ETP Emerging Technology Program

gti

TECHNOLOGY SNAPSHOT

Condensing heating technology in a specialized but growing class of HVAC rooftop units (RTUs) – dedicated outside air systems – with a efficiencies of at least 90%

Condensing Rooftop Units (RTUs)

MARKET SITUATION

Baseline

- Conventional packaged gas heating and electric air conditioning roof top units

Opportunity

- RTUs represent majority of installed heating capacity for commercial buildings
- 100% outdoor air RTUs offer attractive paybacks

Segment

- RTUs are widely used in office, restaurant, and retail buildings – starting with "big box" type stores
- New construction and retrofits

Status

- High efficiency heating RTUs are available from multiple manufacturers, although market penetration is limited

Next Steps

- Strategic, concerted effort to accelerate market adoption
- Collect further data on cost savings in a variety of markets

The Technology

High efficiency rooftop units (RTUs) utilize the same condensing combustion technology that has been applied for years in many HVAC equipment product lines from gas-fired home furnaces to hot water/steam boilers in the residential and industrial sectors. Condensing heating technology can also be applied to all packaged gas heating and electric air conditioning RTUs which are widely utilized for space conditioning in low-rise commercial and institutional buildings. Condensing heating technologies extract additional heat from combustion products by using a second heat exchanger to condense the water vapor produced. This additional heat exchanger allows condensing appliances to increase their thermal efficiency (TE) to a rating of at least 90%, with current offerings as high as 95%. However, the increased efficiency comes with a cost- increased static pressure. The secondary condensing heat exchanger adds an incremental pressure drop that translates into increased supply fan electricity consumption year round and will subtract from the heating season gas savings.

Figure 1: Munters Dedicated Outdoor Air System, furnished by Munters

Adoption has been slow and only recently have smaller HVAC manufacturers such as Engineered Air, Modine, Reznor, and Munters started applying condensing combustion technology in a limited number of RTU product lines (see Table 1). By contrast, major manufacturers have shown little in-house development but have entered the market in a couple different ways. Trane began to offer the installation of a secondary heat exchanger as a retrofit to existing product lines in 2014 and York has rebranded products from the previously mentioned non-major manufacturers as recently as spring 2015.

Market Analysis

About half of all U.S. commercial floor space is cooled by self-contained, packaged air-conditioning units. Many of these packaged units come equipped with a natural gas or an electric heating section. The market potential is significant for efficiency improvements for packaged heating and air conditioning units. However, despite their advantages, high-efficiency gas heating RTUs are not a perfect fit for every application. Essential to the initial economic success of condensing RTUs is identifying applications with sufficient heating loads to drive runtimes and resulting gas usage high enough to pay back installed cost premiums.

Applications where large amounts of cold outdoor air are heated represent the best market entry point to achieve short pay back periods. “Big box” retailers, schools, healthcare facilities, theaters, and day care centers often have dedicated outdoor air systems (DOAS) to meet ventilation requirements and up to 100% of the air supplied by a DOAS may be sourced from outside. The rest of the load is met by RTUs which recirculate inside air that has already been conditioned. Make-up air units (MUAU) which are often found in restaurants, hotels, multi-family buildings, and industrial facilities also use 100% outside air. A recent Northwest Energy Efficiency Alliance (NEEA) market study found 11% of all RTU heating capacity in the Pacific Northwest is served by 100% outdoor air units.

While RTUs that process a lower percentage of outside air represent the majority of the market for gas-fired RTU’s, they represent a less attractive entry point due to current payback economics. As the price premium decreases they may present a secondary point of entry. A report from Minnesota CARD shows that 97% of all RTUs in Minnesota use natural gas as their heating source and that the average efficiency of RTUs is near the current DOE federal minimum efficiency of 81% annual fuel utilization efficiency (AFUE), effective January 1, 2015. For larger units rated with a thermal efficiency, the most recent federal rulemaking will require 81% TE effective January 1, 2023. In both cases, condensing technology is not required to meet current or near-term federal minimums, creating a long-window for energy efficiency program driven adoption of condensing units.

Major HVAC companies are on the sidelines for now, but are introducing staged blowers that are improving their general outlook on condensing RTU economics.

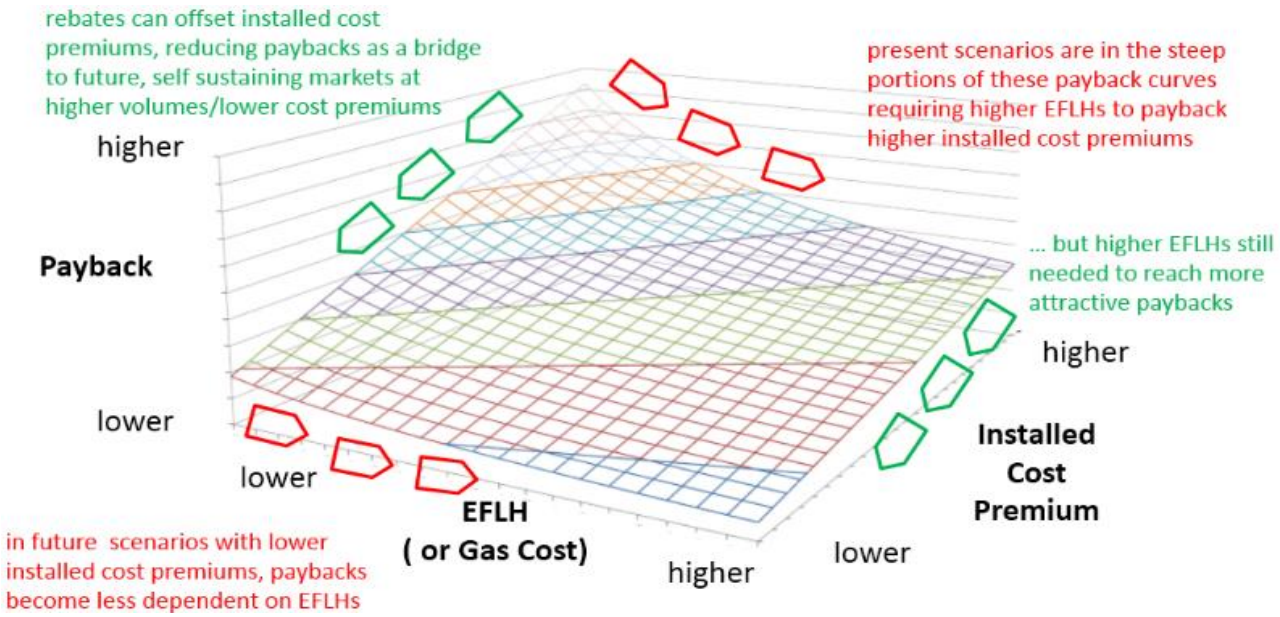

Figure 2: Cost premium and equivalent full load hours vs. payback. High full load hours are needed for short payback when the cost premium is high

Since none of the major HVAC manufacturers have indicated any near term plans for introducing condensing RTUs, the market development relies on the continued emergence of high efficiency product lines from the smaller, second tier HVAC manufacturers for the foreseeable future. Table 1 shows condensing RTU products available on the North American market as of late 2016.

Table 1: Manufacturers and Condensing Gas RTU Offerings

Manufacturer	Availability	Heating Module Specifications w/Hot Link (subject to change)
Trane (Creative Solutions)	now	93% TE, 400 MBH input retrofitted to select 12.5 - 25 ton cooling Voyager Light Commercial RTUs (furnace supplied by others – Beckett and Heatco) Contact Trane directly for further details on this limited product offering
York	now	90% TE, 150 to 600 MBH input, 10:1 turndown, up to 9000 CFM with 5 to 30 tons cooling http://www.johnsoncontrols.com/content/us/en/products/building_efficiency/products-and-systems/integrated_hvac_systems/Industrial___Commercial_HVAC_Equipment/dedicated-outside-air-systems.html (100% OA – DOAS product line supplied by others)
Engineered Air	now	90% TE, 100 – 1,400 MBH input, 15:1 turndown, 1,000 to 44,000 CFM www.engineeredair.com/index.php/our_products/category/indirect-fired#djx-series (DJX Series products)
Modine	now	93%TE, up to 500 MBH input, 7:1 turndown, up to 12,000 CFM with 7 to 30 tons cooling www.modinehvac.com/web/Commercial-HVAC/Commercial-Ventilation-1.htm (Atherion products)
Reznor (now part of Nortek Global HVAC)	now	93% TE, up to 600 MBH package (400MBH split), up to 10:1 turndown, from 500 to 11,500 cfm package (6000 cfm split), with 5 to 20 tons cooling www.rezspec.com/en/me/all-products (YDMA, YDHA, & YDSA products) AND 95% AFUE, 39 to 96 MBH input, 2 stage, up to 1,895 cfm with 3 to 5 tons cooling http://www.reznorhvac.com/en/na/products/product-high-efficiency-packaged-air-conditioning-r8he (R8HE products)
Munters	now	93%TE, up to 800 MBH input, 10:1 turndown, up to 16,000 CFM with 10 to 80 tons cooling https://www.munters.com/en/munters/products/combined-temperature--humidity-control/drycool-standard/ (DryCool product literature does not currently show condensing option, furnace supplied by others – Beckett)

Condensing Rooftop Units (RTUs)

Costs & Benefits

A high-efficiency RTU is more expensive than an equivalent conventional RTU installation since it requires a secondary heat exchanger and combustion condensate drain piping, with an acid neutralizer possibly, depending on local codes. Based on pilot project experience, ETP believes that increased volume and improved contractor guidance will help reduce installation costs and reliability issues.

High-efficiency units can yield up to 16% gas savings over conventional packaged rooftop units with thermal efficiencies ranging from 78% to 82%. The following variables most impact gas savings and improved paybacks: outdoor air percentage, building operating hours, and heating degree days (HDD). For example, the case studies summarized in Table 2 show ideal applications- a 'big box' retail store RTU processing 100% outdoor air operating 24 hours a day in a cold climate.

Table 2: GTI Case Study Summaries

Location	Chicago area suburb
HDD65	6,781
Building Type	200,000 square-foot 24/7 "big box" retail
Heating Systems	38 Lennox RTUs, 25 Modine unit heaters and three dedicated outdoor air systems (DOAS)- all gas-fired heating
Baseline Use	The three DOAS used non-condensing technology and accounted for nearly 50% of the building's annual gas use.
Solution	Munters and the retailer retrofitted DOAS with condensing technology for the 2012/2013 heating season.
Savings	11% annual DOAS savings. Over 2,400 therms per DOAS or nearly $1,100 in net annual operating energy cost savings.
Payback Period	4 to 6 years before incentives with 90% TE DOAS, new units offer 93% TE
Project Sponsor	Nicor Gas Emerging Technology Program

Location	Minneapolis area suburb
HDD65	8,137
Building Type	200,000 square-foot "big box" retail
Savings	11% annual savings. Assuming 2010 Energy Information Agency (EIA) commercial energy prices, this location saves approximately $1,750 before incentives with 90% TE DOAS, new units offer 93% TE
Payback Period	2.5 to 4 years
GTI Program	North American ETP Collaborative CenterPoint, Union Gas, DTE Energy

Barriers and Opportunities

While DOAS provides attractive economics and an early market entry point for condensing RTUs, these systems represent only 10% of the market. The balance is dominated by RTUs processing 30% outdoor air or less. Economics are made more challenging by the current low cost of natural gas, but increasing interest from manufacturers, energy efficiency programs, and increasing DOAS %TE are all colliding to create new opportunities.

Condensate removal and treatment has also been identified as an issue as has the possibility of greater maintenance costs, but work by GTI ETP and others is working toward overcoming these hurdles and identifying best practices. Market progress is also evidenced by condensing RTU technology being incorporated into energy efficiency programs including a prescriptive rebate offered by Questar Gas, which rebates $5 per kBtu/hr input for condensing RTUs with input ≥50,000 Btu/hr, and a custom Nicor Gas rebate (highlighted on next page).

ETP Activity and Next Steps

- GTI led condensing DOAS demonstrations
  - Nicor Gas ETP Chicago area pilot *(complete)*
  - GTI ETP Minnesota demonstration *(complete)*
  - NEEA Pacific Northwest market assessment and 4 site demonstration *(ongoing)*
  - Minnesota CARD 2 site demonstration *(ongoing)*
- UTD Commercial Reference Building Model Project
  - Participating utility "billing analysis" for heating EUI
  - Influencing DOE/ASHRAE model heating loads
- UTD Project for Improving %TE for HE heating RTUs
- CEATI evaluation of advanced RTU technologies and cost effectiveness
- For 2017, the GTI ETP is helping lead a member driven steering committee to foster a national effort to accelerate the market adoption of condensing RTUs, beginning with a focus on 100% outdoor air units.

Condensing Rooftop Units (RTUs)

Nicor Gas Custom Rebate Methodology (Based on Nicor Gas ETP Pilot)

Results

- Custom Rebate: ~ $2,000
- Simple Payback with Rebate: ~ 2.5 Yrs

RTU Characteristics

- Dedicated Outdoor Air System- 93% TE
- 5000 cubic feet per minute (CFM)
- Near Chicago O'Hare
- 24/7 operation
- 95 F supply; 55 F base

Step 1. Apply table of outside air loads based on climate and operating conditions and calculate therms saved:

Q_{OA} from tables = 303,268 Btu/cfm

$$\Delta therms = \frac{\left[Q_{OA} \times cfm \times \left(\frac{1}{TE_{NC}} - \frac{1}{TE_C}\right)\right]}{100{,}000\,\frac{Btu}{therm}}$$

$$\Delta therms = \frac{\left[303{,}268\,\frac{Btu}{cfm} \times 5000 cfm \times \left(\frac{1}{0.8} - \frac{1}{0.93}\right)\right]}{100{,}000\,\frac{Btu}{therm}}$$

$$\Delta therms = 2650$$

Step 2. Determine annual net savings:

Annual Gas Savings	$0.65/therm * 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

Step 3. Apply custom Nicor Gas rebate:

$0.75/therm * 2650 therms/year = $1,987.50

Step 4. Calculate payback period:

- $6,069 for 668 kBtuh input condensing DOAS (includes condensate drainage system and neutralizer)
- Rebate reduced payback from 3.9 to 2.6 years

Resources

The GTI ETP has developed and cataloged information on high efficiency heating RTUs. Members can access the information on the ETP members' site at the following address:
https://teams.gastechnology.org/Emerging%20Technology%20Program/Library/TS_Commercial/TSC01/Forms/AllItems.aspx

Contact Us

Manufacturers

www.munters.com
http://www.reznorhvac.com
https://www.engineeredair.com
http://www.modine.com

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Emerging Technology Program (ETP) is a collaborative program managed by Gas Technology Institute (GTI) focused on accelerating the commercialization and adoption of the latest end use and energy efficiency technologies. The program is designed to help companies assess the benefits of new energy efficiency products and integrated solutions for use in near- to mid-term energy efficiency program implementation.

To learn more about ETP and the program's initiatives, visit www.gastechnology.org/ETP.

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