

# Nuclear Energy Overview

October 18, 2018

**Bradley Williams**

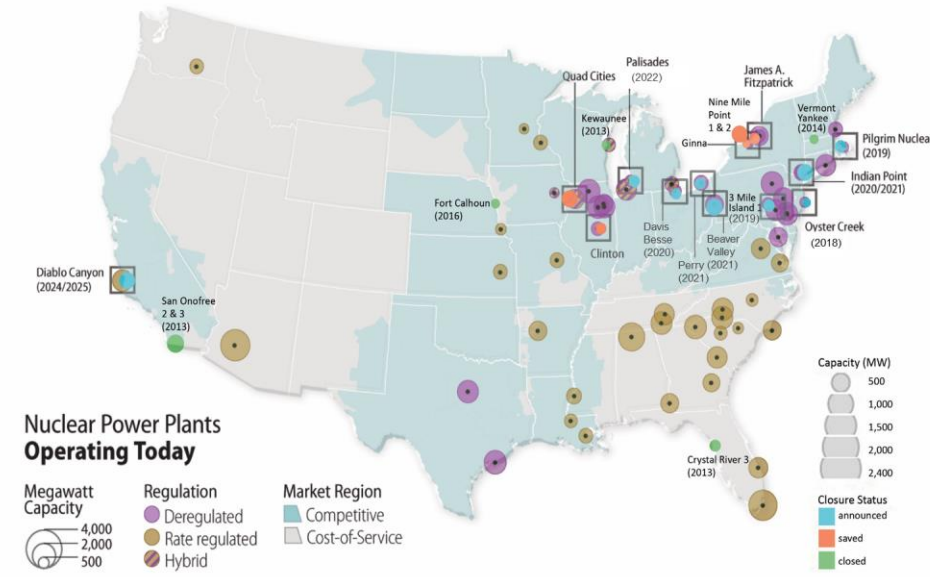
Senior Advisor to the Assistant Secretary for Nuclear Energy

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

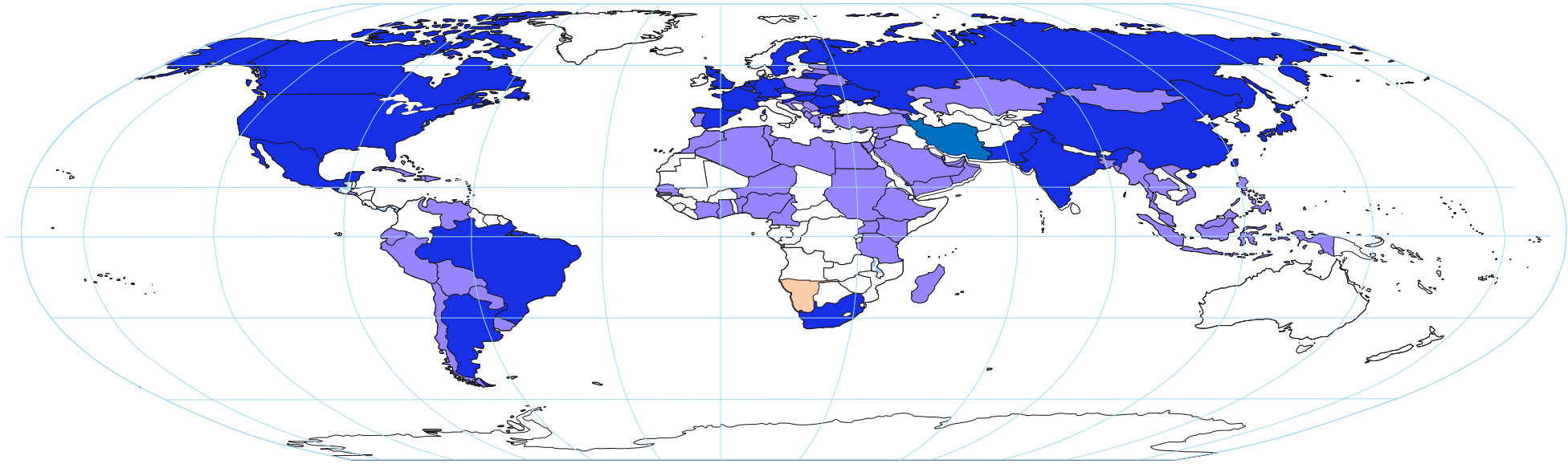


- **20% of electricity (56% of non-emitting)**
- **92% capacity factor**
- **Supports 475,000 jobs**
- **\$10B in federal & \$2.2B in state taxes annually**



*"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 10<sup>th</sup>*

# 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

# Nuclear Power Plants Shutting Down Prematurely

Year	Retirements	MW	Operator	State	License Expiration
2013	Crystal River 3	890	Duke	FL	2016 (40)
	San Onofre 2 & 3	2,254	SoCal Edison	CA	2023 / 2024 (40)
	Kewaunee	560	Dominion	WI	2033 (60)
2014	Vermont Yankee	563	Entergy	VT	2032 (60)
2016	Fort Calhoun	502	Omaha Power	NE	2033 (60)
2018	Oyster Creek	610	Exelon	NJ	2029 (60)
Total Closed since 2013		5,276			
2019	Pilgrim	678	Entergy	MA	2032 (60)
	Three Mile Island 1	803	Exelon	PA	2034 (60)
2020	Davis-Besse*	908	FirstEnergy	OH	2037 (60)
	Duane Arnold	601			
2021	Perry*	1,268	FirstEnergy	OH	2026 (40)
	Indian Point 2 & 3**	2,061	Entergy	NY	2013 / 2015 (40)
	Beaver Valley 1 & 2*	1,872	FirstEnergy	PA	2036 / 2047 (60)
2022	Palisades	789	Entergy	MI	2031 (60)
2024-25	Diablo Canyon 1 & 2	2,240	PG&E	CA	2024 / 2025 (40)
Total Pending Closures		11,220			
2017	FitzPatrick***	852	Entergy	NY	2034 (60)
	Ginna***	582	Exelon	NY	2029 (60)
	Clinton***	1,065	Exelon	IL	2026 (40)
2017-18	Nine Mile Point 1 & 2***	1,937	Exelon	NY	2029 / 2046 (60)
2018	Quad Cities 1 & 2***	1,819	Exelon	IL	2032 (60)
Total Saved		6,255			

\* Pending review and approval by PJM

\*\* One reactor will shut down in 2020, and the other will shut down in 2021.

\*\*\* Closures averted by state policy actions.

# Combined Construction and Operating Licenses (COLs)

SITE/LOCATION		UTILITY	REACTOR TECHNOLOGY/ NO. UNITS		COLA DATES		
					Submitted	Docketed	Issued
Vogtle	GA	Southern Nuclear	AP1000	2	3/28/2008	5/30/2008	2/10/2012
V.C. Summer	SC	SCE&G	AP1000	2	3/27/2008	7/31/2008	3/30/2012
Fermi	MI	DTE Energy	ESBWR	1	9/18/2008	11/25/2008	5/1/2015
South Texas Project	TX	STPNOC	ABWR	2	9/20/2007	11/29/2007	2/12/2016
Levy	FL	Duke Energy	AP1000	2	7/30/2008	10/6/2008	10/26/2016
William States Lee	SC	Duke Energy	AP1000	2	12/13/2007	2/25/2008	12/19/2016
North Anna	VA	Dominion Energy	ESBWR	1	11/27/2007	1/28/2008	6/2/2017
Turkey Point	FL	Florida Power and Light	AP1000	2	6/30/2009	9/4/2009	4/5/2018

- 18 COLs have been docketed by the NRC since 2007
- 8 (totaling 14 reactors) have been approved
- 10 (totaling 14 reactors) were suspended and or withdrawn

# Congressional Support for Nuclear Energy

Nuclear energy has strong bipartisan support from Congress

## Advanced Reactor Concepts

- Support for advanced reactor concepts
- Micro-reactors for national security locations
- Advanced fuels

## DOE Infrastructure

- FY 2019 Appropriations (\$1.3B)
- Authorized construction of the Versatile Test Reactor

## Streamline Innovation

- Regulatory reform
- Licensing cost-sharing for advanced reactor concepts
- Accessibility to DOE facilities
- Export control reform

**Over 20 bills introduced, five reported out of committee, four passed House or Senate, and two signed into law (FY19 DOE Appropriations and the Nuclear Energy Innovation Capabilities Act)**



# Office of Nuclear Energy Mission Pillars

Existing Fleet



Advanced  
Reactor Pipeline



Fuel Cycle  
Infrastructure



Global  
Competitiveness



# Sustaining the Existing Fleet

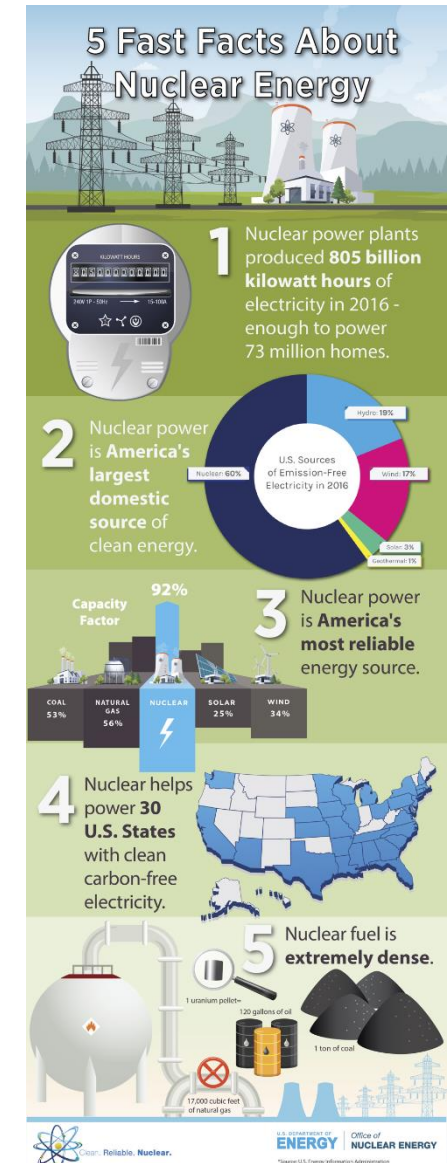
- **Improving Performance and Reducing Costs**
  - LWRS – subsequent license renewal and technical improvements
  - Accident Tolerant fuel – enhanced performance and safety
  - CASL – Energy Innovation Hub for M&S
  - Non-electric applications to improve flexibility and increase revenue generation
- **Policy and Market Reform Support**
  - Level the playing field with technology neutral policies
  - Ensure critical attributes are properly valued
  - Risk-informed, performance-based regulation
- **State and Local Technical Assistance, Education and Outreach**



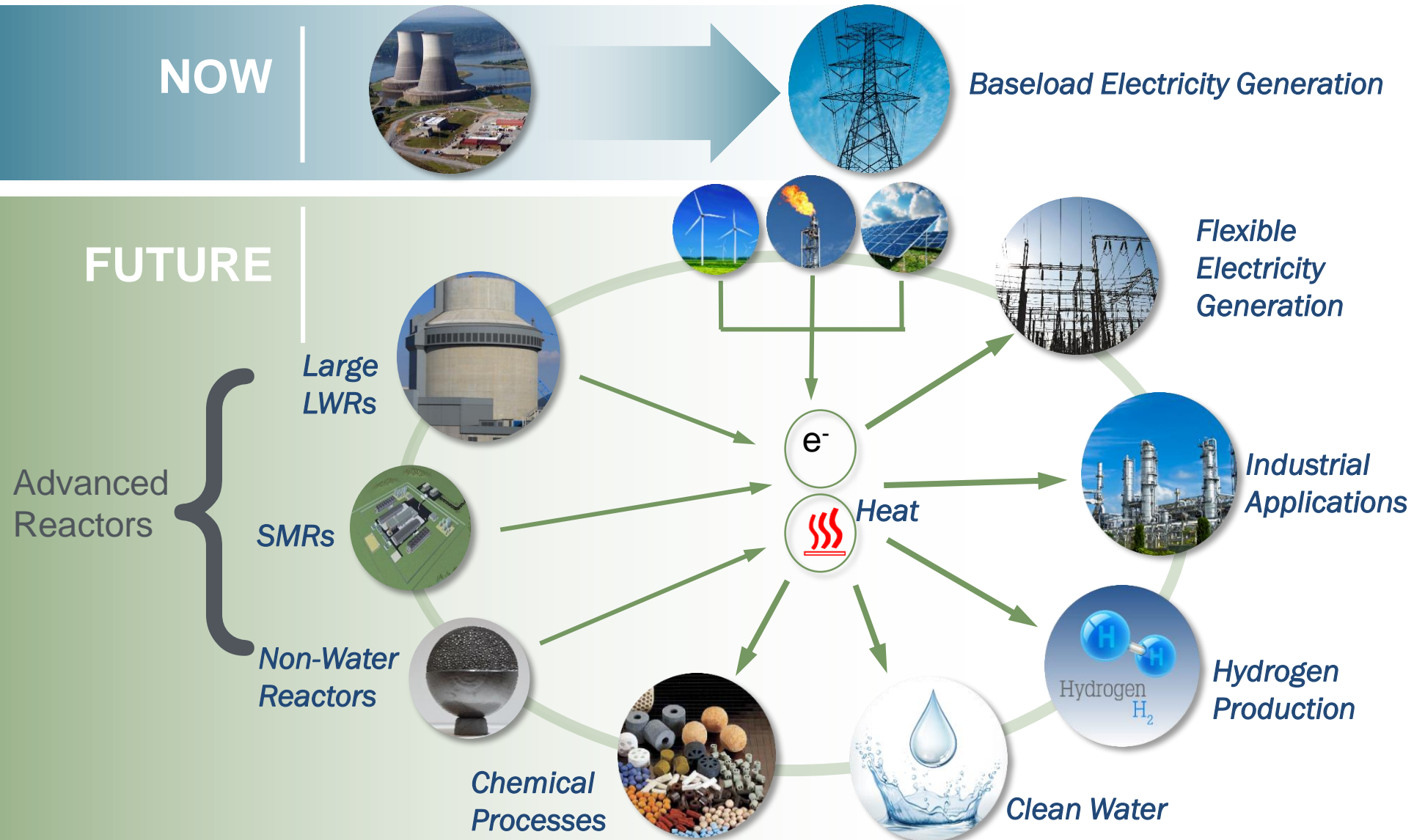


# Office of Nuclear Energy Outreach

- Millennial Nuclear Caucuses
- Learning lunches
- Traditional media relations
- Social media
- Infographics and videos



# Nuclear Beyond Electricity – Advanced Reactors



# 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



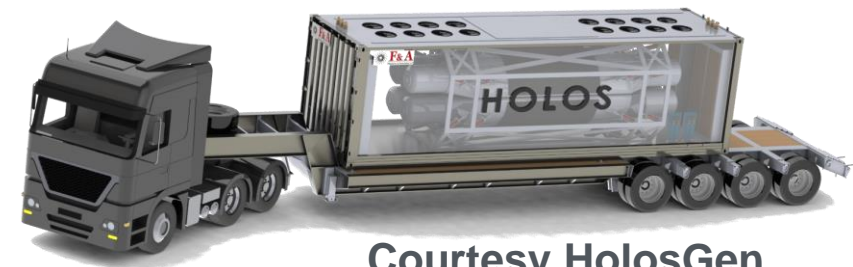
# Micro Reactors

## Designed for Specialized Applications

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



FEMA

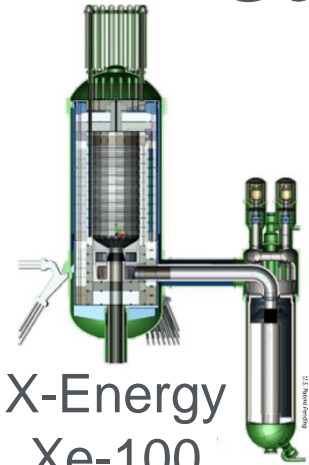


Courtesy HolosGen

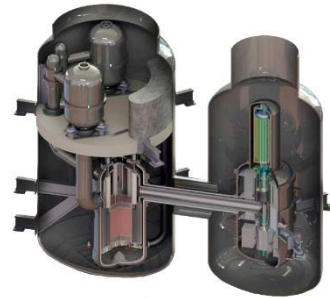


# Non-Water Advanced Reactors

## Gas Reactors

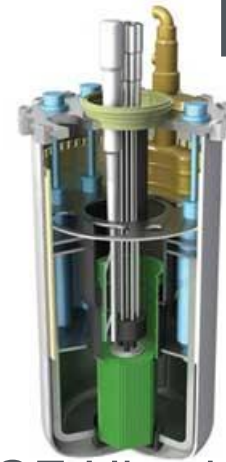


X-Energy  
Xe-100



General Atomics  
Energy Multiplier Module, EM2

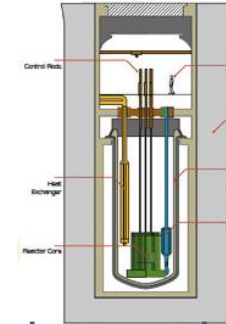
## Fast Reactors



GE Hitachi  
PRISM

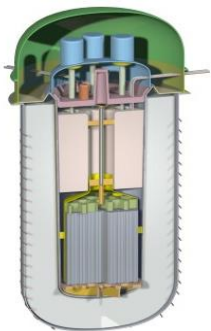


TerraPower  
TWR

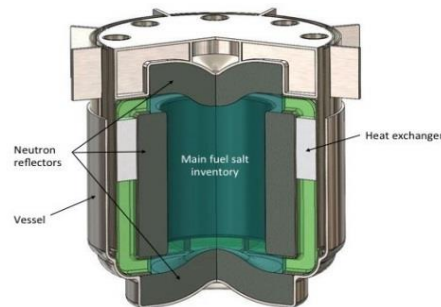


Advanced Reactor  
Concepts LLC  
ARC-100

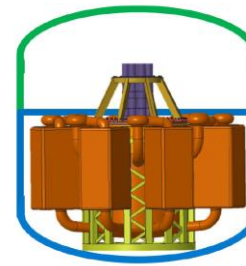
## Molten Salt Reactors



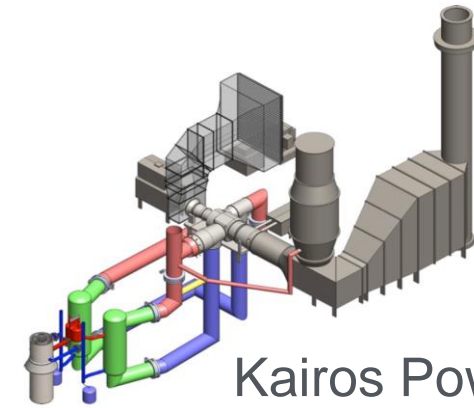
Terrestrial Energy  
USA IMSR



TerraPower  
MCFR



Elysium USA  
MCSFR



Kairos Power  
UCB PB-FHR

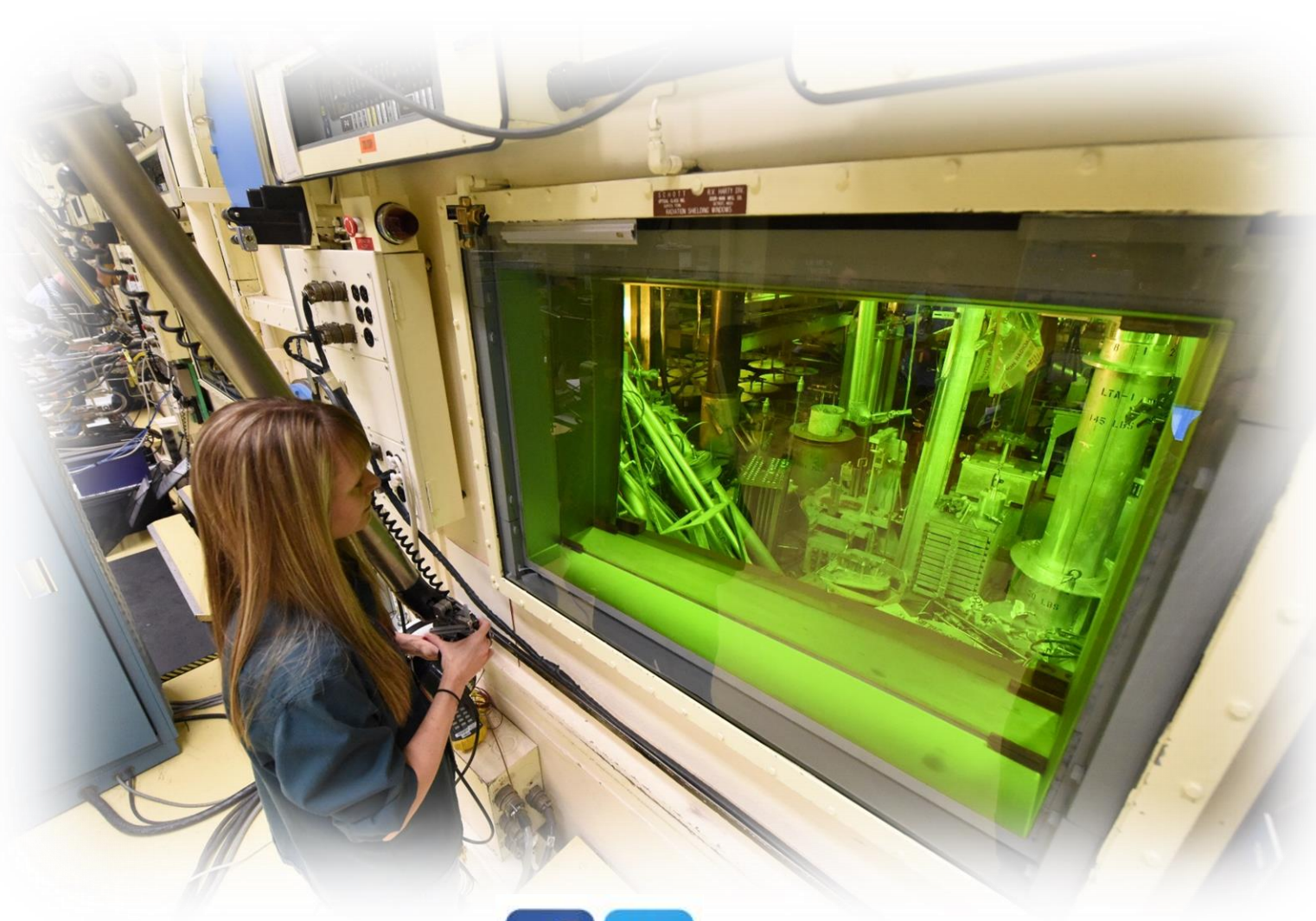
# Gateway for Accelerated Innovation in Nuclear (GAIN)



A private-public partnership framework aimed at rapid and cost-effective development of innovative nuclear energy technologies towards market readiness

## Mission

Provide the nuclear energy industry with access to technical, regulatory and financial support necessary to move innovative nuclear energy technologies toward *commercialization* in an accelerated and cost-effective fashion.

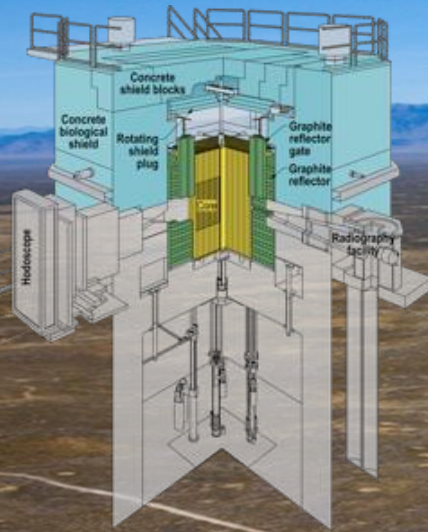


@GAINnuclear

<https://gain.inl.gov>



# Transient Reactor Test (TREAT) Facility



- 100 kW Steady-state power with 19 GW Peak Transient Power
- Core: ~1.2 m high x 2 m. dia.; surrounded by 0.25 m graphite reflector
- 19 x 19 array of 10 x 10-cm. fuel and reflector assemblies
- Fuel: 0.2 wt.% high enriched UO<sub>2</sub> dispersed in graphite
- 12 steady-state and 8 transient control rods
- Instantaneous, large negative temperature coefficient (self protecting driver core)

TREAT Experimental Facility Restarted in 2017

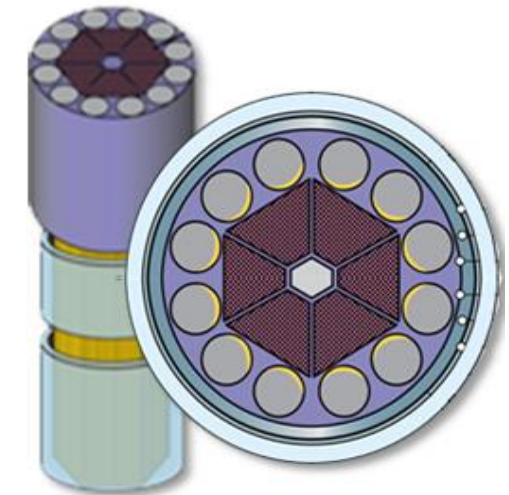
# Versatile Advanced Test Reactor

- **Goal:** An Operational Versatile Advanced Test Reactor by 2026, to support accelerated development of advanced fuels and materials for U.S. advanced reactor vendors, as well as to provide the capability for testing those fuels and materials to support licensing by the Nuclear Regulatory Commission.
- A Versatile Advanced Test Reactor with a high fast neutron flux will revitalize our research infrastructure and remove a critical impediment for U.S. developers of advanced nuclear energy technologies.



# Addressing Need for High-Assay Low Enriched Uranium (HALEU)

- Most advanced reactor concepts require HALEU for startup cores (15-19.75% - u-235)
- Expected demands for HALEU are very significant
  - A typical start-up core requires 4 MT HALEU
- In addition, there are other national missions that require a reliable supply of enriched uranium
- DOE-NE is working towards addressing these needs



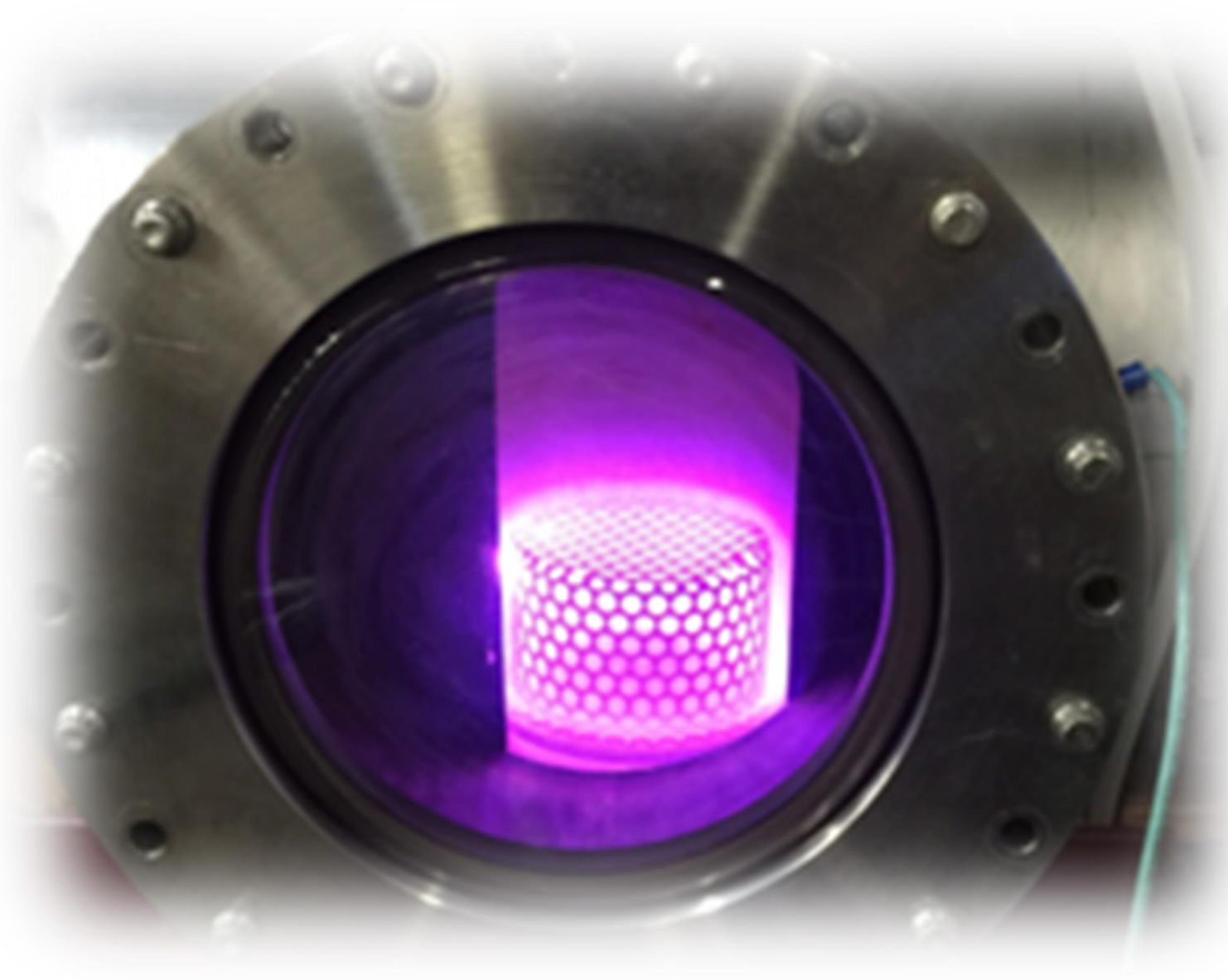
# Advanced Manufacturing

## Vision

- To improve the methods by which nuclear equipment, components, and plants are manufactured, fabricated, and assembled by utilizing practices found in industries such as oil, aircraft, and shipbuilding

## Goal

- To reduce cost and schedule for new nuclear plant construction
- To make fabrication of nuclear power plant (NPP) components faster, cheaper and more reliable



# Bilateral, Multilateral and Commercial International Cooperation

- **Bilateral Engagement**

- R&D coordination and integration with advanced fuel cycle countries, e.g., bilateral action plans, International Nuclear Energy Research Initiatives (I-NERIs), and R&D agreements
- Technical and policy support for civil nuclear energy working groups and bilateral MOUs

- **Multilateral Engagement**

- Coordination and leadership for NE's engagement in multilateral organizations such as the International Atomic Energy Agency (IAEA), Generation IV International Forum (GIF), the International Framework for Nuclear Energy Cooperation (IFNEC), OECD's Nuclear Energy Agency (NEA), and the International Energy Agency (IEA)

- **International Commercial Engagement**

- Promotion of U.S. civil nuclear energy policy and technical objectives through engagement on international commercial nuclear matters
- Advancement of issues associated with developing commercial options for the safe and secure management of used fuel, including regional and international disposal, to support the growth of nuclear power



# Nuclear Innovation: Clean Energy Future (NICE Future)



## Lead Participants:



USA



CANADA



JAPAN

## Participants



ARGENTINA



POLAND



ROMANIA



RUSSIA



UAE



UK

## 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:

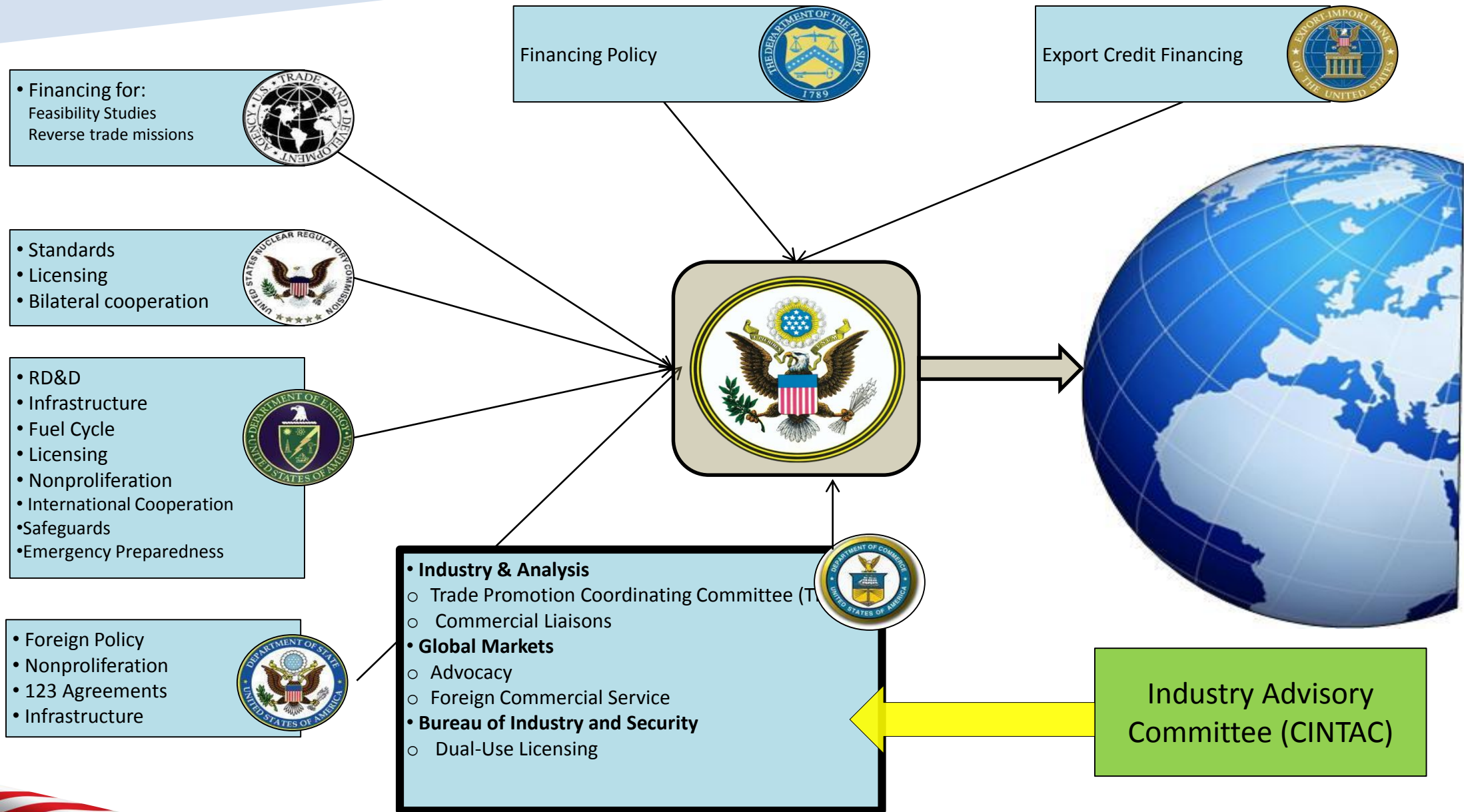
NICE Future focuses on nuclear power as a clean energy option for reliable and resilient baseload electricity, and non-electric applications especially when deployed as hybrid nuclear-renewable systems.

## 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



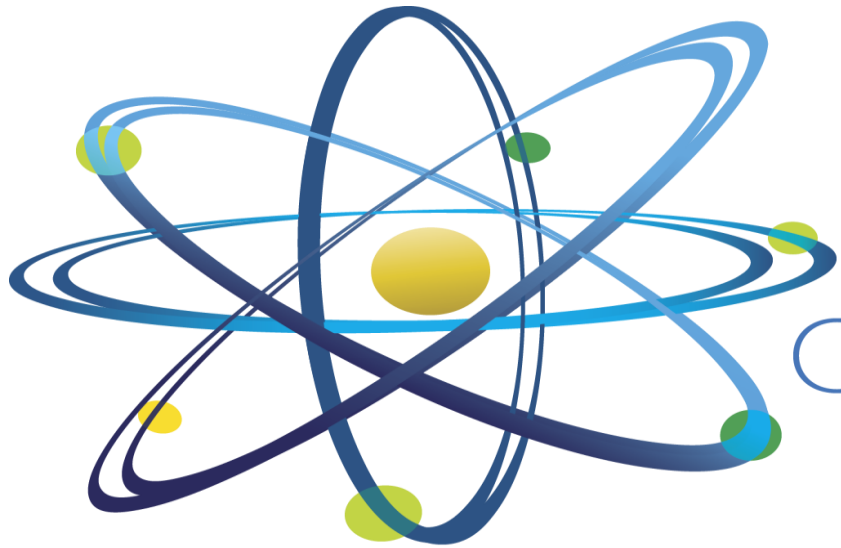
# Team USA: Whole-of-Government Strategy



# Summary

- The demand for domestically-generated, reliable, resilient and clean sources of baseload electricity will continue to drive many countries toward nuclear energy as part of their energy security and national economic and environmental calculus.
- 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.**