the Energy to Lead

Natural Gas Utilization RD&D Overview

CEE Summer Program Meeting

May 30, 2013

Paul Armstrong
Director of Business Development
Gas Technology Institute

gti

GTI Overview

- Not-for-profit research, with 70 year history
- Facilities
  - 18 acre campus near Chicago
  - 200,000 ft^2, 28 specialized labs
  - Offices in AL, CA, MA, PA TX, Wash DC
- Staff of 250
- Market opportunities are creating substantial growth
- 1,200 patents; 500 products

Offices & Labs

Pilot-Scale Gasification Campus

Energy & Environmental Technology Center

Natural Gas Industry Sponsors

- GTI-led, utility supported, **North American collaborative programs** targeting **residential, commercial and industrial** solutions
  - Utilization Technology Development **(UTD)**
  - Emerging Technology Program **(ETP)**
  - Federal & State Agencies

gti

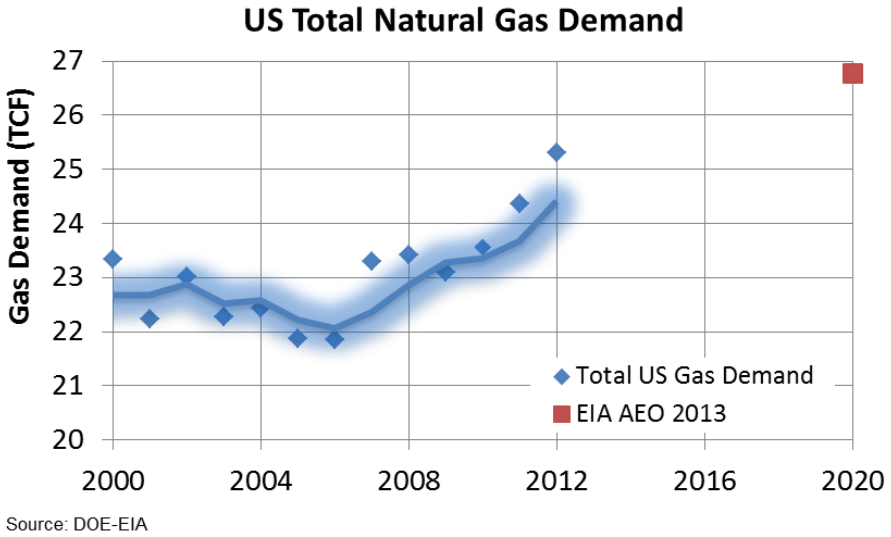
Presentation Overview

- Market Drivers and Trends
- Research Highlights
  - Natural Gas Heat Pump Technology
  - Micro-CHP and CHP
  - Commercial and Industrial Boilers
  - Building America Residential Research Program
- Demonstration and Deployment Highlights
  - Emerging Technology Program
  - Key Project Updates
  - Technology Highlights

US Natural Gas Supply Revolution

Driving Economic Growth, Gas Demand, Eliminating Imports

Tcf/Year	2000	2012	2020
Total Demand	**23.2**	**25.3**	**26.8**
Total Supply	**22.8**	**25.6**	**27.1**
Import %	16%	6%	0%



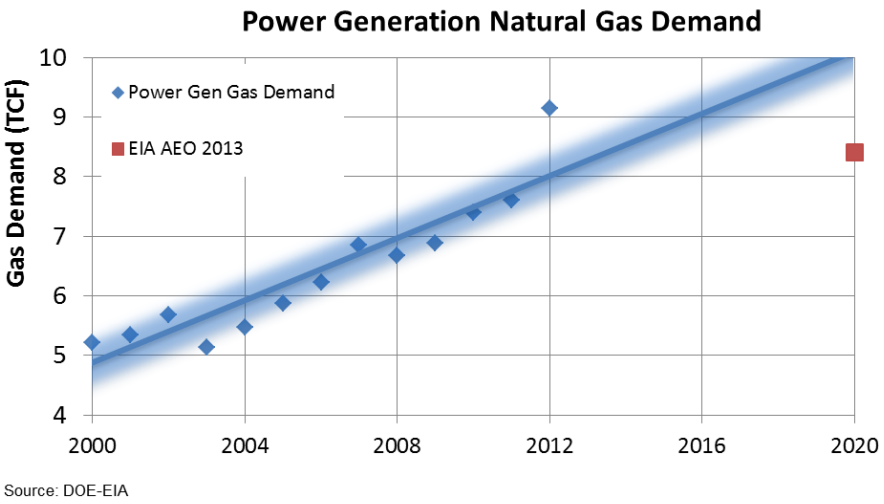
Source: DOE-EIA

- Market Growth:
  - > Power generation
  - > Rebounding Industrial Sector
  - > Transportation (high growth rates)
- Offsetting reliance on coal and oil

gti

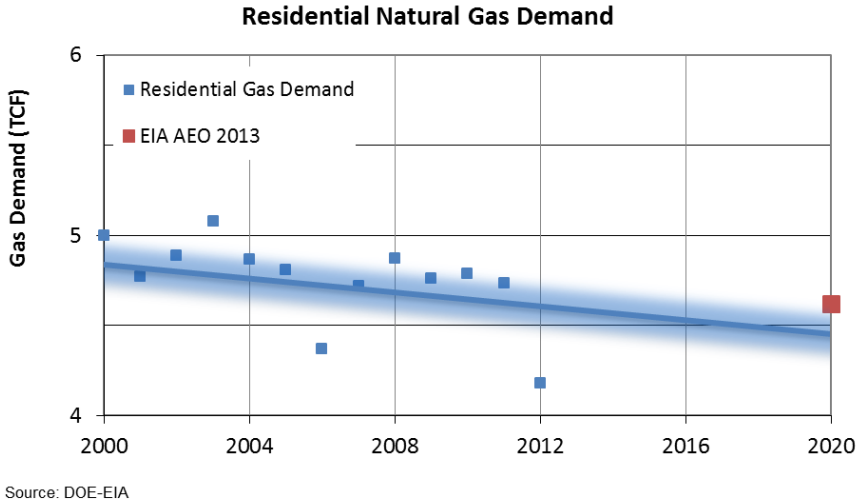
A Tale Of Two Markets

Power Generation and Residential Use



Source: DOE-EIA

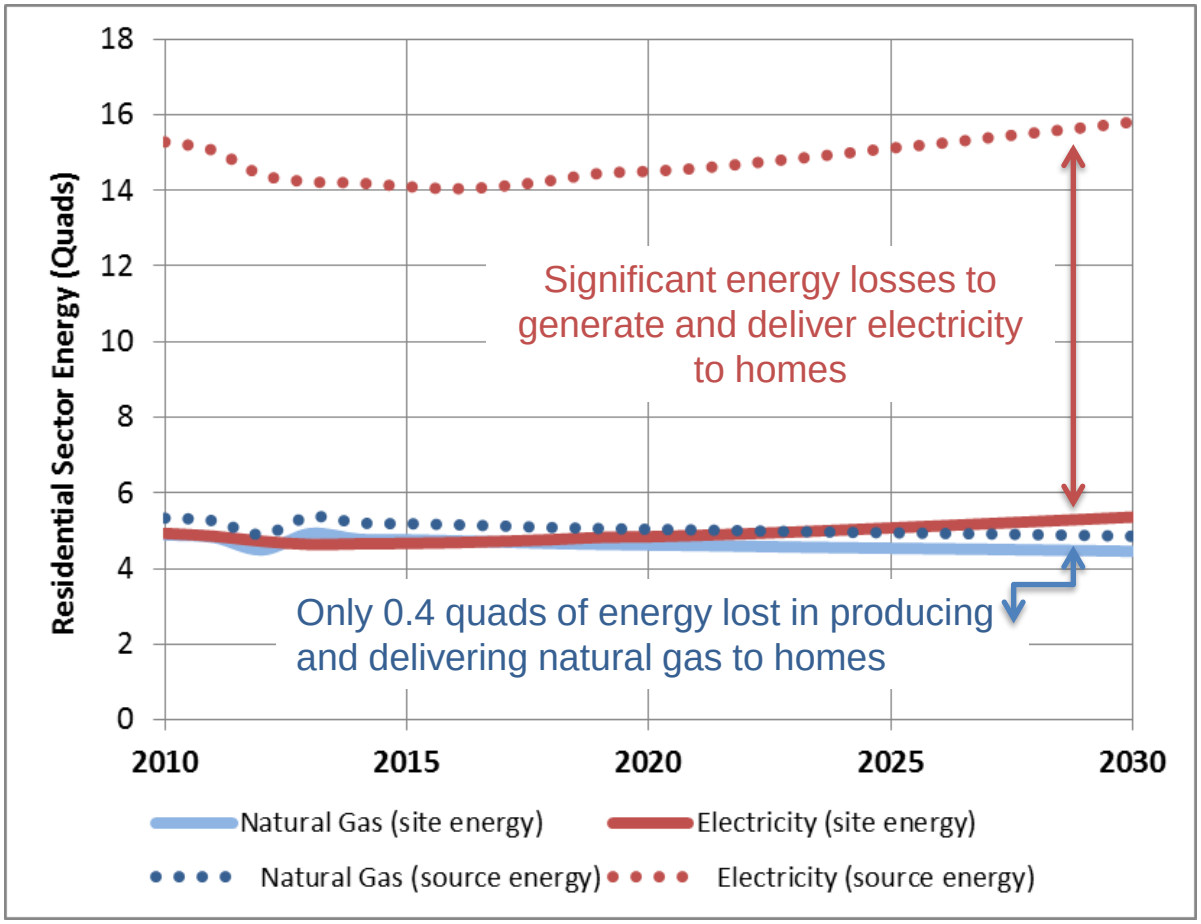
Power is far and away largest use of natural gas now in the US.



Source: DOE-EIA

Continued downward trend in US natural gas use due to efficiency improvements.

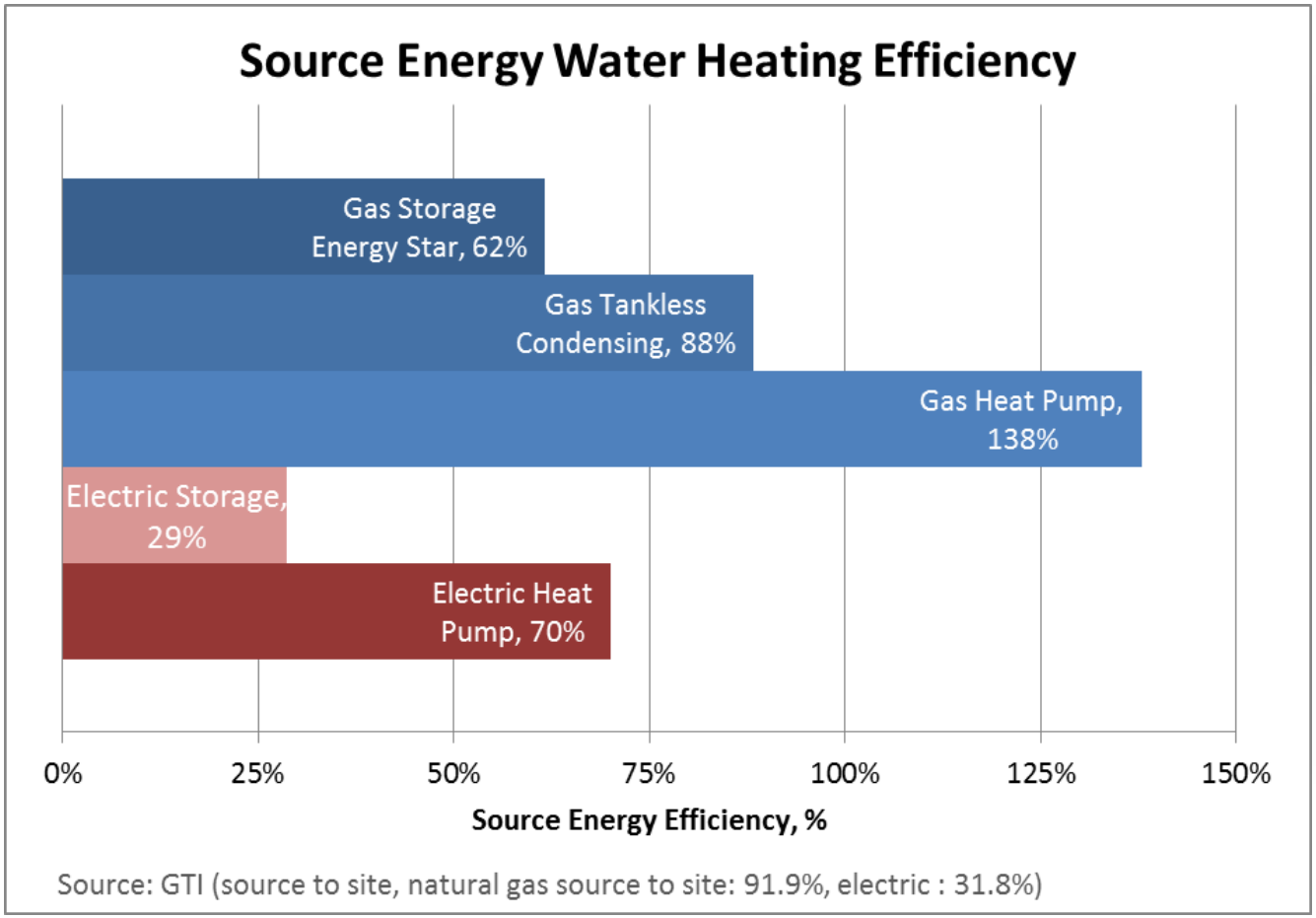
Total U.S. Energy Comparison:
Residential Sector



Direct natural gas use is a highly efficient option for space and water heating, cooking, and drying.

Home natural gas use can be complemented by solar thermal energy to further lower source energy intensity and sustainability.

Source-Based Water Heating Efficiency Comparison

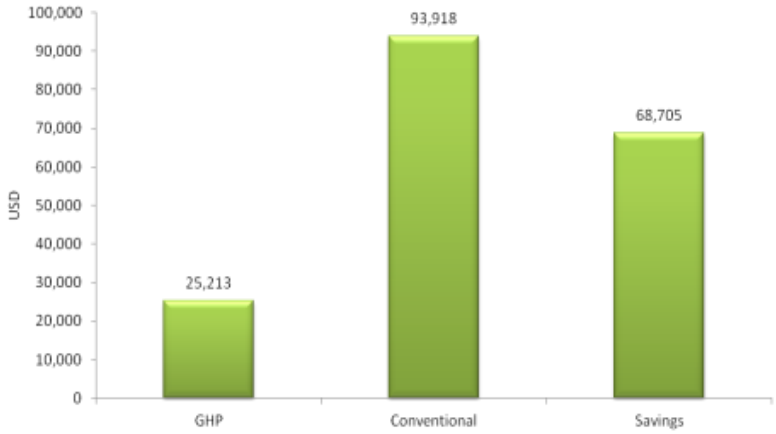


Source: GTI (source to site, natural gas source to site: 91.9%, electric : 31.8%)

Pre-commercial gas heat pump water heater

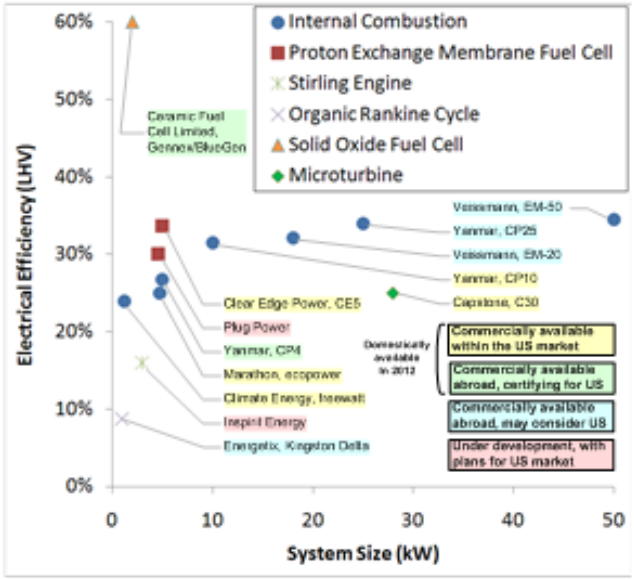
Natural Gas Heat Pump – IntelliChoice Energy Example

- NextAire Gas engine-driven heat pumps (GHPs) combine high efficiency heating (1.2-1.5 COP) and cooling (0.95-1.2 COP) to offer the potential to reduce operating and lifecycle costs compared to conventional HVAC equipment
  - Aisin/Toyota engine with proven performance and durability
  - Modulating engine speed for better part-load performance
  - Engine heat recovery increases efficiency
  - Variable refrigerant flow (VRF) provides heating and cooling for up to 33 zones
- Savings potential compared to conventional chiller/boiler equipment
  - Up to 30% reduction in operating costs
  - 80% less electric power consumption
  - Reduced water consumption



Micro CHP Technology Landscape

- Variety of emerging micro CHP systems (under 50 kW)
  - Engines, fuel cells, Stirling engines – some with promising electric efficiency
  - Commercial activity greater in Europe & Japan due to higher energy costs, drivers
  - Achieving acceptable first costs a challenge



Gas at $6 to $10	Atlanta, GA	Helena, MT	Los Angeles, CA	Phoenix, AZ	Tulsa, OK
Single-family BA2010	$1,740 to $2,570	$1,130 to $1,780	$2,790 to $3,560	$2,410 to $3,590	$1,600 to $2,650
Single-family MaxEE	$1,470 to $2,240	$930 to $1,620	$2,510 to $3,310	$2,020 to $3,120	$1,470 to $2,340
Single-family Vintage	$1,880 to $3,040	$2,250 to $2,270	$3,050 to $3,980	$2,800 to $3,980	$1,620 to $2,730
Multi-family by unit	$1,510 to $2,180	$1,020 to $1,660	$2,760 to $3,400	$2,080 to $2,870	$1,230 to $1,920
Budget Hotel	$1,580 to $3,080	$890 to $2,190	$2,960 to $4,540	$1,370 to $3,010	$970 to $2,440
Chain Restaurant	$710 to $2,330	NA to $1,760	$840 to $3,430	$850 to $2,620	NA to $1,850
Big-box Retail	$690 to $2,550	NA - $1,510	$2,180 to $4,080	$720 to $2,620	NA - $1,880
Small Office	$890 to $1,800	$1,120 to $1,920	$2,690 to $3,180	$720 to $2,430	$700 to $1,510
Multi-family Central	$880 to $2,610	NA to $1,780	$2,220 to $4,030	$900 to $2,730	NA to $2,050

Target first cost needed to achieve six-year payback in different US markets

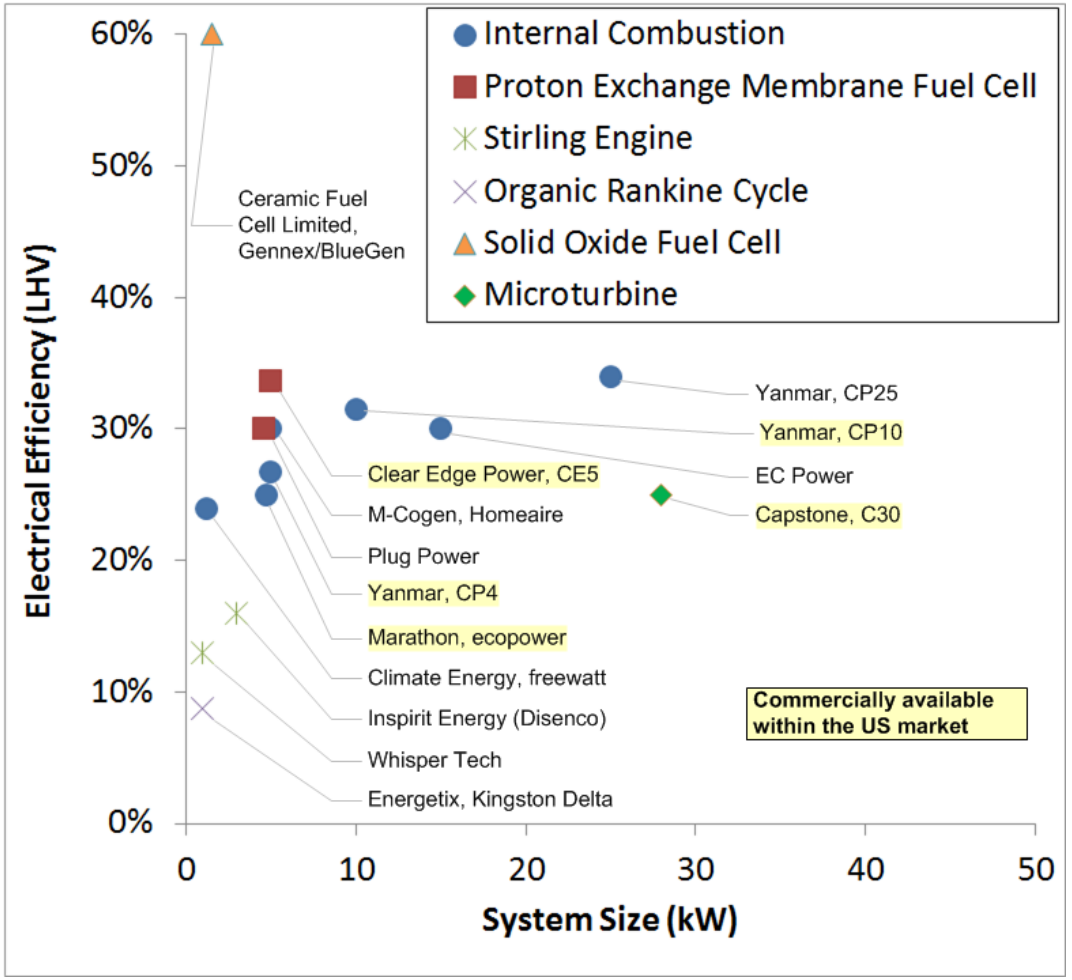
Technology Landscape

Increase Market Penetration

- Marathon ecopower
- Clear Edge CE5
- Yanmar CP4 and CP10

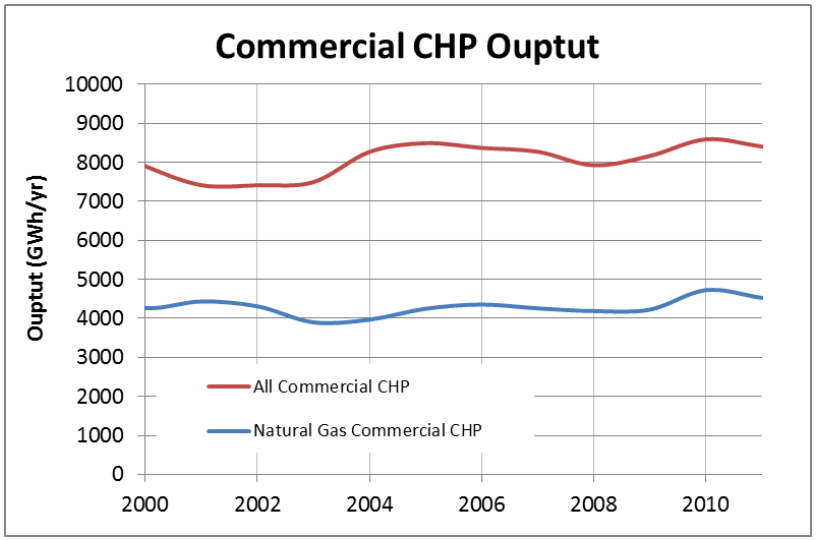
Emerging Technologies

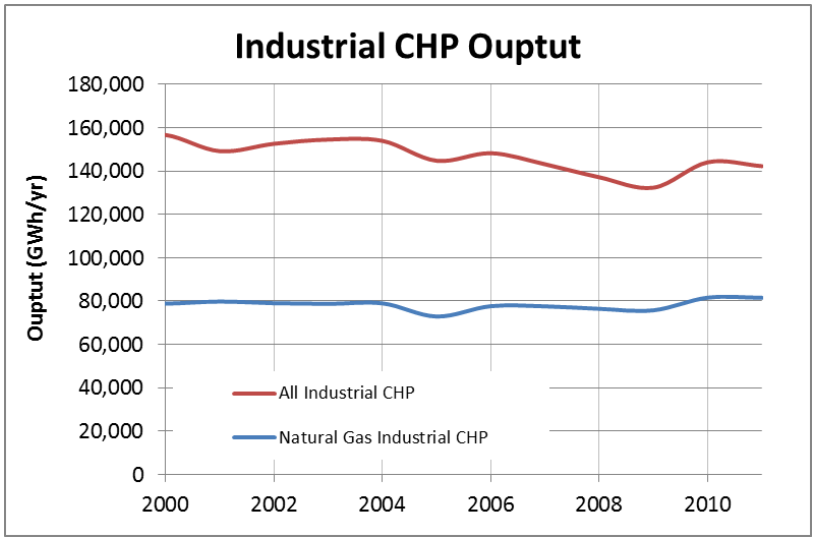
- Climate Energy, freewatt
- CFCL, BlueGen
- M-Cogen, Homeaire
- Plug Power, GenSys Blue
- Inspirit Energy (Disenco)
- Whisper Gen, Whisper Tech
- EC Power, XRGI 15
- Energetix, Kingston Delta
- *2-dozen others*



Commercial and Industrial CHP Market Trends

> C&I CHP markets "status quo" over past decade –***despite large increases in gas use for power generation (missed opportunity)***



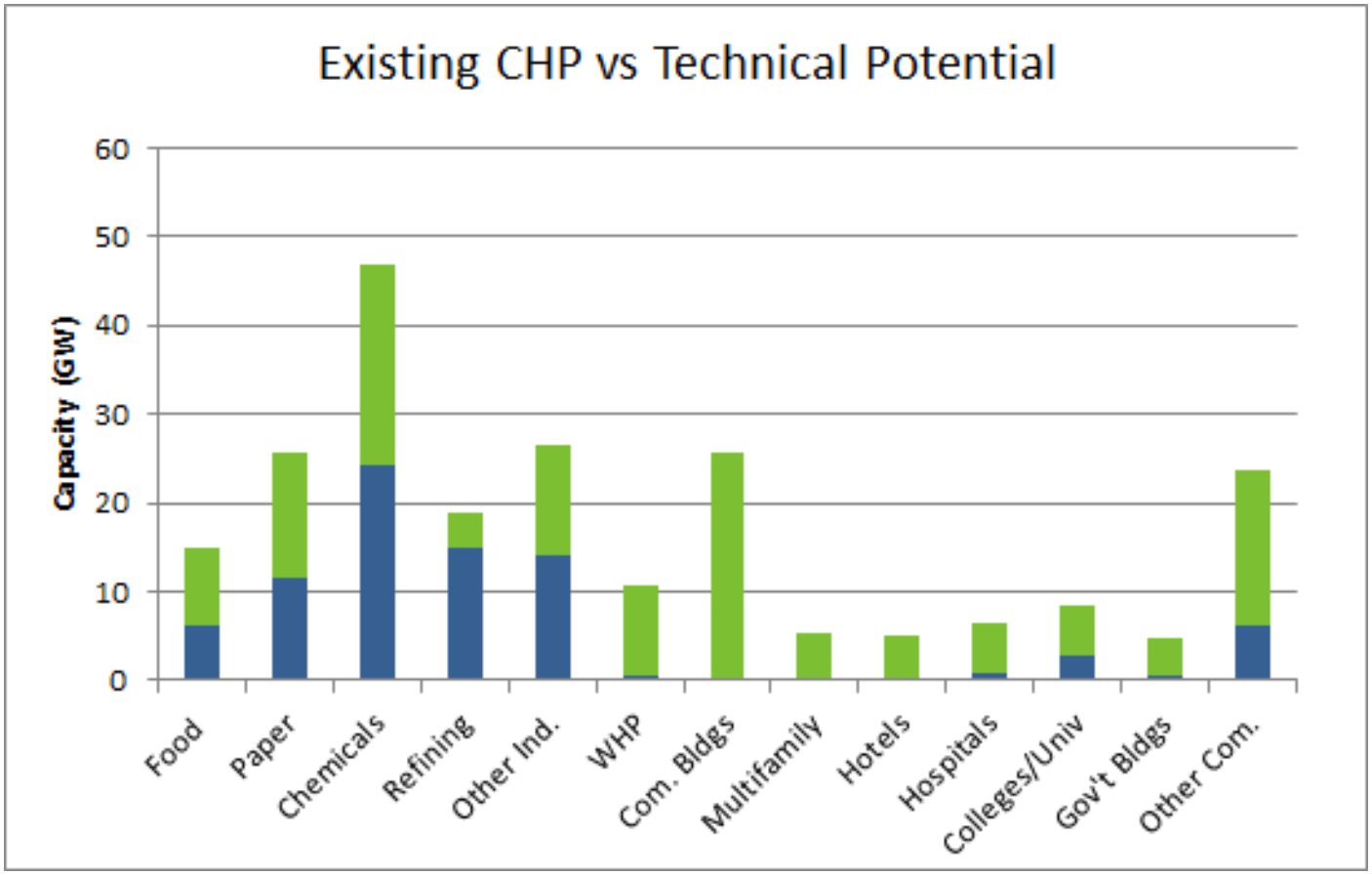


> Industrial growth could help promote new CHP investments and energy efficiency improvements

> **Key issue: resolving long-standing market barriers**

Source: DOE EIA Electric Power Annual

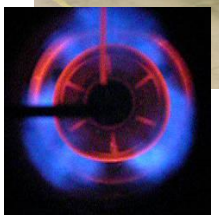
Substantial CHP Remaining Potential



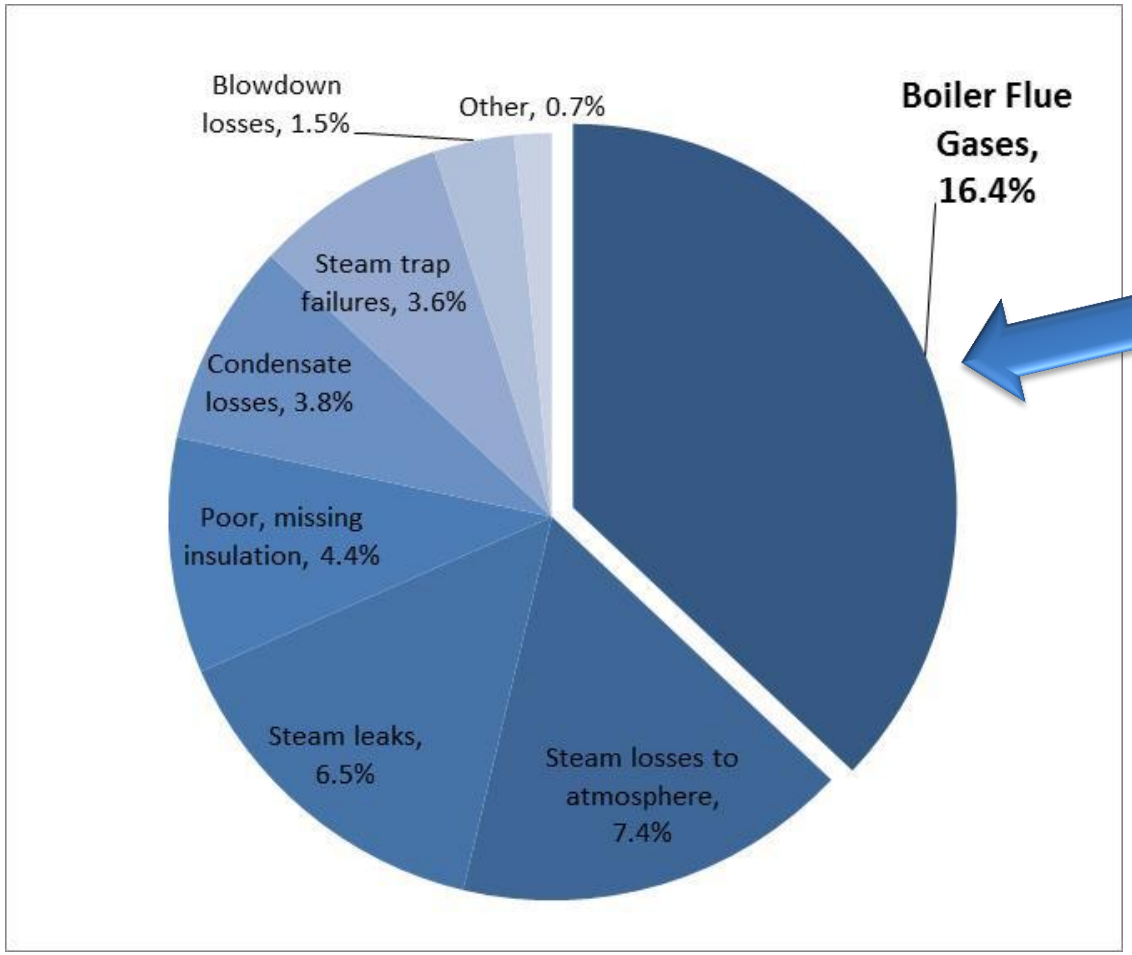
Source: Estimates by ICF International and CHP Installation Database developed by ICF International for Oak Ridge National Laboratory and DOE. 2012.

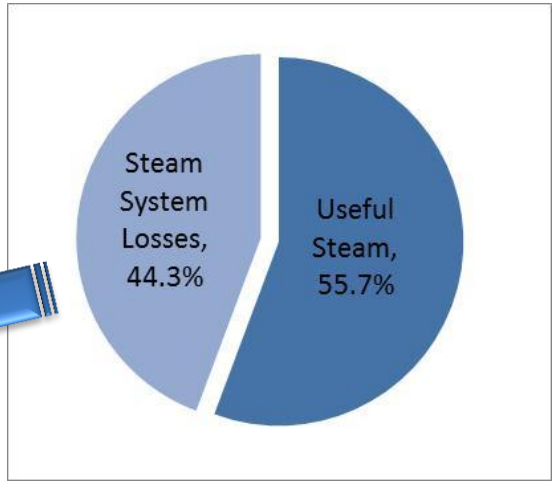
Industrial FlexCHP Power & Steam Package

- Fully integrated high-efficiency ultra-clean power and flexible steam production
  - NOx emissions below 0.07 lb/MWh (for strict California standards)
  - Power generation using microturbine
  - Waste heat boiler fed with turbine exhaust gas plus low emission supplemental burner
    - Variable steam output
  - 85% system efficiency

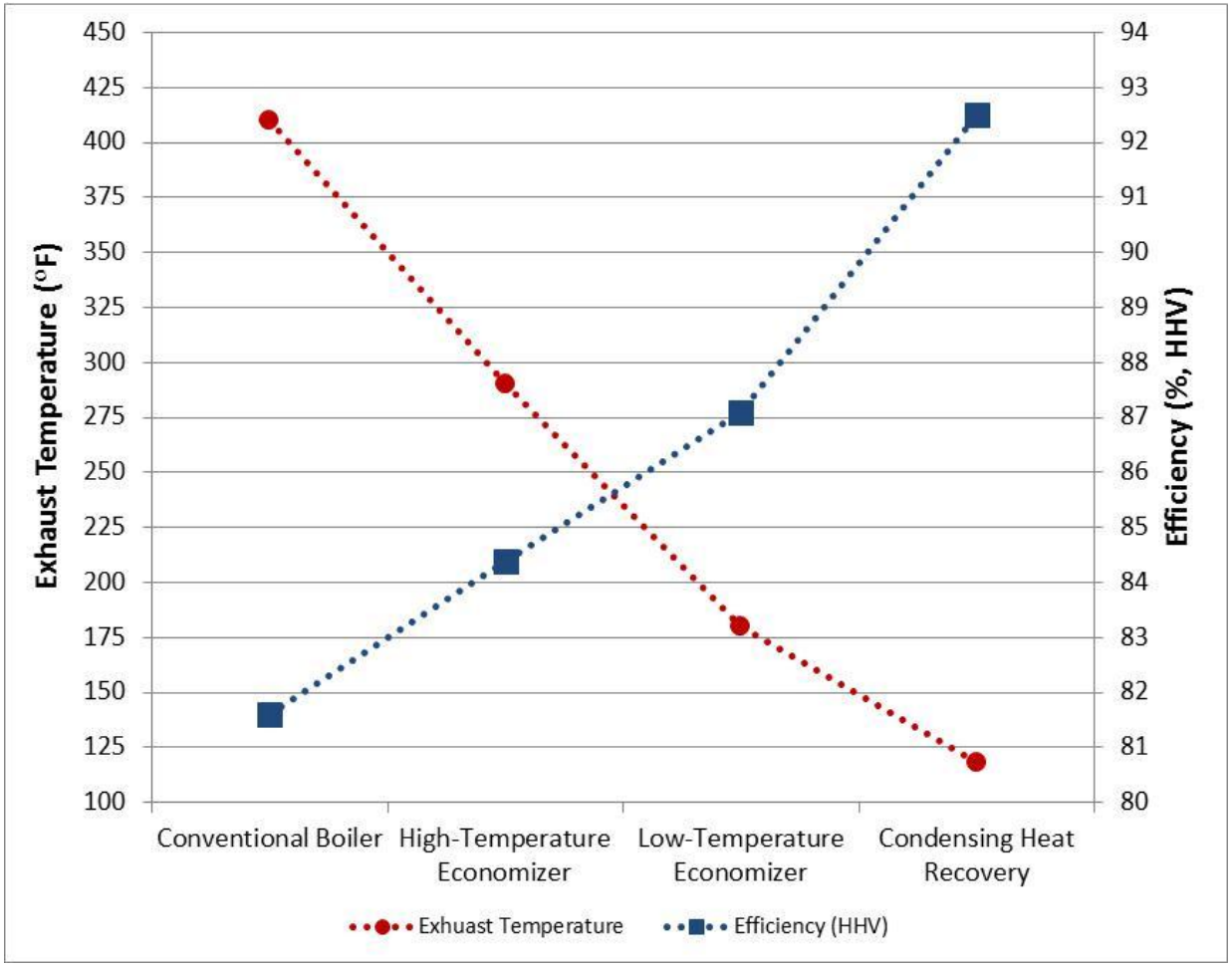


Steam Systems and Energy Efficiency Improvement Opportunities





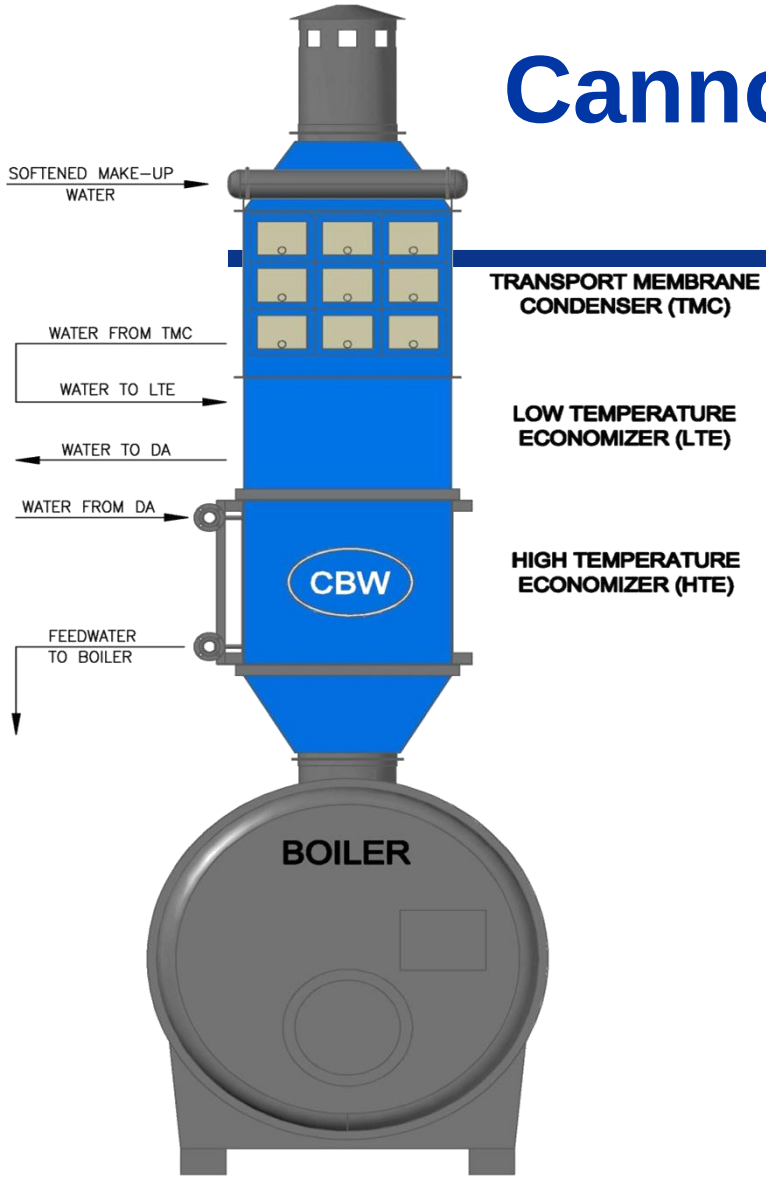
Example Boiler Efficiency Improvement Options



High and low temperature economizers may be made of carbon steel

Condensing economizers often use stainless steel to resist corrosion

Cannon Ultramizer System



CANNON ULTRAMIZER SYSTEM

- Combines Cannon's HTE and LTE Feedwater Heaters with TMC Technology to provide the ultimate in heat and water recovery
- Transport Membrane Condenser (TMC) technology recovers Sensible and Latent Heat from flue gas stream
- Recovers clean water from natural gas burning combustion systems
- Boiler efficiencies of 95% are possible
- Reduction in emissions is equal to the reduction in fuel consumption

Boiler Demand Monitoring Controls

- Devices that act to minimize unnecessary equipment operation & cycling to save energy
  - Boilers and other equipment
- Manufacturer claims of 10-30% energy savings
  - Limited controlled testing to quantify
    - NYSERDA/Brookhaven reported 12.9% savings (+/-3.2%) at 13 sites
  - GTI conducting controlled lab testing on gas-fired boiler

Greffen

Sandler

Intellidyne

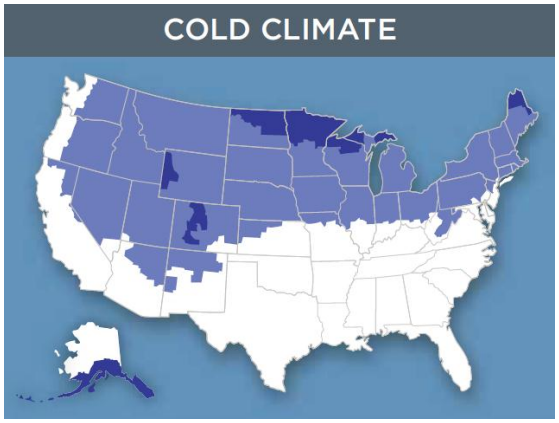
GTI's Building America Role

Partnership for Advanced Residential Retrofit

PARR
The Partnership for Advanced Residential Retrofit

- Giving natural gas an active voice in DOE's Building America Program
- Midwest region, cold climate focus
  1. Seven-state Midwest region with a Chicago "hub"
  2. Systems and whole home solutions for cold climate
  3. Targeting high potential building stock with opportunities for energy savings AND scalability

Building AMERICA
U.S. Department of Energy



gti

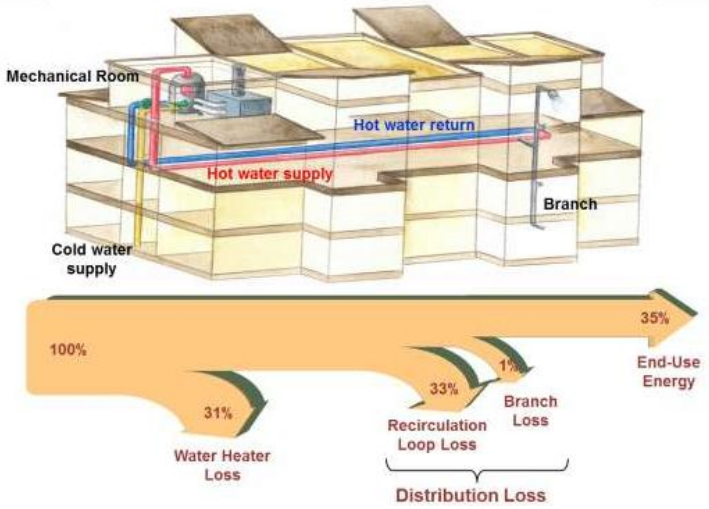
Building America PARR Research

- Laboratory Furnace AFUE vs. Field Measurements at End of Life
  - Field measurements show a reduction in efficiency of 6.4% vs. laboratory testing after adjustment to standard conditions showing the benefits of tune ups. Lab AFUE testing showed no degradation for furnaces operating in the field for more than 20 years
- Evaluation of Retrofit Packages Implemented in Multifamily Buildings
  - Research supporting the 15-30% energy savings associated with applying measure packages in vintage multifamily buildings.
  - 1. Seal & insulate attics; 2. Steam Distribution Systems Balancing and Tuning
- Expert Meetings on Combustion Safety
  - The gas industry, the university research community, and the DOE National Labs discussing the current state of combustion safety in the codes and as practiced in the field, and identify further research needs.

DOE PARR website: http://www1.eere.energy.gov/library/default.aspx?page=2&spid=2

Pilot Field Assessment
Multi-family Demand DHW Controls

- Demand pump for central domestic hot water systems
- System operates only when there is demand, energy savings from reduced thermal loses in recirculation loop (generally 1 - 3 years ROI before rebates)
- Nicor Gas supporting two demos in Chicago area with complete monitoring, collaborative demos in DTE territory, ETIC territory too
- Initial Nicor Gas results suggest roughly 2,000 therms and 750 kWh per building (roughly 40 units/building), with paybacks well below 2 years
- Project goal is to develop qualitative and quantitative data to support prescriptive program



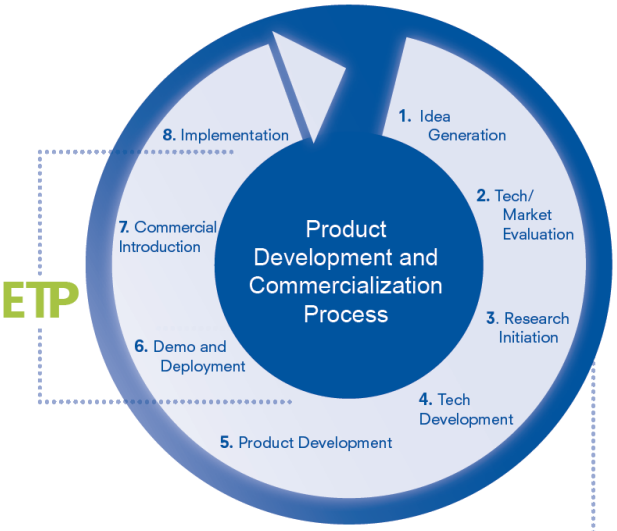
Natural Gas Industry Collaboration

Emerging Technology Program

> Gas Technology Institute led, utility supported, **North American collaborative** targeting **residential, commercial,** and **industrial** solutions

> ETP's principle goal is to **accelerate** the **market acceptance** of emerging gas technologies

AGL Resources
Alagasco AN ENERGEN COMPANY
APGA Research Foundation
ATMOS energy
CenterPoint Energy
CNG
DTE Energy
ENBRIDGE
etic ENERGY TECHNOLOGY & INNOVATION CANADA INNOVATION ET TECHNOLOGIE DE L'ÉNERGIE CANADA
INTERMOUNTAIN GAS COMPANY
National Fuel
Nicor Gas An AGL Resources Company Energy Efficiency Program
NYSEG
PG&E Pacific Gas and Electric Company
QUESTAR Gas
uniongas A Spectra Energy Company
Southern Connecticut Gas Service First! A UIL HOLDINGS COMPANY
Southern California Gas Company A Sempra Energy utility
Yankeegas A Northeast Utilities Company



ETP activities are "beyond development" stage: Field Testing, Demonstration, Pilot Programs, and Deployment — a focused effort to ensure market acceptance of next-generation emerging technologies

2013 Members Listed Above

gti

2013 ETP Technologies and Program Concepts

Residential

1. EcoFactor
2. **Combined Space and Water**
3. ASE Smart Energy RetroSave
4. ShowerStart™ Roadrunner II
5. Opportunities for Residential Natural Gas Feedback
6. **Micro-Combined Heat and Power**
7. Integrated Design: DHW Systems
8. Radiant Heating and Cooling
9. Mantis Condensing Fireplace
10. Hybrid Gas Solar Domestic Hot Water
11. Direct Vent Wall Furnace
12. Essess Thermal Imaging
13. Inspired Bid Management System
14. Combi Boiler Space and Water Heat Systems
15. Gas Water Heater Timer

Commercial

1. **Condensing Heating Rooftop Units Demand Controls for Central Hot Water Systems**
2. Ozone Laundry
3. **Greffen M2G Advanced Load Monitoring Boiler Controller**
4. **IntelliChoice Energy NextAire Multi-Zone GHP**
5. **Commercial Food Service Technologies**
6. **Rheem H_2AC^{TM} Integrated Air and Water RTU**
7. High Efficiency Condensing Unit Heater
8. Pulse Check by Pulse Energy
9. Wireless Pneumatic Thermostat
10. Modulating Dryer Retrofit
11. SentinelWorks Building Energy Management System
12. Ilios High Efficiency Water Heater

Industrial

1. Ultramizer Boiler Heat Recovery
2. Air Curtains
3. SRU Flue Gas Condenser
4. **Automated Steam Trap Monitoring**
5. Destratification Fans
6. VOCGEN Combined Heat and Power
7. Boiler Heat Recovery Workshop
8. Advanced Grain Dryer

= Active ETP Project

Bold = ETP Working Group

gti

ETP National Pilot
Residential HE Combo Systems

- 94 EF condensing tankless water heater + hydronic air handler (Rheem pictured)
  - Improves utility/customer value proposition for water heating by piggy-backing on larger space heating load
- Multi-unit demonstrations/pilots in IL, NY, and CA
  - At least 25 residencies with full data acquisition systems
- Measured field performance, energy savings, cost analysis, and customer reaction
- Contractor technical/sales training, consumer messaging, and rebate program pilot
- GTI is investigating *combi* systems for oil or gas hydronic (e.g. radiator) replacements too


Ferguson Heating & Cooling Presents

Rheem Tankless Pilot Program

Nicor Gas Emerging Technology Program is partnering with Rheem to offer a Pilot Program for a number of combination space and water heating systems. The system will utilize the Rheem Hydronic Air Handler powered by a Rheem Tankless Water Heater. You have been selected for an opportunity to participate in this Pilot Program. The program features lower first cost for equipment and incentives to you and your customers offered by Rheem and Nicor.

If you are interested in participating, you must attend our Pilot Meeting on October 18th. This meeting will include full details of the Pilot Program as well as training on the tankless water heater and air handler.

West Branch
Thursday, October 18th
4:00 p.m. to 7:00 p.m.
Light dinner included
515 Factory Rd.
Addison, IL 60101
please register by 9/28

Registration is required by September 28, 2012
Fax form below to (773) 279-2973

FERGUSON Heating & Cooling

❑ Yes, I will attend the Tankless Pilot Program Meeting on October 18th.
❑ No, we are not interested

Company: _____

Participant(s): _____

Phone: _____ Email: _____

Salesman: _____ Fax: _____

PARR The Partnership for Advanced Residential Retrofit

Southern California Gas Company
A Sempra Energy utility

UTD Utilization Technology Development

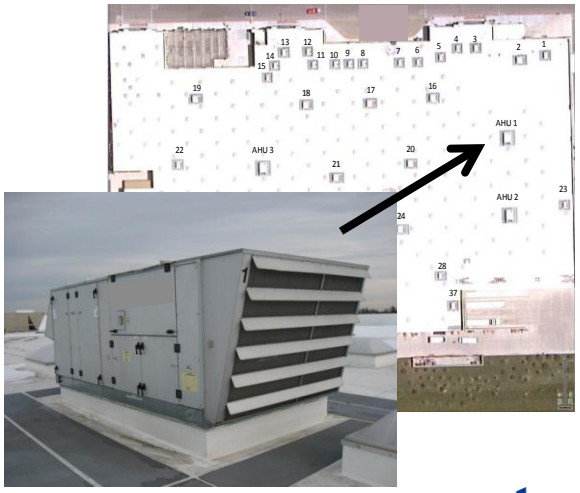
nicor GAS
An AGL Resources Company
Energy Efficiency Program

nyserda Energy. Innovation. Solutions.

gti

Field Assessments
High Efficiency Gas PACs- RTUs

- Collaboration with NREL, DOE, **manufacturers**, **national accounts**, and utilities
- Large-scale monitoring shows **diverse runtimes for RTUs** and more therm use than energy models suggested
- **Dedicated outside air systems** (DOAS) **provide** high efficiency **market entry point** application
  - "big box" retail accounts with established DOAS vendors
  - high heating degree day (HDD)/heating load locations
  - 24/7 retail stores
- Retail partner projected $4,400 premium, = 4.1 years ROI @ 90%TE without incentives
- Northern climates see more than 2,500 therm savings/year/unit!



Active Manufacturers

Manufacturer	Availability	Heating Module Specifications w/Hot Link (subject to change)
Engineered Air	now	90%TE, 100 – 1,400 MBH input, 15:1 turndown, 1,000 to 44,000 CFM www.engineeredair.com/pdf/DJX%20Brochure.pdf
Modine	now	90%TE, up to 500 MBH input, 7:1 turndown, up to 12,000 CFM www.modine.com/download/1/MCP15-110.pdf
Reznor	now	91%TE, up to 350 MBH input, 8:1 turndown, up to 6,000 CFM http://www.rezspec.com/en/products/product-air-handler-rhh
Munters	now	90%TE, up to 800 MBH input, 10:1 turndown, up to 16,000 CFM http://www.munters.us/en/us/Products--Services/Dehumidification/Energy-Recovery/Packaged-Energy-Recovery1/?Product=87392AFD-C031-4BC7-AED9-65E508651504 (product literature does not currently show condensing option)

EcoFactor Home Energy Management

MARKET SITUATION

Baseline
- Conventional and programmable thermostat
- Related to other residential energy savings offerings in thermostat, Home Energy Management (HEM), behavior space

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

Segment
- Residential (single and multi-family) and commercial
- New construction and retrofits

Status
- Technology is mature, and readily available through certain programs

Next Steps
- Program metrics needed
- Large-scale pilot activity underway to better understand delivery channel approach, energy savings, costs (first, ongoing)

ACTIVE ETP PROJECT

- **Technology**
  - EcoFactor is based on proprietary software that analyzes and adjusts a home's thermostat to control the HVAC operation based on weather data and other information, including home occupancy status.
- **Savings Potential**
  - **36%** off the cost to heat and cool a home.
    - **10-20%** savings from automated energy efficiency
    - **16%** savings from personalized schedules
- **ETP Activity**
  - The Nicor Gas Emerging Technology Program is partnering with EcoFactor to install and monitor over 100 EcoFactor Home Energy Monitoring Systems.
  - Systems installed, data collection and analysis ongoing

Modulating Gas Dryer Retrofit

ETP Emerging Technology Program

MARKET SITUATION

Baseline
- Commercial dryers

Opportunity
- Energy efficiency: natural gas savings
- Market potential: retrofit existing systems

Segment
- Commercial on-premises laundry facility retrofits

Status
- Technology is mature and readily available off the shelf

Next Steps
- Third party verification of benefits and market analysis

ACTIVE ETP PROJECT

Figure 1: Bio-Therm modulating controls, furnished by EZ Efficiency

Burner on Time	1 Hour	2 Hours	3 Hours	4 Hours	5 Hours	6 Hours
Dryer BTU						
70K	$ 0.264	0.528	0.792	1.056	1.320	1.584
80K	$ 0.300	0.600	0.900	1.200	1.500	1.800
90K	$ 0.339	0.678	1.017	1.356	1.695	2.034
100K	$ 0.375	0.750	1.125	1.500	1.875	2.250
125K	$ 0.468	0.936	1.404	1.872	2.340	2.808
150K	$ 0.567	1.134	1.701	2.268	2.835	3.402
175K	$ 0.657	1.314	1.971	2.628	3.285	3.942
200K	$ 0.750	1.500	2.250	3.000	3.750	4.500
215K	$ 0.807	1.614	2.421	3.228	4.035	4.842
250K	$ 0.939	1.878	2.817	3.756	4.695	5.634

Figure 2: Bio-Therm savings table by drying time and dryer size, furnished by EZ Efficiency

- **Technology**
  - Modulating gas dryer controls allows the firing rate of standard commercial gas-fired dryers to adjust for the changing demand in heat needed to drive off moisture thereby reducing heat generation and gas use.
- **Savings Potential**
  - 2 year payback period.
- **Barriers**
  - Making changes to a manufacturer's burner system raises safety and liability issues.
  - Burner systems are carefully designed for a specific firing rate and excess air ratio and tested to verify their performance under those conditions.
  - It would require the appliance to no longer be in its warranty coverage since this should void any manufacturer's warranty if installed.
- **ETP Opportunity**
  - Nicor Gas ETP is evaluating this technology in the field with 2 hotel sites, 1 laundromat, and 1 healthcare site. The identification of 1 laundry/linen service site is pending.

Automated Steam Trap Monitoring

MARKET SITUATION

Baseline
- Standard steam trap with no notification upon failure with or without manual steam trap auditing

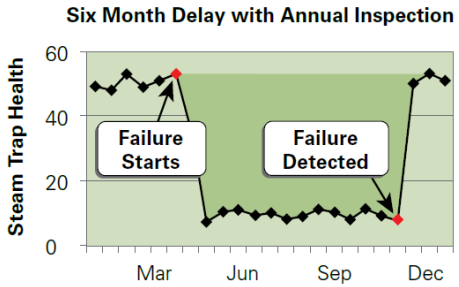
Opportunity
- Energy efficiency: natural gas and electricity savings
- Water Savings
- Market potential: retrofit existing systems and for new installations

Segment
- Industrial steam traps
- New construction and retrofits

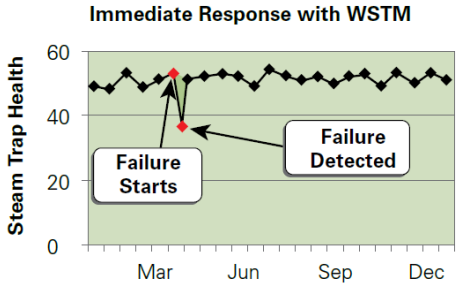
Status
- Technology has been installed at a number of facilities

Next Steps
- Third party verification of benefits and market analysis

ACTIVE ETP PROJECT



Typical monitoring program



After installation of automated steam trap monitoring

- **Technology**
  - Automatic steam trap monitoring is an automated system that can identify a failing steam trap as it is becomes ineffective and notifies a web-based system instantly.
- **Savings Potential**
  - 1 year payback period
- **ETP Activities**
  - Nicor Gas looking for single high pressure steam system site
  - Targeting branch with 200 traps
  - Coordinating with active SoCal Gas project

Gas Water Heater Timer

MARKET SITUATION

Baseline
- Residential domestic hot water storage water heaters

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

Segment
- Residential retrofit
- Limited new construction

Status
- Technology is readily available

Next Steps
- Third party validation and evaluation of benefits

Figure 1: Gas water heater timer connected to gas valve, furnished by American Pacific

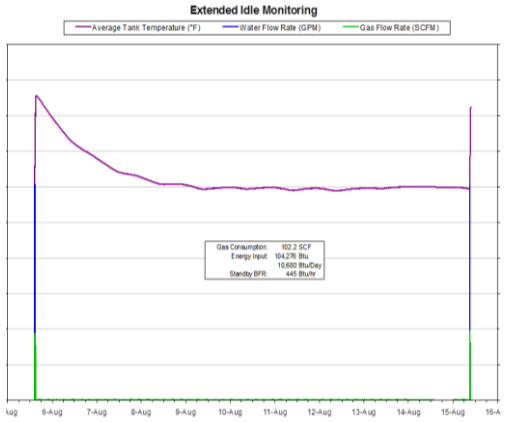


Figure 2: Gas tank temperature over 9 day period

- **Technology**
  - A gas water heater timer is a controller that can automatically "set back" or lower stored temperature within the tank of a water heater for periods of time when hot water demand is low, and raise the temperature for periods of time when hot water demand is high.
- **Savings Potential**
  - 2.5 year payback period
- **ETP Review**
  - GTI and PG&E tested water heaters in both laboratory and field conditions as part of a California Energy Commission Water Heating Program.
  - The graph shows the average tank temperature and gas flow of an atmospherically vented, residential gas storage water heater, .59 EF, left to idle over a 9-day period--pilot light maintained tank temperature at 110°F and the burner performed a single reheat cycle on the 9th day.
  - Question of whether or not there are enough avoided reheat cycles in setback period to provide cost-effective therm savings.

Rheem H_2AC^{TM} Integrated Air and Water RTU

MARKET SITUATION

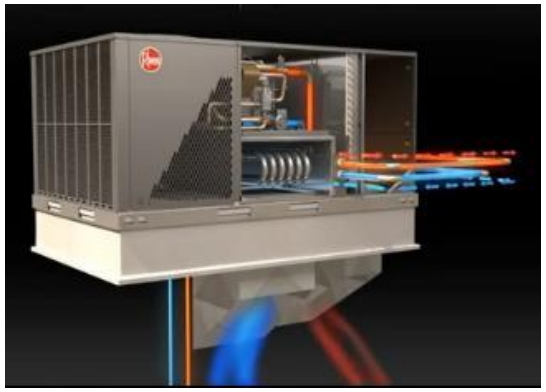
Baseline
- Traditional HVAC equipment

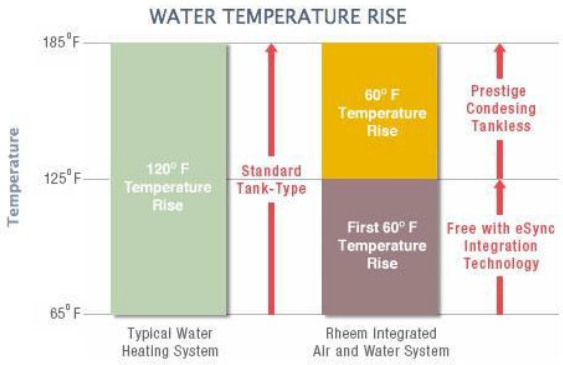
Opportunity
- Energy efficiency: natural gas and electricity savings
- Water savings
- Market potential: retrofit existing systems and for new installations

Segment
- Commercial
- 1500 gallons of hot water loads or more per day
- 1800 cooling degree days or more per year
- New construction and retrofits

Status
- Technology has been tested at a number of facilities
- Available for installation

Next Steps
- Third party verification of benefits and market analysis.



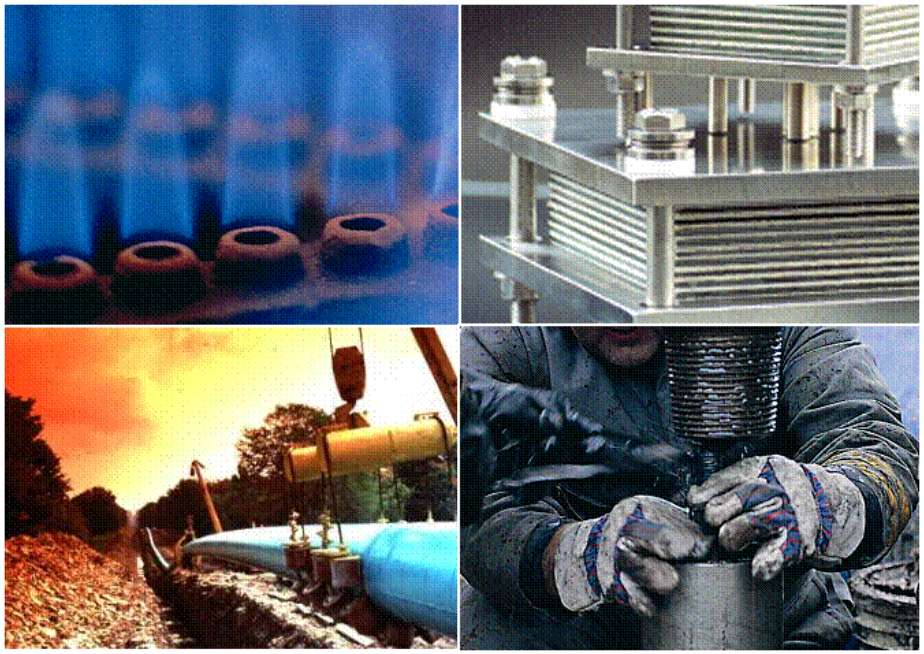


- **Technology**
  - Designed for full-service restaurants, the first-of-its kind Rheem H_2AC^{TM} Packaged Rooftop Unit™ with eSync Integration Technology™ delivers air conditioning and water heating from a single source. The system works by taking the heat removed from the HVAC system — which would normally be rejected into the atmosphere — and uses it to heat water.
- **Cost/Benefits**
  - 1.3 to 2 year payback period on tested systems
- **Market Barriers**
  - High upfront costs and
  - Lack of consumer familiarity

Summary

- U.S. natural gas industry in special period due to confluence of E&P innovations & supply endowment
- Poised for growth: power gen, industrial, transportation
- Integrated solutions needed to grow CHP use coupled with policy efforts to overcome market barriers
- Efficient, smart uses in residential/commercial sectors
- Energy efficiency programs challenged by low gas prices
  - Focused RD&D efforts necessary to develop next generation gas utilization equipment and validate technologies and savings potential

GTI is a company that solves important energy challenges, a company that truly has…



…"the Energy to Lead"

Contact information

Paul Armstrong
Director of Business Development
781-449-1141
Paul.Armstrong@gastechnology.org