Nuclear Power

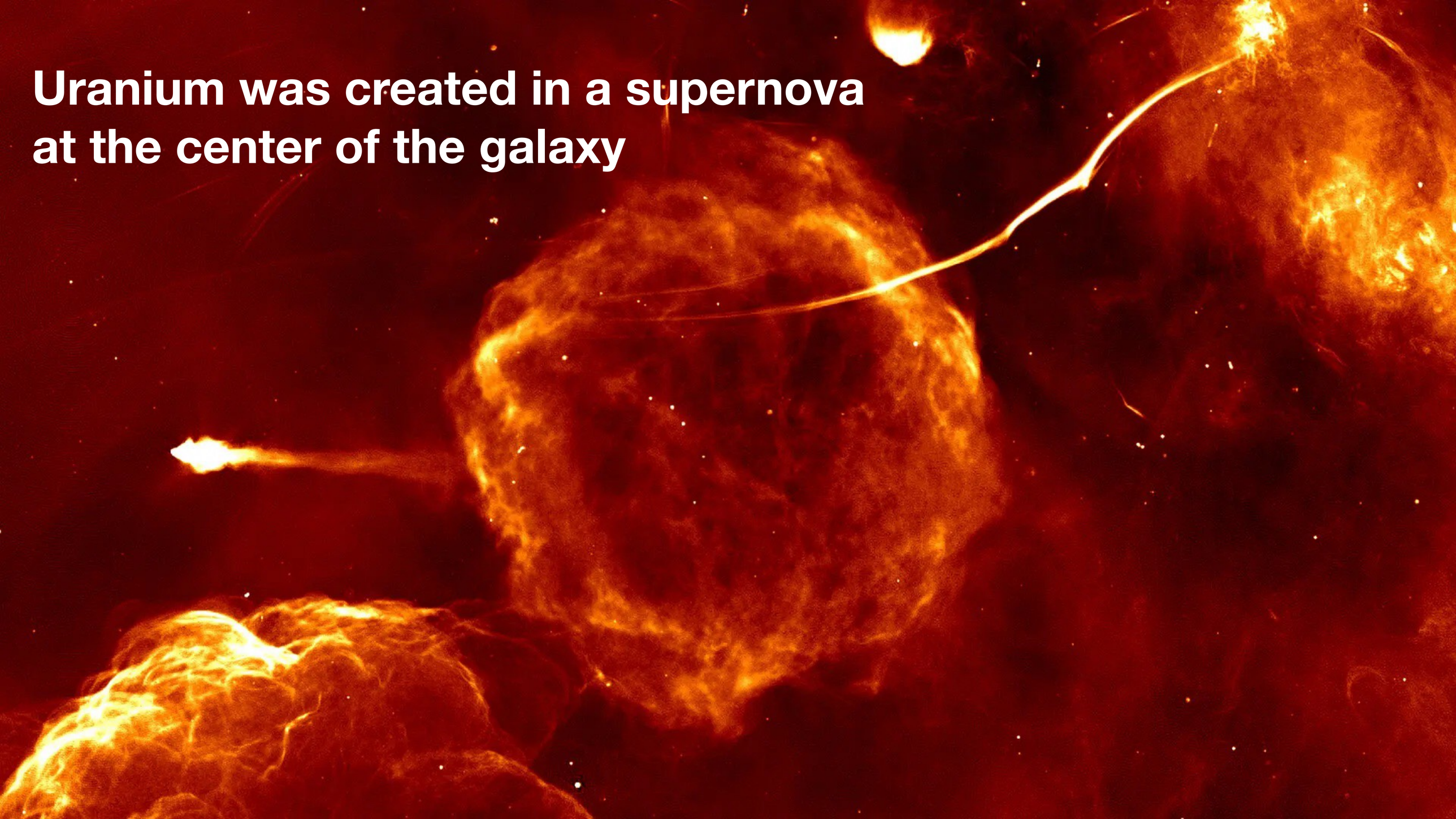
What about the Waste?

But what about the people?

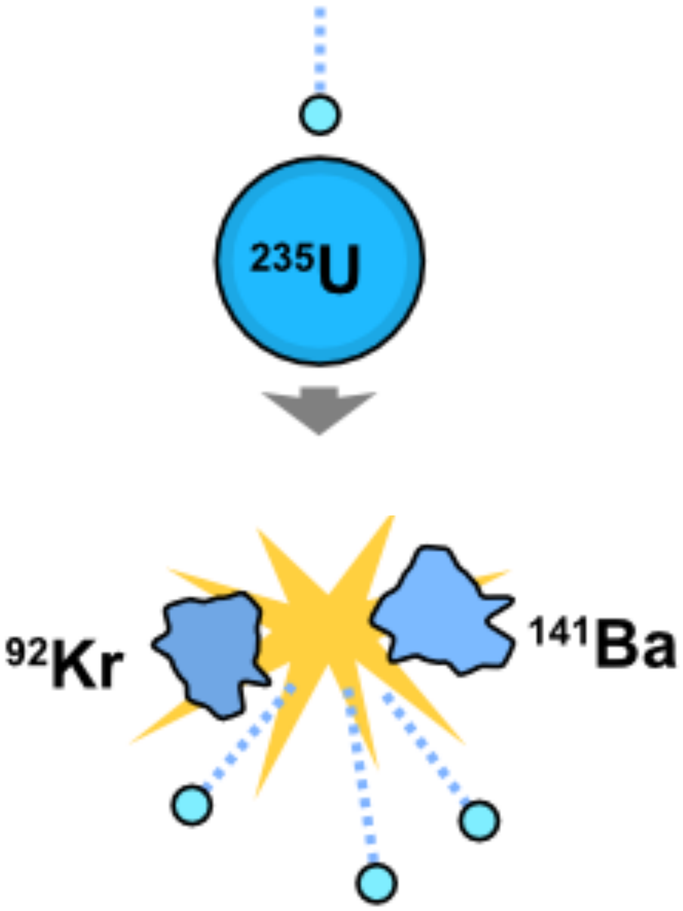
Robert Hargraves

March 9, 2023


RADEX
0.12
MENU
OFF
QUARTA


Uranium was created in a supernova
at the center of the galaxy

Uranium-235 is split into fission products, releasing energy.



The total mass of the resulting

barium-141 <— fission product
krypton-92 <— fission product
neutrons (3)

is a bit less than the mass of the U-235 + neutron.

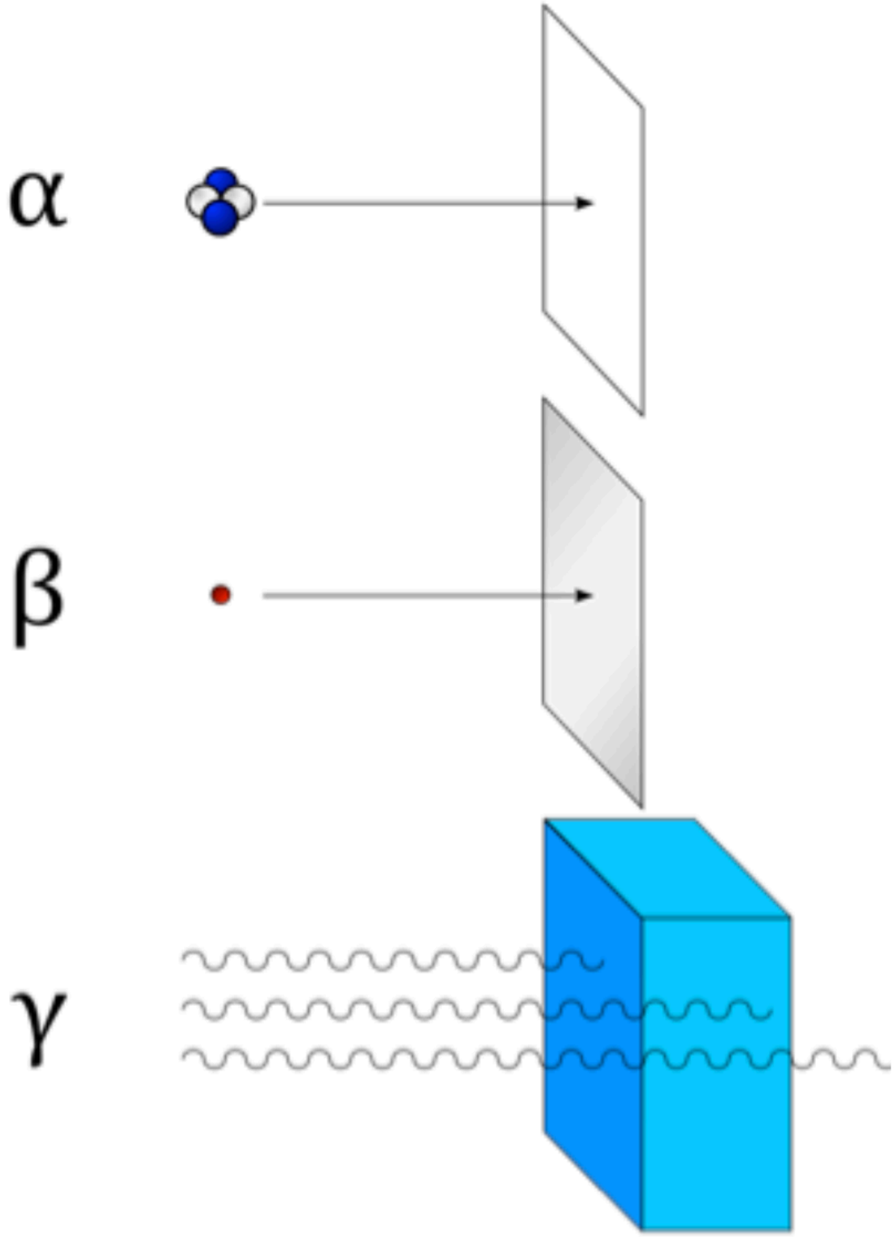
By Einstein's famous $\mathbf{e = mc^2}$

releases 166 MeV of energy, then 34 MeV more by decay of Kr and Ba fission products.

[1 ton U-235 fissioned -> 1 GW-year electricity]


Fission product radiation from fresh used fuel is hazardous, so removal is done under water.

Three kinds of radiation from fission products:

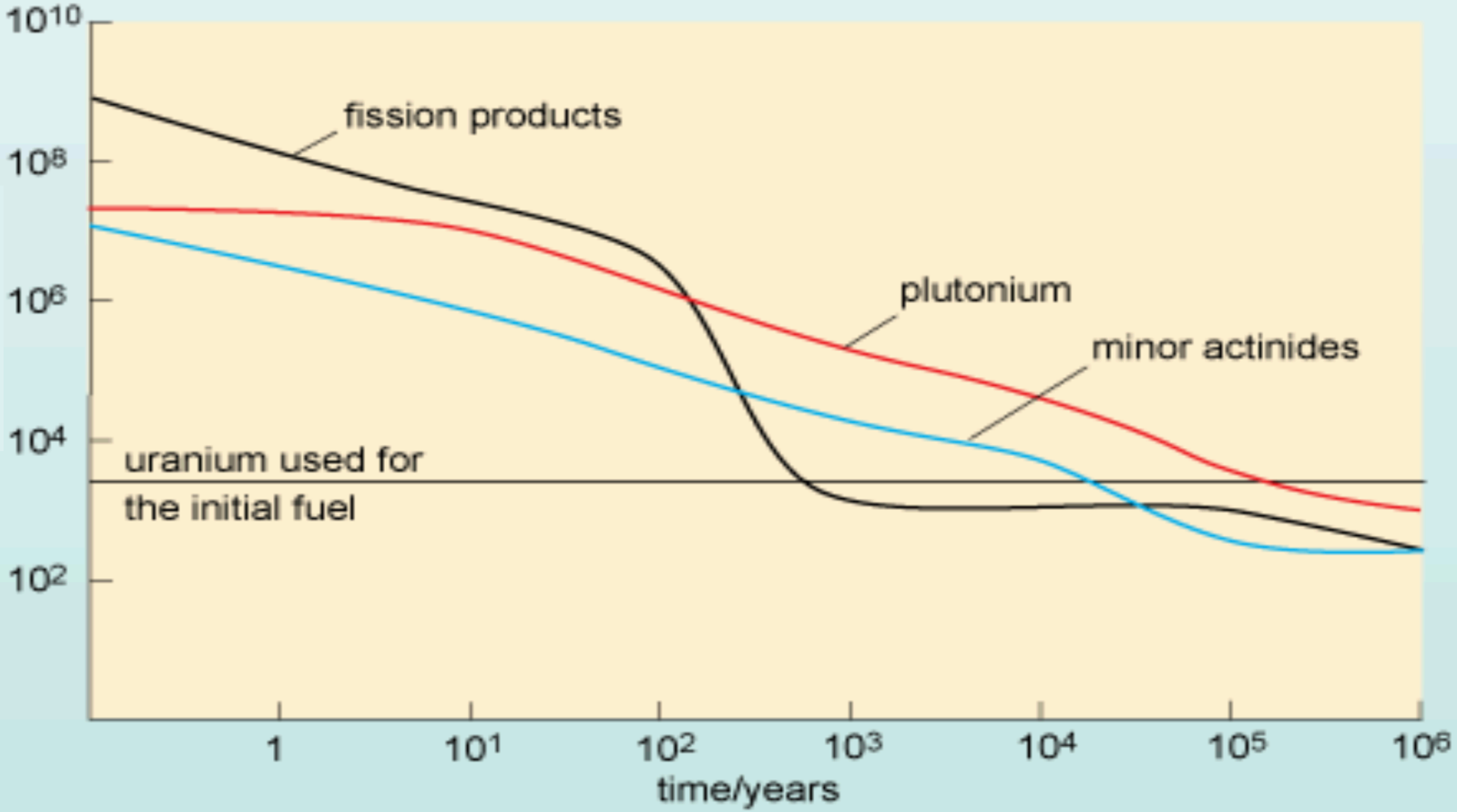


Alpha particles (two protons + two neutrons) can not penetrate skin.

Beta particles (electrons ejected from nuclei) do not penetrate metal foil.

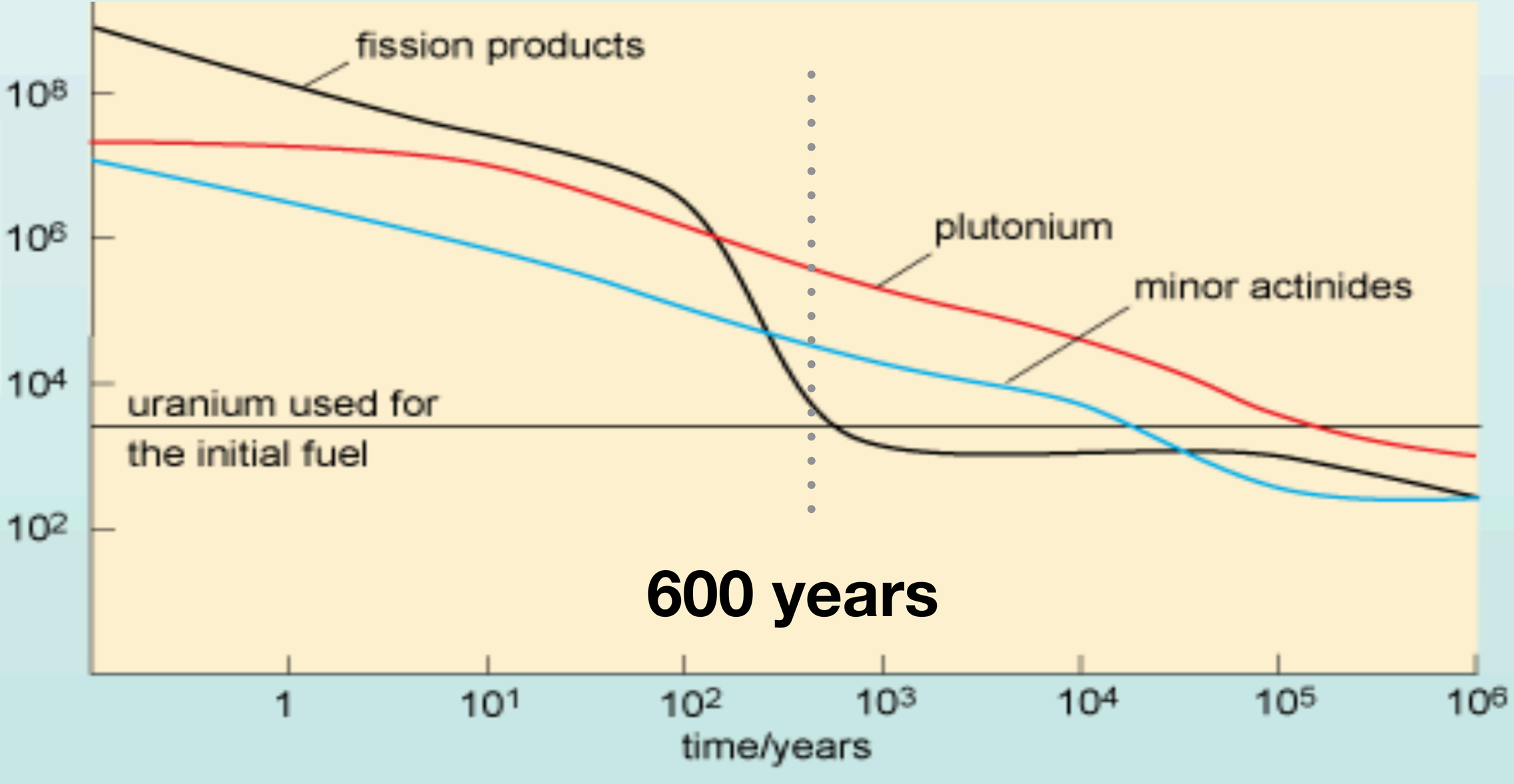
Gamma radiation (energetic photons) is partly absorbed by bone to make X-ray images.

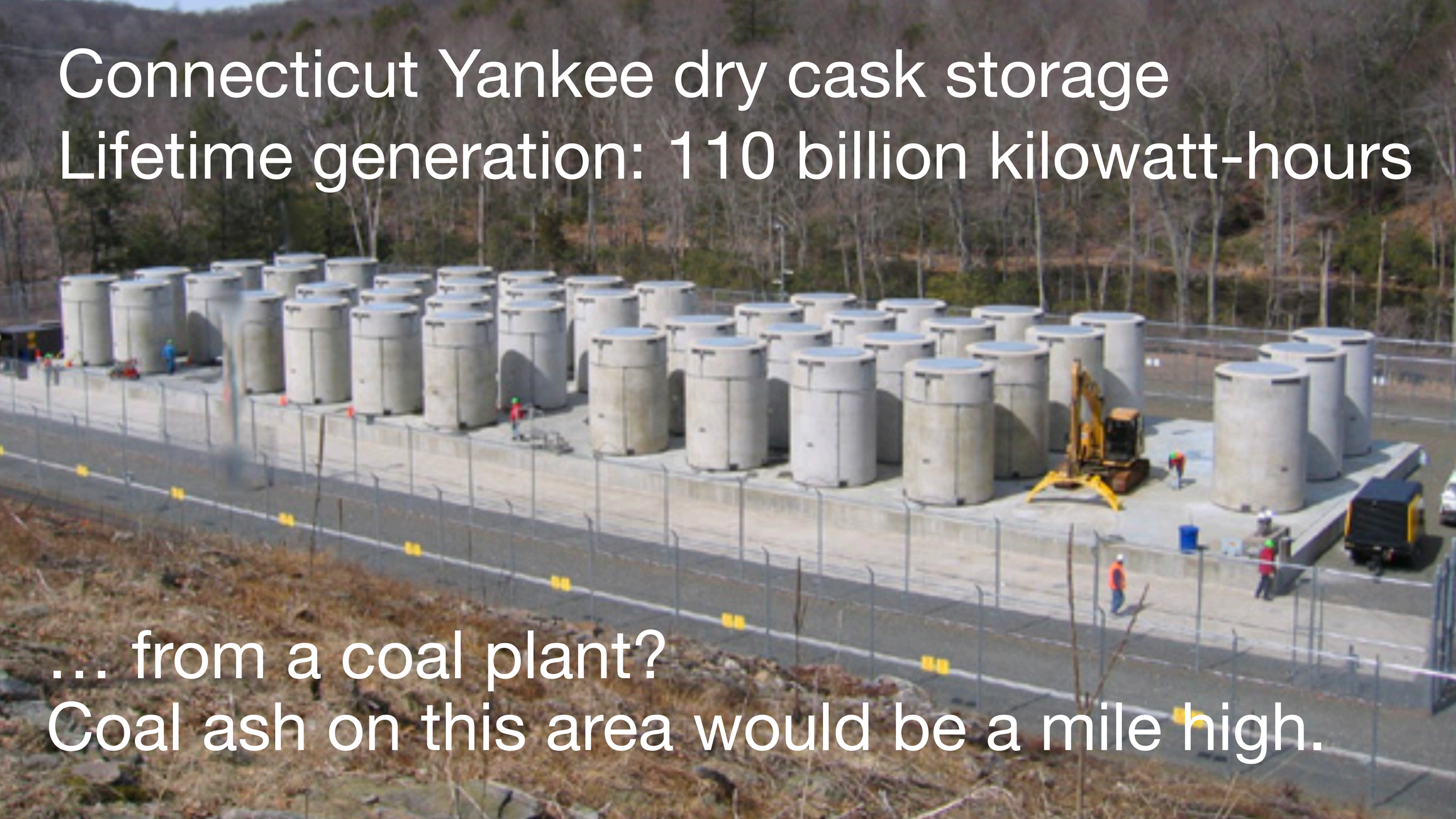
Fission products emit the penetrating photons.

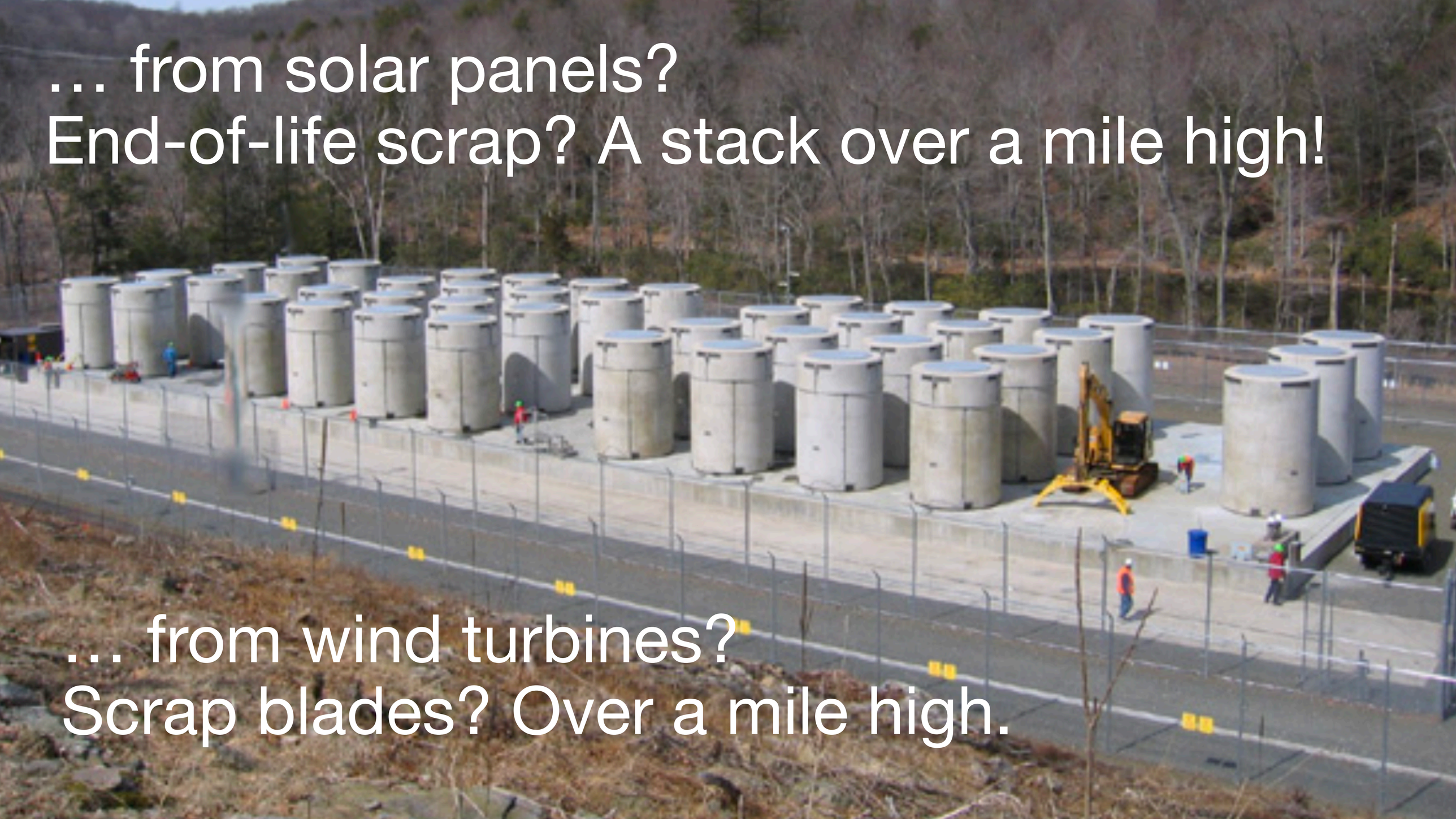



Steel and concrete casks intercept the photons.
By year 600, 99.999% of photon emitters are gone

After 600 years you'd have to eat or inhale the plutonium and minor actinides to be harmed.

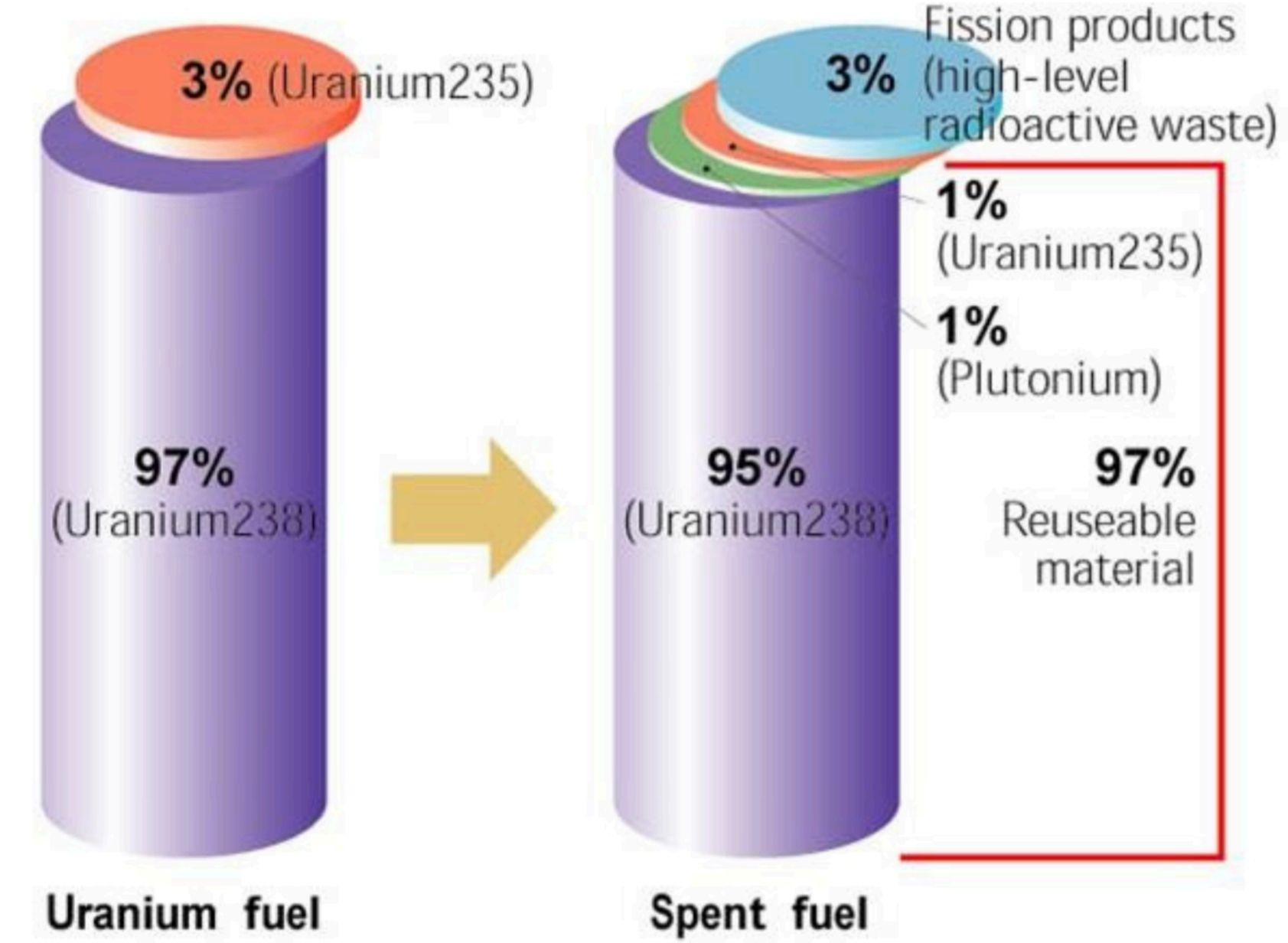



Connecticut Yankee dry cask storage
Lifetime generation: 110 billion kilowatt-hours
… from a coal plant?
Coal ash on this area would be a mile high.


… from solar panels?
End-of-life scrap? A stack over a mile high!
… from wind turbines?
Scrap blades? Over a mile high.

Connecticut Yankee fuel casks now

97% of the spent fuel can be reused in new reactors.



https://www.2lo.co.uk/Elephant-in-the-room/

New York Times prints radiation scares.

ANXIETY

Showdown at the Airport Body Scanner

BY NATHANIEL RICH MAY 25, 2013 1:00 PM Comment

I create delays, futzing with my shoes or laptop, until the line has bottlenecked at the cancer machine.

…

I note that there is a correlation between radiation absorption over a lifetime and cancer rate.

…

ProPublica and PBS NewsHour concluded that the X-ray scanners, then still in use, could cause cancer in 6 to 100 United States airline passengers every year

Fear Sells!

New York Times prints radiation scares.

We Are Giving Ourselves Cancer

By RITA F. REDBERG and REBECCA SMITH-BINDMAN JAN. 30, 2014

"a 2009 study from the National Cancer Institute estimates that CT scans conducted in 2007 will cause a projected 29,000 excess cancer cases and **14,500 excess deaths** over the lifetime of those exposed."

https://www.nytimes.com/2014/01/31/opinion/we-are-giving-ourselves-cancer.html

New York Times prints radiation scares.

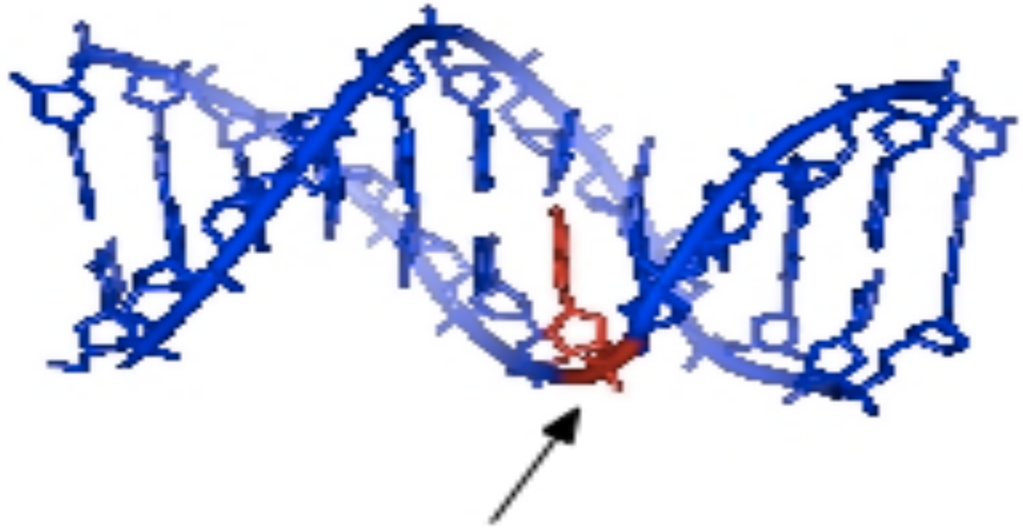
In Chernobyl's Stray Dogs, Scientists Look for Genetic Effects of Radiation

Just recently,

Mar 3, 2023

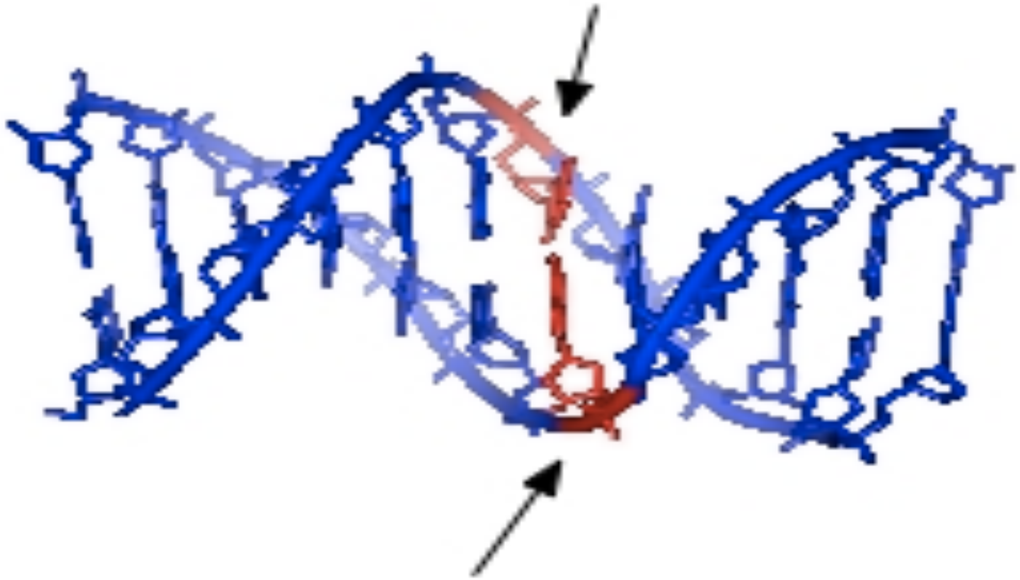
https://www.nytimes.com/2023/03/03/science/chernobyl-dogs-dna.html

DNA strand breaks occur frequently, by ionized oxygen molecules from metabolism.



Single strand breaks occur **10,000 times per day per cell**.

Natural radiation adds 100 per year.



Double strand breaks occur **10 times per day per cell**.

Power plants add less.

2015 Nobel Prize: How DNA is repaired.

Modrich: how cells ***correct errors*** that occur when DNA is replicated during cell division.

Lindahl: excision ***repair*** — the cellular mechanism that repairs damaged DNA during the cell cycle.

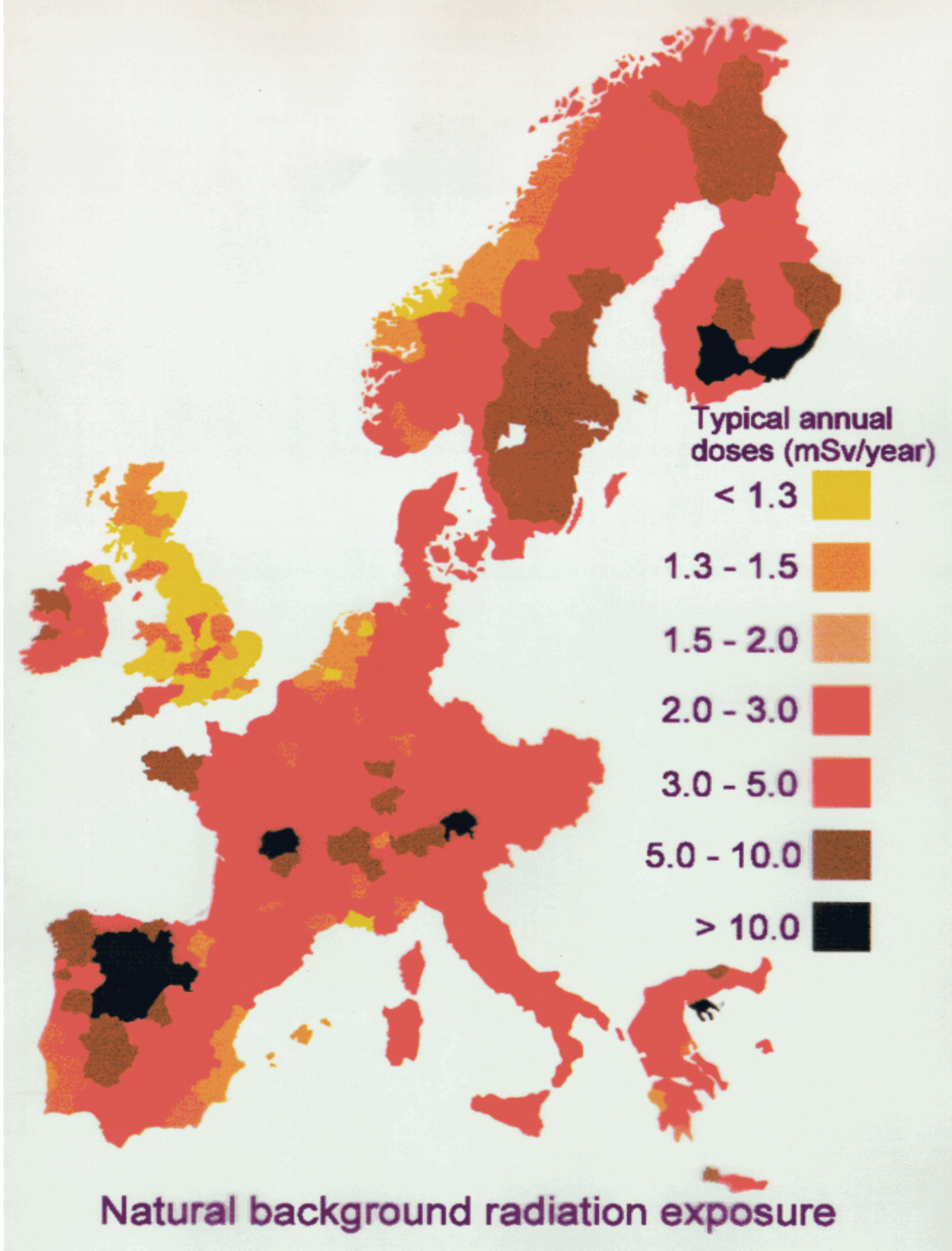
Sancar: mapping the mechanism cells use to ***repair*** ultraviolet damage to DNA.

http://www.nytimes.com/2015/10/08/science/tomas-lindahl-paul-modrich-aziz-sancarn-nobel-chemistry.html

Natural radiation intensity varies, not increasing cancer rates.

Natural sources:
granite radon, cosmic rays, food

Places	**Radiation intensity**
US	3 mSv/year
Denver	4
Finland	7
Brazil beaches	45
Ramsar, Iran	200

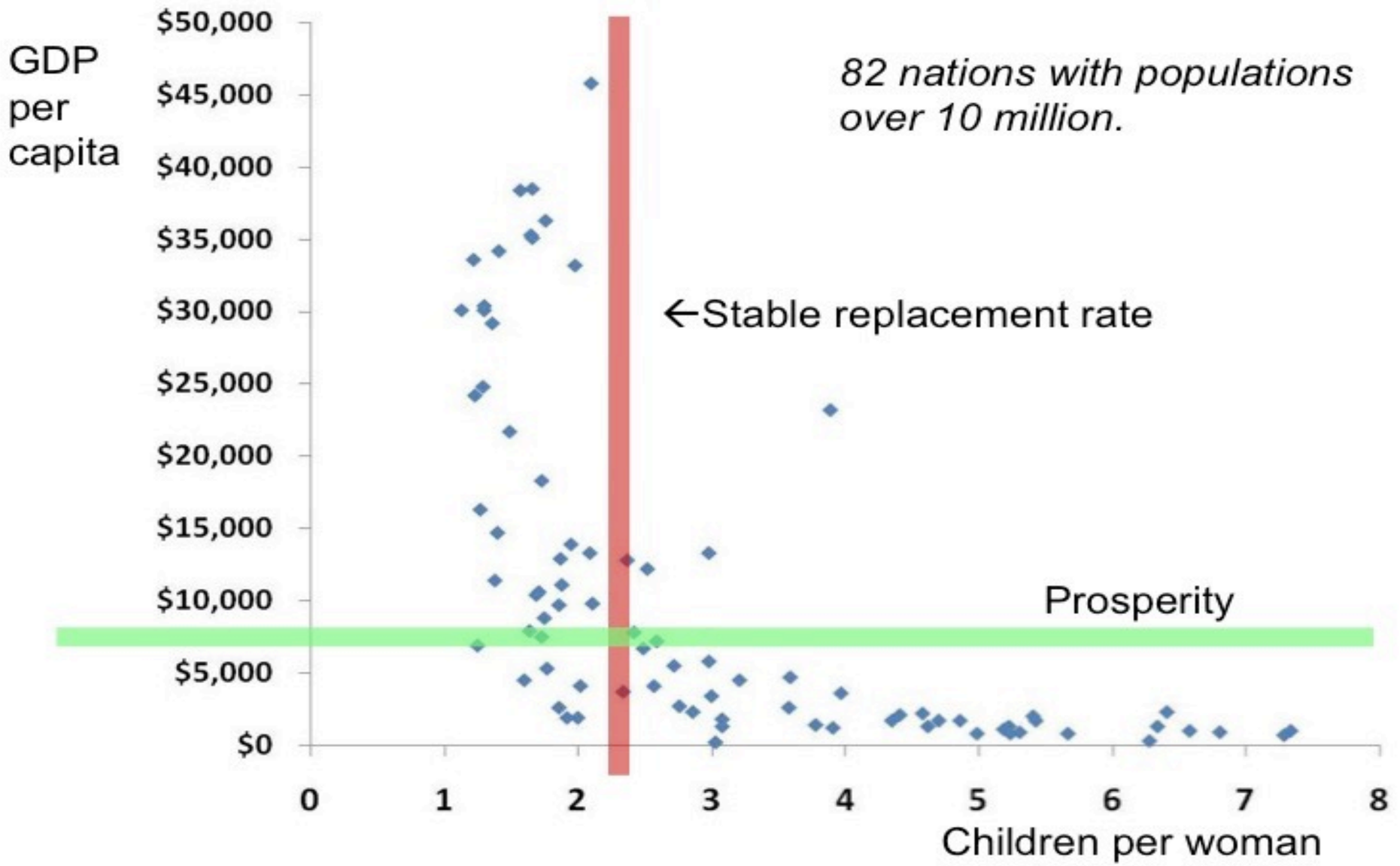


Low intensity radiation is not harmful.

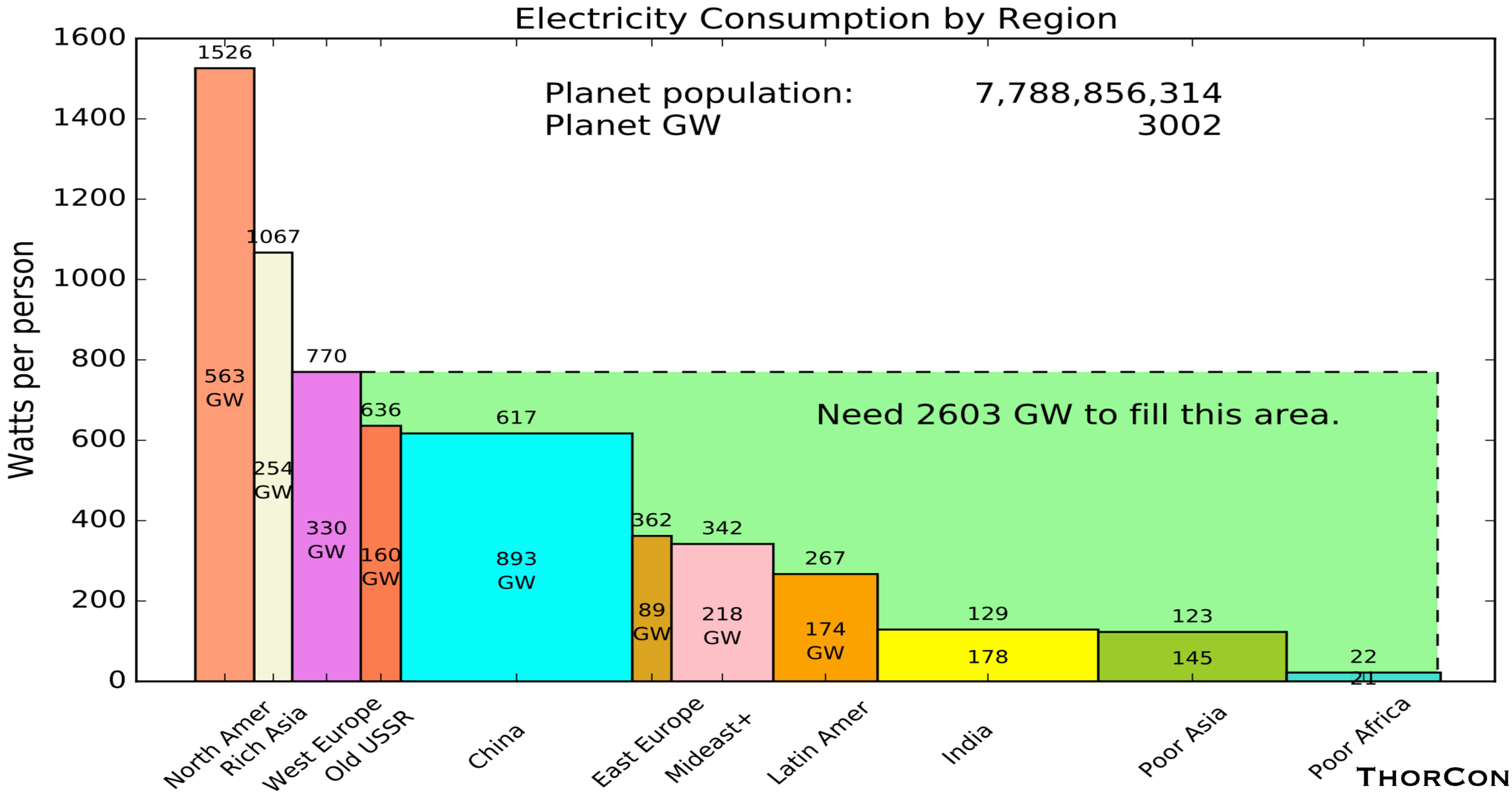
But what about the people?


Fires, Fuel & the Fate of 3 Billion

With prosperity, fewer birthed people compete for finite world resources.



3,000 GW global electricity use, may grow by 2,600 GW.



ThorCon
Powering Up Our World

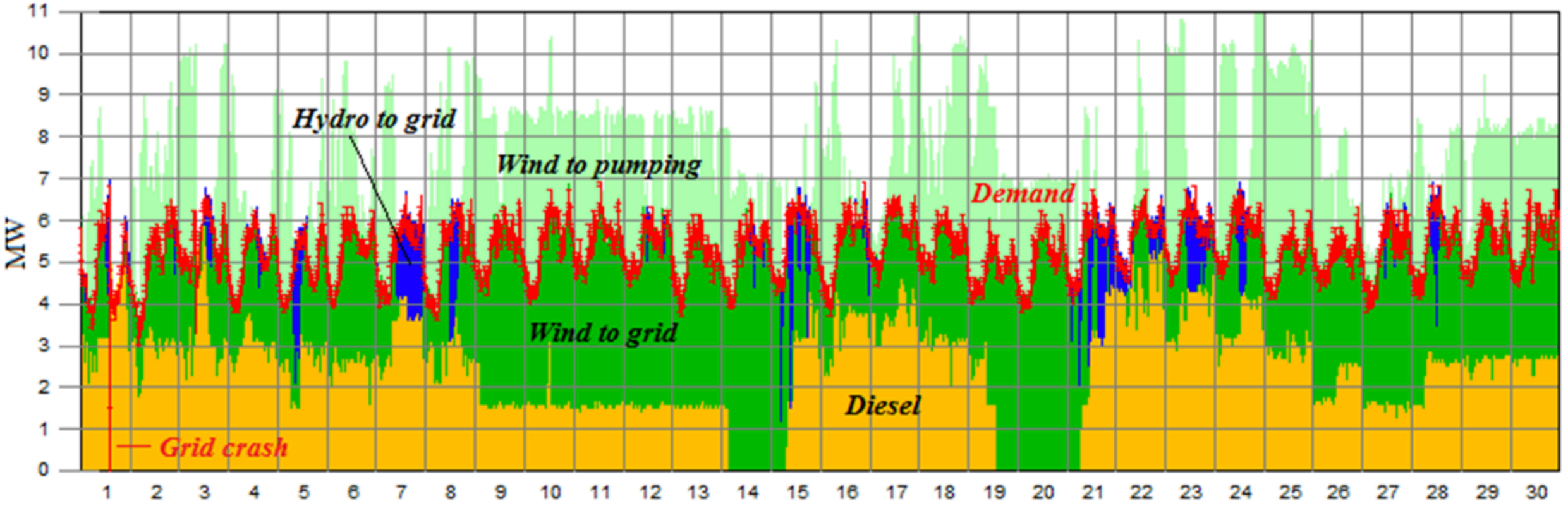

Developing nations now build coal-fired power plants.
Reliable, 24x7, affordable
574 GW in development
ThorCon
Powering Up Our World

"El Hierro is the first fully sustainable island in the world…”

https://www.enel.com/company/stories/articles/2016/09/el-hierro-island-renewables-treasure

Spain’s El Hierro island attempted 100% renewable power.

Three wind turbines with pumped hydro energy storage.



During 2018 it supplied 57% of El Hierro’s electricity, 10 MW

https://euanmearns.com/tag/el-hierro/

100% Delusion! | **Sun sets.** | **Wind lulls.**

Batteries? to give 1 day of energy use...

- 500 million Tesla home Powerwalls
- Build 1 per second for 15 years
- $ 4.5 trillion

Utility-scale Tesla Megapack batteries cost $358/kWh.

Order Megapack

Megapack enables low-cost, high-density commercial and utility projects at large scale. It ships ready to install with fully integrated battery modules, inverters, and thermal systems. View product details

77 MW	308 MWh
Power	Energy

Megapack Quantity
Installation included — 100

Site Location — California
Earliest deliveries in late 2022

Price — $110,346,840
Taxes not included

Annual Maintenance — $375,180
Price escalates at 2% per year

Due Today — $5,000
Non-refundable Order Deposit

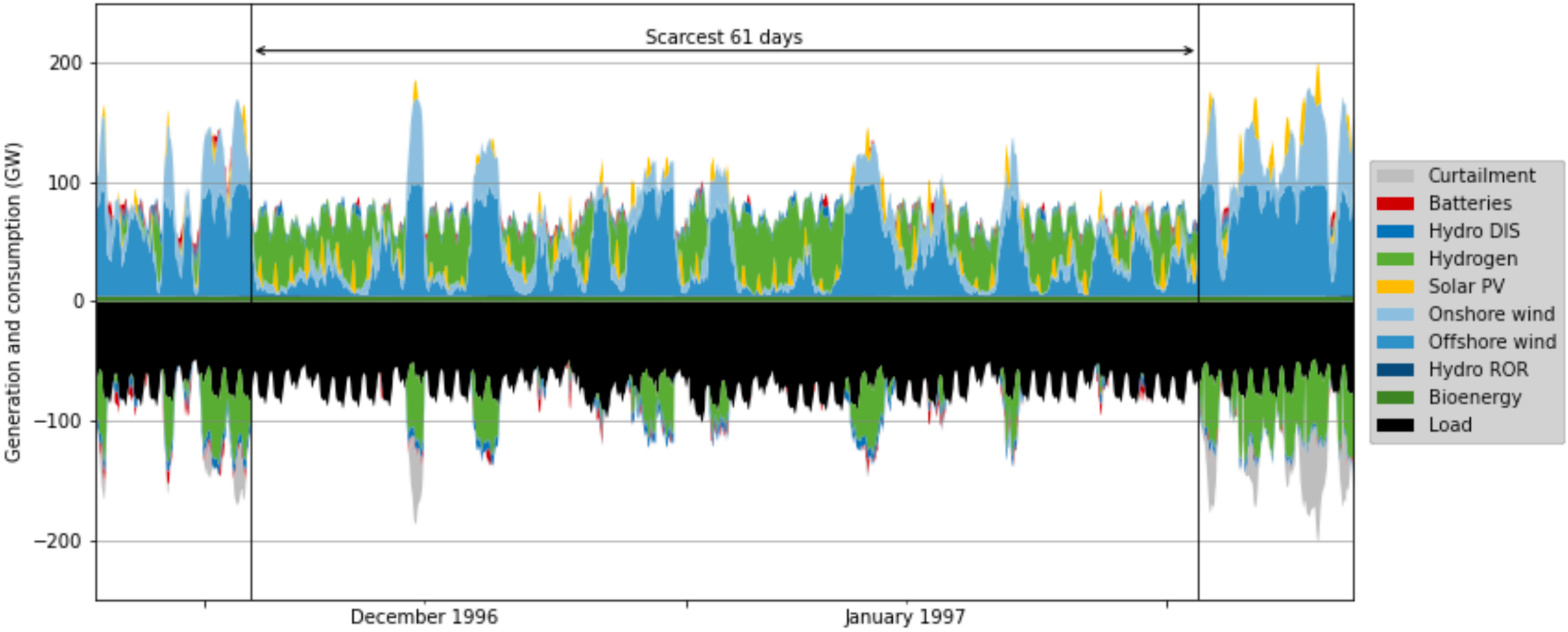
By placing a deposit, I agree to the Megapack Order Agreement, Megapack Maintenance Agreement, and Privacy Notice

Site Contact Information

https://electrek.co/2021/07/26/tesla-reveals-megapack-prices/ https://www.tesla.com/megapack/design

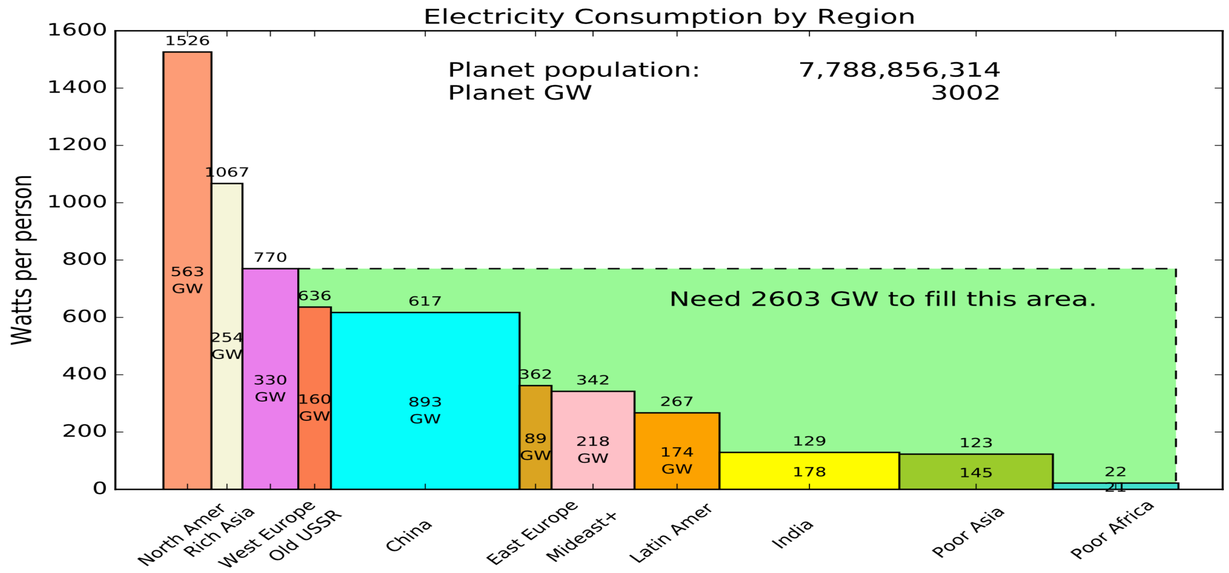
Observed *Dunkleflaute* needs ***24 days*** of electricity storage.

Cost-optimized storage, solar, wind. Studied 35 years of hourly German power. Need time between Dunkleflauten to recharge.



https://www.econstor.eu/handle/10419/236723 Ruhnau, Qvist

Batteries are too costly for 100% renewables!



3,000 GW global electricity average power use

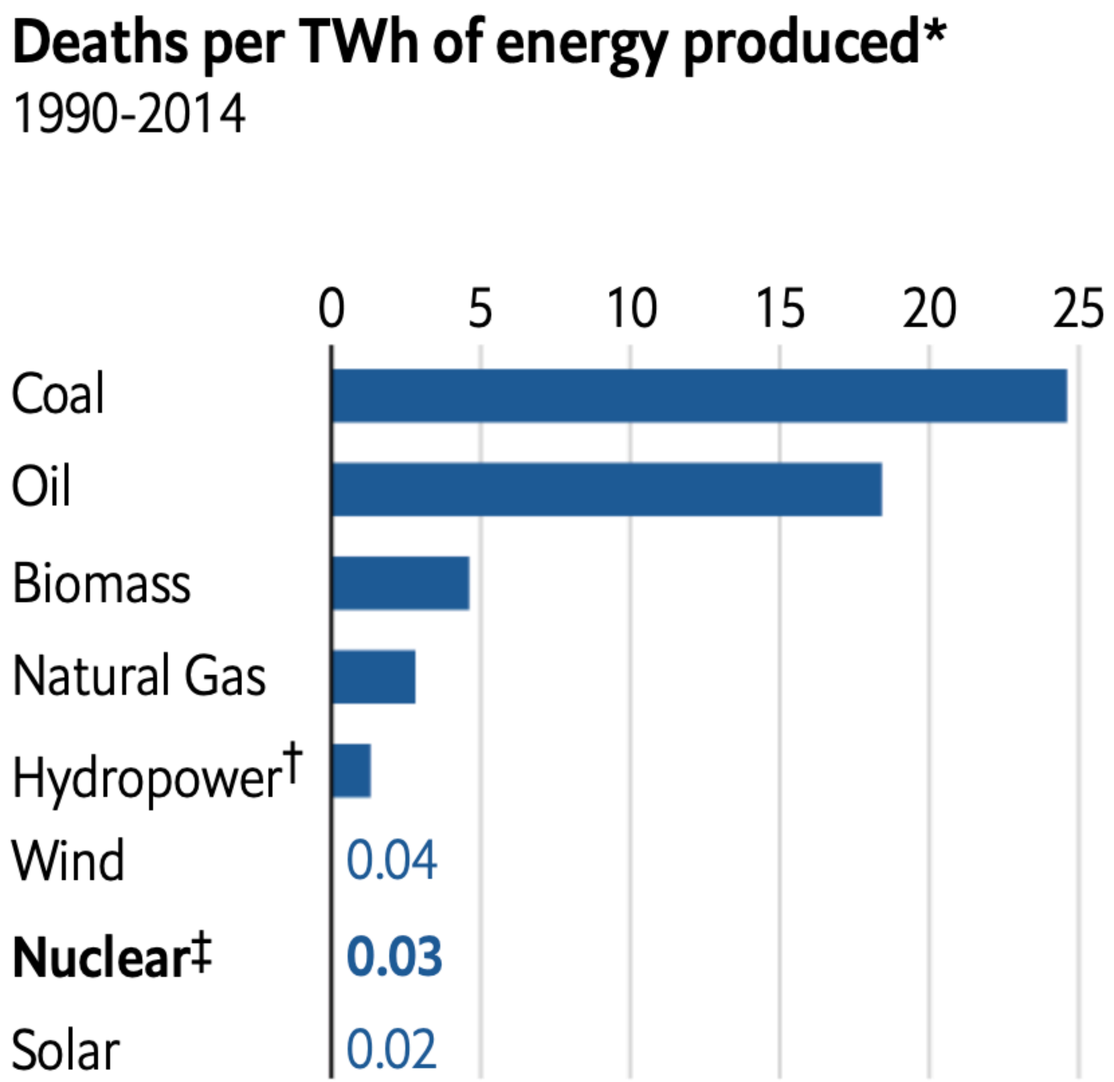
x 24 h x $358/kWh utility-scale batteries by Tesla

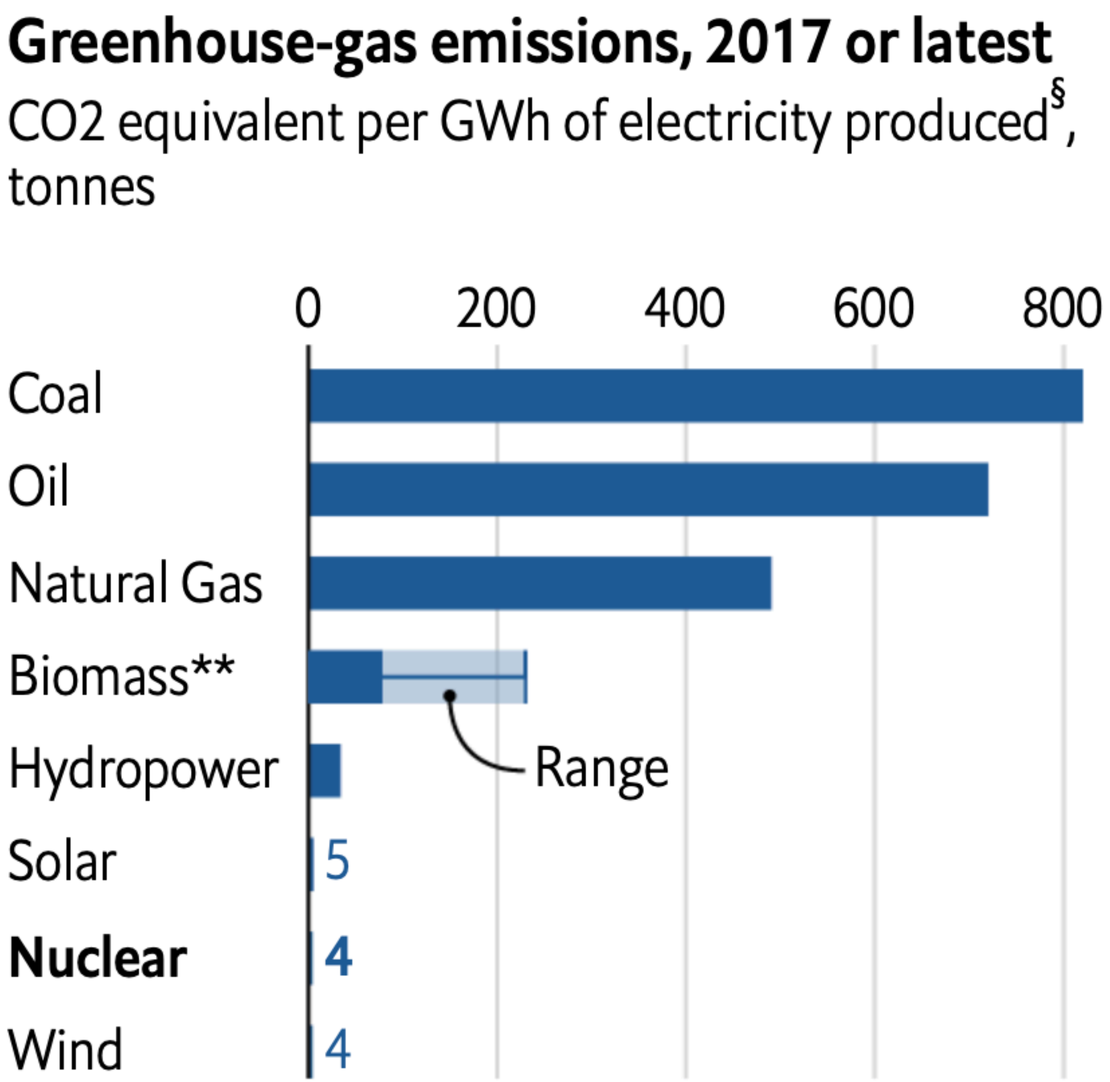
= $2.6 trillion for 1 day of electricity

= $62 trillion for 24 days of Dunkleflaute

Fission power is safe.

The Economist, July 19, 2022





https://www.economist.com/graphic-detail/2022/07/19/how-safe-is-nuclear-energy

Nuclear power opponents with $4.5 billion per year to spend.

Climate Imperative Foundation	$221	ClimateWorks Foundation	$425
Natural Resources Defense Council	$415	League of Conservation Voters	$117
NRDC Action Fund	$33	The Energy Foundation	$199
Sierra Club	$180	Greenpeace	$32
Sierra Club Foundation	$130	National Audubon	$118
Rocky Mountain Institute	$140	Rockefeller Brothers Fund	$838
Environmental Defense Fund	$524	Solar Energy Industries Association	$21
EDF Action Fund	$21	Center for American Progress	$50
World Resources Institute	$440	American Clean Power Association	$40
EarthJustice	$124	Public Citizen	$8
Friends of the Earth	$23	Solutions Project	$7
350.org	$25	Windward Fund	$304
Union of Concerned Scientists	$68	**Total**	**$4,503**

2021 Revenue of Top 25 NGOs in $Millions

Source: Guidestar, ProPublica

https://robertbryce.substack.com/p/the-anti-industry-industry

IAEA Boss Met With Laughter At COP26

"No one died from radiation at Fukushima," Grossi said, **provoking laughter from the audience**.

"I don't know why you're laughing, it's a fact. Thousands of people died because of the tsunami but there were no deaths attributable to exposure to radiation. People died also because of the evacuation, it was very traumatic," he continued.

IPCC ignorance is appalling.

https://www.forbes.com/sites/sofialottopersio/2021/11/04/no-one-died-from-radiation-at-fukushima-iaea-boss-statement-met-with-laughter-at-cop26/?sh=697b8ba27a47

For the **great enemy of the truth** is very often not the lie—deliberate, contrived, and dishonest—but the myth—persistent, persuasive, and unrealistic. Too often we hold fast to the clichés of our forebears. We subject all facts to a prefabricated set of interpretations. We enjoy the comfort of opinion without the discomfort of thought. (1966)

Groupthink occurs when a group of individuals reaches **consensus** *without* **critical reasoning** or evaluation of the **consequences** or **alternatives**.

Examples

Challenger shuttle disaster

Bay of Pigs

Watergate

Escalation of the Vietnam War

https://www.investopedia.com/terms/g/groupthink.asp

ThorCon objectives:

1. to mass-produce fission power plants
2. to generate CO2-free, 24x7 electricity
3. cheaper than from coal or LNG
4. at shipyard scale — 10 GW per year
5. to help people achieve prosperity.

ThorCon
Powering Up Our World

- Nations **will choose** 24x7 fission, if it's **cheaper.**

Economics	**Fission**	**Coal**
Capital cost, $/Watt	1.0	2.0
Fuel cost, cents/kWh	0.53	2.27
Electricity, cents/kWh	**3**	**5**

Two ThorCon 500 MW molten salt reactor plants

24x7

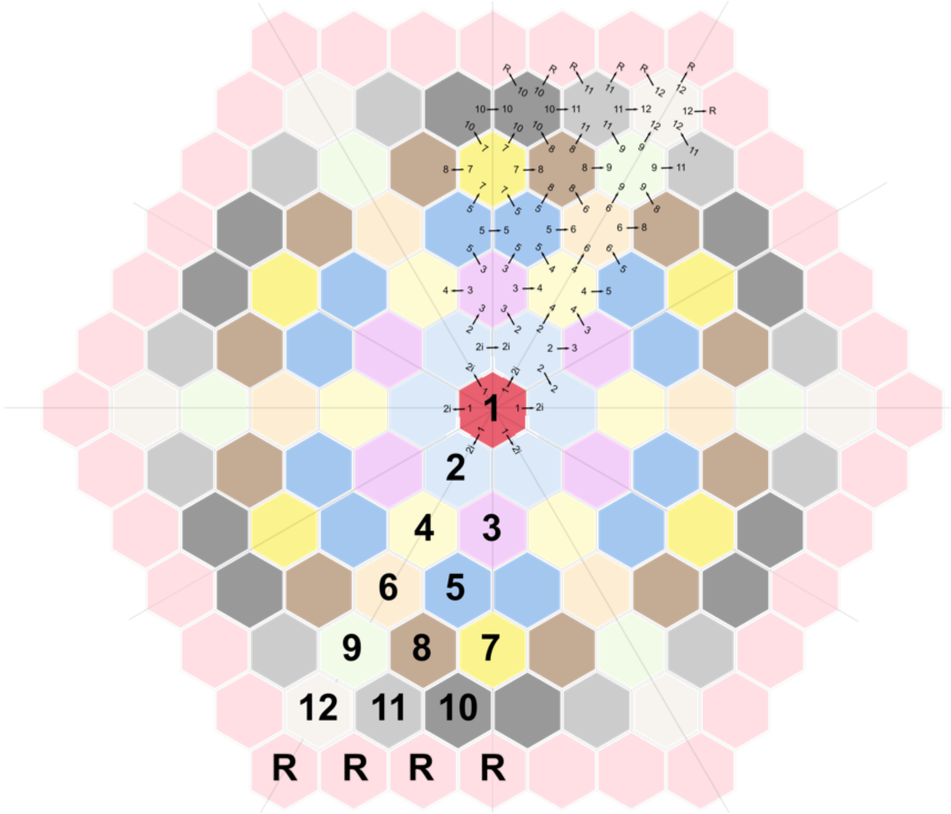
zero CO_2

20 plants per year

3 cents/kWh, cheaper than coal or LNG

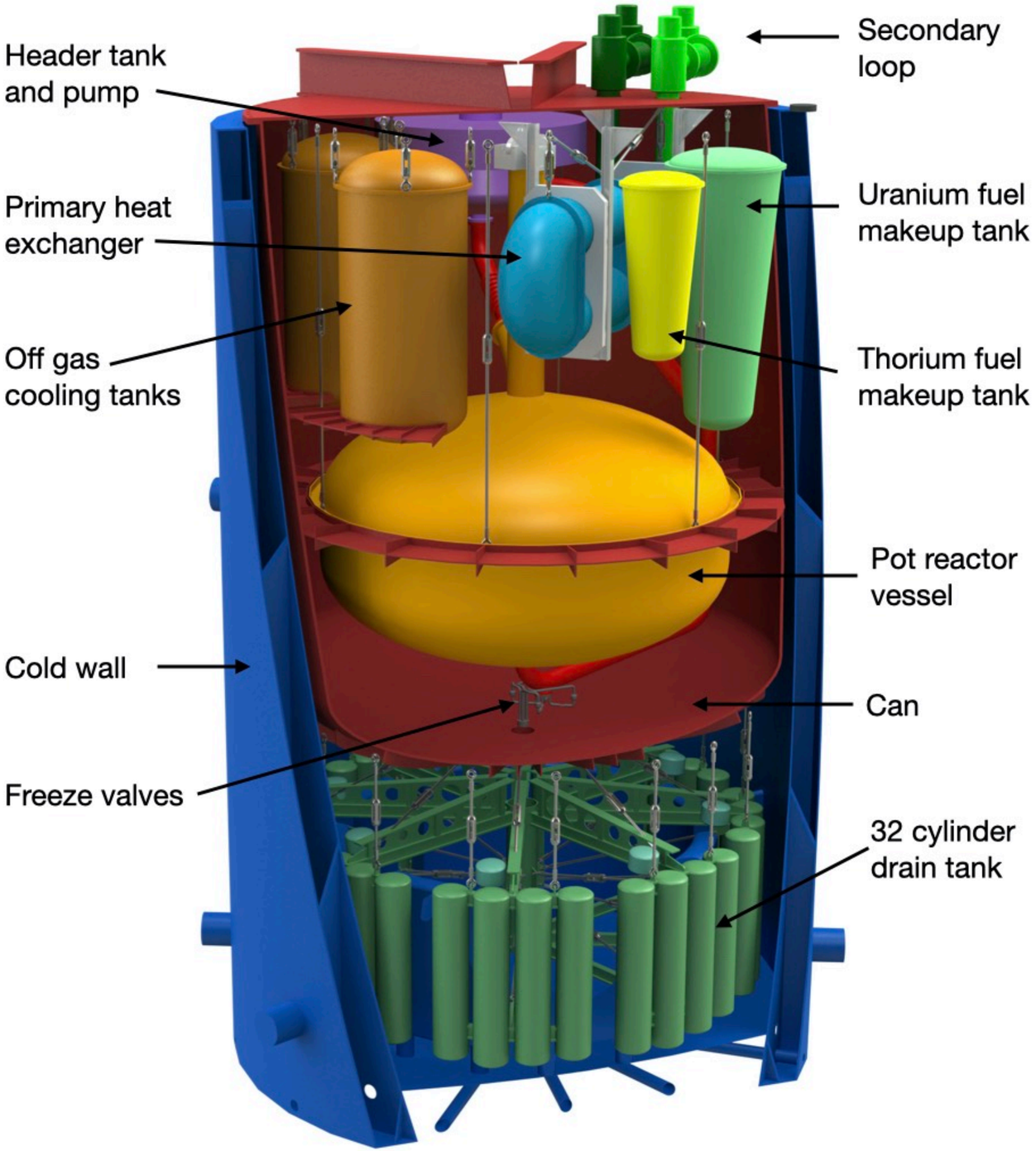
ThorCon
Powering Up Our World

Oak Ridge National Labs' molten salt reactor used uranium fuel in salt flowing up in channels in a graphite moderator.



- Physics stops fission if temperature rises much over 700°C, well below boiling.
- High temperature produces more electric power with less cooling water.

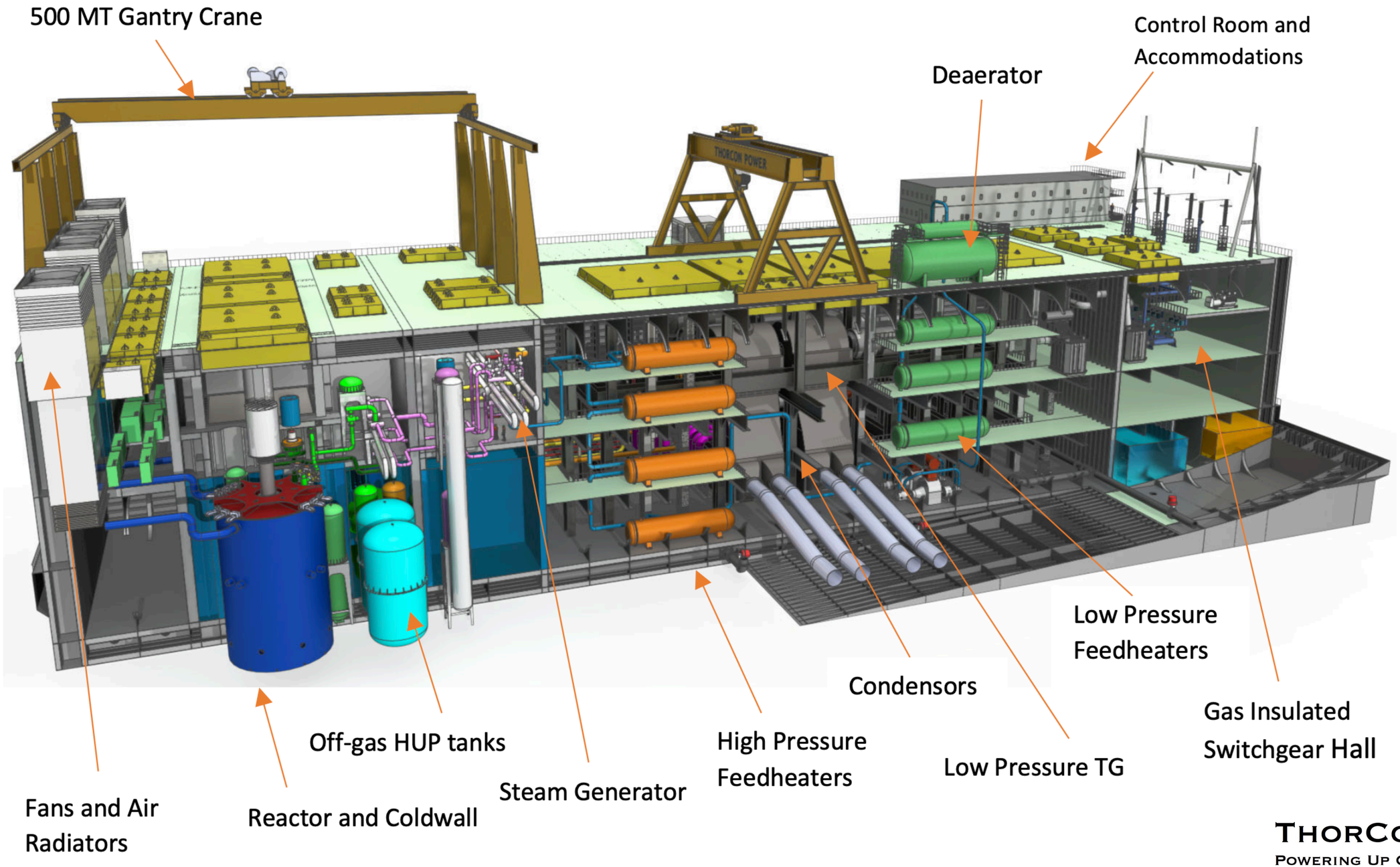
ThorCon
Powering Up Our World



Replaceable Can, in Silo Cold Wall

- The reactor Pot contains the graphite moderator with channels for molten salt flow.
- Overheat drains salt to drain tank.
- Cold wall absorbs heat radiated from drain tank.
- Cold wall is cooled by natural water circulation.

ThorCon 500 MW liquid fuel fission power plant



ThorCon
Powering Up Our World

Daewoo Shipbuilding and Marine Engineering will be ThorCon EPC.

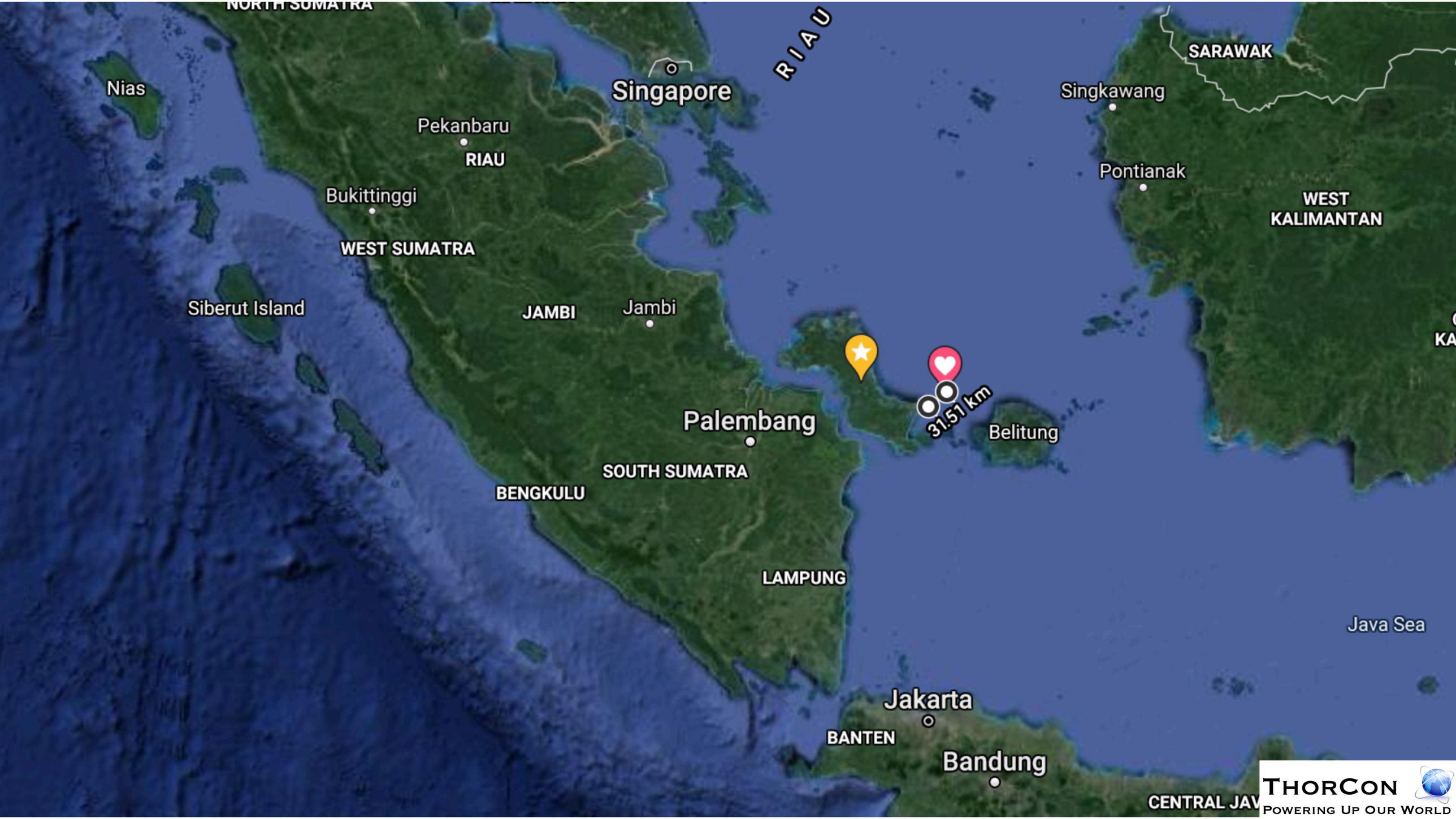
ThorCon
Powering Up Our World

Prototype will be towed to Indonesia.

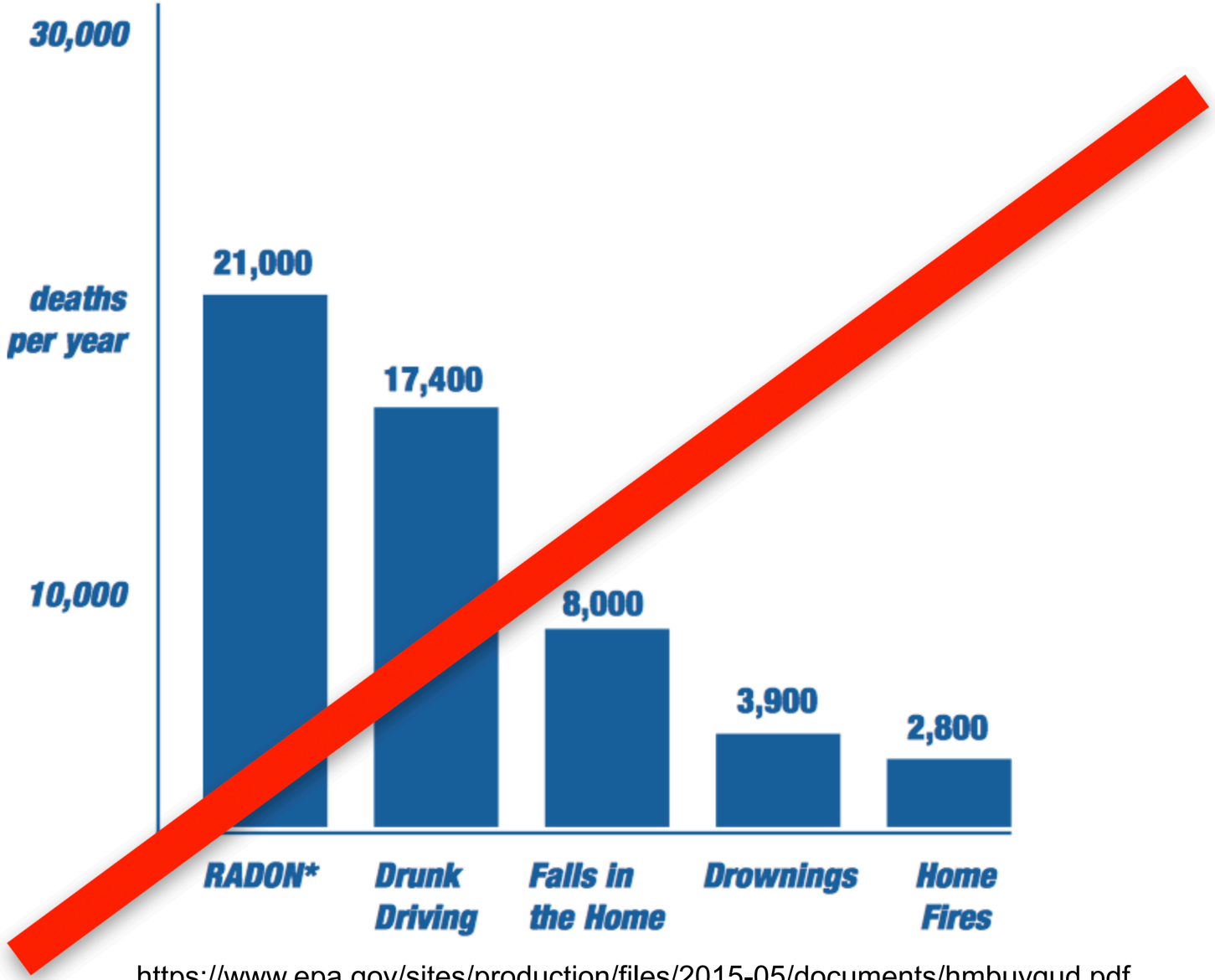
ThorCon
Powering Up Our World

Global benefits:

- CO2-free, 24x7 electric power
- cheaper than from coal
- helping people achieve prosperity
- reducing demand on natural resources


NORTH SUMATRA
Nias
Singapore
RIAU
Pekanbaru
RIAU
Bukittinggi
WEST SUMATRA
Siberut Island
JAMBI
Jambi
Palembang
SOUTH SUMATRA
BENGKULU
LAMPUNG
31.51 km
Belitung
Singkawang
SARAWAK
Pontianak
WEST
KALIMANTAN
Java Sea
Jakarta
BANTEN
Bandung
CENTRAL JAV
ThorCon
Powering Up Our World

Ignoring science, with no observed evidence, EPA claims radon deaths exceed those from drunk driving.



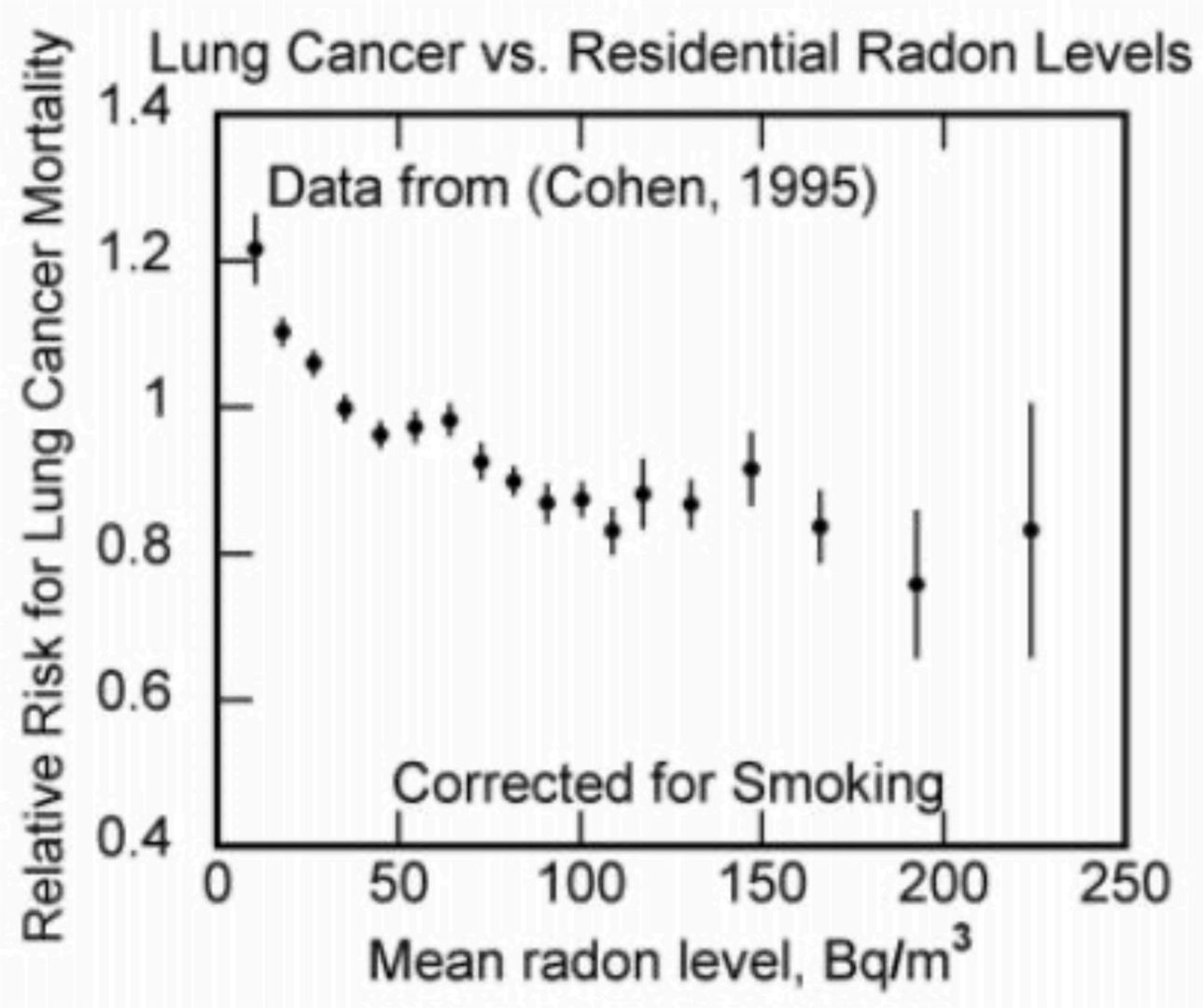
EPA recommends radon testing and remediation if radioactivity exceeds 4 pico-curies per liter of air.
= 0.15 Bq/liter, 20 mSv/yr
1 Bq = 1 decay/sec

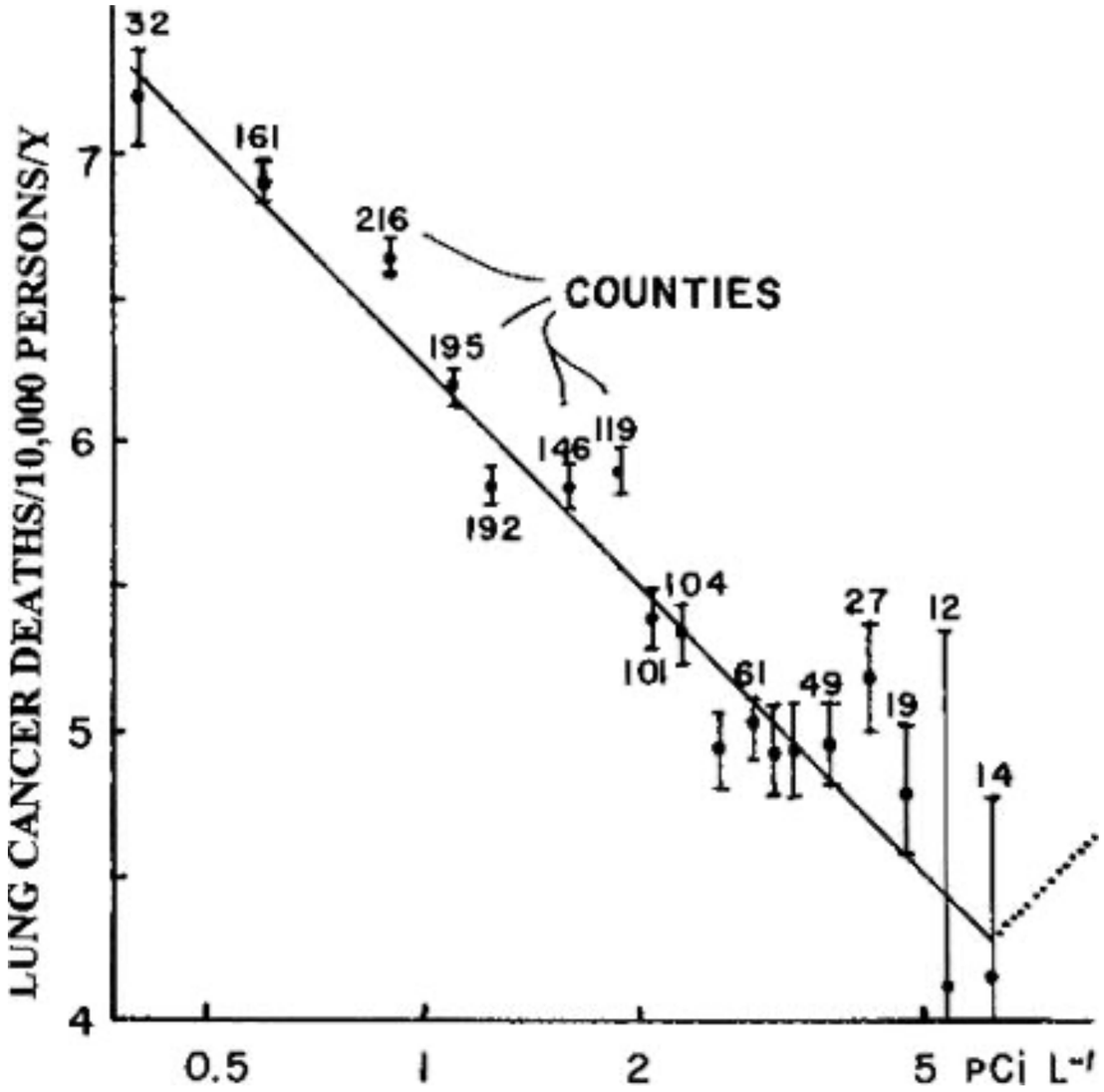
Note: humans are naturally slightly radioactive at about 2,700 pico-curies per liter.
= 100 Bq/liter

https://www.epa.gov/sites/production/files/2015-05/documents/hmbuygud.pdf

https://hps.org/publicinformation/ate/q11963.html

Lung cancer rates decrease with increasing residential radon levels.

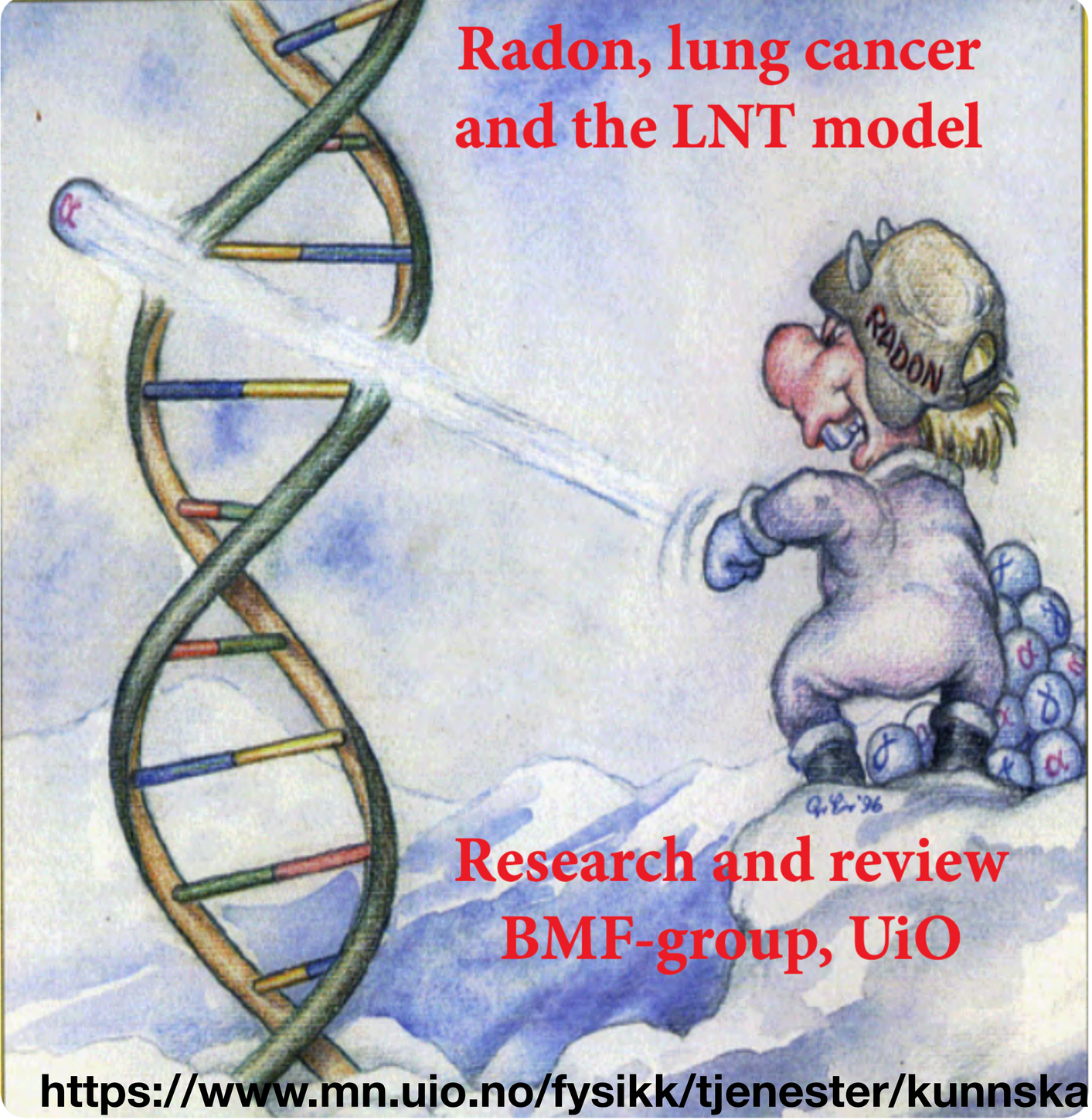




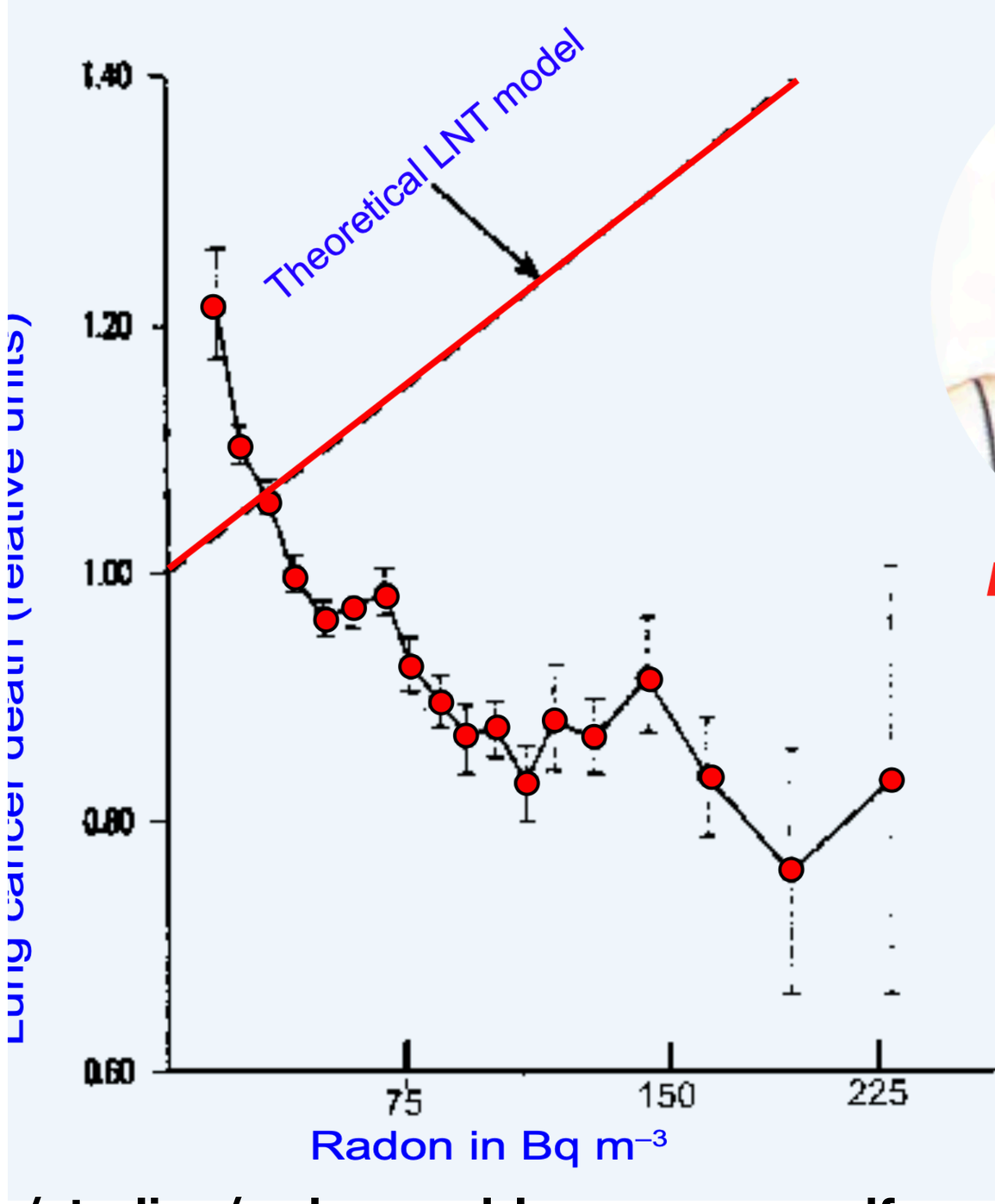
https://www.x-lnt.org/debate-announcement

https://www.ncbi.nlm.nih.gov/labs/pmc/articles/PMC2477686/

Radon, lung cancer and the LNT model



Research and review
BMF-group, UiO



https://www.mn.uio.no/fysikk/tjenester/kunnskap/straling/radon-and-lung-cancer.pdf