Supercritical Water-Cooled Reactor (SCWR) Development through GIF Collaboration

GIF SCWR System Steering Committee

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Outline

• Why SCWR?

• SCWR Reference Parameters

• Conceptual Designs under Consideration

• GIF Collaborative R&D Projects

• Conclusions
Why SCWR?

- Merging proven advanced nuclear and fossil technologies
- Many utilities operate both nuclear and supercritical fossil plants
Supercritical Water-Cooled Reactor

• Many years of experience in
  – Advanced water-cooled reactor
  – Supercritical fossil plant development

• Proven advanced concepts and systems
  – Advanced passive safety systems
  – Supercritical turbine technology

• Main challenge
  – Combine advanced reactor technology with supercritical fossil technology
SCWR Features

• Improved economics
  – Higher thermal efficiency
  – Plant simplification opportunities
    » Once-through reactor
    » Direct thermodynamic cycle

• Enhanced safety, sustainability, proliferation resistance and physical protection
  – Design flexibility for fast and thermal spectra
  – Opportunities to utilize conventional or advanced fuel and fuel cycles

• Applications
  – Design for electricity production
  – Hydrogen and heat generation
SCWR Reference Parameters

- **Design possibilities**
  - Pressure vessel or pressure tube
  - Thermal or fast spectrum
  - Fuel choice
  - Moderator Choice
- **Several designs are under consideration**
  - Most R&D is common to these designs
- **Design activities to define R&D needs**
  - System Integration and Assessment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference Value(s) [unit]</th>
</tr>
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<tbody>
<tr>
<td>Pressure Boundary</td>
<td>Pressure Vessel (PV) or Pressure Tube (PT)</td>
</tr>
<tr>
<td>Neutron Spectrum</td>
<td>Thermal, Fast, or Mixed</td>
</tr>
<tr>
<td>Burnup (Thermal / Fast)</td>
<td>Up to 60/120 [GWd/tHM]</td>
</tr>
<tr>
<td>Fuel</td>
<td>UO₂, MOX, or thorium</td>
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<tr>
<td>Fuel Cycle</td>
<td>Once Through or Closed</td>
</tr>
<tr>
<td>Moderator</td>
<td>Light Water or ZrH₂ (PV) or Heavy Water (PT)</td>
</tr>
<tr>
<td>Coolant</td>
<td>Light Water</td>
</tr>
<tr>
<td>Electric Power</td>
<td>Up to 1700 [MWe]</td>
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<tr>
<td>Operating Pressure</td>
<td>25.0 [MPa]</td>
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<tr>
<td>Core Outlet Temperature</td>
<td>Up to 625 [°C]</td>
</tr>
<tr>
<td>Thermal Efficiency</td>
<td>Up to 50 [%]</td>
</tr>
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Two SCWR Design Options

Pressure Vessel Option

Pressure Tube Option
A number of designs are under consideration to provide a spectrum of possibilities for consideration for the next generation of water-cooled reactor technology.

- **Super Fast Reactor (Japan)**
- **HPLWR (Eu)**
- **CANDU-SCWR (Canada)**
- **SCWR-SM Fuel Assembly with a Solid Moderator (Korea)**
GIF Collaborative R&D

- **GIF SCWR collaborators**
  
  **Members**
  - Canada
  - Euratom
  - Japan

  **Observers***
  - Republic of Korea
  - France

- **Most of the R&D is common to all designs under consideration**

*China is a recent GIF member whose R&D Institutes are “invited observers”*
GIF Collaborative R&D Project: System Integration and Assessment

- Definition of a reference design(s) that meets the GIF Goals:
  - Economics
  - Safety and reliability
  - Proliferation resistance and physical protection
  - Sustainability

- Identification of an achievable outlet temperature based on materials and fuel performance, and linkages to proven steam cycles in supercritical fossil plants

- Design and construct an in-reactor fuel test loop to qualify the reference fuel design.
GIF Collaborative R&D Project: Thermal-hydraulics and Safety

- Establishment of heat transfer and critical flow database for SCWR designs
- Heat transfer tests at prototypical SCWR conditions
- Stability
- Safety system requirements and evaluation
GIF Collaborative R&D Project: Materials and chemistry

- Testing of key materials for in-core and out-core applications
- Selection of key materials for SCWR designs
- Reference chemistry based on materials compatibility and radiolysis behavior
Other R&D Projects

• R&D for specific designs
  – Advanced fuel and fuel cycles
    » Thorium for the pressure-tube design
    » Fast core and mixed core options for the pressure vessel design
  – Non-electricity applications (e.g., hydrogen production)

• Projects to build major test facilities to qualify certain aspects of the SCWR (e.g., in-reactor fuel qualification loop)
Conclusion

• The SCWR has a strong foundation in two advanced technologies
  – Advanced Gen-III+ water-cooled reactor technology
  – Advanced supercritical fossil power technology
• Flexibility in design options to address GIF requirements
• Most R&D needs are common to all designs under consideration
• Major collaborative R&D projects are underway to address R&D needs