Terp Atomics: Exploring Small Modular Reactors

Small Modular Reactors, also known as SMRs, are small-scale nuclear power plants, with a range of roughly 10-300 MW of power production. Current SMRs are being designed and produced incorporating all of the modern technologies and over 60 years of industry experience in building nuclear reactors. It appears that in recent years, there is a new revival in the use of nuclear power using smaller reactors for increased manufacturability, scalability, and increased passive safety systems.

Medical Isotope Production

Molybdenum-99 and cobalt-60 are important medical isotopes that can be created by bombarding natural isotopes with neutrons. Samples of the materials can be inserted in through-tubes of reactors, although having a through-tube results in a higher stress can be created by bombarding natural isotopes with neutrons. Molybdenum-99 and cobalt-60 are important medical isotopes that can be created by bombarding natural isotopes with neutrons. Samples of the materials can be inserted in through-tubes of reactors, although having a through-tube results in a higher stress.

Oil Sands Extraction

The latent heat from a SMR can be used to extract oil from tar sands. Current methods for steam production use natural gas combustion. •Steam Assisted Gravity Drainage (SAGD)
  o Parallel, Horizontal Wells
  o Steam injected into top well, oil and condensate removed from lower well
  •Cyclic Steam Stimulation (CSS)
  o Steam injection, Soak, Oil Production, Repeat
  •Well Lifetime: 6–8 years
  •Steam temperature: 300°C

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Comparison of Reactors

<table>
<thead>
<tr>
<th>Name</th>
<th>NuScale</th>
<th>4S</th>
<th>Westinghouse SMR</th>
<th>EM²</th>
<th>mPower</th>
<th>Antares</th>
<th>PRISM</th>
<th>G4M</th>
<th>HI-SMUR 140</th>
<th>AP1000</th>
<th>ESBWR</th>
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</thead>
<tbody>
<tr>
<td>Designer</td>
<td>NuScale Power</td>
<td>Toshiba</td>
<td>Westinghouse General Atomics</td>
<td>Babcock and Wilcox</td>
<td>Areva</td>
<td>GE Hitachi</td>
<td>Gent Energy</td>
<td>Holtec International</td>
<td>Westinghouse GE Hitachi</td>
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<tr>
<td>Type</td>
<td>LWR</td>
<td>LMFBR</td>
<td>PWR</td>
<td>Helium Cooled</td>
<td>LWR</td>
<td>Helium Cooled</td>
<td>LMFBR (LBU)</td>
<td>PWR</td>
<td>BWR</td>
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<tr>
<td>Reactor Rating (MWh, MW, EPR)</td>
<td>30, 10, 33</td>
<td>30, 10, 33</td>
<td>30, 10, 33</td>
<td>30, 10, 33</td>
<td>30, 10, 33</td>
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<tr>
<td>Cost (per kW)</td>
<td>$4500/kW</td>
<td>$4500/kW</td>
<td>$4500/kW</td>
<td>$4500/kW</td>
<td>$4500/kW</td>
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<td>Core Material</td>
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<tr>
<td>Moderator</td>
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<tr>
<td>Deployment</td>
<td>Train, Truck Barge</td>
<td>Barge</td>
<td>Barge</td>
<td>Train, Truck</td>
<td>Train</td>
<td>Train</td>
<td>Train</td>
<td>&lt;20 metric tons, Truck</td>
<td>Difficult</td>
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<tr>
<td>Fuel Type</td>
<td>UO², Standard LWR fuel</td>
<td>Metallic U-Pu or U-Pu-Zr Alloy</td>
<td>17x17 assembly, Westinghouse Fuel Design</td>
<td>Used Nuclear Fuel or depleted uranium</td>
<td>U-Pu-Zr</td>
<td>Uranium Nitride (UN) in HT-9 (high temp ceramic) tubes</td>
<td>Standard 17x17 PWR</td>
<td>LWR Fuel</td>
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<td>Fuel Enrichment</td>
<td>4.95%</td>
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<td>Refueling Frequency</td>
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</table>

Comparison with Current Fleet

Nuclear reactor designs are categorized by “generation”; that is, Generation I, II, III, III+, and IV. The present analysis of existing reactor concepts focuses on six key reactor attributes: Cost-Effectiveness, Safety, Security and Nonproliferation, Grid Appropriateness, and Commercialization Roadmap.

China

Demand
• China is rapidly industrializing
• Power consumption increasing greatly each year.

Nuclear Power
• China is currently developing over 12 1000 MW nuclear power plants.

SMR’s
• SMR’s will be advantageous through their modularity. To best accommodate China’s future power demands, SMR’s can be built to work in conjunction with planned large scale reactors.

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Passive Cooling: Gen II Reactors relyed on active pumps and systems to remove heat generated by nuclear decay. Gen IV+ remove decay heat through passive systems. Some have a walk away time of over 5 days.

Alaska

Demand
• Inland Alaska, requires approx. 1 Mwe

Nuclear Power
• No roads out of city; No connection to external electric grid

Why Consider an SMR?
• Cost of Electricity
  o Currently ~70 cents/kWh
  o Natural Gas, requires long term storage for yearly supply
  o SMRs rated at 6-9 cents/kWh

Power Source Reliability
• Wind and Annual Solar availability poor
• No Hydropower near Galena
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