Micro-Reactor Opportunities and Challenges - Transportability and Structural Materials

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Xe-Mobile - Remote Locations, Micro-grids, Emergency Response

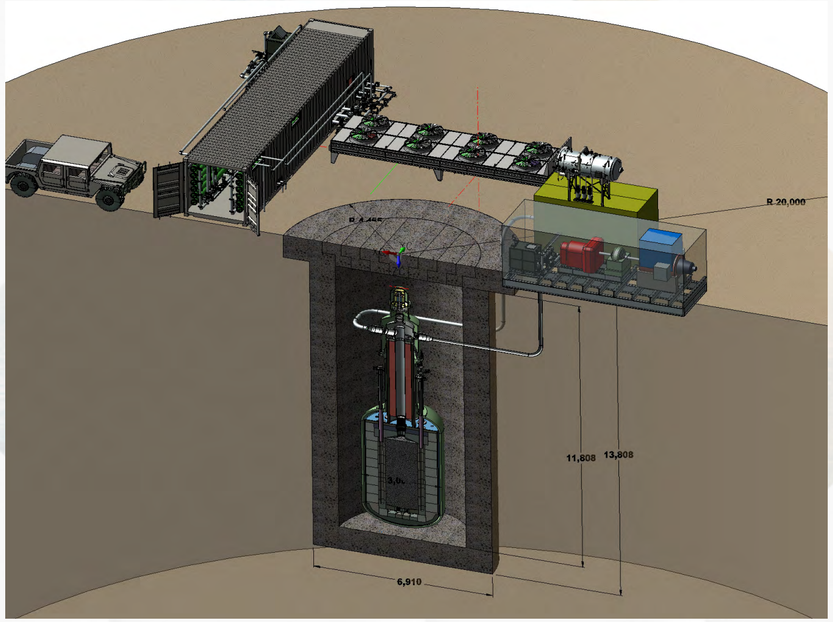
- Many remote applications require “always on” 24/7 power generation for extended periods
- Energy-intensive processes require significant, reliable power, such as remote mining and material processing
- It is highly desirable to avoid transportation of diesel fuel - susceptible to disruptions due to weather, etc.
- Potential for remote monitoring and operation
- Rapid mobility, quick setup, and simple breakdown for transport is desired
- A Mobile Nuclear Power Plant is disruptive innovation*

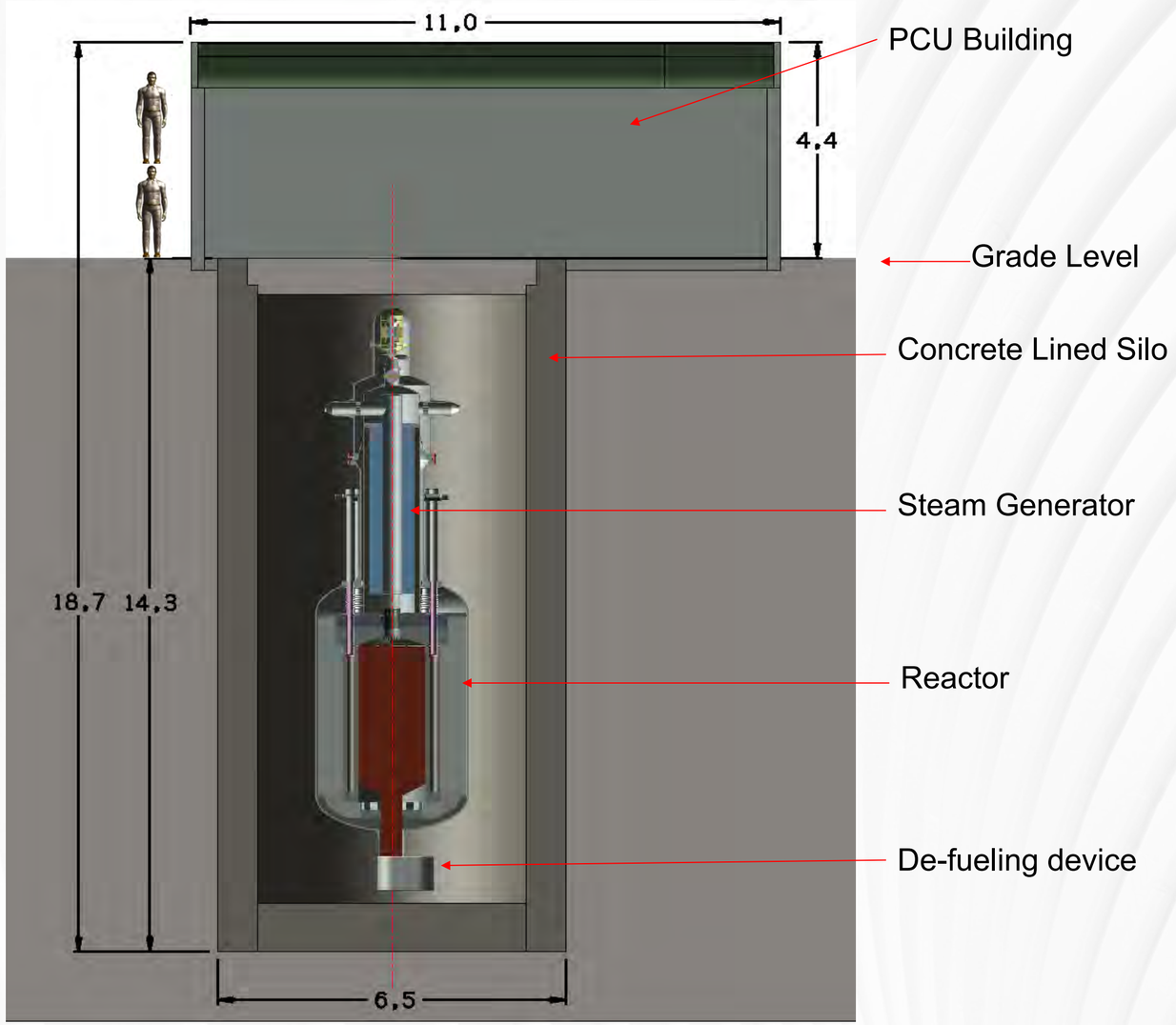
* *Study on the Use of Mobile Nuclear Power Plants for Ground Operations, Oct 26,2018*

- 1-5 MWe net electricity output
- UCO TRISO fuel
- Power conversion via gas or steam turbine generator
- Three to ten-year fuel cycles

Xe-Remote, Resilient, Modular (RRM) Overall Installed Configuration

- Expandable in increments of ~7 Mwe/unit
- Multiple reactor units can share single control room
- Construction time: 3-6 months, depending on site
- Silo concrete walls and subgrade configuration ensures effective shielding and protects reactor
- Concrete silo is part of reactor functional containment
- Reactor supported on seismic bearings to protect against the impact of severe earthquakes



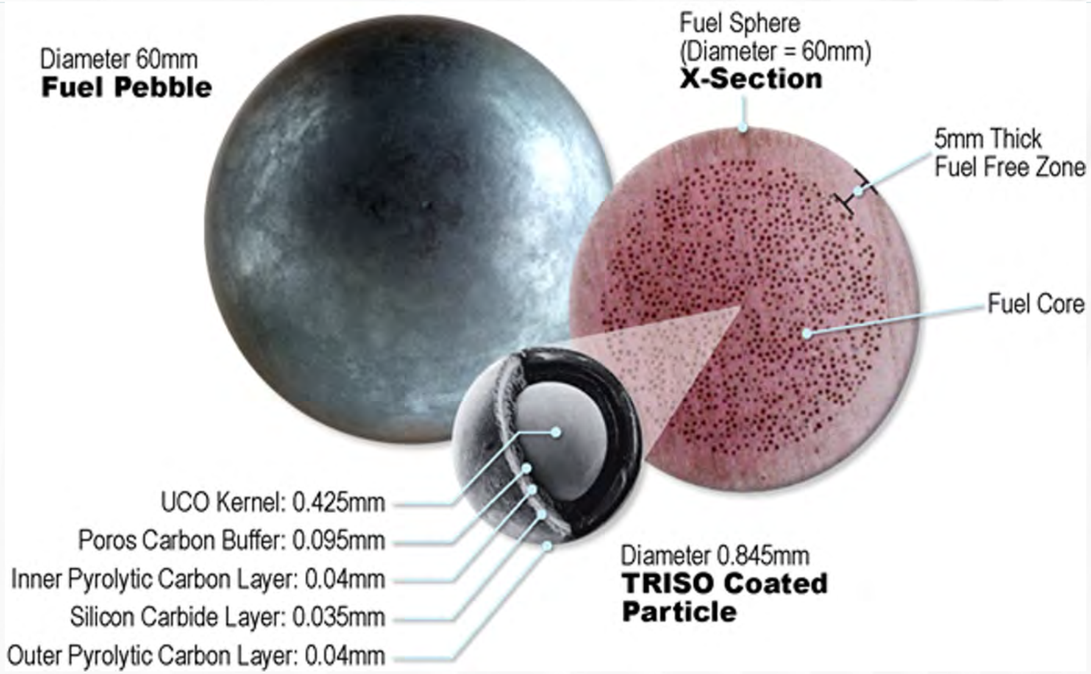


Dimensions in meters

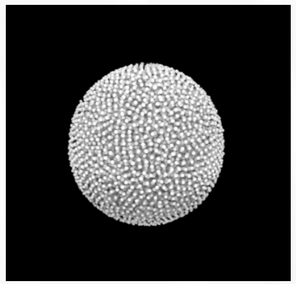
TRISO-X Fuel Production

TRISO Coated Particle Fuel is the Key to Safety

- Each TRISO particle forms a miniature containment vessel that retains radionuclides at the source for full spectrum of off-nominal events
- Demonstrated ability to withstand extremely high temperatures for extended periods (1800 °C for 300+ hours) without fuel failure
- High level of maturity due to >$250M investment by DOE in design and qualification and characterization of the TRISO fuel
- In-place, operational TRISO fuel fabrication facility (at ORNL)



Prototype pebble mold



Innovative visualization of particles in pebble

First fuel form pebbles produced at ORNL, Fall 2016

DOE's Dr. Rita Baranwal tours TRISO-X Pilot Lab

Fuel is an integral part of the HTGR safety basis and economics

Issues/Challenges Related to Transportation and Structural Materials

Transportation Challenges	Structural Materials Challenges
Systems must be designed/tested to ensure they can operate after “over the road” transportation – multiple times - Transport load spectrum differs from seismic environs. - DOT and Mil-Specs to define expected environments	To transport a system, must pay attention to weight and use materials that lead to weight-optimized solutions: - Road restrictions on maximum allowable loads - Fork lift and/or small overhead crane compatibility
Unlike fresh/spent fuel transport packages, these systems are DESIGNED to go critical! - New DOT, NRC, potentially other standards will be needed to govern how these moves are accomplished	Desire to reuse as many systems as possible during refueling/refurbishments – to keep down costs - Minimize activation through shielding, material selection - “Depot” operations concept, where build-up, breakdown, refurbishment, and redeployment has advantages
Like SMRs, factory fabrication, assembly, and acceptance testing of major nuclear systems prior to shipment to the site will be the norm	Selection of external materials that minimize maintenance requirements (water exposure, salts in sea transport, temperature extremes, high humidity, etc.)
Future transportable m-reactor designs may incorporate methods/processes to remove the spent fuel in the field and ship systems/fuel separately	
Licensed packages for shipment of HALEU fuel forms	

Opportunities abound for m-Reactors – Gov’t policy and regulatory challenges must be addressed