

Nuclear Energy

Kirubel Ghebreab, Conor Hunt, Zane Knipe, Peter Reynolds, Connor Spears, Connor Taylor

Agenda

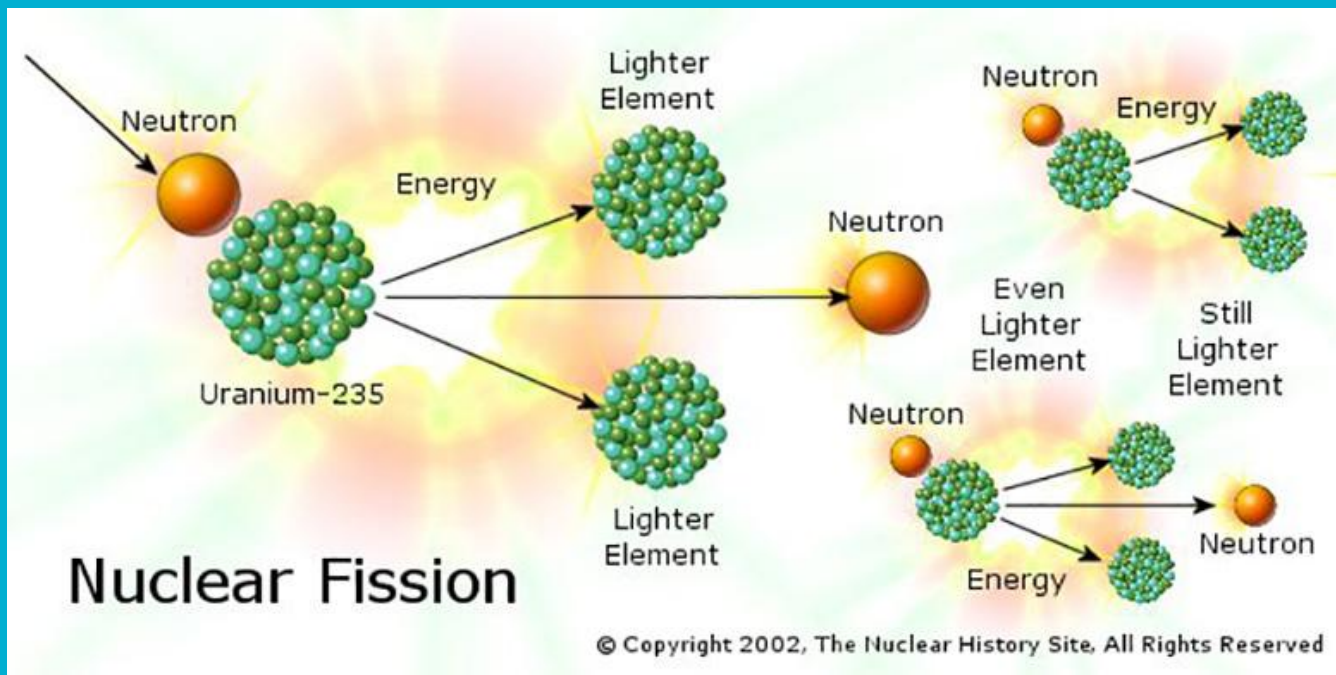
- What is Nuclear Energy?
- History of Nuclear Energy
- Obstacles to Implementation
- Ethics
- Future of Nuclear
- Economy

Nuclear energy should increasingly become a practical option in helping the world's biggest emitters transition to a carbon-free energy system.

How do Nuclear Plants Work?

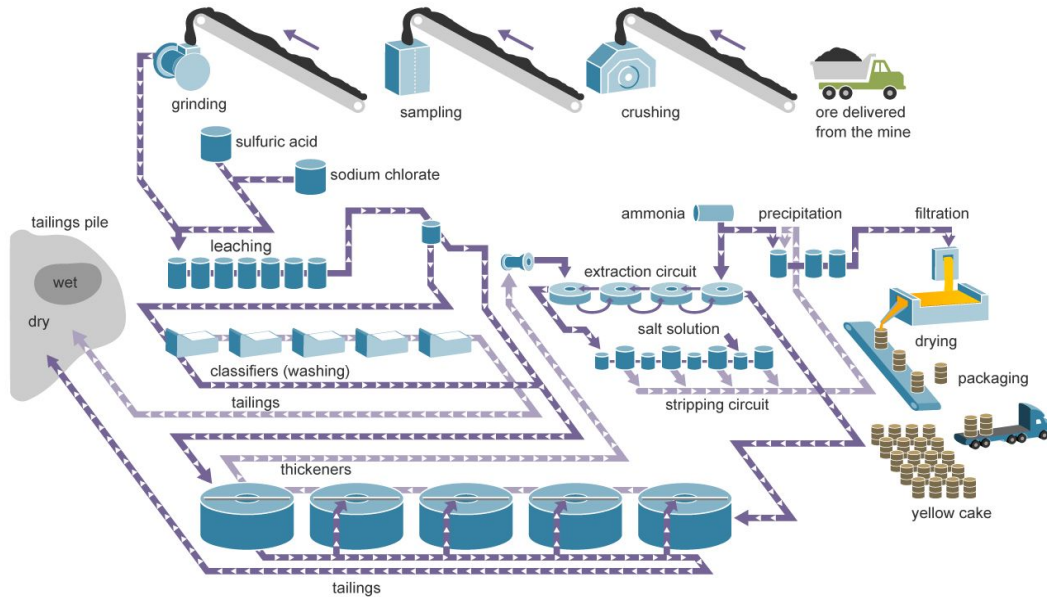


How does Fission Work?



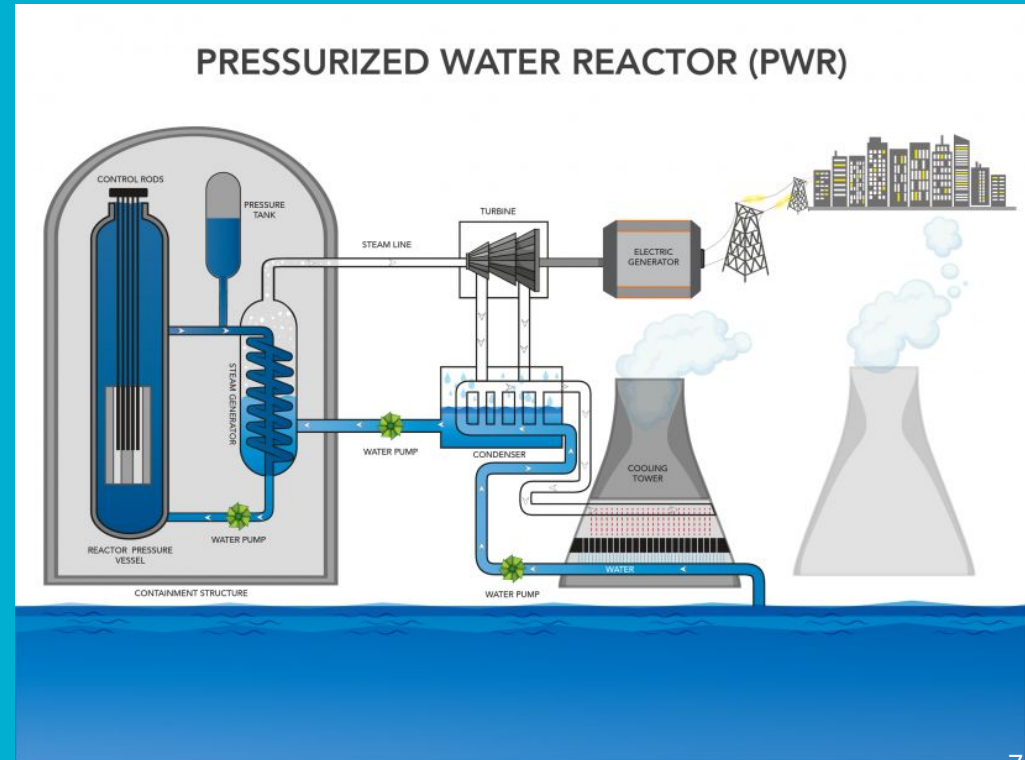
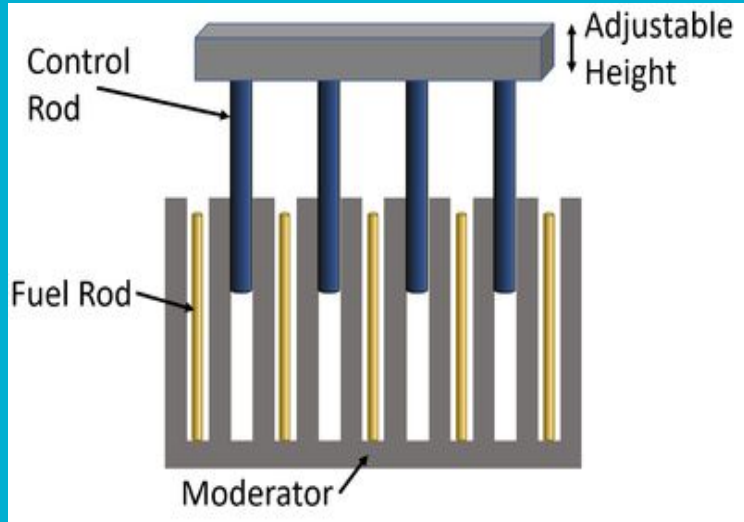
The Nuclear Supply Chain

Typical conventional uranium mill

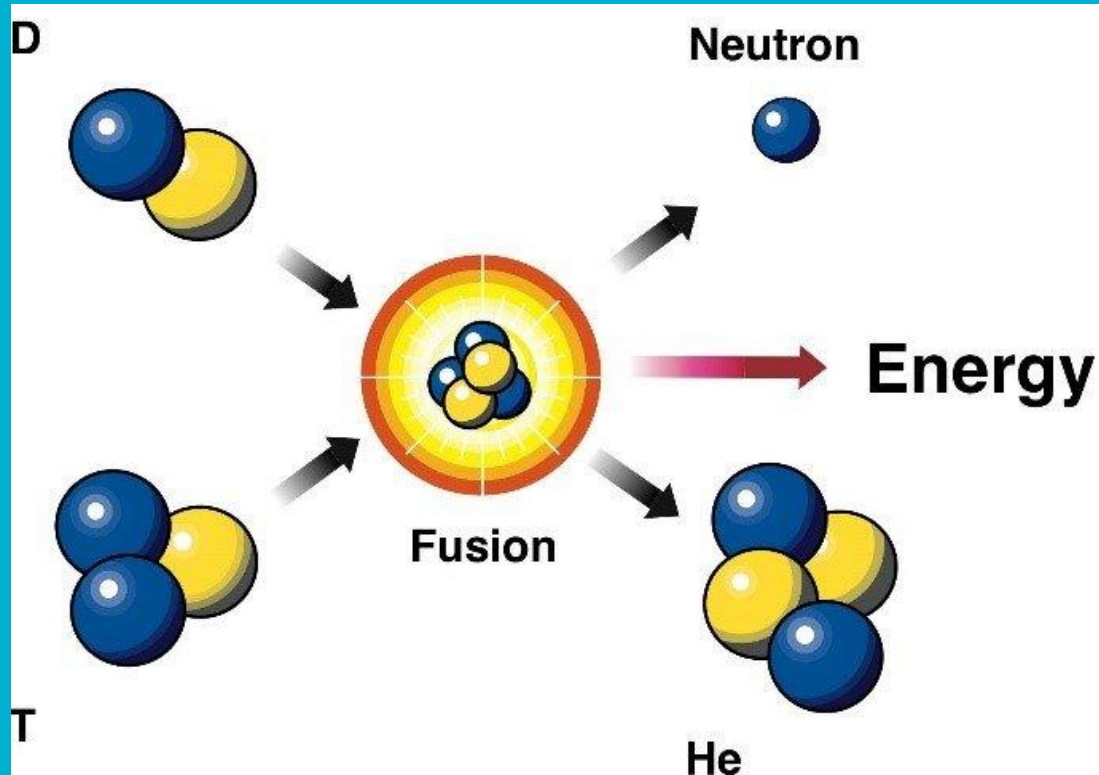


Source: U.S. Energy Information Administration

Nuclear Reactor Thermodynamic Cycle



How does Fusion Work?

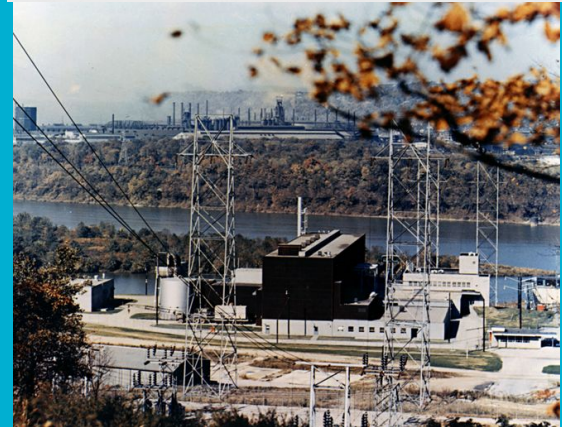
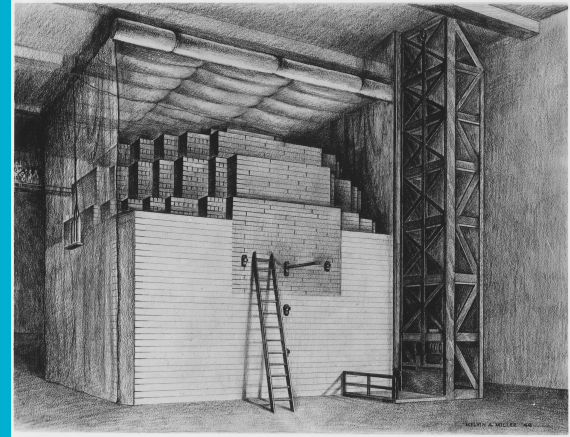


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History of Scientific Development

- 1942: Chicago Pile-1, the first nuclear reactor
- 1942-45: *Manhattan Project*
- 1951: Experimental Breeder Reactor I, the first time nuclear energy produced electricity
- 1954: Obninsk Nuclear Power Plant begins operation
- 1957: First US Nuclear Power Plant in Shippingport, PA



The 70s and 80s

- Continual development of nuclear power plants.
- 1973 oil crisis led some countries (like France and Japan) to invest heavily into nuclear power.
- At the same time, there were rising concerns about the safety of nuclear power.
- Economic conditions were also not great for making nuclear plants.
- This led to a lot of plant projects after 1970 being cancelled.
- Still, in the 1980s a new nuclear reactor was started up every 17 days.



Nuclear Renaissance

- Rising costs in fossil fuels along with a concern for climate change drove a “Nuclear Renaissance” in the 2000s.
- Generation III and Generation IV plants
- For a global renaissance, there needs to be common global regulation



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Weather

Today: Partly cloudy, chance of showers. High 77-79. Low 50-56.
Wednesday: Partly sunny. High 75-80. Light, variable winds.
Yesterday: AQI 45. Temperature range 53-79. Details on Page B2.

The Washington Post

FINAL

Detailed index on Page A2

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Prices May Vary in Areas Outside Metropolitan Washington (See Box on A2)

25¢

Partial Core Meltdown Suspected

By Boyce Rensberger
Washington Post Staff Writer

The Chernobyl nuclear power plant may have sustained at least a partial meltdown of its fuel-containing core, according to American scientists interpreting yesterday's reports that Swedish scientists had detected forms of radioactive fallout usually indicative of such an event.

This would be similar to the 1979 incident at the Three Mile Island atomic power plant, this country's worst accident at a commercial nuclear facility, except that the Pennsylvania plant has a steel-and-concrete "containment" building that enclosed the reactor and prevented radioactive atoms from escaping into the environment. The Soviet facility is not believed to have a containment facility.

The evidence of a meltdown at Chernobyl, according to James McKenzie, senior staff scientist at the Union of Concerned Scientists,



BY DAVE COOK—THE WASHINGTON POST

is the fact that radioactive atoms of iodine and cesium were detected in the atmosphere over Stockholm. Both elements are produced in the nuclear fission reaction that creates a reactor's heat, but they normally stay in the solid-fuel rods. The atoms could be released only if the fuel melted.

Fallout containing radioactive iodine can pose a health threat because the element often finds its way into the grass that dairy cattle eat and becomes concentrated in their milk. In previous incidents of this sort, health officials in various countries found it necessary to

See ACCIDENT, A15, Col. 4

Soviet Nuclear Accident Sends Radioactive Cloud Over Europe

Tass Says Mishap Near Kiev Caused Unspecified Casualties

By Celestine Bohlen
Washington Post Foreign Service

MOSCOW, April 28—The Soviet Union said tonight that an accident at a major nuclear power plant in the Ukraine had damaged a reactor and caused unspecified casualties. The unexplained accident also sent a radioactive cloud hundreds of miles over Scandinavia.

The announcement, unusual for the Soviet Union, which rarely publicizes disasters, came several hours after four Scandinavian countries had reported detecting abnormally high levels of radioactivity in their atmosphere and Sweden's ambassador to Moscow began questioning Soviet officials.

The Soviet statement did not say whether there were deaths in the accident, which the news agency Tass said was at the Chernobyl power plant, 60 miles north of Kiev. It said only that "measures are be-

ing undertaken to eliminate the consequences of the accident. Aid is being given to those affected."

Residents of Kiev told United Press International by telephone that all bus service there had been stopped so the vehicles could be used to evacuate those in the disaster area. They said, however, that they had no information about casualties and had heard no explosion.

The Tass statement, read on the television evening news, said one of the plant's atomic reactors was damaged and "a government commission has been set up" to investigate it. This was seen by western diplomats as an indication of high-level concern.

Some western diplomats here speculated that because of the proximity to Kiev, a city of 2.3 million people, and the unusual public announcement, there may have been a high death toll.

Officials in Sweden, where radio-

activity was detected in the air, soil and tree leaves, said that the amount reaching that country was well above normal, but presented no immediate threat to the population.

Denmark, Finland and Norway also reported unusual radioactivity, with high readings coming from islands in the Baltic Sea.

Sweden said tonight that it is seeking "detailed information" from Soviet authorities about the accident, so that it can take precautionary measures if the contamination can be expected to continue or increase.

Swedish Energy Minister Birgitta Dahl said it was "unacceptable" that Swedish authorities and others outside the Soviet Union had been given no notification. Sweden would demand that the entire Soviet civilian nuclear program be made subject to international in-

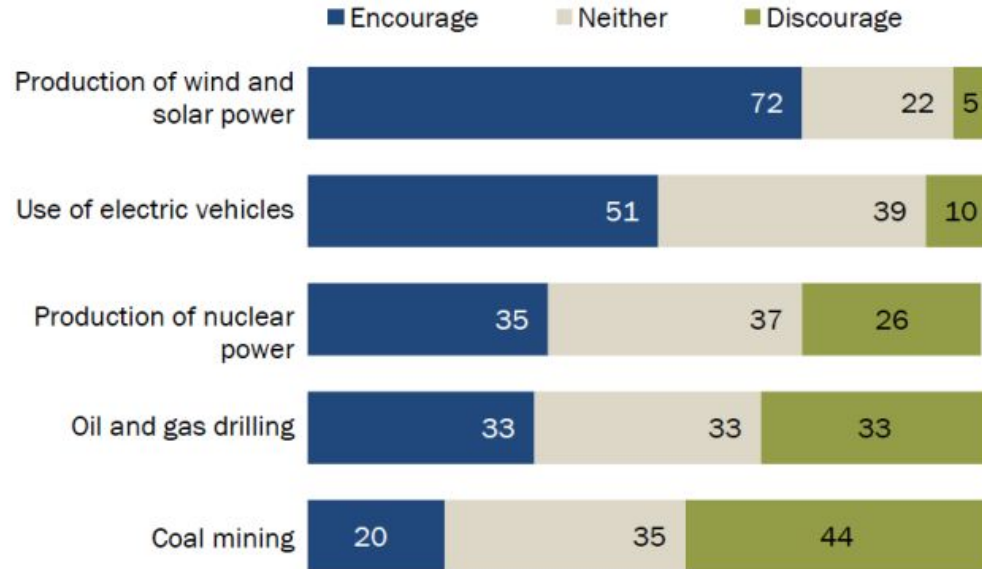
See NUCLEAR, A15, Col. 1

Fear is Powerful

- What if history repeats itself?
- Belief of nuclear being unknown, expensive, and dangerous is quite prevalent
- IEEE cites only 10 nuclear reactor accidents since 1952, with the two worst dominating the narrative

Majority of U.S. adults say federal government should encourage production of wind and solar power

% of U.S. adults who say that the federal government should ___ each of the following activities



Note: Respondents who did not give an answer are not shown.

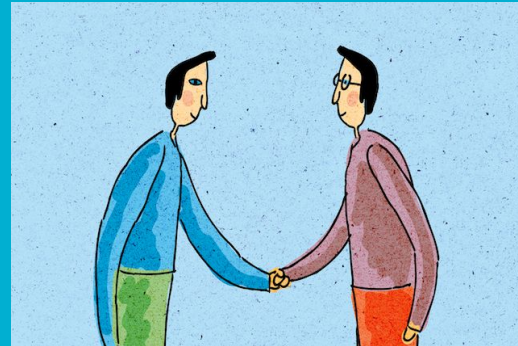
Source: Survey conducted Jan. 24-30, 2022.

"Americans Largely Favor U.S. Taking Steps To Become Carbon Neutral by 2050"

PEW RESEARCH CENTER

Direct Obstacles

- Government
 - In order to get things done in Washington...
 - Need a proactive solution with returns far in the future, which isn't enticing for politicians



Time

- Takes 10-20 years at least for building, not including planning
 - Olkiluoto 3 was proposed in 2000 in Finland with an expected completion of 2009; New completion date is December 2022
 - Hinkley Point nuclear plant in England has an expected build time of 15-17 years



Cost



- Expensive investment with a long time before returns are realized
 - Olkiluoto was supposed to cost 3 billion euros; updated estimates are around 11 billion euros
- Not only is it expensive to build, but also maintain
 - U.S. has spent over 30 billion in nuclear waste storage, according to NEI.
 - As more plants are built, so would the amount of money necessary to safely dispose of waste

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Is Nuclear Energy Safe?

- There have been serious reactor issues in the past
- Chernobyl (1986) and Fukushima (2011)
- Both cases lead to significant impacts on a global scale

- These incidents reveal the dangers of nuclear energy on the public health and the human condition.



Aftermath of Meltdowns

A nuclear power plant meltdown can lead to...

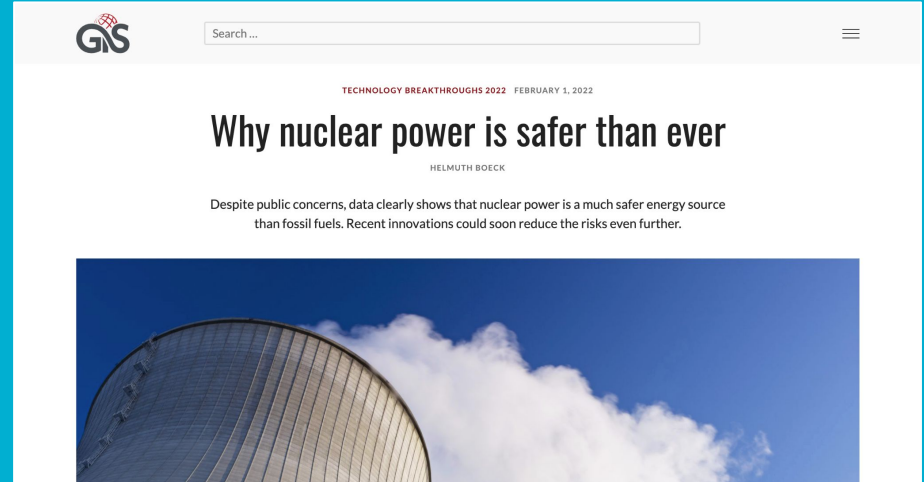
- Long-term physical effects
- Long-term mental health effects
- Childbirth defects
- Radiation in food + water
- Animals/Wildlife/Livestock health effects
- Economy



Considering these risks, is nuclear energy really worth it?

Things have Changed...

- Safety standards are held higher now than in the past
 - Multiple barriers, including steel-reinforced concrete layer
 - 2000 hours of inspection each year
- New generation reactors work at significantly higher operating temperatures.
 - Increased efficiency, more uranium is split, and there is less waste



Nuclear Plants Are Leaders in Safety Performance



Multiple, overlapping safety systems, a commitment to safety culture and training, an independent regulator and peer review organizations like INPO are part of the many elements that ensure that nuclear plants are running safely and smartly.

So, what's my answer to that number one question I get? I share the insight I've gained as well as a quote from Bill Gates: "Nuclear energy, in terms of an overall safety record, is better than other energy."

Moving forward....

- Despite the emphasis on safety, the expansion of power plants shouldn't be rushed
 - The damages (if there are any) are immense and irreversible
 - When it comes to nuclear plant construction: Quality > Quantity
- Nuclear power will lead us towards lower greenhouse emissions.
- So, when thinking about a carbon-free energy system, nuclear energy has to be in the conversation.

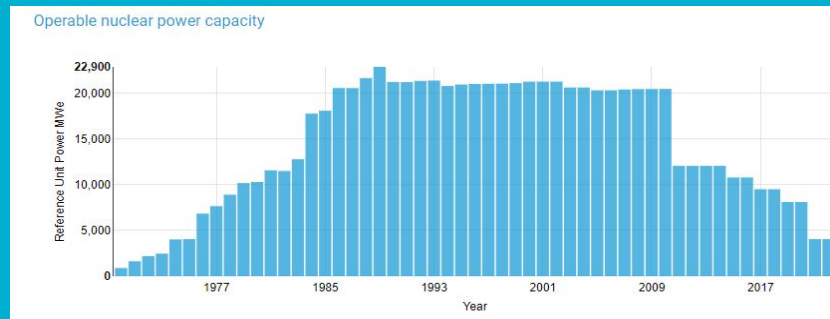


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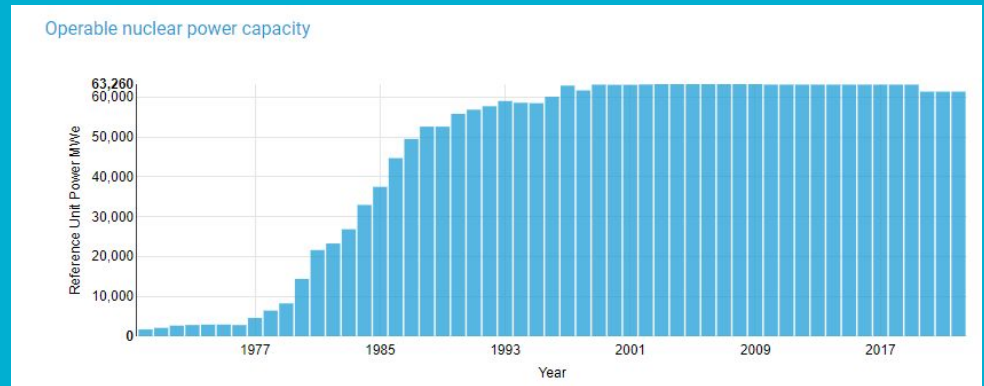
Germany

- Nuclear phase-out reintroduced in 2011
 - Many reactors preceding were Soviet made
- International Energy Agency (IEA) warnings of phase out implications
- Needing 25,000 MWe (capacity) of base-load electricity capacity across its borders to meet green standards
- The Russia-Ukraine conflict has prompted a reappraisal of nuclear plant shutdowns
 - Only 3 plants remain
- Indicative of the nuance of political interference in the nuclear space
- Similar situations across Europe



France – Opposite Case Scenario

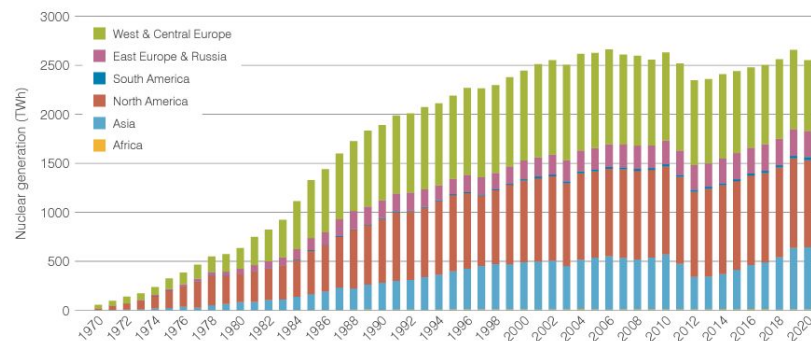
- France derives about 70% of its electricity from nuclear energy
 - Focus on energy security
- Largest net exporter of electricity
 - low cost of generation
 - €3 billion per year
- Technology leaders in reactor space
- About 17% of France's electricity is from recycled nuclear fuel



Global Context

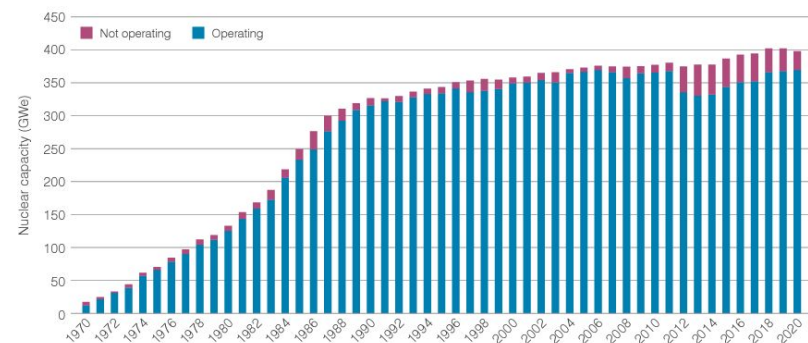
- 441 operable nuclear reactors at the end of 2020
- +50% of nuclear plant shutdowns were a result of political phase out policies
- Nuclear is expensive
 - Limiting technological breakthroughs
 - Most reactors on order are in the Asian region and Russia
 - Significant further capacity is being created by plant upgrading primarily
- Should we subject the nuclear industry to free market conditions?
 - SpaceX

Figure 1. Nuclear electricity production



Source: World Nuclear Association and IAEA Power Reactor Information Service (PRIS)

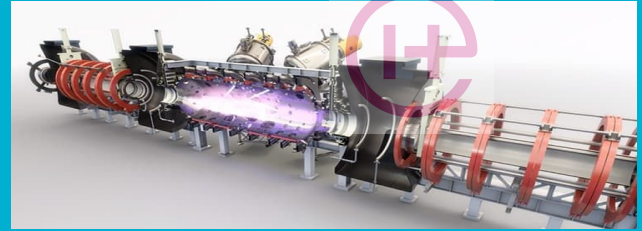
Figure 3. Nuclear generation capacity operable (net)



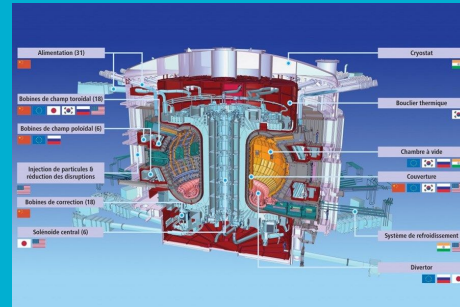
Source: World Nuclear Association, IAEA PRIS

Is Fusion Viable?

- Most nuclear plants subscribe to fission as means of energy generation
- Fusion is a much more energy dense process
 - Sun's power
- Fusion generators are thought to be theoretical
 - Theorized to be the key to unlimited power and could render other energy sources obsolete
- Engineering phenomenon : need to overcome the thermodynamic losses associated with initiating a fusion reaction



Helion - pledging electrical generation in 2024



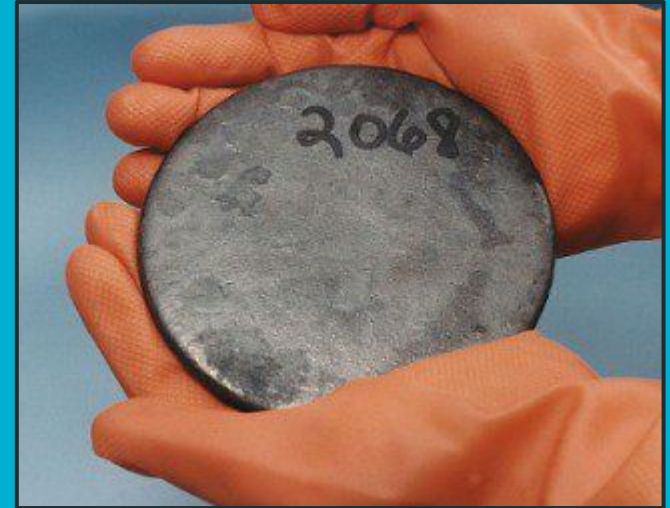
Stellarator (Germany)

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Public Policy

- Inflation Reduction Act signed in 2022
 - \$369 billion in climate provisions
 - Cut US emissions by 40%
- Zero-emission nuclear power production tax credit
 - Supports existing reactors
- Advanced manufacturing production tax credit
 - Investment credits
 - Would get same subsidies as wind and solar power
- Location-based subsidies
- Funding for High-Assay Low Enriched Uranium
 - Advanced reactors
 - 20% of current supply comes from Russia



Geopolitical Implications

- Ukrainian nuclear power plants
 - Zaporizhzhya plant was attacked
 - Lost access to external power
- Saudi Arabia has plans to establish civil nuclear power industry
 - Requesting a license from the IAEA
 - Saudi Nuclear Energy Holding Company has been established
- Concerns over nuclear proliferation or nuclear accidents



Investor Interest

- Bill and Melinda Gates foundation recently raised \$750 million for TerraPower
- Commonwealth Fusion Systems raises \$1.8 billion in funding
- TAE Technologies raised \$1.2 billion dollars
- Helion has secured \$2.2 to commercialize fusion energy



Will Implementation Continue?

- There is precedent of success, meaning it is possible.
- There have been meaningful strides to increase safety and practicality
- It cannot fulfill all energy demand, but it can contribute significantly
- The world is already starting to open and support nuclear, and with its success, more will follow

