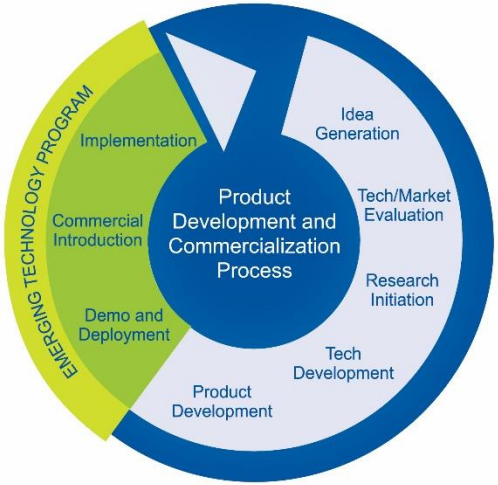
the Energy to Lead

New and Emerging Natural Gas Technologies



2017 Energy Efficiency and Technology Conference

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Company Overview

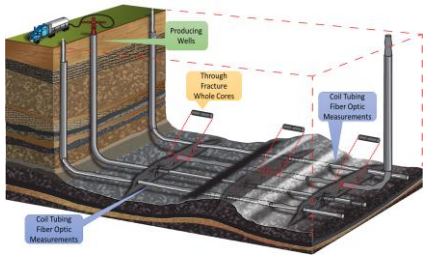
- Independent, not-for-profit established by the natural gas industry
- GTI tackles tough energy challenges turning raw technology into practical solutions
- Downhole to the burner tip
- R&D organization complemented by professional services subsidiaries

Addressing Key Issues Across the Energy Value Chain

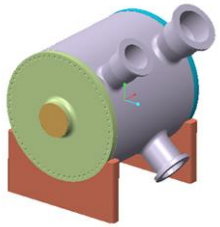
FOR A BETTER ENVIRONMENT AND A BETTER ECONOMY

SUPPLY	CONVERSION	DELIVERY	UTILIZATION
			
Expanding the supply of clean, abundant, affordable natural gas	Transforming natural resources into clean fuels, power, and chemicals	Ensuring a safe and reliable energy delivery infrastructure	Promoting the clean and efficient use of energy resources

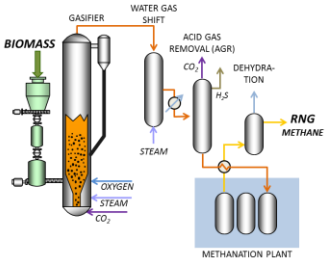
TECHNOLOGY EXAMPLES



Hydraulic Fracturing Test Site



Supercritical CO_2 Power Turbine



Biomass Gasification to Renewable Natural Gas

Asset Lifecycle Tracking

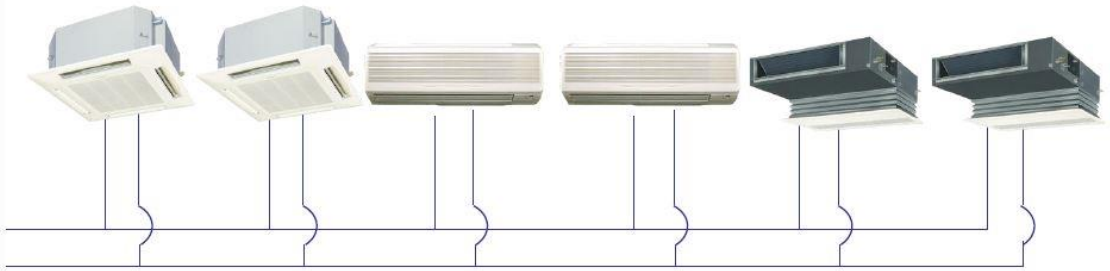
Natural Gas Heat Pumps

Commercial End Use Technologies: *Today's Topics*

- Gas Heat Pumps
- Laundry Retrofits
- Rooftop Units
  - High Efficiency Condensing RTUs
  - HVAC Zoning
- High Efficiency Condensing Condo Packs

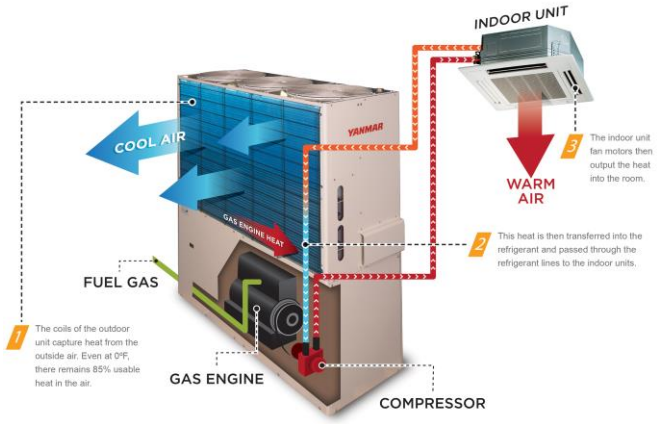
Gas Engine Heat Pumps

- IntelliChoice Energy's (ICE) NextAire™ introduced in 2009
- Models for natural gas or propane; link up to 30 units (+450 tons)
  - Multi-Zone VRF units, 8-ton and 15-ton
  - 11-ton packaged rooftop
  - 4-ton residential GHP certified in February 2016
- Over 400 units installed in schools, government, and commercial offices



Gas Engine Heat Pumps

- Yanmar U.S. product line (2016 entry)
  - Two-pipe VRF systems: 8, 10, 12, 14-ton
  - 14-ton three-pipe system provides simultaneous heating/cooling
  - Initial demos show reduced operating costs compared to electric heat pumps
    - Adairsville, GA (3-pipe)
    - Union Gas, Ontario (2-pipe)
  - Gather more real-world operating results in different regions/uses

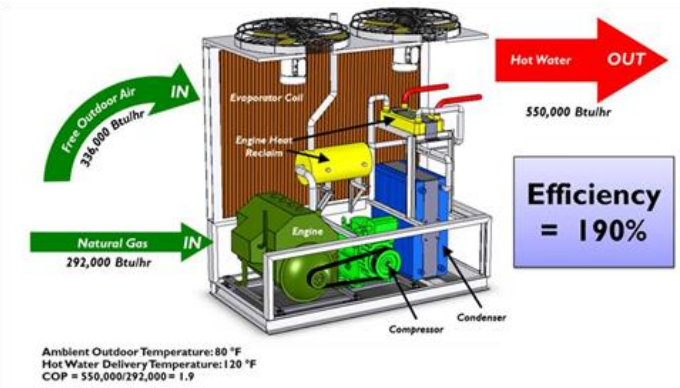


DoD Heat Pump Field Demonstration

- U.S. Department of Defense ESTCP funding side-by-side demonstration of GHP and electric cold climate heat pump:
  - Great Lakes Naval Station in North Chicago, IL.
  - Compare cold climate performance and relative savings in energy, lifecycle costs, and environmental benefits.
  - Baseline monitoring underway.

Ilios Heat Pump Water Heater

- Natural gas internal combustion engine powering a vapor-compression cycle
  - Unit works as a conventional heat pump, extracting heat from the air and putting it into hot water & harvests engine heat
- Commercial use:
  - 400,000 to 600,000 Btu/hr
  - Water temp 100 to 160 °F
  - COP up to 2.2
  - 72 dBA
- Field test Capital Manor – Salem, OR 170-bed assisted living community



Modulating Dryer Technology

- Two-stage modulating gas valve, temperature sensor, control unit.
- Industrial-sized modulating dryers are available at a high up front cost, but modulation is rare in smaller capacity dryers.
- Modulation technology is very mature but its application in dryers is more recent.
- Good fit in hospitality, laundromats, healthcare, dry cleaners, etc.
- Relatively modest installed cost of $700.
- Payback time of 2-3 years.

Nicor Gas ETP Modulating Dryer Project

- 11 dryers were monitored in Nicor Gas territory:
  - Hotel (4 dryers – one 75 lb, one 120 lb, two 170 lb)
  - Laundromat (4 dryers –two 30 lb, two 45 lb)
  - Healthcare (2 dryers – two 75 lb)
  - Dry Cleaner (1 dryer – 50 lb)
- Long-Term Monitoring is considered more accurate

	Long-Term Monitoring	Standardize Test
Average Annual Gas Savings	333 therms	286 therms
% Annual Gas Savings	13.8%	12.4%
Average Annual Electric Savings	N/A	N/A
% Annual Electric Savings	N/A	N/A
Annual Cost Savings	$250	$215
Payback Period	2.10 years	2.44 years

Modulating Dryer Nicor Status

> Included in Illinois Technical Reference Manual. They indicate the following saving number in the TRM:

Application	ΔTherms
Coin- Operated Laundromats[762]	267
Multi-family Dryers[763]	193
On-Premise Laundromats[764]	649

> Nicor offers a $100 rebate for clothes dryer modulating controls which includes one qualifying product at this time: EZ-Efficiency BIO-Therm

> 30 to 250 lb capacity commercial dryer retrofit covered

> Learn more, download the Nicor Gas ETP Project Summary

Moisture Sensor: Technology

- Cost of $250 per dryer for laundromats, $499 for OPL
- Easy installation by facility managers in 10 minutes
- Target markets include laundromats, hotels, health care facilities, dry cleaners, and health clubs
- The technology has been shown to reduce gas use by 25-35% in limited trials by the manufacturer (100-500 annual therm savings per dryer)
- Manufacturer indicates wanting to stay away from older mechanical timer dryers

Moisture Sensor: Nicor Gas Preliminary Results

- Nicor Gas ETP technology evaluation project currently wrapping up
- GTI conducted long-term monitoring before/after retrofit in 4 dryers in hospitality and health club applications (on premise laundry)
- The table below provides ***draft*** results for the 4 dryers with only the moisture sensor.

Preliminary Draft Results	Long-Term Monitoring
Average Annual Gas Savings	460 therms
% Annual Gas Savings	17.1%
Average Annual Electric Savings	410 kWh
% Annual Electric Savings	15.1%
Annual Cost Savings	$363
Simple Payback Period	1.37 years

State of MN ETP Dryer Project

- 12 dryers will be monitored in CenterPoint Energy's territory:
  - 2 Hotels (4 dryers)
  - 1 Laundromat (4 dryers)
  - 1 Healthcare (2 dryers)
  - 1 Dry Cleaner (1 dryer)
  - 1 University (1 Dryer)
- Baseline testing, each technology (moisture sensor and modulating valve) tested for 2 months, followed by testing during simultaneous operation.
- Long term testing as well as standard testing will be performed with the exact same load dried with each technology.
- Testing complete, data analysis and reporting underway, project due to end July 2017. Results published by Minnesota Department of Commerce, Energy Resources Division thereafter.

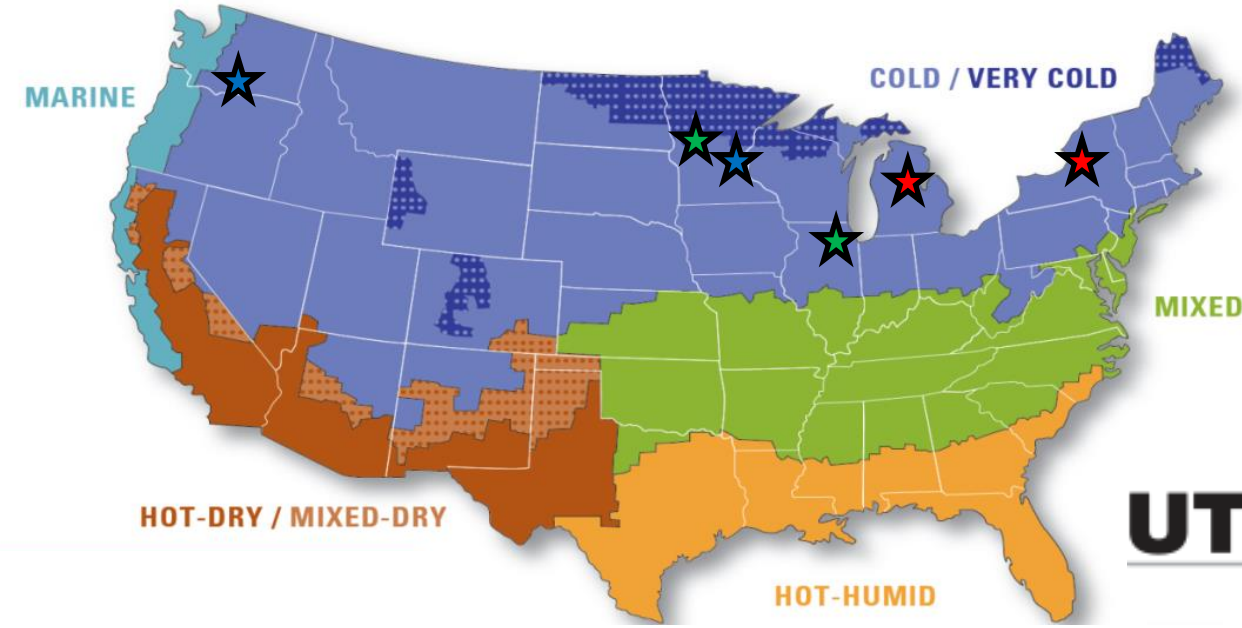
High Efficiency RTUs
Overview

- Condensing RTUs have the potential to create large scale gas savings in the commercial sector, similar to condensing furnaces in the residential sector
- Market development is still in its early stages, but we've made progress over the past few years
  - baselining energy use and runtimes across multiple building types
  - introducing condensing furnace modules for RTUs
  - piloting with pioneering condensing RTU packagers
  - defining the most effective market entry points
  - addressing condensate codes & best practices
- Learn more, download the GTI ETP Technology Snapshot

High Efficiency Heating RTUs:
Condensing Technology's Final Frontier

ETP Emerging Technology Program

For the past 5 years, GTI has been leading an industry-wide effort to assess the technical and market potential of high efficiency heating (condensing) RTUs, this work has included several regional demos and pilots.



DTE Energy

neea

Nicor Gas™
An AGL Resources Company
Energy Efficiency Program

CenterPoint® Energy

UTD Utilization Technology Development

uniongas
A Spectra Energy Company

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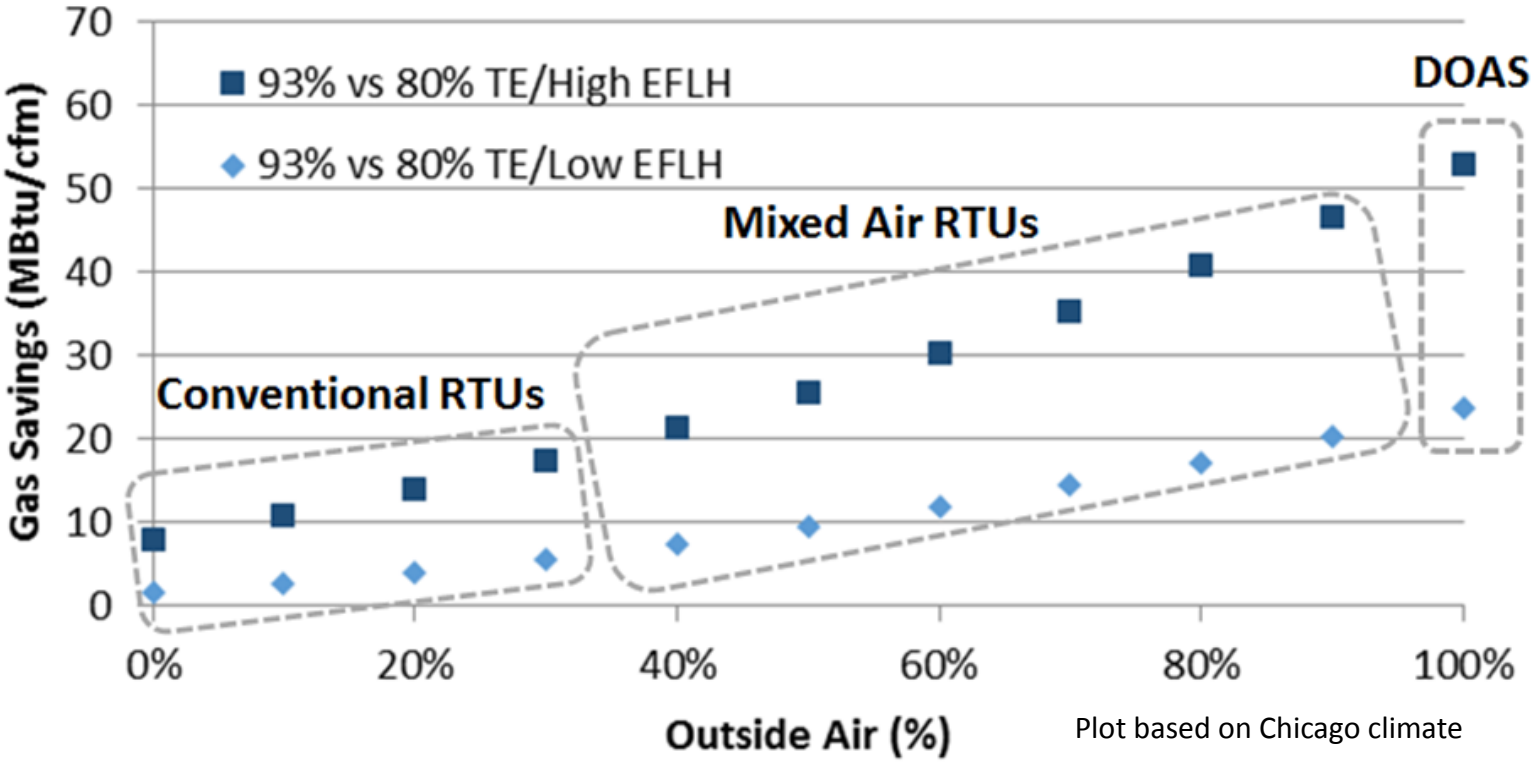
Payback More Favorable as Outside Air Requirements & Run Time Increase



Plot based on Chicago climate

Present Market Situation

- Non-major, second tier HVAC companies offer product lines and provide early market entry point with
  - 100% outside air (OA), such as dedicated outside air systems (DOAS) and make-up air systems (MUAS)
  - Applied by key “big box” retailers and other end users
- Major HVAC companies mostly on the sidelines for now, with exception of Trane Creative Solutions and York targeted efforts

Manufacturer
Trane (Creative Solutions)
York
Engineered Air
Modine
Reznor (Nortek Global HVAC)
Munters

Early Market Entry Points

- 100% outdoor air with high heating load & runtimes
- specialized RTU segment w/~5% commercial floor area & ~7.5 to 15% RTU heating capacity (climate dependent)
- DOAS (ventilation air)
  - retail stores (“big box”)
  - schools
  - healthcare facilities
  - theaters
  - sports arenas
  - day care centers
- MUAS (make-up air)
  - hotels, multifamily buildings, senior living facilities (corridors)
  - commercial kitchens
  - health club facilities
  - industrial production facilities

DOAS Economics

ETP Emerging Technology Program

> *Annual net savings using GTI pilot study data*

Annual Gas Savings	$0.65/therm X 2,650 therms*	+ $1,722.50
Annual Fan Energy Penalty	1,285 kW-h X $0.08/kW-h	- $102.80
Annual Maintenance	$65	- $65
Net savings	$1,723.50 - $65 – $102.80	$1554.70

> *Apply custom rebate (example)*

- $0.75/Therm * 2650 therms/year = **$1,987.50**

> *Determine payback period w/ & w/o rebate*

- $6,069 for 668 kBtuh input condensing DOAS (including condensate drainage system w/neutralizer)
- ***3.9 year payback reduced to 2.6 years w/rebate***

* Calculated savings using real field data for Chicago (more for MN)

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Dynamic Air Balancing 75F Zoning System

ETP Emerging Technology Program

- Target markets are small to medium commercial buildings with 3-20 ton constant volume RTUs.
- 75F Dynamic Air Balancing system designed to improve comfort and save energy:
  - Smart dampers in each zone controlled.
  - Wireless zone controllers (thermostats, occupancy, temp sensors).
  - Proprietary control strategy operates RTU and smart dampers based on zone conditions.
  - Other options include occupancy sensors, setback schedules, DCV/economizer operation.

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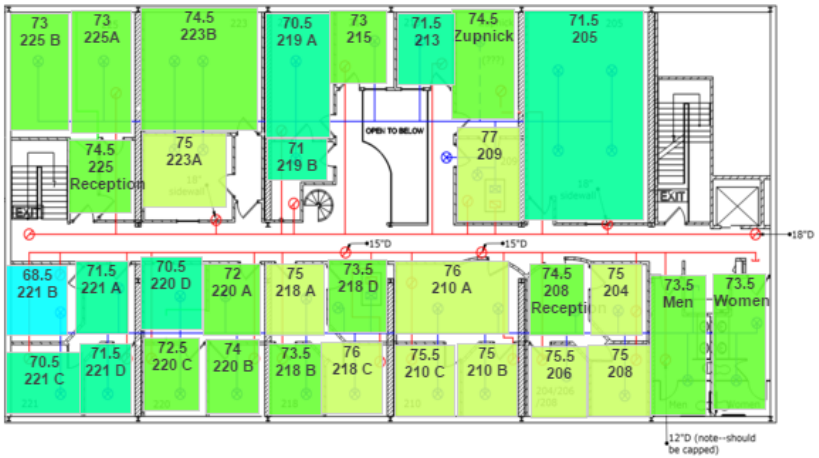
Nicor Gas ETP Project

> Pilot Site
  - Two RTUs serve ~ 6,000 SQFT office space
  - North RTU serves 12 zones and South RTU 21 zones
  - Each application saw at least 25% energy savings w/o DCV



> Learn more, download the [Nicor Gas ETP Project Summary]

Current Multifamily Market Trends

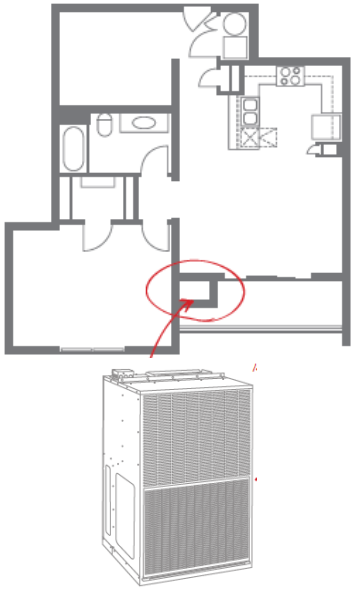
- Faster recovery for multifamily housing than single family housing due to post-recession economic demographics
  - Apartments and condominiums
  - Senior living facilities
- Trending away from centralized heating boilers and shifting to more installations of individual unit HVAC
  - Individual unit utility metering
  - Individual unit equipment ownership
- Opportunity to leapfrog ETP piloting process and propose new measure for utility EEPs

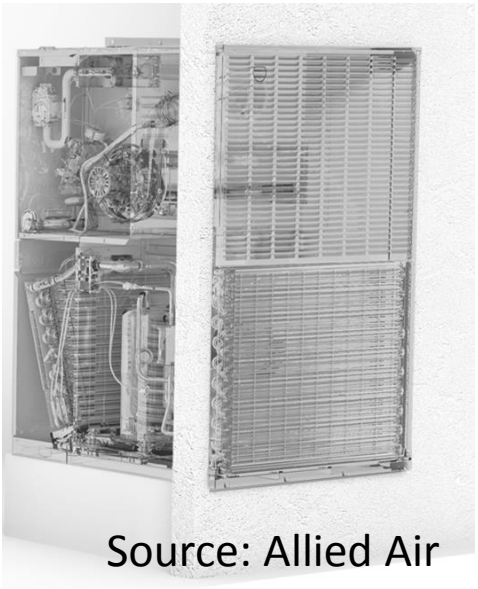
Through-The-Wall (Vertical) Condensing Furnace/AC Package Offerings

ETP Emerging Technology Program

- Over last 24 months,
  4 of 5 top manufacturers
  1. Allied (Lennox)
  2. ~~National~~
  3. Suburban
  4. Aerosys
  5. Napoleon

  introduced condensing!





Source: Allied Air

Company	"Thru-the-Wall" HVAC Product Line	Condensing Offering
Allied Air Enterprises (owned by Lennox)	Magic-Pak www.magic-pak.com/	up to 95% TE with V-Series HWC Single Packaged Vertical Unit www.magic-pak.com/products/v-series/hwc.asp
National Comfort Products	Comfort Pack www.nationalcomfortproducts.com/	none
Suburban Manufacturing	DynaPack http://www.suburbanmanufacturing.com/	up to 92% AFUE with H-Series www.suburbanmanufacturing.com/lit/DYP4pg-8-5-2014_72ppi.pdf
AeroSys Inc.	AeroPak http://www.aerosysinc.com	up to 95% AFUE with G-Series www.aerosysinc.com/pdf/AeroPak-AP-Series.pdf
Napoleon Heating & Cooling	CondoPak http://www.aerosysinc.com	up to 93% AFUE with PSC-Series www.napoleonheatingandcooling.com/products/condo-pack/

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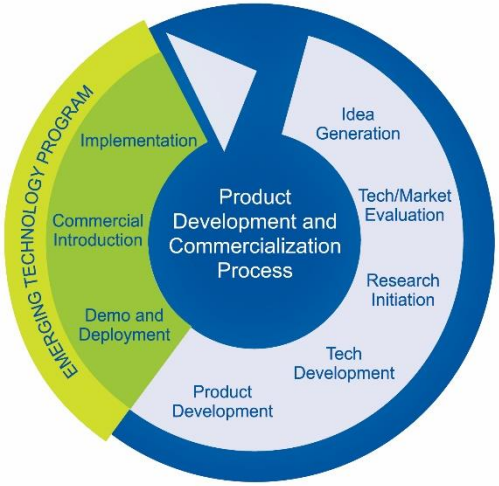
More Detailed Specifications

Product Line	Heating Efficiency	Heating Input (kBtu/hr)	Cooling Efficiency	Cooling Input (ton)
Magic-Pak - HWC Series	93-95% TE	22, 33, 44, or 55	9.2-11 EER	1, 1.5, 2, or 2.5
DynaPack - H Series	91-92% AFUE	39 or 52	10.2-10.7 SEER	1, 1.5, 2, 2.5, or 3
AeroPak - AP Series	94-95% AFUE	30, 40, or 51	9 EER	1, 1.5, 2, or 2.5
Condo Pak - P Series	90.6-93% AFUE	30, 40, or 50	9-10.8 EER	1, 1.4, 1.6, or 2

- Modest cooling efficiencies up to ~11 EER within constrained, existing dimensions while heating efficiencies range 90-95% AFUE (90-95% TE)
- Non-condensing heating products identical in size and carry similar specs but with ~ 80% AFUE/TE heating efficiency
- Learn more, download GTI ETP Technology Snapshot



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