SHINE's Scalable Path to UNF Recycling

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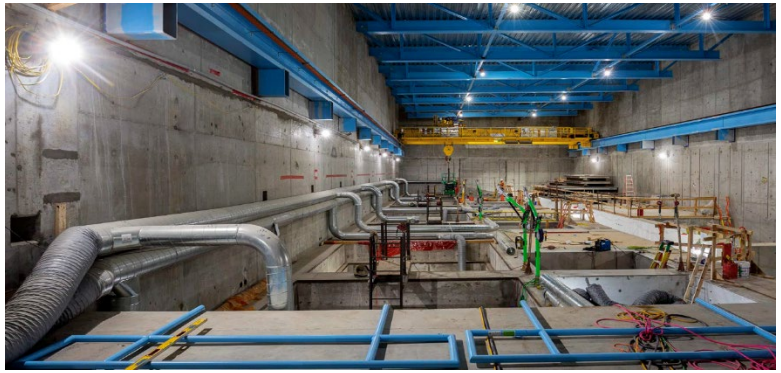
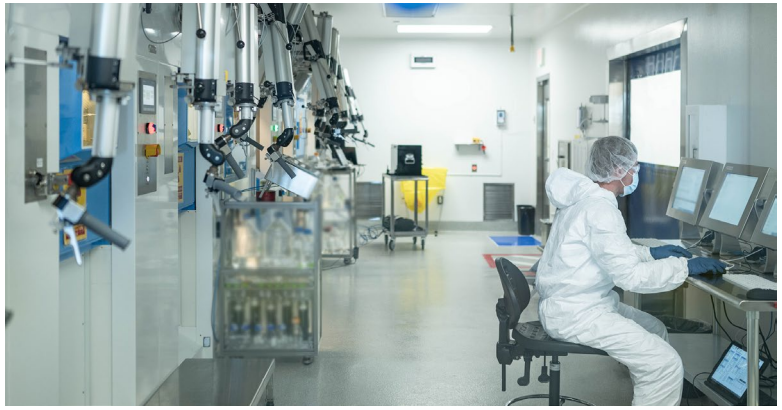
SHINE's Market-Driven Approach To Fusion

VISON: TRANSFORMING HUMANKIND THROUGH FUSION TECHNOLOGY

- Phase 1: Delivering low-yield fusion systems (DD & DT) for 10+ years
  - Years of licensing facilities with activation, tritium, rad waste disposal, etc.
  - Providing commercial neutron radiography and DT irradiation services
- Phase 2: Producing medical isotopes
  - Delivering Lu-177 for cancer treatment; scaling up volume quickly
  - Commissioning Mo-99 facility with 8 fusion systems, fission subcritical assemblies, and liquid U/FP processing
  - Significant experience gained in nuclear construction, licensing, rad waste mitigation/handling, and decommissioning planning
- Phase 3: Applying lessons learned towards aqueous UNF recycling pilot facility and investigating fusion-enabled transmutation
- Phase 4: Scale up transmutation fusion drivers to surpass engineering break-even fusion yields





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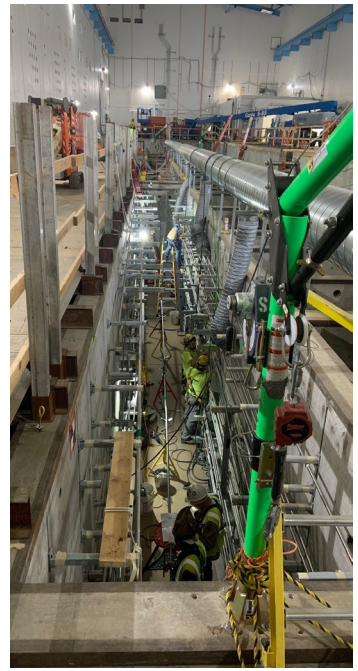
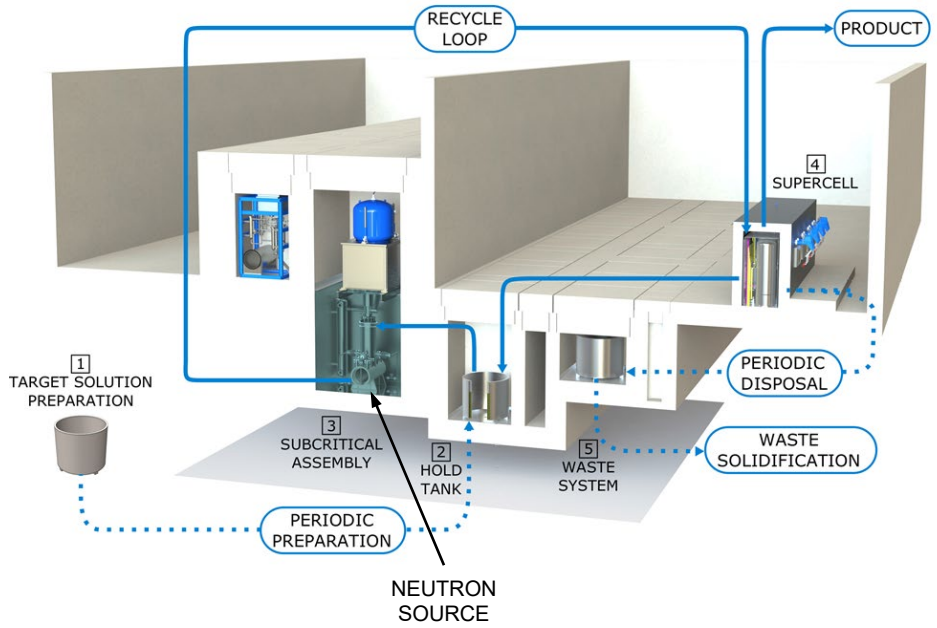
Phase 2: Isotope Production/Separation

- Licensed and constructed. Installing process equipment.
- Facility will produce >50% of US Mo-99 demand
  - **10 CFR Part 50 SER issued in early 2023**
  - 2nd site in Netherlands; site eval and licensing underway
- Production Process
  1. Irradiate aqueous LEU subcritical assembly with DT neutrons
  2. Up to 1 MW of fissions produced
     a. Mo-99 has a ~6% cumulative yield
  3. Transfer UO_2SO_4 to hold tanks and then the “super cell”
     a. Mo-99 extraction, purification, QC & packaging
  4. Final products ship to customers





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Next Phase: Used Nuclear Fuel (UNF) Recycling

ENABLING THE NEXT 100 YEARS OF CLEAN NUCLEAR ENERGY

- SHINE developing a UNF recycling solution to:
  - Provide domestic RecU, MOX, and HALEU alternative
  - Reduce UNF volume and help answer, “what about the waste?”
  - Isolate MA and select FP for further transmutation
- Leveraging unique capabilities
  - Licensing, construction, and commissioning of 10 CFR Part 50 facility
  - Aqueous uranium handling and safety systems
  - Radionuclide separation and handling
- Starting with established technologies to de-risk project
  - Partnering with leaders in this space, such as Orano
- Developing new technologies for improved economics and to ensure US regulatory compliance
  - Working with DOE Labs to leverage expertise and capabilities

SHINE, ANL, and Orano staff touring the La Hauge facility

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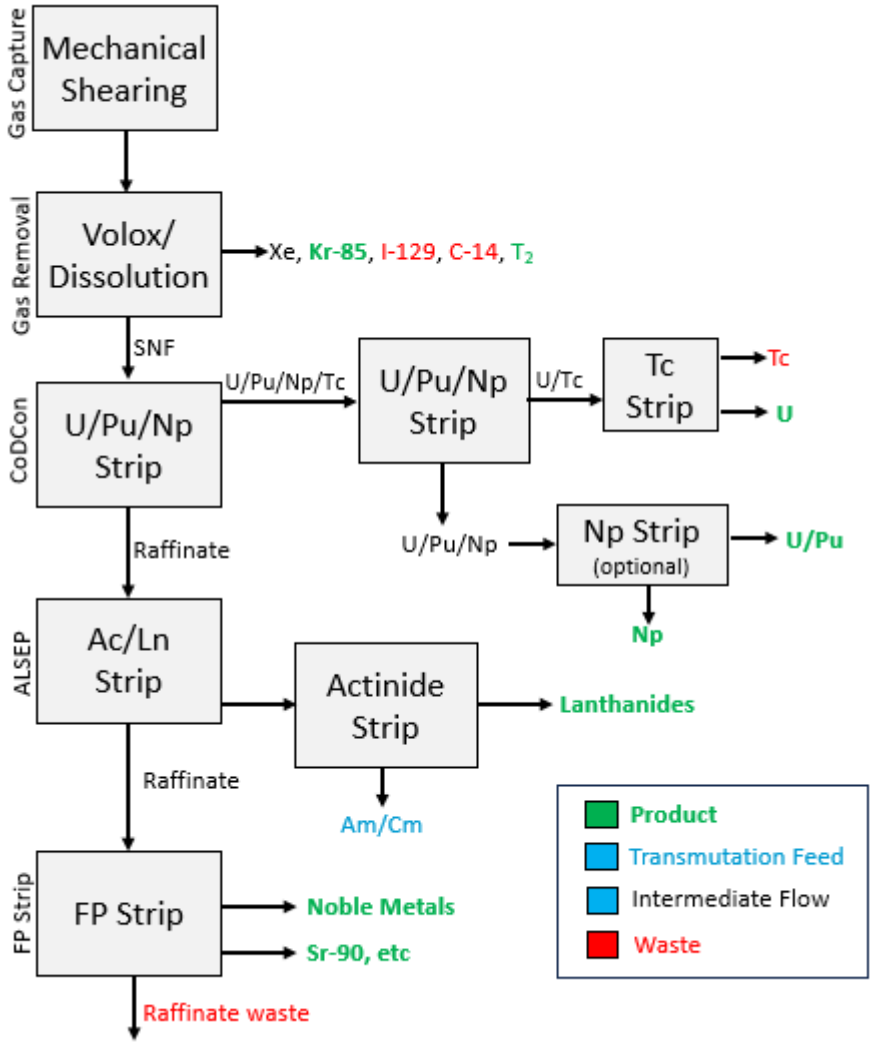
UNF Recycling and Isotope Recovery

NEWLY DEVELOPED TECHNOLOGIES PRESENT UNIQUE OPPORTUNITIES

- Evaluating technology improvements for regulatory compliance and improved economics
  1. Voloxidation for pre-processing fuel assemblies allows isolation of iodine/tritium to avoid liquid contamination
  2. CoDCon extraction to create a **blended U/Pu** stream
  3. Removal of minor actinides (via ALSEP) from the waste stream; future transmutation
  4. Harvest platinum group metals and rare earth elements for sale
     a. Am-241, Kr-85, and Sr-90 are commercial targets as well
  5. >95% of waste volume expected to be suitable for near-surface disposal
     a. Assessing deep bore disposal for remaining 5%

- Approach combines proven and novel technologies and implements SHINE's improved safety and regulatory approach to greatly reduce the lifecycle cost of a recycling facility



Pilot Facility Objectives

- Strategic Goals
  - Full-scale integrated technology and licensing demonstration
  - Sized to fully demonstrate economic potential
  - CP application in late 2025
- Nominal Yield
  - Process 100 MTHM/year
    - Targeting fuel > 40 years old for pilot
- Process Goals
  - Harvest >99% of the U and Pu for new fuel fabrication
  - Extract high-value isotopes (stable and radioactive) for commercial sale
  - Reduce long-term waste disposal cost by >90%
  - Extract long-lived isotopes for destruction through transmutation

- Cost effective first-of-a-kind nuclear construction experience gives SHINE a huge competitive advantage to execute this ambitious project

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Statutory Considerations

- Commercial recycling was halted by President Ford in 1976 (reinforced by Carter in 1977), but President Reagan lifted the ban in 1981
  - Current DOE policy: The United States does not encourage commercial reprocessing but will continue nuclear fuel cycle research and development to assess options as technologies and economics evolve [1].
- Federal policies (and policy gaps) pose a hindrance to commercial recycling of UNF
  - Certainty on waste disposal for waste that is suitable for near surface disposal from a safety standpoint that exceeds class C limits (i.e., GTCC or GTCC-like waste suitable for near-surface disposal)
  - Clarity on value ascribed to the waste volume reductions
- Nuclear Waste Policy Act update needed
  - Recent ruling in Texas shows that courts can use the NWPA to block actions that are outside of the path laid out by congress (i.e., deep geologic repository), risking significant delays and commercial uncertainty
- Rulemaking for update to 40 CFR 190 should be restarted
  - Technical basis for updated limits has already been developed

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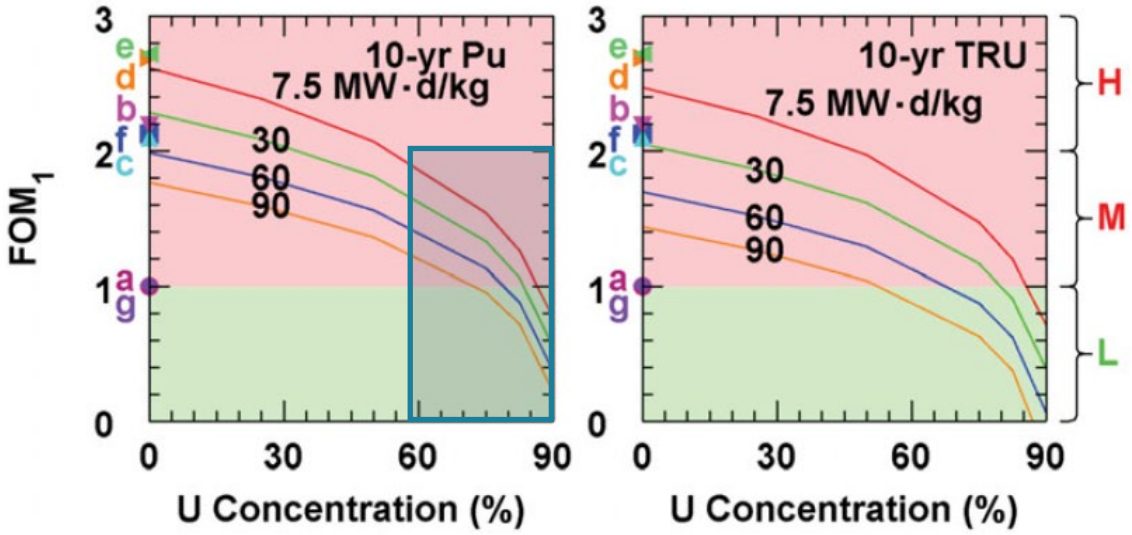
[1] National Security Memorandum (NSM-19), *Countering Weapons of Mass Destruction Terrorism and Advancing Nuclear and Radioactive Material Security*. March 2023.

Nonproliferation Considerations

- CoDCon process ensures no pure Pu stream is produced



FOM_1 of Pu (left) and TRU (right) versus irradiated-uranium concentration for various burnups. The letters H, M, and L denote high, medium, and low attractiveness, respectively. From [1].

- Early assessments being used to optimize design to minimize overall facility risk
  - Security assessment performed by Sandia, evaluating proliferation risk
  - Unmitigated dose analysis providing dispersion and accident risk
  - Material segregation plan and optimized facility layout being developed based on results
- Working with an ANL/Sandia team on a safeguards assessment
- Integrating safety, safeguards, and security into the design at the earliest stage

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[1] Bathke et al. *Materials in Advanced Fuel Cycles for Nonproliferation Scenarios,* 2012

Regulatory Considerations

- NRC has identified gaps to licensing a recycling facility (SECY-09-0082)
  - SHINE has assessed these and believes they can all be addressed in licensing approach for pilot facility
- SHINE strategy and lessons learned
  - Engage with key regulators early and often
    - SHINE began robust engagement with the NRC over years before it formally entered the regulatory process for its Moly-99 production facility, allowing SHINE to develop a regulatory strategy in collaboration with its key regulator
  - Short-term acceptance of a burdensome regulation might shorten a licensing review cycle, but can have long-term consequences to project cost and schedule
    - NRC staff will listen to fact-based arguments on safe alternative approaches and work to find a pathway to approval
  - Use pre-application meetings to gain momentum
    - Focus on topics which support NRC acceptance of the application for review (i.e., ensuring a complete, high-quality application is tendered by the applicant)
- SHINE recycling pilot facility status
  - NRC Project Manager formally assigned in Q2 2023
  - Regulatory engagement plan and first pre-application meeting held in Q4 2023
  - Targeting a CP application in Q2 2025

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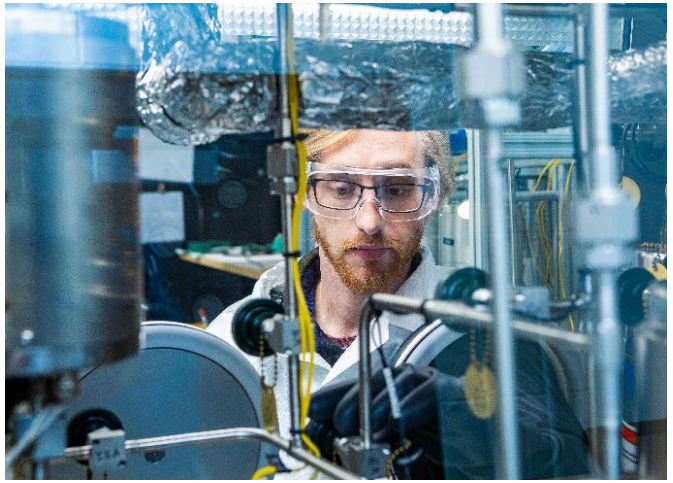
Economic Considerations

- Funding and revenue opportunities
  - Partner with national laboratories where R&D is needed prior to commercialization
  - Performing market validation of output products
    - Commercial utilities (fuel disposition; MOX and RecU sales)
    - Radio/stable isotope customers (public and private)
  - Value in significant reduction of waste volume needing deep geologic disposal
    - Working to understand DOE/Federal appetite for recycling UNF stockpile
    - SHINE willing to provide significant private funding; then collect fees based on processed volume



- Construction/Operation Cost
  - Moly-99 facility costs much lower than conventional FOAK nuclear construction project
    - Graded approach to quality; in-house commercial grade dedication
  - Leveraging lessons learned, especially on seismic matters
  - Utilizing existing project controls, safety analysis, and licensing infrastructure (built over past 10+ years)
  - Government can help by providing loan guarantee programs (like new nuclear power)

Summary: SHINE's Vision

- SHINE is executing its vision by commercializing fusion and related technologies in increasing large and complex markets
- UNF recycling is a strong strategic move for the US
  - Environmentally sustainable approach that significantly mitigates one of the greatest obstacles to broader long-term adoption of nuclear energy
  - Provides critical isotopes domestically
- We are well positioned to aggressively pursue the construction of a pilot facility
  - Proven execution on accelerated regulatory timelines vs. traditional nuclear
  - Proven execution with a cost structure that is more efficient than traditional nuclear
  - Choosing a high-TRL technology foundation to move fast
- Obstacles remain – Our team is tackling technical, economic, regulatory, statutory, and proliferation hurdles in parallel to derisk the program

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