Nuclear Cogeneration Industrial Initiative

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Outline (7 min)

1. **Summary**
2. **Technical Characteristics**
3. **Maturity for deployment of industrial heat supply**
4. **Remaining challenges (technical, licensing)**
5. **TRISO fuel: Reliability and availability**
6. **Waste**

1. Summary

- HTR: process heat > 600°C → displace fossil (electricity, steam, H_2, synfuel) in energy-intensive industries → energy security and climate change mitigation
- Inherent safety: collocation, small EPZ, public acceptance?
- Large market, boundary conditions for deployment getting clearer
- Current R&D focus (GIF, IAEA, OECD-NEA) is on licensing, demonstration, and deployment.
- Example GIF:
  - Development and qualification of i) Fuel, ii) Structural and functional materials, iii) H_2 production and iv) Computer tools.
  - GIF keeps producing guidance for engineers and policy makers:
    Codes & Standards, reactor safety and licensing, fuel qualification, sustainability, economy, non-proliferation, energy system integration.

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1. Summary

- Experimental reactors in Japan (HTTR) and in China (HTR-10): unique opportunities to qualify technologies and design codes.
  - 30 July: Restart of HTTR: further safety demonstrations and coupling to H_2 production
  - 12 September: First criticality of HTR-PM
- Most information in bi-annual International Topical Meeting on High Temperature Reactor Technology: Focus on HTR and process heat applications (https://htr2020.org/).
- High Technology Readiness, Developing Licensing Readiness, more work on Market Readiness

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2. Technical Characteristics

High Performance – Excellent Safety

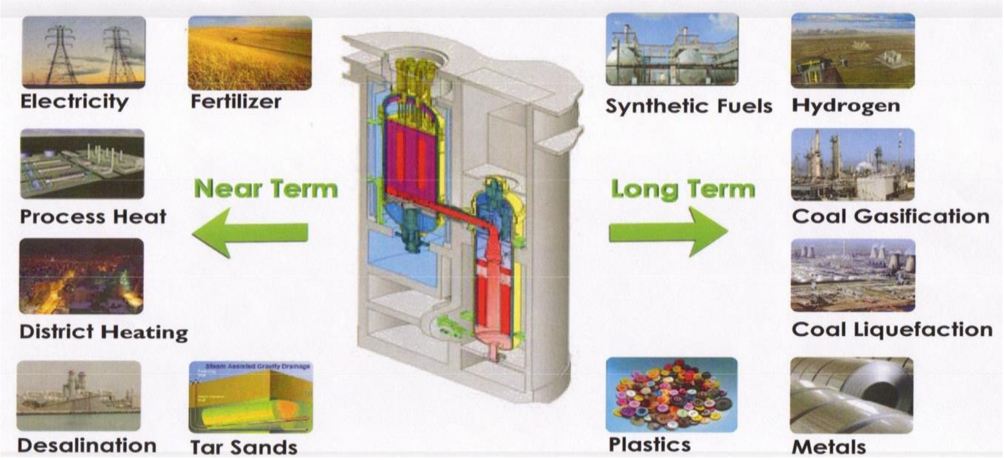
- Fully ceramic core → very high T resistance
- Excellent fission product retention in fuel and structures → low source term
- Pure graphite as moderator and reflector → high thermal inertia
- Low power density → slow transients
- Low unit power ~5 – 625 MWth (Small Modular Reactors)
- High fuel burn-up (> 3 × PWR)
- Primary He coolant is chemically and neutronically inert
- High operating temperature 750 - 950°C, even higher with novel materials → high efficiency, cogeneration beyond electricity
- High conversion rates, possible use of thorium (requires reprocessing)
- Demonstrated inherent safety, small EPZ

3. Maturity

- 7 reactors in 5 countries were built, 2 more under commissioning
- Active reactors in China (HTR-10, HTR-PM) and Japan (HTTR)
- So far was not given the chance to cure teething problems due to impossible competition with cheap fossil and absence of CO_2 tax/restrictions
- Several designs, vendors, suppliers
- Various projects: Canada, China, Indonesia, Poland, US
- Several private initiatives, supported by national efforts
- Cogeneration: 750 reactor-years experience, standard in fossil fuel technology, novelty is to combine nuclear with processes
- Safety of reactor must not be negatively affected by its end-user
- Suitable to address decarbonization of the much neglected industry sector

→ Strong industry and energy policy relevance in many countries

4. Remaining Challenges



- **Licensing authorities need support to get acquainted with non-LWR**
- **Coupling and licensing of coupling**
- **Supply chains for fuel, materials and components need to be revitalized, scale up TRISO fuel fabrication (<20% enrichment)**
- **Cost reduction and component qualification**
- **Financing, business plan, role of state and private investors**

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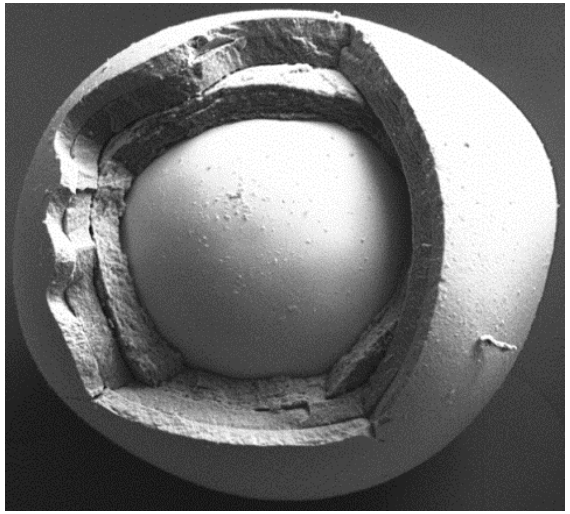
5. TRISO fuel: Reliability and availability



- UO_2 or UCO, < 20% enrichment
- other fuel cycles possible
- large successful qualification effort in several countries including through irradiation tests
- upscaling of production facilities needed

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6. Waste

- **Potential for waste minimization**
- **Specifically for graphite: decontamination and declassification?**
- **Synergies with programs related to treat i-graphite from other graphite-moderated reactors (DRAGON, AGR, RBMK)**
- **In case of closed fuel cycle, expect additional carbonaceous waste from coatings**