

# **WILL YOU FEEL SAFER LIVING NEXT TO A SODIUM COOLED FAST REACTOR, SUCH AS THE NATRIUM DEMONSTRATION PROJECT?**

PREPARED BY

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## Outline

- Overview of NRC Regulations impacting SMRs
- Pictures of a Pressured Water Reactor (PWR) and the Natrum Demonstration Project, a Sodium Cooled Fast Reactor Being Planned for Construction in Kemmerer, Wyoming
- Comparison of Key Metrics of a PWR and a Sodium Cooled Fast Reactor
- Advantages and Disadvantages of a Sodium Cooled Fast Reactor as Compared to a PWR
- Conclusions

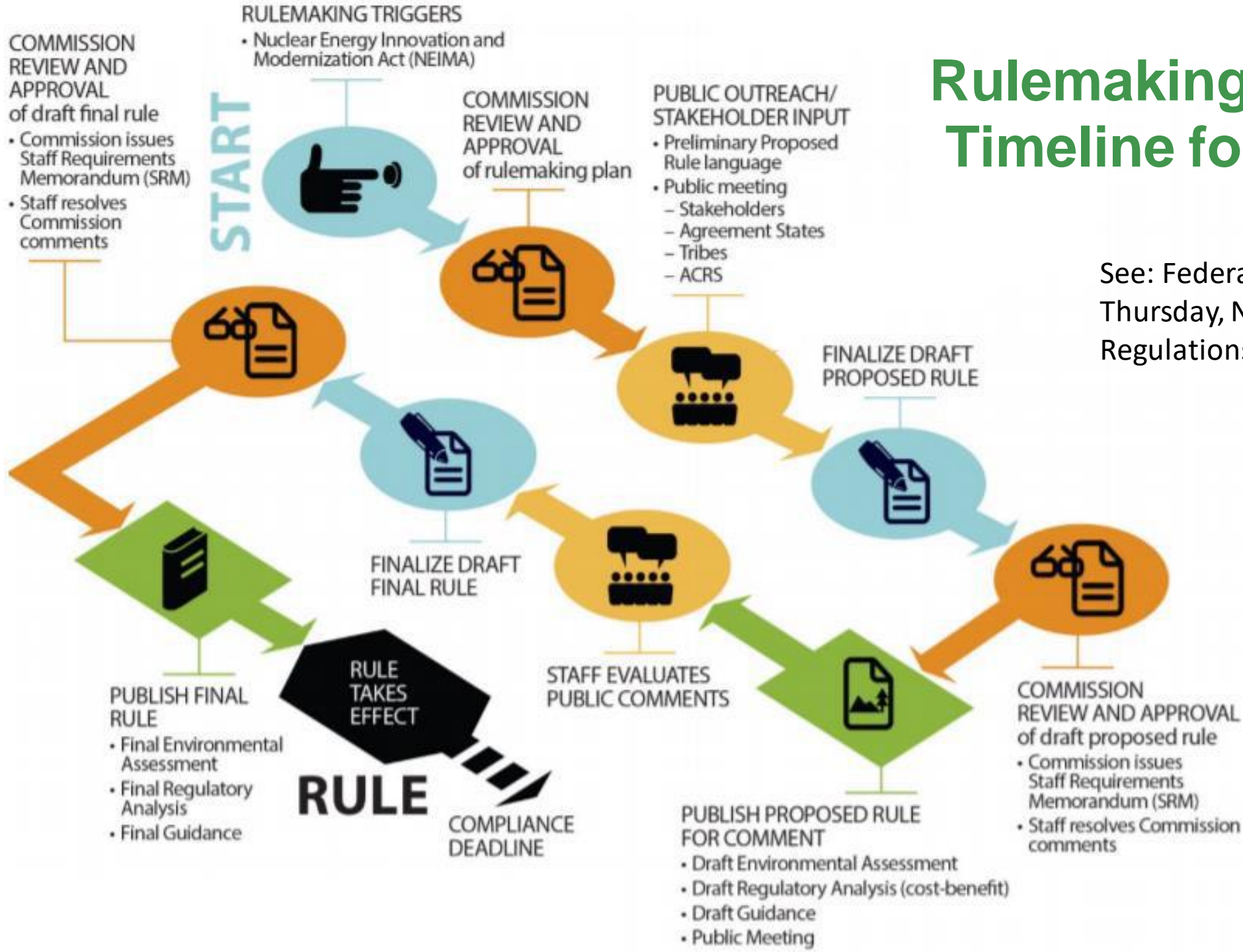
# Examples of SMR/Advanced Reactor Types

- Terrapower Natrium
- The following covered by Joe C:
  - NuScale
  - GE BWXT-300
  - Holtec SMR-300
  - AP - 300
  - Westinghouse eVinci

# Regulation for a New Generation of Nuclear Energy

- A new generation of nuclear energy requires an appropriate regulatory system. U.S. and other countries' regulatory regimes are designed around the characteristics of traditional light water reactors.
- Advanced reactors can be licensed through the existing U.S. regulatory framework under 10 CFR Part 50 and 52 rules implementing the Atomic Energy Act.
- NuScale received its NRC design certification, but currently has no customer committed to build.
- DOE Advanced Reactor Demonstration Program awardees will be applying for licenses under the current framework.
- The NRC continues to operationalize risk-informed, performance-based, technology-inclusive regulation per the Nuclear Energy Innovation and Modernization Act (NEIMA).
- The goal is to make the licensing of new reactors affordable, certain, and timely to enable the rapid build out of clean nuclear energy while continuing to meet high standards.
- A new licensing pathway under development (next slide).

# Rulemaking Plan and Timeline for Part 53



See: Federal Register / Vol. 88, No. 220 / Thursday, November 16, 2023 / Rules and Regulations (NEXT SLIDE)

# Emergency Preparedness for Small Modular Reactors and Other New Technologies

The U.S. Nuclear Regulatory Commission (NRC) is amending its regulations to include new alternative emergency preparedness requirements for small modular reactors and other new technologies.

This final rule acknowledges technological advancements and other differences from large light-water reactors that are inherent in small modular reactors and other new technologies.

The NRC is concurrently issuing Regulatory Guide 1.242, “Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities.”

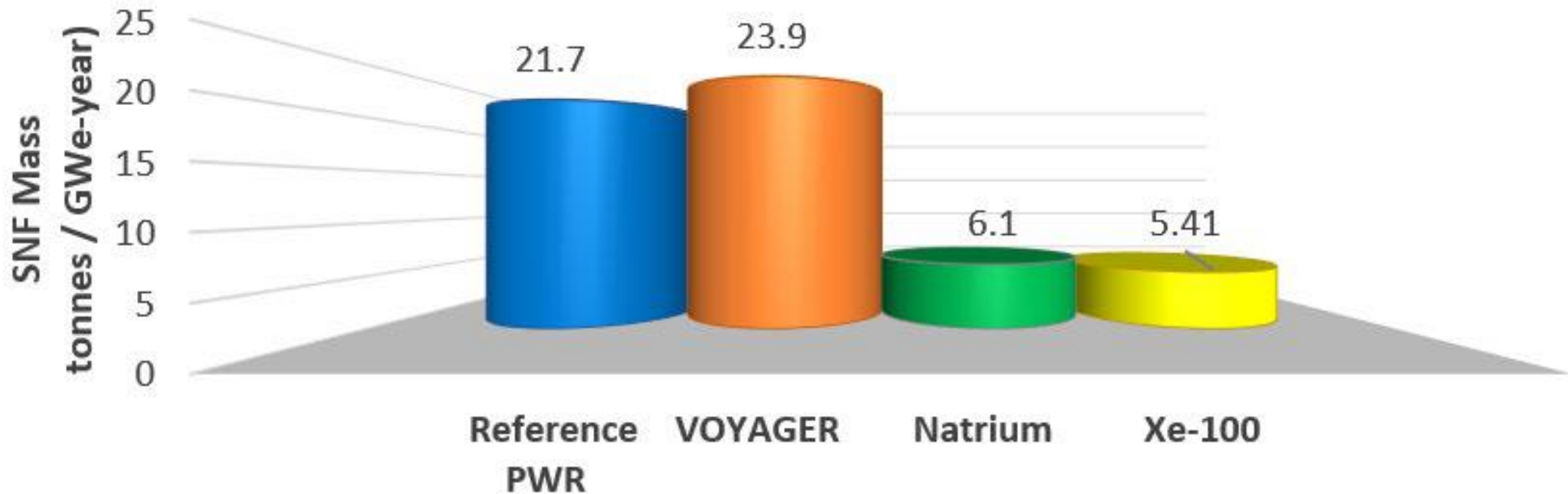
**DATES:** This final rule is effective on December 18, 2023.

## Spent Nuclear Fuel from Advanced Reactors:

Advanced reactors offer opportunities to change the conversation about SNF.

Numerous advanced reactor designs, such as Oklo's Aurora Powerhouse reactor, plan to run on fuel recycled from existing SNF stockpiles.

Additionally, advanced reactor designs generally offer greater efficiency and better utilization of nuclear fuel, reducing the rate at which SNF is generated per unit of nuclear energy produced.





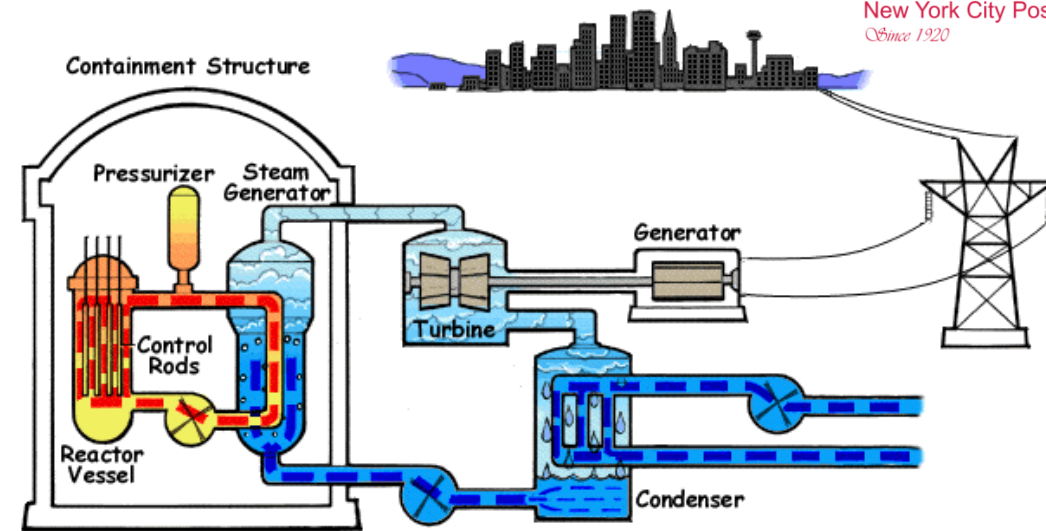
# LWR vs Sodium Fast Reactors

- Shown are Pressured Water Reactor (PWR) and the Natrum Demonstration Project, a Sodium Cooled Fast Reactor Being Planned for Construction in Kemmerer, Wyoming

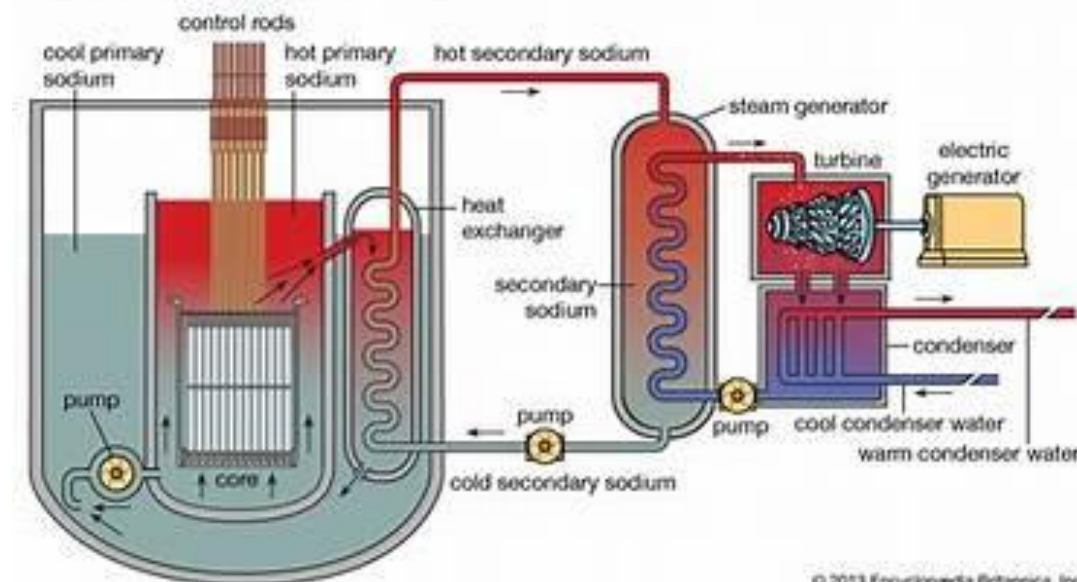
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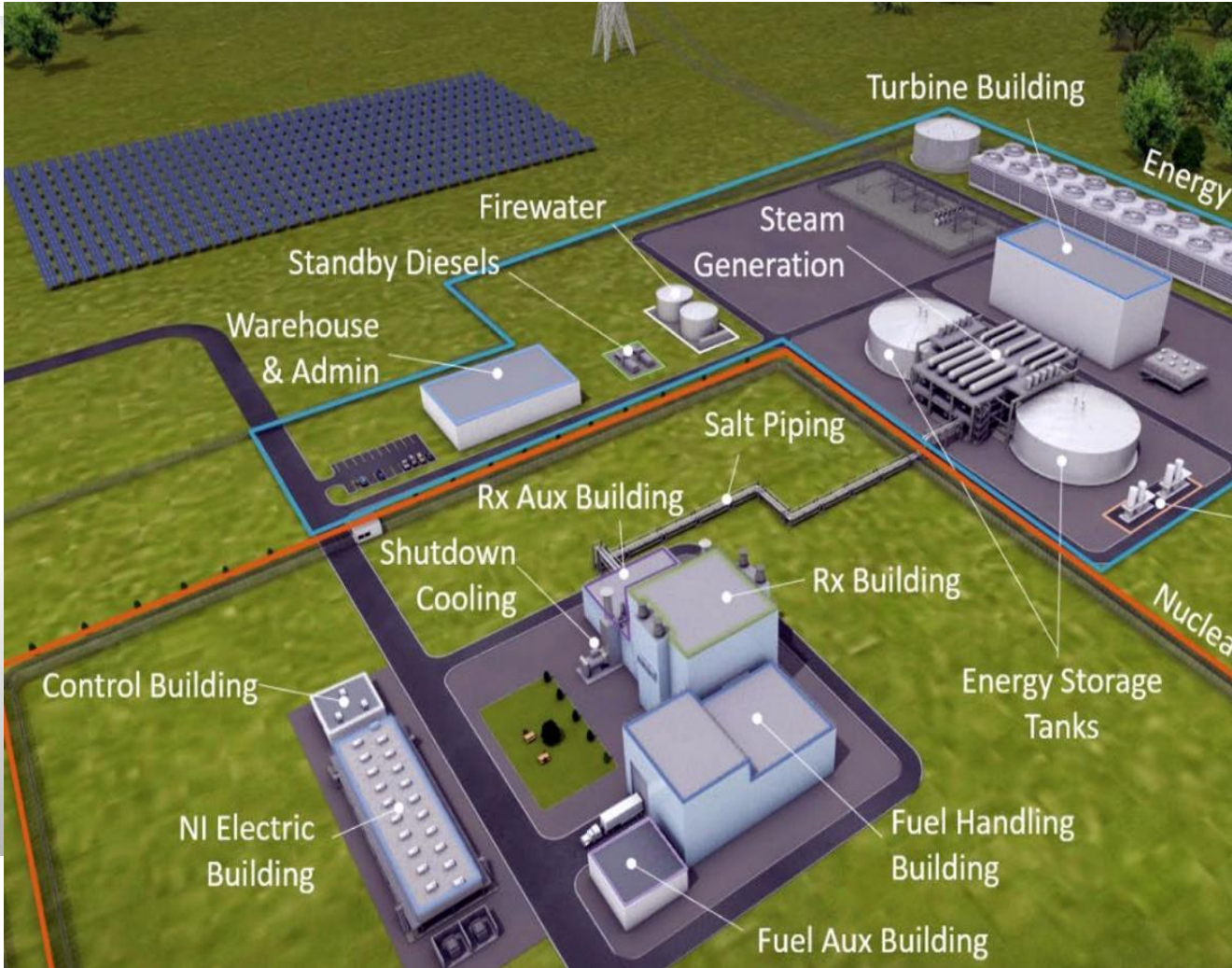
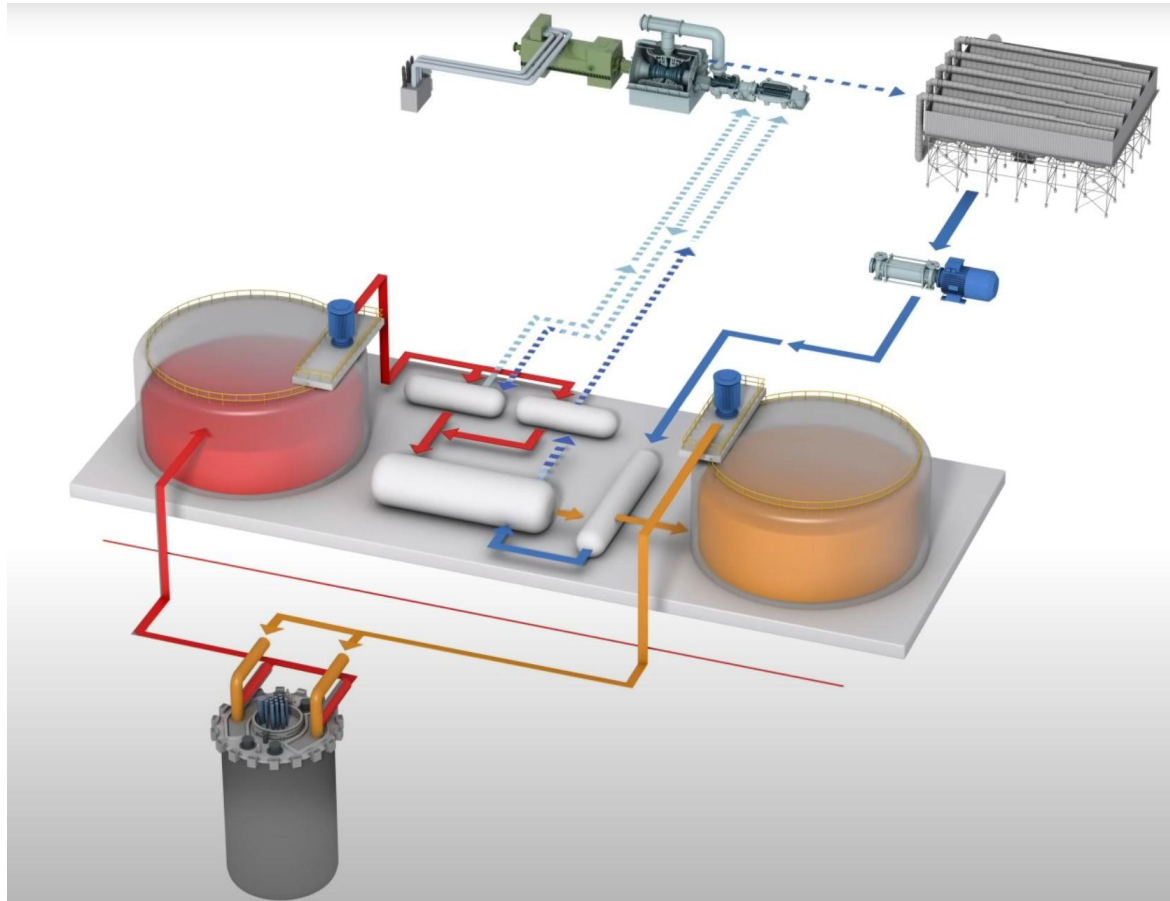
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Sodium-cooled liquid-metal reactor



# Natrium Fast Reactor under NRC Licensing Review

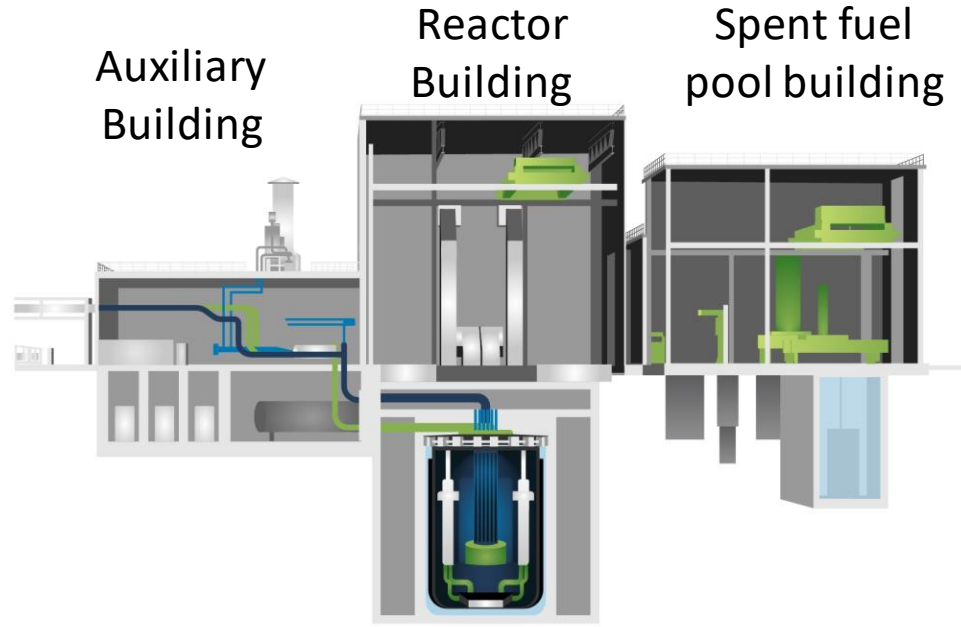
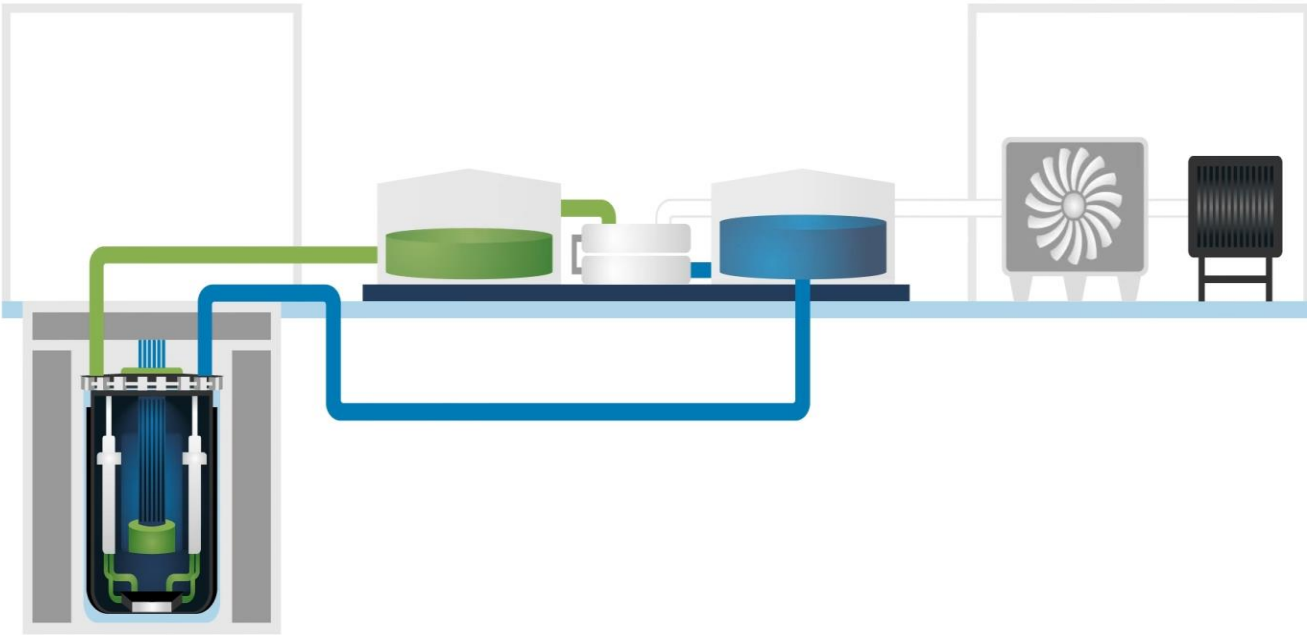




# The Natrium reactor is a TerraPower and GE-Hitachi technology:

A 345 MWe sodium fast reactor coupled with a molten salt-based integrated energy storage system

- With a sodium fast reactor, integrated energy storage and flexible power production, the Natrium technology offers carbon-free energy at a competitive cost and is ready to integrate seamlessly into electric grids with high levels of renewables.



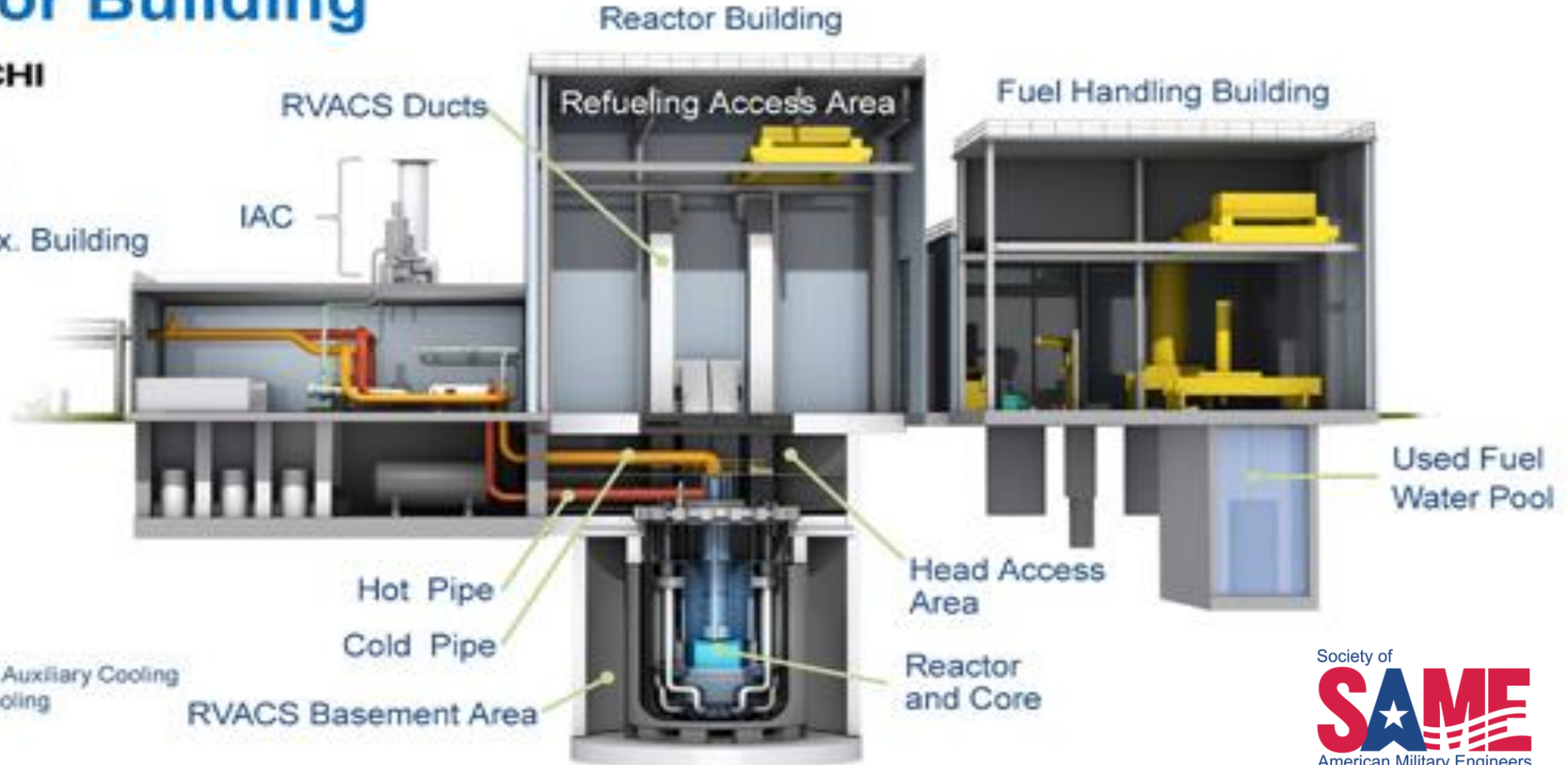
# The TerraPower Sodium reactor is a 345 MWe pool type sodium fast reactor using HALEU metal fuel

## Reactor Building



TerraPower

Reactor Aux. Building



RVACS: Reactor Vessel Auxiliary Cooling  
IAC: Intermediate Air Cooling



# KEY METRICS



| <u>Metrics</u>              | <u>Natrium</u>    | <u>Typical PWR</u> |
|-----------------------------|-------------------|--------------------|
| • Power Level               | 343 Mwe           | 1000 Mwe           |
| • Coolant                   | Liquid Sodium     | Light Water        |
| • Coolant Exit Temperatures | 350 °C            | 325 °              |
| • Pressure                  | Atmospheric       | 153 Atmoshere      |
| • Neutron Energy            | average > 1 MeV   | 0.025 eV           |
| • Fuel Enrichment           | 5% to 20%         | 4%                 |
| • Coolant Temperature       | 662 °F            | 599 °F             |
| • Boiling Point of Coolant  | 1621 °F or 883 °C | 212 °F or 100 °C   |
| • Thermal Efficiency        | > 40%             | < 35%              |

## KEY METRICS cont'd

| <u>Metrics</u>              | <u>Natrium</u>                | <u>Typical PWR</u>            |
|-----------------------------|-------------------------------|-------------------------------|
| • Coolant Temperature       | 662 °F                        | 599 °F                        |
| • Boiling Point of Coolant  | 1621 °F or 883 °C             | 212 °F or 100 °C              |
| • Thermal Efficiency        | about 40%                     | <35%                          |
| • Construction Cost         | \$1 billion                   | \$6 billion                   |
| • Refueling                 | 1/7 <sup>th</sup> core/18 mo. | 1/3 <sup>rd</sup> core/18 mo. |
| • Coefficient of Reactivity | Negative                      | Negative                      |
| • Operations                | Baseload & Load Follow        | Baseload Only                 |
| • Power Cost                | 5 cents/Kw hr                 | 2-3 cents/Kw hr               |



# IMPORTANT ATTRIBUTES OF NATRIUM (SODIUM COOLED FAST RECTOR IN GENERAL)

High Assay Low Enrichment Fuel (HALEU) (5% to 20% enrichment as compared to 4%) allows the reactor to operate using fast neutrons and for longer periods of time before refueling. This allows for:

- burnup of much more U-235 and transuranics,
- thereby reducing the need for reprocessing the fuel,
- leaving only relative short-lived radionuclides in the spent fuel, which
- simplifies spent fuel disposal, and
- reduces concerns over nuclear proliferation

Operating at atmospheric pressure (as opposed to 153 atm. For PWRS) allows for:

- much smaller containment,
- reduces potential for atmospheric radionuclide releases following an accident, and
- lower cost due to less need for thick steel piping and concrete.

# Critics Cite Disadvantages (See Union of Concerned Scientists report on the web)

<https://www.ucsusa.org/resources/small-modular-reactors>

1. Sodium reacts violently with water
2. Claims about lower costs, reduce nuclear waste, burn uranium more efficiently, strengthen safety, and lower the risk of nuclear proliferation are unsubstantiated

## Conclusions

- Engineering evidence, Federal (DOE) support for risk avoidance, High investor interest and community interest in at least one location outside of government research locations supports SMR technology.
- Enough talking and it is time to build, operate, and evaluate sodium cooled fast reactors as another technology that would reduce our use of fossil fuels.