



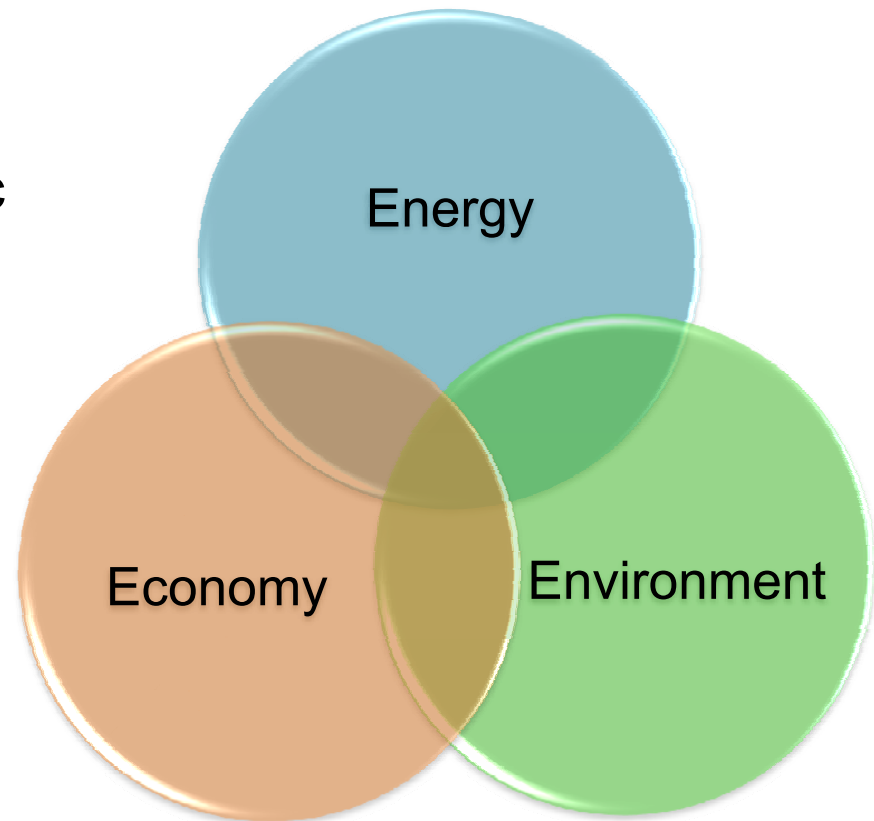
the Energy to Lead

End Use Solutions

-
- > William E. Liss
Managing Director, End Use Solutions
GTI Energy Technology Forum
June 3, 2009

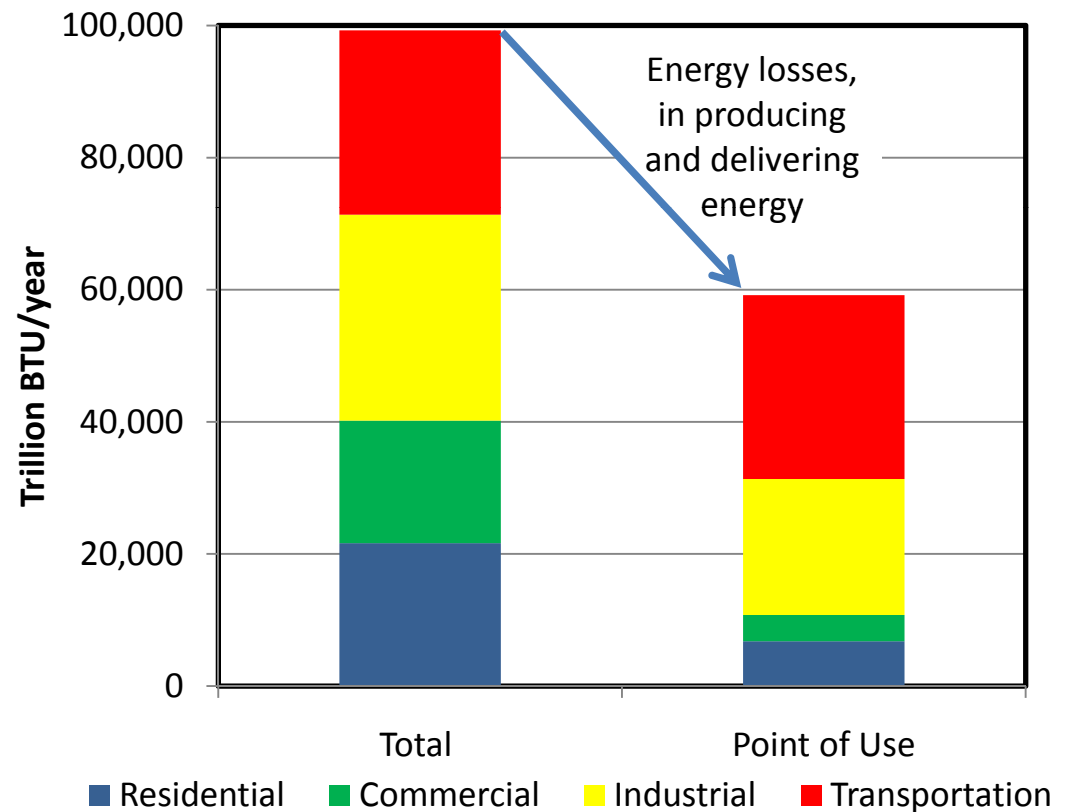
Energy Tightly Woven Into Our Economy...and Our Environment

- > How can we **efficiently use energy**?
- > How can we achieve economic growth and **industrial competitiveness**?
- > How can we ensure **sustainable and affordable energy** supplies?
- > How can we **minimize environmental impacts**?



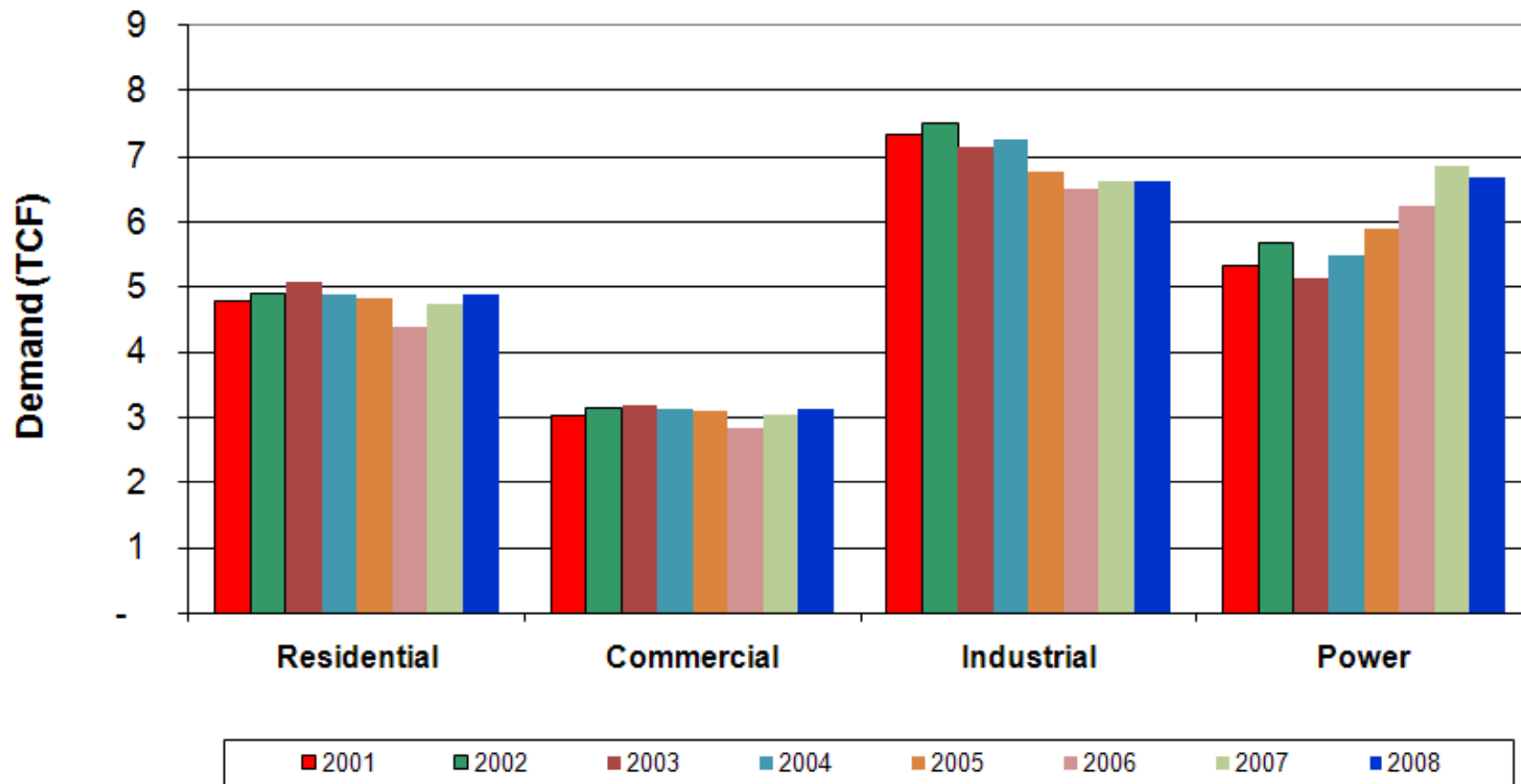
Energy Use in U.S.

- > Four major market segments
 - Residential
 - Commercial
 - Industrial
 - Transportation
- > Nearly 40% of energy is consumed before we actually use it



Source: DOE EIA

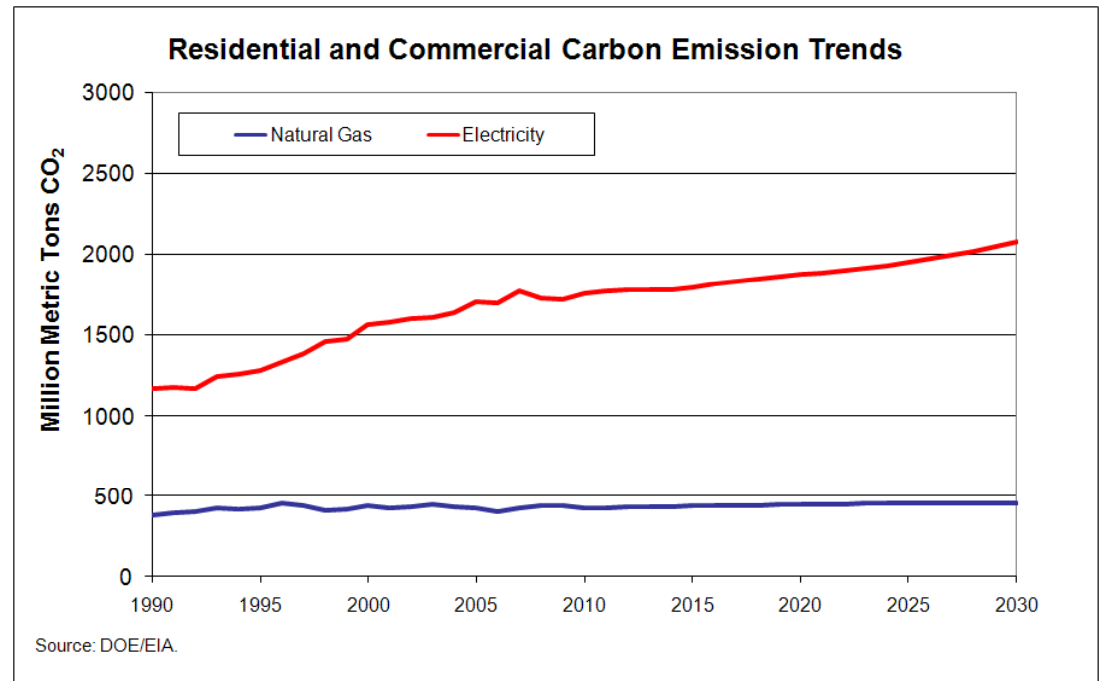
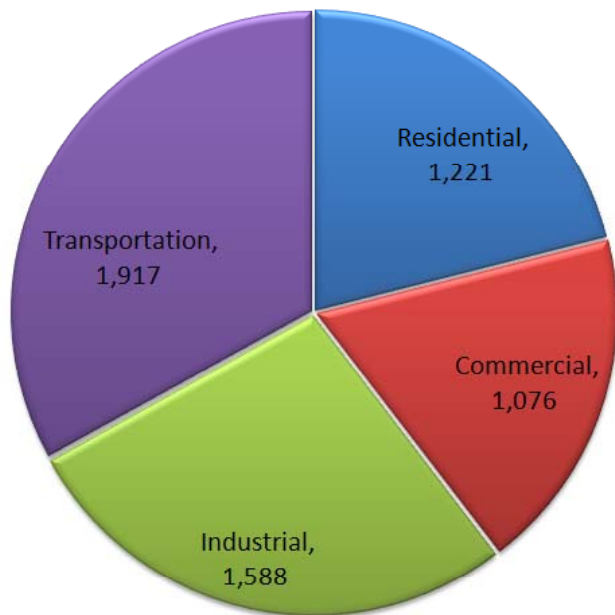
Natural Gas Demand



Source: DOE -EIA

End Use Carbon Emissions

Annual U.S. Carbon Emissions
(Million Metric Tons)



GTI End Use Solutions

- > Develop clean, efficient and cost-effective technology and products with value-added benefits to our partners and stakeholders

Industrial Processes

- > Metals, glass, petrochemicals, paper, food, others

Power & Steam Generation/CHP Systems

- > Industrial boilers
- > Engines, turbines, fuel cells

Residential/Commercial

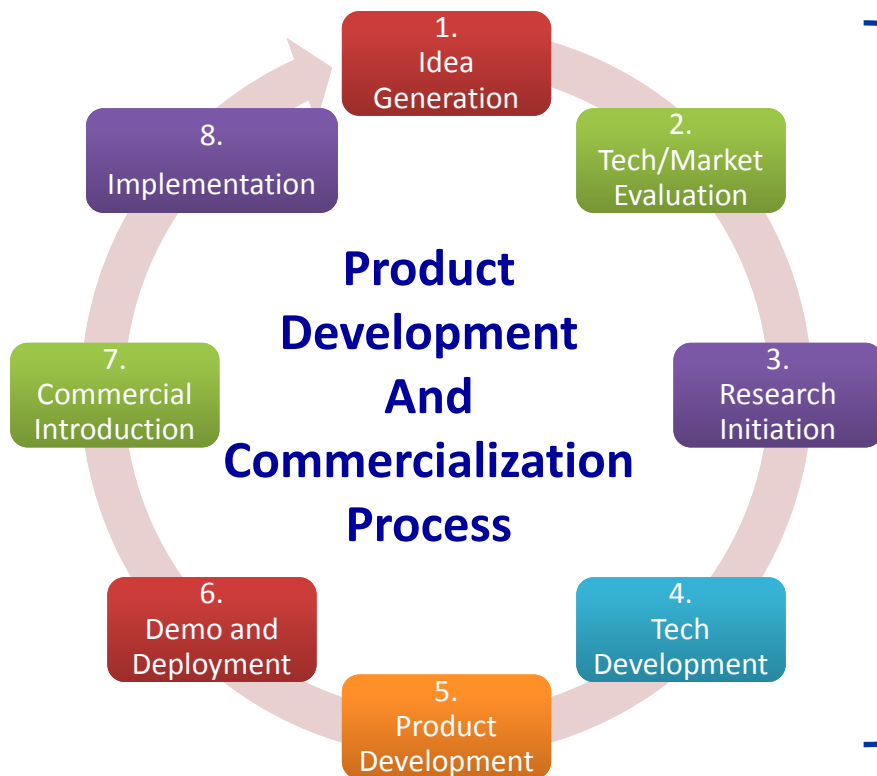
- > Building systems, equipment, and appliances

Transportation

- > Alternative fuel vehicles and infrastructure



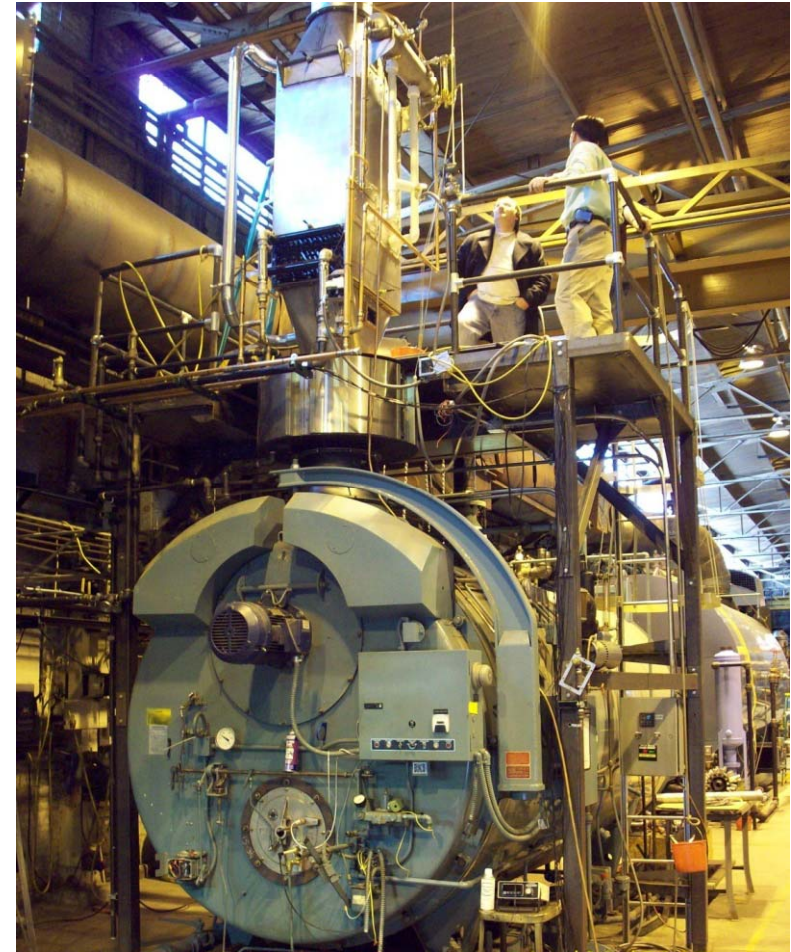
RD&D Process Driven By Collaboration



- > Support from **Natural Gas Industry**
 - **Sustaining Membership Program (SMP)** focused mainly on Stages 1-4
 - **Utilization Technology Development (UTD)** focused mainly on Stages 4-6
- > Leverage with **Federal (e.g., USDOE), State (e.g., CEC), and Manufacturer** cofunding
- > Work with **Utility Energy Efficiency Programs and Energy Solutions Center** for Stages 6-8

Advanced Boiler Technology

- > Maximizing steam generation efficiency for commercial and industrial boilers
 - 94% fuel to steam efficiency with novel heat and water recovery device
 - 15% carbon emission reduction
 - Ultra low NO_x (sub 9 ppmv)
 - Target: < 2 year payback
 - Multiple field tests underway



Transport Membrane Condenser (TMC)

- > Tubes with nano-porous membrane that selectively removes water by low-pressure-drop capillary condensation
 - Simultaneously captures waste heat and pure water (from combustion products)
- > Applicable to many combustion uses
 - Industrial and commercial boilers
 - Steam power plants
 - Industrial drying and humidification processes
 - Home furnace and humidification



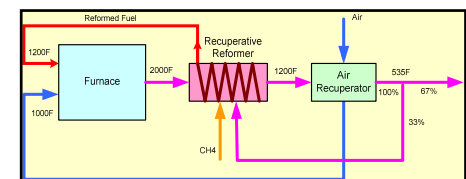
Advanced Industrial Melter

- > Developing revolutionary melter for producing industrial materials
 - Various glass products, sodium silicate, waste material recycling (waste fiberglass, electric arc furnace dust vitrification), etc.
- > Unique submerged combustion process yields major improvement in capital cost, productivity, flexibility, footprint, efficiency
- > Working with variety of industrial partners
- > Multiple licensees



Additional Industrial Technologies and Research Efforts

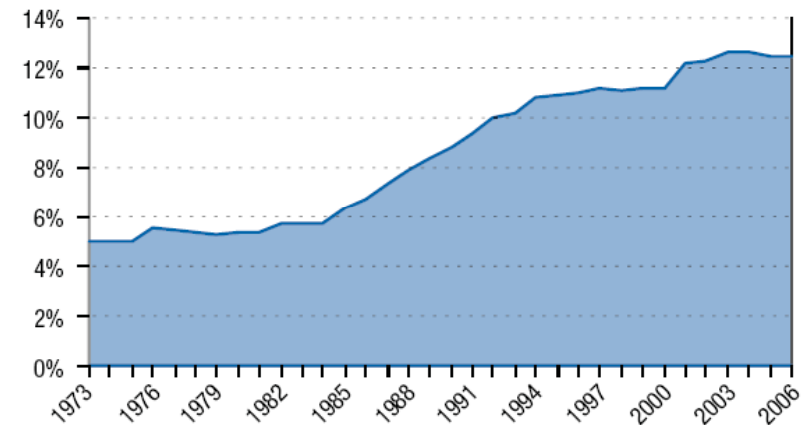
- > RASERT technology for indirect fired heat treating, galvanizing (deployment)
- > Direct-fired drum dryer for food and other industrial uses (field testing)
- > Advanced heat recovery techniques
 - Thermo-chemical recuperation: working with steel industry (AISI) and DOE
 - Corrosive high temperature exhaust gas heat recovery (Gas Guard technology)
 - Early stage low-grade heat recovery for water purification (DOME technology)



Combined Heat and Power (CHP) Systems

- > Goal: Drive CHP to the next level of market acceptance
 - Supported by improved natural gas prices
- > Engine, microturbine, turbine, and fuel cell systems
 - Micro to large commercial and industrial (<5 MW)
 - Raise power efficiency
 - Enhance fuel flexibility to use biomethane and waste fuels
 - Effective heat recovery (hot water, steam, thermal-driven cooling)

CHP as a Percentage of U.S. Annual Electricity Generation



Residential/Commercial

- > GTI has a robust residential and commercial program focused on:
 - New appliance technology for hot water and space conditioning
 - Commercial food service technology
 - Distributed generation/CHP
 - Building systems integration and community planning
 - Solar thermal/natural gas hybrid systems
 - Carbon management solutions



Commercial Food Service Equipment

- > Saving energy
- > Improving product quality
- > Raising productivity rates



High Efficiency Pizza Ovens & Combi-Ovens

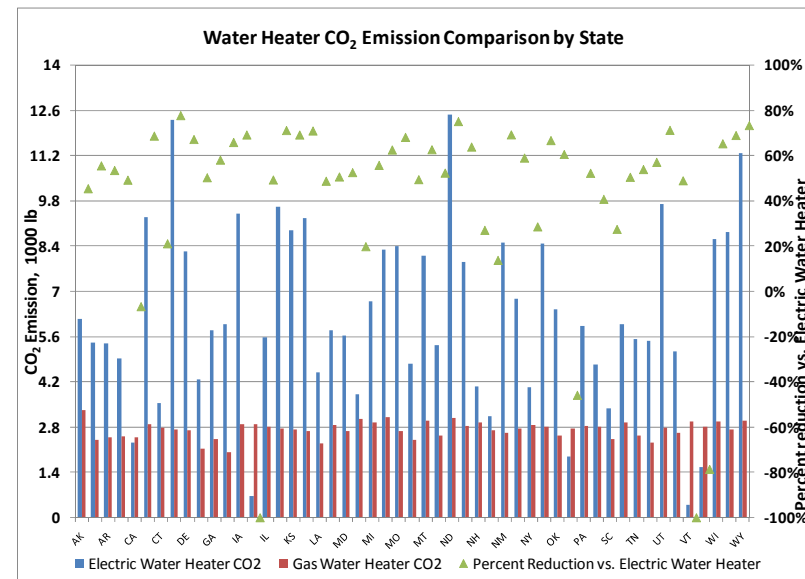
First Boilerless Gas-Fired Steamer



Low Oil Volume Fryers Using Trans Fat Free Oils

Building/Community Energy Analysis and Carbon Management

- > GTI energy efficiency and carbon management tools and capabilities
- > Addresses options for improving energy efficiency and lowering carbon emissions
 - Technology trade-offs, whole building improvements, role of renewable energy



Solar Thermal/Natural Gas Hybrid Energy Systems

- > Push natural gas equipment above 100% efficiency using hybrid solar thermal/natural gas energy solutions
- > Reduced-cost domestic hot water and hydronic heating systems for residential and commercial buildings
- > Higher-temperature concentrated solar thermal for steam generation, absorption cooling, process heating
 - Commercial buildings
 - Industrial plants



Renewable Natural Gas

- > Bio-methane (bio-gas)
 - Landfill gas, wastewater treatment
 - Digestion of agricultural waste and other biomass waste
- > Produce pipeline quality methane, CNG, LNG, clean fuel cell power



Gills Onions –
Digester to
Fuel Cell Quality
Methane



Linde – Waste
Management
Landfill Gas to LNG
for Vehicles

Hydrogen Fueling Stations and Fuel Cell Vehicles

- > Working with partners to develop and demonstrate:
 - Integrated hydrogen fuel stations
 - > Fuel reformers, electrolyzers, delivered hydrogen
 - Specialty fuel cell vehicles

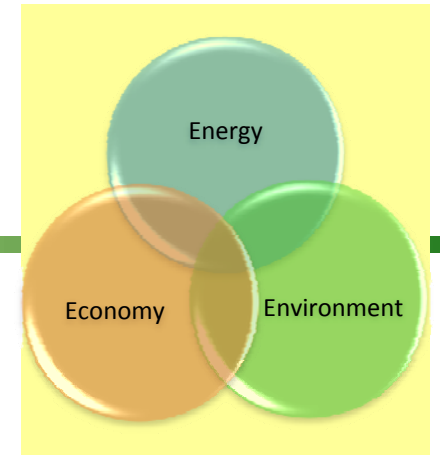


Hybrid hydrogen fuel cell/
battery shuttle bus



Factory packaged natural gas to
high-pressure hydrogen fuel station

Summary



- > GTI's End Use efforts focused on:
 - Residential, commercial buildings:
 - > Energy efficiency and carbon emission reduction
 - Industrial competitiveness
 - Combined heat and power systems
 - Alternative transportation fuels and vehicles
 - Renewable energy:
 - > Solar thermal and biomethane
- > Work collaboratively with energy companies, government partners, manufacturers, and end users