# NUCLEAR + ENERGY STORAGE PANEL

*Moderator: ZHIWEN MA*

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

# Introduction






**Panelists:**

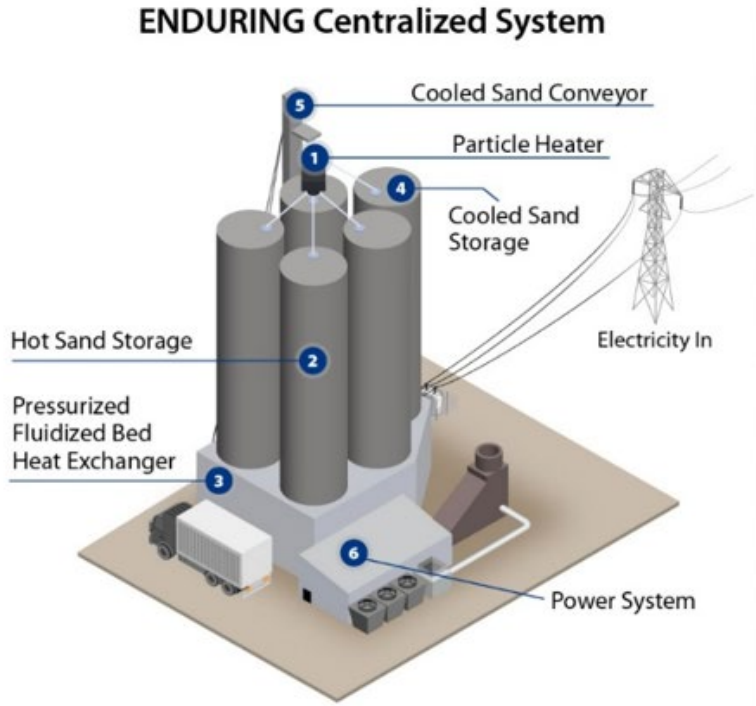
*Kelyn Wood (EPRI), Tim Kowalchik (UOED), Daniel S. Wendt (INL), Supathorn Phongikaroon (UU), Rebecca Barney (NLR)*

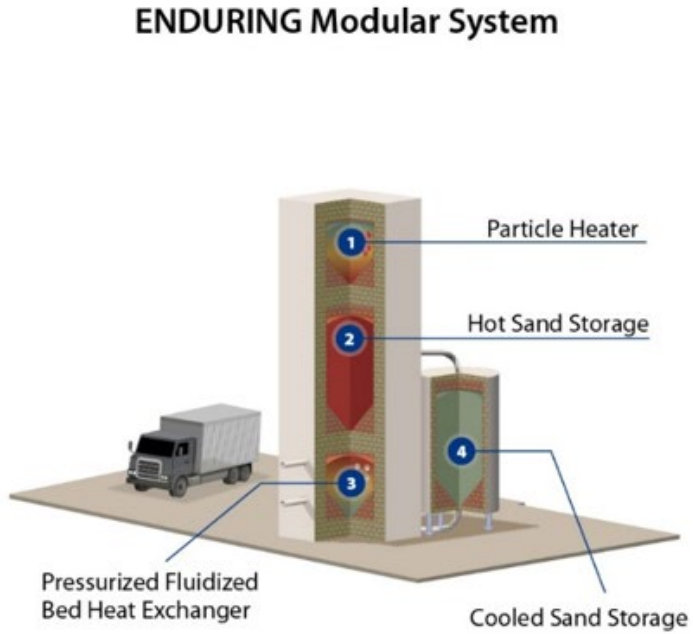
*Moderator: Zhiwen Ma*

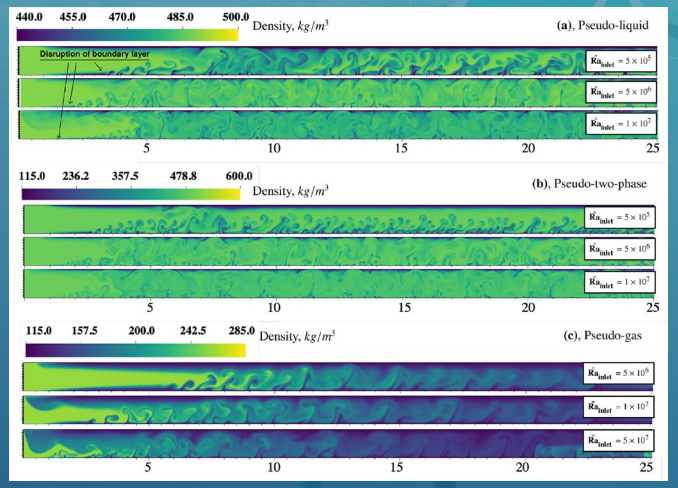
# Technical background:

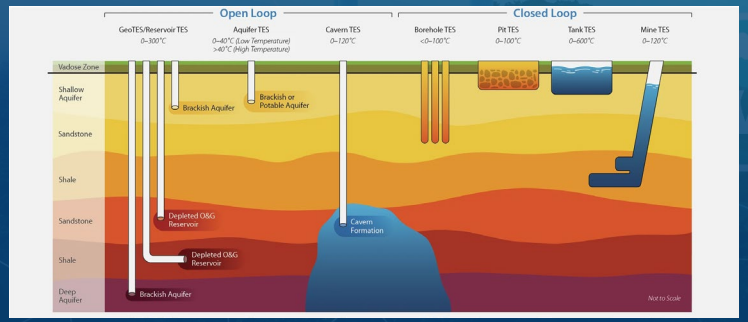
Zhiwen Ma, Ph.D.
National Laboratory the Rockies (NLR)
NLR Distinguished Member of Research Staff
ASME Fellow

- 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.






# 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

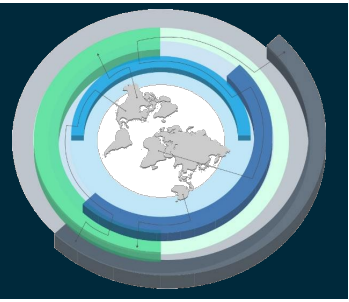
- 8 staff (3 Technical Executives) with total of 9 advanced degrees and 85 years experience combined at EPRI
- 500+ member meetings on energy storage in 2025
- 600+ papers, articles, and other published works

### 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

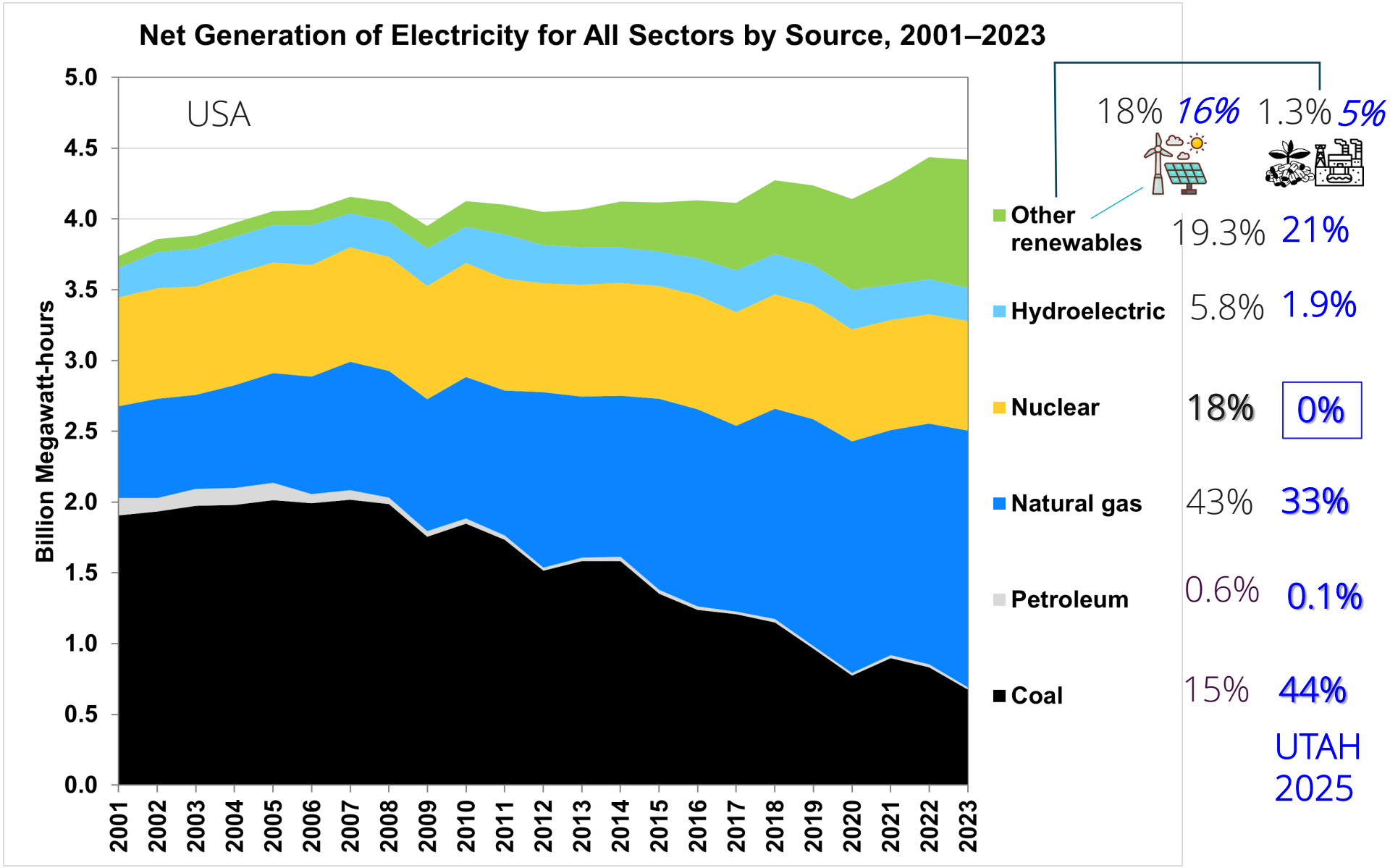
- Education:
  - NRC Postdoctoral Fellow at NRL, Washington D.C., 2001 – 2004;
  - Ph.D. Chemical Engineering from University of Maryland, College Park (2001);
  - B.S. Nuclear Engineering from University of Maryland, College Park, (1997).
- Professional experience (teaching and conducting research in 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



- ✓ 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

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.

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



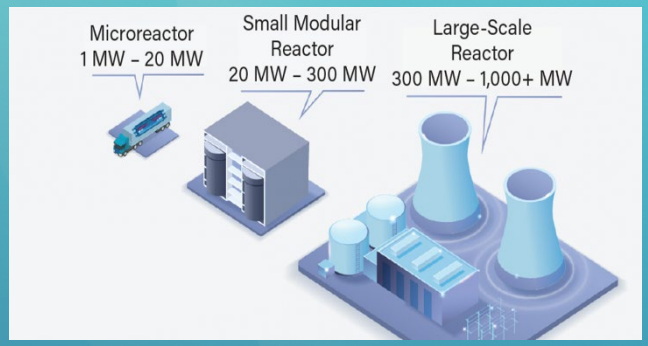
https://www.eia.gov/state/?sid=UT#tabs-4

# 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.*




→ LDES

Reliable Power Grid

LDES NATIONAL CONSORTIUM

# LDES Technology Approaches

| Technology | Duration | Maturity | Best Application |
|---|---|---|---|
| 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

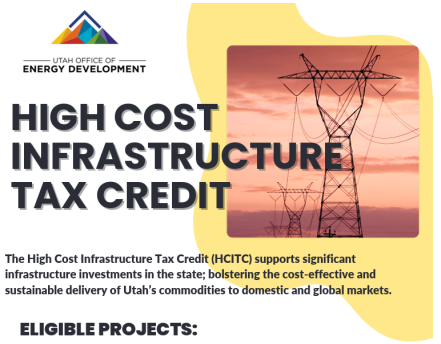
# Utah Office of Energy Development

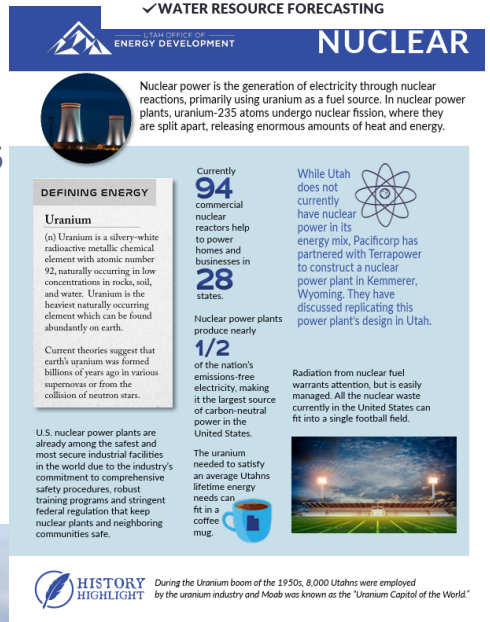
Two main portions of the Office

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



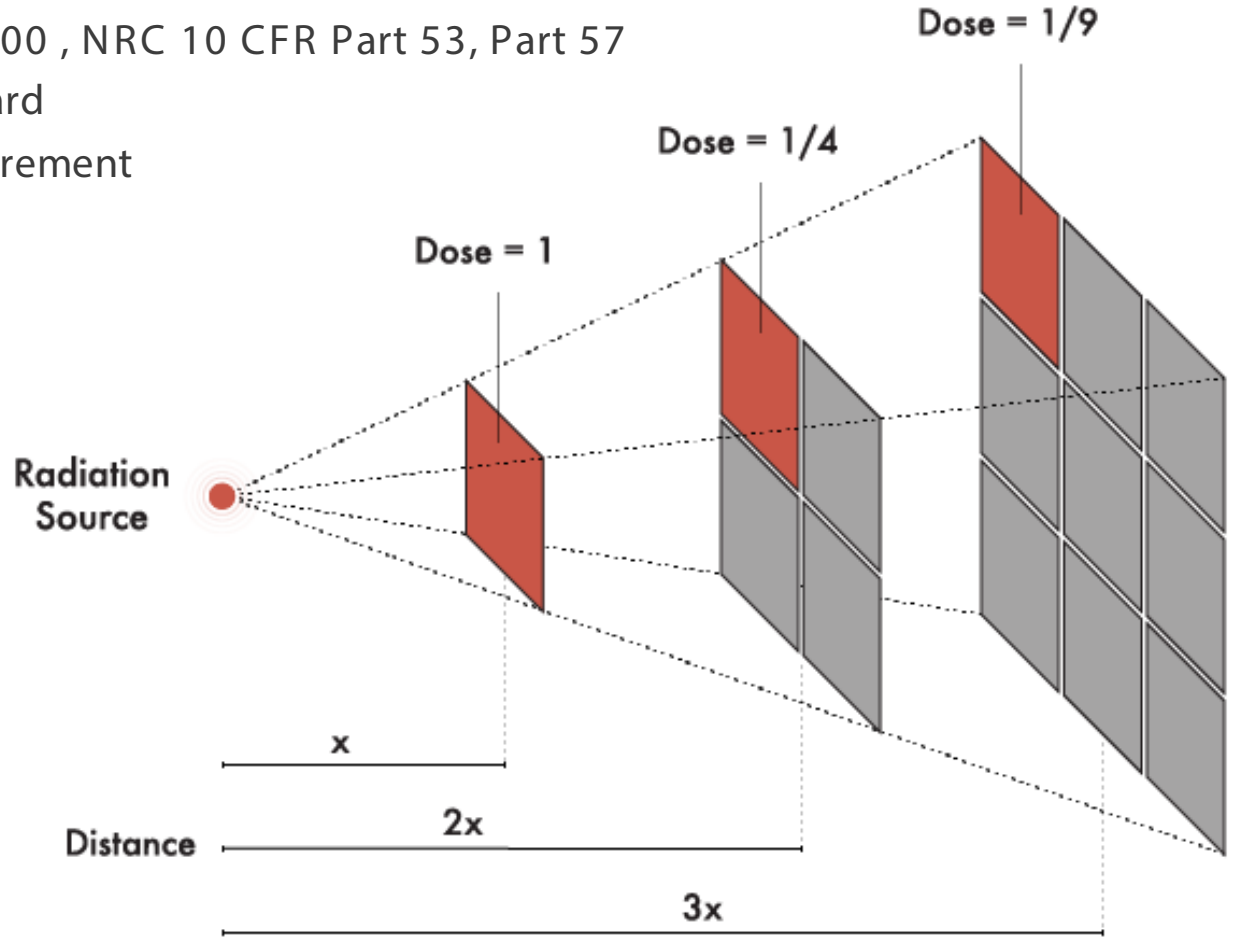

# Modern Nuclear Regulation

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

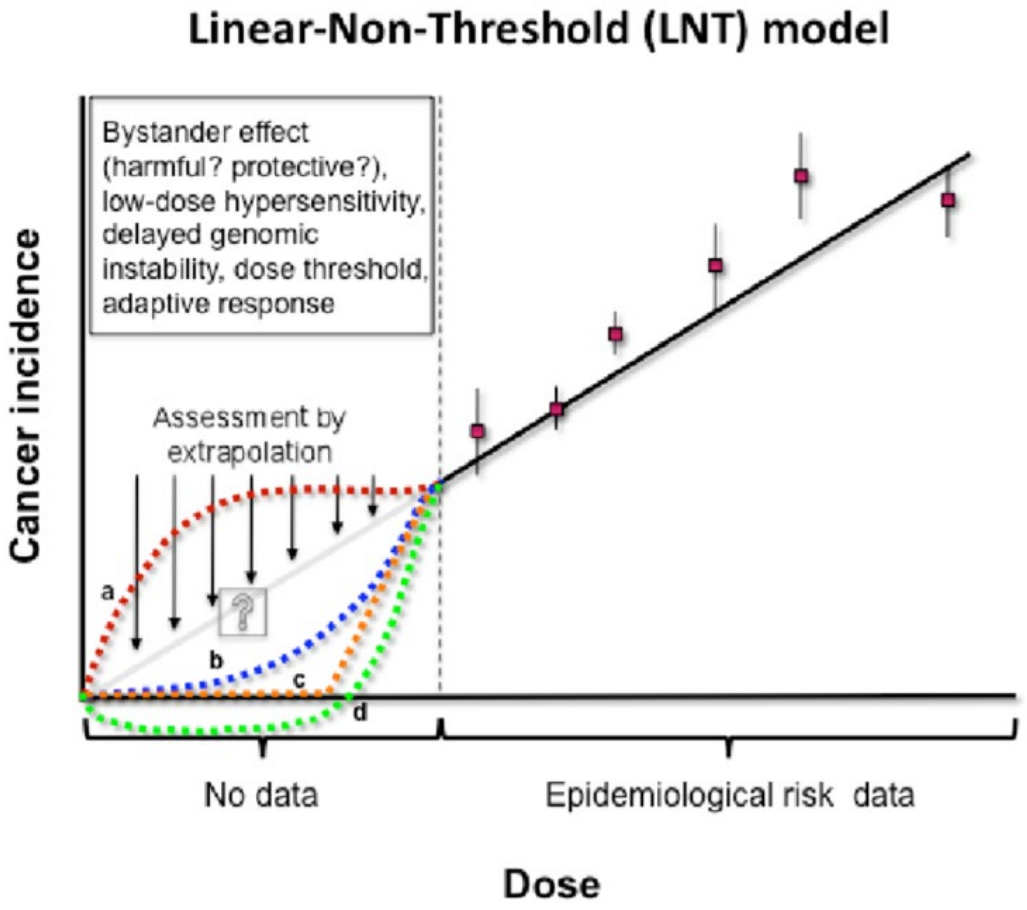
“Risk-informed” regulation/performance requirement

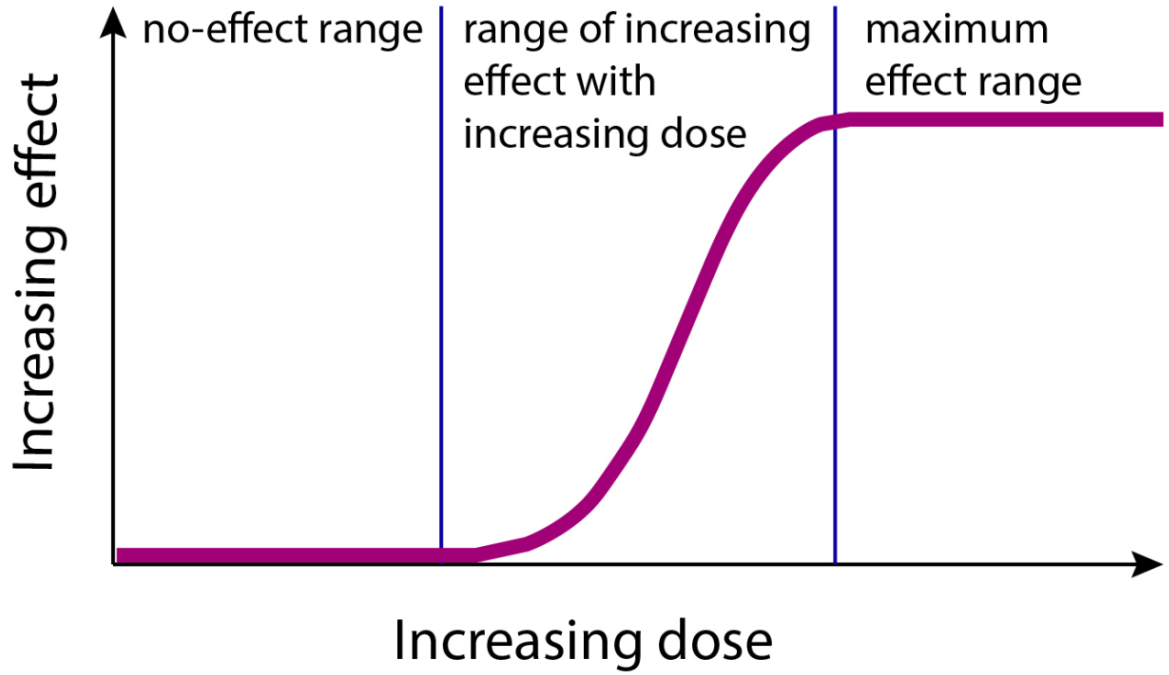




https://www.nrc.gov/reading-rm/doc-collections/maps/emergency-preparedness

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

# Federal landscape – Shifts in ALARA




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

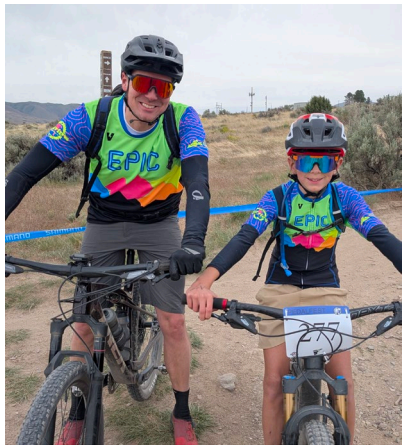
# DANIEL S. WENDT

## 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

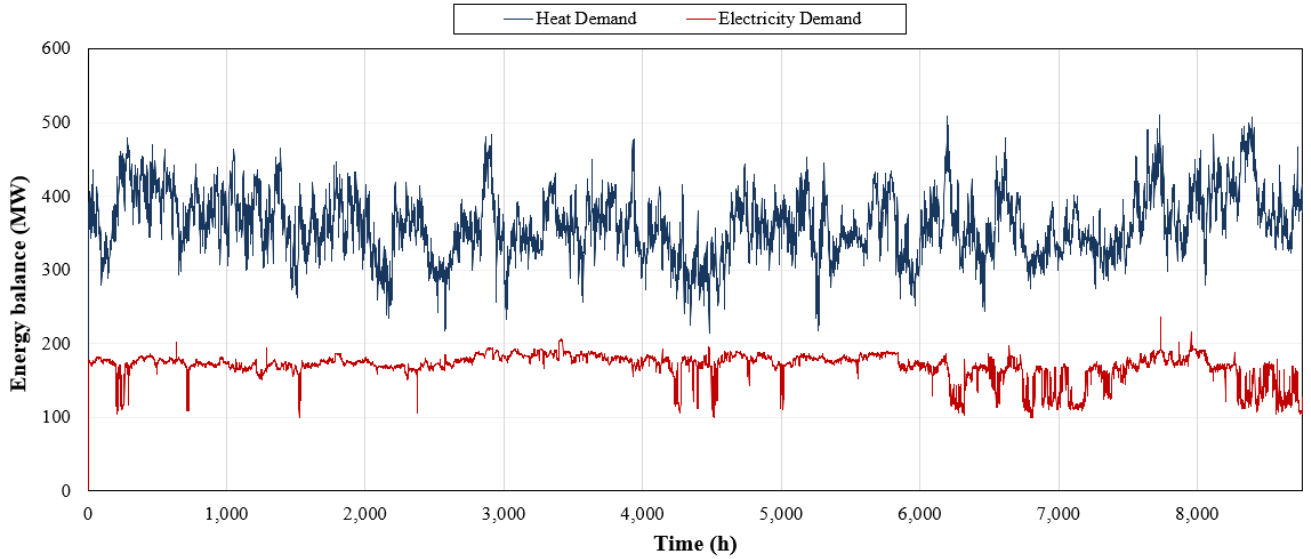



### Education

- 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

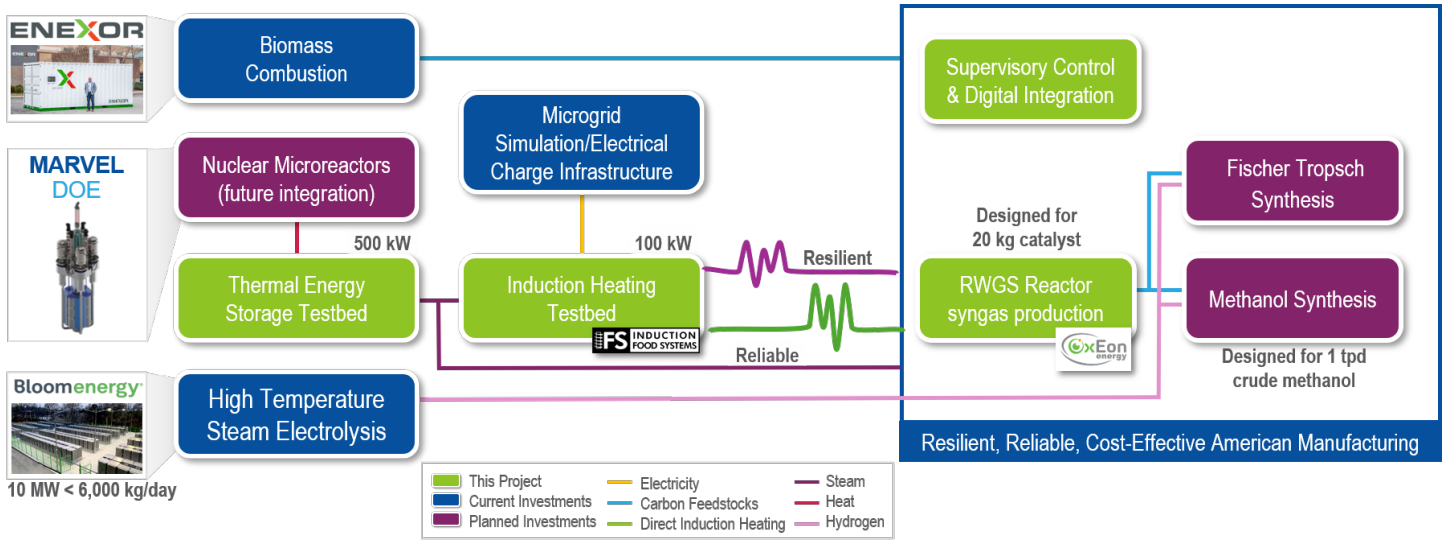
Inserting TES between the reactor and the end user decouples reactor output from process demand, without cycling the reactor.

## 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.)

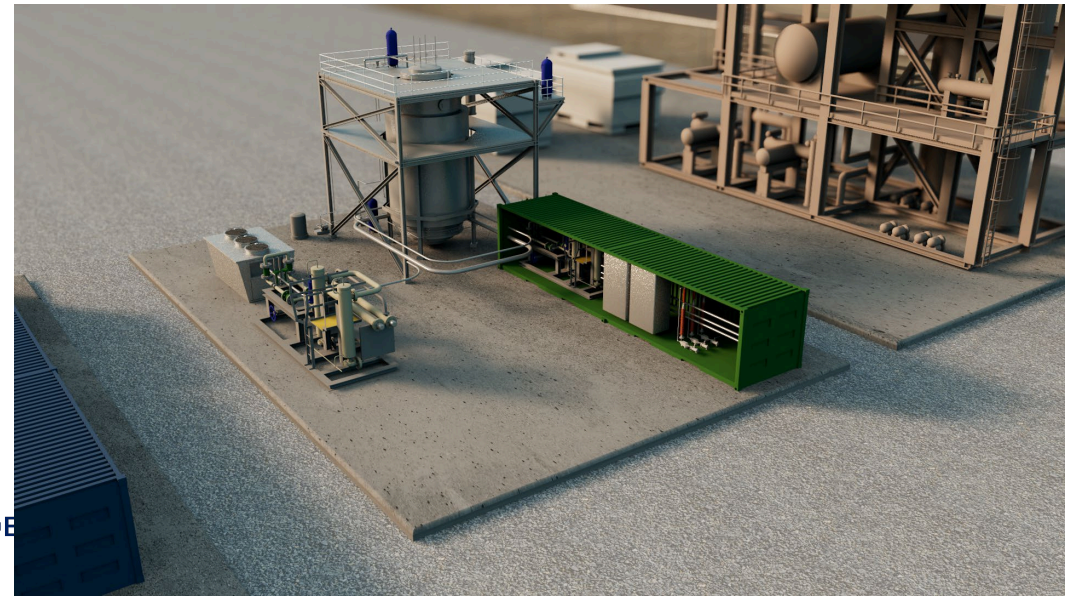
*Sources: DOE Office of Nuclear Energy Integrated Energy Systems program (ies.inl.gov);*
*Mikkelson et al., "Nuclear Technology Selection and Preliminary Integration at the St. Charles and Carrollton Manufacturing Sites," INL/RPT-24-78505*
*Saeed et al., "Nuclear-thermal energy storage configurations … with high temperature gas-cooled reactor," Applied Energy (OSTI 2588612);*
*Saeed et al., "Design and optimization of flexible decoupled HTGR plants with thermal energy storage," Energy Conversion and Management (OSTI 2453861).*

# 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

LDE

# MARVEL + MTEL: REACTOR-COUPLED HEAT DELIVERY

**80**
kWth
MARVEL thermal output

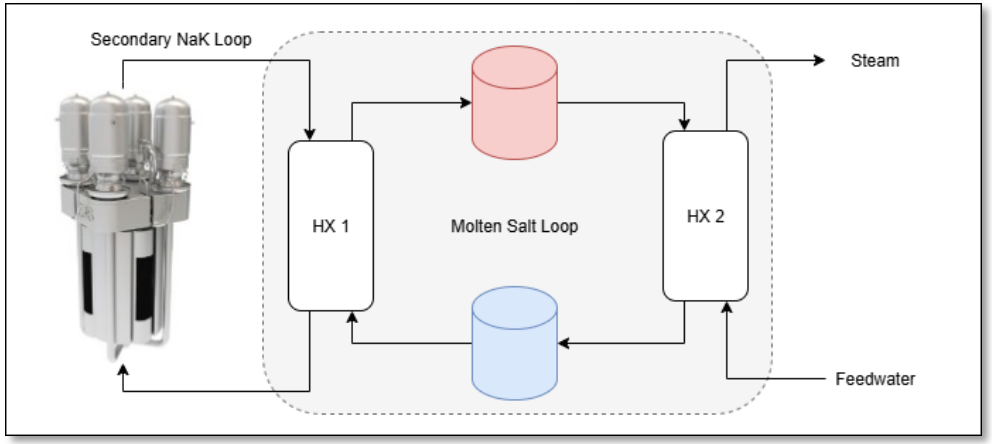
**~20**
kWe
MARVEL electrical output

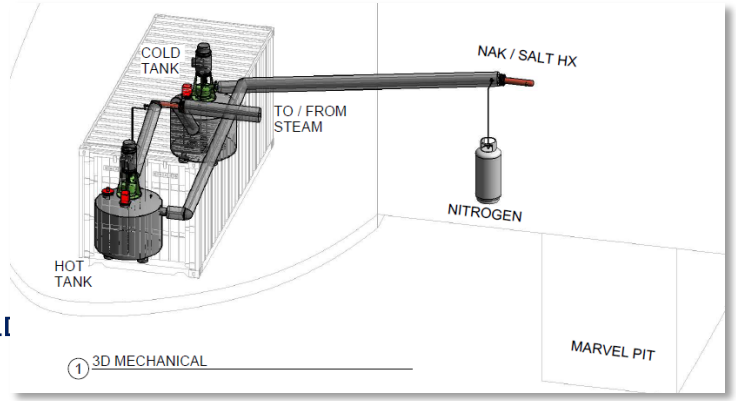
**80-160**
kWth
MTEL nominal heat delivery

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

**400**
°C
Salt / steam delivery temp.

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

### TRIUMPH

Prove electrothermal + TES + induction heating integration at industrial scale, heat-source agnostic

→

### Deployable SMR / Microreactor CHP

De-risked path to pairing advanced reactors with industrial heat users — chemicals, refining, desalination, data centers

←

### MARVEL + MTEL

Prove reactor-to-industrial heat delivery through a secondary loop, at small scale, in an operating facility

*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