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Micro-Reactors: A Technology Option for Accelerated Innovation

Summary / Objectives:

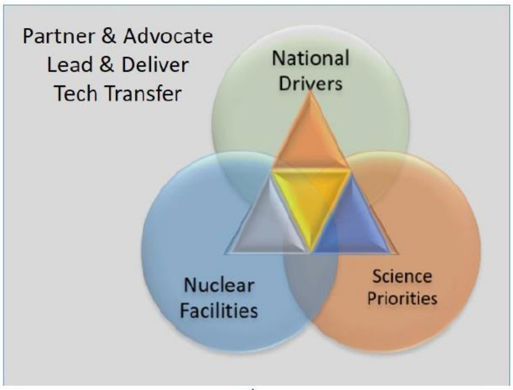
Micro-reactors are very small nuclear reactors capable of operating independently from the electric grid to supply highly resilient power, and are well suited to serve the power needs for remote communities that currently do not have access to reliable, resilient and affordable energy. A typical commercial micro-reactor is envisioned to be a mobile nuclear power plant in a 2-20 MWe range that is fully factory built, fueled and assembled. It is transportable to the remote site via ground, sea or air with black start, renewable integration and island mode operation capability. They are designed to be self-regulating and walk-away safe with minimal operator intervention. NEI estimates that Micro-reactors could deliver electricity at rates between $0.09/kWh and $0.33/kWh. This presentation will describe 'genericized' micro-reactor designs being pursued by various vendors, technology gaps and the role of DOE's Micro-reactor R&D.

Meet the Presenter:

Dr. Dasari V. Rao is a nuclear and mechanical engineer with 25 years of experience in safety and safeguards of nuclear and high hazard facilities. His technical areas of expertise include computational fluid dynamics, neutron and radiation transport, and risk assessment of nuclear energy systems. Dr. Rao is presently Director of the Office of Civilian Nuclear Programs at the Los Alamos National Laboratory. He is also Technical Advisor to Dr. Jess Gehin, National Technical Director for DOE Microreactor Program, and Principle Investigator for the NASA's Fission Surface Power project.

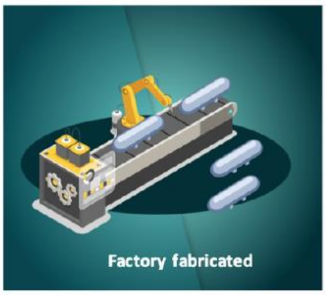
Microreactor R&D at a Glance

- ❖ National Drivers
  - Innovative, Affordable and Rapid
  - DoD and Civilian Microgrids
- ❖ Nuclear Facilities and Technologies
  - Fuels (HALEU)
  - High Temperature Moderators
  - Nuclear Data
- ❖ Prototypes
  - Advanced Manufacturing
  - Sensors and Structures
  - Sub-scale simulation test objects
- ❖ Integration
  - Multi-scale, nuclear validated codes
  - Test Beds: EDU and NDU
  - NRIC



Common strategy between multi-mission Radioisotope Thermoelectric Generator (2kWt) developed for NASA's mars mission, Micro-reactors (2-20 MWe), SMRs, Gen III+, IV (up to 1500MWe).
That is **diagram by National drivers, Nuclear Facilities, and Science priorities**.
By applying this strategy for Micro-reactors, **Micro-reactors become Factory fabricated, Transportable and Self regulating**.

Reimagine Nuclear Generation…



Factory fabricated

The majority of components of a microreactor are anticipated be fully assembled in a factory and shipped out to its location. This can eliminate difficulties associated with large-scale construction, reduce capital costs, and help get the reactor up and running quickly.

Transportable

Smaller unit designs can enable microreactors to be very transportable. This can make it easier for vendors to ship the entire reactor by truck, shipping vessel, airplane, or railcar.

Self-regulating

Simple and responsive design concepts can enable remote and semi-autonomous microreactor operations that may significantly reduce the number of specialized operators required on-site. In addition, microreactors plan to use utilize passive safety systems that can prevent the potential for overheating or reactor meltdown.

DOE Microreactor Program is undertaking some of the most important and challenging research and development efforts to accelerate microreactor deployments by mid-2020s

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National drivers for Micro-reactors are,
+ Innovative, Affordable and Rapid
+ Military and Civilian Microgrids

Key technology are
+Factory built with advanced manufacturing, instrumentation/sensors, and advanced heat removal systems.
+Easy to operate and licensed by power controllability which brings easy load following.

Technology neutral with the common strategies
= Accept various types of fuel including nationally supplied HALEU fuels.

Key Technology Enablers

Factory Built ◆ Easy to operate ◆ Easy to license

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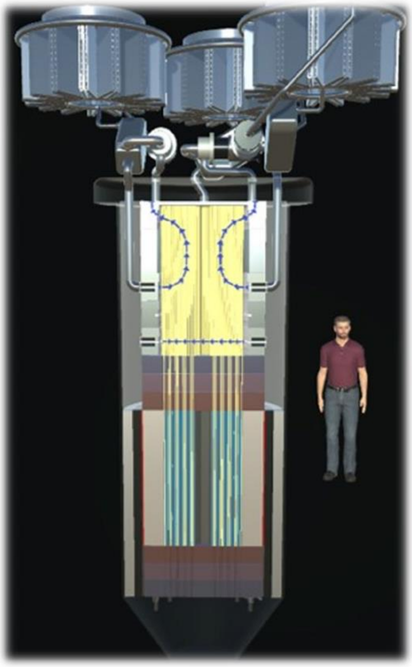
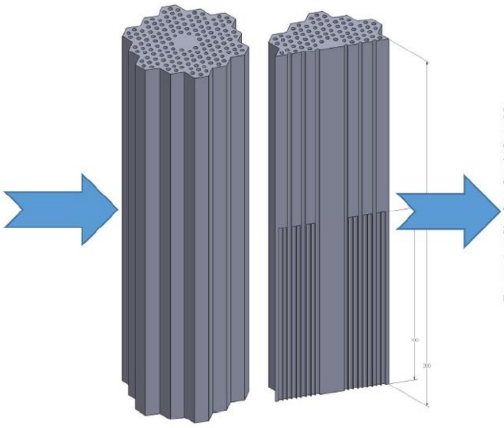
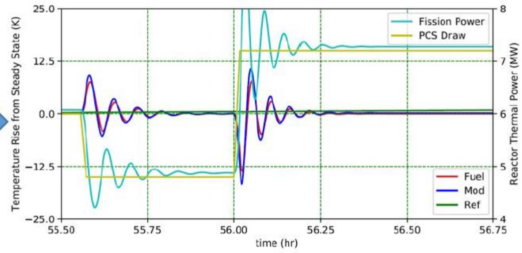


Designs may vary, but challenges are similar…..
…. So, R&D focus is concept and technology neutral



Understanding manufacturability and licenseability



Demonstrating safety, stability and ease of operability

Typical Microreactor Design

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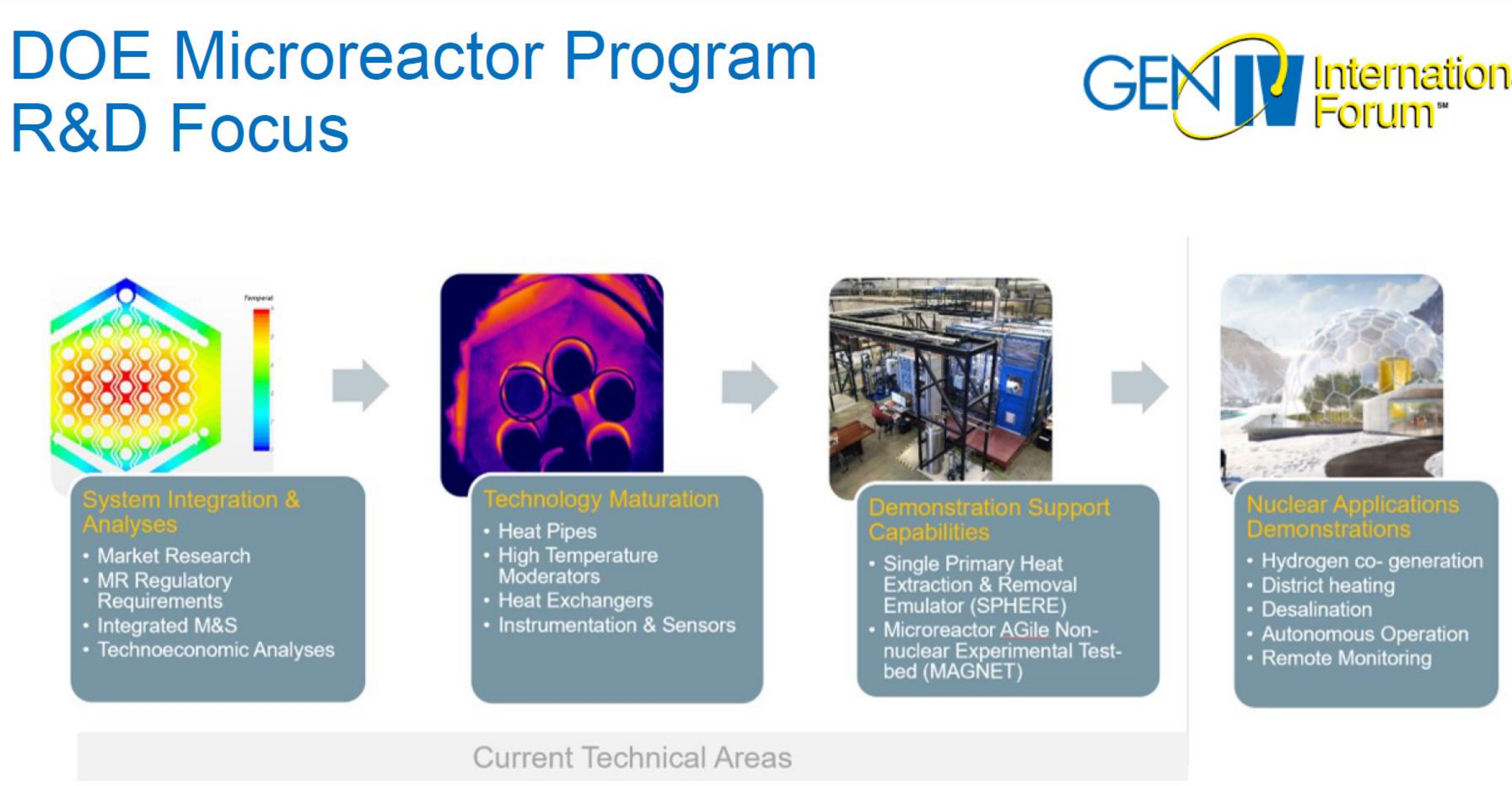
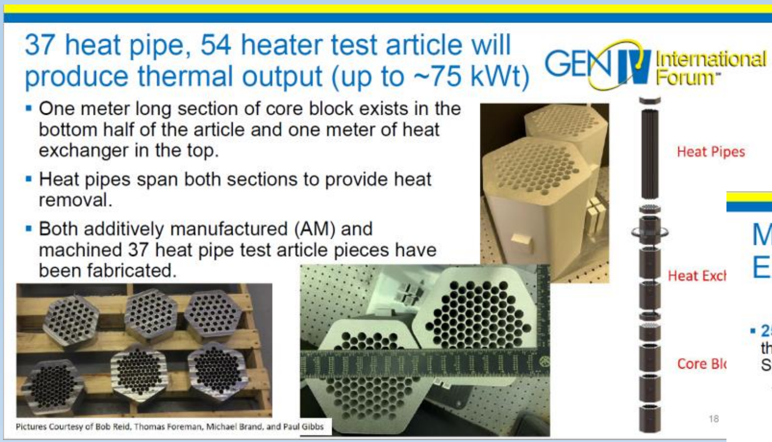
- Reactor designs include following options:
  - HALEU Metallic, Ceramic or TRISO Fuels
  - Fast, intermediate or thermal neutron spectrum enabled by a mixture of high temperature hydrides, beryllium and graphite
  - A large reflector that also performs as a thermal sink and houses control drums
  - Heat pipe-, gas-, molten salt- cooled
  - Brayton power conversion (with or without intermediate HX)
- Structural material options include
  - Metals
    - High temperature creep-resistant steel
    - Molybdenum
  - Ceramics
  - Graphite



Dr. Holly Trellue is a team leader at Los Alamos National Laboratory, the Technical Area Lead for Technology Maturation for the DOE-NE Microreactor Program.,

She introduced Technology Maturations.

+ Possible fuel materials
+ Advanced moderators including metal hydrides
+ Advanced heat removal mechanisms
+ Instrumentation / Sensor developments



Mr. Yasir Arafat is currently serving as the Technical Advisor to the DOE Microreactor Program from Idaho National Laboratory. He was the founder and Technical Lead of the Westinghouse eVinci™ Micro Reactor Program.

He introduced Two demonstration test programs.

SPHERE: Single Primary Heat Extraction & Removal Emulator

MAGNET: Microreactor Agile Non-nuclear Experimental Test-bed