Fuel & HALEU Needs

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Elements of Reactor and Fuel Programs

X-energy

Reactor Development

- Xe-100 Conceptual Design
- X-battery Conceptual Design
- TCF CRADA
- Graphite Qualification
- Heat Transfer Modeling CFD
- Probabilistic Risk Assessment (PRA)
- MST Code Development
- NRC White Paper Development
- NRC Topical Report Development

TRISO-X Fuel Development

- TRISO-based Fuel Development
- Nuclear Criticality Safety Evaluation
- Fresh Fuel Transport Package Evaluation
- Conceptual Layout of Production Module
- Systems Engineering
- TRISO-X Facility Design (Preliminary/Final)
- TRISO-X License Application Development
- NRC Interaction

Key to Deployment of the Advanced Reactor and TRISO-X Fuel Business is HALEU

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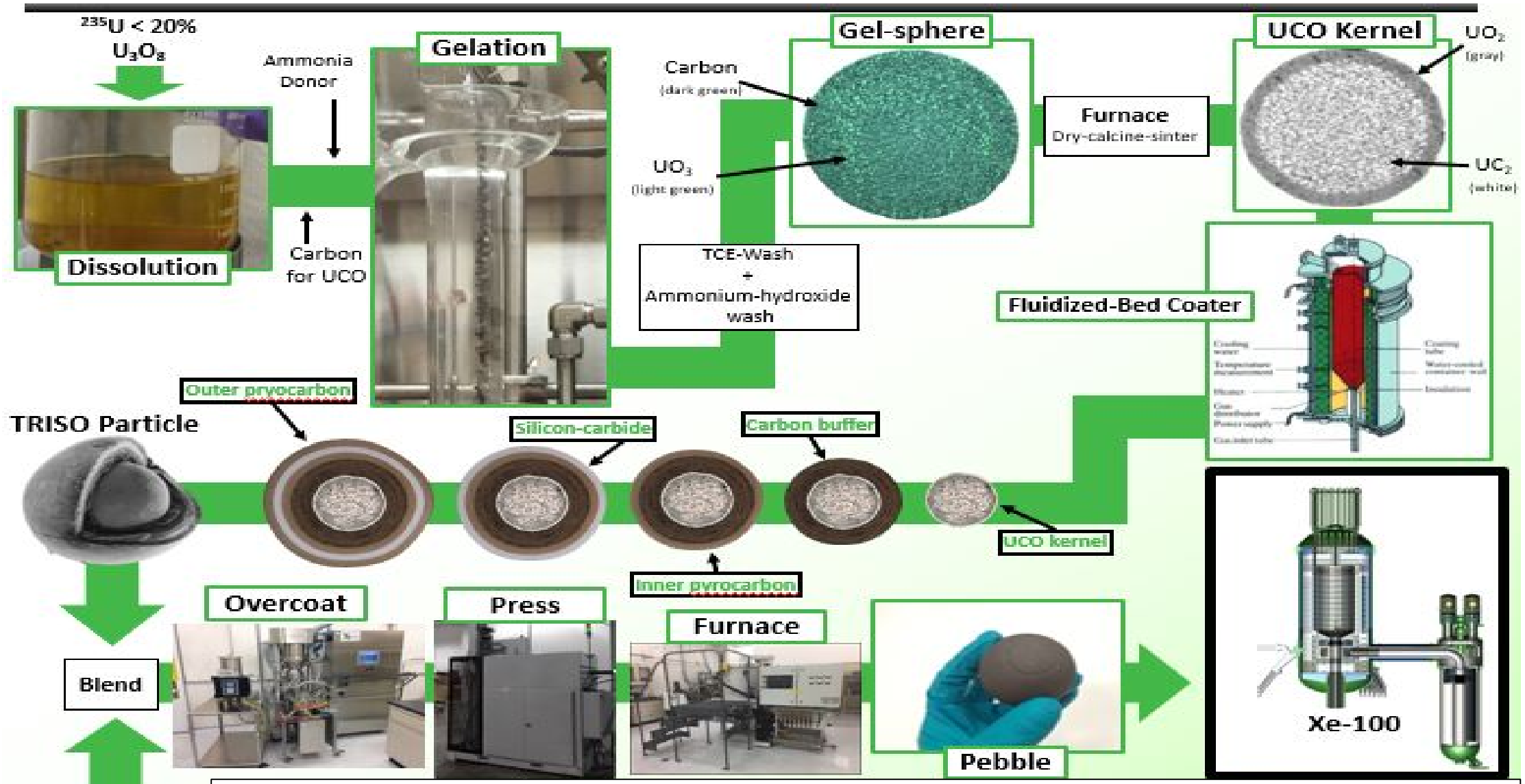
TRISO Fuel Fabrication Overview



HALEU Needed in Oxide Form U_3O_8

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TRISO-X Pilot Facility

TRISO-X Pilot Facility inside ORNL, public/private partnership with X-energy engineers
Ability to produce HALEU fuel elements

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Key Milestones for TRISO-X

Congressman Chuck Fleischmann Participates in Dedication with X-energy and ORNL Leadership

TRISO-X Press Releases

X-energy Dedicates TRISO-X Fuel Fabrication Pilot Line at ORNL
February 27, 2019

X-energy Invited to Submit Part II for DOE Loan Guarantee Application
March 14, 2019

X-energy and Global Nuclear Fuel Announce TRISO Fuel Collaboration
November 6, 2019

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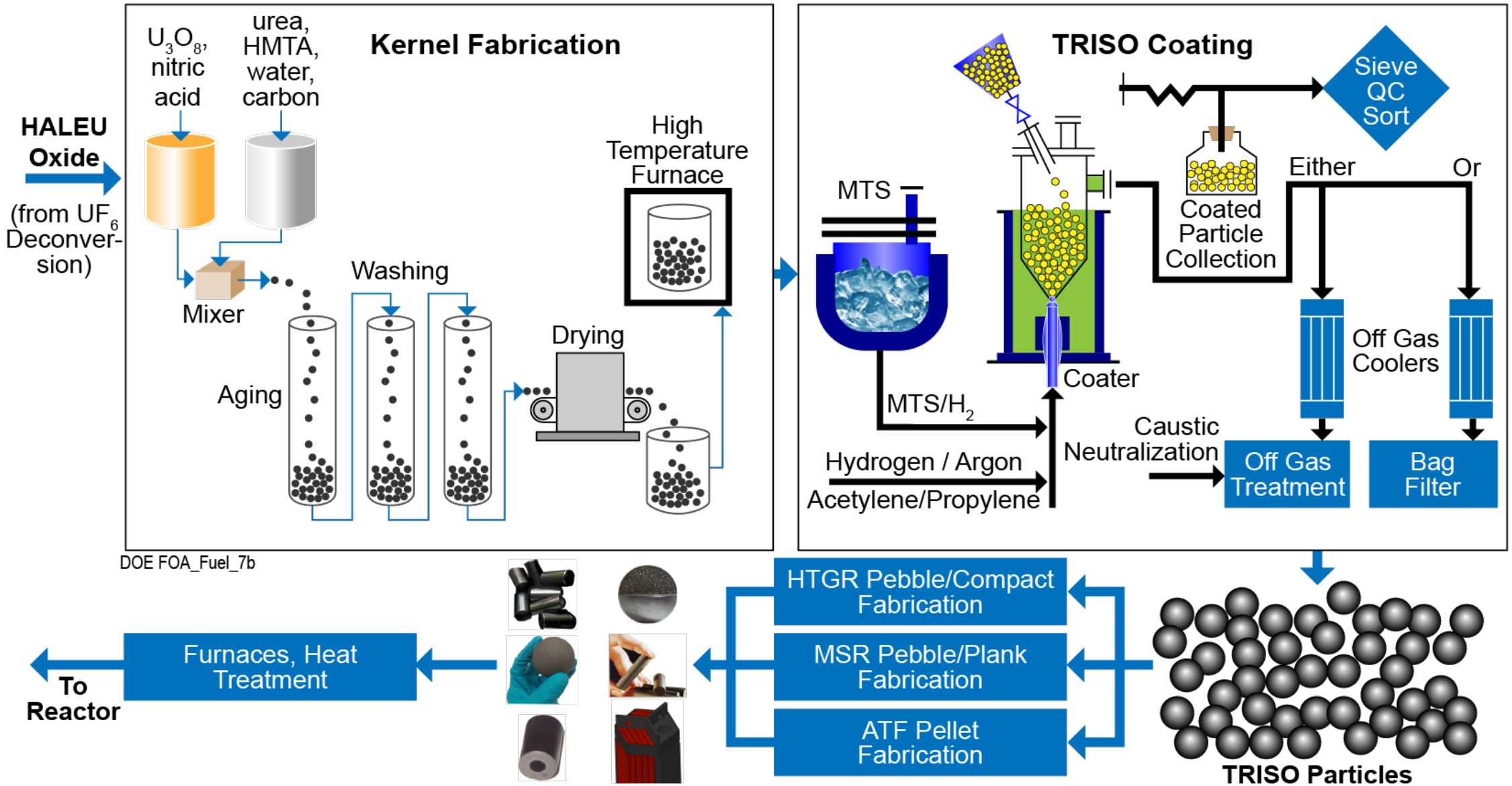
The Cross-cutting TRISO-X Fuel Fabrication Facility



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HALEU Needs and Challenges

- Need HALEU supply chain that mirrors LWR LEU supply chain
  - Mining → Conversion → Enrichment → Fuel Fabrication
- Transport package
  - Production of HALEU is not enough, need NRC approved packages to move material domestically and internationally
- NCS code validation for fuel fabrication
  - X-energy well along the way to V & V of NCS evaluations of equipment and facility layout
- Cost
  - Having a complete supply chain in place is a must, but not sufficient to ensure deployment
  - Costs must NOT be prohibitive
  - On-line calculators are probably unreliable for determining HALEU $ EUP

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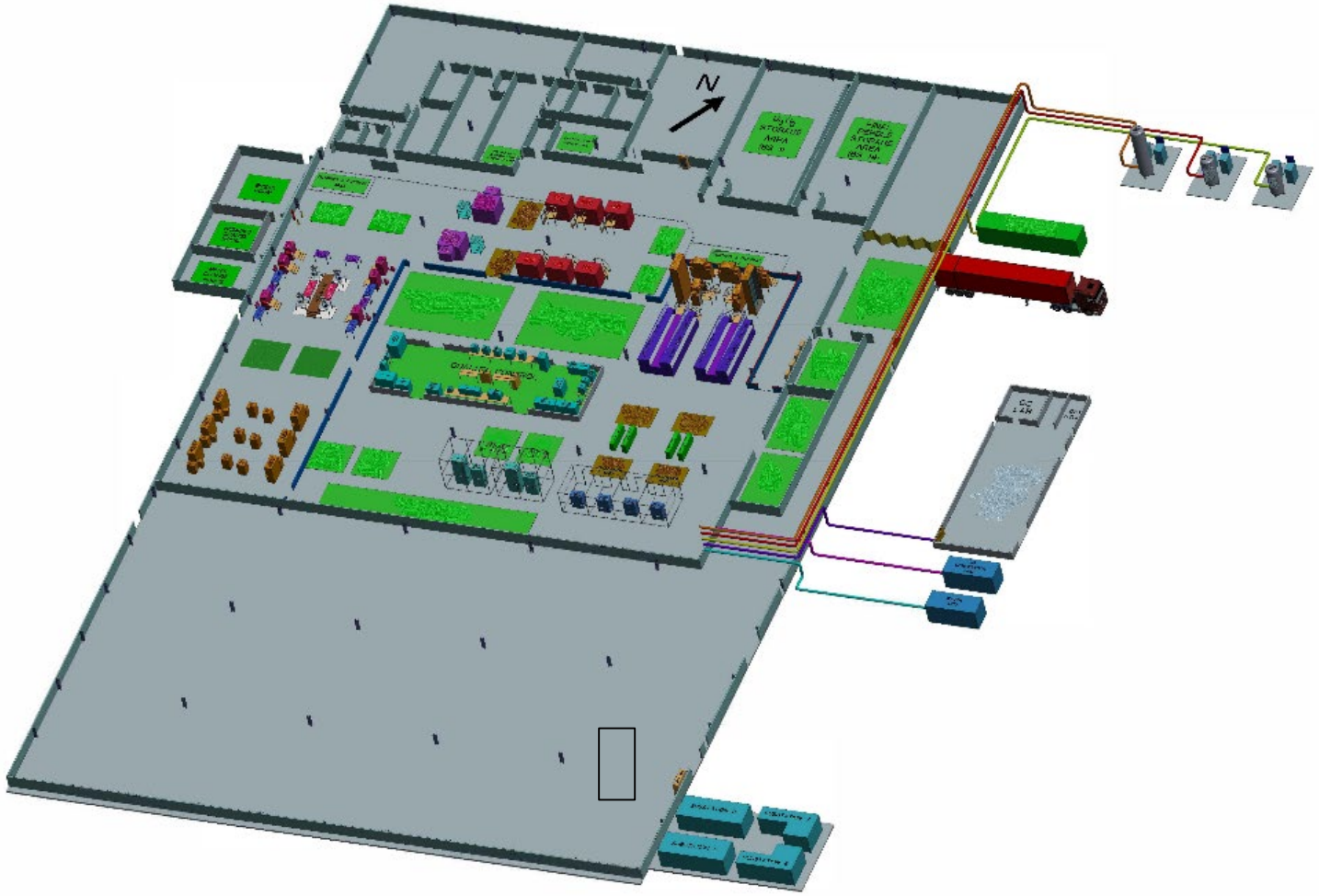
TRISO-X FFF Conceptual Design Complete

- X-energy will receive a Part 70 Cat II SNM license amendment from the NRC
- TRISO-X FFF:
  - ✓ Modular/Scalable design
  - ✓ Already pilot level proven
  - ✓ Lean, NCS compliant layout
  - ✓ Adaptable to multiple fuel forms.
  - ✓ Licensing activities underway
  - ✓ NCS, PHA, ISA all under NRC approved regulations
  - ✓ Designed to 5 MTU capacity to allow Xe-100 expansion and HALEU demand



First US NRC CAT II Facility—NU to 20% enriched U

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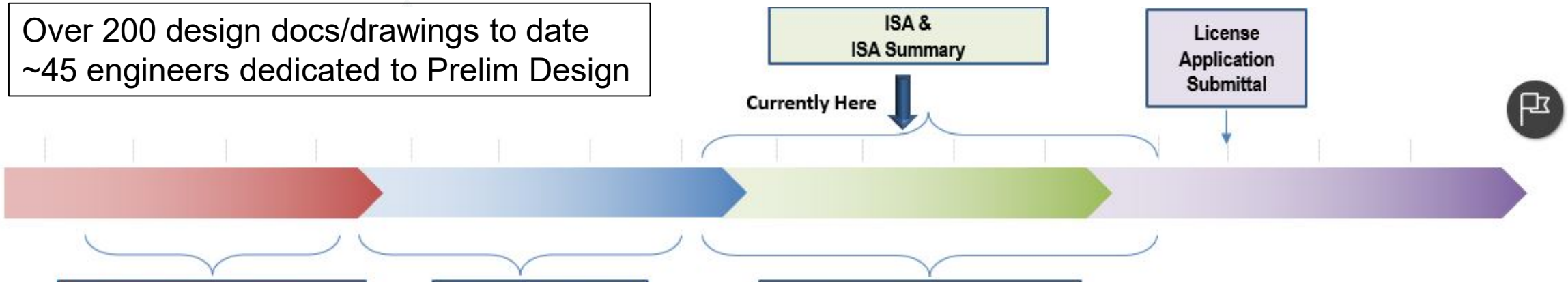
Design and HALEU NCS Licensing Status

Over 200 design docs/drawings to date
~45 engineers dedicated to Prelim Design



Solid NCS Foundation

- NCS Engineer Qualifications
- NCS Orientation to TRISO
- Design Team NCS Orientation
- NCS Program Description (Chapter 5 of License Application)
- NCS Program Procedures
- NCS Software Configuration Control
- SCALE Verification & Validation
- MCNP Shielding Verification & Validation
- NCS Scoping Calculations
- NCS Input for Concept. Design

Preliminary Design & Licensing Support

- Preliminary Nuclear Criticality Safety Evaluations (PNCSEs)
- Design Interface
- License Application Support

Follow-On Support

- Complete Nuclear Criticality Safety Evaluations (NCSEs) based on final design
- Incorporate NCS hazards into ISA
- Complete Criticality Accident Alarms System detector placement calculations
- Complete NCS Program implementing procedures (e.g., oversight, training)
- Develop NCS training program (includes NCS engineer qualification training and basic NCS plant training)

NCS Design Philosophy

NCS is integrated into the design from the onset of the TRISO-X project

NCS limits are based on

Preferred Design Approach

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Summary

- HALEU is the key to deployment of ALL advanced reactors
- A HALEU fuel cycle must be created
  - Enrichment
  - Deconversion
  - Fuel fabrication
  - Transport
- X-energy has addressed HALEU fuel fabrication with the TRISO-X Fuel Facility
- NCS and physical security for CAT II facilties underway
- X-energy supports DOE's HALEU enrichment project in Piketon OH
- Transportation packages must be addressed
- Minimum of 4-6 MTU needed by 2023, if not sooner
- Advanced reactor design funding is useless without a supporting fuel cycle

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