Outline

► What is an SMR
► History
► Benefits
► Operational Challenges
► Path Forward
► Q&A
Small- and Medium-Sized Reactors

Ref: World Nuclear Association website http://www.world-nuclear.org/info/inf33.html
## Current SMRs

<table>
<thead>
<tr>
<th>Company</th>
<th>Reactor</th>
<th>Power (Mwe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toshiba</td>
<td>4S</td>
<td>10 or 50</td>
</tr>
<tr>
<td>GEH</td>
<td>PRISM</td>
<td>311</td>
</tr>
<tr>
<td>B&amp;W</td>
<td>mPower</td>
<td>125</td>
</tr>
<tr>
<td>NuScale Power</td>
<td>NuScale</td>
<td>45</td>
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<tr>
<td>Holtec</td>
<td>SMR-160</td>
<td>160</td>
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<tr>
<td>GEN4</td>
<td>HPM</td>
<td>25</td>
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<tr>
<td>Westinghouse</td>
<td>WSMR</td>
<td>225</td>
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<tr>
<td>KAERI</td>
<td>SMART</td>
<td>90</td>
</tr>
<tr>
<td>INVAP</td>
<td>CAREM</td>
<td>27</td>
</tr>
</tbody>
</table>

Three reactors are in SAFSTOR pending final decommissioning.

First letter: S - stationary, M - mobile, P - portable.
Second letter: H - high power, M - medium power, L - low power.
Digit: Sequence number.
Third letter: A indicates field installation.

Benefits

- Nuclear plants are energy dense assets
- Nuclear plants have robust logistics
- New designs are vastly superior to old designs
- Robust designs/small enough to be hardened
- No GHGs
- Cost competitive
Wind Power in the US uses 85 acres on average per MW peak
- Average output is one fourth peak
- 100 MWe wind farm uses 34,000 acres

100 MWe Solar PV system uses about 5,000 acres

100 MWe SMR uses 35 acres including all outlying buildings
Generic Nuclear Logistics

► Reactors are refueled infrequently
  – Most SMRs have 5 to 10 year fuel cycles
  – Multi-unit reactors can stagger refueling
► Reactors can “ride out” bad weather
► Reactors teamed with storage systems can load follow indefinitely
► Can operate through a scheduled refueling if needed
Improved Operations

► SMRs are based on passive safety systems
  – Do not require diesel generators
  – Some require no emergency actions by operators
► Zero discharge systems
► Digital controls with advanced human-machine interface
► Evacuation boundary is the site fence
SMRs can be designed to:
  - Withstand natural phenomena
  - Resist armed assaults
  - Survive design basis threats of all kinds

Safeguard and Security is intrinsic in design

SMRs are small enough to permit additional hardening
Reactor Types

Credit: U.S. Nuclear Regulatory Commission

Credit: U.S. Department of Energy, GEN-IV Program
GHG Free

- SMRs are essentially pollution free
- No GHGs are emitted during operation
- Radioactive releases approach zero
- Qualify as complying with Executive Order 13514
  - Can meet the 2020 target
  - Can readily meet the 2030 target
Typical for Large LWRs - Large uncertainties in these values not shown for clarity
Cost Competitive

- Large nuclear is the least expensive of all base-load power generating technologies
- SMRs benefit from that heritage
- FOAK SMR cost vary from $100/MW-Hr to $250/MW-Hr
  - Costs projected at 2020 using current $250/MW-Hr
- Expect a 50% reduction by the 20th unit
## US Wholesale Electricity Prices

<table>
<thead>
<tr>
<th>State</th>
<th>Cost ($/MW-Hr)</th>
<th>State</th>
<th>Cost ($/MW-Hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>329.60</td>
<td>California</td>
<td>127.10</td>
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<tr>
<td>Guam</td>
<td>256.90</td>
<td>Maine</td>
<td>124.90</td>
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<tr>
<td>Connecticut</td>
<td>163.20</td>
<td>District of Columbia</td>
<td>120.30</td>
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<tr>
<td>Alaska</td>
<td>159.50</td>
<td>Maryland</td>
<td>115.00</td>
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<tr>
<td>New Hampshire</td>
<td>147.60</td>
<td>Delaware</td>
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<tr>
<td>New York</td>
<td>147.60</td>
<td>Florida</td>
<td>106.90</td>
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<tr>
<td>Massachusetts</td>
<td>144.70</td>
<td>Michigan</td>
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<tr>
<td>Vermont</td>
<td>139.40</td>
<td>Pennsylvania</td>
<td>102.60</td>
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<tr>
<td>New Jersey</td>
<td>135.70</td>
<td>Wisconsin</td>
<td>101.50</td>
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<tr>
<td>Rhode Island</td>
<td>132.80</td>
<td>Alabama</td>
<td>98.50</td>
</tr>
</tbody>
</table>

Trends in Electricity Prices

Average Increase = 35% in a Decade

If this rate continues, $110 → $140/MW-Hr by 2020

Benefits of Multiple Orders

Potential Challenges

► Some States have bans on nuclear plant construction
► Public perception of risk
► U.S. NRC jurisdiction within the DOD facility
► Potential operational emergencies
► Local utility issues
SMRS AT MILITARY BASES
Layout - Interruption

Base

Surrounding Community

SMR

Sub-station

Power from the Grid

SMRS AT MILITARY BASES
Path Forward

► Shaw is part of a team dedicated to launching SMRs as commercial ventures

► The team developer requires
  – A lease for the site
  – A Power Purchase Agreement

► The team will
  – Finance
  – License/Construct
  – Operate
Path Forward

► The site can be on the base or nearby
► As much of the local community as desired can be included
► The nuclear asset will be inside a secured smart microgrid
► Electricity and/or district heating options
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