



NUCLEAR + ENERGY STORAGE PANEL

Moderator: ZHIWEN MA

*Panelists: KOWALCHIK (UOED), KELYN WOOD (EPRI), DANIEL S. WENDT (INL),
SUPATHORN PHONGIKAROON (UU)*

Introduction



Panelists:

*Kelyn Wood (EPRI), Tim Kowalchik (UOED), Daniel S. Wendt (INL),
Supathorn Phongikaroon (UU), Rebecca Barney (NLR)*

Moderator: Zhiwen Ma

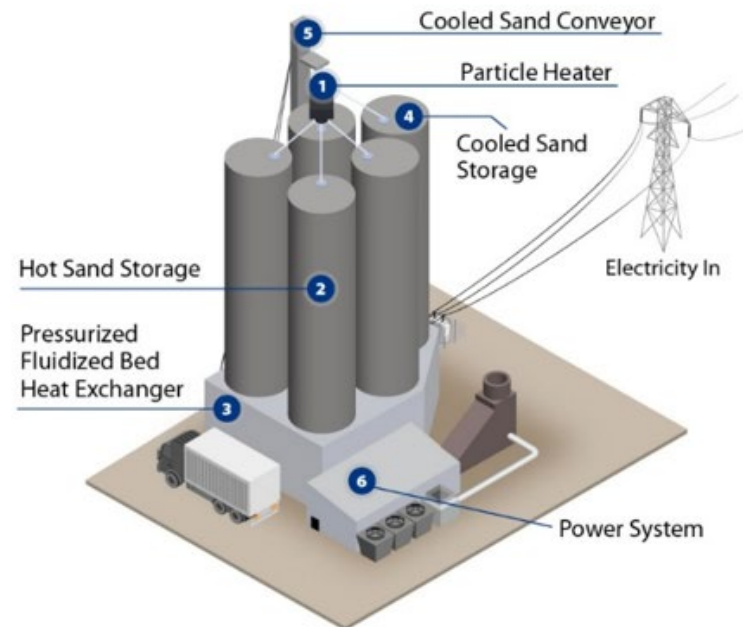


LDES NATIONAL CONSORTIUM

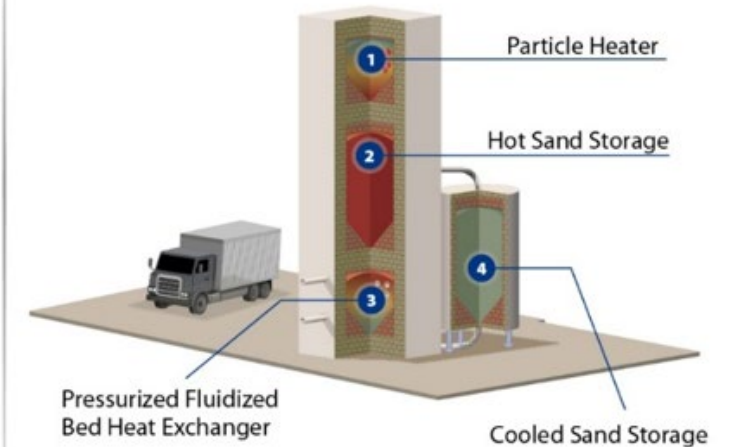
Technical background:

- Works on energy storage, hydrogen production, and concentrating solar power technologies
- Capability node lead in DOE Energy Material Network HydroGEN Advanced Water Splitting Material consortium.
- Principal Investigator of the NREL \$3.80 million SunShot project to develop a particle solar receiver and thermal energy storage.
- 80 peer-reviewed publications and 14 awarded patents.

ENDURING Centralized System



ENDURING Modular System

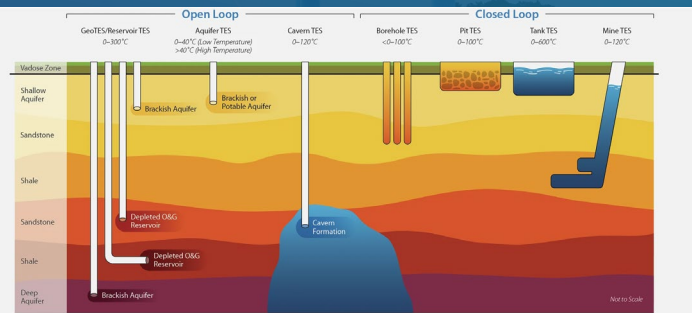
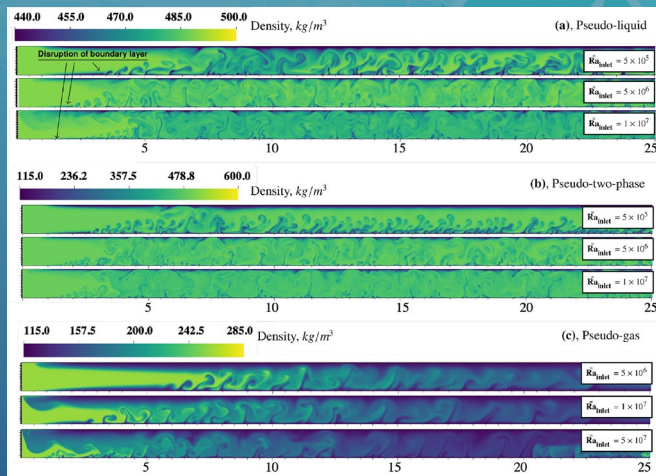


Zhiwen Ma, Ph.D.
National Laboratory the
Rockies (NLR)
NLR Distinguished
Member of Research Staff
ASME Fellow



Rebecca Barney, Researcher at NLR

Dr. Rebecca Barney is a researcher in the Thermal Energy Systems Group at the National Laboratory of the Rockies (NLR). She received her Ph.D. in Mechanical Engineering from University of California, Davis in 2021, and her M.S. in Mechanical Engineering in 2019. During these years she focused on simulation and analysis of supercritical water heat transfer and fluid dynamics for application to nuclear energy. Her research specialized in evaluating the unstable hydrodynamic flow through a channel flow to discover the heat transfer variations for energy cooling systems involving supercritical fluid flow. Prior to joining NLR she worked at MIT Lincoln Laboratory conducting research to aid design, modeling, and testing thermal systems and devices. She currently works on projects related to energy storage including geothermal energy storage and district heating and cooling.





P221: Bulk Energy Storage

Mission

Provide actionable research and innovation to advance large-scale, long-duration energy storage (LDES) with a focus on chemical, mechanical, and thermal technologies

Why EPRI's Bulk Energy Storage?

Value of Collaboration

The Bulk Energy Storage program works closely with multiple programs in the Generation and ED&CS sectors, 100+ energy storage technology developers, and leading R&D and government teams.

Program Manager

Justin Raade
+1 408-515-2983
jraade@epri.com

www.epri.co/bes

Research Focus Areas

- Independent performance testing of LDES pilot plants and demonstrations
- Feasibility studies of energy storage projects
- Strategic insights on emerging LDES technology
- Design and safety reviews
- Energy storage integration to thermal power plants and industrial processes
- Request for proposal support
- Techno-economic and benefit assessments

Unique Insights

- 8 staff (3 Technical Executives) with total of 9 advanced degrees and 85 years experience combined at EPRI
- 500+ member meetings on energy storage in 2025
- 600+ papers, articles, and other published works

Impactful Content

- **Web-based software:** [Energy Storage Technology Database](#) and [Pilots and Demonstrations Database](#)
- **Cost and Benefits assessments:** [3002032493](#), [3002034550](#)
- **Performance studies:** [3002029757](#), [3002034105](#), [3002034104](#), and [3002029725](#)

Technology Application

- [Energy Dome Commercial Plant Testing](#)
- [Hydrostor Goderich Site Visit](#)
- [Commercial Readiness Levels for LDES](#)
- [O&M Guidelines for Bulk Energy Storage](#)



Supathorn Phongikaroon

Education:

- NRC Postdoctoral Fellow at NRL, Washington D.C., 2001 – 2004;
- Ph.D. Chemical Engineering from University of Maryland, College Park (2001);
- B.S. Nuclear Engineering from University of Maryland, College Park, (1997).

Professional experience (teaching and conducting research in Nuclear Fuel Cycle since 2004):

- Energy Solutions Presidential Endowed Chair and Professor, Nuclear Engineering Program, Civil & Environmental Engineering University of Utah, 2025 – Present
- Engineering Foundation Professor, Mechanical and Nuclear Engineering, Virginia Commonwealth University (VCU), 2020 – 2025
- Director of Nuclear Engineering Programs, VCU, 2018 - 2025
- Associate Professor, Mechanical and Nuclear Engineering, VCU, 2014 - 2020
- Associate Professor, Chemical & Materials Engineering and Nuclear Engineering Program, University of Idaho, 2013 – 2014
- Assistant Professor, University of Idaho, 2007 – 2013
- Research Engineer, Idaho National Laboratory, 2004 – 2007

■ Over 60 peer-reviewed publications on molten salt systems.

■ Over 100 presentations at national and international conferences on molten salt systems.

■ Hobbies: Climbing, Backpacking & Hiking, Skiing, Swimming, Road biking, and running



LDEN NATIONAL CONSORTIUM





Utah San Rafael Energy Laboratory (USREL) – Orangeville – has emerged as a leading facility for sustainable energy research, with a particular focus on advancing molten salt technology and medical isotope production.



UNEP

Utah Nuclear Engineering Program

JOHN AND MARCIA PRICE COLLEGE OF ENGINEERING
THE UNIVERSITY OF UTAH



REACTOR-POWERED RESEARCH

We've been conducting research and training on our 100 kW TRIGA reactor since 1975. Its capabilities allow us to perform isotope production, neutron radiography, digital twin, radiation hardness testing, and more.



FACULTY PROFILE

33 full-time faculty with 6 full-time nuclear engineering faculty.



Andrew Allison
Reactor Supervisor



Ed Cazalas
Assistant Professor



Ted Goodell
Reactor Facility Director



Tara Mastren
Associate Professor



Meng-Jen (Vince) Wang
Assistant Professor

TRIGA REACTOR CAPABILITIES

- Isotope Production & Nuclear Medicine
- Nuclear Energy & Safeguards
- Radiochemistry & Actinide Chemistry
- Multiphysics & Digital Twins
- Radiation Hardness Testing
- Advanced Reactor Systems

2024 - 2025 FUNDING FROM DOD AND DOE

\$882,958 DOD
\$225,827 DOE
[view research](#)



Dr. Supathorn Phongikaroon
EnergySolutions Presidential Endowed Chair & Director, Utah Nuclear Engineering Program (UNEP), The University of Utah

A visionary academic and skilled collaborator, Dr. Phongikaroon has secured over \$6 million in research funding, published more than 50 peer-reviewed papers, and, with his team, delivered more than 100 technical presentations. His contributions continue to advance the fields of nuclear chemistry and engineering on both national and international stages.

"I'm thrilled to join UNEP at such an exciting time for Utah, where there's so much momentum around nuclear energy. With the University of Utah's research reactor as a unique asset, we have a real opportunity to blend cutting-edge nuclear science with new energy applications and advanced medical research."



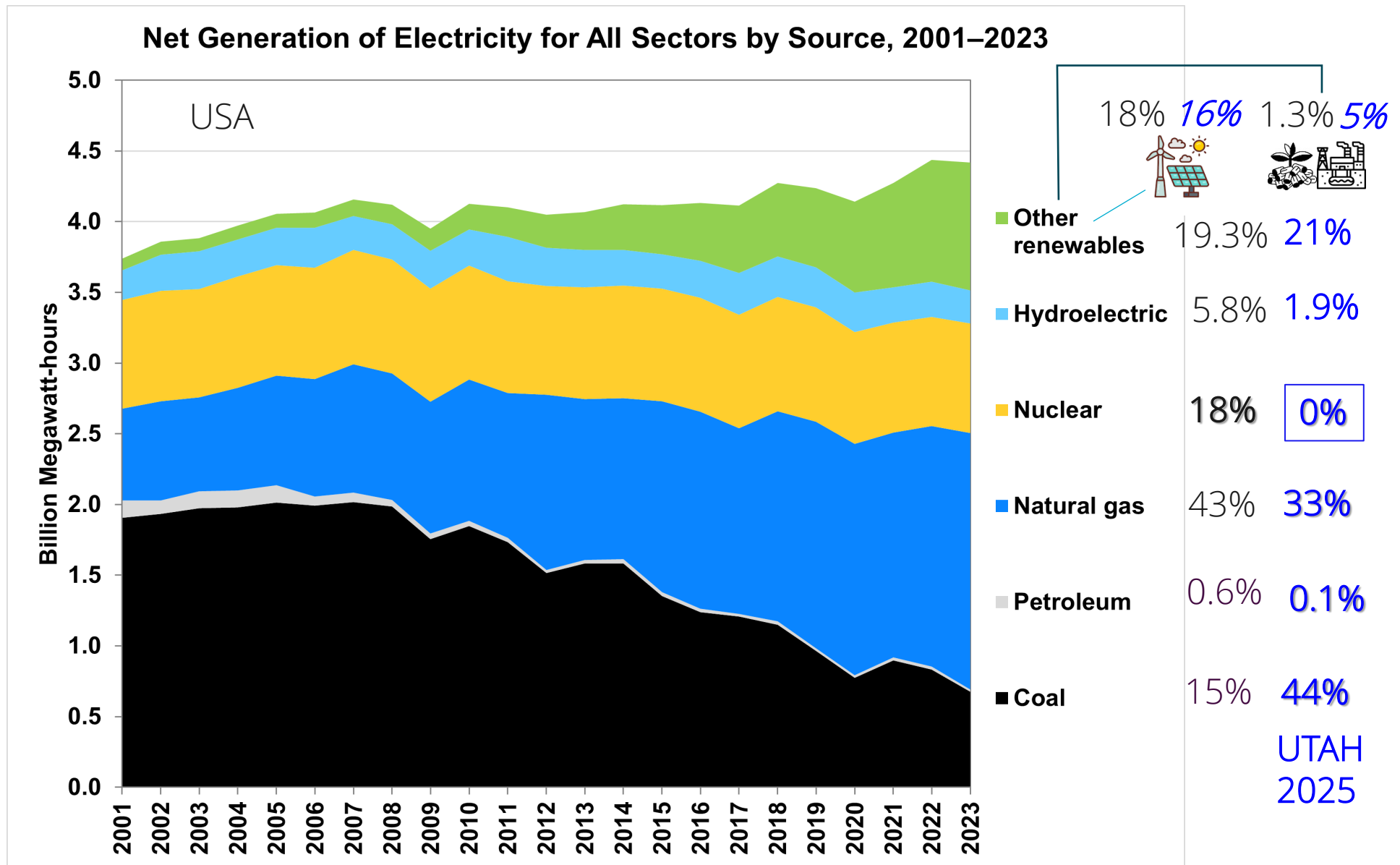
Nuclear Engineering at the University of Utah
Utah's only Nuclear Engineering Program

Housed within the Department of Civil and Environmental Engineering, UNEP has developed a Nuclear Engineering curriculum that fills critical educational and competency gaps for engineers and scientists involved in the nuclear power and radioactive waste industries, nuclear medicine, homeland security, radiation safety, and nuclear materials detection.

Ranking among the nation's top 50 universities for research and development, The University of Utah's research expenditures totaled \$734 million in FY2025.

- ✓ TRIGA reactor since 1975 for research and training purposes.
- ✓ An undergraduate minor in Nuclear Engineering
- ✓ A Master of Science (non-thesis) in Nuclear Engineering
- ✓ A Ph.D. in Nuclear Engineering

University of Utah Medical Center – offers an accredited Nuclear Medicine Technology (NMT) program that includes CT certification. This program is available in both certificate format and through academic partnership with the University of Utah Department of Health.



<https://www.energy.gov/eere/vehicles/articles/fotw-1365-october-21-2024-us-net-generation-electricity-relied-record-use>



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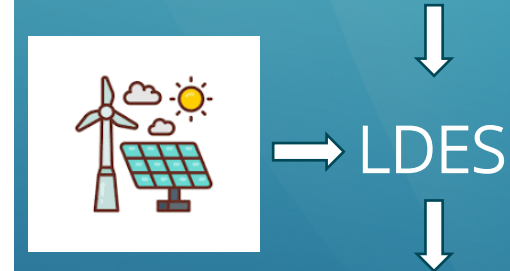
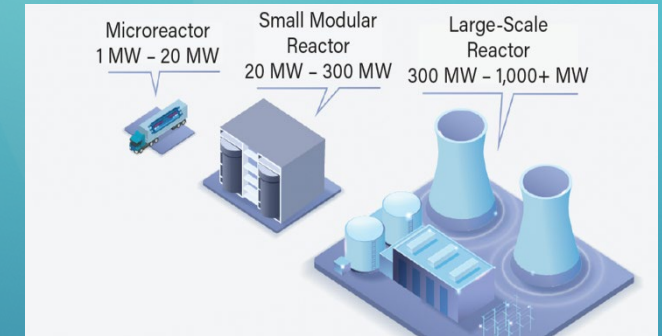
<https://www.eia.gov/state/?sid=UT#tabs-4>

Why Long-Duration Energy Storage (LDES)?

Reliable electricity requires both clean generation and long-duration energy storage.

- ❑ Electricity demand is rapidly increasing due to:
 - ❑ AI data centers
 - ❑ Advanced manufacturing
 - ❑ Electrification
 - ❑ Population growth
- ❑ Renewable generation is variable.
- ❑ Nuclear provides carbon-free 24/7 baseload power.
- ❑ LDES stores excess energy and delivers electricity during peak demand or emergencies.

Nuclear provides continuous clean energy while LDES adds flexibility and resilience.



Reliable Power Grid

LDES Technology Approaches

<u>Technology</u>	<u>Duration</u>	<u>Maturity</u>	<u>Best Application</u>
Pumped Hydro	10–100 hr	Mature	Bulk storage
Flow Batteries	8–24 hr	Commercial	Daily cycling
Thermal Storage	10–100 hr	Emerging	Industrial heat + electricity
Hydrogen	Days–Months	Emerging	Seasonal storage
Compressed Air	10–100 hr	Commercial	Utility scale
Gravity Storage	8–24 hr	Demonstration	Grid support

☐ No single LDES technology fits every application.

☐ Utah has strong opportunities in:

☐ **Hydrogen**

☐ Pumped hydro

☐ Thermal storage

☐ Flow batteries

Nuclear

☐ Store off-peak nuclear electricity

☐ Hybrid nuclear-**hydrogen** production

☐ Flexible reactor operation



Introduction

Research Director, Utah Office of Energy Development, 2025 – Present

Emerging Technology Strategist, UOED, 2024 – Present



B.S, M.S, Ph.D. (2024) Mechanical Engineering, University of Utah

Nanofabrication → Energy Storage



Outside Work: Climbing, Camping, Cooking, Skiing



Utah Office of Energy Development

Two main portions of the Office

Programs and Grants – Federal and state incentive, grants, education efforts

- High cost infrastructure tax credit, rural EV infrastructure, education

Research – In-house expertise on energy issues and guiding policy or initiatives

- Operation Gigawatt, Publications, Strategic Energy Plan, Data Analysis

Self-contained entities

- San Rafael Energy Research Center – Research center for energy-related projects like supercritical CO₂, pilot nuclear projects
- Nuclear Consortium
- Advanced Energy and Nuclear Institute



LDEN NATIONAL CONSORTIUM



HIGH COST INFRASTRUCTURE TAX CREDIT

The High Cost Infrastructure Tax Credit (HCITC) supports significant infrastructure investments in the state; bolstering the cost-effective and sustainable delivery of Utah's commodities to domestic and global markets.

ELIGIBLE PROJECTS:

- ✓ ENERGY DELIVERY
- ✓ TIER-III FUEL STANDARD COMPLIANCE
- ✓ MINERAL PROCESSING
- ✓ UNDERGROUND MINE INFRASTRUCTURE
- ✓ EMISSIONS REDUCTION
- ✓ WATER PURIFICATION
- ✓ WATER RESOURCE FORECASTING



NUCLEAR



Nuclear power is the generation of electricity through nuclear reactions, primarily using uranium as a fuel source. In nuclear power plants, uranium-235 atoms undergo nuclear fission, where they are split apart, releasing enormous amounts of heat and energy.

DEFINING ENERGY

Uranium

(a) Uranium is a silvery-white radioactive metallic chemical element with atomic number 92, naturally occurring in low concentrations in rocks, soil, and water. Uranium is the heaviest naturally occurring element which can be found abundantly on earth.

Current theories suggest that earth's uranium was formed billions of years ago in various supernovas or from the collision of neutron stars.

U.S. nuclear power plants are already among the safest and most secure industrial facilities in the world due to the industry's commitment to comprehensive safety procedures, robust training programs and stringent federal regulation that keep nuclear plants and neighboring communities safe.

Currently **94** commercial nuclear reactors help to power homes and businesses in **28** states.

Nuclear power plants produce nearly **1/2** of the nation's emissions-free electricity, making it the largest source of carbon-neutral power in the United States.

The uranium needed to satisfy an average Utahns lifetime energy needs can fit in a coffee mug.

While Utah does not currently have nuclear power in its energy mix, PacifiCorp has partnered with TerraPower to construct a nuclear power plant in Kemmerer, Wyoming. They have discussed replicating this power plant's design in Utah.

Radiation from nuclear fuel warrants attention, but is easily managed. All the nuclear waste currently in the United States can fit into a single football field.



During the Uranium boom of the 1950s, 8,000 Utahns were employed by the uranium industry and Moab was known as the "Uranium Capital of the World."



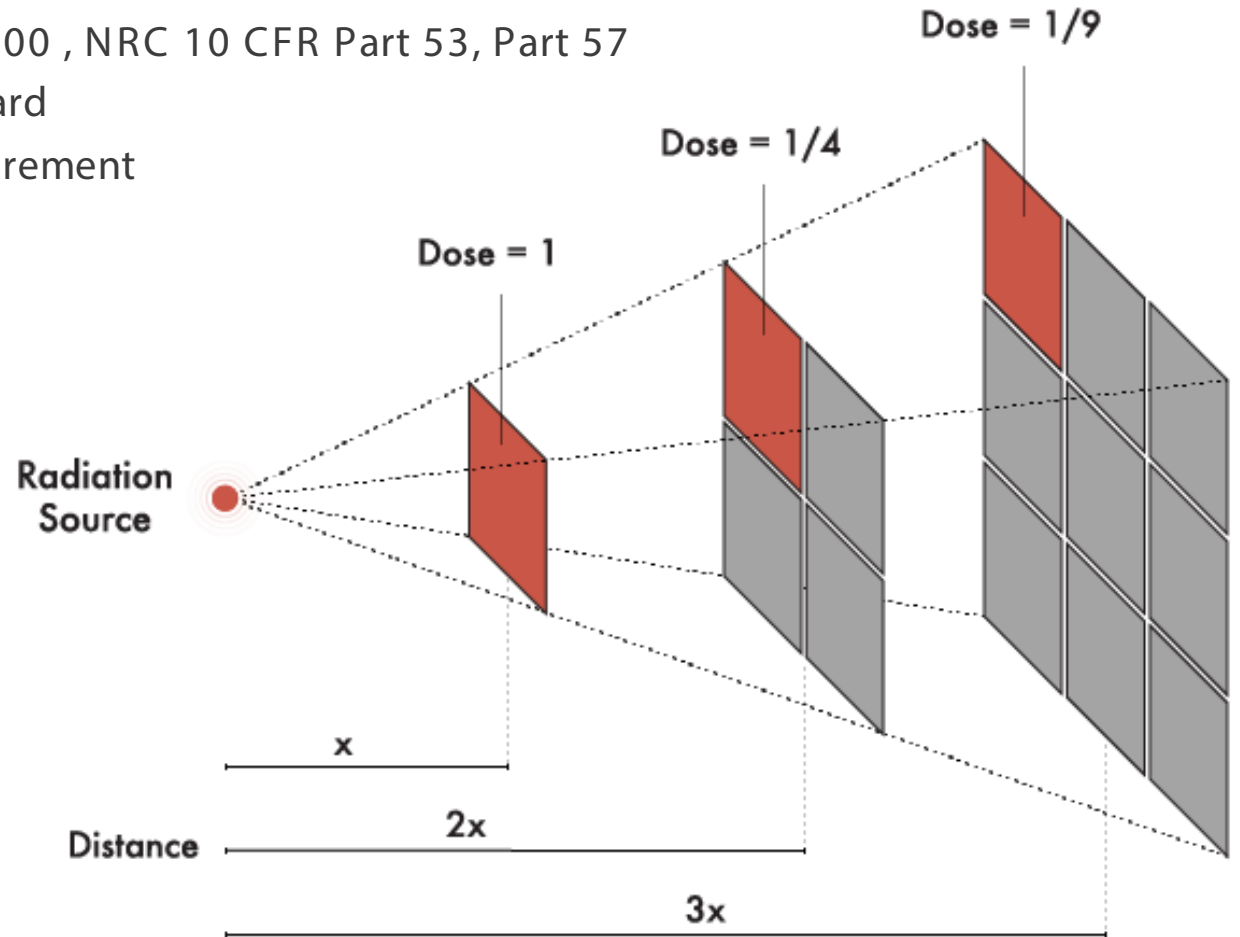
Modern Nuclear Regulation

Direction from congress and executive to reassess current standards

NEIMA, ADVANCE Act , Executive Order 14300 , NRC 10 CFR Part 53, Part 57

Modernized regulations meet the same standard

“Risk-informed” regulation/performance requirement

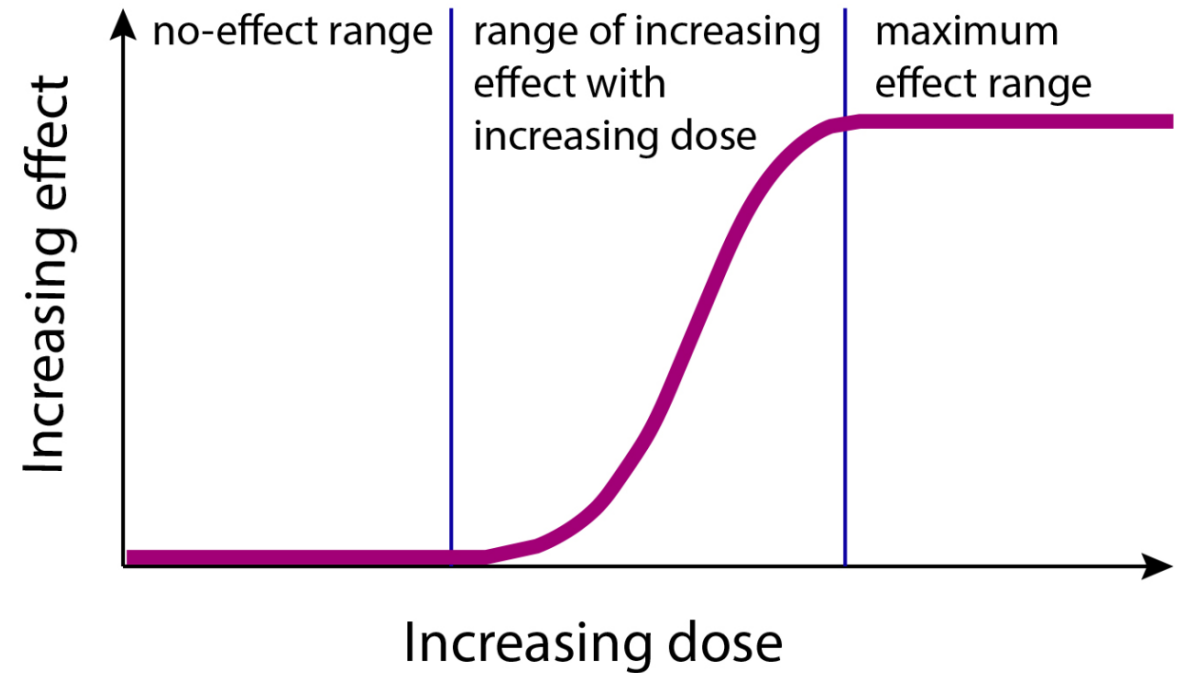
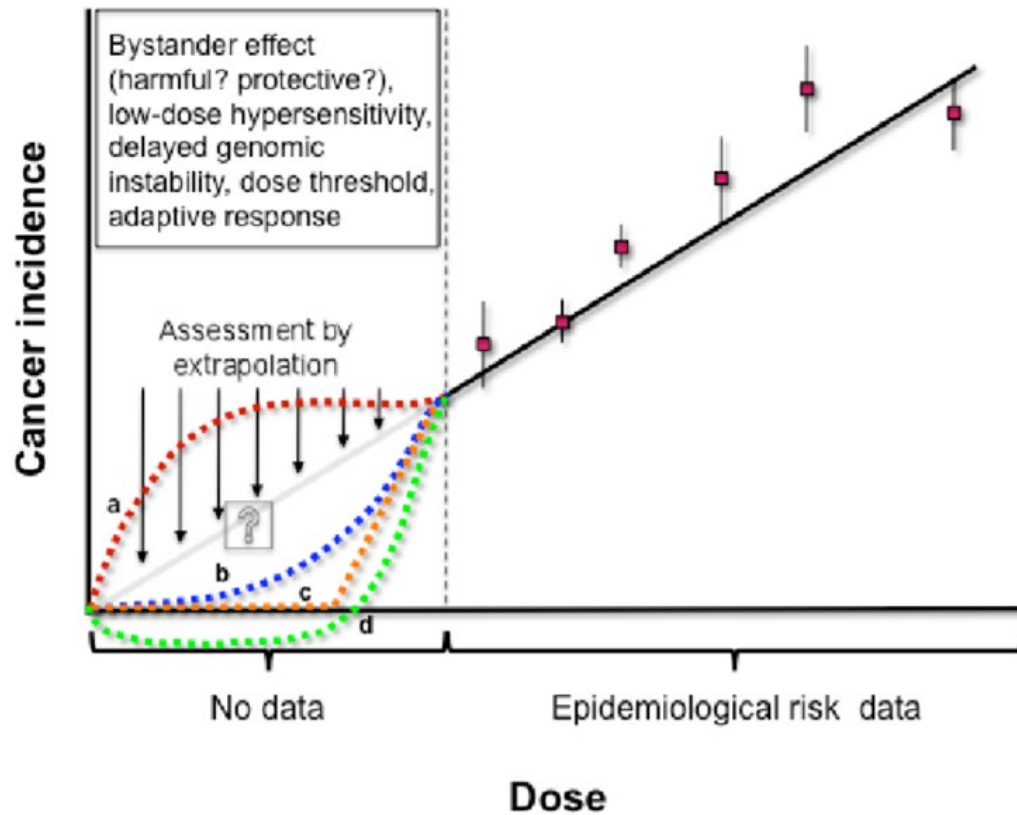


<https://www.nrc.gov/reading-rm/doc-collections/maps/emergency-preparedness>

<https://sites.duke.edu/missiontomars/the-mission/effects-of-radiation/protection-against-radiation/>

Federal landscape – Shifts in ALARA

Linear-Non-Threshold (LNT) model



<https://www.eurekaselect.com/article/42657>
<https://toxedfoundation.org/basics-of-dose-response/>

DANIEL S. WENDT

DISTINGUISHED ENGINEER, IDAHO NATIONAL LABORATORY PROCESS MODELING & ANALYSIS DEPARTMENT

Dan has spent over 25 years at INL building expertise in process modeling and techno-economic analysis (TEA) across hybrid energy systems, nuclear-hydrogen integration, industrial decarbonization, and synthetic fuel production.

Project Highlights

- TRIUMPH — leads the reverse water-gas shift (RWGS) reactor development task within the DOE-funded testbed featured in this talk
- Nuclear-Integrated Hydrogen Production Profitability Evaluation — principal investigator, DOE-NE LWRs program
- HTSE Performance and Cost Baseline — lead and subject matter expert for INL's internal and collaborative high-temperature steam electrolysis reference costing basis
- Multi-year industry CRADA — techno-economic analysis for nuclear-enabled petroleum refinery integration
- Geothermal hybrid power systems — PI across multiple DOE Office of Geothermal projects; Hybrid Systems Task Force Lead for the 2018 GeoVision Study
- Currently leading techno-economic evaluation of nuclear integrated methane pyrolysis in collaboration with X-energy



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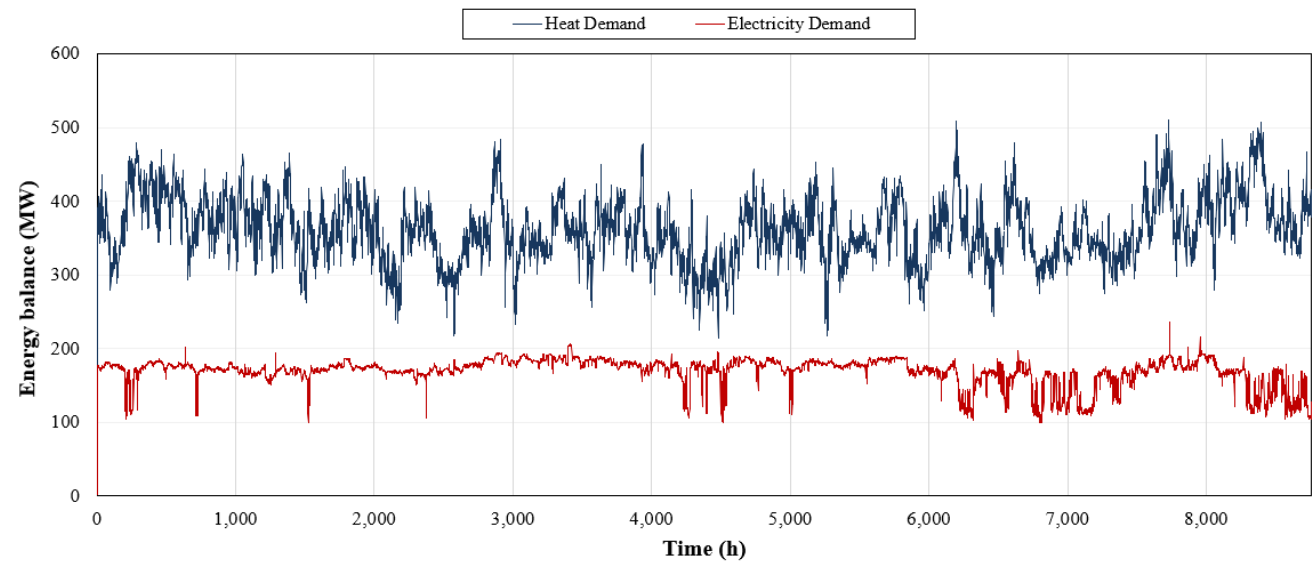
Education

- M.E., Mechanical Engineering
University of Idaho (2009)
- B.S., Chemical Engineering
Cornell University (1999)



Highlights

- 25+ years at INL
- 45+ publications
- 4 issued U.S. patents
- R&D 100 Award (2010), Supercritical Solid Catalyst Biodiesel Process



Baseload vs. transient demand

Nuclear plants are most economic near full, steady power. Industrial thermal and electrical loads fluctuate hour to hour.



Thermal storage as the shock absorber

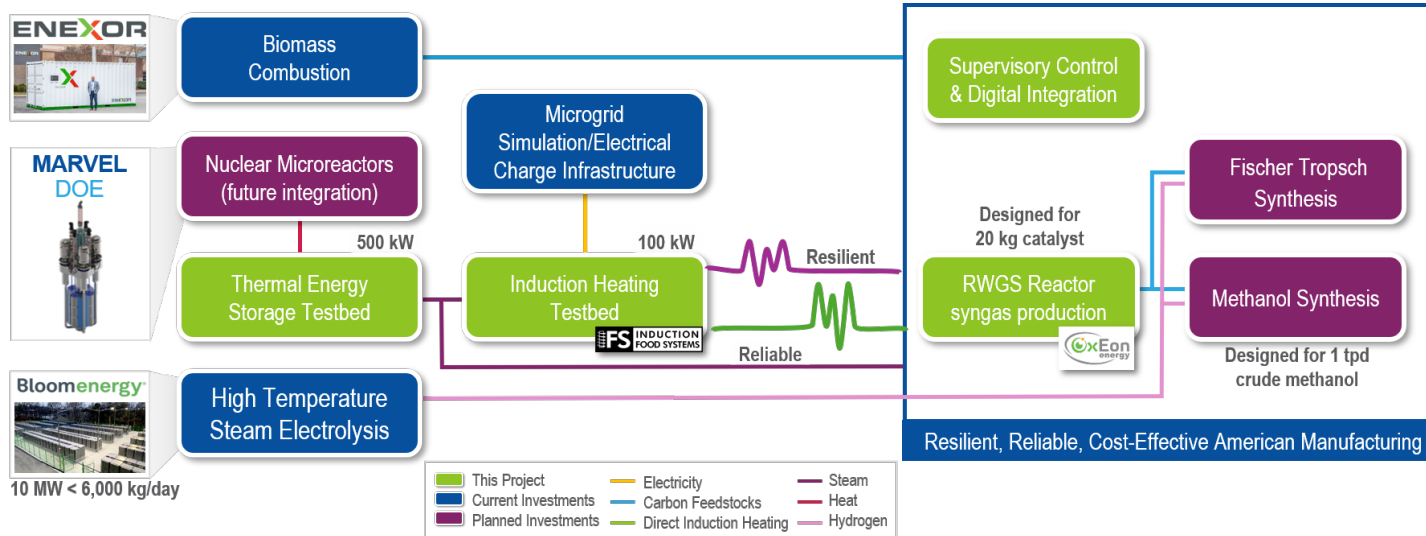
Inserting TES between the reactor and the end user decouples reactor output from process demand, without cycling the reactor.



The coupling advantage

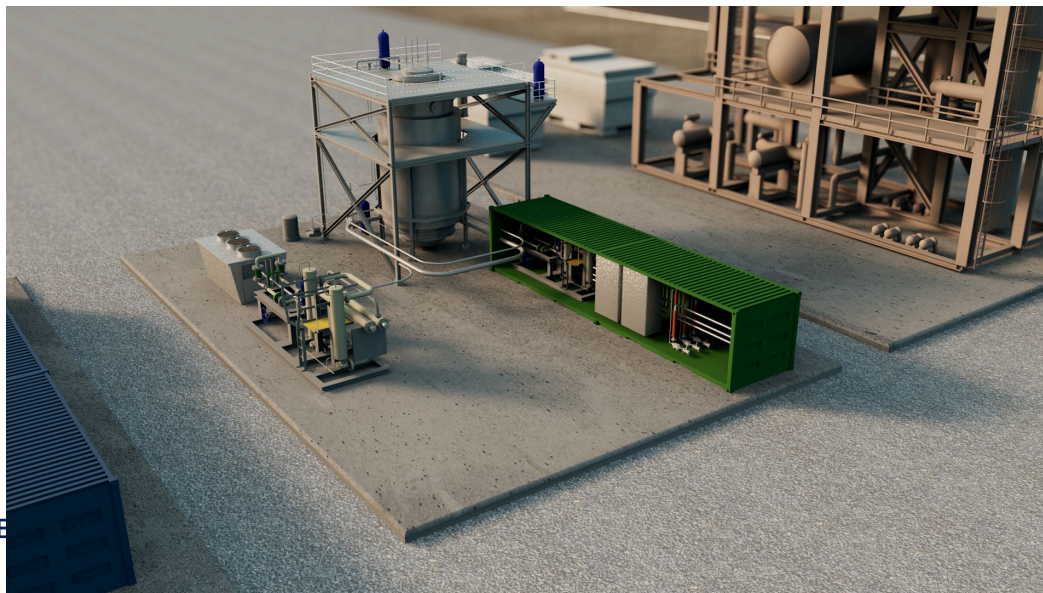
Coupling storage at the reactor's primary-to-steam-cycle interface can improve flexibility and process-heat efficiency while supporting resilient, secure energy delivery. (Saeed et al.)

TRIUMPH: A PILOT-SCALE ELECTROTHERMAL TESTBED



Testbed for Resilient InDUstrial and Manufacturing users of Power and Heat

- DOE Industrial Efficiency & Decarbonization Office award to Idaho National Laboratory (2026).
- Pilot-scale ecosystem integrating thermal energy storage, induction heating, and a chemical reactor unit into one testbed.
- Expands INL's Energy Technology Proving Ground; connects to existing high-temperature steam electrolysis and biomass combustion assets.
- Built with heat-to-heat interface provisions so nuclear and non-nuclear heat sources can be substituted in as they mature.



What TRIUMPH De-Risks

- Electrothermal heating strategies (resistive + induction) at pilot scale, prior to nuclear reactor thermal integration
- Molten-salt TES integration with steam generation and distribution loops
- Coupling of stored heat to an endothermic chemical process (syngas production route)
- Controls interoperability across vendor-supplied test articles



MARVEL + MTEL: REACTOR-COUPLED HEAT DELIVERY

80

kWth

MARVEL thermal output

~20

kWe

MARVEL electrical output

80-160

kWth

MTEL nominal heat delivery

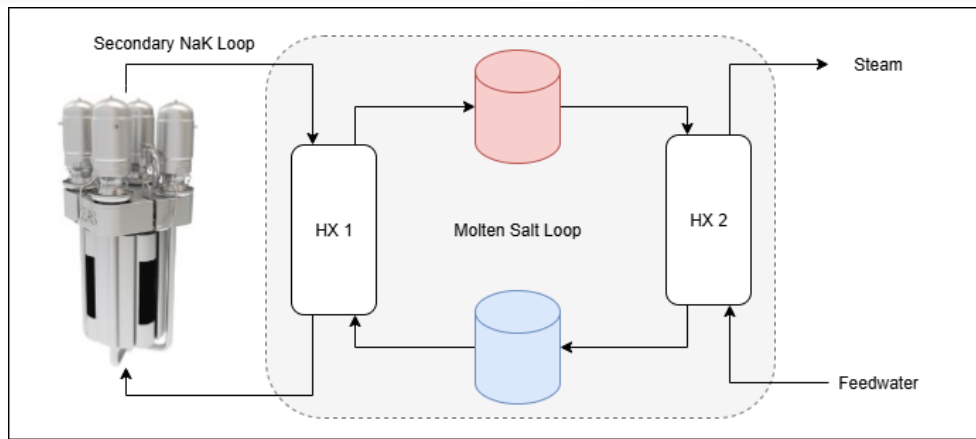
400

°C

Salt / steam delivery temp.

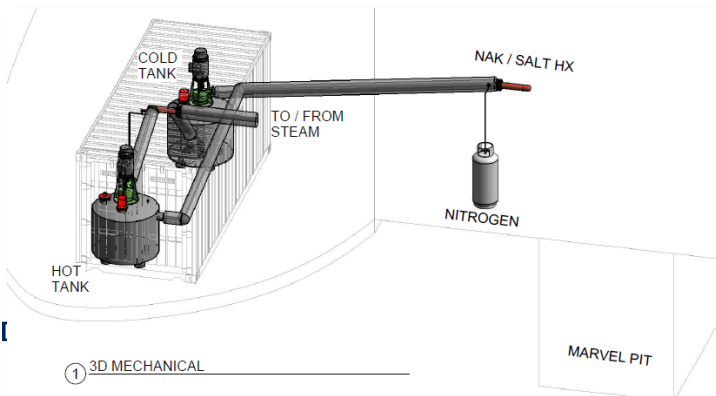
MTEL enables max heat discharge rate at 2X Marvel's nominal power

Supplemental heating available to boost salt T to 400-500°C, steam T to 400-450°C

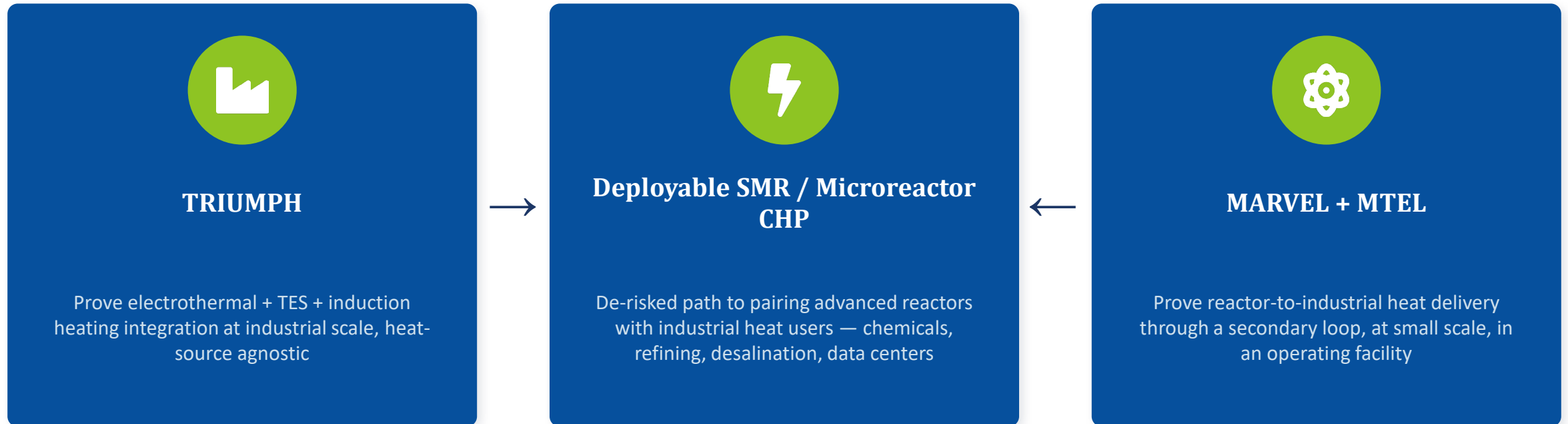


MARVEL is a sodium-potassium-cooled microreactor being installed at INL's TREAT facility (commissioning targeted late 2027). The MARVEL Thermal Energy Loop (MTEL) is a modular secondary loop that extracts reactor heat via a NaK-to-salt exchanger and delivers it — as high-temperature salt or steam — to external industrial skids, without those skids ever touching the nuclear primary system.

Five commercial teams are already lined up for first MARVEL end-user experiments — spanning AI data-center power, remote/autonomous reactor operations, advanced sensing, and a pilot desalination project using nuclear process heat to treat oil & gas produced water.



TWO TESTBEDS SUPPORT COMMON GOAL OF DEPLOYMENT OF NUCLEAR PROCESS HEAT INTEGRATION APPLICATIONS



The same storage-buffered heat delivery pattern that de-risks industrial CHP also underpins energy security: MARVEL's own first end-user proposals (AWS; DCX USA + ASU) frame this as self-sustaining, grid-independent operation for critical, remote, or defense-designated sites.



Suggested Discussion Points

1. Introduction to Nuclear Technologies
2. Path for Nuclear to Markets
3. Potentials for Nuclear + Energy Storage
 1. Nuclear services vs Storage services (to grid or other)
 2. Deployment speed
4. Open Questions and Dialogue with Audiences

