Gas Technologies for Residential and Commercial Consumers

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GTI Overview

ESTABLISHED 1941

> Independent, not-for-profit established by the 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

> Wellhead to the burner tip including energy conversion technologies

Our Staff

292 EMPLOYEES

60% SCIENTISTS/ENGINEERS

44% ADVANCED DEGREES
Residential Customer and Per Home Natural Gas Use Trends

Energy efficiency programs having a positive impact.

Total number of natural gas homes up nearly 50% since 1980.

Average consumer using 30% less natural gas compared to 1980.

Source: DOE-EIA
Comparison of Source Efficiencies Delivered to Customers (%)

**Electricity**
- Extraction, Processing & Transportation: 100%
- Conversion: 95%
- Distribution*: 34%
- Delivered to Customer: 32%

*Based on 2007 actual generation mix of all energy sources

**Natural Gas**
- Extraction, Processing & Transportation: 100%
- Conversion: 93%
- Distribution: 92%

Source: American Gas Association
Source Energy Use Reduction by Increased Natural Gas End Use

> Efficient direct use of natural gas can significantly reduce full-fuel-cycle energy consumption compared to electric resistance technologies

> Natural gas end use technologies uniquely positioned for long term societal benefits
  — Low life-cycle costs to consumers
  — High source energy efficiency
  — Low carbon emissions
  — Energy security
  — Domestic employment
  — Compatible with renewable methane
GTI End-Use Product Development & Commercialization Process

**ETP** helps companies assess the benefits of new energy efficiency products and integrated solutions for use in near- to mid-term energy efficiency program implementation.

**Established in 2012**

**SMP** builds a strong technology base for new technologies, product concepts, and related solutions through the “proof of concept” stage for gas utility members and their customers.

**Established in 1985**

**UTD** and its 16 members serve over 24 million natural gas consumers in the U.S. and Canada. These companies work together on technology developments that meet their end-use customer energy efficiency and environmental needs.

**Established in 2004**
### GTI’s Energy Utilization RD&D Program

**Five Areas of Focus for Efficient, Clean Uses of Natural Gas**

| Highly Efficient Appliances (Including over 100% efficiency) | • Combination Space/Water Heating Systems  
• Gas Heat Pumps (Space Conditioning, Water Heating)  
• Ventilation, Indoor Air Quality  
• Commercial Foodservice |
|---|---|
| Efficient, Clean Industrial Processes | • Efficient, low NOx Boilers  
• Advanced Process Heating  
• Heat Recovery Systems  
• Process Controls and Sensors |
| Combined Heat & Power | • Integrated Commercial/Industrial CHP Systems  
• Micro CHP Systems |
| NGVs, Hydrogen, and Alternative Vehicles | • Ultra-Clean, Efficient HD NGVs and NGV Storage  
• NGV Fuel Stations, Home Fueling  
• Hydrogen Fuel Cells, H₂ Fueling |
| Renewable Energy | • Solar Thermal/Natural Gas Hybrid Systems  
• Bio-Methane Production, Clean-Up, and Use |
GTI Residential and Commercial RD&D Program

> Building energy efficiency technologies
  ─ New appliance technology for hot water and space conditioning
  ─ Commercial food service technology
  ─ Solar thermal/natural gas hybrid systems
  ─ Distributed generation/CHP
Residential ‘Low-Load’ Heating: One Size Does Not Fit All

- **Combined Space and Water Systems**
  - Improves utility/customer value proposition for water heating by piggy-backing on larger space heating load.
  - Equipment, system specification, operation, and load profiles all have significant impact on energy savings potential.
  - Market development and training critical, new construction likely first significant market entry point

- **Through wall packaged heating, cooling systems**
  - Systems represent growing portion of multi-family market
  - Manufacturers are beginning to roll out condensing options
  - Barriers exist related to codes and standards, as well as practical matters such as condensate management and compliance with voluntary programs (e.g. ENERGY STAR)

- **Low capacity ‘right-sized’ furnace**
  - Low capacity high AFUE furnaces with full modulation, very small footprint, quiet operation, variable speed blowers, and high efficiency cooling
  - 15,000-30,000 Btu/hr modulating down to 6,000 Btu/hr
  - Ideal for multi-family with 2.5 inch supply ducts
# Thru-the-wall Furnace/AC

<table>
<thead>
<tr>
<th>Company</th>
<th>“Thru-the-Wall” HVAC Product Line</th>
<th>Condensing Offering</th>
</tr>
</thead>
</table>

> Four of five top makers offer condensing…but…

> …issues with code/standard & voluntary requirements

  – AFUE vs. TE ratings
  – Companion AC SEER levels
  – Condensate disposal access to sanitary sewer
  – Condensate neutralization of acidic content
  – ENERGY STAR Quality Installation duct loss/ft²
Combined Space & Water Heater Systems

- **Technology**
  - Air handling unit and tankless water heater combined in pre-engineered applications to create opportunities for market potential and energy efficiency in residential applications.

- **Savings Potential**
  - >10% whole house energy savings
  - Savings vary based on system design, sizing, air handler, and other factors

**GTI Activity**
- GTI has several ongoing or recently completed demos, pilots with SoCal Gas, Nicor Gas, NYSERDA, and UTD.
Low Capacity Gas Furnace

**Technology**
- Low capacity high AFUE furnaces with
  - Full modulation
  - Very small footprint and quiet
  - Variable speed blowers
  - High efficiency cooling
- 15,000-30,000 Btu/hr
- Accommodates 2.5 inch supply ducts

**GTI Activity**
- Commissioning, installation, duct distribution system, thermostat requirements, and benchmark energy use compared to alternative or traditional system focus
- Develop market strategies for local markets -HVAC, builder coordination, issues with installing and sealing ducts.

### MARKET SITUATION

**Baseline**
- Standard, single stage gas furnace

**Opportunity**
- Energy efficiency: natural gas and electricity savings
- Market potential: retrofit existing systems and for new installations

**Segment**
- Residential
- New construction and retrofits

**Status**
- Technology process is mature and readily available

**Next Steps**
- Third party verification of benefits and market analysis
Gas Heat Pump Hot Water Heater

**Baseline**
- Traditional domestic hot water technologies

**Opportunity**
- Energy efficiency: natural gas, customer cost savings
- Market potential: retrofit existing systems and for new installations

**Segment**
- Residential and commercial
- New construction and retrofits

**Status**
- Pre-commercial technology, currently being deployed across multiple residential applications.
- Expected 2017 commercialization.

**Next Steps**
- Continued field verification, technology enhancements based on measured performance, market development

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**Technology**
- Gas Heat Pump Water Heaters may provide a new way to use existing absorption technologies to maximize energy savings potential for domestic hot water use in homes and in light commercial applications.

**Savings Potential**
- Energy Factor of **1.3**, much higher than baseline technology at 0.6-0.65

**ETP Review**
- Stone Mountain Technologies Inc. (SMTI) led the initial R&D with support from GTI, Major OEMs and Georgia Tech.
- Six site field evaluation just completed in Southeast and Pacific Northwest, focusing on seasonal performance, heating system interaction, end user satisfaction, and contractor education.
- Currently performing reliability tests and work with OEM on enhancements based on field testing, lab testing, and to align with OEM design preferences.
- Commercialization expected for 2017, working with key members to drive agenda and scope.

**Barriers**
- Anticipated unit cost 2-3x conventional minimum efficiency system (similar cost to EHPWH)
- Use of Ammonia, a hazardous refrigerant
- The heat pump itself is a sealed system, not intended for servicing (like EHPWHs). The entire heat pump needs to be replaced at end of life.
- Installers need additional education as this installation crosses trades between plumbing and HVAC/refrigeration, like the EHPWH.
- Due to lower recharge timing, heat pumps systems require a larger storage tank and the 60-80 gallon tank may require a two person install.
Gas Heat Pump Space Heating

> Partnership with SMTI, GTI, and Lochinvar with financial support from USDOE

> Using lessons learned, team has scaled up low-cost, single-effect system to Gas Heat Pump (GHP) for space heating in cold climate

> System COP target of 1.4 at 32°F. Cold climate payback target of 3 years vs. min. eff. furnace.

> GHP will be equivalent to a 80,000 Btu/hr output hydronic boiler, with 3:1 turndown and outdoor installation.

> Capable to couple with storage tank for gas heat pump combi-system.

> Prototypes tested at GTI in psychrometric chamber down to -13°F.

> Currently installing at early-stage field sites in Johnson City, Tennessee funded by NEEA
Commercial Food Service Equipment

- Saving energy
- Improving product quality
- Raising productivity rates
# Whole Restaurant Example

## Energy Consumption and Cost

<table>
<thead>
<tr>
<th></th>
<th>Annual Site Consumption</th>
<th>Annual Source Consumption</th>
<th>Annual Energy Cost ($)</th>
<th>Lifetime Energy Cost ($)</th>
<th>Cost Savings Electric to Gas (%)</th>
<th>Annual Savings Electric to Gas ($)</th>
<th>Lifetime Savings Electric to Gas ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Electric</td>
<td>138,944 kWh</td>
<td>1,683 MMBtu</td>
<td>$12,824.53</td>
<td>$153,894.40</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>All Gas</td>
<td>11,706 therm</td>
<td>1,280 MMBtu</td>
<td>$11,706.00</td>
<td>$140,472.00</td>
<td>8.72 %</td>
<td>$1,118.53</td>
<td>$13,422.38</td>
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<tr>
<td>All Efficient Gas</td>
<td>4,543 therm</td>
<td>497 MMBtu</td>
<td>$4,543.00</td>
<td>$54,516.00</td>
<td>64.58 %</td>
<td>$8,281.53</td>
<td>$99,378.38</td>
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</tbody>
</table>

### Annual Source Energy Consumption

- **All Electric**: 1,683 MMBtu
- **All Gas**: 1,280 MMBtu
- **All Efficient Gas**: 497 MMBtu

### Annual Energy Cost

- **All Electric**: $12,825
- **All Gas**: $11,706
- **All Efficient Gas**: $4,543
Commercial Foodservice Developments

Commercial Wok
Conveyor Oven
Commercial Range

Convection Oven
Rethermalizer
Fryers

Restaurant Industry Sales (In Billions of Current Dollars)

- 2014: $683.4
- 2010: $586.7
- 2000: $379.0
- 1990: $239.3
- 1980: $119.6
- 1970: $42.8

"projected"
Renewables: Solar Thermal/Natural Gas Hybrid Systems

> Push to over 100% efficiency using hybrid solar thermal/natural gas energy solutions

> Reduced-cost for hot water and hydronic systems

> Higher-temperature concentrated solar thermal for steam generation, absorption cooling
  – Commercial buildings
  – Industrial plants
  – Hospitals, Universities

Samuel Billings Center—Charlotte, NC
In collaboration with UTD and Piedmont Gas
Natural gas/solar thermal hybrid system using 5 solar thermal arrays and tankless water heaters
Higher-Temperature Solar Thermal Collector

> Higher-temperature solar thermal array
  — Can generate over 400°F at 50% solar capture efficiency
  — Use for steam, process heat, absorption cooling

> Uses External Concentrating Parabolic Collectors (XCPC) Technology
  — Artic Solar
Current Micro-CHP Activity

> **M-Trigen**: Performance testing in lab (propane)
> **Yanmar**: Finishing up field demo in NY
> **EC Power**: Will be testing in lab and field in CA
> **AO Smith**: Future testing in lab and field in NY
> **Qnergy/ITC**: ARPAe Stirling combustion system
> Continuing to vet technologies (**iGEN** is the latest)
> **SPC 204 ASHRAE mCHP standards development**
> Working toward EPA/CARB certification capability
AO Smith/Briggs & Stratton Micro-CHP

> Major US manufacturers in the hot water and engine industries with networks of installers and trainers to drive market acceptance

> 21kW with synchronous generator and black start-capable without an inverter

> Hot water thermally-led system

> Designed for easy install; “all-in-one box”

> NYSERDA funded project demonstration starting this year

> AOS championing an 8-site USDOE-supported demonstration of larger non-synchronous 30kW system
  > In partnership with another major engine manufacturer
Summary

> Natural gas technologies are a very low carbon and low energy cost option for consumers

> Natural gas technologies continue to become more energy efficient, can integrate with renewables and align well with today’s efficient building envelopes

> Challenges still exist with customer and contractor acceptance with newly designed natural gas technologies
  > Customers, contractors and codes and standards officials need to be further educated
  > Continued R&D and technology demonstrations are needed to address these issues leading to highly efficient natural gas technologies providing low cost, low carbon comfort and performance for consumers