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ELYSIUM INDUSTRIES
Molten Chloride Salt Fast Reactor
Thorium Energy Alliance Conference 10

Website: elysiumindustries.com
Video: https://m.youtube.com/watch?feature=youtu.be&v=pqVt8cxx-44

October 1, 2019

BACKGROUND

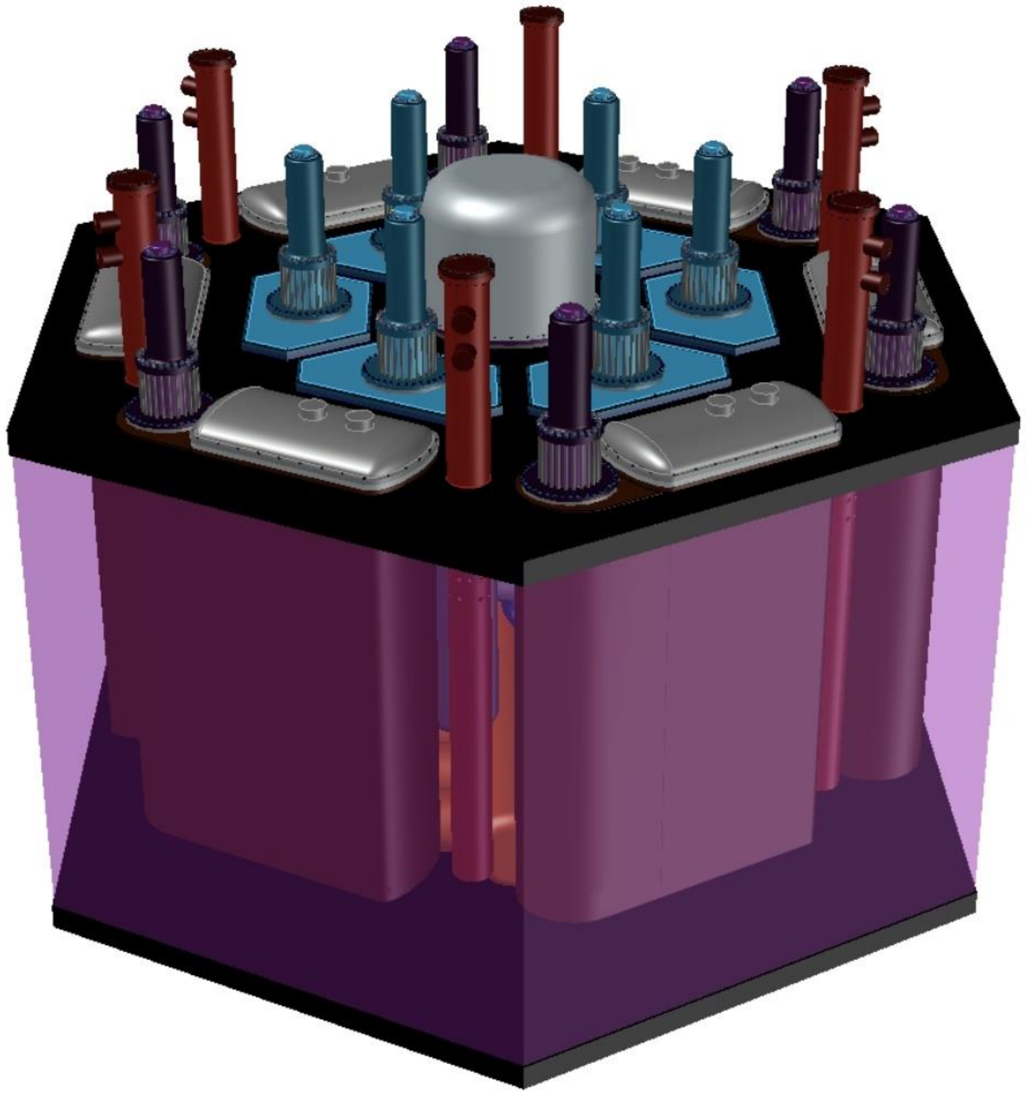
EDWARD PHEIL, CHIEF TECHNOLOGY OFFICER AND CO-FOUNDER

- 34 years experience designing all types of reactors
- Reactor operation and reactor operations trainer
- Reactor design/support for 9 different reactors
  - Los Angeles, Trident, CGN, CVN, Seawolf, Virginia, Columbia, NR-1, Astute, Other
- New reactor or core start up testing for 15 reactors
  - Los Angeles, Trident, NR-1, Virginia
- Jupiter Icy Moon Orbiter
- Extensive design work for reactors of all coolants and the cooling methods
- Consulting at IAEA on Safeguards
  - Reactors: Fission, Fusion, Accelerators, Accelerator Driven Reactors
  - Fuel manufacturing

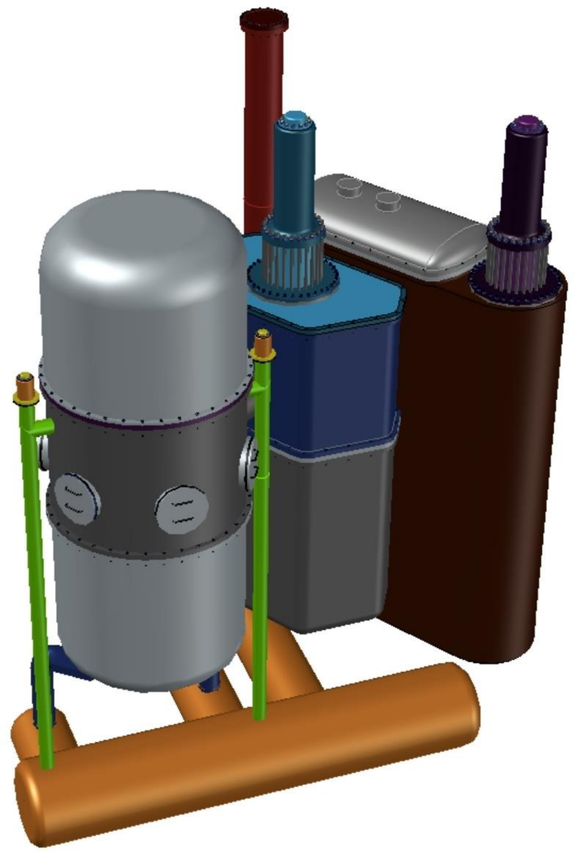
ABOUT OUR TECHNOLOGY

THE MOLTEN CHLORIDE SALT FAST REACTOR (MCSFR)

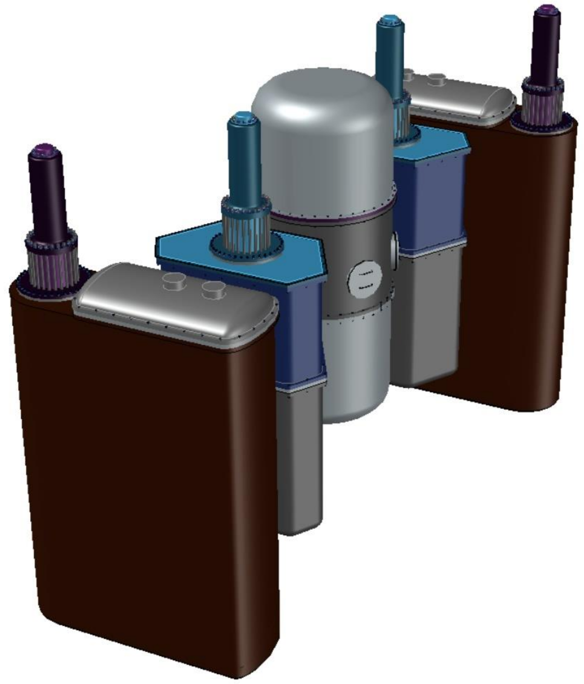
Name	Molten Chloride Salt Fast Reactor (MCSFR)
Neutron Spectrum	Fast Spectrum Neutron Flux
Fuel	Liquid - DU, LEU, SNF, RGPu, WGPu, Th, and Unat, DU
Salt Form	Chloride based Fuel Salt
Thermal Capacity	10 - 3000 – 5000 MWth
Electrical Capacity	4 - 1200 Mwe
Core Outlet Temperature	750-1000 C
Core Inlet Temperature	600 - 650C
Delta Temperature	150-350C
Moderator	None
Operating Pressure	Low



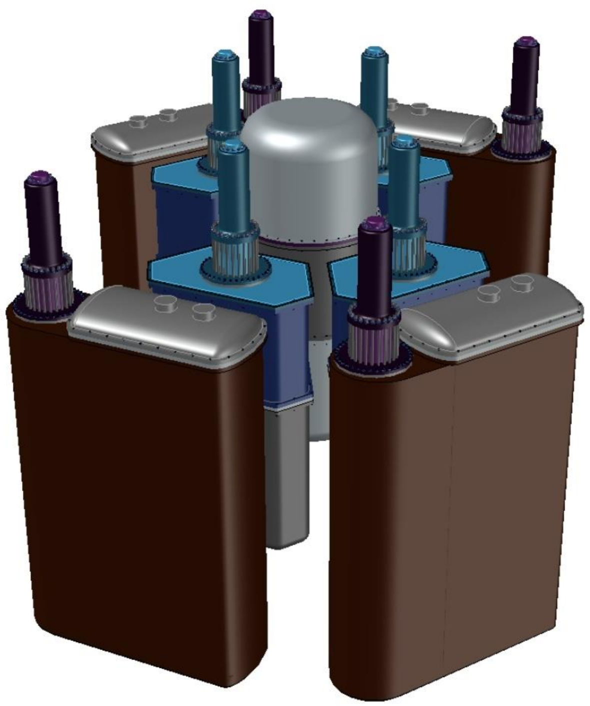
Flexible Power



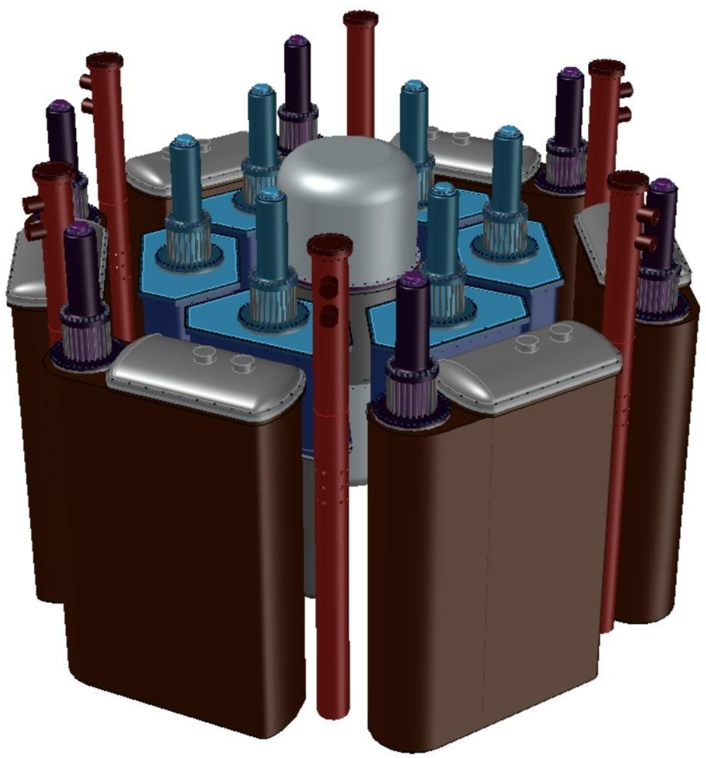
4MWe / 10 MWth
200 Mwe / 500MWth



400 Mwe / 1000MWth



800 Mwe / 2000MWth



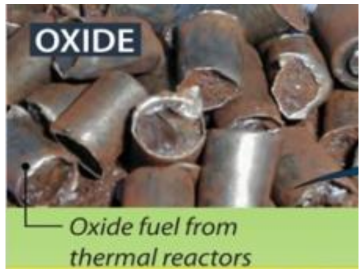
1200 Mwe / 3000MWth
5000 MWth proc. heat

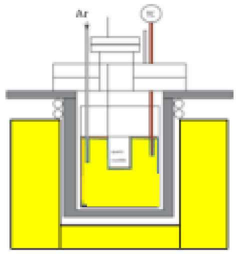
ELYSIUM USED NUCLEAR FUEL CONVERSION – Method I

UNF Method I – UNF w/ Plutonium addition

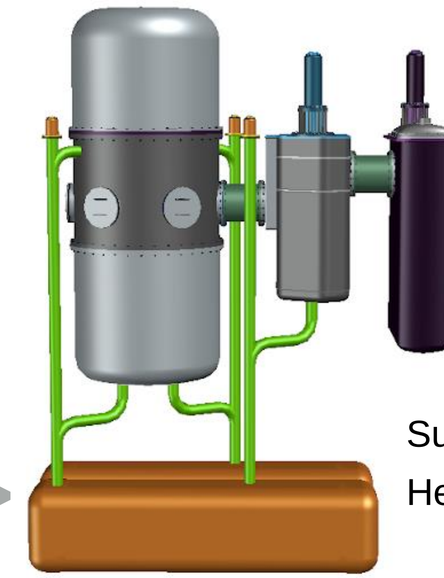
Requires fewer and easier processing steps than existing reprocessing technologies AND requires no separation of proliferation sensitive material

Plutonium Metal or Oxide





Waste Products:
Fission Gas, Cladding, Insoluble Fission Products



Spent LWR/HWR Fuel → Chopping → Liquid Chlorination (Japanese *) → Particulate Filter →

No separation of proliferation sensitive material:

- U/Pu/MA/FP's always kept together
- Main safeguards and proliferation concerns are eliminated

No aqueous processing:

- Decay heat is less of a factor
- Earlier processing possible
- Fewer criticality concerns
- Higher throughput
- Several extra chemical steps vs Method I

■ 100x lower Cost than Purex

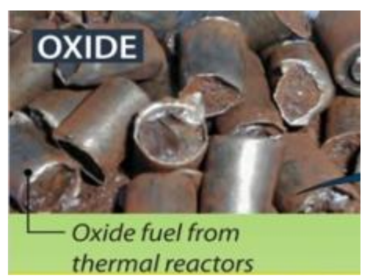
* Y. Sakamara, T. Inoue, et.al. (CRIEPI), J.N. Mat. 340 (2005) pg. 39-51

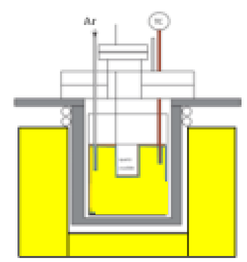
ELYSIUM USED NUCLEAR FUEL CONVERSION – Method II

UNF Method II – Uranium Depletion (No plutonium added)

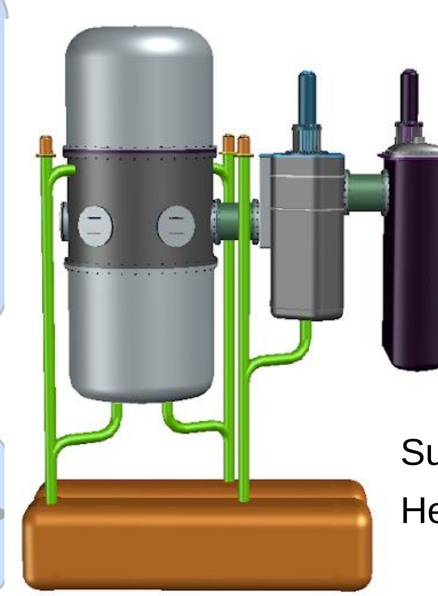
Requires fewer and easier processing steps than existing reprocessing technologies AND requires no separation of proliferation sensitive material

~~Plutonium Metal or Oxide~~





Waste Products:
Fission Gas, Cladding, Insoluble Fission Products



Spent LWR/HWR Fuel → Chopping → Liquid Chlorination (Japanese *) → Partial Uranium Extraction (& Part FP) → Particulate Filter →

No separation of proliferation sensitive material:

- U/Pu/MA/FP's always kept together
- Main safeguards and proliferation concerns are eliminated

No aqueous processing:

- Decay heat is less of a factor
- Earlier processing possible
- Fewer criticality concerns
- Several chemical step more than Method I, but none that isolate the Pu from the U or FP's
- Higher cost than Method I, but >10x lower Cost

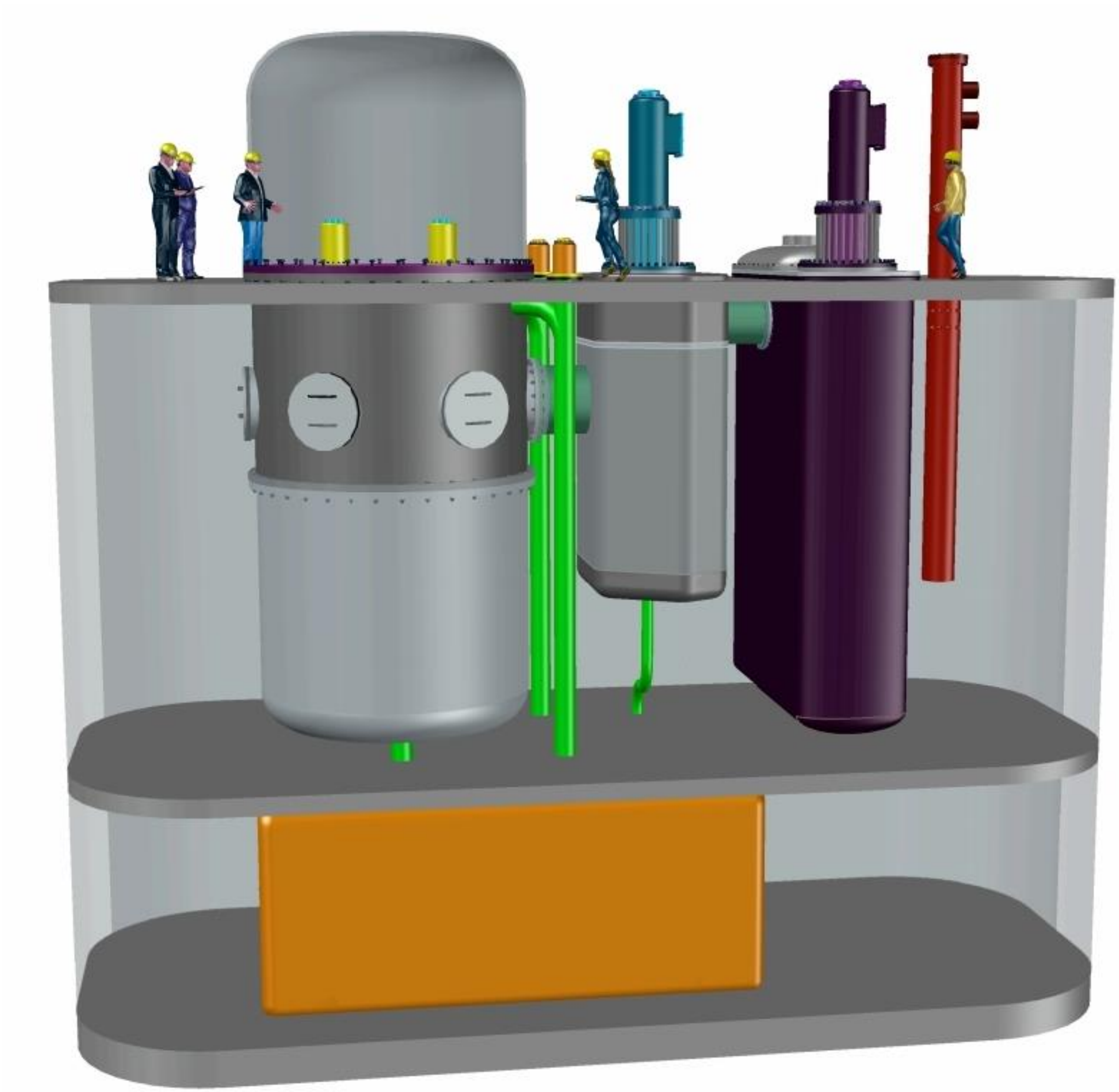
* Y. Sakamara, T. Inoue, et.al. (CRIEPI), J.N. Mat. 340 (2005) pg. 39-51

DEPARTMENT OF ENERGY - GAIN PROJECT

SYNTHESIS OF MCSFR FUEL SALT FROM SPENT NUCLEAR FUEL

Project Title	Synthesis of Molten Chloride Salt Fast Reactor (MCSFR) Fuel Salt from Spent Nuclear Fuel (SNF)
Project Work Scope	1) Assess three different methods for conversion of SNF and metallic fuel to MCSFR fuel salt, recommending best process(es), and 1) Demonstrate the feasibility of the preferred SNF conversion method. Experience will be gained in converting SNF to MCSFR fuel salt, and assess scale-up feasibility.
Testing Location	Idaho National Laboratories
Topic Area	Advanced nuclear fuel development, fabrication and testing (includes fuel materials and cladding)
Project Value	Around US$300,000
Project Timeline	1 year

Decay Heat



Power Conversion

Figure 2: ELYSIUM High Speed Load Following Using a LOEFFLER BOILER (Simple Electricity Only) using existing technology

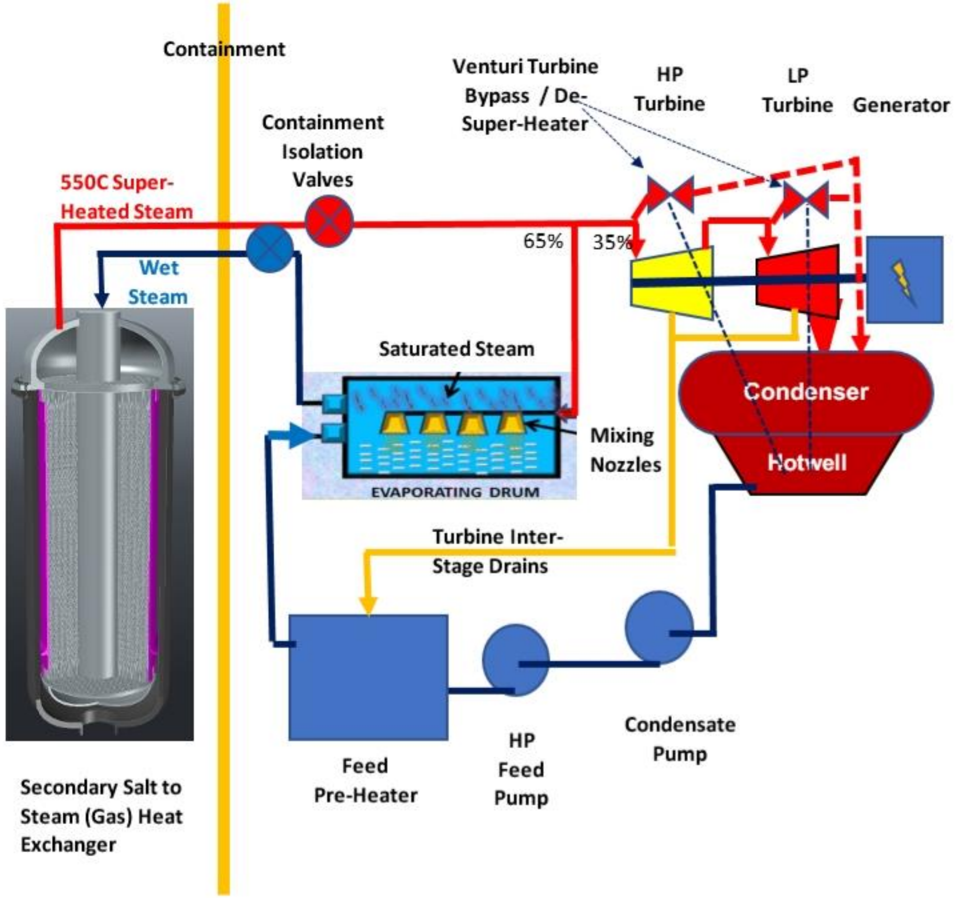
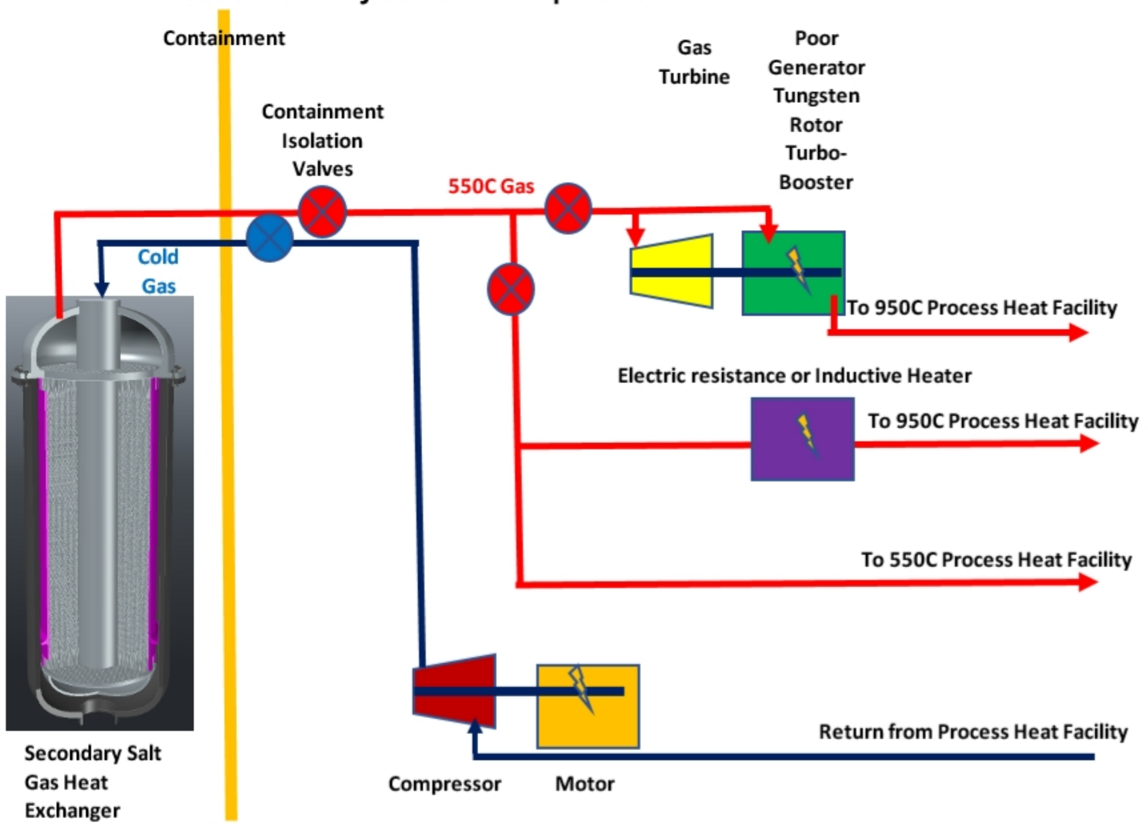
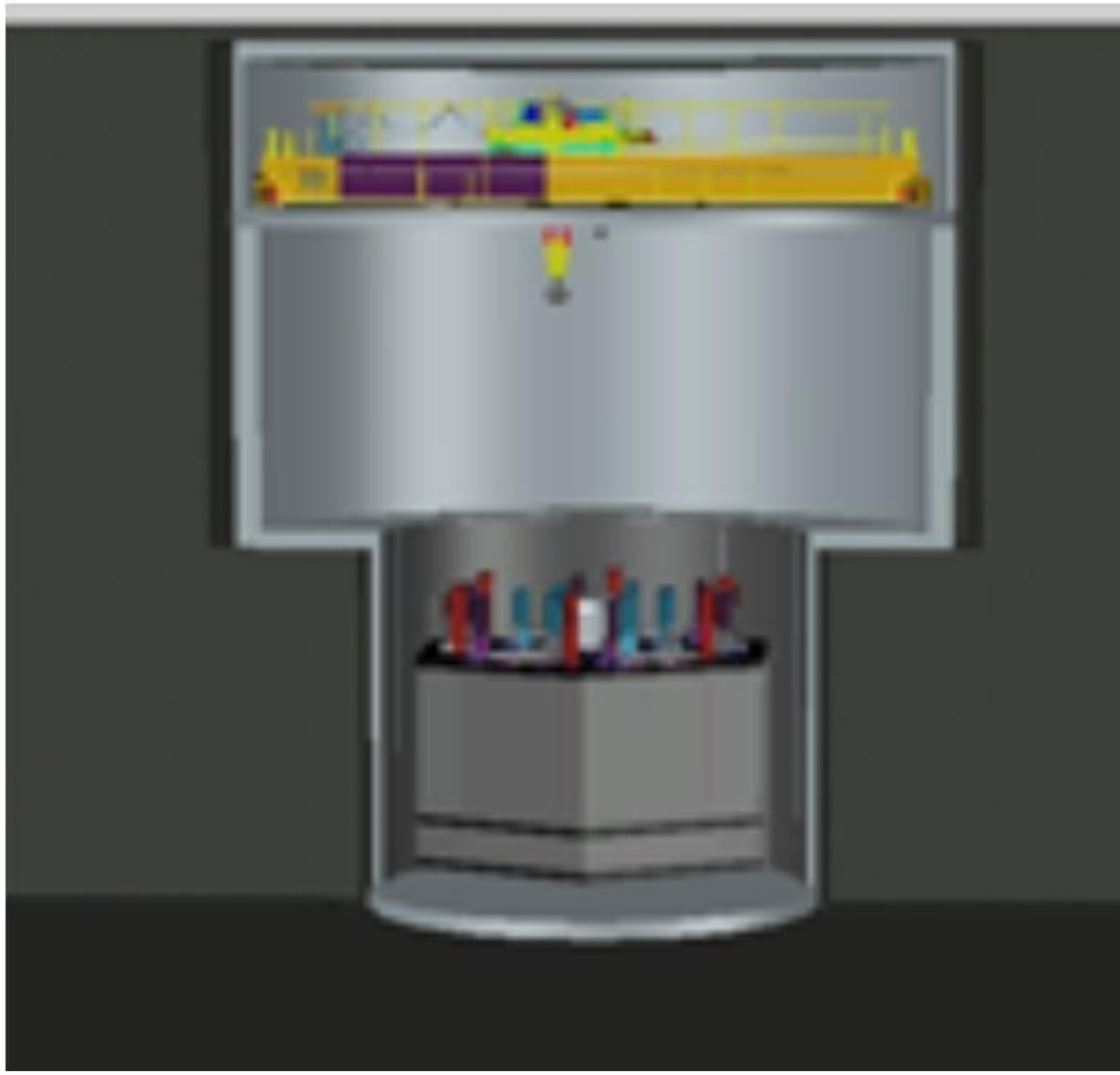


Figure 4: ELYSIUM Process Heat Loop Using same Super-heater Gas Heat Exchanger, Showing Alternative Process Heat Systems & Temperatures



Solving Nuclear Politics

- Cost
  - Liquid Fuel 10x
  - Consume SNF & Pu
  - Low Pressure/KISS
  - Passive Decay heat
  - 85/15 BoP/NSSS
    - Optimize BoP, not NSSS



Solving Nuclear Politics

- Consume proliferation sensitive materials
  - WGPu downblend or convert/RGPu/SNF/HEU/HEU SNF downblend
- Waste Consumption
- Reactor fuel access – 40 year lockup

Why MCSFR vs non-MSR Gen IV

- HTGR
  - Same Temperature capability
  - Low Pressure
  - Lower Flow Rate
  - Much lower COST

- Liquid Metal Reactor
  - Same Low Pressures
  - No Na fire/safety system cost
  - Much higher Temperature/Efficiency “potential”
  - Much lower Fuel cost

Why MCSFR vs MSR Gen IV

- Higher temperatures
- Even Lower fuel cost of waste SNF/Pu
- No graphite cost
- No in-core material damage
- No purification or core fuel/graphite change out, only RV at 40 years.
- No Freeze seals functionality concerns
- Reduced water near any salt
- Optimize power plant cost 85% vs NSSS 15%
- Modular power scale up without new reactor

Current Work

- DOE GAIN Fuel Cycle confirmation
- DOE FOA Fluids confirmation
    - Open Core/Heat Exchanger
- Optimize Balance of Plant
    - Cost is priority/Not efficiency
- Develop US Prototype
    - Simple/Small (10 MWth)
    - Non-Power
    - Building Consortium
    - Building Supply Chain
- First Production Reactors buyer identified