Small Modular Reactors

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Why are SMR technologies of interest to DOE?

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.

Safety Benefits
- Passive decay heat removal by natural circulation
- Smaller source term inventory
- Simplified design eliminates/mitigates several postulated accidents
- Below grade reactor siting
- Potential for reduction in Emergency Planning Zone

Economic Benefits
- Reduced financial risk
- Flexibility to add units
- Right size for replacement of old coal plants
- Use domestic forgings and manufacturing
- Job creation
Common Characteristics of SMR Designs

- **PWRs using LEU fuel** – Established fuel cycle infrastructure
- **Manufacturability** – Enable extensive factory construction
- **Transportability** – Modules delivered to the site for assembly
- **SMR designs share a common set of design principles to enhance plant safety and robustness**
  - Incorporation of primary system components into a single vessel
  - Passive safety systems
  - Smaller core
  - Increased ratio of water inventory to decay heat for more effective decay heat removal
  - Vessel and component layouts that facilitate natural convection cooling of the core and vessel
  - Below-grade construction of the reactor vessel and spent fuel storage pool for enhanced resistance to seismic events and improved security
SMR Program History and Evolution – SMRs have become a top priority for DOE

- Plans first developed for an SMR Program in FY10 as an effort to:
  - Support certification, licensing and deployment of near-term SMR designs
  - Support commercialization of advanced designs with longer-term licensing horizons through focused R&D

- In FY11, SMR Program was unable to get underway during full year continuing resolution (CR)
  - $38 M in President’s Budget Request
  - Program considered a “new start”
  - Funding allocation was divided among existing program

- In FY12, following the CR, NE received full President’s Budget request:
  - LWR SMR Licensing Technical Support - $67 M
  - Advanced SMR R&D – $28 M

- FY12 Conference report dictated that the SMR program consider “all” reactor types that can be “deployed expeditiously”

- “LWR” dropped from program name in FY13
## Small Modular Reactor Licensing Technical Support

### Budget Summary

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 2012 Enacted</th>
<th>FY 2013 Request</th>
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<tbody>
<tr>
<td>SMR Licensing Technical Support</td>
<td>67,000</td>
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<tr>
<td>Total:</td>
<td>67,000</td>
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### Mission
- Support design certification (DC) and licensing activities for 2 SMR designs through cost-shared arrangements with industry partners in order to promote deployment of SMRs that can provide safe, clean, affordable power options.

### FY 2013 Planned Accomplishments
- Complete negotiations on competitively selected cooperative agreements with SMR vendors and utility partners for cost-shared licensing activities.
- Complete milestones and commitments on design and licensing efforts supporting DC submittals to NRC.
- Continue to work with NRC and industry to address technical and regulatory issues that are vital to the licensing of SMR designs.

### Sequence
To accomplish its mission, the program will follow a defined path of action for the tasks that are within its scope.

1. Issue FOA (draft and final) for SMR deployment project proposals
2. Conduct Merit Review and down-select best proposals
3. Establish cooperative agreements with multiple project teams
4. Provide technical support for vendor submission of DCA documentation
5. Provide technical support for utility submission of operating license application documentation
**SMR Licensing Technical Support Program**

*Modeled After NP 2010 Program*

- $1.4B Joint government-industry program to overcome barriers to new reactor deployment
  - 50-50 cost-share between government and industry

**Results:**
- Three Early Site Permits (North Anna, Grand Gulf, Clinton)
- Two Construction and Operating License applications (Vogtle, Fermi)
- Two Design Certification applications (AP1000 received, ESBWR 2012)

*Current Program:*
- Goal is design certification of 2 SMR designs
- Supports first phase for deployment
- Facilitates and accelerates commercial development and deployment of near term U.S. SMR designs at domestic locations
- $452 M in cost-share program over 5 years
  - FY12 funding is $67M and FY13 request is $65M
Solicit applications from teams composed of SMR vendors and utilities or consortia willing to be first movers in constructing and operating mature SMR designs.

Support site permitting, design development, certification and operating license applications and NRC review processes - basically everything required to get to construction.

- Requires vendor to achieve design certification

Open to LWR and Advanced SMRs that can be deployed “expeditiously” – by 2022

Larger focus is on promoting development of a fleet of SMRs

- Proposals that include longer-term, larger scale deployment plans should be considered favorably

Decision was made to issue a draft FOA to increase industry and stakeholder involvement in the process.
Proposed FOA Schedule
Partnering for the Future

- 30 day industry comment period – January 19 – February 17, 2012
- Incorporate industry comments – February 17 – March 23, 2012
- Issue Final FOA – End of March, 2012
- Industry day – April 12, 2012 (tentative)
- Receive Applications – May 2012
- Conduct merit review, make selection, internal reviews – May – September 2012
- Announce selection – September 2012
Unique aspects may require different approaches to meeting regulations

NRC published “Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs” (March 2010)

Other NRC papers published on the following topics:

- Multi-Module Facilities (June 2011)
- Emergency Planning and Preparedness Framework (Oct. 2011)
- Decommissioning Funding (Dec. 2011)
- Insurance and Liability Regulatory Requirements (Dec. 2011)
- Staff Assessment also identified 5 issues that are not expected to require changes.
  - Licensing of Prototype Reactors
  - Operation Programs for Small or Multi-Module Facilities
  - Installation of Reactor Modules during operation for multi-module facilities
  - Industrial facilities using nuclear-generated process heat
  - Aircraft Impact Assessment for small modular reactors

NEI is the lead to resolve generic licensing issues
Economic Challenges Facing SMRs

- Business prospects predicated on (at least) three premises:
  - Significant investment needed to complete certification and licensing
    - 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?
**International Competition**

**Nuclear Energy**

**Russia**
- KLT-40S is a 35MWe barge mounted PWR - Available for commercial deployment
- Other Russian SMR designs include VBER-150/300, VK-300, ABV and the SVBR-100 which is a lead-bismuth variant

**Korea**
- SMART is a 90MWe PWR
  - Plan to begin operation of a Demonstration plant in 2017
  - Plan to be used for electricity and/or thermal applications such as desalination

**China**
- CAP100 /ACP100 is a 100-150MWe PWR
  - Plan to begin construction of a 2 module plant in 2015
  - Plan to be used for electricity, heat or desalination
- HTR-PM is a High Temperature Gas-Cooled Reactor
  - Rebar in place, waiting on government approval to continue construction

**Argentina**
- CAREM-25 is a 27MWe PWR
  - Plan to complete construction of a prototype in 2016
  - Plan to be used for electricity, desalination or as a research reactor
Strategic Vision for SMR Deployment

**PHASE 1**
Near-Term Certification and Licensing

**PHASE 2**
Deployment of First Movers

**PHASE 3**
Deployment of the first 20 Reactor Units

**PHASE 4**
Develop Full Production Capacity

- **DOE/DoD**
  - Issue FOA
  - Make awards
  - Complete Design Certification for 2 Technologies
  - Complete COLs for 2 sites

- **Utilities**
  - PPAs, REC
  - Repower Coal
  - More Affordable

- **Investors**
  - PPAs
  - Profit

- **Vendors**
  - No additional incentives
  - Export Credit Agencies
  - Small Grid
  - Energy Security

- **International**
  - ITC, PTC, Feed-In tariffs, Federal Corporation, Loan Guarantees, Cap & Trade
  - Clean Power
  - Energy Security
  - Jobs
  - Tech Leadership

- **Congress**
  - Complete standardized regulatory requirements
  - Build 2 at 1/year
  - Build up to 20 using existing fabrication
  - Build up to 50/year using new manufacturing plants

Timeline:
- 2012
- 2022
- 2027
- 2040

Fill Order Book and Build Factories
Deploy 50-100 GW
Advanced SMR R&D Program

- Advanced SMR R&D program is funded at $28M in FY12 and the FY13 request is $18.5M
- DOE is seeking greater interaction with U.S. industry in the development of the Advanced SMR R&D program
  - Formed a Technical Review Panel to review advanced reactor concepts and help identify R&D needs
  - DOE intends to issue, on an annual basis, a request for information for external entities to voluntarily submit information on concepts for DOE-NE to consider
  - Process will assess viability of advanced SMR designs and support alignment of R&D portfolio with needs of advanced SMR designs
- DOE is evaluating a spectrum of experimental facilities to support R&D on advanced concepts
  - Irradiation, passive cooling, lead-bismuth, sodium, salt etc.