U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Nuclear – Hydrogen Overview

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Integrated Energy Systems and
Flexible Plant Operation and Generation

DOE 2022 Hydrogen Review
June, 2022

DOE Nuclear Energy Mission and Priorities

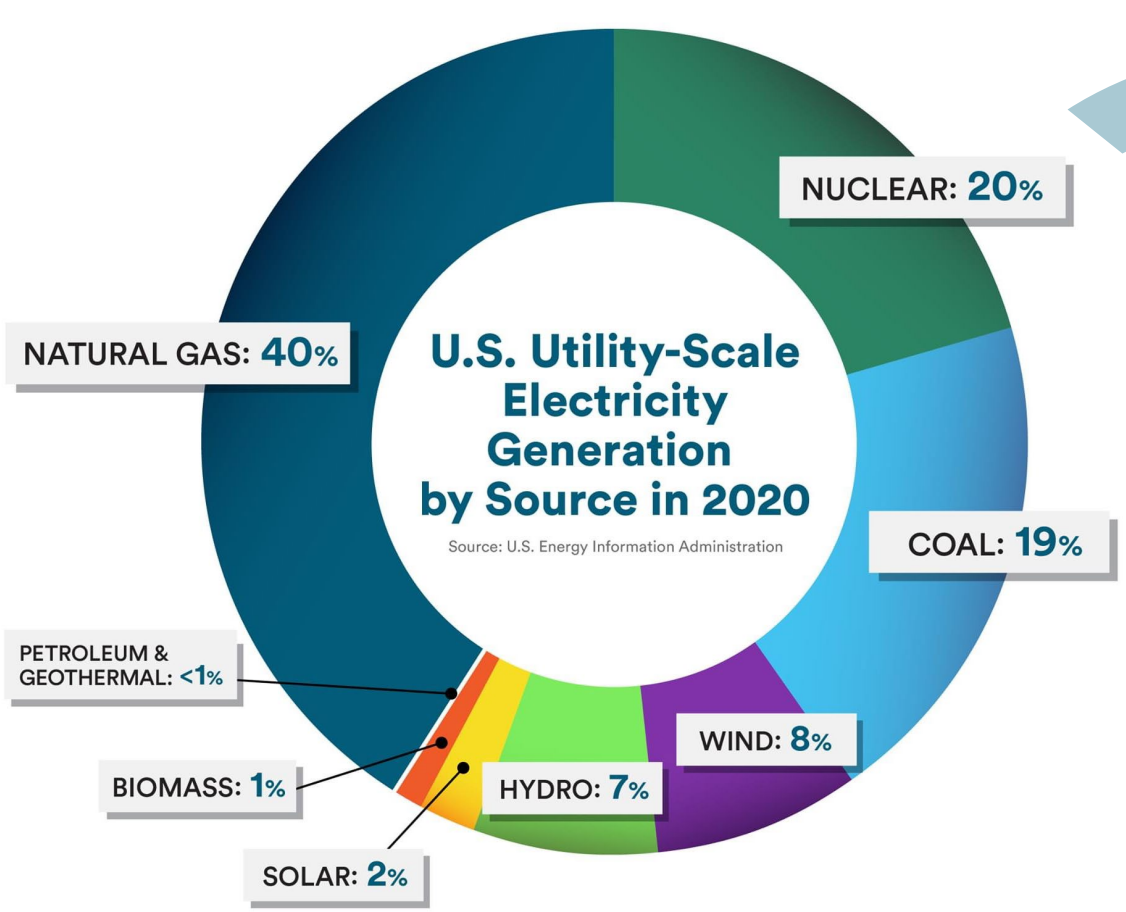
DOE Nuclear Energy Mission

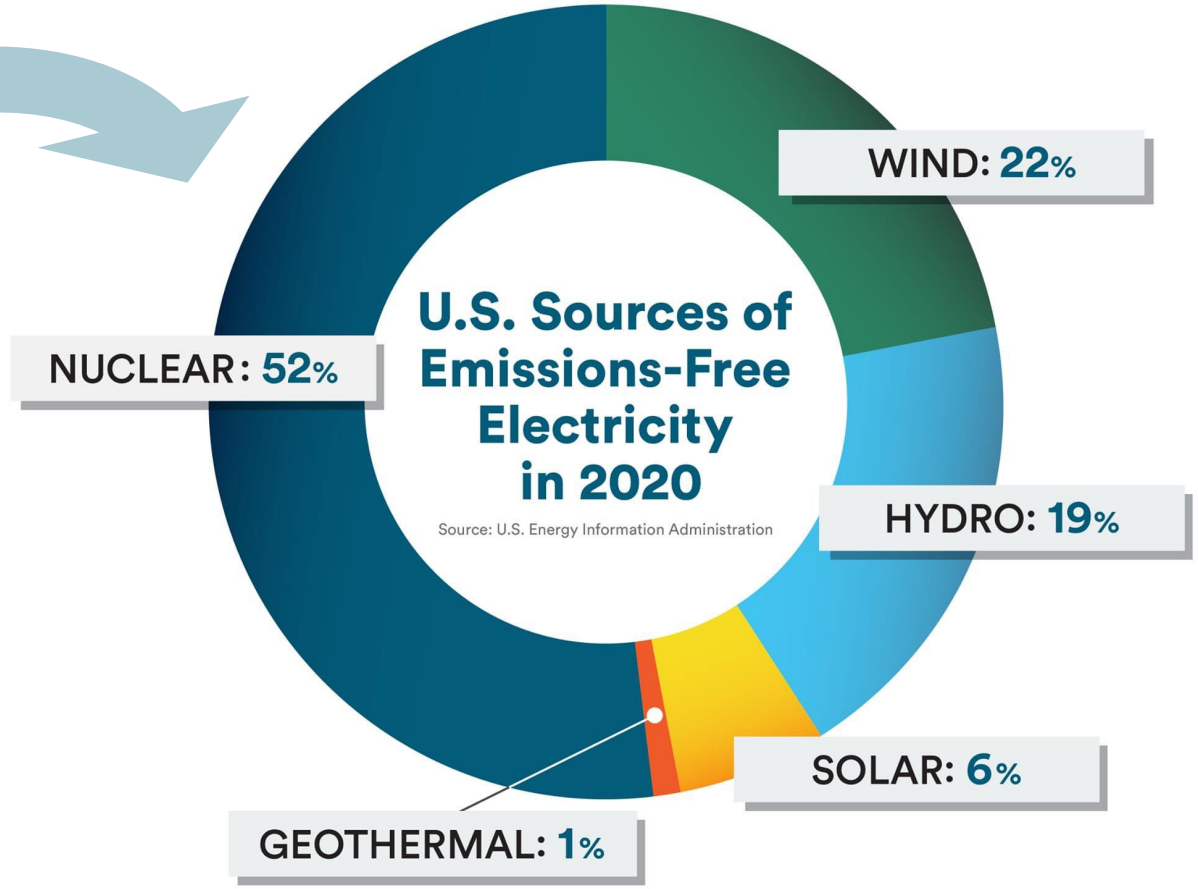
To advance nuclear energy science and technology to meet U.S. **energy**, **environmental**, and **economic** needs. NE also serves as the Lead Program Secretarial Office for the Idaho National Laboratory.

Our Priorities

1. Enable continued operation of existing U.S. nuclear reactors
2. Enable deployment of advanced nuclear reactors
3. Responsibly manage our nation's spent nuclear fuel
4. Maintain U.S. leadership in nuclear energy technology

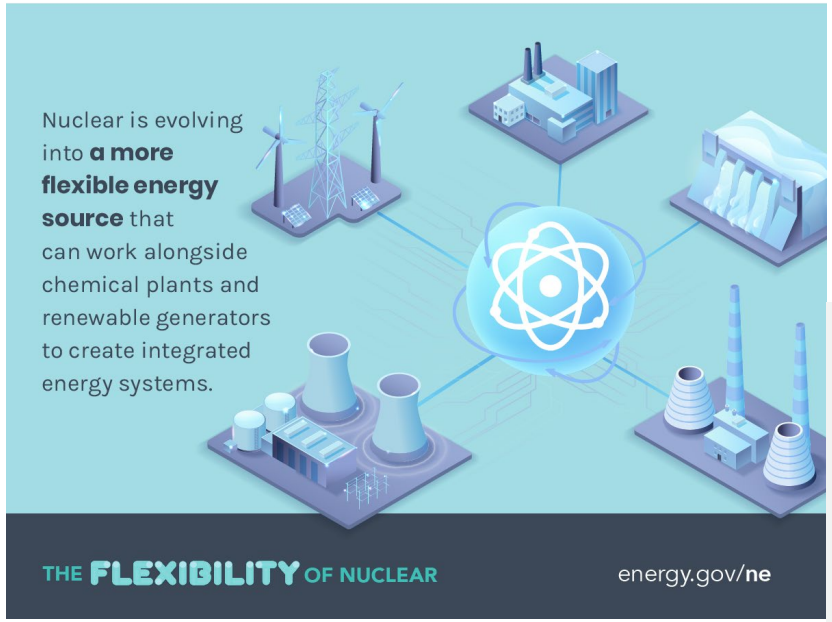
Nuclear: Crucial for Clean Energy Mix



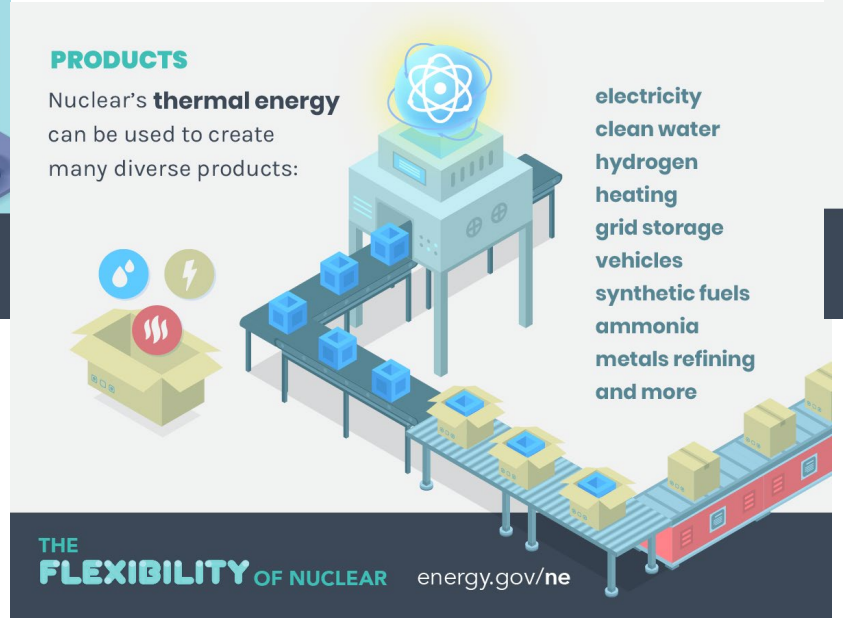


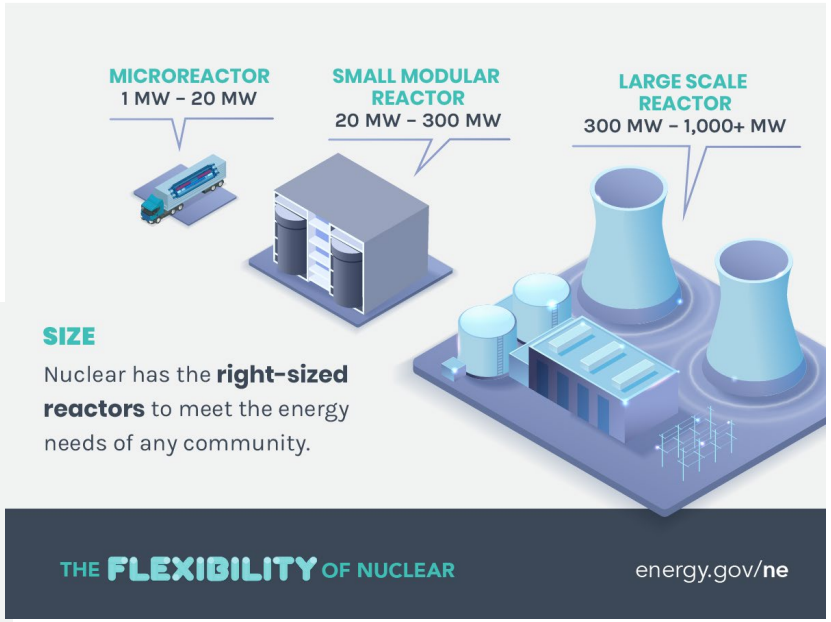
Source: U.S. Energy Information Administration

Operational paradigms—nuclear energy flexibility



Nuclear flexibility is key to enabling other clean energy generators to provide deep decarbonization across multiple sectors.

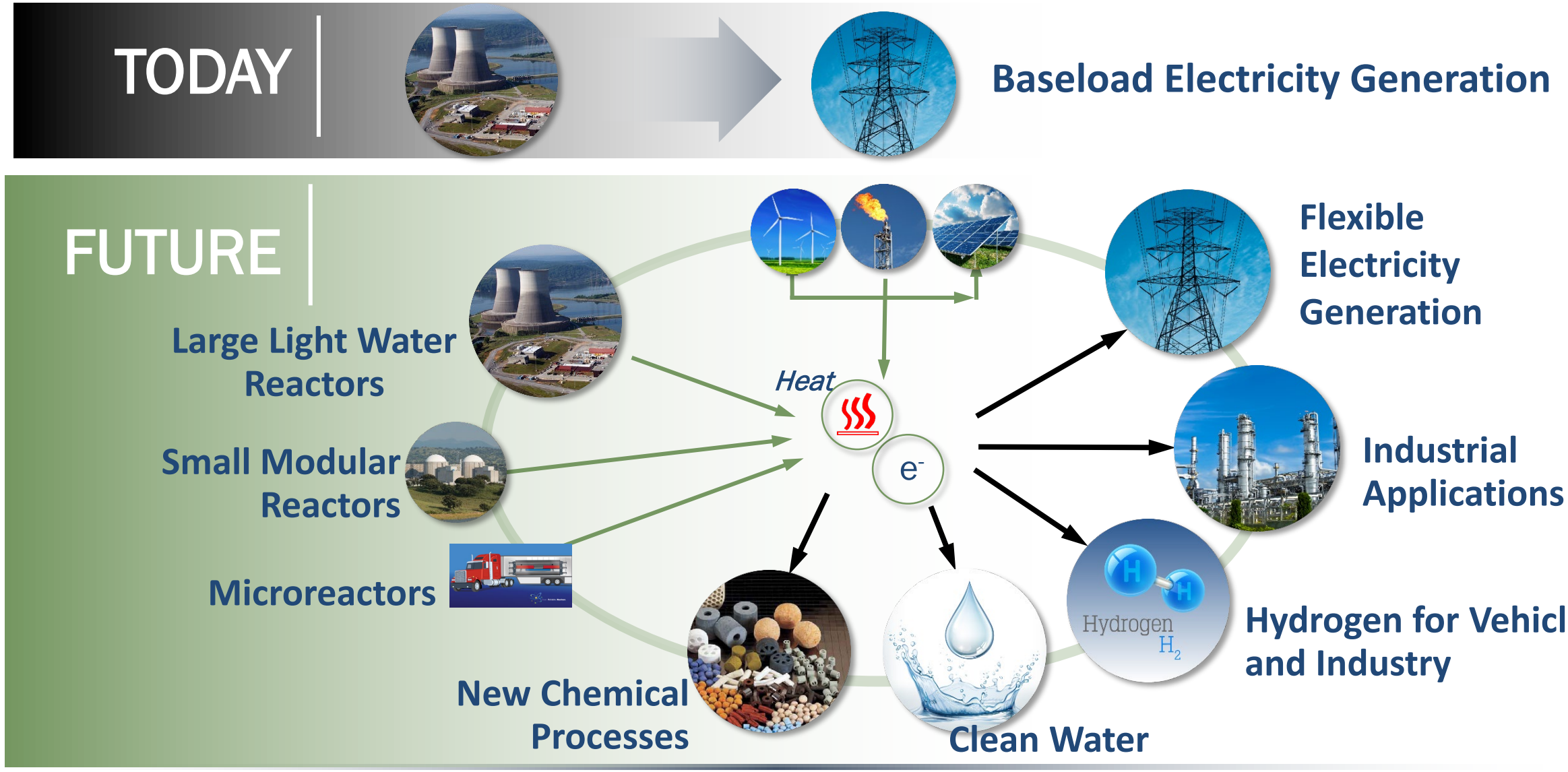




- ***Operational* flexibility**
  - ***Product* flexibility**
    - ***Deployment* flexibility**

Flexible Nuclear Energy for Clean Energy Systems, September 2020
https://www.nice-future.org/flexible-nuclear-energy-clean-energy-systems

Advanced Reactors: Integrated Grid for Net-Zero Future



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Research, Development, and Demonstration

Light Water Reactor Sustainability – Flexible Plant Operation and Generation

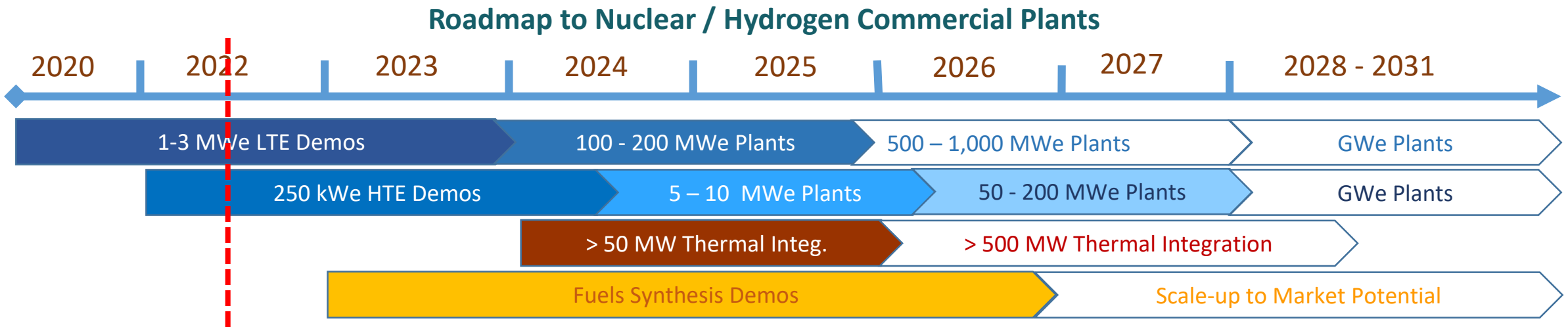
R&D activities to diversify and increase the revenue of the existing fleet of nuclear reactors:

I. **Complete technical and economic assessments** to raise the understanding of LWR owners, investors, and utilities, industrial manufacturing and transportation-sector industries.

II. **Conduct essential R&D required to enable LWR plants to dispatch both thermal and electrical energy** for production of nonelectrical products through FPOG. This work focuses on interfaces between the LWR plant and the industrial-energy user that enable an LWR plant to optimize its revenue through production of electricity and nonelectrical products.

III. **Address the potential safety hazards** of collocated hydrogen and chemical on operating licenses and system-integration interaction with LWR operations.

IV. **Engage Stakeholders** to bring get input of R&D needs and to help develop collaboration among LWRs, utilities, and industries that stand to benefit from FPOG applications



Nuclear-H_2 Production Demonstration Projects

- **Constellation (Exelon): Nine-Mile Point NPP**
  - 1 MWe Low Temperature Electrolysis (LTE)
  - Using “house load” power
  - H_2 production beginning ~October 2022

- **Energy Harbor: Davis-Besse NPP**
  - 1-2 MWe LTE
  - Power provided by completing plant upgrade with new switch gear at the plant transmission station
  - H_2 production beginning ~2023/24

- **Xcel Energy: Prairie Island NPP**
  - 150 kWe High Temperature Electrolysis (HTE)
  - Engineering planned for tie into plant thermal line
  - H_2 production beginning ~Q1 2024

- **APS/PNW Hydrogen: Palo Verde Generating Station**
  - 15-20 MWe LTE H2 production, ~6-8 tons H2/day
  - H_2 storage + H_2 to gas peaking turbines (50%), syngas pilot
  - H_2 production expected 2024 (Award still under negotiation)

Nine Mile Point Nuclear Power Plant



Davis-Besse Nuclear Power Plant



Prairie Island Nuclear Power Plant



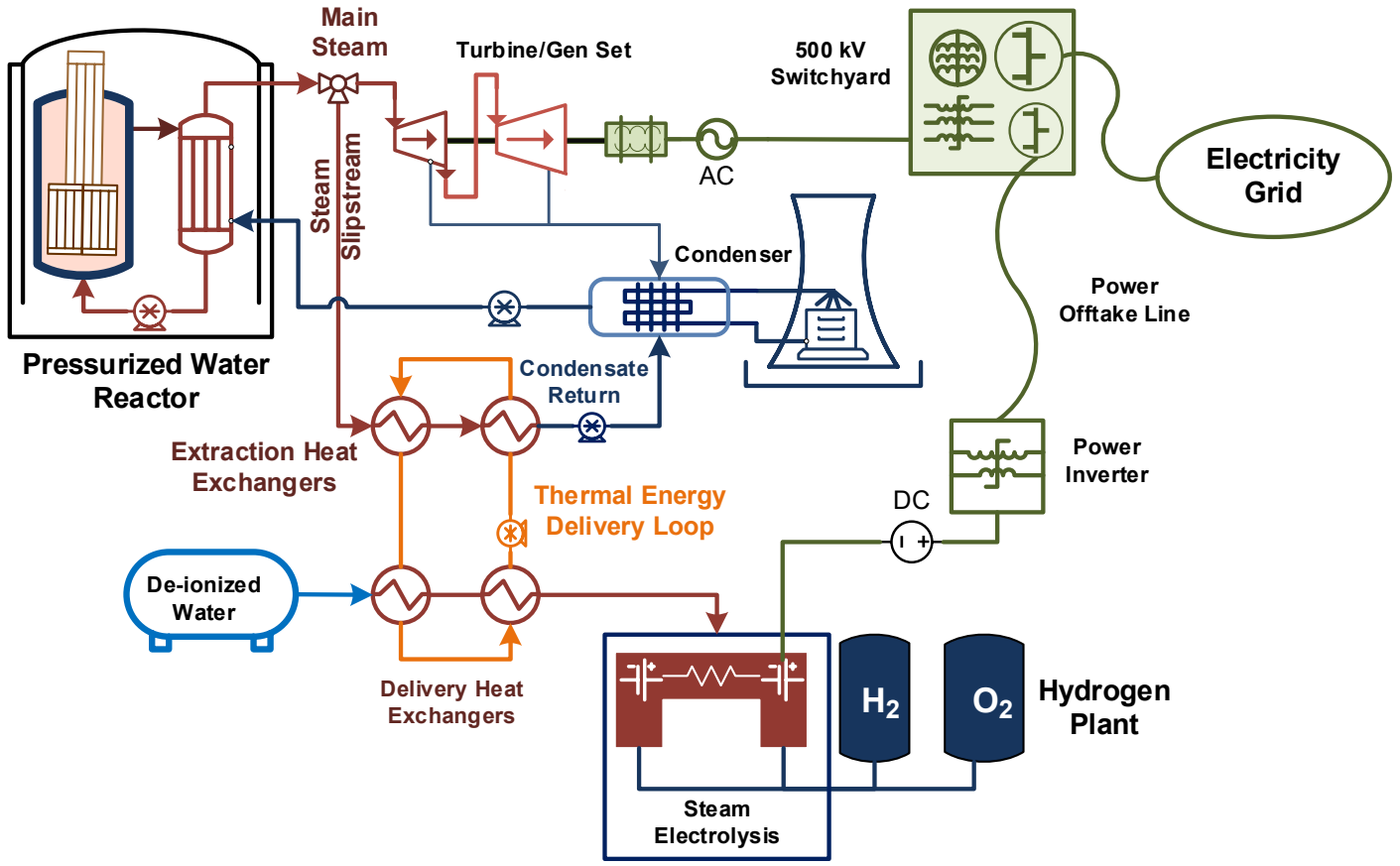
Palo Verde Generating Station



Thermal Integration of Steam Electrolysis

Safety analysis summary conclusions

- **The LWRS generic probabilistic risk assessment (PRA) investigation into licensing considerations concluded that following the assumptions made:**
  - The licensing criteria is met for a large-scale HTE facility sited 1 km from a generic PWR and BWR
  - The safety case for less than 1 km distance is achievable
- **Report available: INL/EXT-20-60104, *Flexible Plant Operation and Generation Probabilistic Risk Assessment of a Light Water Reactor Coupled with a High-Temperature Electrolysis Hydrogen Production Plant*, OSTI link: https://www.osti.gov/biblio/1691486**



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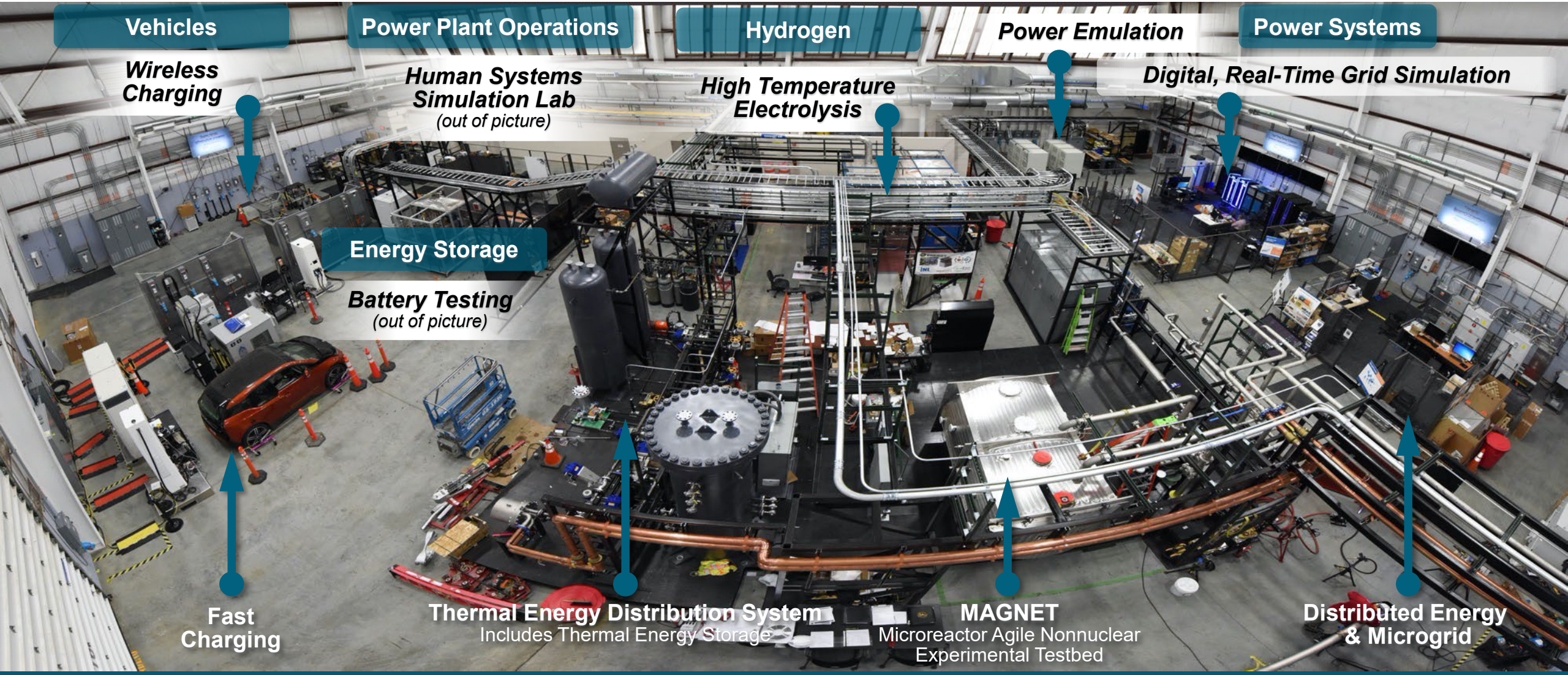
Laboratory Testbeds / Tools

Dynamic Energy Transport and Integration Laboratory (DETAIL) for electrically heated testing of integrated systems



DETAIL enables cross-complex laboratory connections

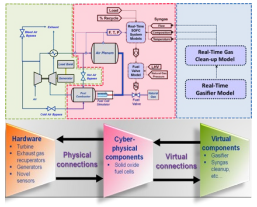
ARIES

IESS at Flatirons Campus



NREL Transforming ENERGY

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY





Human-in-the-Loop





Power Hardware and Grid-in-the-Loop



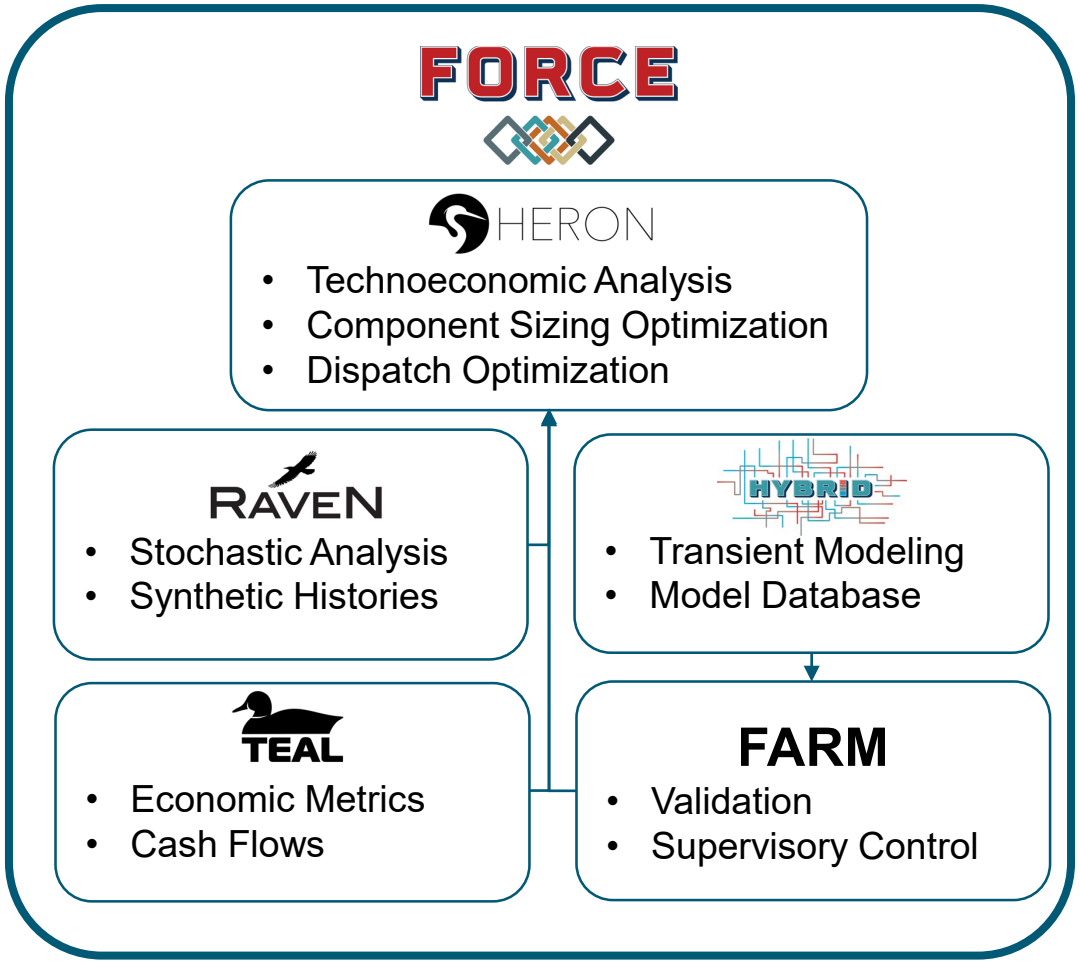
Thermal Energy Generation and Transport



Hydrogen and other Flexible Industrial Processes

Integrated Energy Systems - Analysis and Optimization Tool Suite

- **Framework for Optimization of ResourCes and Economics (FORCE) is a collection of software tools, models, and datasets to enable analysis of technical and economic viability of myriad IES configurations:**
  - Optimization
    - Portfolio
    - Dispatch
  - Analysis
    - Economic
    - Stochastic
    - Physical
  - Supervisory Control
  - Workflow Automation



For more information and to access open source tools, see https://ies.inl.gov/SitePages/System_Simulation.aspx.

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Thank you!

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