

Small Modular Nuclear Reactors - Challenges and Opportunities

Mohammad Modarres

Center for Risk and Reliability

Nicole J. Kim Professor of Engineering

Professor of Nuclear Engineering

Talk Give at the Workshop on

Powering AI: Is Nuclear the Answer?

Environmental Sciences & Policy Programs

University of Maryland

17 April 2025



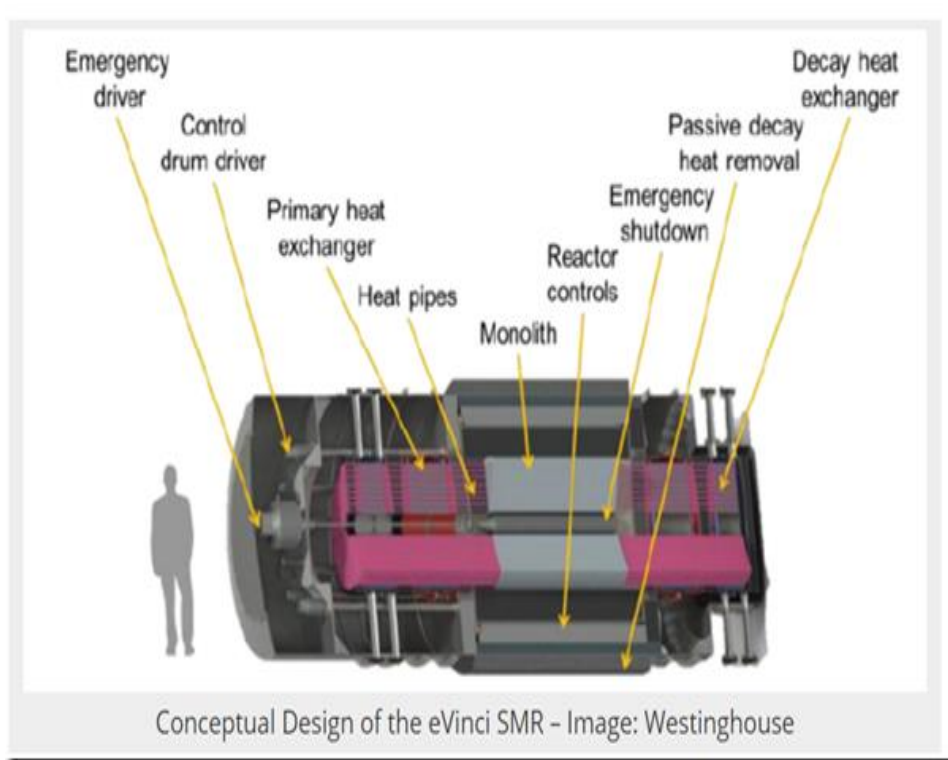
CENTER FOR
RISK AND RELIABILITY

SMR Features

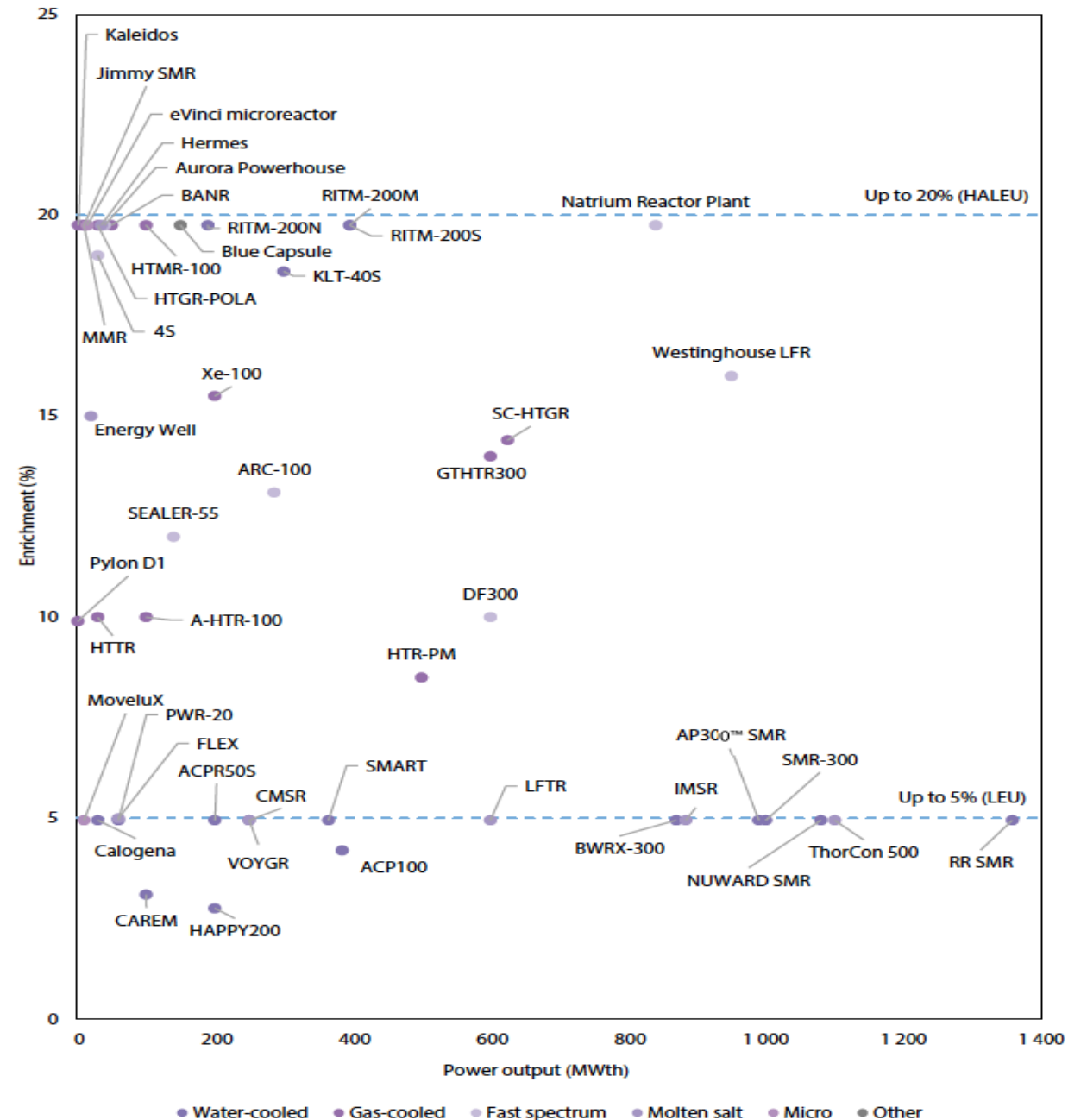
- **Compact Size:** Typically, under 300 MWe
- **Modular Construction:** Factory-built modules, faster built, cost-effective and scalable
- **Enhanced Safety:** Use passive safety systems in normal operations and emergencies.
- **Versatile Deployment:** Suitable for remote areas, industrial applications, and integration with renewables.
- **Lower Initial Investment:** Reduced upfront capital costs.
- **Micro vs. SMR:** SMRs mostly rely on transmission grid integration while microreactors are standalone.

SMR Designs

- Small in physical size
- Many designs under development

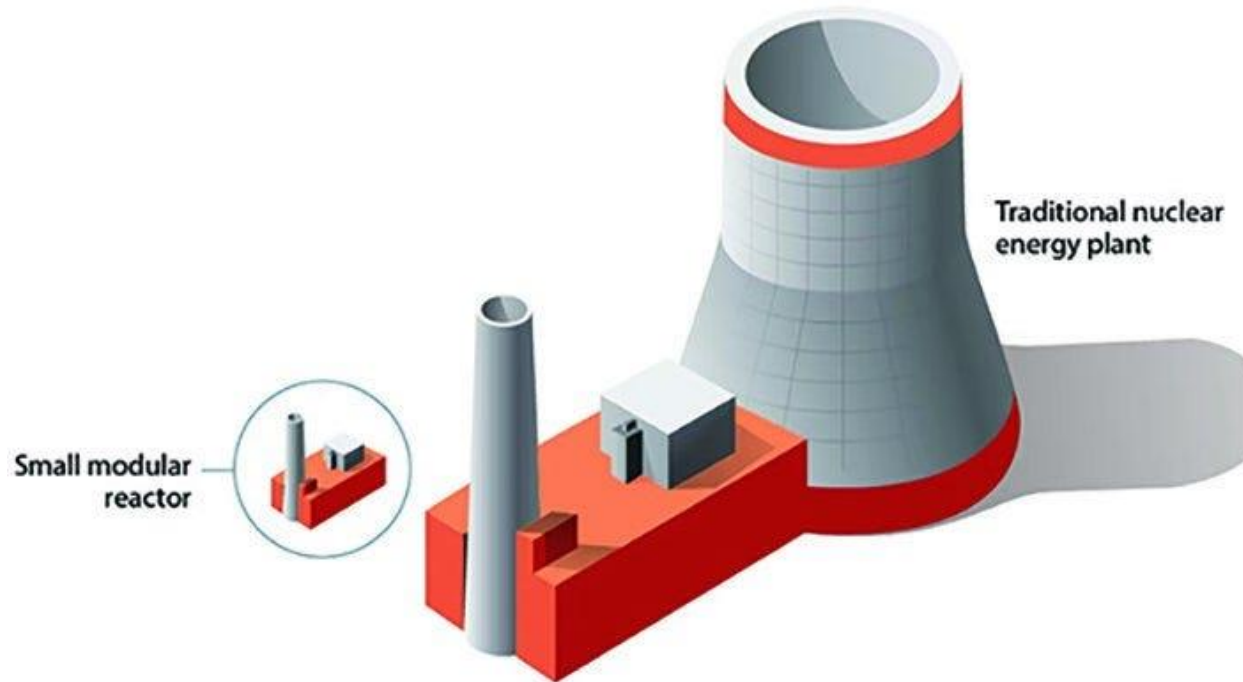


Source: <https://www.energy.gov/ne/downloads/infographic-what-nuclear-microreactor-0>



Source: The NEA Small Modular Reactor Dashboard: Second Edition (NEA, 2024).

Minimal Land Use - Small Exclusion Zones

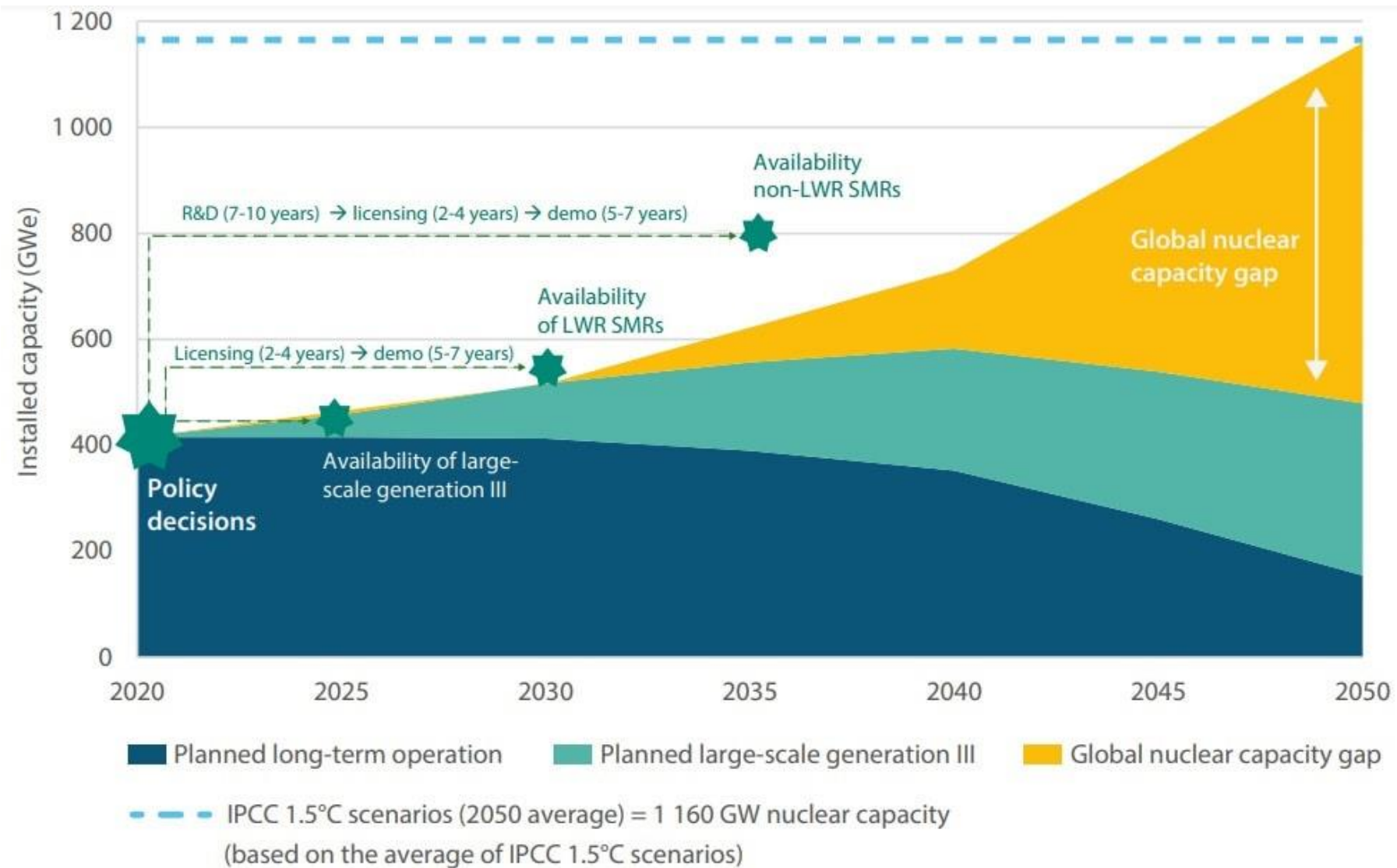


- **Land Use for 1 GWth Power Plant (Sq. miles)**

- **Nuclear: 1**
- **SMR: 0.5**
- **Solar: 16**
- **Wind: 49**

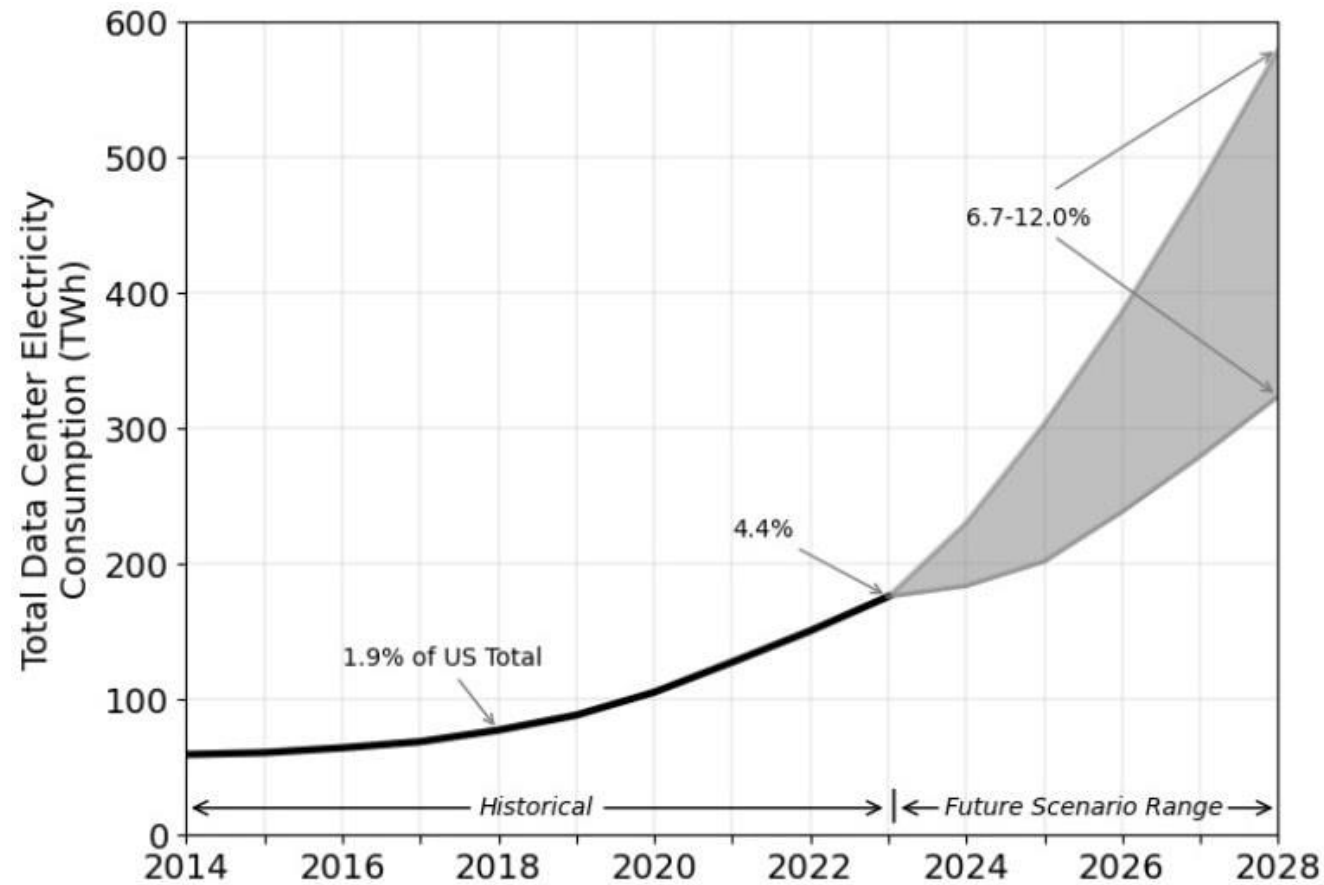
- Data Centers, depending on their size, need 1-100 Mwe power.
- Using above data, a 100 Mwe needs 0.15 (square mile) area.

Forecast Global Nuclear Capacity



Source: OECD Nuclear Energy Agency (NEA)

Data Center Energy Usage



Source: Berkeley Lab's 2024 United States Data Center Energy Usage Report, December 2024



SMRs & Data Center-DOE Report-2025

Nuclear Options for Data Centers

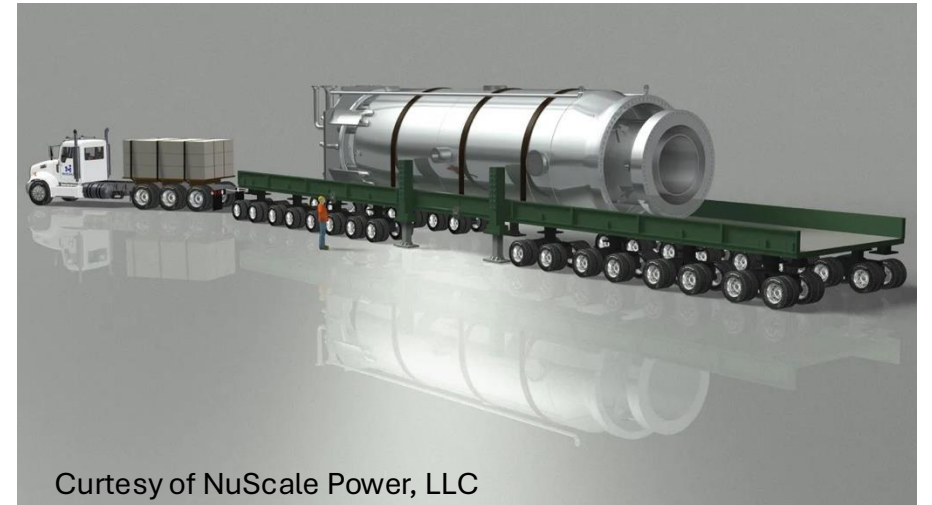
- Co-location in existing or recently shutdown nuclear plants
- Building new large or small modular reactors

Current Examples:

1. Amazon Cumulus Data Center powered by the Susquehanna NPP in PA
2. Google and Kairos' Molten Salt SMR, plans the biggest data center in Bluffs, Iowa
3. Microsoft- TMI-1
4. Amazon – Plans data center in N. VA has agreement with Energy Northwest – X-100 SMR
5. Terra Power has MOU with Sabey Data Centers to deploy Sodium plants



Source- – Talen | Cumulus



Courtesy of NuScale Power, LLC

Benefits

1. Nuclear energy provides 24/7 power: Data centers never sleep, and neither do nuclear plants
2. Nuclear plants rarely need to shut down: Downtime at a data center can be expensive — over \$8 million per day, by some estimates
3. Nuclear reactors are flexible: designs range from 5 megawatts to 1 gigawatt
4. Nuclear energy is compact: SMRs provide grid-independence for security-critical AI data centers
5. Existing nuclear plants have hidden potential: Microsoft 20-year power purchase agreement to restart Three Mile Island Unit 1 is an example

Challenges

1. New reactors will take time to build.
2. First-of-a-kind reactor deployments are expensive.
3. Efforts to add more power behind-the-meter were placed on hold by the Federal Energy Regulatory Commission at the Amazon Cumulus Data Center, as it allow benefiting from transmission systems without paying for them, raising costs for utility customers.
4. The nuclear fuel supply chain is under construction. –HALEU
5. Spent nuclear fuel needs storage.
6. Public perception of risks, subsidies and the ability for the NRC to license multiple designs are impediments.

Conclusions

- Nuclear energy is a viable green solution for data centers.
- It complements renewables, ensures stability, and vital in a climate strategy.
- It is versatile, reliable, and ready.
- There are impediments in regulatory, cost, and deployment timeline, but these are not insurmountable.