Overview and Status of SMRs Being Developed in the United States

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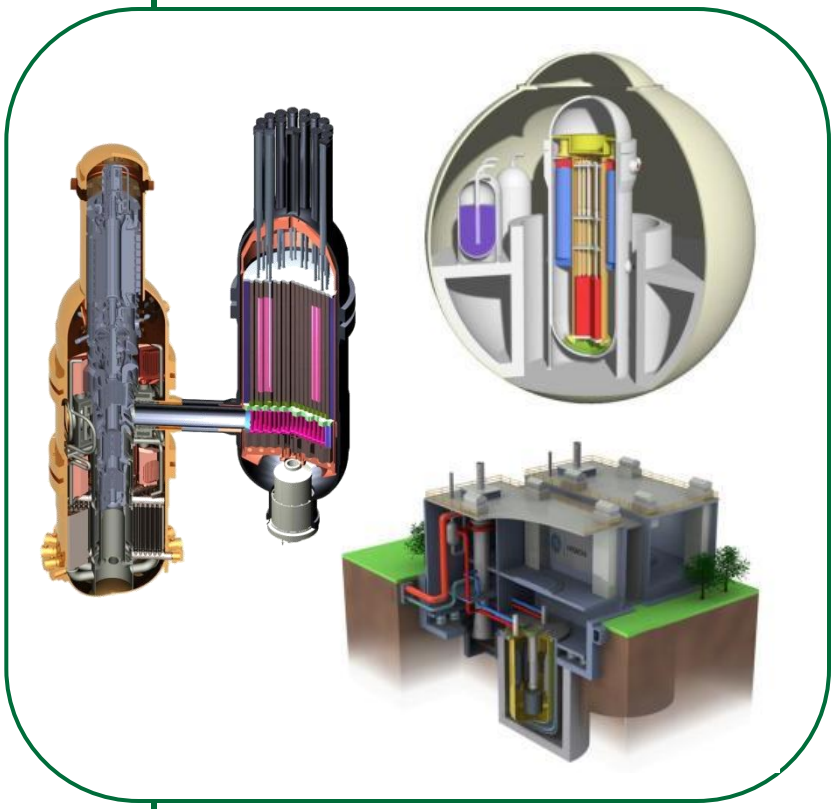


October 10-14, 2011
INPRO Dialog Forum on Common User Considerations for SMRs

U.S. DEPARTMENT OF ENERGY

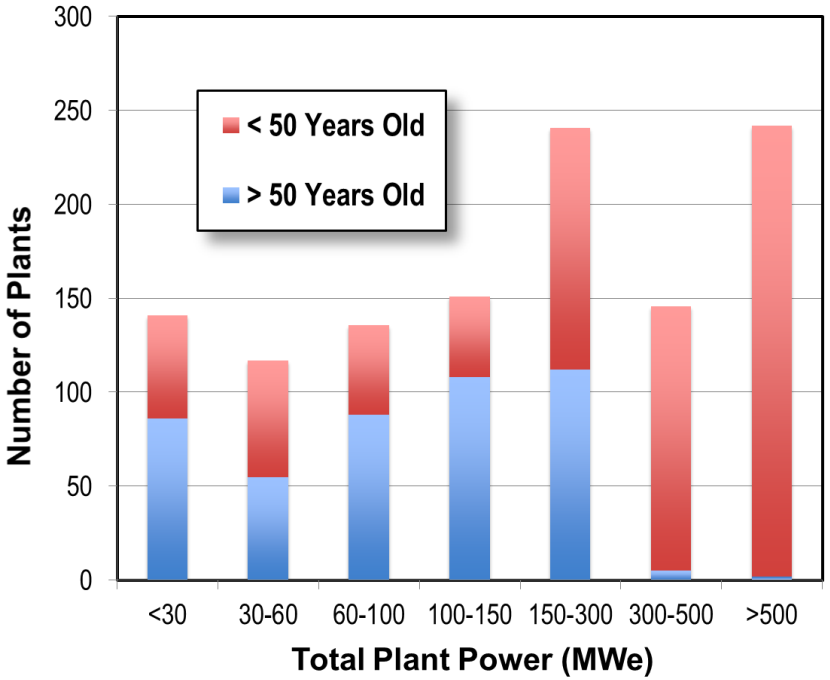
OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

U.S. utility interests in SMRs

- **Affordability**
  - Smaller up-front cost
  - Better financing options
- **Load demand**
  - Better match to power needs
  - Incremental capacity for regions with low growth rate
  - Allows shorter range planning
- **Site selection**
  - Lower land and water usage
  - Replacement of older coal plants
  - Potentially more robust designs
- **Grid stability**
  - Closer match to traditional power generators
  - Smaller fraction of total grid capacity
  - Potential to offset non-dispatchable renewables

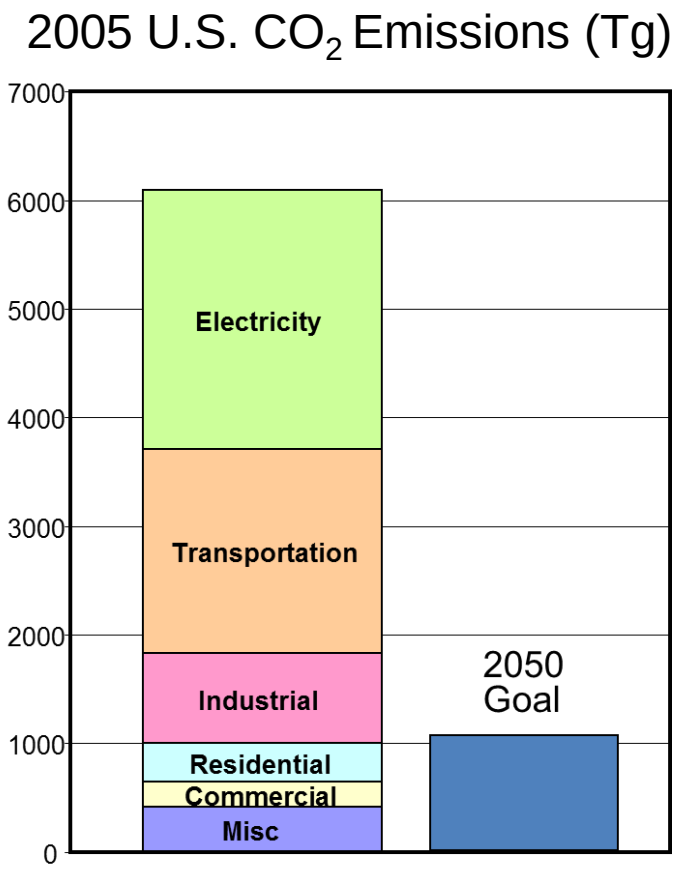
U.S. Coal Plants

Plants >50 yr old have capacities Less than 300 MWe

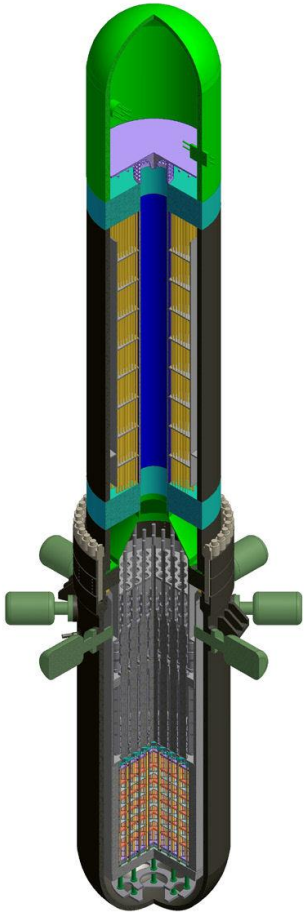


U.S. Government interests in SMRs

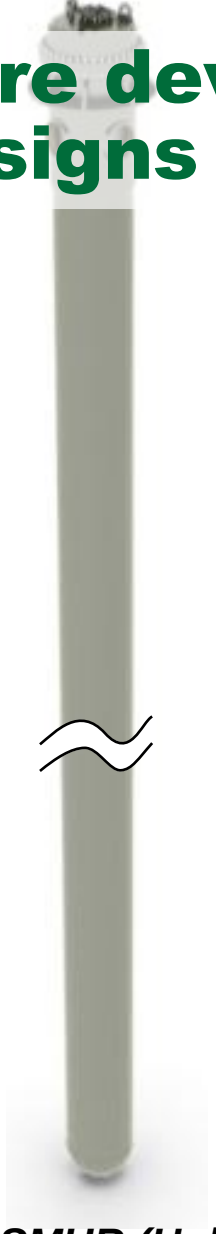
- **Carbon Emission**
  - Reduce U.S. greenhouse gas emissions 17% by 2020…83% by 2050
  - Reduce federal GHG emissions 28% by 2020
- **Defense Mission Surety**
  - Studying SMR deployment at DOD domestic facilities
  - Address grid vulnerabilities and fuel supply needs
- **Energy and Economic Security**
  - Pursue energy security through a diversified energy portfolio
  - Improve the economy through innovation and technology leadership



U.S. vendors are developing several LWR-based SMR designs for electricity production



SMR (Westinghouse)
225 MWe



HI-SMUR (Holtec)
140 MWe

mPower (B&W)
125 MWe

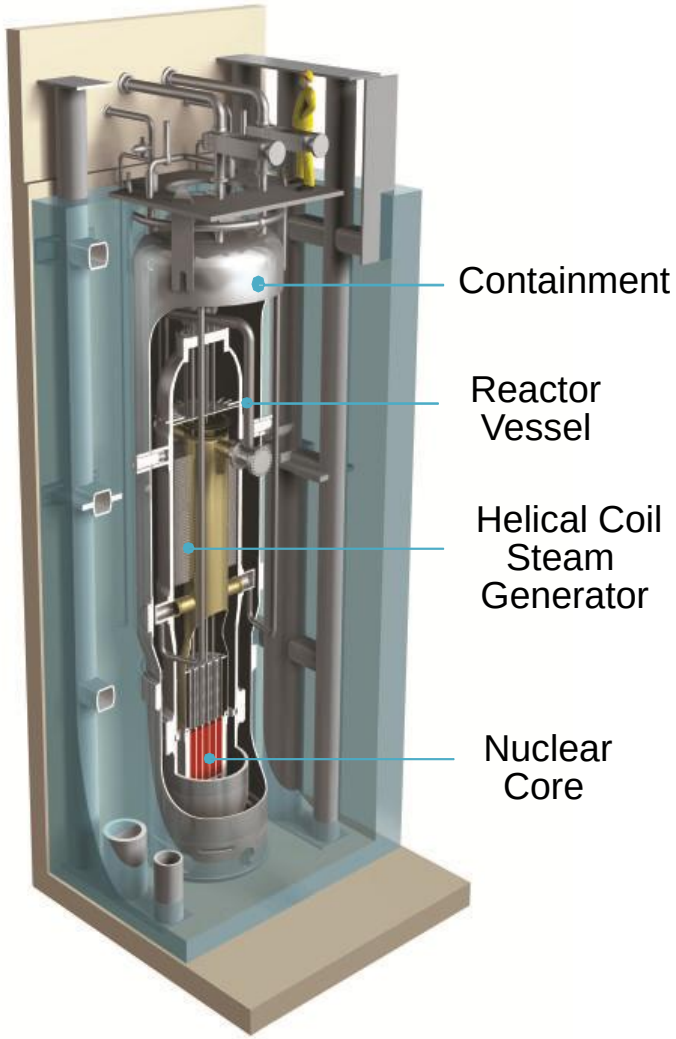
NuScale (NuScale)
45 MWe

Newly announced Westinghouse SMR

- Replaces IRIS as Westinghouse's SMR design
- Integral PWR configuration
- 225 MWe capacity
- Standard 17x17 pin fuel assemblies
- Heavy reliance on AP-1000 and past reactor experience
- Internal control rod drive mechanisms
- Straight tube steam generator
- External primary coolant pump motors
- Small volume containment vessel

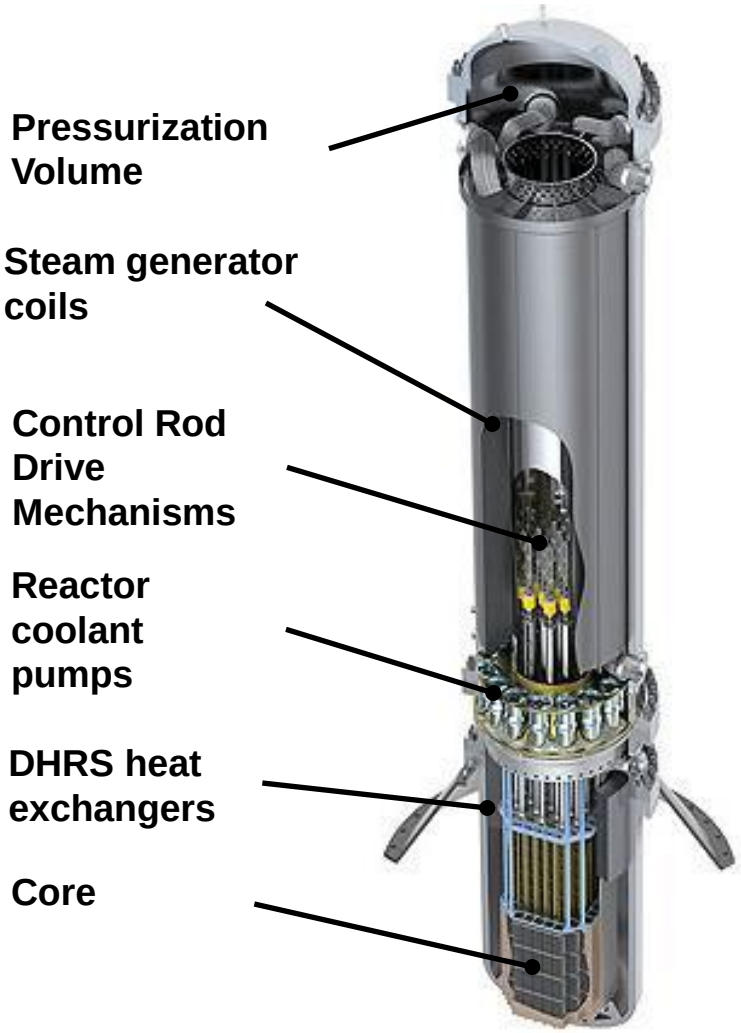
NuScale Module

- **Initially developed by INL/OSU then licensed to NuScale Power**
- **45 MWe capacity**
- **Integral PWR configuration**
- **Natural circulation of primary coolant**
- **Standard 17x17 pin fuel assemblies with 3.5-yr refueling cycle**
- **Dual helical coil steam generators**
- **Reference plant contains 12 modules**



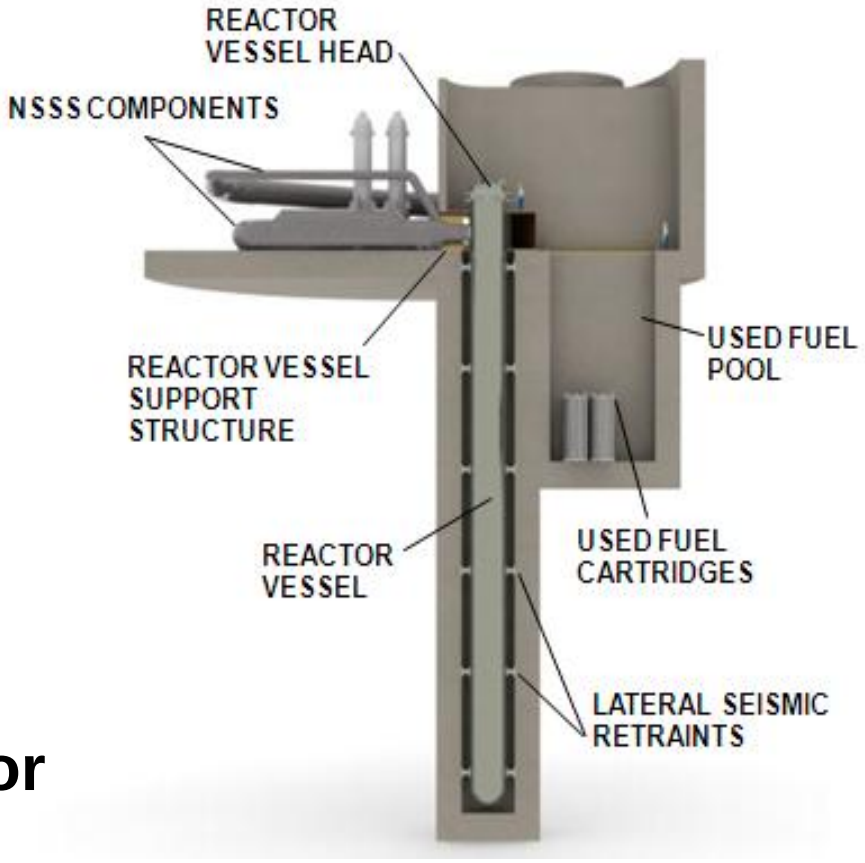
Generation mPower

- Developed by Babcock & Wilcox
- 125 MWe capacity
- Integral PWR configuration
- Forced circulation of primary coolant
- Standard 17x17 pin fuel assemblies with 4.5-yr refueling cycle
- Once-through straight tube steam generator
- 3.6-m-dia by 22-m-tall reactor vessel

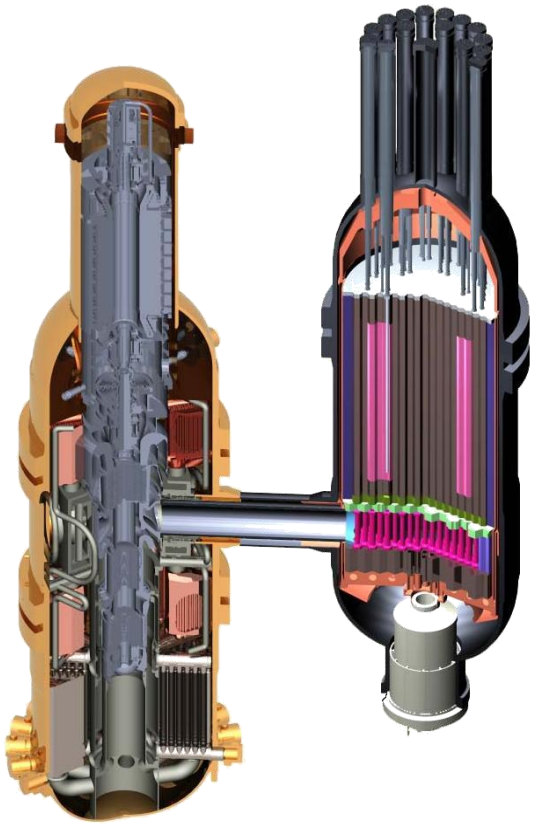


Holtec International SMR

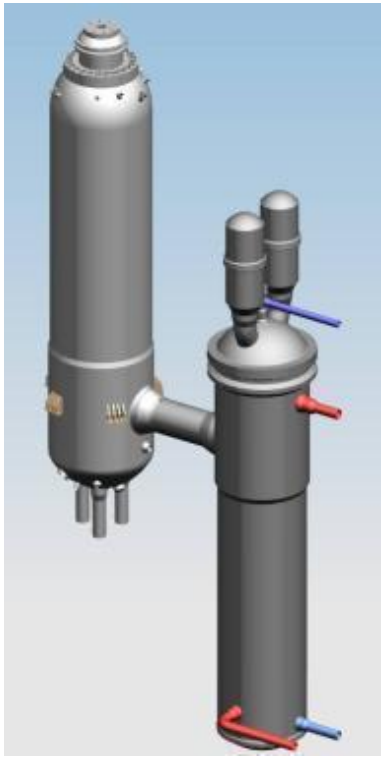
- Developed by SMR, LLC
- 140 MWe capacity
- “Integrally connected” PWR configuration
- Natural circulation of primary coolant
- Standard 17x17 pin fuel assemblies
- Horizontal steam generator
- 2.7-m-dia by 40.2-m-tall reactor vessel



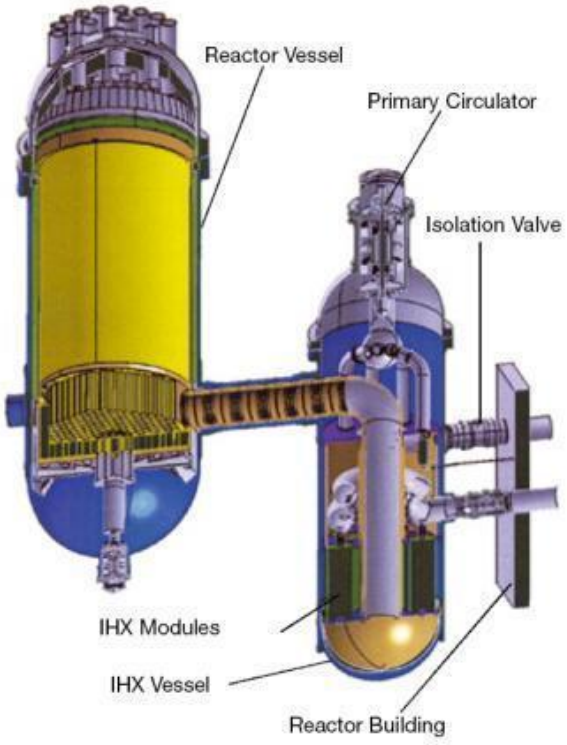
Gas-cooled SMRs are being developed primarily for process heat



MHR (General Atomics)
280 MWe



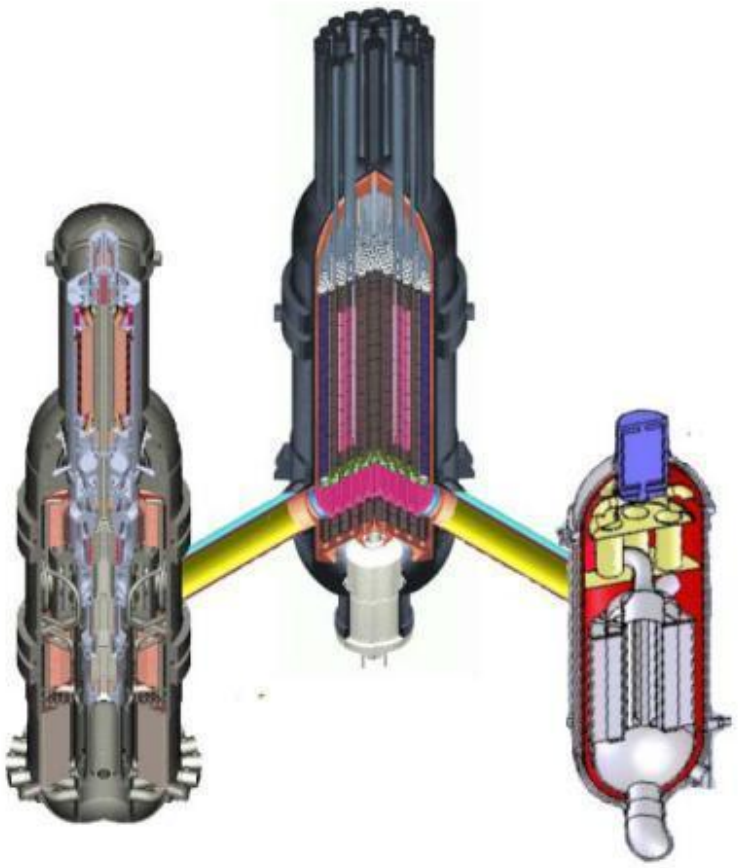
PBMR (Westinghouse)
250 MWe



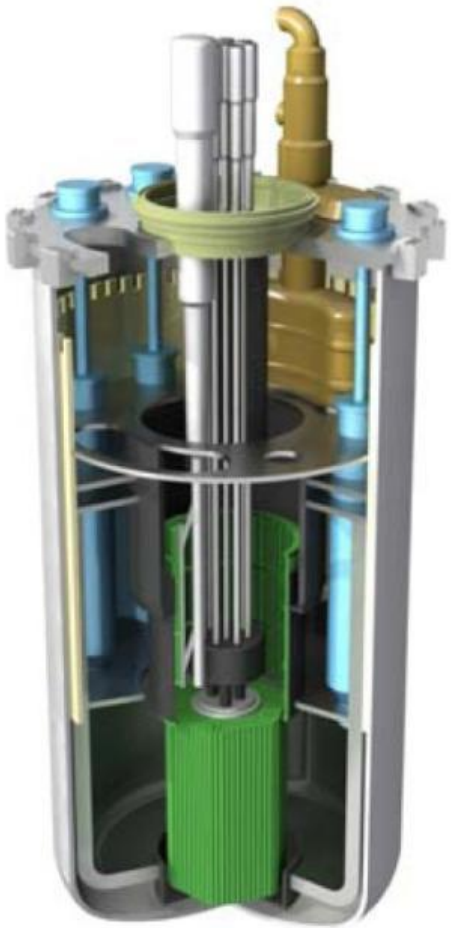
ANTARES (Areva)
275 MWe

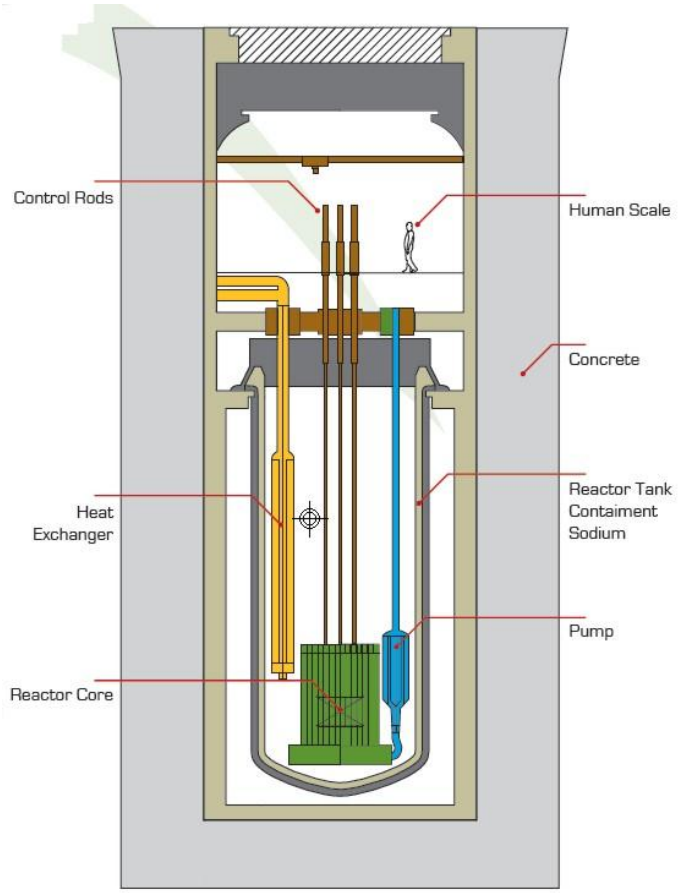
Modular High-temperature Reactor (MHR)

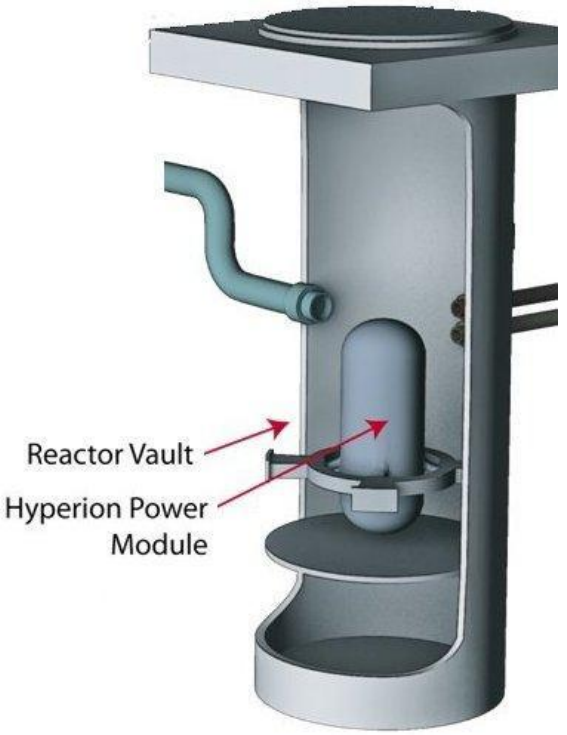
- Sized at 287 MWe to meet the requirements of Next Generation Nuclear Plant (NGNP) project
- Helium coolant
- Prismatic graphite block moderator
- TRSIO coated particle fuel with UO_2 or UCO fuel kernel
- Direct Brayton cycle power conversion and indirect loop for process heat applications
- Passive decay heat removal



Liquid-metal-cooled SMRs are being developed for fuel cycle management



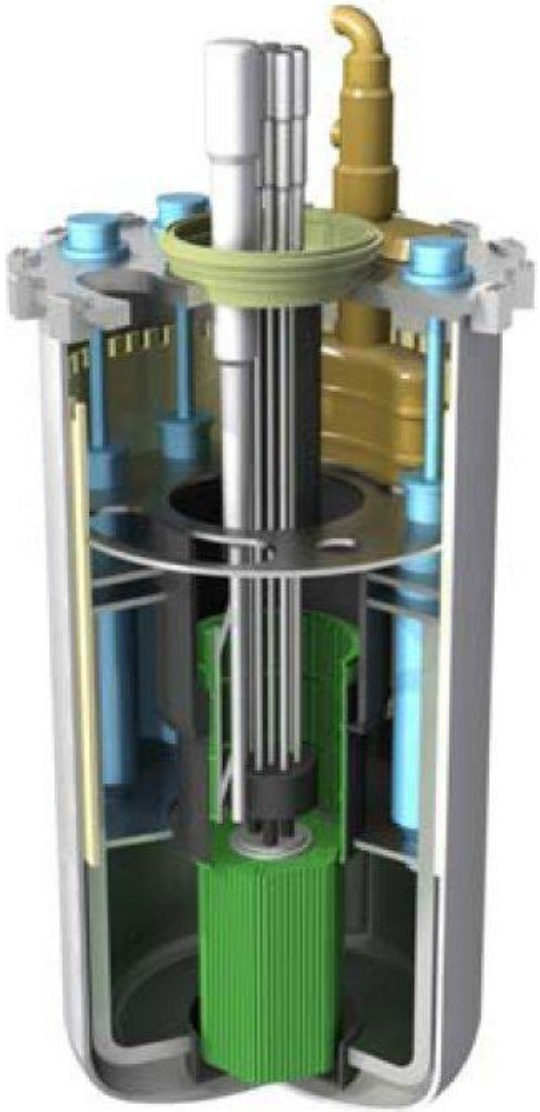




PRISM (General Electric) ***ARC-100 (ARC)*** ***HPM (Hyperion)***

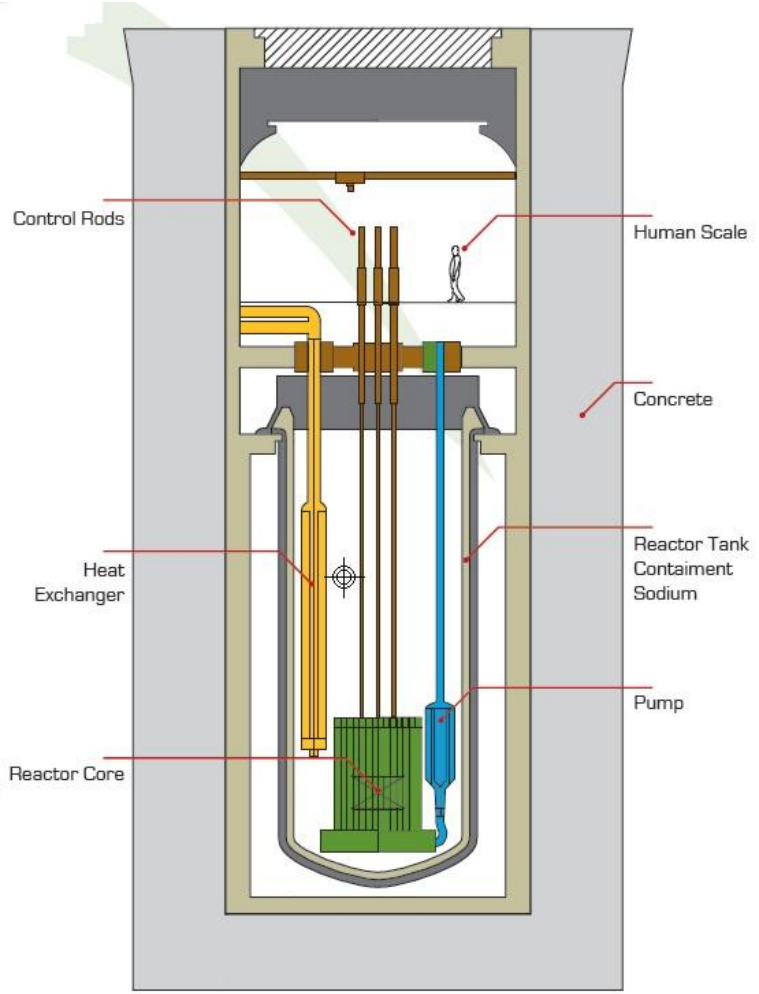
Power Reactor Innovative Small Module (PRISM)

- General Electric design originally sized at 160 MWe per module
- Later upsized to 380 MWe (Super PRISM and then reduced to 311 MWe for GNEP
- Integral (pool) configuration with internal intermediate heat exchangers
- Passive decay heat removal
- Seismic isolation
- U-Pu-Zr metal fuel
- Integrated with reprocessing facility



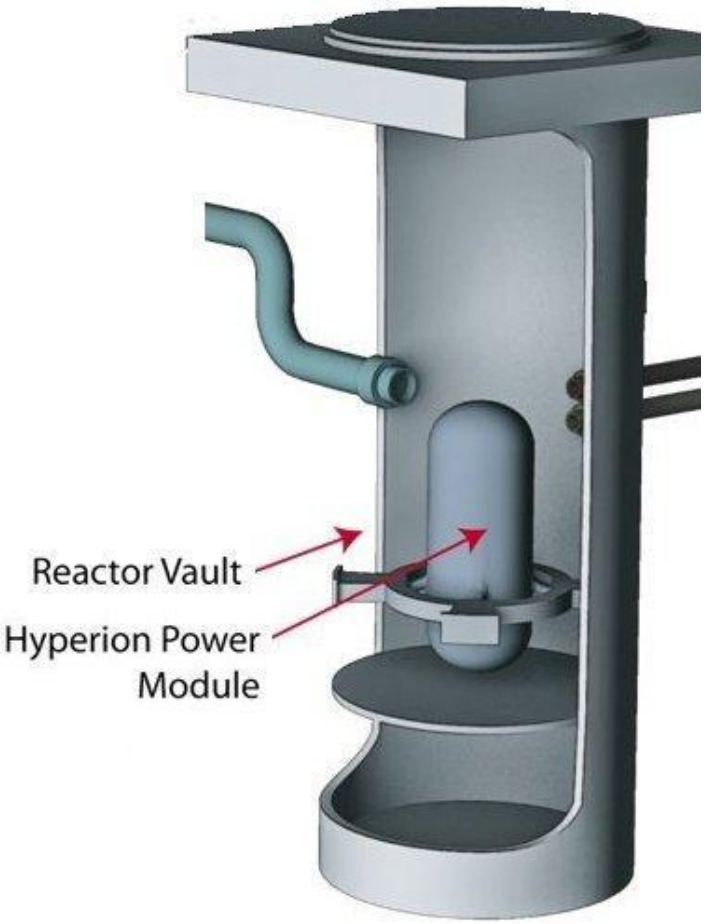
Advanced Reactor Concept (ARC-100)

- Newly formed company supported by several former national lab researchers
- 100 MWe from S-CO_2 Brayton cycle power conversion unit
- Sodium coolant
- U/Zr metallic alloy fuel
- 20-year refueling interval
- Focused on distributed power model with regional fuel cycle centers



Hyperion Power Module (HPM)

- LANL concept licensed to and marketed by Hyperion Power Generation
- 25 MWe units for distributed power generation
- Uranium nitride fuel
- Lead-bismuth eutectic coolant
- Five year core life
- Entire module returned to factory for refueling
- Fully buried unit and concrete enclosure

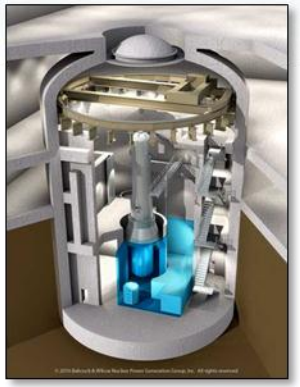


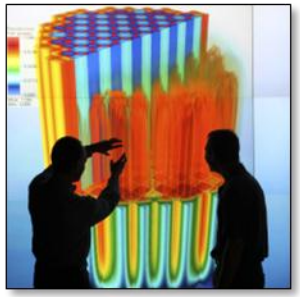
U.S. Nuclear Regulatory Commission is preparing for SMR applications

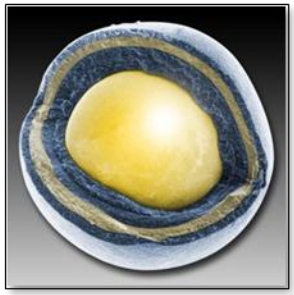
- **Has identified several generic issues in four primary categories:**
  - **Licensing process**
  - **Design requirements**
  - **Operational requirements**
  - **Financial implications**
- **Is aggressively working many of these issues with focus on LWR-based designs**
- **Expect non-LWR designs to require more review time, although some licensing experience exists**

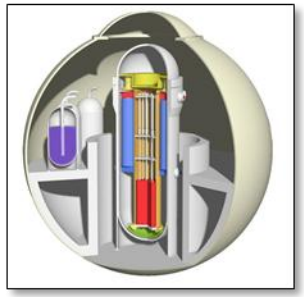
U.S. Department of Energy expects to initiate an SMR program in FY12

Design certification partnerships	Assessment tools	Technology R&D	Advanced concepts
Establish cost-shared projects with industry partners to accelerate design certification	Support development of new simulation tools, codes and standards, and cost models to support objective assessments of safety, performance, and economics	Develop new technologies (fuel, materials, sensors, etc.) that further reduce costs or enable advanced features and functionality	Develop innovative concepts that utilize advanced technologies to achieve expanded functionality









Summary

- **Strong interest in SMRs has emerged in the United States**
- **All sectors are actively engaged:**
  - **U.S. Department of Energy**
  - **U.S. Nuclear Regulatory Commission**
  - **SMR vendors and suppliers**
  - **Utilities**
- **First potential deployment could be as early as 2020**

"If commercially successful, SMRs would significantly expand the options for nuclear power and its applications."

- Steven Chu, Secretary of Energy, 3/23/10