Cover image taken from YouTube channel of Dnews

Nuclear Energy
What, Why and How?

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thebetterenergy.net

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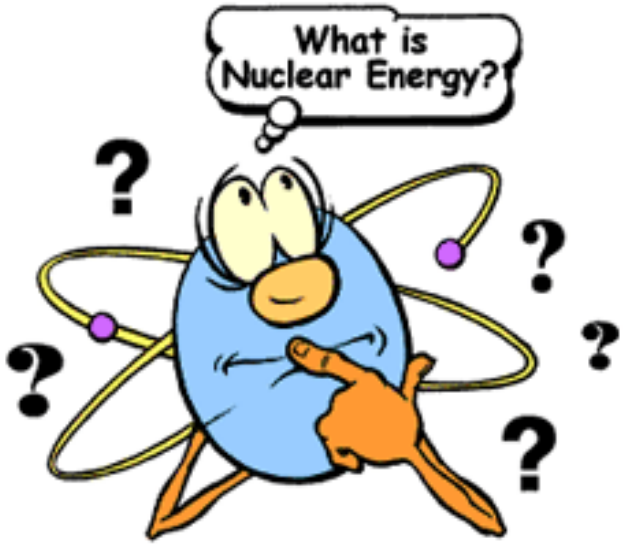
Nuclear Energy
What, Why and How?

Nuclear Power is one hell of a way to boil water!

- Albert Einstein



It is the energy generated during a nuclear reaction. The source of nuclear energy is the mass of the nucleus which is converted into energy by:

$$E = mc^2$$

For electricity generation purposes, nuclear energy usually generated by the splitting of a heavy nuclei (eg. Uranium) in a process called **Fission**.

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$$^{1}n_{0} + {}^{235}U_{92} \rightarrow {}^{142}Ba_{56} + {}^{92}Kr_{36} + 2\,{}^{1}n_{o} + E$$

Energy Released ~ 200 MeV

One fission reaction not enough for electricity generation. Need a chain of reactions that is self sustaining

Courtesy: http://www.newcastle-schools.org.uk/nsn/chemistry/Radioactivity/fissionanim.gif

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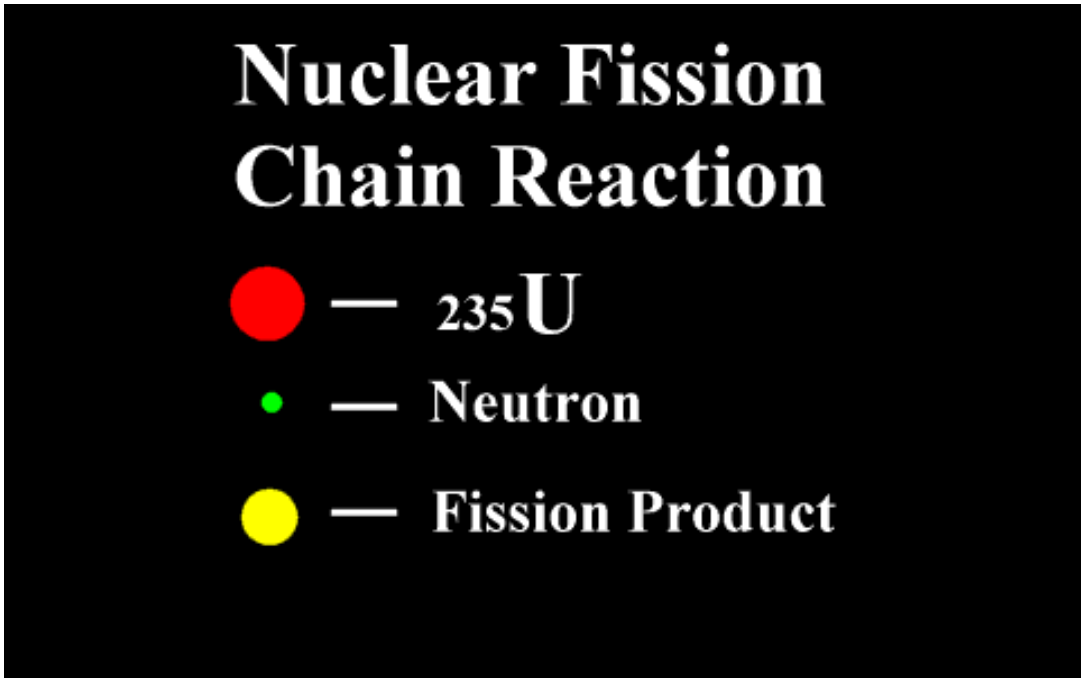


The energy generated from the chain of fission reactions can then be used by Nuclear power plants to generate electricity

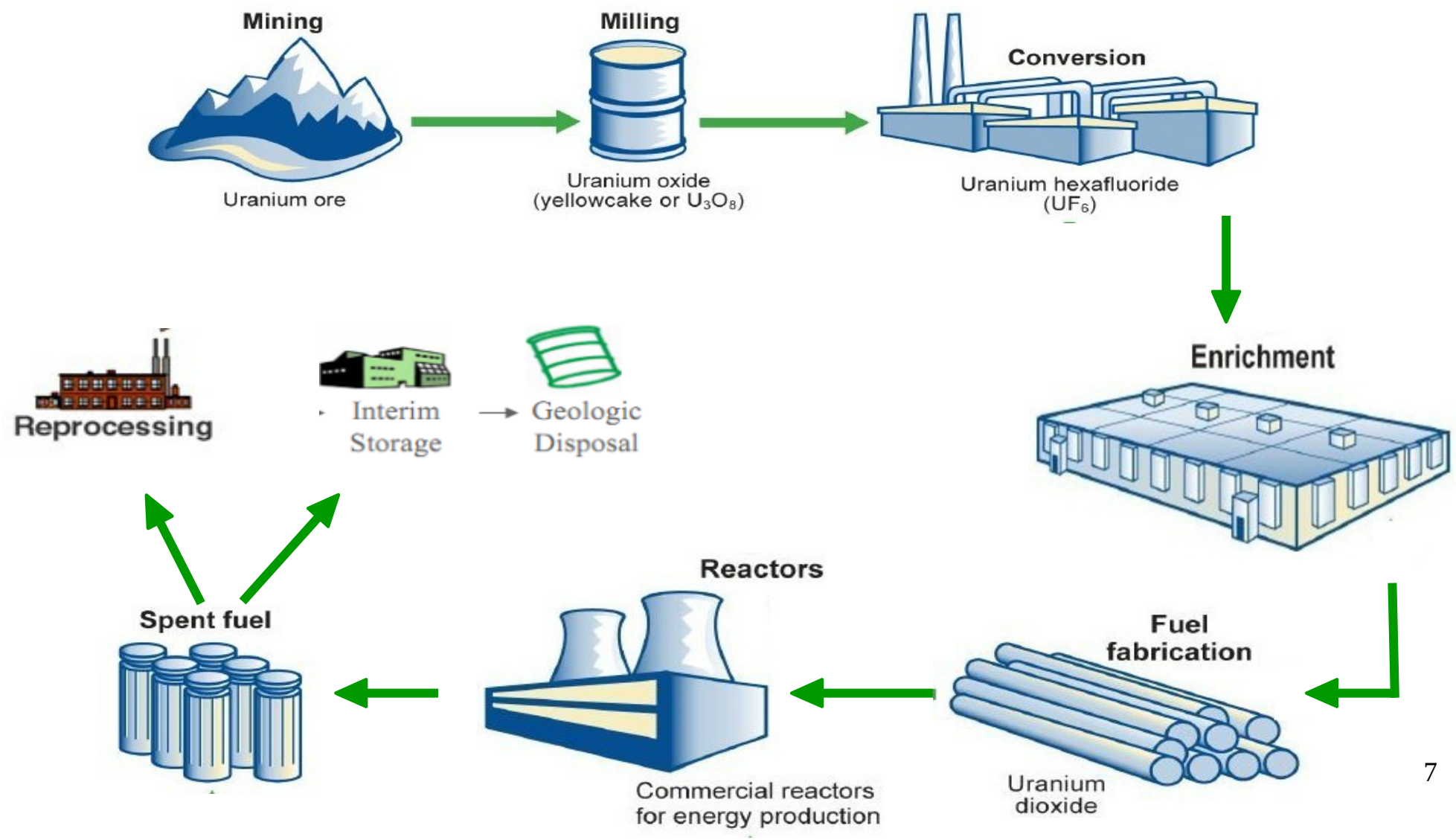
https://mthsenviroscapes.wikispaces.com/Nuclear+Fission

Nuclear Energy
What, Why and How?

If all of your electricity in your lifetime came from nuclear [energy], the waste from that lifetime of electricity would go in a Coke can!

- Stewart Brand

Nuclear Fuel Cycle



Nuclear Fuel Cycle

1. Mining, Milling and Refining

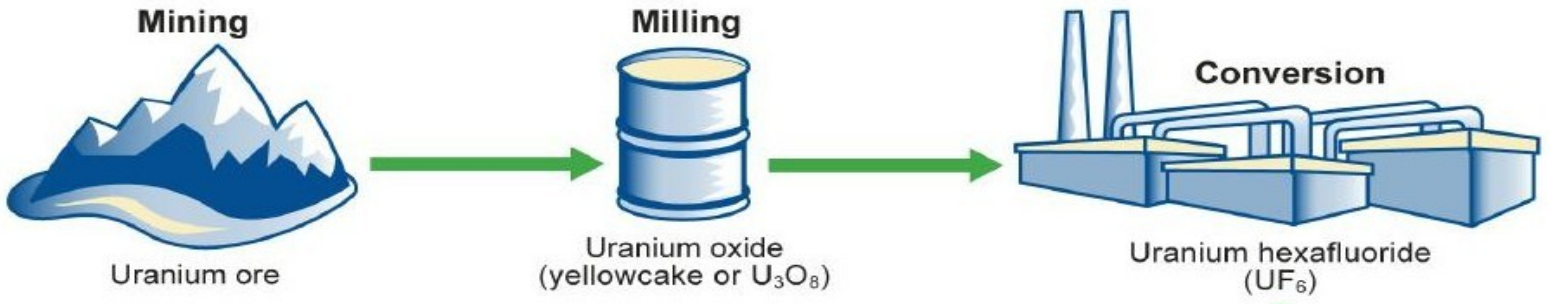
Extraction of Uranium ore from mines

Ore is crushed in mill and ground to fine slurry

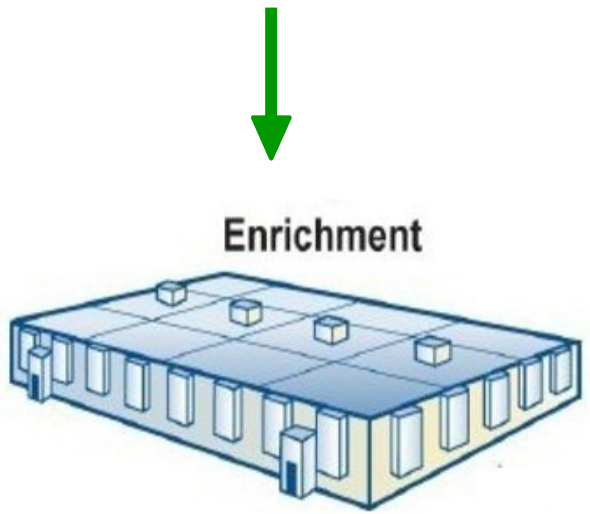
Yellowcake produced → Refining → High purity UO_3 produced → UF_6 produced for enrichment → Sent to enrichment facility

Nuclear Fuel Cycle

2. Enrichment

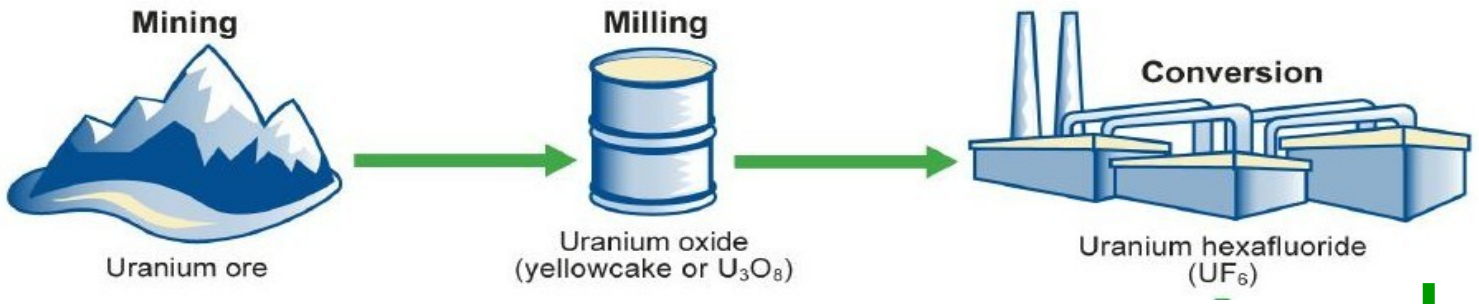


- Need Uranium-235 for fission.
- Natural Uranium (obtained after mining) only has 0.7% of U^{235}.
- **Enrichment processes increase the concentration of U^{235} to about 2% – 4%.**
- Fuel quality ready to be used in reactors.

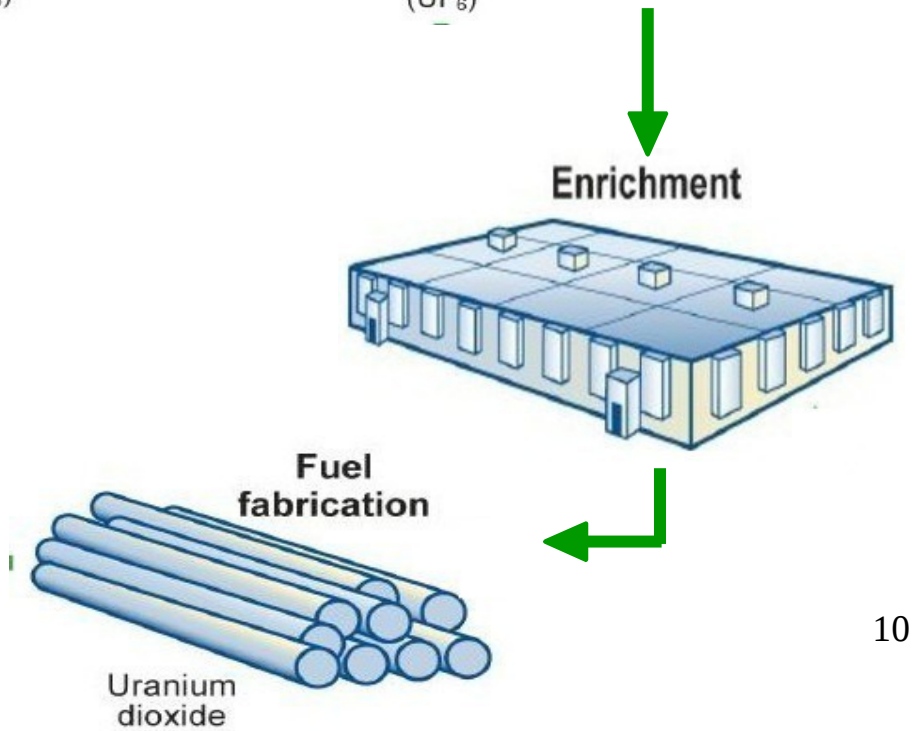


Nuclear Fuel Cycle

3. Fuel Fabrication



- Enriched Uranium powder pressed into cylindrical pellets.
- Fuel pellets put in high temperature
- Finished to precise dimensions to make fuel assemblies.



Nuclear Fuel Cycle

4. Electricity Generation

Mining

Uranium ore

Milling

Uranium oxide
(yellowcake or U_3O_8)

Conversion

Uranium hexafluoride
(UF_6)

Enrichment

Fuel fabrication

Uranium dioxide

Reactors

Commercial reactors for energy production

ELECTRICITY!!

Electricity Generation in Nuclear Reactors – How?

Basic Reactor Components

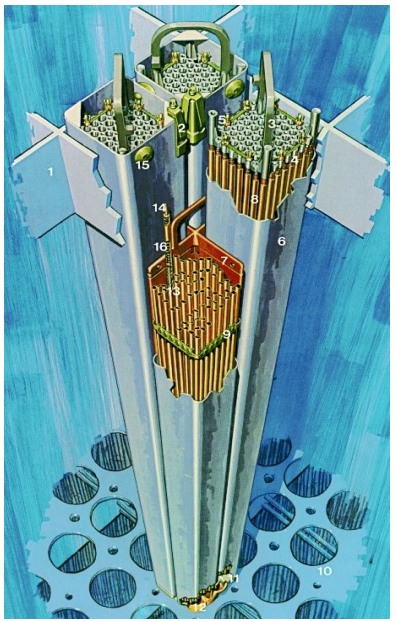
- Fuel Assemblies

  Fuel material

  UO_2

  with 2-4%

  enrichment



- Coolant

  Heat transfer from fuel rods for generation of steam

  Boiling water, Pressurized water, Heavy water, Metallic coolants

- Control Rods

  To control neutron flux for controlled reactor operation

  Boron, Cadmium

- Moderator

  To slow down fast neutrons

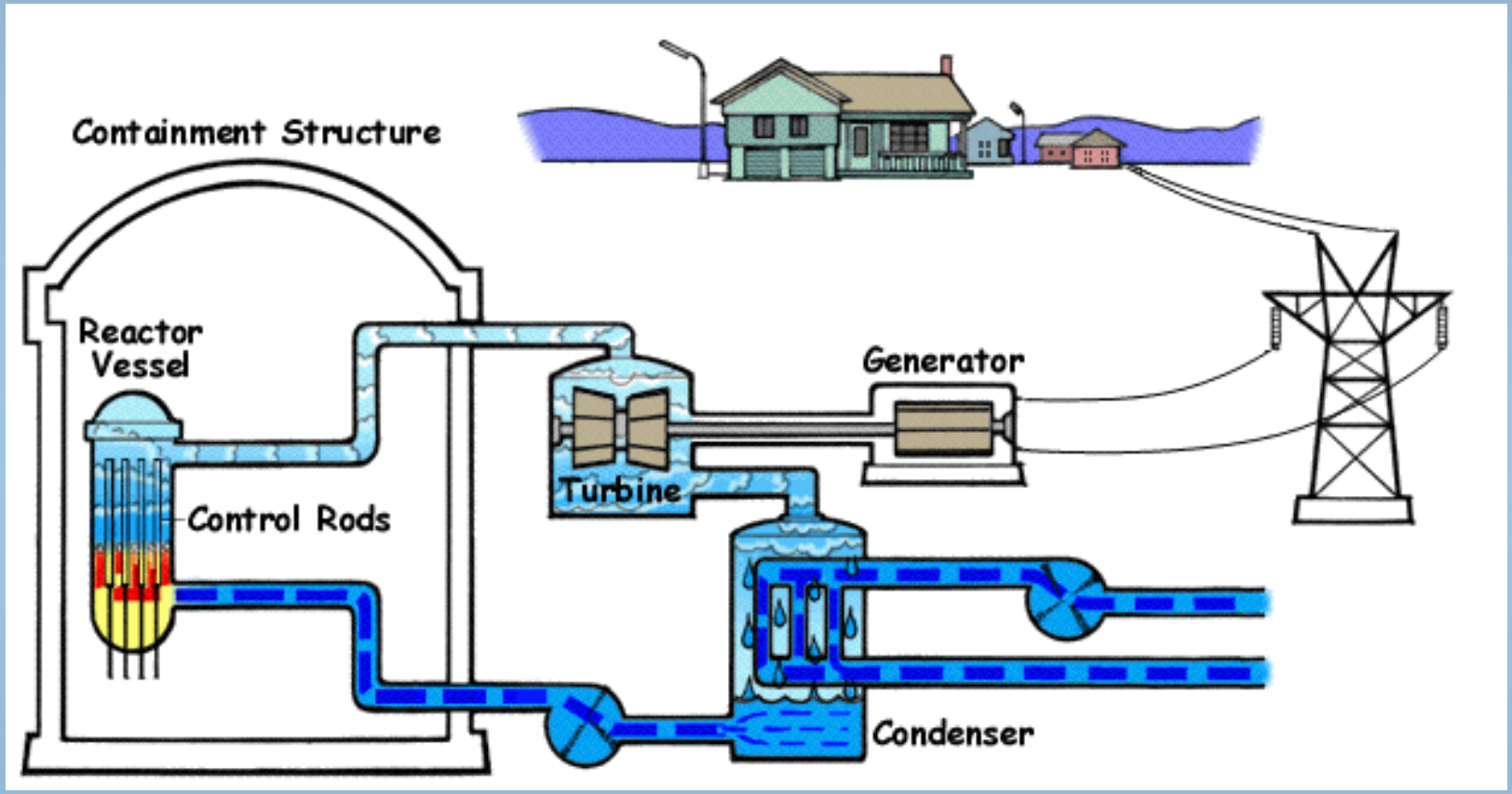
  Boiling water, Pressurized water, Heavy water

- Reactor Containment

  Structure housing the reactor where all the nuclear reactions take place.

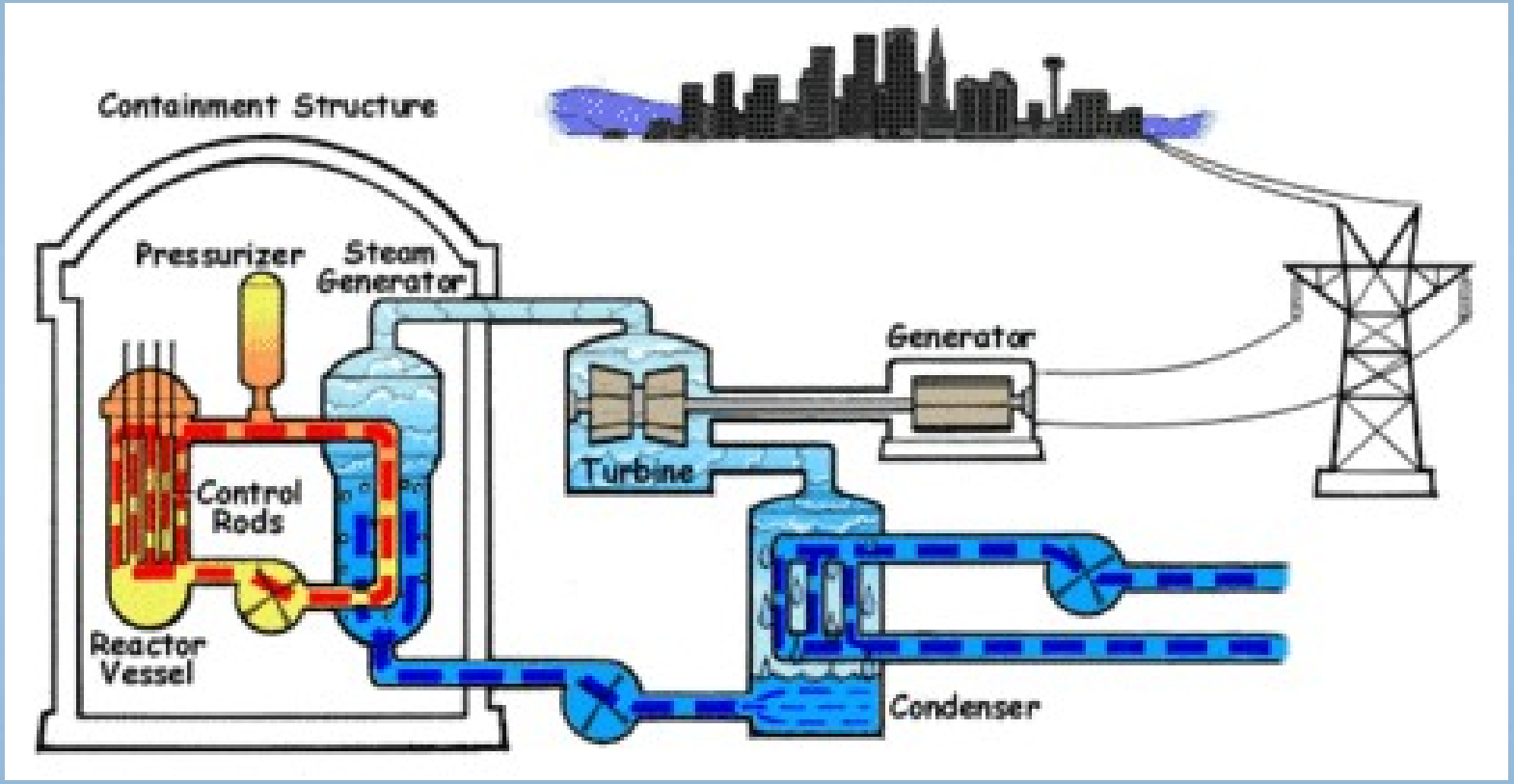
  Lead and concrete structure

Boiling Water Reactors



United States has about 34 operating BWR plants
[Adapted from the NRC website]

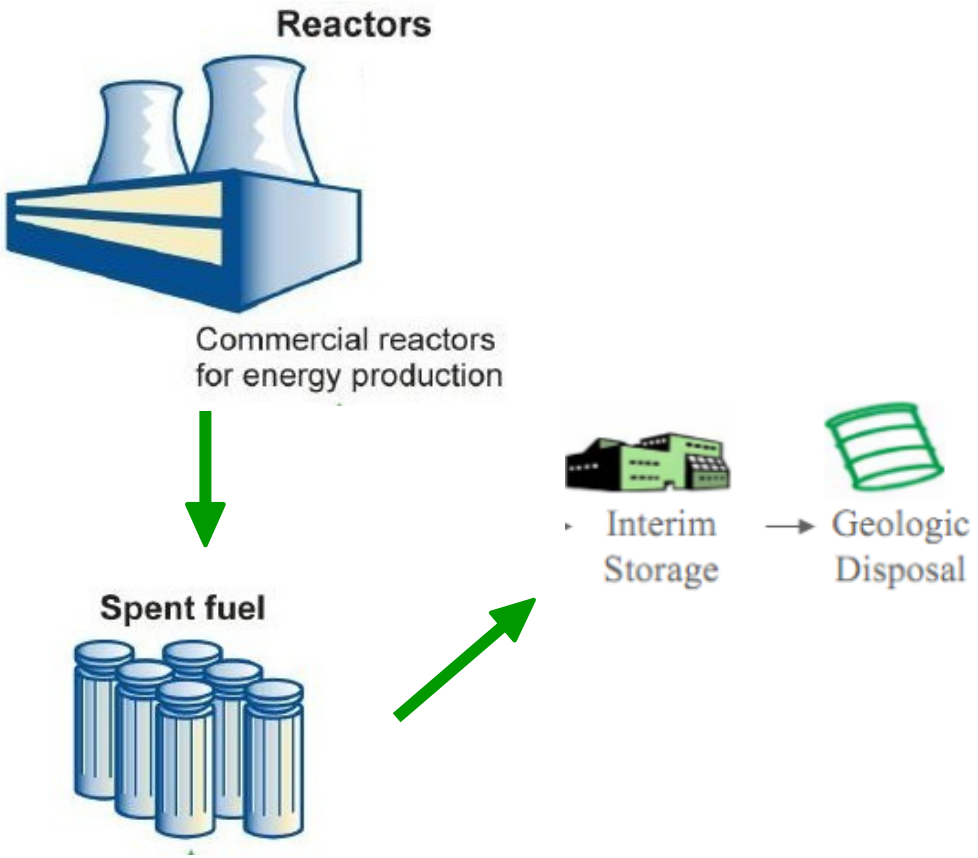
Pressurized Water Reactors



United States has about 65 operating PWR plants
[Adapted from the NRC website]

Nuclear Fuel Cycle

5. Storage and Disposal



Consumed fuel removed from reactor

Temporary storage in cooling pools

After radioactivity and heat subsides

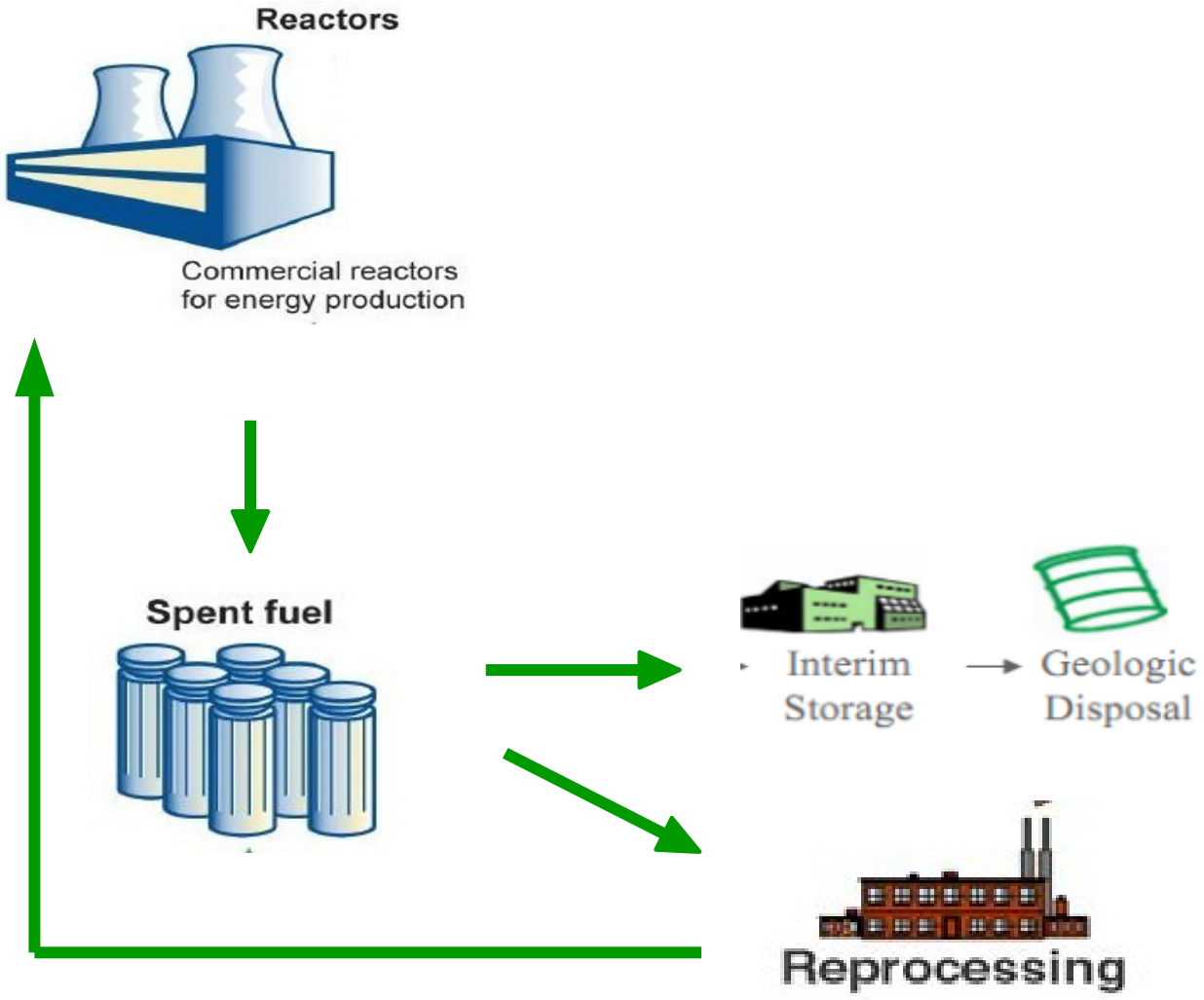
Placed in concrete and steel containers

Stored on-site for a couple years

Disposed in Permanent deep underground storage

Nuclear Fuel Cycle

5. Storage and Disposal or Reprocessing



Chemical Reprocessing

After a period of storage

Residual U/Pu (still useful sources of energy) recovered from spent fuel elements

After Reprocessing

Reused in Reactors

Nuclear Energy
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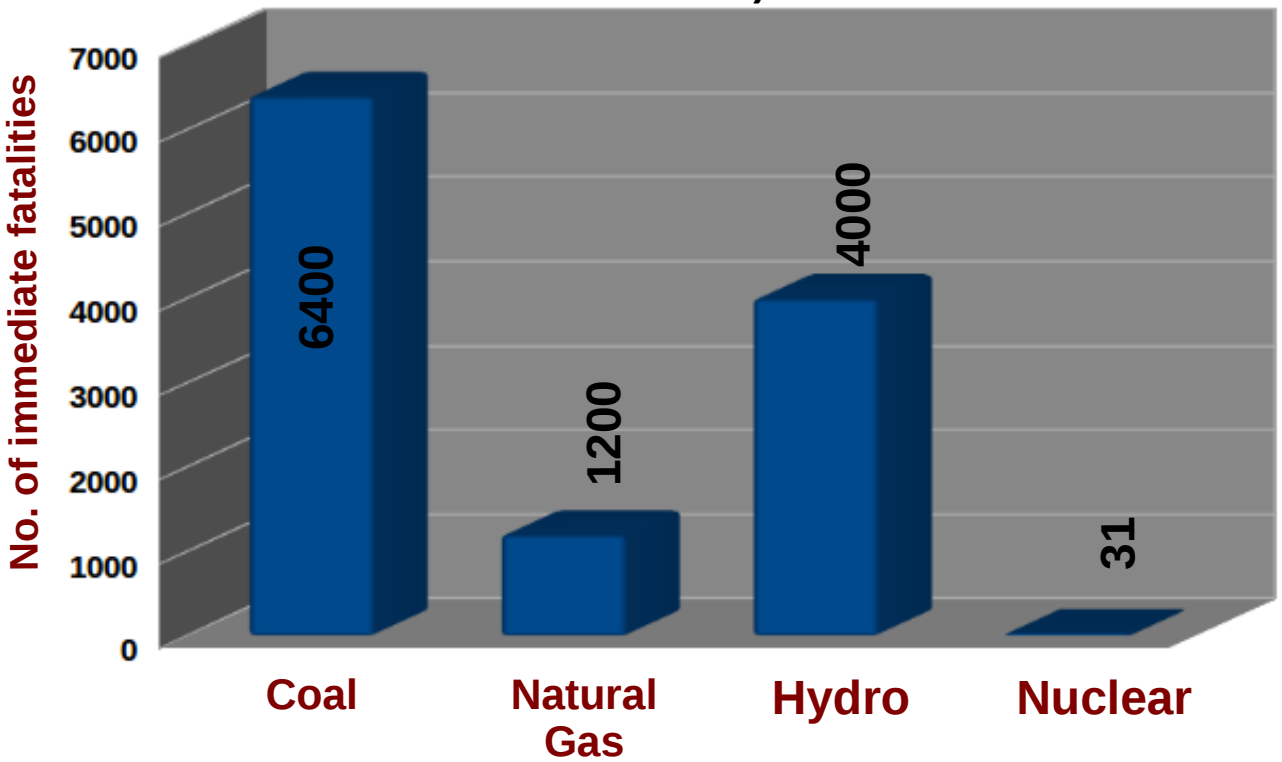
A nuclear-power plant is infinitely safer than eating, because 300 people choke to death on food every year.

- Dixie Lee Ray

Why Nuclear Energy?

Accident Statistics

Accident statistics in the Energy industry (1970-92) Published by IAEA 1999



Affected People	Workers	Workers and Public	Public	Fire fighting workers

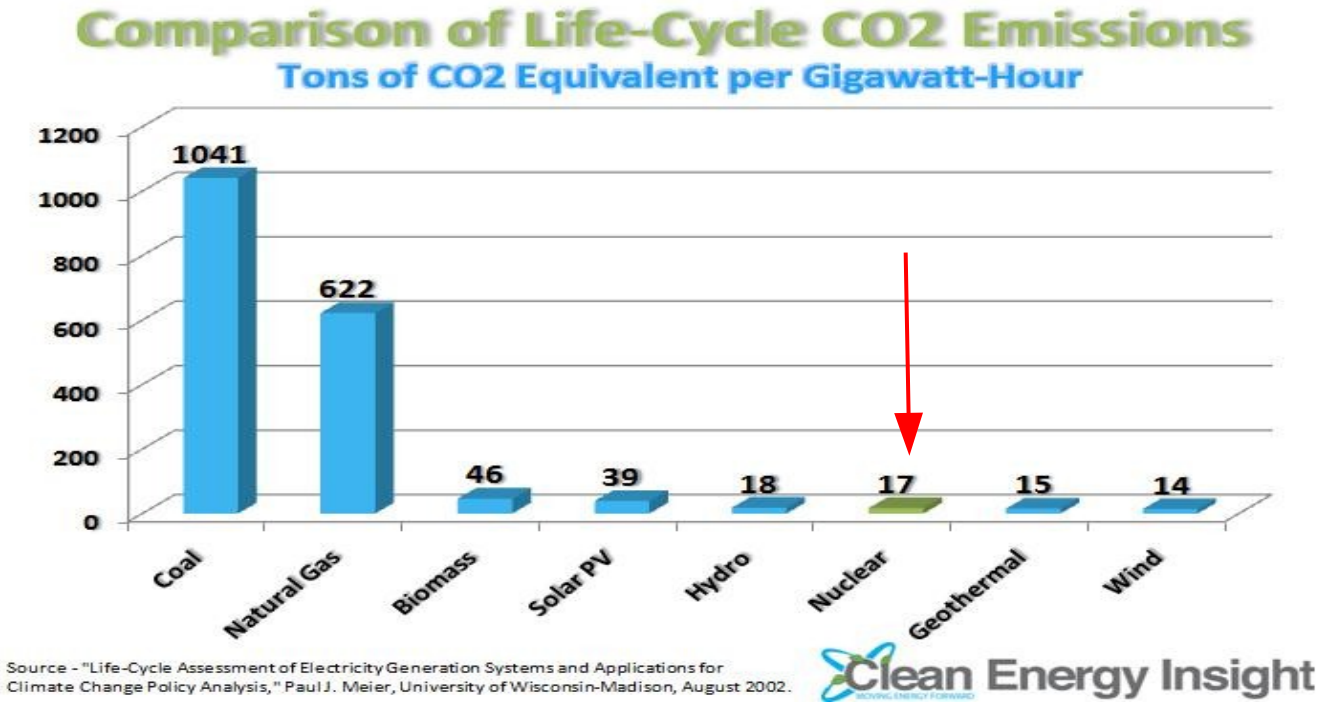
Why Nuclear Energy?

Pollution??

Carbon atoms of coal or any other fossil fuel burns and combines with oxygen to give energy.

$$C + O_2 \rightarrow CO_2 + \text{Energy}$$

The only CO_2 that Uranium burning releases is during the uranium mining phase!



Why Nuclear Energy?

Availability of fuel

To generate ~ 950 MW of power per day:

Amount of coal needed = 2,750 tons
Amount of Uranium needed = 1 kg

US uranium reserves ~ 1,227 million pounds (as in 2008)
enough to last for over ***500 years***

If Reprocessed and Reused in Reactors, Uranium reserves can last for thousands of years

(All figures based on the US Energy Information Administration (EIA) data)

For more information – thebetterenergy.net – Read article 'Nuclear vs. Everything else'

Why Nuclear Energy?

Nuclear Waste

- Usually by-products of Nuclear Power Generation

- Long-lived isotopes (eg. ^{239}Pu has a half-life of 24,000 years) – requires shielding for a very long period.

How much?

- A 1OOO-MWe coal plant burns ~ 11000 tons of coal every 24 h,
  Discharges ~ 3oo tons of SO_2 and ~ 5 tons of fly ash containing elements such as *chlorine*, *cadmium*, *arsenic*, *mercury*, *lead*, and many *radioactive elements*.

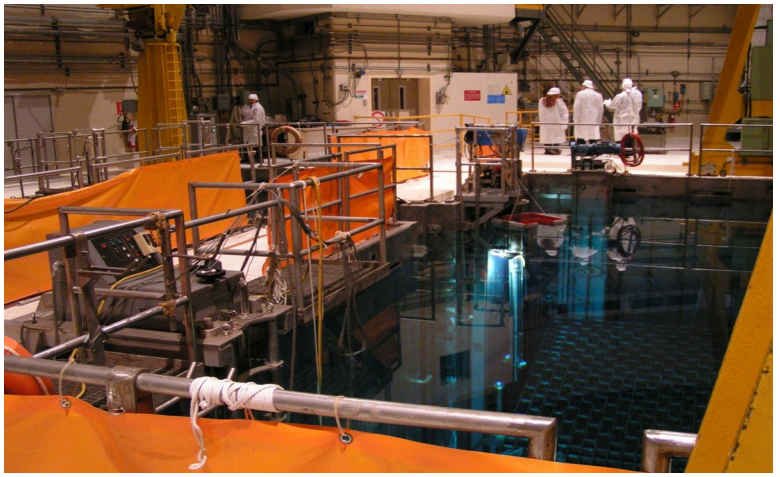
whereas,

- A typical 1000 MWe light water reactor discharges ~ 3.2 m^3 of solid waste.

If made into cylinders of 0.3 m diameter and 3 m length, only 15 such containers will be filled –- can be easily transported and stored with shielding.

Why Nuclear Energy?

Nuclear Waste and what to do with it?



Spent Fuel Pools

Dry Cask Storage

Coal ash released from a power plant delivers more radiation than nuclear waste shielded via water or dry cask storage!!

More information about Nuclear Waste – thebetterenergy.net – Read article 'Nuclear Waste and what to do with it?'

Cover image taken from YouTube channel of Dnews

Recommended Reading:

Power To Save The World by *Gwyneth Cravens*
Alfred A. Knopf, New York 2007

Other Resources:

Nuclear Regulatory commission (US NRC) website: www.nrc.gov

My website: thebetterenergy.net

CONTACT

GET IN TOUCH WITH ME!

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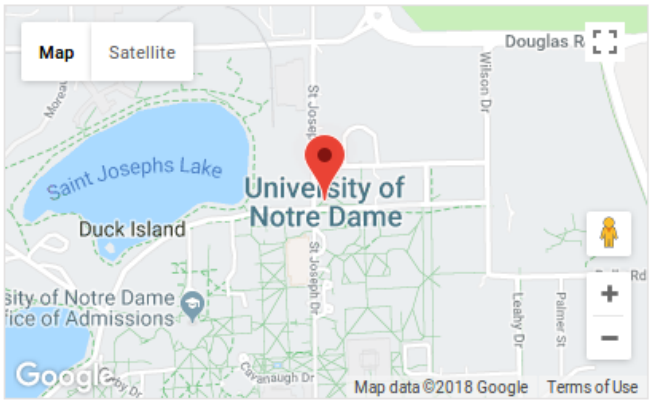

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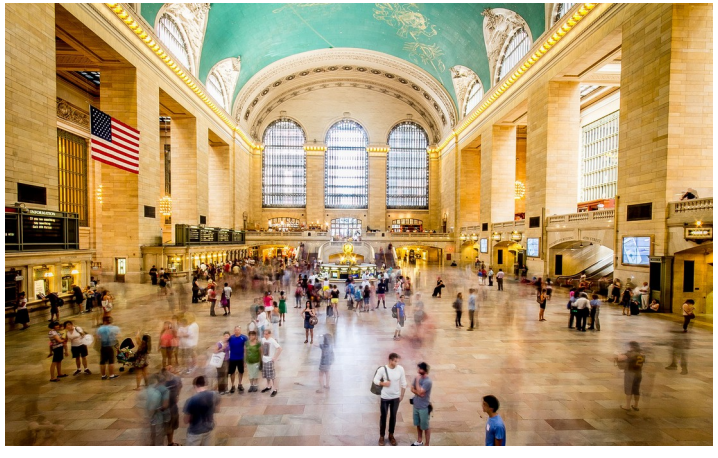
Which do you think leads to a greater average annual radiation dose?

Living within 50 miles of a Nuclear Power Plant

Living within 50 miles of a Coal Power Plant



Regular employee at the Grand Central Station, NYC

Which do you think leads to a greater average annual radiation dose?

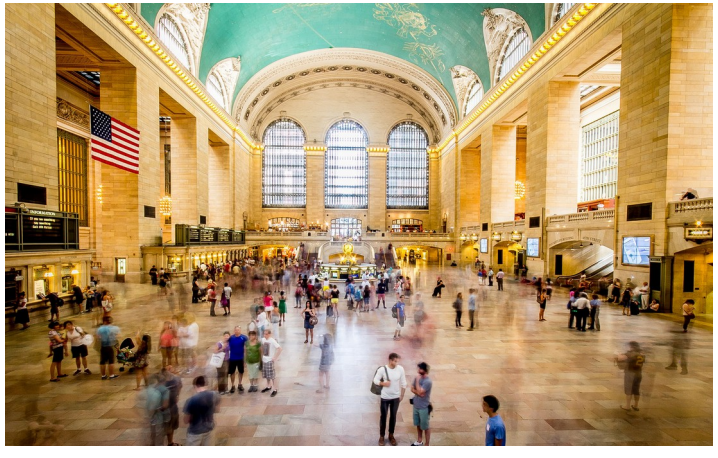
0.009 mrem

Living within 50 miles of a Nuclear Power Plant

Living within 50 miles of a Coal Power Plant

0.03 mrem

120 mrem



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