HTGR Technology Course for the Nuclear Regulatory Commission

May 24 – 27, 2010

Module 2b

HTGR Motivations and Applications

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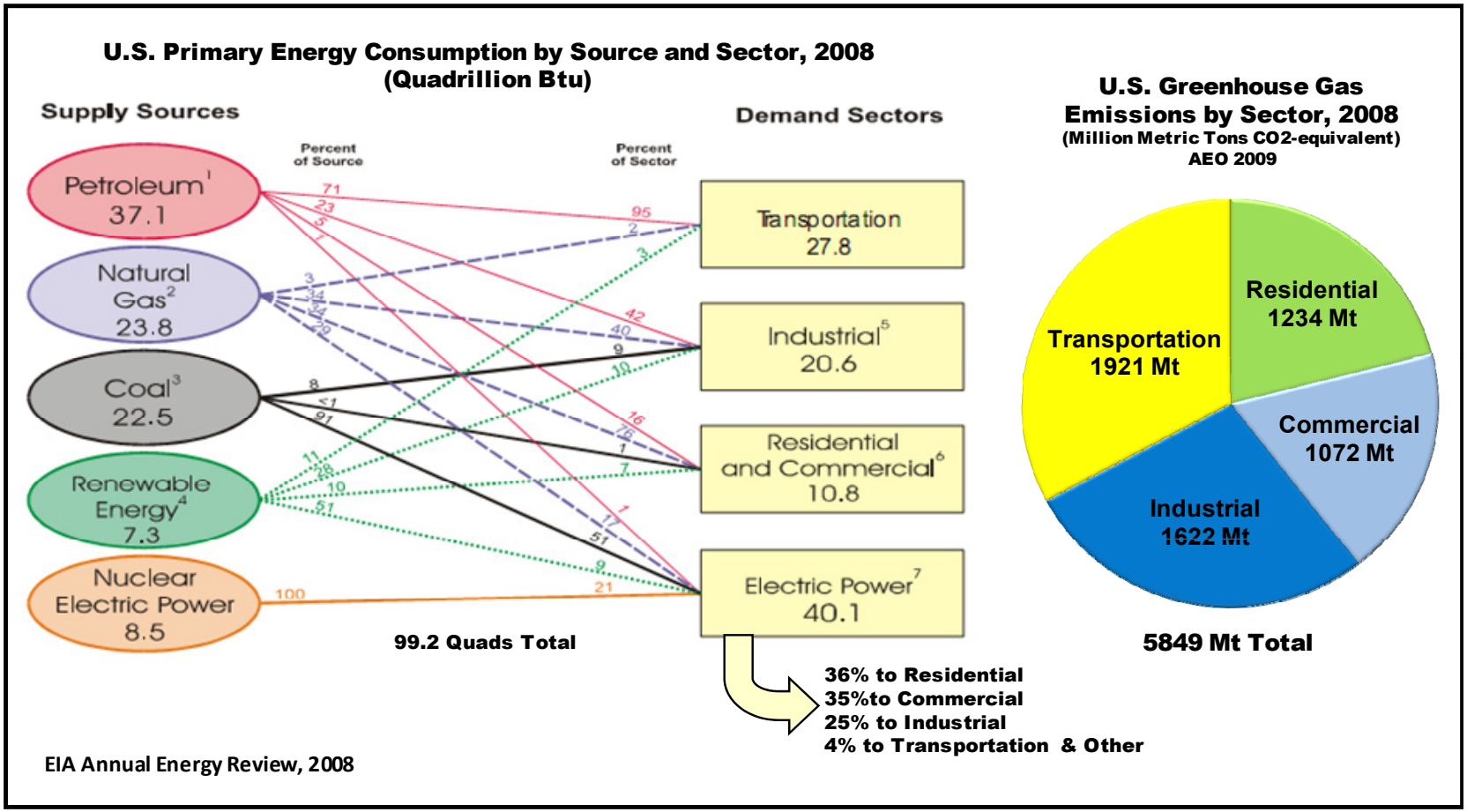
Technology Insights

Outline

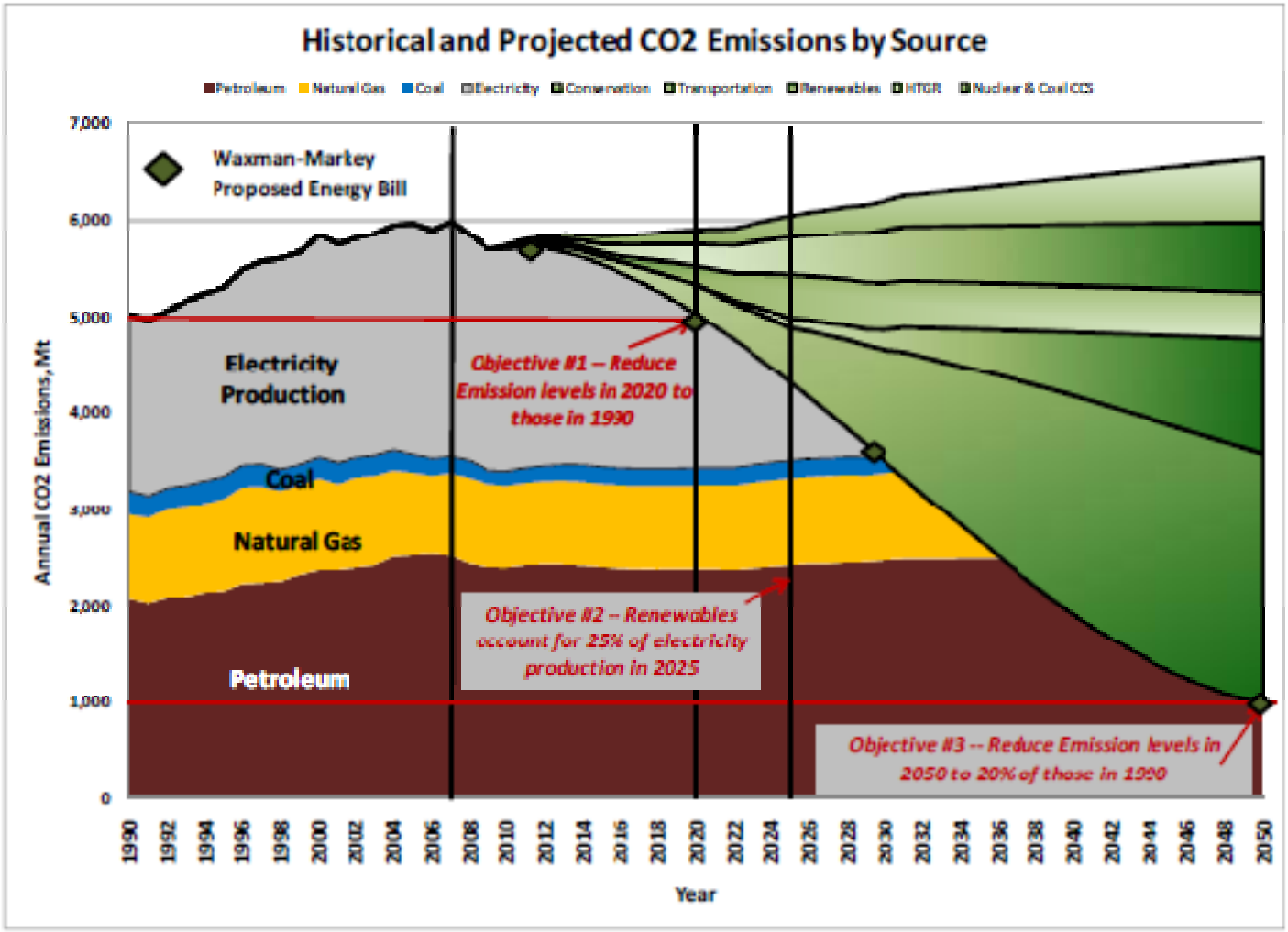
- **Motivations**
- **Applications**

Nuclear Energy – and the Need for the High Temperature Gas-cooled Reactor



HTGR technology targets the industrial process heat needs that represent greater than 20% of US energy use - extends nuclear energy into the broader energy and transportation industries

Meeting the Long Term US Energy and Emissions Objectives



Conservation & Efficiency

Transportation Initiatives

Renewable Additions

HTGR Additions

LWR/Coal CCS Additions

Idaho National Laboratory

PBMR

Why HTGR ?

- **Ceramic fuel particle, graphite core and helium coolant offer unique high temperature working fluid (coolant) capability (700C to 950C)**
  - High efficiency power conversion capability: modern Rankine cycle (Eff ~40%) to advanced closed cycle Brayton (efficiency up to ~47%)
  - High temperature process steam and process heat capability – typically with cogeneration opportunities

- **Proliferation resistant, high burnup fuel cycle with growth potential for advanced fuels and cycles, including deep burn cycles with LWR spent fuel**

- **Altogether, reduces environmental impacts, improves nuclear fuel resource utilization and offsets fossil fuel emissions – the latter unique nuclear option for high temperature process applications**

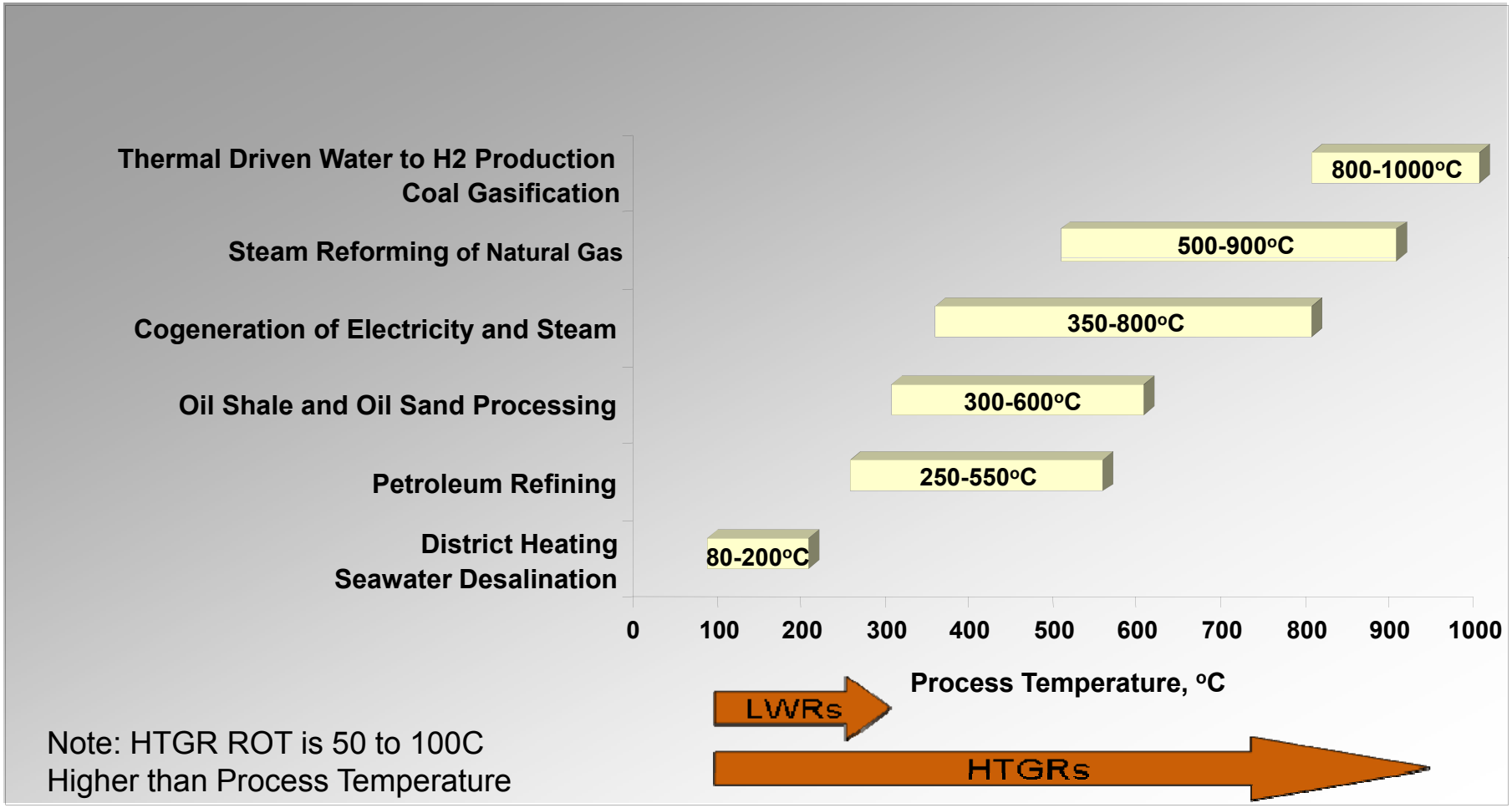
Why Modular HTGR ?

- **Advanced modular designs have evolved that offer enhanced passive nuclear safety - translates to reduced licensing, siting and ownership risks plus improved public acceptance**
  - Limit radionuclide releases and resultant offsite doses for the full spectrum of accidents in order to preclude offsite evacuation and sheltering of public at EAB = 425m - favorable for close-in process steam/heat applications
- **Modular designs match to market requirements to achieve flexible, affordable, competitive products**
  - Small (<~600MWt), multiple increments of capacity
    - Match process user loads, building block and reliability requirements
    - Match small to medium power (co)generation loads – constrained sites, cooling water, transmission capacity, financing, etc
    - Reduce manufacturing, transport and construction costs/risks
- **Altogether, responsive to US energy security, environmental protection and high value jobs/infrastructure objectives**

Outline

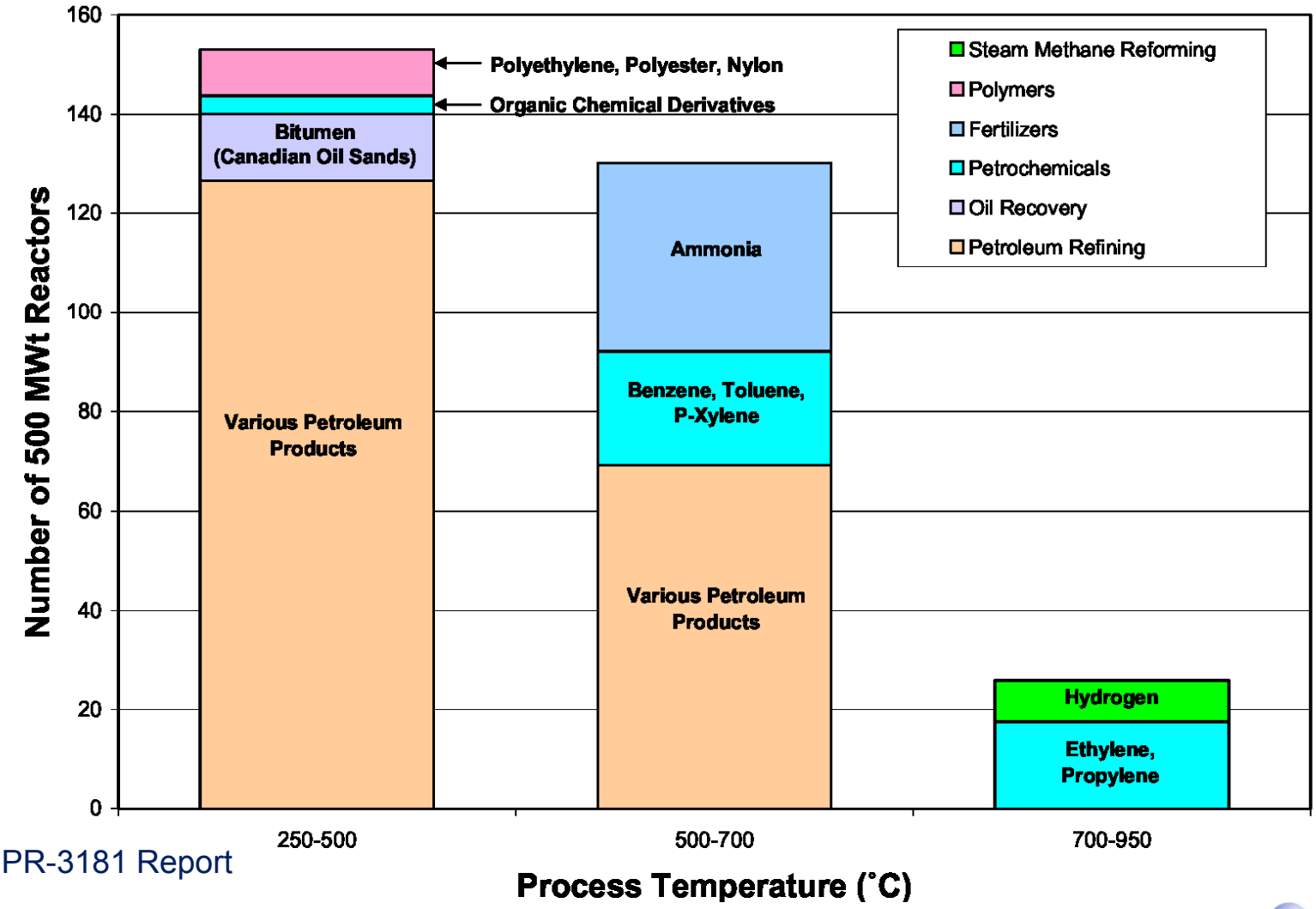
- **Motivations**
- **Applications**

Process Application Temperatures



Note: HTGR ROT is 50 to 100C
Higher than Process Temperature

Number of 500 MWt HTGR Systems Required to Meet Current Demands

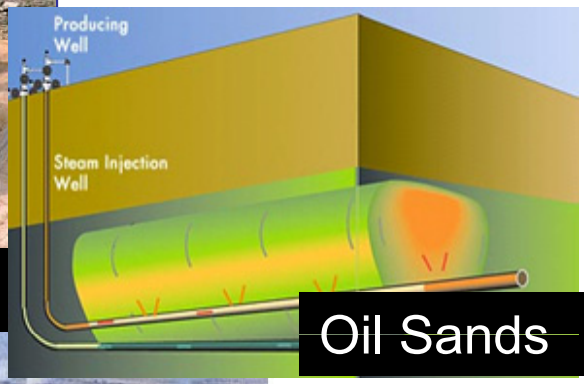


Ref: MPR-3181 Report

Target Process Industry Markets

- Petrochemicals, refineries, ammonia/fertilizer,
  - Process steam – heating, mechanical, injection
  - Process reactors, crackers, reformers
  - Hydrogen upgrades
- Oil sands recovery
  - Process steam injection
  - Hydrogen upgrades
- Coal to liquid or gaseous fuels
  - Process steam for coal gasification
  - Hydrogen upgrades
- Bulk hydrogen for future transport
- For all the above, cogeneration and/or low temp thermal based water desalination opportunities exists


Petrochemical

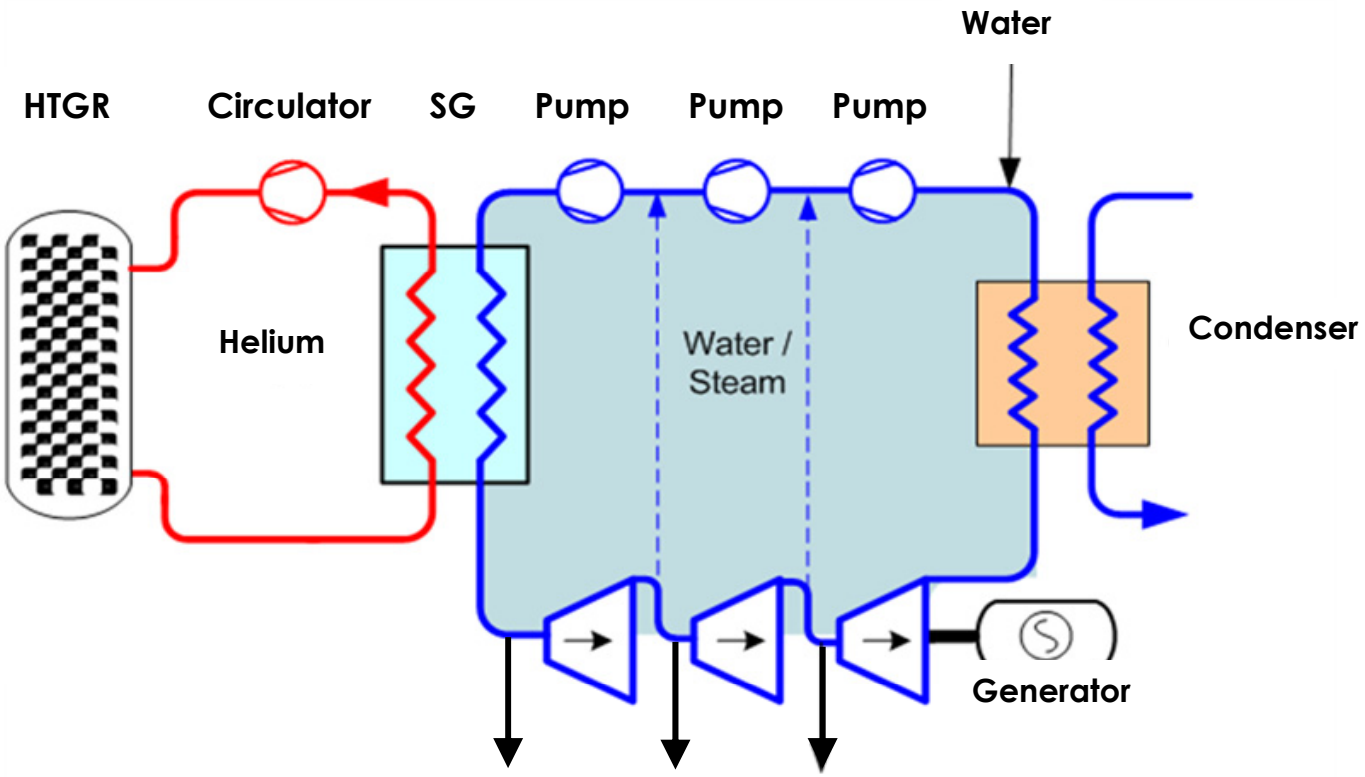


Oil Sands


Coal to Liquids

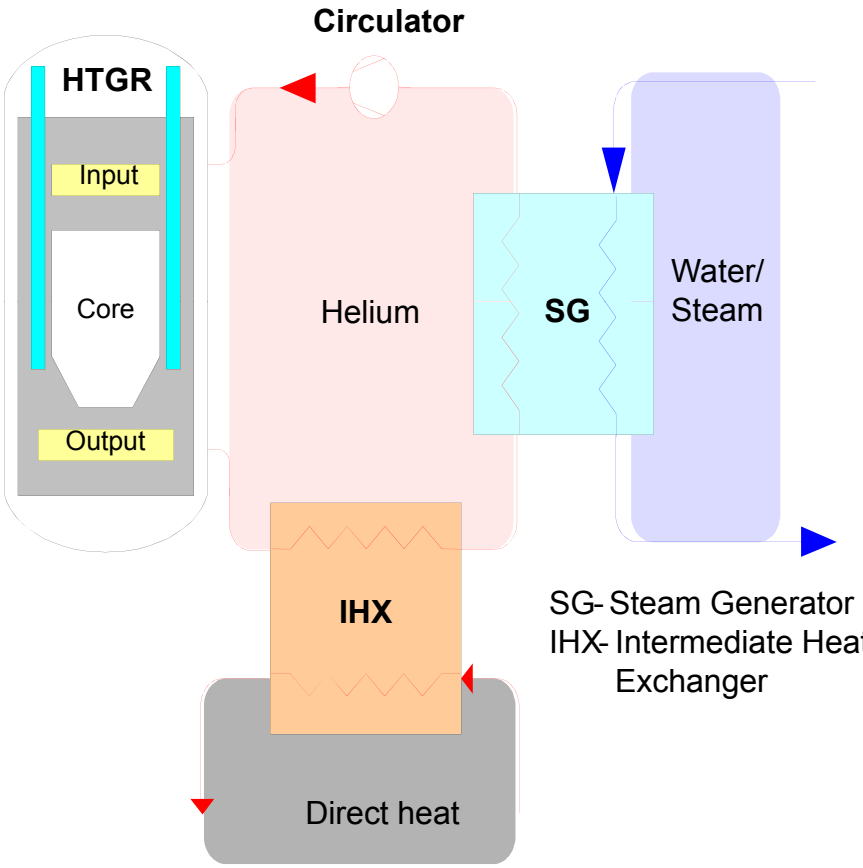

Desalination

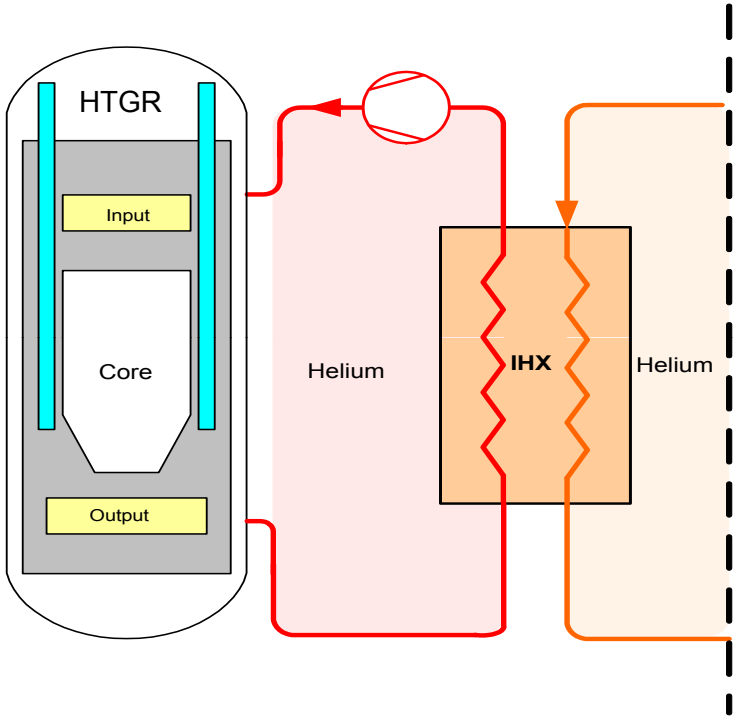
Standard NI – Flexible Process Steam/Cogeneration Applications



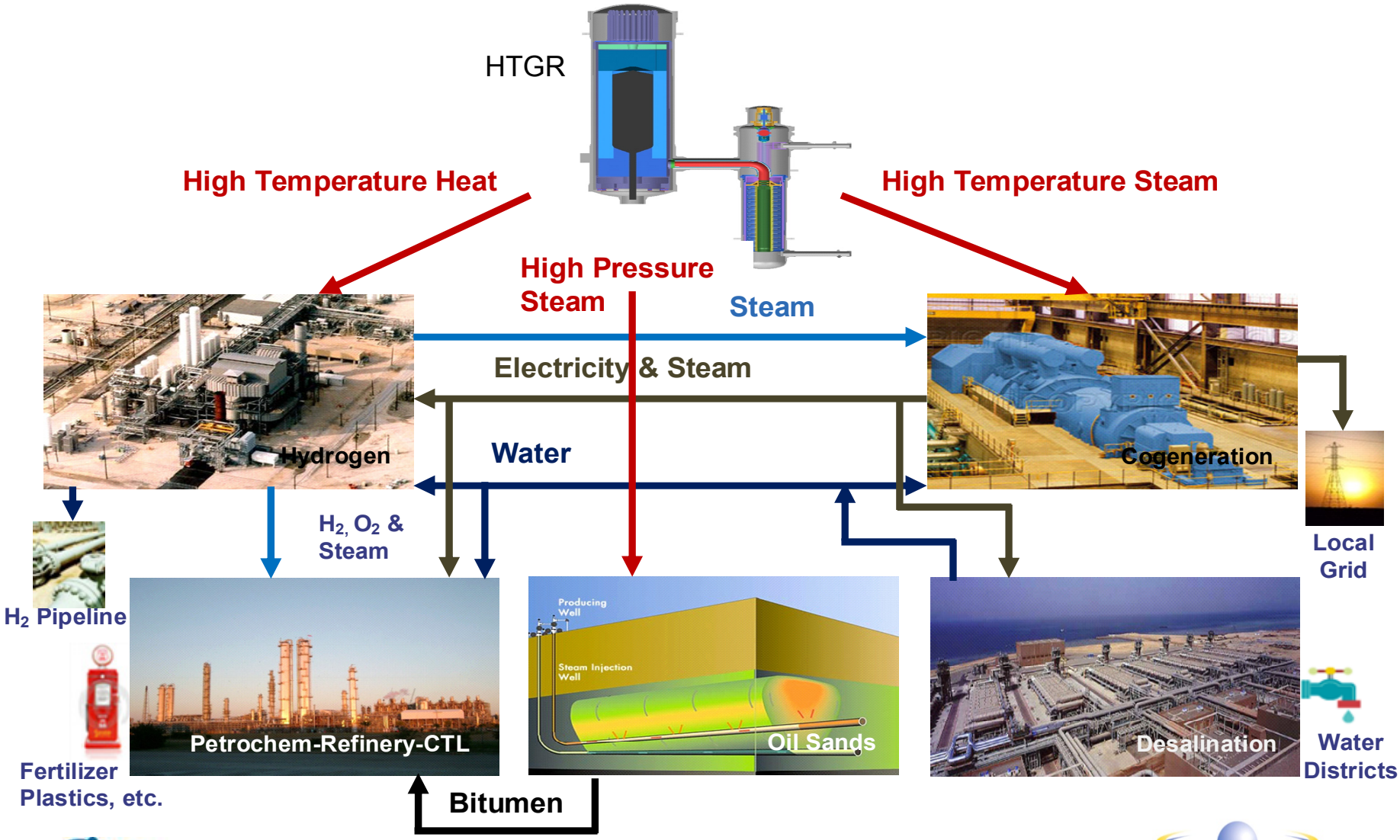
Pressures for Process Steam Applications
- Reboiler Option TBD

Illustrative Configurations for Direct Heat, Higher Temperature Applications





Target Market Applications



Summary

- HTGR technology offers superior performance and unique high temperature capabilities
- Target markets for initial deployment based on process steam cogeneration applications
- Evolutionary growth potential for higher temperature direct heating and gas turbine applications plus advanced fuels/cycles

Suggested Reading

- **Survey of HTGR Process Energy Applications, MPR-3181, May 2008**