Northeast and Mid-Atlantic High Performance Rooftop Unit Market Transformation Strategy Report

December 2016

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About NEEP

NEEP was founded in 1996 as a non-profit whose mission is to serve the Northeast and Mid-Atlantic to accelerate energy efficiency as an essential part of demand-side solutions that enable a sustainable regional energy system. Our vision is that the region will fully embrace next generation energy efficiency as a core strategy to meet energy needs in a carbon-constrained world.

Disclaimer: NEEP verified the data used for this white paper to the best of our ability. This paper reflects the opinion and judgments of the NEEP staff and does not necessarily reflect those of NEEP Board members, NEEP Sponsors, or project participants and funders.

Executive Summary

Commercial Heating, Ventilation, and Air Conditioning (HVAC) is responsible for 26% of energy use in the region's commercial building sector, and contributes significantly to the region's energy demand.[1] Packaged systems, often referred to as 'rooftop units' (RTU), are a ubiquitous Commercial HVAC technology found throughout the Northeast and Mid-Atlantic region.[2] Due to a number of market barriers, the market for energy efficient RTUs has been slow to develop and has resulted in both the persistent sale of inefficient technology and an installed base of aging equipment. This reality has led to a large energy and peak footprint[3] and has left energy efficiency stakeholders wondering what can be done to transform this market towards more efficient options. The U.S. Department of Energy, in addition to undertaking a federal minimum standard, has launched two important national initiatives to address these market barriers: 1) the High Performance Rooftop Unit Challenge to engage the manufacturing community to supply more efficient units to meet unmet market demand; and 2) the Advanced Rooftop Unit Campaign to identify and recognize best practices and kick start market adoption.

High Performance RTU:

"High Performance RTU" refers to systems with best in class energy efficiency. The specific efficiency levels are defined by DOE's High Performance RTU Challenge levels for the ≥135K and <240K Btu/hr bin and remaining capacity bins are described by "Max-Tech" levels in recent DOE rulemakings.

Observing this national effort and a number of evolving market opportunities, including evolving business models and the development of new value streams, NEEP convened a regional stakeholder group of its Sponsors[4] to characterize the Commercial HVAC Rooftop market; identify current efficiency program activity; review market trends and barriers; and project savings from accelerated adoption of high performance equipment. Other stakeholders in this process include state agencies, U.S. DOE and national lab experts, HVAC manufacturers, distributors, and installers. NEEP convened an in-person workshop to discuss the status of the market, new potential business models, regulatory drivers, and pathways towards high performance equipment. The results of that discussion informed the development of this regional market transformation strategy which was circulated to the stakeholder group for peer review.

Market Assessment Findings

The RTU market assessment for the Northeast and Mid-Atlantic region provides a quantitative analysis of the efficiency and savings opportunity. The Market Assessment's high level findings were:

- Approximately 1,018,342 packaged commercial rooftop HVAC units (RTUs) are installed and serve the Northeast and Mid-Atlantic region. Only .15% meet high performance efficiency levels.
- Annual sales in 2016 of new rooftop units is estimated at 55,550 for the Northeast/Mid-Atlantic region.
- These existing units are of a range of vintages with many RTUs kept in service long beyond their expected useful life.

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[1] U.S. Energy Information Administration. Commercial Buildings Energy Consumption Survey website. 2003 CBECS Survey Data. 2003. http://www.eia.gov/consumption/commercial/data/2003

[2] Includes New England, New York and New Jersey

[3] Northeast Energy Efficiency Partnerships and KEMA. *Packaged Commercial HVAC Equipment Market Characterization*. 2006.

[4] Energy efficiency program administrators from Massachusetts, New York, the District of Columbia, Connecticut, Rhode Island, Vermont and New Hampshire

- Efficiency programs across the region have been implementing promotional activities for RTUs for many years. Current practice is to incentivize the purchase of systems meeting CEE Tiers (1 and 2) through a mixture of regionally uncoordinated downstream and upstream promotions.
- Overcoming stubborn market barriers has become a priority for a number of programs seeking additional savings opportunities.

New Equipment and Program Opportunities

- The U.S. Department of Energy's Rooftop Unit (RTU) Challenge was successfully met by a variety of manufacturers which have introduced market-ready high performance 135-240 kBtu/h units with an energy performance rating of 18 IEER that offer both energy savings and reduced peak demand. These advanced units include self-diagnostics and support two-way communications to energy managers regarding performance, need for maintenance, and enable participation in demand-response programs.
- Regulators and program administrators across the region are focusing efficiency programs to relieve system peaks with high performance equipment and demand-response. At the same time, the region's electric grid operators increasingly look to efficiency and demand response to cost-effectively meet system needs and provide market opportunities for end-use customers to be compensated for relieving peak system constraints.[5]
- The U.S. Environmental Protection Agency regulations will phase out the use of R-22 refrigerant in 2020. Until only a few years ago, the large majority of Commercial HVAC systems were designed and charged with R-22. The shift to R-410A refrigerant could drive many building owners with aging RTUs to consider replacing existing, older HVAC systems with new High Performance RTUs.
- A recent Direct Final Rule issued by the U.S. DOE establish new minimum federal appliance efficiency standards for Commercial Packaged HVAC through a two-stage process with effective dates in 2018 and 2023.
- Successful development of alternative market-based business models to deploy clean technologies ("Equipment as a service" offerings, Solar PV industry's no-money down lease options, etc.) drive significant adoption of clean technologies across the region and country.

Recommended Strategies to Achieve Market Transformation

To accelerate market transformation toward high performance RTUs in the Northeast and Mid-Atlantic, and help meet state and regional goals for cost-effective energy savings and relieve system peak constraints, **NEEP recommends a long term regional strategy with the goal to have 33 percent of the region's installed RTUs be high performance systems[6] by 2025**. Using the "Baseline Efficiency" to "Efficiency Level 5" or "Max Tech" established in DOE's Direct Final Rule, by 2025 the market would have transformed to over 330,000 High

[5] For ISO New England, see: http://www.iso-ne.com/markets-operations/markets/demand-resources and for PJM see: http://www.pjm.com/markets-and-operations/demand-response.aspx; for New York ISO see: http://www.nyiso.com/public/webdocs/media_room/press_releases/2015/Child_PowerTrends_2015/ptrends2015_FINAL.pdf

[6] "High Performance RTU" refers to systems with best in class energy efficiency. The specific efficiency levels are defined by DOE's High Performance RTU Challenge levels for the ≥135K AND <240K Btu/hr bin and remaining capacity bins are described by "Max-Tech" levels in recent DOE rulemakings; Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment and Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: ASHRAE Equipment Final Rule.

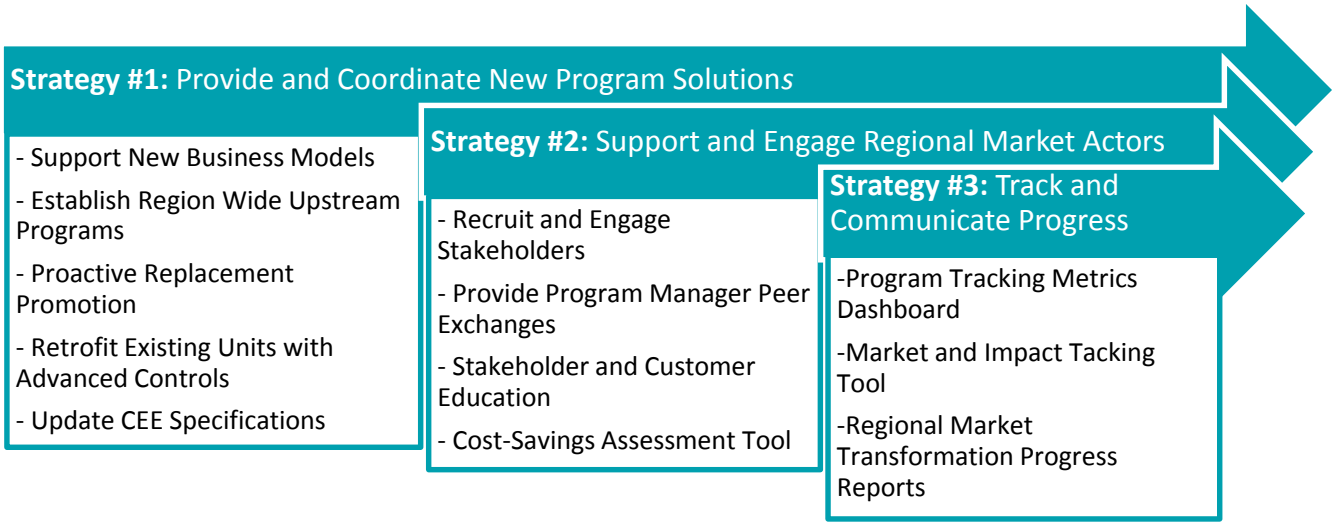
Performance RTUs that would deliver over 890 GWh energy savings annually, a demand reduction of over 1,168 MW, and an equivalent 504,243 Tons of carbon emissions reduction.

Northeast and Mid-Atlantic Regional RTU Goal:

Move penetration of High Performance Units in the installed RTU base from the current penetration of less than 1% to 33% by 2025

Included in this report is the regional market assessment of High Performance RTUs, which helps to inform NEEP of the recommended strategies for coordinated market interventions to overcome existing market barriers and leverage emerging market opportunities to accelerate the adoption of High Performance RTUs and effectively transform the long term market in the Northeast/Mid-Atlantic Region.

Figure ES 1: Regional High Performance RTU Market Transformation Strategy

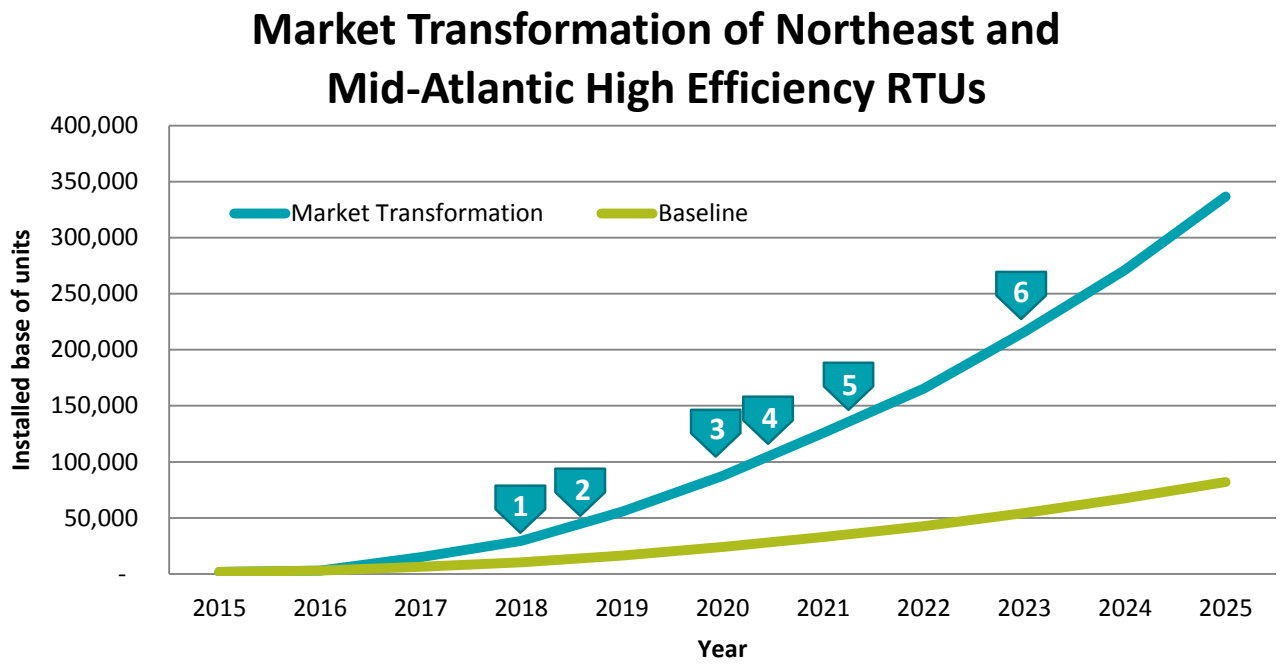


Market Transformation Theory of Change: This strategy is based on a market transformation theory of change and associated roadmap to achieve the 2025 goals. An accelerated regional market adoption of High Performance RTUs over the next 9 years is possible given a convergence of several trends and factors including:

- Upcoming new federal regulations (i.e., R-22 refrigerant phase out beginning 2020 and new appliance efficiency standards in 2018 and 2023) will encourage proactive replacement of RTU units.
- A new generation of High Performance RTUs and retrofit options are able to support a new business model for HVAC service.
- Common interest among Northeast efficiency programs to reduce peak demand - adding economic value to drive equipment replacement programs.
- Efficiency program administrator interest in regionally coordinated upstream incentives and promotions for RTUs.
- The recent and broad success of market-based, turn-key rooftop PV programs that minimize customer risks and logistics to install and maintain new equipment to achieve a high level of performance

Within this context, HVAC customers with aging equipment must consider whether to continue investing in the existing systems or selecting a new one. This presents a special opportunity for efficiency programs and the HVAC industry to work together to offer customers an incentivized, low-risk, high performance equipment replacement package. A successful regionally-coordinated promotion has the potential to drive high performance solutions for a significant portion of annual RTU equipment. Figure ES 2 represents the pathway graphically, with Appendix A providing more detail to how the curve was built.

Figure ES 2: Market Transformation of High Performance RTUs



From the strategy elements developed, a few core market transformation drivers are highlighted in Figure ES 2 and include:

- Inflection Point 1 (2018): New business models drive higher penetrations of High Performance RTU
- Inflection Point 2 (2018-2019): Region leverages refrigerant change-out to drive proactive replacement
- Inflection Point 3 (2020): New commercial HVAC business models mature, further accelerating the adoption of High Performance RTUs
- Inflection Point 4 (2020): EPA R-22 Phase-Out Begins
- Inflection Point 5 (2020-2023): Business model matures leading to reduced need for program support
- Inflection Point 6 (2023): Update to Federal Minimum Efficiency Appliance Standards

The strategies presented, while effective individually, are most successfully implemented regionally to actively engage HVAC industry, including distributors and contracts, and to encourage new EaaS business models. In addition, a regional approach can leverage the collective experiences of a regional working group to facilitate knowledge transfers, identify best practices, share the cost and risk of new approaches, and scale-up through combined efforts to achieve a market transformation tipping point by 2025. NEEP has the potential to facilitate a regional initiative with diverse stakeholders in 2016 and onwards to shape and implement the above-recommended strategies.

Introduction

Purpose, Timing, and Process of the Report

Commercial Heating, Ventilation, and Air Conditioning (HVAC) is responsible for 26% of energy use in the region's commercial building sector, and contributes significantly to the region's energy demand[7]. NEEP's 2010 Potential Study (From Potential to Action) found that commercial HVAC represented 24 percent of potential electricity savings in the region, second only to lighting, and savings almost entirely related to cooling in the summer months.[8] Packaged systems, often referred to as 'rooftop units' (RTU), are a ubiquitous Commercial HVAC technology found throughout the Northeast and Mid-Atlantic. Due to a number of market barriers, the market for energy efficient RTUs has been slow to develop and has resulted in both the sale of inefficient technology and an installed base of aging equipment. This reality has led to a large energy and peak footprint[9] and has left energy efficiency stakeholders wondering what can be done to transform this market towards more efficient options.

Observing a number of evolving market opportunities, including new high performance technology, evolving business models and the development of new value streams, NEEP engaged with a variety of industry stakeholders. Together, we reexamined historic market barriers and explored new market opportunities that could fundamentally change the market towards high performance equipment. Based on the information collected and stakeholders consulted, the following report presents the process that NEEP undertook as well as the Market Transformation strategy. This included the following components:

- ***Stakeholder Engagement:*** *bringing together a broad mix of stakeholders including energy efficiency program managers and industry experts, to share ideas and experiences toward advancing the project's goals.*
- ***Market Assessment:*** *A survey of the current Commercial Packaged HVAC market, including market barriers that prevent adoption of high performance systems.*
- ***Regional Strategy Statement:*** *Recommended regional strategies to overcome key market barriers/leverage key market opportunities to transform the regional Commercial Packaged HVAC market.*

NEEP convened a regional stakeholder group of its Sponsors[10] to inform a market assessment to characterize the Commercial HVAC rooftop market; identify current efficiency program activity; review market trends and barriers; and project savings from accelerated adoption of high performance equipment. Other stakeholders include state agencies, U.S. DOE and national lab experts, HVAC manufacturers, distributors, and installers. NEEP convened an in-person workshop to discuss the status of the market, new potential business models, regulatory drivers, and pathways towards high performance equipment. The results of that discussion informed the development of a regional market transformation strategy, which was circulated to the stakeholder group for peer review. This stakeholder group convened on a quarterly basis.

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[7] U.S. Energy Information Administration. Commercial Buildings Energy Consumption Survey website. 2003 CBECS Survey Data. 2003. http://www.eia.gov/consumption/commercial/data/2003

[8] Why RTUs? From NEEP project proposal, March 17, 2015

[9] Northeast Energy Efficiency Partnerships and KEMA. *Packaged Commercial HVAC Equipment Market Characterization*. 2006.

[10] Energy efficiency program administrators from Massachusetts, New York, the District of Columbia, Connecticut, Rhode Island, Vermont and New Hampshire

Market Assessment for the Northeast and Mid-Atlantic Region

Commercial Packaged HVAC Technology Basics

Commercial Packaged HVAC systems are often referred to as 'rooftop units' (RTU) because they are most commonly installed on a building's roof, although some packaged systems may also be mounted on the ground. Without including installation, a <65 kBtu/h unit typically costs between $2,000 and $4,000, while a 240 kBtu/h unit can be easily over $10,000. RTUs provide cooling and ventilation through vapor compression systems and provide heating through electric resistance, fossil fuel combustion or heat pump cycles. Many advanced control options, such as economizers, variable fan speed, optimal start and stop, variable speed compressors and automated fault detection and diagnostics could be added to the rooftop units separately. In a PNNL field-test, advanced controllers reduced both actual consumption and normalized consumption by between 22% and 90%, with an average of 55% for all RTUs. The capacity of an RTU system often ranges from 12 to 240 kBtu/h, though a system can be more than 760 kBtu/h. This Market Assessment reflects the equipment commonly targeted by efficiency programs, such as commercial air conditioning and air-to-air heat pump units. The term High Performance Rooftop Unit refers to RTUs engineered and produced with enhanced energy efficiency performance to meet DOE's High Performance Rooftop Unit Challenge[11] Initiative (DOE RTU Challenge) from 135-240 kBtu/h. To complement the other unit sizes, this report supplemented the High Performance RTU with the maximum-available efficiency levels, or 'Max-tech' levels, from the DOE's Technical Support Documents for Commercial Equipment.

High Performance RTU:

"High Performance RTU" refers to systems with best in class energy efficiency. The specific efficiency levels are defined by DOE's High Performance RTU Challenge levels for the ≥135 and <240 kBtu/hr bin and remaining capacity bins are described by "Max-Tech" levels in recent DOE rulemakings.

Figure 1: Typical Advanced Rooftop Unit[12]

Packaged systems are engineered, mass produced and marketed such that they are specified on buildings of a wide range of sizes and functions. An alternative, most commonly found on large high-rise buildings is a central plant system which is individually engineered and assembled from separate components (such as air handling units, boilers, chillers, pumps, piping, etc.). Packaged systems are a less expensive option to purchase, install and operate. They are delivered to the building site, hoisted to the roof,

[11] U.S. Department of Energy. High Performance Rooftop Unit Specification. http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/cbea_rtu_spec_long.pdf

[12] Image reference: http://catalyst-control.com/

and installed. Larger buildings will be outfitted with multiple versions of the same model. RTUs are the HVAC system of choice for just about every low-rise commercial building as compared to the alternative site-specific engineered central system.

RTUs and Energy Efficiency

The **American Society of Heating, Refrigeration and Air conditioning Engineers (ASHRAE)** has developed minimum values of Energy Efficiency Ratio (EER), Seasonal Energy Efficiency Ratio (SEER) and Integrated Energy Efficiency Ratio (IEER) for a series of size ranges of RTU's. ASHRAE publishes, and periodically updates, these code minimum ratings in their Standard 90.1: 'Energy Standard for Buildings Except Low-Rise Residential Buildings.' The latest version of this is ASHRAE 90.1 - 2013, is available on the ASHRAE web site.

Minimum efficiency performance standards governing the import and manufacture of RTUs in the U.S. are managed by the US DOE in a periodic process of setting energy efficiency minimum ratings. In 2016, DOE issued a Direct and Final Rule Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment. This standard is effective in two stages, 2018 and 2023, with levels set in Table 1,

Building Energy Codes are administered on a state or local basis, generally based on the latest or most recent version of ASHRAE 90.1 and IECC (International Energy Conservation Codes). Periodic advances in the IECC requirements as well as local adoption of Stretch Codes serve to advance Market Transformation of efficient equipment in new construction. These advances cause a 'cat and mouse' chase between savings potential and utility efficiency programs. As the codes raise the common practice baseline, the savings potential from efficient equipment diminishes. That is until the next increment in technology development and efficiency specifications offers a greater level of savings compared to the new baseline.

The **Consortium for Energy Efficiency (CEE)** establishes voluntary efficiency specifications for commercial packaged HVAC systems. These specifications set minimum efficiency criteria at levels above current codes and standards. Energy efficiency programs throughout the region and country tend to use the CEE performance levels as targets for their RTU programs. CEE specifications for packaged commercial HVAC systems reflect market availability of the highest performing units. CEE's latest HVAC specification is dated January 12, 2016 and is available on the CEE web site.[13]

Table 1 shows the CEE Tiers as well as ASHRAE 90.1 levels for various years and the minimums set by DOE for 2018 and 2023. These levels reflect a range of efficiencies for existing products, but not the levels defined in this report as High Performance RTUs; High Performance RTU levels align with DOE's High Performance RTU Challenge and Max Tech levels established in the 2016 Direct and Final Rule and are referenced in Table 7 as projections.

[13] Available from: https://library.cee1.org/sites/default/files/library/7559/CEE_ComACHP_UnitarySpec2016.pdf

Table 1: Energy Efficiency Specifications

	Minimum Efficiency Values of Non-Electric Resistance Packaged Units as of December 2016							
Unit Size (Btu/h)	**ASHRAE 90.1 2004**	**ASHRAE 90.1 2010**	**IECC 2015**	**CEE Tier 1**	**CEE Tier 2**	**CEE Advanced Tier**	**Conservation Standard, 2018**	**Conservation Standard, 2023**
<65K	12 SEER	13 SEER	14 SEER	15 SEER, 12 EER	16 SEER, 12 EER	17 SEER, 12.5 EER	N/A	N/A
≥65K and <135K	10.1 EER	11 EER 11.2 IEER	11 EER 12.6 IEER	11.5 EER 12.7 IEER	12 EER 13.8 IEER	12.4 EER 17.8 IEER	12.7 IEER	14.6 IEER
≥135K and <240K	9.5 EER	10.8 EER 11 IEER	10.8 EER 12.2 IEER	11.5 EER 12.2 IEER	12 EER 13 IEER	12 EER 16.8 IEER	12.2 IEER	14.0 IEER
≥240K and <760K	9.3 EER	9.8 EER 9.9 IEER	9.8 EER 11.4 IEER	10.3 EER 11.4 IEER	10.6 EER 12.1 IEER	10.6 EER 13.3 IEER	11.4 IEER	13.0 IEER
>760K	9.0 EER	9.5 EER 9.6 IEER	9.5 EER 11 IEER	9.7 EER 11.2 IEER	10.2 EER 11.4 IEER	N/A	N/A	N/A

RTU Building Occupancy and Responsibility Characteristics

Table 2 and Table 3 use US Energy Information Agency (EIA) census data to analyze building energy responsibility in the Northeast region. Although over a third of buildings are occupied by leasing tenants, almost all energy decisions for equipment purchase and O&M arrangements are made by the building's owner which may be passed along to the tenant. Therefore, for a significant segment of the buildings in the region, the party responsible for equipment and operations is not the party ultimately paying the energy bill.

Table 2: Commercial Building Occupancy Characteristics in the Northeast Region[14]

Percentage of Commercial Buildings in the Region	
Owner Occupied	55%
Lease-Tenant Occupied	33%
Other or Unoccupied	12%

Table 3: Responsibility for Equipment and Energy O&M Decisions

	Responsible for Energy Bills	Decision Maker for Energy Equipment Purchase
Owner	85%	85%
Tenant	13%	12%
Other	2%	3%

Supply and Sales Channels

The majority of RTUs are acquired from installation contractors, although manufactures and distributors play a significant role in their sale. As characterized in DOE's CUAC Direct Final Rule, there are three distribution

[14] EIA Census Region # Buildings 2012 Table B3. Northeast: 805K buildings; USA: 5,557K Buildings.

channels to describe how the equipment passes from the manufacturer to the commercial consumer. The first of these channels, the replacement distribution channel, was characterized as follows:

- Manufacturer → Wholesaler → Small or Large Mechanical Contractor → Consumer

The second distribution channel—new construction—was characterized as follows:

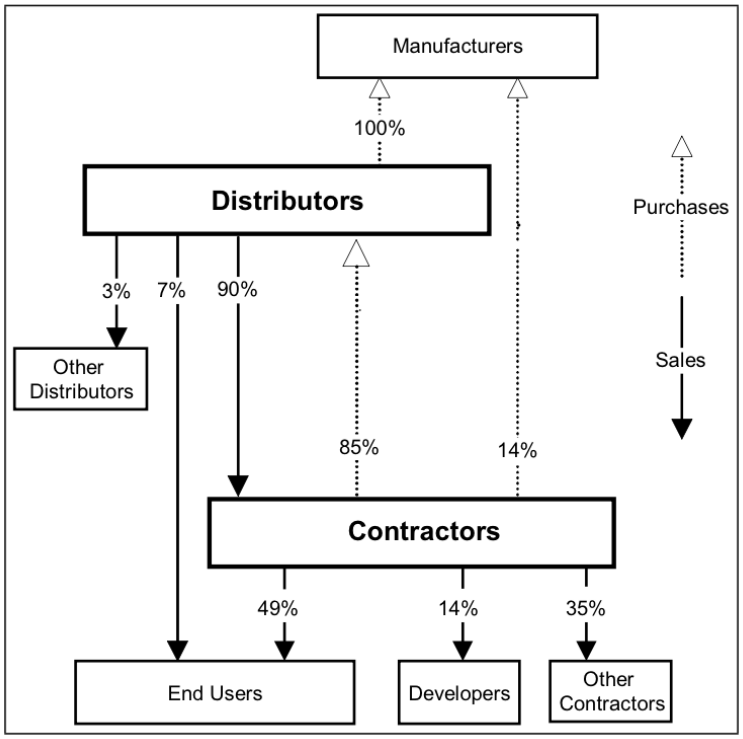
- Manufacturer → Wholesaler → Small or Large Mechanical Contractor → General Contractor → Consumer

In the third distribution channel, which applies to both the replacement and new construction markets, the manufacturer sells the equipment directly to the customer through a national account:

- Manufacturer → Consumer (National Account)

Additionally, Figure 2 presents the variety of routes for RTU equipment procurement for the end user. While the graphic is a generalization of the overall RTU market, the sales distribution flow is clearly demonstrated with a range of end users and purchase situations.

Figure 2: Typical Sales and Supply Channels for Commercial Packaged HVAC Units (RTUs) [15]



[15] Product Sales distribution flow. See pp1-2 and 1-3 of NYSERDA 2001 Market Assessment

Regional Market Size

Annual Sales

In January, 2016 the U.S. DOE released the Direct Final Rule[16] for the Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment. In the supplemental National Impact Analysis Spreadsheet,[17] DOE calculates 2016 national shipment data at 160,114. To estimate the shipments for the Northeast and Mid-Atlantic region, NEEP applied a regional percentage of commercial floor space.[18] Drawing from CBECs Census divisions 1 and 2, a regional percentage of 17.8% brings the regional total to 28,500. NEEP also reviewed numbers from the 2006 KEMA Market Characterization Report , though ultimately used the DOE numbers for our analysis.[19]

For units below 65 kBtu/h, the shipments are calculated in the DOE's Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: ASHRAE Equipment Final Rule. Given that the majority of the units installed in commercial applications are less than 65 kBtu/h, it is imperative that this size bin is taken into account. According to the supplemental National Impact Analysis Spreadsheet, Packaged AC projects 122,270 units shipped in 2017 and given the Northeast regional percentage of 17.8%, the regional total amounts to 21,764 units.

To account for the entire Northeast and Mid-Atlantic region, and states not covered in the Census Divisions 1 and 2, (i.e. District of Columbia, Delaware, Maryland, and Pennsylvania) the unit sales were proportionally increased by applying the number of commercial monthly bill customers.[20] Using the information to incorporate the additional states, the total annual sales for units <65 kBtu/h in the region is estimated at over 31,497 units. Table 4 demonstrates Total Sales for the Northeast and Mid-Atlantic territory covered, as well as the distribution among the states within the greater Northeast and Mid-Atlantic region.

Table 4: 2016 Estimated Annual Sales of RTUs by State and Size (kBtu/h)

State	<65	≥ 65 to < 135	≥ 135 to < 240	≥ 240 to ≤ 760	Total
Delaware	365	345	103	30	844
District of Columbia	185	175	52	15	428
Connecticut	1,087	1,026	307	91	2,511
Maine	641	605	181	53	1,480
Massachusetts	2,791	2,634	788	232	6,445
New Hampshire	741	699	209	62	1,711

[16] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule for Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. Jan, 2016. https://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0113

[17] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule National Impact Analysis Spreadsheet. Nov, 2015. https://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0107

[18] U.S. Energy Information Administration. Commercial Buildings Energy Consumption Survey website. 2012 CBECS Survey Data. 2003. Table B3. http://www.eia.gov/consumption/commercial/data/2012/#b2

[19] For reference, the 2016 KEMA report estimated the total market size of Packaged Commercial units in the Northeast & Mid-Atlantic (New England, New York and New Jersey) to stand at 55,275 unit sales per year.

[20] U.S. Energy Information Administration. 2014 Average Monthly Bill- Commercial. 2014. http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_b.pdf

Rhode Island	408	385	115	34	943
Vermont	367	347	104	31	848
Maryland	1,738	1,641	491	145	4,014
New Jersey	3,579	3,378	1,010	298	8,265
New York	7,318	6,908	2,066	609	16,900
Pennsylvania	4,833	4,562	1,364	402	11,162
Total	**24,052**	**22,705**	**6,790**	**2,003**	**55,550**

DOE's base-case efficiency distribution illustrates that max-tech levels accounts for approximately 0.6% of national shipments. Therefore, in Table 5, Total Regional Sales are multiplied by 0.6% to calculate the number of High Performance RTUs in the region. An estimated 0.6% of total sales for the entire region, or 333 units, are expected to meet High Performance levels.

Table 5: Estimated Annual Sales of High Performance RTUs in the Northeast and Mid-Atlantic Region (2016)

Size (kBtu/h)	Total RTU Sales	High Performance RTU
≥ 65 to < 135	22,705	136
≥ 135 to < 240	6,790	41
≥ 240 to ≤ 760	2,003	12
Total	**55,550**	**333**

Installed Base

Table 6 below is an approximation of the installed base of RTUs in the region. NEEP established a weighted average lifetime of 20.6 years for RTUs, combining shorter lived smaller units with longer lived larger units. 18.4 years for air-cooled commercial air conditioners and heating equipment.[21] Therefore, in our analysis the annual sales of 55,550 units were given an average life span of 20.6 years. Additionally, DOE's analysis found that 18% of the total units sold were for new installations as opposed to replacing existing units. By factoring installation type and the product of annual sales and lifespan, NEEP was able to estimate the Installed Base of Commercial Packaged HVAC Units (RTUs) in the Northeast and Mid-Atlantic Region.

Table 6: Estimated Installed Base of RTUs in the Northeast and Mid-Atlantic Region

Size of Unit in kBtu/H	Total Installed Base (# Units)
<65	440,921
≥ 65 to < 135	416,228
≥ 135 to < 240	124,474
≥ 240 to ≤ 760	36,719
Total	1,018,342

[21] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Notice of Proposed Rulemaking (NOPR) and Public Meeting. 2014 http://energy.gov/sites/prod/files/2014/09/f18/2014-09-18%20Issuance%20cauc_noticeofproposedrulemaking.pdf

In our analysis, an estimated .6 percent of RTU annual sales qualify as High Performance. Given that High Performance RTU's were available in 2012, roughly 1,572 or 0.15% of the installed base is considered High Performance in the Northeast and Mid-Atlantic.

Regional Potential Savings - Energy, Demand, Economic and Carbon

Energy and Demand Savings - Moving Sales from Current Baseline to High Performance RTUs

Table 7 below presents technical potential energy savings and demand reduction of sales for High Performance RTUs at today's sales levels. While actual achievable potential would depend on a number of market and program variables, the results demonstrate the large energy savings potential of High Performance RTUs. Including the full range of sizes, the theoretical maximum savings potential from an individual unit would result in the difference from "Baseline Efficiency" to "Efficiency Level 5."[22] In aggregate, annual sales in the Northeast region could amount to 193 MW demand and 147 GWh energy savings. This calculation is based on the annual energy consumption per unit by a commercial air unit.[23] While interview respondents confirmed that 100% penetration of maximum savings would not be immediately achievable, partial savings may still serve as an indication of the potential of High Performance RTUs.

Table 7: Per Unit Annual Energy/Demand Savings Potential for Region—Baseline to Max Tech RTU

Efficiency Level	Small Equipment <65 kBtu/h		Small Commercial, ≥ 65 to < 135 kBtu/h		Large Commercial, ≥ 135 to < 240 kBtu/h		Extra Large Commercial, ≥ 240 to ≤ 760 kBtu/h	
	SEER	Average (kWh/yr)	IEER	Average (kWh/yr)	IEER	Average (kWh/yr)	IEER	Average (kWh/yr)
Baseline	13	2,701	11.4	6,675	11.2	12,739	10.6	35,896
Max-Tech	19	2,118	21.5	3,540	20.1	7,099	15.6	24,391
Average Per Unit Savings	-	583	-	3,136	-	5,641	-	11,505
Average Per Unit Demand Reduction	.77 kW Demand Reduction		4.12 kW Demand Reduction		7.41 kW Demand Reduction		15.12 kW Demand Reduction	
Total Sales	24,052		22,705		6,790		2,003	
Calculated Savings (GWh/yr)	14		71.2		38.3		23	
Calculated Demand (MW)	18.5		93.5		50.3		30.3	

[22] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule Technical Support Document: Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. Dec, 2015. https://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0105

[23] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule for Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. Jan, 2016. https://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0113

For those units below 65 kBtu/h, savings are calculated in the ASHRAE Equipment Final Rule: Technical Support Document (TSD).[24] Given that the majority of the units installed in commercial applications are less than 65 Btu/h, it is imperative that the savings for this bin is taken into account. The theoretical maximum savings potential from an individual unit would result in the difference from "Baseline" to "Max-Tech." According to the TSD, Packaged AC units would result in a per unit savings of 583kWh/yr.

Additionally, Large Commercial units represent the technical potential energy savings and demand reduction for the DOE RTU Challenge[25] sales at today's activity level. Taking an average of 187.5 kBtu/h unit, the theoretical savings potential from annual sales of Large Commercial RTUs in the Northeast region could be 50.3 MW demand and 38.3 GWh/yr of energy. This calculation is based on 100% penetration of annual sales assumed from the baseline standard to the max-tech.

Economic and Carbon Savings

Equally important as quantifying the energy and demand savings potential for this assessment is the quantification of the economic benefits to the grid and potentially consumers. As explained in the *Regional Avoided Cost Study Update,*[26] the benefits of a measure, in this case High Performance RTUs, is the product of the net savings and avoided costs. Although for our purposes, we are using gross savings in lieu of net savings. The avoided energy and demand costs found in the *New England Avoided Energy Supply Report* are representative of the region.[27] Avoided Electric energy cost, which is calculated to be $56.58/MWh, consists of wholesale electric energy price plus any associated costs. The Avoided capacity costs, which is $140.10/kW, are an estimate of the value of a load reduction by retail customers during hours of system peak demand. This is attributed to the reduction of the load at the system annual peak hour and the capacity credit attributed to energy-efficiency programs.

Table 8 and Table 9 show the monetary benefits from moving all new sales to high performance RTUs.

Table 8: New Sales Demand Reduction Benefits

Gross Demand Reduction (MW)	Avoided Cost ($/kW)	Benefits ($)
193	140.1	27 million

Table 9: New Sales Energy Savings Benefits

Gross Energy Savings (GWh)	Avoided Cost ($/MWh)	Benefits ($)
147	56.58	8.3 million

[24]U .S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: ASHRAE Equipment. Dec, 2015. https://www.regulations.gov/#!documentDetail;D=EERE-2014-BT-STD-0015-0043

[25] U.S. Department of Energy. High Performance Rooftop Unit Specification. http://apps1.eere.energy.gov/buildings/publications/pdfs/alliances/cbea_rtu_spec_long.pdf

[26] 2015 AESC Regional Avoided Cost Study: Update http://ma-eeac.org/wordpress/wp-content/uploads/MA-EEAC-Consultant-Team-Presentation-on-2015-Regional-Avoided-Cost-Study1.pdf

[27]Avoided Energy Supply Costs in New England: 2015 Report http://ma-eeac.org/wordpress/wp-content/uploads/2015-Regional-Avoided-Cost-Study-Report1.pdf

Additionally, the savings from sale of High Performance units could result in roughly 103,308 Tons of CO_2 emissions reduced from the atmosphere, or the equivalent of about 21,822 passenger vehicles' emissions.[28]

Savings from Proactive Replacement of 5% of Installed Base with High Performance RTUs

The combination of a rapid advancement in RTU equipment efficiency and an aging fleet in the Northeast leads to the potential for cost effective retirement/replacement of RTU before the end of its claimed technical useful life. Table 10 below presents potential energy savings and demand reduction for proactive replacement. Assuming an annual replacement rate of 5 percent of the installed base, the opportunity would be 176.6 MW of demand and 134.3 GWh/yr of energy savings. These calculations are based on moving an individual unit within a size bin from "Baseline Efficiency" to "Efficiency Level 5."[29]

Table 10: Technical Potential: Proactive Replacement of 5% Region Installed Base with High Performance RTUs

Size in kBtu/H	Total Installed Base (# Units)	5% Installed Base No. Units	Average Demand reduction (kW) per Unit	Total demand reduction; 5% of Installed Base (MW)	Energy Savings (kWh/yr) per Unit	Total energy savings at 5% of Installed Base (GWh/yr)
<65	440,921	22,046	0.77	17.0	583	12.9
≥ 65 to < 135	416,228	20,811	4.12	85.7	3,136	65.3
≥ 135 to < 240	124,474	6,224	7.41	46.1	5,641	35.1
≥ 240 to ≤ 760	36,719	1,836	15.12	27.8	11,505	21.1
Total	**1,018,343**	**50,917**		**176.6**		**134.3**

The ≥ 135 to < 240 sized units represent the technical potential energy savings and demand reduction for the DOE RTU Challenge for proactive replacement. Assuming an annual replacement rate of five percent of this sized unit's installed base, the regional opportunity would be 46.1 MW of demand and 35.1 GWh/yr of energy savings.

Table 11: 5% Proactive Replacement Demand Reduction Benefits

Gross Demand Reduction (MW)	Avoided Cost ($/kW)	Benefits ($)
176.6	140.1	24.7 million

Table 12: 5% Proactive Replacement Energy Savings Benefits

Gross Energy Savings (GWh)	Avoided Cost ($/MWh)	Benefits ($)
134.3	56.58	7.6 million

[28] U.S. Environmental Protection Agency. Greenhouse Gas Equivalencies Calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[29] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule Technical Support Document: Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. Dec, 2015. https://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0105

When comparing which strategy, proactive replacement of 5% or total conversion of new sales, a side-by-side comparison of benefits shows that converting all new sales is slightly more impactful. Both approaches, however, yield significant impacts, particularly in the high volume ≥ 65 to < 135 kBtu/h size units. Figure 3 and Figure 4 presents these opportunities.

Figure 3: Comparison of Energy Savings, New Sales vs. 5% Proactive Replacement

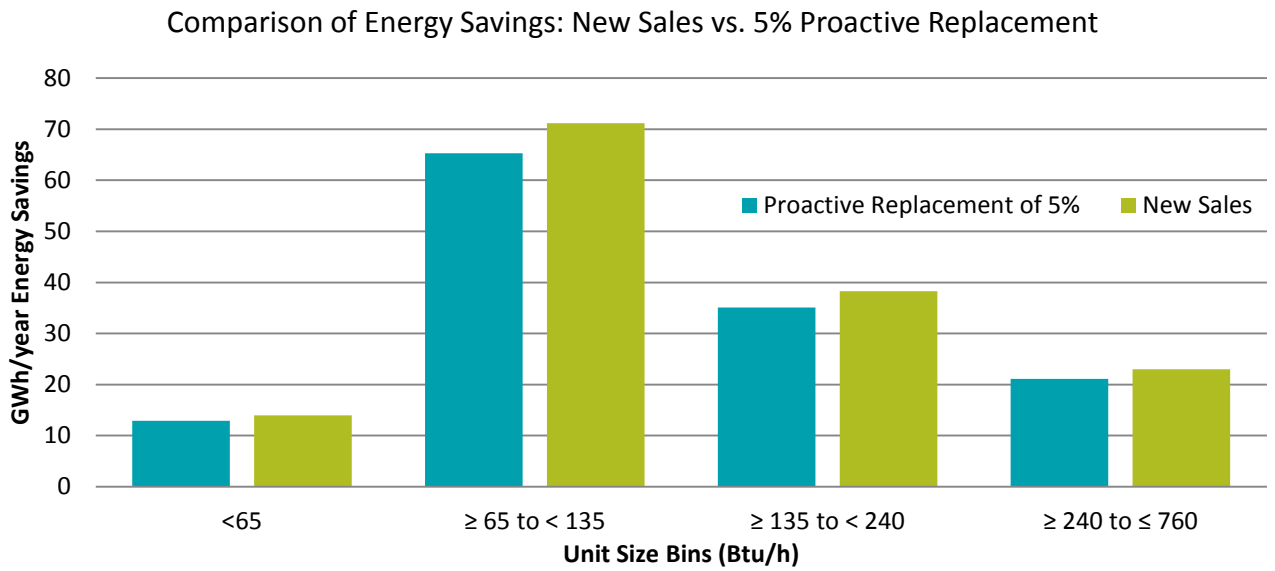
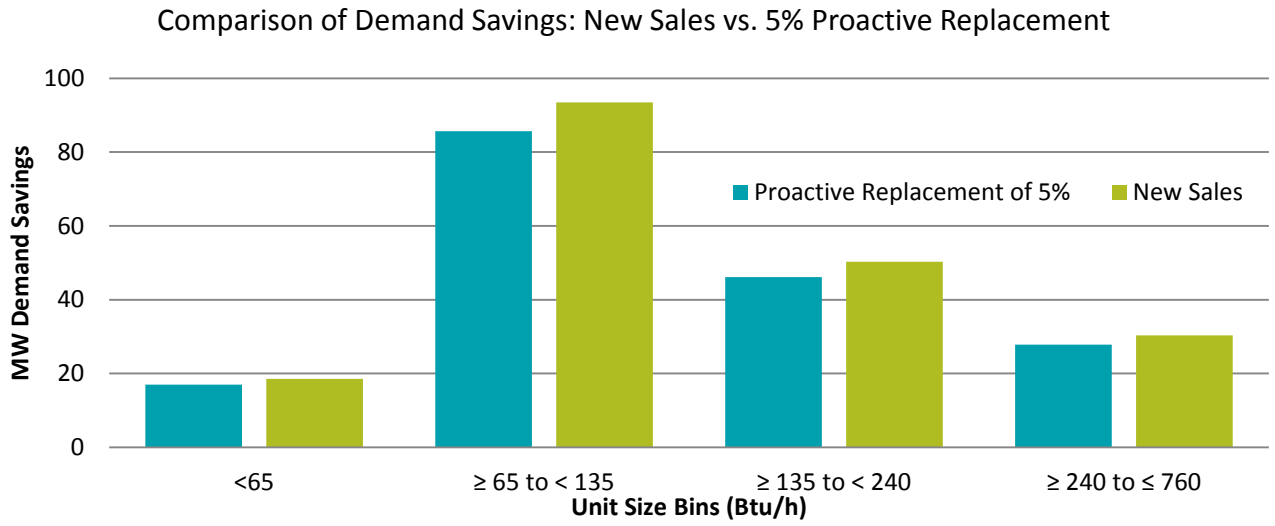


Figure 4: Comparison of Demand Savings: New Sales vs. 5% Proactive Replacement



Supplemental Controls

Controls are a major advancement for RTU operation and the majority of programs offer incentives for a variety of control equipment. Many of these advanced control options, such as economizers, supply-fan speed, optimal start and stop, and demand-controlled ventilation, could be retrofitted to rooftop units in the field. In a PNNL

field-test, buildings were retrofitted with a commercially available advanced controller to test if it improved an RTU's operational efficiency. The study's controller was representative of a commercially available RTU retrofit controllers in today's market. The findings from this work were not limited to one specific product, but apply to all products with advanced RTU control strategies.

In this study the advanced controller reduced both actual consumption and normalized consumption by between 22 percent and 90 percent, with an average of 55 percent for all RTUs. The majority of RTUs had their electricity savings in the range between 40 percent and 90 percent. For absolute savings, actual RTU electricity savings was in the range between 0.35 and 7.68 kWh per hour of unit operation, with an average of 2.41 kWh/h. Normalized annual electricity savings ranged between 0.47 and 7.21 kWh per hour of unit operation, with an average of 2.39 kWh/h.[30] It is clear that programs looking to increase the savings from their commercial HVAC programs, should look to RTU controllers.

[30] U.S. Department of Energy. Wang, W. et al. *Advanced Rooftop Control (ARC) Retrofit: Field-Test Results*. 2013. http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf

Existing Promotional Activity in Support of High Performance RTUs

There are a number of programs and resources in place now, focused on promoting deployment of efficient RTUs, and on overcoming market barriers to their selection. The major market transformation interventions in the Northeast/Mid-Atlantic region are through rate-payer funded energy efficiency programs administered by utilities and state organizations. The programs also have access to tools from national organizations.

US Department of Energy

The DOE is involved in major efforts for the advancement of energy efficiency in commercial packaged HVAC: Standards setting and resources through the Better Buildings program.

DOE's Appliance and Equipment Standards Programs: In January, 2016 the U.S. DOE released the Direct Final Rule[31] for the Small, Large, and Very Large Air-Cooled Commercial Package Air Conditioning and Heating Equipment. This program is discussed further in *RTUs and Energy Efficiency.*

Better Buildings Alliance RTU Challenge: DOE conducted a three year challenge, from 2011 to 2013 for industry to develop and market an Advanced Rooftop Unit meeting unprecedented efficiencies. The Challenge focused on RTUs in the 135 to 240 kBtu/h capacity range, specifying 18.0 IEER, as well as other quality operating parameters. In May 2012, Daikin's Rebel rooftop unit system became the first to meet the challenge. At the time of this report, in May 2015 there were more than 20 RTU models that met the DOE RTU Challenge performance specification.

Better Buildings Alliance Advanced Rooftop Unit Campaign: DOE's Advanced RTU Campaign (ARC) runs from 2013 through 2016. The campaign looks at RTUs that exceed the CEE Tier 2 efficiency levels. Units built according to the specification are expected to reduce energy use by as much as 50 percent compared to the current ASHRAE 90.1 standard, depending on location and facility type. DOE has developed tools, resources and an awards program all aimed at promoting selection of qualifying units. Campaign Supporters are organizations committed to promoting the benefits of energy efficient commercial cooling. While campaign participants are organizations that have pledged to adopt high efficiency RTUs and/or advanced controls in their facilities. In the Northeast and Mid-Atlantic region, there are efficiency programs that have registered as either Advanced RTU Campaign supporters or participants. It also promotes advanced controls for RTUs, focusing on a range of sophistication from simply controlling the speed of the unit's fans to controlling a full range of refrigeration and ventilation system components. Advanced controls can be OEM included on new units or retrofitted onto existing ones. [32]

Utility and State Administered Efficiency Programs

NEEP has aggregated Energy Efficiency Program information as presented in Table 13 below. A pattern of three trends emerged in the course of this compilation: consistent use of CEE tiers, a mix of rebates and upstream models, and an increasing emphasis on controls. Of particular interest to program administrators is a regional

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[31] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule for Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. Jan, 2016. https://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0113

[32] Retail Industry Leaders Association (RILA), ASHRAE, Better Buildings Alliance Advanced Rooftop Unit Campaign, http://www.advancedrtu.org/about.html.

forum for peer exchange and program-information sharing. Expanding Table 13 with incentive values and contractor contact information is seen as a valuable tool.

Table 13: Utility and State SBC Programs for Commercial Packaged HVAC (RTU) Efficiency

Commercial Air Conditioner and Heat Pump Programs in NEEP Sponsor States			
	Air Conditioning	**Heat Pump***	**Controls**
VT	CEE Tier II		Yes
NH	Incentive Level 1: CEE Tier I	Incentive Level 1:CEE Tier I	Yes
	Incentive Level 2: CEE Tier II	Incentive Level 2: CEE Tier II	
DC	CEE Tier I		Yes
LI	Incentive Level 1: CEE Tier I	Incentive Level 1:CEE Tier I	
	Incentive Level 2: CEE Tier II	Incentive Level 2:CEE Tier II§	
	Early Replacement: CEE Tier I		
CT	Incentive Level 1: CEE Tier I	Incentive Level 1: CEE Tier I	
	Incentive Level 2: CEE Tier II	Incentive Level 2: CEE Tier II	
MA (upstream)	Incentive Level 1: CEE Tier I	Incentive Level 1:CEE Tier I	Yes
	Incentive Level 2: CEE Tier II	Incentive Level 2:CEE Tier II§	
RI (upstream)	Incentive Level 1: CEE Tier I	Incentive Level 1:CEE Tier I	Yes
	Incentive Level 2: CEE Tier II	Incentive Level 2:CEE Tier II§	
NYSERDA	CEE Tier II	CEE Tier I	Yes

Across the Northeast and Mid-Atlantic region, programs are reliant on the commercial packaged HVAC (RTU) CEE Tier specifications. There is a pattern of using CEE's Tier 1 and 2 for the varying sizes of units. Also of note is that while programs also use the 'tier' system for commercial air conditioners, CEE does not list a heat pump Tier 2 for units greater than 65 Btu/h. Programs, in turn, allot the EER values from CEE's air conditioning specification to the respective heat pump size range. While the end result is not an officially CEE Tier 2 for higher capacity heat pumps, many programs abide by this method.

The majority of programs continue to employ downstream incentives (rebates granted to end-use customers) and have seen little change in the units through the program.

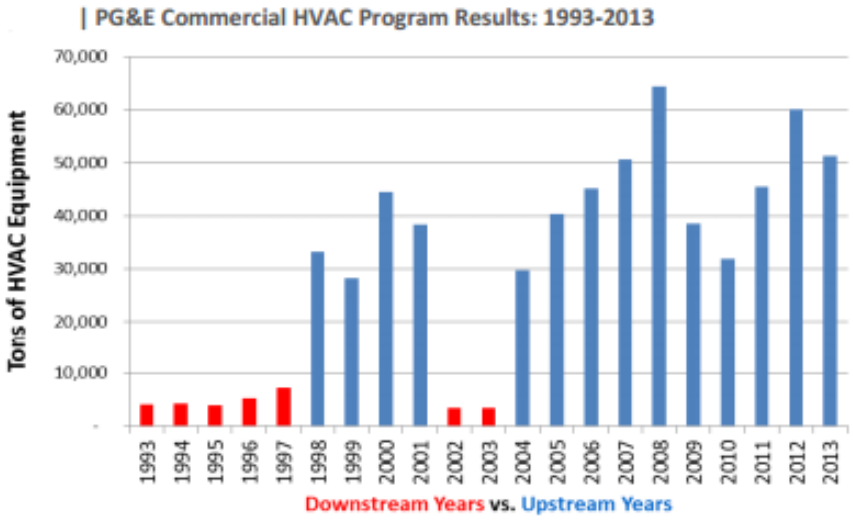
Recently some programs have begun to implement upstream incentive structures. Program experience in residential & commercial lighting products has shown that issuing incentive dollars directly to the manufacturer or retailer tends to ease the paperwork and the decision burden on the end user, while greatly reducing the overall number of transactions for the utility. Upstream programs also enable distributors to have high efficiency equipment stocked for emergency replacement situations as customers are often impatient to have systems repaired in these circumstances. In upstream programs, utilities incentivize a product by working with the manufacturer, retailer, or supplier rather than offering a rebate to the end-use consumer directly.

The Massachusetts and Rhode Island utilities currently offer only upstream incentives in their commercial RTU programs. Vermont and NYSERDA programs use a combination of upstream and downstream methods, where a customer can authorize their supplier to receive the rebate. Other programs use specifically downstream

methods. As demonstrated in SWEEP's report[33], upstream incentives dramatically influence the volume of energy-efficient HVAC equipment passing through the programs.

Figure 5 illustrates the volume of HVAC equipment funded through PG&E's programs over a twenty year period, with downstream (red) compared to upstream (blue) program methods. Quite clearly, the upstream program was more effective at funding equipment though the correlation to the number of units entering the market is not clear. The California programs are certain about the upstream model's ability to significantly affect stocking of qualifying units; building relationships with distributors and program maturation were listed as crucial aspects of the program.

Figure 5: Comparison of Annual Rebate Dollars Downstream vs. Upstream Strategy – PG&E 1993 to 2013[34]



Building Energy Codes

State and municipality level institutions impose a variety of building codes at times of major and sometimes minor construction events such as new construction and renovations. As mentioned above, the energy components of these codes may be combinations of ASHRAE, IECC and 'stretch code' based requirements. Advancements in codes as well as standards both impact utility market transformation programs to raise the baseline of standard practice, thus forcing programs to seek higher levels of performance from technology and practice options.

[33] Southwest Energy Efficiency Project. Quaid, M. and Geller, H. *Upstream Utility Incentive Programs: Experience and Lessons Learned*. 2014. http://swenergy.org/publications/documents/Upstream_Utility_Incentive_Programs_05-2014.pdf

[34] Southwest Energy Efficiency Project. Quaid, M. and Geller, H. *Upstream Utility Incentive Programs: Experience and Lessons Learned*. 2014. http://swenergy.org/publications/documents/Upstream_Utility_Incentive_Programs_05-2014.pdf

Market Barriers to the Adoption of High Performance RTUs

While a number of the barriers presented pertain to RTUs as a category, several challenges are unique to and become more acute for High Performance RTUs. The decision for building owners is made at two distinct events and by a variety of market players. The events which trigger purchase options of RTUs are *new construction/major renovation* of a building or the *replacement* of failed existing units. The decision makers can be any combination of market players ultimately responsible for the building. In a perfect world the responsible party would choose a High Performance RTU over a standard RTU because the incremental cost of an efficient unit is less than the lifetime savings from operation. However there are a variety of barriers to making this selection, both financial and business cultural. In addition to the comments received in interviews with key market actors, NEEP convened stakeholders in a June, 2015 workshop in which commercial HVAC barriers and solutions were prioritized to determine new and progressive tactics to overcome them. By collaboratively ranking various barriers that impede the Commercial HVAC market, the following key barriers emerged.

Financial Barriers

Financial barriers are typically the most apparent barriers facing High Performance RTU adoption.

- The predominant and most apparent barrier is **availability or prioritization of capital** to cover the High Performance RTU's incremental cost. A business owner who has limited liquidity may not be in a position to consider extended break-even payback for a marginal up-front cost. Often when a business owner has available cash, the preference is to make profit-making business investments rather than energy saving ones.
- While costs may be a barrier, **hidden costs** may, in some cases, dwarf incremental costs for High Performance RTU adoption. In addition to the incremental cost of the unit, High Performance RTUs may require added architectural costs. For example, the roof structure may need to be strengthened to accommodate the unit's added weight. In the case of replacement, the geometry of the new unit may not perfectly match the existing one, so structural modifications or curb adaptors would add costs not needed in an exact model replacement.
- Compounded by occasionally weak business cases for High Performance RTUs, the customers' willingness to take on debt is low. In order to preserve the business' ongoing credit availability, borrowing for an incremental added cost can be a barrier. A business owner may be naturally averse to borrowing any more than absolutely necessary. The **perceived lack of value** for High Performance RTUs coupled with the higher price of the units leaves many savings unclaimed.

Business and Cultural Barriers

Contrasted with the financial barriers are the culture barriers facing High Performance RTU adoption, which includes Education, Availability, and Authority. These barriers may be linked to financial pressures; but they may also be driven by uncertainties and perceptions of risk.

- **Limited education and knowledge for both contractors and customers** can hamper sales of High Performance RTUs in the region. Contractor education and perceived risks of new technology are frequent considerations which drives decision makers to the same existing and inefficient model rather than upgrading to a new and more efficient option.

- **Availability of efficient options**, especially in the case of failed unit replacement, can be a major barrier in the industry. This is especially critical in high-load periods such as mid-summer. Just as important to resolve, is the assurance needed from distributors that the stocked efficient units will make a positive impact for their business.
- **Decision-making authority in owner-tenant relationships** can have an important effect on product selection. The 'Split Incentive', when the person making the selection and paying the capital cost (building owner) is different from the person paying the operating costs and reaping the savings (tenant of leased space) can inhibit selection of a High Performance RTU over standard RTU. Even in cases where the building owner is responsible for both capital costs and operating costs, the owner may be indifferent to power bill savings since this may be dwarfed by rent payments from tenants.

Ultimately these business culture barriers to adopting a High Performance RTU over the standard options need to be addressed in conjunction with the financial barriers to develop robust strategies going forward.

Market Opportunities to Leverage

Marketplaces are constantly evolving, and there are often related market opportunities to leverage in order to drive adoption of High Performance equipment. These opportunities might include new technological advances, evolving business models, development of new value streams, etc. We present these potential opportunities for the Commercial HVAC market. Specific strategies that seek to leverage some of these opportunities are presented in the regional strategies section.

Equipment as a Service (EaaS): EaaS takes long term service agreements and goes a step beyond. A service provider, instead of selling the equipment and servicing the equipment over its life, instead owns the equipment and offers the utility of the equipment to a customer over an agreed length of time. Instead of making a large investment in equipment, a consumer pays the vendor a fee for delivering a certain service on an ongoing basis. This provides a potentially new model for the delivery and service of commercial HVAC systems.

Solar Power Purchase Agreements (SPPA): A Solar Power Purchase Agreement (SPPA) is a financial arrangement in which a third-party developer owns, operates, and maintains a photovoltaic (PV) system, and a host customer agrees to site the system on its roof or elsewhere on its property and purchases the system's electric output from the solar services provider for a predetermined period. This financial arrangement allows the host customer to receive stable, and sometimes lower cost electricity, while the solar services provider or another party acquires valuable financial benefits such as tax credits and income generated from the sale of electricity to the host customer. [35] In a similar way, this model could provide insights in the development of new business models for High Performance RTUs.

Demand Response (DR): Many utilities and some energy efficiency programs currently run programs that incentivize residential and commercial customers for "on-call" peak load reduction. At instances of high demand, utilities offer financial rewards to those who can sizably reduce their use of electricity. Commercial HVAC systems are an underutilized target of DR since they have high coincidence factors. New control capabilities provide opportunities for High Performance RTUs to more broadly participate in DR programs.

Forward Capacity Market (FCM): The Forward Capacity Market (FCM) is a long-term wholesale electricity market that assures resource adequacy, locally and system wide. The market is designed to promote economic investment in supply and demand resources where they are needed most. Capacity resources may be new or existing resources, and include supply from power plants, import capacity, or demand resources. (Demand resources reduce electricity consumption.) Forward Capacity Auctions, are held annually, three years in advance of the operating period. Resources compete in the auctions to obtain a commitment to supply capacity in exchange for a market-priced capacity payment. These payments help support the development of new resources and maintain existing resources. [36]. High Performance RTUs provide significant demand reductions which could theoretically be bid into the FCM.

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[35] U.S. Environmental Protection Agency. Green Power Partnership webpage. Solar Power Purchase Agreements http://www.epa.gov/greenpower/buygp/solarpower.htm.

[36] ISO New England website. Forward Capacity Market. http://www.iso-ne.com/markets-operations/markets/forward-capacity-market

Refrigerant Phase-out: The manufacture and sale of new refrigerant R-22 will be phased-out of the market in 2020.[37] Chemical manufacturers can continue production and import of R-22 until 2020 for use in servicing existing equipment. After 2020, the servicing of R-22-based systems will rely solely on recycled or reclaimed refrigerants. R-22 is used in 90% of 2012's commercial units.[38] and since R-410A is unable to be used as a drop-in replacement, the upcoming refrigerant phase-out is certain to make an impact on many HVAC equipment repair/replace decisions.

Emerging Financing Mechanisms:

Prioritization of capital is a barrier to the adoption of High Performance RTUs. Several new financing mechanisms could serve as new solutions.

- **Revolving Loan Funds**: A capital pool is loaned for energy-saving projects that pay back the loans in a way that allows for repaid funds to be recycled in perpetuity. Currently, the U.S. DOE runs the PowerSaver loans, which are backed by the Federal Housing Administration (FHA) and offer up to $25,000 to homeowners for energy efficiency improvements. State and local governments may consider promoting similar incentives or working in conjunction with the U.S. DOE.
- **Lease or Loan through Utility Program**: Also known as "Green Lease", programs have demonstrated lease or loans for qualifying high efficient equipment, mainly in the residential market and for HVAC as well as lighting systems. These programs tend to include on-bill repayment which simplifies participation for end users. Interview respondents indicated that this might be useful for the smallest commercial customers, but a non-starter for most medium and larger ones. In prior experiences, medium and large commercial customers have readily-accessible capital and therefor do not require assistance from lease or loan programs.
- **Commercial Property Asset Clean Energy (CPACE):** This is a strategy wherein the capital cost of the energy efficiency equipment is covered by from the municipality or state, and an associated value goes into the affected property assessed value. Thus the payment is made through property taxes. This government-run program spreads payments over a long term, and the assessment stays with the property in the event of ownership transfer.
- **Energy Efficiency Credits**: Also known as "white certificates." These mechanisms are similar to renewable energy credits (RECS) in that they are tradable permits that can be used to meet energy efficiency resource standards (EERS).[39]. These financial markets may allow tradable credits or certificates, often aimed at valuing the multiple social goods of energy efficiency. This provides a financial incentive to invest in energy saving projects and are analogous to the concept of emissions trading. Energy Efficiency Credits are issued by an authorized body to set the overall target and to guarantee that energy savings has been achieved.

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[37] U.S. Environmental Protection Agency. Ozone Layer Protection - Regulatory Program website. What You Should Know about Refrigerants When Purchasing or Repairing a Residential A/C System or Heat Pump. http://www.epa.gov/ozone/title6/phaseout/22phaseout.html

[38]Cooper Oates Air Conditioning Risk Awareness: Critical Industry Update. *Plan Now For R-22 Refrigerant Phase-Out*. 2013. http://www.coacair.com/files/COAC__R22_Critical_Industry_Information_32013.pdf

[39] American Council for an Energy-Efficient Economy. Hayes, S., and Mackres, E. *Sustainably Funding Local Energy Efficiency Initiatives*. 2012. http://aceee.org/files/proceedings/2012/data/papers/0193-000265.pdf

- **Loan Loss Reserves**: These credit enhancement mechanisms make energy efficiency projects more attractive to lenders by offering partial risk coverage. Ultimately, a credit enhancement improves the chances that the financing (regardless of the mechanism) will be repaid. This approach is commonly used by state and local governments to cover a percentage of a lender's potential losses.

Product Specifications: Across the Northeast and Mid-Atlantic region, programs have historically leveraged the CEE Tiers for Commercial HVAC. Incentive programs, which are reliant on efficiency requirements, have the opportunity to align the High Performance RTU or DOE RTU Challenge specification with their programs in order to accelerate cost-effective savings above minimum requirements.

Regional Strategy to Achieve Market Transformation

Long term Market Transformation Goal

NEEP estimates that much less than one percent of the installed base of RTUs in the region meet the High Performance RTU specification. To accelerate market transformation toward High Performance RTUs in the Northeast and Mid-Atlantic, **NEEP recommends a long term regional strategy with the goal to have 33 percent of the region's installed RTUs be High Performance systems**[40] **by 2025**. Based on current sales and replacement trends this transformation would significantly change the face of the installed base in the region. Using the "Baseline Efficiency" to "Efficiency Level 5" or "Max Tech"[41] established in DOE's Direct Final Rule, by 2025 the market would have transformed to over 330,000 High Performance RTUs that would deliver over 890 GWh energy savings annually, a demand reduction of over 1,168 MW, and an equivalent 504,243 Tons of carbon emissions reduction.

Northeast and Mid-Atlantic Regional RTU Goal:

Move penetration of High Performance Units in the installed RTU base from the current penetration of less than 1% to 33% by 2025

Theory of Change

The findings from the Market Assessment of Commercial RTUs in the Northeast Region provided NEEP and regional stakeholders a foundation from which a series of market interventions were developed that are designed to either overcome existing market barriers or leverage emerging market opportunities to accelerate the adoption of High Performance RTUs and effectively transform the long term market in the Northeast/Mid-Atlantic Region.

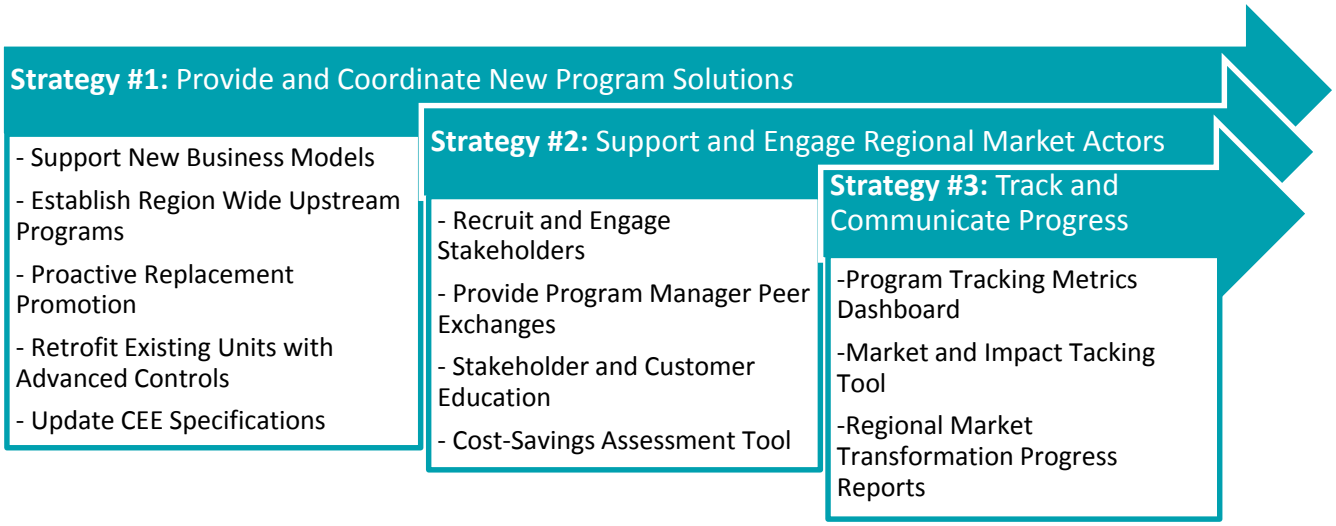
NEEP recommends a three-part integrated strategy to achieve this and includes:

1. *Provide and Coordinate New Program Solutions*
2. *Support and Engage Regional Market Actors*
3. *Track and Communicate Market Progress*

[40] High Performance RTU reflects Max-Tech specifications with the exception of the ≥135K AND <240K Btu/hr bin, in which DOE ARTU Challenge is used, and the <65K Btu/h bin, the Max-Tech specification from the Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: ASHRAE Equipment Final Rule

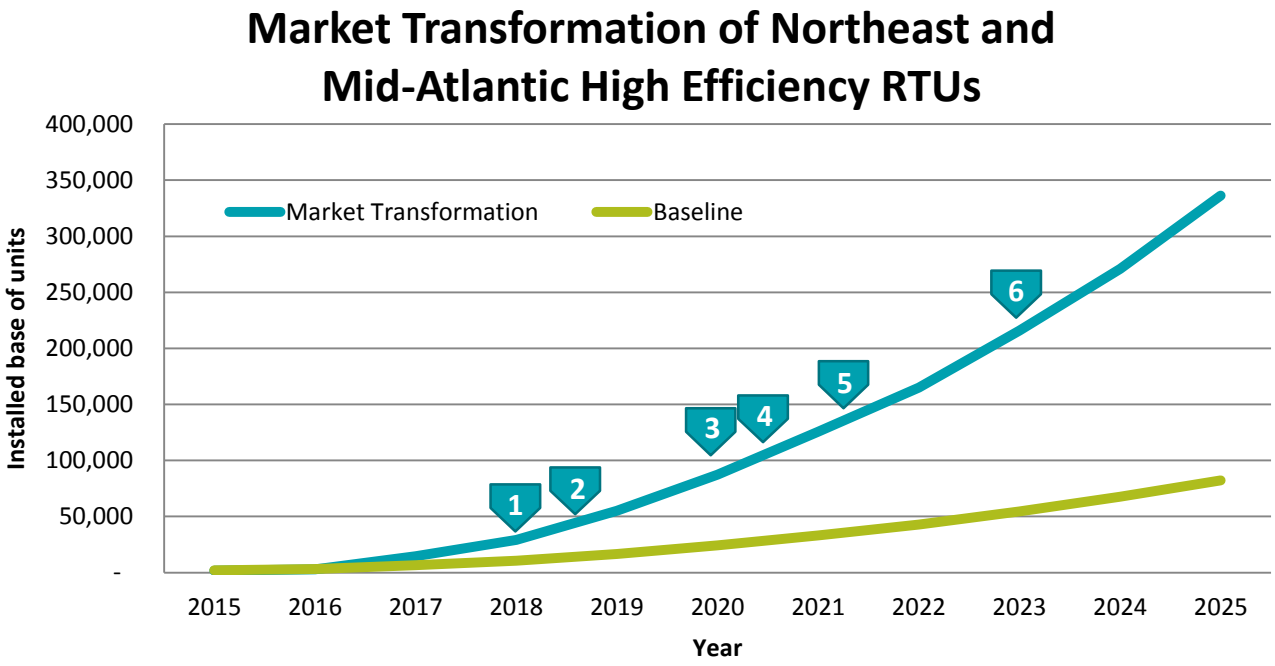
[41] U.S. Department of Energy: Energy Efficiency and Renewable Energy Office. Direct Final Rule Technical Support Document: Small, Large, and Very Large Commercial Package Air Conditioning and Heating Equipment. Dec, 2015. https://www.regulations.gov/#!documentDetail;D=EERE-2013-BT-STD-0007-0105

Figure 6: Regional Commercial ARTU Market Transformation Strategy Elements



Through this process of strategy development, a vision or roadmap emerged for how these separate strategy elements could work together in such a way that allows the region to reach this ambitious goal. How do we impact nearly 330,000 units in the next 9 years? Figure 7 represents the pathway graphically.

Figure 7: Market Transformation of Northeast and Mid-Atlantic High Performance RTUs.[42]



[42] See Appendix A for detailed assumptions related to baseline and market intervention projections.

From the strategy elements developed, a few core market transformation drivers are highlighted in Figure 7 and include:

- **Inflection Point 1 (2018): New business models drive higher penetrations of High Performance RTUs:** Coordinated regional upstream HVAC program incentives combined with new business models (e.g., an Equipment as a Service "EaaS" model), can accelerate market adoption of High Performance RTU equipment in new sales and proactive equipment replacement markets by overcoming key market barriers that keep building owners from investing in new high performing equipment (e.g., upfront capital costs and performance uncertainty). While EaaS service offerings may take time to develop, once established and scaled, they could revolutionize the way space conditioning is delivered to commercial customers. In the near-term, a regional upstream program offering can contribute to improved education and training for distributors and increased sales of efficient units.
- **Inflection Point 2 (2018-2019): Region leverages refrigerant change-out to drive proactive replacement:** The Proactive Replacement market begins to pick up in advance of a 2020 refrigerant phase out. Although some of this increase will naturally occur, driven by the increased cost of R-22 refrigerant, a focused regional effort to leverage this phase out could drive significant proactive replacement activity. The region can coordinate a marketing campaign emphasizing the wisdom of "planning ahead for the future."
- **Inflection Point 3 (2020): New commercial HVAC business models mature, further accelerating the adoption of High Performance RTUs:** Following the planning and piloting of the upstream programs and EasS models in 2016-2017, full scale implementation could result in a further boost of High Performance units in 2020.
- **Inflection Point 4 (2020): EPA R-22 Phase-Out Begins:** EPA regulations banning the manufacture and sale of R-22 refrigerant take effect, accelerating proactive replacement of Commercial HVAC systems. The region can continue to leverage this important market event by stepping-up proactive replacement promotions.
- **Inflection Point 5 (2020-2023): Business model matures leading to reduced need for program support**: In the process of maturing, EaaS service providers offering new delivery models rely less and less on efficiency program support, eventually operating fully independently.
- I**nflection Point 6 (2023): Update to Federal Minimum Efficiency Appliance Standards:** The new federal minimum standard would increase viability of high performance RTUs starting in 2023, thus ramping up the market transformation.

The development of new solutions stands at the center of the strategy for transforming the Commercial HVAC market with High Performance RTUs.

Regional Market Strategies

Strategy Element #1: Provide and Coordinate New Program Solutions

Support New Business Models

Equipment as a Service (EaaS) business model has roots in other industries in heavy equipment. This strategy involves bringing a variety of existing and new market actors together, including current HVAC sales and service companies, energy service companies, energy efficiency program administrators, demand response market actors, etc. to develop turnkey solutions for the region's commercial HVAC customers. In this new business model, an energy service entity purchases, installs and maintains the High Performance RTU, and the customer pays a regular service or subscription fee for the service it is providing. In this case, conditioned air is the service that is being provided.

The time is ripe for the concept of EaaS to take hold. People have become accustomed to subscription services in the internet age. This may be useful in the RTU market for some classes of commercial customers as it offers a new opportunity to bundle a number of emerging value streams. This strategy has the potential for incorporating the value of demand reduction into the program. When a third party is responsible for managing 100's or 1000's of large HVAC units, the incentive for responding to a demand response event is more pronounced. While existing contractors may have little experience bidding these types of resources into the FCM, efficiency programs could partner with these market actors to assist in this process. Further, with High Performance RTUs' advanced controls, collectively bidding them into the forward capacity market can become a reality. ESCOs would compete in auctions to obtain commitments to supply the difference in capacity in exchange for the market-priced payment.

This model encourages vendors to improve start-up and commissioning, perform regular preventive maintenance, and also demands that vendors are aware of materials and parts that are not performing to expectations and are at risk for failure, so they can be replaced or repaired. That, in turn, requires timely, accurate data from and about the critical equipment assets. Connected sensors within High Performance RTU can gather and transmit detailed data that tell the service provider about the performance, material conditions, operational details, and location of the equipment, enabling proactive maintenance. If EaaS is implemented with the proper business intelligence, well-maintained equipment may be productive much longer and failures would be rare. EaaS providers will also be able to gather data from customer sites that help them improve their designs to ensure that RTUs were robust and up to expectation.

Ultimately, while there is the opportunity for detailed data and automated unit performance, leveraging this information to share with program evaluators is a potential barrier. In related programs vendors have been hesitant to share what they consider proprietary data. Integrating the needs of vendors, evaluators, regulators, and program administrators from the onset could accelerate the implementation of this new business model.

A vast collection of networked High Performance RTUs under the "supervision" of responsible ESCOs could also lead to more comprehensive/integrated building management across a number of key building systems. With experience gained through the management of High Performance RTUs , other systems such as connected lighting can be rolled into such a management agreement, bringing new levels of building to grid communication and response.

Establish Region Wide Upstream Program

Many programs in the region have implemented upstream incentive structures. Program experience in residential & commercial lighting products has shown that issuing incentive dollars directly to the manufacturer or retailer has a tendency to ease the paperwork and the decision burden on the end user, while greatly reducing the overall number of transactions for the utility. In these upstream programs utilities incentivize a product by working with the manufacturer, retailer, or supplier, rather than offering a rebate to the end-use consumer. These programs go beyond just the rebates to include intense relationship-building between utilities and industry stakeholders.

Yet we can do better together rather than in isolated territories. A combination of warehousing and equipment distribution locations and practices make the upstream program model ideal for regional cooperation. The major HVAC manufacturers serving the Northeast tend to have warehouses located in a single state or even beyond any utilities' designated territory boundaries. Also, the cost and complications of inventory management are relieved by reduced variety of requirements and numbers of transactions. During our interviews we heard accounts concerning upstream programs in which the value is not evident to certain market actors. There is variability in the region in the various delivery channels and the culture of distribution/supply companies has to be taken into account when structuring a regional upstream program. A single coordinated, yet flexible, effort throughout the region will have economies of scale that several individual program efforts cannot achieve. Also, upstream incentives that are based on performance, are in general, lower that downstream rebate incentives because upstream offsets manufacturer or regional distributor costs, not retail costs.

The concept of region-wide program cooperation can work. In the early 2000s the utilities in the Northeast joined forces for the Cool Choice commercial HVAC program, coordinated by NEEP. This was modified downstream (customer rebate) promotion, proving that the utilities can work together. A new region-wide upstream approach would take this experience to an even more effective result by joining forces with industry to substantially streamline the promotion, making it cheaper and more impactful.

Proactive Replacement Promotion

Convincing customers to abandon in-service RTUs in favor of High Performance RTU replacements has been challenging. This is an expensive action since the whole project cost is 'incremental' (as opposed to a new purchase where the increment is the difference between standard and premium choices). On the up-side, though since this is a planned rather than emergency change-out product availability is not a barrier so there is time to make the informed choice.

The region has a great opportunity to drive proactive replacement by effectively leveraging the upcoming refrigerant phase-out in 2020. While the phase-out will not take full effect until 2020, the market is beginning to feel its effect today. Fewer and fewer refrigerant producers are manufacturing R-22 which is leading escalating prices. Regional stakeholders, including efficiency programs, should take advantage of this reality through its marketing and contractor sales training. Potential campaigns such as, "Prepare for the future" and "Replace your unit today with a High Performance RTU" could help the transition. One contractor is messaging "If the building has an R-22 system that is more than 10 years old, then start planning for the safe, systematic process

of replacement[43]". Messaging and educating contractors to accelerate the early retirement of old units will be central component of the Northeast and Mid-Atlantic Strategy.

Given the large amount of savings to be gained from addressing a small percentage of units, early retirement poses real potential despite its challenges. Programs who implement early retirement programs, despite small penetration rates, could realize large savings.

Retrofit Existing Units with Advanced Controls

Recognizing that, for some customers, there might be significant resistance to replacing functioning RTUs, there are positive opportunities for energy and demand savings through upgrade retrofits of existing units. This generally involves measures such as maintenance or basic and advanced controls.

Simple measures, which amount to maintenance costs of the general equipment, help improve the functionality and efficiency of the units over their lifetime. This may include checking and maintaining refrigerant charge levels and cleaning heat-exchanger coils. U.S. DOE estimates that annualized maintenance cost ranges from $298 - $408 per unit[44]. The maintenance required to upkeep these units will result in contractor training and materials required. Although, more holistically, the building's efficiency is a contributing factor to the lifetime and effectiveness of an existing unit.

Adding basic controls to gain energy savings from fan and compressor motor operation, or advanced controls can generate further savings from energy and demand reduction. The biggest savers are variable speed fan controls. However there are a variety of other measures available: ECM motors (electrically commutated motors), advanced controls which go beyond variable speed motor control to thermostat telemetry, fault detection and diagnosis (FDD) network communication for switching and monitoring, etc. Most utility programs now offer rebates for economizer controls and demand controls for ventilation. However a coordinated effort focused on advanced controls would benefit from a regional effort through additional demand response capability. Again in this case, further research and development would be warranted to develop simplified packages of control retrofits.

Update CEE Specifications

Given CEE's prominence in the Northeast and Mid-Atlantic region's efficiency programs, attention should be given to the establishment of updated tier levels. Aligning DOE's RTU Challenge specification with the highest CEE tier would spur additional promotion of High performance units among the programs in the region. The efficiency programs' history of using CEE's Tiers for the varying unit sizes would dovetail with the DOE RTU Challenge specification; thus leaving the remaining size bins for individualized specification setting. Regional programs should provide input to the CEE update process that seeks integration of the DOE RTU Challenge and levels set in DOE's Direct and Final Rule, leveraging the market development work that DOE has spurred.

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[43] Cooper Oates Air Conditioning Risk Awareness: Critical Industry Update. *Plan Now For R-22 Refrigerant Phase-Out*. 2013. http://www.coacair.com/files/COAC__R22_Critical_Industry_Information_32013.pdf

[44] U.S. Department of Energy. Notice of proposed rulemaking (NOPR) and public meeting. 2014 http://energy.gov/sites/prod/files/2014/09/f18/2014-09-18%20Issuance%20cauc_noticeofproposedrulemaking.pdf

Strategy Element #2: Support and Engage Regional Market Actors

Recruit and Engage Stakeholders

A primary element of the regional strategy is to transfer learning from across the region where utilities, states, equipment distributors and financing companies have already overcome financial and cultural barriers. Available solutions and related expertise should be made available through a combination of networking opportunities, educational resources, peer exchanges and other relevant resources available nationally (e.g., through US DOE efforts).

As was evident from NEEP's June Workshop in 2015 there is a clear demand for industry representatives to have regular opportunities for stakeholder exchange. The regional program models discussed above require cooperation among utilities and industry players. It's not enough to have a brilliant and elegant program design; for it to really work one requires input from all participants. Relationships developed in conjunction with program design and operation can make allies out of disparate communities. This contributes a great deal in achieving the 33 percent efficiency goal. This concept leads to opportunities in joint regional curriculum and training, workshops and shared outreach.

Provide Program Manager Peer Exchanges

Among the Commercial HVAC programs, there are many powerful and effective experiences in the Northeast. While there is a variety of implementation techniques and solutions to solving barriers, periodic peer exchanges among program managers have proven to develop better overall solutions. Sharing best practices and lessons learned can even help the best performing programs. The Northeast is ripe for such a peer exchange of programs, with NEEP as an available and expert facilitator.

Stakeholder and Customer Education

Incorporating educational opportunities may include trainings and curriculums for a variety of stakeholders and customers. Training would cover three important concepts: *Upselling efficiency, the importance and use of efficiency programs, and contracting with customers for equipment and services*. A solid curriculum will help ensure that distributors and customers all relay and understand how efficiency programs can help. Training can help improve the understanding of new High Performance RTUs' potential impacts, as well as equipment and control strategies for customers. While it may be difficult to get many regional stakeholders on the same page, trainings can be very useful at distributor & contractor level on how to make the value proposition for efficiency technology.

To improve the awareness of and expertise surrounding High Performance RTUs, different consumers must be segmented for marketing and messaging. Educating channel partners on the value of upgrading & investing in a targeted marketing for specific channel partner or end customer. For example, at the contractor & distributor level, they need to know more about the product, specific commissioning and operations/maintenance requirements, and the need to be able to make the case for high performance. Additionally, there may be value in targeted geographic segmentation given the difference in programs and offerings.

Cost-Savings Assessment Tool:

In a world of changing energy codes and standards and rapid developments in equipment features and efficiency, old standards become obsolete quickly. Program managers from across the region have asked for a

tool to indicate costs and benefits of High Performance RTU efficiency measures. Such a tool would be useful for program and project development and it would be useful in regulatory advocacy. Leveraging the DOE's Rooftop Unit Comparison Calculator would lend itself to regional coordination as it would be redundant to develop separate tools for each individual state or program. The Calculator evaluates the energy and cost savings of simulated replacement units.

Strategy Element #3: Track and Communicate Market Progress

Tracking and presenting results associated with market effects and related success indicators of the regional strategy are a key component of a market transformation approach. Stakeholders will need to understand what impacts our activities are making to adjust strategies and tactics. NEEP envisions two main resources, an energy efficiency program tracking dashboard, and a higher level regional market tracker. Cumulatively they will help to ensure the acceleration and tracking of market transformation toward efficient commercial HVAC systems in the Northeast and Mid-Atlantic.

Program Tracking Metrics Dashboard:

A live, on-line dashboard of programs' progress metrics would help accelerate activity and program improvements among participating utilities and states in the region. Useful metrics might include

- Number of regional programs that engage efforts to develop new program solutions such:
    - New Business Model
    - Regionally Coordinated Upstream Program
    - Proactive Replacement Promotion
    - Retrofit Existing Units
- Number of High Performance RTUs Promoted through the Region's Energy Efficiency Programs
    - Sizes of Units
    - Shipment Destination
    - Incentive Dollars Advanced to Upstream Partners
    - Numbers of Equipment Distributors Participating
- Participation of Stakeholders in the Regional Working Group and Workshop Peer Exchanges.

Regional programs would have to agree to submit detailed program results to help build a regional program dashboard.

Market and Impact Tracking Tool:

Given the analysis and feedback produced from this Market Assessment, a high level of potential savings is achievable in the near and long term. A Market-level Impact Tool would work in conjunction or separately from the program dashboard mentioned above. While might be as simple as a thermometer showing kWh or carbon savings through the program year due to market transformation of highly efficient units With substantive data, and incorporating the lessons learned from active regional stakeholders and their programs, this tool has the potential to tell stories, from the successes of past efforts to opportunities for future developments.

- Increasing market penetration of High Performance RTUs towards the 33 percent goal by 2025
- Number of market actors offering new business models to deliver High Performance RTU equipment to the market

- Estimated energy and peak demand reduction savings
- Estimated carbon emission reductions
- Estimated economic benefits

While the RTU Efficiency Tracker and Inventory Spreadsheet, which were developed by the DOE as tools for efficiency programs, State-level and comprehensive market data that indicates market penetration of new High Performance RTU sales and/or of the installed base is not publically available. It is this crucial information that is necessary to understanding market progress and status. Regional stakeholders should leverage these tools to gather basic information and simultaneously seek to obtain market-level information through a variety of pathways:

- Collect sales and shipment data from RTU manufacturers and HVAC trade association (i.e. AHRI). Data that can be shared publically may come at a cost. This data can also be part of a promotional agreement between programs and manufacturers and distributors.
- Conduct regional market assessments to gauge evolving market penetration of both new sales and/or installed base (via surveys of regional distributors).

These Market-level impact tools could be disseminated to media outlets as well as provided to policymakers and other stakeholders to support achievement of the 2025 and long-term market transformation goals. Given NEEP's experience as a regional program data collector and aggregator, NEEP could assist in processing and tracking the region's progress towards 33 percent installed base goal.

Regional Market Transformation Progress Reports:

Using the information from the two tasks above coupled with information gathered by through an independent regional program process review, provide an updated look at the progress towards the long-term market transformation goal with a summary of accomplishments and lessons learned with recommended areas for potential change to achieve the long-term market transformation goal and maximize energy, cost and carbon reduction benefits.

Conclusion

Developing a theoretical regional market transformation strategy is an important first step in arming regional stakeholders with strategies to achieve a common goal. Effective implementation of these strategies is far more complicated and will require focused efforts over the course of several years. NEEP is poised to pivot from strategy development to strategy implementation. With stakeholder support, NEEP is prepared to lead a regional market transformation initiative in 2016 and beyond to facilitate such a regional market transformation effort with diverse stakeholders. Such a campaign should leverage the collective market levers of a regional working group to facilitate knowledge transfers, identify best practices, and scale up through combined efforts until regional rooftop units have reached a transformation tipping point of approximately 33 percent installed High Performance RTUs.

The strategies presented, while effective individually, are most successfully implemented regionally to actively engage HVAC industry participation and to encourage new EaaS business models. In addition, a regional approach can leverage the collective experiences of a regional working group to facilitate knowledge transfers, identify best practices, share the cost and risk of new approaches, and scale-up through combined efforts to achieve a market transformation tipping point by 2025. NEEP has the potential to facilitate a regional initiative with diverse stakeholders in 2016 and onwards to shape and implement the above-recommended strategies.

Working cooperatively with regional stakeholders, a NEEP lead process promises to deliver more results & savings, in an accelerated timeframe, and at a cheaper cost than individual implementation.

- **Greater savings**- New program solutions described in the report will provide new avenues for program savings.
- **Accelerated timeframe**- Market adoption of new program/business models will be accelerated if a broad range of stakeholders are committed to their implementation.
- **Reduced Program Cost and Risk**- The necessary resources to engage new market actors to design and implement new business practices are likely to be very high from a singular stakeholder's perspective. Those same resources spread across a regional group with active peer exchange can deliver greatly reduced individual costs while sharing the risk and learning of trying something new.

We invite regional efficiency programs, the HVAC industry and other market interests to work together with NEEP and your fellow regional RTU market actors to transform the High Performance RTU market in the Northeast/Mid-Atlantic region.

Appendix A

The tables below provide the assumptions that went into the development of the baseline and market intervention market projections. Both the Baseline and Market Transformation curves have an initial set point of 3,095 installed High Performance RTUs in the market in 2015.

Baseline Projection for High Performance RTUs from 2015-2023

# of Units Sold	2015 RTUs	2016 RTUs	2017 RTUs	2018 RTUs	2019 RTUs	2020 RTUs	2021 RTUs	2022 RTUs	2023 RTUs	2024 RTUs	2025 RTUs	Total
New Equipment Purchased	333	1,111	1,667	2,222	2,778	3,333	3,889	4,444	5,000	5,555	6,111	36,663
New Equipment percentage of new sales	.6%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	
Proactive Replacement	-	-	1,697	1,697	3,394	4,243	5,092	5,092	6,789	7,638	8,486	44,128
Proactive Replacement installed base	0%	0%	0.16%	0.16%	0.33%	0.42%	0.5%	0.5%	0.66%	0.75%	0.83%	
Grand Total												**80,791**

Market Transformation Projection for High Performance RTUs from 2015-2023

Number of Units Sold	2015 RTUs	2016 RTUs	2017 RTUs	2018 RTUs	2019 RTUs	2020 RTUs	2021 RTUs	2022 RTUs	2023 RTUs	2024 RTUs	2025 RTUs	Total Units
New Equipment Purchased	333	1,111	1,666	4,444	5,555	6,666	7,777	8,888	9,999	11,943	14,443	72,825
New Equipment penetration rate	.6%	2%	3%	8%	10%	12%	14%	16%	18%	21.5%	26%	
Proactive Replacement	-	-	5,092	5,092	10,183	12,729	15,275	15,275	20,367	22,913	25,459	132,384
Proactive Replacement installed base	0%	0%	0.5%	0.5%	1%	1.25%	1.5%	1.5%	2%	2.25%	2%	
Retrofit	-	-	5,092	5,092	10,183	12,729	15,275	15,275	20,367	20,367	25,459	129,838
Retrofit installed base	0%	0%	0.5%	0.5%	1%	1.25%	1.5%	1.5%	2%	2%	2.5%	
Grand Total												**335,049**