



REPLACING AND RETROFITTING ROOFTOP UNITS THROUGH THE ADVANCED RTU CAMPAIGN

WHITE PAPER

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ABOUT THE AUTHORS

Marta Milan

Waypoint Building Group

Michael Deru, PhD

Engineering Manager, Commercial Buildings Research Group
National Renewable Energy Laboratory (NREL)

Grant Gable, LEED AP

Executive Vice President, Sales and Marketing
AES Industries, Inc

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INTRODUCTION

A rooftop unit (RTU) is one of a class of heating, ventilating, and air conditioning (HVAC) equipment that contains all the components in one package and is typically mounted on the roof of a building. RTUs range in size from three tons to 40 tons (and larger for custom units) and have a wide range of features for various heating types, compressor configurations, coil configurations, economizers, and controls. Within the United States, RTUs and other packaged HVAC units are used in approximately 60% of U.S. commercial building floor areas and account for 2.6 quads of annual primary energy use.¹

RTUs typically have a useful lifetime of 15 to 20 years, although they can fail earlier or last longer. Inefficient RTUs older than 10 years are common and can waste \$1,000–\$3,700 (USD) annually in energy per unit, depending on location, size, and type. By replacing or retrofitting them, owners and operators can save money, improve energy efficiency, increase building comfort, and mitigate environmental impacts. Because RTUs are out of sight and tend to operate continuously, proper maintenance is often neglected and the units are replaced only after they fail.

Recent technology advancements provide significant savings opportunities for building owners and operators for replacing older RTUs or retrofitting newer constant-speed (as opposed to variable-speed) RTUs. The highest performing RTUs on the market are up to 50% more efficient than RTUs available 10 years ago. Nationwide, if 50% of the 10-ton to 20-ton commercial units were replaced with the most efficient units available today, businesses would save about \$3 billion annually in energy costs.

Advanced RTU controllers in retrofits have the potential for significant energy savings. Advanced retrofit control packages with variable-speed fan control can reduce electricity use by 57% over RTUs larger than seven tons.² Several features contribute to the savings. Essential features include variable- or multi-speed fan control, integrated economizer control, and demand controlled ventilation. Additional features may include economizer control with differential dry-bulb and dew-point lockout, advanced thermostat control with optimum start and predictive cooling with smart economizer controls, peak demand reduction or demand management, remote monitoring and communication, fault detection and diagnostic capabilities, condenser fan control, and compressor variable-capacity control.

**THE HIGHEST PERFORMING RTUs ON THE
MARKET ARE UP TO 50% MORE EFFICIENT THAN
RTUs AVAILABLE 10 YEARS AGO.**

¹Energy Information Agency, Commercial Buildings Energy Consumption Survey 2003 Table C1, the percent cooling for packaged air conditioning and heat pumps and includes spaces with more than one cooling system (packaged air conditioning electricity + heat pumps electricity /total cooling electricity),

²Pacific Northwest National Laboratory, Advanced Rooftop Control (ARC) Retrofit: Field-Test Results, July 2013.

THE ADVANCED RTU CAMPAIGN AND THE RTU CHALLENGE

The Advanced RTU Campaign (ARC) is a recognition and guidance program designed to encourage building owners and operators to take advantage of savings opportunities from high-efficiency RTUs. ARC was created to drive the market toward the widespread adoption of higher efficiency units by developing solutions and resources that help to overcome technical and market barriers. The aim is to move the commercial building market to greater adoption of high-efficiency RTU solutions. This is a collaboration between ASHRAE and the Retail Industry Leaders Association (RILA); the U.S. Department of Energy (DOE) provides technical support to campaign participants (through the Better Buildings Alliance and the Federal Energy Management Program). Its goal is to ultimately realize savings by installing advanced RTUs or retrofitting inefficient RTUs with advanced controls.

Building owners and operators (including commercial and government facilities) with RTUs are eligible to participate in ARC. Depending on the age and size of the RTU, building owners and operators should consider a high-efficiency replacement or an advanced control retrofit. The benefits of upgrading to a more efficient technology are outlined below:

- Replace RTUs older than 10 years with high-efficiency RTUs and reduce energy costs by up to 44% (compared to Standard 90.1-2010).
- Retrofit RTUs newer than 10 years and larger than seven tons with advanced controls and save up to 57% with a payback as short as two years.
- Improve humidity control and occupant comfort through more consistent conditioning throughout the building space.
- Reduce the amount of R22 in the portfolio inventory with new RTU replacements.

DOE realized that RTUs represent a tremendous energy savings potential and developed two initiatives to move the market toward higher efficiency. In January 2011, DOE joined industry partners in the Better Buildings Alliance to form the High Performance Rooftop Unit Challenge initiative and release a design specification for 10-ton capacity commercial RTUs to urge U.S. manufacturers to build and deliver innovative, competitively priced, energy-saving RTUs. Units built according to the RTU Challenge Specification are expected to reduce electricity use by 44% compared to the ASHRAE 90.1-2010 standard, depending on location and facility type. The RTU Challenge specification was developed in coordination with building owners and challenged manufacturers to develop RTUs with an integrated energy efficiency ratio (IEER) rating of 18 in January 2011.

UNITS BUILT ACCORDING TO THE RTU CHALLENGE SPECIFICATION ARE EXPECTED TO REDUCE ELECTRICITY USE BY 44% COMPARED TO THE ASHRAE 90.1-2010 STANDARD

On May 30, 2013, DOE, along with ASHRE and RILA, launched the Advanced RTU Campaign to promote and accelerate the market adoption of these high-efficiency RTU solutions. An advanced RTU is defined as one that meets or exceeds the Consortium for Energy Efficiency (CEE) Tier 2 unitary air conditioning specification. The CEE is a consortium of U.S. and Canadian gas and electricity efficiency program administrators who accelerate the development and availability of energy-efficient products and services for lasting public benefit. The table below shows the energy efficiency ratio (EER) and IEER ratings for a 10-ton RTU based on different specifications over time. The CEE Tier 2 standard represents a significant improvement over the ASHRAE 90.1-2010 standard, and most manufacturers offer RTUs that meet this specification. A specific EER and IEER align to CEE Tier 2, depending on the size (tonnage) of the RTU.

ASHRAE					CEE		DOE
90.1-1999	90.1-2001	90.1-2004	90.1-2010		Tier 2		RTU Challenge
EER	EER	EER	EER	IEER	EER	IEER	IEER
8.7	10.1	10.1	11	11.2	12	13.8	18

WALGREENS RTU REPLACEMENT CASE STUDY

Walgreens developed a successful RTU early retirement program to methodically replace its buildings' air conditioning equipment. In one store, it was able to reduce RTU energy consumption by more than 50%, saving \$14,000 in energy costs annually. In just 150 stores, the company saved more than \$1 million in materials and labor. By developing a Planned RTU Replacement process that includes right-sizing equipment and optimizing replacements, Walgreens has become a retail leader in the area of RTU replacements. Over the past three years, Walgreens has applied the Planned RTU Replacement Model to more than 5,000 RTU early retirements.

Before 2010, Walgreens did not have a comprehensive replacement plan, and had to perform many emergency replacements. These projects were costly because of the expensive labor rates involved, the small purchasing size, the lack of rebates, and the failure to address the potential for downsizing. This "run to fail" model missed many opportunities that corresponded to drastic cost savings at each building site.

Starting in 2010, Walgreens developed a portfolio-wide Planned RTU Replacement Model that resulted in significant energy and cost savings. A business case was made by evaluating the current process against a proactive asset retirement program. The risks identified of not doing the project played a large role in acquiring capital to begin the program. The data for the emergency replacement program were already available through maintenance numbers, and the data for the proactive retirement program were captured through Walgreens' engineering group, energy and sustainability team, and the vendors.

Missed Opportunities with Emergency Replacements	Opportunity Costs per Site with Planned Replacement
Redesign/Tonnage Reduction/Downsizing	\$4,800 (Material)
EPAct Calculations/Site Review/Signatures	\$2,300 (Net)
Mobilization Savings (6 installs/6 RTUs versus 1 install/6 RTUs)	\$3,700 per RTU 15-25% premium for expedited curb adapters
Volume Discounts through High-Volume Purchases with Economies of Scale	Varies depending on vendor discounts

Walgreens conducted a sizing review with a whole-building load analysis and determined that many stores could downsize their RTUs. For example, by incorporating the benefits that lighting retrofits bring to heat reduction, Walgreens could reduce RTU tonnage and achieve higher overall savings and financial return. Other activities that make load reduction possible include reducing infiltration, controlling air ventilation more tightly, installing more efficient equipment in plug loads, and reducing the safety factor in calculations.

In the three years since its inception, the program has become more streamlined and now covers a larger number of sites. Walgreens was able to reduce its number of contractors and simultaneously increase the number of points per project and include more sites in its budget. Timing of fiscal year budgeting makes program implementation challenging, and blackout periods around holidays and fiscal year budgeting reduced Walgreens' time for implementation per year to approximately seven months. In spite of these constraints, the success of the program has led to its continued expansion.

Program Evolution	2010	2013
Contractors	10-12 Contractors	1 Contractor
Initiatives	7-8 Points per Project (50/50)	30 Points per Project (22 Trane and Installing Contract/8 WAG)
Budget	~150 Sites	~200 Sites

The efficiencies of Walgreens' new units meet or exceed the CEE Tier 2 IEER ratings; the IEER of some units exceeds 15. For its RTU financial analysis, Walgreens focused on a 14,500 square-foot store. They reasoned that its existing RTU with an EER of 6.5 (assuming an initial EER of 8.5, which degraded over 12 years of operation) would use 1.85 kW/ton, and its planned replacement RTU with an EER of 12.6 would use 0.95 kW/ton. Accounting for the impact of the 15 IEER, projected energy use is further reduced to 0.8 kW/ton. Walgreens was also able to reduce the installed capacity (from 35 tons to 31 tons) through proper right sizing. By reducing RTU tonnage in 150 stores, Walgreens saved materials and labor costs. With an average reduction of five tons per project, Walgreens saved more than \$1 million across the 150 stores (\$791,895 in material savings, \$327,522 in labor savings).

CREATING VALUE AND SUSTAINABILITY FROM END-OF-LIFE ROOFTOP EQUIPMENT

The ultimate goal of the Advanced RTU Campaign and its supporters is to have a significant impact on energy consumption across the country. Energy efficiency brings value to building owners and operators through monetary savings; the reduction in electrical energy use mitigates the environmental impact. However, mechanical equipment replacement requires that the retired equipment be disposed; thus, the question turns to the environmental impact on landfills and proper disposal. Most people realize that there is value in the expired equipment (evidenced by the increased theft of exposed copper and aluminum coils). However, this equipment comprises motors and compressors that contain petroleum-based oils and is subject to U.S. Environmental Protection Agency (EPA) mandates for documenting refrigeration removal; many large users of mechanical equipment have begun to ask how their expired rooftop equipment is being disposed.

Recycling service companies focus on the 100% cradle-to-grave recycling of expired RTUs, including salvage of low-use parts, EPA documentation, and landfill avoidance reporting. When specified by the property owner or operator, these programs provide financial value to the owner of the expired equipment as well as the complete documentation that they have contributed sustainably to reduce landfill waste. (Ref. Fig. 1. HVAC/Refrigeration Annual Recycle Report)

ENERGY EFFICIENCY BRINGS VALUE TO BUILDING OWNERS AND OPERATORS THROUGH MONETARY SAVINGS; THE REDUCTION IN ELECTRICAL ENERGY USE MITIGATES THE ENVIRONMENTAL IMPACT.

Through this specification, the chosen mechanical services contractor is responsible for coordinating logistics and release of expired HVAC equipment to the approved HVAC recycling company. The mechanical services contractor is responsible to remove exterior connections, secure access panels, and remove the RTU from the building. From this point, the HVAC recycling company receives the expired equipment and provides for 100% recycling of the expired unit.

The refrigerant must be removed by a Universal Certified refrigerant technician who documents the refrigerant quantity per circuit, by unit, by model, and quantity removed as required by U.S. EPA standards and tied to the equipment serial number. The value of the refrigerant is provided to the building owner through a national banking program or as cash.

The recycling company must remove and document all lubrication oils from motors and compressors and recycle those oils through a national oil reclamation company. Complete documentation of the recycled lubricating oils must be maintained for the retailer and made available as needed per U.S. EPA requirements.

The RTU is then disassembled and the components are sorted for reuse and recycling. A sustainability landfill avoidance report is generated via records from a cataloged and managed Equipment Disposal Report (EDR). (Fig. 2) An EDR provides 100% cradle-to-grave responsibility release of any environmental liabilities for the building owner/operator from expired equipment. A library of completed EDR's shall be maintained for review by the building owner/operator.

Another added value provided by some HVAC recycling companies is a managed inventory of reusable service parts. Because many multi-building owners and operators have similar equipment in service across their building footprints, the ability to harvest low-use service parts provides a substantial opportunity for cost avoidance. HVAC recycling companies can identify these usable parts and put them in a managed inventory that the owner's chosen field service contractors can draw from at no additional cost. Building owners have thus already recognized as much as 82% maintenance cost avoidance. (Ref. Fig. 3 Asset Utilization Impact Report)

Documented recycling of rooftop HVAC equipment is a valuable service that produces a monetary return and increases the return on investment of upgrades to rooftop equipment as well as 100% cradle-to-grave release of liability through measurable sustainability efforts. By specifying these services as part of equipment upgrade plans, the building owner will be able to turn expired equipment liabilities into valuable assets.

National Retailer

2014 HVAC/Refrigeration Annual Recycle Report

(6/06/2014 YTD)

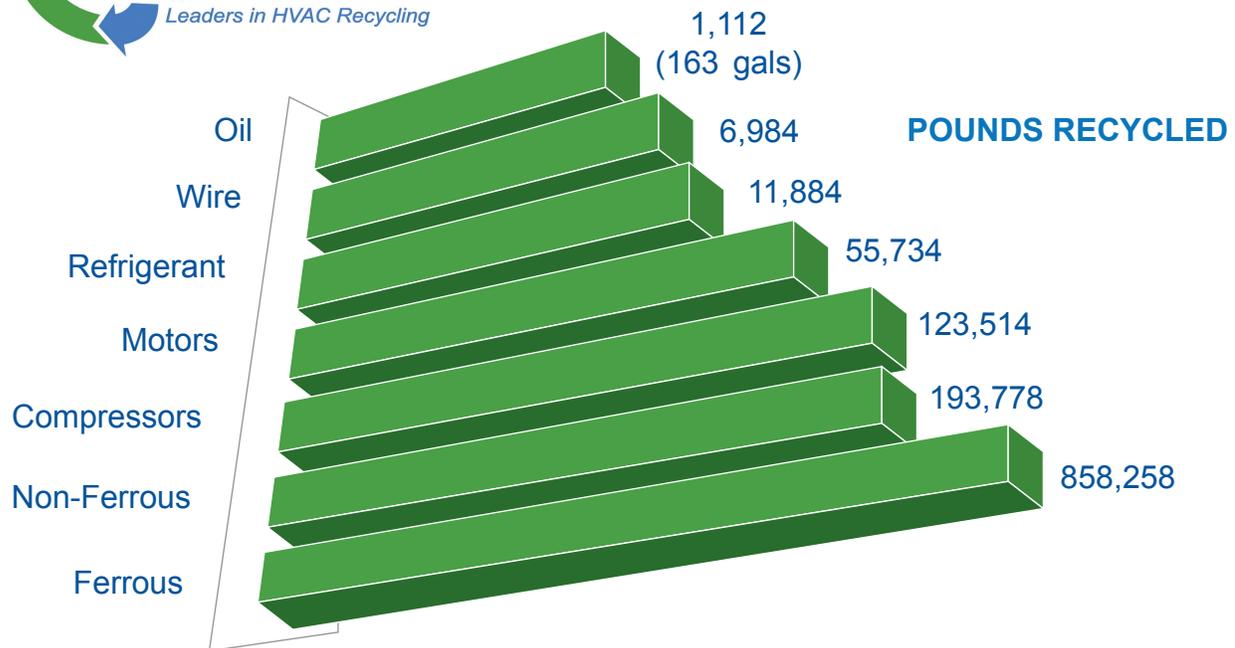


Figure 1

Equipment Disposal Record

21815



- | | |
|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| <input type="checkbox"/> 2171 Hwy 229
Tallassee, AL 36078
800-786-0402 | <input type="checkbox"/> 127 Peninsula St.
Wheeling, WV 26003
800-786-0402 |
| <input checked="" type="checkbox"/> 1831 Barnett Dr.
Weatherford, TX 76083
800-786-0402 | <input type="checkbox"/> 14325 Mt Lola
Reno, NV 89506
800-786-0402 |

Customer Name: National Retailer				Date Received 5/21/2014			
Store Name: National Retailer				Store Location: Yankton, SD			
Store Number: 9806							
Unit Description: Trane						RTU # 2	
Unit Model Number: YHC120A3RHA0HG6						Tonnage 10	
Unit Serial Number: 549100341L							
Date of Recovery: 5/21/2014							
Technician Name: Tony Taylor							
Refrigerant Type: R-22							
Recovery Equipment I.D.: Appion							
Circuit No.	Start/End Wt.	Total	Vacuum Level Achieved	Circuit No.	Start/End Wt.	Total	Vacuum Level Achieved
Circuit #1	49/56	7	-20	Circuit #7	/		
Circuit #2	53/63	10	-20	Circuit #8	/		
Circuit #3	/			Circuit #9	/		
Circuit #4	/			Circuit #10	/		
Circuit #5	/			Circuit #11	/		
Circuit #6	/			Circuit #12	/		

Comments: _____

I hereby affirm that the equipment above has been disposed of in accordance with section 608 of the Clean Air Act.

Tony Taylor
Signature

Figure 2

2014 Asset Utilization Impact Report

National Retailer

Compressors		
Manufacturer	Model	Qty
Carrier	CC228	1
	CC337	2
	DR337	1
	CY665	3
	CY675	8
	DR820	1
	EM450	1
Copeland	5 Through 20 Ton	61
Trane	S20 Compressors	6
	Total	84

2013 Total
436 Request
290 Shipped
67%

2014 YTD
227 Request
147 Shipped
65%

Novar	9
2024	17
Spectrum Boards	1
Novar DTS Temp Sensors	8
Novar Compressor Modules	2
Total	37

2012 – 347 – Shipped
2013 – 541 - Shipped
56% Increase

Condenser Fan Motors	
850 RPM	11
1100 RPM	1
1140 RPM	3
Lennox	6
Total	21

Breakers/Fuses/Blocks	
90 AMP	2
31 AMP	1
15 AMP	3
Total	6

Disconnect/Contactors	
Disconnect	1
Contactors	40
Total	41

VFD's	
Danfoss	3
HCUW Condenser	3
Emerson	1
Mitsubishi	1
Yaskawa	5
Total	13

Desiccant	
S20	4
S30	3
Total	7

Combustion/Blower/React Motors	
Lennox	9
Lennox	15
S20	1
HCU	1
3 HP	3
5 HP	5
S20	9
S30	3
RTU	13
Total	59



2014 Items Shipped
307 Total
Projected Increase over 2013
13%

Misc Items	
Airflow Switches	10
Gas Actuator Valves	7
S30 Burner Controls	1
S20 Desiccant Drive Motors	3
S30 Desiccant Drive Motor	2
HCU Desiccant Drive Motors	2
Total	25

Figure 3

VALUE PROPOSITION TO JOINING ARC AS A PARTICIPANT OR SUPPORTER

The two ways to become involved in the Advanced RTU Campaign are to join as a participant or as a supporter. A participant pledges to evaluate and implement an RTU replacement or retrofit and share the results with the campaign. ARC tracks progress of the RTU retrofits and replacements over the course of the campaign to measure their impact on the market. Commercial and government buildings are eligible to join the campaign as participants. A supporter commits to promoting the benefits of energy-efficient commercial cooling. Trade and industry organizations, utility and efficiency programs, and manufacturers and service providers are eligible to join the campaign as supporters.

Once a company has joined the Advanced RTU Campaign, there are valuable benefits to explore:

- Technical and financial resources are available on the campaign website. Members can search for rebates and incentives, case studies, and useful contacts to help them take advantage of RTU energy savings opportunities. (<http://www.advancedrtu.org/>)
- Campaign technical expertise from DOE national laboratory experts is available, limited based on availability, to participants as they are estimating their energy savings potential and submitting this information to the campaign.
- Receive awards and recognition publicity on the website for campaign involvement.
- Gain credibility from the experience of supporting a national campaign as a business opportunity.
- Stay informed about innovative RTU technologies and resources produced through the campaign.
- Save energy and money by installing high-efficiency RTUs or advanced controls.

ARC TRACKS PROGRESS OF THE RTU RETROFITS AND REPLACEMENTS OVER THE COURSE OF THE CAMPAIGN TO MEASURE THEIR IMPACT ON THE MARKET.

▶▶ EXPECTATIONS FOR ARC PARTICIPANTS AND SUPPORTERS

The Advanced RTU Campaign does set some expectations for campaign participants and supporters:

Participants	Supporters
Pledge to evaluate existing RTUs, implement a replacement or retrofit, and share savings with the campaign	Promote the benefits of high-efficiency RTU practices and the Advanced RTU Campaign
Evaluate energy savings potential and share this information with the campaign	Offer resources to help building owners and managers improve their buildings' efficiency
Submit documentation of RTU replacements or retrofits to earn an ARC Achievement Award that demonstrates leadership in building energy efficiency	Share data from energy efficient RTU replacement cases
	Recruit participants and earn an ARC Supporter Achievement Award for demonstrating active involvement

▶▶ SUMMARY/CONCLUSION

Advanced RTUs are valuable investments for retail building owners and managers to save energy and improve services. The Advanced RTU Campaign works to educate and encourage high-level decision-makers to consider the long-term benefits of energy savings and optimized operations with high-efficiency RTU replacements or advanced RTU retrofit controls. Joining the Advanced RTU Campaign sends a message to the market that it should promote the installation and use of high-efficiency units and advanced RTU controls. Over time, this will transform the RTU market into a culture where manufacturers make more high-efficiency RTUs, vendors stock more of these high-efficiency units on their shelves, and commercial building owners and operators automatically install the higher efficiency models to save energy and money.

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vimeo.com/PRSMAssociation



5000 Quorum Drive, #700
Dallas, TX 75254

866.963.1895 t
972.231.4081 f

info@prsm.com
www.prsm.com

IndProg012
09/2014