

Nuclear Energy | The Good News

Luke Lewandowski

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Thanks to Professor Pat Walden

- Physics Professor
- Expert in nuclear energy and climate change

Which is the Most Radioactive?



Radium Hot Springs 2.6 μ Sv/h from external sources, 14 μ Sv/h from radon
Chernobyl varies 16 μ Sv/h hot spots in Pripyat
Fukushima 10 μ Sv/h
Guarapari 56 μ Sv/h

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| Location | μSv per hour |
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Guarapari, Brazil



<https://www.youtube.com/watch?v=RvgAx1yIKjg>

Convert mSv per hour to mSv per year: <https://www.translatorscafe.com/unit-converter/en-US/radiation/24-22/microsievert/hour-millisievert/year/>

Guarapari, Brazil



<https://www.youtube.com/watch?v=RvgAx1yIKjg>

Convert mSv per hour to mSv per year: <https://www.translatorscafe.com/unit-converter/en-US/radiation/24-22/microsievert/hour-millisievert/year/>

30 Hours On Guarapari Beach

Same as 1 year background radiation dosage



4 Hours/Day on Guarapari Beach

4 times max annual dose allowed for nuclear worker



Chernobyl April 26, 1986

Worst nuclear accident in history



<https://pixabay.com/photos/monument-chernobyl-ukraine-npp-1062297/>

So Chernobyl. How much of a disaster was it?

Thyroid cancer because Soviet authorities did nothing for the first 48 hrs.

Chernobyl Deaths

2 nuclear plant workers from blast



* Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2008 Report to the General Assembly with Scientific Annexes, Volume II Scientific Annexes C, D and E

** <https://www.bbc.com/news/science-environment-54211450>

Chernobyl Deaths

29 plant staff and emergency workers from radiation exposure



* Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2008 Report to the General Assembly with Scientific Annexes, Volume II Scientific Annexes C, D and E

** <https://www.bbc.com/news/science-environment-54211450>

Chernobyl Deaths

15 from thyroid cancer



* Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2008 Report to the General Assembly with Scientific Annexes, Volume II Scientific Annexes C, D and E

** <https://www.bbc.com/news/science-environment-54211450>

Chernobyl Deaths

- 6,000 cases of thyroid cancer in children
Only 15 fatal as of 2005
 - Gov't did not start evacuation for 48 hours
 - Took 30 days to evacuate everyone
 - Gov't did not prevent people from drinking radioactive iodine-contaminated milk



* Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2008 Report to the General Assembly with Scientific Annexes, Volume II Scientific Annexes C, D and E

** <https://www.bbc.com/news/science-environment-54211450>

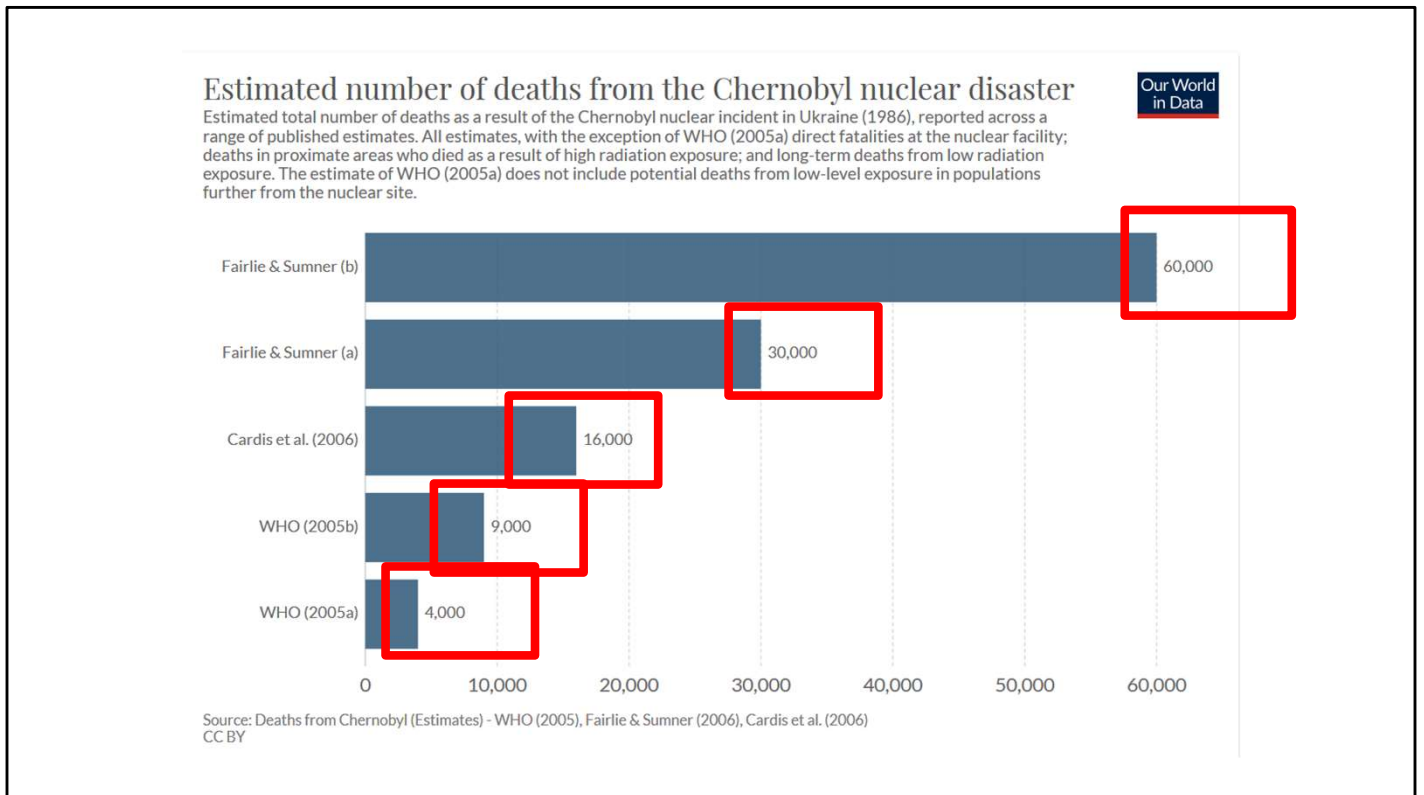
46 Chernobyl Deaths

2 + 29 + 15



* Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effects of Atomic Radiation. UNSCEAR 2008 Report to the General Assembly with Scientific Annexes, Volume II Scientific Annexes C, D and E

** <https://www.bbc.com/news/science-environment-54211450>



<https://ourworldindata.org/grapher/estimated-number-of-deaths-from-the-chernobyl-nuclear-disaster>

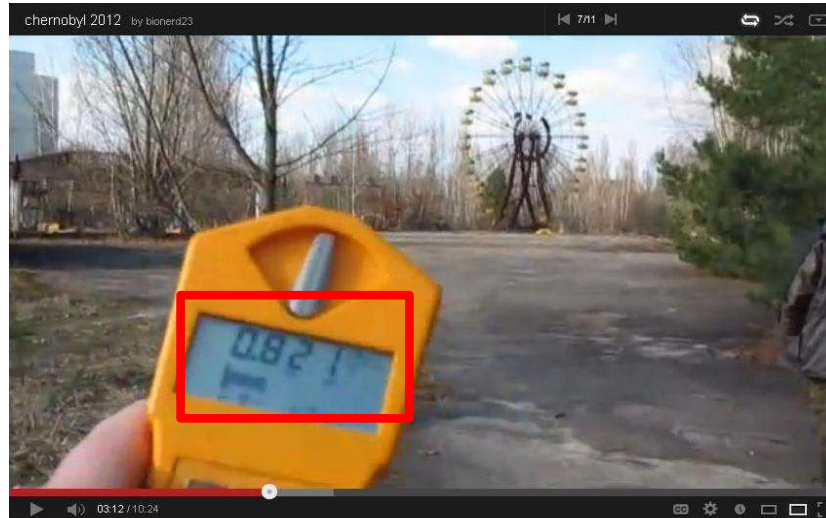
Chernobyl Today

Eco-system is healthy and intact, although radioactive



Photo by [Ilja Nedilko](https://unsplash.com/photos/g-GcNWvAVsc) on [Unsplash](https://unsplash.com/photos/g-GcNWvAVsc). <https://unsplash.com/photos/g-GcNWvAVsc>

City of Pripyat 15 km from Chernobyl Power Plant



<https://www.youtube.com/watch?v=aptV35As8jY>

Convert mSv per hour to mSv per year: <https://www.translatorscafe.com/unit-converter/en-US/radiation/24-22/microsievert/hour-millisievert/year/>

Distance from Pripyat to Chernobyl <http://pripyat.com/en/pripyat-and-chernobyl.html>

City of Pripyat

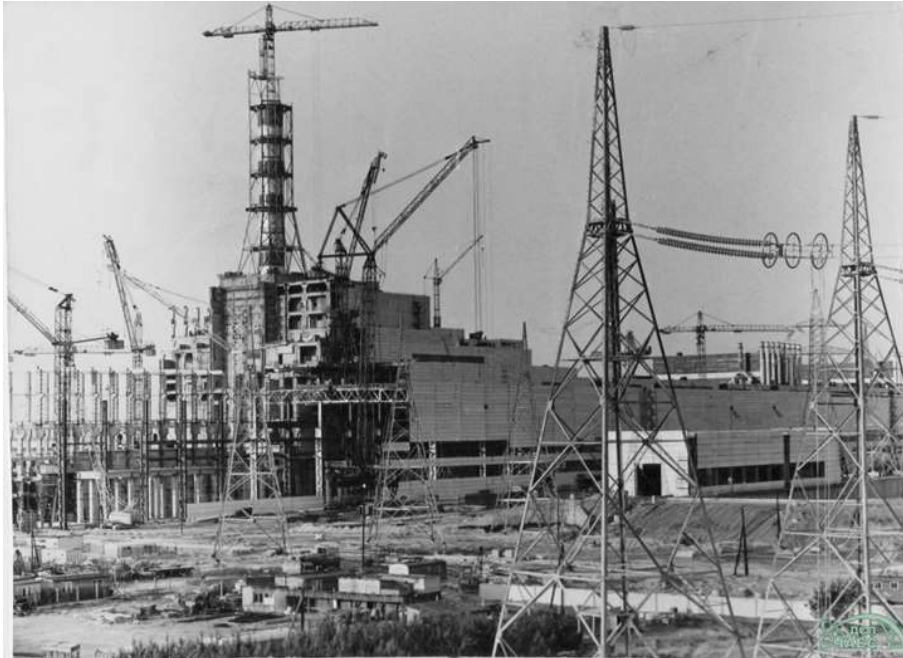


<https://www.youtube.com/watch?v=aptV35As8jY>

Pripyat go to 1:30 for 1 $\mu\text{Sv/h}$ go to 3:45 for 16 $\mu\text{Sv/h}$

Convert μSv per hour to mSv per year: <https://www.translatorscafe.com/unit-converter/en-US/radiation/24-22/microsievert/hour-millisievert/year/>

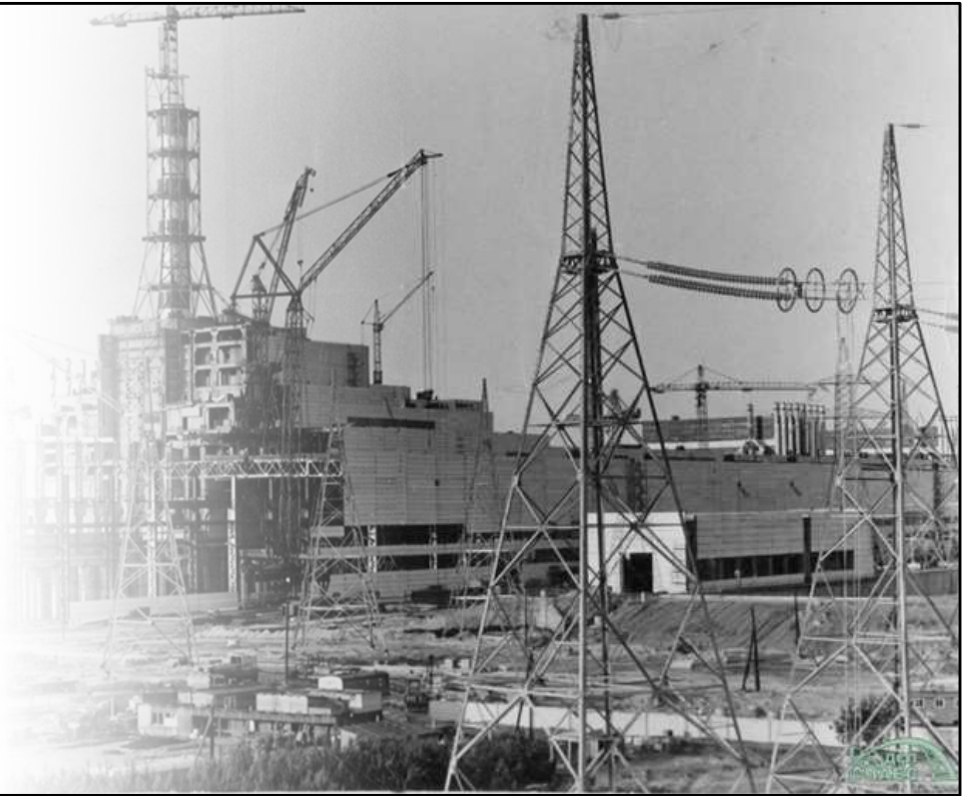
Why Did Chernobyl Happen?



<http://www.chernobylgallery.com/chernobyl-disaster/timeline/>

Why Did Chernobyl Happen?

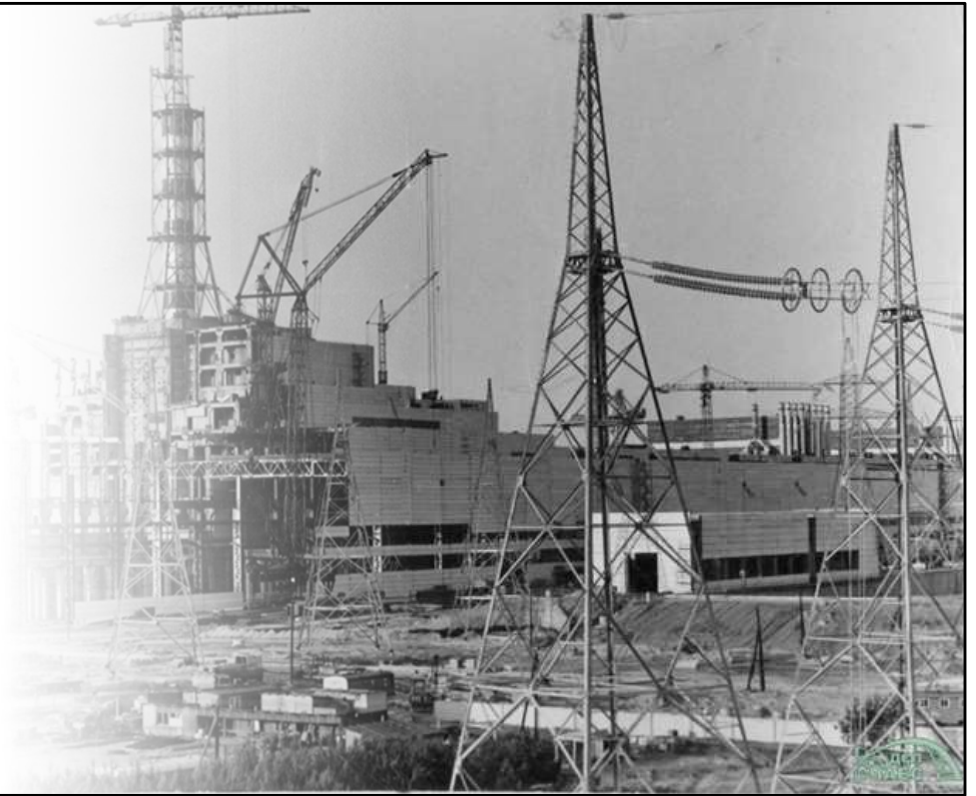
- Old Gen II Design (Now at Gen IV)
- Built 1970-1977



<http://www.chernobylgallery.com/chernobyl-disaster/timeline/>
<https://en.wikipedia.org/wiki/RBMK>

Why Did Chernobyl Happen?

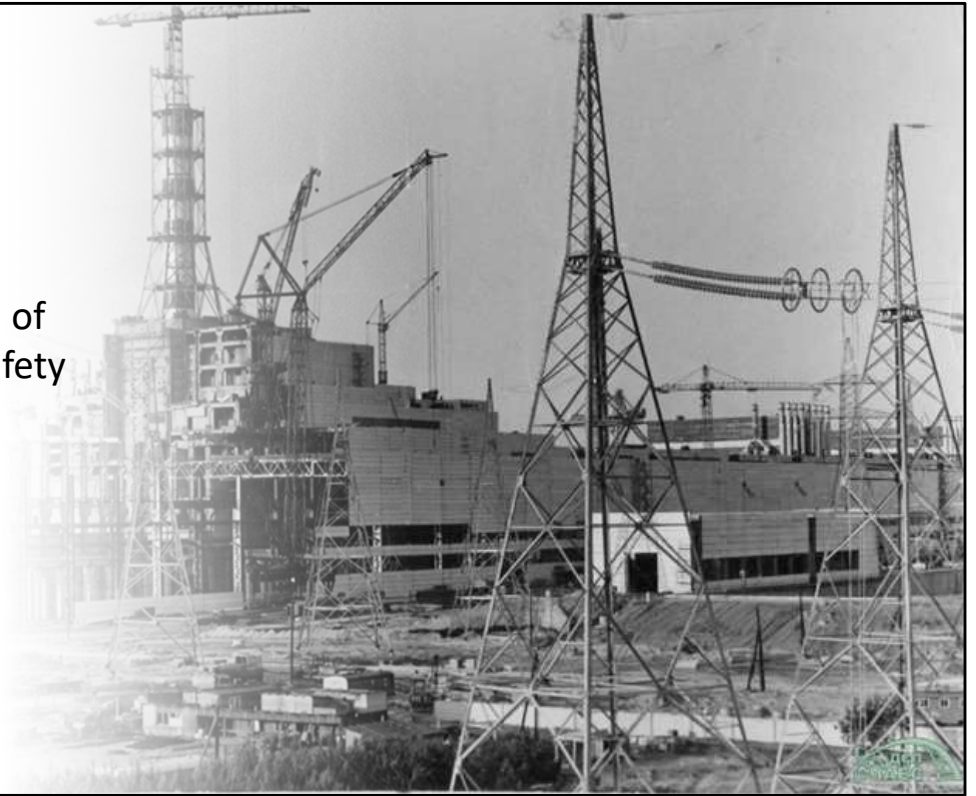
Based on 1950 technology



<http://www.chernobylgallery.com/chernobyl-disaster/timeline/>
<https://en.wikipedia.org/wiki/RBMK>

Why Did Chernobyl Happen?

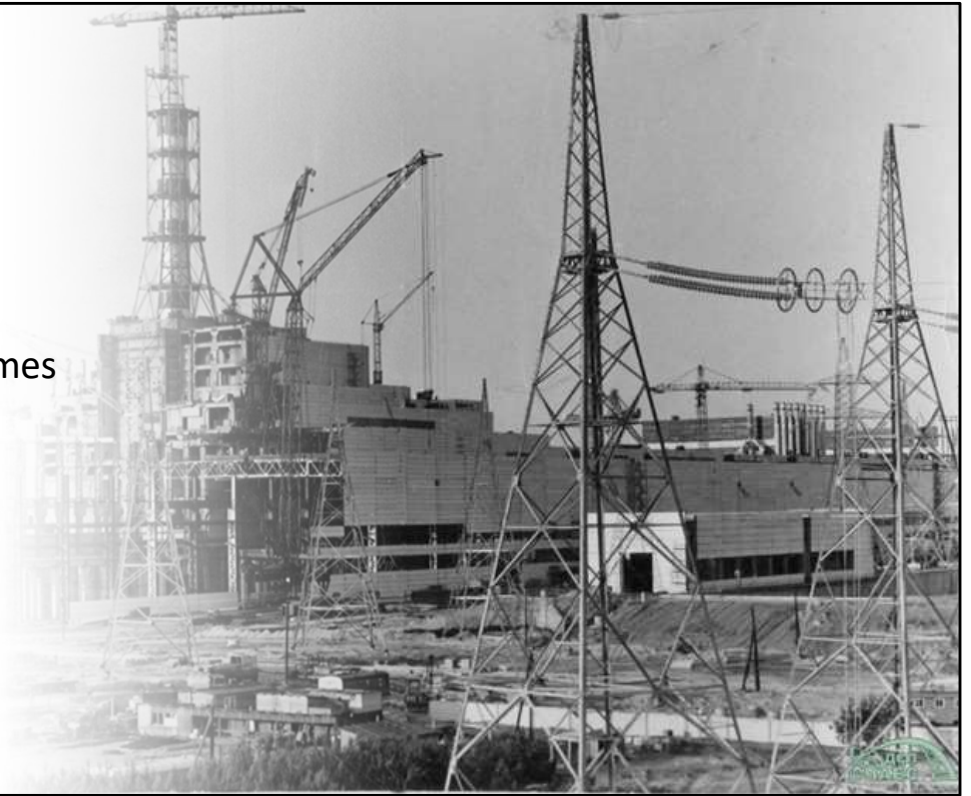
Optimized for speed of
construction over safety



<http://www.chernobylgallery.com/chernobyl-disaster/timeline/>
<https://en.wikipedia.org/wiki/RBMK>

Why Did Chernobyl Happen?

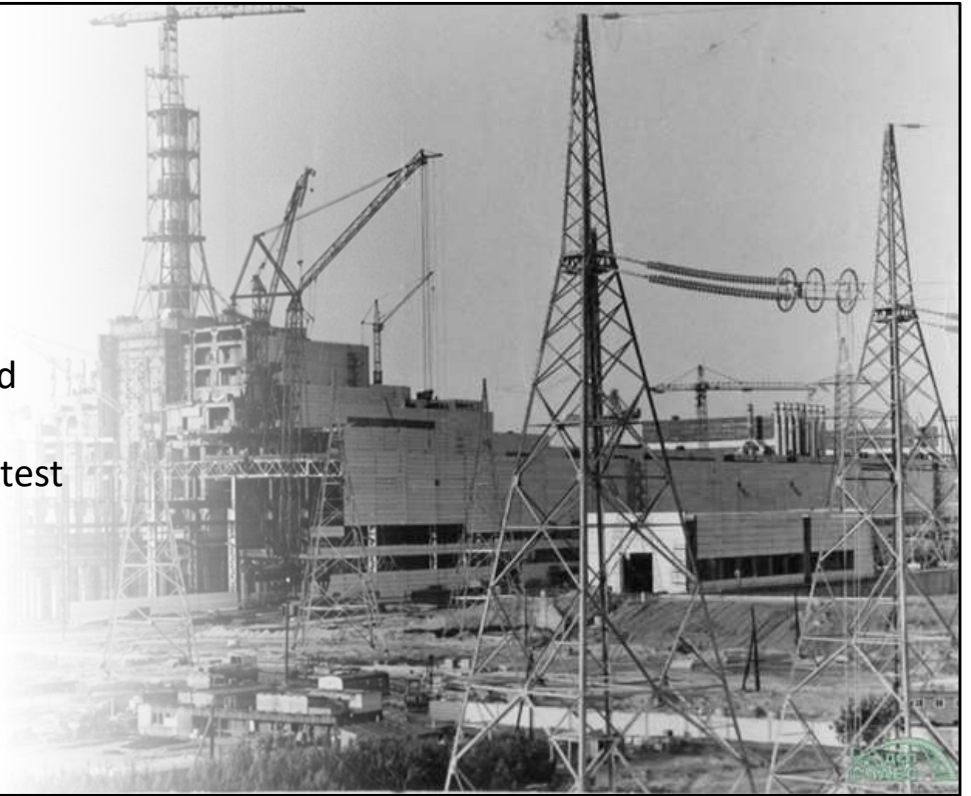
Chose RBMK design,
which releases 40 times
more radiation than
PWR



<http://www.chernobylgallery.com/chernobyl-disaster/timeline/>
<https://en.wikipedia.org/wiki/RBMK>

Why Did Chernobyl Happen?

- Human error
- An improper, failed emergency safety system shutdown test



<http://www.chernobylgallery.com/chernobyl-disaster/timeline/>

Why Did Chernobyl Happen?

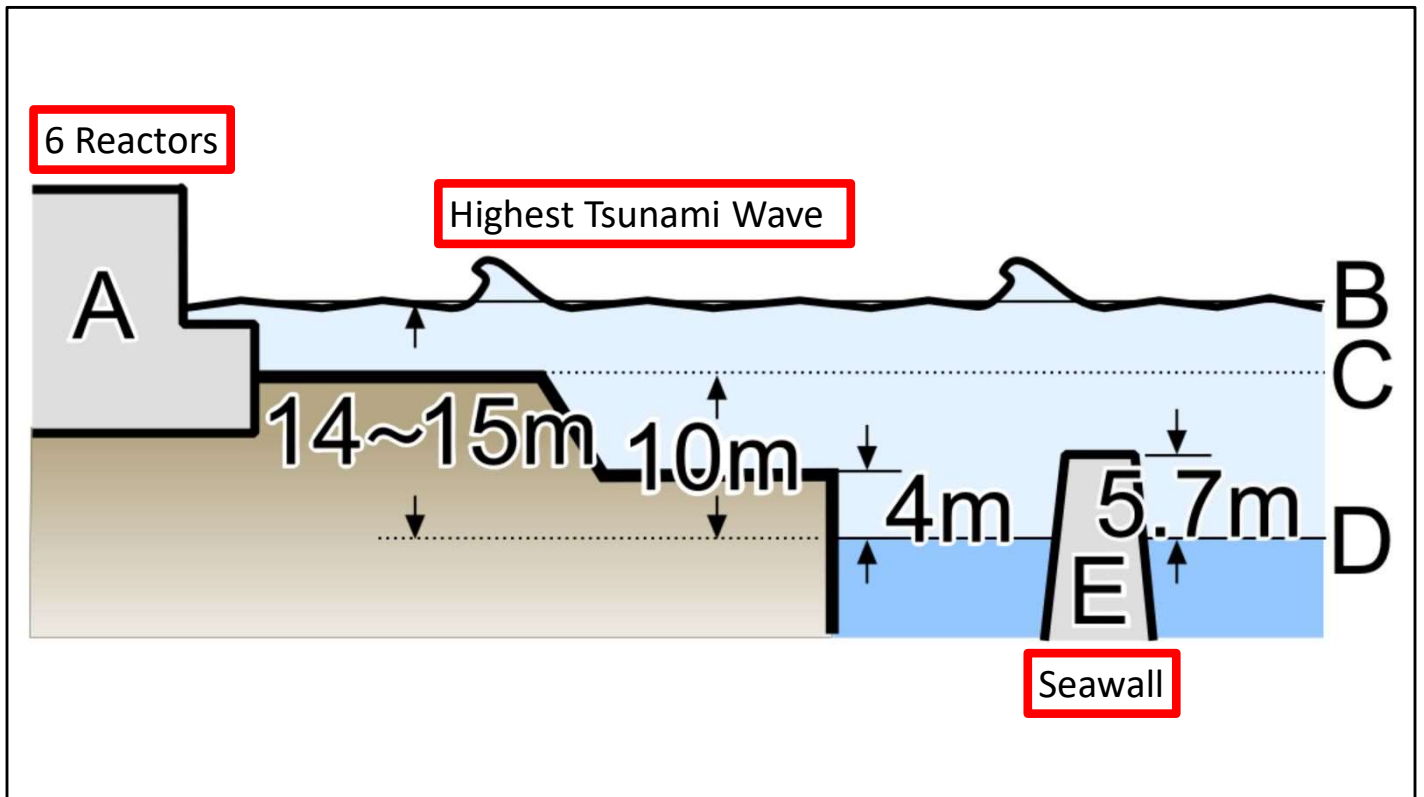
- No containment structure
- Would have doubled the construction cost
- Deemed to be “safe”



<http://www.chernobylgallery.com/chernobyl-disaster/timeline/>
<https://en.wikipedia.org/wiki/RBMK>

Fukushima March 11, 2011 | Tsunami





By Shigeru23 - Own work (ref:[1] [2]), CC BY-SA 3.0,
<https://commons.wikimedia.org/w/index.php?curid=14896539>

Fukushima 6 Reactors

Ground Level is
33 ft above sea level

Seawall
19 feet

Highest Tsunami Wave
46 feet



<https://www.e-education.psu.edu/earth107/node/1426>
[This Photo](#) by Unknown Author is licensed under [CC BY-SA](#)

Fukushima Accident March 11, 2011 Caused By Tsunami



Fukushima Deaths

1 from radiation – 4
years after accident



https://en.wikipedia.org/wiki/Fukushima_Daiichi_nuclear_disaster_casualties

What about Fukushima? Same thing, same hyped up over response, same result, except 5 times less radiation than Chernobyl.

extra notes:

-WHO got wise to the projecting of deaths from very small probabilities multiplied by very large populations. It is not even apparent that the model they were using was applicable to such small doses. In fact the most recent indications are that it is **NOT** applicable to such small doses.

-doses to the thyroid were 4 mSv. In Chernobyl they were 500 mSv

Fukushima Deaths

No increase in rate of
cancer deaths



https://en.wikipedia.org/wiki/Fukushima_Daiichi_nuclear_disaster_casualties

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Fukushima Deaths

About 2,200 deaths due to evacuation and displacement **from Tsunami**



https://en.wikipedia.org/wiki/Fukushima_Daiichi_nuclear_disaster_casualties

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Fukushima Feb 2016





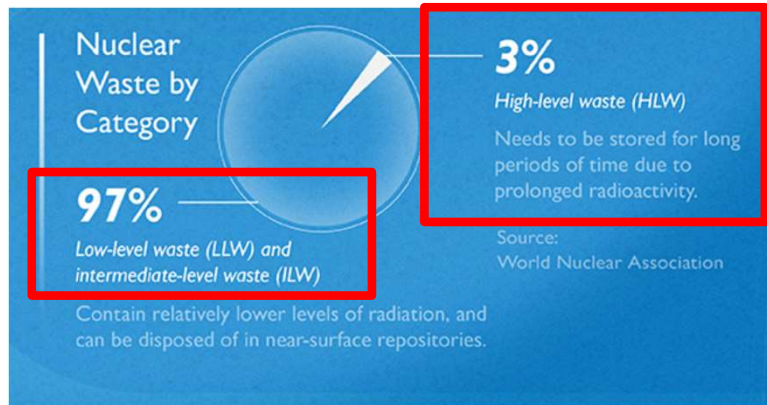
Radiation Risk

"If you put a completely legal luminous watch in a barrel containing half a ton of dirt, that dirt would technically be intermediate-level nuclear waste according to the regulations." *

* Book Where's My Flying Car, J. Storrs Hall

* Book Where's My Flying Car, J. Storrs Hall

Nuclear Waste



<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

Nuclear Waste

- Covers a football field
 - Estimates from 3.3 to 10 yards deep
- Older reactors used as little as **0.25%** of the fuel



<https://whatisnuclear.com/calcs/how-much-waste.html>

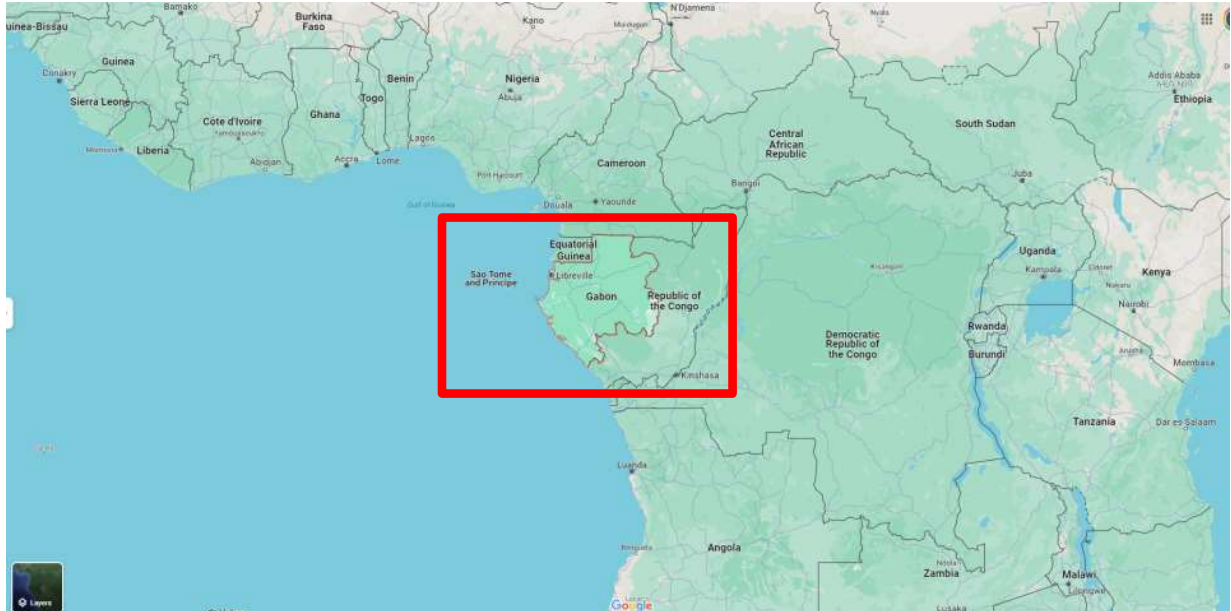
<https://pixabay.com/photos/football-field-football-games-78394/>

<https://www.sciencedirect.com/science/article/pii/S2214993714000050>

New methods for efficiently recycling the used fuel (already proven and currently in an advanced stage of development for commercial application) will drastically reduce the radioactive hazards as well as the volume of the waste that must be kept isolated from the environment. As an example, the level of [radioactivity](#) of a repository containing this type of waste will, after about 300 years, be comparable to that of the [natural uranium](#) deposits that are widely distributed around the world. Furthermore, modern waste isolation technology will equal or exceed the level of isolation originally provided by nature for radioactive ores. In this way, the much-publicized radioactivity issue of the waste will be reduced to a historical time scale of a few hundred years, rather than a geological time scale of hundreds of thousands of years. It is important to note that this waste will be disposed of in an environmentally inert form, i.e., ceramic or vitrified solids that will not start [leaching](#) any material into the environment for thousands of years, long after their radioactivity will have dissipated. On the other hand, large amounts of solid and [gaseous waste](#) from coal-fired stations (including mercury and heavy metals) will remain poisonous in perpetuity and are not kept well separated from the environment.

<https://www.nei.org/resources/statistics>

Oklo, Gabon 16 Natural Nuclear Fission Reactors



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

Oklo, Gabon

16 Natural Nuclear Fission Reactors

1.7 billion years ago



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

Oklo, Gabon

16 Natural Nuclear Fission Reactors

Self-sustaining reactors ran for a few 100,000 years, then burned out

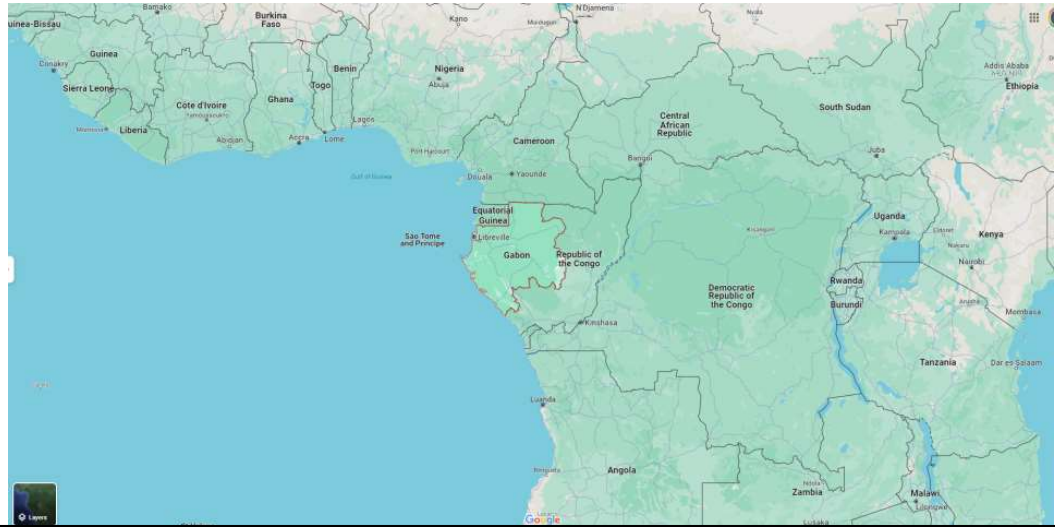


https://en.wikipedia.org/wiki/Natural_nuclear_fission_reactor

Oklo, Gabon

16 Natural Nuclear Fission Reactors

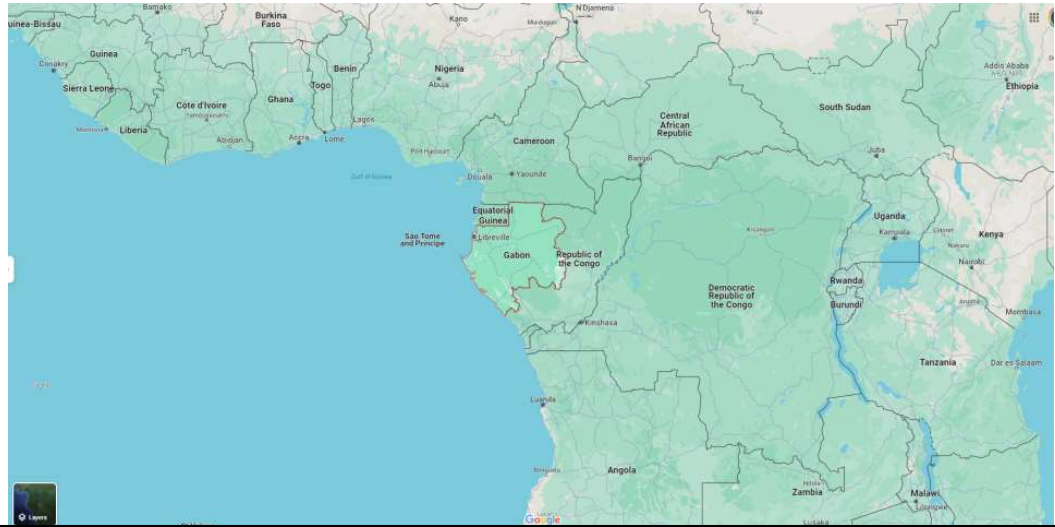
Spent Uranium fuel buried in bedrock



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

Oklo, Gabon 16 Natural Nuclear Fission Reactors

Uranium waste completely stable for more than **1 Billion** years



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

“Nuclear is Dangerous”



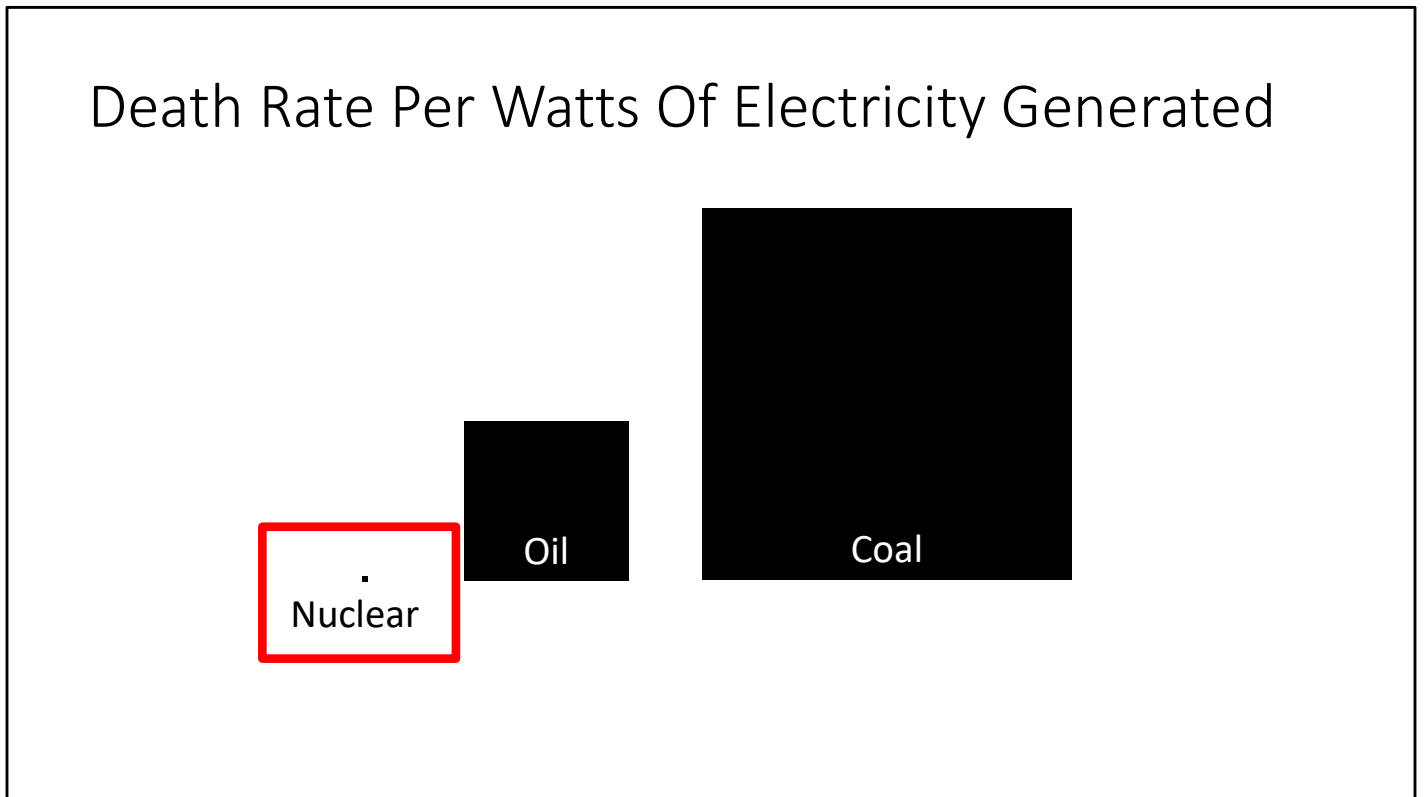
<https://www.publicdomainpictures.net/en/view-image.php?image=674&picture=radioactive-sign>

https://en.wikipedia.org/wiki/Energy_accidents#Fatalities

Have You Ever Heard “Coal is Dangerous”



<https://www.publicdomainpictures.net/en/view-image.php?image=674&picture=radioactive-sign>
https://en.wikipedia.org/wiki/Energy_accidents#Fatalities



<https://seths.blog/2011/03/the-triumph-of-coal-marketing/>

London Smog Dec 1952



By N T Stobbs, CC BY-SA 2.0,
<https://commons.wikimedia.org/w/index.php?curid=4094275>

London Smog Casualties

- 12,000 Dead
- 100,000 sick from smog in lungs
- Caused mostly from burning coal



<https://www.britannica.com/event/Great-Smog-of-London>

Nuclear causes calamities when it goes wrong

Coal causes calamities when it goes right

Coal is right more often than nuclear is wrong

<https://www.monbiot.com/2011/03/16/atomised/>

Nuclear **accidents** do less damage
than coal stations operating **normally**

<https://www.monbiot.com/2011/03/16/atomised/>



Nuclear Safety US Navy

- 700 nuclear reactors used since the 1950s
- Currently, around 200 in operation

<https://www.forbes.com/sites/jamesconca/2019/12/23/americas-nuclear-navy-still-the-masters-of-nuclear-power/?sh=7c8dced26bcd>

Photo; <https://weaponsandwarfare.com/2016/04/19/nuclear-powered-aircraft-carriers/>

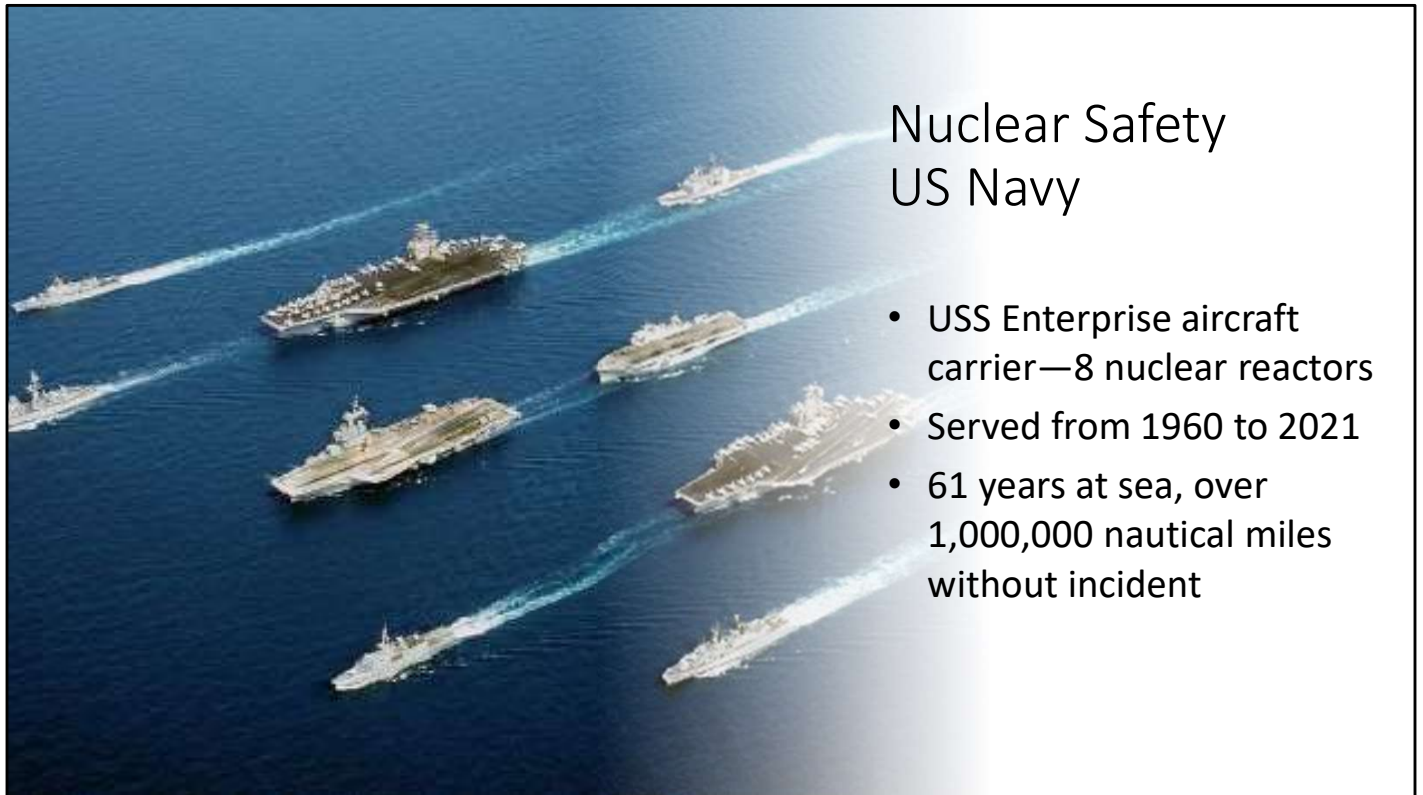


Nuclear Safety US Navy

- Best safety record of any industry, better than desk jobs
- Nobody among more than 100,000 personnel has been harmed by radiation

<https://www.forbes.com/sites/jamesconca/2019/12/23/americas-nuclear-navy-still-the-masters-of-nuclear-power/?sh=7c8dced26bcd>

Photo; <https://weaponsandwarfare.com/2016/04/19/nuclear-powered-aircraft-carriers/>

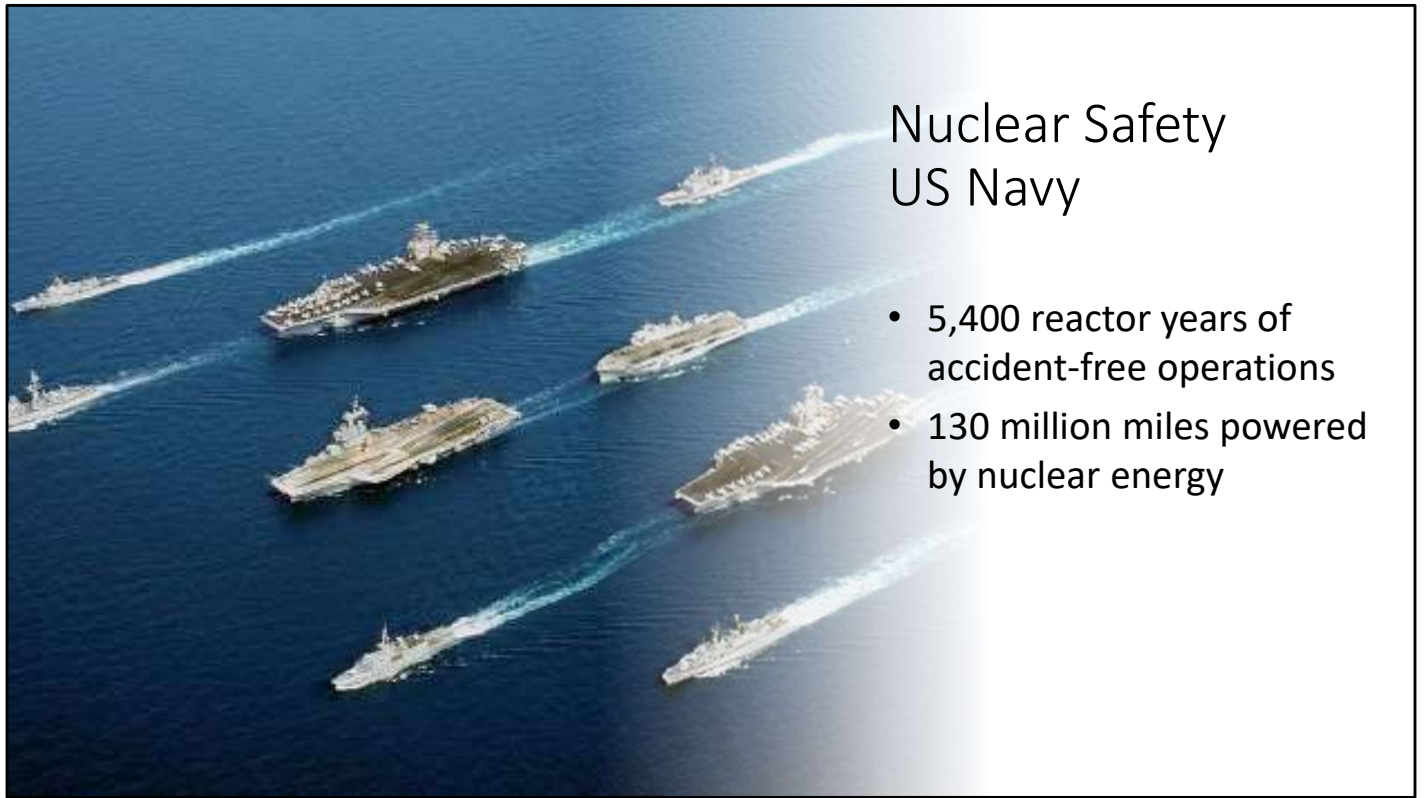


Nuclear Safety US Navy

- USS Enterprise aircraft carrier—8 nuclear reactors
- Served from 1960 to 2021
- 61 years at sea, over 1,000,000 nautical miles without incident

<https://www.forbes.com/sites/jamesconca/2019/12/23/americas-nuclear-navy-still-the-masters-of-nuclear-power/?sh=7c8dced26bcd>

Photo; <https://weaponsandwarfare.com/2016/04/19/nuclear-powered-aircraft-carriers/>

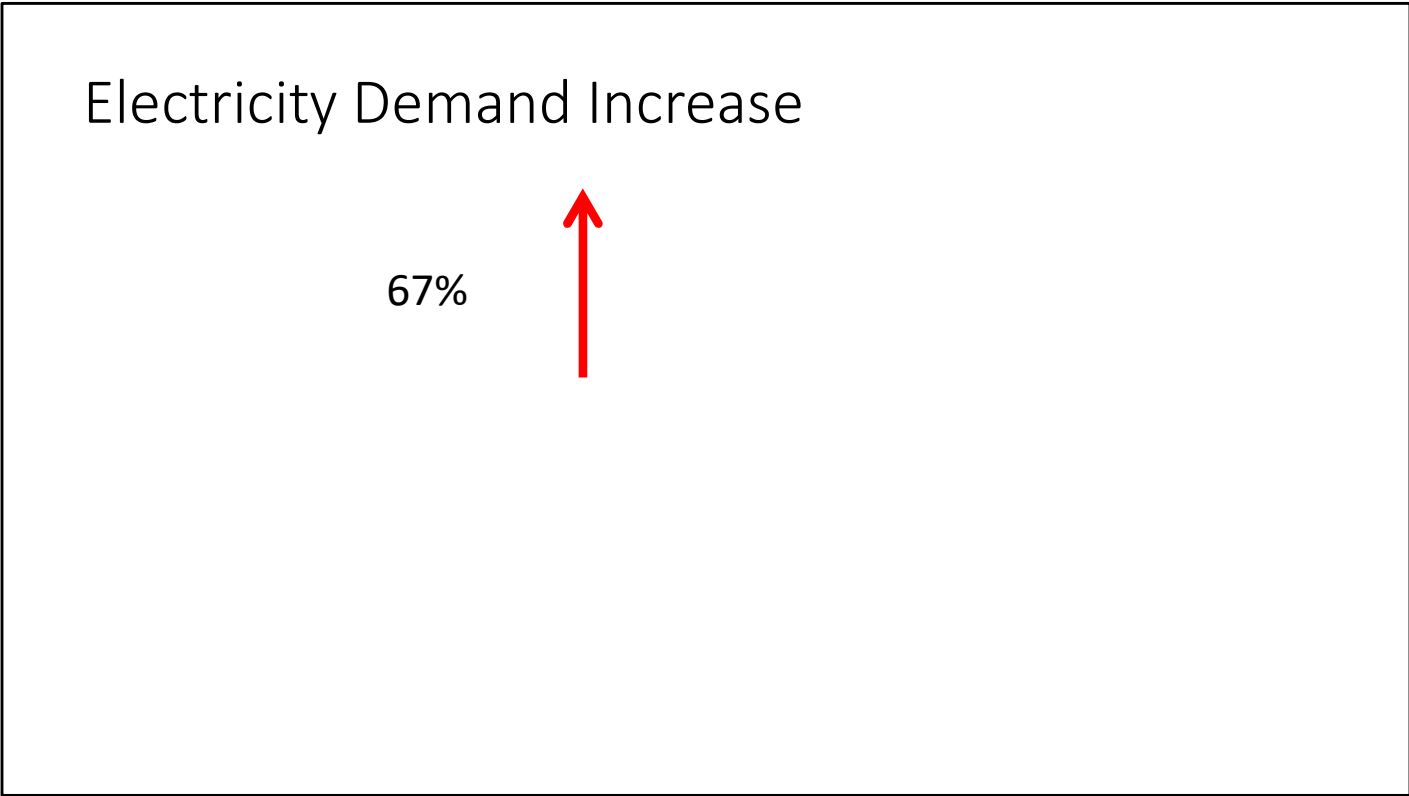


Nuclear Safety US Navy

- 5,400 reactor years of accident-free operations
- 130 million miles powered by nuclear energy

<https://www.forbes.com/sites/jamesconca/2019/12/23/americas-nuclear-navy-still-the-masters-of-nuclear-power/?sh=7c8dced26bcd>

Photo; <https://weaponsandwarfare.com/2016/04/19/nuclear-powered-aircraft-carriers/>



1.3 Billion People Do Not Have Electricity



Electric Vehicle Growth

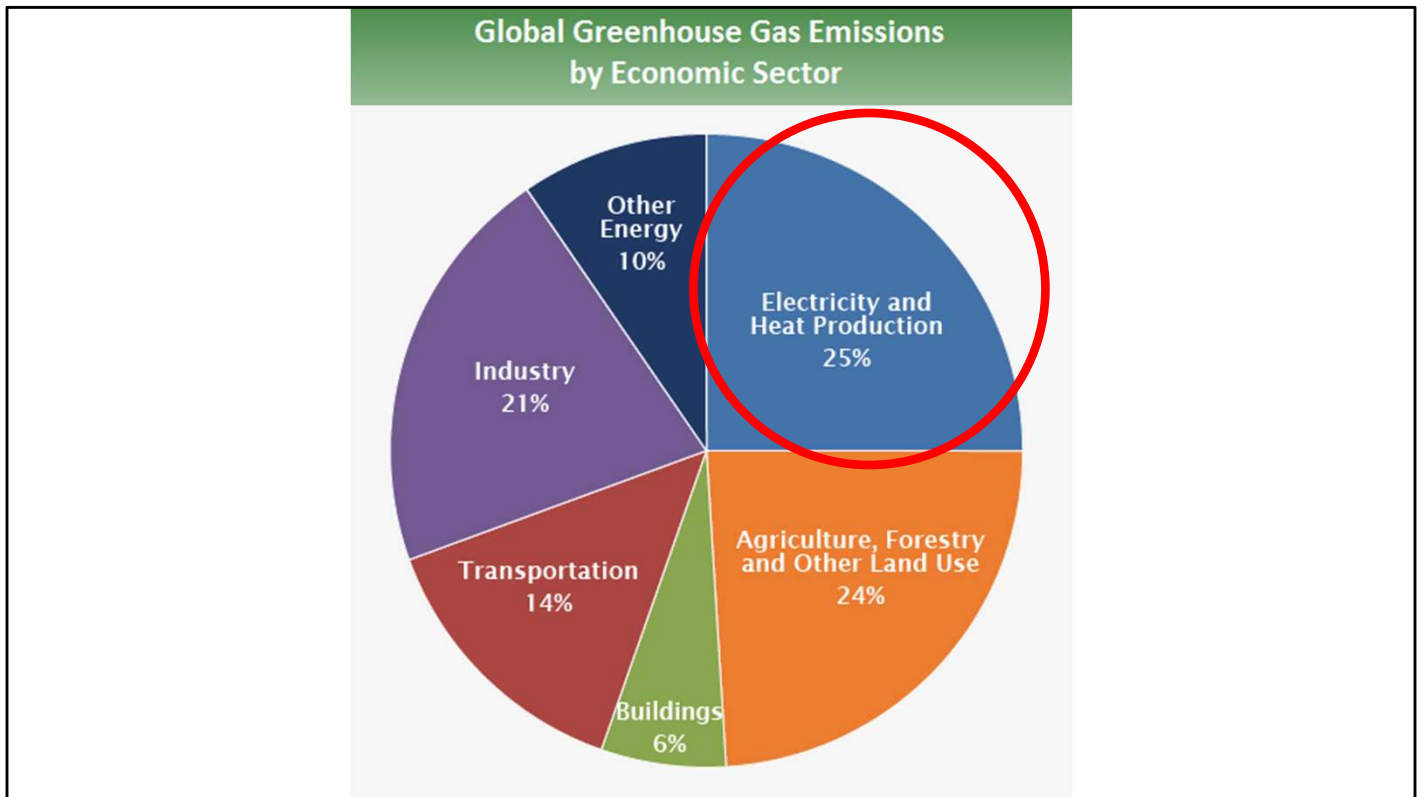
| Year | Electric Vehicles |
|------|-------------------|
| 2023 | 14 Million |
| 2050 | 700 Million |



<https://www.woodmac.com/press-releases/700-million-electric-vehicles-will-be-on-the-roads-by-2050/>

Dilemma

- More people need more Electricity
- We Are Emitting More GHG



<https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>

Is There a Solution?

Increase electricity production

Decrease GHG emissions







Is Wind a Solution?



Photo by [Aleksey Kuprikov](#) from [Pexels](#).

<https://www.pexels.com/photo/photo-of-wind-turbine-under-blue-sky-3551252/>

| Plant Type | Capacity factor (%) | Cost \$/MWh | GHG emissions g(CO _{2e})/kWh |
|------------------|--|-------------|---|
| Advanced Nuclear | 90 % | \$99.1 | 12  |
| Geothermal | 91 % | \$46.5 | 38 |
| Advanced Gas | 87 % | \$56.5 | 490  |
| Hydro | 59 % | \$66.2 | 24 |
| Wind | 39 %  | \$63.7 | 11  |
| Wind - Offshore | 45 % | \$157.4 | 12 |
| Solar PV | 24 % | \$85.0 | 48 |
| Solar - Thermal | 20 % | \$242.0 | 27 |

U.S. Energy Information Administration

GHG emissions from IPCC

Explain Levelized costs of electricity & life cycle GHG emissions.

- CCGT (Combine cycle gas turbine) Natural gas. Not really green. ½ the emissions of coal. CCGT cheap. Currently putting Nuclear out of business.
- nuclear it is competitively priced and it's GHG emissions are very low.
- note Solar PV has 4 times the emissions.
- wind has even lower GHG emissions and it's cheaper. So why use Nuclear?
- there's a problem. Wind is intermittent, random, and only on 36% of the time. This represents a **BIG** problem, especially if you want to go 100% renewable.

Can We Rely on Wind?

- Generates electricity 39% of the time
- The other 61%?
 - Use backup electricity generation facility

https://en.wikipedia.org/wiki/Cost_of_electricity_by_source

Backup For Wind Electricity Generation

- Combined Cycle Gas Turbine (CCGT)
- Powered by natural gas

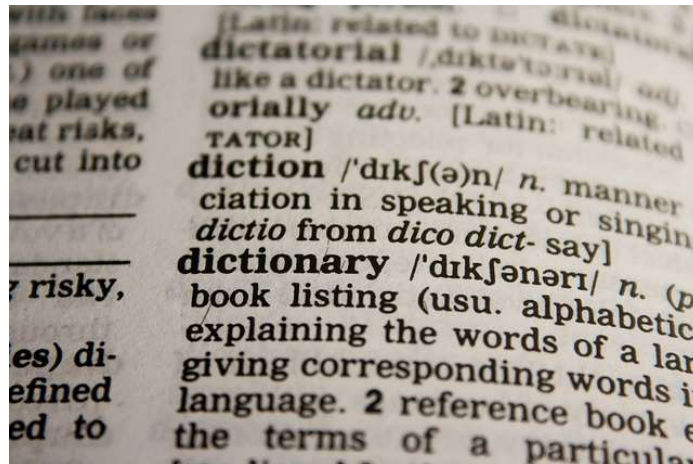


Image by [PDPics](https://pixabay.com/users/PDPics-44804/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=390055) from [Pixabay](https://pixabay.com/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=390055)
<https://pixabay.com/photos/dictionary-words-grammar-abc-390055/>

Wind + CCGT 5 Locations

| No. of locations | % renewable | Cost \$/MWh | GHG emissions g(CO _{2e})/kWh |
|------------------|-------------|-----------------------------|---|
| 1 | 39.0 % | \$66.5 | 303 |
| 2 | 62.8 % | <i>Increasing</i> \$85.1 | <i>Decreasing</i> 196 |
| 3 | 77.3 % | \$110.0 | 137 |
| 4 | 86.2 % | \$139.9 | 106 |
| 5 | 91.6 % | \$173.8 | 92 |

Analysis By Professor Pat Walden

Geography? How far do we have to range to find 5 locations where the wind patterns are completely uncorrelated? Correlations make things worse. Will it be the size of a continent? Transmission lines will not transmit energy over the length of the continent due to resistive heat losses.

-To get to a 5 location solution is a ways off into the future.

-Meanwhile nuclear is cheaper, emits far less GHG, and is ready to go now.

Similar Analysis for Solar And Solar + Wind



Can We Eliminate The Backup CCGT?

Can we store electricity?

Store Electricity in Batteries



Image by [Clker-Free-Vector-Images](https://pixabay.com/users/Clker-Free-Vector-Images-3736/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=312747) from [Pixabay](https://pixabay.com/?utm_source=link-attribution&utm_medium=referral&utm_campaign=image&utm_content=312747)
<https://pixabay.com/vectors/battery-electrical-electricity-312747/>

Storage Assumptions



- Wind is “on” about 39% of the time
- Assume 3 battery storage systems
- Each battery storage system supplies 100% of the energy for one day

Storage Assumptions



- When wind is on
 - Some wind turbines supply energy
 - Some wind turbines charge the batteries
- No wind and no battery storage
 - Use CCGT (fossil fuel) backup

Wind, Batteries, CCGT



39% renewable (same location)
 45% batteries
 16% CCGT
 \$174/MWh
 113 g(CO_{2e})/kWh

Batteries last 8 years
 Over 40 years must be
 replaced 5 times, which
 increases the costs and GHG

39% renewable
 45% batteries
 16% CCGT
 \$474/MWh (battery replace)
 199 g(CO_{2e})/kWh

Analysis By Professor Pat Walden

-Since wind is "on" about 1/3 of the time, we need to build 300% of the infrastructure that is needed to supply 100% of the power when wind in on.

-Let's assume we have 3 days supply of energy storage. Each battery can supply 100% of the energy for one day. When wind in on, a third of the infrastructure supplies the energy, the other two charge up the batteries.

-and when we run out of wind and storage, we fall back on the fossil fuel backup.

It does not get much better if we add more storage. A 7-day supply gets us only to 90%. Renewables will be off 10% of the time.

Wind + Battery + CCGT

| type | % renewable | Cost \$/MWh | GHG emissions g(CO _{2e})/kWh |
|-----------------------|-------------|----------------|---|
| 3 Station Wind + CCGT | 77.3 % | \$110.0 | 137 |
| Batteries for storage | 84.0 % | \$174.1 | 113 |
| Battery replacement | 84.0 % | \$474.1 | 199 |

Analysis By Professor Pat Walden

- the cost of the turbines can be actually the cheap part of wind power.
- Maybe renewables together with storage, and smart grid can make inroads on the problem, but it gets more expensive, emissions will never get down to the level with nuclear, and it will never be able to supply 100% of the power 100% of the time. For a random intermittent source there is always the possibility that it can be off long enough to outlast your storage. You can approach 100% coverage, but never get there, and it will be very very expensive.
- Meanwhile nuclear is cheaper, emits far less GHG, and is ready to go now.

Similar Analysis For Solar + Batteries And Solar + Wind + Batteries



Battery Storage



- Not enough **Lead** and **Lithium**
- Only enough for less than 10% of US requirement
- Need some other battery technology

However presently energy storage has some problems

- Tom Murphy blogger and Physicist from UCSD. "Do the Math". Black are his observations/calculations. **Red are mine.**

<http://physics.ucsd.edu/do-the-math/post-index/>

<https://dothemath.ucsd.edu/2012/02/the-alternative-energy-matrix/>

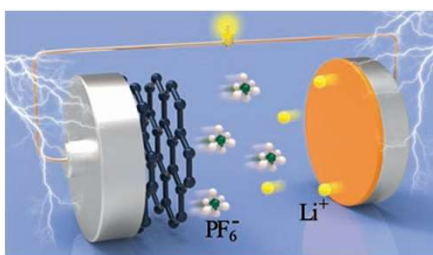
Google "Murphy Do the Math"

"A Nation Sized Battery"

"Pump up the Storage"

<https://www.formenergy.com/>

Race to Build a Better Battery



Battery

Photo by [Alessandro Paiva](/photographer/Ale_Paiva-42398) from [FreeImages](https://freeimages.com/)

<https://www.freeimages.com/photo/battery-1308664>

<https://fortune.com/longform/race-build-better-battery/>

Other Ways To Store Electricity?

Pumped Hydro Electric Storage



<https://www.technologyreview.com/s/611683/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/>

California Electricity Storage

| Goal | Energy Storage MWh | Cost per MegaWatt hour |
|----------|--------------------|------------------------|
| 2020 (?) | 150,000 | \$49 |



<https://www.technologyreview.com/s/611683/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/>

California Electricity Storage

| Goal | Energy Storage MWh | Cost per MegaWatt hour |
|----------------|--------------------|------------------------|
| 2020 (?) | 150,000 | \$49 |
| 80% renewables | 9.6 million | \$405 |

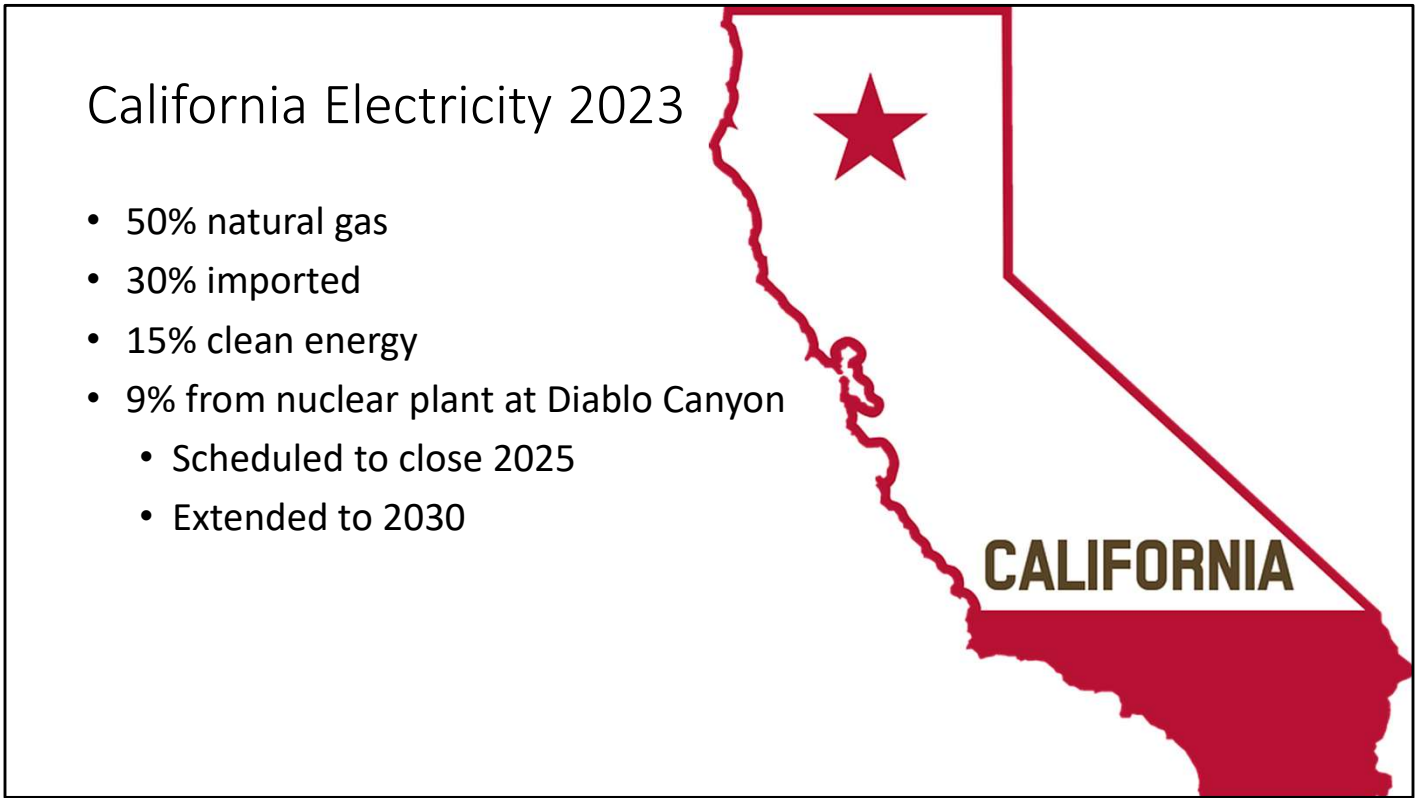
<https://www.technologyreview.com/s/611683/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/>

California Electricity Storage

| Goal | Energy Storage MWh | Cost per MegaWatt hour |
|-----------------|--------------------|------------------------|
| Today | 150,000 | \$49 |
| 80% renewables | 9.6 million | \$405 |
| 100% renewables | 36.3 million | \$1,612 * |

* Cost to consumer today, \$153.40 per megawatt hour

<https://www.technologyreview.com/s/611683/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/>



California Law

| Year | Percent Renewables |
|------|--------------------|
| 2020 | 33% |
| 2026 | 50% |
| 2030 | 60% |
| 2045 | 100% |

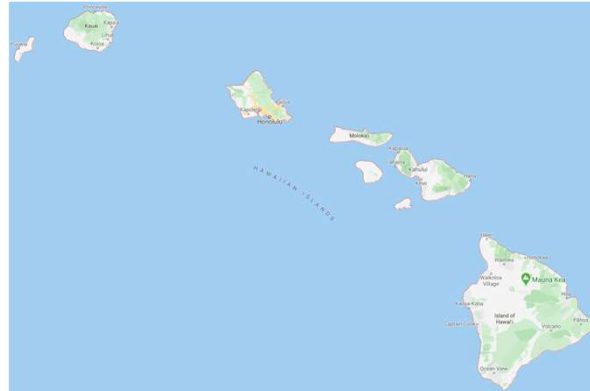


<https://www.npr.org/2018/09/10/646373423/california-sets-goal-of-100-percent-renewable-electric-power-by-2045>

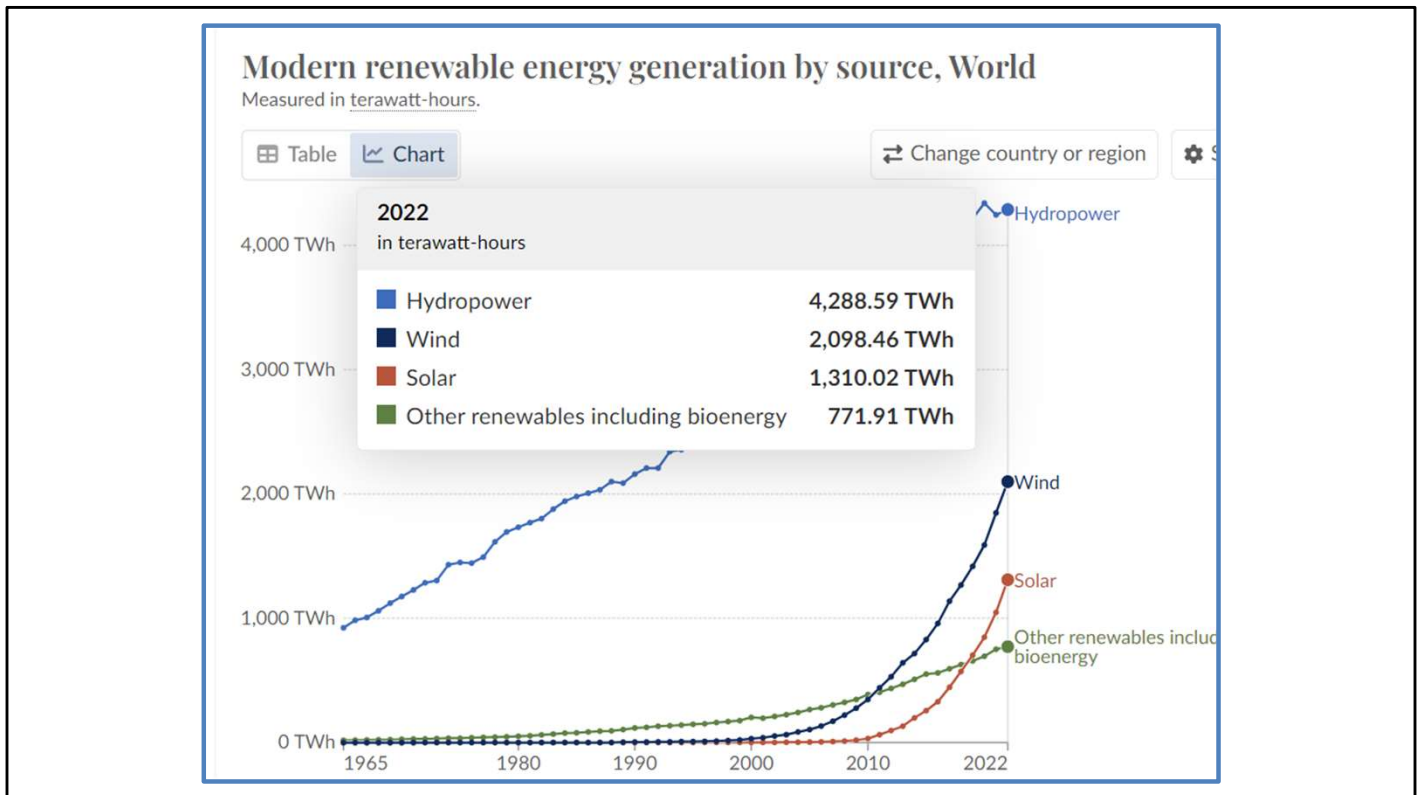
<https://redgreenandblue.org/2018/08/30/new-california-law-mandates-100-renewable-energy-2045/>

Hawaii Law

| Year | Percent Renewables |
|------|--------------------|
| 2020 | 30% |
| 2040 | 70% |
| 2045 | 100% |



<https://www.utilitydive.com/news/hawaii-legislature-sets-100-renewable-portfolio-standard-by-2045/394804/>



<https://www.statista.com/statistics/280704/world-power-consumption/>

Total Electricity Generation 2022

| Terawatts | Source | Percent |
|-----------|--------|---------|
| 25,530 | All | 100% |

<https://www.statista.com/statistics/280704/world-power-consumption/>

Total Electricity Generation 2022

| Terawatts | Source | Percent |
|-----------|------------|---------|
| 25,530 | All | 100% |
| 8,469 | Renewables | 33 % |

<https://www.statista.com/statistics/280704/world-power-consumption/>

What about Nuclear?

Wind + Battery + CCGT

| type | % renewable | Cost \$/MWh | GHG emissions g(CO _{2e})/kWh |
|-----------------------|-------------|----------------|---|
| 3 Station Wind + CCGT | 77.3 % | \$110.0 | 137 |
| Batteries for storage | 84.0 % | \$174.1 | 113 |
| Battery replacement | 84.0 % | \$474.1 | 199 |
| Advanced Nuclear | 100.0 % | \$99.1 | 12 |

Analysis By Professor Pat Walden

- the cost of the turbines can be actually the cheap part of wind power.
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- Meanwhile nuclear is cheaper, emits far less GHG, and is ready to go now.

A Nuclear Solution

Increase electricity production

Decrease GHG emissions



Gen IV Reactors



<http://starcorenuclear.ca/#!/welcome/> Resources page, free to download images
<http://starcorenuclear.ca/wp-content/uploads/2014/01/starcore-wallpapers-2500x1440-3.jpg>
No Copyright, no Terms & Conditions
<https://www.world-nuclear.org/>

The Database on Nuclear Power Reactors

The Power Reactor Information System (PRIS), developed and maintained by the IAEA for over five decades, is a comprehensive database focusing on nuclear power plants worldwide. PRIS contains information on power reactors in operation, under construction, or those being decommissioned.

<https://pris.iaea.org/PRIS/home.aspx>

Gen IV International Forum. https://www.gen-4.org/gif/jcms/c_9334/origins

U.S. Nuclear Regulatory Commission. <https://www.nrc.gov/reactors/operating.html>

https://en.wikipedia.org/wiki/Generation_IV_reactor

Gen IV Reactor Features



Gen IV Waste

60% inert, **not radioactive**



<http://www.world-nuclear-news.org/NN-Canadian-design-review-for-StarCore-HTGR-0811167.html>

Gen IV Fuel | Existing Nuclear Waste

- Existing nuclear waste provides 200,000 years of Gen IV fuel
- No mining

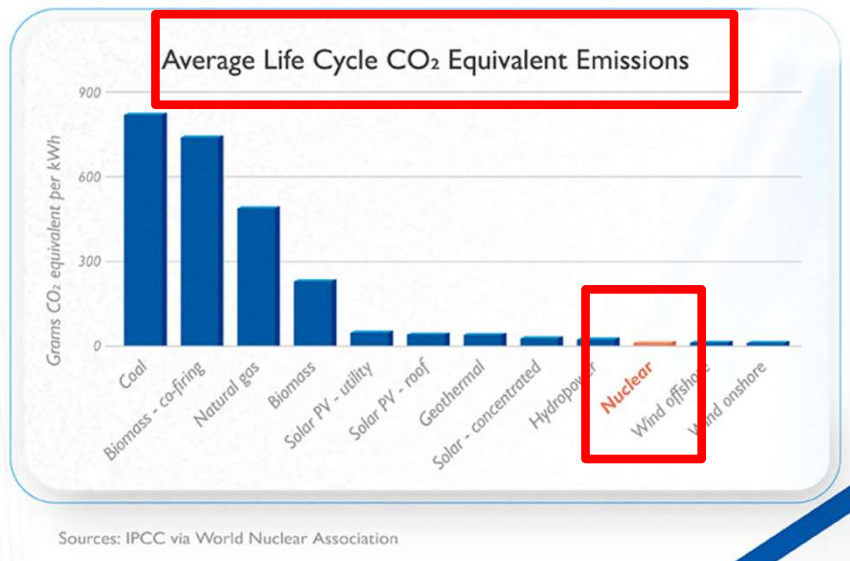


Nuclear Comparisons

1. Carbon-Free Energy

<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

1. Carbon-Free Energy



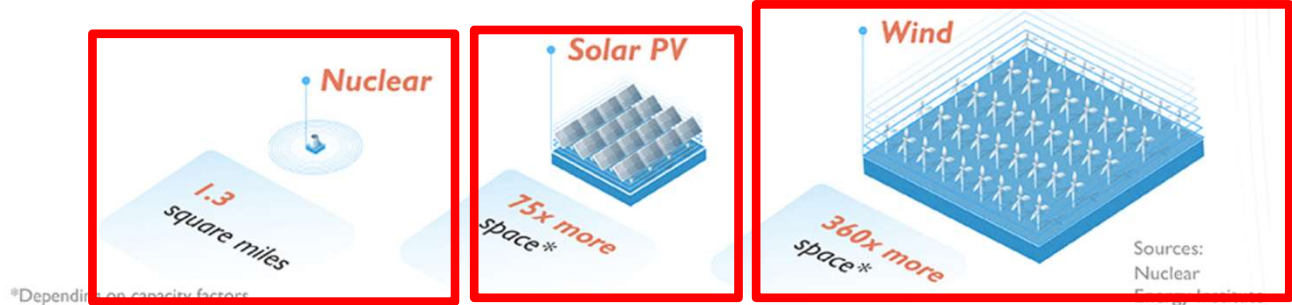
<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

2. Low Land Footprint

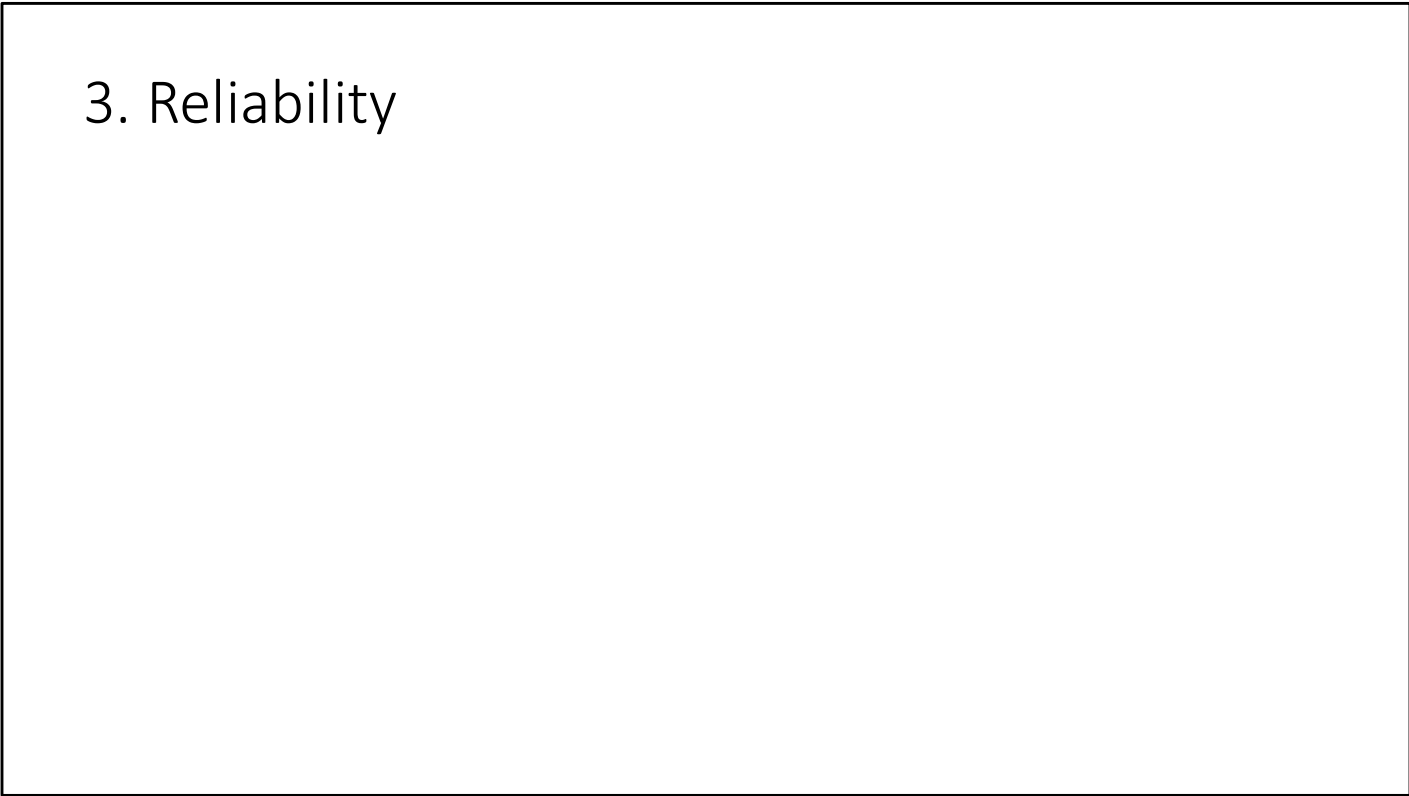
<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

2. Low Land Footprint

Land Footprint per 1,000 Megawatts of Electricity in a Year



<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>



3. Reliability

<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

3. Reliability

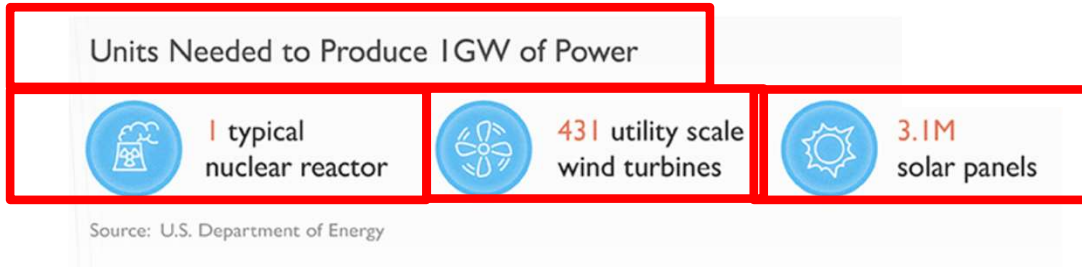


<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

4. Resource Efficiency

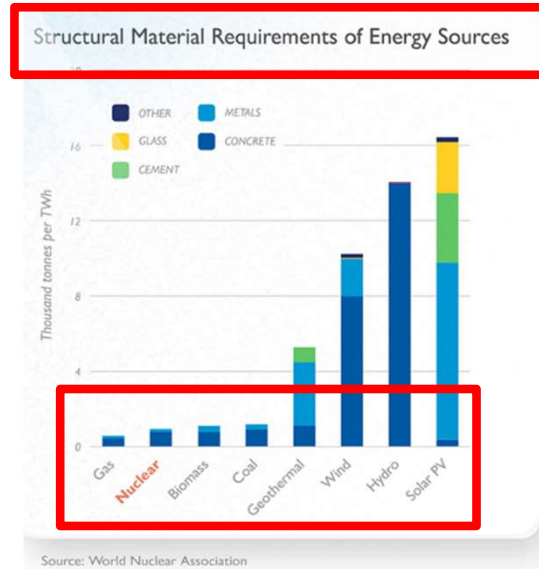
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<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

4. Resource Efficiency

Besides their low material requirements, nuclear reactors are also built for long useful lives.

USEFUL LIVES:

- **NUCLEAR: 30-80 YEARS**
- SOLAR PV: 20-25 YEARS
- WIND: 20 YEARS

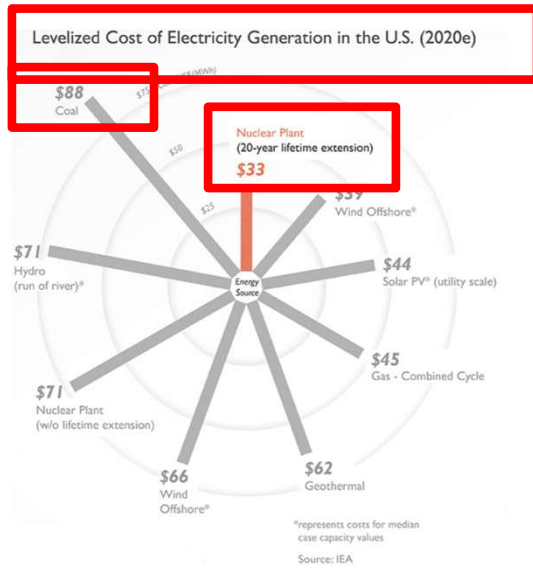
Source:
National Renewable
Energy Laboratory

<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

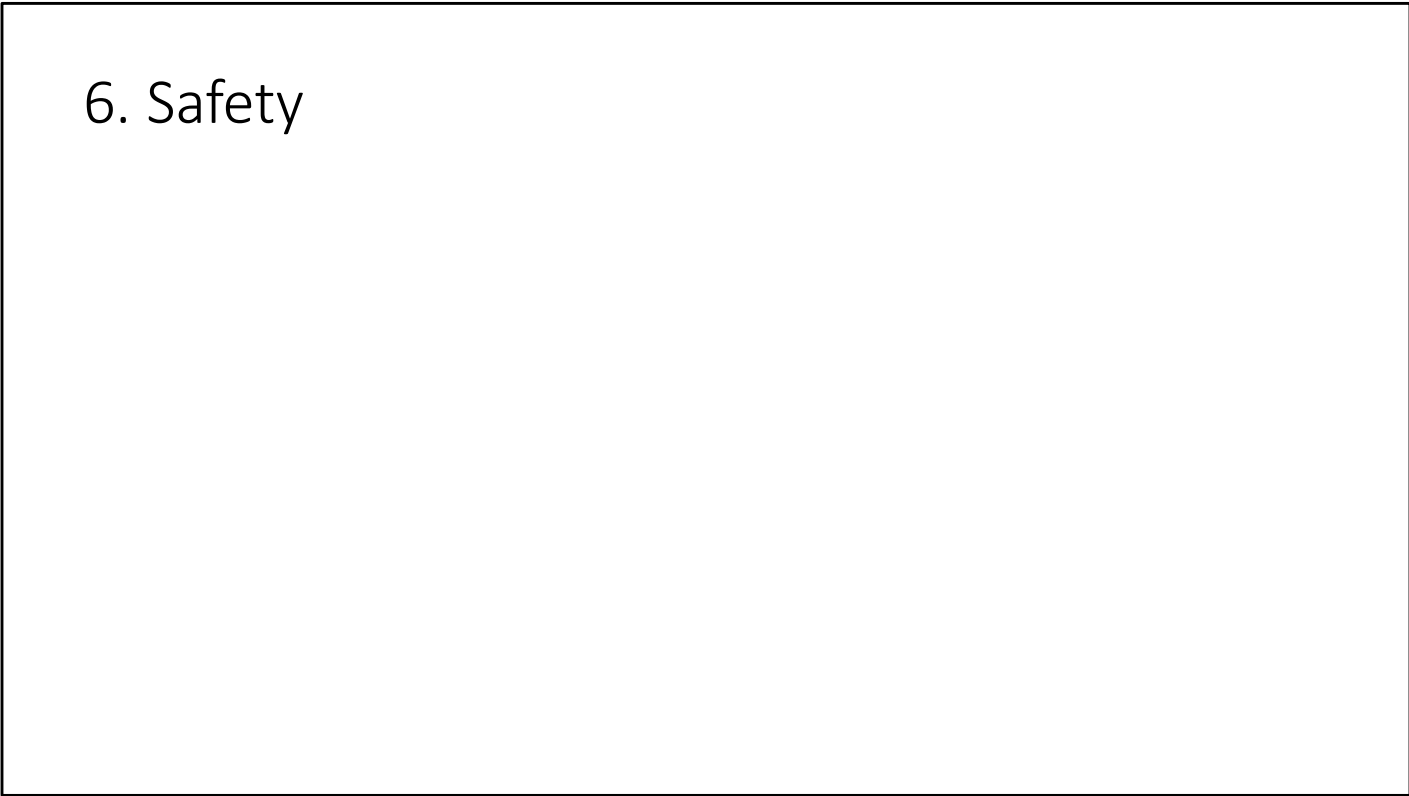
5. Long-Term Affordability

<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

5. Long-Term Affordability



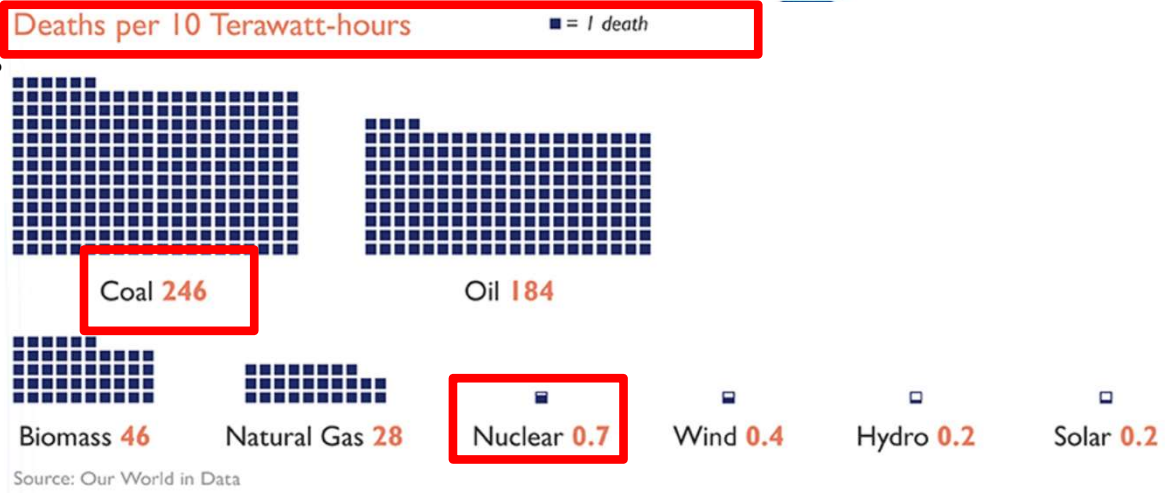
<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>



6. Safety

<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

6. Safety

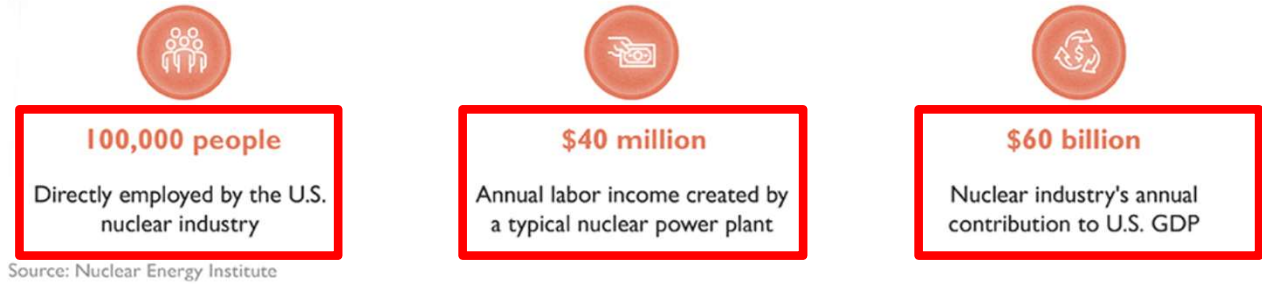


<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

7. Economic Contribution

<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

7. Economic Contribution

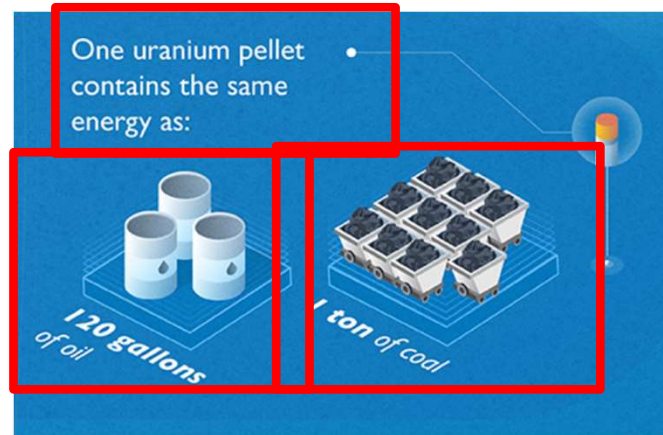


<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

8. Energy Density

<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

8. Energy Density



<https://elements.visualcapitalist.com/nuclear-energy-in-the-clean-energy-transition/>

COP28 | UAE | Nov 30 – Dec 12, 2023

- Declaration to Triple Nuclear Energy Capacity by 2050
- Recognizes the Key Role of Nuclear Energy in Reaching Net Zero

<https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key>

Is there a credible path to climate stabilization that does not include a substantial role for nuclear power?



Thank You

Download slides and list of sources used in this presentation

betterpresentations.ca/orpsnuc

mlewandowski@hotmail.com



TerraPower Natrium Reactor, Kemmerer, WY

- Liquid Sodium Reactor
- Water stops absorbing heat at 100 C, pressure increases
- Water needs to be circulated with pumps to remove heat
- Liquid sodium absorbs 8 times more heat
- Liquid sodium does not need to be pumped, rises and cools when hot
- Can lose power and sodium keeps absorbing heat – no meltdown risk

https://www.gatesnotes.com/Wyoming-TerraPower?WT.mc_id=20230505100000_Wyoming_BG-EM_&WT.tsrc=BGEM

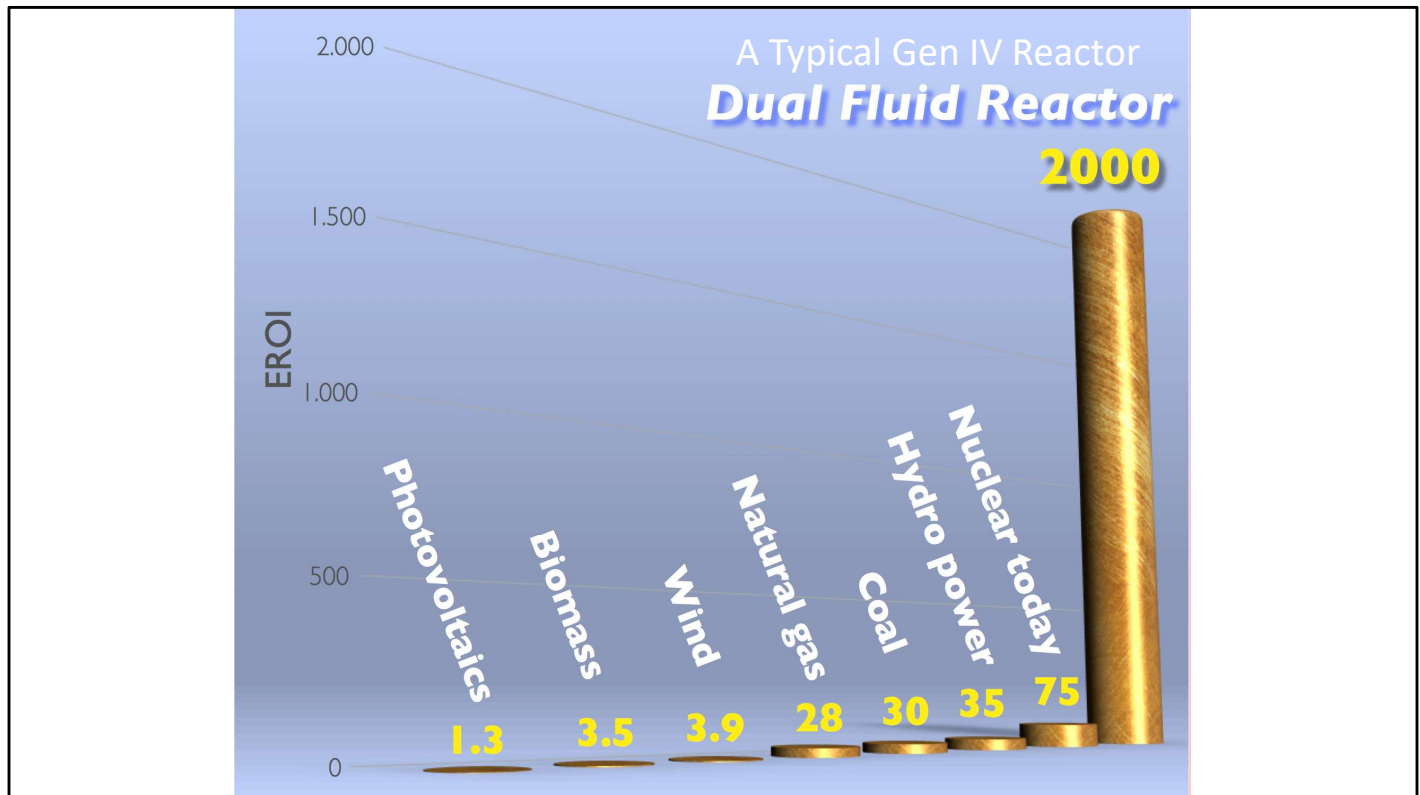
TerraPower Natrium Reactor Install At Kemmerer WY

- Coal plant operating for 50 years shutting down, 110 workers
- Natrium plant , 200 – 250 jobs
- 1,600 construction jobs

https://www.gatesnotes.com/Wyoming-TerraPower?WT.mc_id=20230505100000_Wyoming_BG-EM_&WT.tsrc=BGEM

EROI

- Energy Return on Energy Invested
- The higher the better
- Less than 1 is an energy loss



-And once the GEN IV reactors come on line we get an expanded fuel supply virtually for free and the EROI expands accordingly. EROI=2000!

-Very little energy has to be expended to get this payback.

-Is this not the way to go?

One ton of coal has the volume of one cubic meter. It produces 3.7 tons of CO₂ in a volume of a cube 12 m on each side.

The same amount of energy can be obtained from a conventional reactor with enriched uranium the size of a 1.5 cm diameter marble.

With the Gen IV reactors, this same energy can be elicited from Uranium or Thorium the size of a speck.