
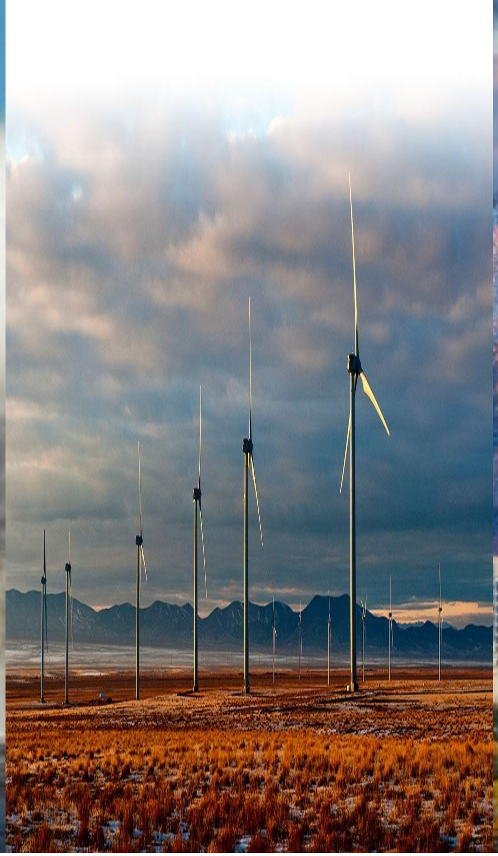


Nuclear 101: The Modern Nuclear Era

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Energy Development

April 28, 2026 | Wasatch Back Nuclear Energy Forum

Tim Kowalchik | Research Director
tkowalchik@utah.gov, energy.utah.gov

Energy Basics

Energy Development

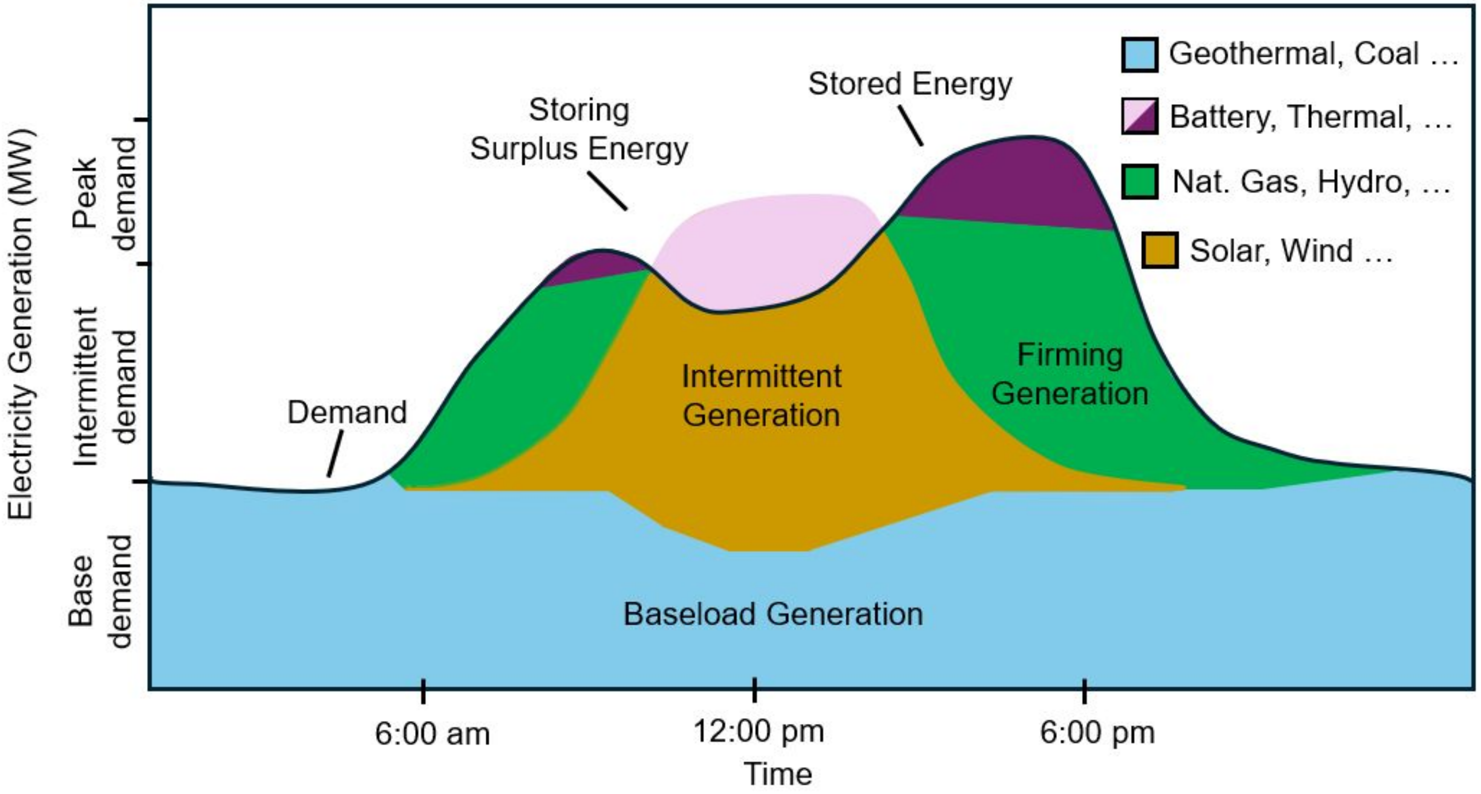
Energy Basics

The electrical grid balances demand (black line) with generation perfectly at all times

Baseload generation - dispatchable, always online

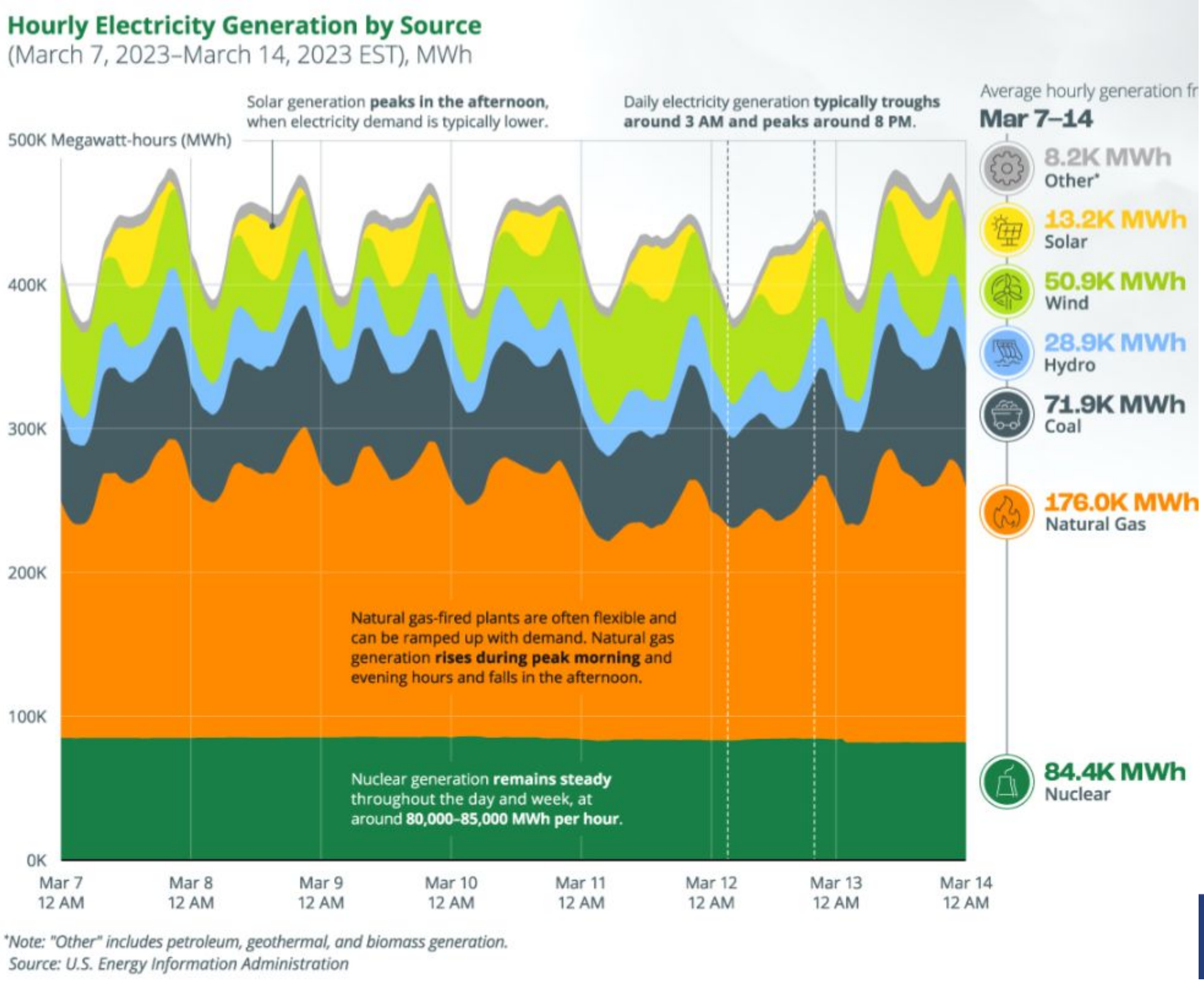
Firming (peaking) generation - dispatchable, used as needed to match demand

Intermittent generation - use it or lose it, typically cheapest when available



Energy Mix

Utah is "all-of-the-above" - use the right resource at the right time for the right purpose



https://decarbonization.visualcapitalist.com/how-does-us-electricity-generation-change-over-one-week/

Old vs New Nuclear

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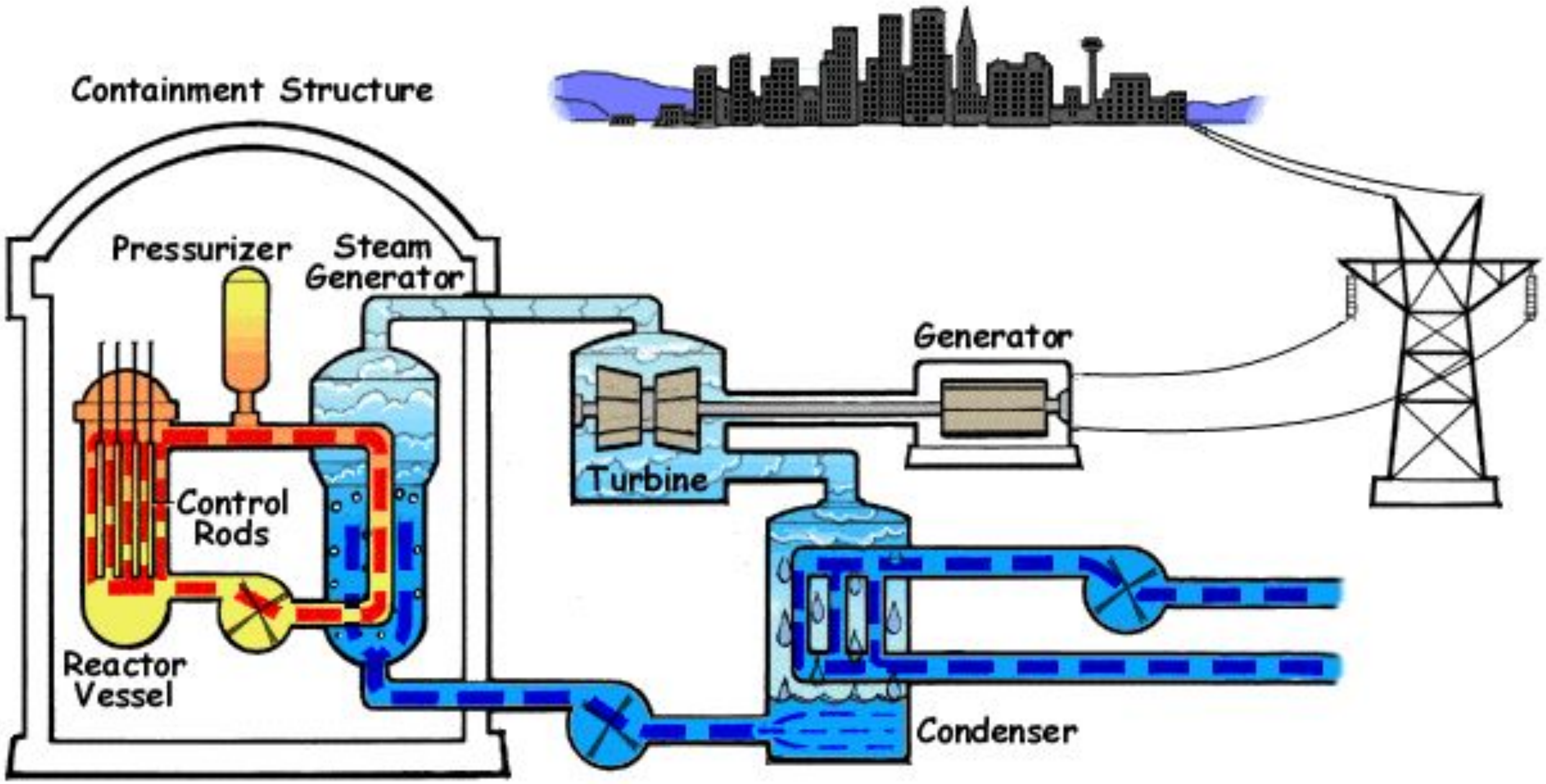
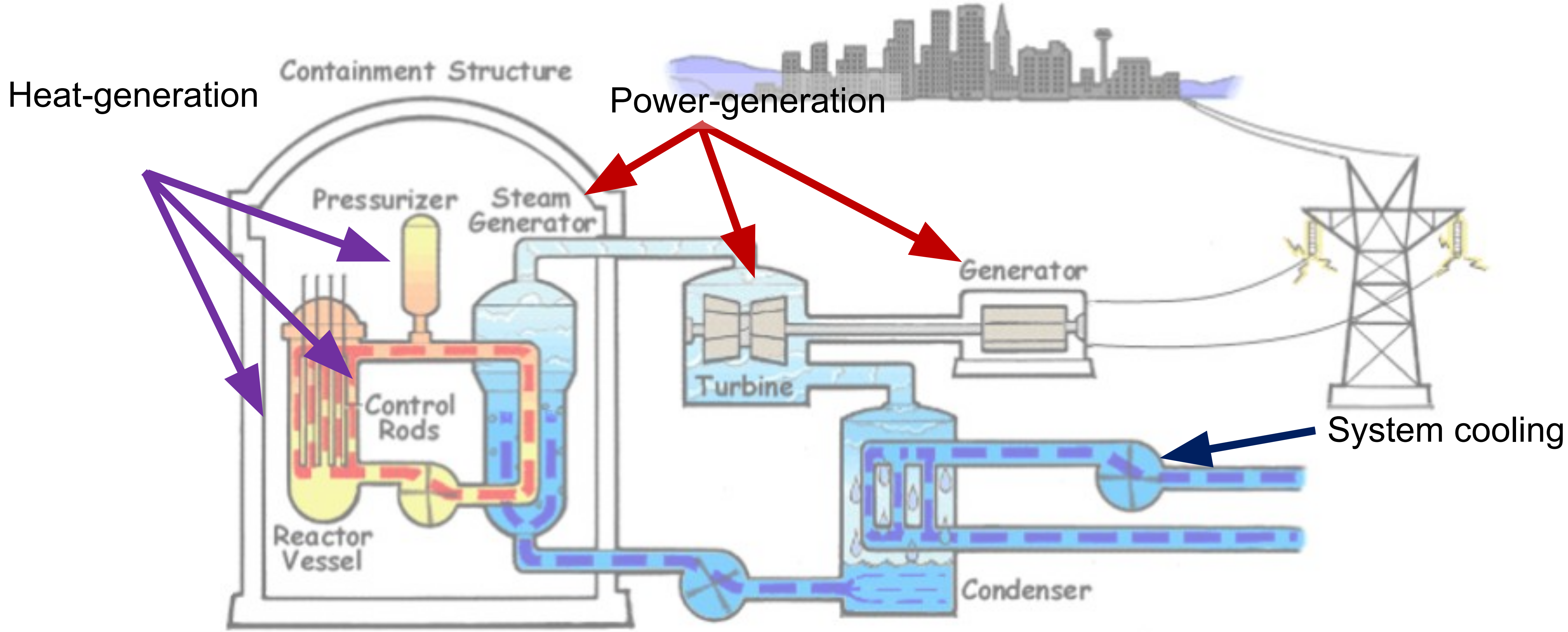
Nuclear Reactors



https://www.nrc.gov/reading-rm/basic-ref/students/animated-pwr

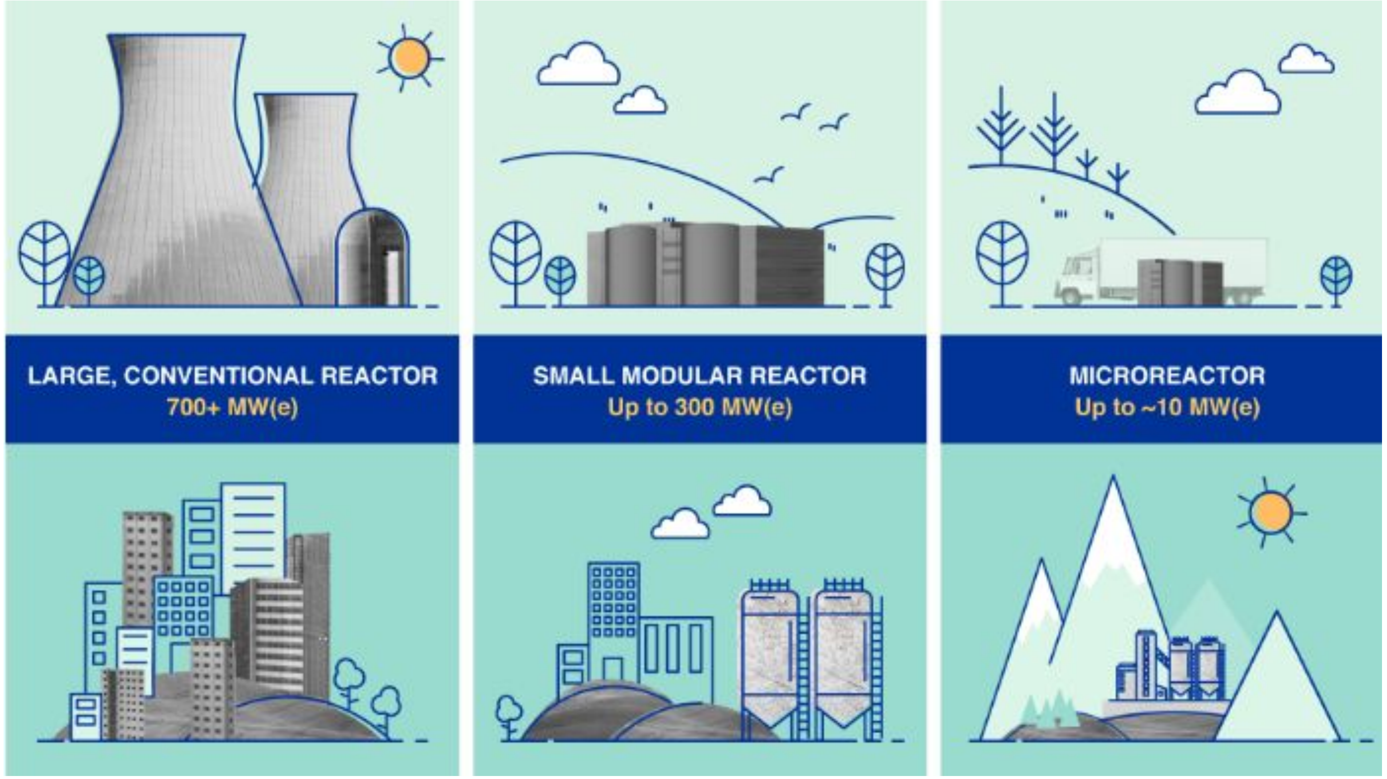
The Nuclear Loop



https://www.nrc.gov/reading-rm/basic-ref/students/animated-pwr

The Nuclear Loop – Power Generation

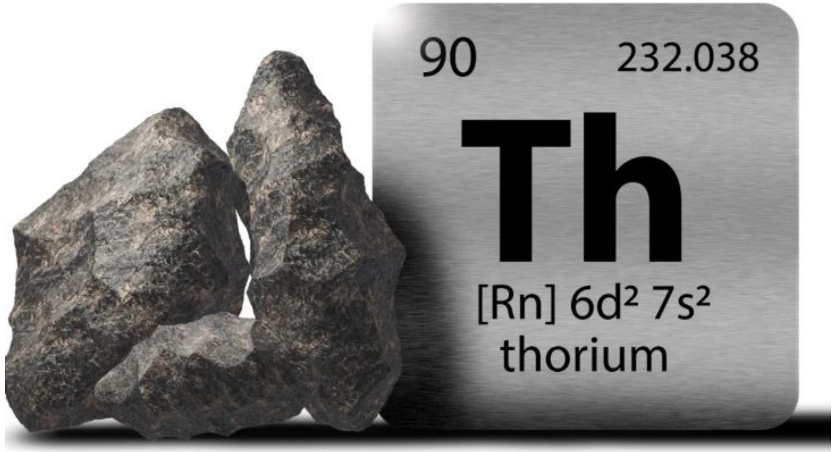
Modern reactors use new fuel, hardware, processes
- Molten salt, high temperature gas reactors, heat pipe, many more
- Smaller size means more flexible deployment, operation, and siting

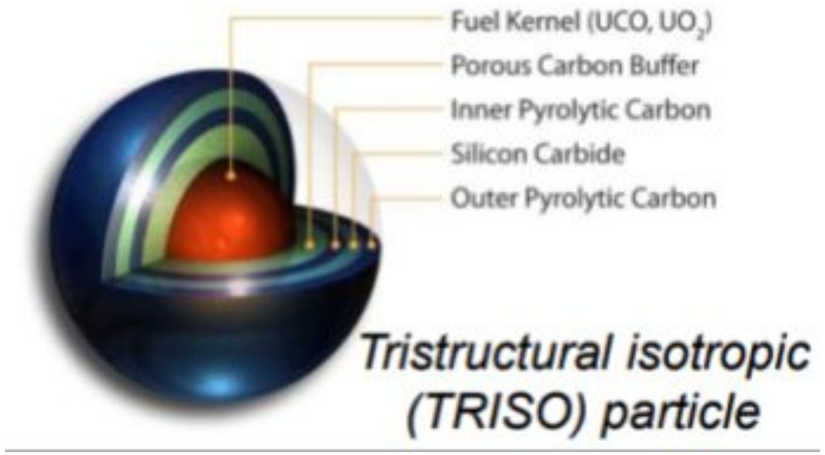


https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs

The Nuclear Loop - Fuel

Modern fuels are designed to be safer and more efficient



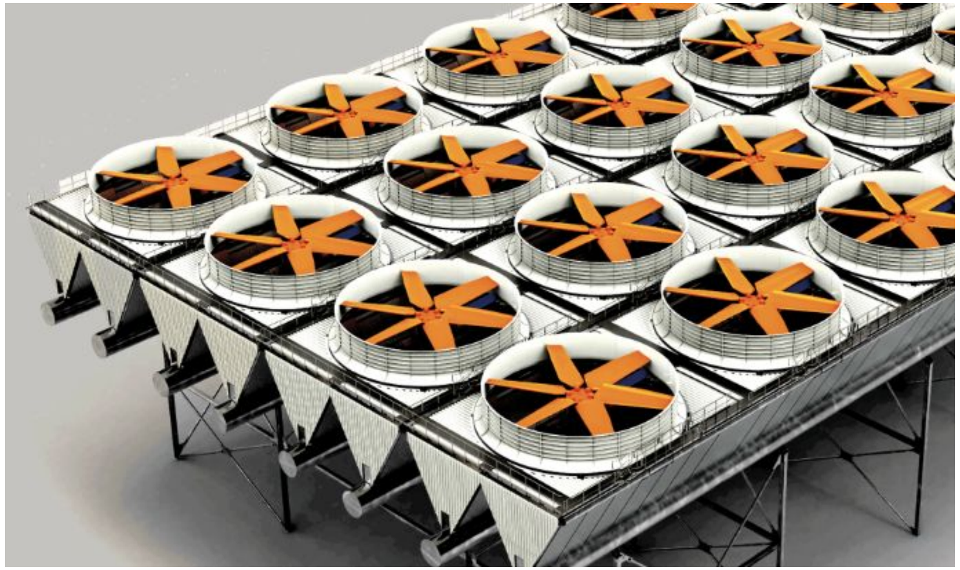


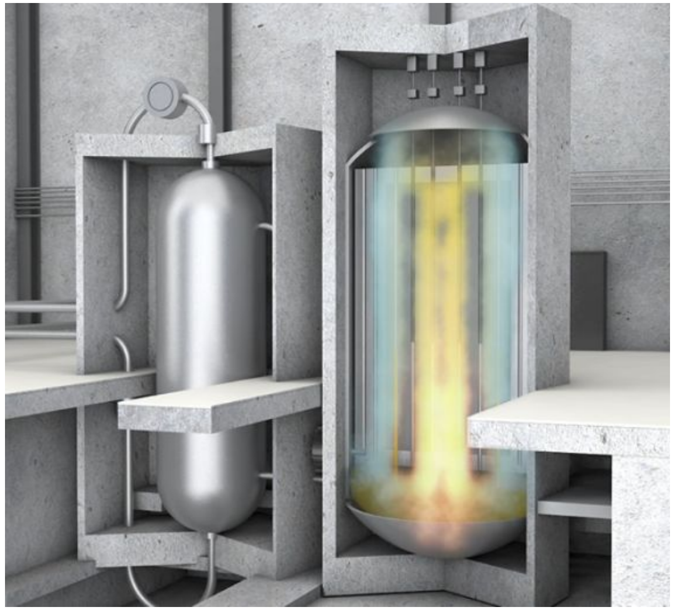
https://thermalprocessing.com/use-of-molten-salt-in-heat-treatment/
https://neutronbytes.com/2022/12/11/x-energy-to-go-public/
https://www.scmp.com/news/china/science/article/3271978/china-sets-launch-date-worlds-first-thorium-molten-salt-nuclear-power-station

The Nuclear Loop - System Cooling

How heat is moved dictates how cooling needs to occur

Air cooling, inert gas, co-location





https://www.harlowgroup.com/air-cooled-condenser-acc-at-al-khairat-thermal-power-plant/
https://www.energy.gov/ne/articles/nuclear-101-what-high-temperature-gas-reactor
https://newsletter.blogs.wesleyan.edu/2014/06/06/steampipe/

Water Demands

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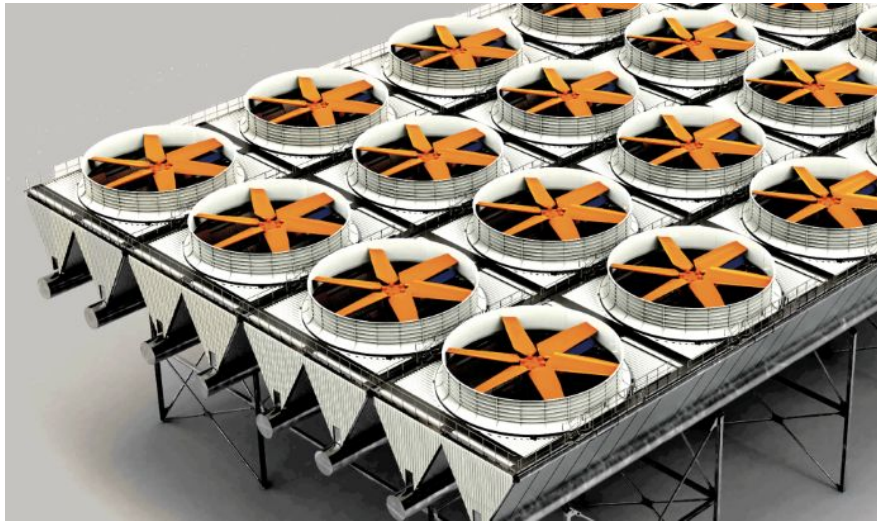
Water Consumption

Two big tranches of water consumption and potential reduction
- Cooling system: the largest project-specific water cost
- Water sourcing: wastewater streams, desalination, co-location

Water is **location**, **technology**, and **design** specific



https://www.harlowgroup.com/air-cooled-condenser-acc-at-al-khairat-thermal-power-plant/
https://mentorwater.com/what-are-wastewater-treatment-plant/
https://water.usgs.gov/edu/gallery/watercyclekids/evaporation.html

Safety

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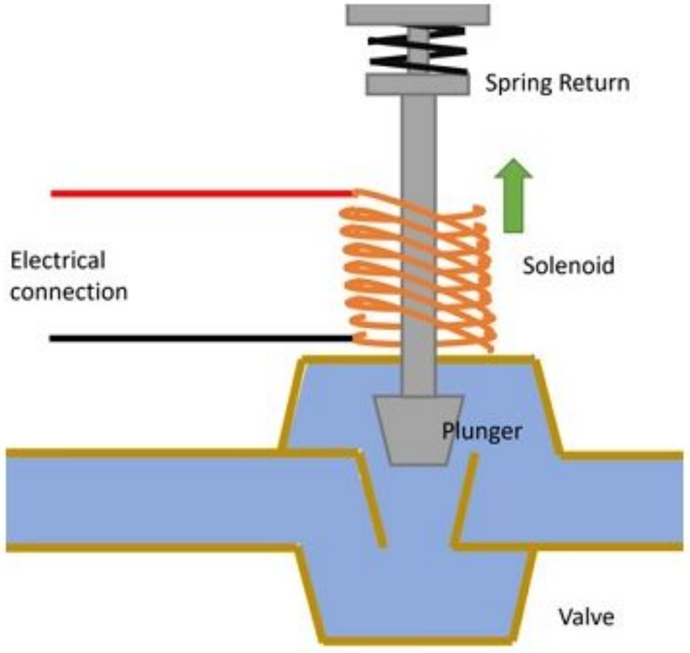
Passive Safety

Advanced nuclear designs taking advantage of passive safety features

- If a loss of power occurs, the system automatically shuts down
- "Fail closed" safety systems
- Self-modulating nuclear reactions



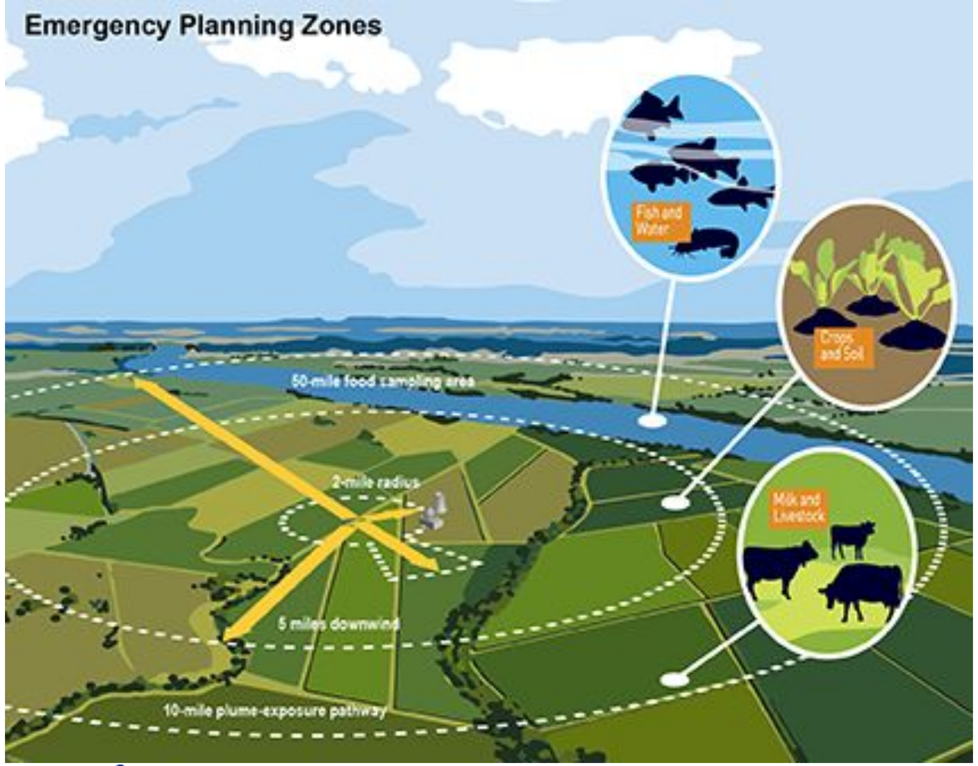
This diagram shows a solenoid actuated valve. There is power in the solenoid and the valve is open, water can flow.

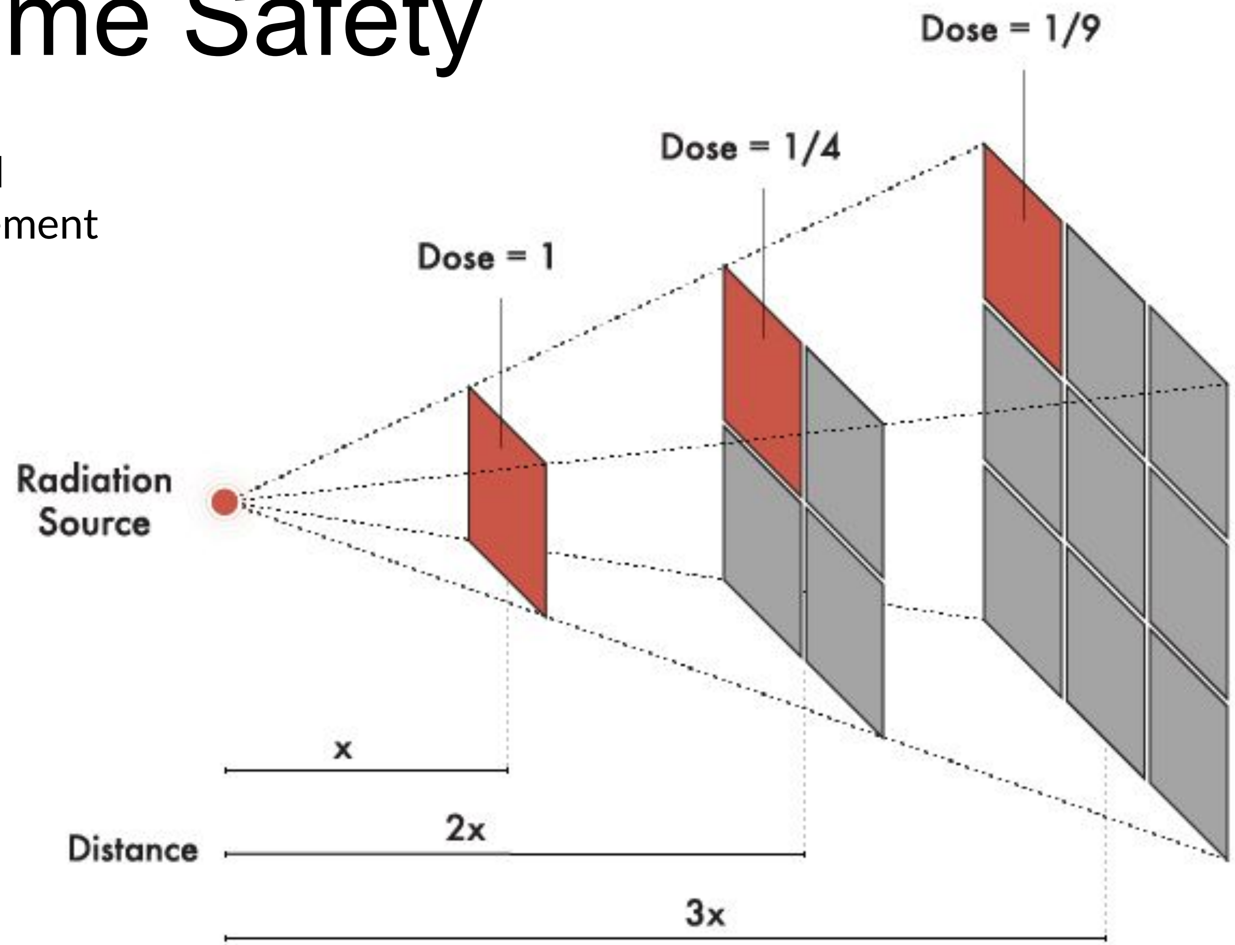
https://www.ntanet.net/how-passive-safety-keeps-nuclear-reactors-under-control/
https://www.sciencephoto.com/media/1258417/view/thermal-expansion-of-lid-under-hot-water

New Regulations, Same Safety

Nuclear is already one of a safest resources

- Modernized regulations meet the same standard
- “Risk-informed” regulation/performance requirement





https://www.nrc.gov/reading-rm/doc-collections/maps/emergency-preparedness
https://sites.duke.edu/missiontomars/the-mission/effects-of-radiation/protection-against-radiation/

WASATCH BACK NUCLEAR ENERGY FORUM

4/28/2026

6:00PM - 8:00PM

LOCATION

BLAIR EDUCATION CENTER
900 ROUND VALLEY DR.
PARK CITY, UT

SUBJECT MATTER EXPERTS

TIM KOWALCHIK,
Office of Energy Development

GAY WYN QUANCE, Nuclear
Safety and Operations Expert

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Waste

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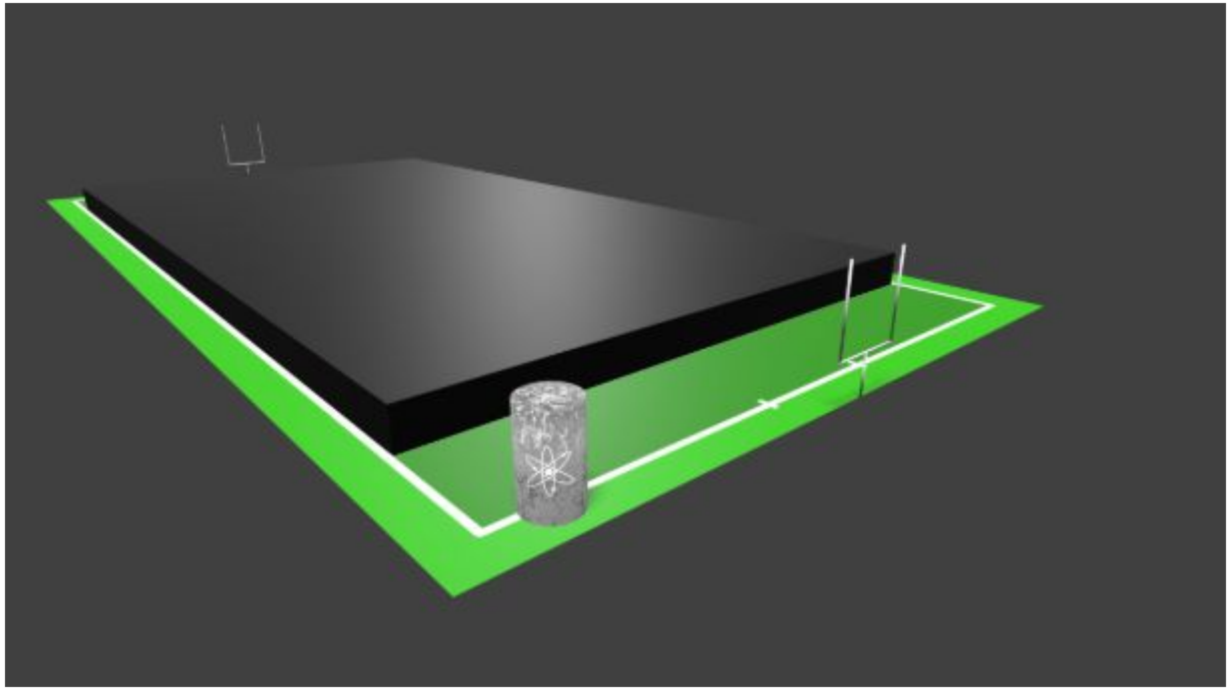
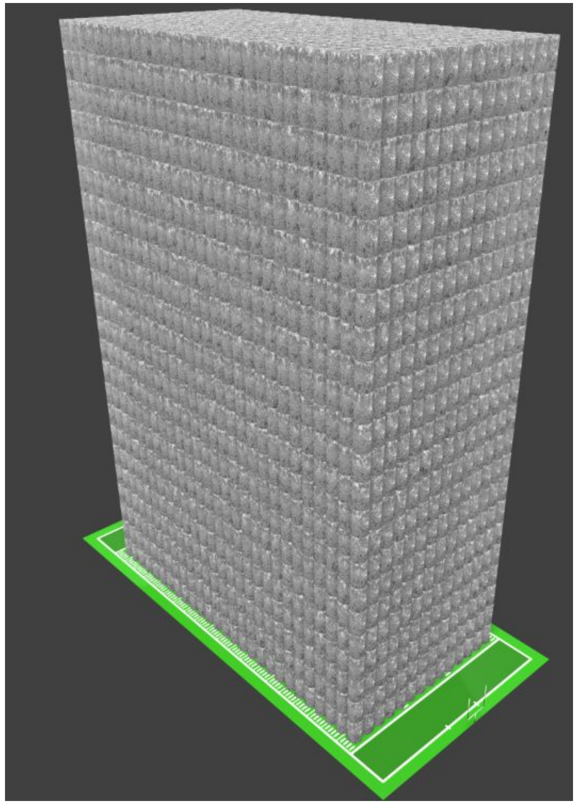
How Much Waste is There?

The 50+ years of US nuclear operation has led to about ~100,000 metric tons of spent nuclear fuel

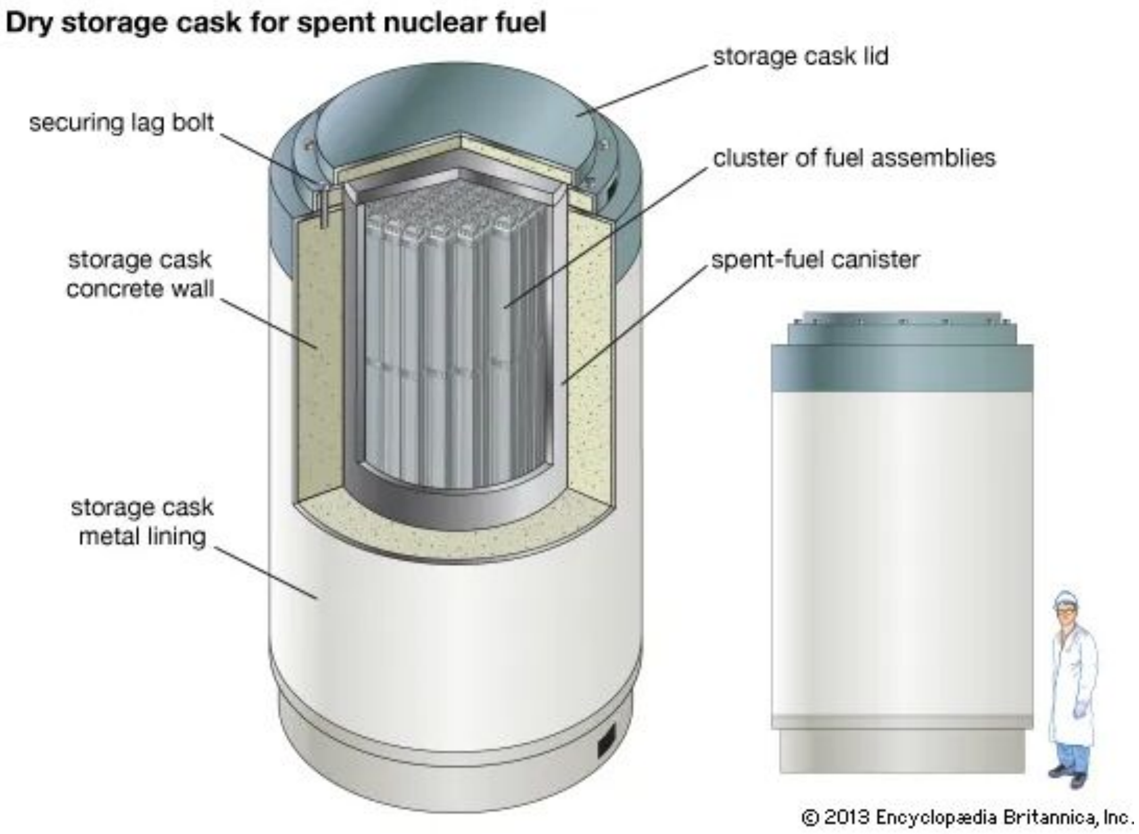


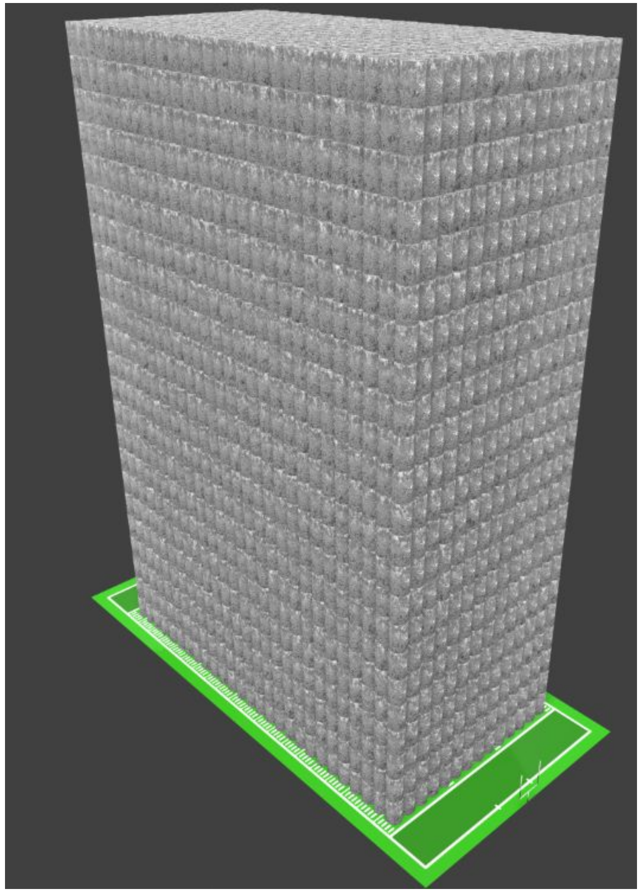


https://whatisnuclear.com/calcs/how-much-waste.html

How Much Waste is There?

Stored in "Dry Casks" at the moment



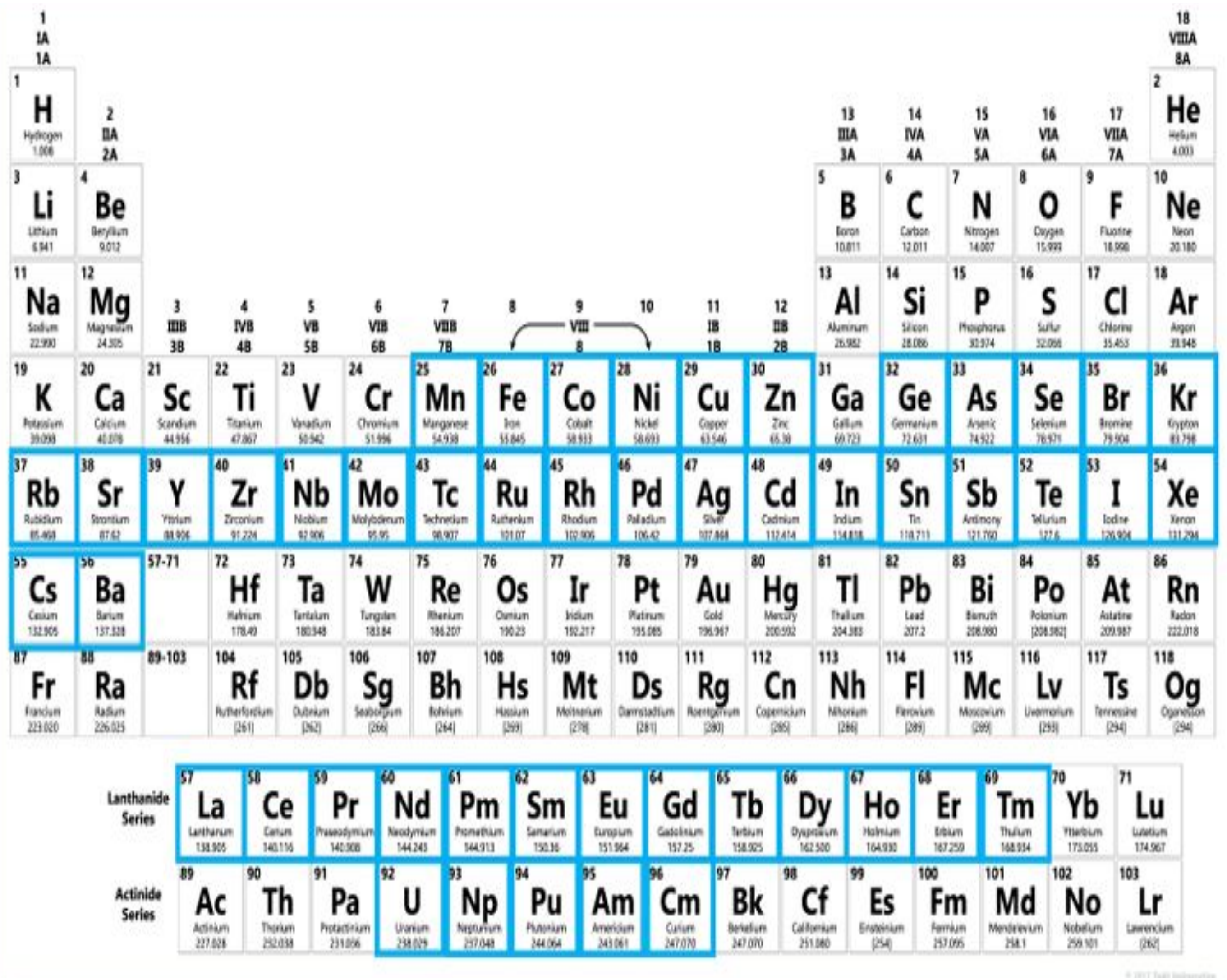


https://whatisnuclear.com/calcs/how-much-waste.html
https://kids.britannica.com/students/assembly/view/177392

Waste Is A Challenge

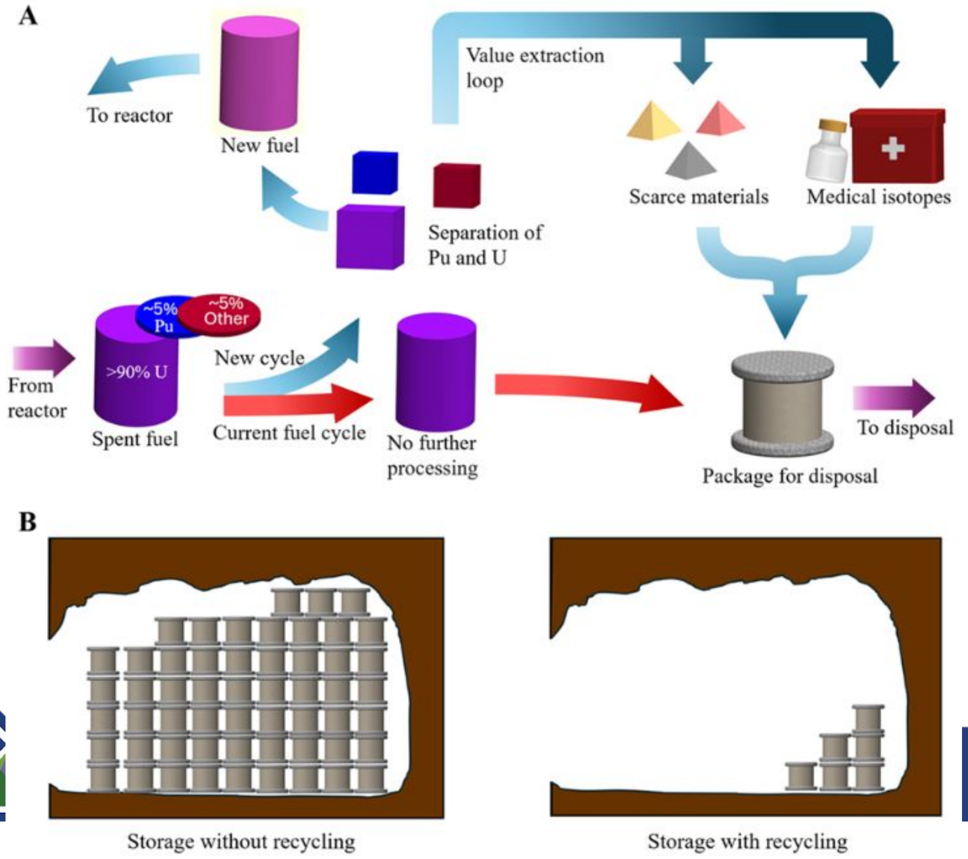
Current spent nuclear fuel contains half the periodic table

Specific makeup depends on time, reactor technology, reactor burnup



Waste Is An Opportunity

Current spent nuclear fuel contains half the periodic table
- New nuclear technologies will produce new waste profiles
- Modern regulations on how to handle multiple sites
- National waste storage and reprocessing
- Recycled fuel has benefits from energy to medicine



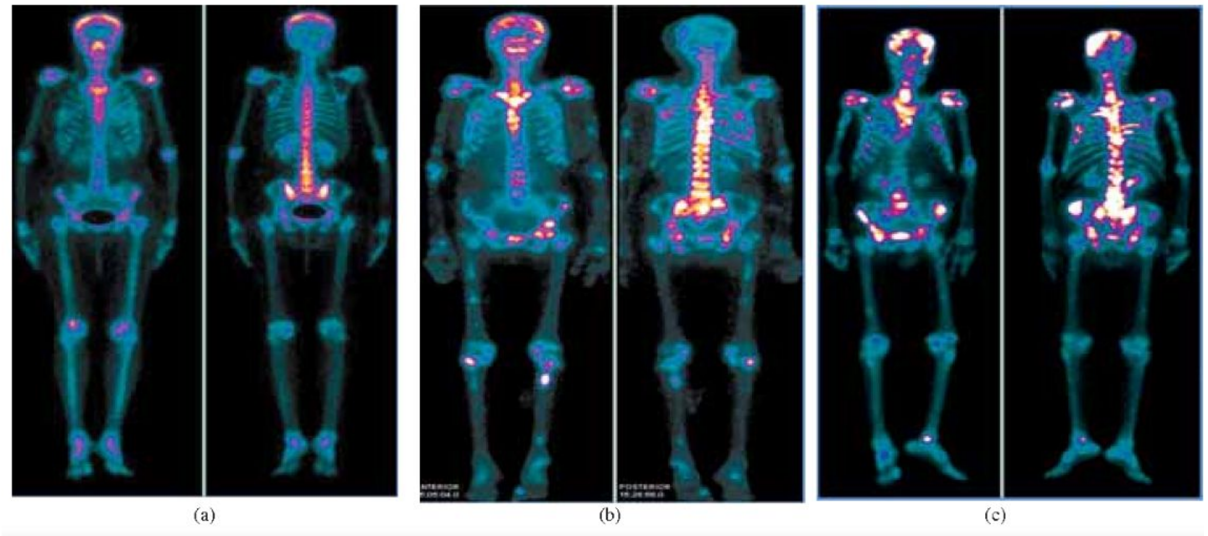


Figure 1: Typical whole-body images recorded using 99mTc-MDP, a bone imaging agent. (a) Normal human, (b) breast cancer patient with multiple metastases and (c) prostate cancer patient with extensive metastases

https://energy.utah.gov/homepage/resources/nuclear-energy/nuclear-energy-fact-sheets/
https://www.semanticscholar.org/paper/APPLICATIONS-OF-RADIOISOTOPES-IN-MEDICINE-Das/a252f6ef028dd56a6059a33a7358d4eb55d92d37/figure/0

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Costs

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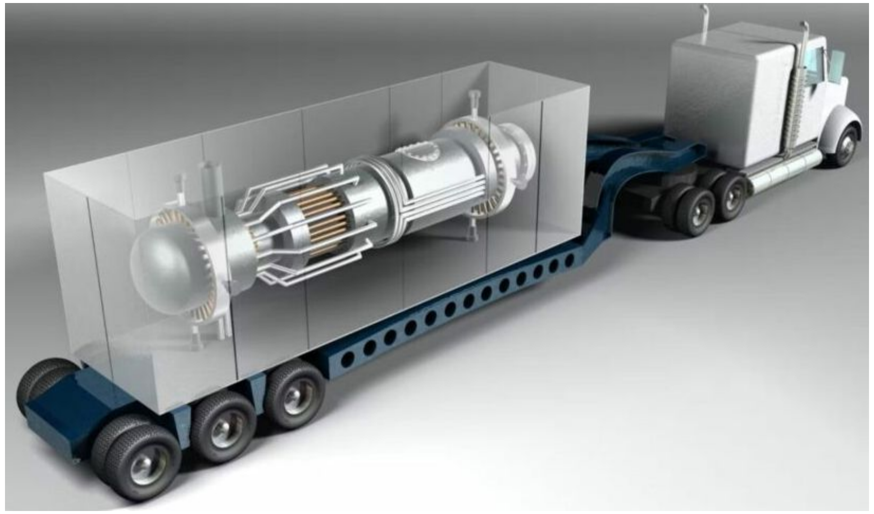
A Systemic Approach

De-risking nuclear is critical to lowering costs

- Public education
- Financial premiums
- Less complex designs
- Modular manufacturing
- Modernized regulations
- Co-location of secondary industry



https://c3newsmag.com/dod-advances-x-energy-mobile-nuclear-microreactor-as-second-project-pele-design/
https://www.youtube.com/watch?v=_vXE3qoUNPU

Timeline

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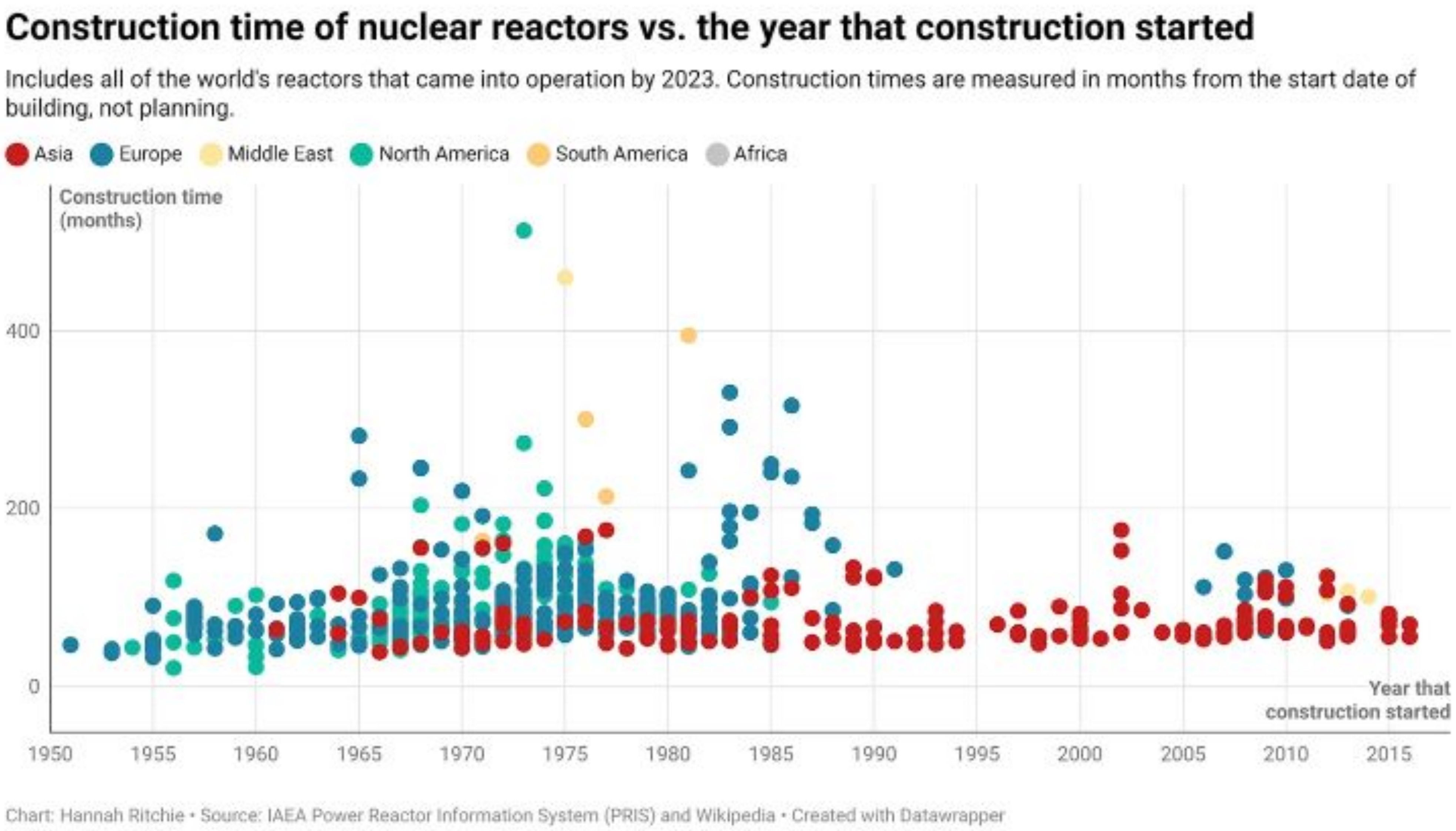
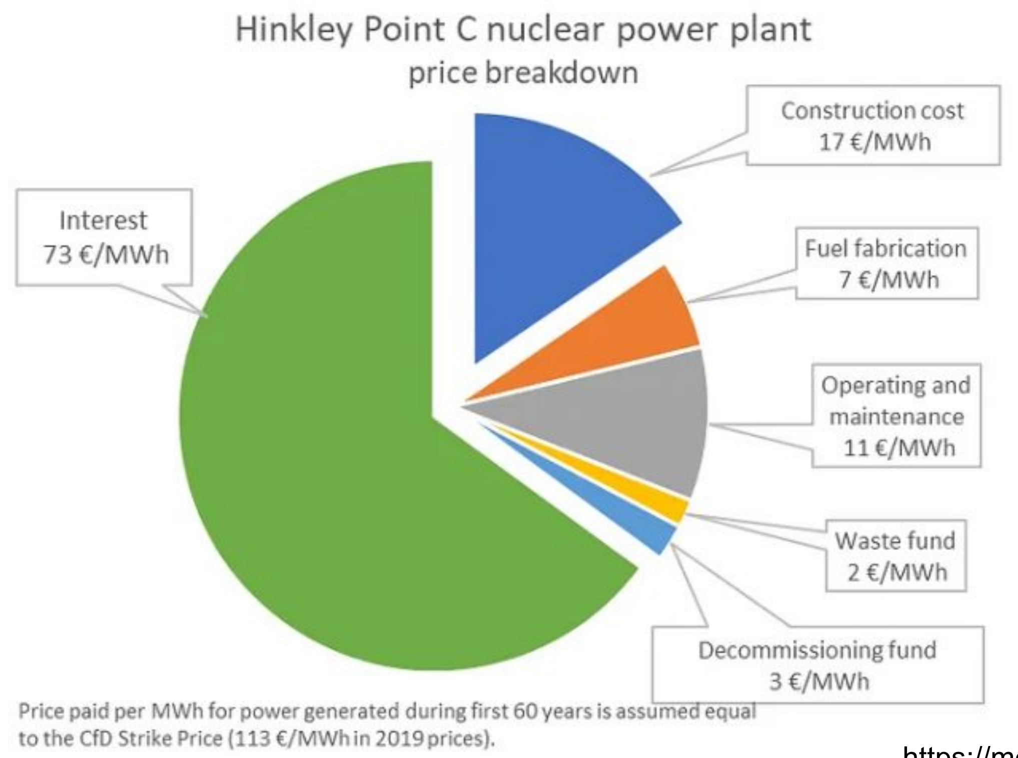
Slow Construction Not Required

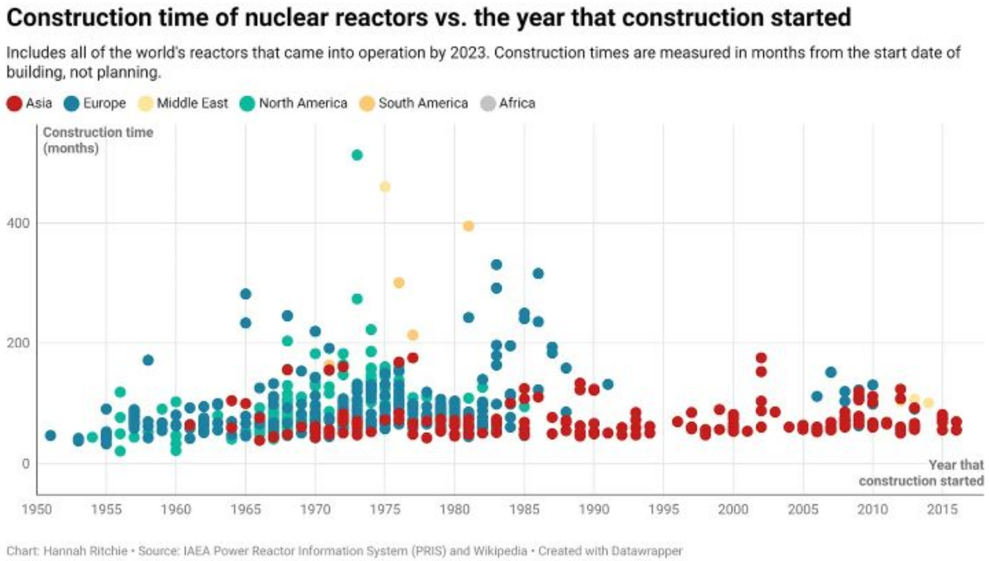


ah.gov

Industry Needs to Prove Timelines

Faster timelines are critical to driving down nuclear costs
- New regulations and supply chain need to be established
- Small modular/micro reactor factories need demonstration
- Modernized siting and waste handling





https://www.sustainabilitybynumbers.com/p/nuclear-construction-time
https://medium.com/generation-atomic/the-hinkley-point-c-case-is-nuclear-energy-expensive-f89b1aa05c27

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LCOE vs System Costs

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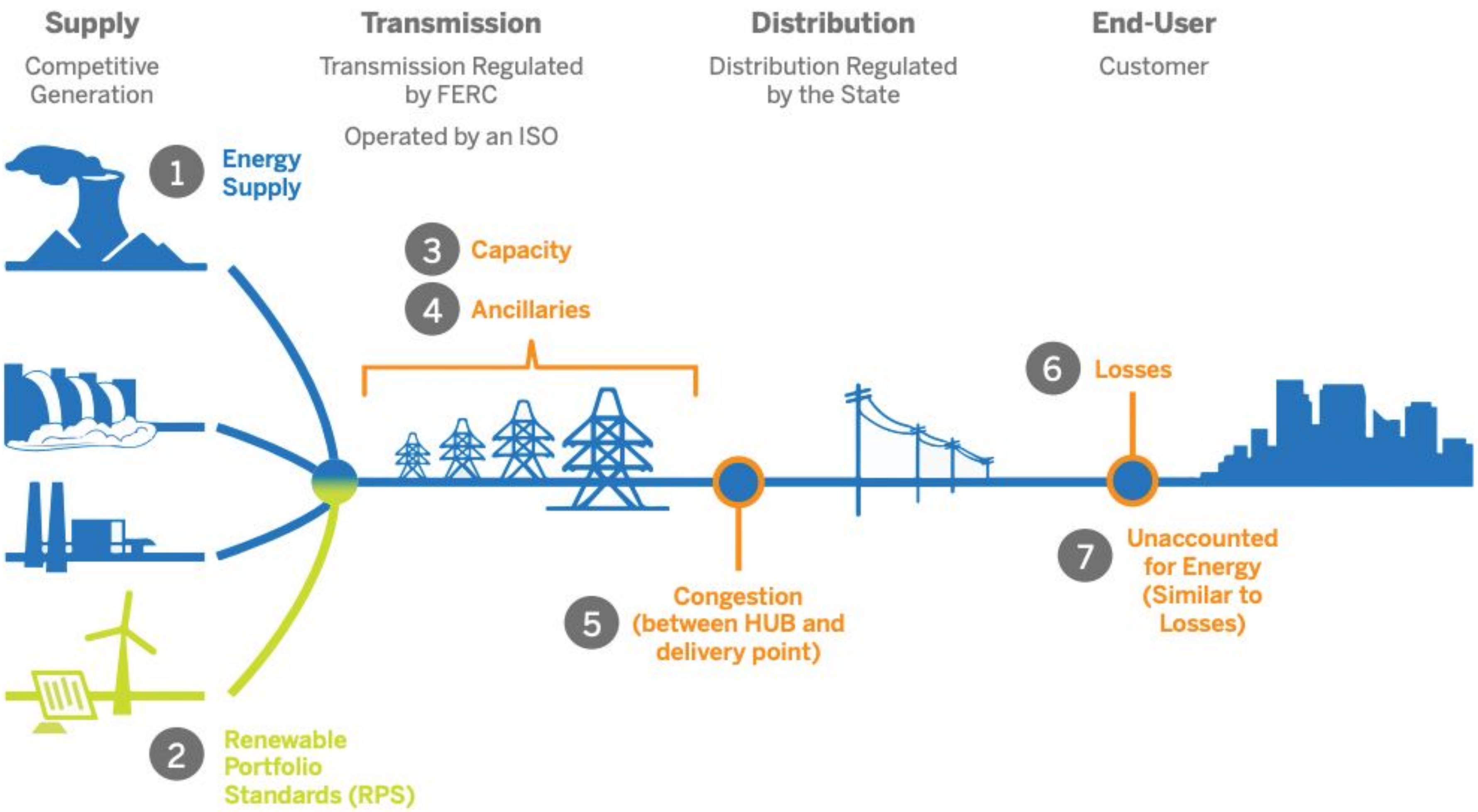
LCOEvsSC - What is the System?



https://energy.constellation.com/resources/choices/understanding-electric-cost-components

LCOEvsSC - Why LCOE is Insufficient

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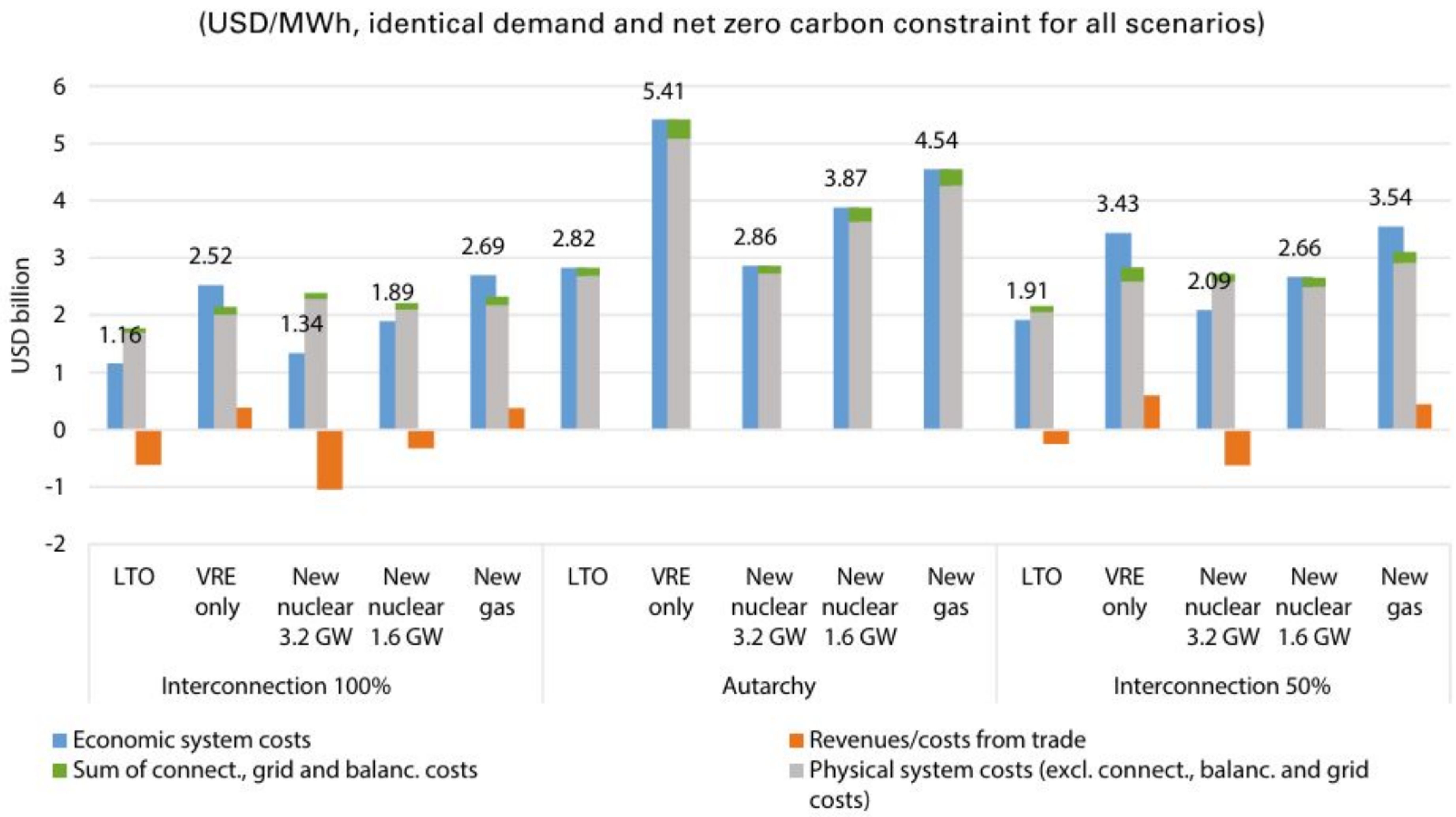
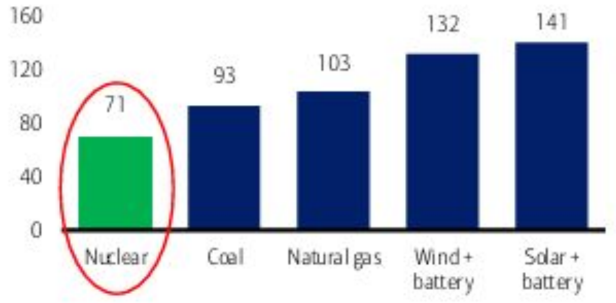


LCOEvsSC - Analysis Beyond LCOE

Moving beyond plant-level costs allows economic analysis of the grid as it will actually operate

- A more distributed and complex grid has various benefits
- It also comes with more difficult operation and economics

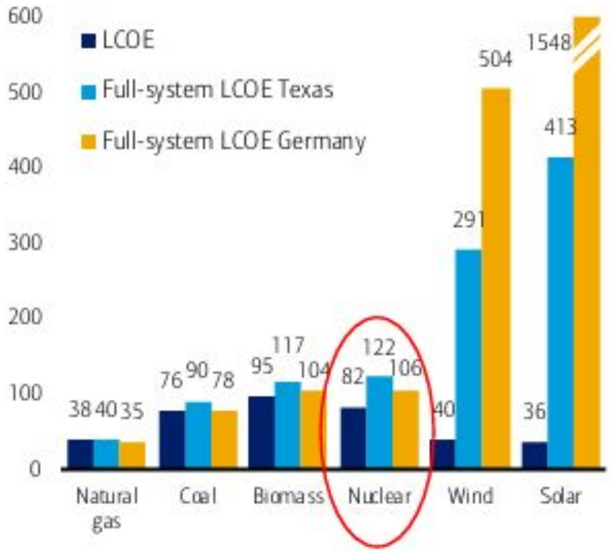
Exhibit 20: Nuclear is cost-effective...
Cost of generation, different sources ($/MWh)



Source: BofA Research Investment Committee, Lazard, Entler, et al. (2018). Note: nuclear, coal, and natural gas price estimates from Entler, et al. Wind and solar cost estimates are from Lazard's 2023 Levelized Cost of Energy+ report. Wind + battery and solar + battery use estimates from California's Independent System Operator (CAISO) and assume a 4-hour lithium-ion battery storage system to account for firming costs. All cost estimates show unsubsidized costs.

BofA GLOBAL RESEARCH

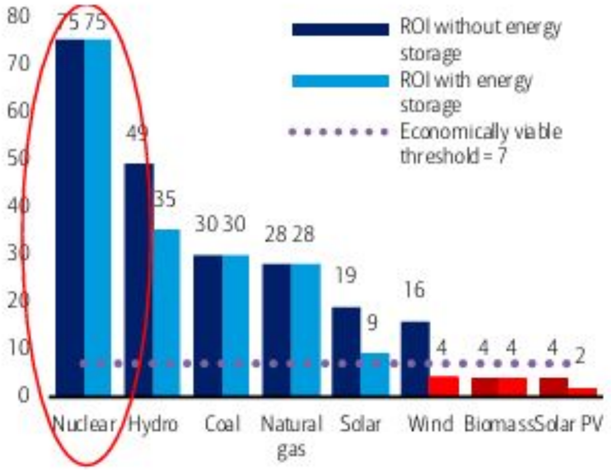
Exhibit 21: ...especially on an "all-in basis"...
LCOE & LFSCOE calculations by energy source



Source: BofA Research Investment Committee, Idel 2022

BofA GLOBAL RESEARCH

Exhibit 22: ...and has the highest energy ROI
Energy returned on energy invested, by source



Source: BofA Research Investment Committee, D. Weißbach, G. Ruprecht, A. Huke, K. Czerski, S. Gottlie, A. Hussein; Red signals EROI below economically viable threshold

BofA GLOBAL RESEARCH

https://advisoranalyst.com/wp-content/uploads/2023/05/bofa-the-ric-report-the-nuclear-necessity-20230509.pdf

Grid Value VRE

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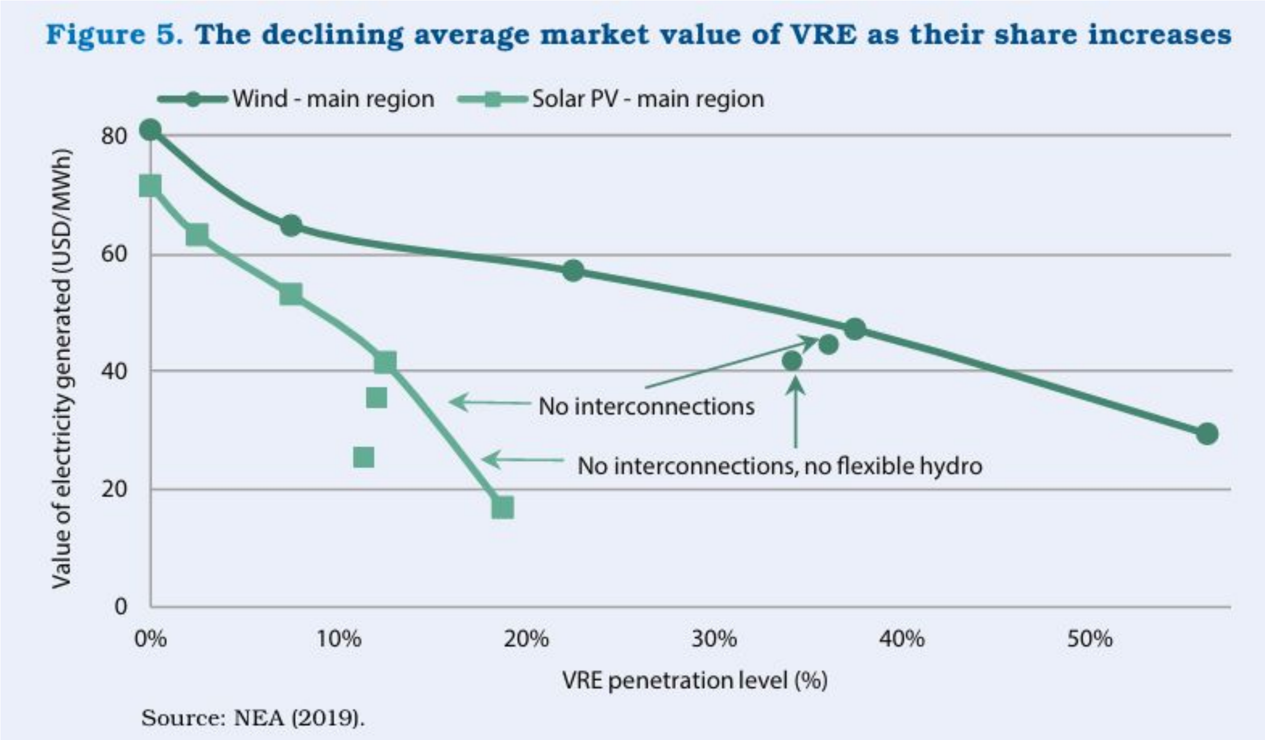
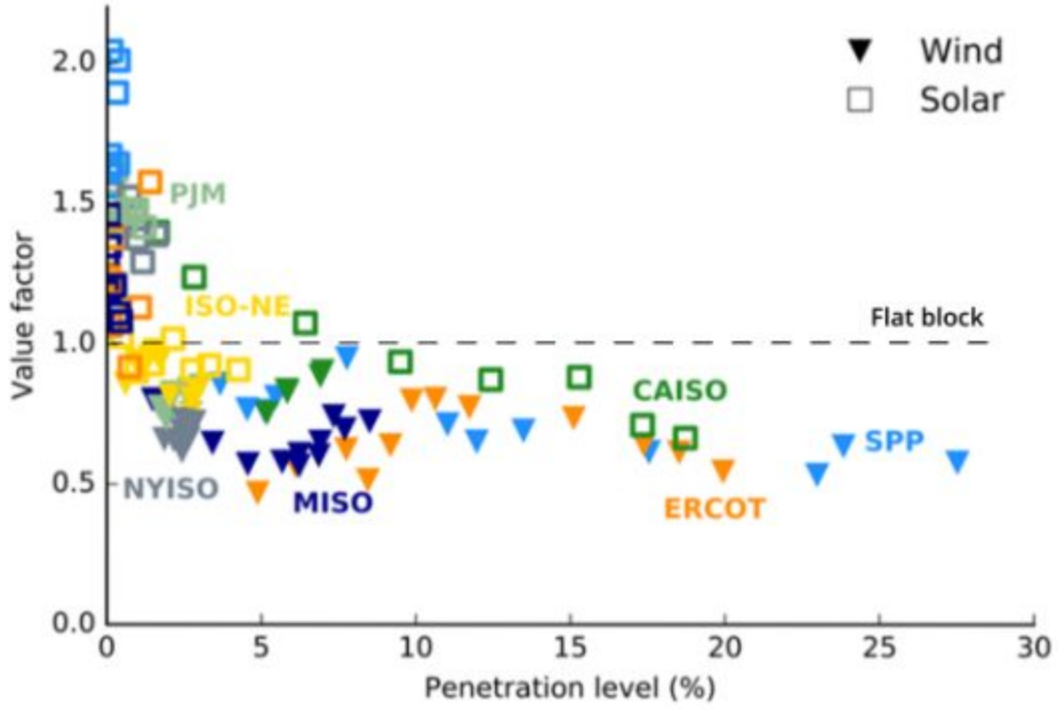
Grid Value VRE

As technologies reach higher %'s of the generation mix, they lose value

- Higher risk with a single-technology profile
- Less monetary value for each added plant
- Less systemic benefit





https://emp.lbl.gov/news/declining-cost-wind-and-solar-power
https://medium.com/generation-atomic/the-hinkley-point-c-case-is-nuclear-energy-expensive-f89b1aa05c27

Waste Storage

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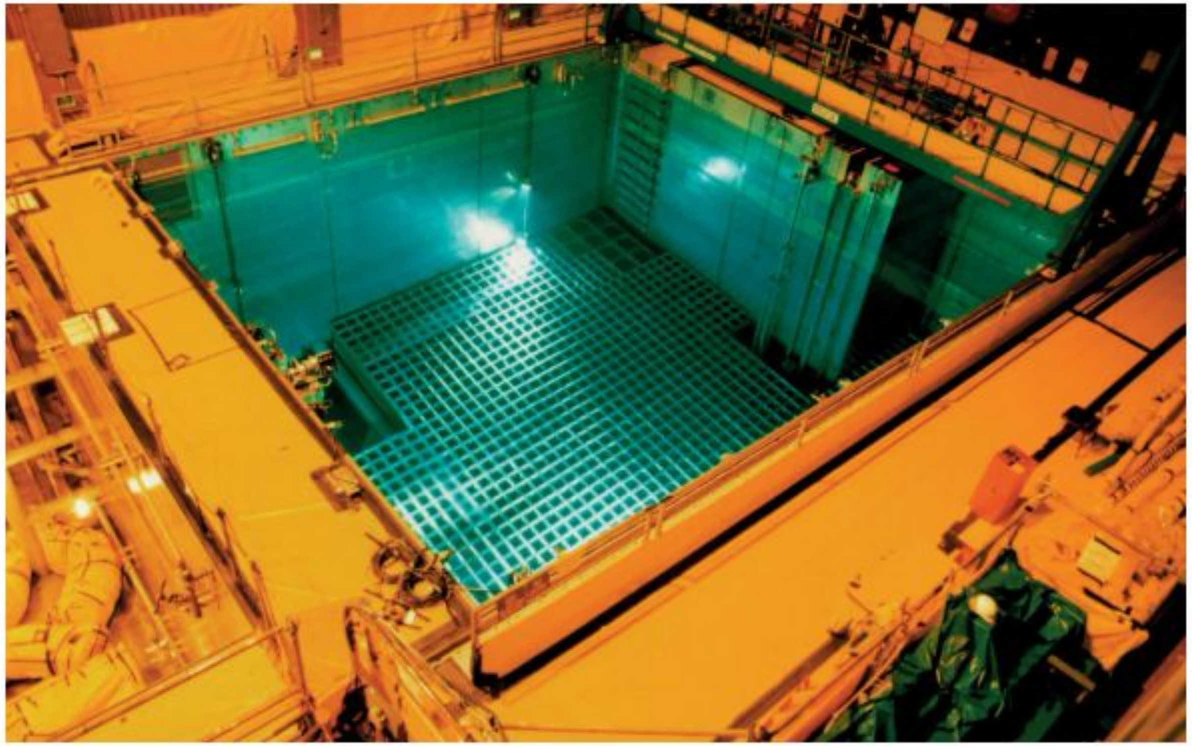
Waste Storage

Interim storage consists of on-site spent fuel pools and dry cask storage



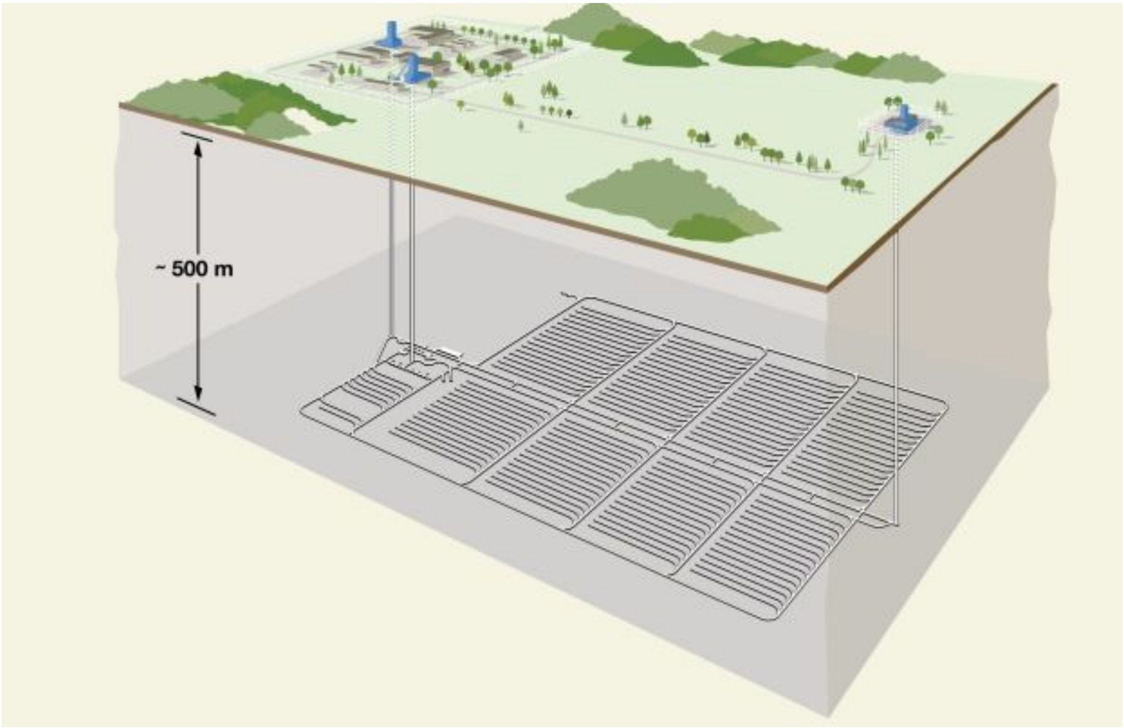
Spent Fuel Pool

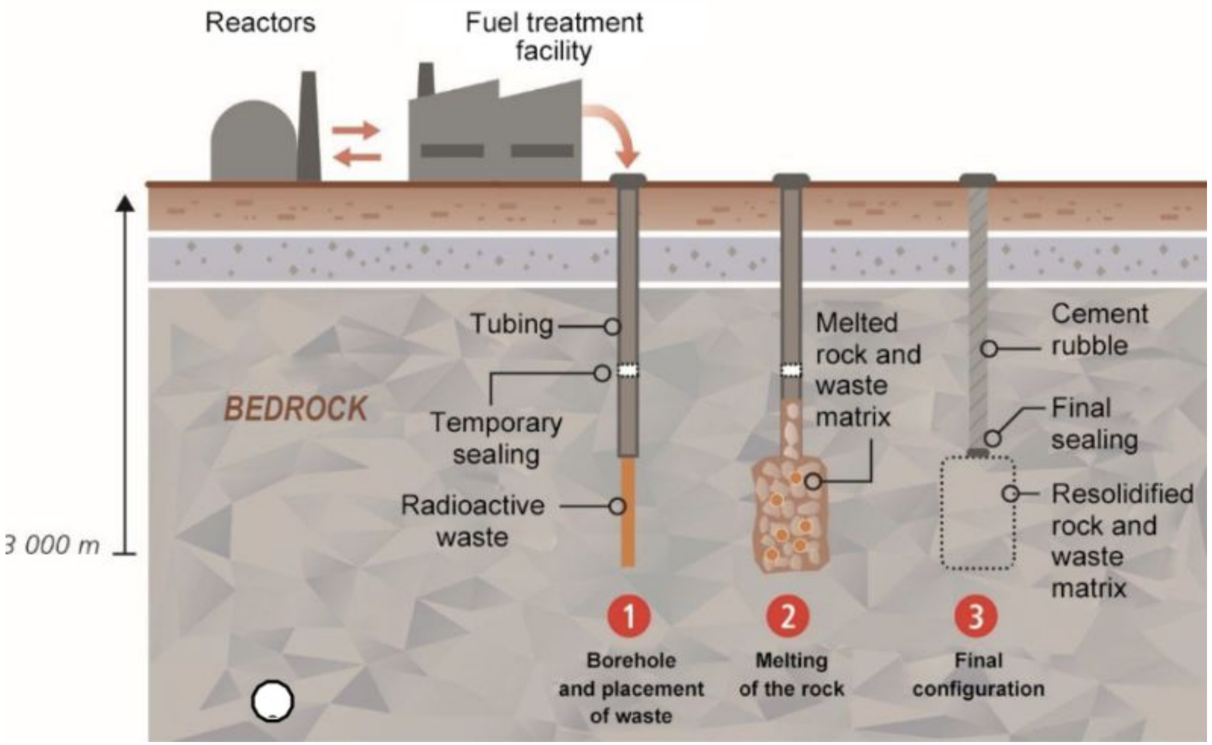
Dry Cask Storage Used at Connecticut Yankee

https://www.deepisolation.com/about-nuclear-waste/what-is-spent-nuclear-fuel/

Waste Storage

Final internment permanently buries waste





https://www.world-nuclear-news.org/articles/how-are-geological-repository-projects-progressing
https://www.sitex.network/deep-bore-hole-repository-for-high-level-waste-report/

Radiation

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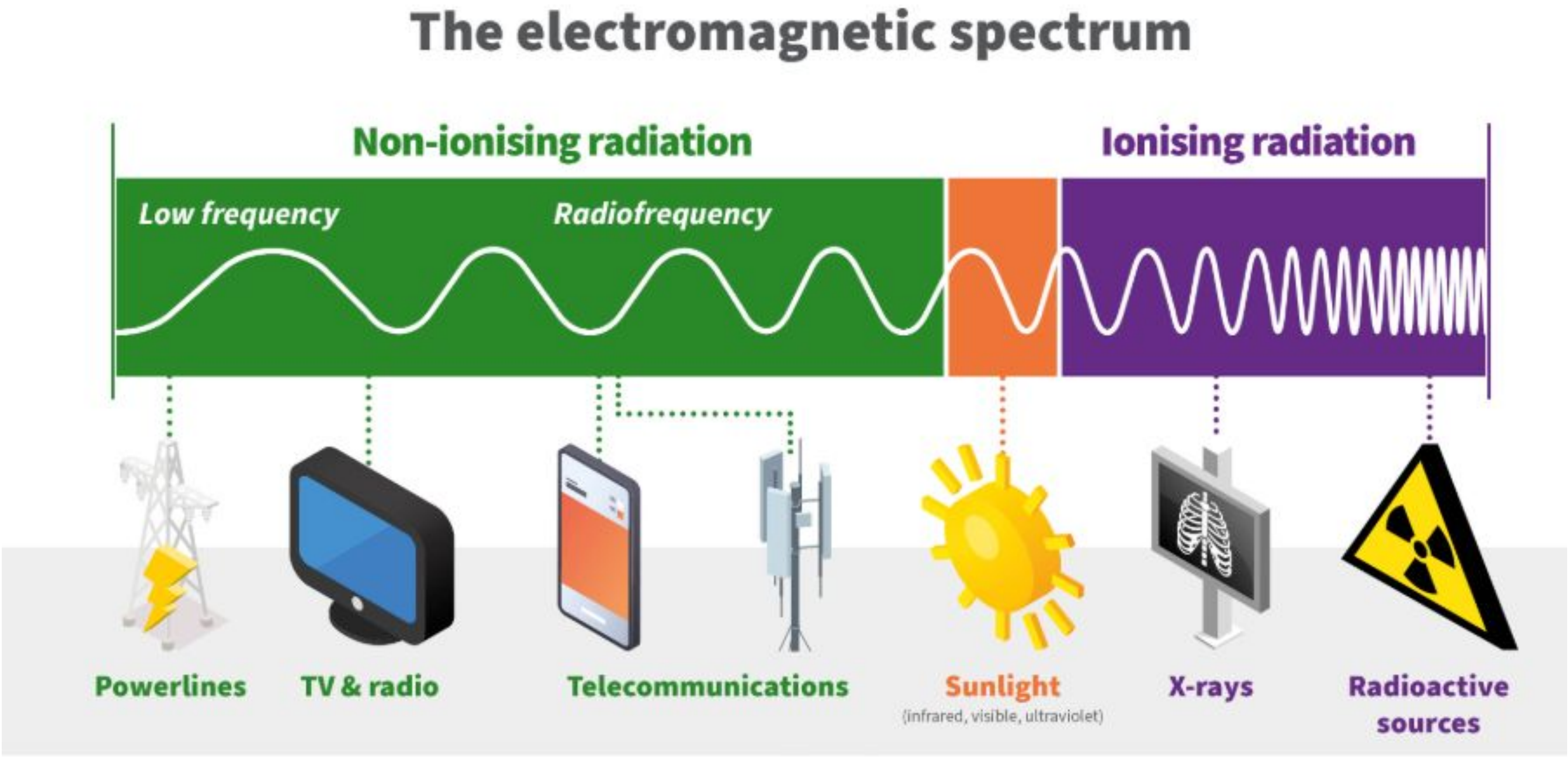
Radiation - The Foundation of Life

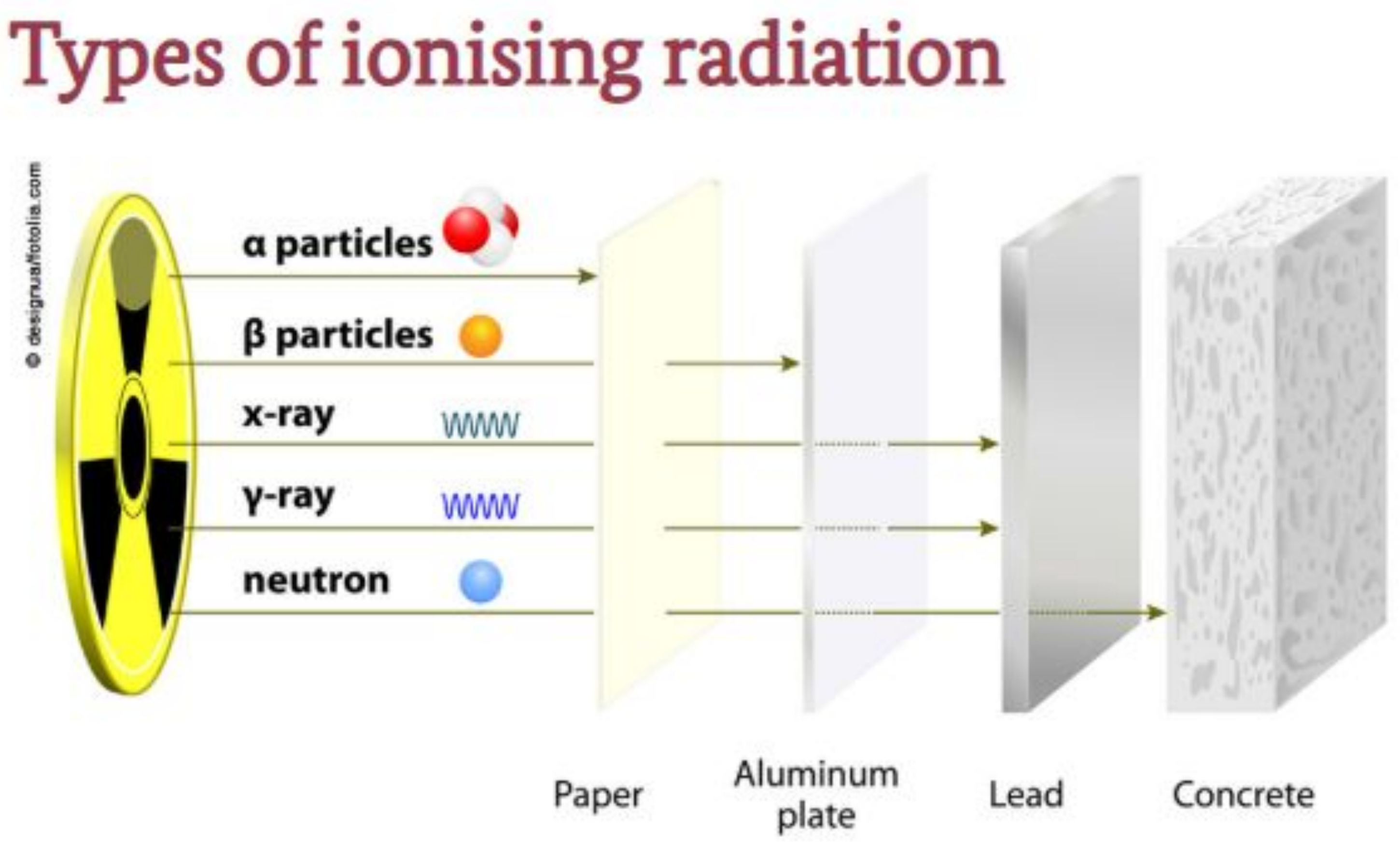
Humans are no stranger to radiation, its heat, light, communcations, medicine



https://www.arpansa.gov.au/understanding-radiation/what-is-radiation

Radiation - Ionizing Radiation

Ionising radiation is the more energetic - and hazardous - form of radiation that harms people



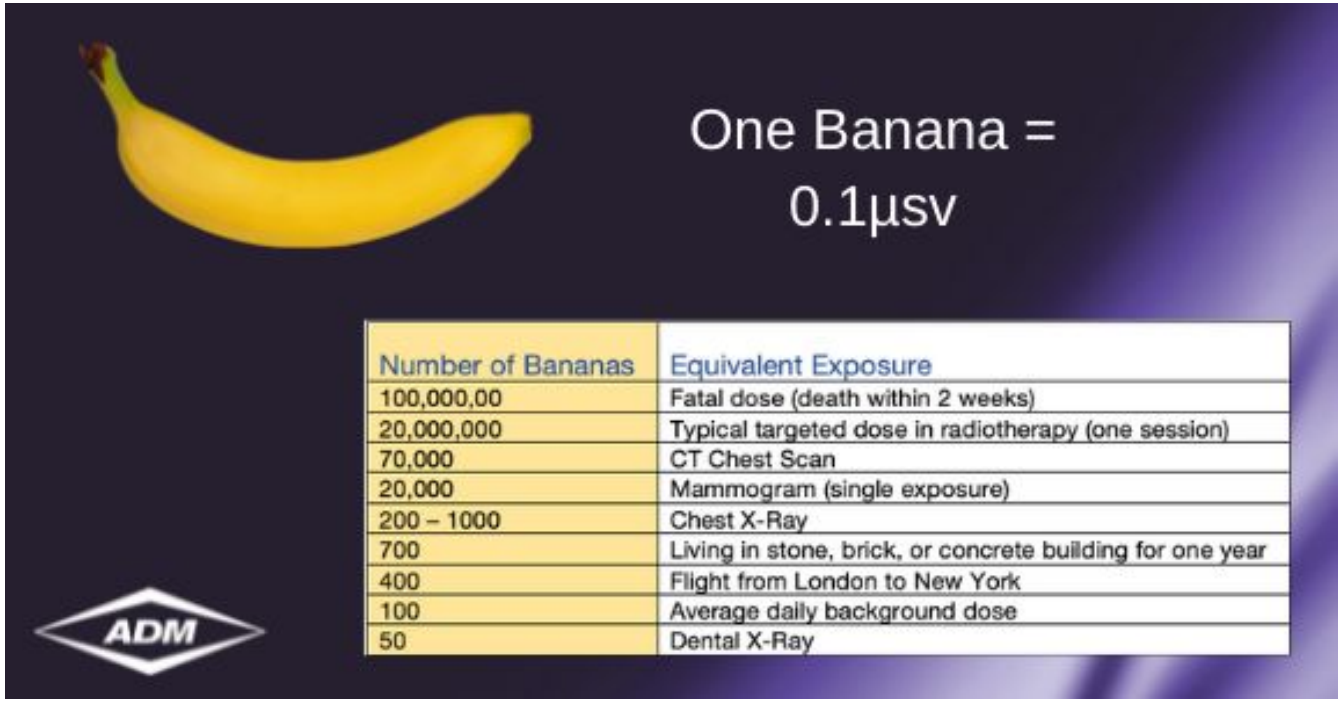
https://www.nuklearesicherheit.de/en/science/physics/ionising-radiation/types-of-ionising-radiation/

Radiation - Banana Scale of Radiation

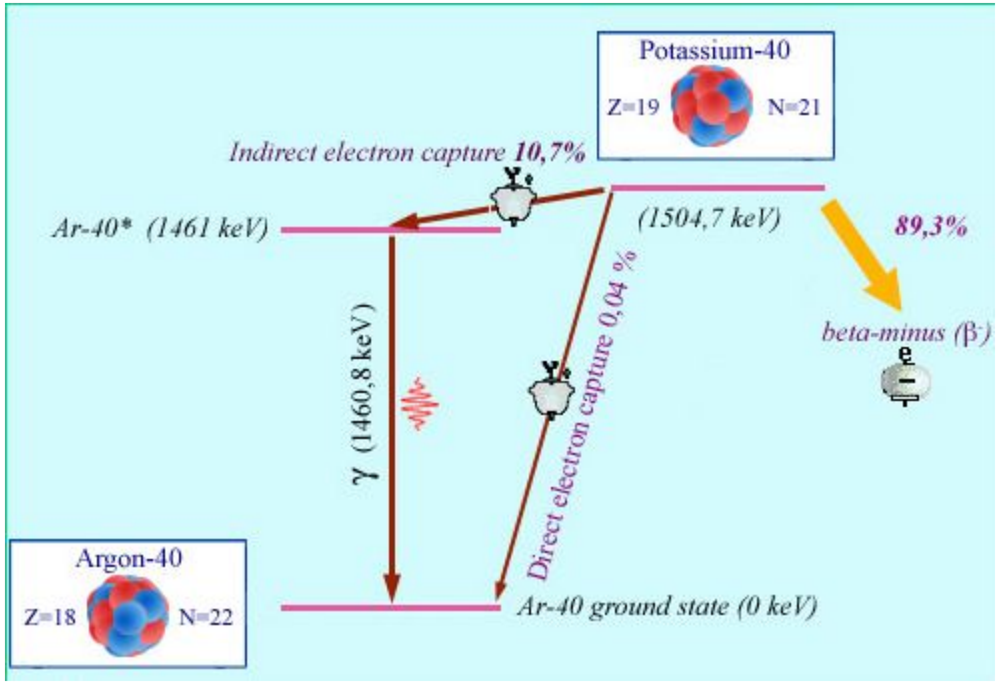
Radiation is a daily part of your life, even in bananas!

  Banana's have a very slow beta decay, ~4000 decay/s in the human body

  Living within 50 miles of a nuclear reactor is like eating

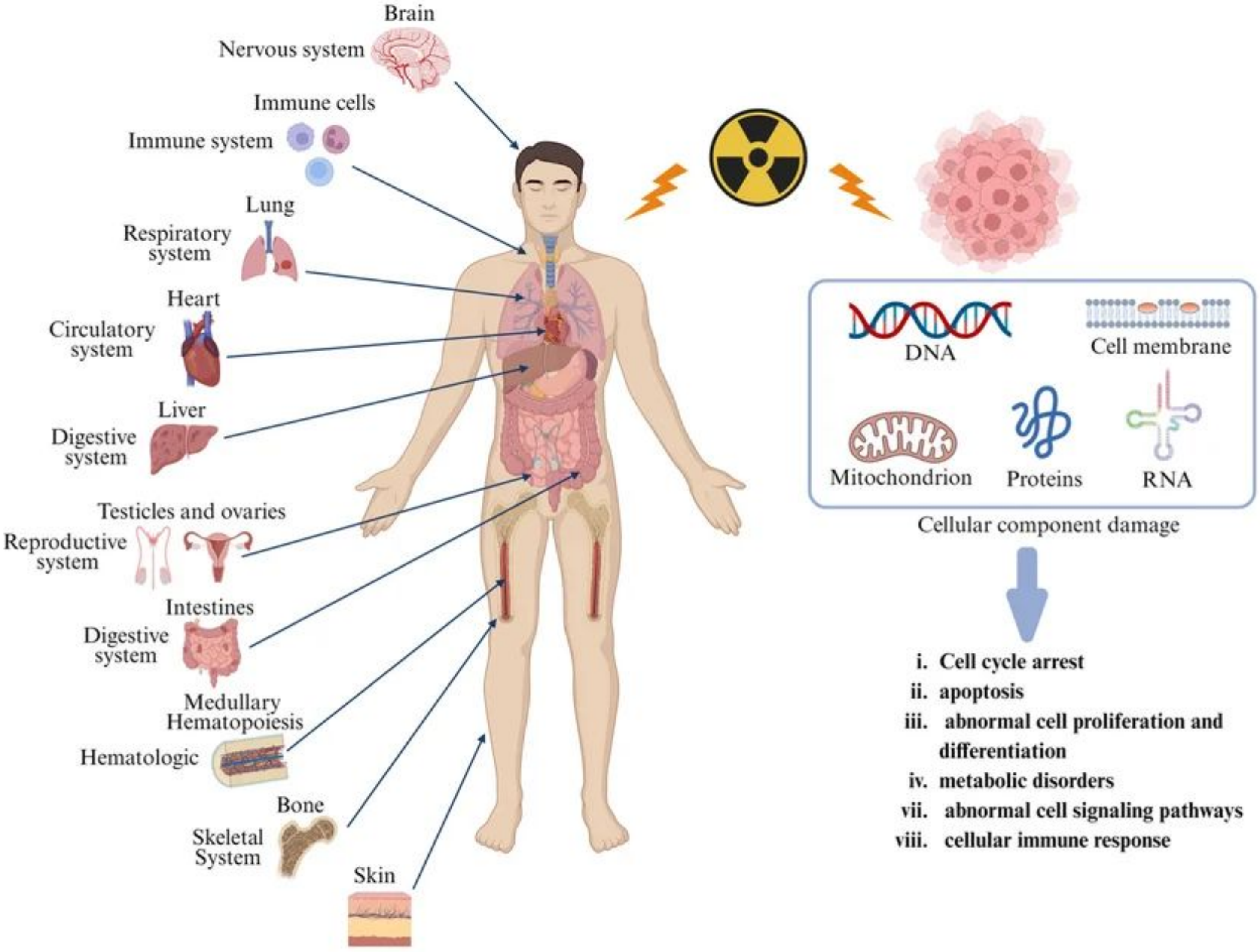


Number of Bananas	Equivalent Exposure
100,000,00	Fatal dose (death within 2 weeks)
20,000,000	Typical targeted dose in radiotherapy (one session)
70,000	CT Chest Scan
20,000	Mammogram (single exposure)
200 – 1000	Chest X-Ray
700	Living in stone, brick, or concrete building for one year
400	Flight from London to New York
100	Average daily background dose
50	Dental X-Ray



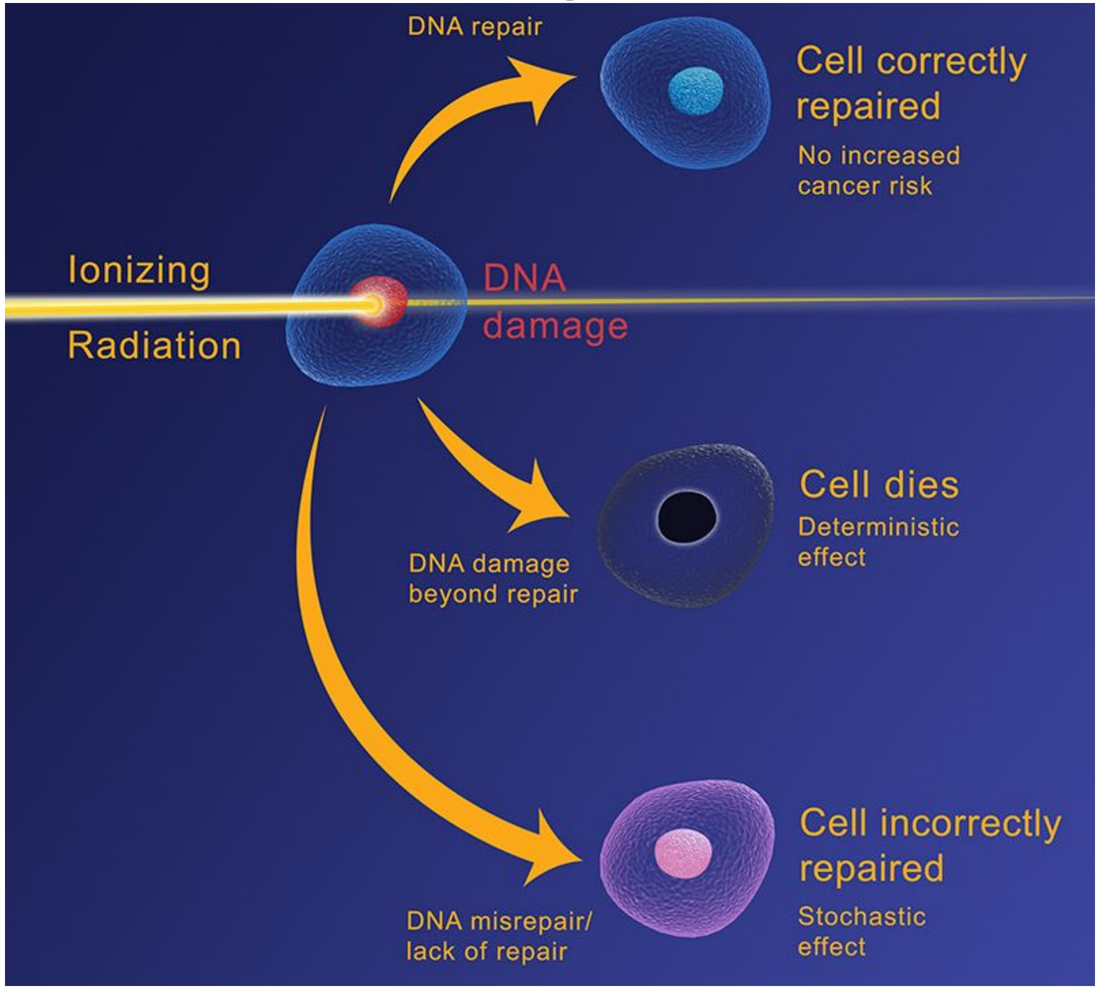
https://radioactivity.eu.com/articles/phenomenon/potassium_40
https://www.admnucleartechnologies.com.au/blog/did-you-know-bananas-are-radioactive

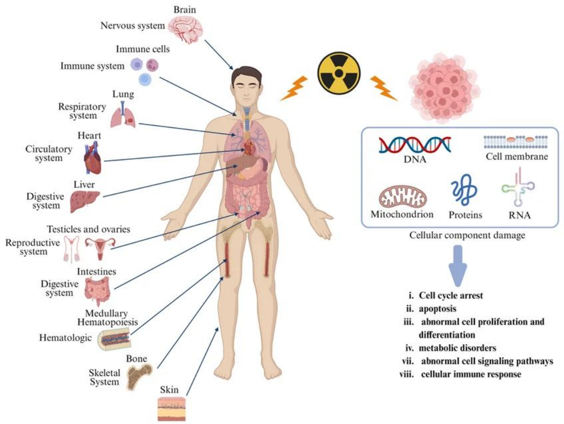
Radiation - DNA Damage



https://www.mdpi.com/1999-4923/17/5/652?utm_source=researchgate.net&utm_medium=article

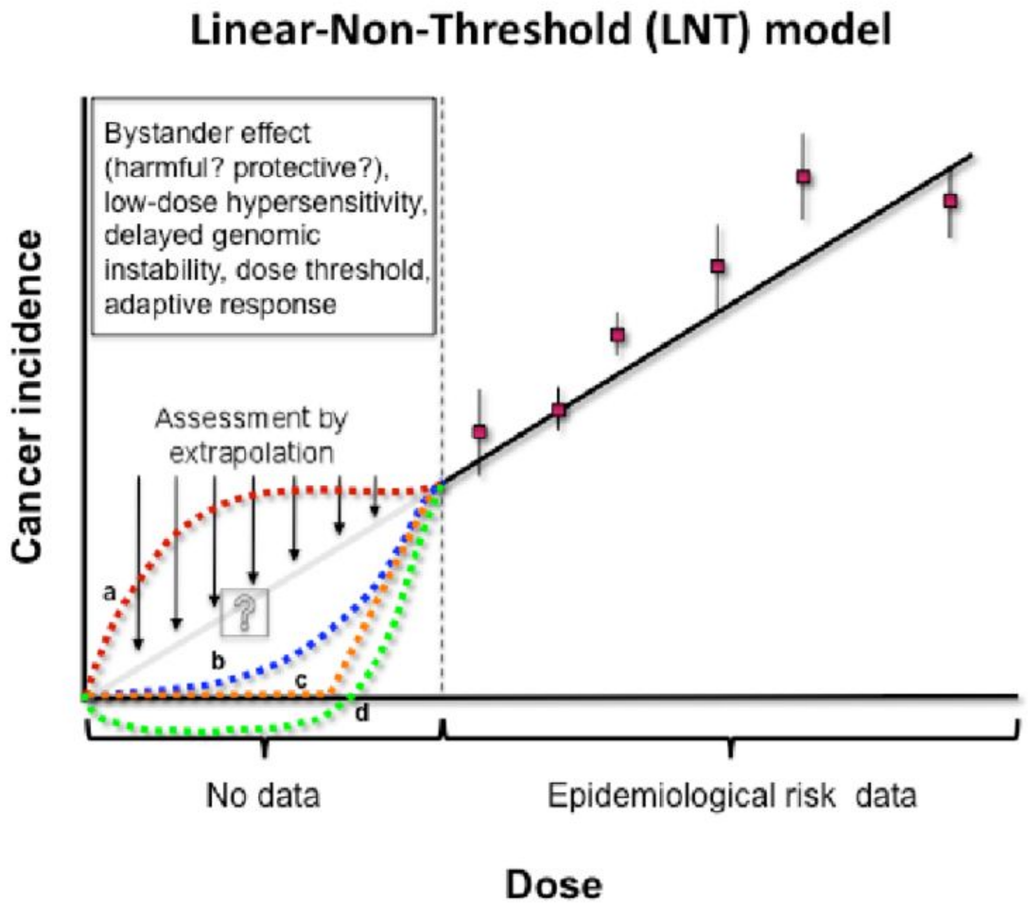
Radiation - DNA Damage

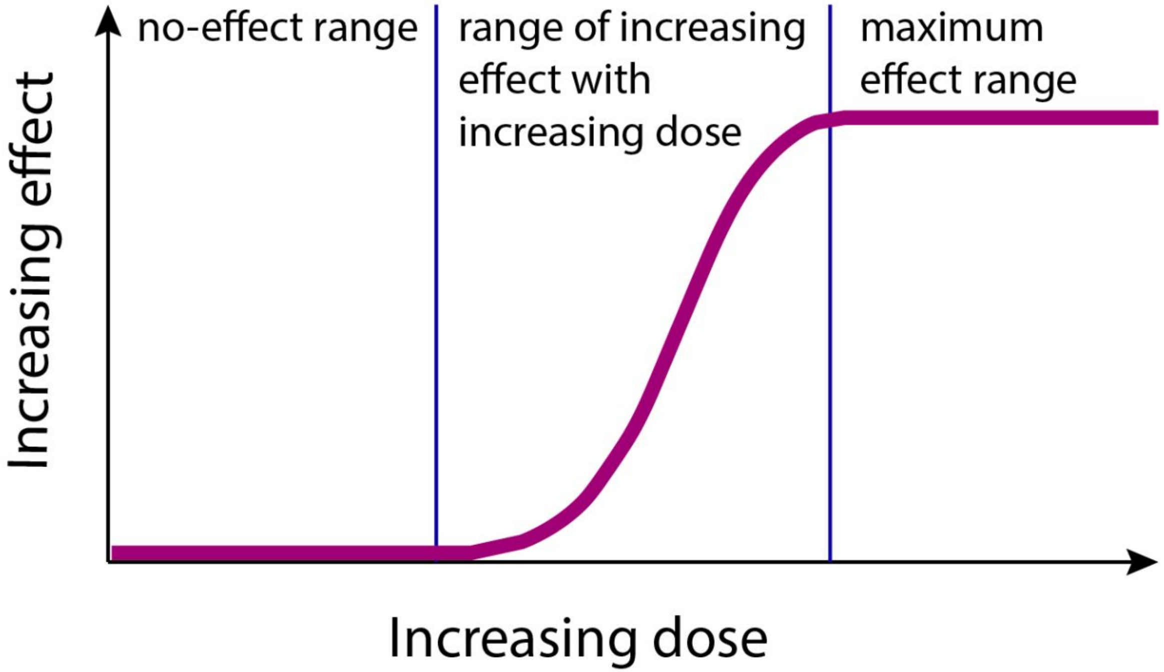




https://www.mdpi.com/1999-4923/17/5/652?utm_source=researchgate.net&utm_medium=article
https://www.cnsc-ccsn.gc.ca/eng/resources/radiation/radiation-health-effects/

Radiation - Regulation





https://www.eurekaselect.com/article/42657
https://toxedfoundation.org/basics-of-dose-response/

The Office

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Utah Office of Energy Development

Two main portions of the Office

Programs and Grants - Federal and state incentive, grants, education efforts

- High cost infrastructure tax credit, rural EV infrastructure, STEMfest

Research – In-house expertise on energy issues and guiding policy or initiatives

- Operation Gigawatt, Publications, Strategic Energy Plan, Data Analysis

Self-contained entities

- San Rafael Energy Research Center – Research center for energy-related projects like supercritical CO2, pilot nuclear projects
- Nuclear Consortium – Foster statewide coordination between nuclear stakeholders to drive to nuclear deployments
- Advanced Energy and Nuclear Institute – Similar to the consortium, but between academia and the national labs and focusing on research