Overview of Non-electric Applications of Nuclear Heat (NEANH)

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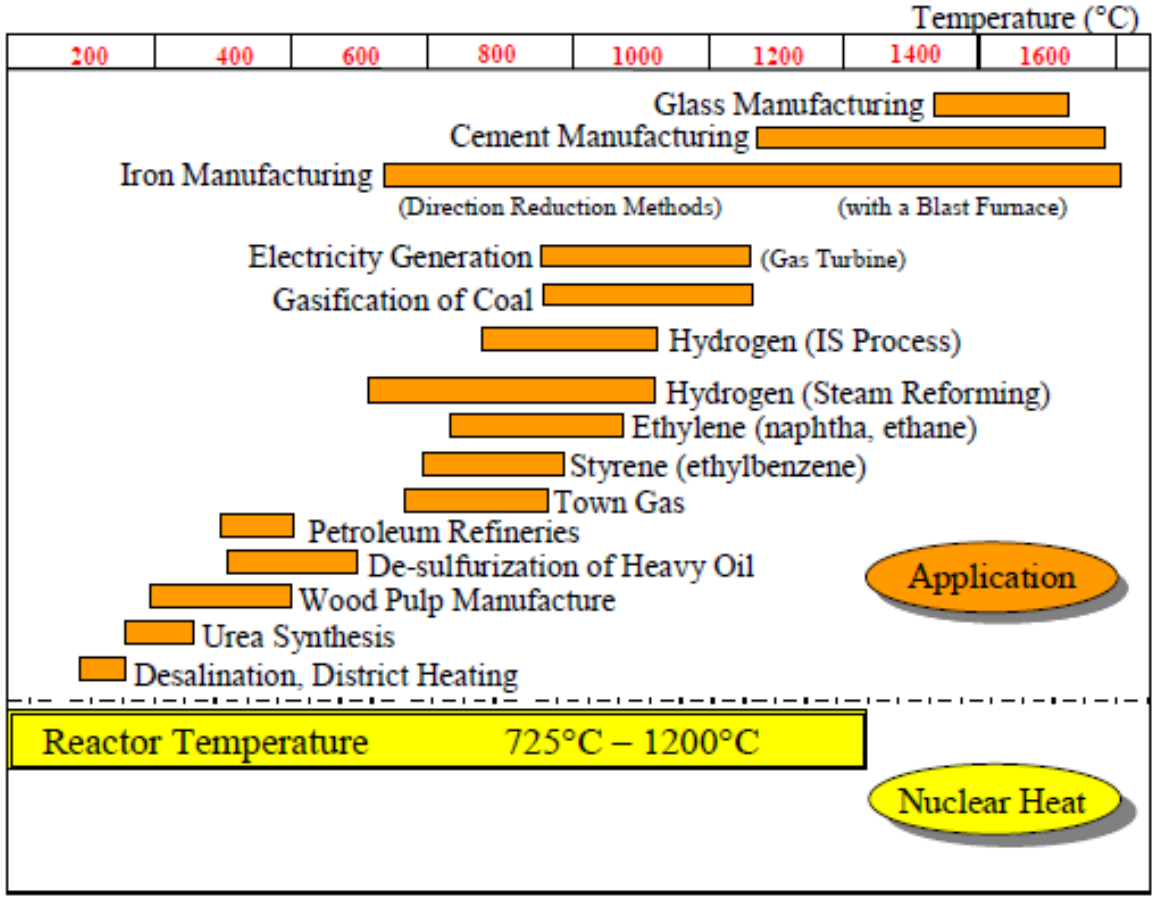
A brief history - GIF & NEANH

- **GIF Gen IV concepts**
  - A Technology Roadmap was released in 2002
  - 6 systems – GFR,LFR, MSR, SFR, SCWR & VHTR
  - Ambitious goals – sustainability, economics, safety and reliability, proliferation resistance and physical protection

- **Gen IV beyond electricity production**
  - Roadmap on crosscutting energy products released in 2002
  - Four applications examined
    - desalination, district heating, hydrogen, high temperature process heat,
  - Collaborative R&D project on hydrogen production started in 2008 under the VHTR system

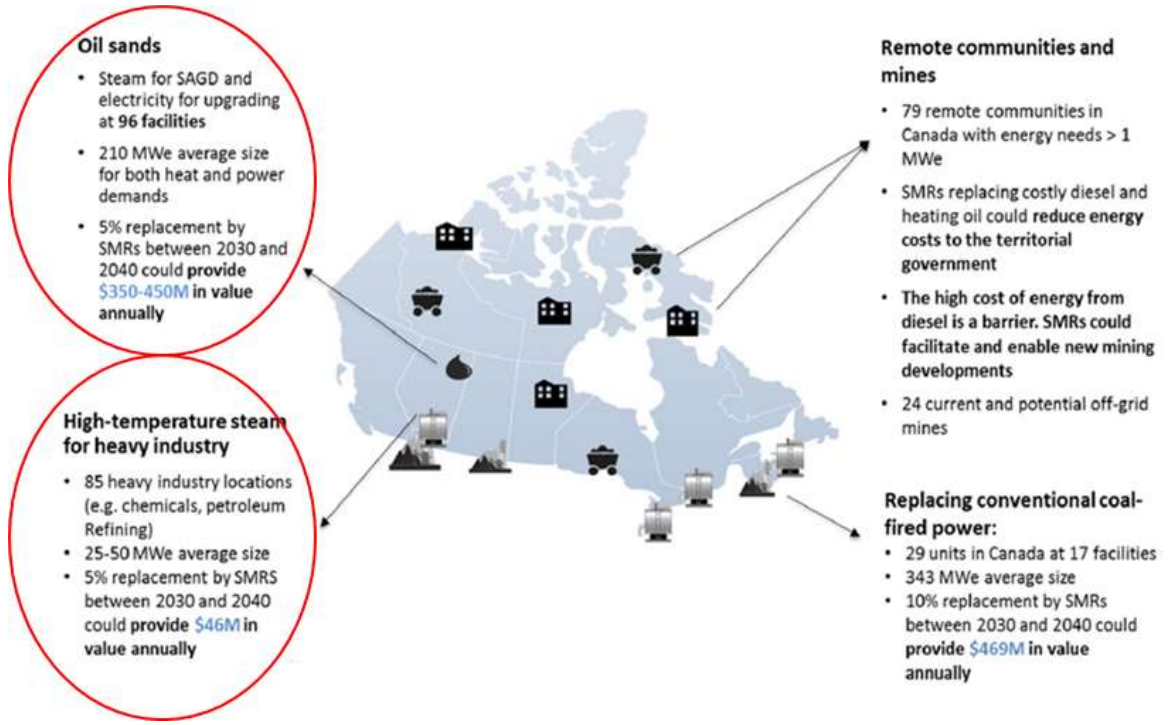


GIF - "Generation IV Roadmap – Crosscutting Energy Products R&D Scope Report" December 2002

What changed since early 2000s for NEANH

- **Policies to incentivize transition to net zero by 2050**
  - Some industries considering nuclear energy option in decarbonization plans
- ***Worldwide development of SMRs presents new opportunities for decarbonization***
- ***Low-emission hydrogen production using nuclear energy is being pursued***
- ***NEANH offers possibilities of integrating nuclear and renewable power (hybrid energy systems)***

GIF set up NEANH Task Force in 2021



Canada's SMR Roadmap 2018 – Domestic Market Potential

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Past Experience – Use of Nuclear Heat

- Over 750 reactor-years of experience – accounts for less than 0.5% of the total nuclear thermal output of over 440 reactors.
  - Mostly water-cooled reactors
- ***District Heating:*** 43 reactors have been used, ~500 reactor years
  - Average 5% thermal output; range 5 to 240 MWth
  - Typically <150º C
- ***Desalination of water:*** 17 reactors have been used, ~250 reactor years
  - Mostly using thermal processes (multi-effect distillation and multi-stage flash), <130º C
- **Industrial Process Heat:** 7 reactors (4 in Canada)
  - Typically based on medium pressure steam, <250ºC

IAEA - "Opportunities for Cogeneration with Nuclear Energy" NP-T-4.1, 2017

IAEA - "Guidance on Nuclear Energy Cogeneration" NP-T-1.17, 2019

NEA – "Beyond Electricity: The Economics of Nuclear Cogeneration", 2022

Industrial Process Applications of Nuclear Heat

Country/ Reactor Type	Application	Location	Capacity of Steam System MWth	Operation
Canada, Bruce A CANDU reactors	Heavy Water Production, Bruce Energy Centre (BEC)	Onsite heavy water production Off-site supply to BEC	5,350	1981-1997
Germany, Stade PWR	Salt Refinery	Off-site	30	1984-2003
Switzerland, Gösgen, PWR	Cardboard factory	Off-site	54	1979-
UK, Calder Hall MAGNOX	Fuel plant	Adjacent site		1956-2003

Nuclear Steam System at Bruce, Canada

- **Largest nuclear bulk steam system built**
  - Medium pressure steam from 4 X 848 MWe Bruce A reactors
- **Steam Users**
  - On-site: 2 heavy water production plants
  - Off-site: Bruce Energy Centre industrial park
    - Plastic and alcohol production, green houses
    - Cascading heat supply; Steam to condensate
- **Things to note**
  - Process plant on nuclear site
  - Contained significant quantities of H_2S gas (combustible, toxic, corrosive)
  - 3 barriers between nuclear plant and users
  - Back-up steam supply: 3 oil-fired boilers
  - Back-up power for condensate pumps
  - Different ownerships – NPP, heavy water plant, Bruce Energy Centre

Bruce Heavy Water Plant

Past Initiatives – with end user involvement

- ***NGNP Industry Alliance***
  - Formed in 2010 to develop high-temperature gas-cooled reactor and expand its industrial applications
  - Members included potential end user industries
  - Several process heat applications of HTGR were examined by INL – hydrogen, ammonia, coal to natural gas, synthetic diesel using natural gas, oil sands
  - Plant Design Requirements included requirements from prospective owner/operators and end users
- ***EUROPAIRS:*** End User Requirements fOr Process heat Applications with Innovative Reactors for Sustainable energy supply
  - Funded by European Commission in 2009 – evaluated potential coupling of HTGRs with industrial processes
  - 50% of industrial heat demand is below 550ºC - significant potential of HTGRs in replacing conventional fossil CHPs
  - Recommended strong partnership between nuclear technology developers and end users and joint technology development for coupling of reactors with industrial processes
    - Prototype demonstrations at industrial scale required to give confidence to industrial heat users

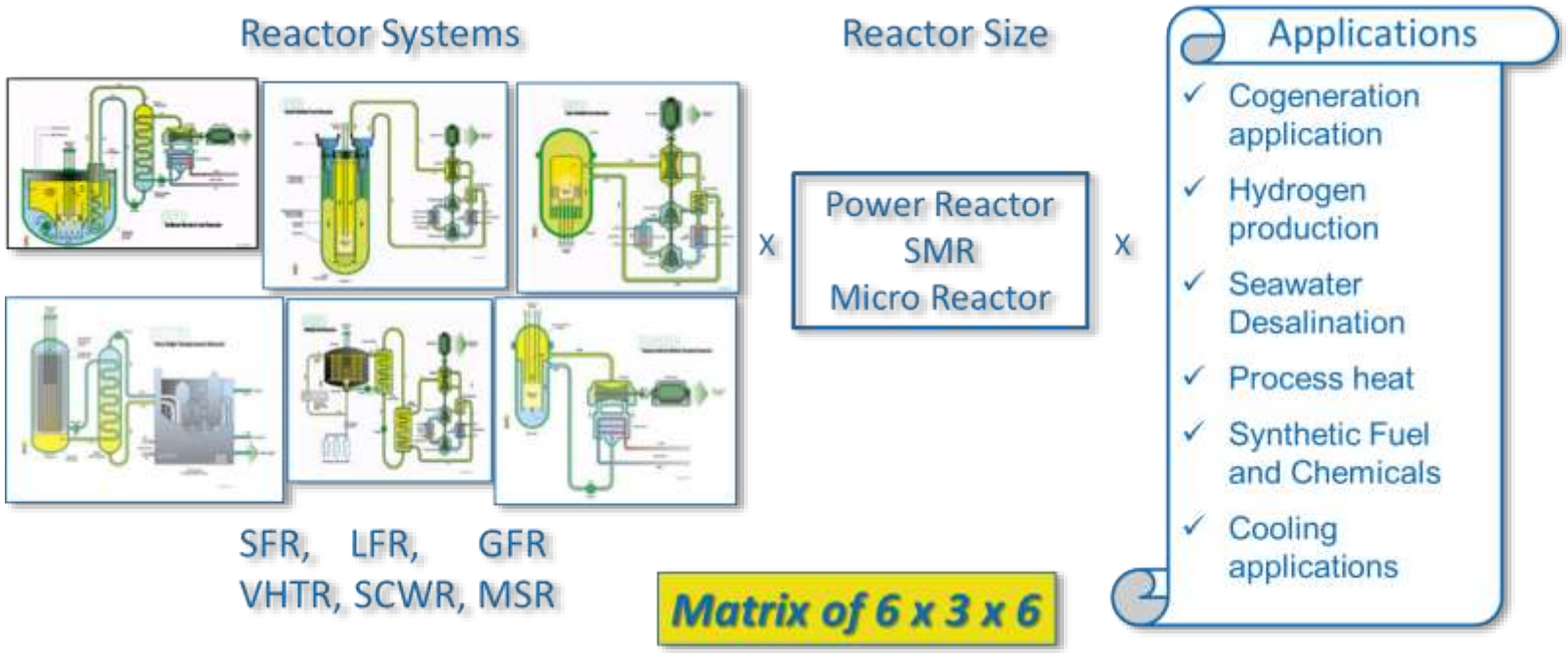
GIF NEANH Task Force

Key questions to be addressed

- How do the different advanced reactor technologies map to non-electric process applications?
  - Reactor type, size, applications
  - Role of NEANH in integrated (hybrid) systems, regionally optimal systems
- Understand challenges – technical, licensing, regulations and codes
- Economic viability

Anticipated Outcomes:

- Clarify challenges and constraints
- Provide guidance to energy system developers, users
- Identify R&D to accelerate development and deployment



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Thank you