Outline

• Motivations

• Applications
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

- **Objective #1** – Reduce Emission levels in 2020 to those in 1990
- **Objective #2** – Renewables account for 25% of electricity production in 2025
- **Objective #3** – Reduce Emission levels in 2050 to 20% of those in 1990

- Conservation & Efficiency
- Transportation Initiatives
- Renewable Additions
- HTGR Additions
- LWR/Coal CCS Additions
Why HTGR?

- Ceramic fuel particle, graphite core and helium coolant offer unique high temperature working fluid (coolant) capability (700°C to 950°C)
  - 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
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Process Application Temperatures

- **Thermal Driven Water to H2 Production**
  - Coal Gasification: 500-1000°C
- **Steam Reforming of Natural Gas**
  - 800-1000°C
- **Cogeneration of Electricity and Steam**
  - 350-800°C
- **Oil Shale and Oil Sand Processing**
  - 300-600°C
- **Petroleum Refining**
  - 250-550°C
- **District Heating Seawater Desalination**
  - 80-200°C

Note: HTGR ROT is 50 to 100°C
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
Standard NI – Flexible Process Steam/Cogeneration Applications

- High Pressures for Process Steam Applications
- Reboiler Option TBD

Diagram of steam/cogeneration applications including HTGR, Circulator, SG, Pumps, Condenser, and Water/Steam flow.
Illustrative Configurations for Direct Heat, Higher Temperature Applications

- HTGR
- Circulator
- Core
- Helium
- Water/Steam
- SG
- IHX
- Direct heat
- SG- Steam Generator
- IHX- Intermediate Heat Exchanger

INL Idaho National Laboratory
Target Market Applications

PBMR

HTGR

High Temperature Heat

High Temperature Steam

High Pressure Steam

Steam

Electricity & Steam

Water

H₂, O₂ & Steam

H₂ Pipeline

Petrochem-Refinery-CTL

Desalination

Local Grid

Water Districts

Cogeneration

Bitumen

Fertilizer

Plastics, etc.

Oil Sands

Producing Wall

Steam Injection Wall

Inland National Laboratory (INL)
• 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