

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 concept with Stirling engines.

MARVEL

Will provide a 100-kW fission reactor for researchers and technology developers to test new microreactor applications in a relevant environment to advance technical maturity.

The program coordinates work and activities across participating laboratories, universities, and industry as well as other DOE programs. Participating national laboratories are Argonne National Laboratory, INL, Los Alamos National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory and Sandia National Laboratory.

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 at INL to perform research and development on various operational features of microreactors to improve integration of microreactors with end-user applications.

Through collaboration between the DOE Microreactor Program and the National Reactor Innovation Center (NRIC), development of the MARVEL test bed provides an opportunity to establish and exercise key NRIC capabilities to support future reactor 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 40 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 heating, hydrogen production, and water purification.

- Research and development to investigate and address issues and challenges related to the fabrication, assembly, rapid installation, and deployment and operation of microreactors to facilitate end-user adoption.

How will MARVEL complement MAGNET?

The nuclear microreactor applications test bed extends capabilities beyond those of MAGNET to provide a nuclear test platform that includes a full-physics system representing actual operational features of a microreactor including the nuclear behavior for application demonstrations.

Lessons learned and experience gained with component testing and instrumentation control from MAGNET testing will ensure accelerated demonstration with MARVEL.

The combination of MAGNET and the nuclear microreactor testbed provides unique capabilities to support industry in accelerating development, testing, demonstration, and qualification of key microreactor technologies.

Where are 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 based on an existing design and technology (SNAP-10A with TRIGA fuel, which has a high safety pedigree) that can be designed, fabricated, and started up within approximately 2 years.

The reactor will be a sodium-cooled reactor with natural circulation cooling and an operating temperature of 500–550°C. Power conversion will be via existing-technology Stirling engines.

The reactor core life is anticipated to be 2 years. Detailed neutronics evaluations have been completed for several core and reflector geometries.

What are the specific technical objectives of MARVEL?

Test, demonstrate, and address issues to achieve unattended operation:

- Normal operating transients such as startup and load management
- Maintaining reactor safety
- Cyber and physical security hardening.

Enable remote monitoring

- Demonstrate radiation and temperature-hardened sensors and instrumentation for live data acquisition from the reactor and wireless transmission to a remote monitoring location. The test bed can also perform sensor reliability and qualification tests.
- 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.

Perform application integration and control

- The control systems manage the grid demand and reactor power 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.



MARVEL reactor at INL's Transient Reactor Test (TREAT) facility.



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

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