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Small Modular Reactor Program Overview for Electric Power Research Institute

Energy and Climate Change Research Seminar

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Why is the U.S. Government Interested in Supporting SMR Technologies?

NE working definition of SMRs: reactor units with a nominal output of 300 MWe or less and are able to have large components or modules fabricated remotely and transported to the site for assembly of components and operation.

Potential Benefits

- Enhanced safety and security
- Reduced capital cost makes nuclear power feasible for more utilities
- Shorter construction schedules due to modular construction
- Improved quality due to replication in factory-setting
- Meets electric demand growth incrementally
- Re-establish U.S. technical leadership in nuclear energy via international sales
- Domestic job creation potential very high

Potential Markets

- Domestic and international utility markets
- Non-electrical (process heat/desalination) customers

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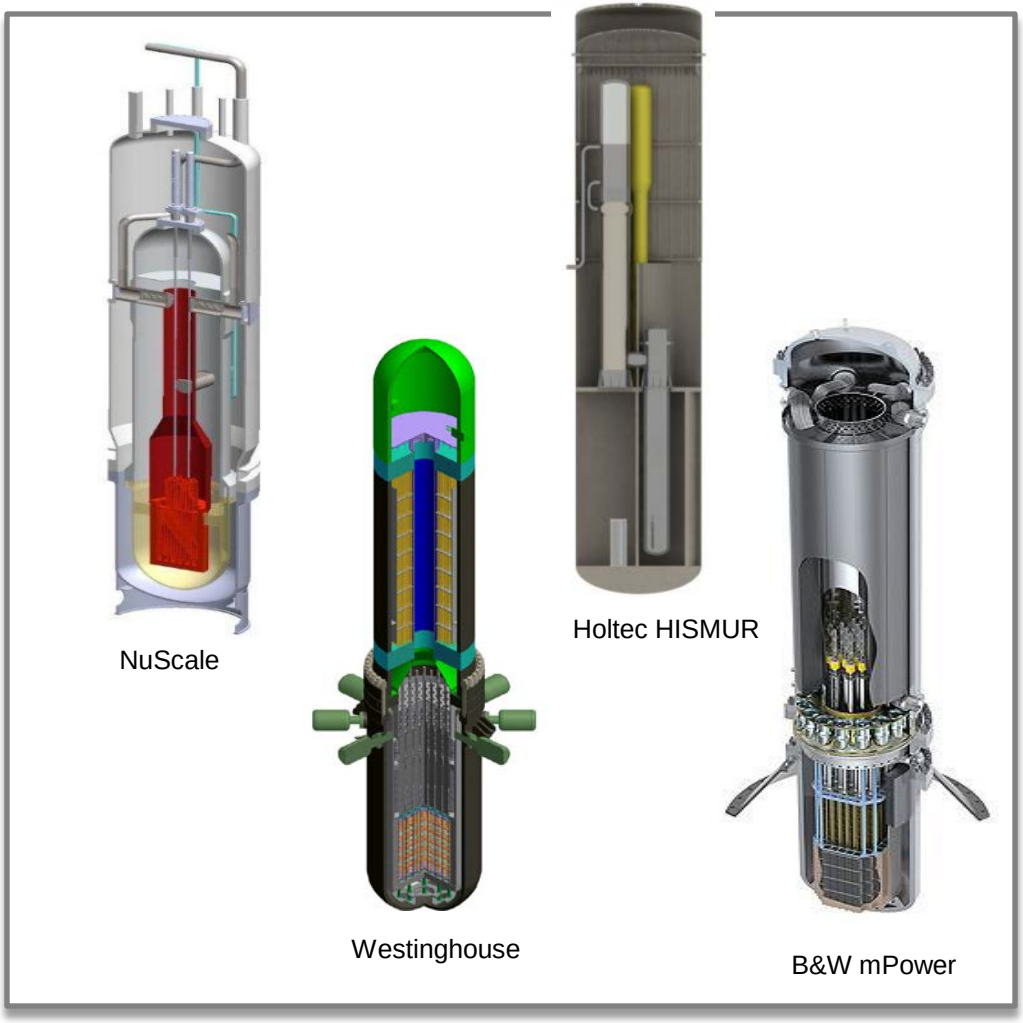
Light Water-Based SMR Designs

- **Well-understood Technology**
  - Uranium Oxide fuels
  - Applicable regulatory and operating experience
  - Safety features that build on GEN III+ reactors
  - Licensing horizon 5-10 years
- **Commercial Interest**
  - Vendor/Utility coalitions being established in response to DOE program
  - Primary focus is on electric



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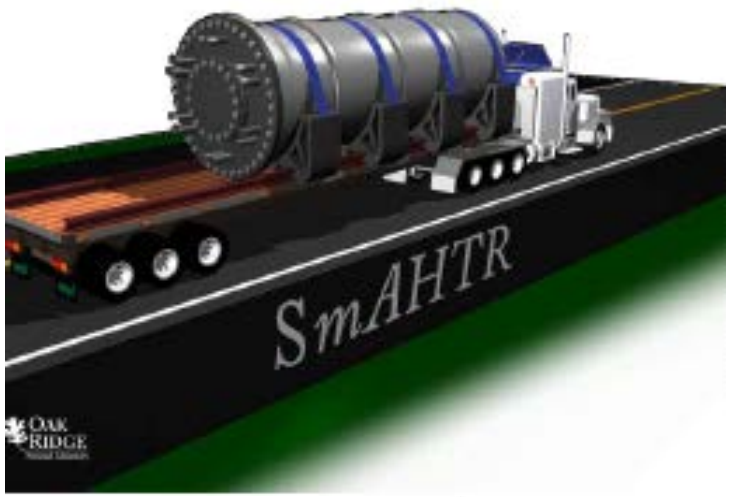
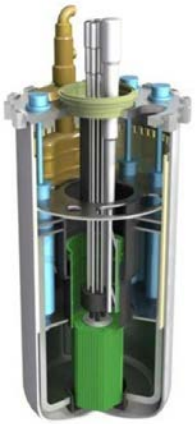
Advanced Small Modular Reactors

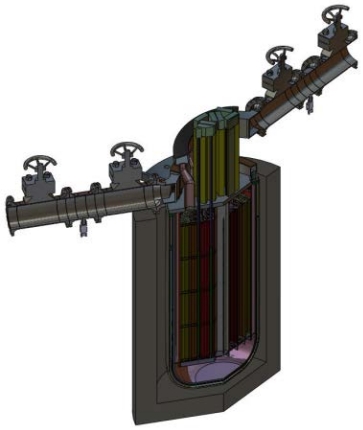
- **New Innovative Technologies**
  - Mostly non-LWR based designs
  - Liquid metal, gas and molten salt-cooled
  - Licensing horizon 10-20 years
  - Less near-term commercial interest



- **Characteristics such as high temperature operation allow broader applications**
  - Process heat
  - Desalination
  - Hydrogen generation
  - Transportable/mobile
  - Long-lived cores
  - Waste management



GE PRISM



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Policy Drivers for Pursuing SMR Programs

- **Climate Change**
  - Reduce U.S. greenhouse gas emissions 17% by 2020…83% by 2050
  - E.O. 13514 – Reduce federal GHG emissions 28% by 2020
    - ***Government missions cannot be curtailed to meet GHG target***
- **Energy and Economic Security**
  - Pursue energy security through a diversified energy portfolio
  - Improve the economy through innovation and technology leadership
- **Department of Defense Mission Surety**
  - Studying SMR deployment at DoD facilities
  - Address grid stability and fuel supply needs

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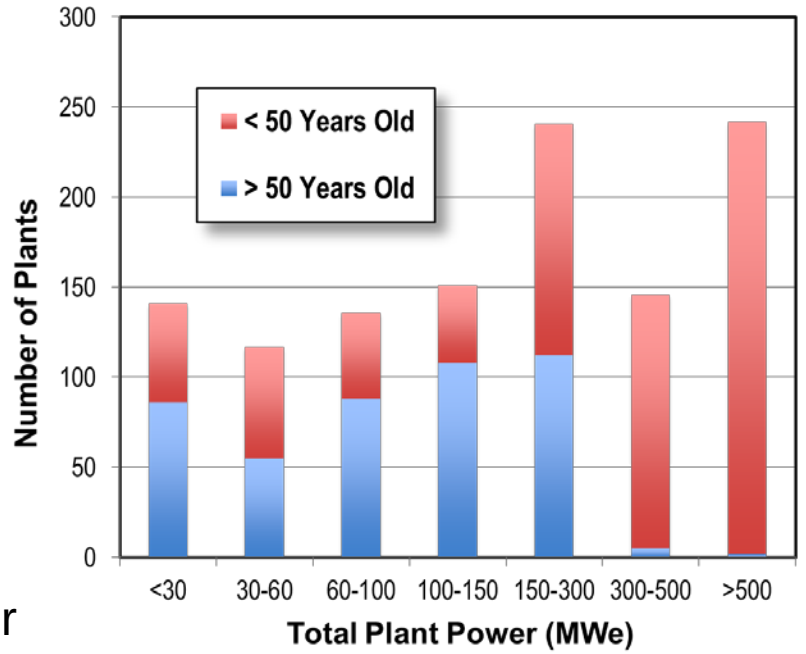
U.S. Utility Considerations

- **Site selection**
  - More siting flexibility than traditional nuclear plants
  - Lower land and water usage
- **Load demand**
  - Better match to power needs
  - Potential replacement of older coal plants
  - Use of existing infrastructure
- **Incremental demand growth**
  - Multiple modules
  - Operating units can provide financing for future additional units.

U.S. Coal Plants

99% of plants > 50 years old have less than 300 MWe capacity



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Economic Challenges Facing SMRs

Economic viability depends on several factors:

- **Significant investment needed to reach commercialization**
  - On the order of $500 + M per design
- **Can the plants be built cheaply enough?**
  - Economies of replication > economies of scale?
  - Need a factory to make the price attractive, need an attractive price to produce the orders to warrant building the factory
- **Can the operations and maintenance costs be kept down?**
  - How will simplified “inherently safe” designs translate into smaller workforce and operation costs and comply with regulatory requirements?

DOE commissioned an SMR economic study last year that implied SMRs can be competitive under certain conditions – We are following this up with a harder look at the economies of mass manufacturing

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Goal of SMR Licensing Technical Support Program

- Facilitate and accelerate commercial development and deployment of U.S.-based SMR designs at domestic locations
- Soliciting applications from vendor/utility teams that have plans to construct SMRs at a domestic site by 2022
- 5 year/$452 M program
- FY12 Conference Report dictated that DOE should consider any SMR that can be “deployed expeditiously”
- Support up to 2 SMR designs, consistent with FY12 budget
- Support only design certification and licensing for new designs – no construction
- Events in Japan have prompted us to place additional emphasis on safety of SMR designs in selection process

SMR SMALL MODULAR REACTOR PROGRAM

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Nominal Solicitation Schedule - *DOE is motivated to make awards before the end of the calendar year 2012*

- **Release draft FOA** – January 19, 2012 (Completed)
- **30 day industry comment period**– January 19 – February 17, 2012 (Completed)
- **Incorporate industry comments** – February 17 – March 21, 2012 (Completed)
- **Issue Final FOA** – March 22, 2012 (Completed)
- **Industry Day** – April 12, 2012 (Completed)
- **Receive Applications** – May 21, 2012
- **Conduct merit review, make selection** – May 22 – September 2012
- **Announcement of Selections** – September 2012 (Goal)
- **Complete cooperative agreements and release funding** – November - December 2012 (Goal)

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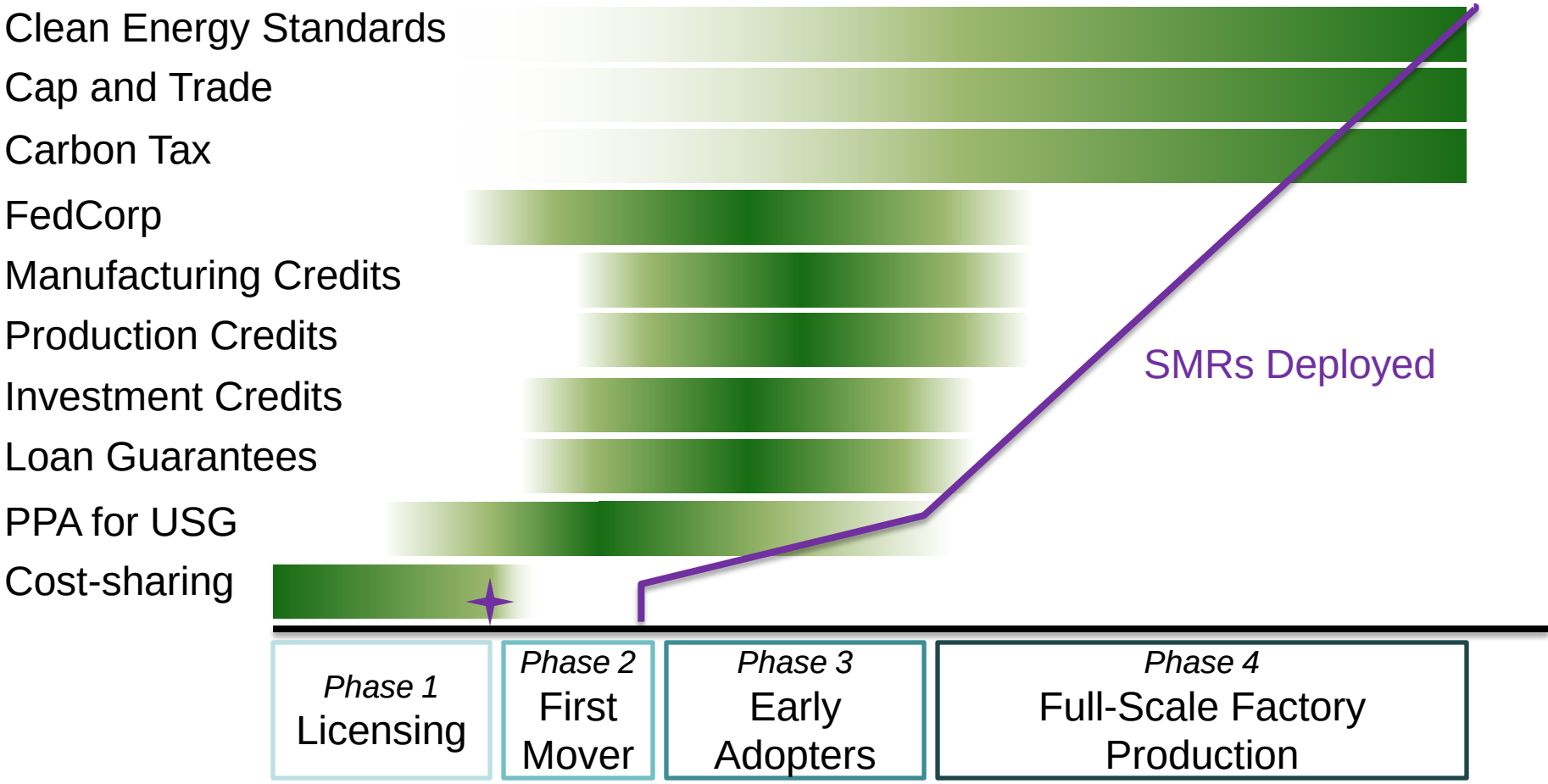
SMR Deployment Strategy Phases



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Conclusion

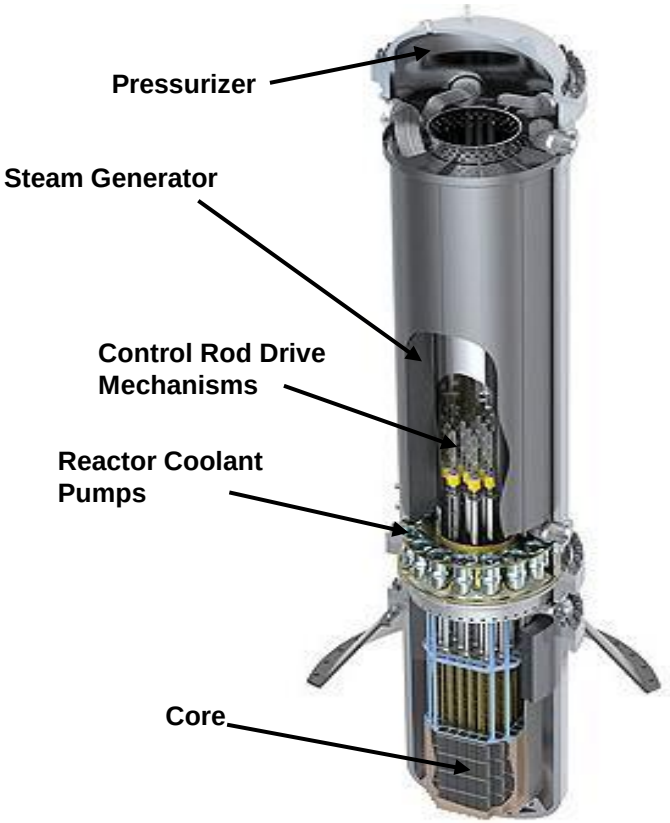
- **NE has the full support of the Administration to aggressively promote SMRs**
- **We believe that SMRs can provide a safe, secure and economical option to meet the Nation's energy needs**
- **DOE funding should have a significant impact on accelerating the first movers and building the momentum for the subsequent builds**

"The Obama Administration and the Energy Department are committed to an all-of-the-above energy strategy that develops every source of American energy, including nuclear power, and strengthens our competitive edge in the global clean energy race "Through the funding for small modular nuclear reactors announced today, the Energy Department and private industry are working to position America as the leader in advanced nuclear energy technology and manufacturing."

Backup Slides

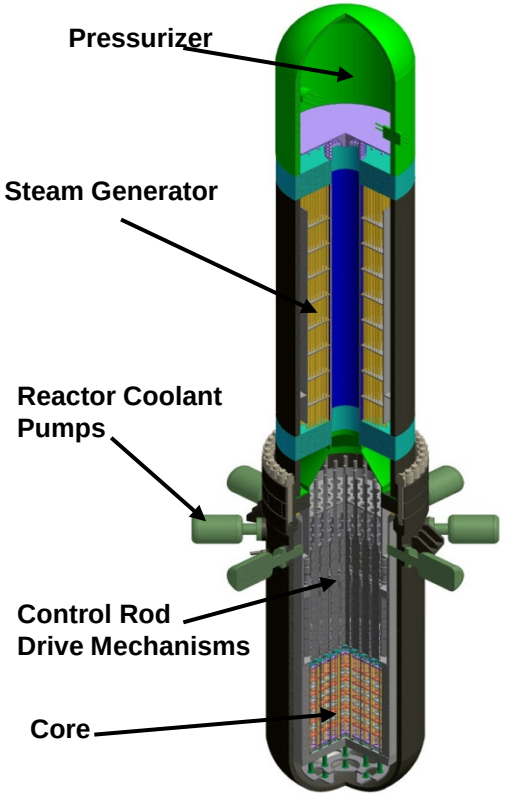
Generation mPower

- 180 MWe
- Utilizes standard UO2 LWR fuel
- Up to 4 year refueling interval
- Provides air-cooled condenser option
- Generation mPower is a consortium between B&W and Bechtel
- TVA signed letter of intent (LOI) on June 16, 2011, to build up to 6 mPower modules at the Clinch River Site in Oak Ridge, TN
- Design Certification (DC) application estimated Q4 2013



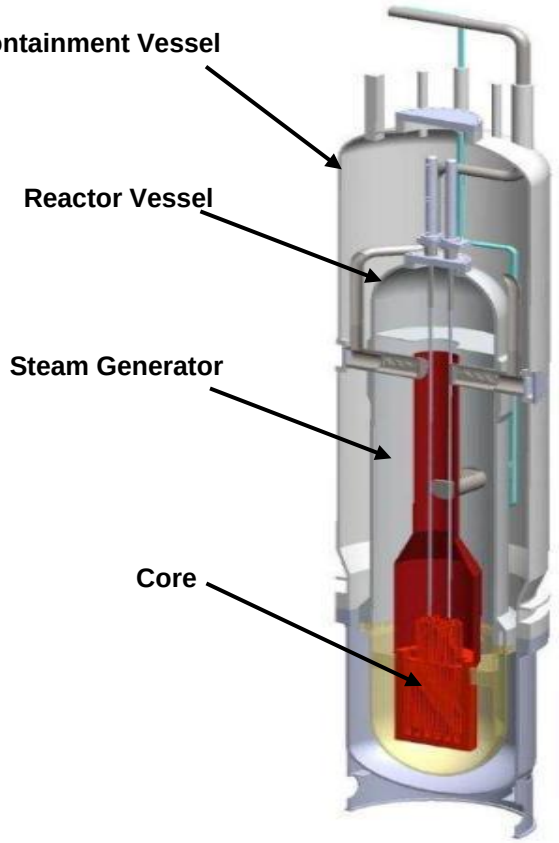
Westinghouse SMR

- >225 MWe
- Utilizes shortened UO2 AP1000 fuel
- 24 month refueling interval
- Horizontally mounted, canned coolant pumps remove seal concerns (i.e., small-break LOCA)
- Utilizes passive safety systems derived from AP1000 design
- DC application estimated Q3 2013



NuScale

- 45 MWe per unit – up to 12 units/plant
- Utilizes standard UO2 LWR fuel
- 2.5 year refueling interval
- Utilizes passive circulation cooling under normal operating conditions
- Design features entire containment vessel submerged in reactor pool for improved safety
- Long-term passive cooling capability extends time required for operator intervention
- DC application estimated Q2 2014



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Holtec Inherently Safe Modular Underground Reactor (HI-SMUR)

- 160 MWe
- Utilizes standard LWR UO2 fuel
- 3 year refueling interval
- Utilizes passive circulation cooling under normal operating conditions
- Utilizes horizontal steam generator configuration to improve superheating capacity
- Extensive existing manufacturing capabilities for containers and fuel racks
- Experience with NRC licensing processes
- DC application estimated Q1 2015