Westinghouse eVinci™ Microreactor

February 2023

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eVinci Microreactor Capability

Nuclear battery designed for safe and reliable electricity and heat generation

Technical Capabilities

- 5 MWe + ~8MWth @ 200C cogeneration
- Minimum 8 year refueling cycle
- Transportable for ease of installation and elimination of spent fuel storage on site
- Cost-competitive plant lifecycle
- Minimal onsite personnel
- Mature technology, manufacturing, and regulatory readiness
- High speed load-following capability

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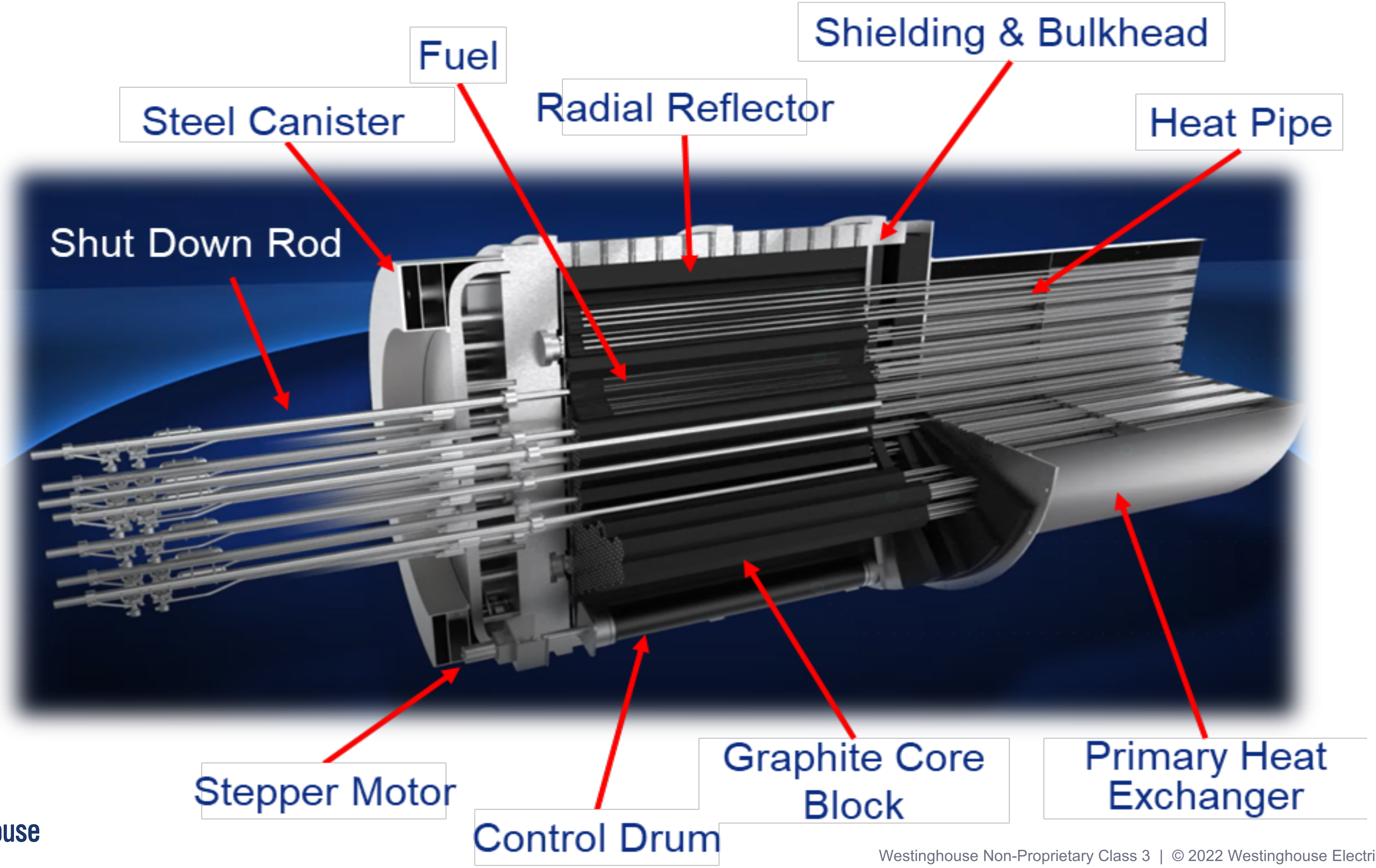
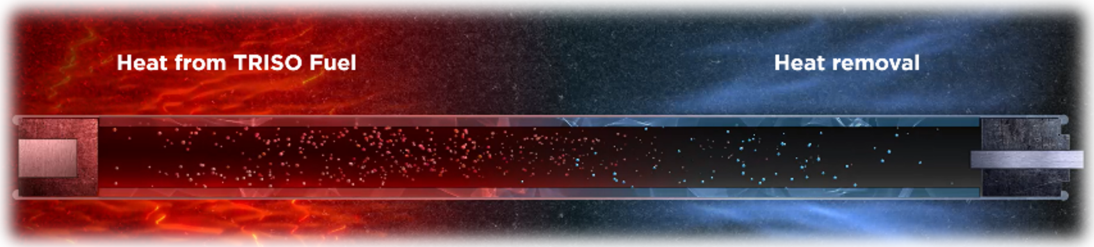
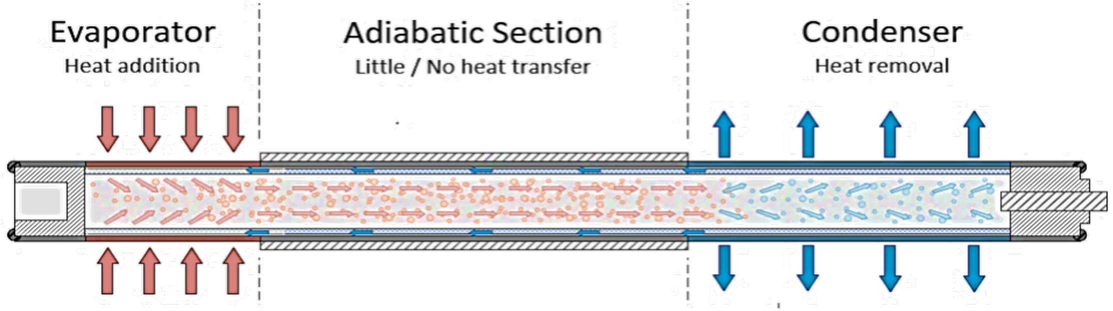
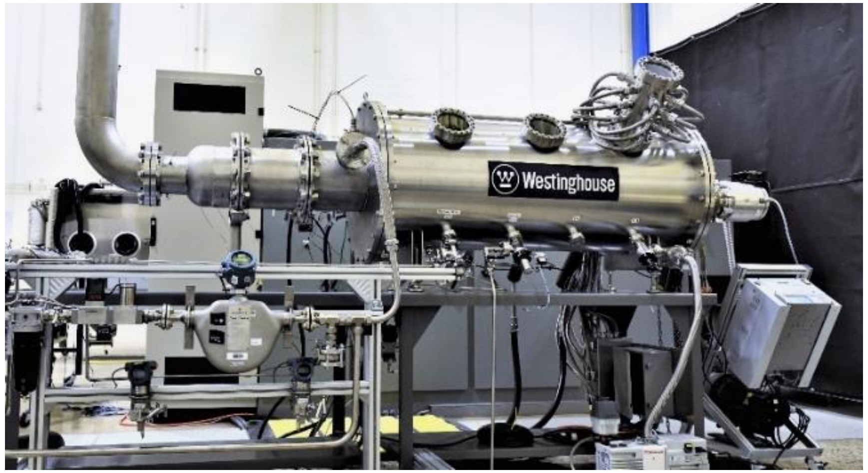
Minimal Components for Simplicity, Safety and Reliability



Heat Pipe Technology Development







eVinci R&D Facility near Pittsburgh, PA

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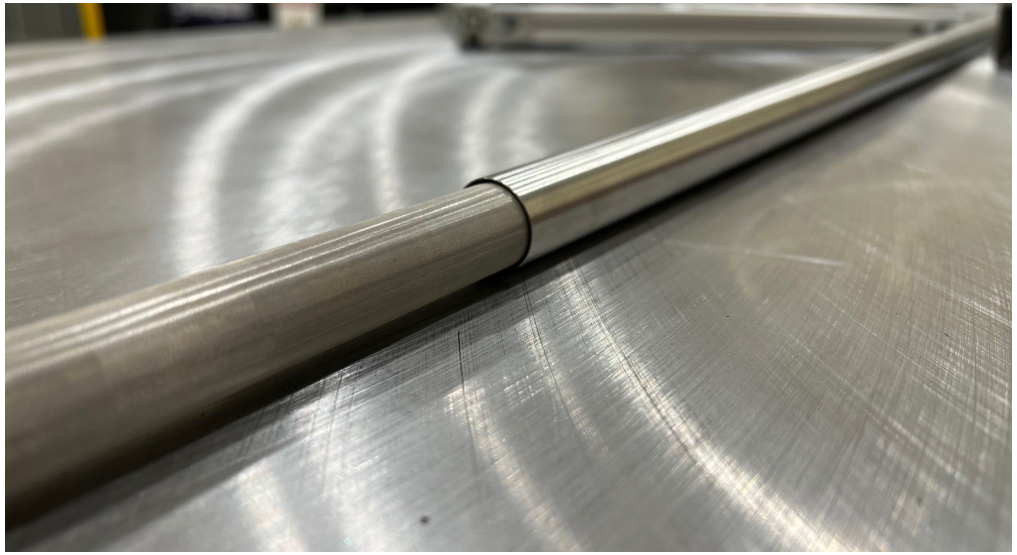
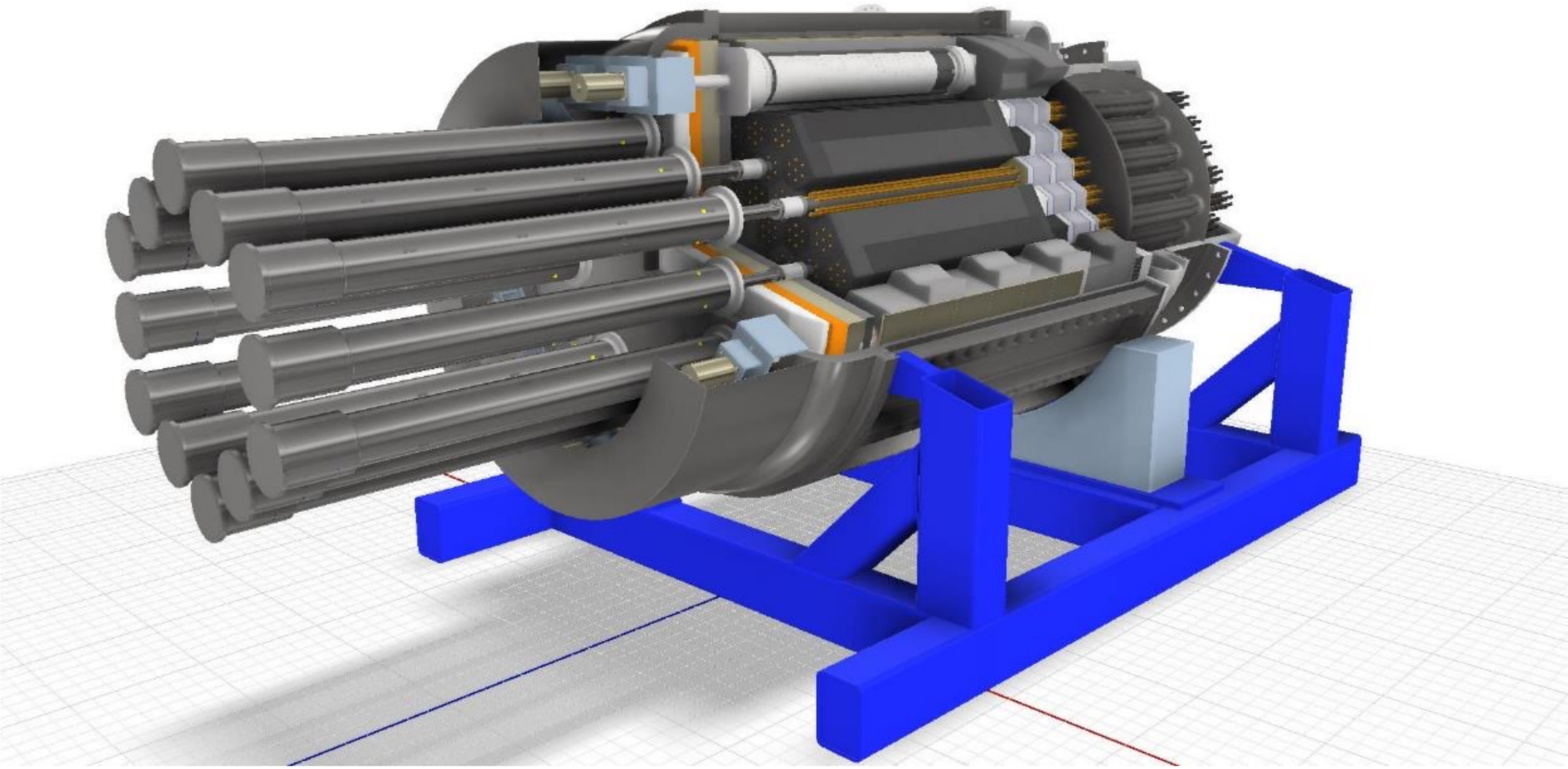
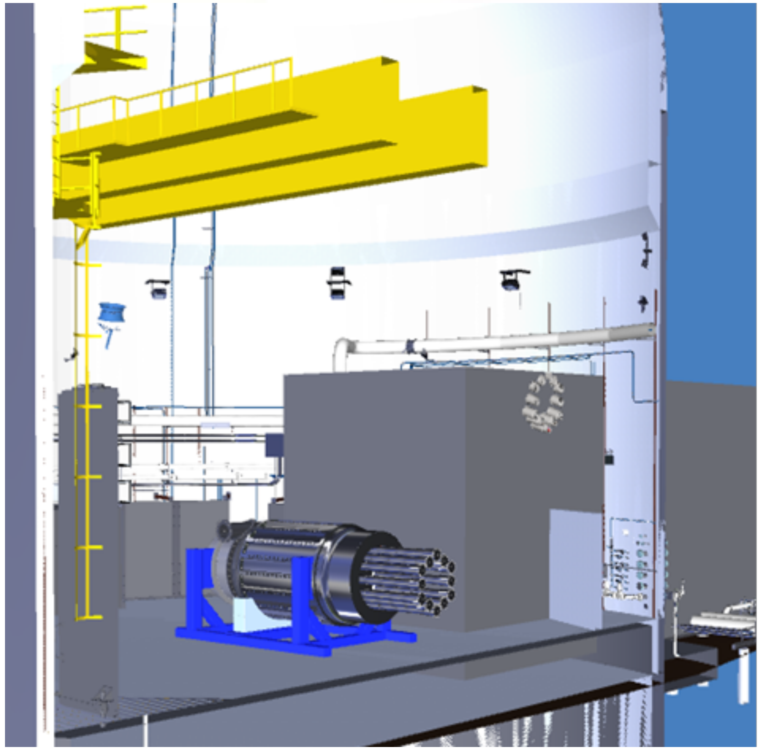
Heat Pipe Manufacturing Progress



Nuclear Test Reactor in 2026

- Idaho National Labs – EBR-II Dome
- 1/5th scale test reactor
- Currently developing detailed design





Licensing Progress with US NRC

Current Status:
https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/evinci.html

#	Topic	Submittal Wave		#	Topic	Submittal Wave		#	Topic	Submittal Wave
1	Facility Level Design Description	Submitted - 1		13	Advanced Logic System®(ALS) v2	Submitted - 3		25	Inservice Inspection Program/Inservice Testing Program	5 (March 23)
2	Principal Design Criteria	Submitted - 1		14	Component Qualification	Submitted- 3		26	Post-Accident Monitoring System	5 (March 23)
3	Safety and Accident Analysis Methodologies	Submitted - 1		15	EPZ Sizing Methodology	Submitted - 3		27	Equipment Qualification	5 (March 23)
4	LMP Implementation	Submitted - 1		16	Physical Security	Submitted - 3		28	PRA Program Strategy	5 (March 23)
5	Regulatory Analysis	Submitted - 2		17	Heat Pipe Design, Qualification, and Testing	Submitted - 3		29	Fire Protection	5 (March 23)
6	Deployment Model	Submitted - 2		18	Nuclear Design	Submitted - 3		30	Cyber Security	5 (March 23)
7	Safeguards Information Plan	Submitted - 2		19	U.S Transportation Strategy	Submitted - 3		31	Radiation Protection and Contamination Methodology	5*/6 (Q2 23)
8	Test and Analysis Process	Submitted - 2		20	Phenomena Identification and Ranking Table (PIRT)	Submitted - 4				
9	Functional Containment and Mechanistic Source Term	Submitted - 2		21	Integral Effects and Transient Testing	Submitted - 4				
10	Composite Material Qualification and Testing	Submitted - 2		22	Refueling and Decommissioning	Submitted - 4				
11	Fuel Qualification and Testing	Submitted - 3		23	Seismic Methodology	Submitted - 4				
12	Code Qualification	Submitted - 3		24	Operations and Remote Monitoring	Submitted - 4				

NRC Topical Report Submittals

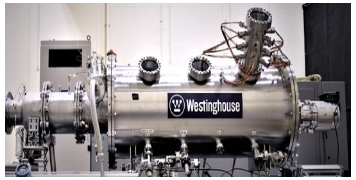
#	Report Title	Anticipated Submission
1	ALS v2 Platform	Dec-22 (submitted)
2	ALS v2 Development Process	Dec-22 (submitted)
3	ALS v2 Technical Specification Surveillance Requirement Elimination	Mar-23
4	Principal Design Criteria	Mar-23
5	Fuel Design	Jun-23
6	Functional Containment and Mechanistic Source Term	Nov-23
7	DBA Methodology Report	Apr-24
8	EPZ Sizing	Apr-24
9	ALS v2 eVinci Microreactor Specific	Jun-24
10	Nuclear Design	Jun-24
11	Inservice Inspection	Oct-24
12	Inservice Testing	Oct-24
13	Component Qualification Methodology	Oct-24
14	Composite Materials	Dec-24
15	Metallic Materials	Dec-24
16	Graphite Materials	Dec-24
17	Heat Pipe Qualification Criteria	Dec-25

eVinci Microreactor – Technology Development & Timeline

Leading the way in advanced reactor development and commercialization

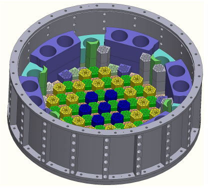
Technology Development and Manufacturing

2021-2022



- Conceptual design complete
- Electrical demonstration unit operational
- Initiated licensing engagement with US and Canadian regulators

2023

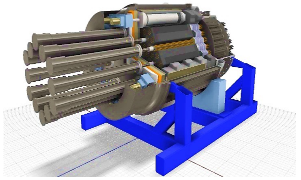


- NTR design for procurement
- Integrated manufacturing demonstrations and prototyping
- Separate effect and component testing

2024

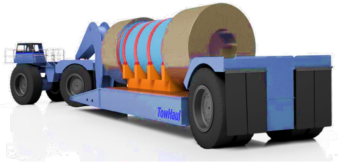
- NTR component fabrication
- Criticality and irradiation testing
- eVinci manufacturing design

2025-2026



- NTR assembly and operation
- Analysis code validation
- Initiate eVinci manufacturing
- Power conversion system testing

2027+



- eVinci design complete
- Receive regulatory licensing approvals
- Commercial unit delivery and operation

Licensing

- **US NRC pre-licensing engagement** *(Technical papers & Topical report submittals)*
- **Prepare & submit design license to NRC**
- **NRC review & approve design certification**
- **Canadian Nuclear Safety Commission (CNSC) vendor design review**
- **Other countries' licensing activities**

Taking nuclear energy to **new frontiers**

Westinghouse is excited about our technology's promise for the Fission Surface Power project seeking 40 kWe for 10 years.

Our space reactor is designed for lunar surface operation under NASA's Artemis program and leverages eVinci microreactor technology, Uranium Nitride fuel, a hydride moderator and our vast experience across terrestrial and space nuclear fission systems.

Thank You

valorema@westinghouse.com

Long Duration Energy Storage

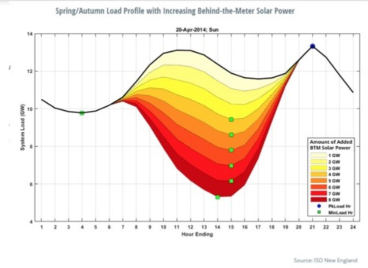
Robert Bernard

February 16, 2023

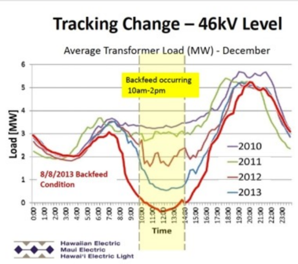
Evolving Power Markets

Dynamics

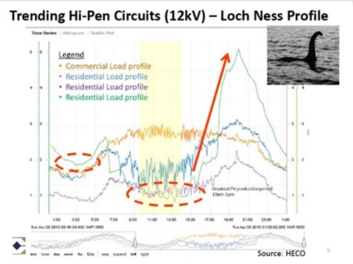
- Widely accepted that the power generation industry has a significant role to play in the global effort to curb greenhouse gas emissions (GHG)
- As non-dispatchable generation has entered the market, traditional paradigms have shifted
- Increased penetration of wind and solar power brings inherent variability in the grid generation profile
- Growth of renewable power drives several key challenges
    - Balancing electricity supply and demand
    - Overall reduction in system stability
    - Changes to electricity transmission flow patterns
- A suite of solutions will be required to fully address these challenges
    - Long duration energy storage (LDES)
    - Addition of baseload nuclear power (large and small)
    - Hydrogen turbines
    - Lithium-ion batteries



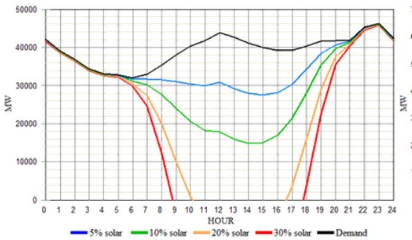
New England



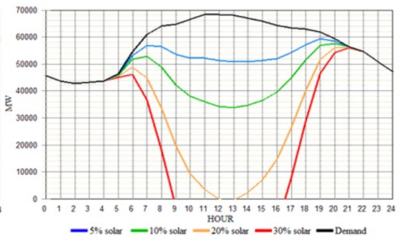
Hawaii



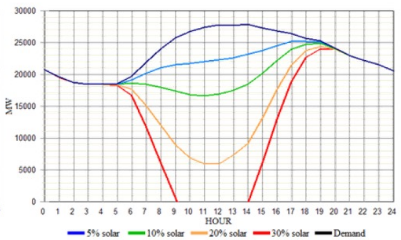
Hawaii “Nessie” Curve



France



Germany



Australia

<u>LDES Definition</u>: Any technology that can be competitively deployed and economically scaled to store energy for prolonged periods and sustain electricity provision for multiple hours, days, or weeks

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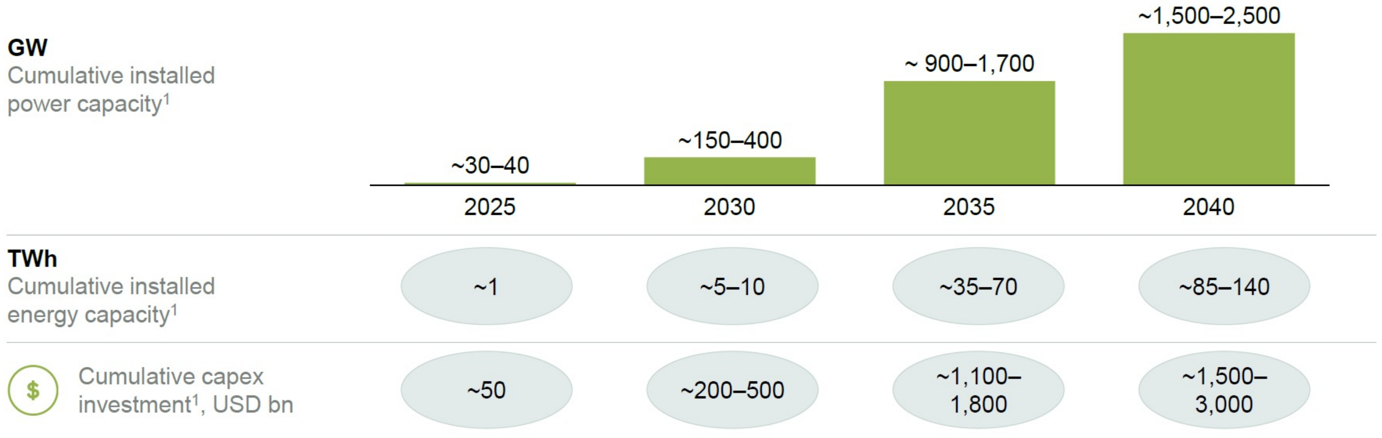
Renewables growth, electrification, favorable policy result in Rapid LDES Growth

LDES total addressable market and cumulative capex investment, 2025-2040



Technology	Round-Trip Efficiency	Responsiveness	Voltage/pF Control	Scalability	LCOS	Cost/Power	Marketability
Chemical	2.5	7.5	7	10	1	8	7.7
Lead Acid	8	10	5	5	5	7	7.6
Lithium Ion	8.8	10	5	6.5	8	6	8.3
Flow Battery	7	7.5	5	7.5	8	4	7.3
Metal Air	7.5	7.5	5	7.5	8	5	7.5
Supercaps	9.5	10	5	2.5	0	10	6.7
Superconducting Magnets	9.5	10	3	2.5	0	10	6.3
Compressed Air Storage	7	5	7	9	4	3	6.3
Liquid Air Storage	6	5	7	8.5	6.5	3	6.7
Flywheels	9	10	3	1	2	10	6.4
Pumped Hydro	7.5	7.5	10	10	10	7	10
Pumped Heat Storage w/ Nuke (Sensible + Latent)	7	7.5	10	9	8.5	5	9.1

Market Dynamics

- The LDES market is projected to grow rapidly as utilities and governments commit to storage technology to match increased renewable energy deployment
- Government policy around the globe is driving dramatically improved LDES economics
  - Inflation Reduction Act: 30% to 50% tax incentives for energy storage products
  - DOE planning > $500M on LDES demonstration projects
  - State driven storage credits
- Lithium-ion price continues to increase due to supply chain challenges

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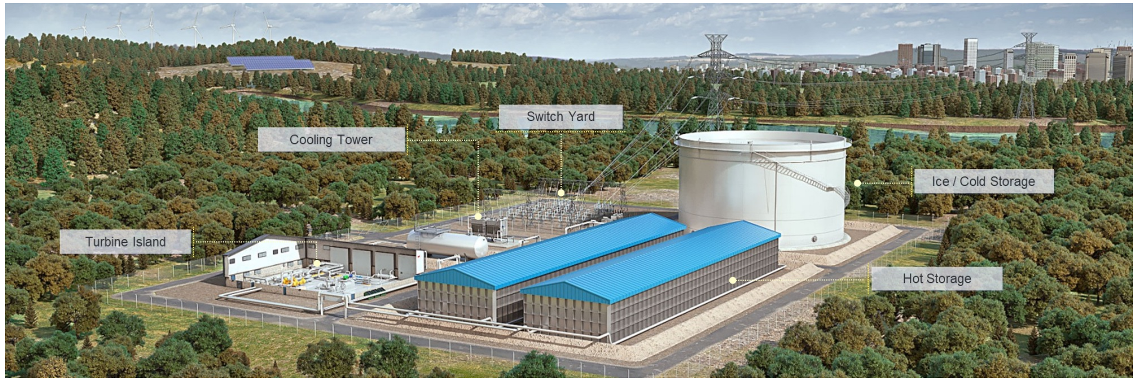
Note: 1. Range is McKinsey LDES central scenario and LDES progressive scenario

Source: McKinsey LDES Council Report 2021

A Unique Solution for a Growing Challenge Pumped Thermal Energy Storage (PTES)

WEC's Design is Engineered to Fill the LDES Gap to Achieve the Global Energy Transition

Low cost	• Offers a lower levelized cost than currently available technology – capex, opex and end-of-life • **Low-cost bulk storage materials: water and concrete**
Proven Technology	• Power turbine and low-temperature compressor are derivatives of existing designs • Heat exchangers, piping, valves, controls are of similar design to existing SCO_2 systems
Scalable	• No topographical or geologic dependencies; can be built anywhere with a fully domestic supply chain
Flexible	• Modular solution that can uniquely serve high power needs at both medium and longer GWh durations (8 – 200+ hours) • **Provides grid inertia and other ancillary services**
Minimal degradation	• Unlike lithium or chemical batteries, power generation equipment has **no degradation in capacity or capability over time** • No limitations on cycling or discharge depth
Sustainable	• No chemical, fire or safety risks • Capable of utilizing waste materials • **Long asset operational lifespan (50yr+)** • Recyclable at end-of-life



Nominal system size 1,000 MWh: 100MW, 10hr on less than 6 acres

Total Cost of Ownership Compared to li-ion ($/kWh) 20 years	100MW/1000MWh System	PTES
	Overnight Capital	<60%
	Capex (replace cells)	0%
	O&M	<60%
	Total ownership cost	**<50% of li-ion**

Simplified Levelized Cost of Storage (LCOS)		
	Round Trip Efficiency (RTE)	**~ 60%**
	Comparative LCOS	**~ 65% of li-ion**

Calculations based on 10 hrs of storage duration

How Does Pumped Thermal Energy Storage Work

Thermodynamic cycles transform energy between electricity and heat

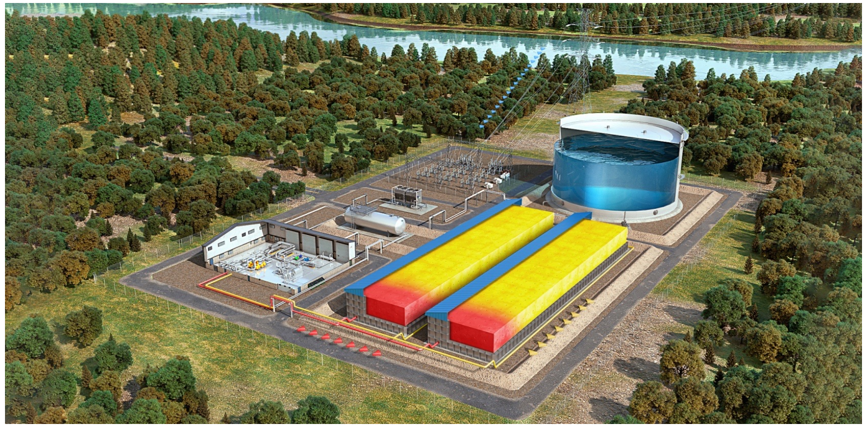
Charging Cycle (Heat Pump)

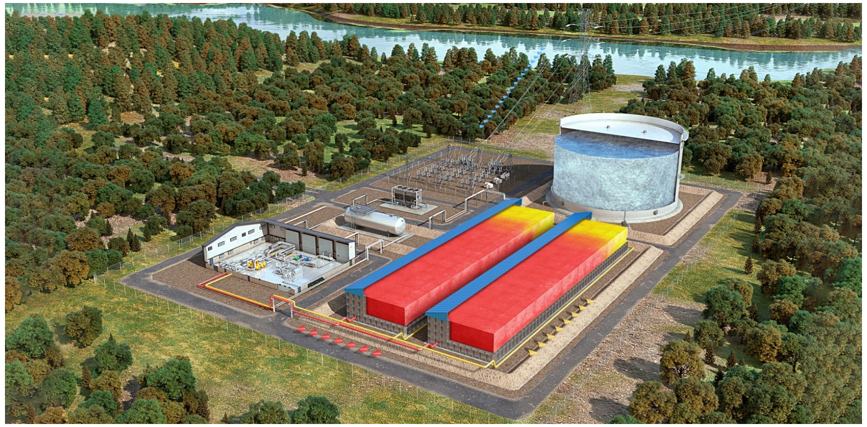
- Supercritical CO_2 heat pump (refrigeration) cycle
- Uses electrical power to move heat from a cold reservoir to a hot reservoir
- Creates stored energy as both "heat" and "cold"

Generating Cycle (Heat Engine)

- Supercritical CO_2 heat engine (power) cycle
- Uses heat stored in hot reservoir to generate electrical power
- "Cold" energy improves performance of heat engine

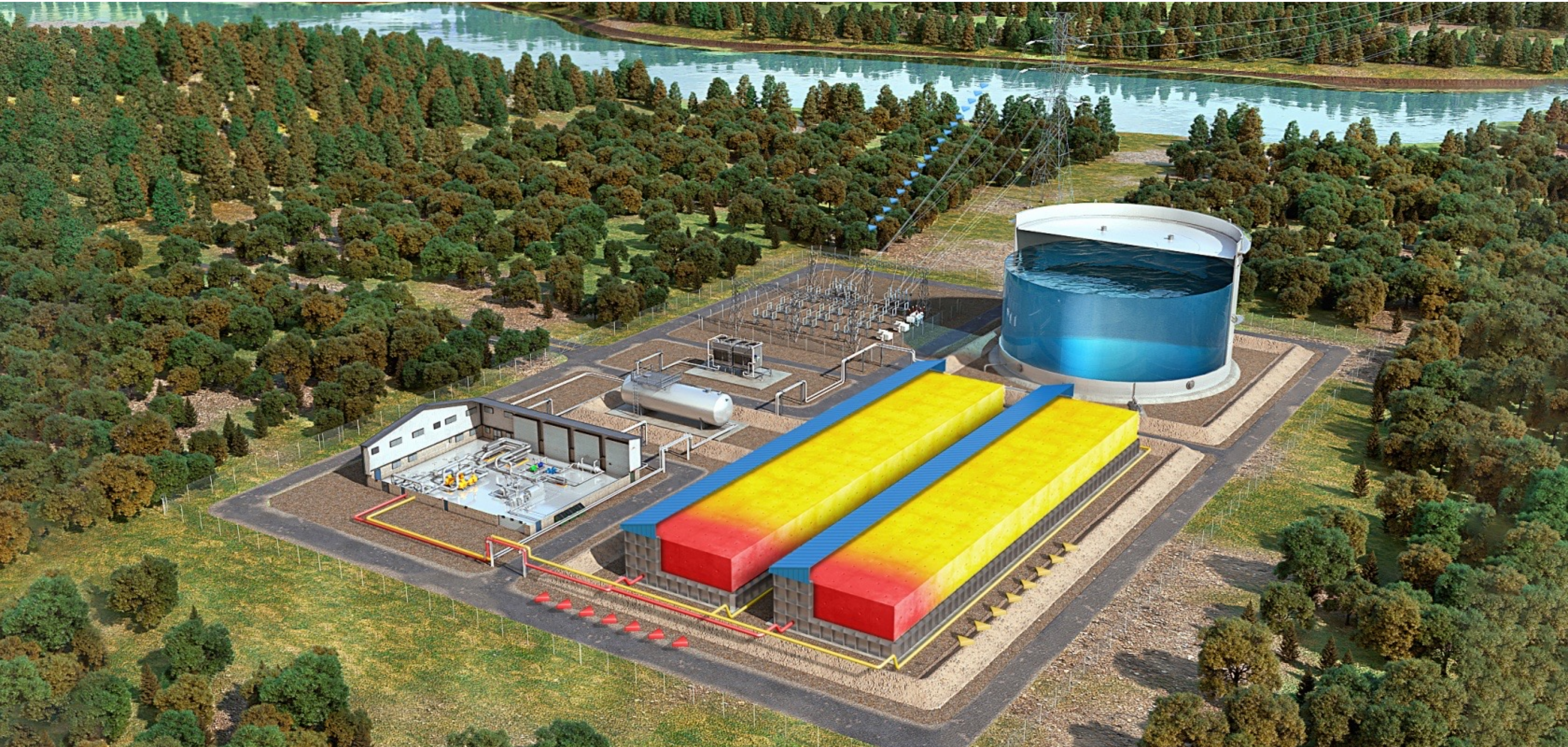
Leveraging Existing Equipment and Known Components Local Supply Chain	
Power Turbine	Derivative of Existing design (commercial EPS100 system)
Low Temp Compressor	Derivative of Existing design (commercial EPS100 system)
Charging Compressor	Based on readily available designs Commercial 10:1 adiabatic compressor
Heat Exchangers	Heat exchangers, piping, valves, controls are of similar design to existing commercial heat recovery system
Reservoirs	Low temperature materials, existing tank designs Easy to obtain materials (water, concrete)





PTES in operation

PTES at GWh Scale



PTES at GWh Scale (Charged)

Clean Resilient Energy in Alaska

Optimization of existing generation assets

- LDES provides value with all generation types (it's not only for renewables)
  - Bridge gaps between supply and demand
  - Optimize operations of existing oil or gas fired generation
  - Provide meaningful backup against transmission failures

Cost effective decarbonization

- Enables meaningful addition of renewable energy to meet emission objectives

Alaskan Jobs

- Local construction jobs
- Local supply of parts and equipment

Energy resiliency for remote users

- Provide clean, cost effective and reliable power to all users including mining sites and military bases
- Boost inertia provision on weak electrical grids

Backup Information

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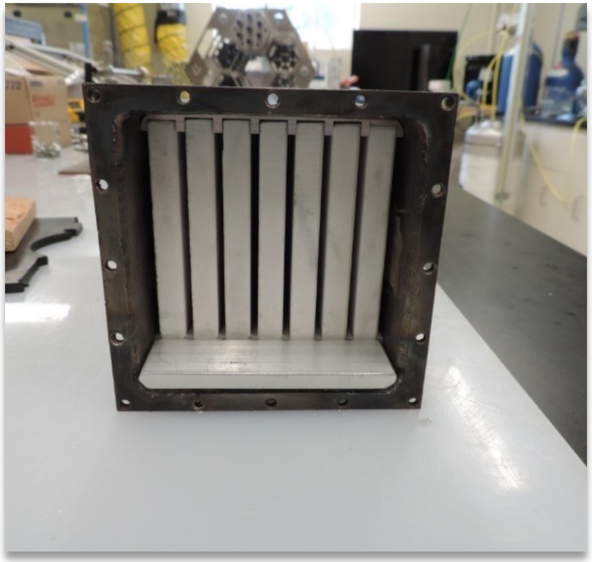
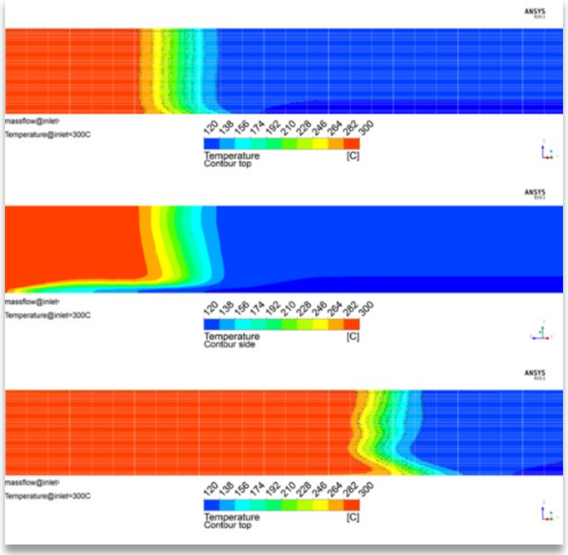
Westinghouse Concrete "Thermal Battery" Technology

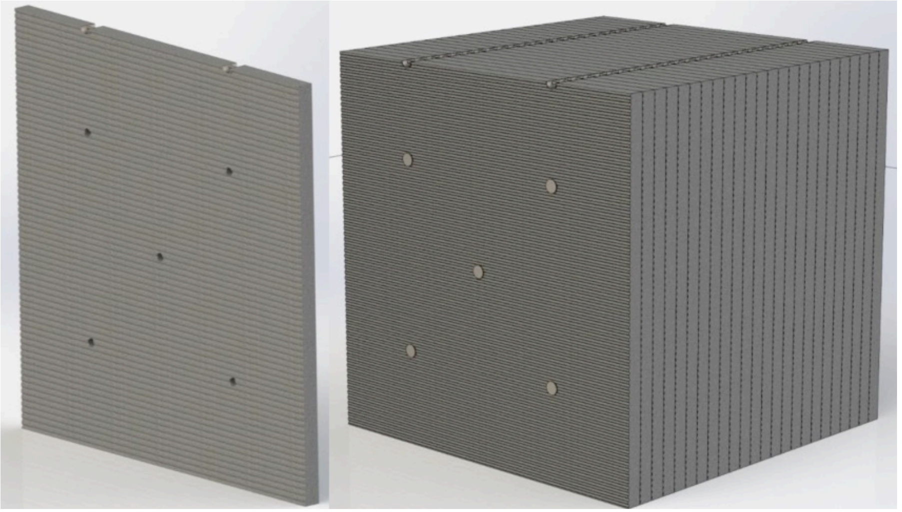
- Low pressure operation
- No exotic materials
- No pressure vessels
- Single tank design
- Onsite construction
- Non-toxic, non-hazardous oil



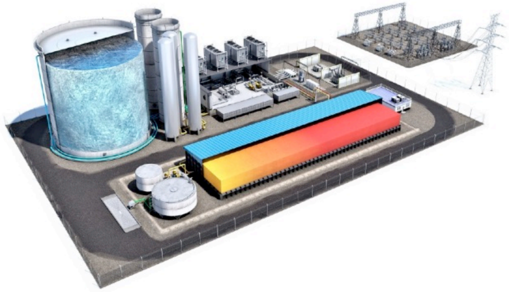
Modeling →
Validated by
← Test Mockup



- Battery modules are cubes comprised of molded plates
- Cast-in features create flow passages
- Modules are directly submerged in heat transfer oil
- Heat transfer oil is a specific Duratherm mineral oil with post-life use in other applications
- Potential to use recycled coal ash or other materials in concrete mix



Energy Density



PTES has a highly compact footprint, packing more energy per acre than other LDES technologies