Leading the Way to A Bright Energy Future

Bringing GenIV to Market:
A Vendor’s Perspective

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Terrestrial Energy Inc.
The value of molten salts – IMSR® safety case

Central challenge is heat dissipation in all circumstances
Central pillar of Safety Case

**CONTROLL**
- Strong negative reactivity coefficient of temperature
- Passive shutdown Safety Case

**COOL**
- Assures heat dissipation in all circumstances
- Fuel is a molten salt and also the coolant
- Enables convective and natural circulation cooling to move heat internally
- Vessel wall at ~600 °C
  - Extremely effective radiative cooling

**CONTAIN**
- Chemical containment
  - Salts chemically bind volatile fission products, Cs, I etc...
- No chemical driving forces
- Zirconium Metal-Water reactions absent
- No physical driving forces
  - Operates at one atmosphere

IMSR® Safety Case achieved with simple, natural and passive mechanisms that are secure and robust

*IMSR® has a Safety Case to drive cost reduction*
What is Terrestrial Energy’s IMSR®?

• Integral Molten Salt Reactor
• MSR-Burner design, ~2% LEU startup and <5% LEU makeup
• Integrates all primary systems into a sealed reactor vessel
• 7 year Core unit “Seal and Swap” approach to graphite lifetime
• Planned as 400 MWth (~ 190 MWe)
• 3.6 m wide Core-unit for eased transportability
• Safety at forefront which leads to cost innovation
• 2020’s deployment the goal
How an IMSR® power plant works

- **Fuel-Salt Pump Drive Motors**
- **Secondary Coolant Salt (non-radioactive)**
- **Secondary Coolant Heat Exchanger**
- **600°C INDUSTRIAL SOLAR SALT LOOPS**
- **Power Generation**
- **GRID SERVICES**
- **CHEMICAL SYNTHESIS**
  - H₂
  - NH₃
  - Syn-fuels
- **PROCESS HEAT USES**
- **H₂O DESALINATION**

**IMSR® CORE-UNIT**
IMSR® is for industrial heat use and electric power provision

IMSR® Nuclear Island produces 600 °C industrial heat. Balance-of-Plant can be a broad range of industrial applications – not just power provision
IMSR® - Pragmatic Design Decisions

- 7 year Core-unit replacement
  - Allows advantages of graphite moderation
  - Simplifies vessel and heat exchanger code qualification
- Soft spectrum
  - Very low enrichment startup and 4.95% makeup
- Inexpensive carrier salt
  - Avoids tritium production of $^7\text{LiF}$ or $\text{BeF}_2$
- Strongly negative temperature coefficients
  - Inherent load following & passive shutdown...control rods not needed
- Large reduction in Pu waste production while avoiding any salt processing
- Greatly simplified Off-Gas management
- Passive decay heat removal
  - Innovative closed cycle gas (similar to RVACS)
Demonstrating design licensability is key to commercial progress in the nuclear industry

- **IMSR®** has successfully completed CNSC Vendor Design Review Phase 1
- A nuclear industry first for a Generation IV reactor

Process has been very beneficial to TEI, much learned on both sides

Terrestrial Energy has recently started VDR Phase 2

- For now, only GenlIV system at this stage

Terrestrial Energy’s successful completion of VDR Phase 2 will be catalytic

- Regulatory statement of “No fundamental barriers to licensing” viewed by TEI as key to Utility confidence
<table>
<thead>
<tr>
<th>Vendor</th>
<th>Name of design and cooling type</th>
<th>Review start date</th>
<th>Status</th>
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<tbody>
<tr>
<td>Terrestrial Energy Inc.</td>
<td>IMSR Integral Molten Salt Reactor</td>
<td>April 2016</td>
<td>Phase 1 complete</td>
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<td></td>
<td>December 2018</td>
<td>Phase 2 assessment in progress</td>
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<tr>
<td>NuScale Power, LLC</td>
<td>NuScale Integral Pressurized Water Reactor</td>
<td>Pending early 2019</td>
<td>Service agreement under development</td>
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<td>Ultra Safe Nuclear Corporation / Global First Power</td>
<td>MMR-5 and MMR-10 High Temperature Gas</td>
<td>December 2016</td>
<td>Completion expected October 2018</td>
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<td>Pending late 2018</td>
<td>PHASE 2 Service Agreement in place – Project start pending</td>
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<tr>
<td>Westinghouse Electric Company, LLC</td>
<td>eVinci Micro Reactor Solid core and heat pipes</td>
<td>Pending early 2019</td>
<td>Service agreement under development</td>
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<tr>
<td>LeadCold Nuclear Inc.</td>
<td>SEALER Molten Lead</td>
<td>January 2017</td>
<td>Phase 1 on hold at vendor's request</td>
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<td>Advanced Reactor Concepts Ltd.</td>
<td>ARC-100 Liquid Sodium</td>
<td>Fall 2017</td>
<td>Phase I assessment in progress</td>
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<td>URENCO</td>
<td>U-Battery High-Temperature Gas</td>
<td>To be determined</td>
<td>Service agreement under development</td>
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<td>Moltex Energy</td>
<td>Moltex Energy Stable Salt Reactor</td>
<td>December 2017</td>
<td>Phase 1 assessment in progress</td>
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<tr>
<td>SMR, LLC. (A Holtec International Company)</td>
<td>SMR-160 Pressurized Light Water</td>
<td>July 2018</td>
<td>Phase I assessment in progress</td>
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<tr>
<td>StarCore Nuclear</td>
<td>StarCore Module High-Temperature Gas</td>
<td>To be determined</td>
<td>Service agreement under development</td>
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Why the influx to Canada?

- Canada only moderate future energy expansion but generally favorable views on nuclear power and the need for greenhouse gas reduction
- Regulatory environment sees favorable aspects
- At risk of oversimplification;
  - Canadian and UK systems more Performance or Principles based
  - US NRC more Prescriptive based on 60 years of LWR experience
- CNSC’s Pre-licensing process is also more a staged gate approach
  - Aligned better to milestone based investment of the private sector
- Appears to be a healthy world cooperation between regulators to assure the safe and timely arrival of GenIV systems to a world in need of clean, cost competitive and scalable energy.
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