



Nuclear Energy for a
Peaceful and
Sustainable Future



pollev.com/samueldotson352

In a couple of words, describe your ideal energy source.



Outline

1. The role of nuclear energy in a sustainable grid
 - a. Every place that has shut down their nuclear plants saw increased emissions (or very slow improvement)*. (*Unless that place has a significant amount of hydro power.)
 - b. Every place that has appreciably decarbonized has a large fraction of nuclear energy.
 - c. Good news! Poland has announced a plan to build 6 reactors by 2040.
2. Nuclear energy in Illinois
 - a. Over half of the electricity produced in Illinois is from nuclear power.
 - b. Less than 1% of the electricity produced in Illinois is from solar power.
3. The future of nuclear energy in Illinois
 - a. One of the appeals of solar panels is the idea that communities could set up their own electricity sources. Could that be done with nuclear energy?
 - b. What if Highland Park had its own nuclear reactor?
 - i. would that make sense? → yes, HP has its own water utility.
 - ii. how much would we need?
 - c. UIUC is pioneering advanced nuclear technology!
4. Political obstacles

The State of Nuclear Power

Reactors in the United States

- Fuel: Uranium-235
- Fuel Enrichment: 3-4%
- Coolant: Water
- Power: 1000 MW (electric)
(=1GW)

There are 99 operating reactors in the United States.

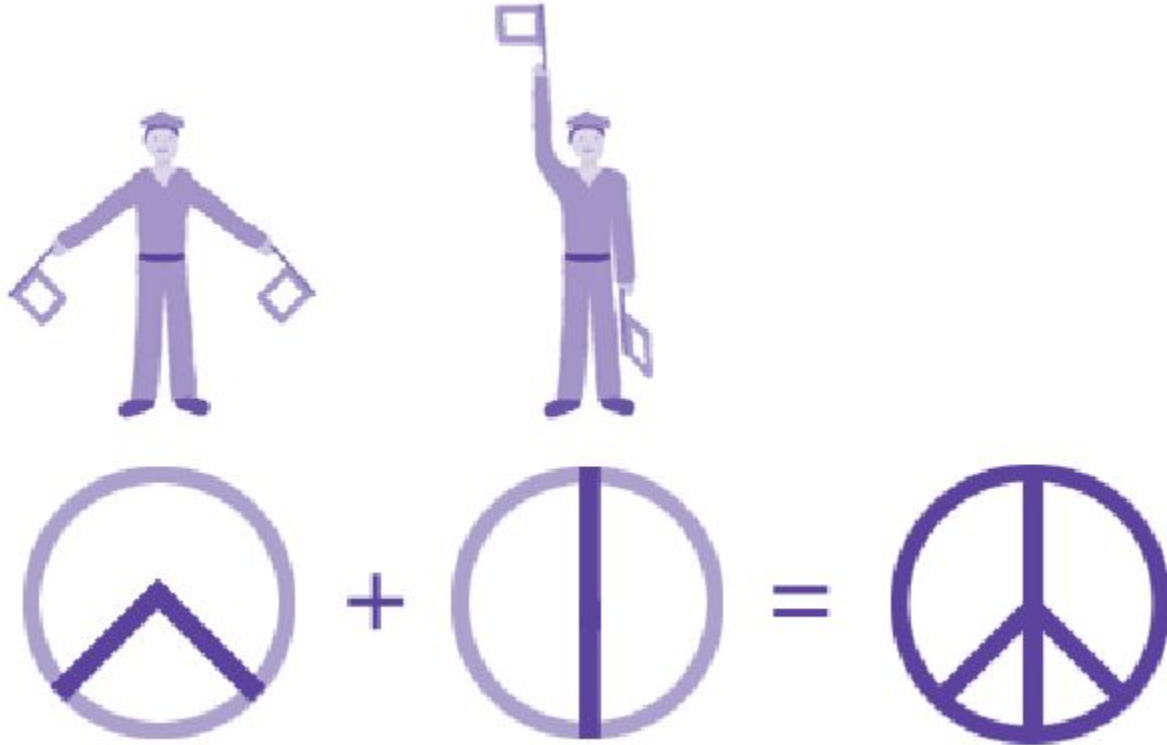
A **single** nuclear reactor can power almost **one million homes**.

1 GW Capacity = 3.125 million solar panels
(320 Watts per panel)





N + D = Nuclear Disarmament



Nuclear Energy Promotes Peace



20,000

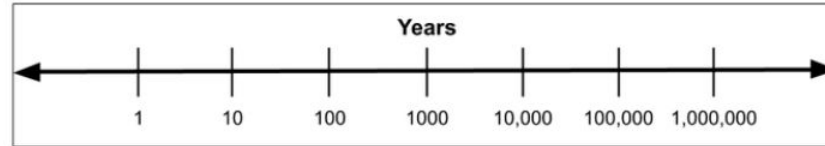
NUCLEAR WARHEADS ELIMINATED

TO PRODUCE

7,000,000,000

MEGAWATT HOURS

How many years could Megatons to Megawatts power the city of Highland Park (a town of 28,000)?



Nuclear Energy Promotes Peace

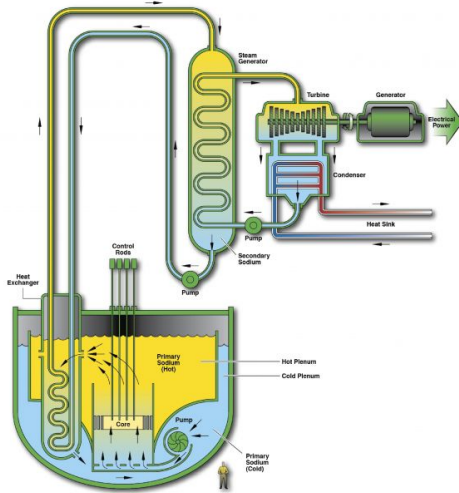


Enough electricity to:

1. power all of Highland Park for ***75,000 years.***
2. power all of Illinois for almost ***500 years.***

Megatons to Megawatts... Plutonium?

Sodium-Cooled Fast Reactor design



- Requires a type of advanced reactor called a “fast reactor.”

Possible Designs

- GE-Hitachi: PRISM Reactor
- TerraPower: Molten Chloride Fast Reactor (MCFR)

Weapons Stewardship

What substance is coming out of these towers at a nuclear power plant?



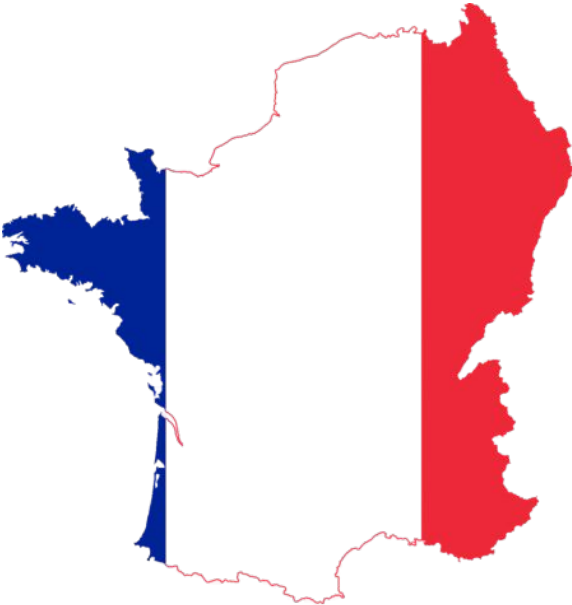


Answer: Water!

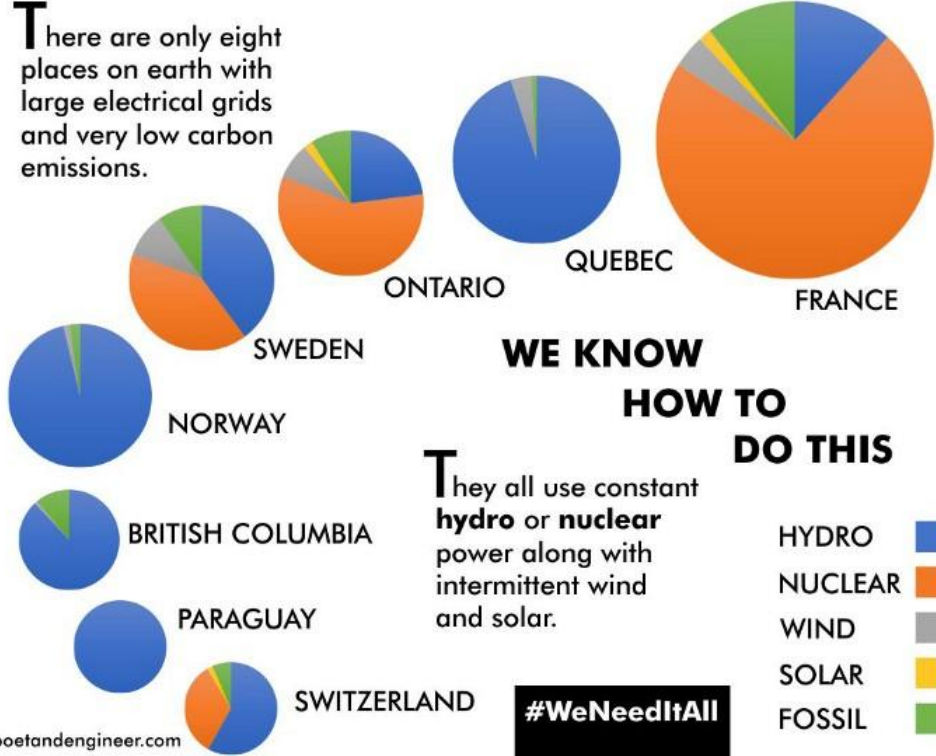
Also accepted:

- steam***
- water vapor***

Nuclear Power for Sustainability



There are only eight places on earth with large electrical grids and very low carbon emissions.



When poll is active, respond at PollEv.com/samueldotson352

Text **SAMUELDOTSON352** to **22333** once to join

How much of Illinois' electricity comes from nuclear?



5-15%

20-30%

50-55%

75%

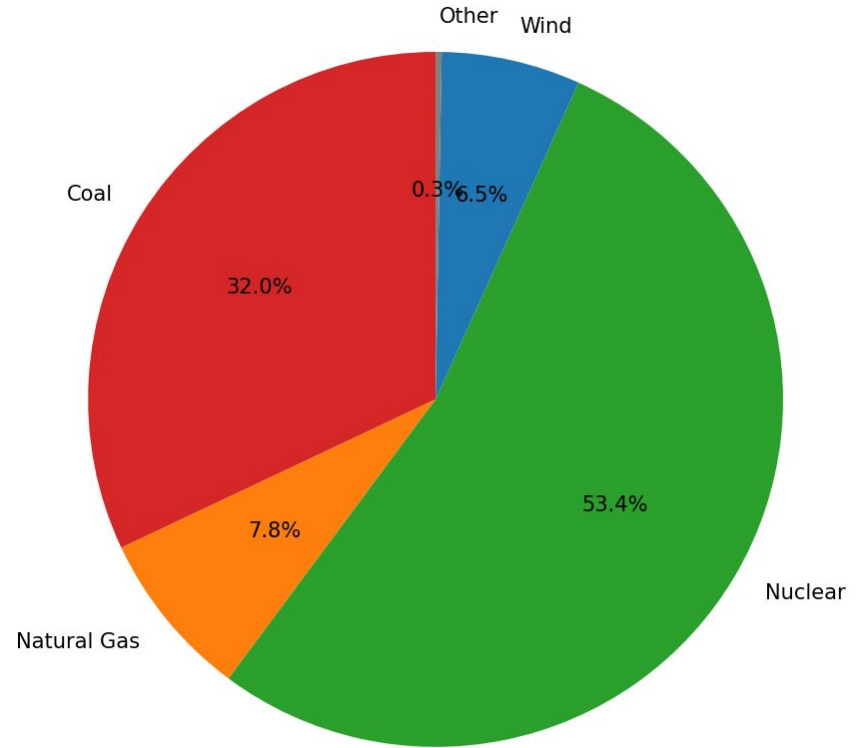
Greater than 75%



Answer: C / 50-55%

- Other < 1% : Biomass, Petroleum, Solar, Hydro

Illinois Electricity Generation by Source, 2018



Data Source: Energy Information Agency, Illinois 2018

Nuclear accounts for 53% of Illinois electricity: How many nuclear plants are there?

3 nuclear plants

6 nuclear plants

11 nuclear plants

18 nuclear plants

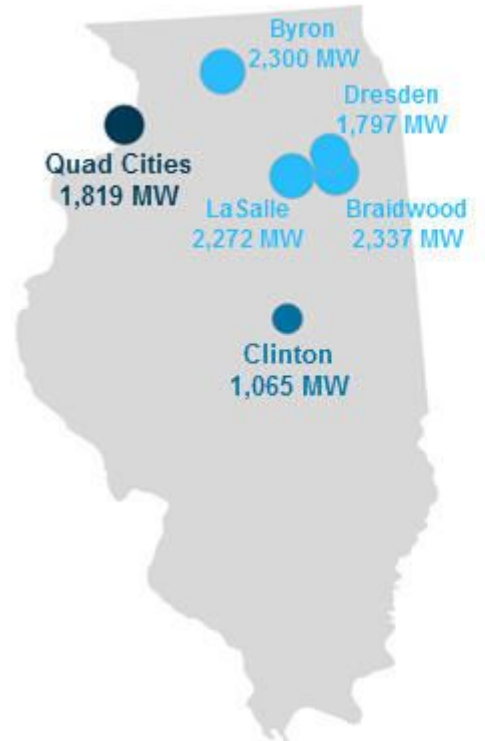
25 nuclear plants



Answer: 6 nuclear plants

That's a lot of electricity.

Nuclear power plants in Illinois (2016)

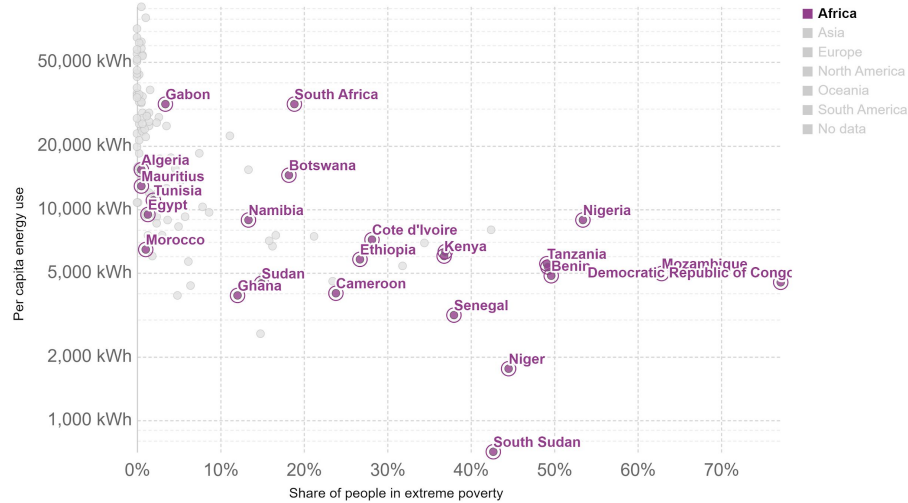


Energy and Quality of Life

Energy use per capita vs. share of population in extreme poverty, 2014

Per capita energy use is measured in kilowatt-hours (kWh) per year. Extreme poverty is defined as living at a consumption (or income) level below 1.90 "international-\$" per day. International \$ are adjusted for price differences between countries and price changes over time (inflation).

Our World
in Data

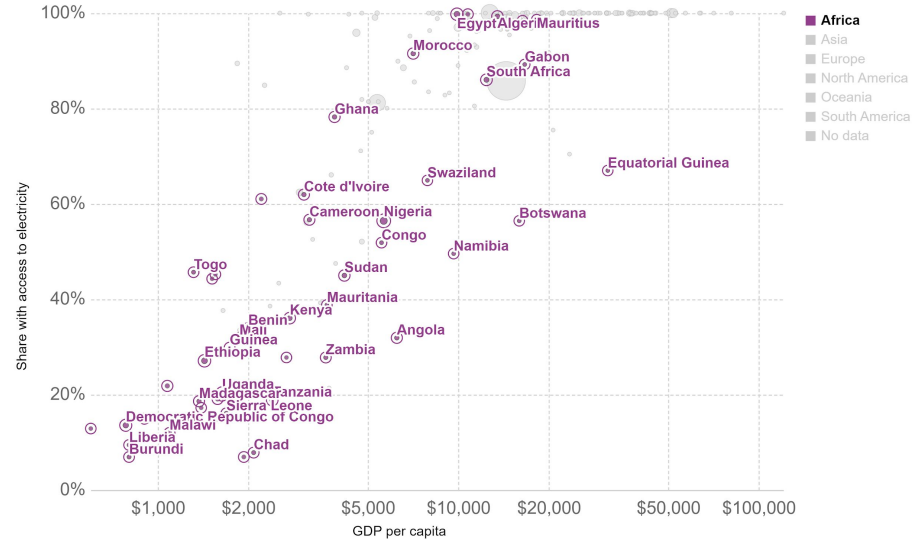


Source: International Energy Agency (IEA) via The World Bank | OurWorldInData.org/energy-production-and-changing-energy-sources/ • CC BY

Access to electricity vs. GDP per capita, 2014

GDP per capita is adjusted for price differences between countries and inflation and measured in international-\$.

Our World
in Data



Source: The World Bank - World Development Indicators (WDI)

OurWorldInData.org/energy-access • CC BY

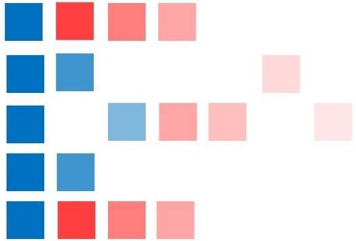
Emerging Market for Small and Micro-Nuclear

- Factory assembled
- Walk away safe because of their size
- Easily transportable

USNC is building reactors for:

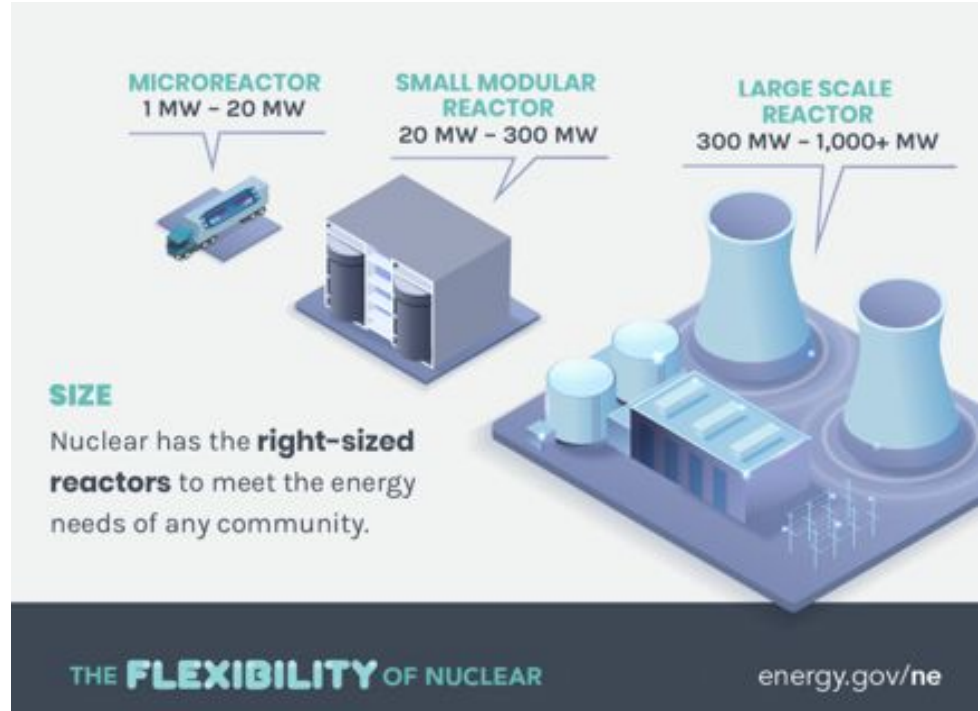
- Remote locations
- Developing grid systems

THE NUCLEAR
ALTERNATIVE
PROJECT

A decorative graphic consisting of a grid of colored squares in shades of blue, red, and light pink, arranged in a pattern that tapers to the right.

What is a micro-reactor?

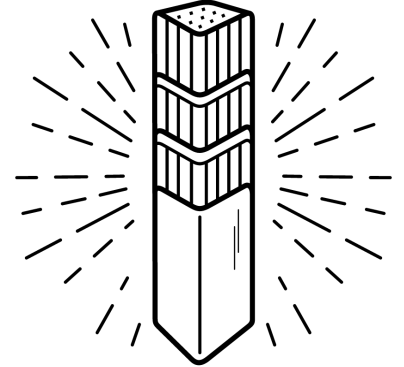
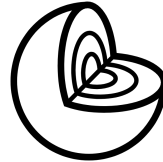
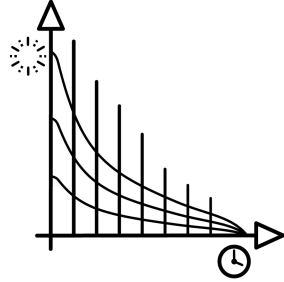
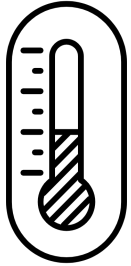
- Small physical size
- Transportable
- Factory built
- ***Walk-away safe***



Nuclear Demonstration: Illinois Micro-Reactor Initiative



Walk-Away Safety



Physics-limited
core
temperature

+

Passive
decay heat
removal

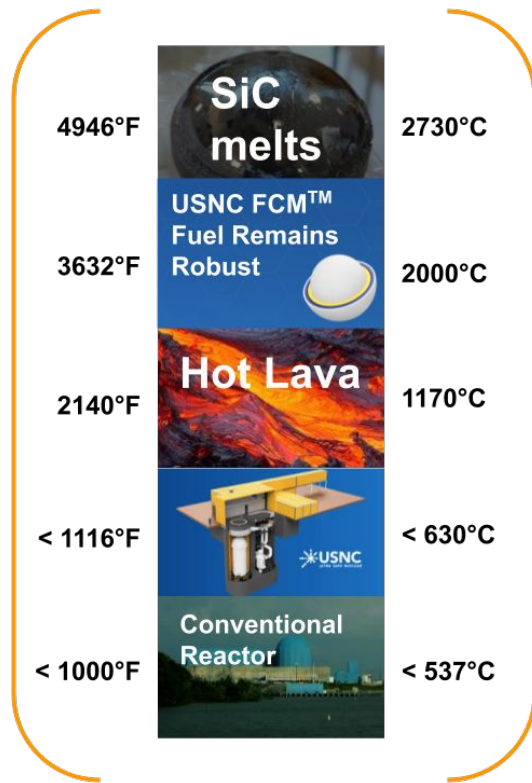
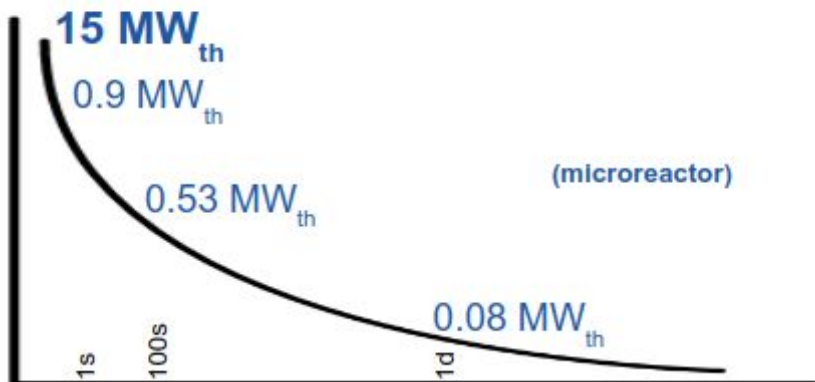
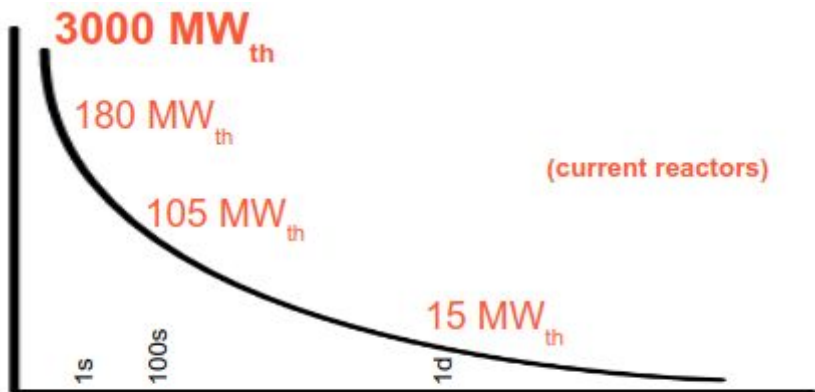
+

Extremely
thermally
robust fuel

=

Fission products
retained in any
accident scenario.

Small Size + Robust Fuel = Safe



Courtesy of Prof. Kathryn D. Huff

Community Nuclear



- Just three micro-reactors could power Highland Park
- All three could fit easily inside the water treatment plant!



The Future of Nuclear Energy in the U.S.

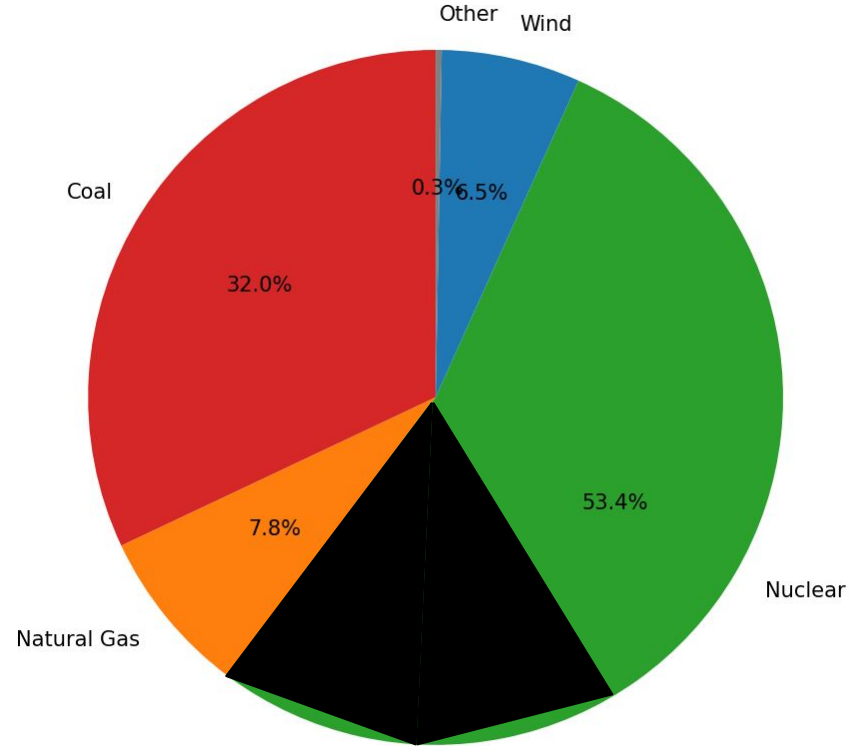
Illinois Electricity Generation by Source, 2018

The good news:

- A new plant in Georgia is nearly complete!

The bad news:

- Several nuclear plants are at risk of closure
- Two Illinois reactors are scheduled to close by Fall 2021
 - With two more at risk of premature closure.



Summary

- Nuclear energy promotes ***peace*** by reducing the nuclear stockpile.
- Nuclear energy is important for solving ***climate change***
- ***Advanced nuclear could benefit communities*** like Highland Park but also
 - remote locations
 - island nations
 - developing grids
- The existing Illinois fleet is at ***risk of shutdown***
 - But we can keep them online!

Q & A

Q&A: What would you like to know more about?

Top



For more questions:



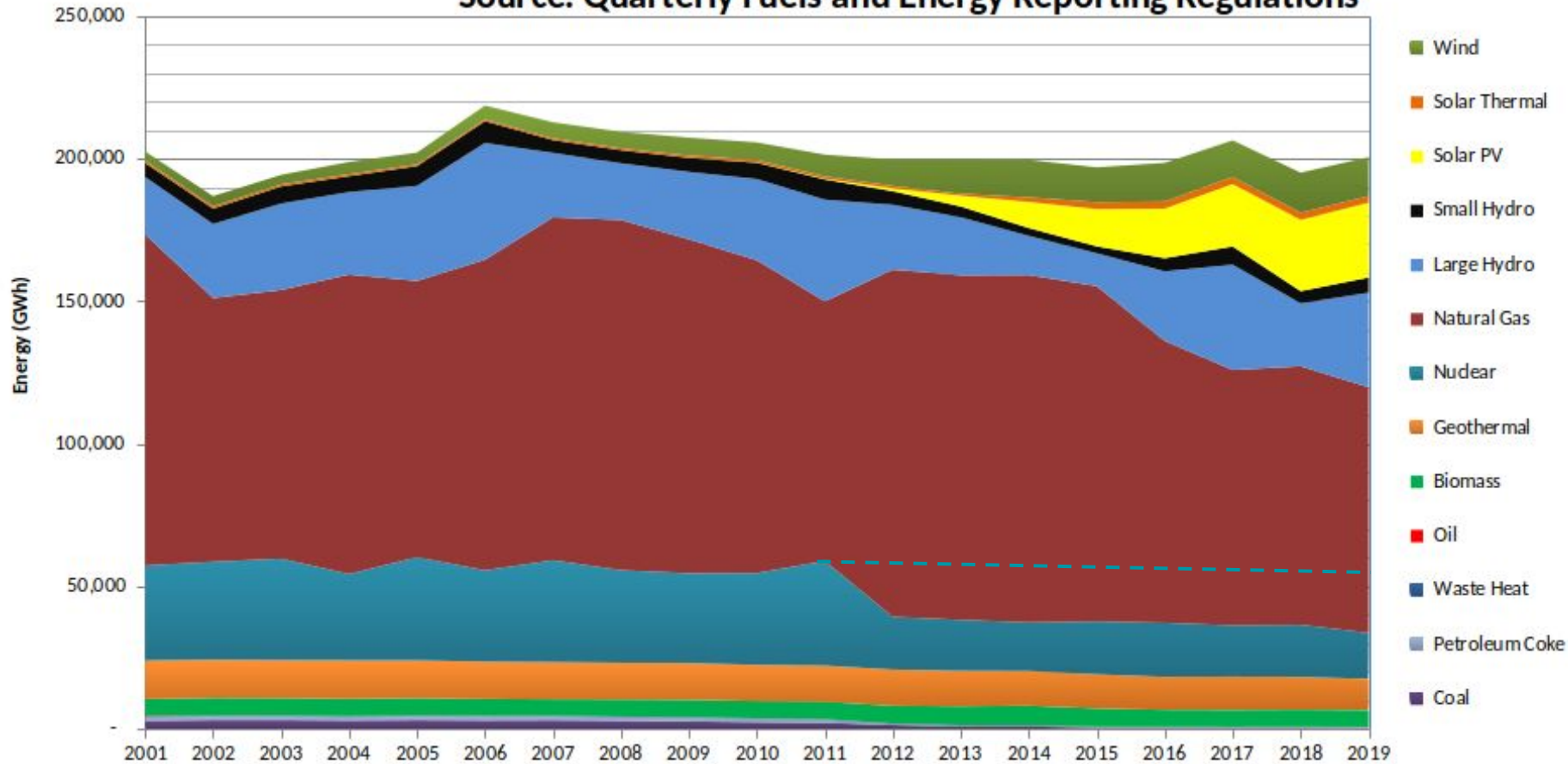
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How do you know that nuclear will be replaced by natural gas and not wind?

In-State Electric Generation by Fuel Type

Source: Quarterly Fuels and Energy Reporting Regulations



Source: California Energy Commission Almanac

U.S.

New Blackouts Darken California

CALIFORNIA

California power prices have skyrocketed. Is this normal — or more Enron-style ‘manipulation’?

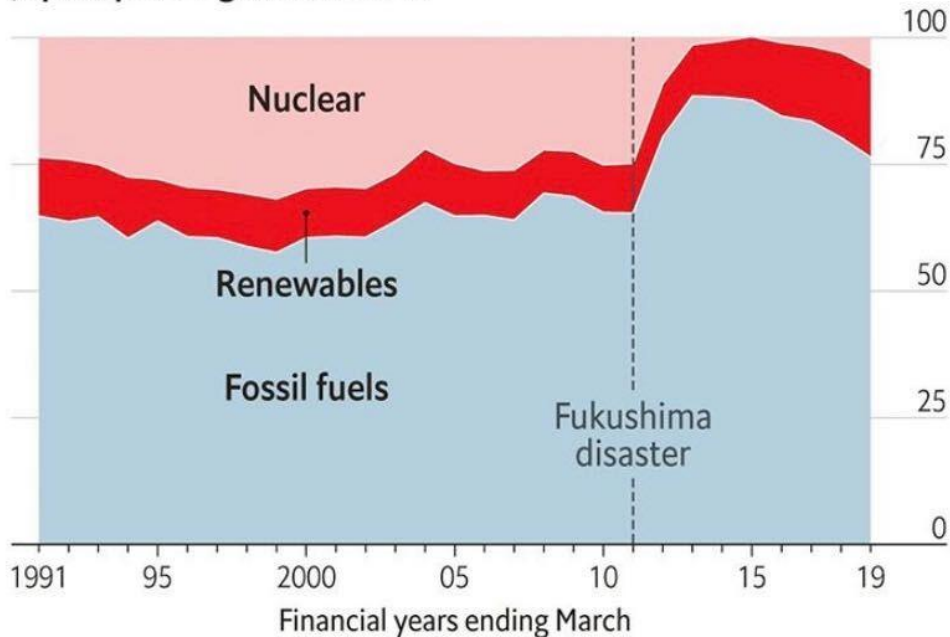
CALIFORNIA

Rolling blackouts ‘likely’ with California power grid expected to near record demand due to extreme heat

‘Mad Max’ in California? Energy crisis is avoidable

Why can't Japan transition to renewable energy?

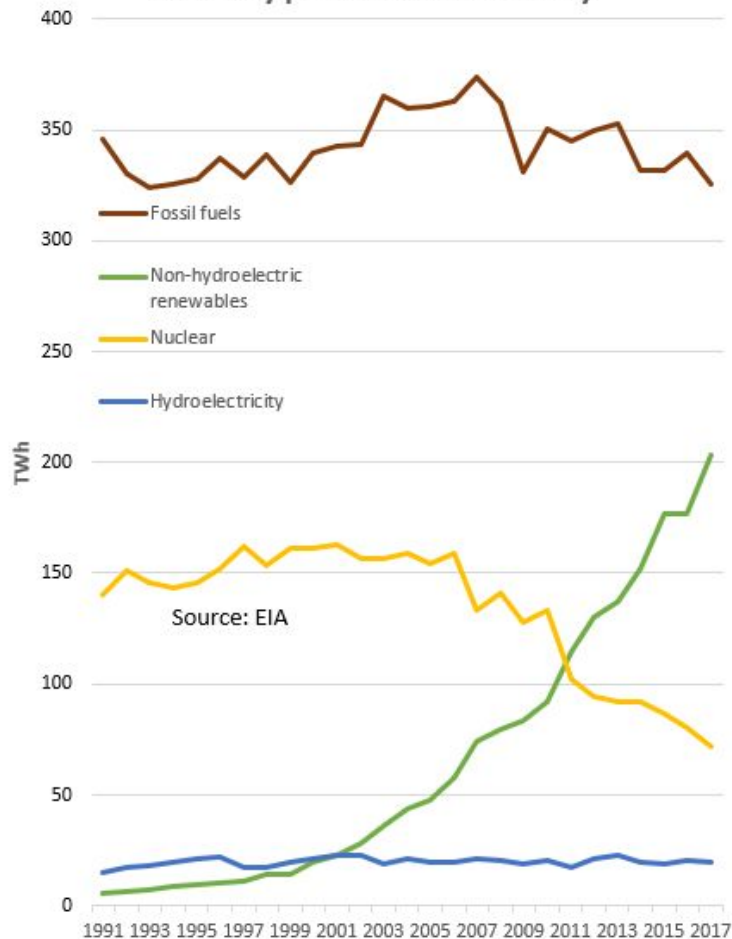
Japan, power generation, %



Source: Institute for Sustainable Energy Policies

The Economist

Electricity production in Germany



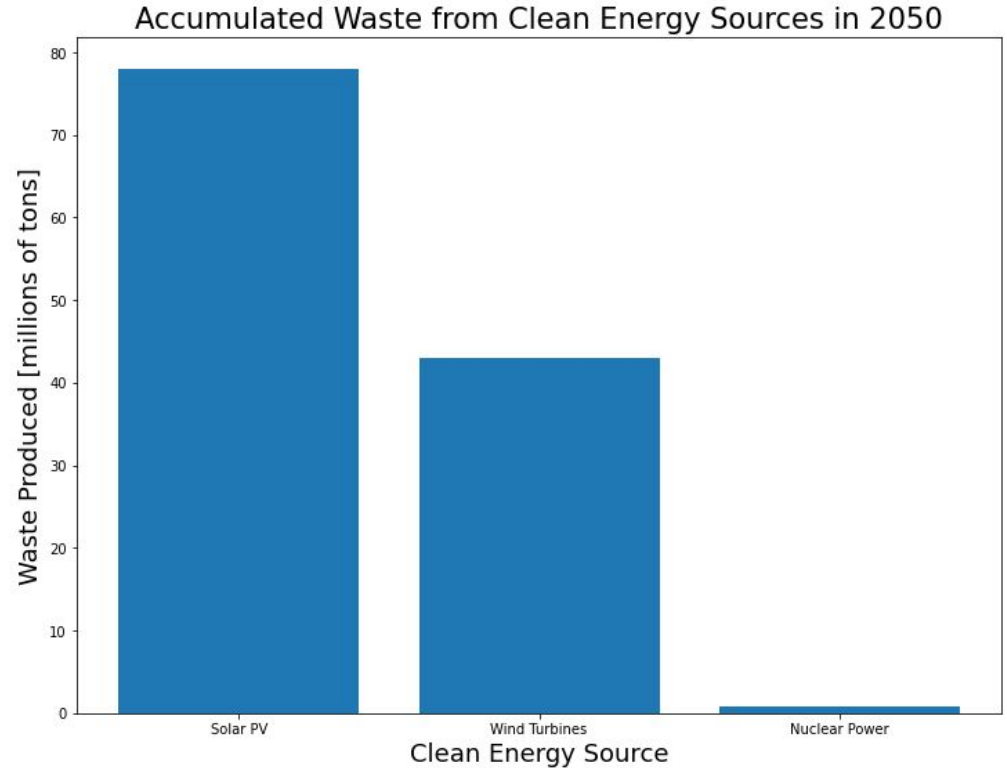
Source: EIA

What are we going to do about the nuclear waste?

Waste: A Problem Shared By All

We need to consider:

1. The waste form (solid, liquid, gas)
2. How much volume
3. The toxicity of the waste



Nuclear “Waste”: A solved problem!

Nuclear “waste” = Spent Nuclear Fuel

1. Dry cask storage
2. Geologic repository
3. Recycle it!

It’s solid!

There isn’t a lot!

We can recycle 96% of “waste!”

Dry Cask Storage



Dry casks at Dresden Generating Station, Morris, IL

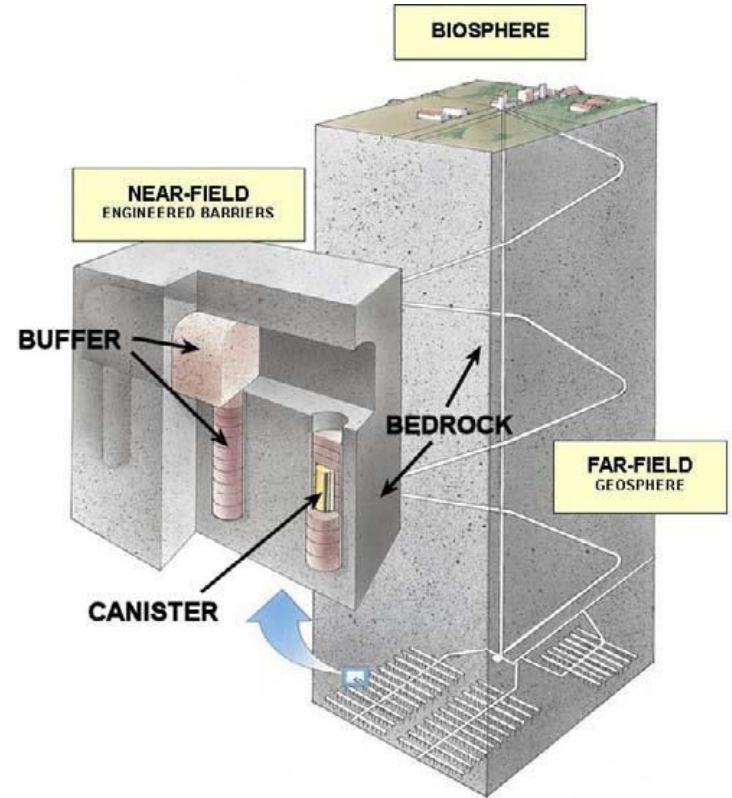
Dry Cask Storage



Dilan and Anna in front of dry casks at Dresden Generating Station, Morris, IL. *February, 2020*

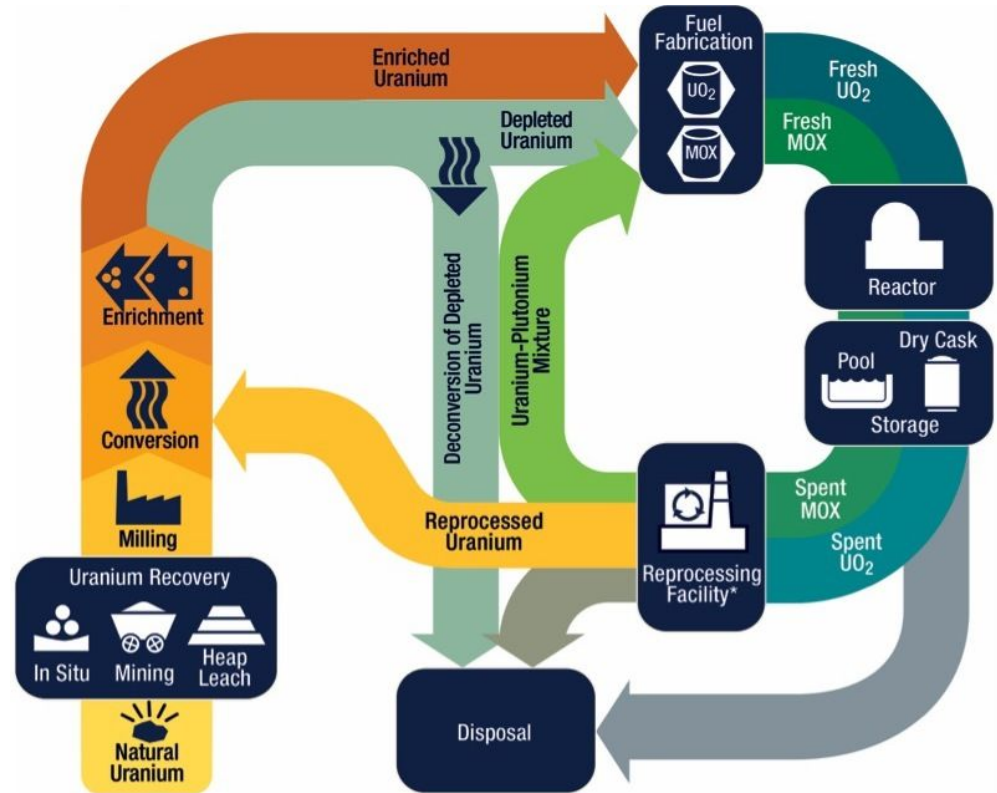
Geologic Repository

- The NRC *approved* Yucca Mountain in Nevada
- Cancelled for political reasons
- Several countries have repositories.



Recycling Spent Nuclear Fuel

- SNF contains 96% of original potential energy.
- Only 4% of the volume is actually “waste.”
- France has been doing this for decades!



Can't we just build lots of Solar Panels and Wind Turbines?

Estimated Land Use Required to Generate 4100 TWh

■ **Nuclear** ~ 192 km²



Chicago ~ 590 km²

Wind

~ 76,960 km²



Solar

~ 86,581 km²



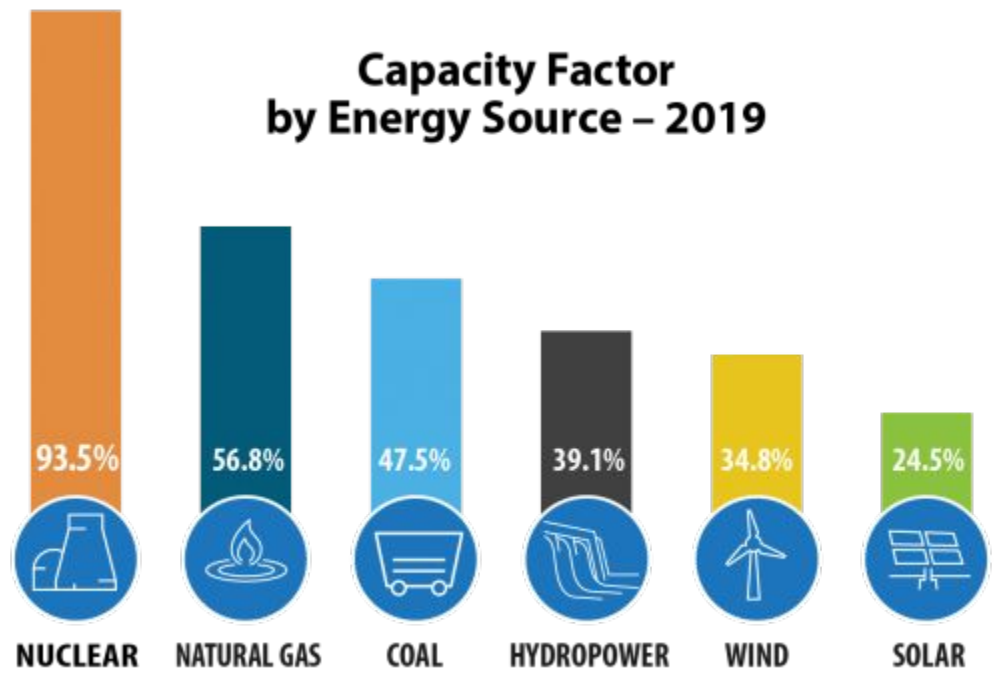
Ohio

~ 116,098 km²



From Generation Atomic

Capacity Factor



Nuclear Accidents: Fukushima, TMI, Chernobyl

Chernobyl: A Systemic Failure

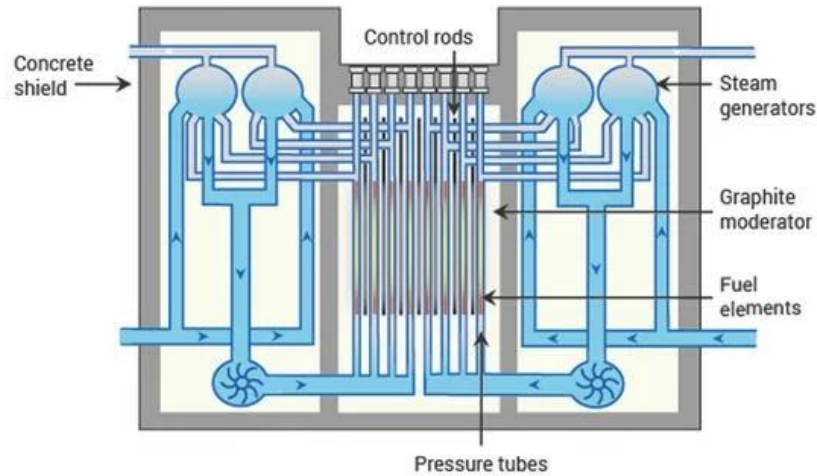
- Caused by human error and government secrecy.
- A ***steam*** explosion.
- No containment building.



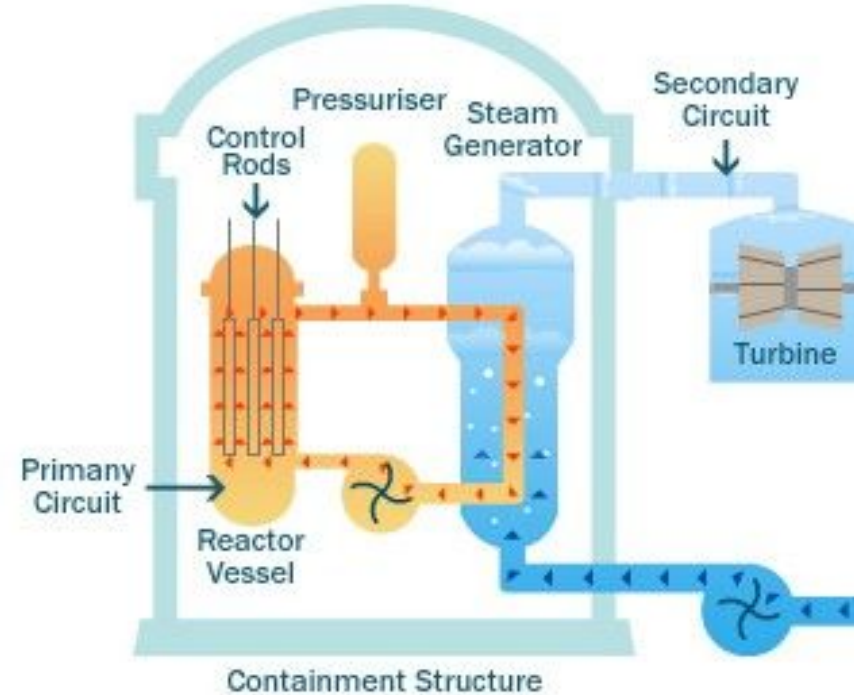
The Chernobyl Accident is not physically possible in U.S. reactors

RBMK (Chernobyl) vs PWR (U.S.)

A Light Water Graphite-moderated Reactor (LWGR/RBMK)



Light Water, Graphite Moderated (RBMK)



Light Water Cooled and Moderated (PWR)

Fukushima: A Systemic Failure

Why:

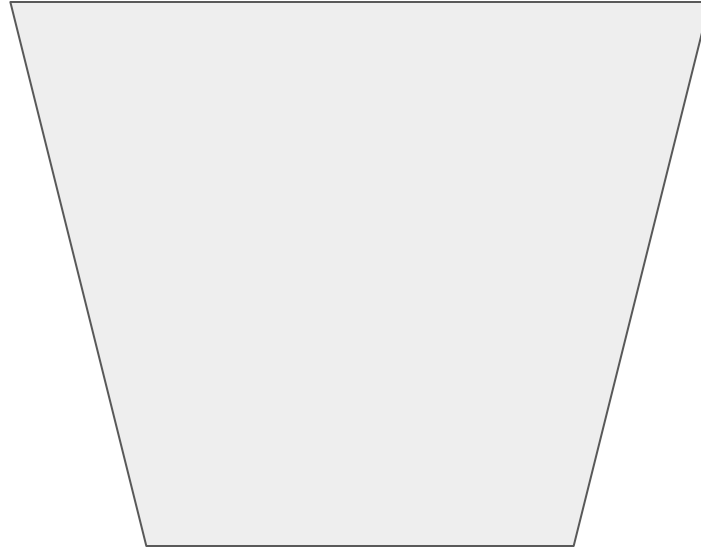
- Weak Regulator
- Natural Disaster
- Poor Risk Communication + Unnecessary Evacuation = Preventable Loss

Zero deaths caused by radiation from the reactor.

Can it happen in the United States? **No***

Why are nuclear plants closing in Illinois (or elsewhere)?

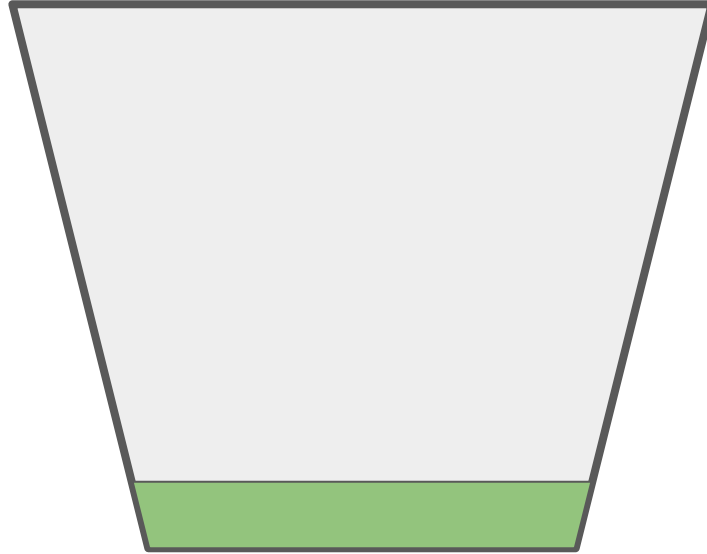
Market Clearing Price



Tomorrow's Electricity Demand

Market Clearing Price

Market Clearing Price

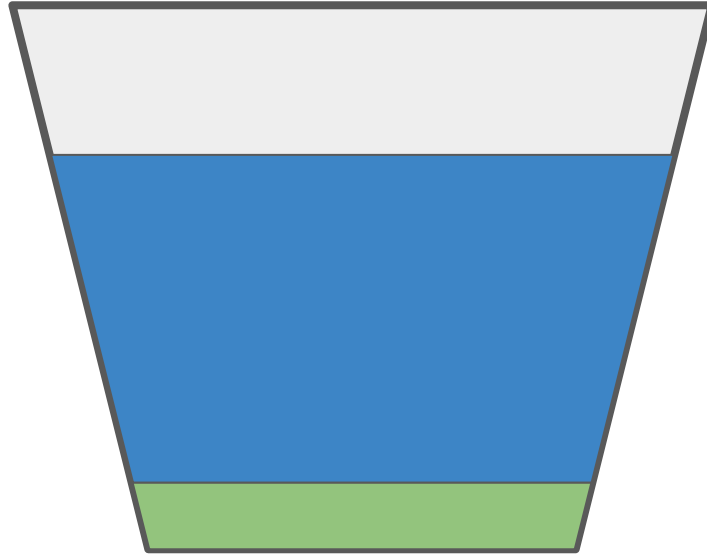


Solar + Wind: \$0

Tomorrow's Electricity Demand

Market Clearing Price

Market Clearing Price



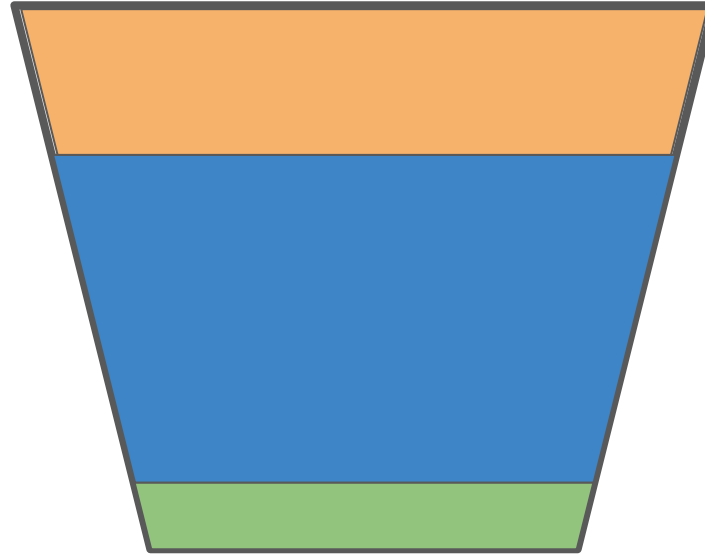
Nuclear Power: \$0

Solar + Wind: \$0

Tomorrow's Electricity Demand

Market Clearing Price

Market Clearing Price



Natural Gas: \$20

Nuclear Power: \$0

Solar + Wind: \$0

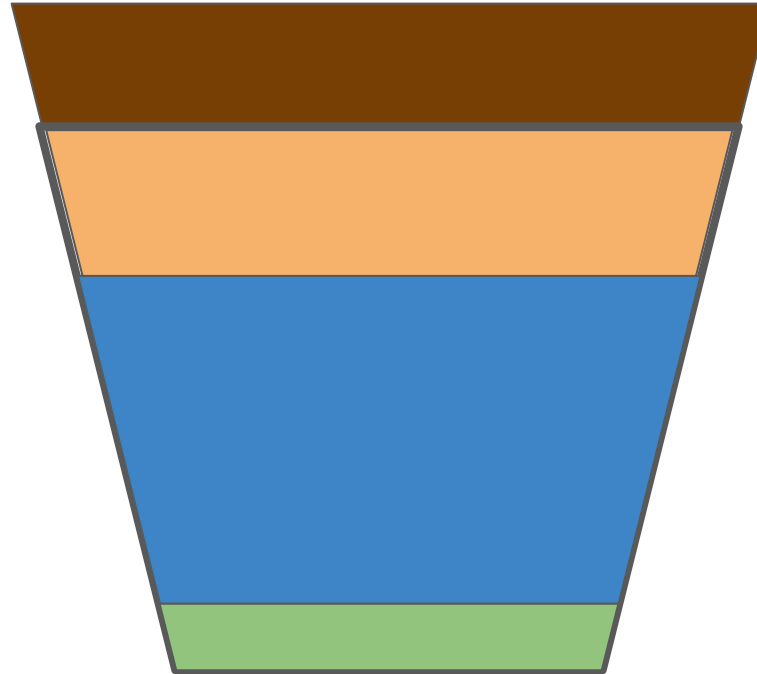
Tomorrow's Electricity Demand

Market Clearing Price

Market Clearing Price

Natural gas fills up remaining demand!

Everyone below gets paid \$20 per unit.



Coal: \$25

Natural Gas: \$20

Nuclear Power: \$0

Solar + Wind: \$0

Tomorrow's Electricity Demand

Rewarding Clean Energy

- Solar and Wind benefit from Renewable Energy Credits
- Nuclear plants can (and should) get a similar reward through “Zero Emissions Credits”

ZECs in Illinois

- Future Energy Jobs Act ***introduced*** ZECs
- Clean Energy Jobs Act should ***expand*** ZECs

Radiation

Living within 50 miles of a nuclear power plant for a year

Living near a nuclear power plant for a whole year exposes you to less radiation than eating one banana – and less than living near a coal power plant.



0.9 BANANAS
0.09 μSv

Airport security scan



2.5 BANANAS
0.25 μSv

Dose at which an increased risk of death from cancer is evident

Now it's starting to get a little bananas. There's no precise line at which radiation becomes dangerous, but cancer risk starts to increase to measurable levels around here.

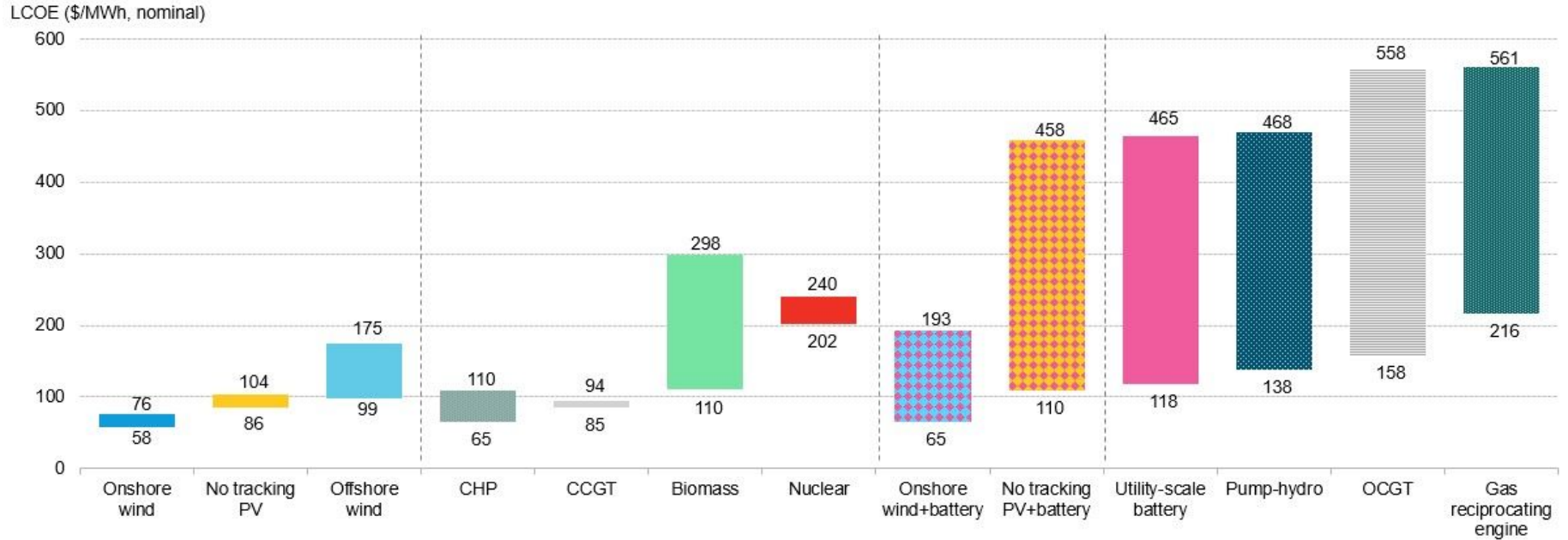
1 MILLION BANANAS
100,000 μSv



Won't expanding nuclear energy lead to more nuclear weapons?

Isn't Nuclear Power Too Expensive?

Levelized Cost of Electricity



Source: WindEurope, 2019 -- <https://windeurope.org/policy/topics/economics/>

Don't Nuclear Power Plants Take Too Long to Build?