

# Advancement of Nuclear Power Technologies

Steven Biegalski, Ph.D., P.E.

[sbiegalski6@gatech.edu](mailto:sbiegalski6@gatech.edu)

# 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.

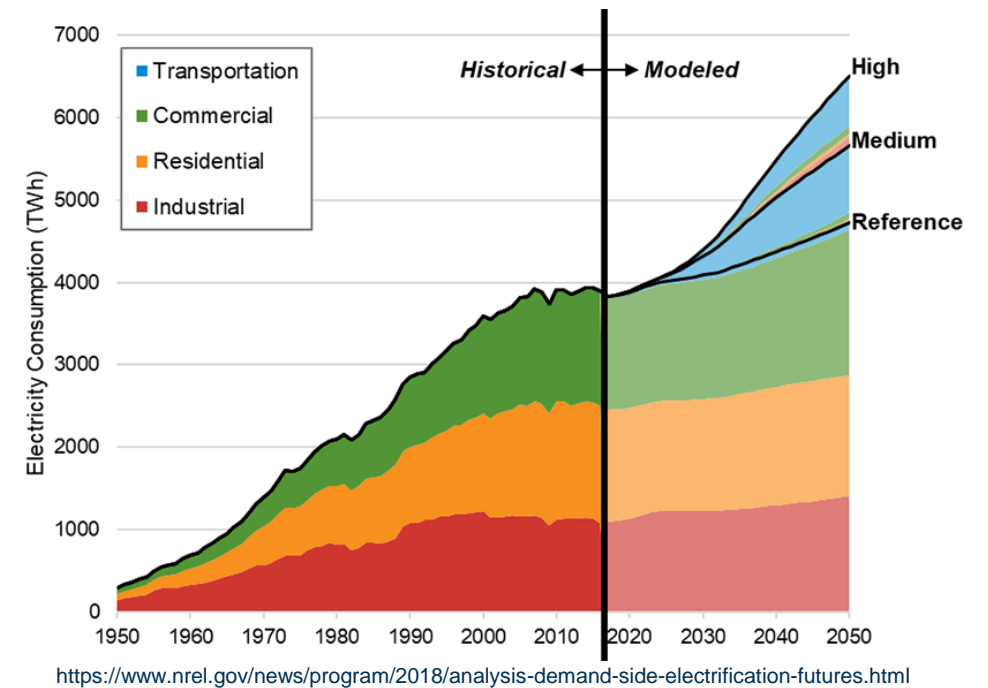


Vogtle 3 AP 1000 started operations in 2023.

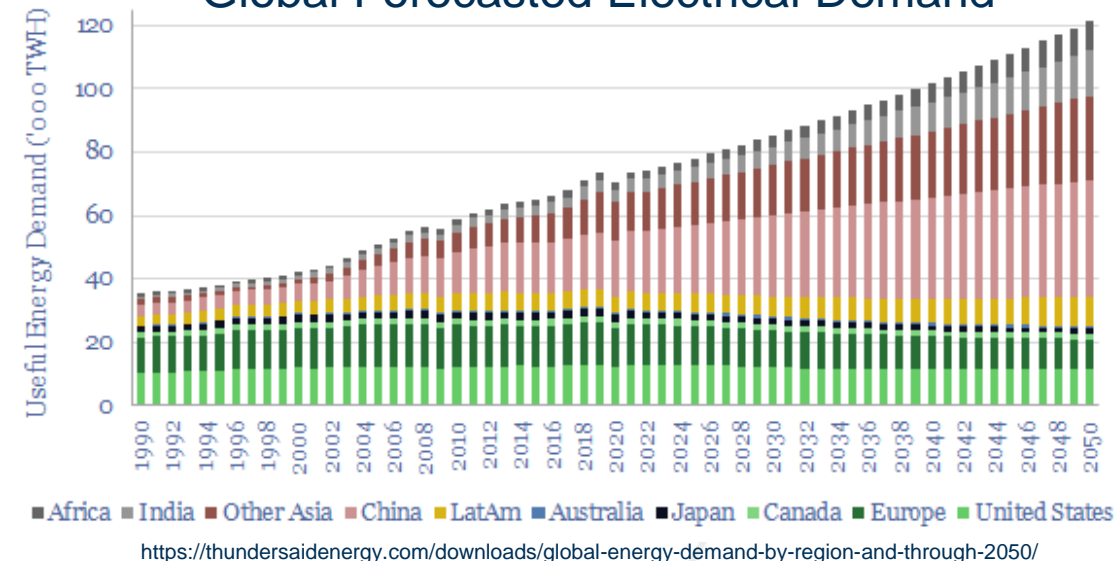
# Increased Electricity Demand

- 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

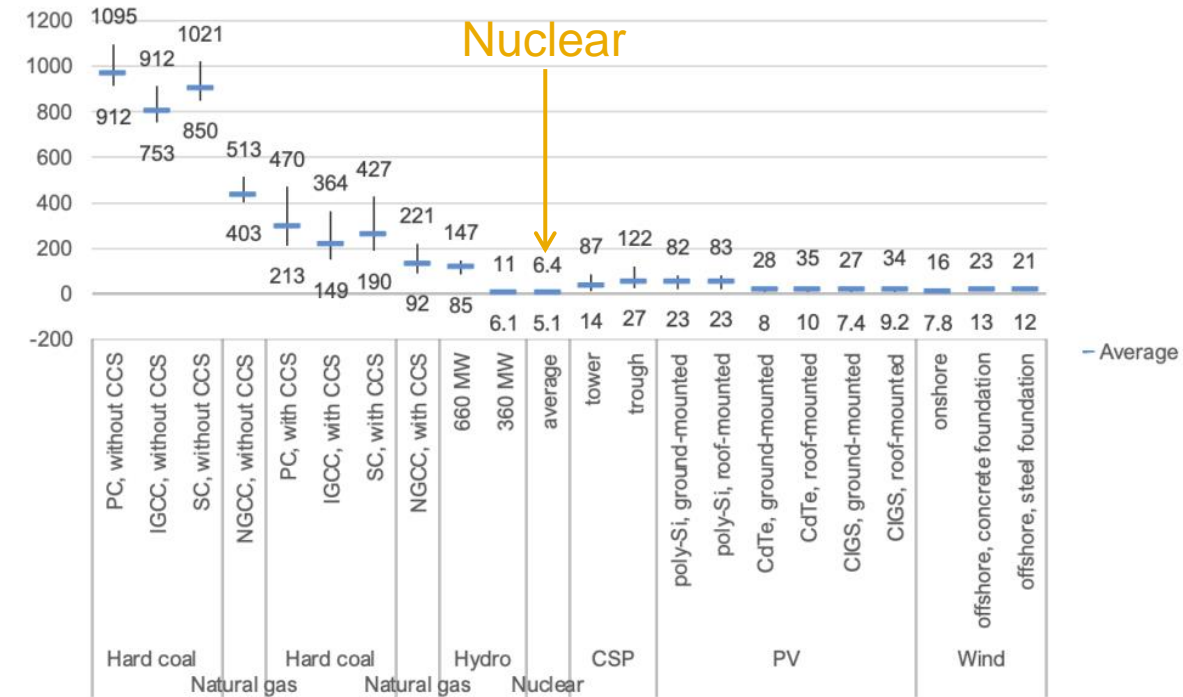


## Global Forecasted Electrical Demand

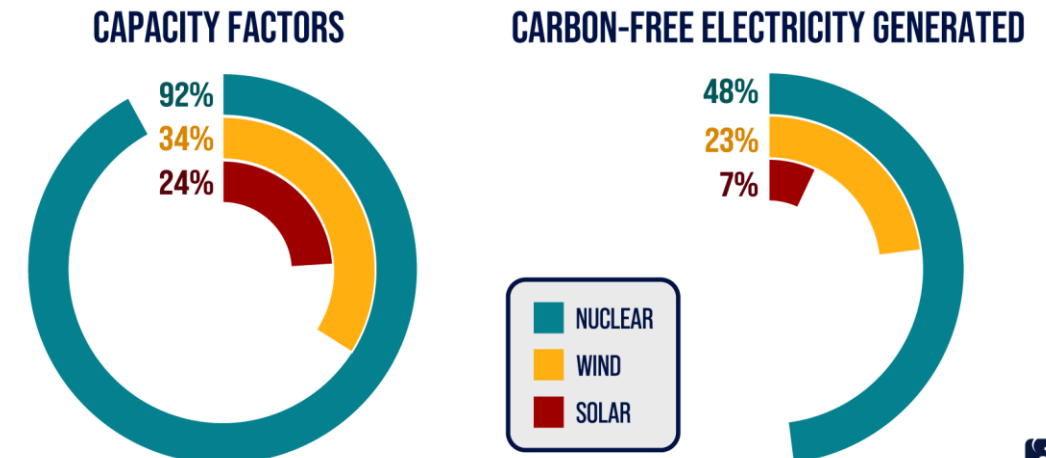


# Carbon Free Electricity

- Nuclear power is “carbon-free” meaning that it does not produce CO<sub>2</sub> 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.**



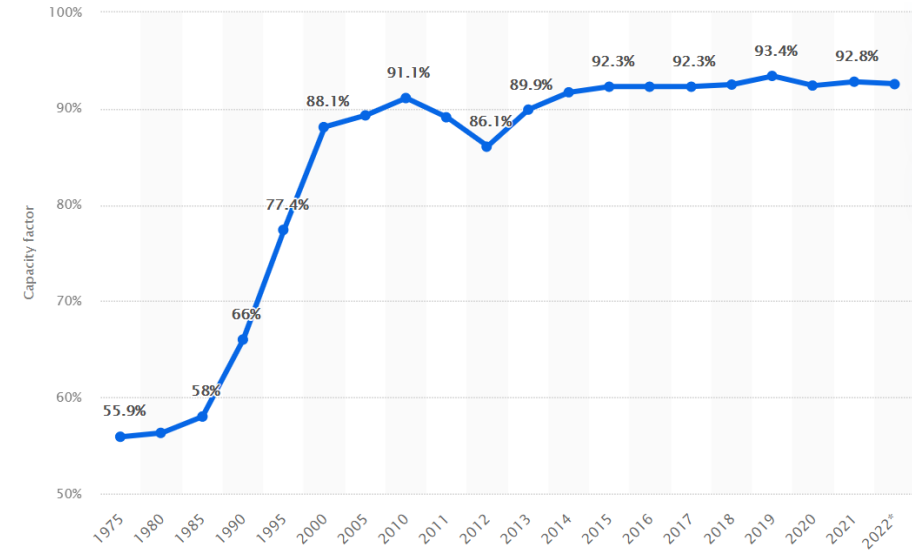
<https://world-nuclear.org/information-library/energy-and-the-environment/carbon-dioxide-emissions-from-electricity.aspx>



<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

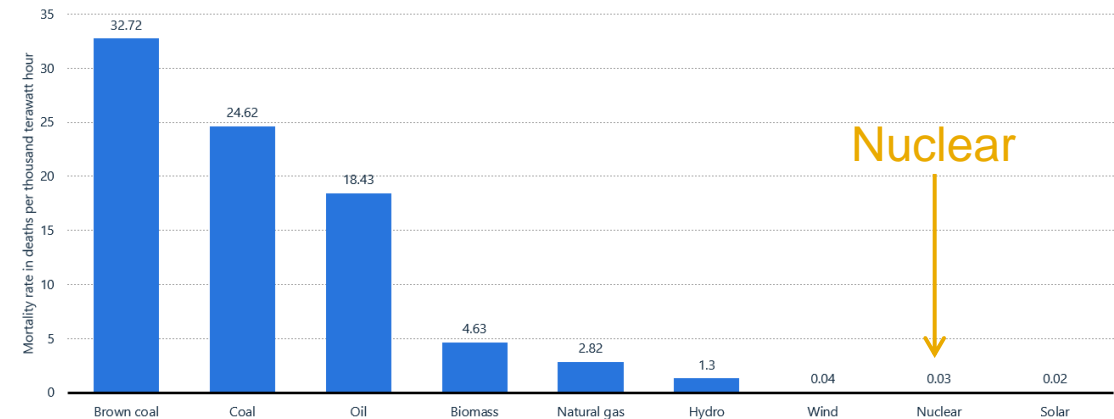
- Successful operation of the US nuclear reactor fleet has significantly increased the viability of nuclear power as a source of electricity.
- Nuclear power has the highest capacity factor of any other energy source producing reliable, carbon-free power more than 92% of the time.
- Mortality rates from 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)

Global mortality rate by energy source



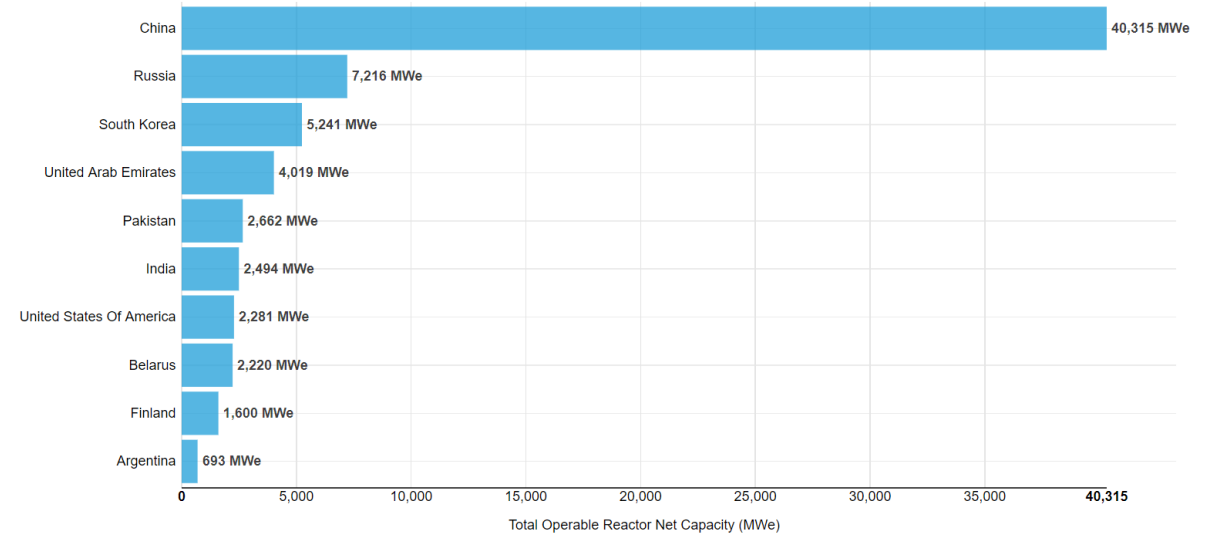
Notes: Worldwide; 2018

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

Source(s): Canary Media; OWID; Expert(s) (Markandya & Wilkinson (2007); Sovacool et al. (2016); UNSCEAR (2008; & 2018)); ID 494425

# Success in Building New Nuclear Power Plants

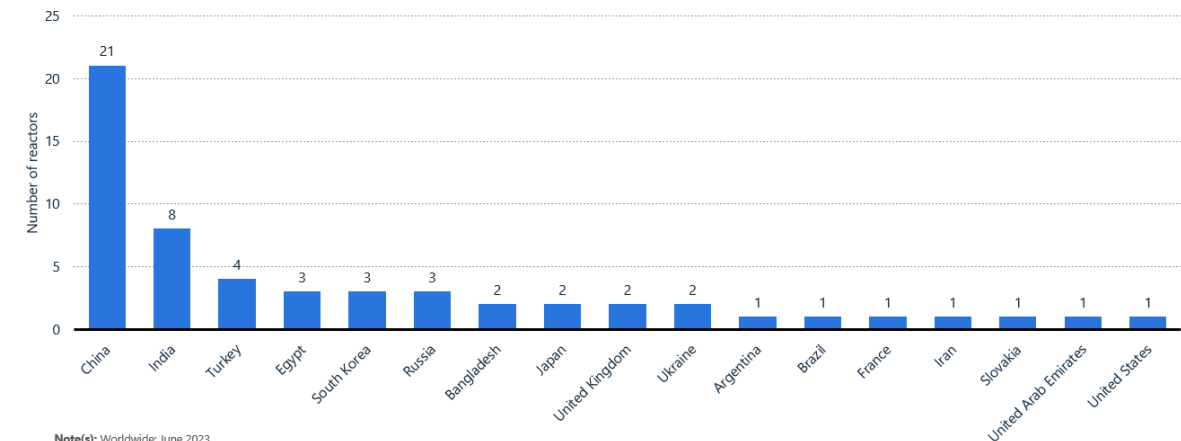
- The world has seen a significant expansion of the nuclear reactor fleet.
- 69 new nuclear power plants have been added to the world-wide grid in the last decade.
- 39 new nuclear reactors in China alone over the last decade.
- United States has two new nuclear power plant on the grid (Vogtle 3 and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

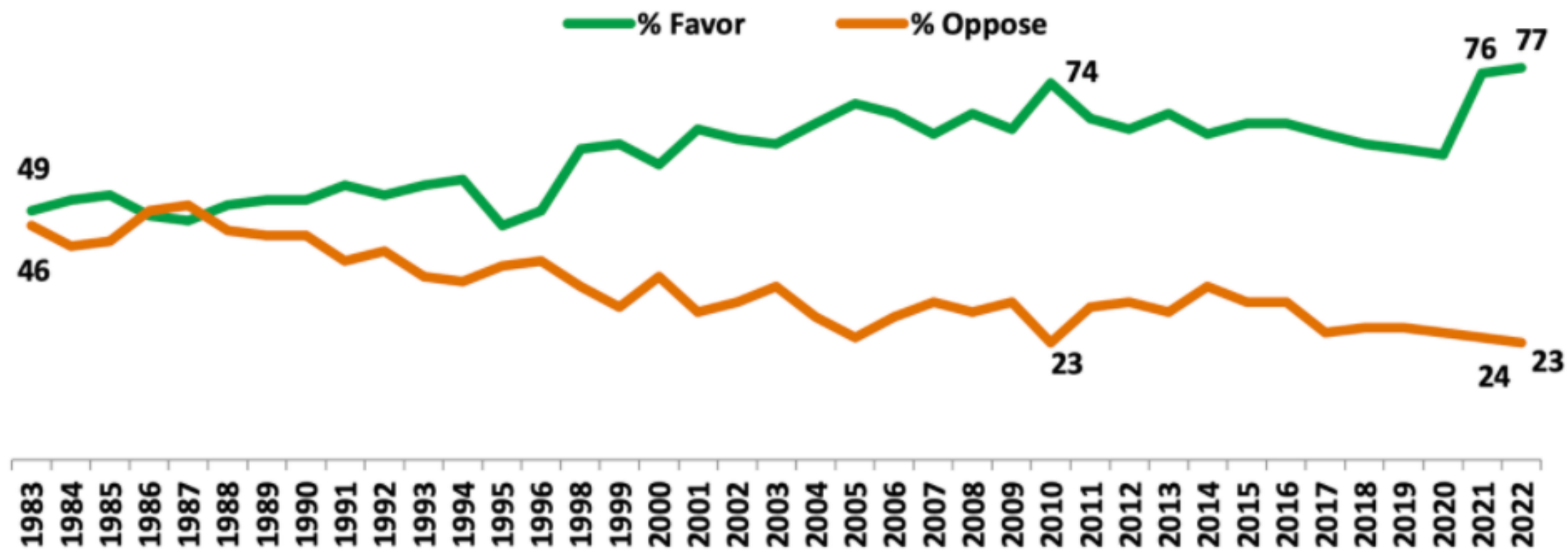


**Note(s):** Worldwide; June 2023  
Further information regarding this statistic can be found on page 8.  
**Source(s):** IAEA; ID 513671



# 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? (%)*





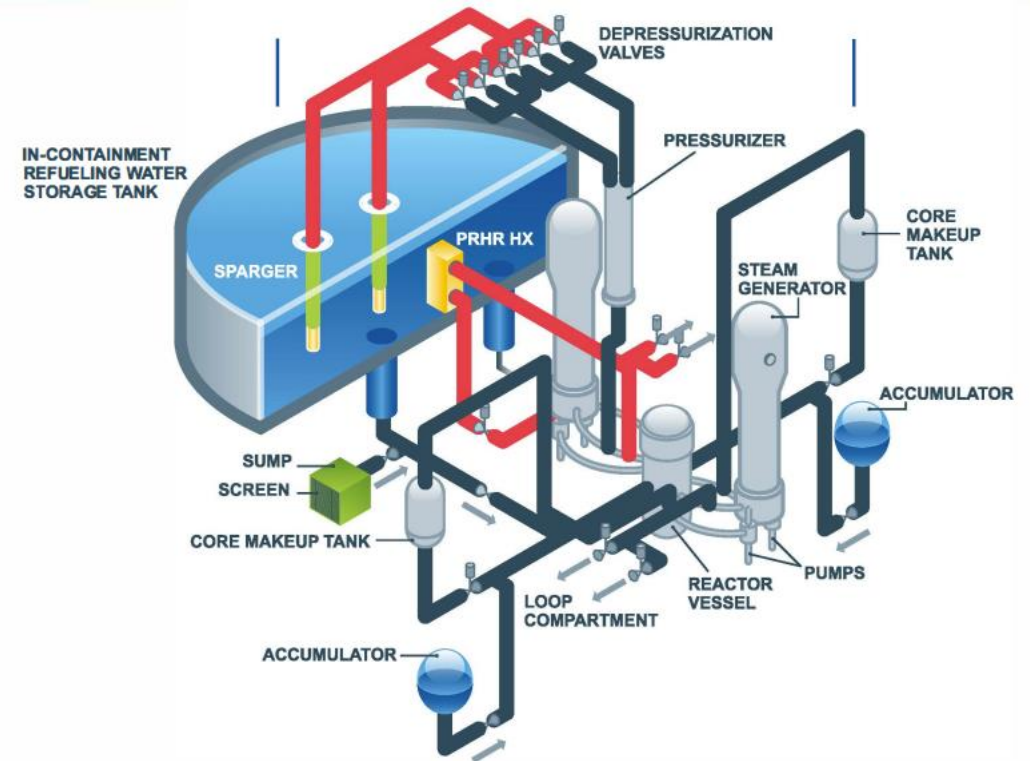
# What options are available for new nuclear reactors?

- 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

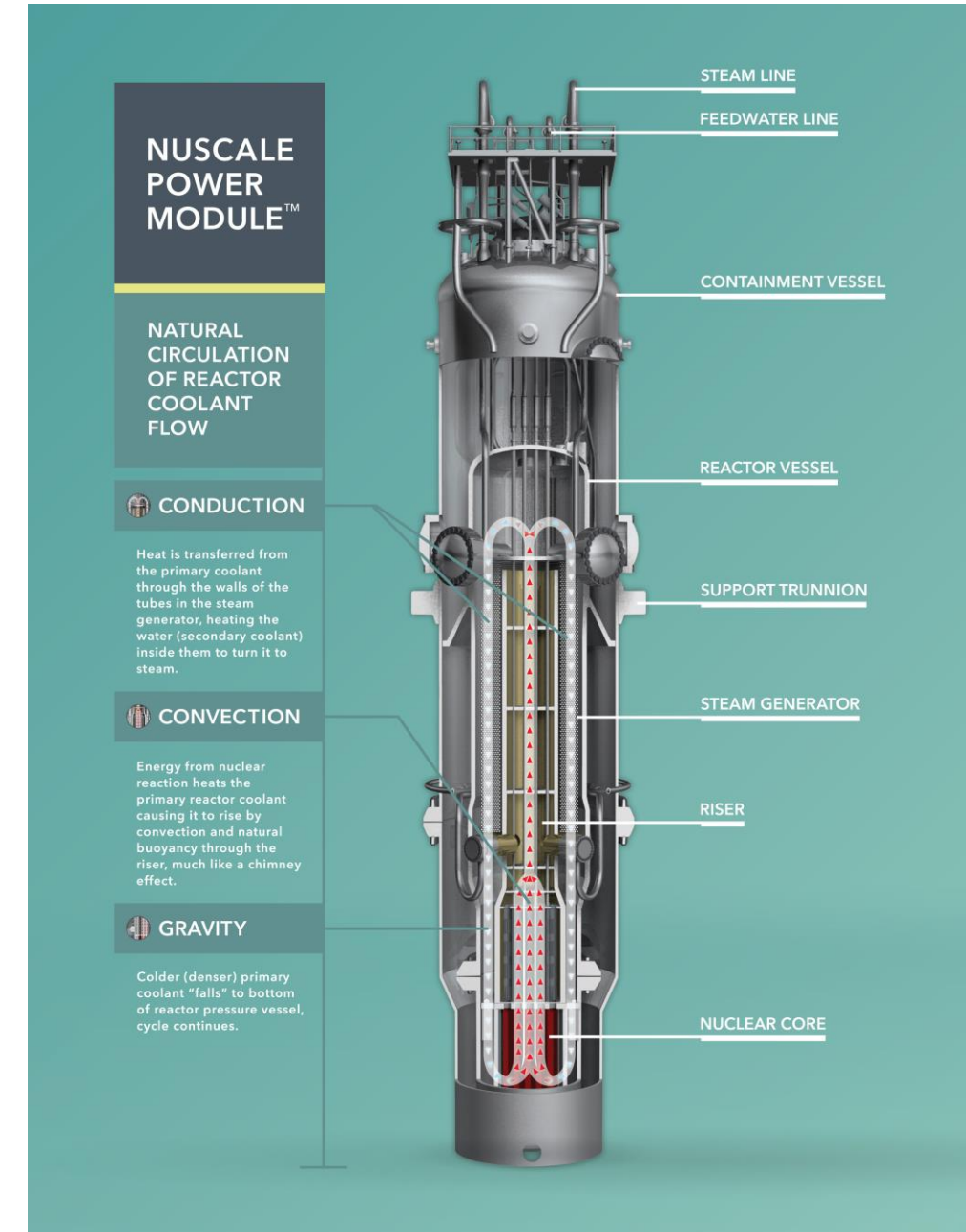
- The Westinghouse AP1000 nuclear power plant is an advanced Pressurized Water Reactor (PWR).
- The AP1000 has many advanced features including:
  - Passive safety allowing natural circulation to remove heat in a station blackout accident (e.g., Fukushima nuclear accident).
  - Increased simplicity.
  - 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 (SMRs)

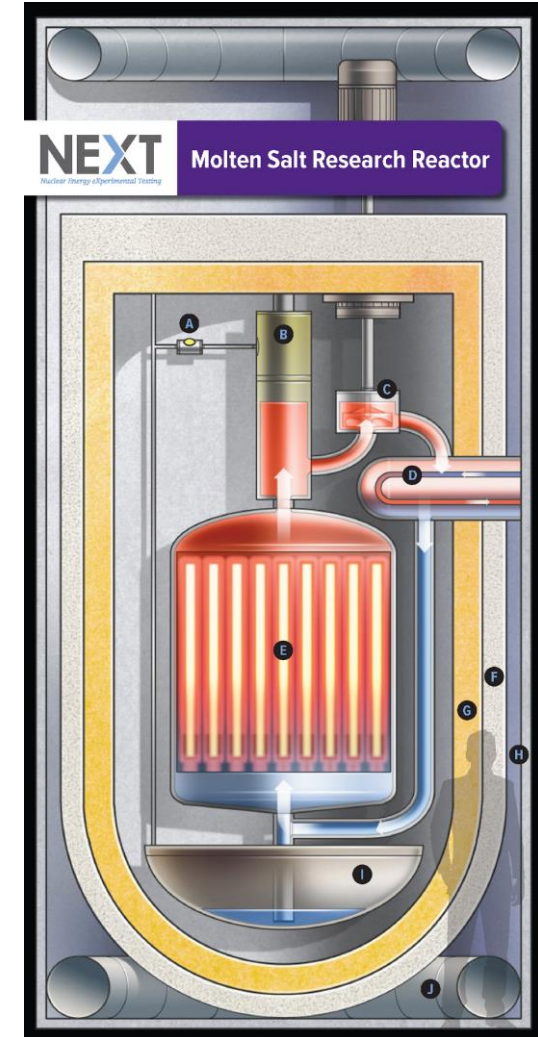
- SMRs are:
  - Smaller than most current commercial nuclear reactor designs (10% to 20% of size).
  - Modular: they can be built in factories and shipped to a site for installation. This is anticipated to improve costs and schedule for new plant construction.
  - Simpler than current commercial reactors.
  - 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 Reactor (MSR) projects 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 are 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 support the use of nuclear power in Oklahoma:
  - Increased demand for electricity.
  - Desire to lower CO<sub>2</sub> emissions.
  - History of reliable nuclear power plant operations.
  - History of safe nuclear power plant operations.
  - Success in building new nuclear power plants.
  - Positive public opinion.
  - 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 infrastructure.