

TEAC8 St. Louis, 21-22 Aug. 2017

Dr. A. Cannara, cannara@sbcglobal.net

Topics...

- a) Nuclear-power support groups.
(participate & contribute \$)
- b) Ocean threats update.
- c) Nuclear-power and waste facts.
- d) IPCC is seeking reviewers for upcoming compendium on consequences of a 1.5C increase in global mean temperature:
<http://ipcc.ch/apps/comments/sr15/fod/register.php> Sign up by 18 Sept. 2017.

Dr. Alexander Cannara
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650-400-3071
19 Sep. 2017



Nuclear Groups

Facebook Groups...

Energy Reality Project
Nuke Warriors
The Ecomodernist
Ecomodernist Podcast
Nukes

Others...

ThoriumenergyAlliance.com*
HiroshimaSyndrome.com (acurate Fukushima info)*
AtomicInsights.com
EnvironmentalProgress.org
YesVY.blogspot.com (VT Yankee)
NuclearEnergyInsider.com
NuclearStreet.com
ThoriumEnergyWorld.com (itheo.org)
GenerationAtomic.org
Calioirniains for Green Nuclear Power (CGNP.org)*

* Means contribute some \$!

Important New Companies...

Terrestrial Energy:
<http://www.terrestrialenergy.com>
Thorcon: <http://thorconpower.com>
Moltex: www.moltexenergy.com
Elysium: <https://www.elysiumindustries.com>
NuScale: www.nuscalepower.com

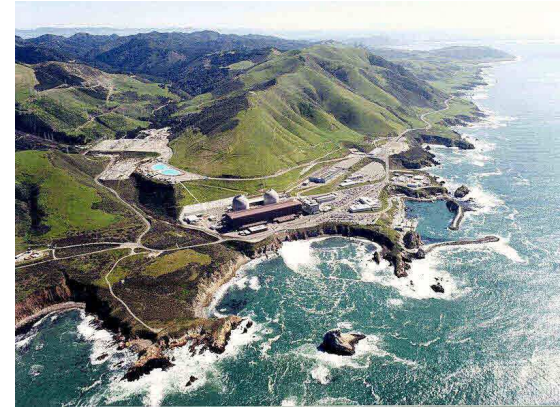


CGNP's Legal Filings

CGNP docs:

Calif. SB100 -- suggested amendments...

http://cgnp.org/cgnp_rec---amendmentsSB100.pdf



CGNP filings for the CPUC Diablo Canyon Proceeding...

http://www.cgnp.org/CGNP-OpeningBrief-A1608006_05-26-17.pdf

<http://cgnp.org/CGNP-Reply-Brief-A1608006.pdf>

http://www.cgnp.org/CGNP-OpeningBrief-A1608006_05-26-17.pdf

http://www.cgnp.org/CGNP_Direct_Testimony_01-27-17.pdf

http://www.cgnp.org/CGNP_Rebuttal_Testimony_03-17-17.pdf

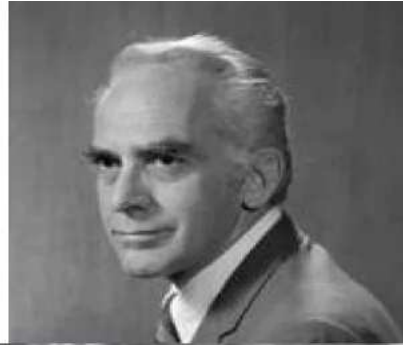
http://www.cgnp.org/CGNP_Direct_Testimony_Workpapers_01-28-17.pdf

http://www.cgnp.org/CGNP_Rebuttal_Testimony_Workpapers_03-17-17.zip

Sections (Scope) 2.2 & 2.6 in the above are most relevant to environmental inadequacies of 'renewables' and advantages of nuclear power.

Nuclear's Environmental Value

David Siri,
Sierra Club
Director,
1966



“Nuclear power is one of the chief long-term hopes for conservation...Cheap energy in unlimited quantities is one of the chief factors in allowing a large rapidly growing population to preserve wildlands, open space, and lands of high scenic value... With energy we can afford the luxury of setting aside lands from productive uses.”

The Sierra Club's motto was wisely: "Atoms, not dams", and Ansel Adams said: ***“Nuclear energy is the only practical alternative that we have to destroying the environment with oil and coal.”*** And, now we know, all 'renewables' require oil, coal, or gas to make up for more energy than they deliver.

Nuclear Power Safety

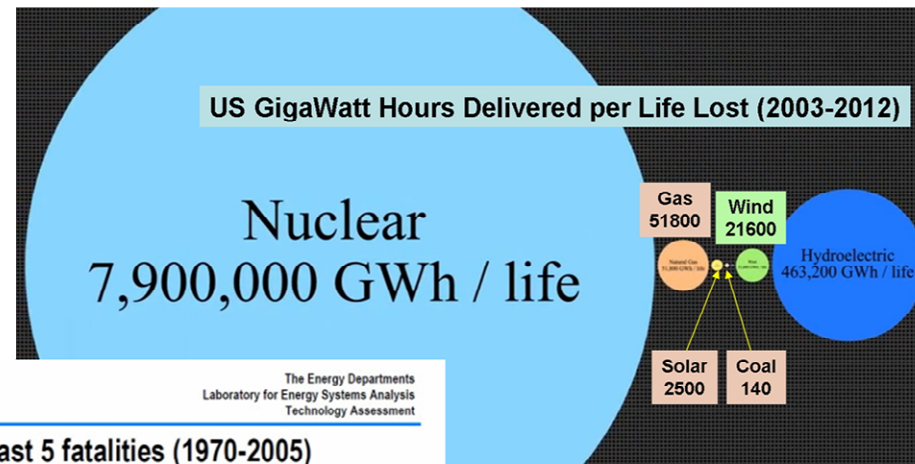
Present Civilian & Naval Nuclear Power is the Safest Form of Power Generation Ever Deployed by Humanity: PSI ENSAD 1998;

www.scientificamerican.com/article.cfm?id=the-human-cost-of-energy (2013)

<http://cen.acs.org/articles/91/web/2013/04/Nuclear-Power-Prevents-Deaths-Causes.html>

**Comparative
Power Source
Safety**

<http://thoriumremix.com/th/>



PAUL SCHERRER INSTITUT
PSI

The Energy Departments
Laboratory for Energy Systems Analysis
Technology Assessment

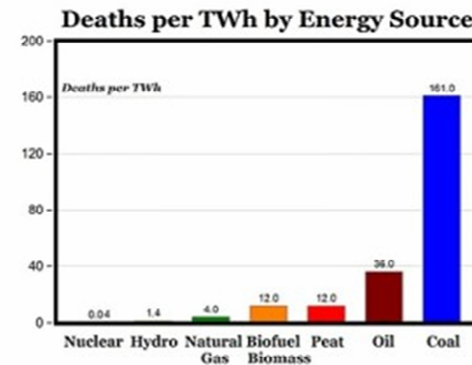
Severe accidents with at least 5 fatalities (1970-2005)

Energy chain	OECD		EU 27		non-OECD	
	Accidents	Fatalities	Accidents	Fatalities	Accidents	Fatalities
Coal	81	2123	41	942	144 1363 (a)	5360 24'456 (a)
Oil	174	3388	64	1236	308	17'990
Natural Gas	103	1204	33	337	61	1366
LPG	59	1875	20	559	61	2636
Hydro	1	14	1	116 (b)	12	30'007 (c)
Nuclear	—	—	—	—	1	31 (d)

- (a) First line: coal non-OECD without China; second line: coal China
 (b) Belci dam Romania (1991)
 (c) Banqiao and Shimantan dam failures alone caused 26'000 fatalities
 (d) Latent fatalities treated separately

Burgherr & Hirschberg, 2008

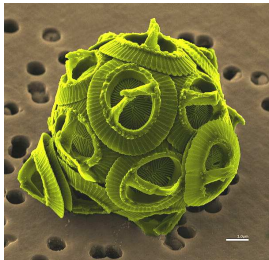
IDRC, 25 - 29 August 2008, Davos, Switzerland



Oceans: Heat, pH, Oxygen

TEAC8, <http://tinyurl.com/zprh78l> (2015) <http://tinyurl.com/hhlrd4o>

What we must know to prevent oceanic extinctions, on track to occur by 2050.



**“Let’s work the problem.
Let’s not make things worse by guessing.”**



***Eugene Kranz,
Apollo 13
Flight Director,
April 1970.***

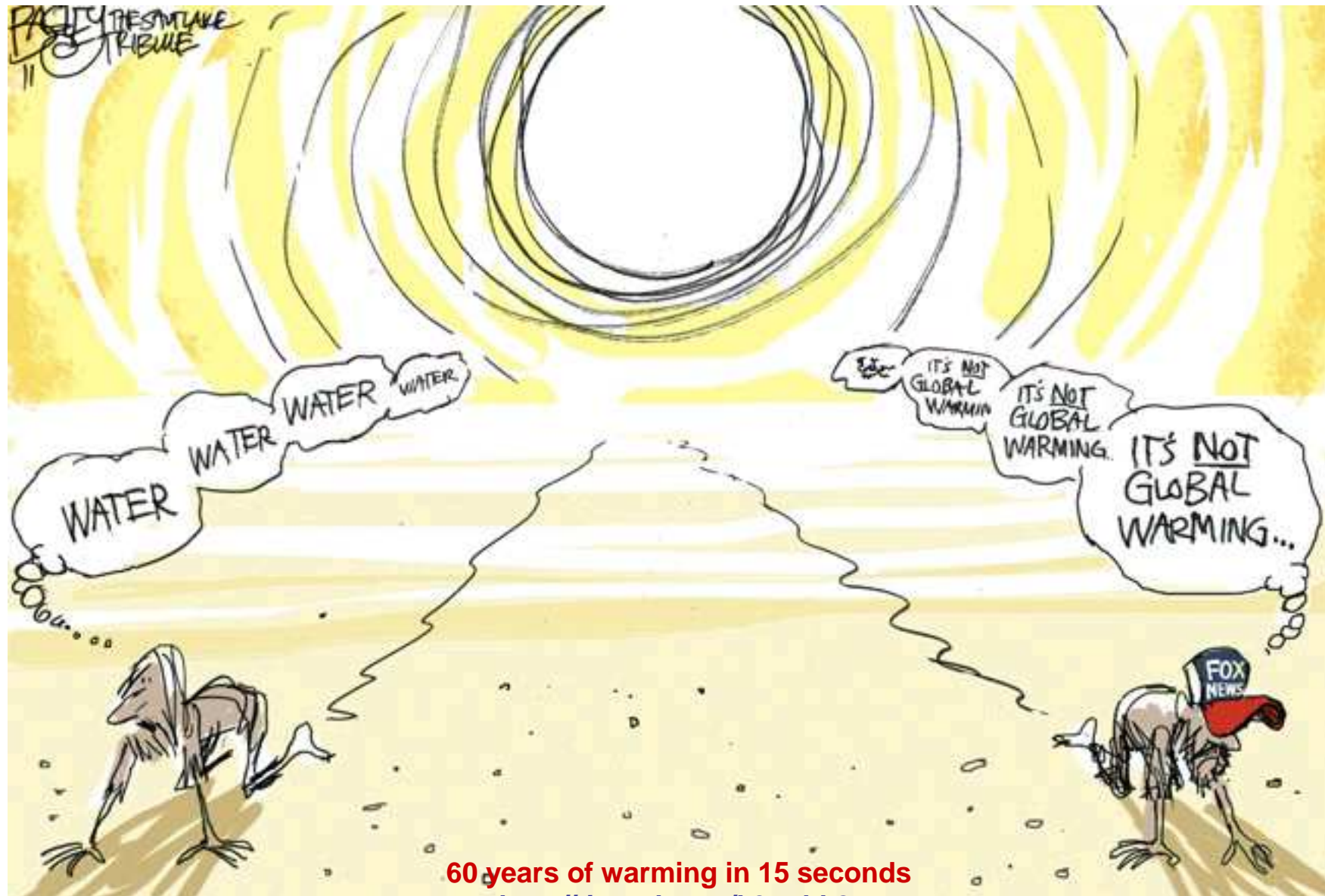


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18 Sep. 2017

Why Energy From Fire Must Go

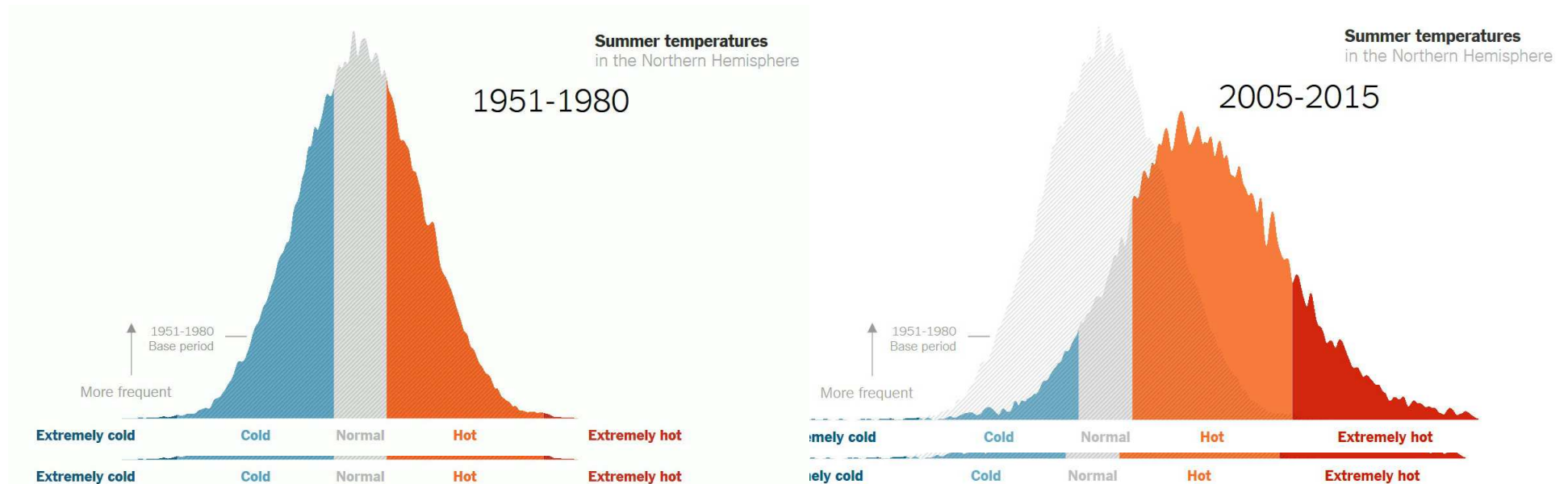


60 years of warming in 15 seconds

<http://tinyurl.com/k3guhk2>

Warming (1951-2015)

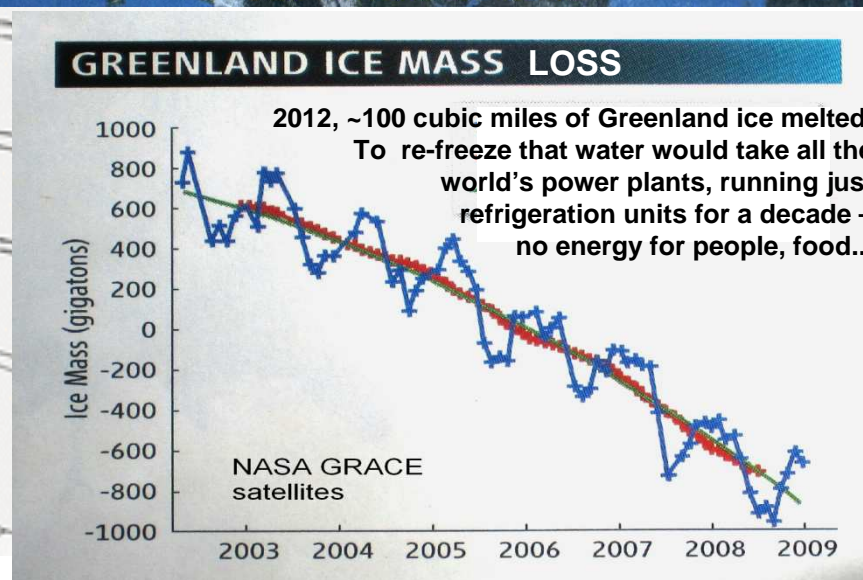
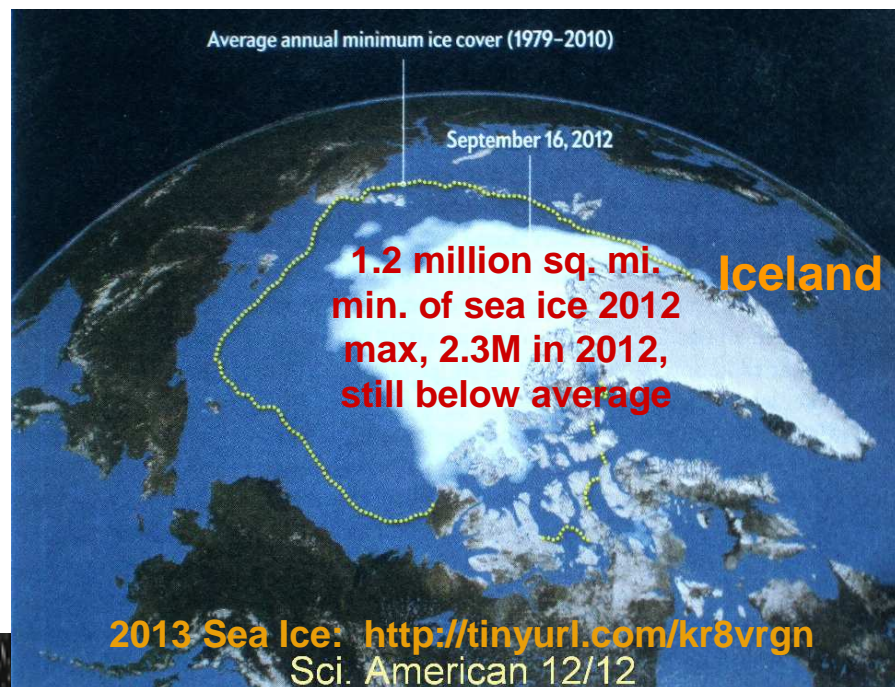
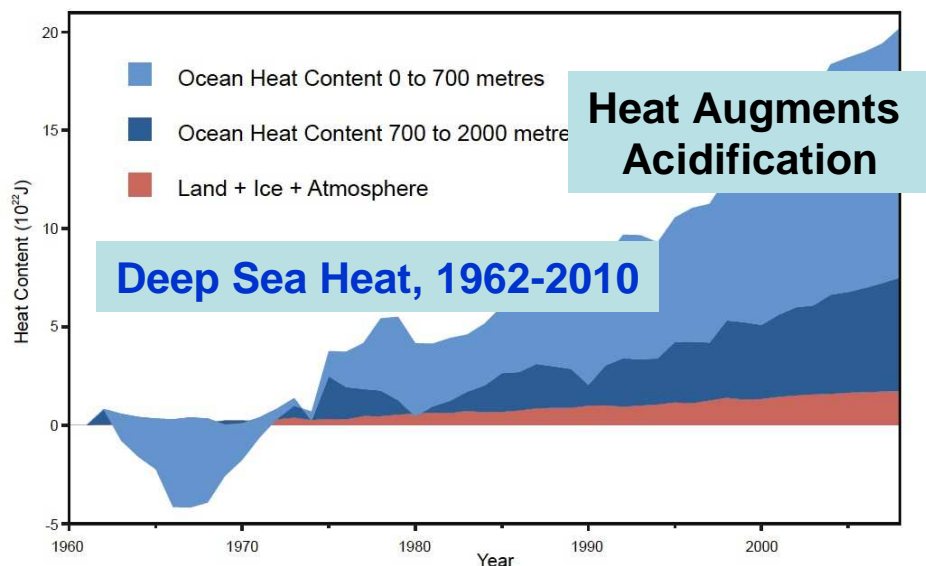
<http://tinyurl.com/yaaewjkm>
(note animation)



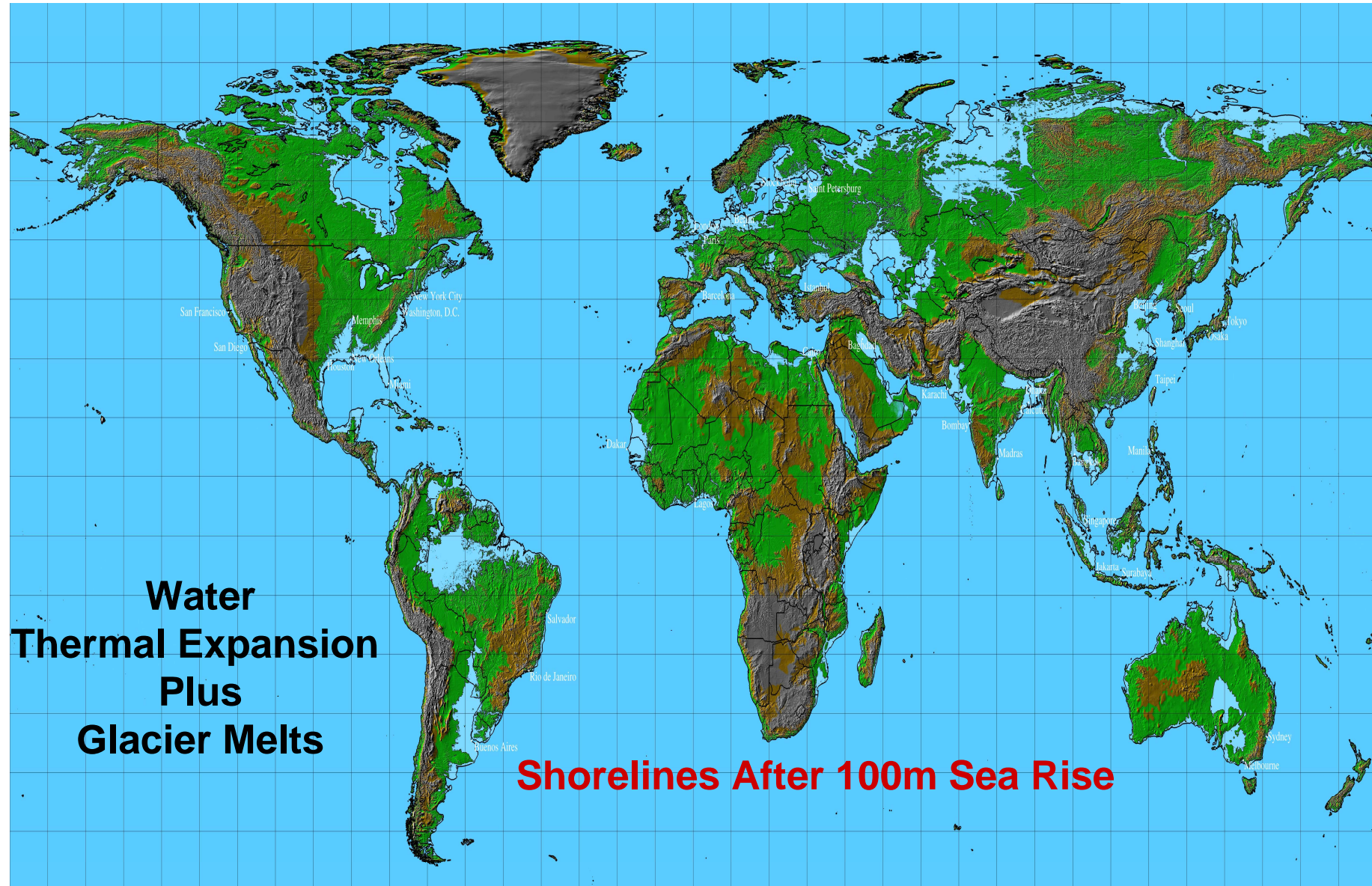
Extraordinarily hot summers (red), that were virtually unheard-of in the 1950s, have become commonplace.

Northern Hemisphere

Emissions Effects: Sea Warming



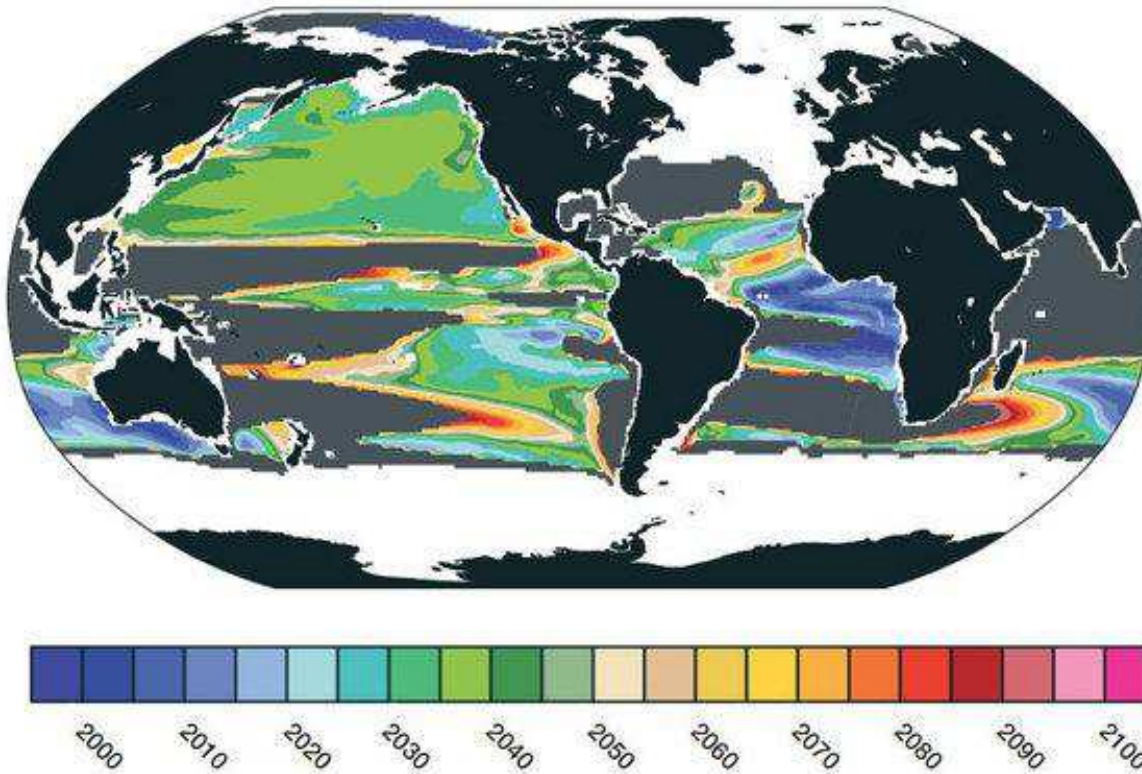
Warming => Sea Rise



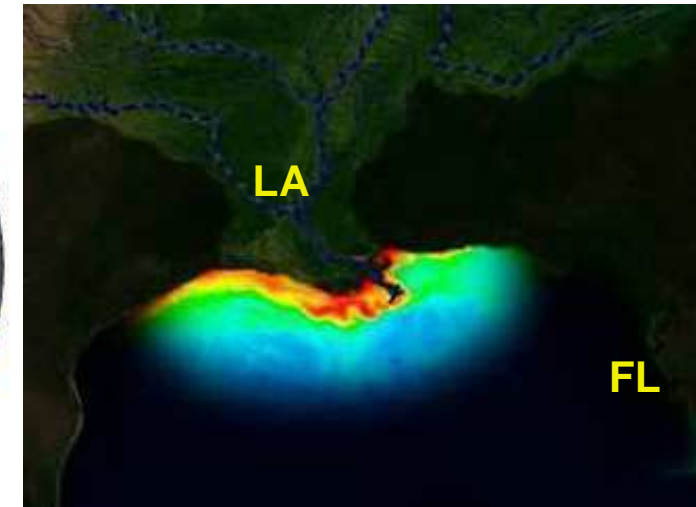
Oceanic Oxygen Loss & Extinctions

Oxygen loss in the oceans

Timeframe when ocean deoxygenation due to climate change is expected to become detectable



Gulf of Mexico & Mississippi Dead Zone



<http://tinyurl.com/z8dahhk> (above), <http://tinyurl.com/yd6mkoec> and...

“A short history of ocean acidification science in the 20th century: a chemist’s view”, P. Brewer, 2013, www.biogeosciences.net/10/7411/2013/

Warming/Acidification Warnings

- Tyndall & Chamberlin (1800s)...

- www.aip.org/history/climate/co2.htm

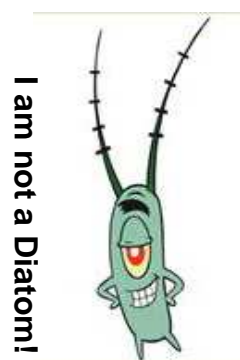
- <https://theconversation.com/life-on-earth-was-nothing-but-slime-for-a-boring-billion-years-23358>

- “How Oxygen Stifled Animal’s Emergence”, AAAS Science, 31 Oct. 2014, p537.

While Each CO₂ Molecule Stays in Air, It Heats Air ~100,000 Times More Than The Energy Released When Its C Was Burned

- Arrhenius (1896, 1905)...

CO₂ + H₂O => H₂CO₃ = Carbonic Acid



*On the Influence of Carbonic Acid
in the Air upon the Temperature of
the Ground*

Svante Arrhenius

Philosophical Magazine and Journal of Science
Series 5, Volume 41, April 1896, pages 237-276.

LONDON, EDINBURGH, AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND
JOURNAL OF SCIENCE.

[FIFTH SERIES.]

APRIL 1896.

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

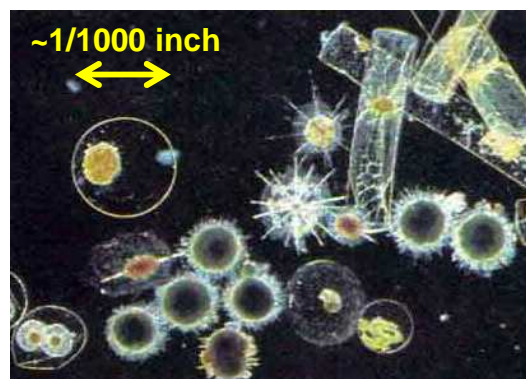
I. Introduction : Observations of Langley on Atmospheric Absorption.

A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall† in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of the temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier‡ maintained that the atmosphere acts like the glass of a hot-house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet§; and Langley was by some of his researches led to the view, that “the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to –200° C., if that atmosphere did not possess the quality of selective

“Carbonic Acid” is what CO₂ makes when combined with water – soda pop.

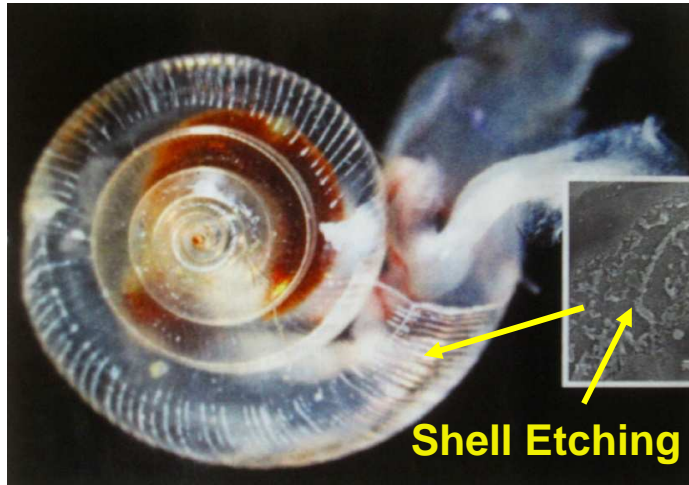
Since seas dissolve CO₂ well, they become more acidic every year we overload the natural Carbon Cycle (among plants, air, water & land) by burning fossil Carbon compounds made millions of years ago by plants, especially ocean Plankton...

Plankton are the initial prey for almost all fish larvae. Their Carbonate shells sink when they die, removing Carbon to sea floors & they make most of our Oxygen.



Acidification

"Lethal Seas" -- PBS Nova 2015



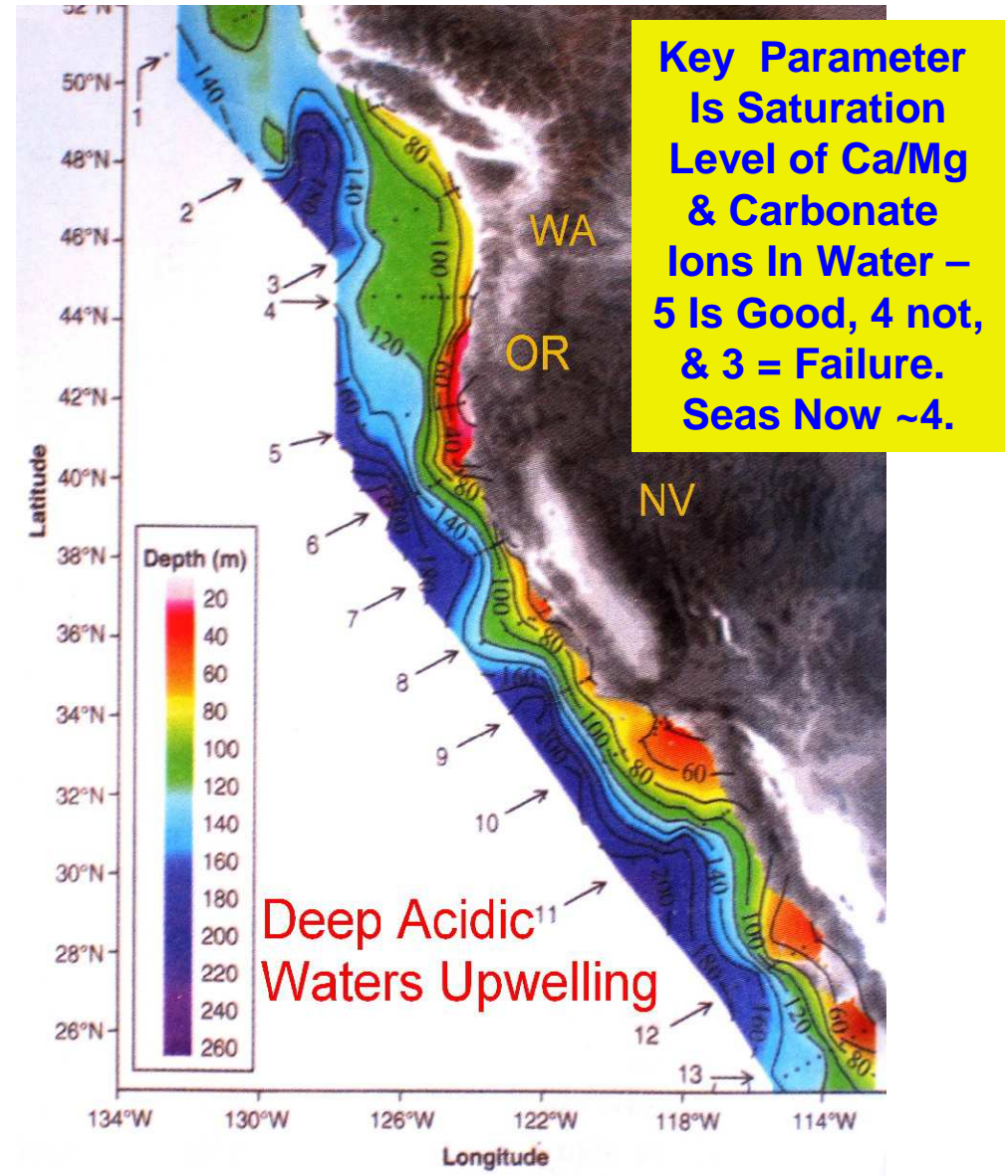
AAAS Science, Vol 344, 9 May 2014, p569

Oyster Stress, <http://tinyurl.com/lqrj5v7>
<http://tinyurl.com/pfjc4ud>



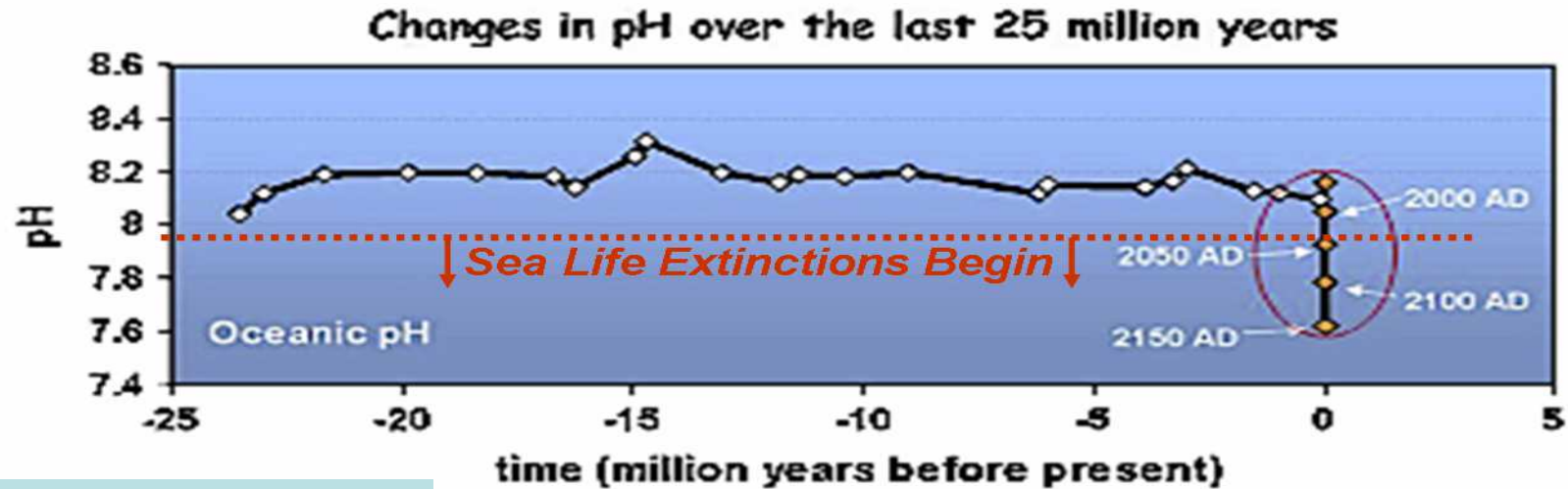
Also see April 2013 Scientific American

www.tos.org/oceanography/archive/22-4_kump.html



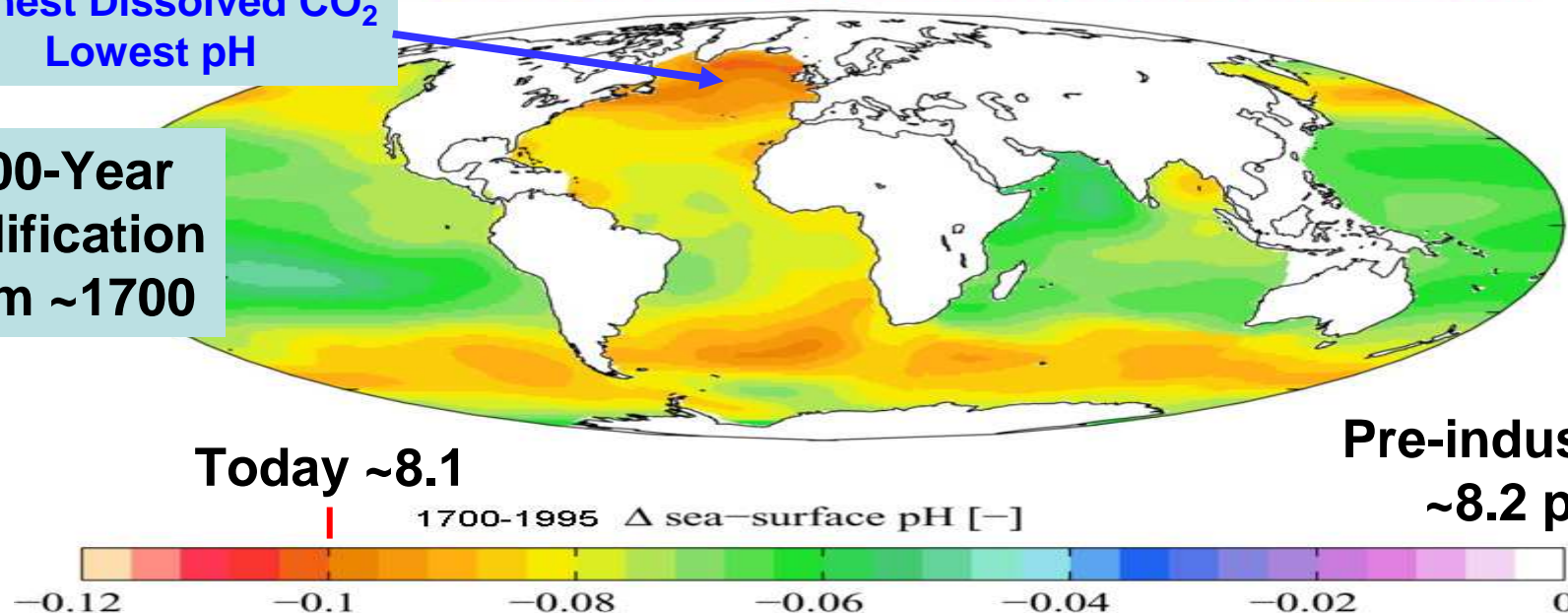
Emissions Effects: Sea Chemistry

Oceans are Acidifying Fast -- Ceasing All CO₂ Emissions Has Little Effect

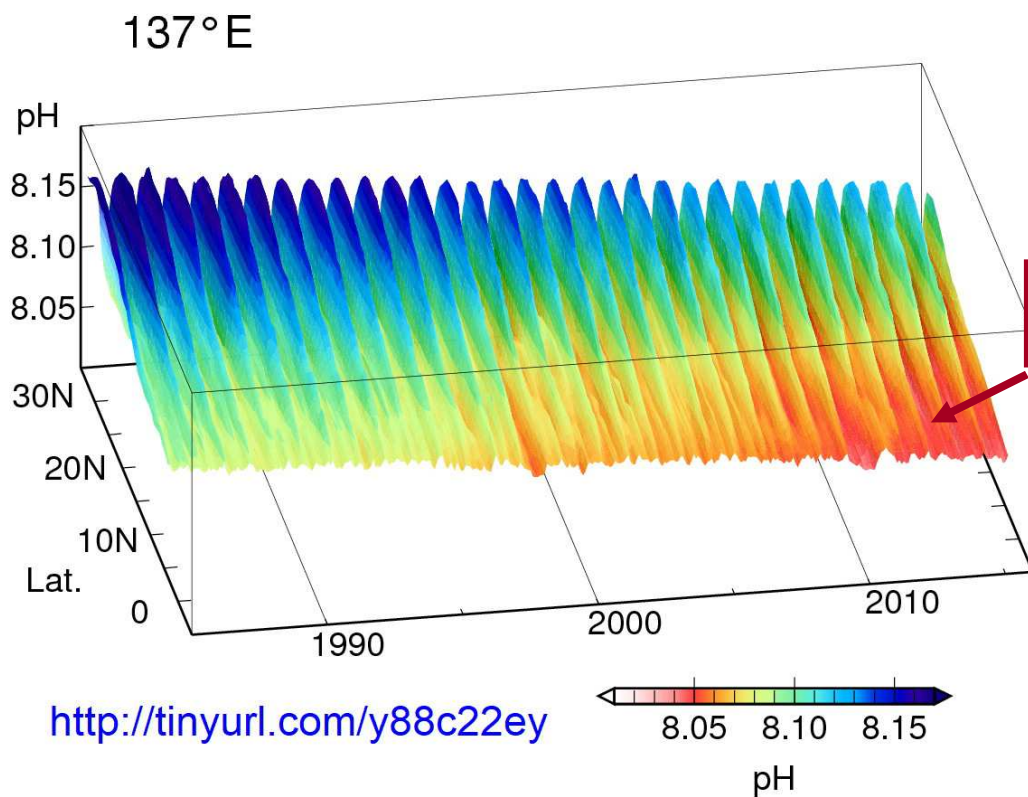


Highest Dissolved CO₂
Lowest pH

~300-Year
Acidification
From ~1700

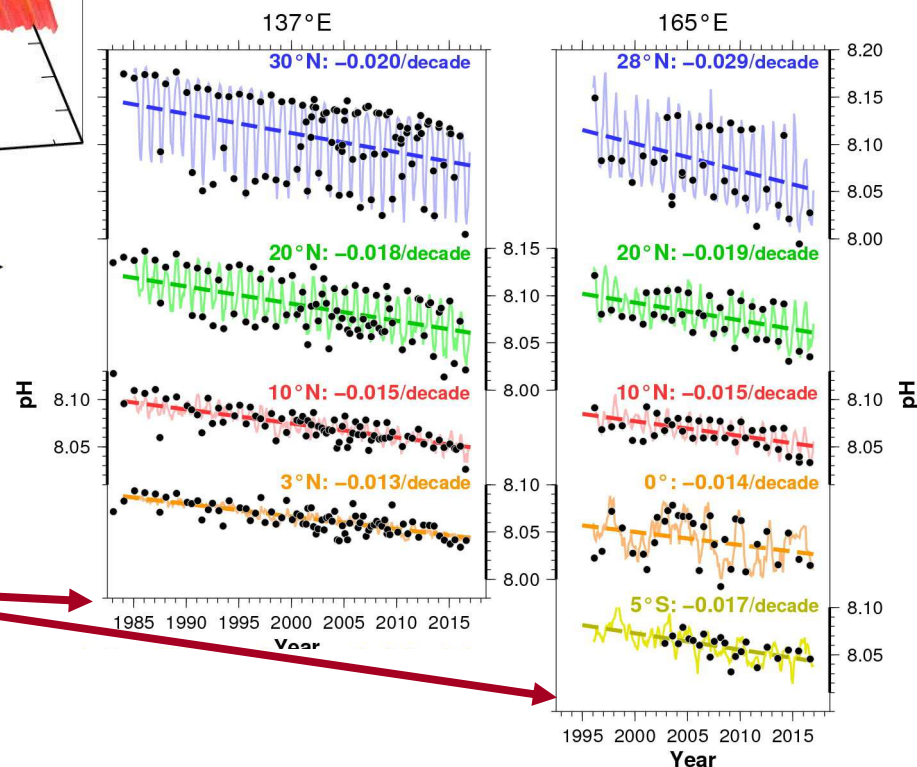


Western Pacific pH 1986-2016

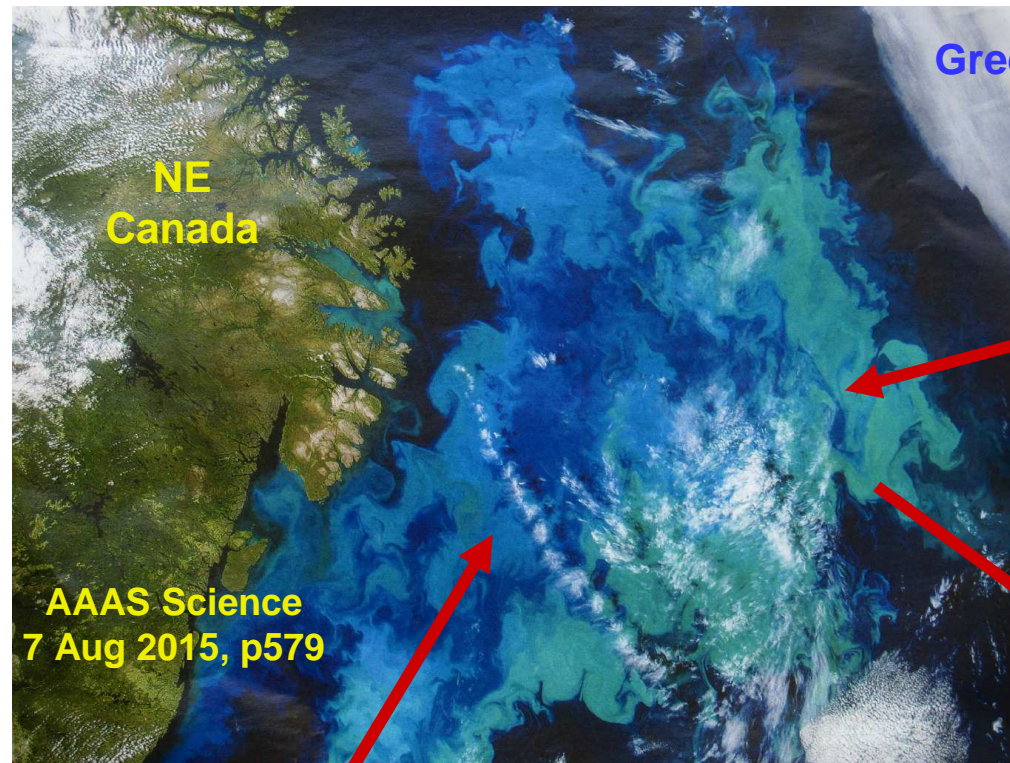


Extinctions Below 8.0pH

Extinctions Below 8.0pH

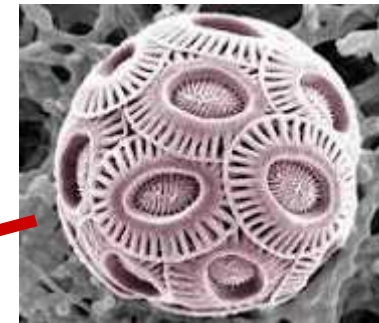


Emissions Effects: Algal Blooms



Greenland

~0.000001 Meter

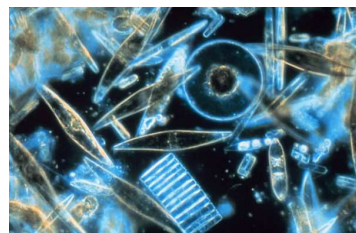
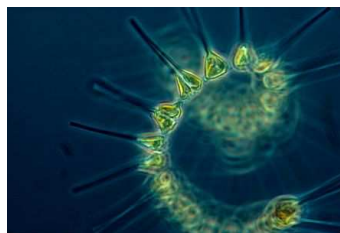


Coccolith:
Calcite Shields
Around Single
Algal Cell of
*Emiliana
Huxleyi*

<https://en.wikipedia.org/wiki/Coccolith>

AAAS Science
7 Aug 2015, p579

Arctic Algae Blooms 2015



<https://en.wikipedia.org/wiki/Phytoplankton>

Ocean Food Chain:
Sun & Plankton
to Krill, Fish,
Whales, Birds;
pH >8.0

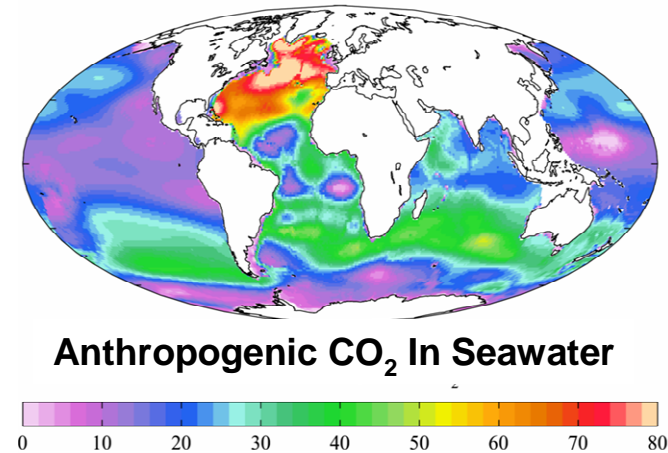
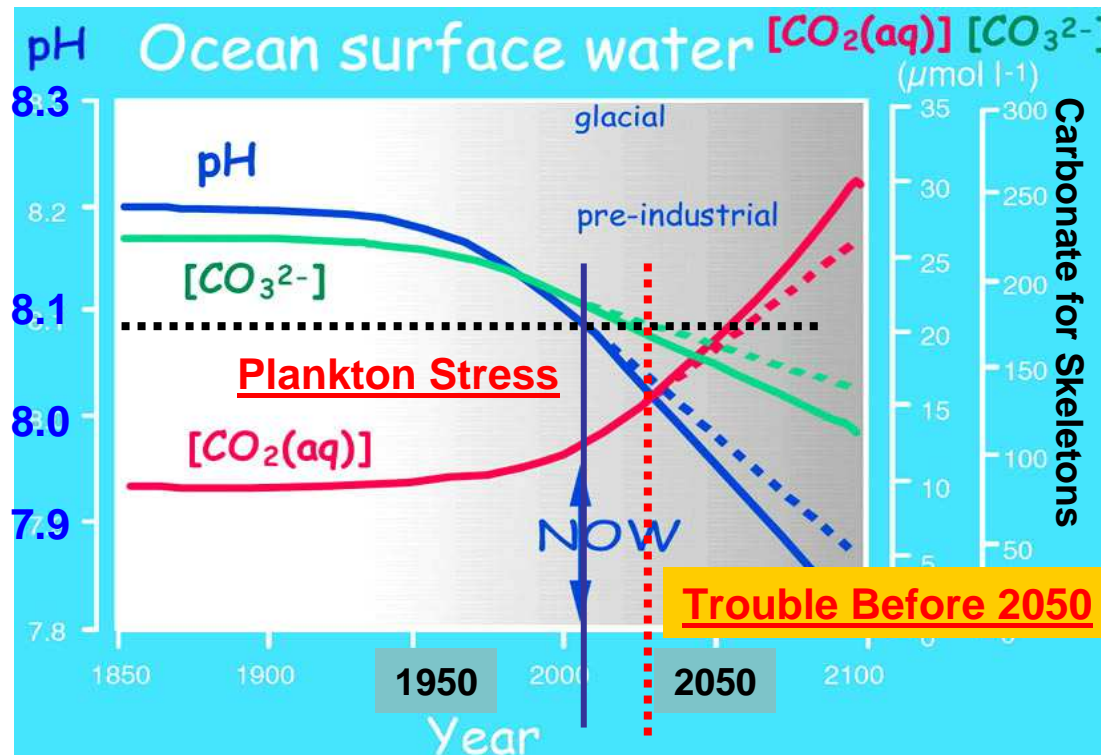
The hexacopter
observed humpback
whales engaging in
"bubble-net feeding."



Acidification & Extinctions

~30% of all ~1.5 trillion tons of CO₂ emissions are now in oceans creating less alkaline seawater, affecting entire sea food chains -- sea life provides ~20% of all human food protein – “The Sixth Extinction” by Kolbert 2014

www.kqed.org/a/forum/R201405260900



Anthropogenic CO₂ In Seawater



Deformed Larvae

www.ocean-acidification.net/

<http://tinyurl.com/6mtd8db>

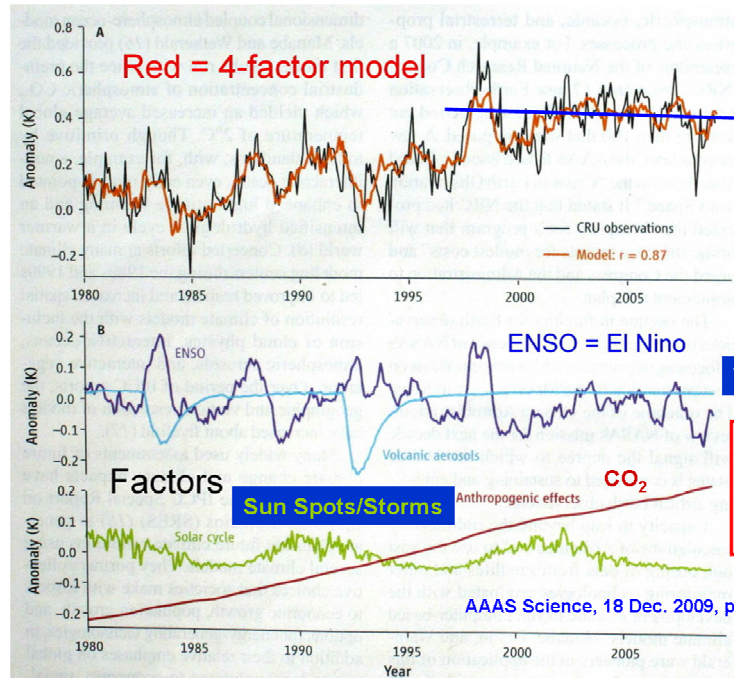
www.noaa.gov/video/administrator/acidification/index.html

www.bbc.co.uk/news/science-environment-18938002

Normal Larvae:

Warmer, acidifying North Atlantic

Temperature History

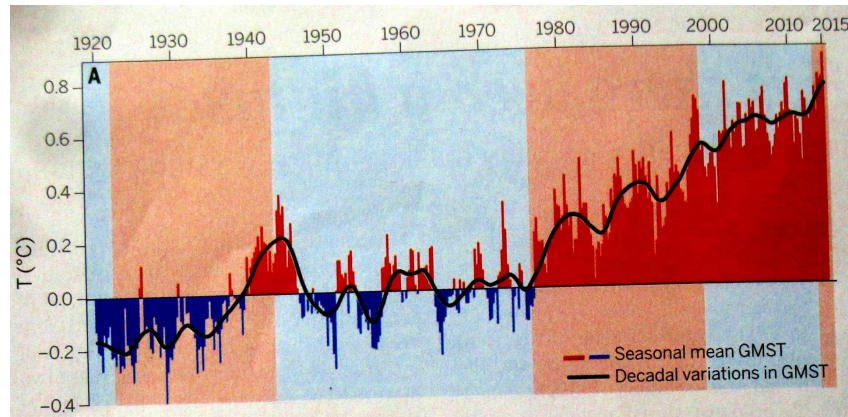
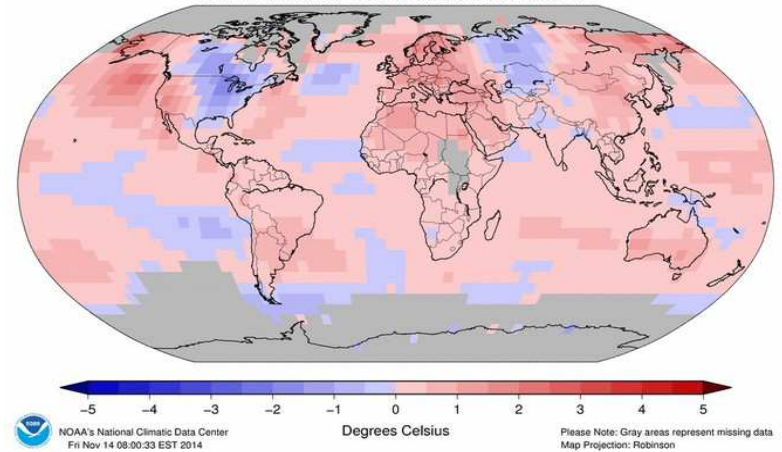


Climate Deniers'
Imagined Period
of No Warming

But Taking CO₂
Out of Model Says
We Should Have
Seen Great Cooling

AAAS Science, 18 Dec. 2009, pp1646-1655

Land & Ocean Temperature Departure from Average Jan–Oct 2014
(with respect to a 1981–2010 base period)
Data Source: GHCN–M version 3.2.2 & ERSST version 3b



Average temperature and carbon dioxide increases 1880-2010

Global averages

Temperature

58.5°F

58.0°F

57.5°F

57.0°F

56.5°F

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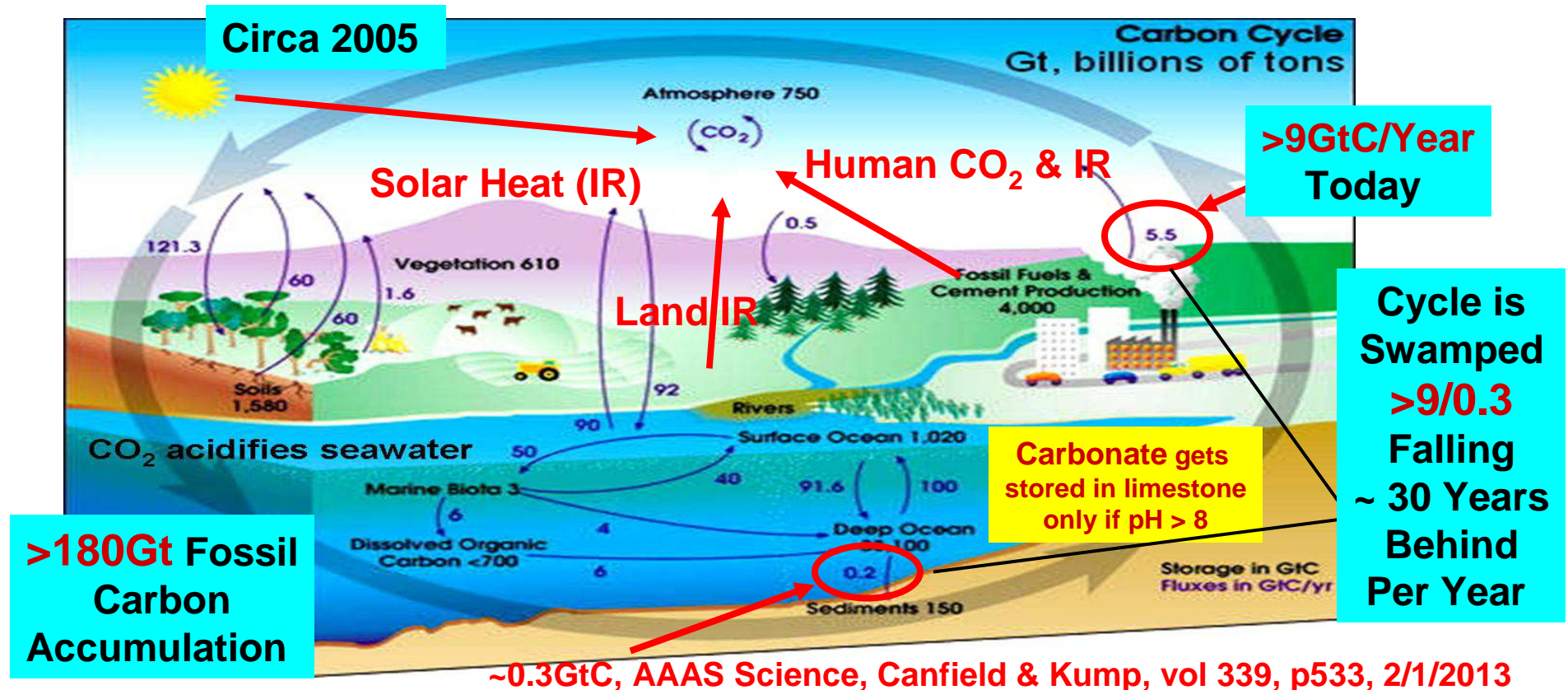
Acidification & Remediation (**3 Numbers**)

Cyanobacteria, plankton & algae produced most of the Oxygen we have to breathe & use, starting >2 billion years ago, with earliest photosynthesizing ocean life. Land plants later evolved & helped. All fossil fuels we dig up were made from plant decay. Carbon emissions today are **>9GtC** (>30Gt CO₂)

www.ocean-acidification.net

www.atmo.arizona.edu/courses/fall07/atmo551a/pdf/CarbonCycle.pdf

www.annualreviews.org/doi/abs/10.1146/annurev.earth.031208.100206?journalCode=earth



C & CO₂ Emissions (2013)

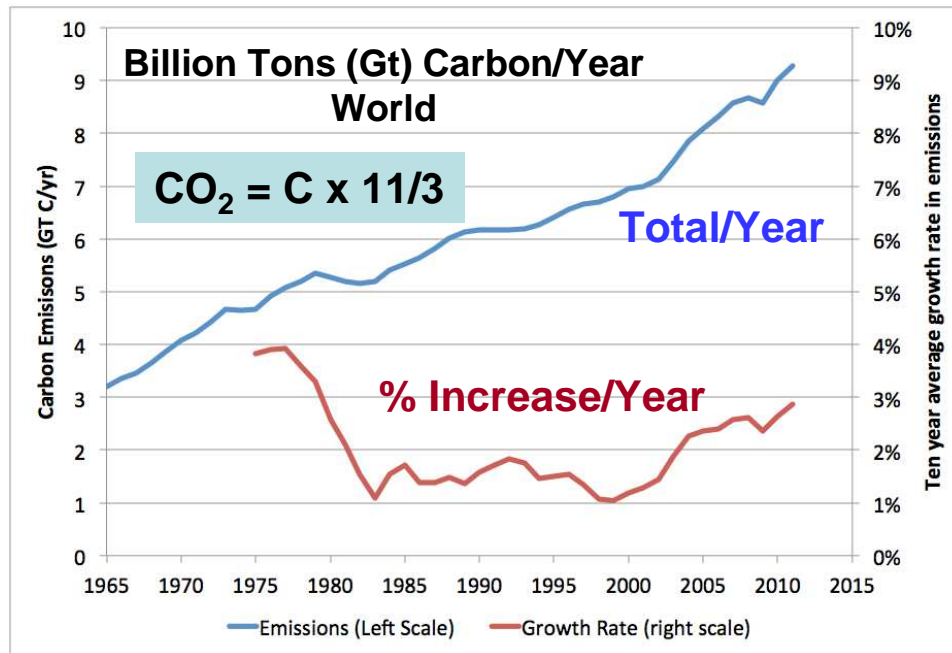
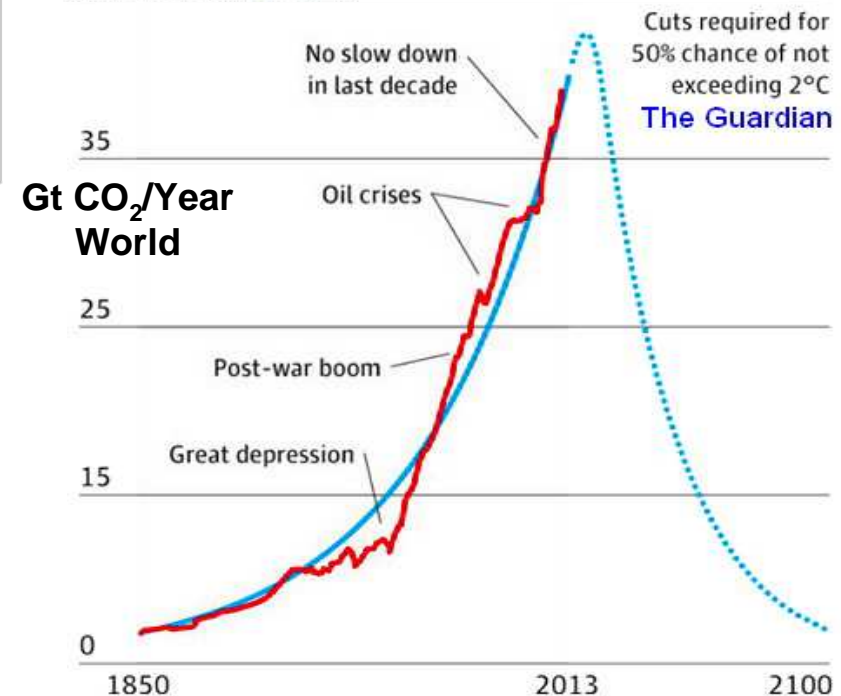
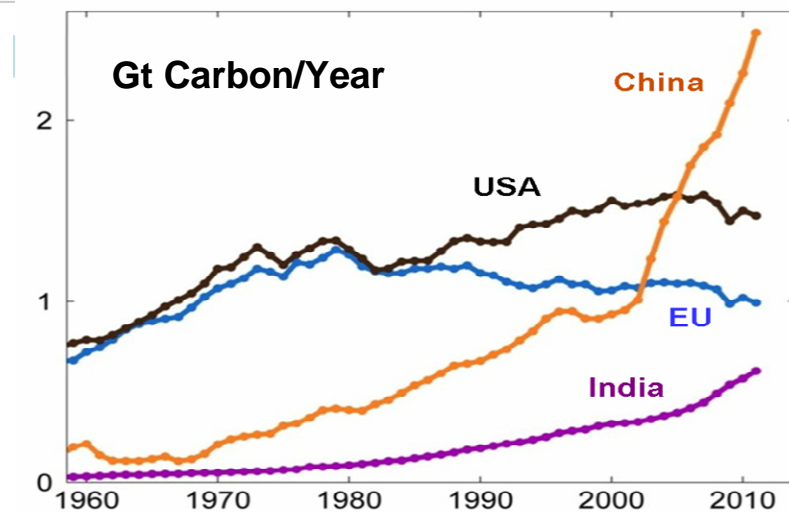
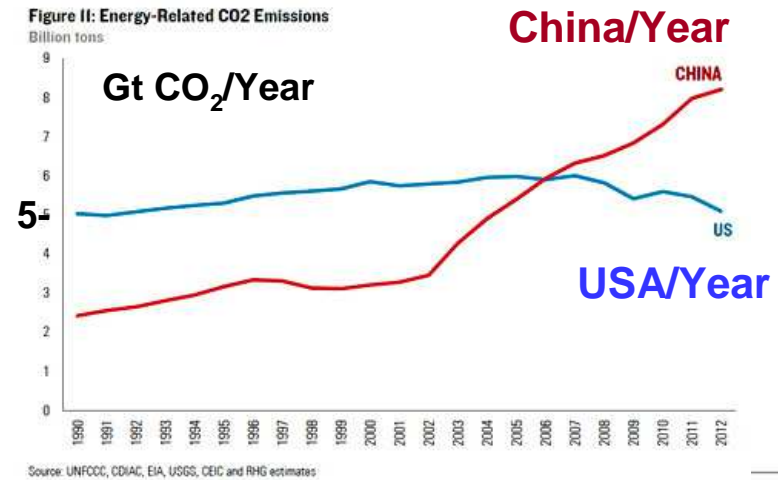
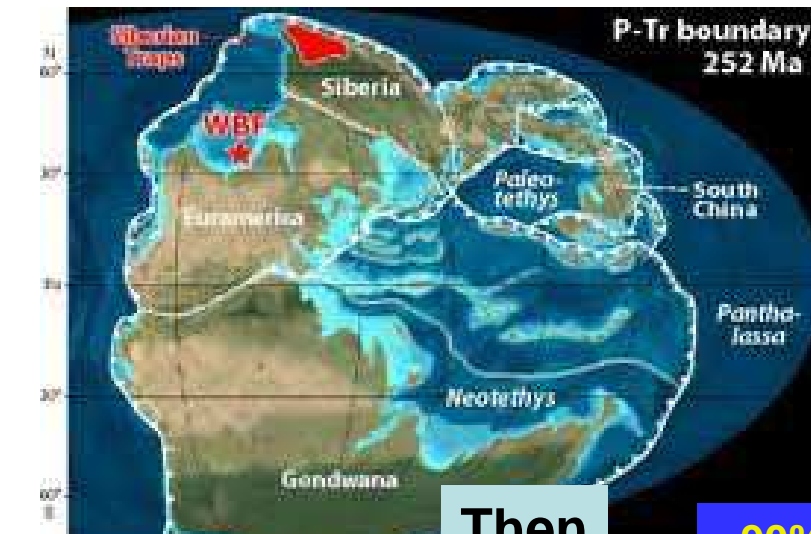


Figure II: Energy-Related CO₂ Emissions



CO₂ & 1,000,000 Sq. Miles of Basalt



Coal, laid down in Carboniferous was ignited & burned underground for thousands of years.



Then

~90% of Species Gone

Now



Emissions Now Just as High



Siberian Traps

Lime Cycle & Cement Making

Possible CO₂ Sequestration to Basalt

Sodium aluminate: NaAlO_2 , Na_5AlO_4 , $\text{Na}_7\text{Al}_3\text{O}_8$...
Tricalcium aluminate: $\text{Ca}_3\text{Al}_2\text{O}_6$ plus many possible mixed oxides with B, Be, Mg...

750g

Limestone (750gr)

Silica (150gr)

Aluminate (50gr)

Iron (50gr)

1
Grind and carefully mix the ingredients.

1kg

48%)

CO₂ 360g

2
~300kWhr/ton
~1500C

4 Add 50 g of gypsum

Gypsum
 $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

3
Cool rapidly

640g

5
Grind the mixture into a fine powder.

690g

6
Cement

This will give you 690 g Portland cement. Store in dry conditions until ready for use.

CO₂

Carbonated

Limestone
 CaCO_3

Heated

Slaked lime
 Ca(OH)_2

Quicklime
 CaO

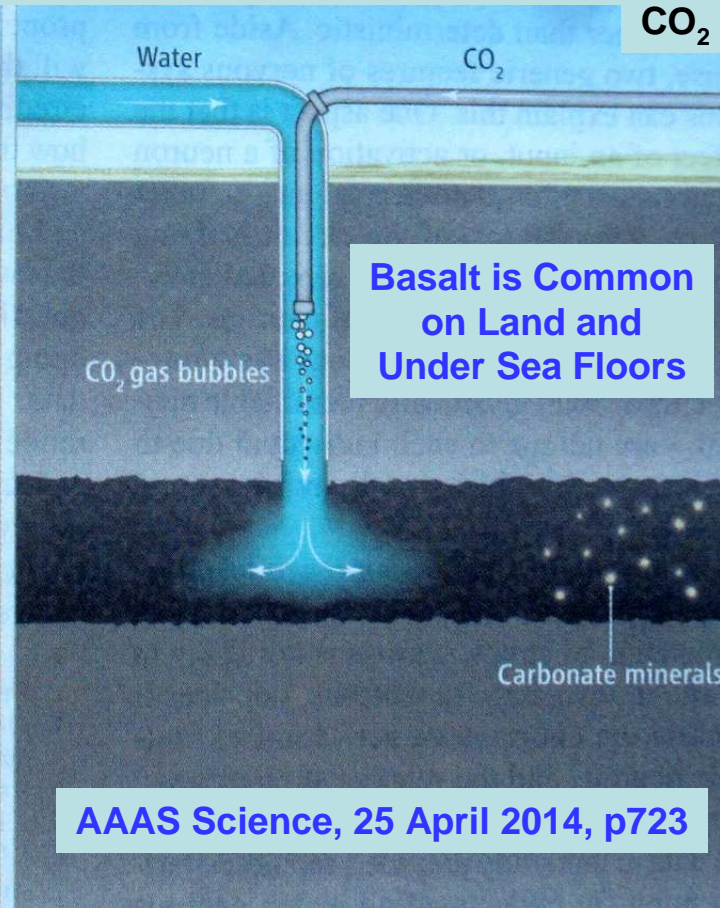
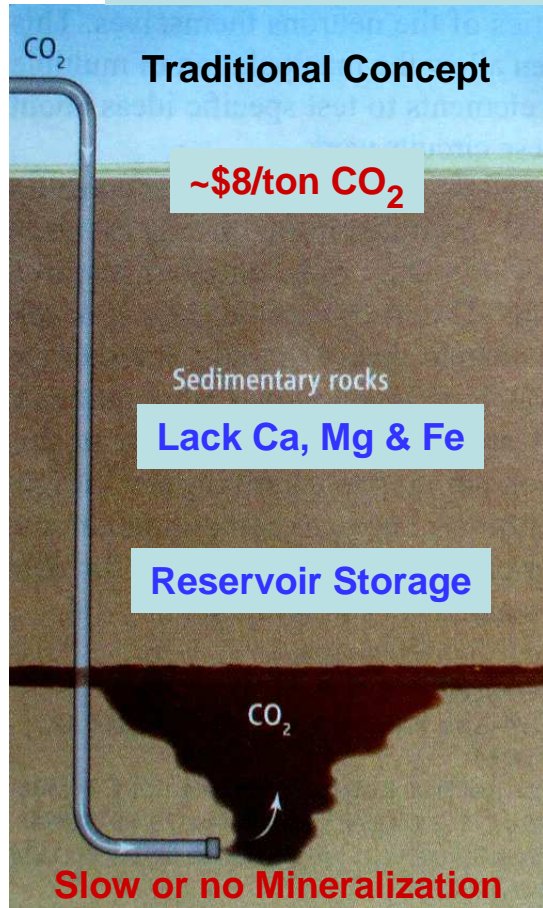
Water added

Wikipedia

**CaO Yield = 390/750
= 52% (no additives)
~5000 tons/day/plant**

CO₂ Sequestered to Basalt

CO₂ Capture from Emissions Sources ~\$60-120/ton



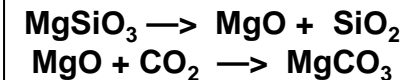
CO₂ Input = 5% of H₂O

~\$17/ton CO₂

Present EU Carbon Trades at ~\$7/ton

Porous Basalt Can Hold >50kg/m³ CO₂ as Permanent Carbonates

Example Reactions



Can also crush basalt with high alkali content and distribute in seas, If biologically safe.



Basalt is ~25% Ca, Mg & Fe Oxides.

Projects: Carbfix, 2012 in Iceland & BSCP, 2013 in Wallula, Washington

<http://tinyurl.com/hk6yxgv>

Env. Sci. & Tech. Ltrs. 2016; 10.1021/acs.estlett.6b00387

Areas Needed to Replace US Fossil Fuels

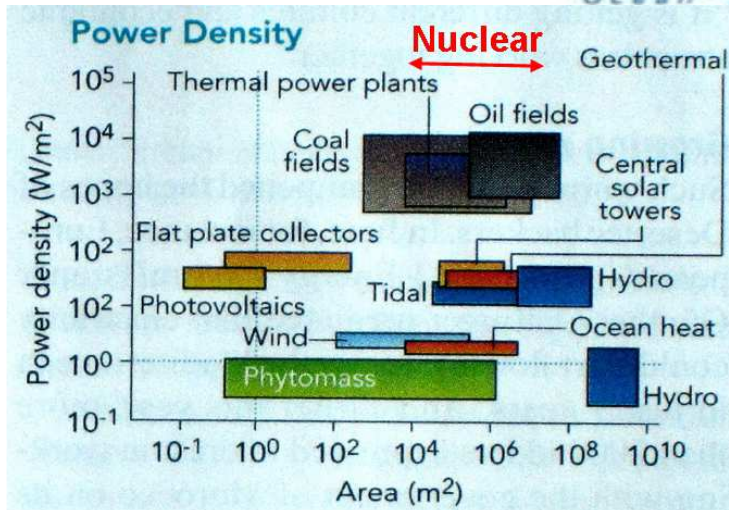
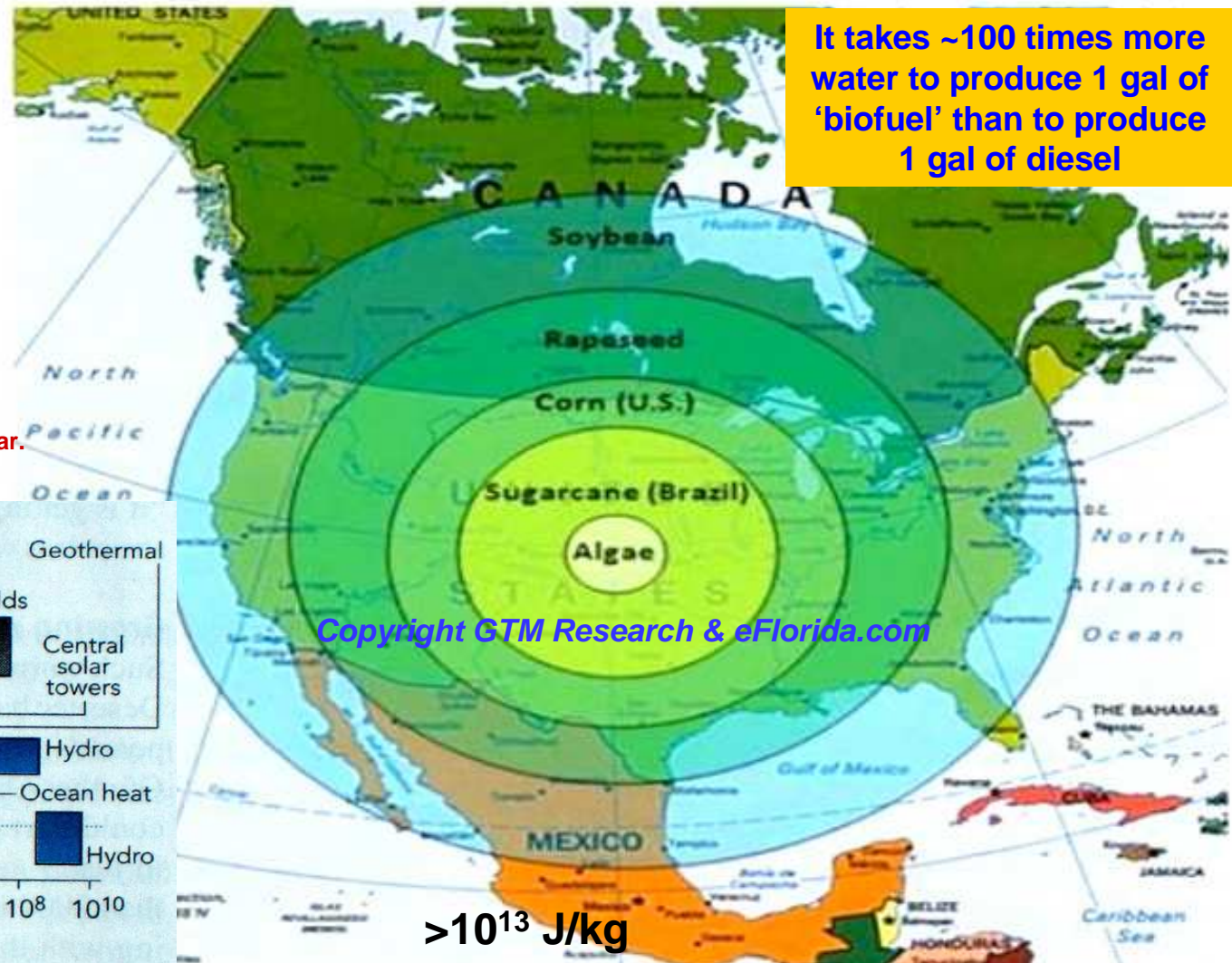
Area Needed
for Nuclear*



Area Needed for Solar PV*
(Wind is much larger)

* All mining, construction, power & vehicular uses included in nuclear & solar.

It takes ~100 times more water to produce 1 gal of 'biofuel' than to produce 1 gal of diesel



$>10^{13}$ J/kg

Combustion

Fission

Fusion

~10kWhr/lb

$\times 1,000,000$



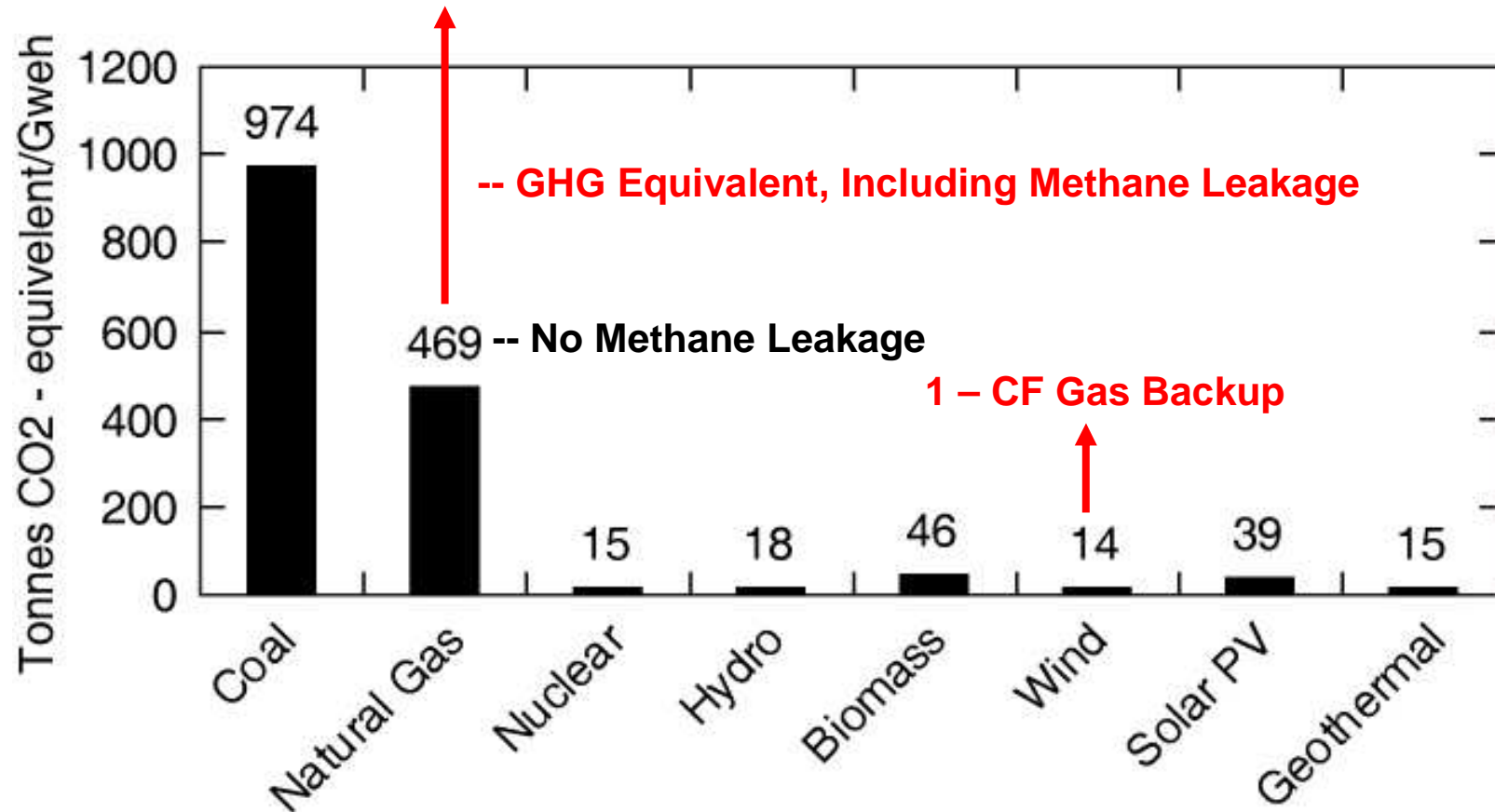
~3GWhr/lb

$\times 100$



~ 10^{11} Whr/lb

Lifecycle CO₂ Emissions

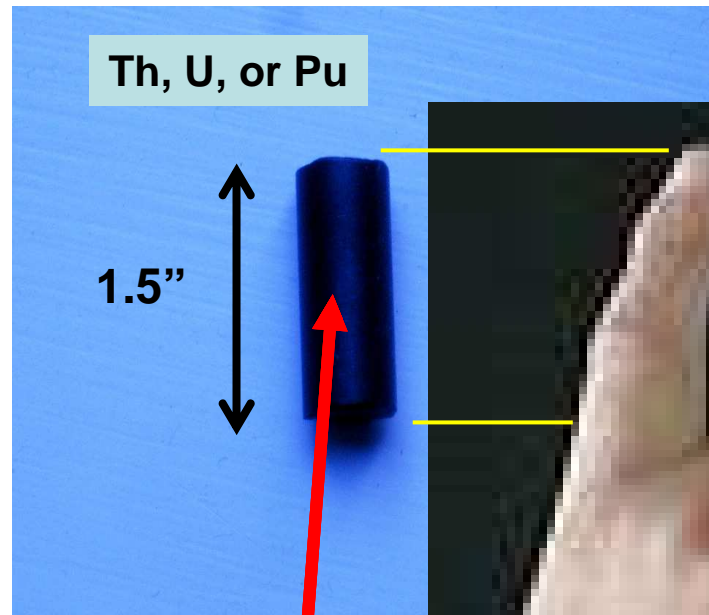


Courtesy Burton Richter -- Comparison of Life Cycle Emissions in Metric Tonnes of CO₂e per GW-hour for various modes of Electricity Production; P.J. Meier, *Life-Cycle Assessment of electricity Generation Systems with Applications for Climate Change Policy Analysis*,

Remediation – The Numbers

- Processing limestone/dolomite to lime ~300kWHrs/ton
- Lime transport to ocean (rail 0.085kWHr/ton-mile + ship 4kWHr/ton-mile)
- CO₂ cracking (assume electrochemical reduction of at least 505 kJ/mole ~1.5GJ/ton ~420kWHrs/ton)
- H₂O cracking -- @2000C, or electrolysis @850C 225 GJ/ton H₂ (64% efficient incl electricity gen)
- C-H compound reforming (use H₂O cracking heat)
 - Fuels (for critical uses – aircraft, etc.)
 - Feedstocks (petroleum/gas/coal substitutes)
 - For geologic sequestration (waxes – C₂₅+))
- Assume **remediate 10% of yearly CO₂ emissions = 3Gt**
 - $(3 \times 10^9 (1 + 1.5) \times 10^9) \times 2.8 \times 10^{-7} = 700 \text{ TWHrs} + \text{H}_2\text{O cracking}$
 - **~90, 1GWe 0-emission powerplants + H₂O cracking energy**

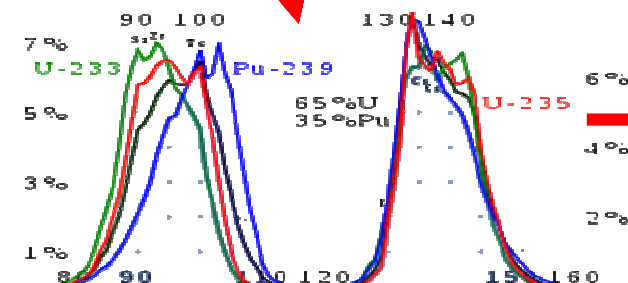
Nuclear Waste



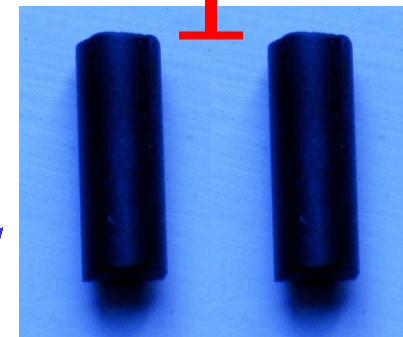
All US fission waste

All 57 years of
US nuclear
power's
true waste

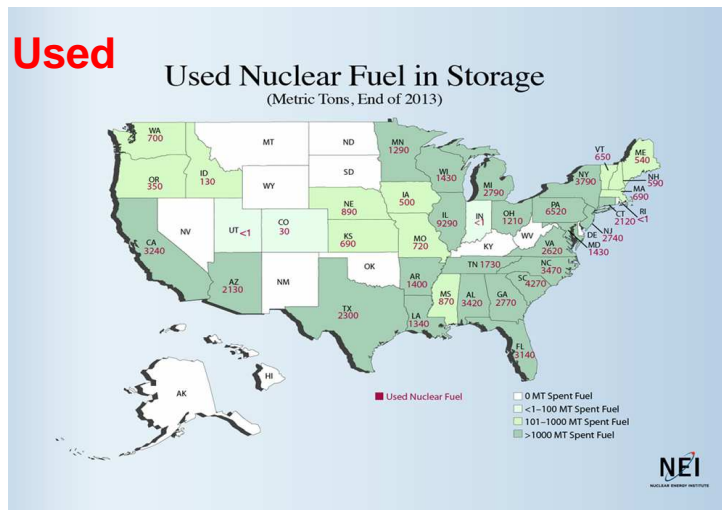
This ~20g of fissile, whether from Thorium, Uranium or Plutonium, releases all the energy needed by a US citizen for a decade – all energy needs for 10 years.



The result is two 'pinkies' of fission products, (per Avogadro) which are already stable, or mostly radioactive for hundreds of years, not thousands.



Used 'Spent' Fuel = Not Waste



>74,000 tons = 1 football field

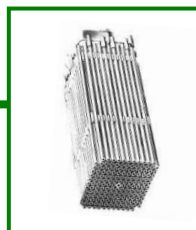
Enrichment >500,000 tons pure U238

Used + unused Uranium = >570,000 GW-years of clean energy, when used to breed new fuel for fast-neutron reactors (IFR, EBR, MSFR...)

“...and...make possible the exploitation of the vast energy resources latent in the fertile materials, uranium-238 and thorium.” – Glenn Seaborg to JFK, 1962.



Used LWR Fuel Bundle



>95% Not Waste: ~1% unused fissile fuel, ~4% fission products, ~95% Uranium, and <1% transuranics.

Natural Fission

The mountains in Oklo, south-eastern Gabon are home to several natural ^{235}U fission reactors. They operated about 2 billion years ago, when the 700-million-year half life of that isotope would have meant it was about 8 times as abundant in typical rock containing Uranium ore. The Earth's growing *atmospheric Oxygen content, water & bacteria concentrated UO_2 enough that rainfall & groundwater acted as a neutron moderator to enhance fission* by slowing neutrons to 'thermal' speeds, making their capture by ^{235}U nuclei more probable. When water stopped flowing, the reactors stopped fissioning. When it flowed again, they restarted. The site is now useful to judge stability of fission wastes. Niger & Gabon have very significant U deposits.



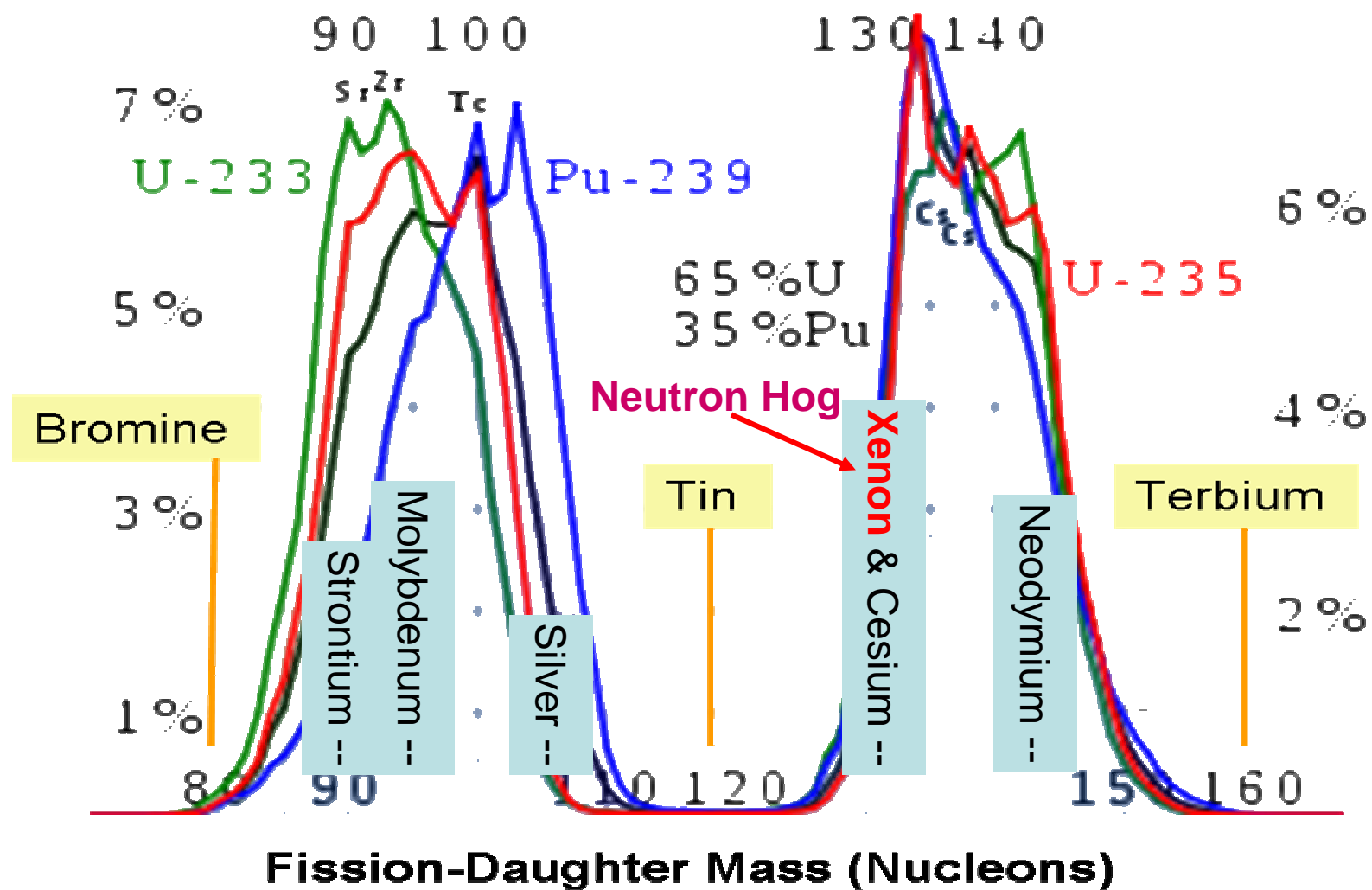
<http://www.ans.org/pi/np/oklo/>

<http://www.ans.org/pi/np/oklo/>

http://en.wikipedia.org/wiki/Natural_nuclear_fission_reactor

www.physics.isu.edu/radinf/Files/Okloreactor.pdf

Fission Products

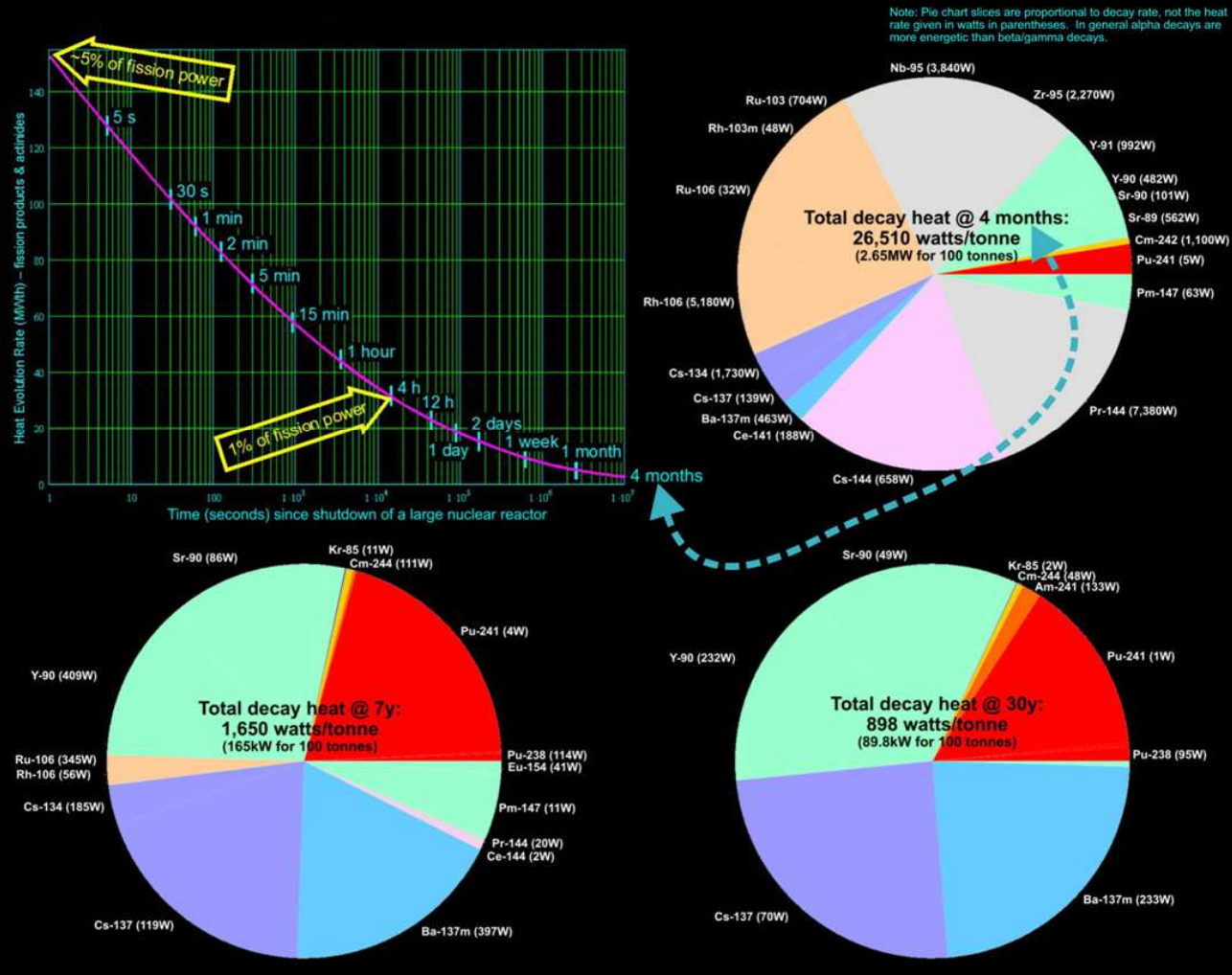


Asymmetrical yields of thermal-fission-product pairs versus fissile element

$^{235}/^{238}\text{U}$ Reactor Decay Heat (notes)

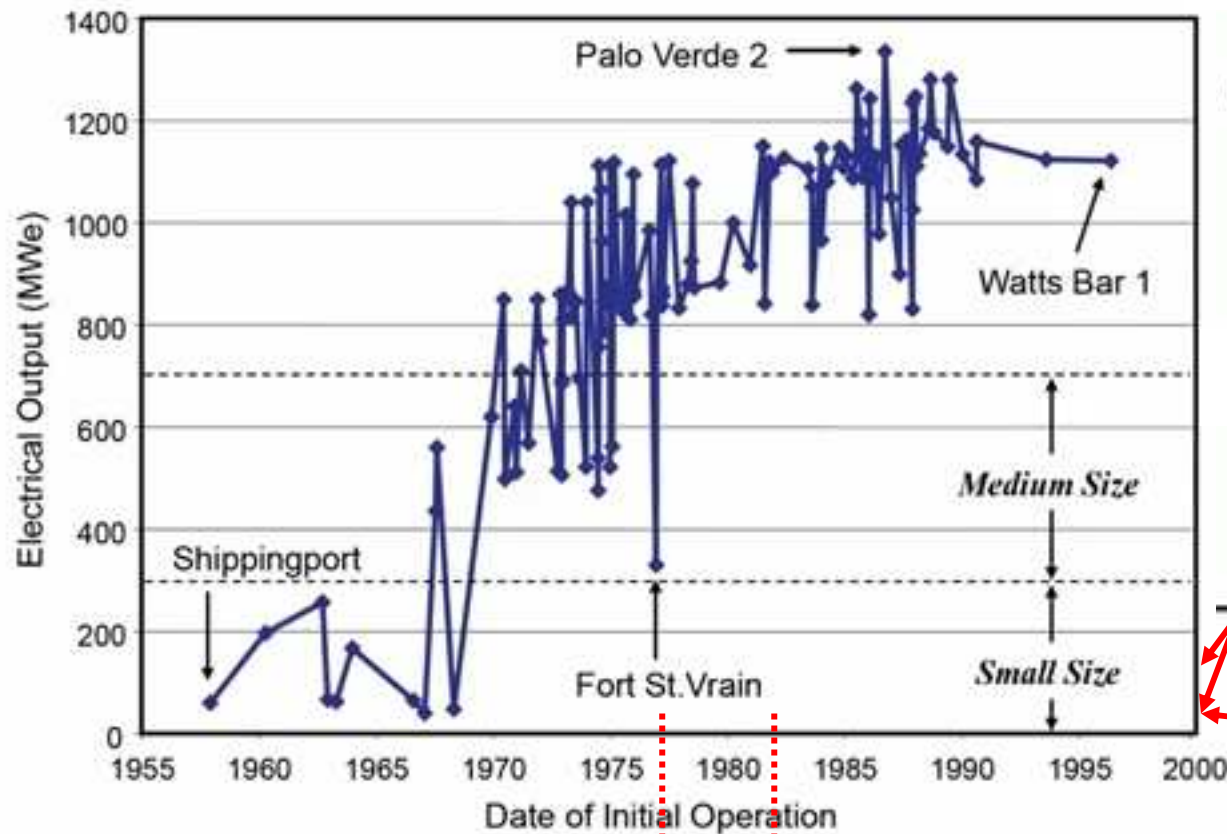
Spent nuclear fuel decay heat - from reactor shutdown to 30 years

Reference natural geothermal heat flux: 65 kilowatts per square kilometer (65kW/km²)



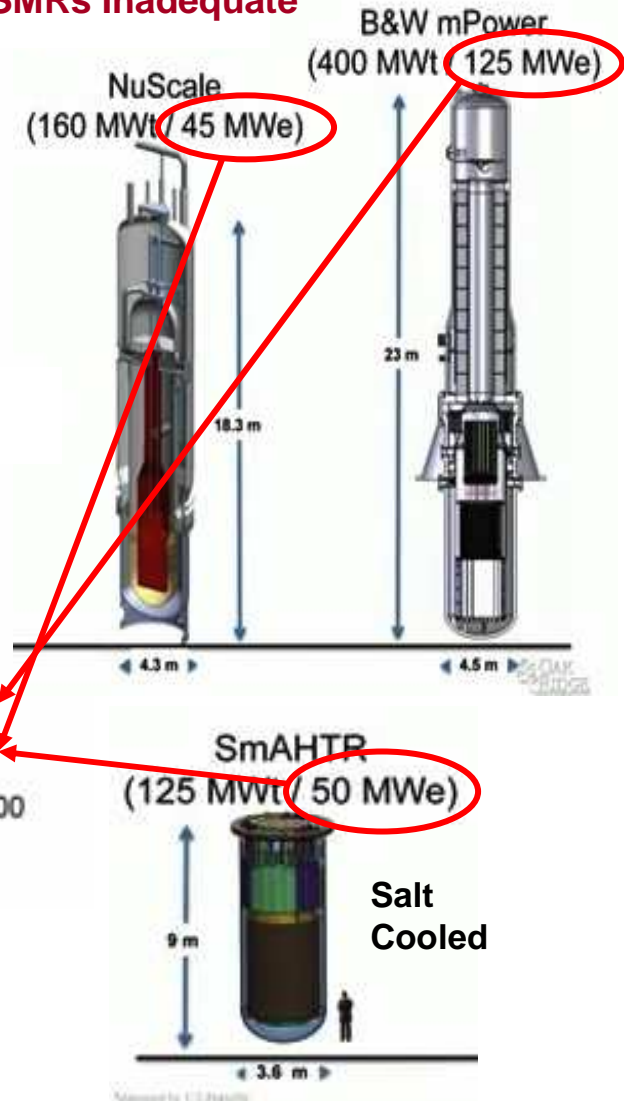
After 3 Years,
Solid Used
Fuel Can Be
Stored in Air

$^{235}\text{U}/^{238}\text{U}$ Uranium Light-Water Reactors



**Solid Thorium Fuel Breeding Expt. at Shippingport
1977-1982, >1% Fuel Gain in 5 Years**

SMRs Inadequate





See movie "Pandora's Promise"
<http://pandoraspromise.com/>
 by Richard Stone

*"I'm sure you're a nice man, but I'm not interested
 in hearing about Thorium."*

www.thoriumremix.com
<https://www.youtube.com/watch?v=nQpuGwWyFQ0>

THORIUM
 energy cheaper
 than coal



Robert Hargraves

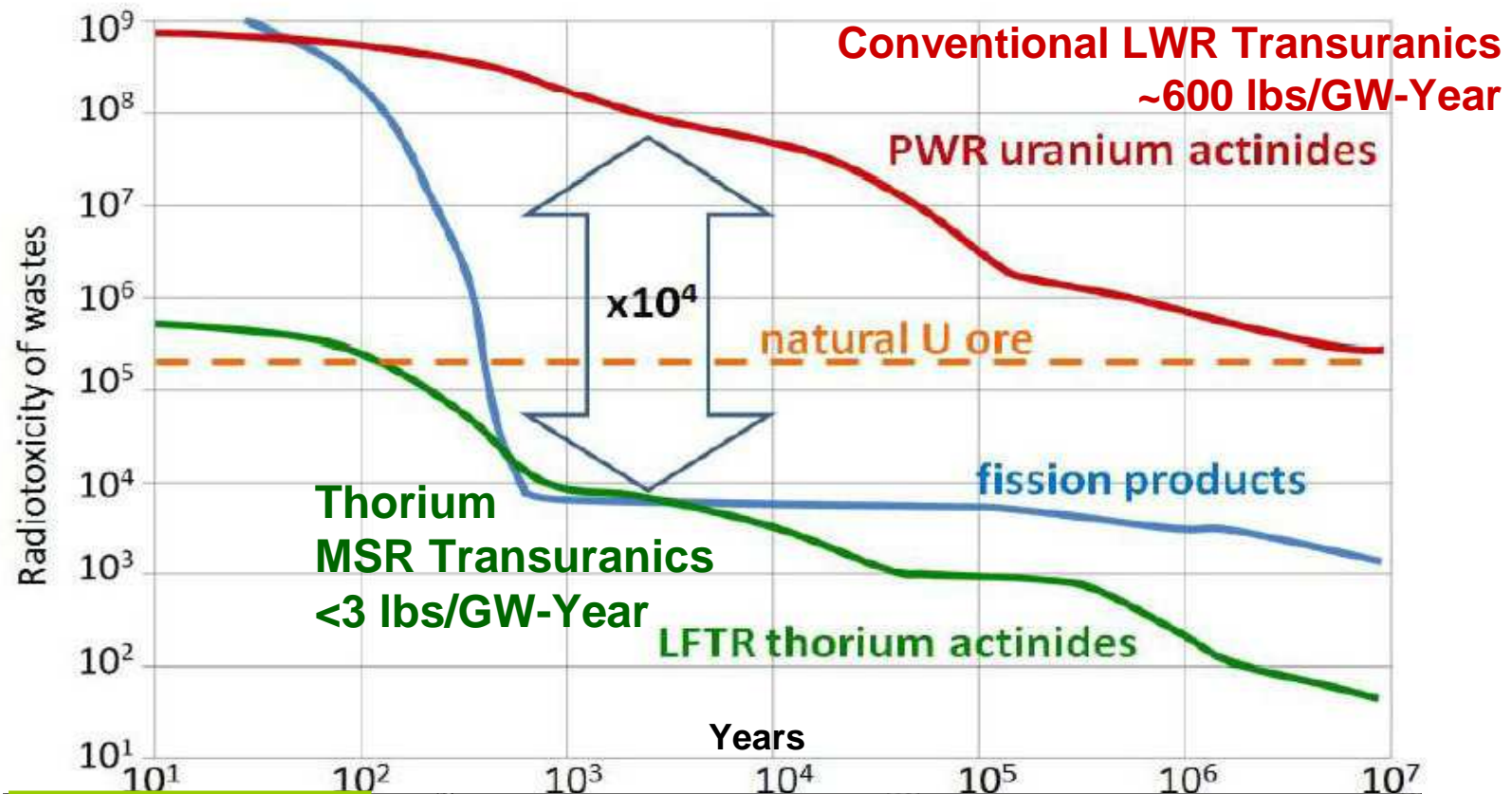
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THORIUM, THE GREEN ENERGY
 SOURCE FOR THE FUTURE

RICHARD MARTIN
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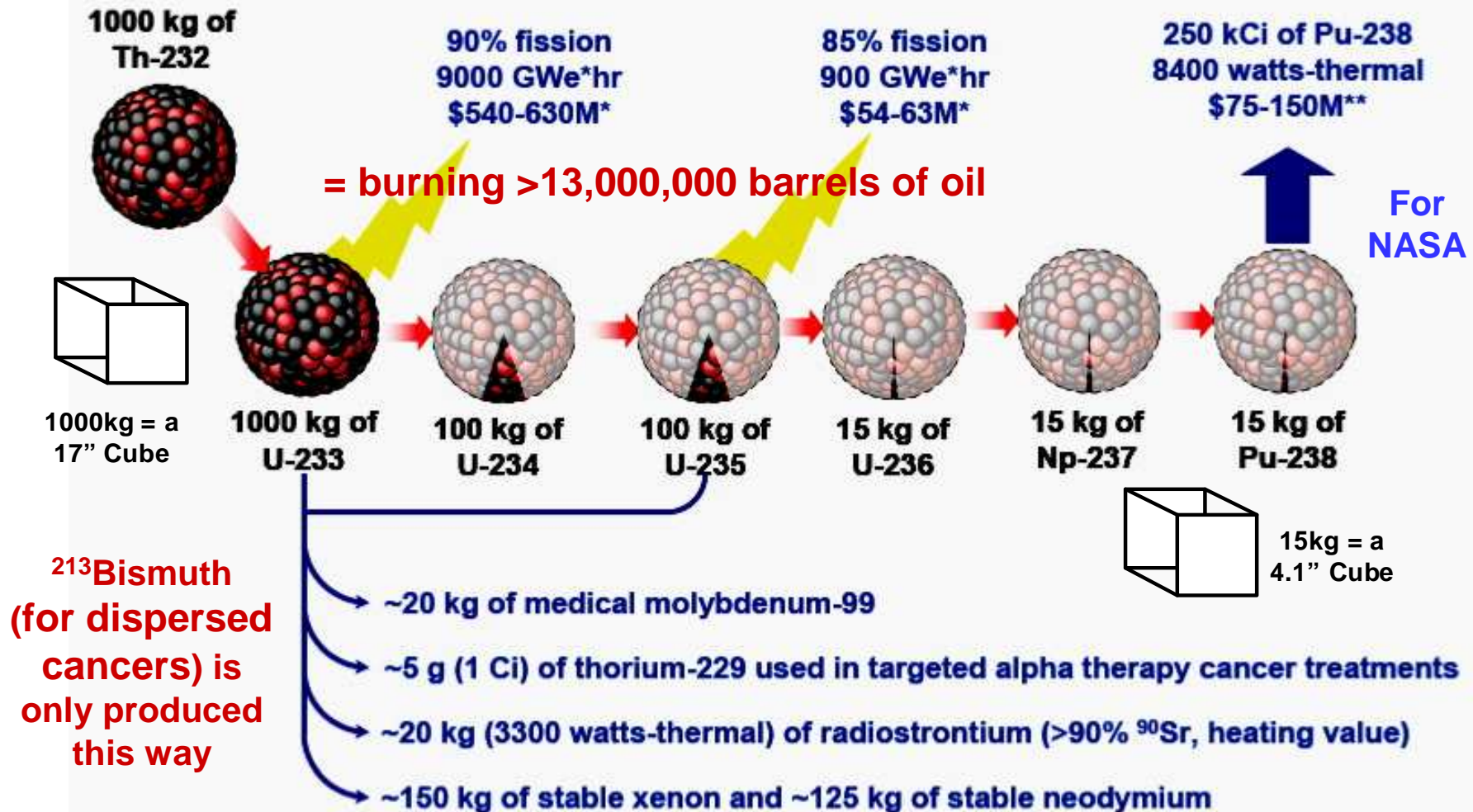
Waste Comparisons



For 30 years total:	FUJI-U3 (1GWe)	Relative to 1GWe BWR
Fissile requirement	7.8 t (reusable)	32%
Pu production	4 kg	0.1%
MA (Np/Am/Cm) production	23 kg	4 %

Japanese Example
~60 lbs in 30 GW yrs

Electricity and Isotope Production from LFTR



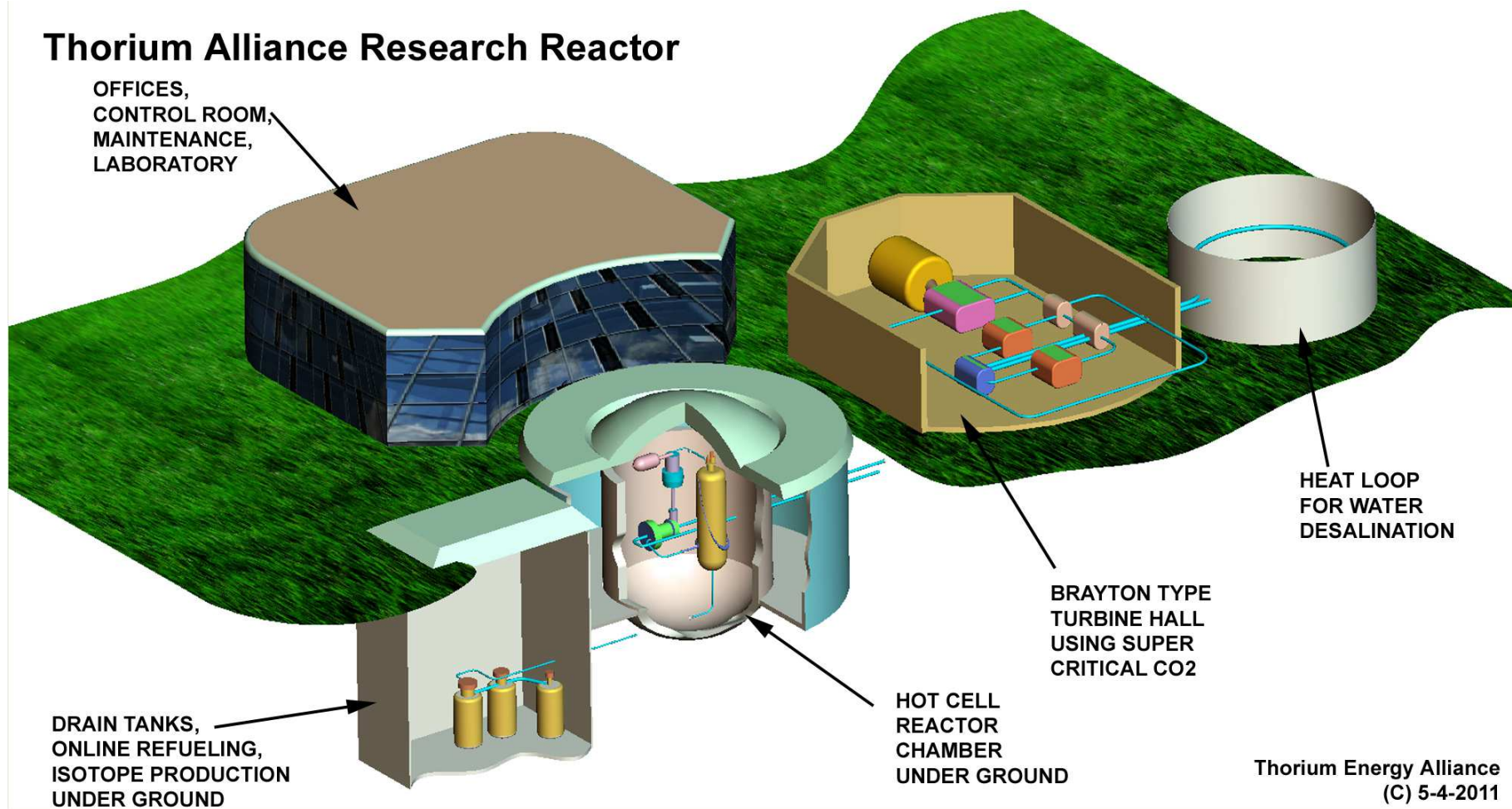
Courtesy Flibe Energy



1/2 Oz. Thorium runs 1 American's life for 1 decade

Molten-Salt Reactors

Thorium Alliance Research Reactor



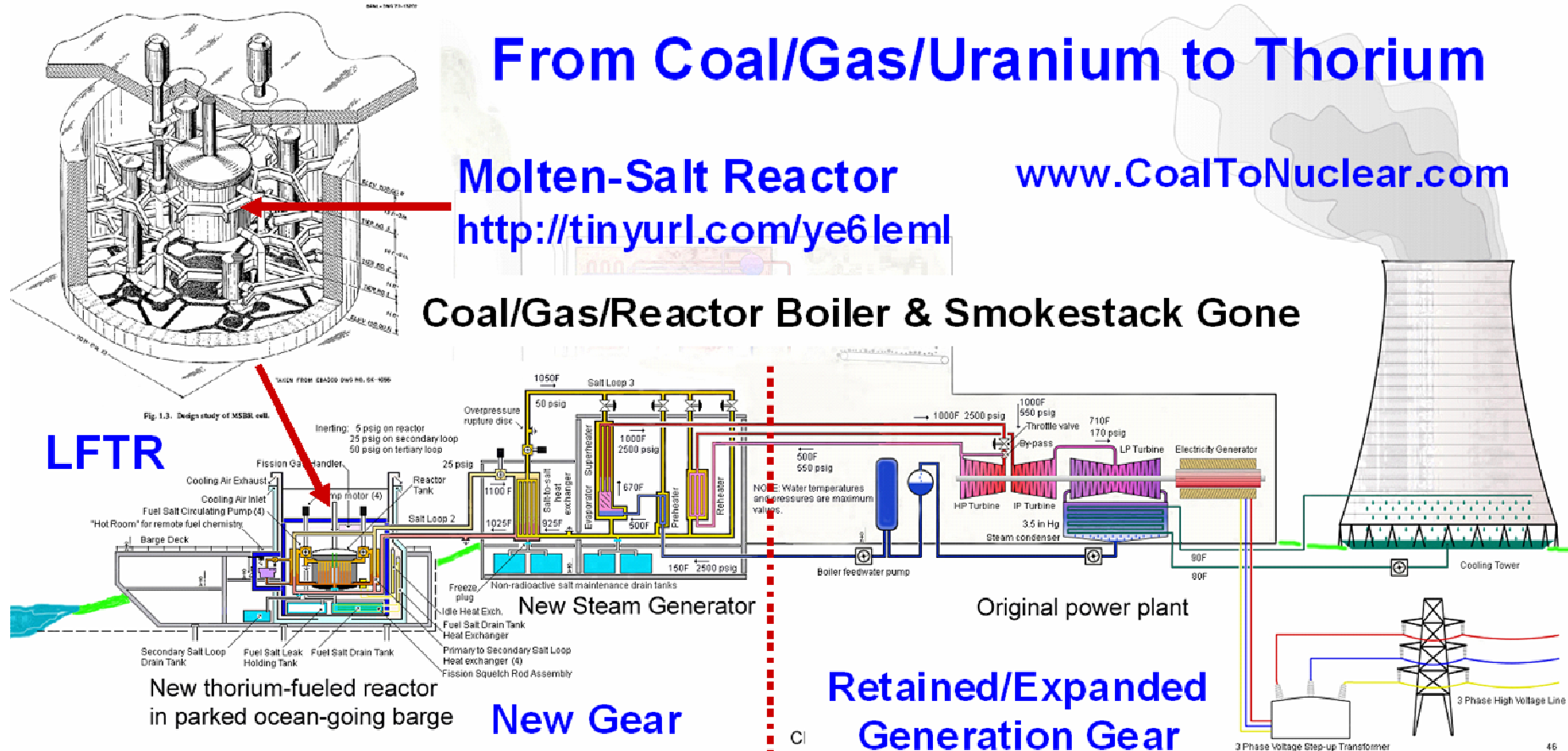
Using MSR/LFTR Modules

From Coal/Gas/Uranium to Thorium

Molten-Salt Reactor
<http://tinyurl.com/ye6leml>

www.CoalToNuclear.com

Coal/Gas/Reactor Boiler & Smokestack Gone



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<http://www.thoriumenergyworld.com/news/india-aims-to-build-worlds-first-thorium-ads>

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