



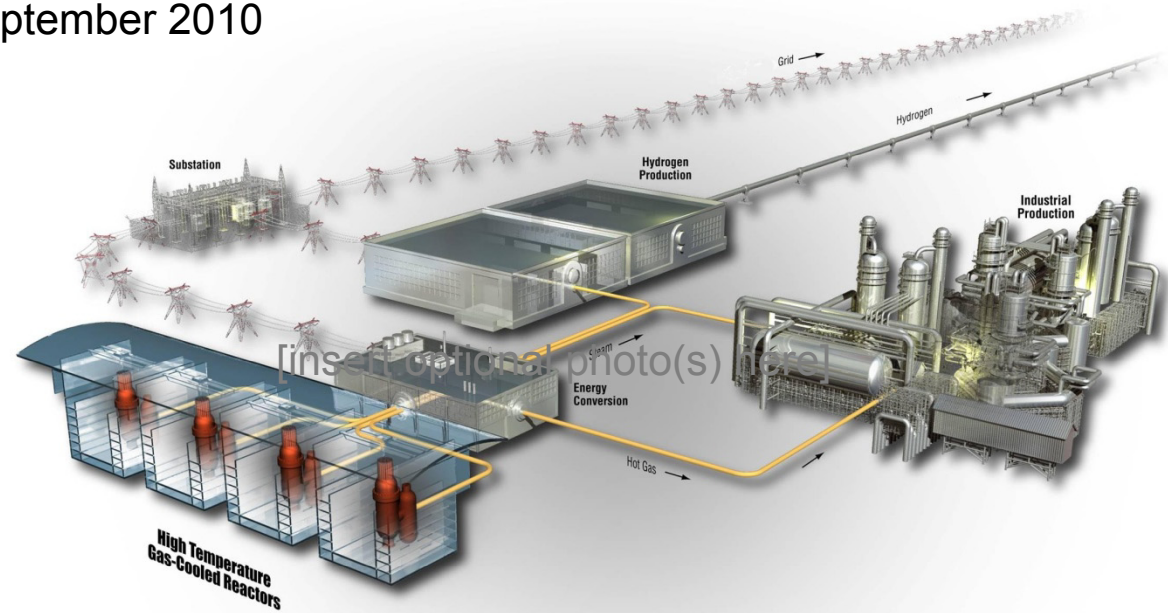
HTGR Potential Market and Preliminary Economics

Briefing for Nuclear Energy Advisory Committee

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September 2010

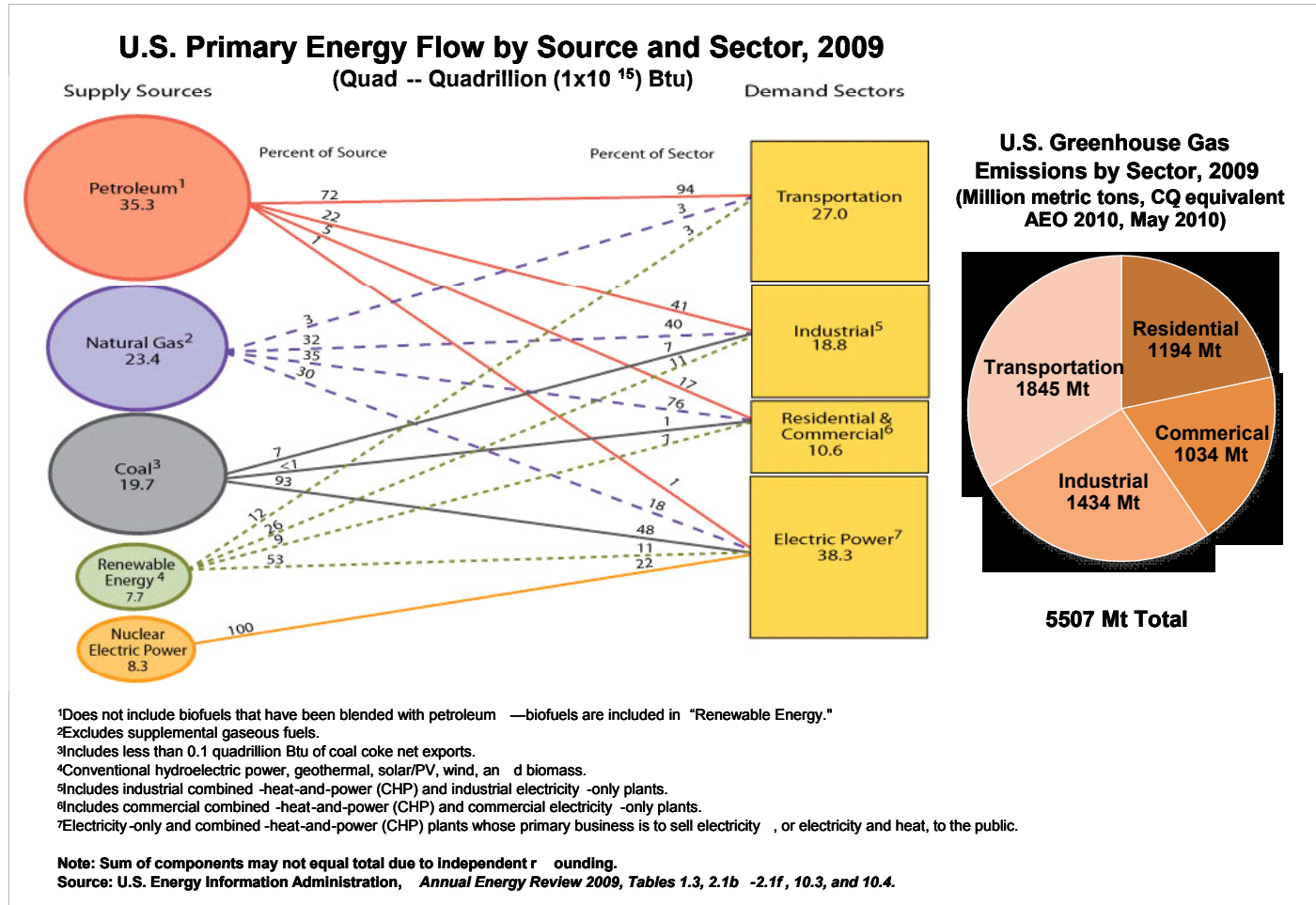
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Outline

- **Potential market for HTGR produced energy**
- **Evaluations of HTGRs integrated with industrial processes**
- **Possible business model for HTGR process heat to industry**
- **Economic analyses for industrial applications**
- **Conclusions and uncertainties**

Energy Production and Consumption in U.S. – the Potential Market



Vulnerabilities of fossil fuel consumption (83% of today's energy consumption in US)

- **Price volatility**
- **Reliance on imports**
- **GHG emissions**
- **Use of natural resources**

Industrial Applications – the Principal Market

The Opportunity — Providing High Temperature Process Heat and Electricity without Burning Hydrocarbon Fuels



Petrochemical (170 plants in U.S. – 6.7 quads*)



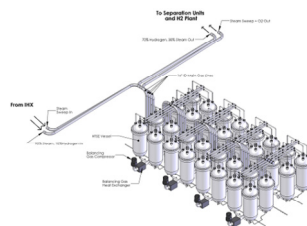
Petroleum Refining (137 plant in U.S. – 3.7 quads)



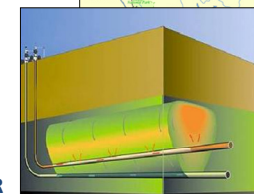
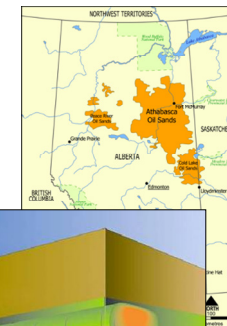
Fertilizers/Ammonia
(23 plants in U.S. – 0.3 quads NH₃ production)



Coal-to-Liquids (24 – 100,000 bpd new plants)
Project 250 GW_{th} HTGR application



Hydrogen Production
(60 – 600 MW_{th} HTGR Modules)



Oil Sands/Shale
(43 – 600 MW_{th} HTGR Modules)

* Quad = 1×10^{15} Btu (293 MM MW_{th}) annual energy consumption

Thermal Power Requirements for Postulated Market

Scoping evaluations performed for HTGR technology in industrial sector

- ✓ **75,000 MWth Co-Generation Supply of Process Heat to Industrial Processes**

(25% of Process Heat & Power, including electricity)

- ✓ **36,000 MWth for Production of Hydrogen**

(25% of growth in the merchant market)

- ✓ **25,800 MWth for Oil Sands Bitumen Recovery**

(25% of projected growth in energy required to extract & upgrade bitumen)

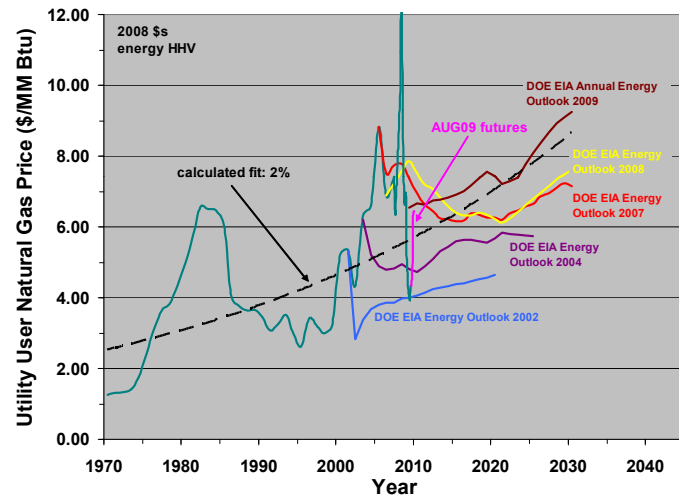
- ✓ **249,000 MWth for Coal to Transportation Fuels**

(Reduces imports by 25% of 2009 imports of crude oil – 9.1 MMBPD)

- ✓ **110,400 MWth for Electricity Production**

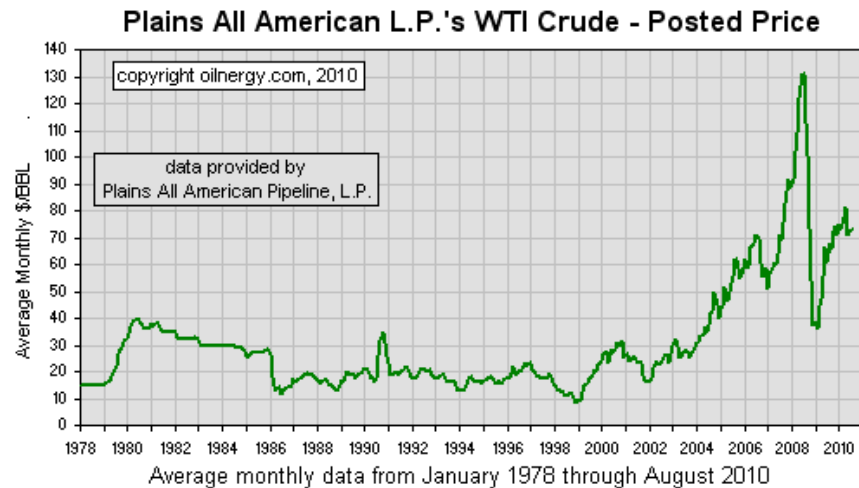
(10% of the nuclear electrical supply increase required to achieve pending Government objectives for emissions reductions by 2050)

Postulated Deployment of HTGR Results in Stable Energy Prices, Secure Source and Reduced Emissions

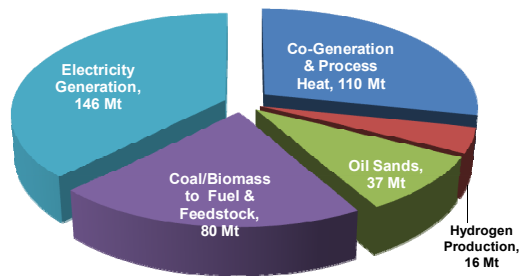


Natural Gas and Crude Oil Prices exhibit high volatility

HTGR Energy Prices affected only by normal inflationary factors, (e.g., wages, material)



Emissions Reductions

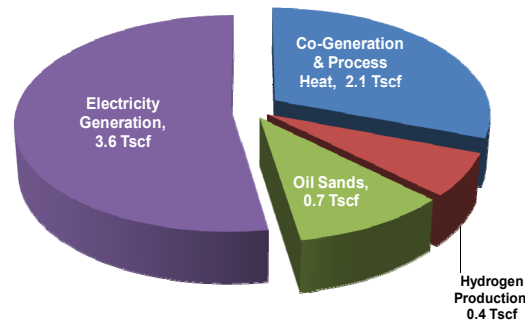


CO2 emissions are reduced by ~400 million metric tons by 2050; ~7% of pending Government objective

Natural Gas Conservation

Reduce Oil Imports by 25% of 2009 Rate

Reduces the need to import oil by ~2.5 million barrels per day (on an energy equivalent basis). Outflow of US dollars reduced by \$150 million per day (based on an average \$60/BBL price)

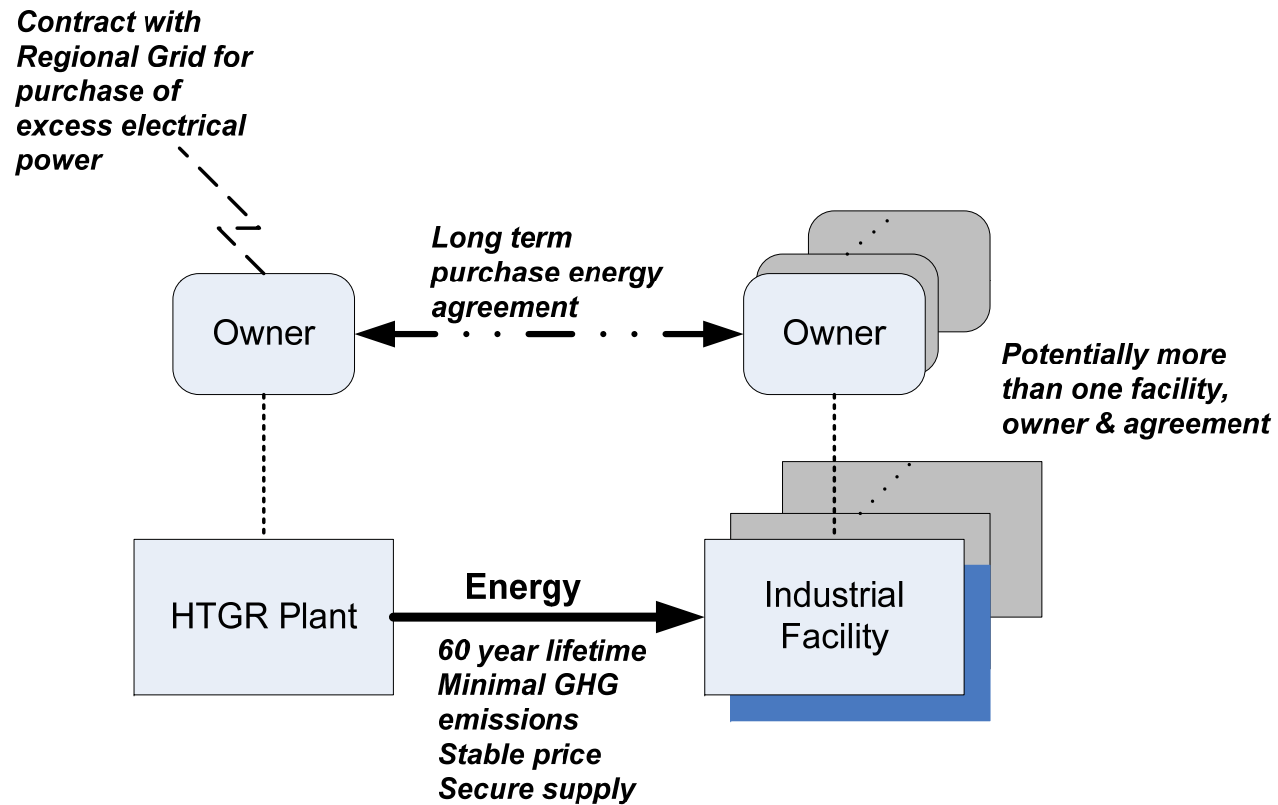


Natural gas combustion is reduced by ~7 trillion scf by 2050; ~30% of U.S. consumption in 2009

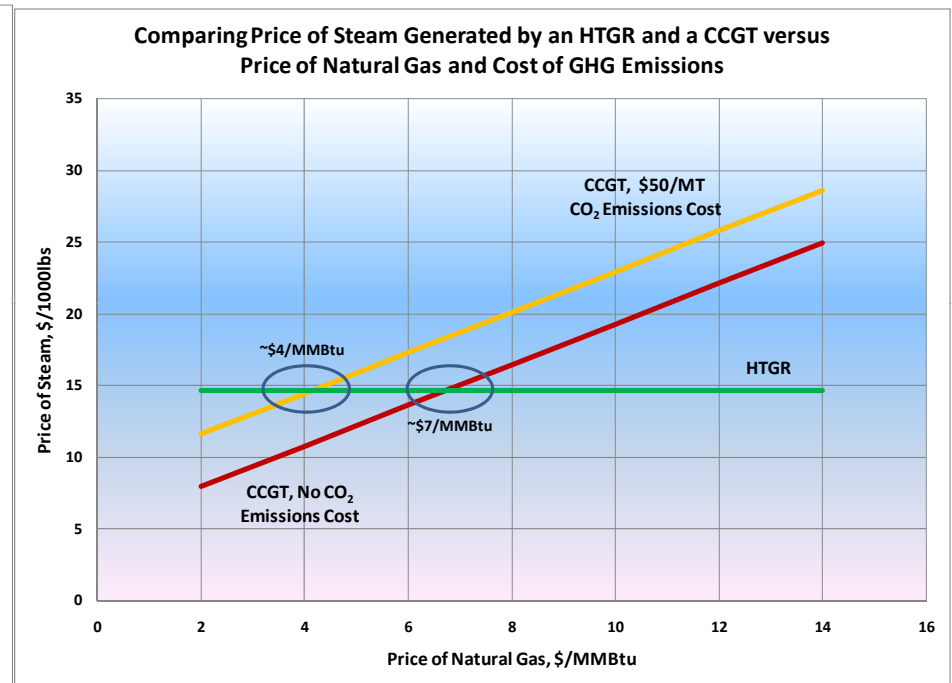
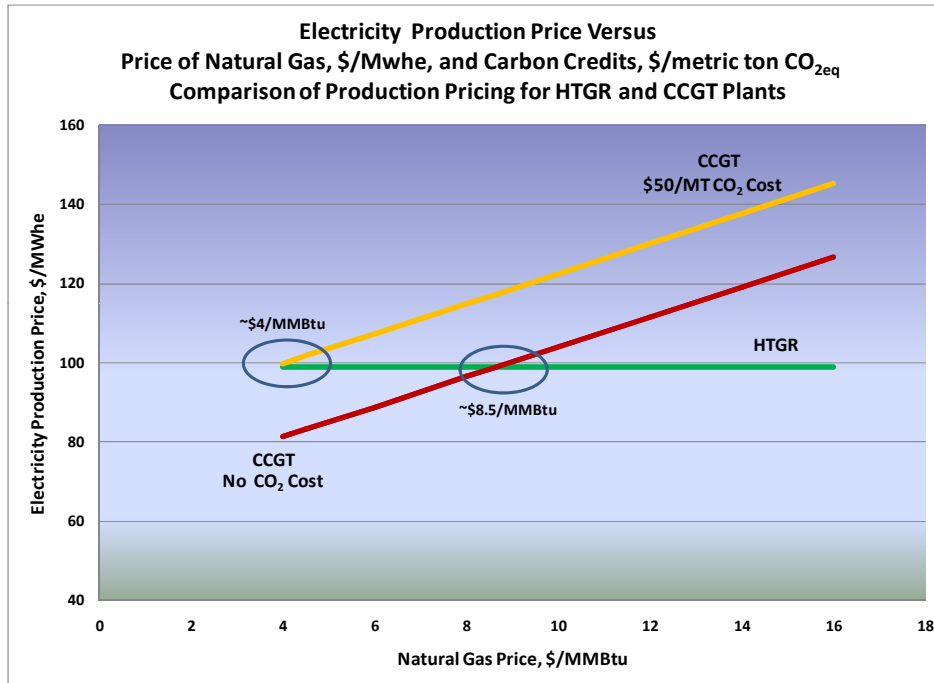
Evaluations of HTGR Integration with Industrial Processes

- **Co-Generation Supply of Steam, Electricity and High Temperature Gas**
- **Ammonia and Ammonia Derivatives Production**
- **Hydrogen Production**
- **Conversion of Coal and Natural Gas to Transportation Fuels**
- **Oil Recovery from Oil Sands and Oil Shale**
- **Electricity Production**

Possible Business Model



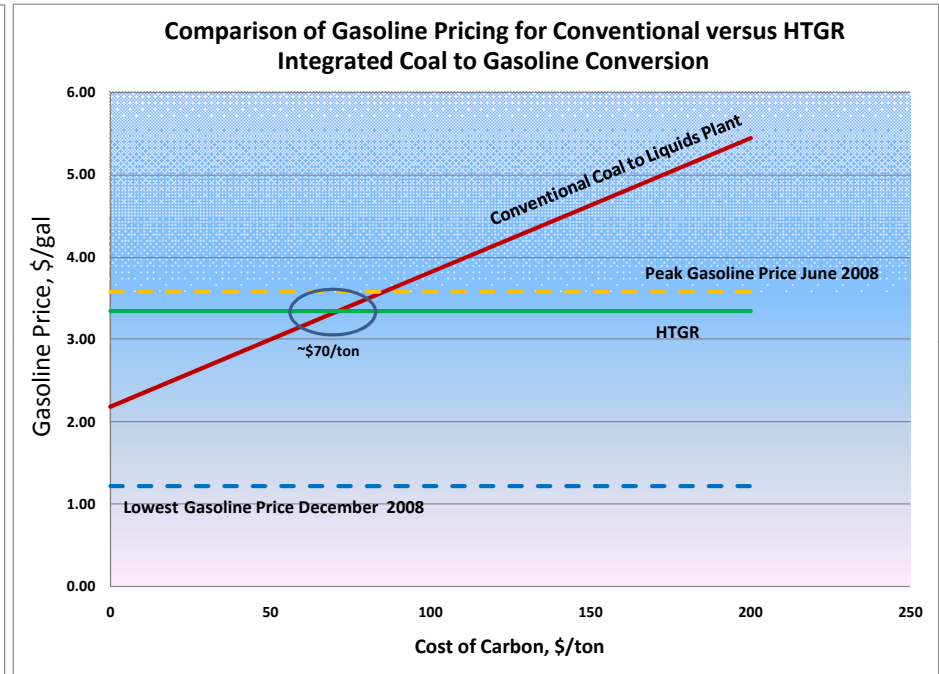
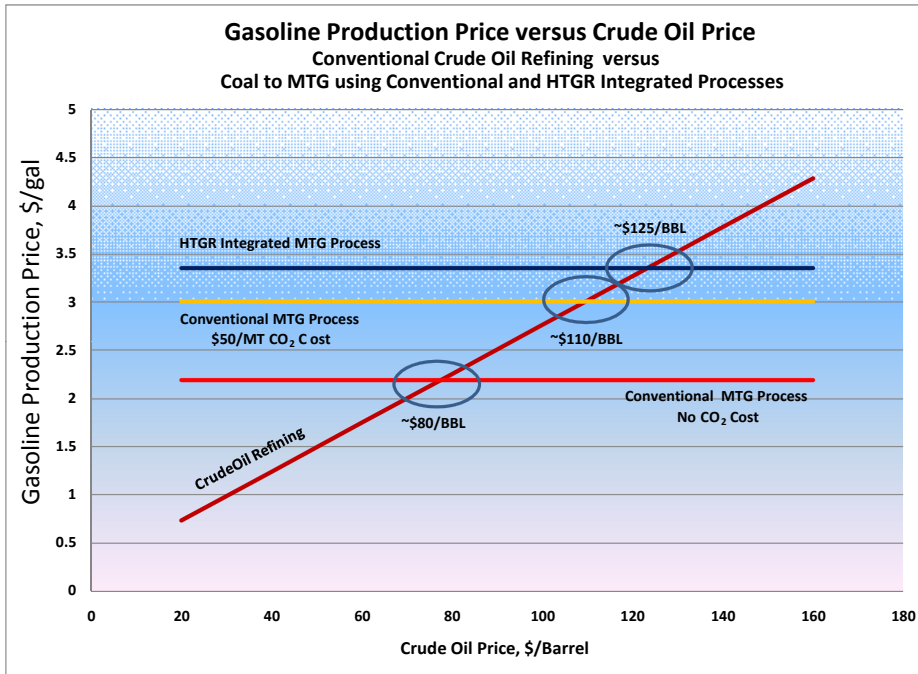
Electricity and Steam Production



Economic Factors

<i>HTGR Plant Capital Cost</i>	<i>\$1,700/KWt</i>
<i>CCGT Capital Cost</i>	<i>\$625/KWt</i>
<i>Debt</i>	<i>80%</i>
<i>Internal Rate of Return</i>	<i>15%</i>
<i>Financing Interest</i>	<i>8%</i>
<i>Financing Term</i>	<i>20 years</i>
<i>Tax Rate</i>	<i>38.9%</i>

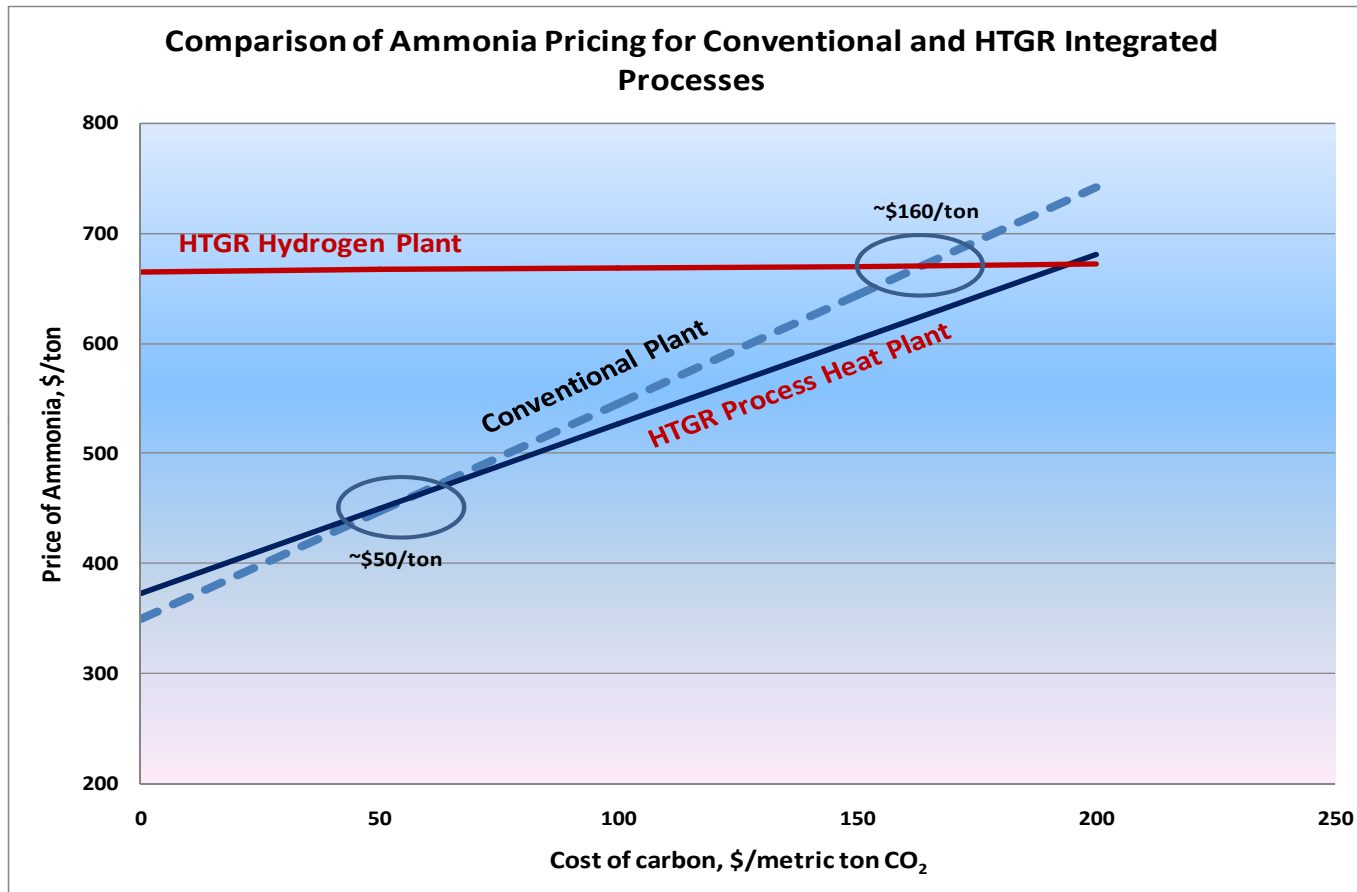
Conversion of Coal to Gasoline (MTG Process)



Economic Factors

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Ammonia Production



Economic Factors

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Conclusions

- **A large and viable potential market has been identified**
- **The economics of each application have been scoped**
- **The economic viability of applications is mixed & dependent on assumptions, (e.g., policy for CO₂ emissions)**
- **There is large uncertainty in the results of the economic evaluations:**
 - ***Capital costs***
 - ***Operating costs***
 - ***Financing***
- **Design work is needed to improve cost estimates**
- **Market evaluations to date were to establish end-user technical requirements – detailed market study is required**