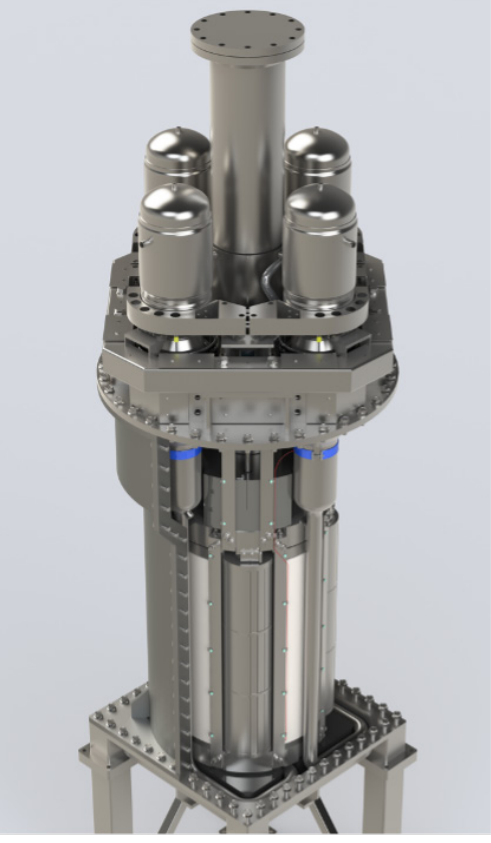
MICRO
DOE MICROREACTOR PROGRAM

# Microreactor Applications Research Validation and Evaluation Project (MARVEL)

*Integrating Microreactors with End-User Applications*

The U.S. Department of Energy (DOE) Microreactor Program supports research and development (R&D) of technologies related to the development, demonstration, and deployment of very small, factory-fabricated, transportable reactors to provide power and heat for decentralized generation in civilian, industrial, and defense energy sectors.

Led by Idaho National Laboratory (INL), the program conducts both fundamental and applied R&D to reduce the risks associated with new technology performance and manufacturing readiness of microreactors. The intent is to ensure that microreactor concepts can be licensed and deployed by commercial entities to meet specific use case requirements.



*MARVEL Reactor Illustration.*

**MARVEL Project Goal**

*Provide a 100-kW fission reactor for researchers and technology developers to gain operational experience with a real microreactor to advance technical maturity and enable new microreactor applications*

## What is the Microreactor Applications Research Validation and Evaluation (MARVEL) Project?

Under the auspices of the DOE Microreactor Program, INL is developing a nuclear microreactor applications test bed to perform research and development on various operational features of microreactors and enable improved integration of microreactors with end-user applications.

Development of the MARVEL test bed provides an opportunity to establish and exercise key capabilities to support future microreactor demonstrations by addressing:

- The need identified in engagements with potential end users of microreactor systems wanting more information about how microreactors meet their application needs.
- Development of a small-scale reactor for R&D purposes for the first time in nearly 50 years.
- Engagement and outreach with end users and stakeholders to perform research and development on the integration of microreactors with a range of anticipated applications, such as load-following electricity demand, process heat, hydrogen production, and water purification.
- Research and development to investigate and address issues and challenges related to the fabrication, assembly, rapid installation, deployment, authorization, and operation of microreactors to facilitate end-user adoption.

The MARVEL development project coordinates work and activities across participating laboratories, universities, and industry as well as other DOE programs. Participating national laboratories are Idaho National Laboratory, Los Alamos National Laboratory, and Argonne National Laboratory, as well as private organizations including Walsh Engineering, Creative Engineers Inc, and Qnergy.

## Where are the specific technical characteristics of MARVEL?

MARVEL will be installed and operated at INL's Transient Reactor Test (TREAT) facility. MARVEL will encompass a 100-kW thermal fission reactor inspired by an existing design and technology with TRIGA fuel, which has a high safety pedigree, that can be designed, fabricated, and started up within approximately 2-3 years.

The reactor will be a sodium-potassium cooled reactor with natural circulation cooling and an operating temperature of 500–550°C. Off-the-shelf Stirling engines will convert thermal energy to ~20kW electrical power. The system is anticipated to operate for approximately 2 years.


*MARVEL Microgrid illustration at INL's Transient Reactor Test (TREAT) facility (not to scale)*

*MARVEL will be available to researchers once it is operational. Please contact the National Technical Director or Technical Lead for more information.*

## What R&D can be enabled by MARVEL Operation?

Test, demonstrate, and address issues related to installation, startup, and operation:

- Simplify siting and environmental review process
- Startup methodology for microreactors
- Normal operating transients such as startup and load management
- Cyber and physical security hardening
- Seamless integration to a net-zero, electrical microgrid
- Demonstration of high and low-grade heat extraction.

Enable Autonomous Operation Technologies

- Automate operator functions, while maintaining reactor safety
- Demonstrate radiation and temperature-hardened sensors and instrumentation to enable remote monitoring, advanced sensor reliability tests, and online calibration.
- Live data can feed a digital twin of the reactor to "train" an artificial intelligence-based control system
- Demonstrate wireless transmission of live data of both electrical and thermal power output during startup, operation, and shut down. This allows real-time feedback on system output, performance, and prediction of any unplanned maintenance needed in an operating microreactor.

Enable Seamless Application Integration

- The control systems manage the energy grid demand and reactor power and heat supply. This management requires a carefully designed control system that can predict the interplay of controls, thermal inertia, and reactivity feedback.
- Demonstrate integration approaches for a range of applications investigating both reactor power management and load management approaches.

For more information:

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