



Energy Development

Nuclear 101: The Modern Nuclear Era

April 28, 2026 | Wasatch Back Nuclear Energy Forum

Tim Kowalchik | Research Director

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Energy Basics



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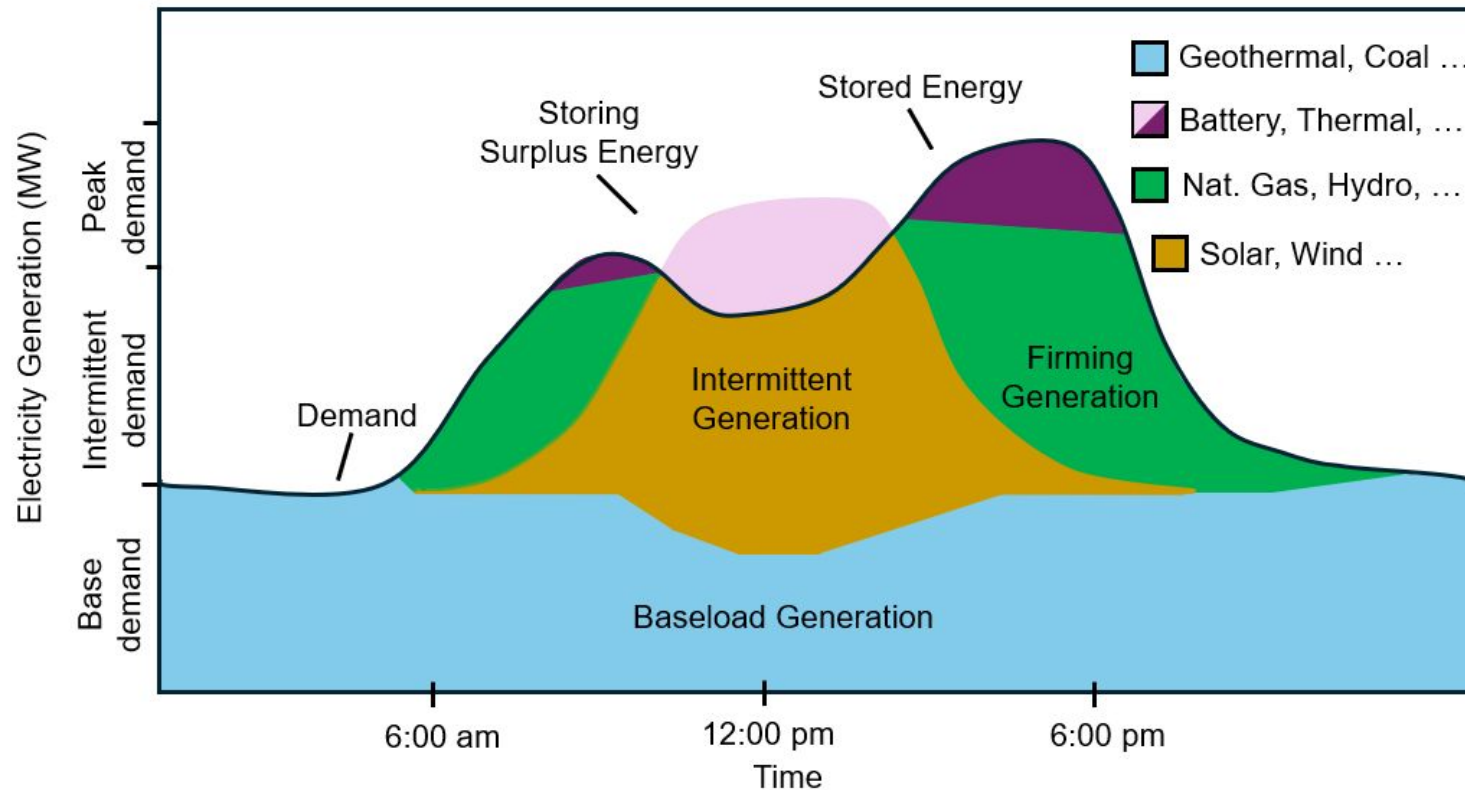
Energy Basics

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

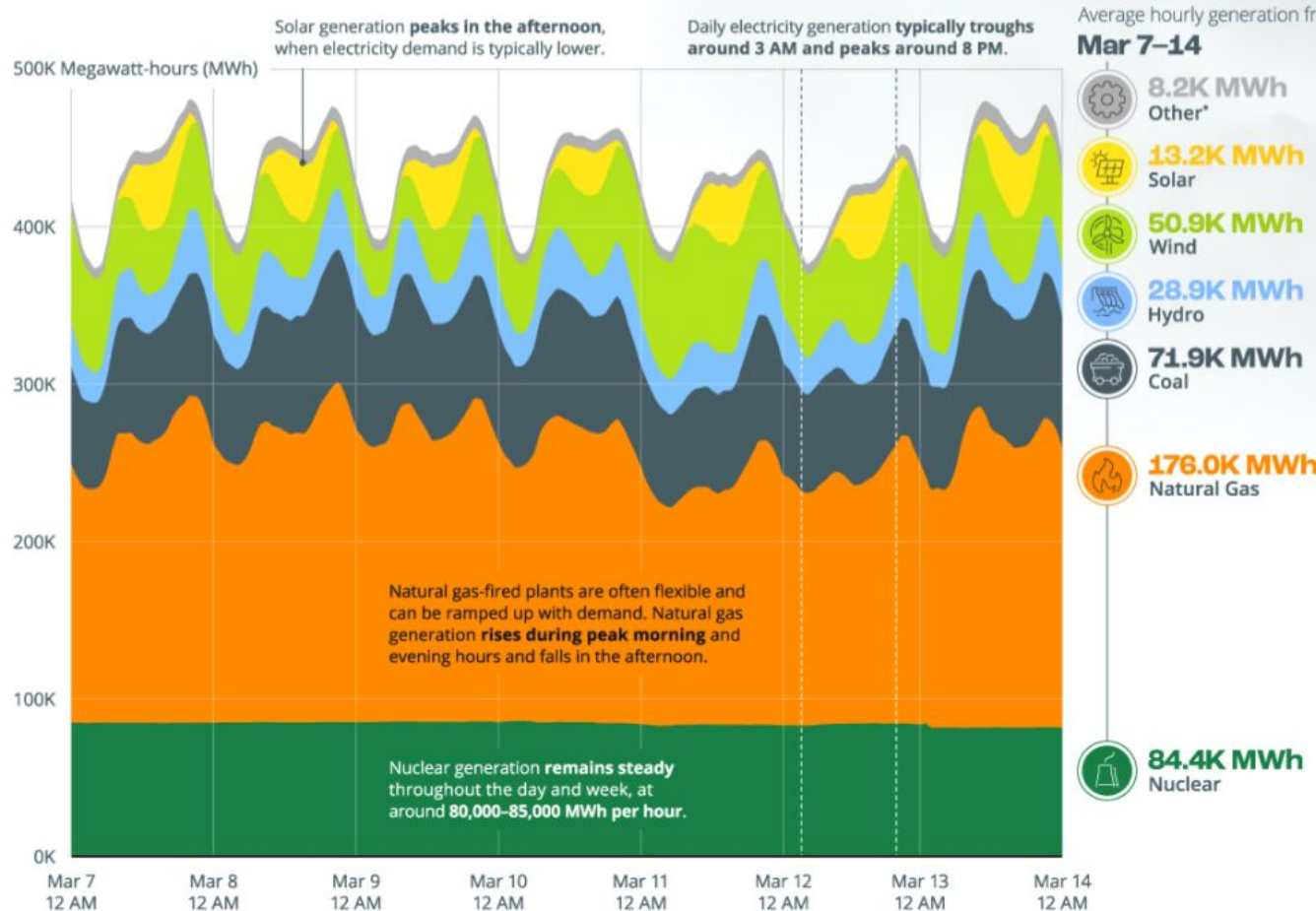


Energy Mix

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

Hourly Electricity Generation by Source

(March 7, 2023–March 14, 2023 EST), MWh



*Note: "Other" includes petroleum, geothermal, and biomass generation.

Source: U.S. Energy Information Administration

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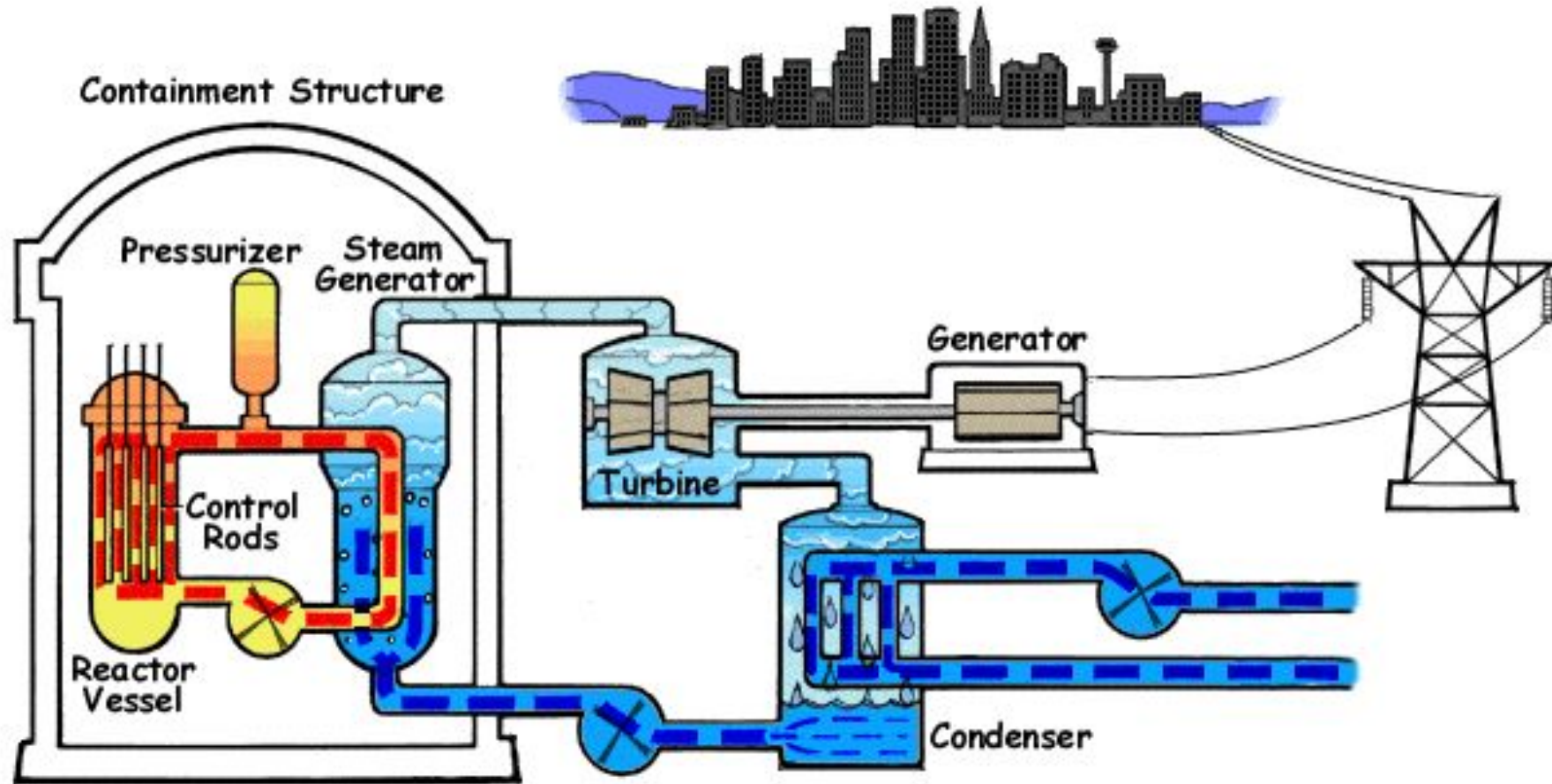
<https://decarbonization.visualcapitalist.com/how-does-us-electricity-generation-change-over-one-week/>

Old vs New Nuclear

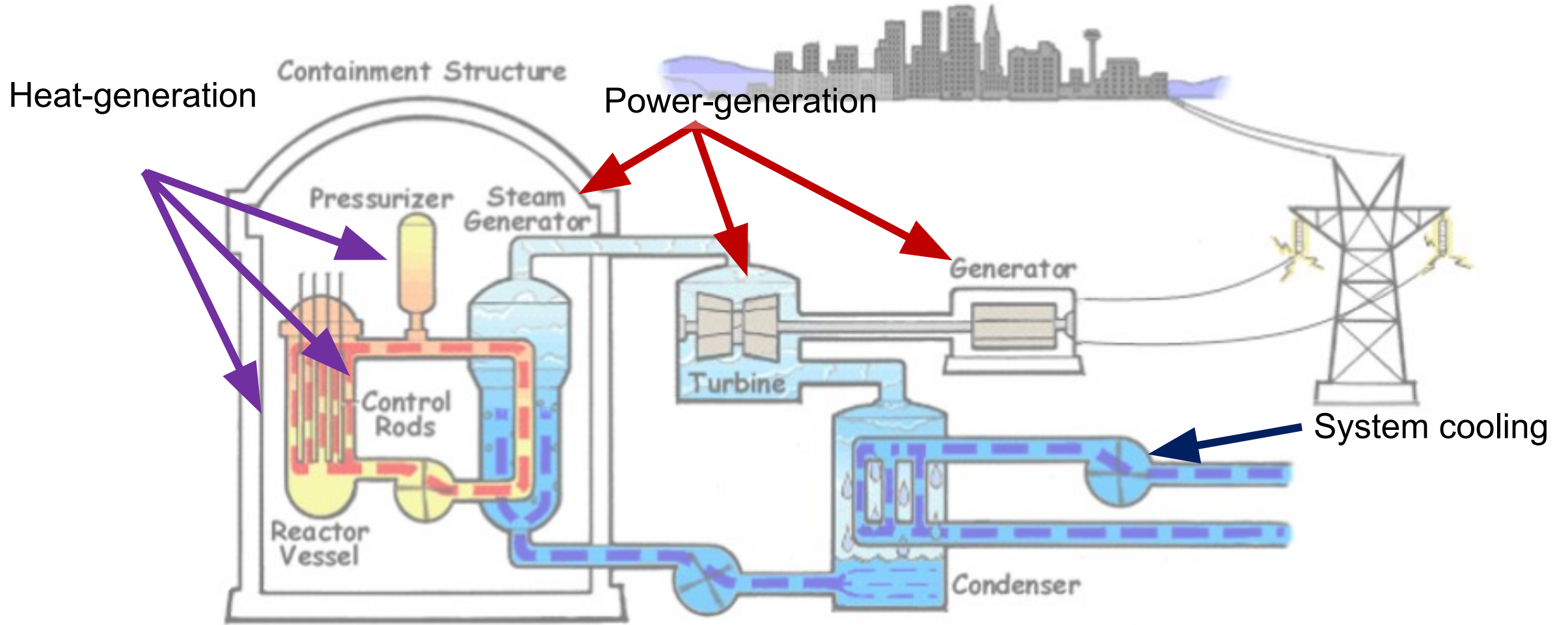


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Nuclear Reactors



The Nuclear Loop



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

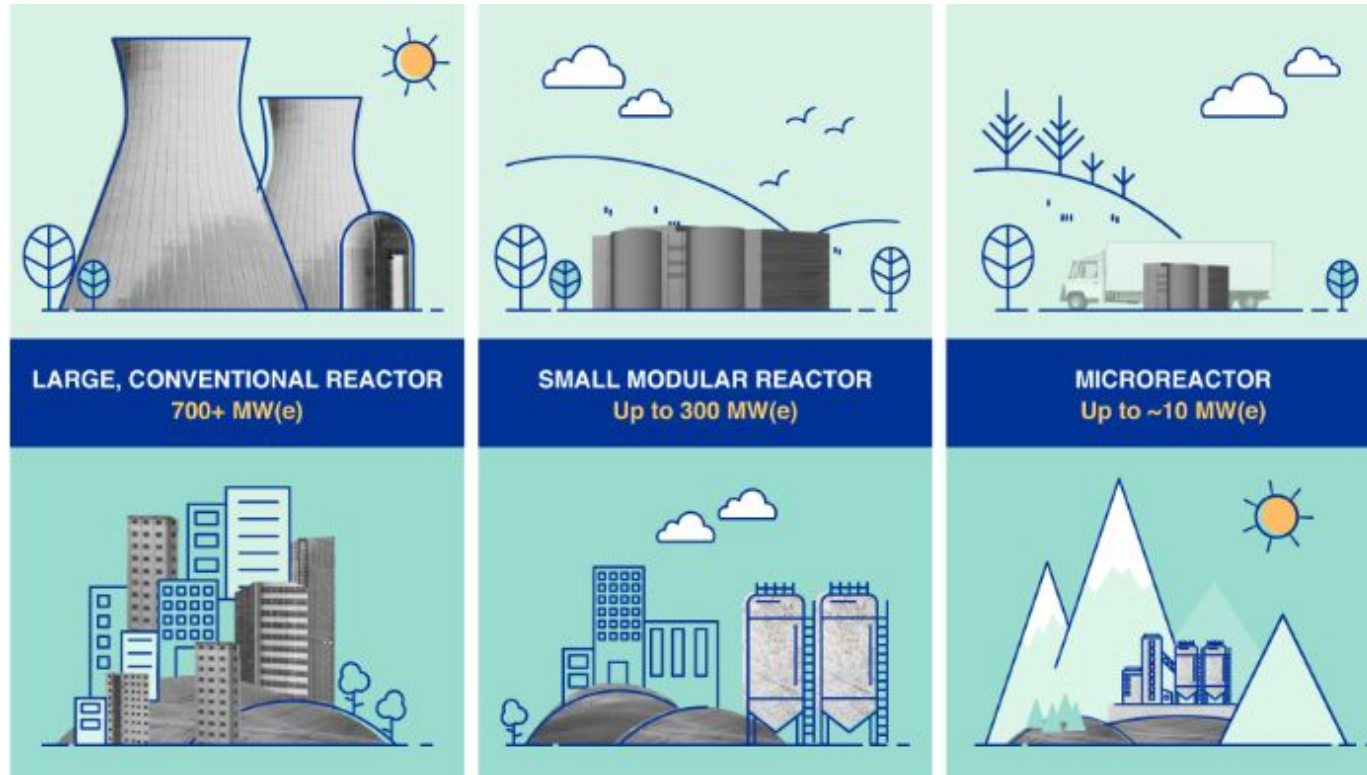


The Nuclear Loop – Power Generation

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

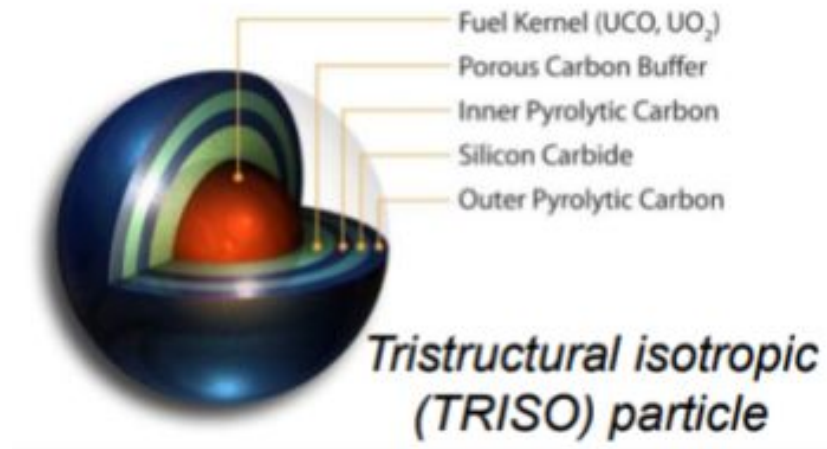
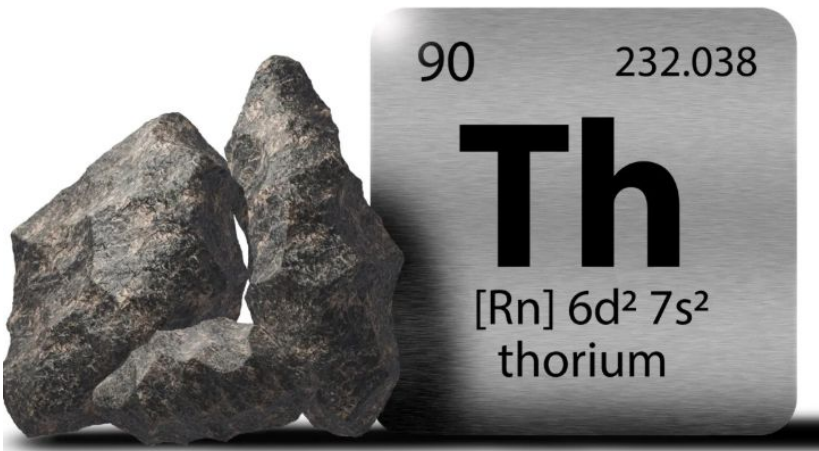


<https://www.iaea.org/newscenter/news/what-are-small-modular-reactors-smrs>



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>

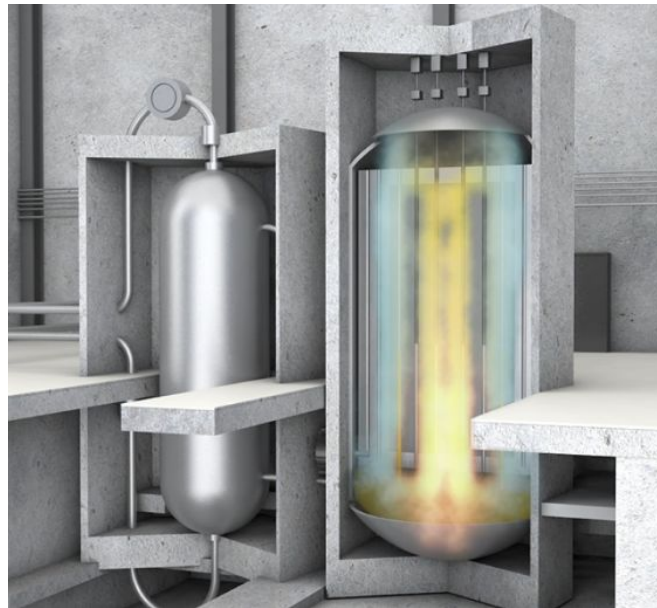
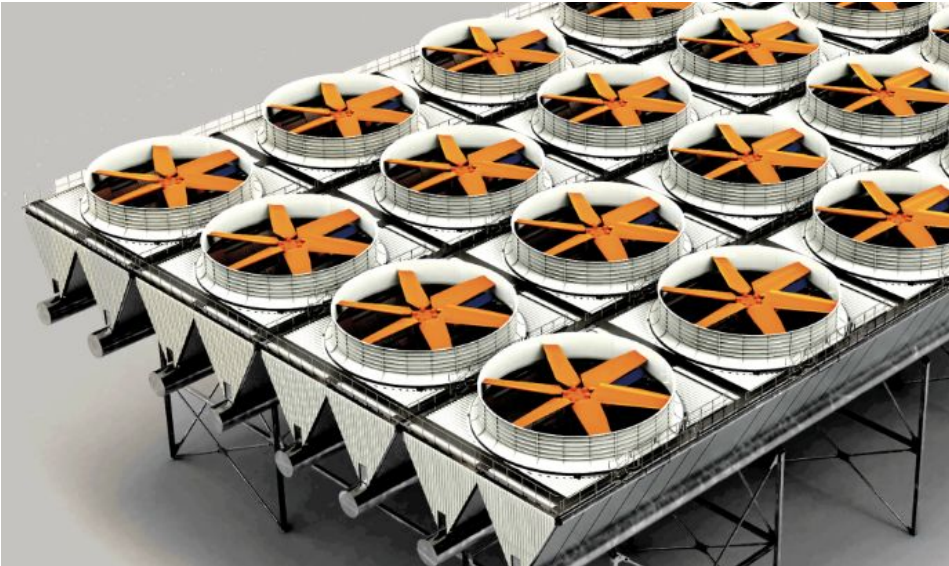


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The Nuclear Loop - System Cooling

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/>



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Water Demands



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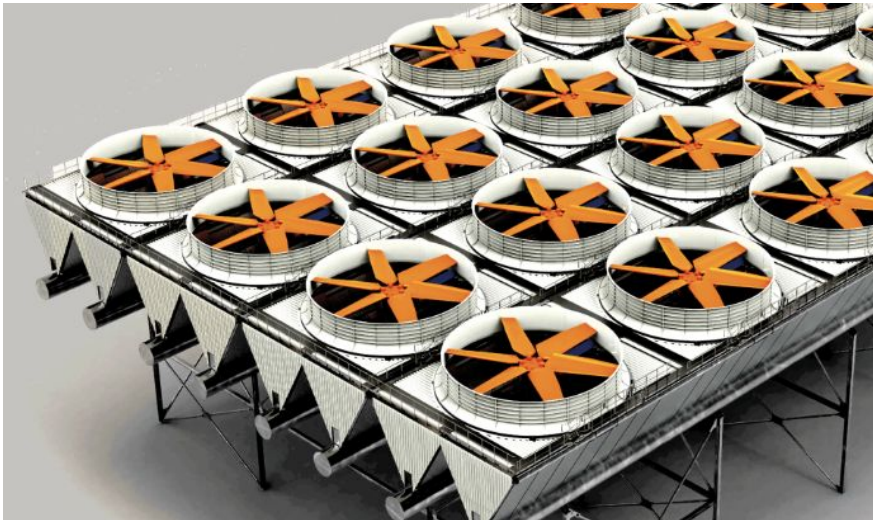
Water Consumption

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>



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Safety



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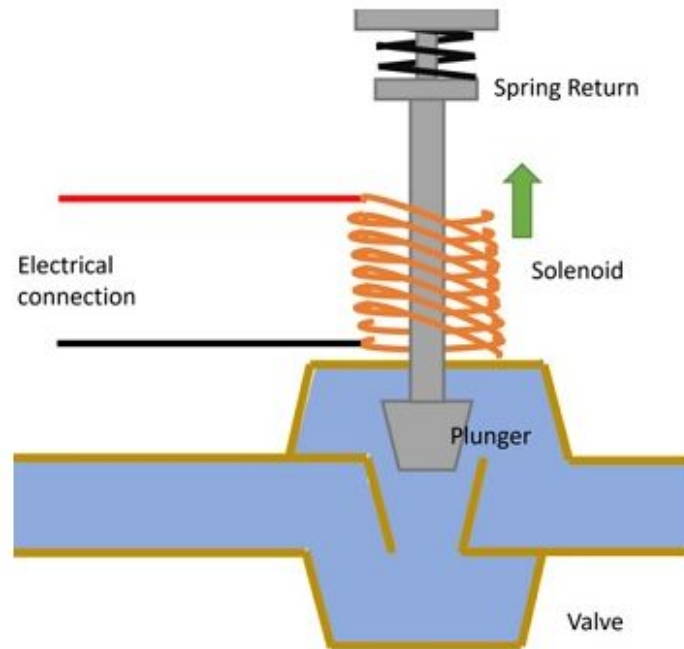
Passive Safety

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>

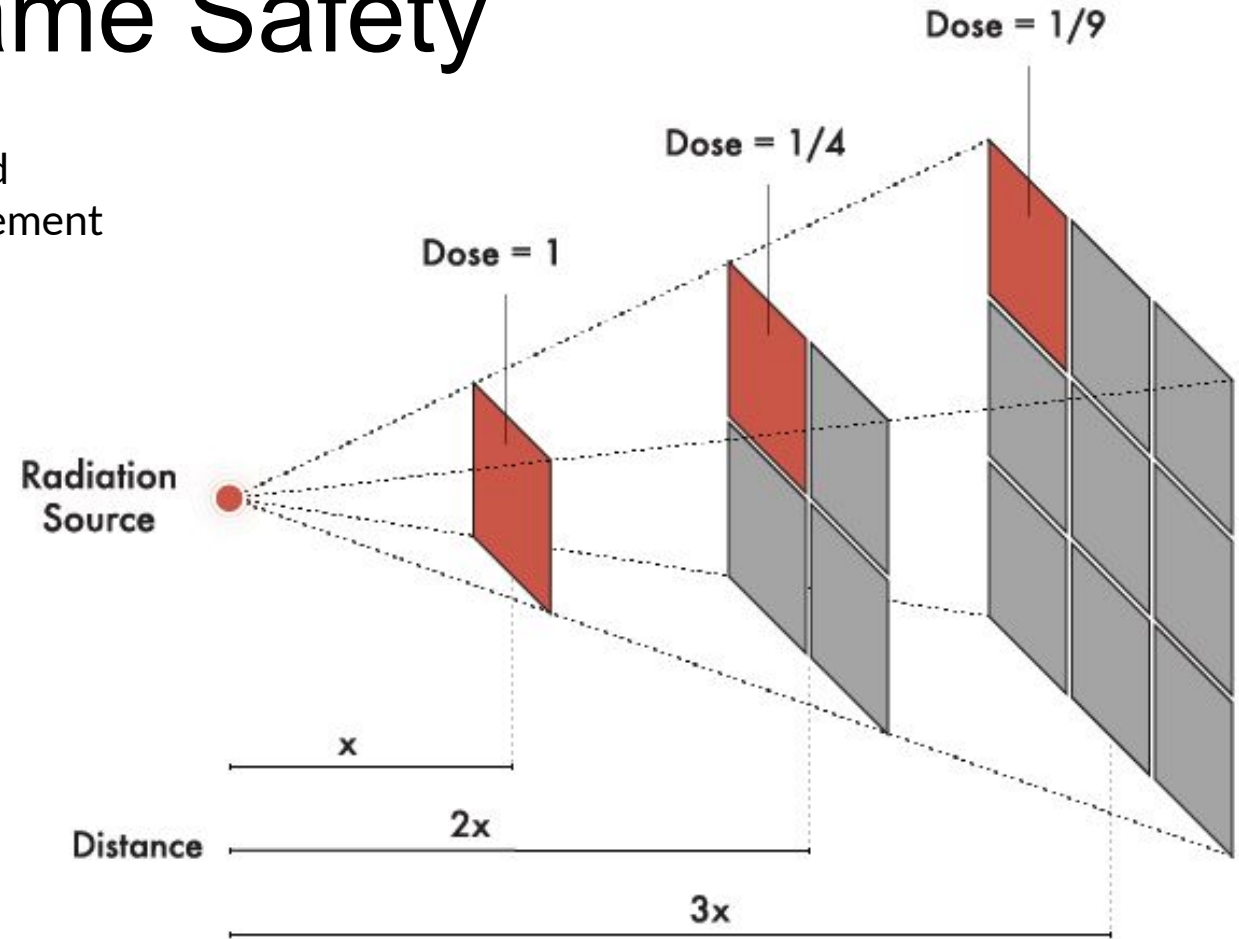


New Regulations, Same Safety

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/>



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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,
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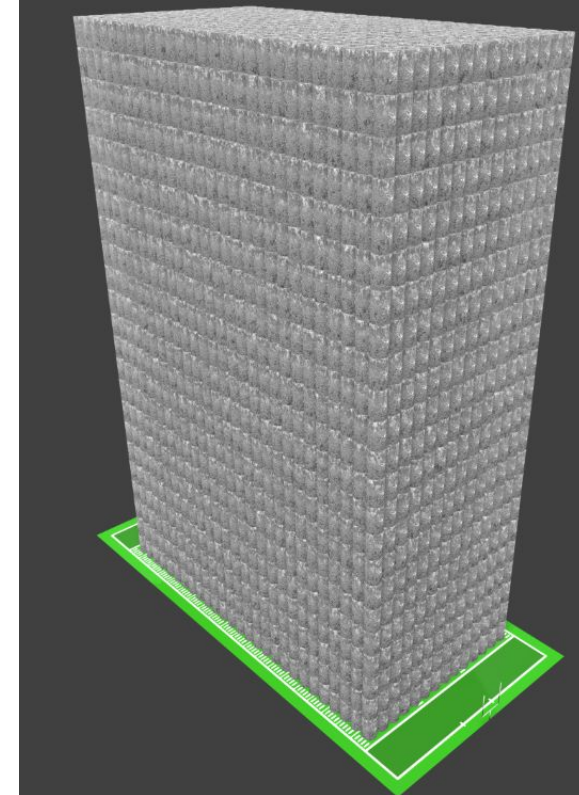
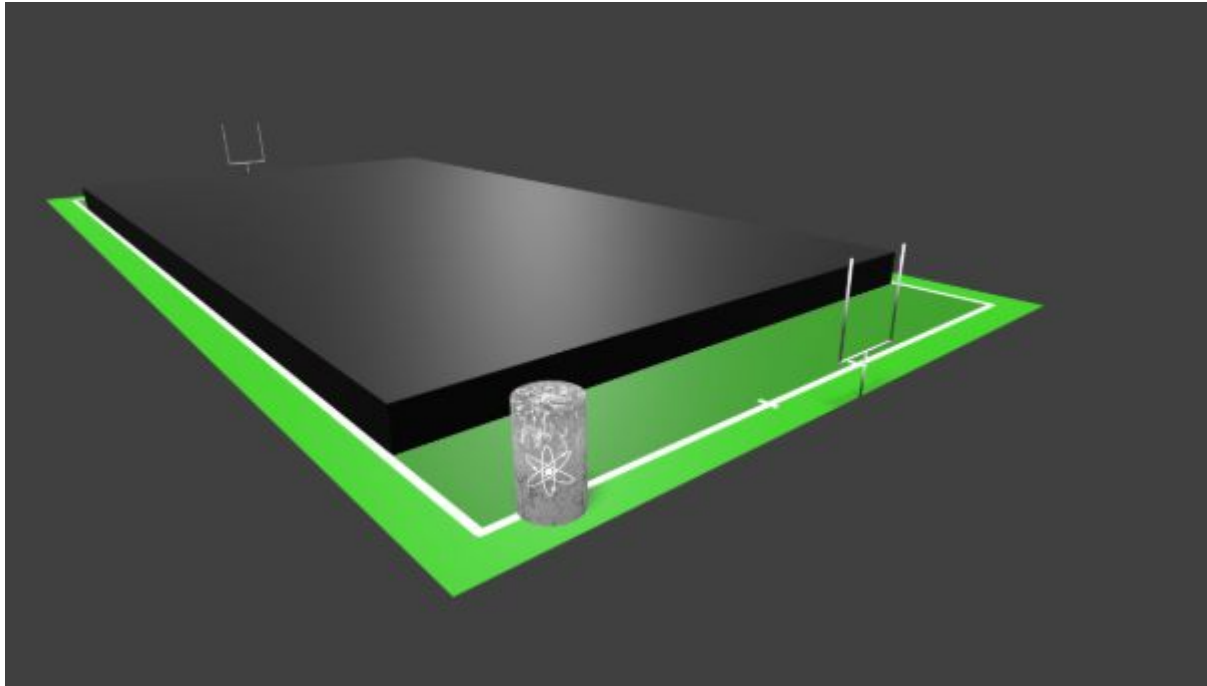
Waste



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How Much Waste is There?

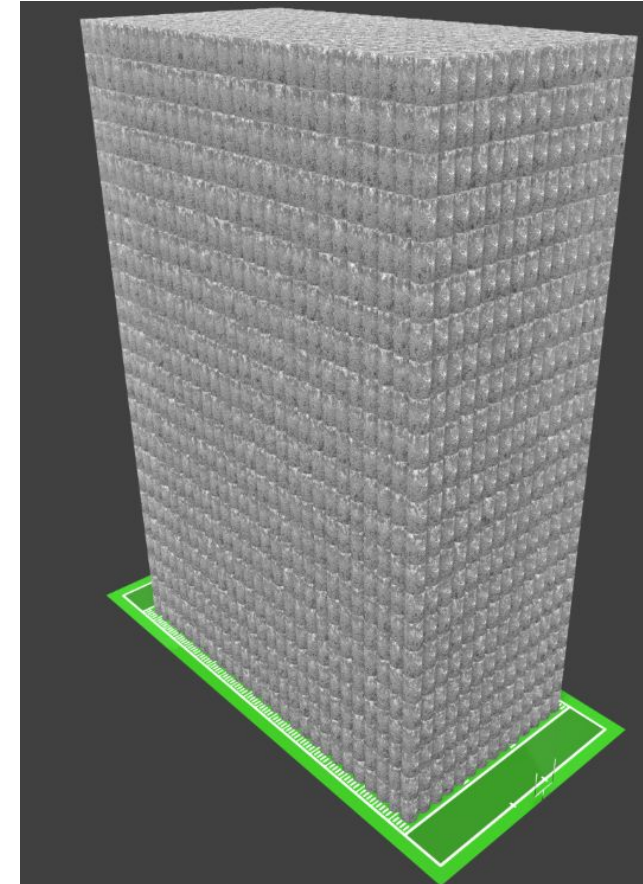
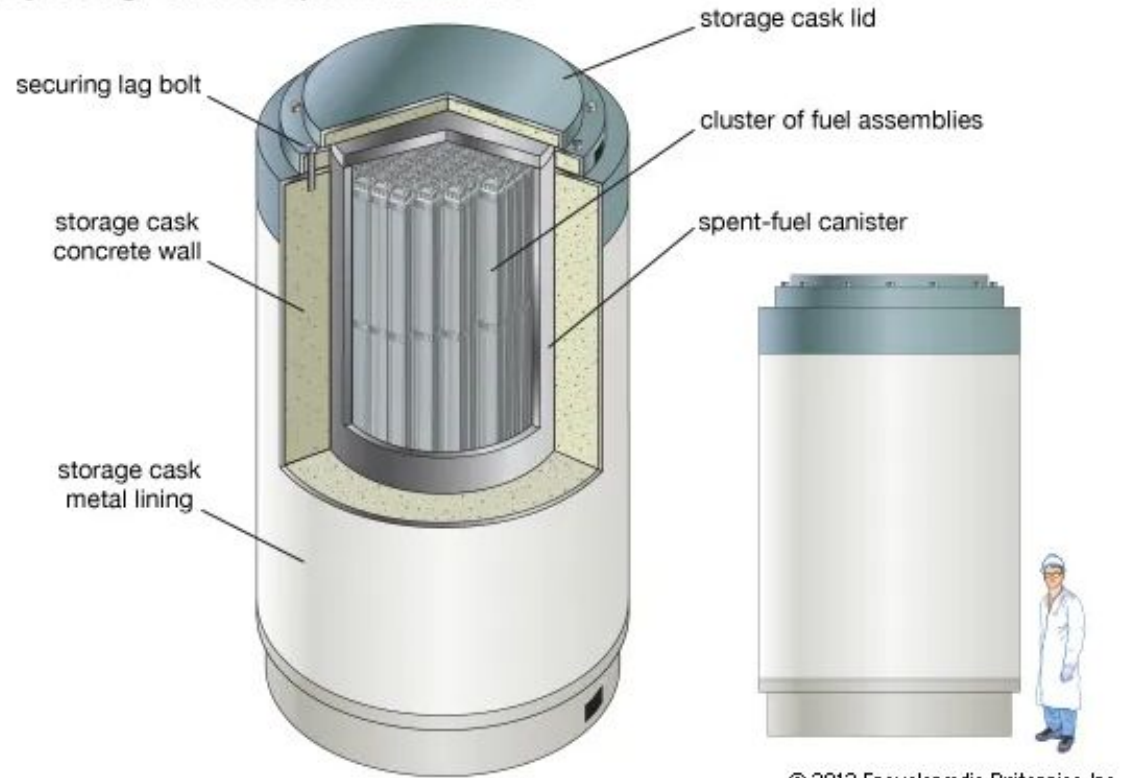
The 50+ years of US nuclear operation has led to about ~100,000 metric tons of spent nuclear fuel



How Much Waste is There?

Stored in “Dry Casks” at the moment

Dry storage cask for spent nuclear fuel



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

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Waste Is A Challenge

Current spent nuclear fuel contains half the periodic table

Specific makeup depends on time, reactor technology, reactor burnup

1 1A TA																	18 VIIIA 8A
1 H Hydrogen 1.008	2 He Helium 4.003																
3 Li Lithium 6.941	4 Be Beryllium 9.012																
11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948										
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.905	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.227	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [277]	109 Mt Meitnerium [276]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [282]	112 Cn Copernicium [285]	113 Nh Nihonium [284]	114 Fl Flerovium [289]	115 Mc Moscovium [288]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]
57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967			
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]	103 Lr Lawrencium [262]			



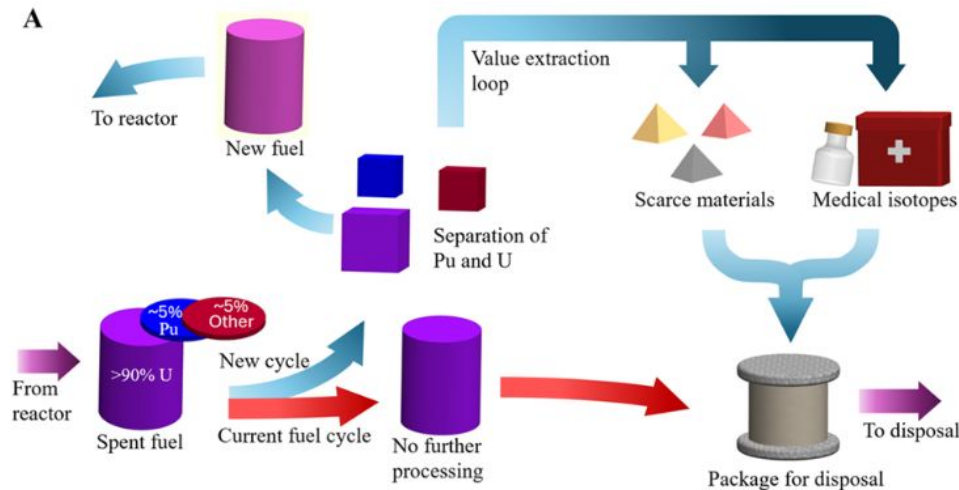
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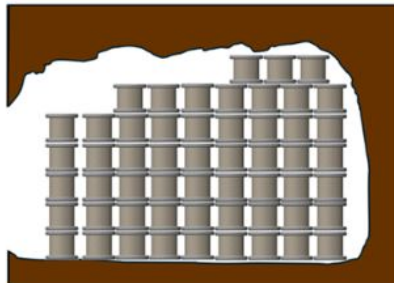
© 2017 Utah Department of Energy

Waste Is An Opportunity

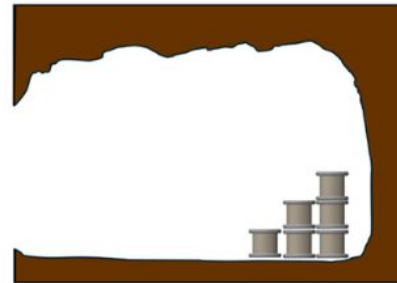
Current spent nuclear fuel contains half the periodic table
New nuclear technologies will produce new waste profiles
Modern regulations on how to handle multiple sites
National waste storage and reprocessing
Recycled fuel has benefits from energy to medicine



B



Storage without recycling



Storage with recycling

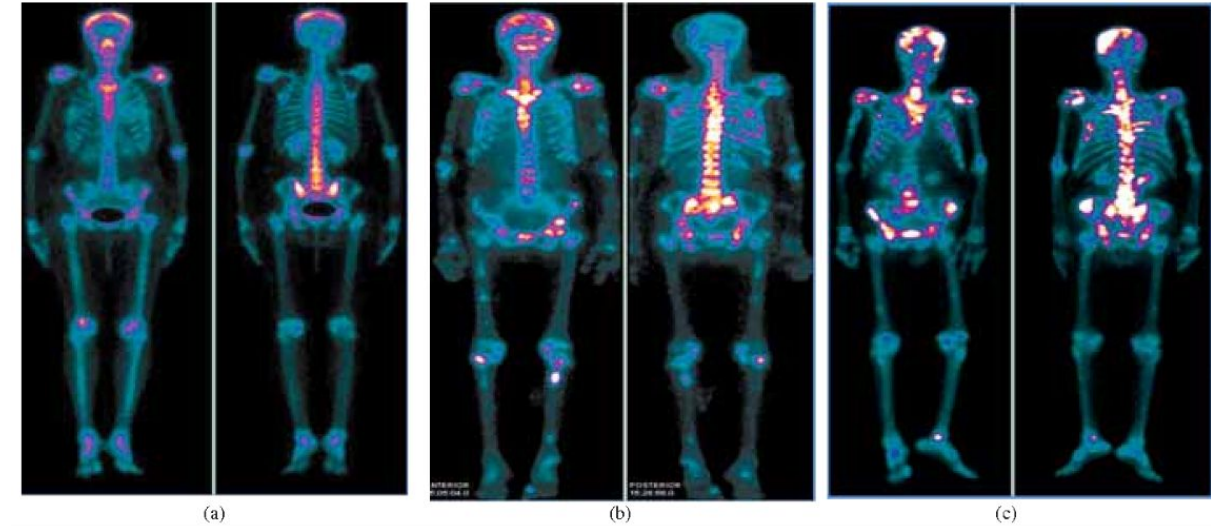


Figure 1: Typical whole-body images recorded using ^{99m}Tc -MDP, a bone imaging agent. (a) Normal human, (b) breast cancer patient with multiple metastases and (c) prostate cancer patient with extensive metastases

<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

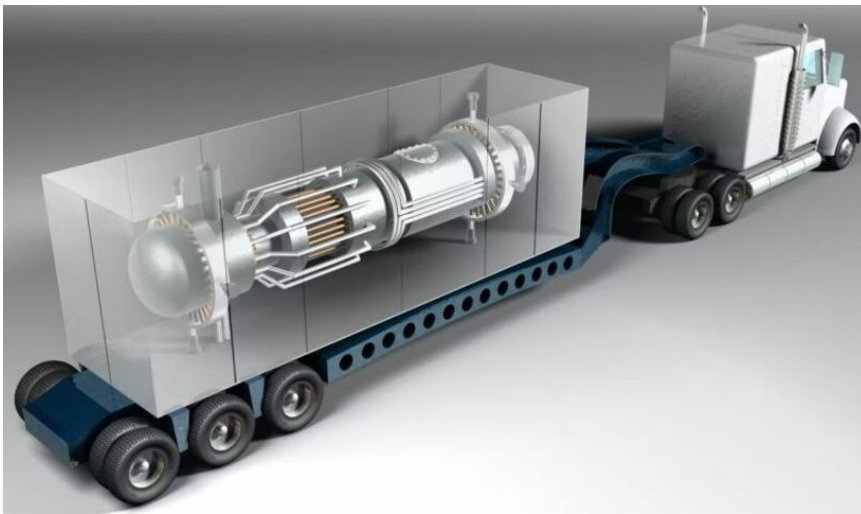
Financial premiums

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=vXE3goUNPU>



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Timeline

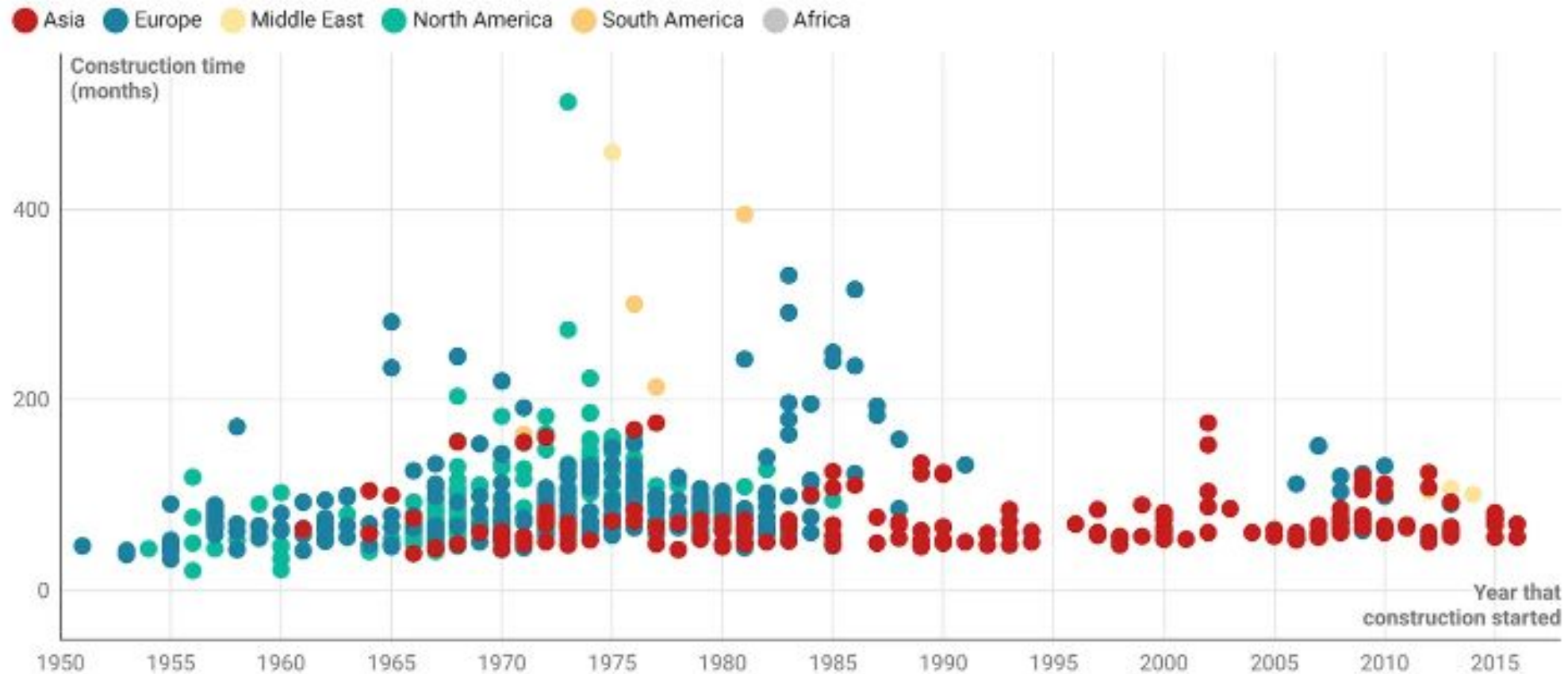


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Slow Construction Not Required

Construction time of nuclear reactors vs. the year that construction started

Includes all of the world's reactors that came into operation by 2023. Construction times are measured in months from the start date of building, not planning.



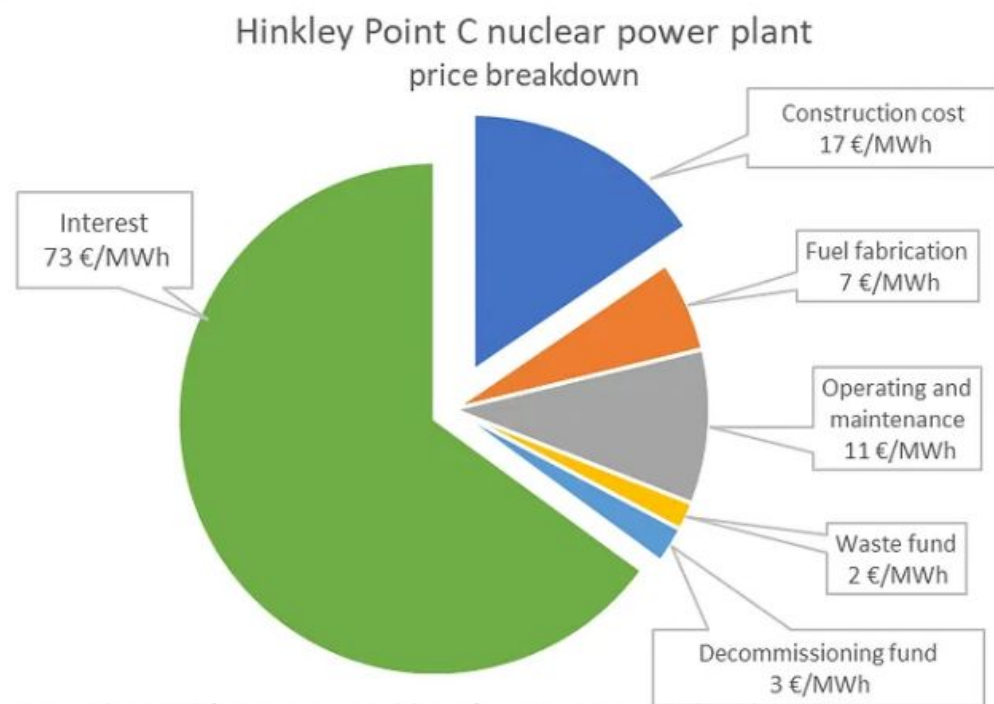
Industry Needs to Prove Timelines

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



Price paid per MWh for power generated during first 60 years is assumed equal to the CfD Strike Price (113 €/MWh in 2019 prices).

Construction time of nuclear reactors vs. the year that construction started

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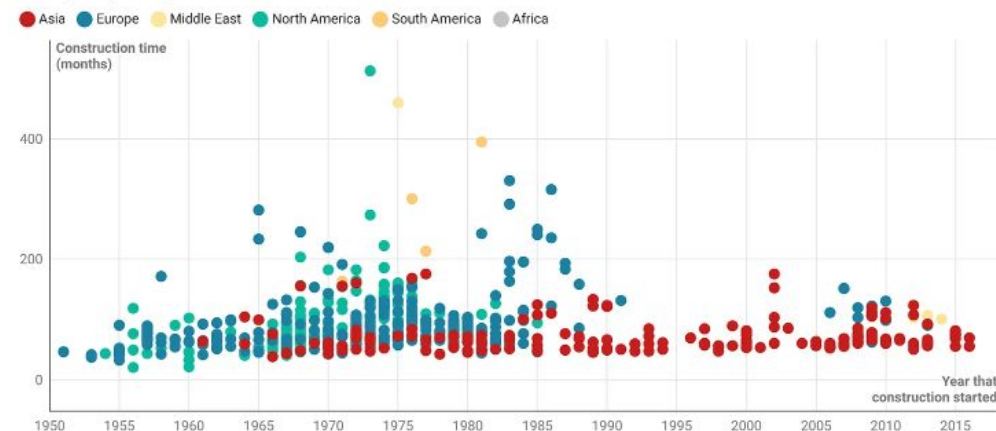


Chart: Hannah Ritchie • Source: IAEA Power Reactor Information System (PRIS) and Wikipedia • Created with Datawrapper

<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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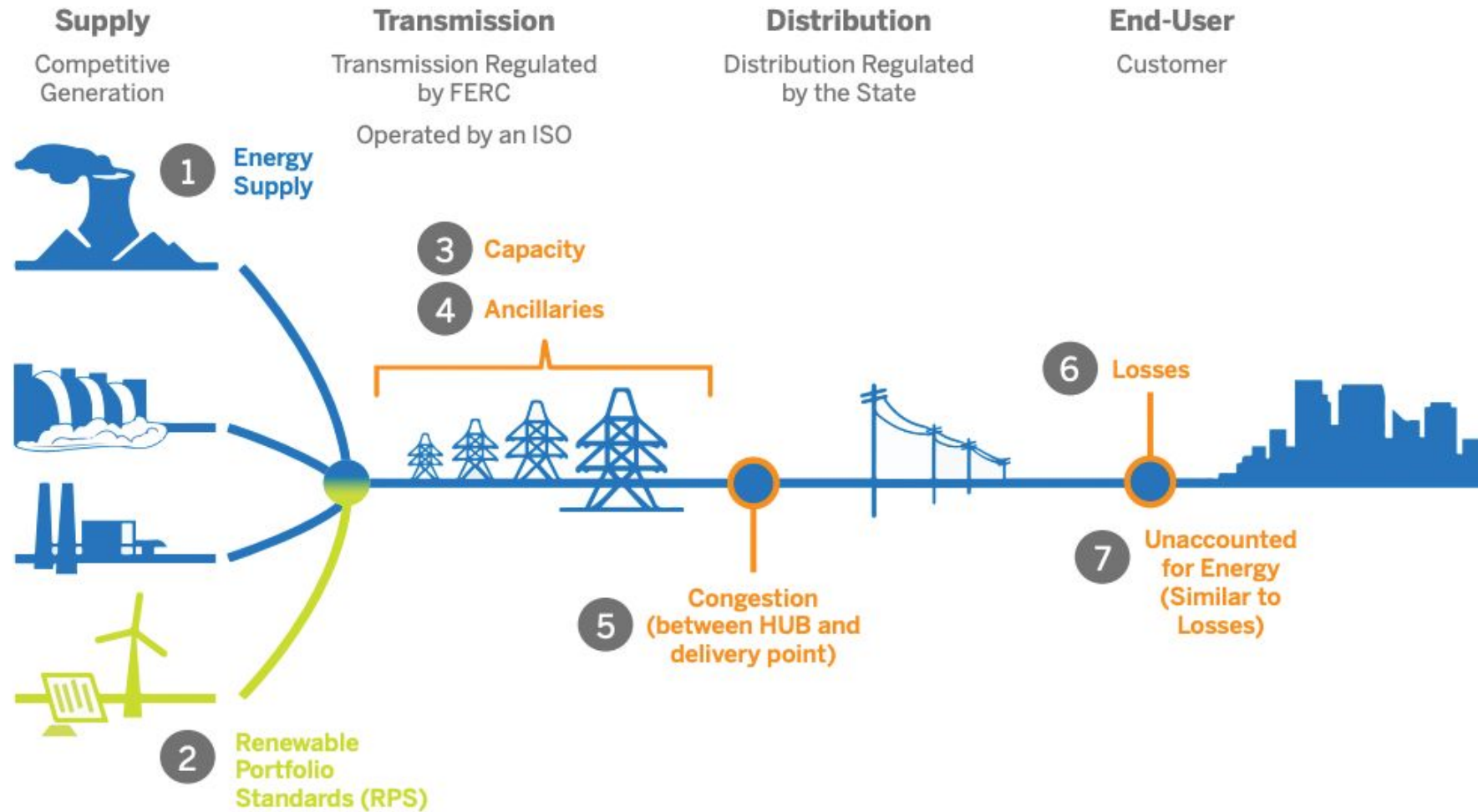
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LCOE vs System Costs



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LCOE vs SC - What is the System?



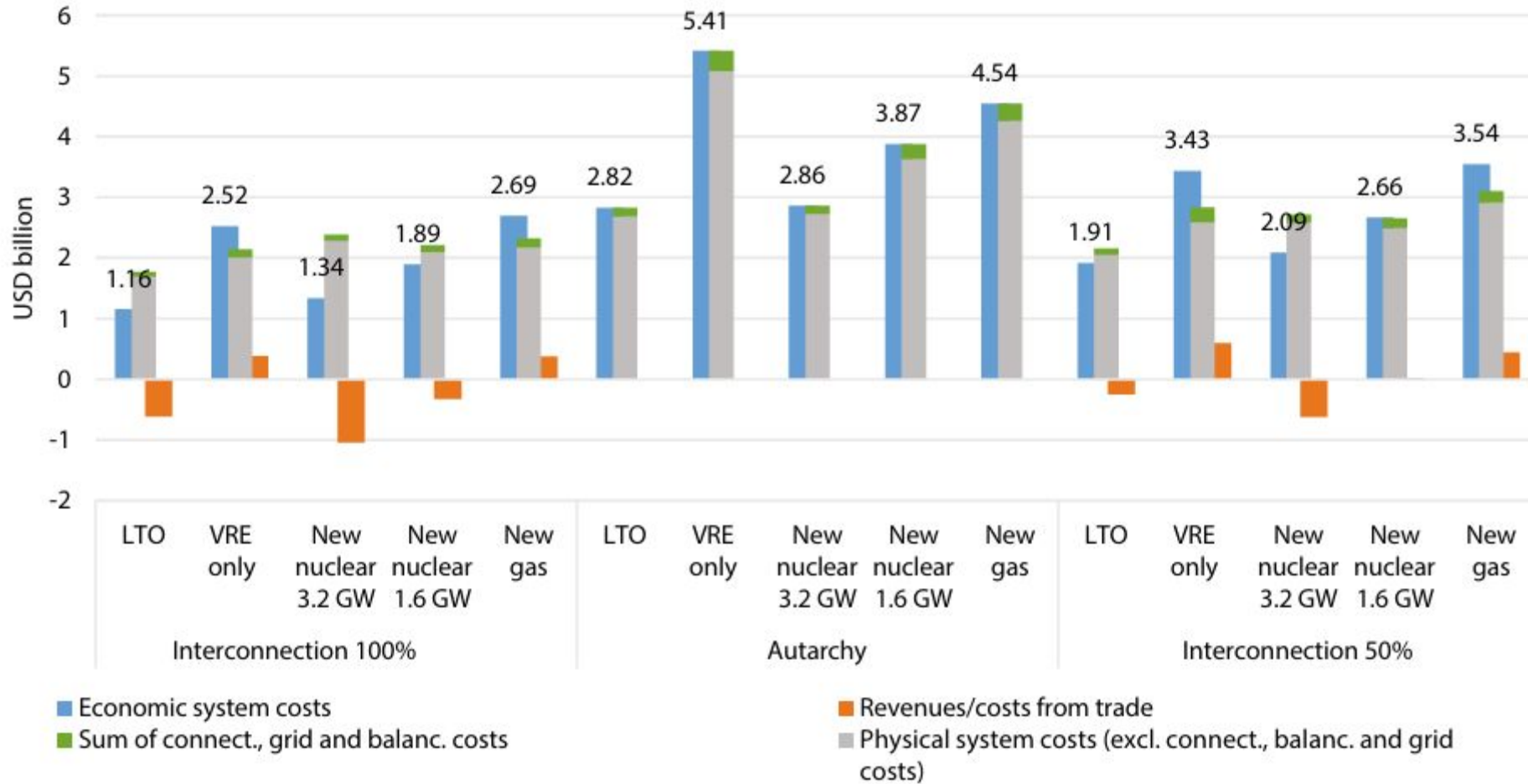
<https://energy.constellation.com/resources/choices/understanding-electric-cost-components>



LCOE vs SC - Why LCOE is Insufficient

(USD/MWh, identical demand and net zero carbon constraint for all scenarios)

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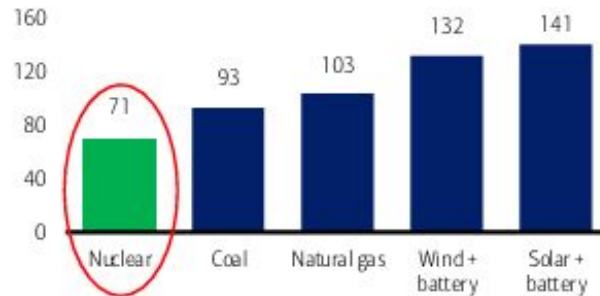


LCOE vs SC - Analysis Beyond LCOE

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)

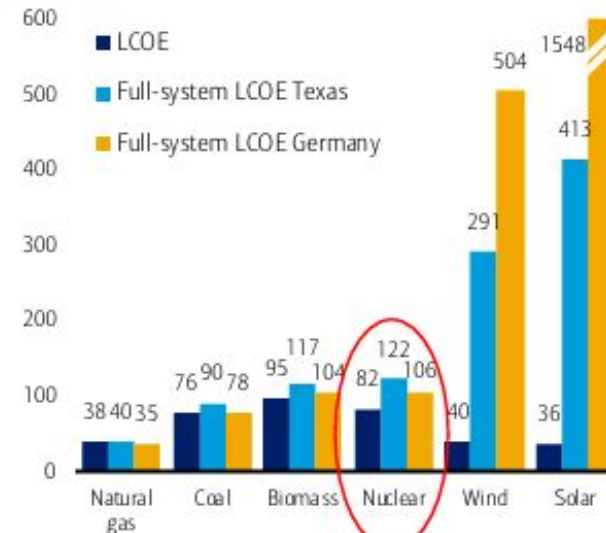


Source: BofA Research Investment Committee, Lazard, Entler, et al. (2018). Note: nuclear, coal, and natural gas price estimates from Entler, et al. Wind and solar cost estimates are from Lazard's 2023 Levelized Cost of Energy+ report. Wind + battery and solar + battery use estimates from California's 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 & LFSCOPE calculations by energy source

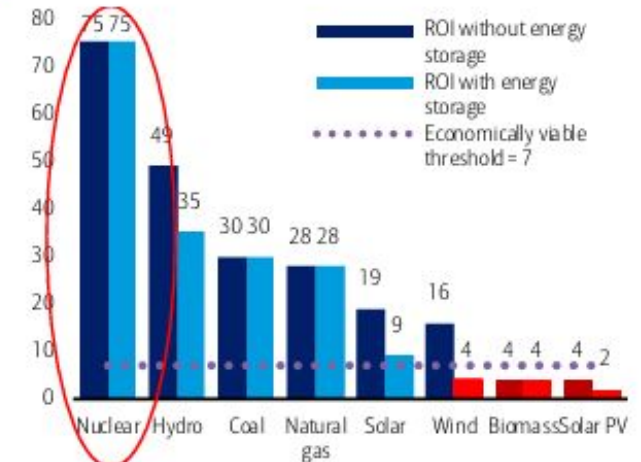


Source: BofA Research Investment Committee, Idel 2022

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

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Grid Value VRE

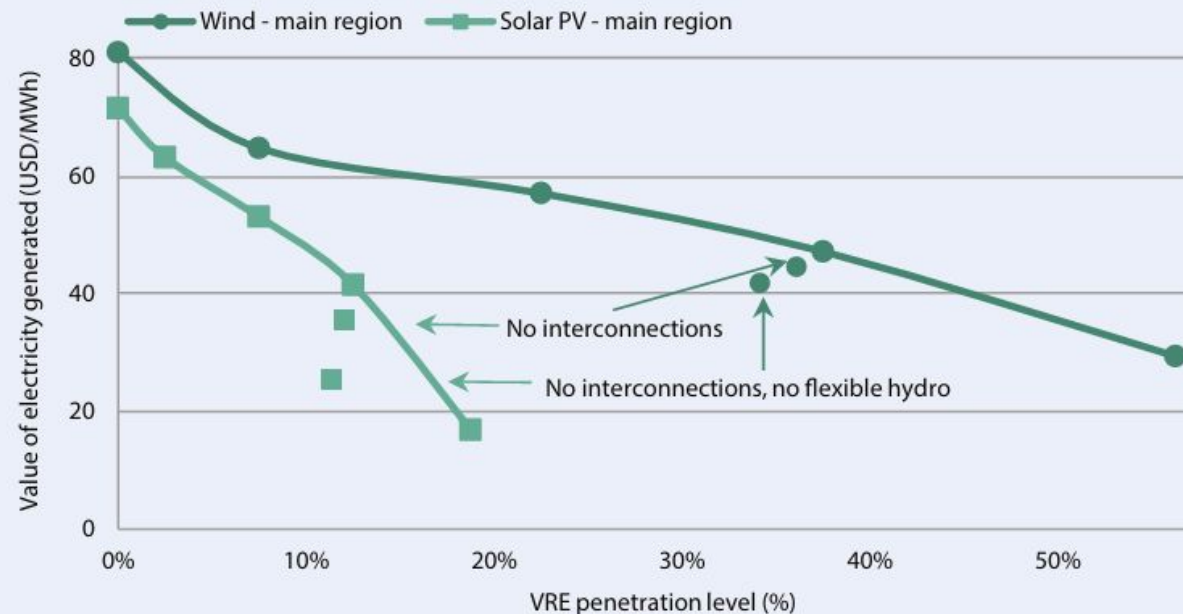


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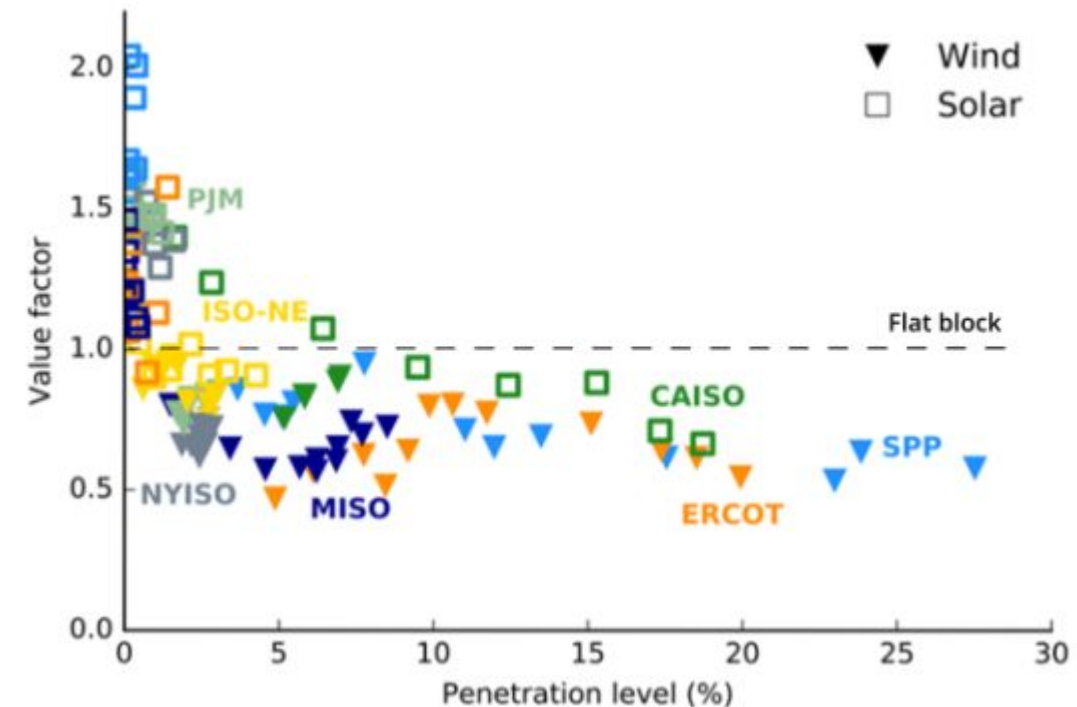
Grid Value VRE

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

Figure 5. The declining average market value of VRE as their share increases



Source: NEA (2019).



<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>



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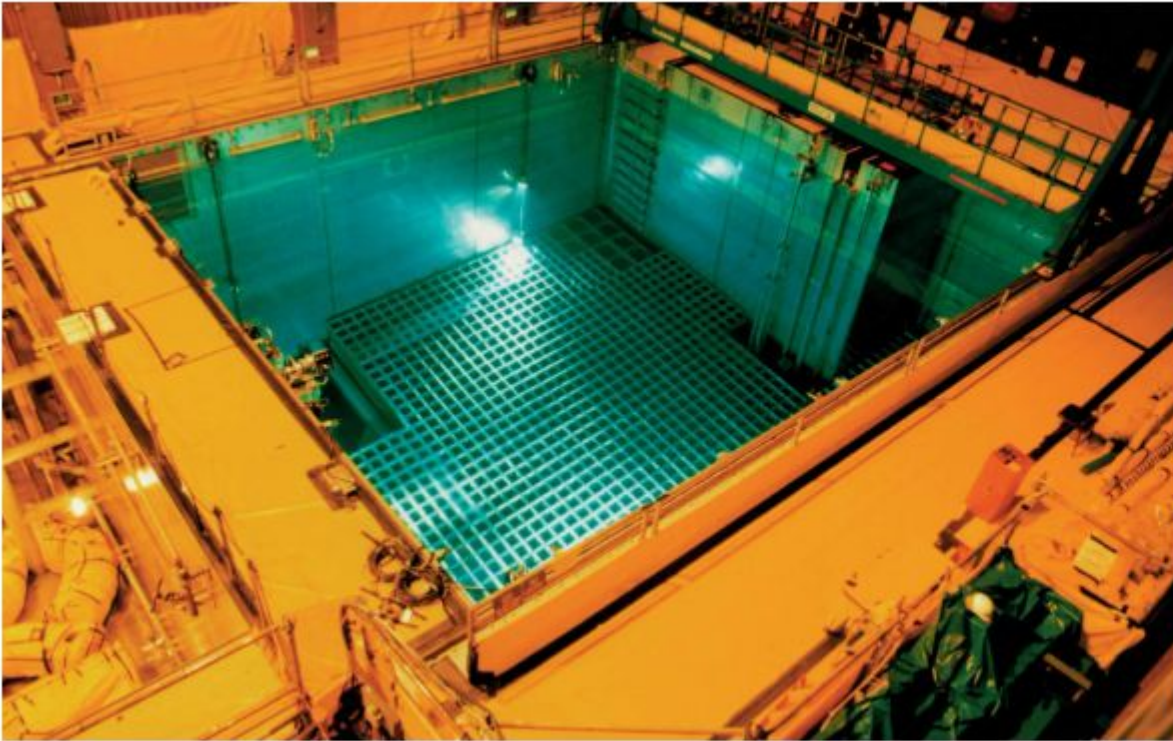
Waste Storage



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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/>

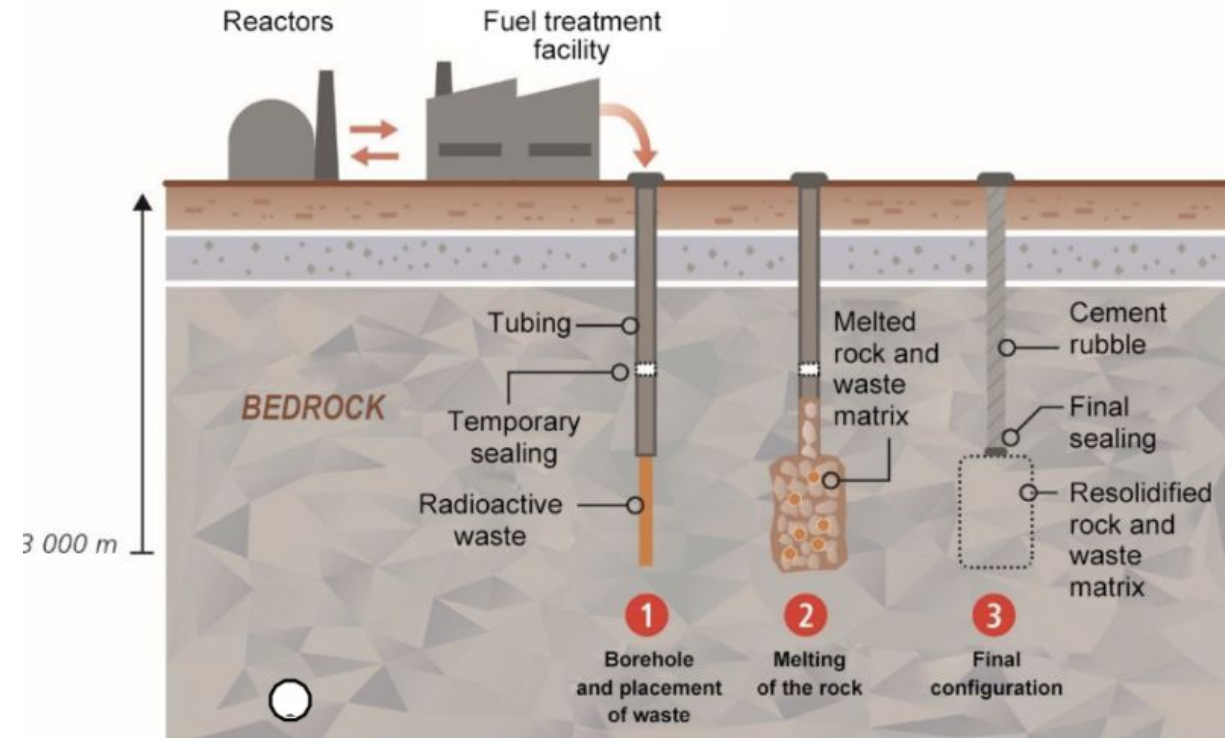
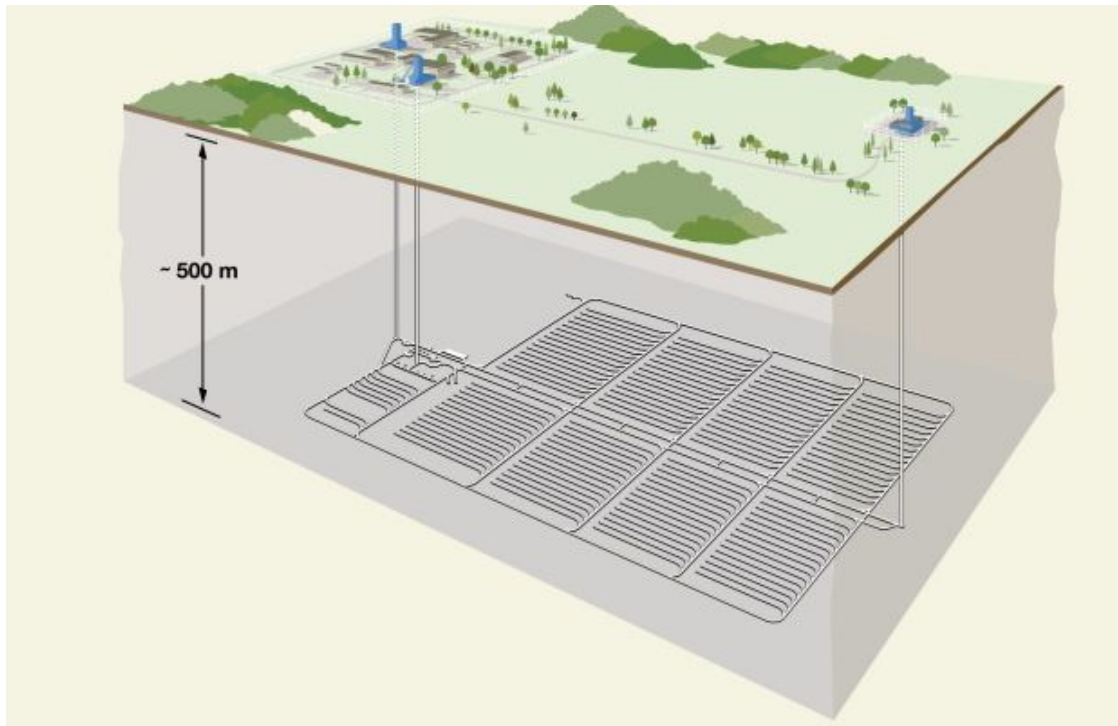


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Waste Storage

Final internment permanently buries waste



Radiation

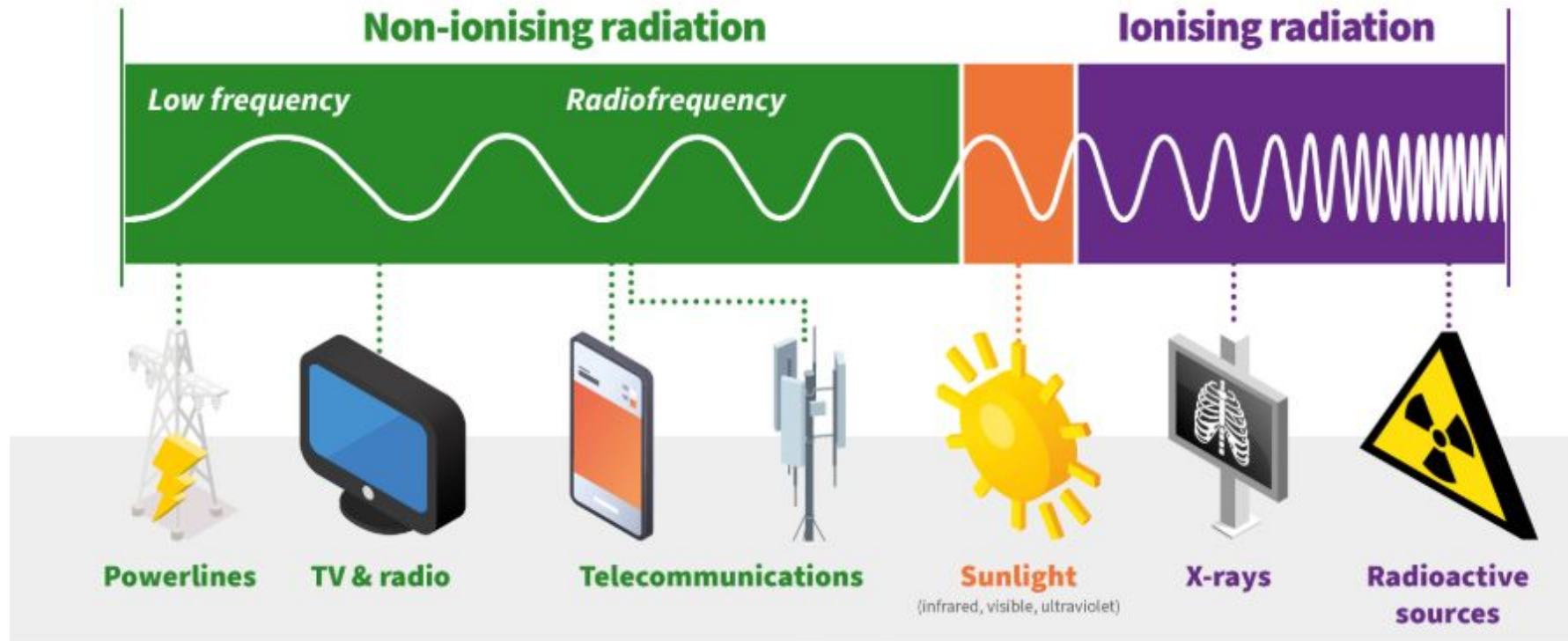


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Radiation - The Foundation of Life

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

The electromagnetic spectrum



<https://www.arpana.gov.au/understanding-radiation/what-is-radiation>



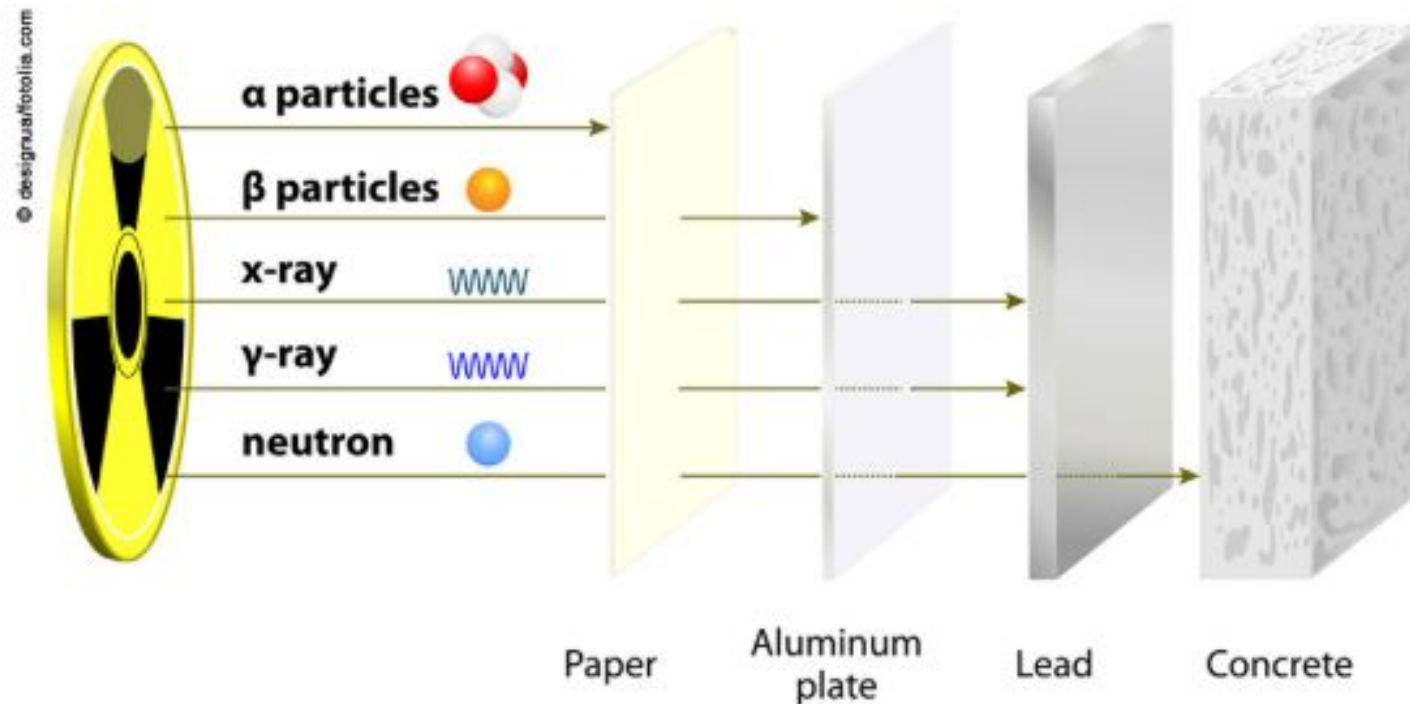
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Radiation - Ionizing Radiation

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

Types of ionising radiation



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



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Radiation - Banana Scale of Radiation

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

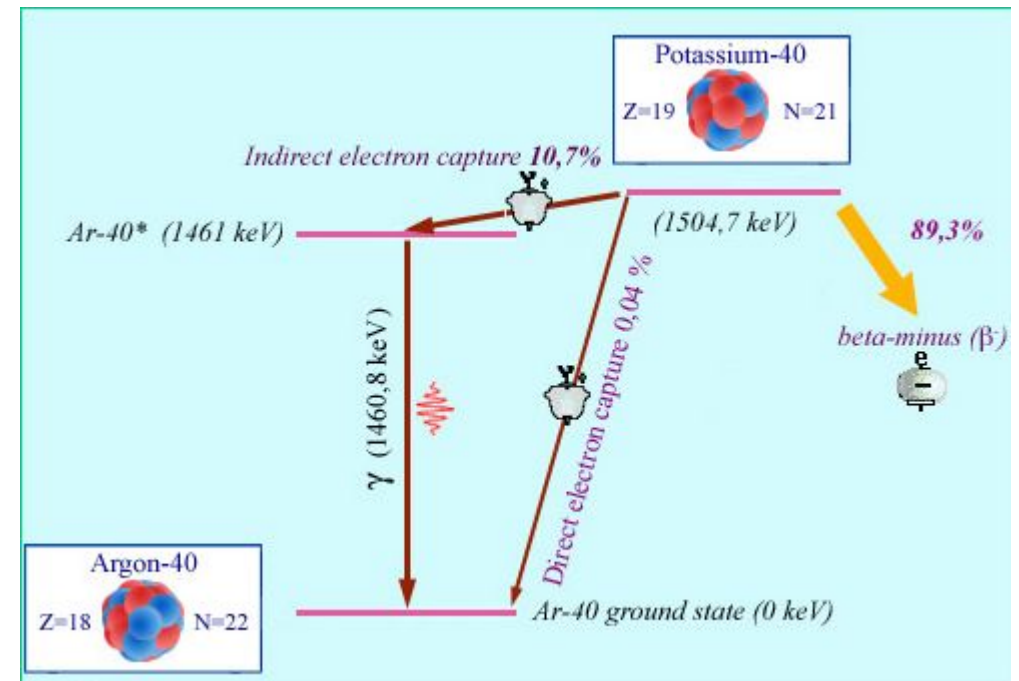
Banana's have a very slow beta decay, ~4000 decay/s in the human body

Living within 50 miles of a nuclear reactor is like eating



One Banana =
 $0.1\mu\text{sv}$

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

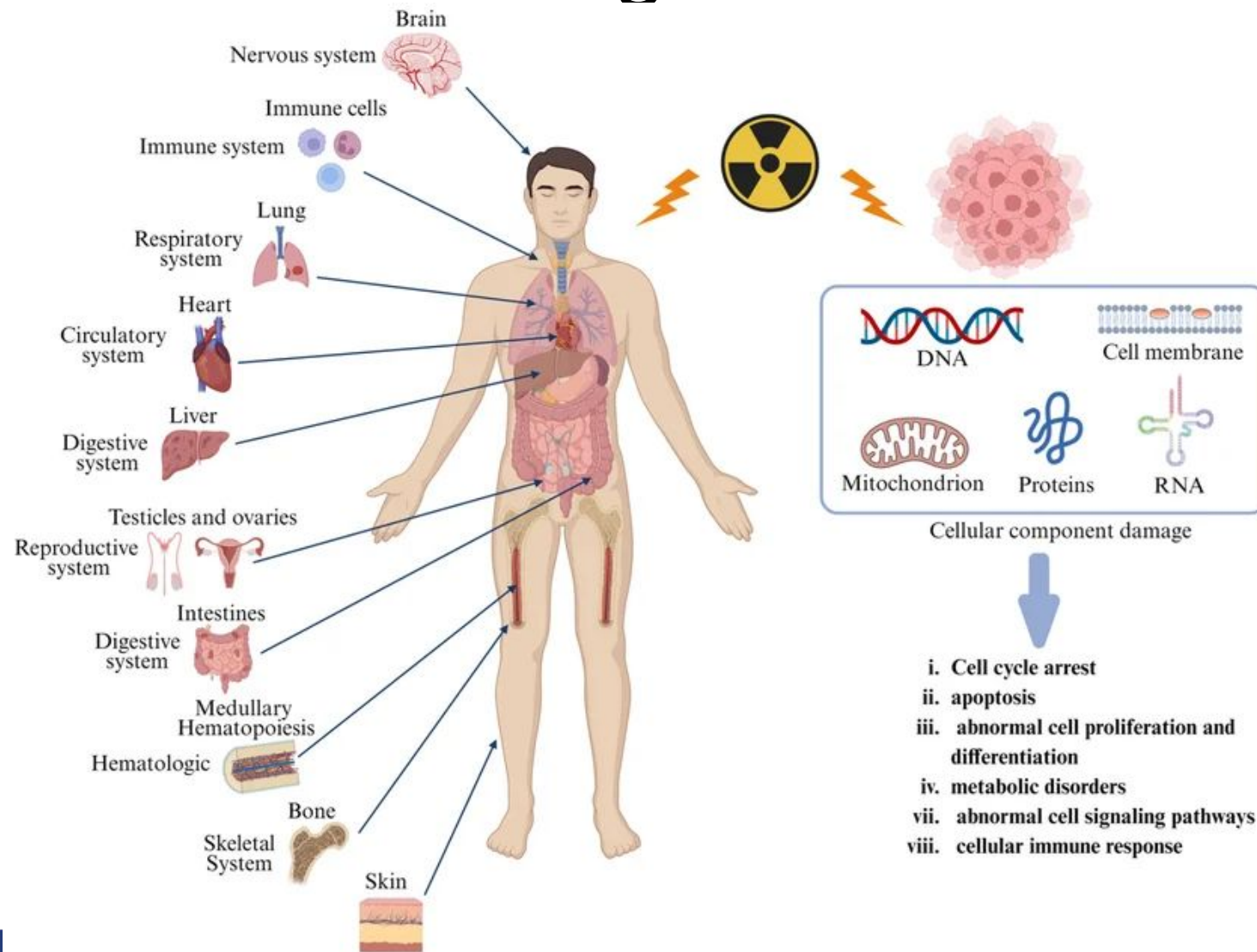
<https://www.admnucleartechnologies.com.au/blog/did-you-know-bananas-are-radioactive>



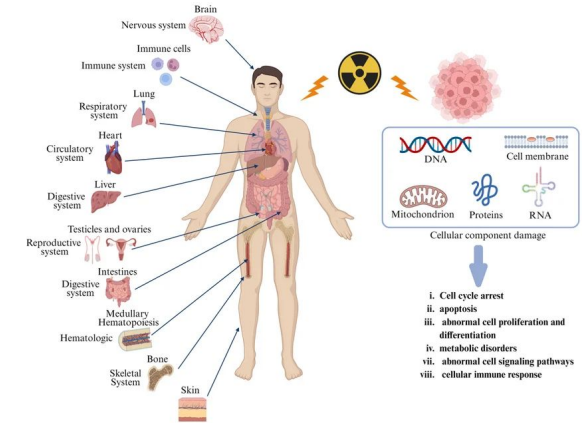
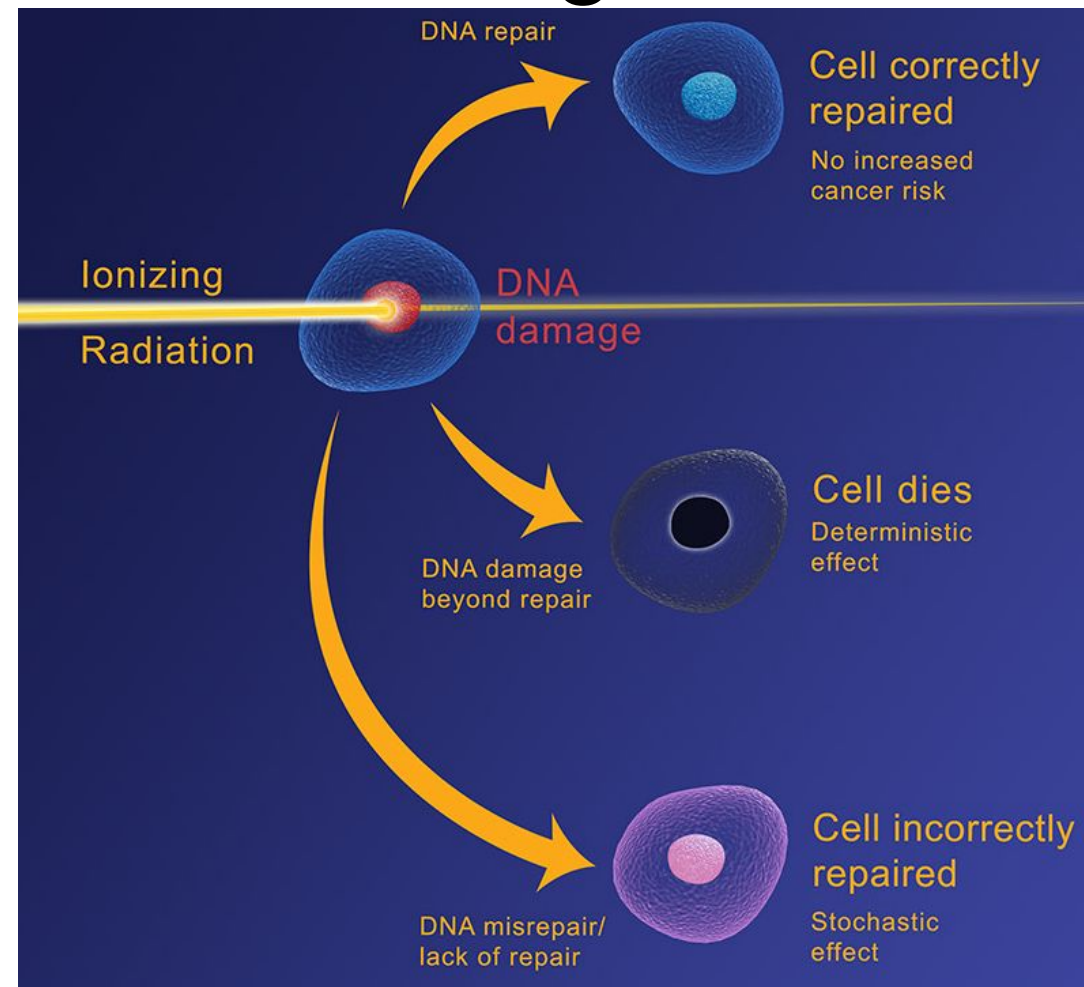
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Radiation - DNA Damage



Radiation - DNA Damage



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

<https://www.cnsccsn.gc.ca/eng/resources/radiation/radiation-health-effects/>

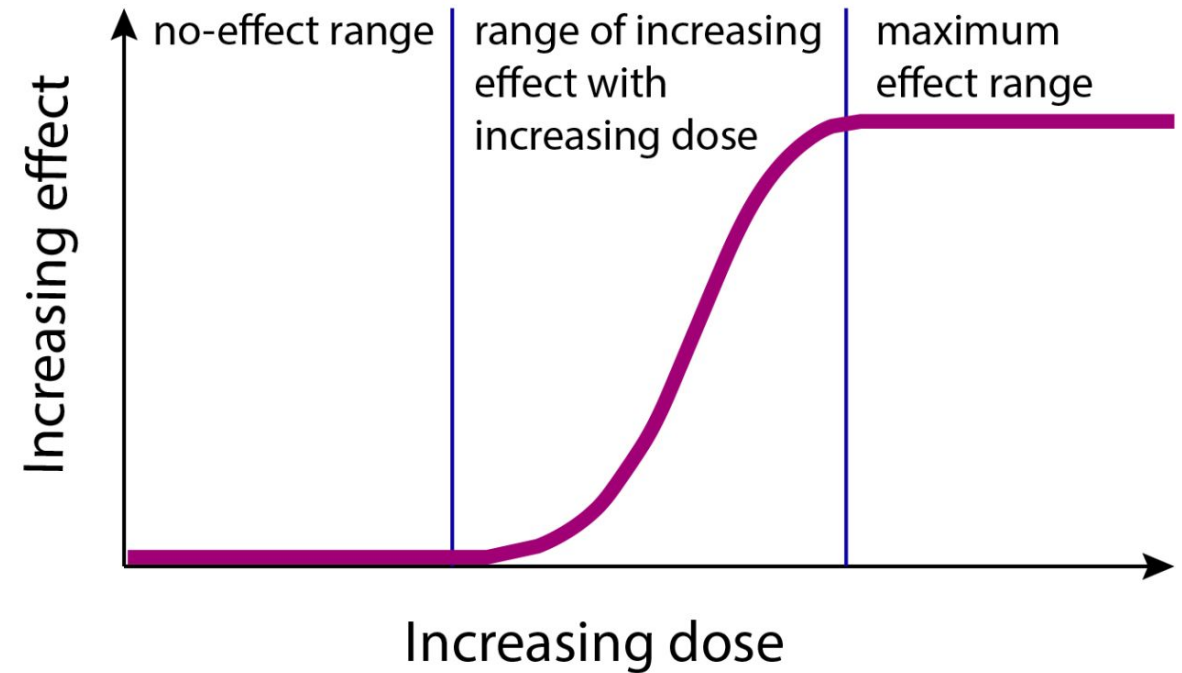
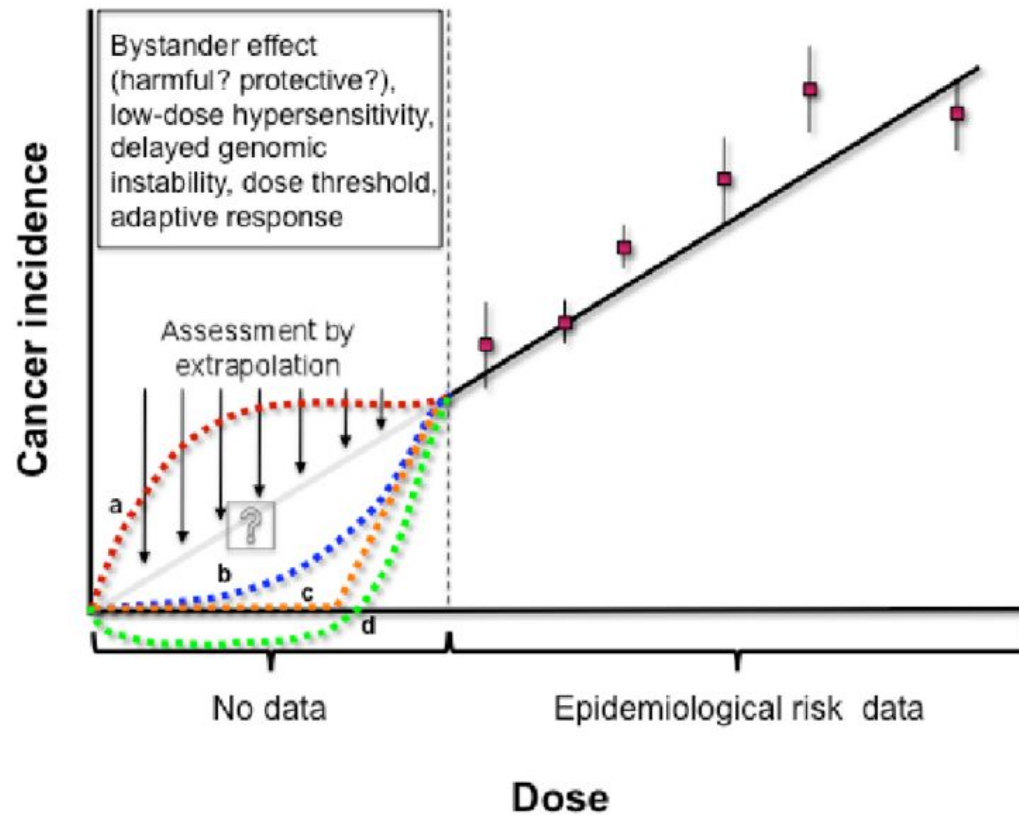


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Radiation - Regulation

Linear-Non-Threshold (LNT) model



The Office



**Energy
Development**

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



Utah Office of Energy Development



HIGH COST INFRASTRUCTURE TAX CREDIT



The High Cost Infrastructure Tax Credit (HCITC) supports significant infrastructure investments in the state; bolstering the cost-effective and sustainable delivery of Utah's commodities to domestic and global markets.

ELIGIBLE PROJECTS:



NUCLEAR



Nuclear power is the generation of electricity through nuclear reactions, primarily using uranium as a fuel source. In nuclear power plants, uranium-235 atoms undergo nuclear fission, where they are split apart, releasing enormous amounts of heat and energy.

DEFINING ENERGY

Uranium

(n) Uranium is a silvery-white radioactive metallic chemical element with atomic number 92, naturally occurring in low concentrations in rocks, soil, and water. Uranium is the heaviest naturally occurring element which can be found abundantly on earth.

Current theories suggest that earth's uranium was formed billions of years ago in various supernovas or from the collision of neutron stars.

U.S. nuclear power plants are

Currently **94** commercial nuclear reactors help to power homes and businesses in **28** states.

Nuclear power plants produce nearly **1/2** of the nation's emissions-free electricity, making it the largest source of carbon-neutral power in the United States.

While Utah does not currently have nuclear power in its energy mix, PacifiCorp has partnered with TerraPower to construct a nuclear power plant in Kemmerer, Wyoming. They have discussed replicating this power plant's design in Utah.

Radiation from nuclear fuel warrants attention, but is easily managed. All the nuclear waste currently in the United States can fit into a single football field.



were employed "Uranium Capital of the World."



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