Advanced Reactor Fuel Challenges for EM^2

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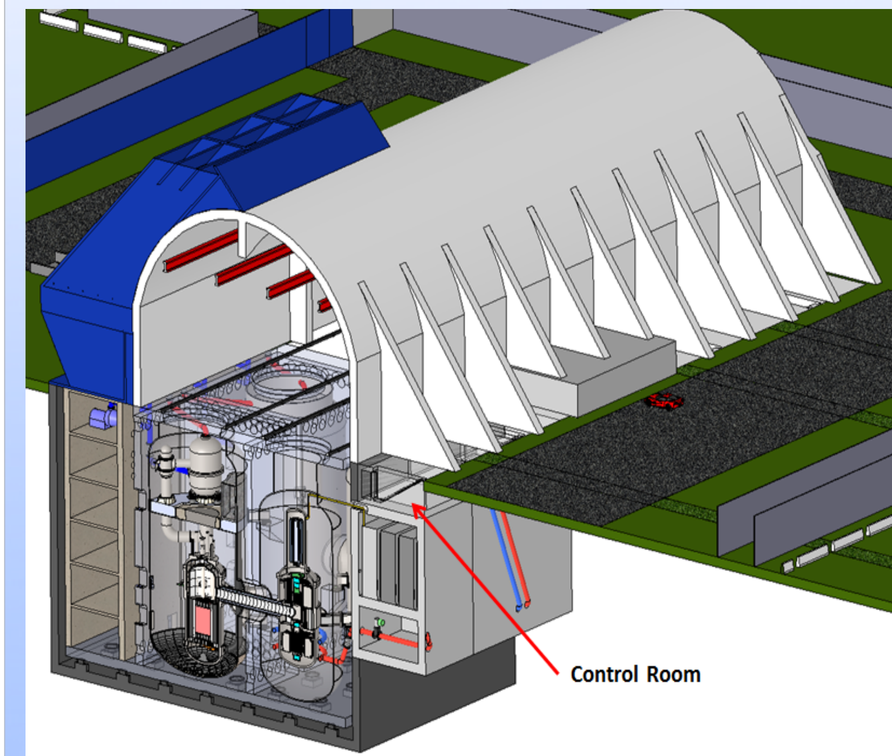
Energy Multiplier Modules (EM²) Is a Compact Fast Gas Reactor Producing 265 MWe

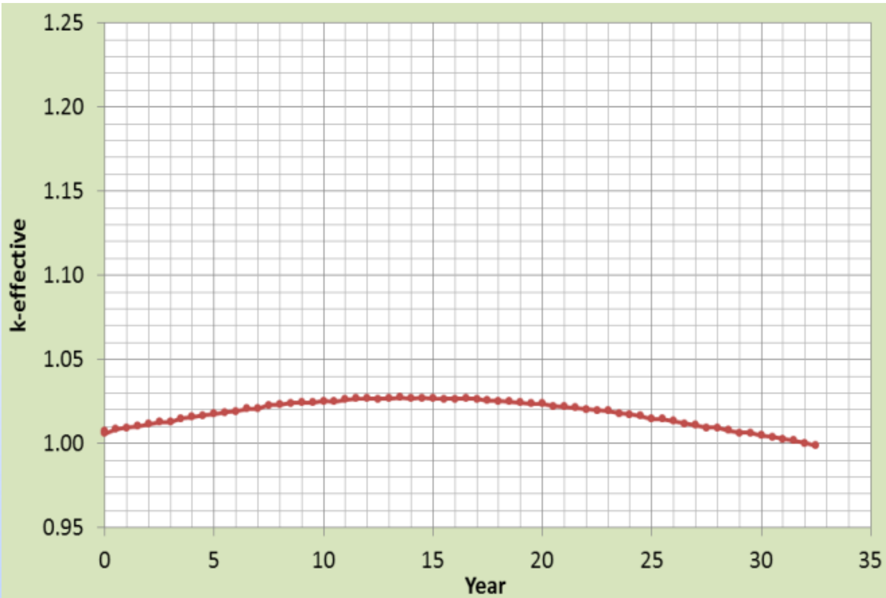
Below-ground construction negates many physical threats and improves security



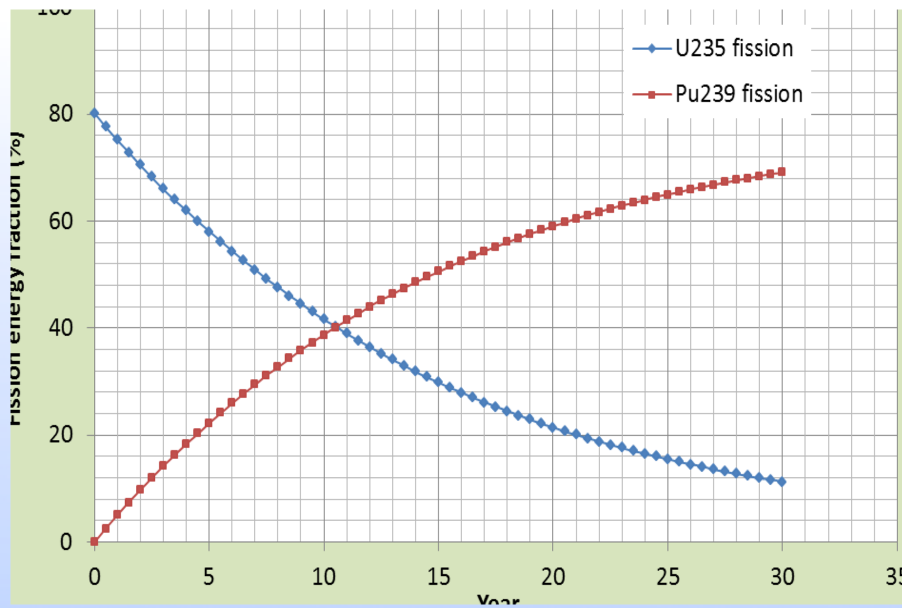
- 30-year fuel life with no shuffling
- Employs a convert-and-burn core design that works with LEU, depleted uranium, spent fuel, plutonium and thorium
- 53% efficient with evaporative cooling and 48% dry cooling
- Flexible siting
- Factory built, truck transportable
- Waste stream reduced 80% for single pass through
- Rapid load following

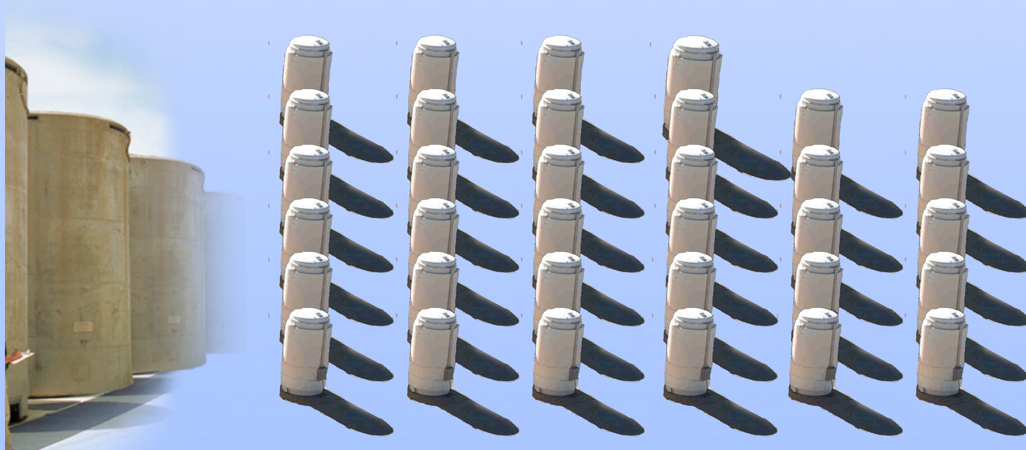
EM^2 Employs a 30-Year Convert and Burn Core Design To Improve Fuel Utilization and Reduce Waste

- 50/50 core is LEU at ~12% and DU



- Most of the energy comes from ^{238}U





One LWR produces ~600 tonnes of waste in 30 yrs

$$\frac{1}{1.6} \times \frac{1}{3} \simeq \frac{1}{5}$$

- $\frac{1}{1.6}$: 60% more efficient than LWR
- $\frac{1}{3}$: Higher burnup
- $\frac{1}{5}$: The fuel of LWR

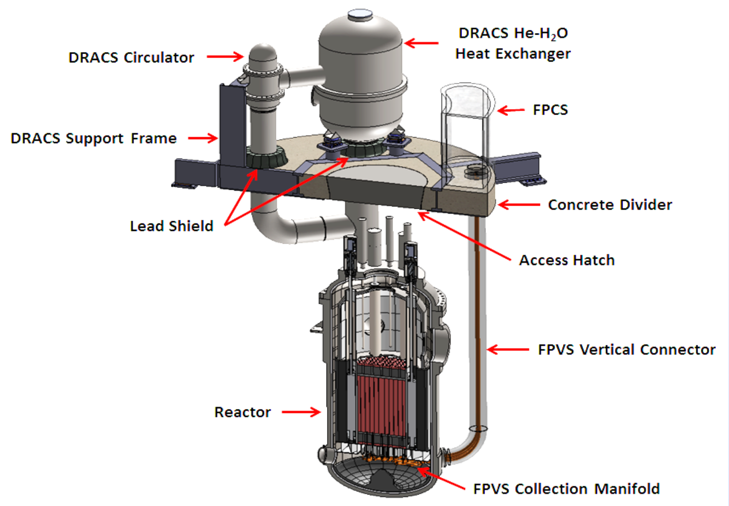
4-unit EM^2 produces 80% less waste in 30 yrs

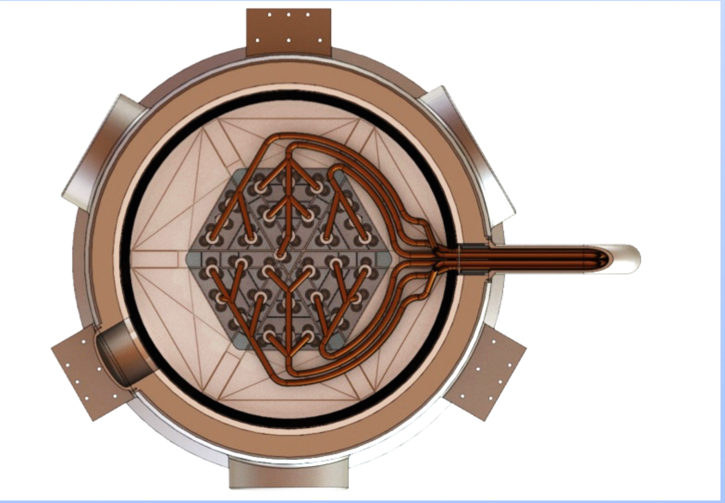
GENERAL ATOMICS

Long-life Cores Introduce New Licensing Issues

- **Every long lived fuel element (>10 yrs) will need to deal with pressure from volatile fission products**
  - Fuel venting changes defense in depth philosophy and meaning of fission product barrier
- **Fuel performance codes must be validated for extended effects of fast fluence and burnup**
  - Relevant irradiation data of materials must be incorporated into database
  - New physics must be incorporated
- **Qualification of long-lived fuels requires incremental validation using a prototype**
  - Staged licensing is needed to enable timely attention to innovative technologies

As an Example, Every 30-Year Fuel Will Require Volatile Fission Product Management





- EM^2 chooses to collect and capture the fission products (FP)
- The Fission Product Collection System (FPCS) prevents build up of volatile FP in cladding
  - Volatile FP transported to passively-cooled high temperature absorber (HTA) in containment
  - Coolant pressure maintained higher than fuel internal pressure to ensures FP capture, even if cladding is breached

Peach Bottom 1 HTGR operated successfully with FP collection for 7 years

GENERAL ATOMICS

Key Areas Require Require Evaluation by NRC To Determine Regulatory Approaches

- **Regulatory framework to obtain a prototype license needs to be clearly defined**
  - Can cost of licensing be bounded ?
- **For new fuels, irradiation data will be obtained**
  - Can advanced guidance be obtained on data necessary for NRC approval is critical ?
- **Use of the prototype to obtain on-going data for commercial fuel qualification is planned**
  - How many years of data is must be accumulated to extend prototype fuel lifetime qualification ?
- **An out-of-reactor fission product collection system will be demonstrated**
  - What tests will be needed to achieve NRC acceptance ?

Questions ?

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