NUCLEAR
INNOVATION
ALLIANCE

Commercializing Advanced Nuclear Energy

4/19/2023

EESI Briefing: *The State of Play for Nuclear Energy in the United States*

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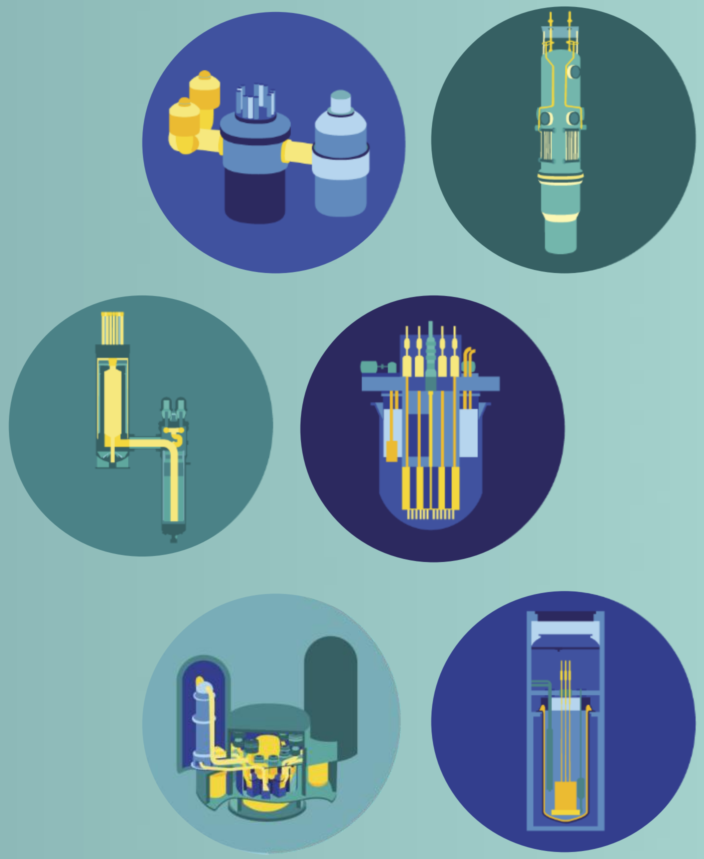
Who is Nuclear Innovation Alliance (NIA)?

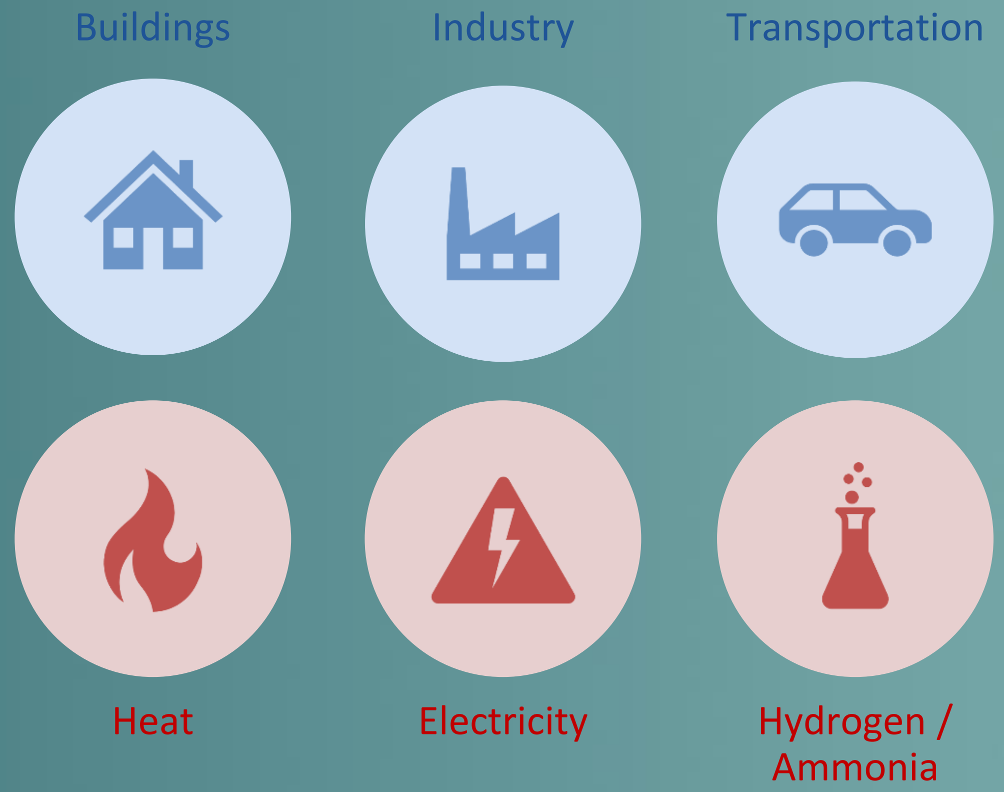
- NIA is a "think-and-do" tank working to ensure advanced nuclear energy can be a key part of the climate solution.
- NIA identifies barriers, performs analysis, engages with stakeholders and policy makers, and nurtures entrepreneurship through its Nuclear Innovation Bootcamp.

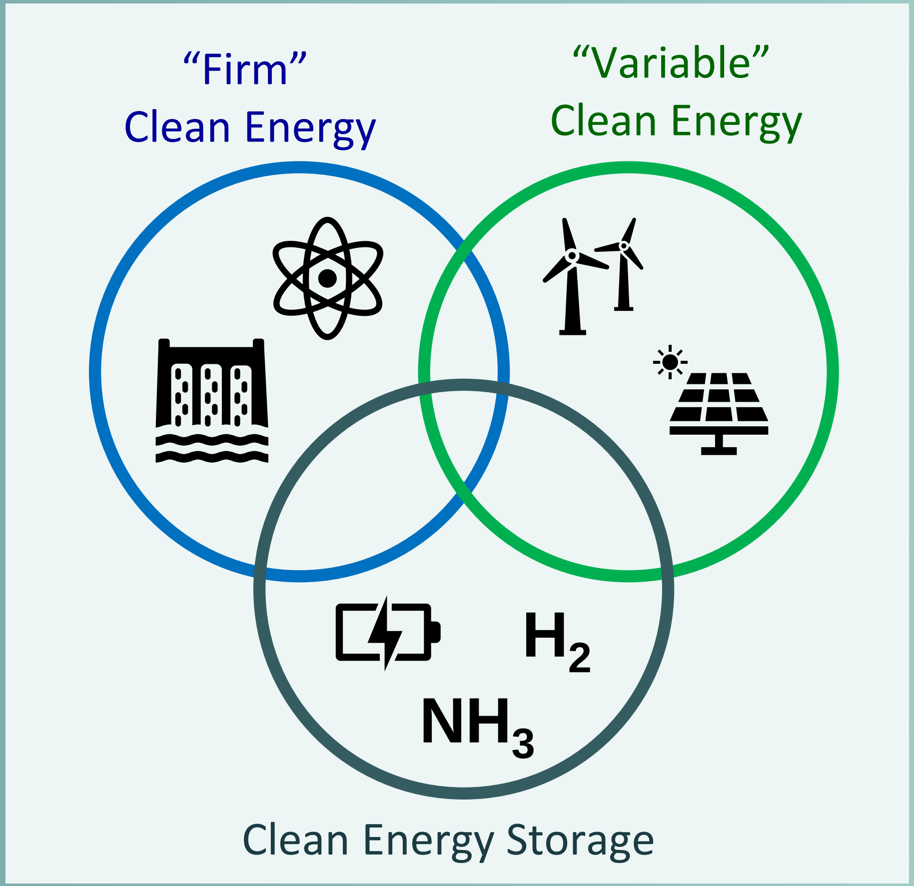
Takeaways on Commercializing Advanced Nuclear Energy

- Nuclear energy can play a major role in creating a clean energy economy
- Advanced reactors have a wide array of different commercial use cases
- Developers are leveraging DOE support to accelerate reactor deployment
- Continued federal support and incentives can catalyze private investments

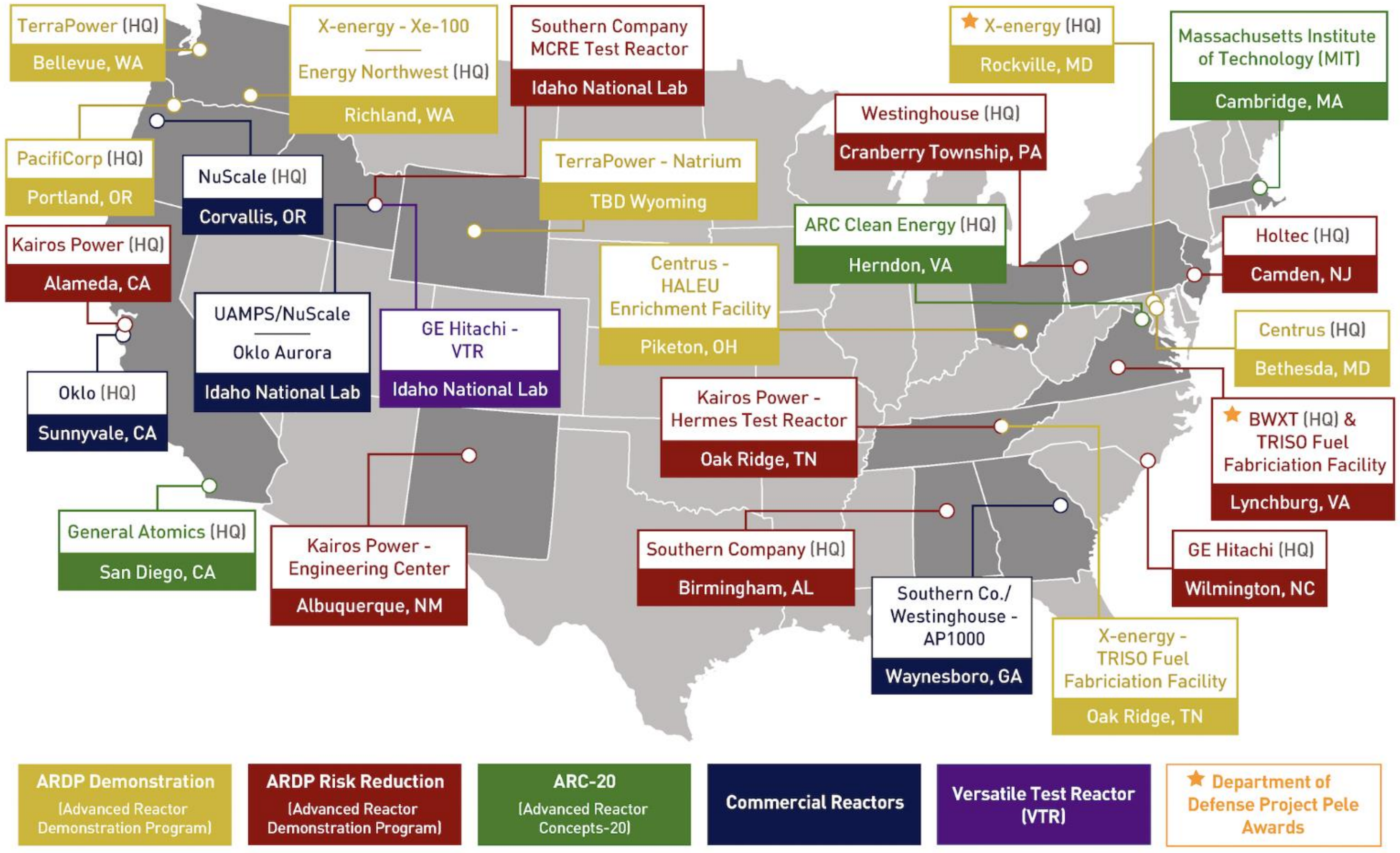


Advanced nuclear energy is an important complementary clean energy source to help fully decarbonize U.S. energy production





Large (and growing) group of private companies are developing advanced nuclear energy to meet clean energy needs



Utility partners and industrial energy users have expressed interest in deploying advanced nuclear energy

ONTARIO POWER GENERATION
DUKE ENERGY
Bruce Power
UAMPS
SMARTENERGY
PACIFICORP
Southern Company
ENERGY NORTHWEST
Constellation
DOW
TVA

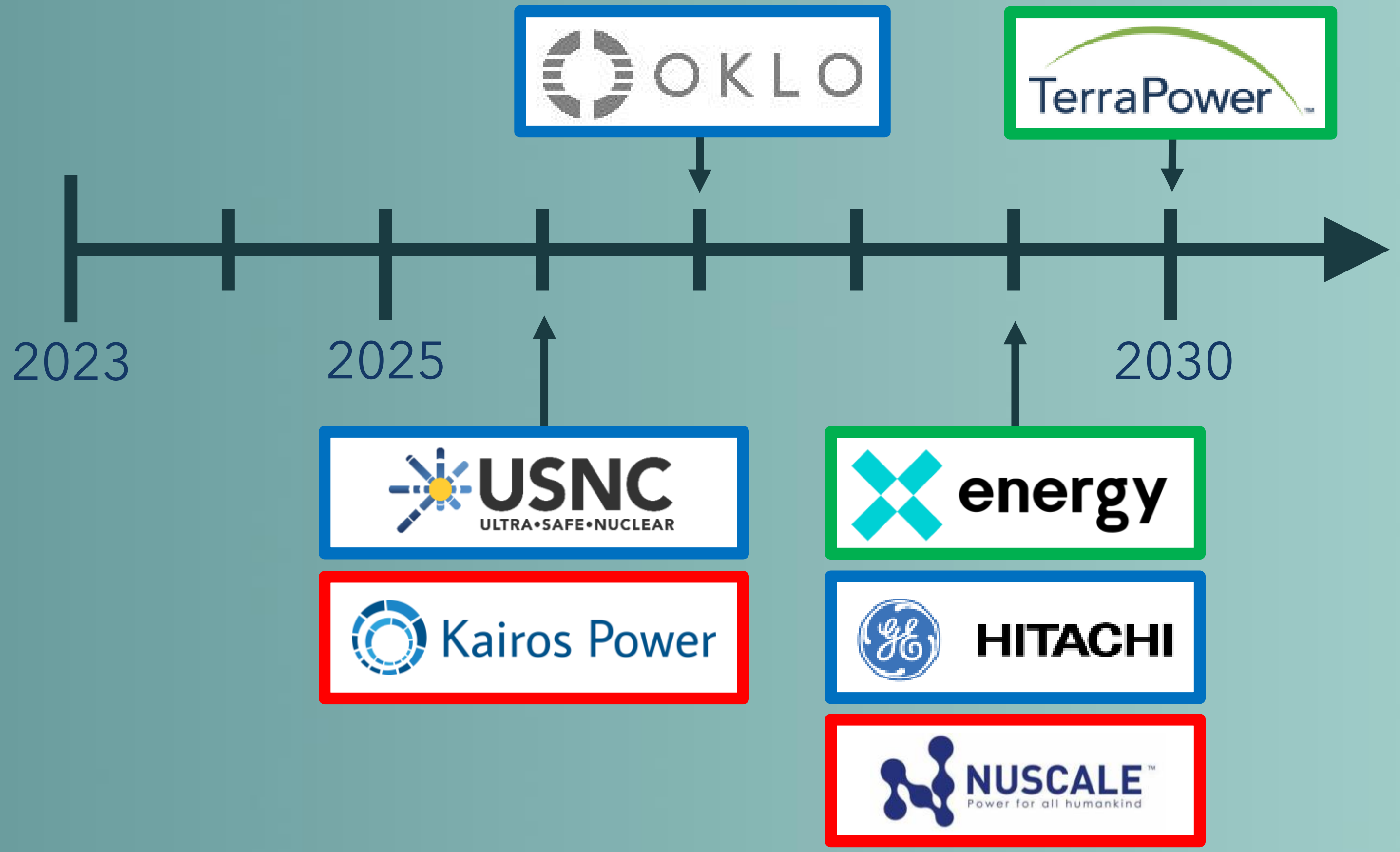
Public-private partnerships are accelerating the demonstration and deployment of first-of-a-kind advanced reactors

Federal Partnerships with Private Companies

Advanced reactor demonstration award

Advanced reactor development award

Enabling technology development award



Developers are preparing to submit a large number of formal license applications for review to the NRC in FY23

Site-Specific Applications

- Kairos: Hermes (*in progress*)
- ACU: NEXT MSR (*in progress*)
- X-energy: Xe-100
- TerraPower: Natrium
- GEH: BWRX-300
- Oklo: NCSFR-1
- Oklo: NCSFR-2

Design-Specific Applications

- NuScale: VOYGR (*complete*)
- NuScale: NPM-20 (*in progress*)
- Terrestrial Energy: IMSR
- Westinghouse: eVinci

Pre-Application Interactions

- NuScale: UAMPS (COL)
- Holtec: SMR-160 (CP)
- GA: EM2 (CP)
- BWXT: BANR
- FLiBe: LFTR (ESP)
- ARC: ARC-100
- Radiant Energy: Kaleidos
- USNC: UIUC MMR (CP)
- TerraPower: MCFR
- GA: FMR (CP)

Pathway from first-of-a-kind to widescale deployment requires an orderbook, on-time and on-budget delivery, and supply chains

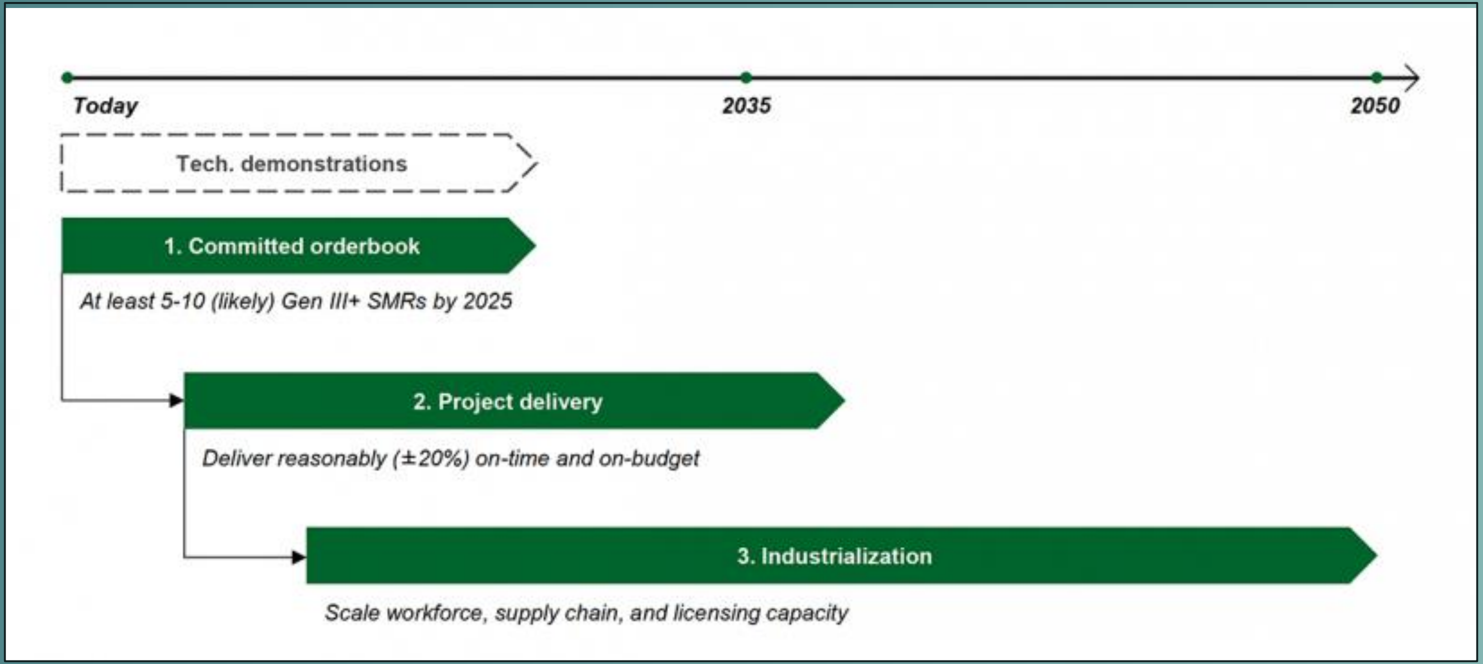


Figure from 2023 DOE Report *Pathways to Commercial Liftoff - Advanced Nuclear*

Example: *BWRX-300*

GE HITACHI

ONTARIO POWER GENERATION

TVA

synthos green energy

Link: BWRX-300 Partnership Announcement

Successful commercialization could dramatically increase demand for advanced nuclear energy for a wide variety of applications

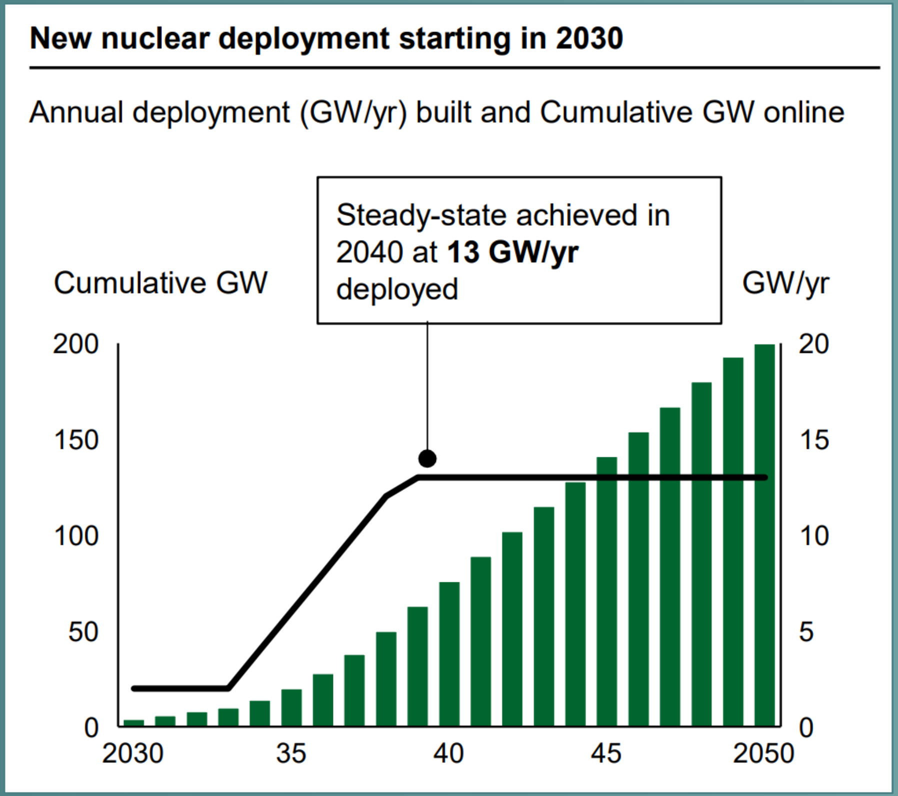
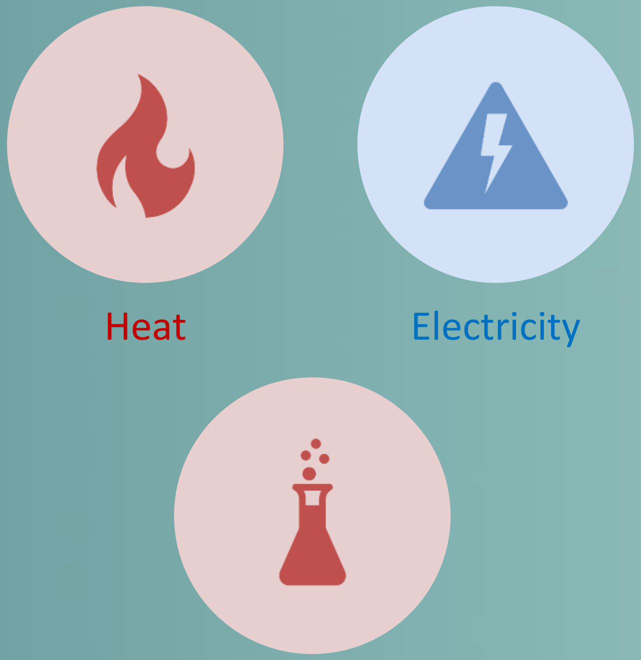


Figure from 2023 DOE Report *Pathways to Commercial Liftoff - Advanced Nuclear*



Heat

Electricity

Hydrogen / Ammonia

2022 Nuclear Energy Institute survey of 19 member utilities:

- More than 300 new SMRs deployed for electricity generation by 2050
- More than 90 GW of new nuclear generation by existing owners alone
- Evaluations of sites that currently host operating or retired coal plants for new nuclear reactors

Continued federal support and incentives can catalyze private investments in advanced nuclear energy

Inflation Reduction Act (IRA) Funding for HALEU
Fuel Cycle Development Support
$700M

IRA Nuclear Hydrogen Production Credits
Non-electric Deployment Incentives
$3.00/kg H_2

Advanced Reactor Licensing at the Nuclear Regulatory Commission
Effective, Efficient, and Predictable Regulation

DOE ARC 20 Risk Reduction Awards in Appropriations
Reactor Development Funding
$650M

Infrastructure Investment and Jobs Act (IIJA) Funding and Appropriations
Demonstration Reactor Support
$4600M

IRA Nuclear Production and Investment Tax Credits (see NIA Fact Sheet for Details)
Commercial Deployment Incentives
2.5¢/kWh* OR 30% of costs*

Takeaways on Commercializing Advanced Nuclear Energy

Nuclear energy can play a major role in creating a clean energy economy

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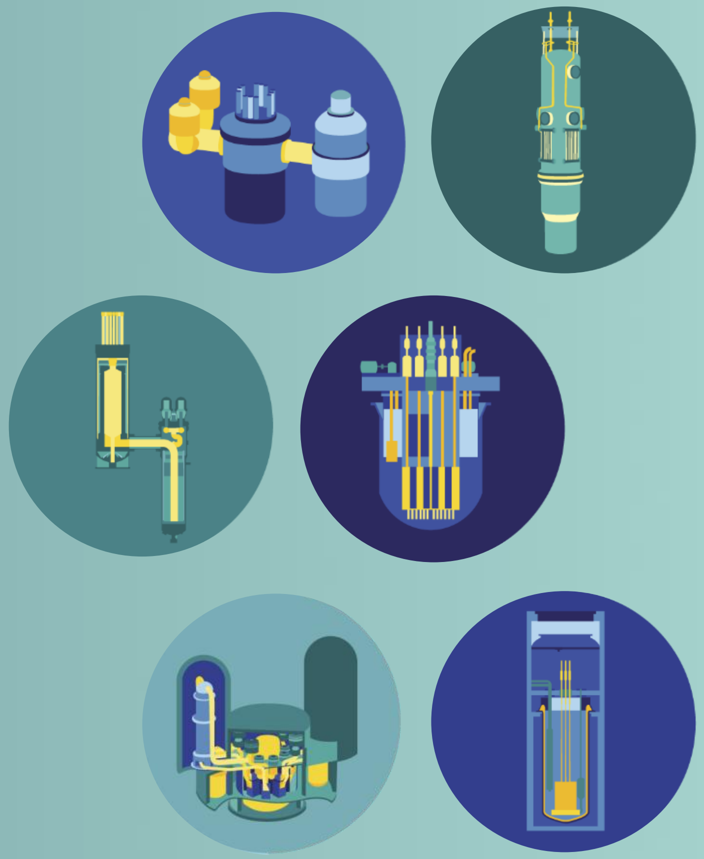


Back-up Slides

Advanced nuclear energy adds flexibility and versatility in comparison to conventional nuclear through innovative design

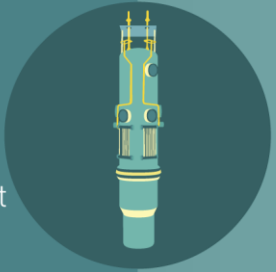
Conventional Nuclear Energy		Advanced Nuclear Energy
Predominantly Large: More than 1000 MW_e	Reactor Size	Versatile: 1.5 MW_e to 300+ MW_e
Predominantly Light-Water Reactors	Reactor Technology	Wide Variety of Reactor Technologies
Primarily Baseload Generation	Generation Type	Flexible and Dispatchable Generation
Designed with Active Safety Systems	Safety Approach	Designed with Inherent Safety Systems

Definition of advanced nuclear energy includes a variety of nuclear technologies with different advantages

Thermal Fission

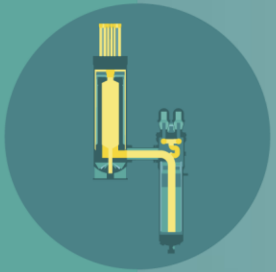
Advanced Light-Water Reactors

Evolutionary design from existing reactors with inherent safety features



High-temperature reactors (HTRs)

High temperatures drive high efficiency, well-suited for process heat or hydrogen production. Uses TRISO fuel



Thermal or Fast Fission

Molten Salt-Fueled Reactors (MSRs)

Using molten salt for coolant and a fuel form, MSRs can bring significant safety benefits

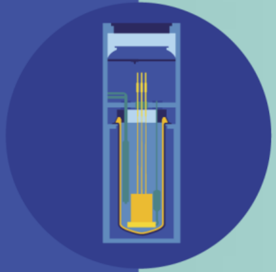
Fast Fission

Gas-cooled fast reactor (GFR)

An evolution of HTRs, GFRs operate at very high temperatures while using a more sustainable fuel cycle

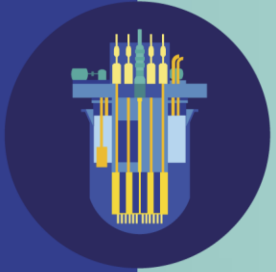
Sodium-cooled fast reactor (SFR)

With many existing experimental reactors, SFRs offer increased fuel efficiency, reduced waste, and passive safety features



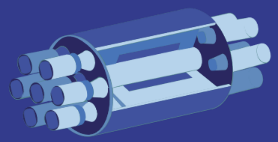
Lead-cooled Fast Reactor (LFR)

Similar in design to SFRs, LFRs are advantageous as lead is operationally safer than sodium



Variety of reactor sizes and low-carbon products enable integration of advanced nuclear into future energy systems

Electricity Production

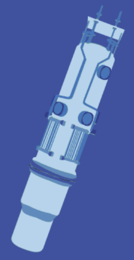


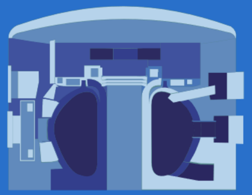
Microreactors

Can provide decentralized power and co-products to rural and off-grid locations

Small Modular Reactors

Scalable power small enough to be available to co-ops, munis, and industrial users for the first time





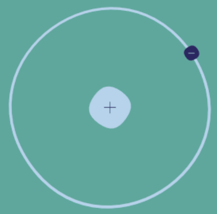
Large Reactors

Advanced designs can play the traditional role of large, base-load nuclear power while providing improved operations, safety, and economics

Co-Products

Heat

Through cogeneration, advanced nuclear can provide district heating or process heating for industrial applications, allowing for decarbonization of non-electric sectors

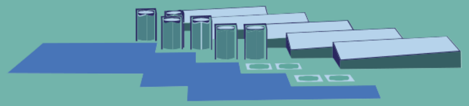


Hydrogen

Advanced nuclear power can produce hydrogen, potentially enabling a hydrogen economy to decarbonize non-electric sectors

Desalination

Some advanced designs can produce fresh water



Both NRC and companies play a role in improving licensing under current rules and creating a new regulatory framework

Optional Licensing Tools

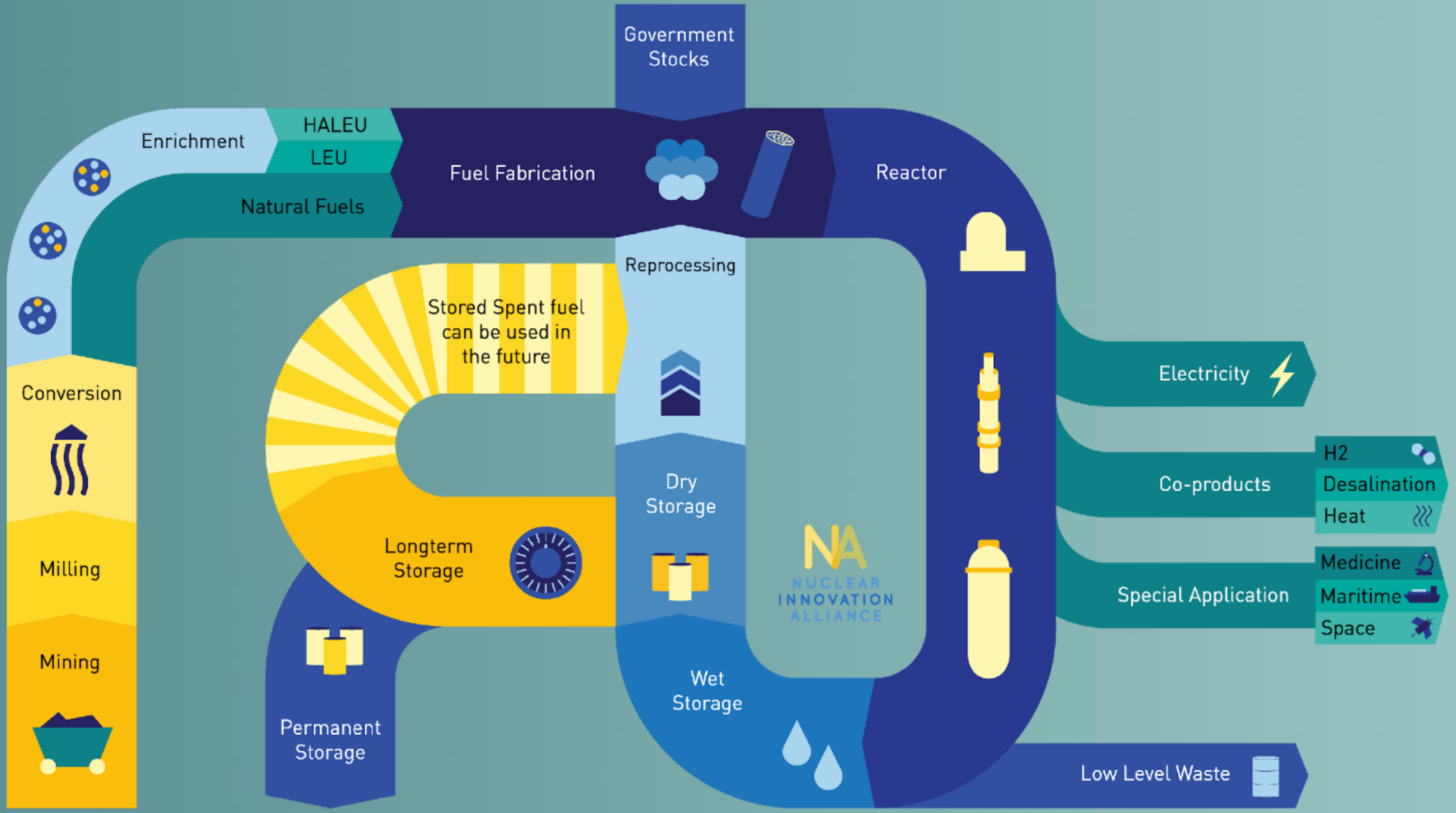
- Preapplication Interactions
- Topical Reports
- Early Site Permits
- Standard Design Approvals
- Standard Design Certifications

Construction Permit → Operating License — Licensing Path 1 ("Part 50")

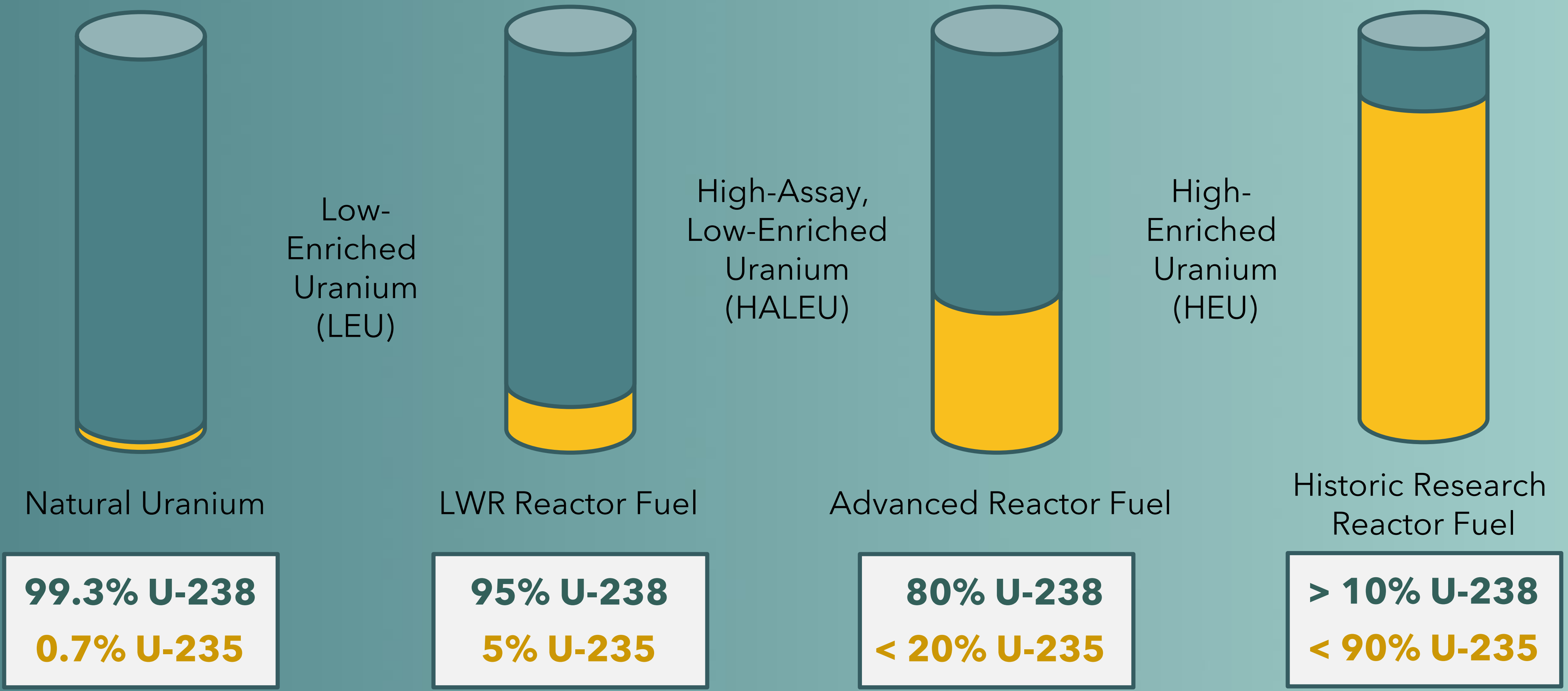
Combined Operating License — Licensing Path 2 ("Part 52")

New Regulatory Framework — Licensing Path 3 ("Part 53")

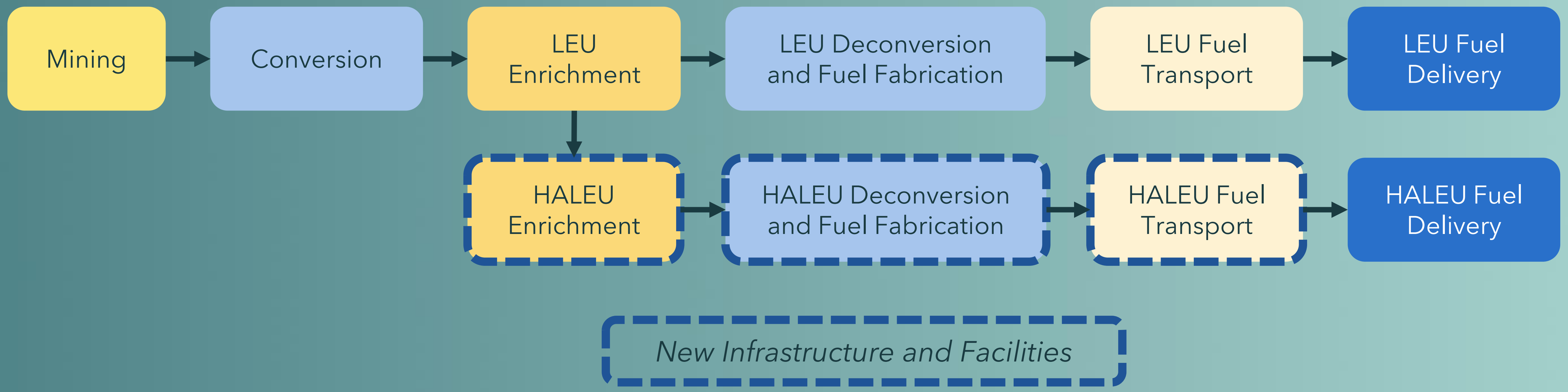
Advanced reactor commercialization requires coordination and planning across all stages of a sustainable fuel cycle



Some advanced reactor technologies will require nuclear fuel cycles with higher uranium enrichment levels



Advanced reactors that require HALEU or recycled fuels will need new fuel cycle infrastructure and facilities



Stakeholders can get up to speed on advanced nuclear energy and engage with policymakers on clean energy deployment

Advanced Nuclear Primer
March 2023 Update
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Advanced Nuclear Compendium
July 2022
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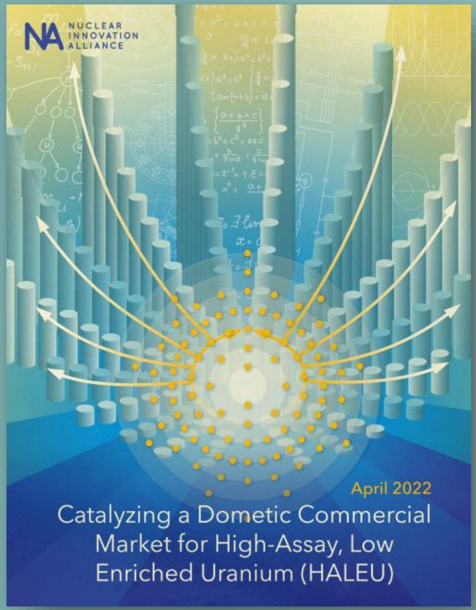

HALEU Fuel Availability
April 2022
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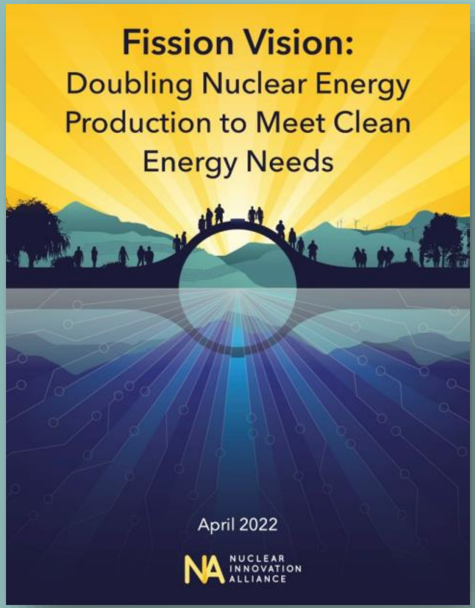

Fission Vision
April 2022
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