Nuclear Energy State of Advanced Reactors

Indiana House
Utilities Committee

Marc Nichol
Senior Director of New Reactors
February 15, 2022

NUCLEAR ENERGY INSTITUTE

mrn@nei.org; 202-739-8131

Considering Advanced Reactors

For a clean, affordable and reliable electric system

- System benefits
  - Flexible/dispatchable
  - Resilience/reliability
  - Renewables integration
- Economic benefits

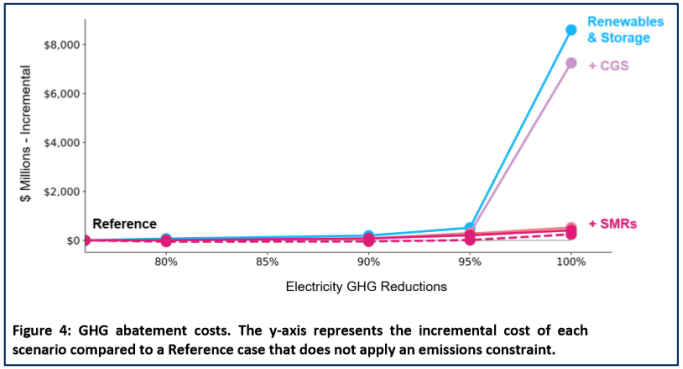


Figure 4: GHG abatement costs. The y-axis represents the incremental cost of each scenario compared to a Reference case that does not apply an emissions constraint.

E3 Study of Pacific Northwest

- Technology readiness
  - First design approved
  - Federal government support
  - First plants operational by 2030
- Project planning
  - State policy support
  - Dozens of projects planned or being considered
  - Reusing retired plant sites

Additional Information

Types of Advanced Reactors

Range of sizes and features to meet diverse market needs

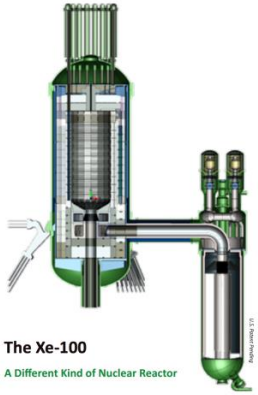
Micro Reactors (< 20MW)

Oklo (shown)
Approximately a dozen in development

Light-water SMRs <300MW

NuScale (shown)
GEH X-300
Holtec SMR-160

High Temp Gas Reactors

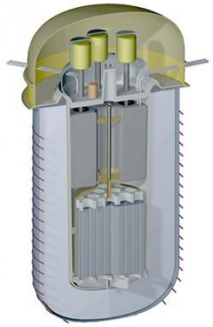


X-energy (shown)
Several in development

Liquid Metal Reactors

TerraPower Natrium (shown)
Several in development

Molten Salt Reactors

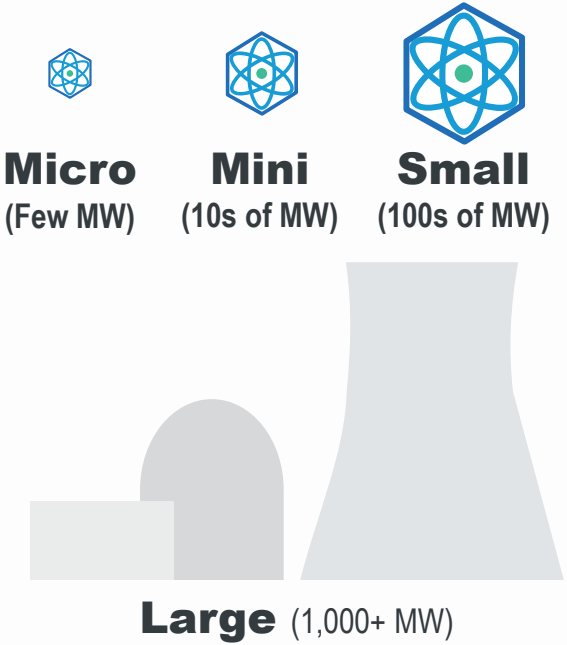


Terrestrial (shown)
Several in development

Non-Water Cooled
Most <300MW, some as large as 1,000 MW

Advanced Nuclear Versatility

Spectrum of Sizes/Options



Variety of Outputs

Multitude of Uses

System Benefits of SMRs

- Fuel diversity
  - Lowest cost systems have fuel diversity
  - Long term price stability
- Reliable dispatchable generation
  - 24/7, 365 days per year, years between refueling
  - Capacity factors of 95% or more
- Integration with renewables and storage
  - Paired with heat storage and able to quickly change power
- Carbon-free generation
  - Zero-carbon emissions, one of the lowest total carbon footprints
- Resilience for mission critical activities
  - Black-start capability and able to operate independent from the grid
  - Protect against natural phenomena, cyber threats and electro-magnetic pulses
- Use existing transmission infrastructure

Source: SMR Start, *SMRs in Integrated Resource Planning*

SMRs Are Environmentally Friendly

- Air Quality
  - Zero-carbon emissions, one of the lowest total carbon footprint
  - No emissions of SOx, NOx or other air pollutants
- Water Use
  - Many SMRs are being designed with ability for dry air cooling
  - Would enable SMRs to be located where water is scarce or expensive
- Land Use (per 1,000 MWe)

	SMR	NGCC	Wind	Solar
Capacity factor (%)[12]	95	55[13]	35	25
Plant life (years)	60 to 80	40 to 50	20 to 25	20 to 25
Lifetime TWh	647	241	76	55
Land required (acres)[14,15,16]	50[17]	343	85,240	7,900
Land Utilization (acres per Lifetime TWh)	<0.1	1.4	1,125	144

Source: SMR Start, *SMRs in Integrated Resource Planning*

Economic Benefits of SMRs

- Employment
  - 900 manufacturing and construction jobs over 4 years (average)
  - 300 permanent positions during 60+ years of operation
  - Multiplier effect: additional 1.66 jobs in local economy, 2.36 rest of the state
  - Nuclear jobs pay 20% more, on average, than jobs at other energy sources
  - Nuclear jobs pay 36% more than average salaries in local area
- Economic Activity
  - $500M+ in direct and indirect economic output annually
    - $270 million in electricity sales
    - Spending at local ($10M), State ($48M) and national ($236M) level
  - Taxes: $10M in state and local, and $40M in federal annually

Source: SMR Start, *Economics of Small Modular Reactors*
Based on a 600 MWe SMR plant

Affordable, Resilient and Flexible

SIMPLER

- Inherent Safety
- Less Equipment
- Smaller Facility
- Regulatory Efficiency

READILY AVAILABLE EQUIPMENT

- Off-the-shelf Equipment
- Proven Performance

FACTORY-BUILT

- 60-80% of Equipment
- U.S. Supply Chain Growth

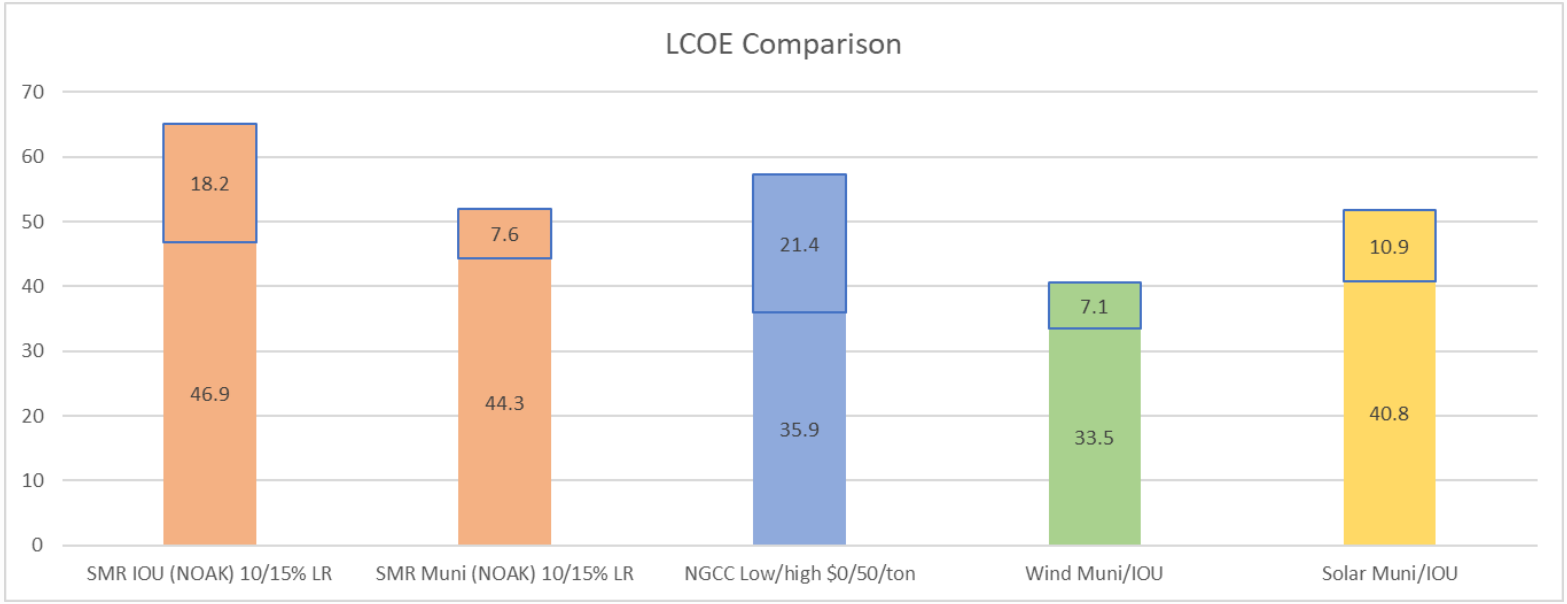
FASTER CONSTRUCTION

- Smaller Structures
- Assembly vs. Construction
- Modern Construction Methods

IMPROVED PERFORMANCE

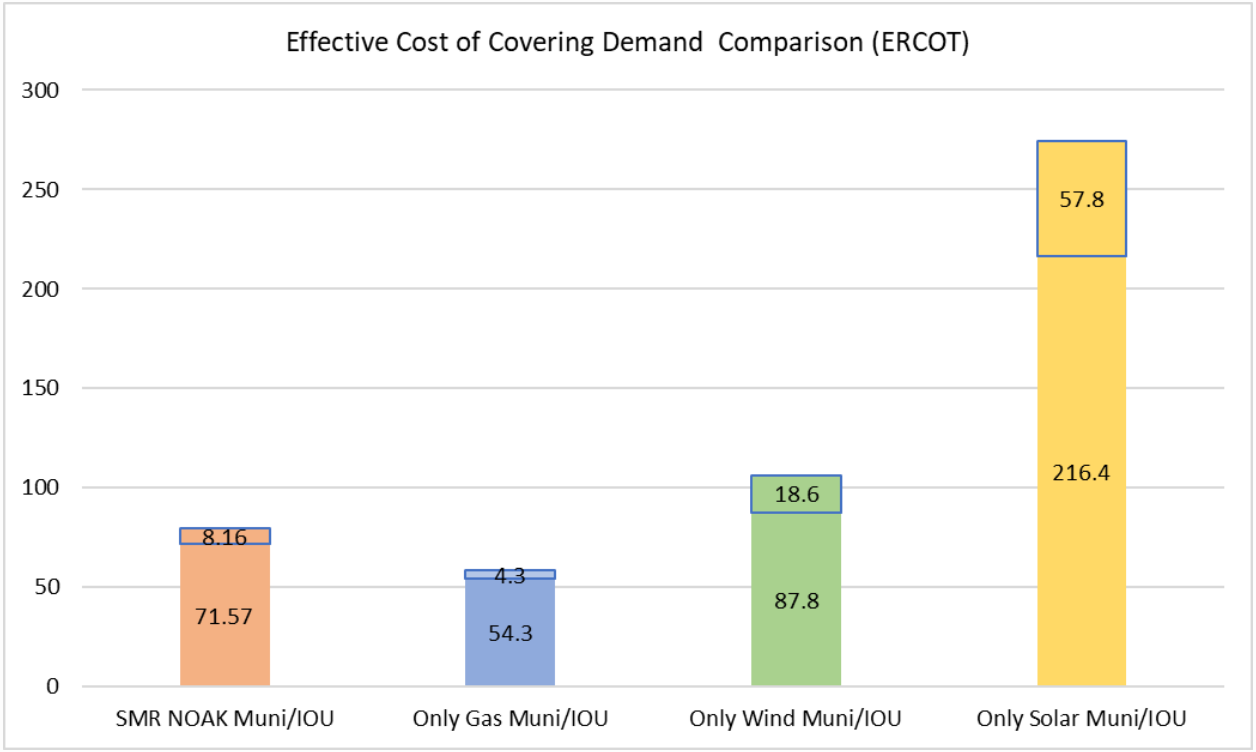
- Higher Thermal Efficiency
- Design and Construction Best Practices
- Operational Excellence

Advanced Reactor Cost Competitiveness in Electric Markets



From SMR Start Report on SMR Economics: http://smrstart.org/wp-content/uploads/2021/03/SMR-Start-Economic-Analysis-2021-APPROVED-2021-03-22.pdf

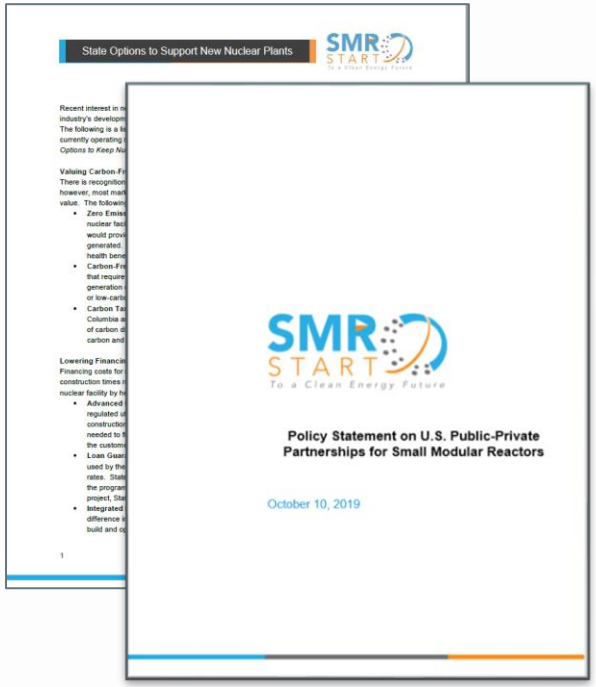
Considering the need for system reliability makes nuclear even more affordable



Source: SMR Start, *Economics of Small Modular Reactors*

Government Deployment Support

- Valuing all carbon-free sources of energy
- Federal Programs
  - Demonstrations
  - Tax Credits (e.g., Production)
  - Loan Guarantees
  - Federal Power Purchase Agreements
- State Programs
  - Tax incentives (e.g., property)
  - Advanced cost recovery
  - Infrastructure



http://smrstart.org/wp-content/uploads/2017/07/SMR-Start-State-Options-for-New-Nuclear-Approved-2017-06-26.pdf

http://smrstart.org/policy-statement/

Current Status – Demonstrations by 2030

Developer	Technology	Utility	Location	Size
NuScale	Light Water SMR	UAMPS	Idaho	6 @ 77MW
TerraPower & GE-Hitachi	Liquid Metal	Pacific Corp.	Wyoming	345 - 500MW w/thermal storage
X-energy	High Temp. Gas	Energy Northwest	Washington	4 @ 80MW
GEH BWR X-300	Light Water SMR	OPG	Ontario, Canada	300 MW
Oklo	Micro-reactor	Oklo	Idaho	1.5 MW
Ultra Safe Nuclear	Micro-reactor	Global First / OPG	Chalk River, Canada	5 MW
TBD	Micro Reactor	Department of Defense	Alaska	TBD
TBD (X-energy or BWXT)	Mobile Micro Reactor	Department of Defense	Idaho	TBD

Utility and State Interest

State	Legislative Action	Utility Action
Alaska	Bills introduced to repeal voter approval to site	Eielson AFB site for first micro-reactor for DoD
Arizona	Clean energy standard under development	Utility interest in 25 MWe of UAMPS/NuScale
Idaho	Tax incentives passed	Host of UAMPS/NuScale SMR
Montana	Passed bill to study coal to SMR Repealed voter approval to site	NorthWestern Energy interested in coal to nuclear
Nebraska	Passed bill on SMR tax incentives	Broad support for SMRs in state
North Carolina	Passed decarbonization plan bill	Duke Energy includes SMRs in IRP
Virginia	Nuclear Energy Strategic Plan Clean energy standard including nuclear	Dominion includes SMRs in IRP
Washington	Clean energy standard including nuclear	Energy Northwest with X-energy demo Grant County PUD MOU with X-energy and NuScale
Wyoming	Passed bill calling for coal retirements to be replaced with SMRs	Rocky Mt. Power siting for TerraPower demo

Coal to Nuclear Transition

- Coal power plant shutdowns can be devastating to local communities
- Transition to a small modular reactor (SMR) can provide carbon-free replacement power while:
  - Saving jobs and local economy
  - Benefiting the electric grid system
  - Generating environmentally friendly power
- Pursuing policy actions to encourage coal to nuclear

1. Scott Madden, *Gone with the Steam*, October 2021
2. INL, *Transitioning Coal Power Plants to Nuclear Power,* December 2021
3. Good Energy Collective, *Opportunities for Coal Communities through Nuclear,* December 2021
4. ORNL, *Evaluation of Suitability of Selected Set of Coal Plant Sites for Repowering with Small Modular Reactors*, March 2013
5. ORNL, *TVA Coal-Fired Plant Potential for Advanced Reactor Siting*, September 2021
6. NuScale SMR Technology: An Ideal Solution for Repurposing Coal Plant Infrastructure and Revitalizing Communities

Advanced Reactors Offer Significant Well-Paying Jobs

Generation Type	Permanent Jobs on Site	Industry Wage Median	Carbon Free?	Firm Energy?	Benefits Concentrated Locally?
Nuclear	237*	$41.32	Yes	Yes	Yes
Coal	107	$33.64	No	Yes	Yes
Natural Gas	30	$34.02	No	Yes	Yes
Wind	80	$25.95	Yes	No	No
Solar	36	$24.48	Yes	No	No

*Based on NuScale 12-pack design

Note: Comparison of alternatives producing annual electricity output equivalent to a typical 1,000 MWe coal plan

Source: Scott Madden, *Gone with the Steam*

Similar Jobs and Limited Retraining

Coal Plant Position	# Dedicated Coal Positions	SMR Position	# Dedicated SMR Positions	Position Type	Degree of Retraining Required
Operations Supervisor	5	Senior Reactor Operator	5	Supervisor	High
Control Room Operator	10	Reactor Operator	15	Operator	High
Field Operator	15	Non-Licensed Operator	25	Operator	Low
Lab Operator/Chemistry/Scrubber	4	Chem Tech	14	Craft	Medium
Maintenance Supervisor	2	Maintenance Supervisor	3	Supervisor	Medium
Mechanical Craft	12	Mechanical Craft	21	Craft	Low
I&C Craft	9	I&C Craft	10	Craft	Medium
Electrician Craft	5	Electrician Craft	11	Craft	Low
Technician	11	Technician	13	Laborer	Low
Security Officer	20	Security Officer	48	Laborer	Low
Sub-Total	**93**		**165**		
All Other Positions	14		72	42 are O&M Support (Planners, Outage, etc.)	Medium
Total On-Site Positions	**107**		**237**		
Possible Centralized Positions			33		
Total Positions			**270**		

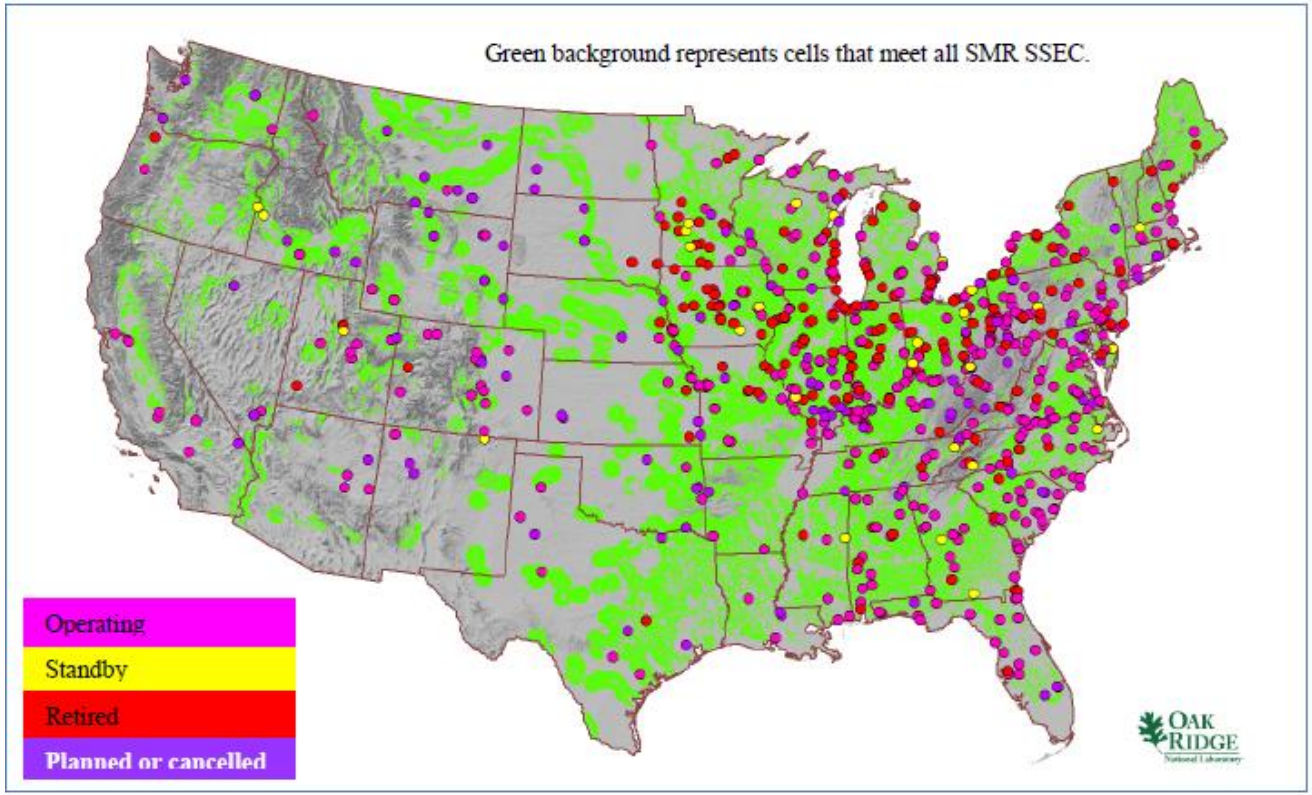
Source: NuScale and Scott Madden, *Gone with the Steam*

Policy Support for Coal Communities

- E.O. 14008 created Interagency Working Group within DOE to identify and provide federal support to coal, oil, gas and powerplant communities
  - April report on existing ways to provide grants, loans, and other assistance
  - Identified over $45 billion currently available in existing federal programs
- Federal Legislation
  - Infrastructure Investment and Jobs Act and American Rescue Plan
    - Promote new opportunities in communities where coal plants are shutdown
  - Fission for the Future Act – S.3428 (Manchin and Barrasso)
    - Financial assistance priority for activities considering coal to nuclear
- State Initiatives
  - Colorado established Office to help coal communities move into new jobs
  - New Mexico enacted provisions for funding coal community assistance
  - Montana – Study bill for feasibility of SMRs to replace coal-fired boilers

Source: Good Energy Collective, *Opportunities for Coal Communities through Nuclear*, December 2021

Coal Plants and SMR Suitability



Source: ORNL, *Evaluation of Suitability of Selected Set of Coal Plant Sites for Repowering with Small Modular Reactors*, March 2013

QUESTIONS?

By Third Way, GENSLER