Natural Gas Applications: Technology & Policy

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GTI Overview

ESTABLISHED 1941 (Gas Research Institute est. 1977)

> Independent, *not-for-profit* company established by natural gas industry
> Providing natural gas research, development and technology deployment services to industry and government clients
> Performing contract research, program management, consulting, and training
> Facilities
  – 18 acre laboratory in Des Plaines
  – 200,000 ft² with 28 labs
> Staff of 250
> Wellhead to the burner tip including energy conversion technologies
Addressing Key Issues Across the Energy Value Chain

**SUPPLY**
Expanding the supply of affordable energy

**DELIVERY**
Ensuring a safe and reliable energy delivery infrastructure

**END USE**
Developing technology for the efficient use of energy resources

Reducing carbon emissions to the environment
Supporting sustainable economic growth
GTI/DOE Research Investments Sowed the Seeds of Unconventional Natural Gas Production Into The Future

DOE Coalbed Methane R&D
1978 – 1982 $30 million

DOE Shale Gas R&D
1978 – 1992 $137 million

GRI/GTI Unconventional Gas R&D
1978 – 2013 $577 million

Shale expected to exceed 50% of U.S. gas production by 2035

Sources: GTI, EIA, DOE Department of Fossil Energy
## Efficient, Clean Uses of Natural Gas

| Highly Efficient Appliances (Over 100% efficiency) | • Gas Heat Pumps (Space Conditioning, Water Heating)  
• Combination Space/Water Heating Systems  
• Ventilation, Indoor Air Quality  
• Commercial Foodservice |
| EFFICIENT, CLEAN INDUSTRIAL PROCESSES | • Chemical Processes  
• Efficient, low NOx Boilers  
• Advanced Process Heating  
• Heat Recovery Systems |
| COMBINED HEAT & POWER | • Integrated Commercial/Industrial CHP Systems  
• Micro CHP Systems |
| NGVS AND ALTERNATIVE VEHICLES | • Ultra-Clean, Efficient HD NGVs  
• NGV Storage  
• Advanced NGV Fuel Stations  
• Home Fueling |
| RENEWABLE ENERGY | • Solar Thermal/Natural Gas Hybrid Systems  
• Bio-Methane Production, Clean-Up, and Use |
U.S Industrial Sector

Offshoring is Now Onshoring
U.S. Industrial Sector: The Bad News and the Good News

> The bad news: For the last 20 years, the decline of American manufacturing has been accelerating:

  – Manufacturing was 19% of the economy in 2000 and 11% by 2012

> The good news: U.S. manufacturing is becoming competitive again!

> Two primary drivers:

  – The natural gas (and oil) shale revolution has led to a dramatic decline in the cost of energy: U.S. natural gas prices are 1/4 of European prices and 1/5 of Japanese prices

  – The productivity of the American worker has increased
According to Boston Consulting Group:

- This manufacturing rebound will derive from the U.S. attracting manufacturing operations from other developed countries.

- Additionally, the cost of producing a good in China will only be 10-15% cheaper than producing a good in the U.S. When one figures in the cost of supply disruption, the calculus begins to shift toward domestic American manufacturing.

- Many experts believe the U.S. is in the early phases of a manufacturing resurgence.
Durable Good Shipments

**Figure B2.1** U.S. shipments and value added rose during 1997-11, while employment fell (NAICS 31-33)

**Figure B2.2** U.S. durable goods shipment trends reflected demand during 2002-11
FIGURE 16
NEW CHEMICAL INDUSTRY CAPITAL INVESTMENT BY REGION

- Gulf Coast: 78%
- Ohio Valley: 13%
- Midwest: 8%
- Other: 1%

The pie chart illustrates the distribution of new chemical industry capital investment by region, with the Gulf Coast receiving the highest investment at 78%, followed by Ohio Valley at 13%, Midwest at 8%, and Other at 1%.
What Can States do to Encourage Onshoring?

- Expedited permitting
- Ensure natural gas is available to industrial parks/sites
- Favorable tax treatment
Small-Scale GTL Commercial/Policy Drivers

Energy Supply
- Flare Gas reduction policy drivers (domestic and international)
  - EPA
  - World Bank
  - State PUC’s / Local Governments
- Reduce energy resource wastes
- Stranded gas production and access to markets

Energy Infrastructure
- Gas pipeline congestion mitigation
- Existing rail/trucking infrastructure can be leveraged for small GTL
- Less permitting / regulatory complexity for plant site
- Lower investment risk with modular/scalable plant design

Energy Consumption
- Zero-sulfur diesel/gasoline comply with emissions reduction regulations
- Fuels can be used by existing/conventional vehicles
- Chemicals production also an option
- Advances domestic / energy independence policies
Many Small-Scale GTL Companies Are Emerging

Velocys
Primus Green Energy
Compact GTL
Oberon Fuels
Gas2 Ltd.
Greyrock Energy
Emerging Fuels Technology
Infra Technologies
Verdis Synthetic Fuels
Gas Techno LLC
Etc....
Gas-To-Liquids and Gas-to-Products

Natural Gas + Oxidant (Steam/Oxygen)

Step 1: Syngas Manufacture (40-60% of CAPEX)

Steps 2/3: GTL-FT Fischer-Tropsch + Wax-Upgrading

Diesel/Naphtha/Lubes

Gas to Products (GTP) and Other Fuels
- Methanol ➔ DME ➔ Gasoline (MTG)
- Butanol and other alcohols
- PDMM: Poly-Dimethoxy-Methane (Diesel Oxygenates being commercialized in China)
- Others: Hydrogen, Olefins (MTO), Ammonia, Urea, etc.
Methane To Methanol –
A Low Temperature Process

GTI’s process uses an electrochemical reactor with a nickel-based catalyst. The overall reaction stoichiometry is:

\[ \text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{OH} + \text{H}_2 \]

Thermal efficiency of the overall process is 83% and the carbon efficiency is >90%.

Test results include a lab unit operating at 0.5 gallon/day methanol production and up to 200 hours continuous operation.

Methane is continuously fed to the cell anode where it reacts at the catalyst site to produce methanol and \( \text{Ni(OH)}_2 \). The charging reaction then immediately converts the \( \text{Ni(OH)}_2 \) back to \( \text{NiOOH} \).
GTI End-Use R&D Areas of Technology Focus

> Residential/Commercial Water Heating
> Venting Safety
> Residential/Commercial Space Conditioning
> Commercial Food Service
> Industrial Processes
> Distributed Power/CHP and Steam Generation
> Transportation
> Renewable Energy (biogas, solar thermal)
> Carbon Management
GTI (UTD’s) Expanding Market Impact
Example Commercialized Products

Cummins Westport Inc. 11.9L NGV Engine
Cummins Westport Inc. 8.9L NGV Engine
Ultimate CNG FuelMule
High-Efficiency Rooftop Dedicated Outdoor Air Systems
Cannon Boiler Works Ultramizer System

High-Efficiency Low Oil Volume Fryers (Pitco, Frymaster)
High-Efficiency Broilers (Montague, Royal)
Lincoln (Manitowoc) Energy Star Conveyor Oven
NextAire Gas Heat Pump
Equinox Solar Assisted Heating System

UTD working with manufacturing partners to bring new natural gas products to the market
GTI (UTD’s) New Product Pipeline
Example Technology Developments

**FlexCHP Power & Steam Package**

**Power Flame Ultra Low NOx Industrial Burner**

**Heat Sponge Economizer for C&I Boilers**

**Stone Mountain Gas Heat Pump Water Heater**

**Low Cost Space/Water Heating (Rheem, Rinnai)**

**Energy Star Rated Gas Dryer**

**Cummins Westport 6.7L Medium Duty NGV Engine**

**Free-Piston NGV Home/Fleet Compressor**

**Micro CHP System Testing and CMR Group Fast-Response Natural Gas Quality Sensor**

*UTD “priming the pump” with new technology options to meet customer needs*
Natural Gas for Transportation

Larger and high-fuel-use vehicles most attractive. Initially those which can be centrally fueled and longer-term those that can use a public fueling infrastructure.
Well-to-Wheel CO$_2$ Analysis

Well-to-Wheels Greenhouse Gases Emissions

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<th>Fuel Source</th>
<th>CO$_2$ Emissions (grams per mile)</th>
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<td>Gasoline (Today's Vehicle)</td>
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<tr>
<td>Gasoline</td>
<td>340</td>
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<td>Gasoline &amp; Ultra-low Carbon Renewable</td>
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<td>H2 - Coal Gasification w/ Sequestration</td>
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<tr>
<td>H2 - Biomass Gasification</td>
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<tr>
<td>H2 - Nuclear High-T Electrolysis or Ultra-low Carbon Renewable</td>
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Conventional Internal Combustion Vehicles

Hybrid Electric Vehicles

Plug-in Hybrid Electric Vehicles (power-split, 10-mile electric range)

Plug-in Hybrid Electric Vehicles (series, 40-mile electric range)

Battery Electric Vehicles (100-mile range)

Fuel Cell Electric Vehicles

Source: U.S. DOE EERE
U.S. CNG Stations

US CNG Station Growth - 2009 thru 2014

- 2009: 772
- 2010: 899
- 2011: 947
- 2012: 1,155
- 2013: 1,290
- 2014: 1,525

Ref: NGV America
What Can States Do to Encourage NGVs?

> LNG/CNG filling stations on interstates
> Encourage rate structure to allow utilities to rate base part or all of NGV station components
  > 1,525 CNG stations
  > 111 LNG stations
  > By comparison,
    > 168,000 gasoline stations
    > 9,758 EV charging stations
> Favorable treatment of NGVs (157,000 on the road) as a low-pollution alternative to gasoline or diesel vehicles
> Give NGV filling stations “equal opportunity” compared to EV fueling stations
New Operations Technologies

> Crossbore prevention best practices

> Handheld Acoustic PE Pipe Locator*

> Radio Frequency ID tags for Gas Distribution

> Obstacle Detection for Horizontal Boring Tools

> Metallic Joint Locator*

> Portable Methane Detector*

*Commercialized

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What Can States Do to Encourage Energy R&D?

> Support state R&D agencies (e.g., CEC, NYSERDA, IL DCEO, MN DOC)

> Encourage emerging technology in DSM/market transformation programs
Questions

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