ELYSIUM INDUSTRIES
Molten Chloride Salt Fast Reactor
Thorium Energy Alliance Conference

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

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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)

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

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

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

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 steps 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

# 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