Presentation to North Dakota Public Utilities Commission Nuclear Energy in 2023: Where Are We and What's Ahead

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Overview

- Overview of current and advanced reactor technologies
- Technical, system, climate change, and commercial benefits of and challenges for advanced nuclear
- Durable U.S. Government support for speedy commercialization



Conceptual Diagram of Advanced Nuclear Integrated in a Hybrid Decarbonized Grid. (INL 2017)





Jeffrey S. (Jeff) Merrifield

- <u>Energy Section Leader</u> Pillsbury Law Firm (2015-Present)
- <u>Commissioner</u> Appointed by Presidents Clinton and Bush to serve as U.S. NRC Commissioner (1998-2007)
- <u>Senior V.P. Business Development</u> Shaw Power Group/CBI nuclear engineering, construction, maintenance and decommissioning (2007-2014)
- Vice Chairman Nuclear Industry Council
- Financial Times Most Innovative Law Firm in the Energy Transition (2023)
- <u>American Nuclear Society Presidential Award for Advanced Reactor Leadership (2023)</u>
- <u>Business Insider Top 10 Nuclear Regulatory Attorneys (2023)</u>

• Pillsbury Winthrop Shaw Pittman LLP

- International, 700+ attorney firm with 21 offices in key financial, energy, technology, and government centers (New York, Washington DC, London, Los Angeles, Houston, Austin, Silicon Valley, Beijing, Taipei, Shanghai, and Tokyo)
- The oldest dedicated nuclear law group in the world
- First hydrogen practice and first fusion practice of a major law firm
- Industry-leading experience in energy and environmental regulatory and transactional law



Practice Areas/Industries

- Energy
- Nuclear Energy
- Strategic Planning
- Advanced Reactors
- Fusion Energy
- Decommissioning
- Nuclear Security
- Mergers and Acquisitions
- Employee Concerns





COP-28 – United Arab Emirates, December 2023

- Declaration to transition away from the use of fossil fuels to achieve net zero by 2050
- Declaration to triple the use of renewables by 2050
- Declaration by 24 nations (including the U.S.) to triple the use of nuclear energy by 2050







U.S. Energy Companies that Have Pledged to Achieve 80-100% Carbon Free Generation By 2050





Nuclear Power - Today

- Currently 420+ nuclear reactors worldwide in over 33 countries
 - 394 GWe total net installed nuclear capacity
 - 10.5% of world's total energy/ 35% of world carbon free generation
 - 13 countries rely on nuclear power for at least ¼ of total generation
- United States is the largest operator with 94 nuclear units
 - 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
- 50+ 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 (Sodium and Lead)
 - Molten salt

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



Shippingport: the first U.S. commercial nuclear power plant —and an SMR!



Representative Technologies

Design	Classification	Nameplate Capacity	Licensing Status
NuScale Reactor	Light Water	77 MWe	NRC Certified 50 MWe design in 2022. UAMPs 6-module reactor at Idaho National Lab recently cancelled.
GE Hitachi BWRX-300	Light Water	300 MWe	Selected for deployment by Ontario Power Generation (OPG) and Tennessee Valley Authority (TVA).
Westinghouse AP300	Light Water	300 MWe	Recently announced smaller version of AP1000. Early discussions with USNRC.
Holtec SMR 300	Light Water	300 MWe	Recent announcement of 2 unit (300 MWe design) at existing site in Michigan.
X-Energy XE-100	High-Temp Gas (Pebble Bed)	80 MWe	Selected for ARDP - deployment at Dow site in Texas.
Terrestrial Energy IMSR	Molten Salt	195 Mwe	Selected for USNRC/CNSC pilot project. NRC pre-application discussions.
TerraPower Natrium Reactor	Sodium Fast Reactor with Molten Salt Storage System	345 MWe 500 MWe (5 ½ hours) - with Molten Salt	Selected for ARDP- Partnered with PacificCorp to construct near former Wyoming coal plant.
Oklo Aurora	Liquid Metal Cooled	1.5 MWe/15 MWe	1.5 MWe design under review by USNRC.2 – 15 MWe units to be deployed in Ohio.
Kairos Power	Pebble Bed with Molten Salt Coolant	140 MWe	Non power site in Tennessee received USNRC construction license on December 12, 2024.
Natrium/ACU	Molten Salt Research Reactor	5 MWe	Abliene Christian University selected Natrium for Texas based molten salt research reactor.



Increasing Interest in Advanced Reactors

<u>States</u>

- 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-nuclear-states: Wyoming, Montana, West Virginia, Idaho, Colorado, North Dakota – non-nuclear states

Non-Utility Interest

- Dow
- Nucor
- Microsoft
- Google

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Developments in Canada



- New Brunswick Power Selected two technologies: Moltex (Molten Salt) and Advanced Reactor Concepts (Fast Reactor) for potential deployment at Point Lepreau
- Ontario Power Generation Selected GE/Hitachi-BWRX-300 (LWR) for deployment at the Darlington (December 2021)
 - SaskPower, Bruce Power, Alberta are collaborating with OPG on potential deployment
 - Bruce Power also recently announced 4,800 MWe of new nuclear generation
- Canadian National Laboratory (Chalk River) will serve as the site for the UltraSafe Microreactor
- Canadian Nuclear Safety Commission currently has 10 reactors under review in the Vendor Design Review Process





Europe

- Poland GE Hitachi, BWXT and Synthos Green Energy signed an agreement in December of 2021 signed agreement to deploy up to 10 of GEH's BWRX-300 reactors in Poland by the 2030s
- United Kingdom November 2021, Rolls Royce Granted \$285 million by UK Government to deploy 470 MWe light water reactor technology up to 16 units planned
- Romania Chernavoda Utility and NuScale announcement agreement for deployment of NuScale reactor in Romania by 2028
- Other potential entrants:
- Finland, Sweden, Ukraine, Netherlands, Estonia, Bulgaria



Rolls Royce SMR Rendering



NuScale Rendering



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Technical Advantages

- Smaller size/modularity
- Lower accident risk from improved safety features
- Reduced emergency evacuation zone
- Emissions-free generation
- Load-following capability



The famous CAISO duck curve—illustrating the system challenges from pursuing decarbonization primarily through intermittent resources on a typical spring day (CPUC 2019, based on 2018 CAISO data)





Challenges and Opportunities v.s. Large LWRs

Traditional 1000+ Mw Designs

- Construction length/delays
- Higher up-front cost
- Significant civil site preparation
- Traditional fuel enrichments
- NRC has more established track record with light water reactor regulation
- 10 Mile EPZ

Small and Advanced Reactors

- Reduced size/factory-built components
- Lower total cost of project
- Small footprint eases overall cost
- Some designs utilize HALEU fuels more difficult to obtain
- New designs can present novel features not reviewed by NRC previously
 - But Kairos met this challenge
- EPZ could be as small as fence line





Cost-Effective Element of a Deep Decarbonization Portfolio





Other Commercial/Regulatory Benefits

- Scalable, 24/7 power to meet incremental electric demand growth.
- Reduced overnight costs
 - Developer's targeting combined cycle costs for Nth of a kind plants
- Unique resilience benefits
- Greater flexibility means more potential applications, including...
 - Repowering existing fossil fuel sites
 - Process heat for industrial applications and water purification/desalination and hydrogen production
 - Critical service applications



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





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











Nuclear Regulatory Commission

<u>Part 50</u> – 2 step licensing process (construction and operation)

Part 52 – 1 step licensing process (utilizing design cert and early site permit)

- Both processes can be utilized for advanced reactors
- Requires exemptions from light water requirements
- Early engagement has proven to be fruitful

Part 53 Developments

- Nuclear Energy Innovation and Modernization Act of 2019 (PL 115-439)
- Required NRC to develop risk informed performance-based regulation targeted for advanced reactors by 2027
- Draft proposed rule currently before the Commission





Closing Thoughts and Contact Information

Questions?

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