

TECHNOLOGY SNAPSHOT

While the use of condensing technology in residential gas furnaces for single family homes is very well established, the multi-family market has lagged behind with the introduction of through-the-wall condensing furnace/AC packages. However, most of the major manufacturers of such packages have now established condensing version product lines.

MARKET SITUATION

Baseline

- Standard through-the-wall, non-condensing gas furnace/AC package

Opportunity

- Energy efficiency: natural gas and electricity savings
- Market potential: new construction and replacement of existing systems

Segment

- Residential, multi-family
- Apartments, condominiums, senior living facilities, etc.

Status

- Technology is mature and readily available

Next Steps

- Third party verification of benefits, combustion condensate disposal best practices, and market analysis



Source:
Suburban Manufacturing

Residential, Multi-Family, Through-the-Wall Condensing Furnace/AC Package

The Technology

Condensing technology has achieved dramatic market penetration in residential, single family furnace applications. Heating, ventilating, and air conditioning (HVAC) manufacturers have produced these condensing product lines for many years. Gas heating efficiencies have reached 98% Annual Fuel Utilization Efficiency (AFUE). Many utilities offer incentives for furnace installations that exceed the federal minimum AFUE of 80%.

The gas heating efficiency of multifamily furnaces, in particular the popular through-the-wall furnace/air conditioning (AC) packages, have lagged behind by comparison. However starting in late 2013, manufacturers of through-the-wall furnace/AC packages began introducing condensing heating technology in their product lines with up to a 95% AFUE or thermal efficiency (TE) ratings. While these products are still in an early commercialization phase, they have the potential to deliver significant gas savings to utilities and their customers compared to conventional, non-condensing systems with an 80% AFUE/TE rating. Presently, four of the five major manufacturers now offer condensing versions of their through-the-wall furnace/air conditioning (AC) packages.

Through-the-Wall Furnace/AC Packages for Multifamily Housing

As the housing market is recovering from the recent economic recession, the multifamily housing market continues to rebound faster than the single-family housing market. Freddie Mac forecasts the multifamily housing demand to remain strong, primarily due to post-recession trends in demographics and homeownership. Specifically, many past and present “want-to-be” homeowners now find themselves unable to secure mortgages for single family homes given the more conservative lending practices today. Such trends are increasing demand for lower cost condominium and rental housing units. Utilities, especially in metropolitan areas, are seeing significant condo/rental housing growth in both new and retrofit construction in their service territories. Utilities are also seeing an increasing shift away from centralized, boiler based heating systems in multifamily buildings to individually metered systems using through-the-wall furnace/AC packages in each housing unit.

The through-the-wall furnace/AC package (also known as a vertical packaged furnace/AC unit) is installed in multifamily buildings, typically low- and mid-rise residences. It provides the benefit of individual unit temperature control and utility billing. It also allows each housing unit to use heating or cooling as their occupants see fit, a substantial benefit in shoulder months where a centralized system will be in one mode or the other. Additionally, in condominiums, it shifts not just operational costs, but equipment upkeep and replacement expenses to each housing unit owner, keeping assessments low.

Currently five major manufacturers market this style of equipment as shown in Table 1. Sales throughout the U.S. and Canada are estimated near 70,000 units per year and are broken down by manufacturer market share as further estimated in Table 2. About 80% of those units sold are equipped with a gas furnace, while the balance is mostly heat pumps. Some estimates conclude that two-thirds of currently-installed units are over ten years old, nearing the end of their life expectancy. As illustrated in Figure 1, all share the common features of:

- Self-contained, vertical unit with gas heating (on top) and electric cooling (on bottom).

- Condenser heat from air conditioning operation is rejected out an outside wall/door louver.
- Flues discharge combustion products heating through the wall/door louver as well.
- The units are intended for ducted operation and are typically installed in a service closet accessible by the unit owner/renter.

Until recently, manufacturers only produced 80% AFUE units. However, manufacturers are rolling out models making use of condensing technology, improving efficiency up to 95% AFUE/TE. For new construction projects, some manufacturers have worked to have condensing furnaces written into the project specifications. Such early aggressive marketing tactics have forced most of the manufacturers to create condensing versions of their products as well in order to be able to compete on all new construction projects.

One issue with the replacement market is that each manufacturer often has their own unique dimensions for their units. In some situations it may be difficult to replace one manufacturer’s unit with that of another manufacturer. But for a given manufacturer, their new high efficiency units are designed to match their conventional system dimensions and fit into new and existing multifamily layouts, including the typical closet installation layouts of Figure 1.

Positioning for Utilization by Energy Efficiency Programs

While condensing gas heating furnaces and associated rebates have long been major measures in utility energy efficiency programs (EEPs) for single family homes, through-the-wall condensing furnace/AC packages for multifamily buildings have not been available until the last couple of years. The recent introduction of condensing technology into these individual packages provides a much more efficient heating option for the multifamily market, and it would benefit from a utility incentive to encourage the adoption of these new systems.

However, given the early commercialization status of this technology, there remain issues that may impact overall implementation of these products, such as:

- How will furnace condensate be handled, both in terms of drainage, neutralization, and sanitary

Through-the-Wall Condensing Furnace/AC Package

Table 1: Five Major Manufacturers of Through-the-Wall Furnace/AC Packages (Source: GTI)

Company	“Thru-the-Wall” HVAC Product Line	Condensing Product 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/

Table 2: Estimated Annual Sales Volume for U.S. & Canada and Manufacturer Market Share (Source: GTI)

Company	Annual Sales	Market Share
Allied Air Enterprises	30,000	43%
National Comfort Products	18,000	26%
Suburban Manufacturing	12,000	17%
AeroSys Inc.	7,000	10%
Napoleon/Others	3,000	4%
Total	70,000	100%

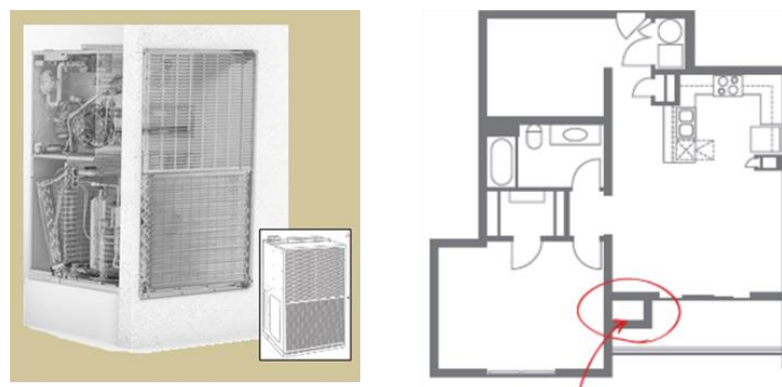


Figure 1: Through-the-Wall Condensing Furnace/AC Packaged System and Typical Multifamily Layout with Closet for Packaged System (Source: Allied Air)

sewer connection requirements in multifamily, multistory buildings?

- Do the condensing furnace flues that are a part of through-the-wall systems create icing issues on the exterior grille and building wall during winter conditions?
- Do these “first generation” condensing versions of through-the-wall systems have any impact on delivered air temperature and occupant comfort?
- How do the measured energy savings compare to savings estimates based on the rated efficiencies?
- What is the natural gas cost savings and the resulting paybacks of the incremental costs of condensing equipment and its installation, including the combustion condensate drainage and disposal system, including neutralization if code required?

Although these and other issues need to be addressed, the growth in multifamily buildings since the economic recession and the development of through-the-wall condensing heating packages, represent a significant opportunity for gas and electricity savings through future utility EEP measures.

Emerging Product Specifications

As indicated previously, four out of the five major manufacturers of through-the-wall furnace/AC packages have launched condensing product lines within the last 24 months. At the time of this writing, only National Comfort Products does not have a condensing product offering. Per the specifications in Table 3, these packaged units provide modest cooling efficiencies up to about 11 EER within the constrained, existing product dimensions, while heating efficiencies range from 90-95% AFUE/TE.

Table 3: Through-the-Wall Condensing Furnace/AC Package Specifications by Manufacturer Product Line (Source: GTI)

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

Table 4: Installed Cost Premium and Payback Economics for Nicor Gas Service Territory (Source: GTI)

Premium (\$)	Payback (Years)
400	1.81
500	2.27
600	2.72
700	3.17
800	3.63

The non-condensing versions carry similar heating and cooling capacity specifications but with an 80% AFUE (or 80% TE) heating efficiency rating. The 80% AFUE heating efficiency level has already become a well-established baseline offering in this heating product category, which is consistent with the baseline heating efficiency normally prescribed in many state EEP technical reference manuals, including the Illinois Technical Reference Manual (TRM) for condensing furnace gas savings calculations [TRM 2015].

In the past, the Department of Energy (DOE) concluded that through-the-wall packages (also referred to by DOE as single-packaged vertical equipment) for multifamily residences were commercial and not residential products [ACHR News 2000]. Over time this situation has created some confusion among the manufacturers as to whether they should provide an AFUE or TE heating efficiency rating, as seen in Table 3. There is a current DOE federal minimum efficiency standard for commercial warm-air furnaces that requires an 80% TE (to be 81% TE effective January 1, 2023). However, this TE standard is specified for gas-fired warm air furnaces of 225 kBtu/hr input capacity or higher [DOE 2016A]. For gas-fired warm air furnaces of less than 225 kBtu/hr input capacity, the current DOE federal minimum efficiency is 80% AFUE (increased on November 19, 2015 from 78% AFUE for non-weatherized indoor equipment) [DOE 2016B]. To further complicate the heating efficiency rating issue, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), in the current version of their Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings, allows compliance with either a minimum efficiency of 78% AFUE or 80% TE [ASHRAE 2013]. ASHRAE Standard 90.1 is often cited in national, state, and local codes, setting the stage for conflict on which minimum heating efficiency rating should be applied in a utility EEP measure development. And finally, to satisfy all governing standard/code authorities it appears that manufacturers of through-the-wall furnace/AC packages should be providing AFUE not TE ratings.

Potential Energy Savings and Payback Economics

Utilizing the Illinois TRM as a basis, the potential gas and electricity savings can be calculated to provide

representative payback economics. The following therm savings projection is based on the calculation methodology from the Illinois TRM for residential gas condensing furnaces in single family homes, using a 40,000 Btu/hr input unit for a through-the-wall furnace and the TRM deemed multifamily equivalent full hours (EFLHs) of 1,685 for space heating for Illinois Climate Zone 2 (Chicago) in the Multifamily Mid-Rise Building Type.

Therms Savings =

$$\text{EFLH} * \text{Capacity} * [(\text{AFUE}_{\text{cond}} - \text{AFUE}_{\text{non-cond}}) / \text{AFUE}_{\text{non-cond}}] / (100,000 \text{ Btu/Therm})$$

The above calculation results in 110 therms saved per unit per year as shown below.

Therms Savings =

$$1,685 \text{ hrs} * 40,000 \text{ Btu/hr} * [(93 - 80) / 80] / (100,000 \text{ Btu/Therm}) = 110 \text{ per unit}$$

Through-the-wall condensing furnace/AC packages have been designed for cold-climate multifamily applications, and most multifamily residences do not have large individual cooling loads, as indicated in the product specifications in the previous table. Therefore, high efficiency cooling has not been a priority, especially given the dimensional constraints in these product lines that limits the use of larger, higher efficiency refrigerant condenser and evaporator coils. However, some manufacturers do offer packages with slightly higher EER ratings up to 11 in the smaller cooling capacity models where the product dimensions can accommodate somewhat larger refrigerant coils.

These “space-constrained systems”, as DOE refers to them, are not subject to the same higher, federal minimum cooling efficiency requirements of residential AC in single family homes. In fact, before 2010, through-the-wall equipment was regulated under the broader scope of commercial heating and AC equipment. However, since then DOE has begun identifying through-the-wall packages as a distinct equipment class and requiring separate federal minimum EER efficiency levels. Presently, the federal minimum efficiency level is a 9.0 EER (for cooling capacities of 5.4 tons and less), with that minimum increasing to an 11.0 EER on September 23, 2019 [DOE 2016C]. Complicating the rating issue again, this time for cooling efficiency, the often code-cited



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ASHRAE Standard 90.1 identifies a minimum 10.0 EER (for cooling capacities of 5.4 tons and less) [ASHRAE 2013]. All the manufacturers meet the present DOE federal minimum 9.0 EER, but only Suburban Manufacturing meets the ASHRAE minimum 10.0 EER across its entire product line.

Based on the following calculation methodology from the TRM with a deemed 767 EFLHs for multifamily space cooling for Illinois Climate Zone 2 (Chicago) in the Multifamily Mid-Rise Building Type, an EER increase from 9 to 11 results in electricity savings of 372 kWh per unit per year for a 2 ton AC.

kWh Savings =

$$\text{Capacity} * \text{EFLH} * [(1/\text{EER}_{\text{base}}) - (1/\text{EER}_{\text{ee}})]$$

kWh Savings =

$$24 \text{ kBtu/hr} * 767 \text{ hrs} * [(1/9) - (1/11)] = 372 \text{ per unit}$$

The condensing furnace/AC packages also use a more efficient electronically commutated motor (ECM) driven supply air blower. The TRM deems the electricity savings for ECM blower equipped residential furnaces to be 732 kWh per unit per year, although this is likely subject to verification for a multifamily versus single family home application since the TRM does not differentiate between the two sectors in this measure. The reduced fan heat generated in turn increases the gas heating required by 15 therms per unit per year. This results in a net total of 95 therms in gas savings and 1104 kWh in electricity savings per unit per year.

Based on the 2014 average residential energy prices for Illinois from the Energy Information Administration (EIA), the energy cost savings would be 95 therms x \$0.94/therm = \$89.30 and 1104 x \$0.119/kWh = \$131.38, for a total energy cost savings of \$220.68 per unit per year. The resulting paybacks are shown in the Table 4. The condensing equipment premium is on the order of \$400 to \$500 by itself, with wide ranging added cost scenarios possible for combustion condensate drainage and neutralization that can make the total cost premium much higher and extend the payback timeframes as shown on that table.

Next Steps for Utilities

In states with established energy savings calculation methodologies for higher efficiency furnace/AC and deemed multifamily heating/cooling EFLHs in their

TRMs, this technology has the potential to leapfrog the ETP piloting process and be directly proposed as a new measure in utility EEPs, via the state TRM required new measure proposal documentation, called a work paper for the Illinois TRM. For Illinois, as cited in the preceding section, its state TRM has well-established energy savings calculation methodologies already in place for other condensing furnace technologies for various residential and commercial measures, and already has deemed EFLHs for heating and cooling in multifamily buildings. So the simple TRM based calculation methodology, shown in the preceding section, which uses TRM accepted equipment AFUE and EER ratings along with TRM deemed heating and cooling EFLHs to determine therm and electricity savings, can be the basis for a proposed new measure in the Illinois TRM for through-the-wall condensing furnace/AC packages. Other states and utilities in similar situations can follow those straightforward proposal steps to a new measure for through-the-wall condensing furnace/AC packages, as well.

However, there are some key remaining issues to be addressed as noted earlier in this document, including the approach to the combustion condensate drainage and disposal system, and its installation cost, in multifamily buildings. This is especially true in existing buildings where retrofit scenarios could vary in approach and range widely in cost. As such, new construction may be the best initial target for a new TRM measure for a utility, while the other stakeholders in the marketplace, including the manufacturers, determine over time how best to approach combustion condensate management for retrofits of existing multifamily buildings.

References

Air Conditioning, Heating, and Refrigeration News (ACHR News). 2000. "Comment Deadline Set for DOE Efficiency Standards", November 20, 2000, <http://www.achrnews.com/articles/84626-comment-deadline-set-for-doe-efficiency-standards> (accessed February 22, 2016).

Department of Energy (DOE) Energy Efficiency and Renewable Energy Office (EERE). 2016A. Commercial Warm Air Furnaces, https://www1.eere.energy.gov/buildings/appliance_sta



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[standards/product.aspx/productid/71](#) (accessed February 22, 2016).

Department of Energy (DOE) Energy Efficiency and Renewable Energy Office (EERE). 2016B. Residential Furnaces.

https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/72 (accessed February 22, 2016).

Department of Energy (DOE) Energy Efficiency and Renewable Energy Office (EERE). 2016C. Single Package Vertical Air Conditioners and Heat Pumps, https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/35 (accessed February 22, 2016).

Illinois Statewide Technical Reference Manual (TRM), Version 4.0 (effective June 1, 2015), 2015. <http://www.ilsag.info/technical-reference-manual.html> (accessed February 22, 2016).

Product Cut Sheets

Allied Air Enterprises (Magic-Pak):

http://www.magic-pak.com/literature/technical-specifications/V-Series_HWC4_Tech_Spec.pdf

Product intro page - <http://www.magic-pak.com/products/v-series/hwc.asp>

Suburban Manufacturing (DynaPack):

http://www.suburbanmanufacturing.com/lit/DYP4pg-8-5-2014_72ppi.pdf

Product intro page - http://www.suburbanmanufacturing.com/products/dp_hp#

AeroSys Inc. (AeroPak):

<http://www.aerosysinc.com/pdf/AeroPak-AP-Series.pdf>

Product intro page – <http://www.aerosysinc.com/>

Napoleon Heating & Cooling (Condo Pack):

<http://napoleonproducts.com/downloads/hvac/specifications/W415-1318.pdf>

Product intro page - <http://www.napoleonheatingandcooling.com/products/condo-pack/>

Contact Us

GTI Contact


Ryan Kerr, Emerging Technologies Manager,
End Use Solutions, GTI
ryan.kerr@gastechnology.org
847-768-0941

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Gas Technology Institute

1700 South Mount Prospect Road
Des Plaines, IL 60018
www.gastechnology.org

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