the Energy to Lead

# Expanded Use of Natural Gas to Reduce US Carbon Emissions

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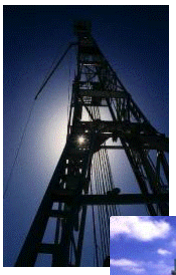
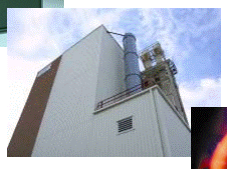
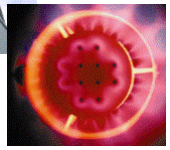
## Gas Technology Institute



**Addressing Key Issues for the Energy Industry**

> Contract Research
> Program Management
> Technical Services
> Education and Training





**> Over 1,000 patents**
**> Nearly 500 products commercialized**



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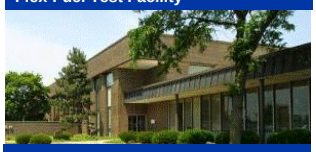
# GTI Overview

- Not-for-Profit Research, with 60+ Year History
  - Over $50MM/yr energy R&D
  - Facilities
    - 18 acre campus near Chicago
    - 200,000 $ft^2$, 28 specialized labs
    - Other sites in Oklahoma and Alabama
- Staff of 250
- Market Opportunities are Creating Substantial Growth


Flex-Fuel Test Facility



Headquarters Offices & Labs

Energy & Environmental Technology Center



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# Practical Solutions to Tough Energy Challenges

- Contract Research
- Program Management
- Technical Services
- Education and Training

Expand Supply ♦ Secure Infrastructure ♦ Energy Efficiency



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# GTI R&D Market Units

**Supply—Gasification**

Vann Bush, Managing Director

- Gasification process and feedstock evaluation
- Syngas generation and processing for production of power, fuels, and chemicals
- Syngas cleanup and separation technologies
- Subquality gas upgrading

**Supply—Unconventional Gas**

Guy Lewis, Managing Director

- Unconventional gas resources
- Field drilling and completion
- Downhole laser energy applications
- Carbon sequestration
- Methane hydrate resources

**Aligned with the Energy Industry**

**Delivery**

Eddie Johnston, Managing Director

- Third party damage prevention and leak detection
- Construction innovations
- Operations innovations
- Pipeline integrity/distribution integrity management
- Materials testing and evaluation
- Pipeline and storage solutions
- Environmental and chemical research services

**End Use Solutions**

William Liss, Managing Director

- Combustion
- Industrial process heating
- Power generation and combined heat and power
- Residential/commercial appliances
- Hydrogen and alternative fuel storage, fueling stations, and vehicle integration
- High-temperature and low-temperature fuel cell components and systems
- Energy conversion, fuel processors and catalysts
- Codes and standards
- LNG interchangeability



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# Alignment with the Industry Value Chain

| | SUPPLY | DELIVERY | END USE |
|---|---|---|---|
| |   |  |  |
| ***Needs*** | **Secure, stable, competitive domestic energy supply** | **Address strategic concerns of domestic gas T&D infrastructure** | **Maintain industrial competitiveness and improve affordability of end use technologies** |
| ***Strategic Focus*** | • Unconventional Gas Resources<br>• Gasification for Alternative Supply | • Safety<br>• Pipeline Integrity<br>• Cost Reduction<br>• Efficiency | • Efficiency and environmental<br>• Product development and commercialization |

***Carbon Management***



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## GTI's Carbon Management Information Center

- Objectives
  - Serve as a clearinghouse for relevant carbon management information
  - Develop credible information products and functional tools to meet the needs of investors and their customers
- Scope
  - Develop an online information resource
  - Conduct technology and market assessments
  - Provide technical input to voluntary standards and regulatory initiatives



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## Issue

- The U.S. and state governments are beginning to develop strategies to reduce $CO_2$ and other greenhouse gas (GHG) emissions.
  - Current focus is to reduce emissions by sector
  - Superior approach is to take a holistic view and utilize energy sources for most efficient applications
    - This approach requires a full fuel cycle analysis



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# Why Full Fuel Cycle Analysis is Important

- For every Btu of energy of coal in the mine, only 0.26–0.38 Btu of that energy gets delivered to the end-use customer through the electric grid.
- For every Btu of natural gas in the well, only 0.26–0.51 Btu of that energy gets delivered to the end-use customer through the electric grid.
- For every Btu of natural gas in the well, 0.91 Btu is delivered to the end-use customer through the gas lines.



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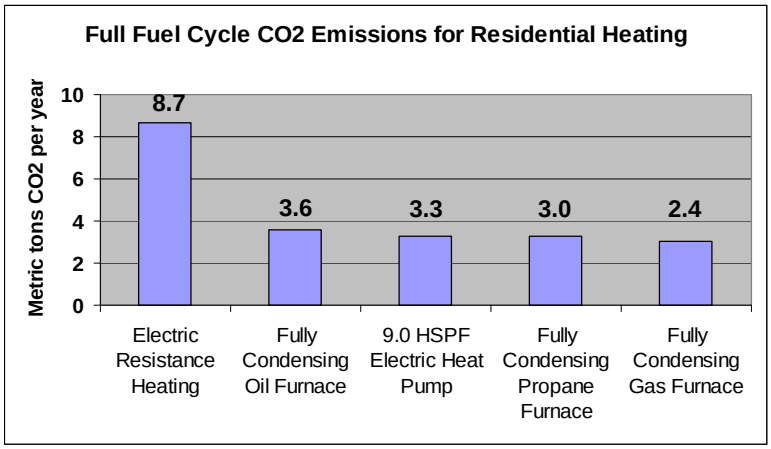
# Full Fuel Cycle $CO_2$ Emissions




Note: Based on BAT and average U.S. electricity mix



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## Opportunity

- Optimizing how the U.S. uses energy has the potential to reduce $CO_2$ emissions by 430 – 645 million metric tons per year
- Energy efficiency gains, using full fuel cycle analysis, are about 4.3 quads per year



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## Strategy

- In the near term, aggressive deployment of high-efficiency natural gas equipment in the nation's homes, offices, and industries and CHP deployment can achieve substantial $CO_2$ savings
- In the midterm, additional GHG savings by reducing methane leakage from the nation's natural gas infrastructure and from expanded deployment of NGV's
- In the long term, renewable gas can be fed into the pipelines to create a sustainable, zero-carbon option



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# Implementation

> Implementing this strategy will require…

- Appropriate regulatory and market structures
- Enhanced development and deployment of energy technologies
- Maintaining and expanding our nation's current natural gas infrastructure
- Expansion of current renewables incentives



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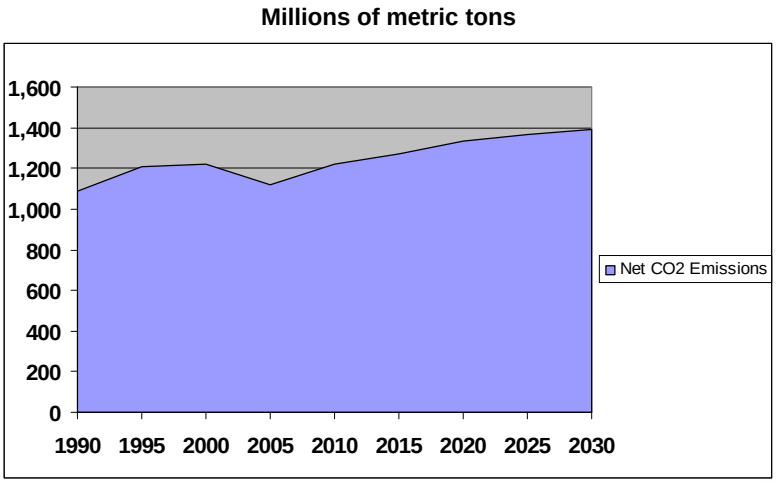
# Reference Case: $CO_2$ Emissions from Natural Gas Systems and End Uses*




* Excludes natural-gas-fired electricity generation



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# Near-Term Approach

- Displacement of electric-resistance and oil-based space and water heating and other applications
- Displacement of lower-efficiency natural gas appliances
- Deployment of residential, commercial and industrial CHP
- Goals:
  - Generate up to 4.3 quads per year of energy savings
  - Reduce $CO_2$ emissions by 370 million metric tons per year
- This approach will lessen the pressure to use natural gas for power generation as the growth in overall residential and commercial electricity use will be lower than current projections, and is less expensive than nuclear or $CO_2$ sequestration



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# Other Analyses Support this Conclusion

- Black & Veatch Study*
  - Energy savings: 1.25-2.0 Quads per year by 2030
  - CO2 savings: 60 – 200 MM tonnes $CO_2$ per year
  - Avoided new generation: 63-80 GW
- Northwest Power Planning Council Study**
  - Peak electricity savings: 2.2 GW (NW only)

**•Direct Use of Natural Gas: *Implications for Power Generation, Energy Efficiency, and Carbon Emissions,* April 2008, for American Gas Foundation**
**** http://www.nwcouncil.org/Library/2001/2001-17.htm**



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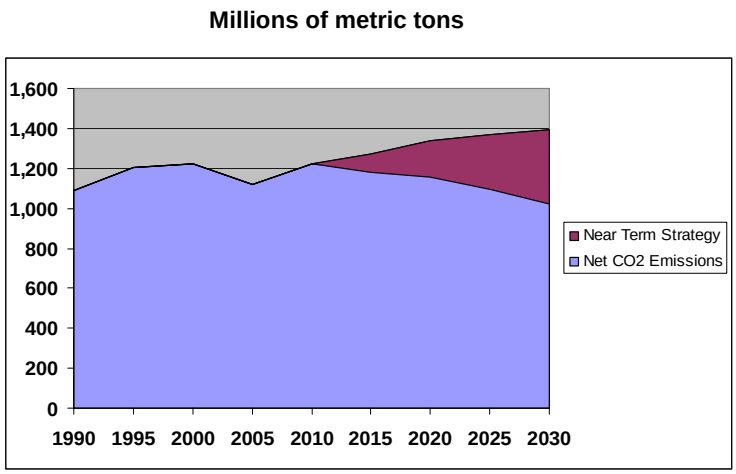
# Near-Term Strategy: Deployment of Gas Energy Efficiency Technologies



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# Mid-term Approach

- Reduced emissions from natural gas production, transport and distribution systems
  - Goal: reduce methane emissions by 50%
- NGV deployment
  - Goal: Displace 10 billion gallons of oil
  - Represents 25 to 30% penetration into medium an heavy duty fleet vehicle market
  - Much greater impacts (up to four times) available with greater penetration into fleet market and passenger vehicle market
- Achieve incremental $CO_2$ equivalent ($CO_2$ e) reductions of another 100 million metric tons per year



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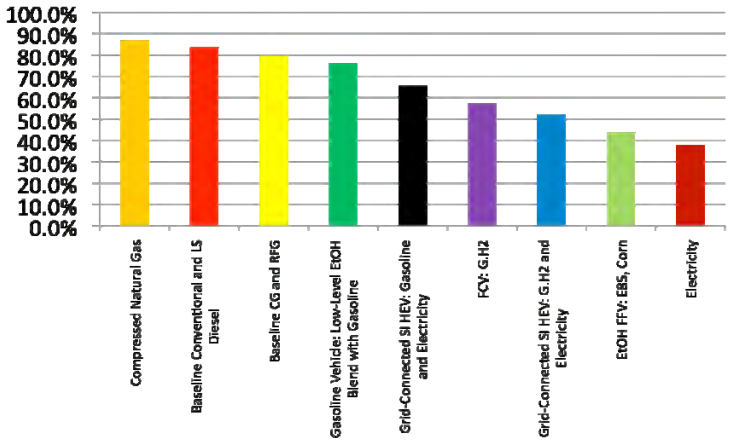
# “Well-to-Pump” Efficiency of Various Vehicle Fuel Options




Ref: American Clean Skies Foundation (results using GREET Model)



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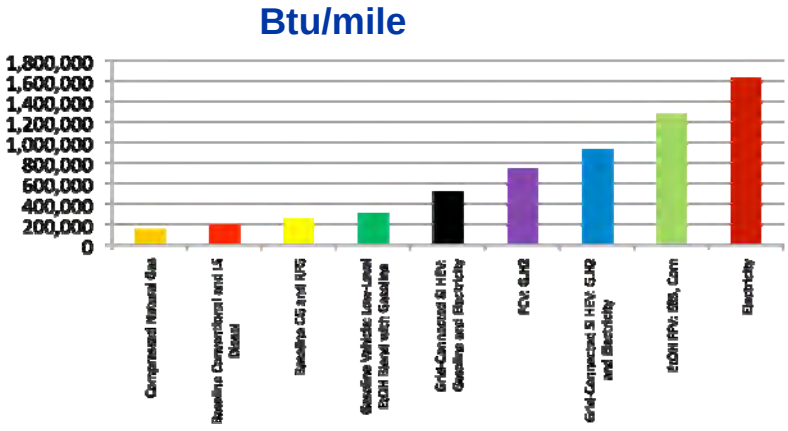
# “Well to Wheels” Total Energy Consumption of Select Alternative Fuel Choices




Ref: American Clean Skies Foundation (results using GREET model)



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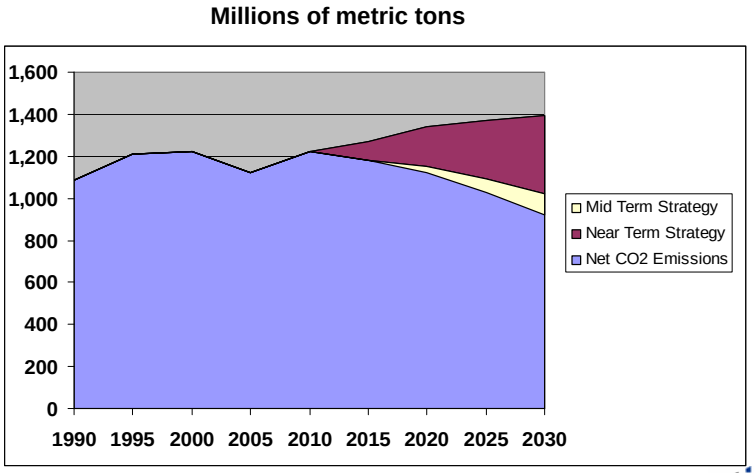
# Midterm Strategy: Reduction of Methane Emissions and NGV Deployment



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# Long-Term Approach

> Expanded renewable gas generated from cattle and swine feedlots, forest and crop residues, municipal solid waste

- Pipeline quality gas from biomass including forest residues and agricultural wastes can be produced at efficiencies ranging from 60-70%. This compares to biomass-to-liquid-fuels efficiencies of 45-60% and biomass-to-electricity efficiencies of 20-35%.(1)

> Goals:

- Up to 1 quad (5% of consumption) of pipeline gas from renewable resources
- Incremental reduction of $CO_2$ emissions of another 70 million metric tons per year.
- May be able to quadruple this goal by 2030 depending on resource acquisition, market forces and U.S. energy policy

(1) ttp://sgc.se/Rapporter/Resources/seminar_screen.pdf, p.305



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# Renewable gas is…

> Methane produced from digesters
  - Animal manure (dairy cows, swine)
  - Waste water treatment facilities

> Bio-gas produced from thermal chemical processes like gasification utilizing renewable feed-stocks including forest residues and agricultural wastes.

**RENEWABLE GAS CAN BE CLEANED UP AND PLACED IN THE NATURAL GAS PIPELINE SYSTEM**



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# Renewable Gas Rationale

> Renewable Gas
  - Natural gas is 25% of US primary energy, has an extensive and the most efficient distribution infrastructure, and in many parts of the country expansion of its use can reduce carbon emissions in residential and commercial sectors

> Value
  - Most efficient conversion option for biomass, which is likely to be a premium feedstock
  - Enhances value of forest and agricultural by-products by providing additional markets
  - Renewable option for end-use combustion applications
  - Carbon neutral fuel



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# Gasification – A Means to a Secure, Renewable Gas Supply



Gasification

Syngas

Carbon Management Opportunity

Excellent Environmental Performance

Liquefaction

Pipeline Quality Gas / Chemical Feedstock

Power Plant Fuel

Transportation Fuels

Pipeline / Chemical Plant

Power Plant



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# Flex-Fuel Test Facility Overview

**Features**

- Biomass – 24 tpd w/air; 40 tpd w/oxygen
- Coal – 10 tpd w/air; 20 tpd w/oxygen
- Gasification Pressure to 27 bara
- Multi-contaminant Syngas Cleanup
- On-line Syngas Analysis Systems

**Process Evaluations**

- SNG Production
- Syngas-to-Liquids Production
- Hydrogen Production
- $CO_2$ Capture Technologies
- Advanced Power Conversion Systems
- Industrial Syngas End-Use

**Commercial Operator Training**




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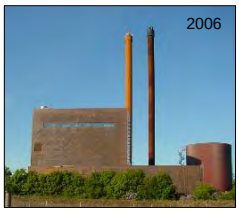
# Gasifier Projects


80 ton per day Gasification Pilot Plant in Finland using biomass & coal


1000 ton per day U-GAS® Industrial fuel gas in Shanghai, China using coal


100 ton per day Bioenergy Demo Plant in Hawaii using bagasse




165 ton per day CHP Plant in Denmark using wood


400 ton per day U-GAS® in Hai Hua, China using coal



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# Skive, Denmark
# Combined Heat & Power Project




CARBONA

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# Biomass Feedstocks

- Hard wood chips
- Soft wood chips
- Hard & soft wood mix
- Forest residue
- Bark
- Paper mill waste
- Wood pellets
- Saw dust
- RDF pellets
- Wheat straw
- Willow
- Alfalfa
- Rice straw
- Oil palm
- Bagasse



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# Process Economics: Site Considerations

- Proximity to biomass resources which are managed to sustainable standards
- Existing mill site with natural gas supply and option for CHP integration
- Renewable standards in place
- Lack of other renewable options
- Supportive social/political climate
- Opportunity for Rural Economic Development



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## Current Renewable Gas Legislation

- US Representative Higgins (D NY) Bill - HR 7097
  - Co-sponsors from Ways and Means Committee
    - Rahm Emanuel (D IL)  Devin Nunes (R CA)
  - $4.27 per MMBTU production tax credit
  - Feedstock definition broad
  - Supports digester and gasification technologies
  - On-site use or pipeline production eligible for credit
  - If you support – Let your Congressman know



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## Renewable Gas Coalition

- Participants are currently gas utilities, AGA, GTI and Environmental Power
- Third meeting in DC on October 17th
- Looking for agricultural participants (manure, agricultural wastes, forestry)
- Goals
  - Information dissemination (education of policy makers and public)
  - Passing tax credit into law



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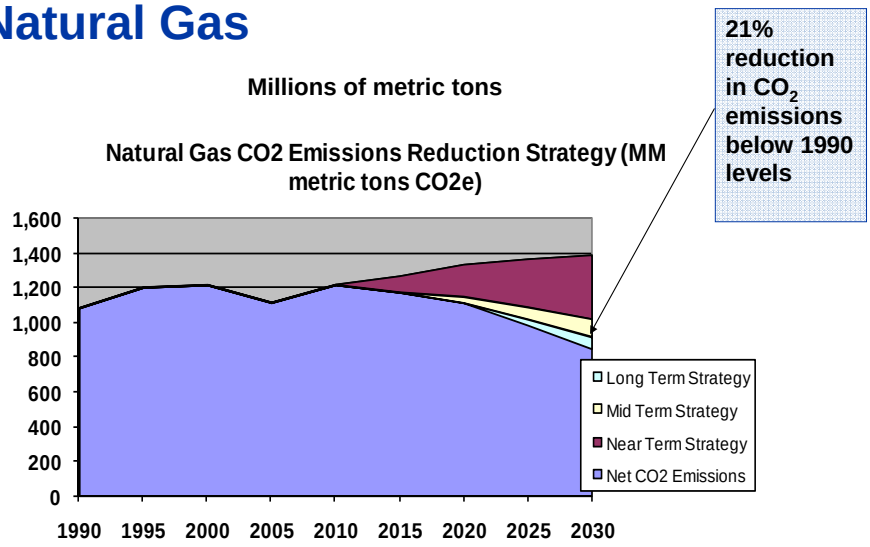
# Long-Term Strategy: Renewable Natural Gas



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# How will we get there?

> Full energy cycle analysis and validation - coupled with aggressive deployment of high-efficiency gas appliances

> Development funding for new, more efficient energy technologies

> Upstream $CO_2$ credits for energy efficiency and methane emissions reductions

> Deployment of renewables into pipeline gas

***Implementing this strategy will require appropriate regulatory and market structures, enhanced development and deployment of energy technologies, maintaining and expanding our nation's current natural gas infrastructure, and expansion of current renewables incentives.***



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# Recommendations

> Congress and policy makers should consider a holistic approach to reducing $CO_2$ emissions and move away from the current practice of reviewing each energy sector independently
  - By taking a holistic approach, a more reasonable and less costly means to a lower carbon future can be discovered.

***If the approach outlined in this presentation is coupled with a robust use of renewables (solar and wind) for electricity production, expansion of distributed energy opportunities, and a more inclusive focus on "full energy cycle" and end use product and system efficiency, the nation can lessen the need for new nuclear and coal-fired facilities, reduce electricity demand, and improve the economics of energy use for U.S. consumers.***



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# Questions?