Overview of the NRC's Regulatory Programs on the Advanced Reactor Fuel Cycle

Office of Nuclear Material Safety and Safeguards

Opening Remarks

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Office of Nuclear Material Safety and Safeguards

U.S. Nuclear Regulatory Commission

Mission of the NRC

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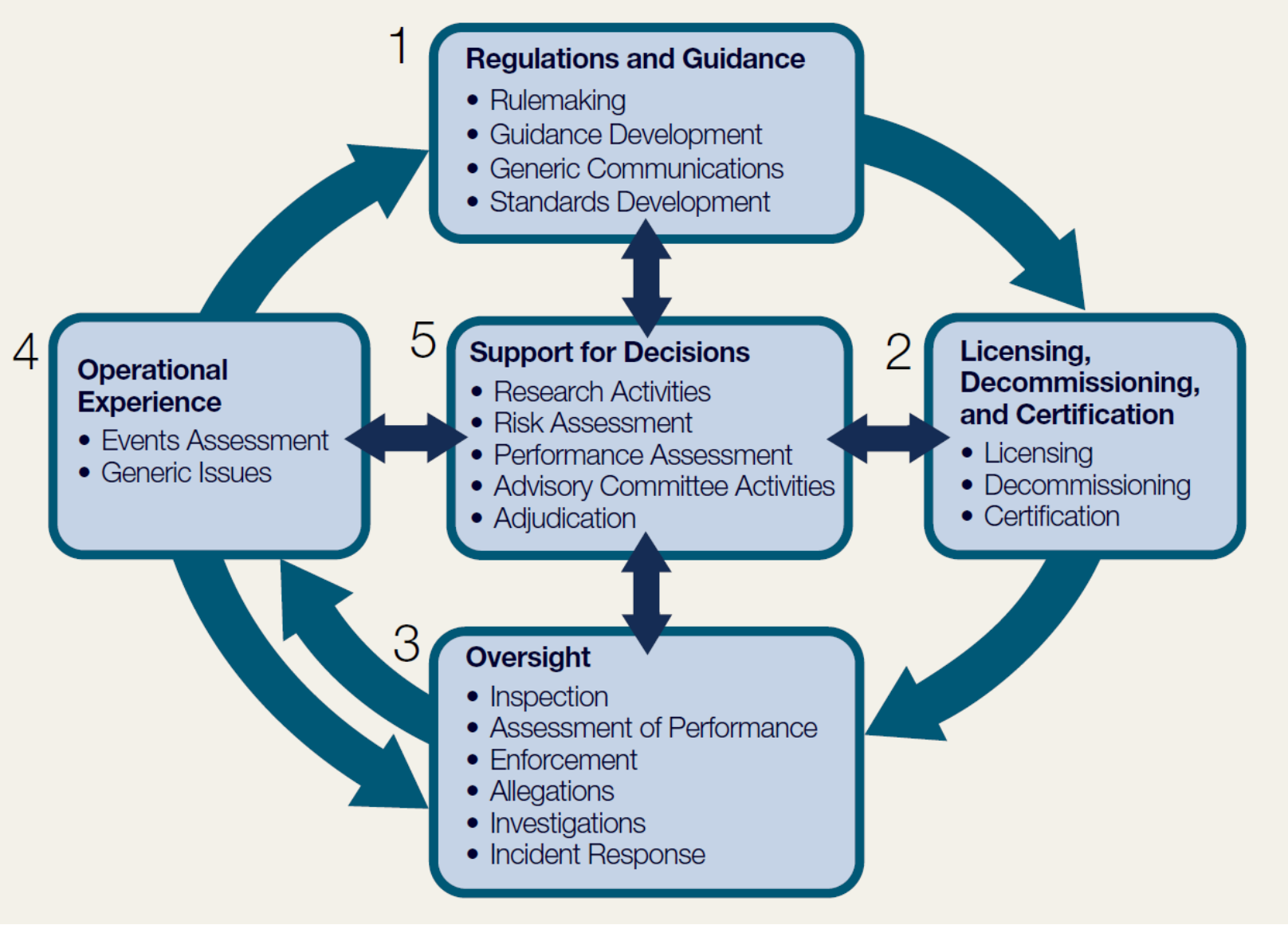
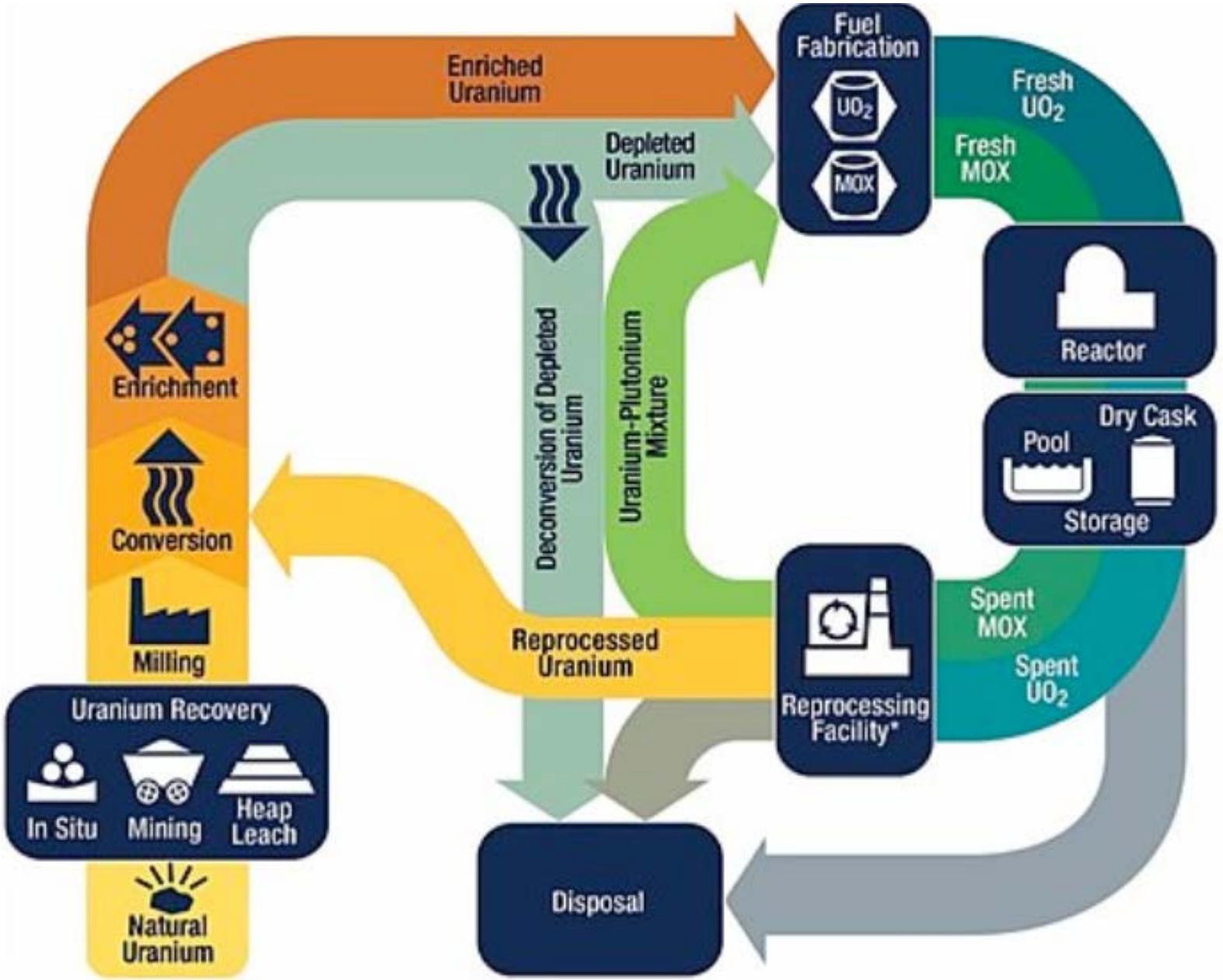
The NRC licenses and regulates the Nation's civilian use of radioactive materials to provide reasonable assurance of adequate protection of public health and safety to promote the common defense and security and to protect the environment.

How the NRC Regulates



Nuclear Fuel Cycle



Regulatory Framework for the Fresh and Spent Fuel Portions of the Nuclear Fuel Cycle

- Source material including uranium conversion – 10 CFR Part 40
- Quality assurance programs (for fresh fuel) – 10 CFR Part 50
- Environmental protection – 10 CFR Part 51
- HLW disposal – 10 CFR Part 60 and 63
- SNM including uranium enrichment and fuel fabrication – 10 CFR Part 70
- Transportation of radioactive material – 10 CFR Part 71
- Interim spent fuel storage – 10 CFR Part 72
- Physical security – 10 CFR Part 73
- MC&A – 10 CFR Part 74
- International safeguards – 10 CFR Part 75
- Classified information protection – 10 CFR Part 95
- Export and import – 10 CFR Part 110

Key Messages

- The NRC's preparations for regulation of the advanced reactor fuel cycle include the supply of advanced reactor fuel and the management of advanced reactor spent fuel.
- The existing risk-informed and performance-based regulatory framework for licensing and oversight has sufficient flexibility to ensure the safe and secure operation of the complete fuel cycle for advanced reactors.
- NRC staff is coordinating internally and with other agencies to gain insight, develop technical information, and assess industry approaches.
- NRC staff encourages potential applicants to engage early and often in the interest of ensuring complete, high-quality license applications.

Outline

- NRC's regulatory framework for the nuclear fuel cycle
- NRC's fuel cycle licensing and oversight experience
- NRC's assessment of the existing regulatory framework
- NRC's activities to prepare for an advanced reactor fuel cycle
  - Fuel facilities
  - Physical security and MC&A
  - Nuclear nonproliferation and export control
  - Transportation, storage, and disposal

Fuel Cycle Facilities Overview

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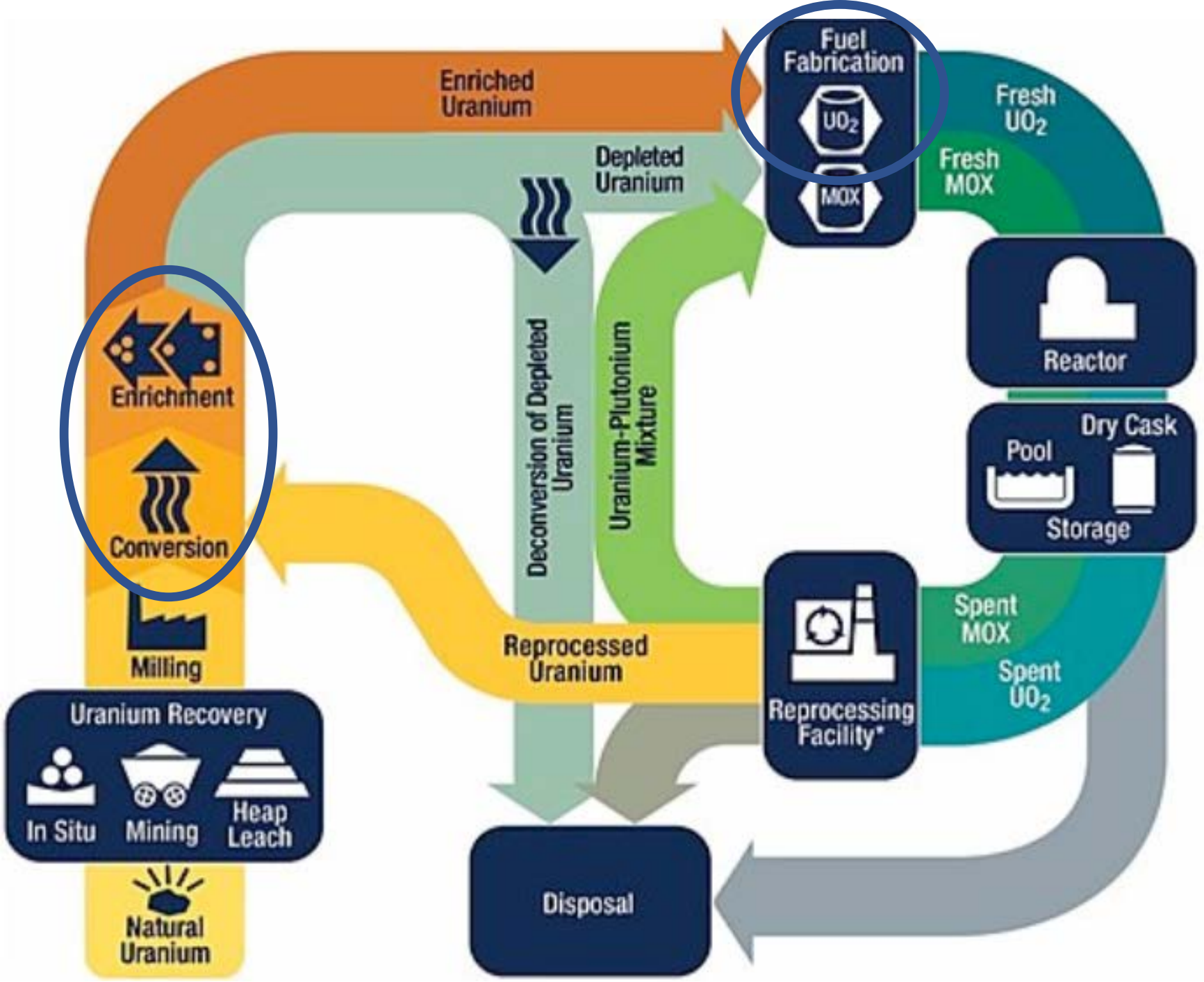
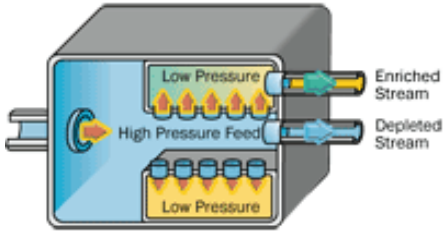

Fuel Fabrication
UO2
MOX
Enriched Uranium
Depleted Uranium
Fresh UO2
Fresh MOX
Reactor
Dry Cask
Pool
Storage
Enrichment
Conversion
Milling
Deconversion of Depleted Uranium
Uranium-Plutonium Mixture
Reprocessed Uranium
Reprocessing Facility*
Spent MOX
Spent UO2
Uranium Recovery
In Situ
Mining
Heap Leach
Natural Uranium
Disposal

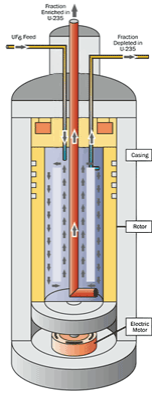
Overview of Fuel Cycle Facilities

- NRC has licensed a broad range of fuel cycle facilities.
  - Category III quantity of material (up to 10wt% U-235, LEU)
    - Facilities handling current LWRs fuel
  - Category II quantity of material (>10wt% and <20wt% U-235)
    - No facilities currently licensed
  - Category I quantity of material (>20wt% U-235, HEU)
    - Facilities producing fuel for U.S. Naval Nuclear Propulsion Program
- NRC oversight of licensed facilities helps ensure compliance and safe and secure operations.

U.S. Fuel Cycle Facilities

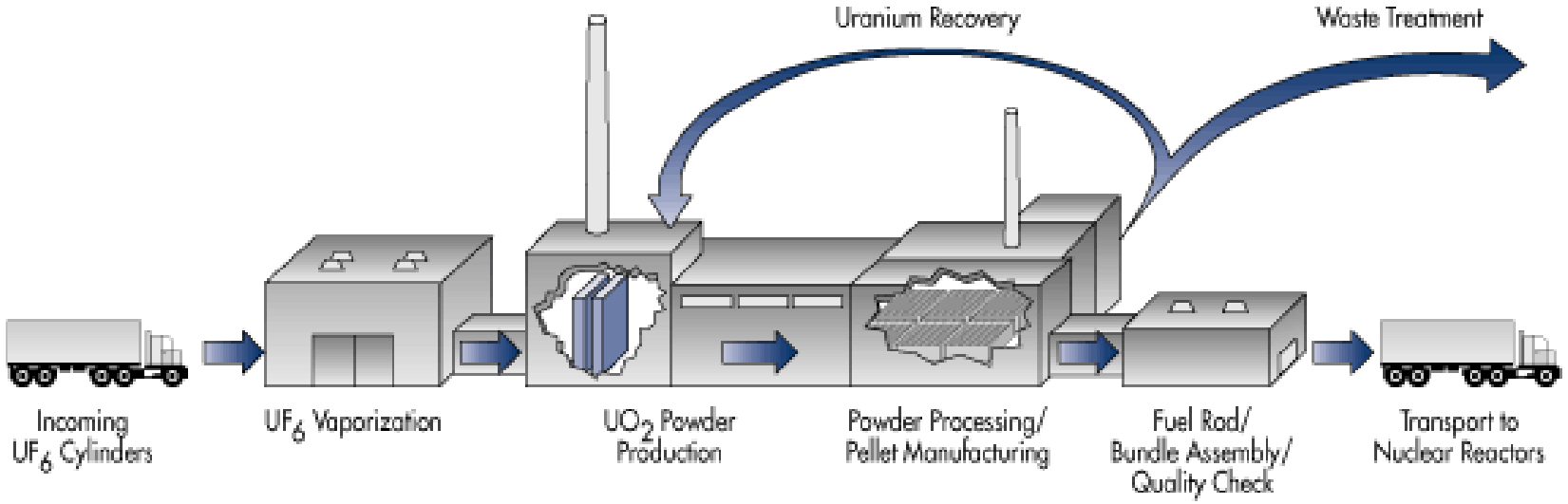
- Uranium conversion
  - Metropolis plant licensed in late 1950s (10 CFR Part 40)
- Enrichment
  - Gaseous diffusion (10 CFR Part 76)
    - Two gaseous diffusion plants previously certified
  - Gas centrifuge (10 CFR Part 70)
    - Urenco USA, currently licensed and operating
    - Centrus, two current licenses
      - Lead Cascade - demonstration facility, currently being decommissioned
      - American Centrifuge Plant – currently processing amendment to conduct demonstration production of HALEU for DOE
  - Laser separation (10 CFR Part 70)
    - Global Laser Enrichment - test loop built and operated





U.S. Fuel Cycle Facilities (continued)

- Fuel fabrication
  - Three LEU facilities, two HEU facilities (10 CFR Part 70)
    - LEU facilities support current LWRs (Category III)
    - HEU facilities support the U.S. Naval Nuclear Propulsion Program, research and test reactors, and special projects (Category I)



NRC's Regulatory Framework for Fuel Cycle Facilities

- NRC has safety, security, and environmental regulations for licensing fuel cycle facilities.
- Reviews include criticality safety, fire safety, radiation protection, chemical safety, emergency planning, security, MC&A, and environmental protection.

Assessment of Existing Regulatory Framework for Fuel Cycle Facilities

- The regulations for fuel facilities are performance-based and can accommodate the variety of fuel types and processes that have been proposed for an advanced reactor fuel cycle.
- Guidance documents for staff and applicants can aid in understanding regulatory requirements and acceptable approaches.
- The NRC continues to review its regulations and guidance documents as it learns new information on potential advanced reactor fuel.

Preparations for Advanced Reactor Fuel Cycle Activities – Fuel Facilities

- NRC staff continues to encourage applicants and technology developers to engage in pre-application discussions with the NRC.
  - The NRC staff has conducted multiple pre-application meetings with one developer (X-Energy) discussing plans for fuel fabrication in an NRC-licensed facility.
- NRC contracted with the national laboratories to identify potential hazards associated with metal fuel fabrication and MSR fuel salt preparation.

Physical Security and MC&A

- Physical security provides early detection and assessment of unauthorized access or activities by an external adversary to SNM and provides an appropriate response.
- MC&A serves to deter and detect any loss, theft, or diversion of SNM for unauthorized use.
- Both sets of regulations take a graded approach, based on the quantity and type of SNM possessed.
- More rigorous requirements apply at higher enrichment levels (e.g., HALEU) and for MC&A, to facilities that process unencapsulated SNM (e.g., fuel cycle facilities).
- DOE-NE is funding technical studies of safeguards for advanced reactor technology, including security and MC&A, and is engaged with NRC staff on the projects.
- NRC can use site-specific license conditions as needed to ensure security and safeguards requirements are fairly and reasonably applied.

Nuclear Nonproliferation and Export Control

- Commercial fuel cycle facilities for advanced reactors would be subject to international safeguards in accord with the U.S.-IAEA Safeguards Agreements.
- These may include reporting of SNM transactions and inventory, providing design information, and possible design verification visits by IAEA.
- The NRC export and import licensing process includes review and consultation with DOE-NNSA and other Executive Branch agencies to ensure appropriate controls on nuclear equipment, components, and material.
- The advanced reactor fuel cycle would have the same controls.
- NRC also works closely with interagency and international groups to support U.S. nonproliferation objectives.

Relevant Activities for Licensing Advanced Reactor Fuel Cycle Facilities

- NRC has a regulatory framework and technical experience that it can apply to the licensing of advanced reactor fuel cycle facilities.
- NRC is monitoring industry plans for advanced reactor fuel facility licensing.
- NRC has collected and documented technical information on advanced reactor fuel processing hazards that will facilitate licensing future fuel facilities.
- NRC encourages pre-application engagements to support an efficient review of new applications and amendments.

Waste Transportation, Storage, and Disposal Overview

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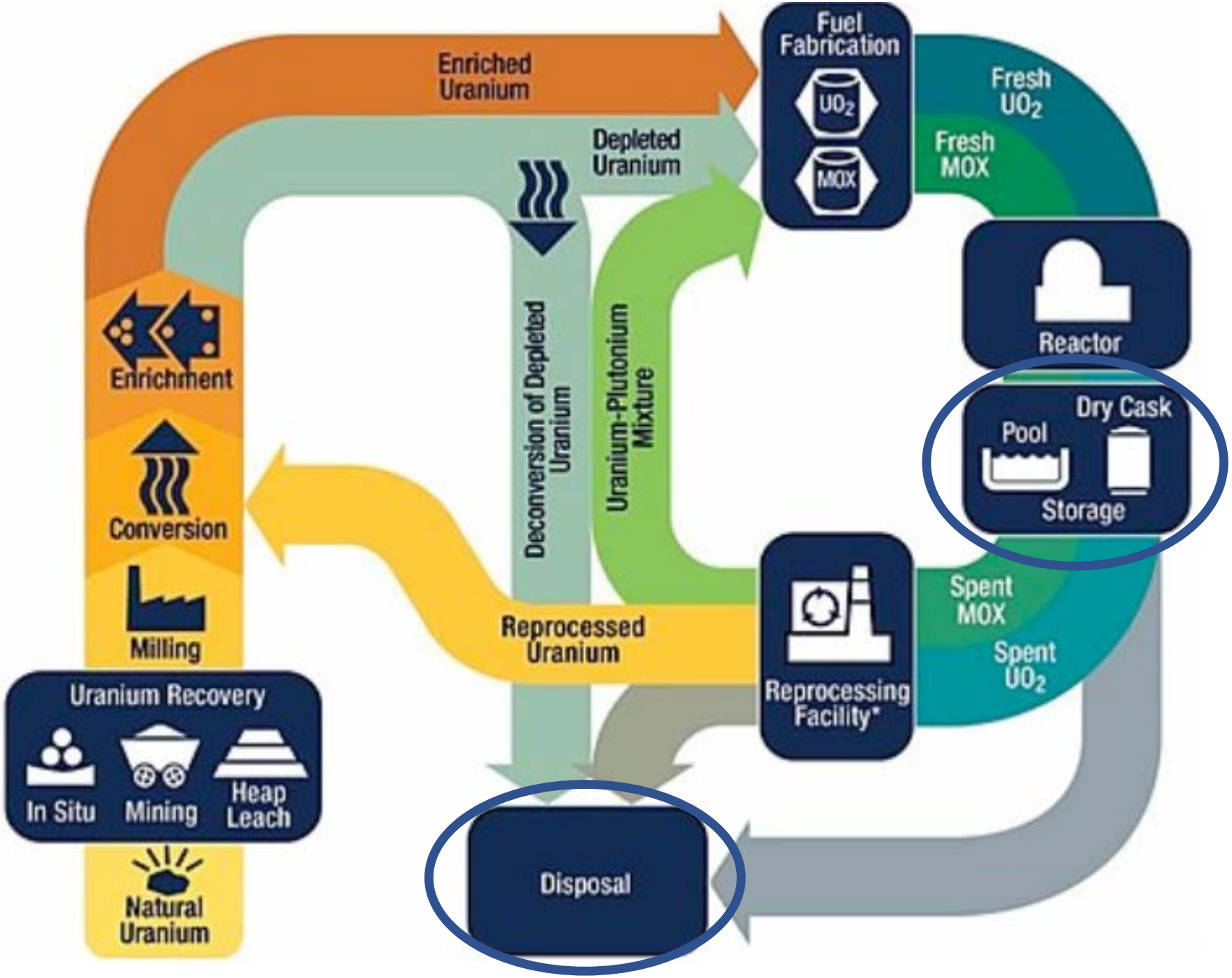
U.S. Nuclear Regulatory Commission


Enriched Uranium
Depleted Uranium
Fuel Fabrication
UO_2
MOX
Fresh UO_2
Fresh MOX
Reactor
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Storage
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Uranium-Plutonium Mixture
Reprocessed Uranium
Reprocessing Facility*
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Spent UO_2
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NRC's Regulatory Framework for Transportation

- NRC and DOT co-regulate transportation of radioactive materials
  - NRC-DOT MOU lays out the agencies' responsibilities
  - DOT regulates carriers, modes of transport (rail, road, air, etc.) (49 CFR Part 170-180)
- NRC establishes regulations for:
  - Package design standards for transportation packages (10 CFR Part 71)
  - Physical security requirements for SNM in transit (10 CFR Part 73)
- NRC roles include:
  - Reviews and issues certificates for transportation package designs
  - Reviews and approves routes and security plans for commercial shipments of spent nuclear fuel
  - Inspects and oversees certificate holders, package fabricators, licensee shippers, and carriers
- NRC certifies several types of transportation package designs:
  - Low-enriched UF_6 overpacks
  - UO_2 powder and pellets
  - Unirradiated reactor fuel (LWR and non-LWR)
  - Irradiated spent nuclear fuel

NRC's Regulatory Framework for Spent Fuel Storage

- NRC establishes safety, security, and environmental regulations for:
  - Licensing of facilities for wet and dry interim storage of commercial spent nuclear fuel
  - Certification of dry storage cask designs for spent nuclear fuel
- NRC safety reviews verify compliance with:
  - Dose limits for workers and the public
  - Radioactive material confinement
  - Nuclear criticality safety
  - Fuel retrievability
- NRC also establishes requirements for:
  - Quality assurance
  - Emergency planning
  - Physical security
  - Financial qualification and decommissioning funding
  - Training and qualifications programs

NRC's Regulatory Framework for Spent Fuel Storage (continued)

- NRC currently licenses and oversees 81 spent fuel storage facilities in 35 states:
  - Over 3,300 dry storage casks in service
- NRC currently certifies 15 different dry storage cask designs for use at reactor sites
- NRC is currently reviewing 2 license applications for consolidated interim storage facilities away from reactor sites

- NRC inspects and oversees applicants and licensees during:
  - Construction, operation, and decommissioning of interim storage facilities
  - Manufacturing of dry storage cask equipment

NRC's Regulatory Framework for HLW Disposal

- Yucca Mountain
  - NRC regulations (10 CFR Part 63)
  - EPA standards (40 CFR Part 197)
- Generic HLW Disposal Standards
  - NRC regulations (10 CFR Part 60)
  - EPA standards (40 CFR Part 191)

- NRC staff is not currently aware of any technical issues that would require changes to its disposal safety requirements to accommodate other fuel types and waste forms and is prepared to support the National Program consistent with statutory direction.

Relevant NRC Activities for Transportation, Storage, and Disposal of Advanced Reactor Fuel

- NRC has approved changes to existing fresh fuel transportation packages for shipment of accident tolerant fuels.
- NRC has experience in the approval of transportation packages and storage systems for TRISO and metallic fuels.
- NRC is completing technical evaluations on transport, storage, and disposal activities of advanced reactor fuel designs to identify potential information needs and determine whether additional updates to safety review guidance may be warranted.
- NRC encourages pre-application engagements to support an efficient review of new applications and amendments.

Concluding Remarks

- The NRC's preparations for regulation of the advanced reactor fuel cycle include the supply of advanced reactor fuel and the management of advanced reactor spent fuel.
- The existing risk-informed and performance-based regulatory framework for licensing and oversight has sufficient flexibility to ensure the safe and secure operation of the complete fuel cycle for advanced reactors.
- NRC staff is coordinating with other agencies to gain insight, develop technical information, and assess industry approaches.
- NRC staff encourages potential applicants to engage early and often in the interest of ensuring complete, high-quality license applications.
- NRC is ready to support the National Program for HLW management consistent with statutory direction.

Acronyms

CFR	Code of Federal Regulations
DFM	Division of Fuel Management
DOE	Department of Energy
DOE-NE	Department of Energy - Office of Nuclear Energy
DOE-NNSA	Department of Energy - National Nuclear Security Administration
DOT	Department of Transportation
EPA	Environmental Protection Agency
HALEU	High-Assay Low-Enriched Uranium
HEU	Highly Enriched Uranium
HLW	High-Level Waste

Acronyms (continued)

IAEA	International Atomic Energy Agency
LEU	Low Enriched Uranium
LWR	Light Water Reactor
MC&A	Material Control & Accounting
MOU	Memorandum of Understanding
MSR	Molten Salt Reactor
NMSS	Office of Nuclear Material Safety and Safeguards
NRC	U.S. Nuclear Regulatory Commission
SNM	Special Nuclear Material
TRISO	Tri-structural Isotropic
U.S.	United States

References

- Commercial fuel facilities
  https://www.nrc.gov/materials/fuel-cycle-fac.html
- Transportation of radioactive material
  https://www.nrc.gov/materials/transportation.html
- Spent fuel transportation
  https://www.nrc.gov/waste/spent-fuel-transp.html
- Spent fuel storage
  https://www.nrc.gov/waste/spent-fuel-storage.html
- Disposal of spent fuel and HLW
  https://www.nrc.gov/waste/hlw-disposal.html
- Advanced reactors (non-LWR designs)
  https://www.nrc.gov/reactors/new-reactors/advanced.html