

Small Modular Reactor Applications to Nuclear Medicine, Maritime Deployment, and Waste Transmutation

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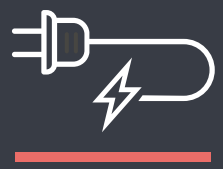
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ARPA-E's Congressional Statute

1 To enhance the economic and energy security of the United States through the development of energy technologies that:



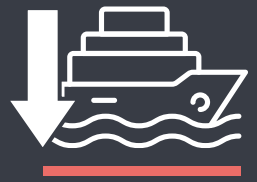
IMPROVE
Energy Efficiency



IMPROVE
Infrastructure Resilience



IMPROVE
Radioactive Waste Management



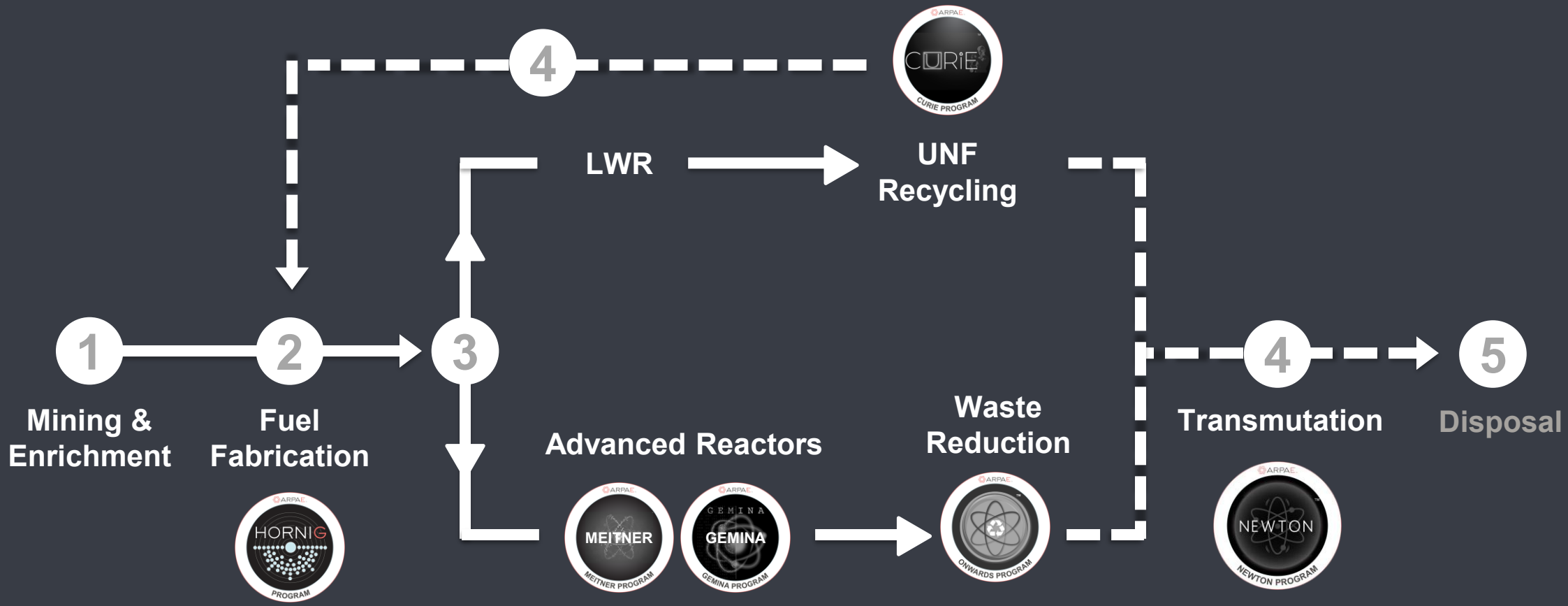
REDUCE
Energy Imports



REDUCE
Emissions

2 To ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies

ARPA-E Fission Portfolio



Accelerator-Based Transmutation: NEWTON

Nuclear Energy Waste Transmutation Optimized Now

- Accelerator-based transmutation of used nuclear fuel components to provide a solution to permanent disposal of difficult nuclear waste streams



Greater than 60% reduction in decay heat



Greater than 90% reduction in radiotoxicity



Greater than 99% reduction in half-life



Increased capacity factor of accelerator-driven systems



Increased resiliency of accelerator components



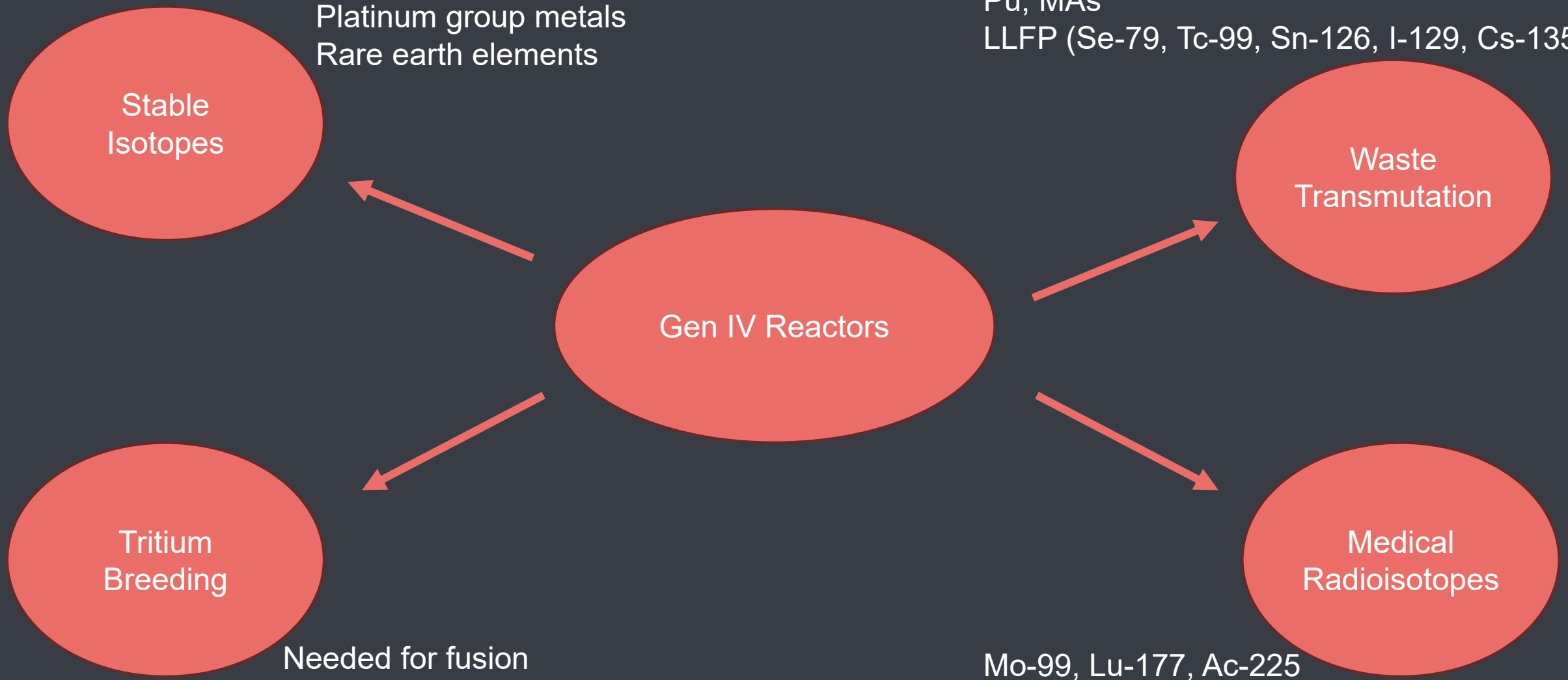
Lower power requirements for accelerators

Category A:
Improved particle generation
High reliability systems, lower OpEx

Category B:
Target Systems
High-throughput systems, reduction of repository footprint

Category C:
System Level Economics
Integrated system design, cost effectiveness vs. other options

Transmutation in Advanced Reactors



Reactor Core Optimization

Design the fuel and reactor to burn these isotopes of interest

Homogeneous vs. Heterogeneous Fueling

Molten Salts + Solid Targets

Homogeneous

Pros	Cons
+ Simplified core design	- Remote handling of fuel
	- Reduced Am/Cm transmutation

Heterogeneous

Pros	Cons
+ Fuel fabrication not affected	- Two production streams
+ Increased Am/Cm transmutation	- Complicates core loading

HORNIG

High-performance Optimized Recycled Nuclear Isotopes for Gen IV reactors

Fuels of interest: Metallic, nitride, TRISO, molten salt

Goal: Create a path to domestic nuclear fuel security by supporting the design, fabrication, and qualification of transuranic (TRU)-bearing fuels.

Overall objectives:

- Enable $10/MWh levelized cost of fuel
- Compress qualification timeline from 20+ years to under 7 years
- Establish the first U.S. industrial base for TRU fuel manufacturing



Small Modular Reactors for Maritime Applications

Offshore Fixed or Floating Applications



Source: Politico



Source: Autonocion

- Powering offshore industry
- Floating/submerged data centers
- Offshore synthetic fuels production
- Desalination
- Coastal Industries
- Ports

Mobile Applications



Source: LNG Industry



Source: Poseidon Expeditions

- Container ships
- Dry cargo ship
- LNG carriers
- Car carriers
- Passenger ship
- Deep-sea tug
- Ice breaker
- Dredging vessel

Serial Manufacturing

Enable the serial manufacture of small modular reactors and microreactors, at rates comparable to airliners (~100 per year), and their deployment into existing and beachhead markets to provide economically competitive electricity costs



Licensing

- Type license for all reactors of same design



Advanced Manufacturing

- High-throughput, high-reliability manufacturing
- Qualification of materials and methods
  - Non-destructive examination methods
  - Advanced joining methods
  - Additive manufacturing techniques
  - Redesigned parts to minimize failure modes
  - Parts of interest: heat pipes, pressure vessels, other safety-critical structures, systems and components

Codes & Standards (C&S) Development and Structure

- 1995 National Technology Transfer and Advancement Act (NTTAA, Pub. L. 104-113)
  - Requires federal government agencies to consider consensus C&S in lieu of Government-specific requirements
  - OMB Circular A-119, “Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities”, provides guidance for implementing NTTAA
  - NRC incorporates some consensus C&S, per 10 CFR 50.55a, into regulations and endorses others as meeting the intent of specific regulations
- Consensus C&S are typically developed/updated by SMEs who volunteer their time and expertise on a part-time ad hoc basis and typically takes years to complete.
- NRC and DOE have previously considered funding a dedicated cadre of SMEs to develop/update C&S, but effort faltered when demand for new nuclear stalled.

Codes and standards are technical positions that govern specific activities (e.g., welding, fabrication, testing and non-destructive examination) that are crucial to establishing and maintaining safe and reliable nuclear operations, and are used by regulatory bodies, designers, manufacturers, operators, and researchers .

DoW Advanced Nuclear Microreactor Programs

ARMY JANUS PROGRAM

- Using fuel enriched to 20% or less U-235
- <20 Mwe
- 5 Companies selected:
  - Antares Nuclear Inc. at Fort Bragg, North Carolina.
  - BWXT Advanced Technologies LLC at Fort Campbell, Kentucky.
  - General Atomics Electromagnetic Systems at Fort Hood, Texas.
  - Radiant Industries Inc. at Fort Benning, Georgia.
  - Westinghouse Government Services at Fort Drum, New York.

•Aligns to EO for *Deploying Advanced Nuclear Technologies for National Security*

- Army Regulated
- Supports Installations and Operational Requirements (deployable)

AIR FORCE ANPI PROGRAM

•Advanced Nuclear Power for Installations (ANPI)

•3-10 MWe

- 3 Companies selected:
  - Buckley SFB, Colorado – Radiant Industries, Inc.
  - Malmstrom AFB, Montana – Westinghouse Government Services
  - Joint Base San Antonio, Texas – Antares Nuclear, Inc.
- NRC regulated, Power Purchase Agreement model
- Air Force funding prototype build and testing

ARPA·E

We Bring Power to Possibility

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