

Advancement of Nuclear Power Technologies

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Outline

- What has changed to put nuclear power in demand?
- What options are available for new nuclear reactors?
- Summary

What has changed to put nuclear power in demand?

- Increased electricity demand.
- Focus on carbon-free electrical production.
- Success in operation of current nuclear reactor fleet.
- Success in building new nuclear reactors.
- Public perception.

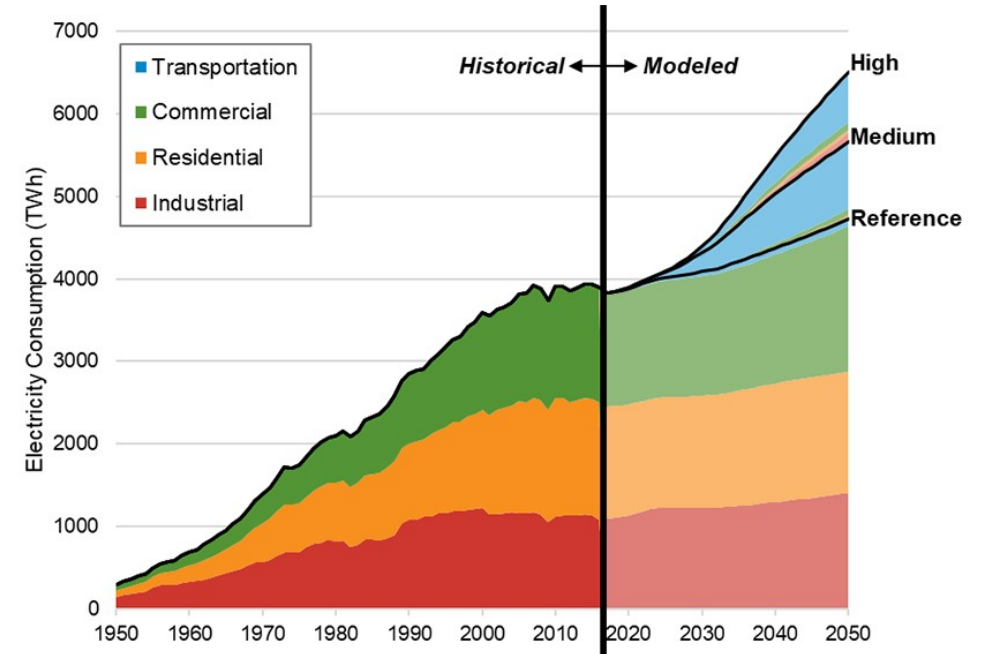


Vogtle 3 AP 1000 started operations in 2023.

Increased Electricity Dem

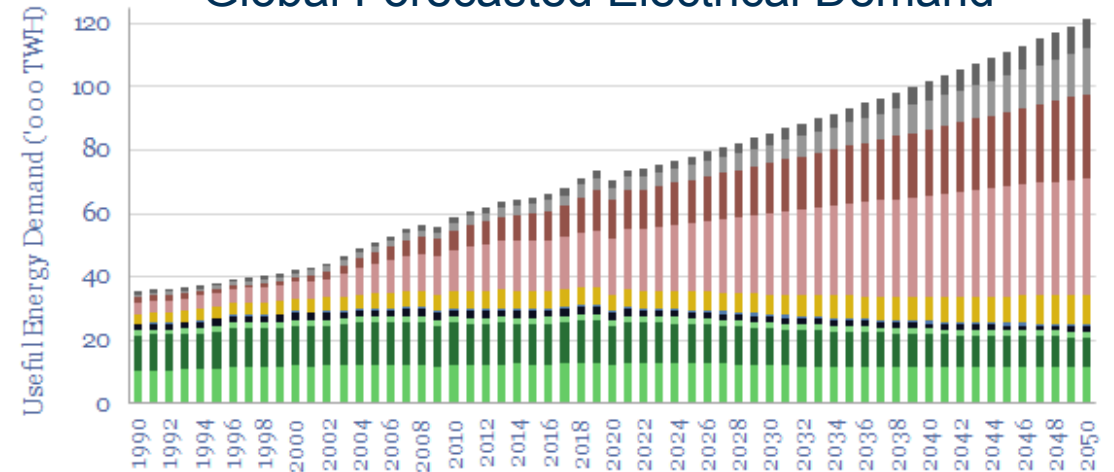
- Electrical demand is increased within the US and globally.
- Retirement of current power plants.
- Factors driving growth include:
 - Transportation transformation to utilize electric vehicles.
 - Data centers (one big new data center could require multiple dedicated nuclear reactors for electricity).
 - Industrial process heat.
 - Desalination.
 - Hydrogen production.

U.S. Forecasted Electrical Demand



<https://www.nrel.gov/news/program/2018/analysis-demand-side-electrification-futures.html>

Global Forecasted Electrical Demand

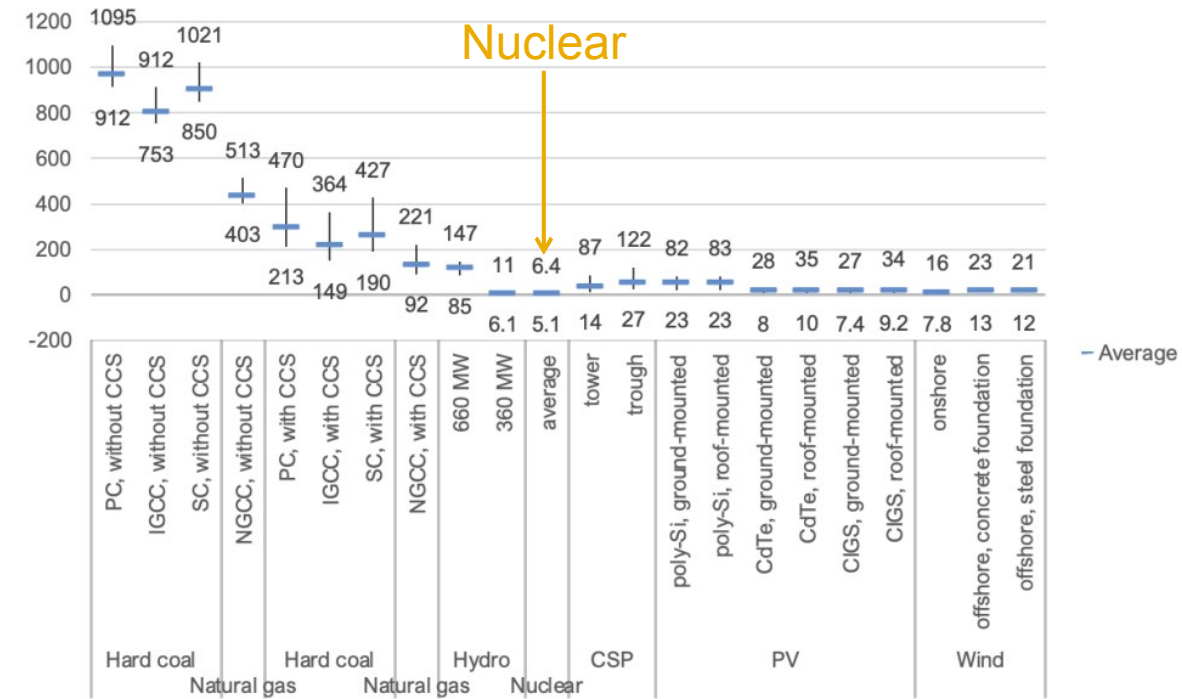


■ Africa ■ India ■ Other Asia ■ China ■ LatAm ■ Australia ■ Japan ■ Canada ■ Europe ■ United States

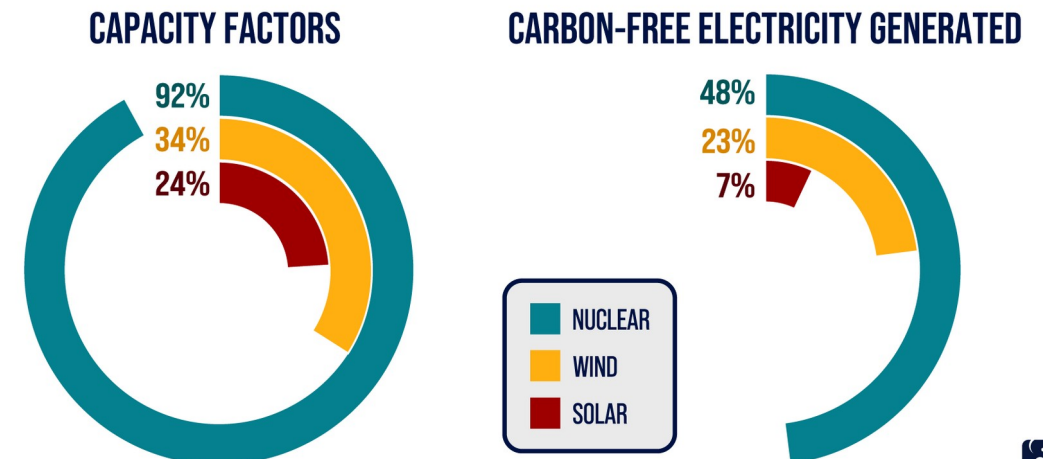
<https://thundersaidenergy.com/downloads/global-energy-demand-by-region-and-through-2050/>

Carbon Free Electricity

- Nuclear power is “carbon-free” meaning that it does not produce CO₂ during operation.
- Currently, nuclear power produces more carbon-free electricity in the United States than any other source.
- Of the carbon-free electricity sources, nuclear power has the highest capacity factor (**this means that nuclear power is a very reliable source of electricity**).
- **Each nuclear power plant prevents** the emission of over two million tons of carbon dioxide into the atmosphere annually and **100 million tons of carbon dioxide over its lifetime**.



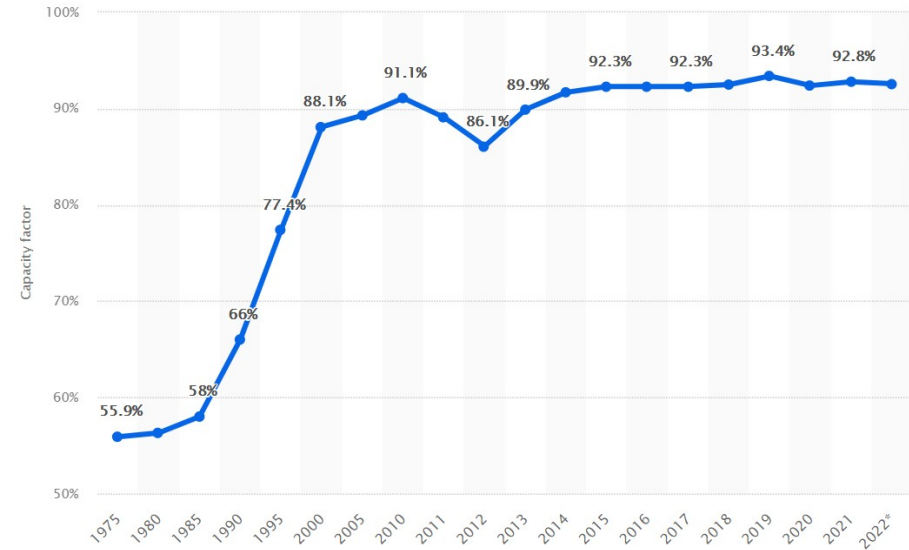
<https://world-nuclear.org/information-library/energy-and-the-environment/carbon-dioxide-emissions-from-electricity.aspx>



<https://www.rpc.senate.gov/policy-papers/democrats-try-to-pull-the-plug-on-carbon-free-nuclear-power>

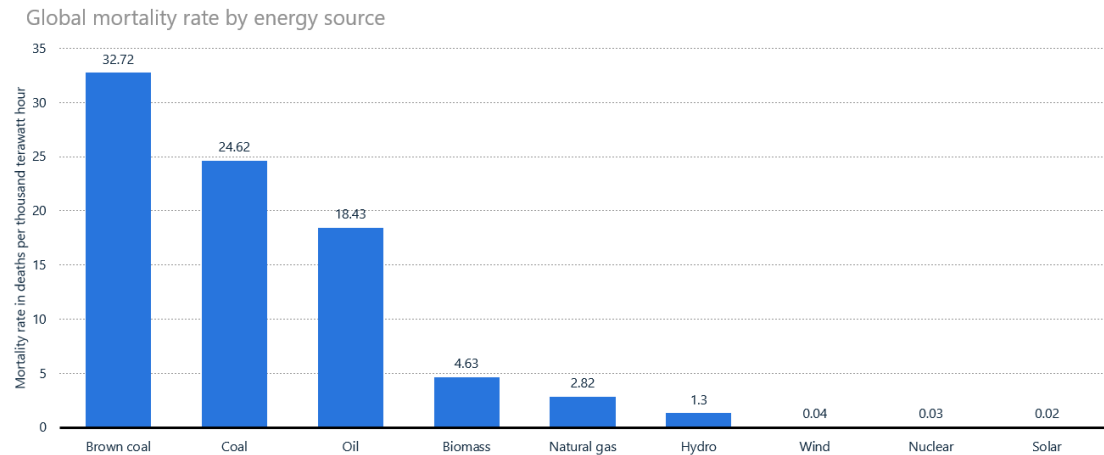
Success in Operation of Current Nuclear Reactor Fleet

- Successful operation of the US nuclear reactor fleet has significantly increased the viability of nuclear power as a source of electricity.
- Nuclear power has the highest capacity factor of any other energy source producing reliable, carbon-free power more than 92% of the time.
- Mortality rates from air pollution and air pollution show that nuclear power is one of the safest sources of electrical production.



<https://www.statista.com/statistics/191201/capacity-factor-of-nuclear-power-plants-in-the-us-since-1975/>

Mortality rate from accidents and air pollution per unit of electricity worldwide, by energy source (in deaths per thousand terawatt hour)



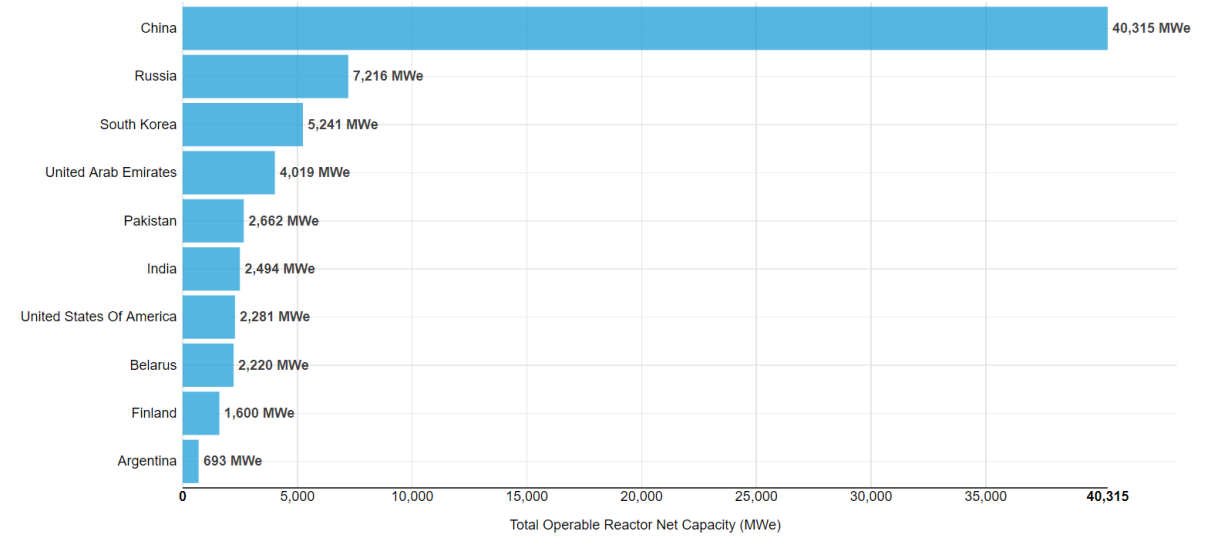
Notes: Worldwide; 2018

Further information regarding this statistic can be found on page 8.

Sources: Canary Media; OWID; Experts (Markandya & Wilkinson (2007); Sovacool et al. (2016); UNSCEAR (2008; & 2018)); ID_494425

Success in Building New Nuclear Power Plants

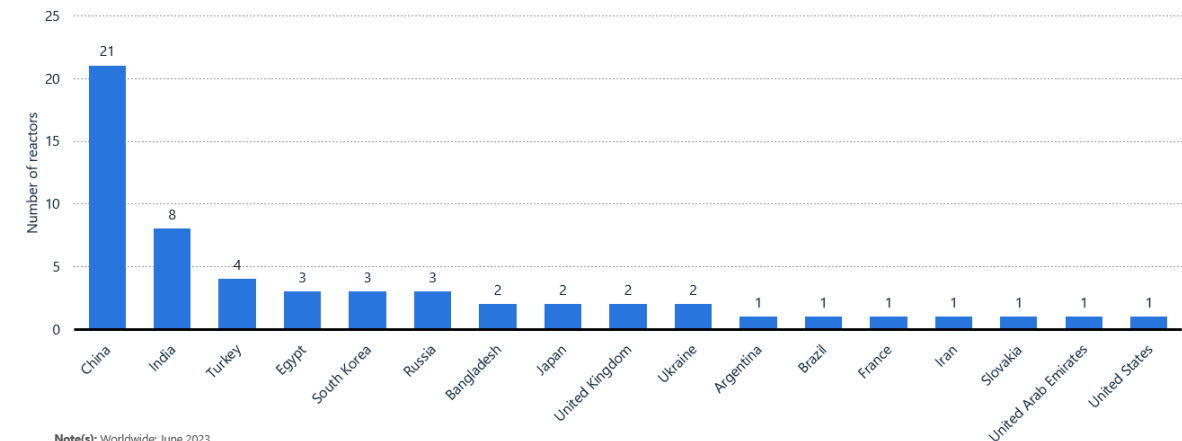
- The world has seen a significant expansion of the nuclear reactor fleet.
- 69 new nuclear power plants have been added to the world-wide grid in the last decade.
- 39 new nuclear reactors in China alone over the last decade.
- United States has two new nuclear power plant on the grid (Vogtle 3 and Watts Bar 2) in the last decade.
- 57 new nuclear power plants under construction world-wide.



<https://world-nuclear.org/information-library/facts-and-figures/reactor-database-data/>

Number of nuclear reactors under construction worldwide as of June 2023, by country

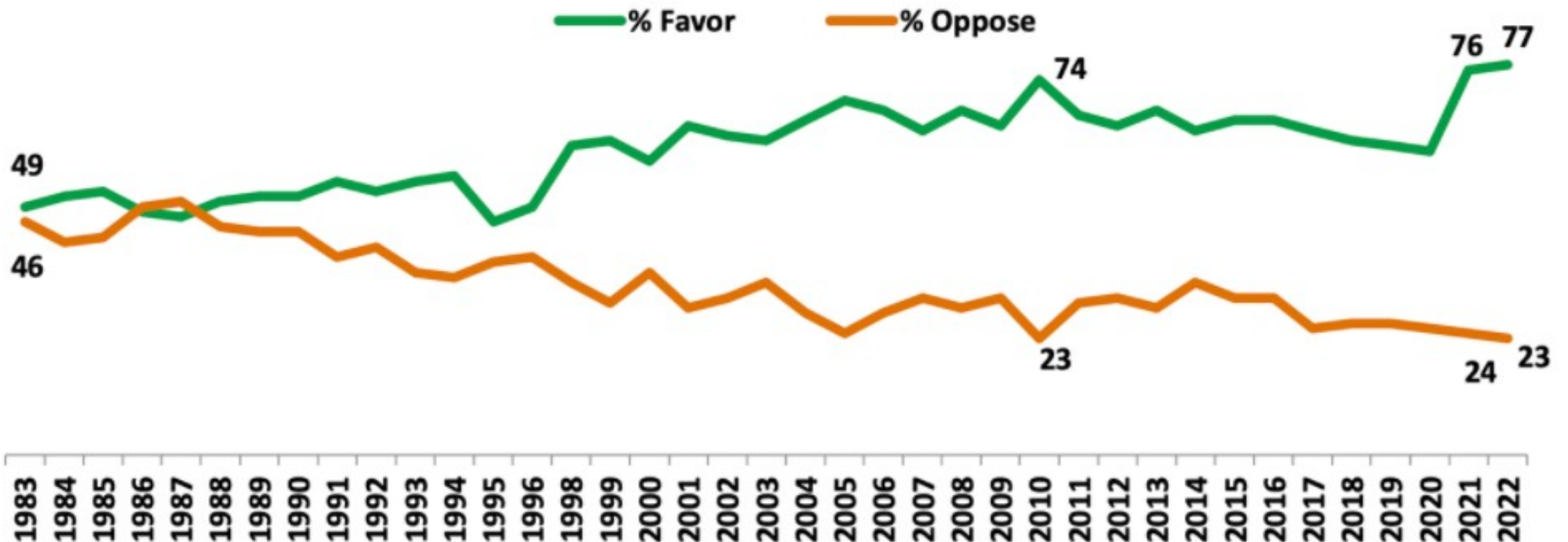
Global number of nuclear reactors under construction 2023, by country



Note(s): Worldwide; June 2023
Further information regarding this statistic can be found on page 8.
Source(s): IAEA, ID_513671

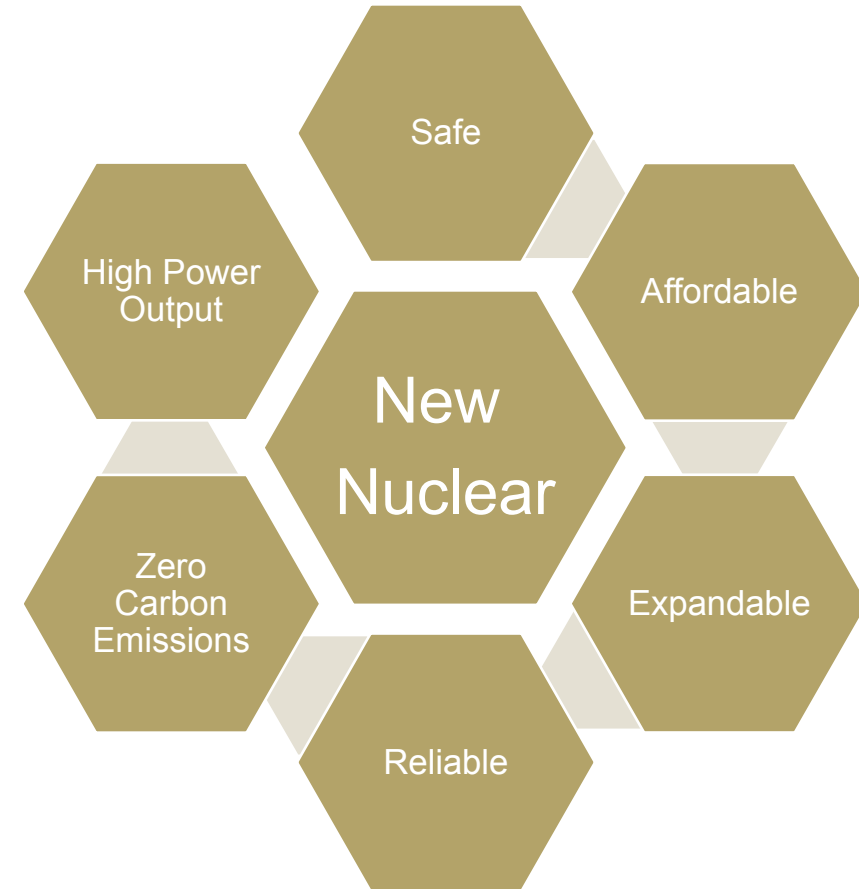
Public Perception on Nuclear Power

Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity in the United States? (%)



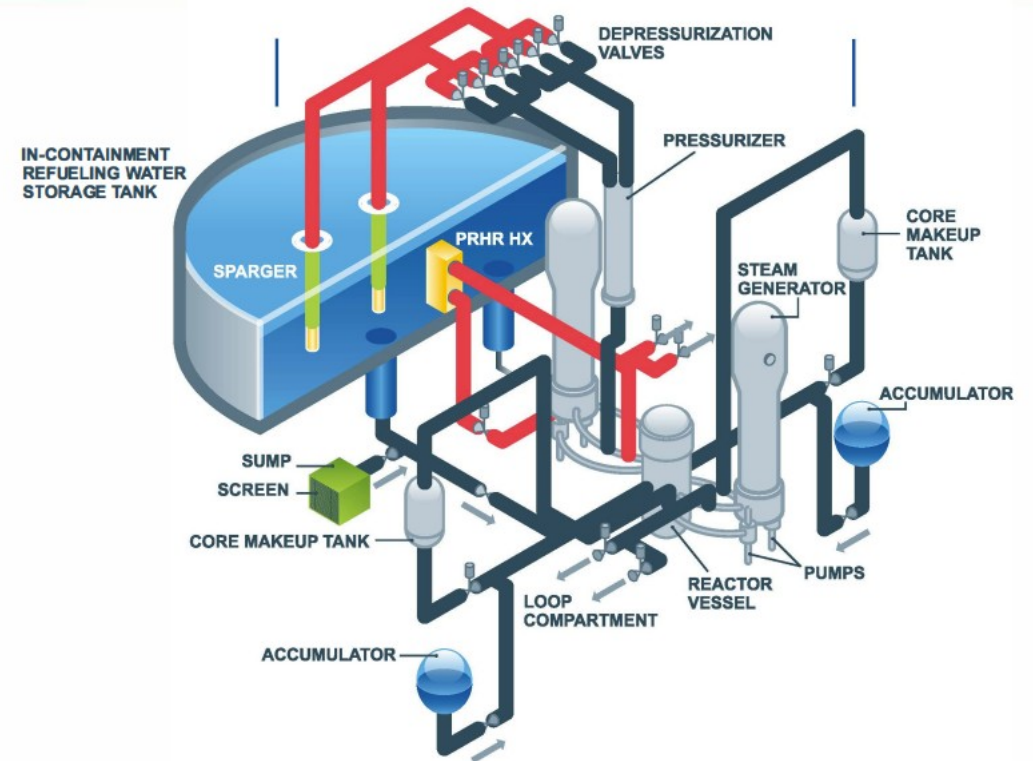
What options are available for new nuclear reactors?

- There are many new nuclear reactor designs available for consideration.
- Currently available new designs include the AP1000 design built at Vogtle 3 and 4.
- Small modular reactors (SMRs) will be available within the next five to ten years for commercial deployment.
- Advanced nuclear reactor designs will be available to start construction in the ten-to-twenty-year timeframe.
- Many new nuclear reactor designs are under development.



AP1000

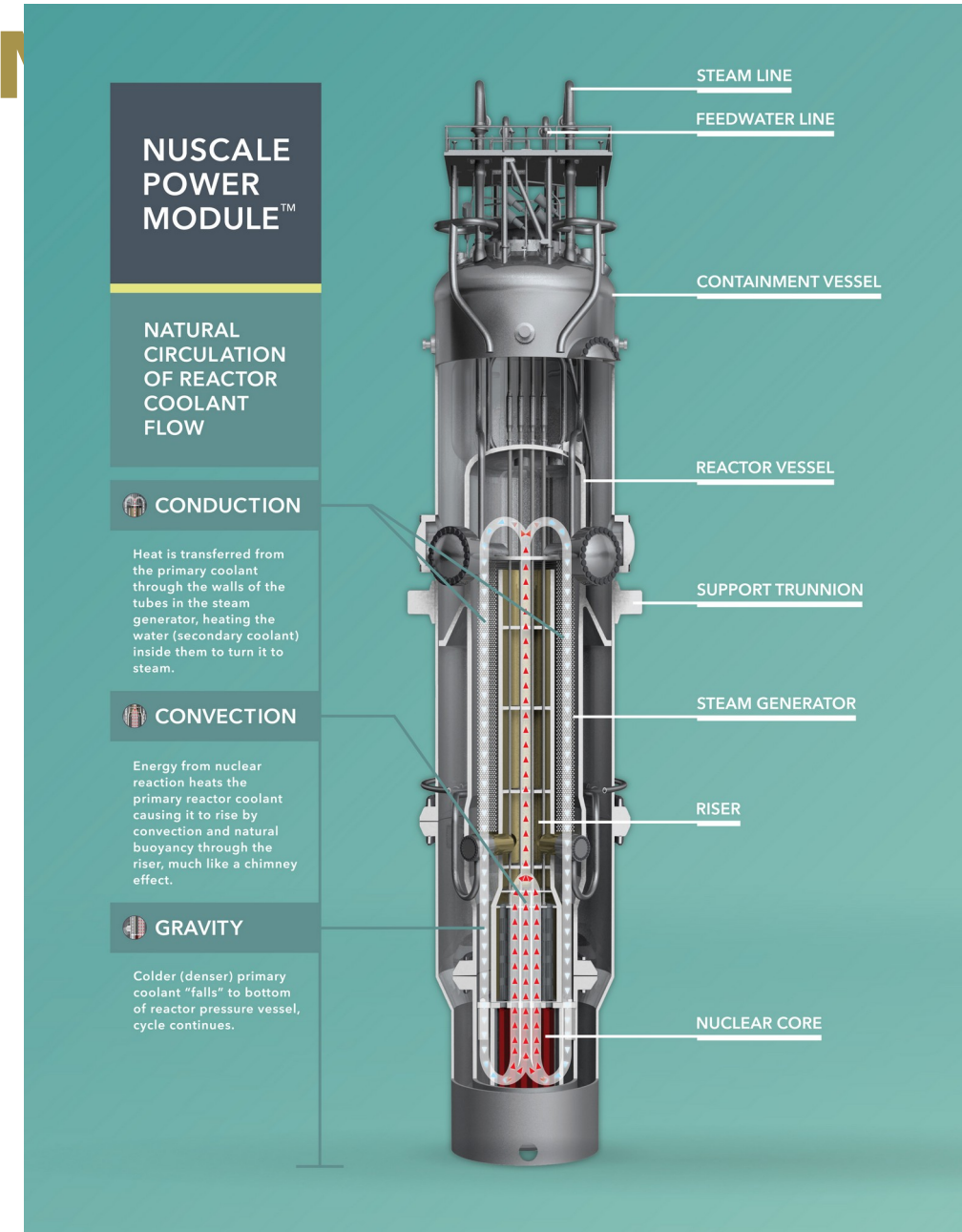
- The Westinghouse AP1000 nuclear power plant is an advanced Pressurized Water Reactor (PWR).
- The AP1000 has many advanced features including:
 - Passive safety allowing natural circulation to remove heat in a station blackout accident (e.g., Fukushima nuclear accident).
 - Increased simplicity.
 - Very low probability of core damage.
- Currently licensed in the United States.
- Success with building and operation in the United States and China.



<https://www.westinghousenuclear.com/Portals/0/New%20Plants/AP1000/AP1000%20Station%20Blackout.pdf?timestamp=1404842353431>

Small Modular Reactors (SMR)

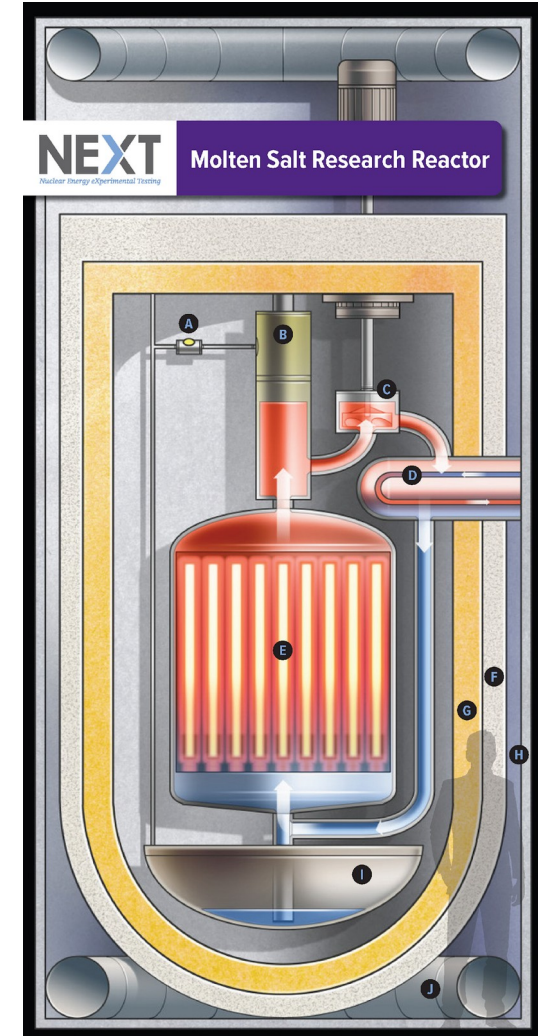
- SMRs are:
 - Smaller than most current commercial nuclear reactor designs (10% to 20% of size).
 - Modular: they can be built in factories and shipped to a site for installation. This is anticipated to improve costs and schedule for new plant construction.
 - Simpler than current commercial reactors.
 - Safer than current commercial reactors.
- Many SMR designs are under development.
- No SMRs have been built yet.
- In August of 2020, the U.S. Nuclear Regulatory Commission (NRC) approved a design for an SMR from NuScale Power, LLC.



Advanced Nuclear Reactors

- Many advanced nuclear reactor designs are under development.
- Two Molten Salt Reactors (MSRs) have submitted licensing applications to the NRC:
 - Abilene Christian University (ACU) submitted a research reactor construction permit application for a Natura Resources, LLC design.
 - Kairos Power, LLC has submitted construction permits for two test reactors.
- Research and test reactors should be built within the next five years.
- Commercial advanced nuclear reactor designs optimistically anticipated in ten years.

Natura Resources, LLC MSR Design



<https://naturaresources.org/>

Summary

- The Black Fox Nuclear Power Plant was proposed by the Public Service Company of Oklahoma (PSO) but was cancelled in 1982.
- Many factors have changed over the last forty years including:
 - Increased demand for electricity.
 - Desire to lower CO₂ emissions.
 - History of reliable nuclear power plant operations.
 - History of safe nuclear power plant operations.
 - Success in building new nuclear power plants.
 - Public opinion.
 - Options for new nuclear power plant designs with increased safety.
- Oklahoma should take these new developments into account and move towards including nuclear power as part of its electrical power plant portfolio.