Microreactor Application

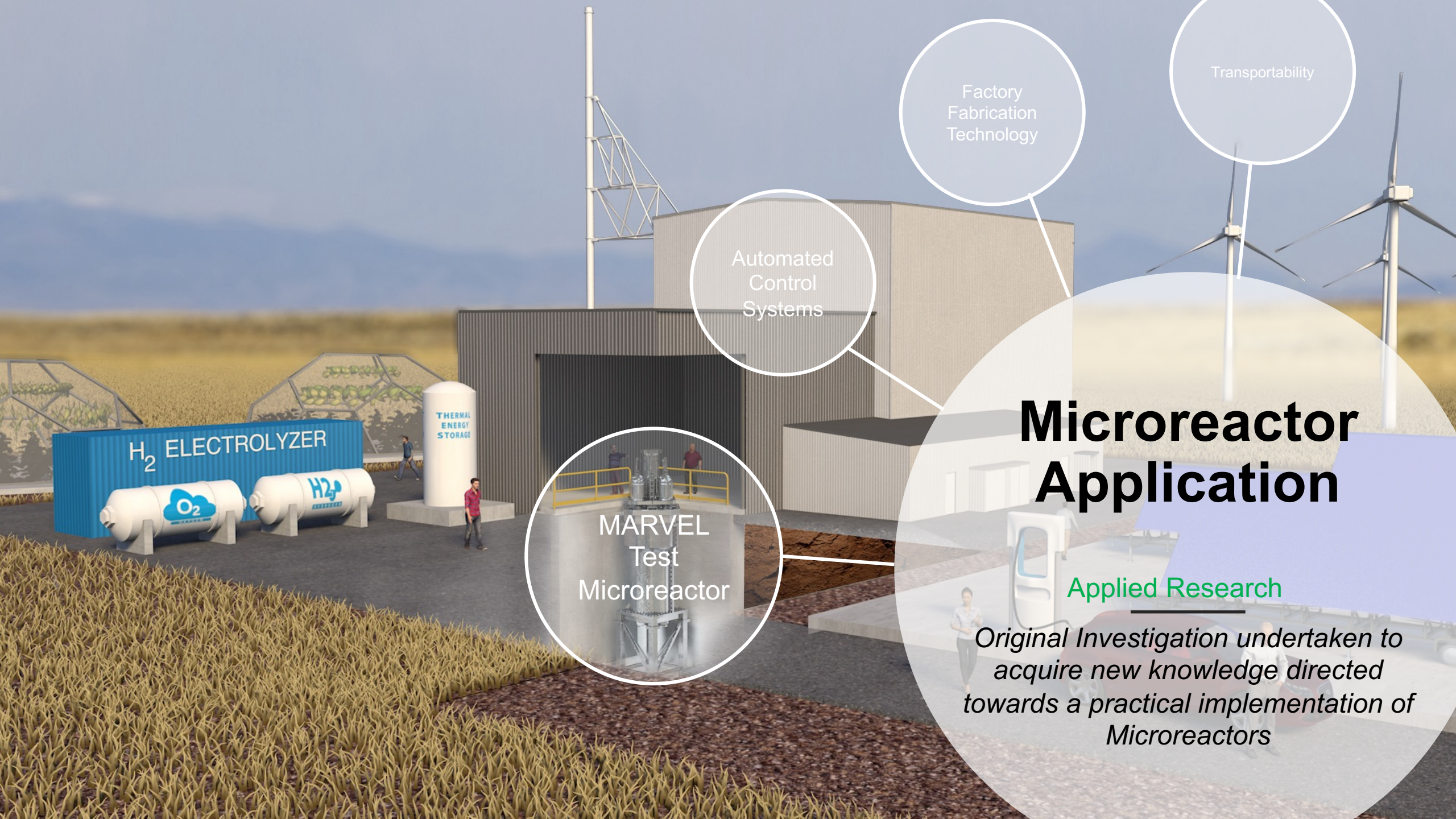
Yasir Arafat

MRP Technical Area Lead, Microreactor Application

MARVEL Technical and Project Lead

NS&T Microreactor Technical Lead, Idaho National Laboratory

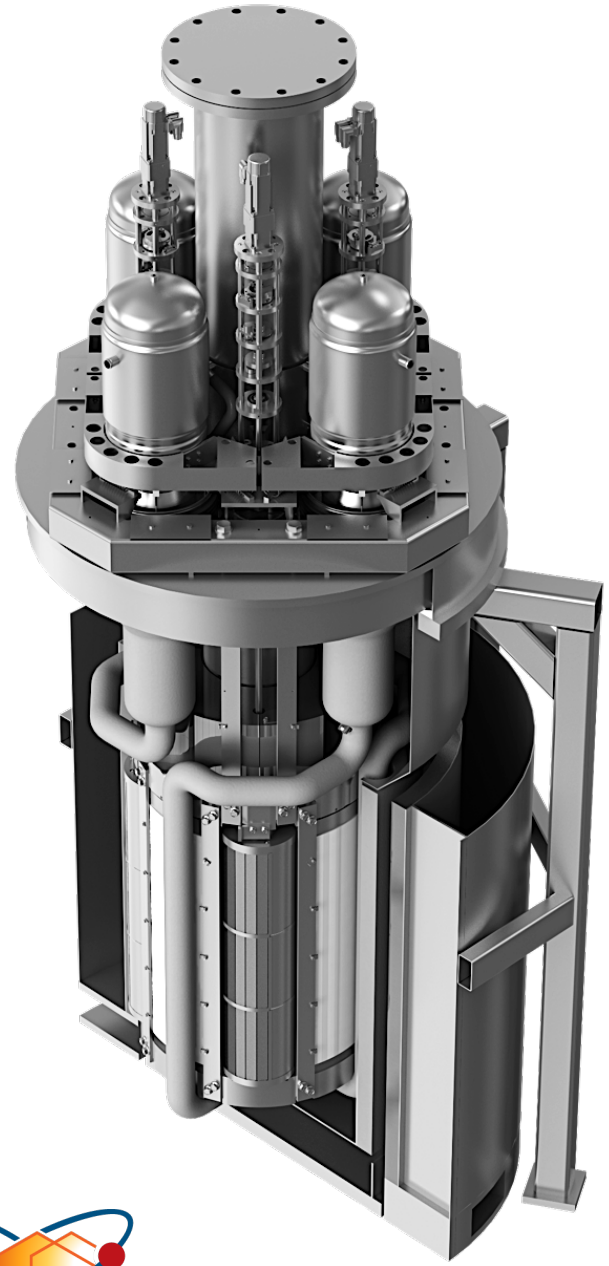
March 4th 2022


Factory Fabrication Technology
Transportability
Automated Control Systems
MARVEL Test Microreactor
H_2 ELECTROLYZER
O_2
H_2
THERMAL ENERGY STORAGE
Microreactor Application
Applied Research
Original Investigation undertaken to acquire new knowledge directed towards a practical implementation of Microreactors

MARVEL

Microreactor Application Research, Validation and EvaLuation Project

Key Design Features	
Thermal Power	100 kW
Electrical Power	20 kWe (QB80 Stirling Engines)
Weight	< 5 US ton
Primary Coolant	Sodium-Potassium eutectic
Intermediate Coolant	Lead-Bismuth eutectic
Coolant Driver	Natural Convection, single phase
Fuel	HALE(UZrH), 304SS clad, end caps
Moderator	Hydrogen
Neutron Reflector	Graphite, Beryllium (S200), Beryllium oxide
Reactivity Control	Radial Control Drums, Central Absorber
Primary Coolant Boundary	SS316H



MARVEL Team is Innovating in every areas of a microreactor

MRP Microreactor Program

Small Reactor...Big Opportunities

Idaho National Laboratory

WALSH ENGINEERING SERVICES

Los Alamos NATIONAL LABORATORY EST. 1943

Argonne NATIONAL LABORATORY

Qnergy Reliable Remote Power

Creative Engineers, Inc. UNITED STATES | CANADA | INTERNATIONAL

NC STATE UNIVERSITY

Idaho State University

U.S. DEPARTMENT OF ENERGY Idaho Operations Office

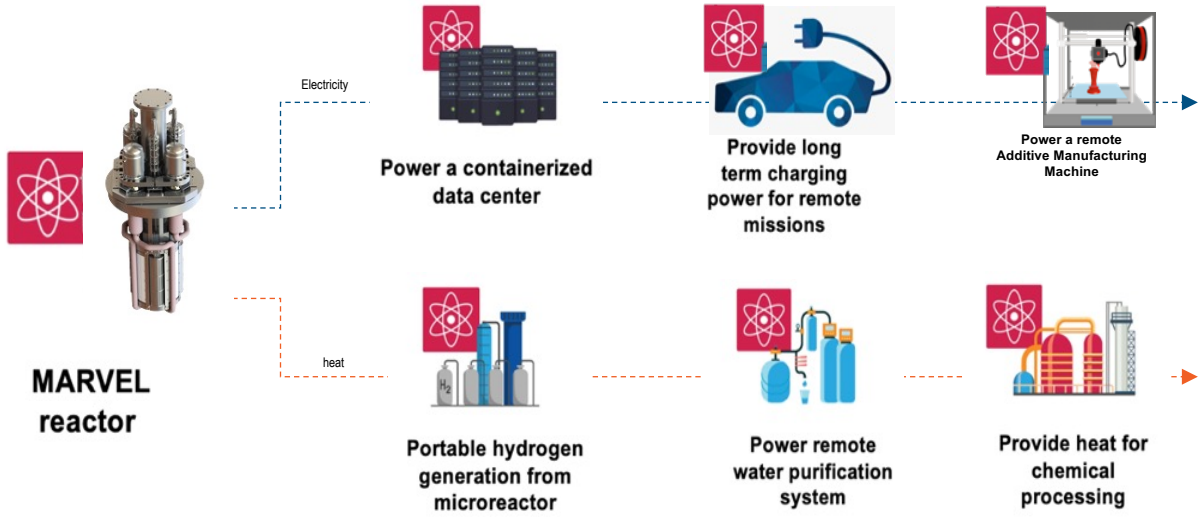
U.S. DEPARTMENT OF ENERGY Office of NUCLEAR ENERGY

Integrated with Private Industry

OKLO Westinghouse BWXT Technologies, Inc. X-energy RADIANT GENERAL ATOMICS LOCKHEED MARTIN

NQA-1 & Commercial Supply Chain

Premier Technologies, Petersen Inc., American Fabrication, Materion, Triga International



External Program Collaborators

INL Net-Zero; DOE System Integration & Analysis; DOE Research Reactor Infrastructure Program

End-user companies engaged:

- ✓Dell
- ✓Tesla
- ✓Electrify America
- ✓Chargepoint
- ✓ExxonMobil
- ✓Oxeon
- ✓Bloom
- ✓Fuelcell Energy
- ✓Envoy Public Labs
- ✓Eastman/Kodak
- ✓GSE
- ✓Shell
- ✓Chevron
- ✓AVEC
- ✓Idaho Power
- ✓Southern Company
- ✓Holtec
- ✓Battery 500
- ✓Proton Conduction H2
- ✓LIFEPo4

MRP Microreactor Program

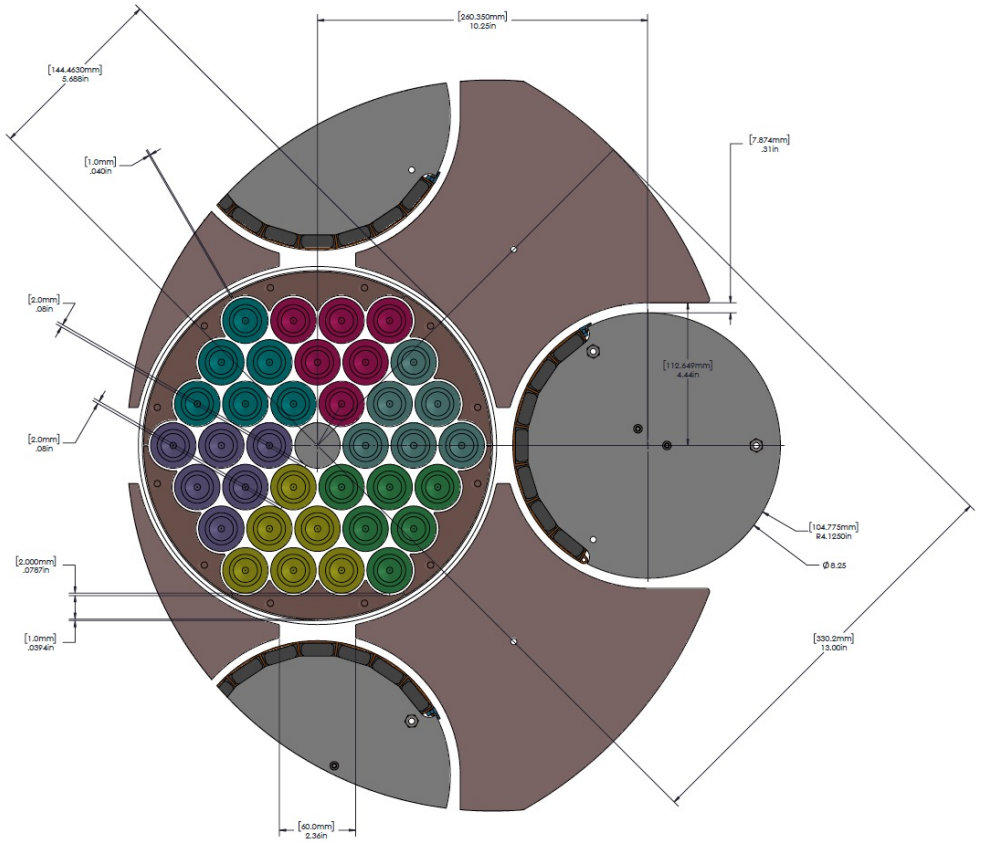
MARVEL is at 10% Final Design

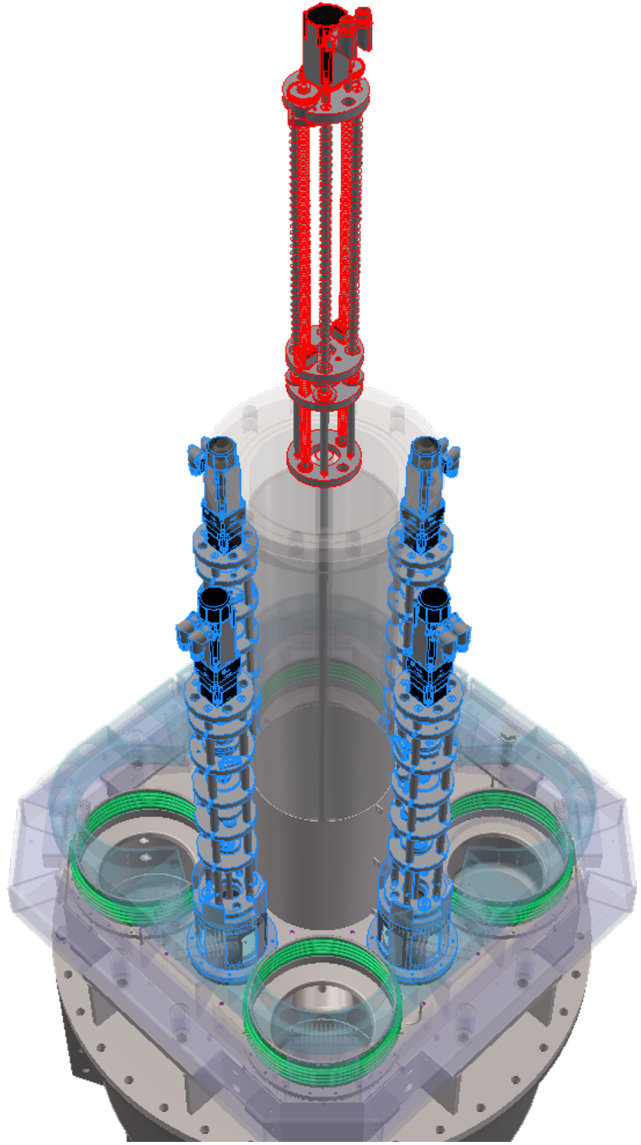
Final Fuel & Core Design

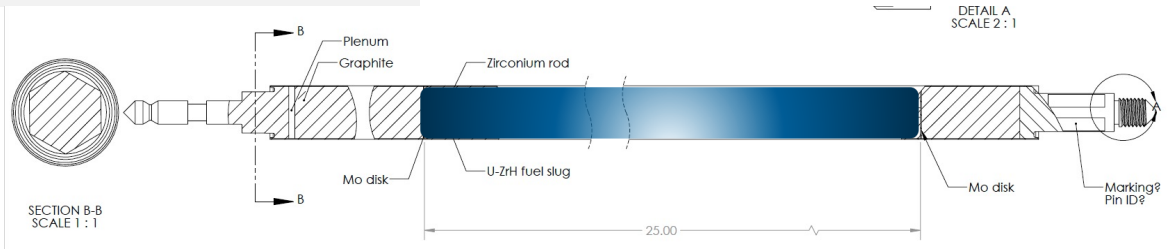
- “longer” TRIGA fuel (catalog # 419)
- Core barrell-11” NPS Sch 80S
- HALEU from Y12
- Fuel Fab. at TRIGA International
- TNBGC-1 transport relicensing

Central Insurance Absorber Rod

- DID shutdown
- Inherent adjustment for Burnup
- Hot standby heater
- Neutron Source for NI calibration





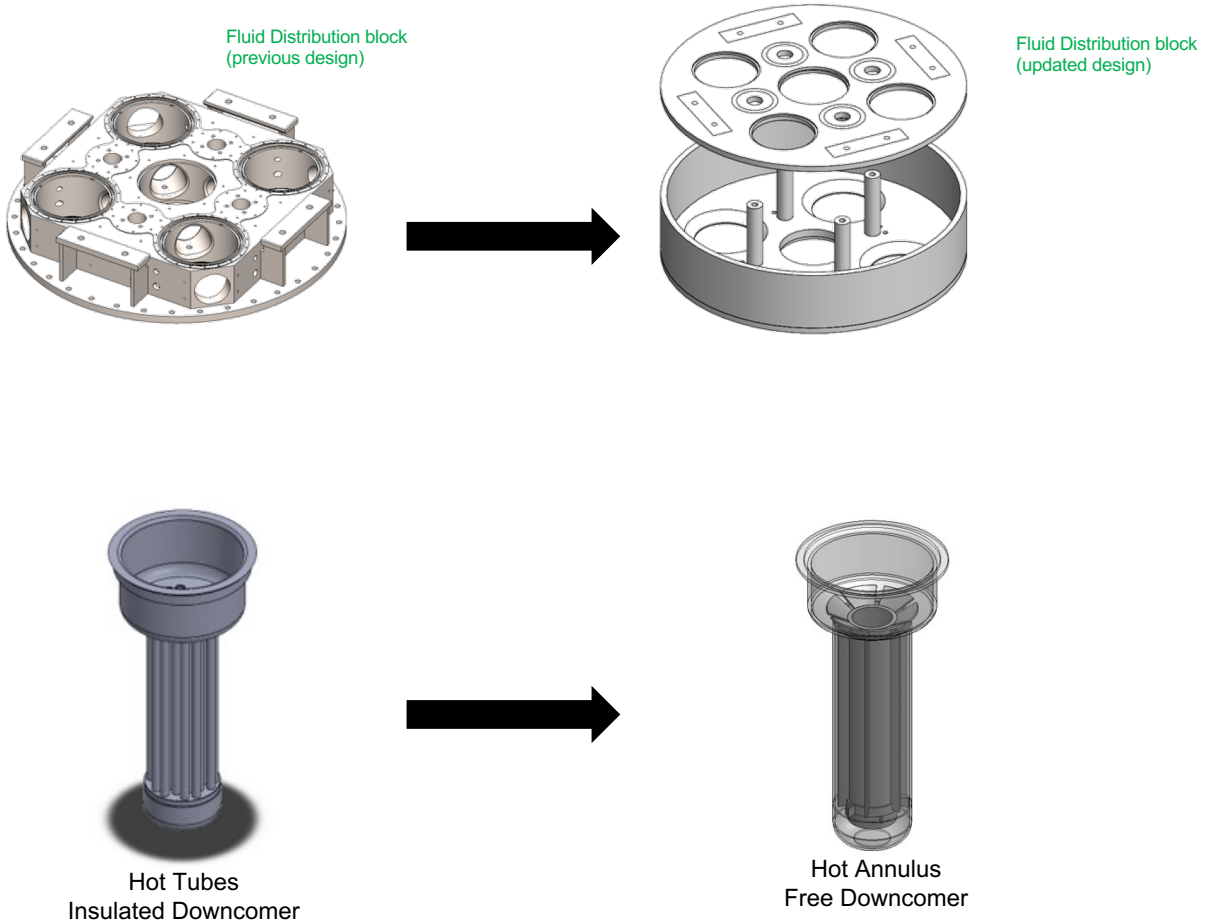


MRP Microreactor Program

MARVEL is at 10% Final Design

Primary Coolant Boundary Evolutions

1. **Thermal Distribution "Block"→ "Plenum"**
   - Thermal Stress was significantly reduced by updating solid metal distribution block to "plenum-style" fluid distribution
   - Allows sufficient NaK inventory for maintaining submerged core, during postulated LOCA
2. **Intermediate Heat Exchanger "S&T"→ "finned plate"**
   - High stress shell and tube design was updated to fin tube-in-tube design for improved flow rate and ease of fabrication

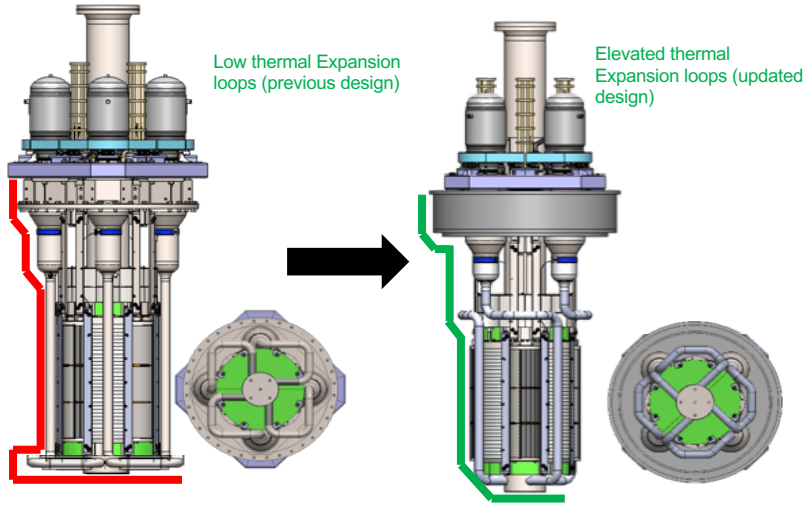


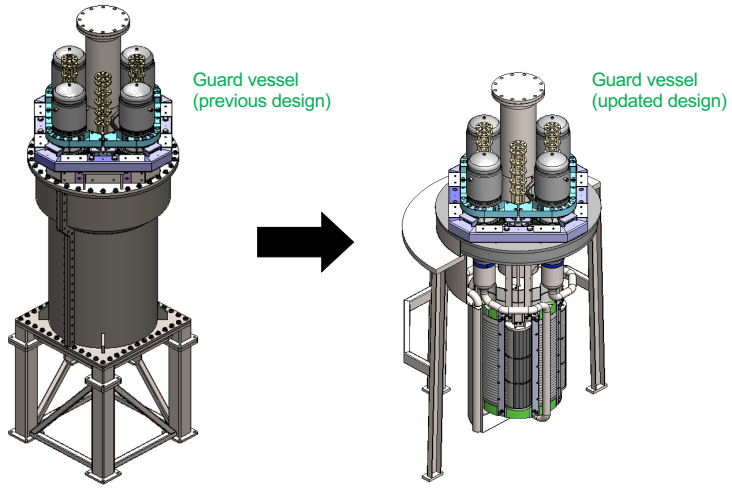
MRP Microreactor Program

MARVEL is at 10% Final Design

Secondary Guard Vessel Evolutions

3. **Expansion loops "pyramid"→ "cone"**
   - Expansion joints elevated to enable "top-down" assembly
   - Enables minimum guard vessel volume
4. **Guard Vessel "bolted" → joint**
   - Multi-surface bolts replaced by a single-weld design for ease of fabrication and assembly
   - Higher performance for gas retention
   - Wider based and lower center of gravity for seismic resistance





MRP Microreactor Program

Procurement, Fabrication, NQA-1 Vendors

- Procurement Agent: MFC
  - Four major procurement packages
- Four NQA-1 vendors engaged
  - Premier Technologies, Blackfoot, ID
  - Petersen Inc., Ogden Utah
  - American Fabrication, Idaho Falls, ID
  - Avantech, Seattle, WA
- Applicable Codes and Standards
  - ASME BPVC Section III Division 5
  - Inspections/fab per BPVC code
  - AISC N690
- Early Procurement List to DOE underway

avantech

PREMIER Technology, Inc.

PETERSEN INCORPORATED "A Winning Combination."

AMERICAN FABRICATION An Employee Owned Company

MATERION

TRIGA INTERNATIONAL

PCAT lessons learned and experience shared with potential reactor fabricators

MRP Microreactor Program

Reactor Hardware is Challenging but Achievable

Idaho National Laborc

Office of NUCLEAR ENERGY

Idah
Scale

Office of Nucle

FORGING
AS

Machinists at INL's Mater
for the Department of En
months.

NuclearNewswire

TOPICS | SOURCES | SIGN UP | ADVERTISE | American Nuclear Society

Headlines | For You

NuScale solidifies plans for SMR deployment in Poland
1h ago

DOE announces $18 million for advanced particle accelerator R&D
17h ago

ANS Grand Challenge: Closing the nuclear fuel cycle
20h ago

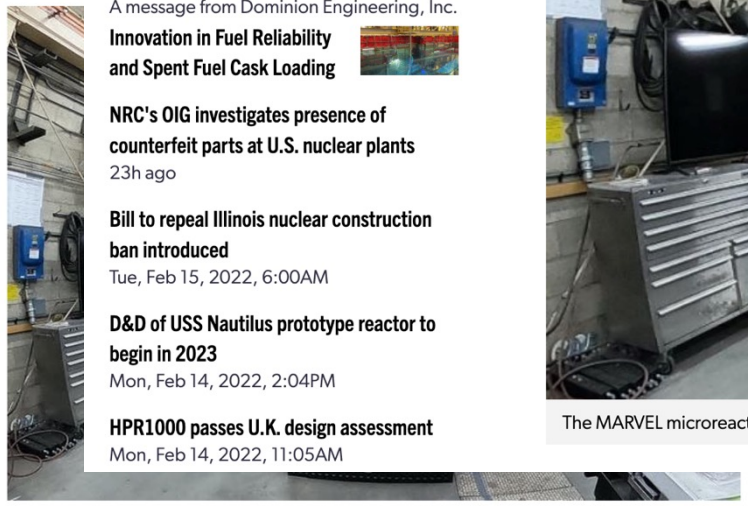
A message from Dominion Engineering, Inc.
Innovation in Fuel Reliability and Spent Fuel Cask Loading

NRC's OIG investigates presence of counterfeit parts at U.S. nuclear plants
23h ago

Bill to repeal Illinois nuclear construction ban introduced
Tue, Feb 15, 2022, 6:00AM

D&D of USS Nautilus prototype reactor to begin in 2023
Mon, Feb 14, 2022, 2:04PM

HPR1000 passes U.K. design assessment
Mon, Feb 14, 2022, 11:05AM



The MARVEL microreactor prototype in the Materials and Fuels Complex's machine shop

RESEARCH & APPLICATIONS

INL team ass

Mon, Feb 7, 2022, 2:04PM

The MARVEL microreactor prototype in the INL machine shop. (Photo: DOE)

wnn world nuclear news
Celebrating 15 years

Energy & Environment | New Nuclear | Regulation & Safety | Nuclear Policies | Corporate | Uranium & Fuel |

US prototype supports microreactor development

08 February 2022

Share

A full-scale electrically heated prototype for the US Department of Energy's (DOE) Microreactor Applications Research Validation and Evaluation (MARVEL) reactor has been built at Idaho National Laboratory (INL). The prototype will help validate the final design for a demonstration microreactor that could be operational within the next two years.

INL machinists pictured with the PCAT prototype (Image: INL)

MRP Microreactor Program

Agenda

- 1:10 – 1:25 MARVEL Interim Design Review ..... MW Patterson
- 1:25 – 1:45 MARVEL PCAT ..... Blair Grover, Scott Reed
- 1:45 – 2:00 MARVEL Structural Design Evolution .....Luke Andrew
- 2:15 – 2:30 MARVEL Instrumentation & Control System.....Benjamin Baker
- 2:30 – 2:45 MARVEL Reactivity Shutdown Rod.....Travis Lange, Anthony Crawford
- 2:45 – 3:05 (NEUP Project 19-16802) Evaluation of Semi-Autonomous Passive Control Systems for HTGR Type Special Purpose Reactors ..... Brendan Kochunas
- 3:05 – 3:25 (NEUP Project 19-17185) Demonstrating Reactor Autonomous Control Framework Using Graphite Exponential Pile ..... Bren Phillips
- 3:25 – 3:40 Wrap Up ..... Yasir Arafat

MRP Microreactor Program