

Nuclear Energy Overview

December 12, 2018

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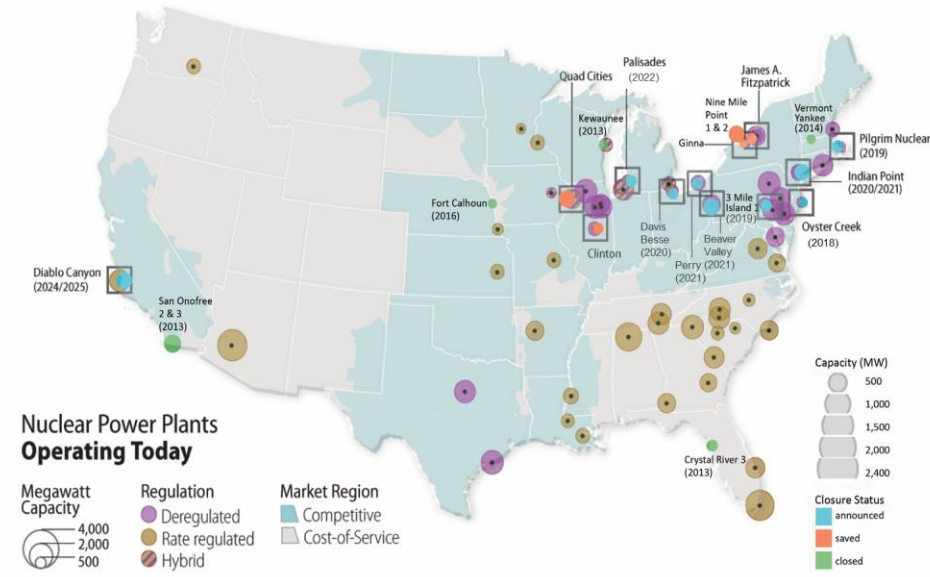
Senior Advisor to the Assistant Secretary for Nuclear Energy

Office of Nuclear Energy

U.S. Department of Energy

Nuclear Energy: A National Strategic Asset

- Recognition of the importance of nuclear – today and in the future
 - Energy Security
 - National Security
 - Economic Prosperity
 - Environmental Sustainability
- Concern about the financial viability of some currently operating plants, yet benefits from keeping them running
- Increased interest in nuclear in domestic and international markets to address climate change and ensure reliable, resilient power
- Innovators and utilities looking at advanced nuclear as a way to move beyond electricity
- **Secretary Perry: Make Nuclear Energy Cool Again!**
- **President Trump: Revive, Revitalize and Expand**

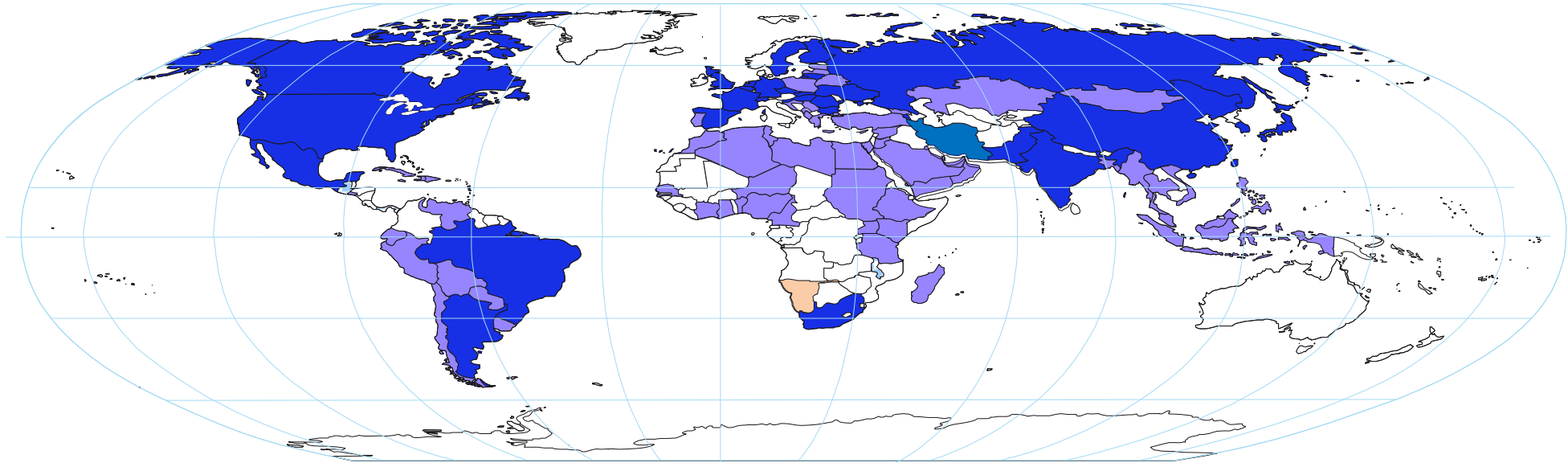


- **20% of electricity (56% of non-emitting)**
- **92% capacity factor**
- **Supports 475,000 jobs**
- **\$10B in federal & \$2.2B in state taxes annually**

"If you really care about this environment that we live in... then you need to be a supporter of this [nuclear energy] amazingly clean, resilient, safe, reliable source of energy."

Secretary Rick Perry at Press conference, May 10th

Global Growth and Market Opportunity



Potential Nuclear Power Expansion

- 35 countries taking steps to develop nuclear power
- 30 countries with operating reactors developing expansion plans

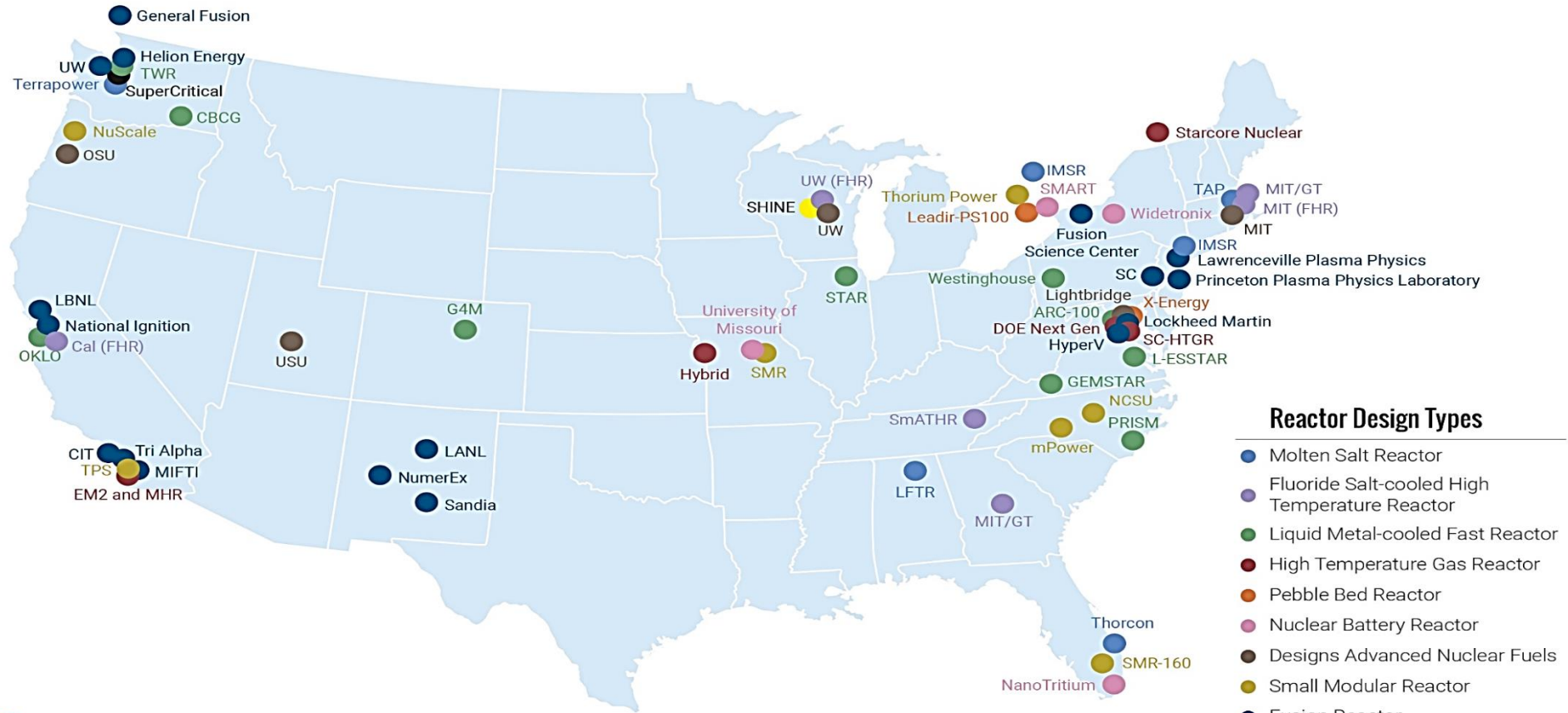
~450 reactors operating
11% of electricity / 40% of clean electricity

- ~60 reactors under construction in 15 countries (20 in China)
- ~170 reactors planned in over 25 countries, worth as much as \$700 billion over the next 5-10 years
- ~370 reactors proposed in 36 countries, worth as much as \$1.6 trillion over the next 10-25 years

Source: IAEA/PRIS & WNA

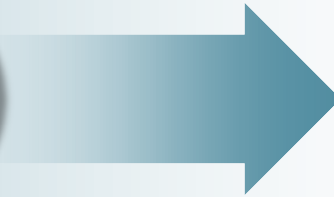
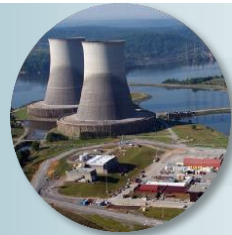
American Innovation Can Capture the Global Market

Advanced Nuclear Industry: Next Generation



Nuclear Beyond Electricity

NOW



Baseload Electricity Generation

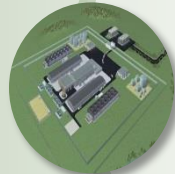
FUTURE

Advanced Reactors

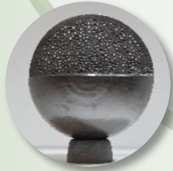
Large LWRs



SMRs



Non-Water Reactors



Chemical Processes



e⁻

Heat



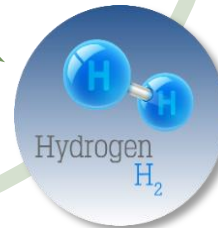
Flexible Electricity Generation



Industrial Applications



Hydrogen Production



Clean Water



Small Modular Reactors

Greater affordability

- Easier financing for public power entities
- Lower capital investment
- Factory fabrication, shorter construction times

New standard of passive nuclear safety

Energy and environmental benefits

- Greenhouse gas and air pollution avoided
- Grid benefits: stability, security, quality, availability, reliability
- Siting flexibility
- Hybrid energy systems and flexible integration with renewables

Importance to National Security

Economic development and job growth

- Manufacturing jobs and supply chain opportunities in the United States

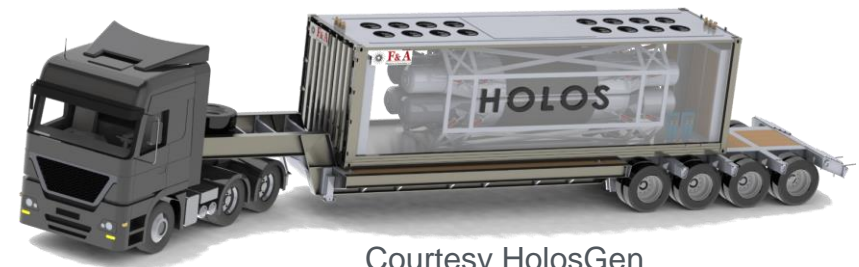


Micro Reactors

Designed for Specialized Applications

- Siting flexibility including near population centers
- Micro-grids
- Remote Operating Bases
- Data Centers
- Disaster Relief (FEMA)
- Specialized Non-electric Applications

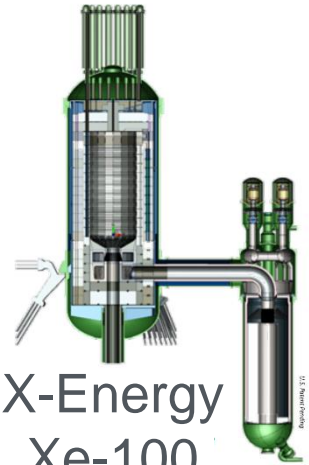
Westinghouse eVinci™ Micro Reactor



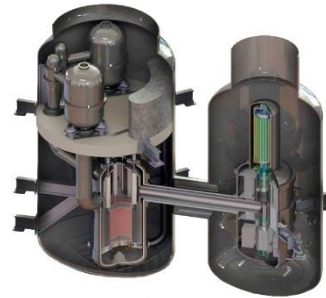
Courtesy HolosGen

Non-Water Advanced Reactor Designs Being Developed By Industry

Gas Reactors

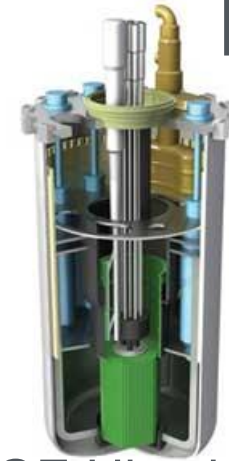


X-Energy
Xe-100



General Atomics
Energy Multiplier Module, EM2

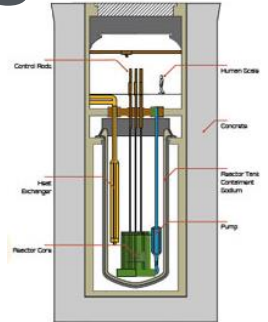
Fast Reactors



GE Hitachi
PRISM

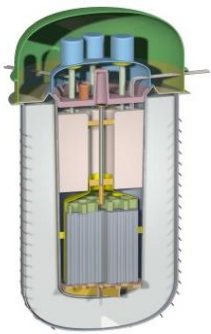


TerraPower
TWR

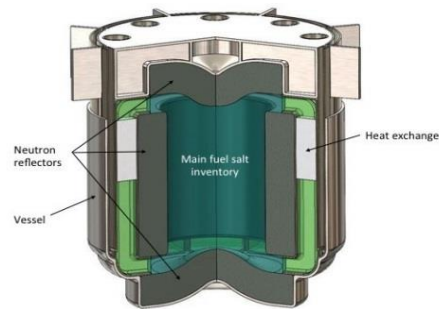


Advanced Reactor
Concepts LLC
ARC-100

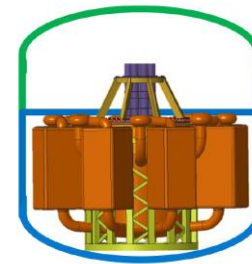
Molten Salt Reactors



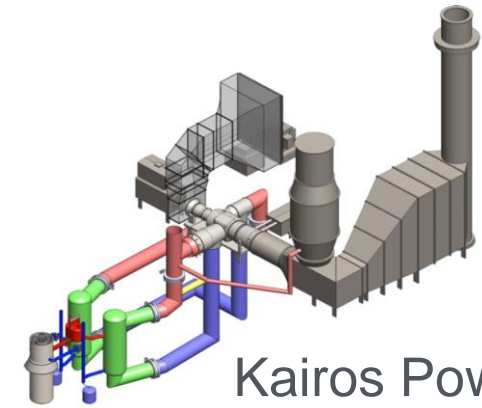
Terrestrial Energy
USA IMSR



TerraPower
MCFR



Elysium USA
MCSFR



Kairos Power
UCB PB-FHR

Nuclear-Renewable Hybrid Energy Systems: Program Overview

- **Modeling and Simulation**

Tool development and associated analysis to assess technical and economic viability and to determine optimal system design and energy dispatch

FY-18 Focus: Pilot case studies for specific plants and regions with utility partners

- **Demonstration / Experimental Systems**

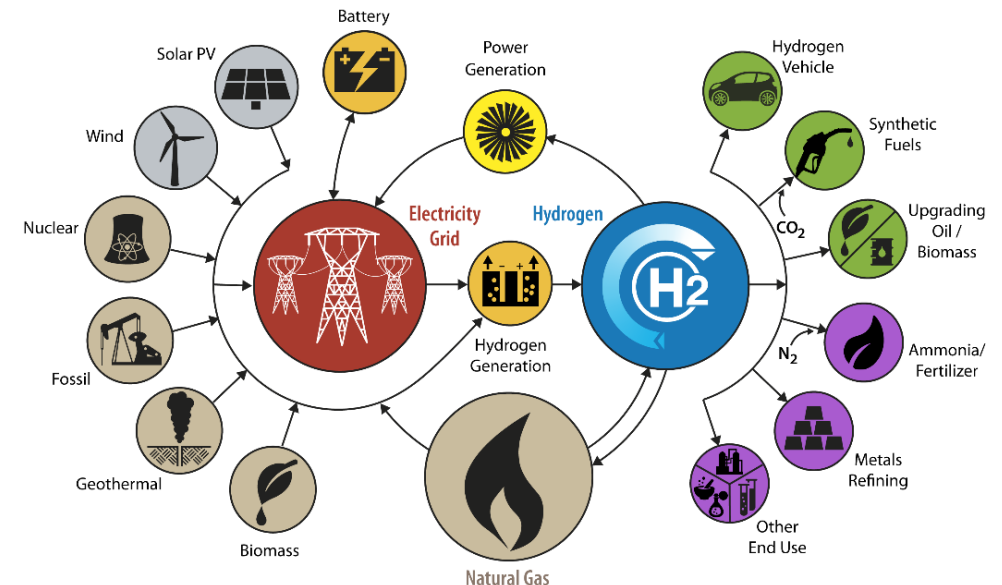
Electrically heated system testing to demonstrate hardware interfaces, control systems, dynamic operation

FY-18 Focus: Design review with key stakeholders for PWR-emulation loop

Design/build thermal energy distribution system (TEDS) to connect PWR loop to hydrogen electrolysis.

- **Stakeholder engagement**

- Federal: DOE-EERE collaboration, complementary work in -OE, -FE, DOD
- Industry: Utilities (incl. Utility Advisory Committee), developers, end users
- International: Clean Energy Ministerial, various others



***H2@Scale is a complementary, collaborating program supported by the DOE EERE Fuel Cell Technologies Office.*

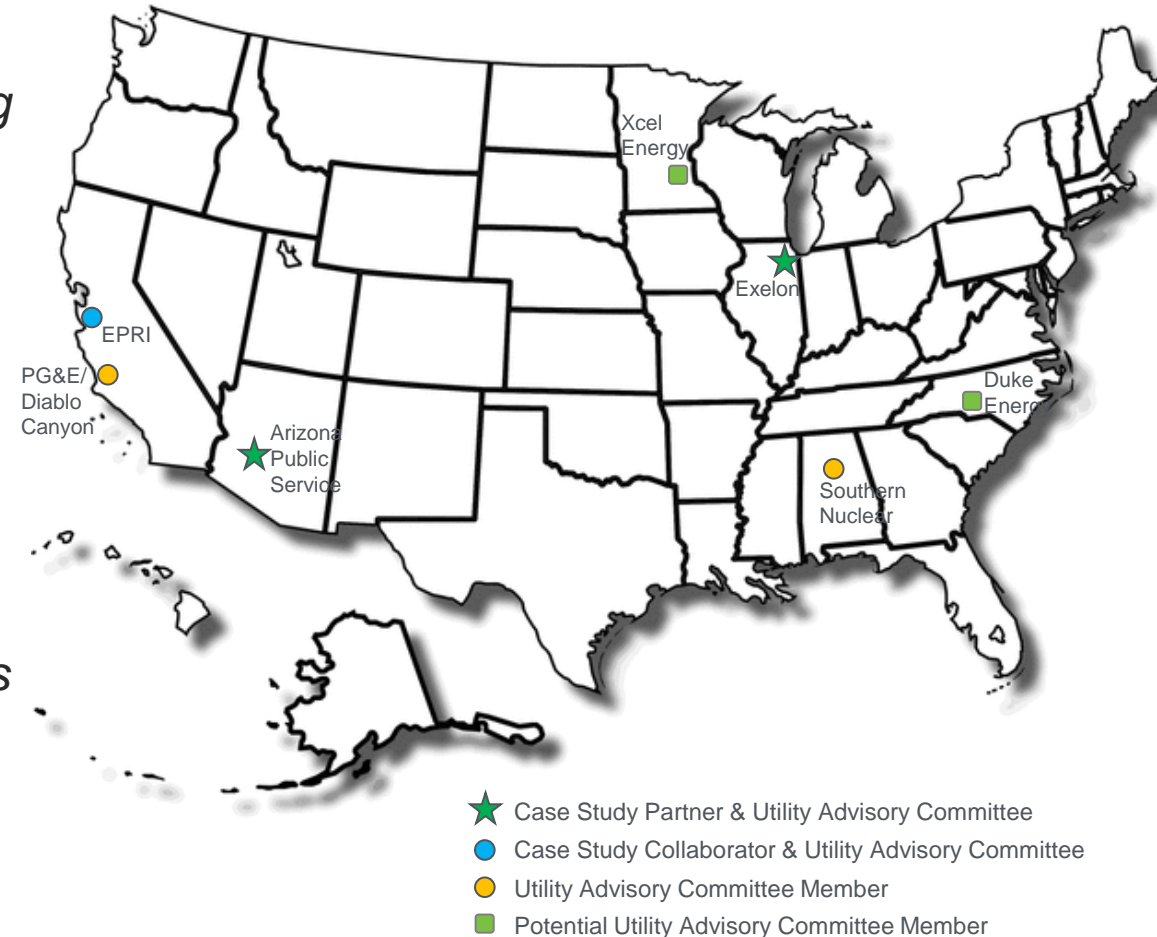
Evaluating Technical and Economic Feasibility with Utility Partners

Case I: Nuclear-Renewable-Water Integration in Arizona

- *Electrical integration of existing nuclear generation and desalination in a region with significant solar generation*
- *Collaboration with Arizona Public Service (APS), operating owner of Palo Verde Generating Station, with consultation from Electric Power Research Institute (EPRI)*

Case II: Nuclear-Industrial Process Variable Hybrid in the Midwest

- *Retrofit of an existing LWR to support an industrial application and electricity production in a region with significant wind generation*
- *Focus on H2 generation and associated off-take industries (e.g., steel making or ammonia production)*
- *Collaboration with multiple industrial partners, led by Exelon, with consultation from EPRI*



Nuclear Innovation: Clean Energy Future (NICE Future)



Official Launch:

At the 9th Clean Energy Ministerial (May 2018, Denmark) NICE Future was launched by the United States, Canada and Japan to spotlight nuclear energy in the international clean energy community.

Overview:

NICE Future focuses on nuclear power as a clean energy option for reliable and resilient baseload electricity, and non-electric applications especially when deployed as hybrid nuclear-renewable systems.

Areas of Work:

- 1) Evaluations of innovative systems, technology, storage, uses
- 2) Policy-maker and Stakeholder Engagement
- 3) Economics
- 4) Communicating nuclear energy's role in clean energy systems

Lead Participants:



USA



CANADA



JAPAN

Participants



ARGENTINA



POLAND



ROMANIA



RUSSIA



UAE

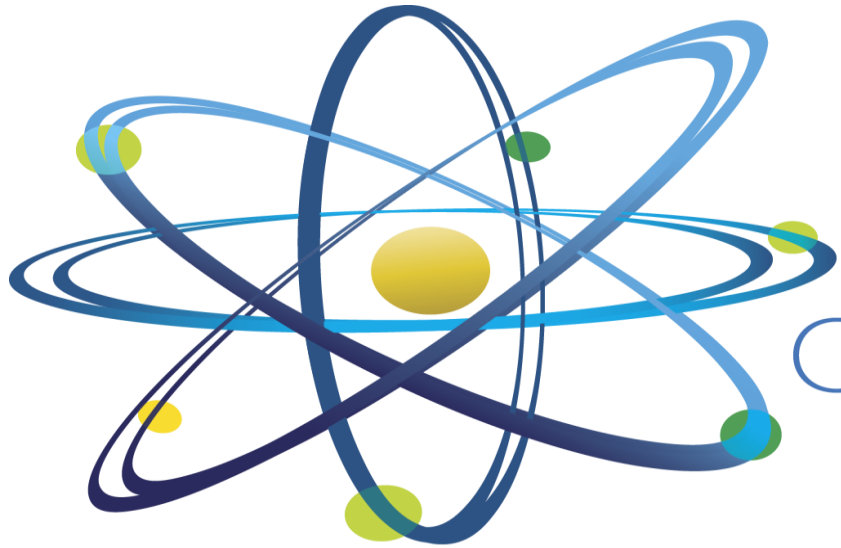


UK

Summary

- The demand for domestically-generated, reliable, resilient, and clean sources of baseload electricity will continue to drive nuclear energy expansion.
- Nuclear Energy is critical to our Nation's energy security, national security, economic prosperity, and environmental sustainability.
- A profound opportunity for new nuclear growth exists:
 - Strong global market interest
 - Growing need for increased global access to electricity
 - Support energy security, economic and environmental goals
 - U.S. leadership to ensure safety & nonproliferation are as important as ever
- The Administration is committed to advancing nuclear energy in the U.S. and abroad.

Questions?



Clean. **Reliable. Nuclear.**