

February 2024

Dr. Steven Aumeier
Idaho National Laboratory

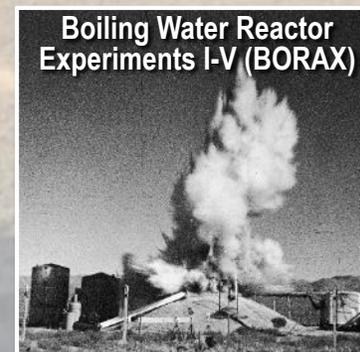
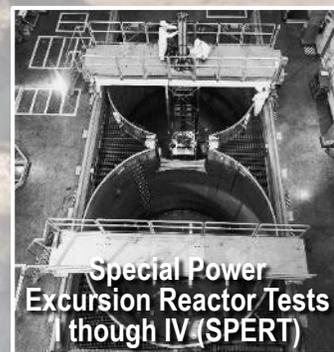
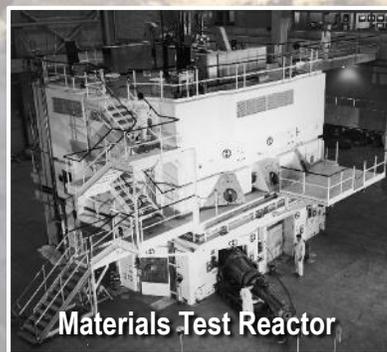
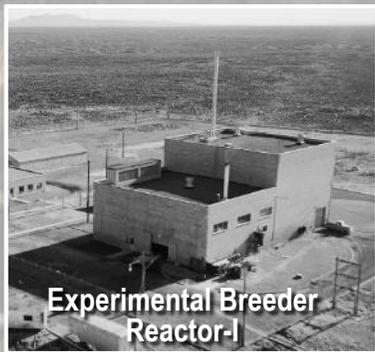
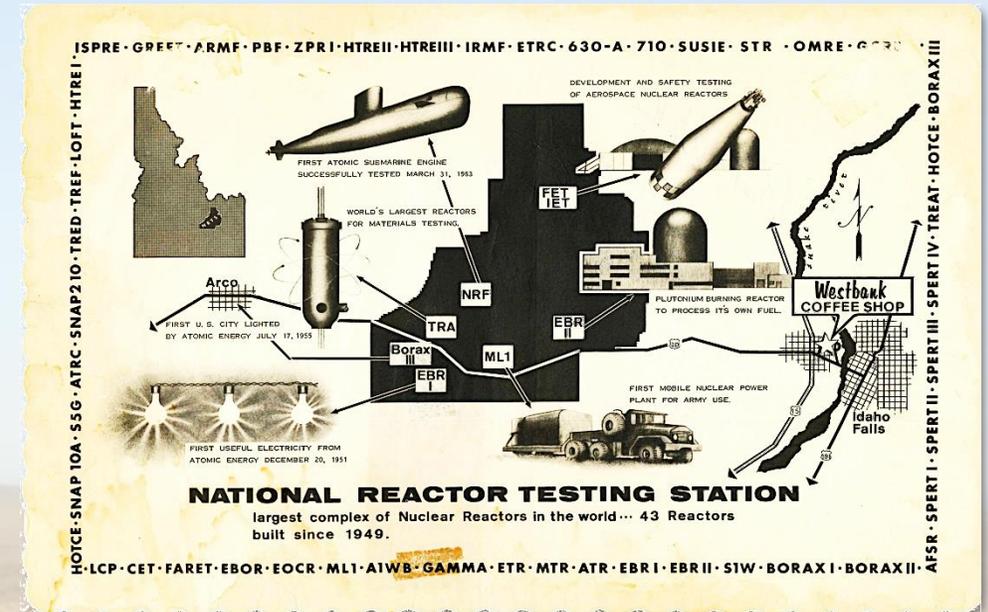
Perspectives on Deployment of Advanced Nuclear Energy

Prepared for
Louisiana Public Service Commission
February 2024

Idaho National Laboratory: The Nation's Nuclear Energy Laboratory

Over Seventy Years of Leading Into New Frontiers:

- First nuclear power plant
- First U.S. city to be powered by nuclear energy
- First submarine reactor tested; training of nearly 40,000 reactor operators until mid-90s
- First mobile nuclear power plant for the army
- Demonstration of self-sustaining fuel cycle
- Basis for LWR reactor safety
- Aircraft and aerospace reactor testing
- Materials testing reactors



Looking at the Landscape Through a Different Lens – A Global Manufacturing Opportunity



Projects to cut carbon emissions from steel manufacturing are being driven by consumer demand and government subsidies, according to BloombergNEF, a research firm.
-- NPR, June 27 2023



Russia- Year-round navigation of eastern part of Northern Sea Route planned for 2024 (Powered by nuclear)

Washington Heats Up Nuclear Energy Competition With Russia, China

U.S. puts diplomatic clout behind sales of cutting-edge reactors that have yet to show commercial success
--- WSJ January 8, 2024

Europe Reaches Historic Deal to Put Pollution Price on Imports

--- Bloomberg December 13, 2022



U.S. floats new steel, aluminum tariffs based on carbon emissions

--- Reuters December 7, 2022. 9:23 PM.



The New Global Frontier of Economic Competition and Security

A New Frontier of Economic Opportunity and Competition

- Simpler, appropriately sized reactors intersect emerging market demands for low emission, reliable energy
 - Heat and power – Beyond bulk grid applications
- **State energy, policy, and regulatory officials and energy consumers will need to know the landscape** -- Classes of Reactors, Size, Applications, and Terminology
 - What's available and what's new
 - Why
 - Attributes and terms, what's hype, what's real, where are the risks – the “alphabet soup” of advanced nuclear
- Disruptive new business models and applications – an opportunity and imperative for U.S. leadership
- The way forward – leading into the new **global economic frontier** – will be led by state and community innovation

A Regional-to-Global Path Where Louisiana Can Develop Market Dominant Positions



What's New

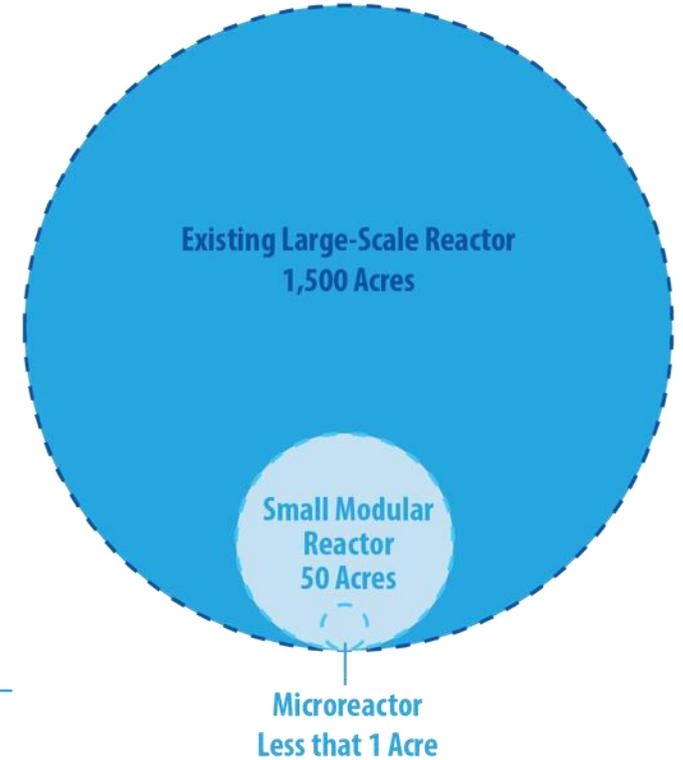
Why Do We (or Should We) Care

Existing large-scale reactors



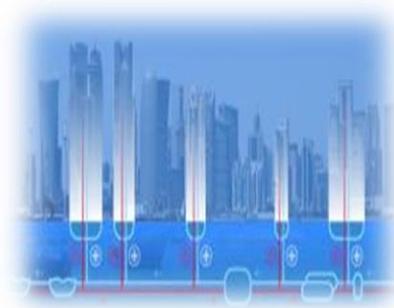
Number in operation:	95 in U.S.
Timeframe:	Built in the 1950s-1980s
Products:	Electricity
Megawatts:	1,000+ megawatts
Customers:	Large utilities
Emergency zone:	200,000 acres
Construction:	Custom built on site
Scalability:	Difficult due to size and cost

FOOTPRINT



Applications:

Baseload electricity; 24/7; process heat; district heating



Did you know?

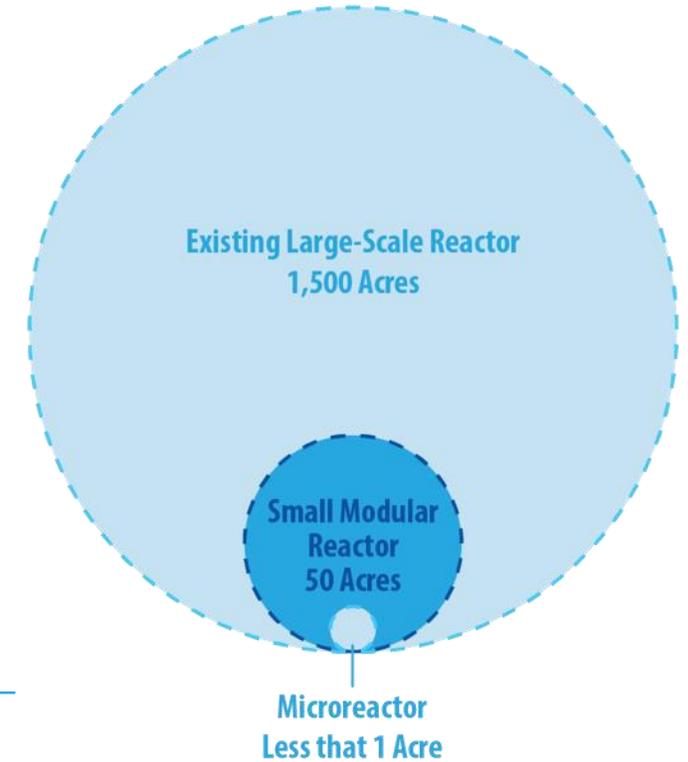
In October 2023, the Department of Energy announced that seven proposed "hydrogen hubs" in 16 states will share \$7 billion in grants to jump-start the emerging industry.

Small modular reactors



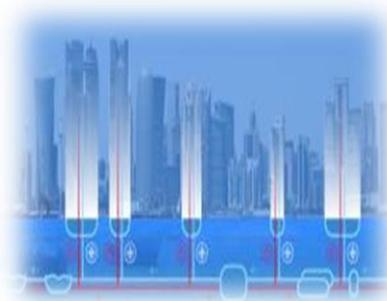
Number in operation:	None*
Timeframe:	First reactors expected by 2029
Products:	Electricity, heat, and steam
Megawatts:	50-300 MWe per module
Customers:	Large utilities; municipalities; industry
Emergency zone:	35-50 acres
Construction:	Factory built; assembled on site
Scalability:	Reactor modules added as demand increases

FOOTPRINT



Applications:

Baseload electricity, industrial heat, industrial processes; microgrids; district heating



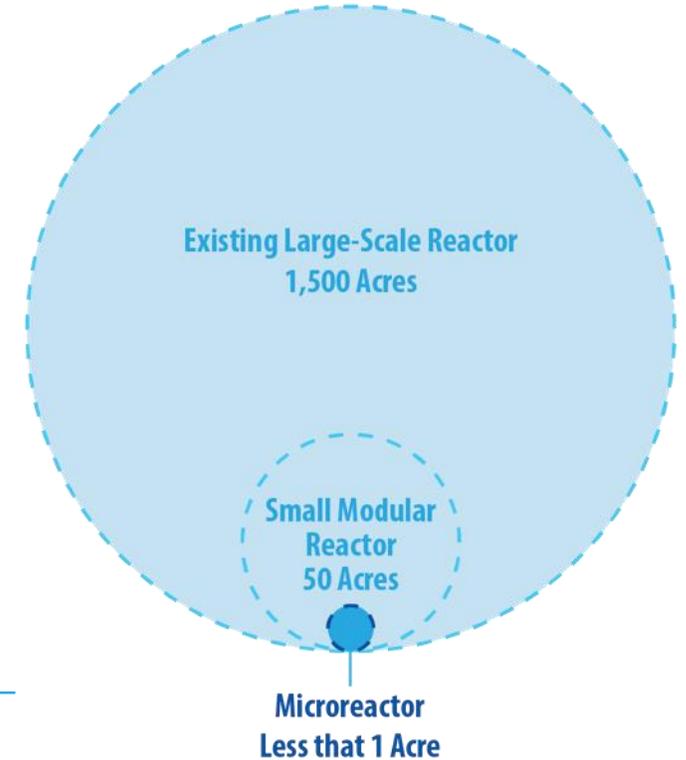
*NuScale received NRC approval for its 50 MWe design in 2020 and design certification in 2023, making it the first and only SMR to achieve either milestone.

Microreactors



Number in operation:	None
Timeframe:	First reactors expected by 2025
Products:	Electricity, heat, and steam
Megawatts:	50 MWe or less
Customers:	Military; municipalities; industry
Emergency zone:	Less than 1 acre
Construction:	Factory built; assembled on site
Scalability:	Reactor modules added as demand increases

FOOTPRINT



Applications:

Power for remote locations, process industry & manufacturing, IT Infrastructure, maritime shipping, military installations, water management, disaster relief

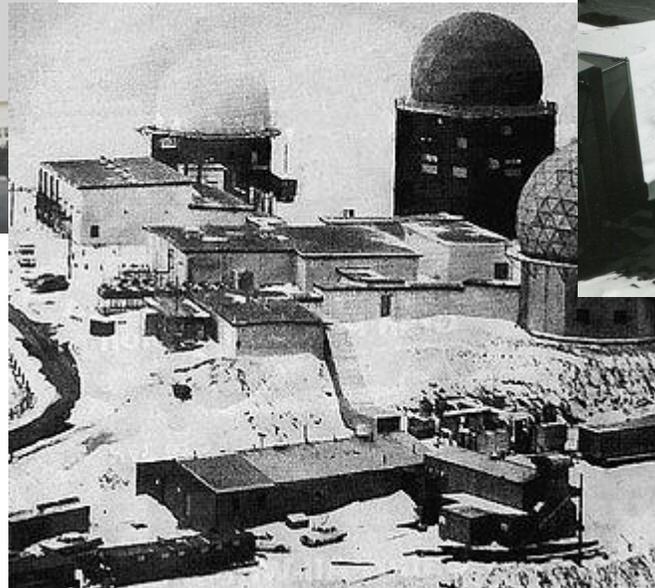


Governor Mike Dunleavy,
 October 23, 2023
 on signing SB-177 into law that streamlines the regulatory process to provide nuclear microreactor generation.

“For rural Alaska villages that are now dependent on diesel power generation, power from nuclear microreactors can be a gamechanger that reduce both the cost for electricity and carbon emissions.”

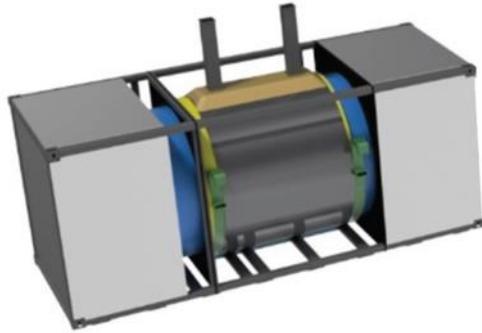
Microreactors, Transportable Reactors – Back to the Future !

- PM-1 – Sundance Wyoming
 - Transportable reactor powered military radars 1962-1967

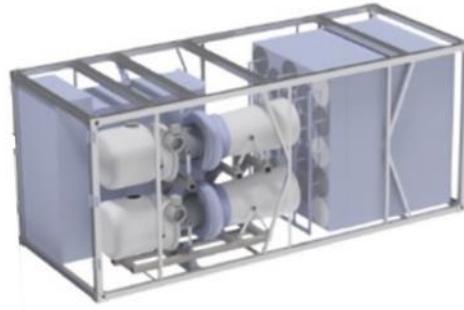


Microreactors in a “nuclear battery” framework

Moving from construction to manufacturing, incremental provisioning of industry



REACTOR CONTAINER



POWER CONVERSION CONTAINER



ICE CONTAINER

(eVinci™ Westinghouse)

- Plug-and-play system producing 1-50 MW of heat
- Carbon emissions free
- Dry cooling (no water needed)
- Standardized, factory fabricated
- Transportable in ISO containers
- Semi-autonomous operation
- Offsite refueling every 5-10 years
- No onsite storage of radioactive material
- Very small footprint
- US suppliers are in the lead (Westinghouse, BWXT, X-energy)



10 MW Vestas



10 MW Community Solar

10 MW Nuclear Battery

Size of the Prize - Establishing U.S. Leadership on the Frontier

The Development of Microreactor Markets for Low Emission Industry

Lead Market- Military
(First-Tier Pricing)



Military Operations

Second Tier Market- Remote



Microgrids (remote communities, islands)



Mining



Shipping & Ports

Third Tier Market- Modular Industry



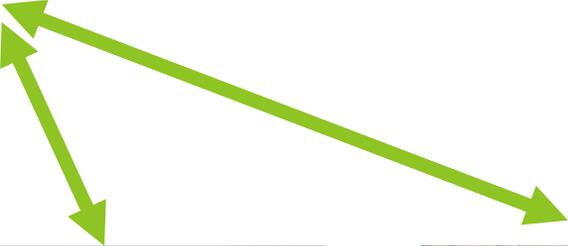
Data Centers



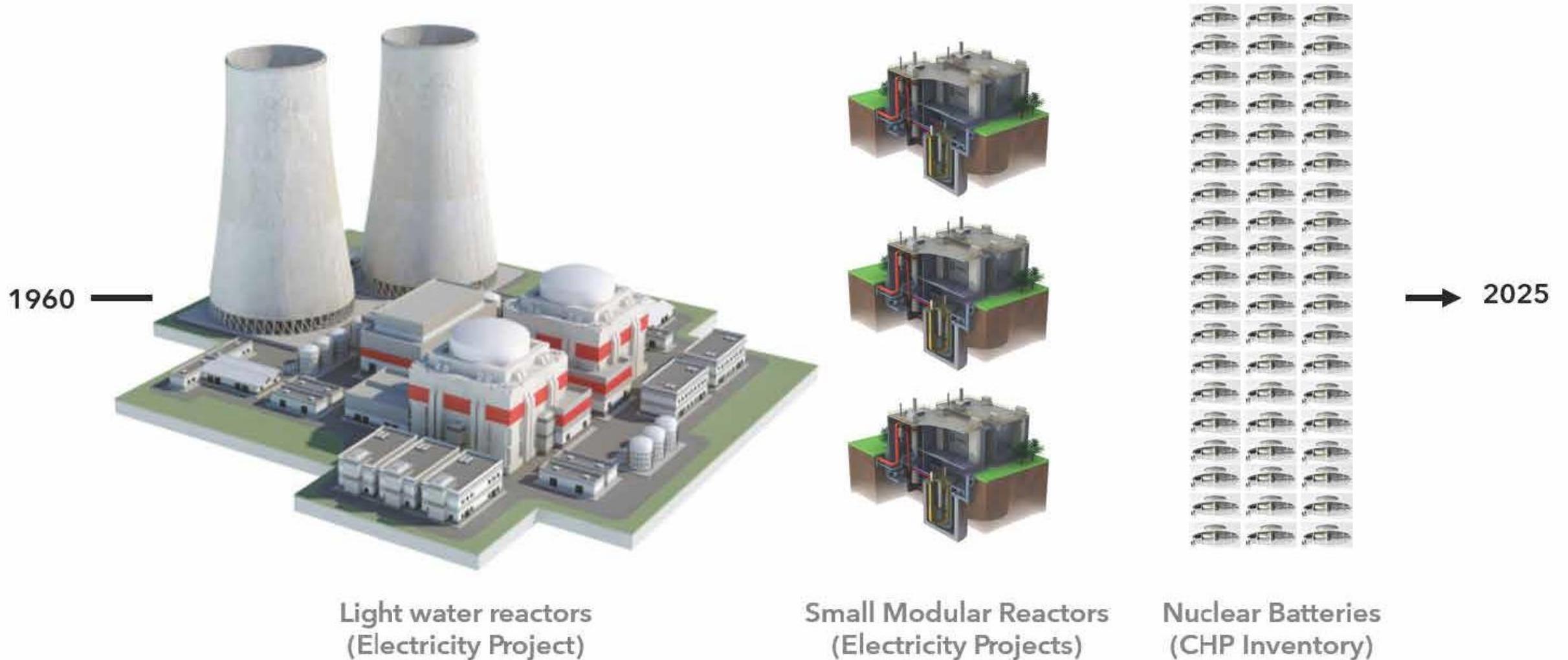
Desalination



Modular Industrial Plants



The March Toward "Embedded", Localized Energy As A Competitive Advantage



* All nuclear batteries are microreactors, but not all microreactors are nuclear batteries



Innovative Partnerships: The Frontiers Initiative, State Leadership

- Help first-mover states innovate, accelerate, lead
 - A *catalyst* for advancing US leadership
 - Focus on advanced nuclear energy as a *key* to enable competitive edge
 - Bring best information to key stakeholders, e.g. Nuclear 101, connect suppliers to load owners and innovators, envision “art of the possible”
- Key Partnerships: Government, Industry, Academia, NGO, Finance, etc
 - The Atlantic Council
 - Utah
 - Alaska
 - Wyoming
 - Idaho
- Team-of-Teams – Opportunity for Louisiana?

OPINION U.S. & WORLD GUEST OPINION

Opinion: The U.S. could reshape the global economy for the next century. Will it seize the opportunity?

The Frontiers Collaboration is an example of how states are leading the energy and economic transformation to secure our nation and enable their citizenry

By Steven E. Aumeier | Dec 8, 2023, 10:00am MST

Leadership at the Frontier – Wyoming as a Pathfinder

The “New Frontier” – Low Emissions Power AND Industrial Processes

- **A Strategic Framework**
- **Generation**
 - Put zero emission electrons on the regional grid
- **Supply Chain**
 - Selectively capture slices of the \$8T market
 - E.g. Wyoming Innovative Entrepreneurs
- **Value Chain**
 - Low emission industry (e.g. chemicals, steel, data, etc)– EXPORT LEADERSHIP
 - The manufacturing of equipment to do that (reactor parts, professional services, etc)
 - The new business to sell and service all that

Major Disruptor



Wyoming Governor Mark Gordon, representatives, and WEA visited INL on May 4, 2022.