Environmental Law Institute
Nuclear Energy in 2023: Where Are We and What’s Ahead

Jeffrey S. Merrifield, Partner, Global Energy Practice Leader
Former NRC Commissioner (1998-2007)

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Nuclear Power - Today

• Currently 420+ nuclear reactors worldwide in over 33 countries
  o 394 GWe – total net installed nuclear capacity
  o 10.5% of world’s total energy/ 35% of world carbon free generation
  o 13 countries rely on nuclear power for at least ¼ of total generation

• United States is the largest operator with 93 nuclear units
  o 20% of electricity supply/45% of carbon free generation

• 53 countries operate 223 research reactors and more than 200 nuclear reactors power over 160 ships and submarines worldwide

• 54 reactors are in construction in 17 countries – China largest builder

• 30 countries are considering embarking on new nuclear programs
Advanced Nuclear Reactors – Definition/Classification

- Advanced nuclear is categorized in terms of electrical generation capacity
  - Microreactors: <20 MWe
  - Small-scale reactors: 20 MWe - <300 MWe
  - Large-scale reactors: >300 MWe

- Small-scale reactors are often characterized as small modular reactors (SMRs) to reflect method of fabrication and construction

- Further classified by type of moderator transferring heat from the fission reaction to the steam plant
  - Light water (LWRs)
  - High-temperature gas (HTGRs)
  - Liquid metal-cooled
  - Molten salt

Advanced nuclear largely represents innovative, evolutionary applications of historically proven design elements.
# Representative Technologies

<table>
<thead>
<tr>
<th>Design</th>
<th>Classification</th>
<th>Nameplate Capacity</th>
<th>Licensing Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>NuScale Reactor</td>
<td>Light Water</td>
<td>77 MWe</td>
<td>NRC Certified 50 MWe design in 2022. 77 MWe currently under review. $1.4 billion DOE funding for UAMPs demonstration of 6-module reactor at Idaho National Lab.</td>
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<tr>
<td>GE Hitachi BWRX-300</td>
<td>Light Water</td>
<td>300 MWe</td>
<td>Selected for deployment by Ontario Power Generation (OPG) and Tennessee Valley Authority (TVA).</td>
</tr>
<tr>
<td>Westinghouse AP300</td>
<td>Light Water</td>
<td>300 MWe</td>
<td>Recently announced smaller version of AP1000. Early discussions with USNRC.</td>
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<tr>
<td>Holtec SMR 160</td>
<td>Light Water</td>
<td>160 MWe</td>
<td>Ukraine intends to deploy 20 SMR-160 reactors. Potential deployment in Michigan.</td>
</tr>
<tr>
<td>X-Energy XE-100</td>
<td>High-Temp Gas (Pebble Bed)</td>
<td>80 MWe</td>
<td>Selected for ARDP - deployment at Dow site in Texas.</td>
</tr>
<tr>
<td>Terrestrial Energy IMSR</td>
<td>Molten Salt</td>
<td>195 Mwe</td>
<td>Selected for USNRC/CNSC pilot project. NRC pre-application discussions.</td>
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<tr>
<td>TerraPower Natrium</td>
<td>Sodium Fast Reactor with Molten Salt Storage System</td>
<td>345 MWe 500 MWe (5 ½ hours) - with Molten Salt</td>
<td>Selected for ARDP - Partnered with PacficCorp to construct near former coal plant in Wyoming.</td>
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<tr>
<td>Oklo Aurora</td>
<td>Liquid Metal Cooled</td>
<td>1.5 MWe/15 MWe</td>
<td>1.5 MWe design under review by USNRC. 2–15 MWe units to be deployed in Ohio.</td>
</tr>
<tr>
<td>Kairos Power</td>
<td>Pebble Bed with Molten Salt Coolant</td>
<td>140 MWe</td>
<td>Selected for $30 million risk reduction award by DOE.</td>
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Increasing Interest in Advanced Reactors

States

- Increasing number of states have shown interest in deploying advanced reactors as an element of their carbon-avoidance strategies
  - National Association of Regulatory Utility Commissioners

Non-Utility Interest

- Dow
- Nucor
- Microsoft
- Google
Federal Incentives for Advanced Reactors

Bi-Partisan Infrastructure Bill

- Advanced Reactor Demonstration Program - $2.5 billion for X-energy and TerraPower
- Nuclear Hydrogen Hubs - $8 billion total funding

Inflation Reduction Act

- Production Tax Credit (PTC) for operating plants - up to $15 per MWh
- Technology-Inclusive PTC for Clean Energy - $30 per MWh
- Technology-Inclusive Investment Tax Credit (ITC) for Clean Electricity – 30%
  - Additional 10% for energy communities and 10% for using U.S. components (stackable)
- Clean Hydrogen Credit - $3 per kilogram
- $700 million for high assay low enriched uranium production
Additional Federal Action

Bipartisan support for advanced nuclear
- FY2023 omnibus - nuclear funding set at $1.47 billion
- FY2024 – Biden request of $1.56 billion
- H.R. 4394 provides $1.783 billion (Passed House 10/26)

Advance Act of 2023 – Caputo/Carper Co-Sponsors
- Includes a variety of beneficial provisions –
  - Reduction in NRC licensing fees
  - Eliminates foreign ownership requirement
  - Simplified program for brownfield redevelopment
  - Creates prizes for first mover advanced nuclear companies
  - Extends Price-Anderson Insurance to 2045

- Wide variety of bills introduced in the House and Senate by advanced reactor supporters
Commercial/Regulatory Benefits

- Scalable, 24/7 power to meet incremental electric demand growth.
- Greater flexibility means more potential applications
  - Repowering existing fossil fuel sites
  - Process heat for industrial applications and water purification/desalination and hydrogen production
- Smaller size/modularity
- Lower accident risk from improved safety features
- Reduced emergency evacuation zone
- Emissions-free generation
- Load-following capability

Oklo’s Aurora reactor: construction at INL expected to start in mid-2020s. (Oklo 2019)