

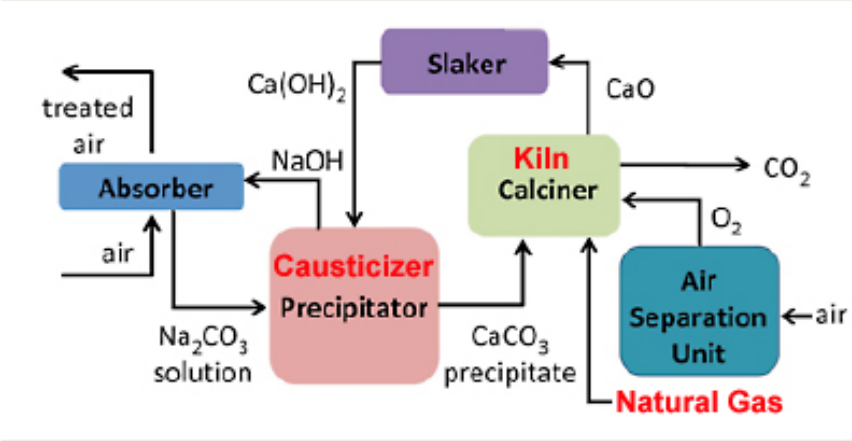


Figure 2.B5.1b. Scheme of a plant for CO_2 capture from air that uses NaOH as the absorber. The pulp and paper industry calls the reactor labeled "precipitator" a "causticizer." In this reactor, calcium carbonate is precipitated and sodium hydroxide (popularly called "caustic soda" as well as "lime") is regenerated.

Comparison of Energy Requirements (in kJ/mol) for Air Capture

item	Zeman	Keith et al.	Baciocchi et al.
energy required			
air contacting	88	12	30
causticization	0	96	0
evaporation	63	180	202
calcination (eff.)	256 (70%)	204 (88%)	239 (75%)
CO_2 purification[a]	16	168	27
CO_2 compression	19	19	18
total energy required	442	679	516
energy available			
heat of hydration	105	0	0

332

[a] O_2 production (Zeman, Baciocchi et al.), MEA capture (Keith et al.)

$H_2O_{(l)} \rightarrow H_2O_{(g)}$ $\Delta H_{vap}=41\text{kJ/mol@}373\text{K},0.1\text{MPa}$

CRC Handbook of Chemistry and Physics, D.R. Lide Editor in Chief, CRC Press, 2000

(Author had to "Cherry-Pick" among the various processes for nuclear.)

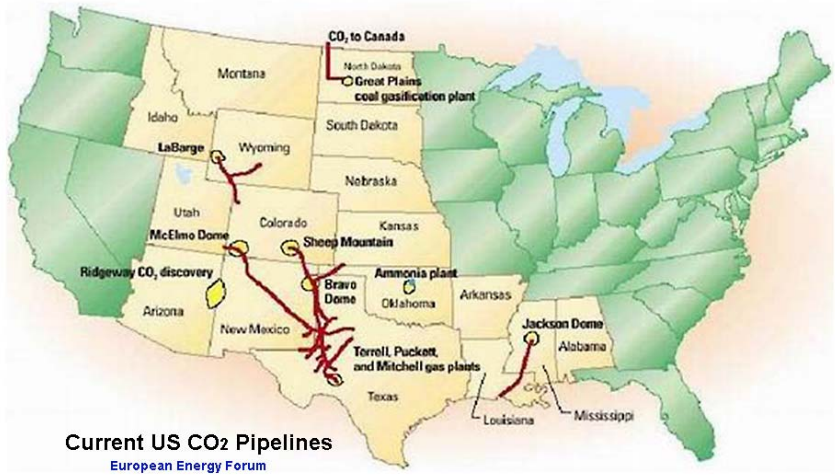
- Practical example: Comparing The Cost of Thorium Heat vs. Coal Heat
- (Coal:) It takes about 3 million tons of coal (costing $120,000,000 at US $40 per ton, delivered) to make 1,000 megaWatts of electricity for a year.
- (Thorium:) "Once up and running, 800 kg [1,760 pounds] of thorium (costing $50,000 at US $28.40 per pound), would produce 1,000 megaWatts of electricity for a year [using a molten salt reactor]." (Stated by Dr. David LeBlanc, Ottawa, Canada, Ottawa_Valley_Research_Associates_Ltd. in a Google lecture on Feb 19, 2009.)
- Comparing 3 million tons of coal priced at $40 per ton delivered with 1,760 pounds of thorium priced at $28.40 per pound, we have $120,000,000 for coal [divided by] $50,000 for thorium.
- So, heat from thorium is 2,400 times cheaper than heat from coal.
- Watch Dr. LeBlanc's Feb 19, 2009, Google lecture on this subject: http://www.youtube.com/watch?v=8F0tUDJ35So

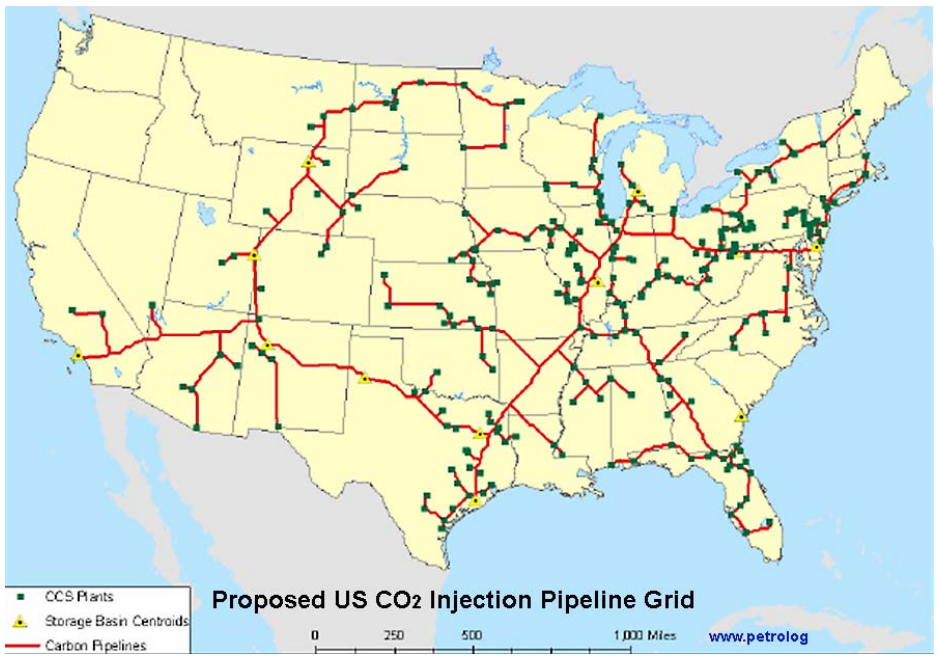
Carbon (CO_2) Markets

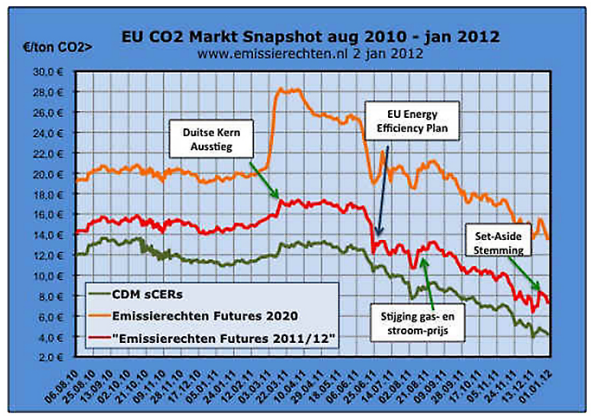
Enhanced oil recovery

Cap-and-Trade

Carbon Tax







Uses for hotter reactors

- **Replacing Coal, Natural Gas, and Oil Fires With Fire-Hot Molten Salt**
- **Powering plasma gasifiers to reduce almost anything organic to carbon**
- **Splitting water to obtain the hydrogen needed to upgrade almost any carbon to gasoline**
- **Loeffler Boiler Emulator - Replacing coal boilers in today's power plants (i.e., TECO's "Big Bend" power plant)**
- **Stirling Hot-Air Turbines - Replacing natural gas turbines in today's power plants (i.e., TECO's "Bayside" power plant)**
- **Molten Salt Reactor Heated Kiln – Many industrial applications - concrete**
- **Drive Brayton-Cycle helium gas turbines – more efficient electricity**