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Efficient Rooftop Unit Tiers Market Research

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Efficient RTU Tiers Market Research

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Executive Summary

Introduction

The Northwest Energy Efficiency Alliance's (NEEA's) Efficient Rooftop Unit (Efficient RTU) program aims to increase the efficiency of rooftop units, starting with gas heated RTUs, and increase their adoption on existing commercial buildings. As of 2020, NEEA's Efficient RTU product specification includes two tiers or types of RTUs:

TIER 1 The unit has at least 80% Thermal Efficiency (TE) and additional energy efficiency gains via insulation and reduced damper leakage.

TIER 2 The unit includes everything in Tier 1, and either heating via a condensing gas furnace with 90% or greater TE or the unit includes heat- or energy-recovery ventilation.

Currently, only a small number of manufacturers build RTUs that meet NEEA's specification for Efficient RTUs. None of the three largest RTU manufacturers (who hold about 80% of the commercial market) make RTUs that meet NEEA's specification as a standard option. NEEA hired D+R International (D+R) to gather market feedback and information to shape program strategy and intervention creation for both tiers.

NEEA designed their research to assess the following five research objectives:

1. Get feedback on NEEA's Efficient RTU specification to ensure it aligns with industry practice.
2. Learn incremental price to customer (equipment and labor) to replace existing heating, ventilation, and air conditioning (HVAC) with Tier 1 and Tier 2 units with heat- or energy-recovery ventilation, relative to a code minimum RTU, to inform intervention design and the baseline adoption curve.
3. Identify barriers to adoption for Tier 1 and Tier 2 units with heat- or energy-recovery ventilation to inform intervention design.
4. Determine each tier's value propositions for HVAC contractors and engineers at energy service companies (ESCOs) to inform intervention design.
5. Identify drivers of new system adoption/behavior change learned from a prior RTU program (specifically the federal Department of Energy's Advanced RTU program) to inform intervention design.

Methodology

D+R conducted 11 in-depth interviews with a selection of market actors from the commercial HVAC sector including contractors, distributors, ESCOs, and program administrators with prior RTU experience (Participants). Interviews took place between November and December 2021 (See Appendices B and C for recruiting text and interview discussion guides). The table below shows the sample size by participant group and the corresponding states where interviewee offices are located.

Table 1. Participation Sample Size and Office Locations

Participant Groups	Sample Size	Participant Office Locations		
		Washington	Oregon	Idaho
Contractor	3		X	
Distributor	2		X	
ESCO	3	X	X	
Program Administrators	3	Program administrators came from prior federal RTU programs located outside NEEA's service territory.		
Total	**11**			

While participant office locations are headquartered in Oregon and Washington, many of these firms have satellite offices throughout region that cover all three states which reflect the geographic diversity of NEEA's gas utility stakeholders and provide HVAC services to all three states as shown in the table below:

Table 2: Participant Service Territory

Participant Groups	Regional Service Territory		
	Washington	Oregon	Idaho
Contractor 1	X	X	
Contractor 2	X	X	X
Contractor 3		X	
Distributor 1	X	X	
Distributor 2	X	X	X
ESCO 1	X	X	X
ESCO 2	X	X	X
ESCO 3	X	X	

D+R divided the data collection process into two categories: Interviews and Bid Collection.

Interviews

Before each interview, all participants received copies of prospective NEEA marketing materials including NEEA's qualified products list and specification requirements for Tier 1 and Tier 2 Efficient RTUs, as well as NEEA's List of Benefits of Efficient RTUs (See Appendices D to F). Participants reviewed and provided feedback during the interview process.

Bid Collection

In addition to providing feedback on NEEA's marketing materials and product specification, contractors submitted bids to replace an existing 10-ton RTU from a real but unidentified commercial building. These bids included a like-for-like standard unit along with bids for Tier 1 and/or Tier 2 units for the same building based on NEEA's qualified products list and specification documents. The goal of gathering these bids was to calculate the incremental price to customer between a standard, Tier 1, and Tier 2 RTU. In order to ensure consistency between the various bids, contractors received a List of Assumptions to help identify specific material and labor costs to exclude from their bids (See Appendix G).

Key Findings and Recommendations

NEEA had five key research objectives and each is listed below along with a key finding and several recommendations based on participant feedback.

Research Objective #1

Get feedback on NEEA's Efficient RTU specification to ensure it aligns with industry practice.

Participants generally agreed that the specifications aligned with industry practice, but rather than having a single document serve as the messaging platform for all market actors, they recommend creating a portfolio of marketing collateral to help align key messages with a broader cross-section of customer interests.

Participants noted that NEEA's specification documents could benefit from including more diverse messaging for multiple audiences who have slightly different motivations and concerns from each other.

- Offer more side-by-side comparisons between standard and efficient units.
- Expand messaging around non-efficiency benefits and features such as improved comfort, environmental impacts, and systems integration.
- Be clear and transparent about best-case scenarios and use these documents as an opportunity to educate participants that the technologies are foolproof.

The table below shows a selection of potential target audiences as identified by participants in the study and the types of messages they recommended would resonate with them.

Table 3: Target Audience and Key Messages

Target Audience	Key Messages
Tenant	Improved indoor air quality, improved comfort, better performance and reliability. Easy to understand incentive opportunities.
Building Owner	Long-term energy savings. Easy to understand incentive opportunities. Territory specific code requirements and penalties for non-compliance.
Building Manager	Streamlined O&M and improved systems integration.
Maintenance Team	Fewer moving parts, greater reliability. Self-diagnostics with remote access. Improved systems integration.

Research Objective #2

Learn incremental price to customer (equipment and labor) to replace existing HVAC with Tier 1 and Tier 2 units with heat- or energy-recovery ventilation, relative to a code minimum RTU, to inform intervention design and the baseline adoption curve.

Based on the eight bids received, the incremental price to customer to upgrade from a standard RTU to a Tier 1 or Tier 2 RTU varied widely between each of the participating contractors:

- The incremental price to customer to upgrade from a standard RTU to a Tier 1 ranged between $32,613 and $131,345.
- The incremental price to customer to upgrade from a standard RTU to a Tier 2 ranged between $45,805 and $194,980.

There are several market factors driving the variation of incremental price of both standard and Efficient RTUs. These factors include: Supply chain delays for manufacturing materials and delivery, structural and visual upgrades, workload or backlog in the market, a contractor's buying power, and relationships with suppliers.

- Work with existing trade ally networks and HVAC program implementors to promote a strategy that incorporates planned replacements for older, less efficient units.
- Create a communication platform to encourage business owners to consider several estimates from both large and small companies in order to determine the best pricing for RTU upgrades.
- Continue engaging with manufacturers to expand the development and availability of more Efficient RTUs.
- Build partnerships with ESCO-like organizations that can provide energy audits to owners of small and mid-sized buildings and advice on the benefits of upgrading to an Efficient RTU.

Research Objective #3

Identify barriers to adoption for Tier 1 and Tier 2 units with heat- or energy-recovery ventilation to inform intervention design.

Participants pointed to high first costs as the main barrier to more widespread adoption of Efficient RTUs. They also emphasized that limited product availability and lack of customer awareness are key factors in driving those high first costs.

Product availability is constrained due to the low number of manufacturers currently producing Efficient RTUs. This limits the quantity of distributors who sell them, installers who purchase them, customers who would otherwise learn about them, and makes it difficult for any of these market actors to have access to Efficient RTUs at competitive prices or even know they exist. Moreover, if customers have not been educated about the benefits of an Efficient RTU or cannot find one at a competitive price when they need to replace an existing unit, they will purchase the least expensive, in-stock option available to them.

These barriers are interrelated and identifying strategies that address product availability and customer awareness will help to bring down prices and foster an environment of improved product adoption.

- Continue building strong partnerships with manufacturers to encourage the development of more Efficient RTUs.
- Develop outreach and training campaigns to educate distributors, contractors and end-use customers about the availability and benefits of upgrading to an Efficient RTU.
- Promote packages that offer free energy audits or more general engineering and technical support to drive proactive replacements and upgrades to Efficient RTUs among property owners/managers.

Research Objective #4

Determine each tier's value propositions for HVAC contractors and ESCOs to inform intervention design.

While the greater efficiency of each tier was a part of the value proposition for participants and decision makers, it was rarely the primary value proposition mentioned by participants. Value propositions mentioned as key to the sales and decision-making process included: improved indoor environment, lower life-cycle costs, design configurability, corporate image, and in some cases, faster lead times in the current economic environment.

- Integrate value propositions identified by ESCOs and HVAC contractors into NEEA's Efficient RTU promotional documents.
- Develop tools and messages that highlight all the benefits of Tier 1 and Tier 2 RTUs.
- Document the scenarios that show the high-performance capabilities of Efficient RTUs and how it contributes to energy savings and payback.
- Demonstrate how Efficient RTUs are highly configurable and can simplify the replacement process.
- Identify businesses who align green technology with their brand image and engage them as early adopters of Efficient RTUs.

Research Objective #5

Identify drivers of new system adoption/ behavior change learned from a prior RTU program (specifically the federal Department of Energy's Advanced RTU program) to inform intervention design.

Code improvements, appropriate incentive design, training and education, and coordination among market actors were identified by RTU program administrators as key intervention strategies that lead to new system adoption.

- Build market readiness for Efficient RTUs with gradual improvements to HVAC codes.
- Promote the adoption of midstream incentives to influence improved stocking practices at the distribution level.
- Work with industry organizations like ASHRAE and BOMA to spread awareness of Efficient RTU benefits.
- Engage with regional and national organizations that support advancement of efficiency codes.
- Collaborate with local governments and businesses to form coalitions of business leaders to promote the adoption of Efficient RTUs.

Introduction

About the Northwest Energy Efficiency Alliance

The Northwest Energy Efficiency Alliance (NEEA) is an alliance of more than 140 utilities and energy efficiency organizations working on behalf of more than 13 million energy customers. NEEA is dedicated to accelerating both electric and natural gas energy efficiency, leveraging its regional partnerships to advance the adoption of energy-efficient products, services, and practices.

NEEA's Efficient RTU program aims to increase the efficiency of rooftop units, starting with gas heated RTUs, and increase their adoption on existing commercial buildings. In 2021, a major focus of NEEA's gas Efficient RTU program was to develop strategies and interventions that would encourage commercial HVAC market actors to adopt Efficient RTUs. Specifically, the program is learning how to motivate manufacturers, distributors, and manufacturer representatives to stock and sell Efficient RTUs, HVAC contractors to install them, and mechanical engineers to recommend them.

As of 2020, NEEA's Efficient RTU product specification includes two tiers or types of RTUs:

TIER 1 The unit has at least 80% Thermal Efficiency (TE) and additional energy efficiency gains via insulation and reduced damper leakage.

TIER 2 The unit includes everything in Tier 1, and either heating via a condensing gas furnace with 90% or greater TE or the unit includes heat- or energy-recovery ventilation.

Currently, only a small number of manufacturers build RTUs that meet NEEA's specification for Efficient RTUs, and only a small number of their RTU models meet the specification. None of the three largest RTU manufacturers (who hold about 80% of the commercial market) make RTUs that meet NEEA's specification as a standard option. Further complicating the market is that "RTU" isn't the only term used for commercial HVAC units installed on building roofs, and NEEA needs to ensure its Efficient RTU specification can be clearly understood by anyone in the industry.

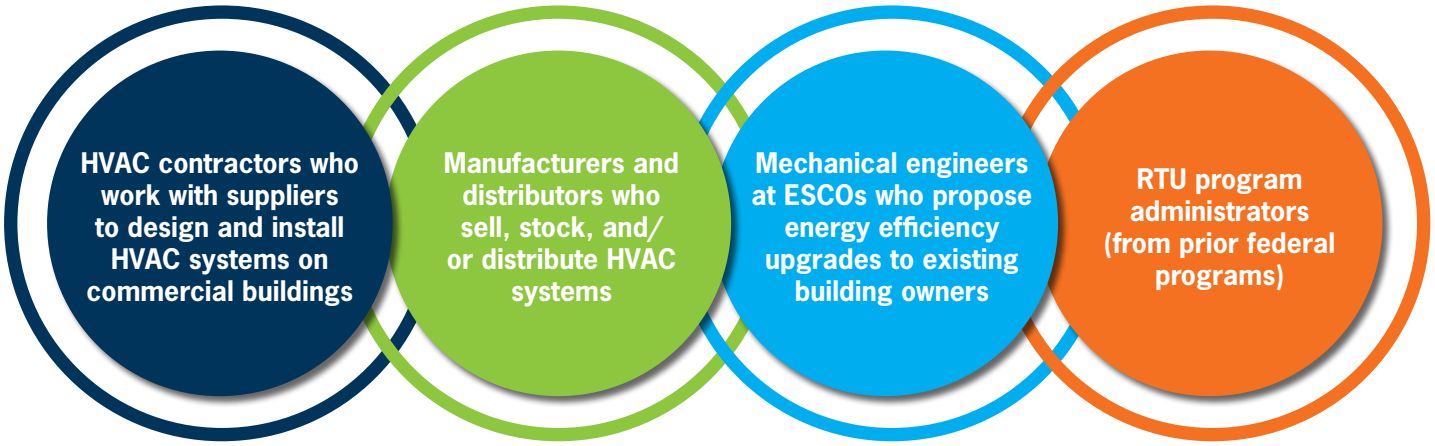
To gain a more complete picture of current market conditions for Efficient RTUs and to learn what strategies can be deployed to increase adoption for NEEA's two tiers of RTUs, NEEA hired D+R to recruit candidates to participate in this study. The study was designed to address five key research objectives. The table below shows the research objectives and the intended participants for each objective:

Table 4: Research Objectives and Targeted Audiences for Research

Research Objective	Targeted Audience
1. Get feedback on NEEA's Efficient RTU specification to ensure it aligns with industry practice.	All Participants
2. Learn incremental price to customer (equipment and labor) to replace existing HVAC with Tier 1 and Tier 2 units with heat- or energy-recovery ventilation, relative to a code minimum RTU, to inform intervention design and the baseline adoption curve.	Contractors
3. Identify barriers to adoption for Tier 1 and Tier 2 units with heat- or energy-recovery ventilation to inform intervention design.	Contractors, Distributors, Program Administrators
4. Determine each tier's value propositions for HVAC contractors and ESCOs to inform intervention design.	Contractors and ESCOs
5. Identify drivers of new system adoption/behavior change learned from a prior RTU program (specifically the federal Department of Energy's Advanced RTU program) to inform intervention design.	Contractors, Distributors, Program Administrators

Methodology

NEEA collaborated with D+R to set the sample frame and identify and approve candidates who would be recruited to take part in this study. The sample frame included:



All prospective participants included in the sample frame reflected the geographic diversity of NEEA's gas utility stakeholders, which are based in a small section of Idaho, and all of Oregon and Washington, except for RTU program administrators, which could be from anywhere in the US.

Prospective participants were further evaluated based on their familiarity with the commercial RTU market, their ability to provide feedback for the research objectives, and their willingness to participate in a one-hour interview between November and December 2021. Candidates who met those criteria were selected for participation and received a program package including NEEA's proposed marketing materials and RTU specifications. Contractors also received building specifications and guidelines for how to submit their bids.

Recruitment began by phone in October 2021 and continued through the end of the study in December 2021 (See Appendix B).

Initially, NEEA and the research team planned to include interviews and focus groups in the study design. Research participants' schedules, especially HVAC contractors, were exceptionally busy and scheduling focus groups was not possible. Final methodology for this study included a series of one-hour interviews with participants along with bid collections from participating contractors who had the option to submit bids for a standard unit and either a Tier 1 or a Tier 2 unit, or both, for a potential of three complete bids. Bids included separate cost for labor and materials of the units.

Interview guides were developed for each type of market actor selected for the study (See Appendix C).

Bids submitted by contractors were reviewed by D+R for completeness and responsiveness. If a bid failed to meet the criteria for the study (See Appendices D, E, and G) D+R provided feedback to the participating contractor and requested an updated bid. D+R received a total of eight bids from three different contractors.

In total, D+R conducted interviews with 11 participants including three contractors, two distributors, three program administrators, and three ESCOs.

Interview notes were compiled, reviewed, and sorted for common themes that answered each research question. For bid data, information was consolidated into a tabular format and anonymized, and basic information about price and incremental cost was calculated for each equipment type.

Study Limitations

This was a small research study with a small sample size including eight bids from three contractors and therefore it may not be possible to generalize the conclusions or recommendations below. While general trends and statistical significance are not possible from such a small sample, the data does provide quantitative information to combine with the qualitative data gathered during the broader interview effort, which can be used to support feedback individual interviewees provided during the interview process. Additionally, research was focused on northwest market (ID, OR, and WA) by design and data gathered may not be representative of other markets in other parts of the country.

Key Findings and Recommendations

In this section, D+R presents key findings by research objective, followed by supported detailed findings learned during our in-depth interviews with contractors, distributors, ESCOs, and program administrators.

Research Objective #1

Get feedback on NEEA's Efficient RTU specification to ensure it aligns with industry practice.

Participants were asked to review and provide feedback on NEEA's specification documents (See Appendices D and E) which include a six-page document on "System Requirements and Compliant Equipment" and a three-page flier providing detail diagrams of the different compliant equipment and its component parts.

1 The documents are fine for a technical audience, but lack information that supports the decision making process.

When asked to provide feedback on NEEA's specification documents, participants agreed that the specifications are effective in calling out some of the differences and benefits between a standard and an Efficient RTU, but also shared observations that would help clarify their messaging.

Participants noted that they view documents like NEEA's specification documents as effective sales tools to show the value that Efficient RTUs provide to individuals who they identified as playing a key role in the decision-making process; this includes building owners, property managers, and tenants. We discovered during the course of our interviews that while participants believed the documents were fine for a technical audience, they were not of much value for anyone seeking more details on economic or non-efficiency benefits.

> ***"Have different iterations of the specs and tweak them according to the ideas/opinions of the manufacturers/distributors."***
> **—PROGRAM ADMINISTRATOR**

From a sales standpoint, the message we heard from participants was that the technical details in the specification documents are ideal for an engineer or maintenance manager who understand the technical complexity of an HVAC system. However, the individual making the purchasing decisions may be looking for details on payback and incentives or improved comfort and

air quality, so having a set of documents that speak to those interests and concerns in a less technical way is fundamental to overcoming the first cost barrier which is a predominant theme throughout this research.

As one contractor noted, these are expensive products so *"The documents need to help define what their customers are getting for the money,"* and this requires details on helping customers see the economic and non-efficiency benefits of purchasing Efficient RTUs.

Participants noted that NEEA's specification documents could benefit from including more diverse messaging for multiple audiences who have slightly different motivations and concerns from each other, and be available in more interactive or online formats. We heard from all interviewees that they are using handouts and fliers less frequently and would like to see different versions of documents that focus more specifically on messages that resonate with a wider range of prospective customers and organizations interested in promoting the adoption of Efficient RTUs.

Rather than having a single document serve as the messaging platform for all market actors, a portfolio of marketing collateral could help align key messages with a broader cross-section of customer interests. The table below highlights an example of the type of messaging that could cater to multiple types of market actors for Efficient RTUs.

> ***"Having a clear message and consistent message is really important."***
> **—PROGRAM ADMINISTRATOR**

> ***"Different audiences need different messaging… architect vs engineer vs maintenance vs owners."***
> **— ESCO**

> ***"Market projects using the big picture perspective and outline innovation."***
> **— PROGRAM ADMINISTRATOR**

Table 5: Key Messages for Diverse Target Markets

Market Actor	Area of Focus	Key Messages	Quotes
Engineers Maintenance teams Contractors	Improved/stream-lined O & M	• Reliability • Performance • Controllability • Improved systems integration	*"Not just a 2-stage control with an on / off switch. They are much more interactive and connectable with other building systems." —Contractor*
Customers for whom high first costs may be a deterrent	Non-energy benefits / non-economic benefits	• Improved Air Quality • Improved Comfort • Reduced Environmental Impact • Improved Tenant Satisfaction	*"A good selling point is not just EE/ performance. It's EE/performance AND indoor comfort AND the environment." —Program Administrator* *"It's not hard to sell efficiency. But it's hard to sell efficiency if you're ONLY selling efficiency." —Contractor*
Building owners who make those purchasing decisions and tenants who frequently pay the monthly bills	Economic benefits	• Payback scenarios with estimates • Explanation of how incentives are offered (downstream/midstream/split incentives) • Codes requirements and potential penalties for non-compliance, specifically in a region like Washington where energy codes mandate adoption of more efficient technologies.	*"Economic value is the number one factor with building owners. There has to be motivation for them to participate and consider the unit." —Program Administrator* *"Non-energy benefits are starting to become part of the conversation." — Contractor*

2 Participants requested additional information on the technical details outlined in the specification documents.

All interviewees had questions about the savings claims and would like to see more details around different scenarios in which those savings targets are achieved. In particular, when promoting Efficient RTUs to a more technical audience, participants use documents like NEEA's Specification documents (See Appendices D and E) to build trust with their customers who understand and want to see those details. The following are examples of technical details that participants discussed during the course of our interviews:

- One program administrator observed, *"We need more technical data to show that customers would see a 40% reduction in any applications."*
- Mechanical engineers (ESCOs) wanted to know the weight of the replacement units listed in the documents to ensure there were no structural impacts, and pointed out that the drawings in the specification documents called out MERV 8 filters while the Efficient Manual Benefits Guide identified high efficiency filtration calling for MERV 13 efficiency rating.
- Contractors asked to have the specific dimensions of each qualified Efficient RTUs. *"Engineers would likely want to know the weight to ensure there were no structural impacts. Contractors would want to know the size and whether the new RTU will fit on an existing footprint."* — ESCO
- Program Administrators noted an absence of detail about fan control. In their experience, *"Fan control is not an advanced control. Fan control should be standard on every Efficient RTU."*

3 When asked about what distinguishes an RTU from other rooftop equipment the consensus from all participants we interviewed was that it was more a question of function than location.

There was some confusion among participants over what qualifies as an RTU. When asked if there were any types of equipment that are typically on a roof that are not commonly called an RTU one contractor noted that, *"An air handler, exhaust fan, gas packs, sit on a roof but they are not called an RTU,"* while another participant told us rather emphatically that "*If it's on the roof, it's an RTU."*

- One contractor pointed out that commercial buildings with restaurants and kitchens often have ventilation systems piped through the roof, but that does not make them RTUs. He went on to say, *"People in the industry know the difference."*
- Based on the feedback received, when HVAC experts think about RTUs they are generally referring to the whole system, not just the cooling side. According to one contractor, *"A heating and cooling unit combined into one unit means an RTU."*

Additionally, when discussing Efficient RTUs, several participants noted that a bit more explanation could be useful when describing these higher efficiency units because, in their experience, the industry has so many ways to define the term "efficiency." One ESCO in particular stated that, "*Everything that meets code is efficient.*"

One program administrator acknowledged that there was not a lot of good language around what makes an RTU an Efficient RTU or whether the term Efficient RTU accurately describes the category of equipment in the specification document. This program administrator suggested that the term "Efficient 'Gas' RTU" might be more specific when considering how to refer to the Efficient RTUs in this study.

Participants we interviewed understood that the specifications in the documents referred to Efficient RTUs because the documents called them out that way, but they also understood that using terms like Tier 1 or Tier 2 to define the level of efficiency for an Efficient RTU might be confusing for some of their customers or even trade allies throughout the industry.

One ESCO said that Tier 1 and Tier 2, *"Lack definition and his customers wouldn't understand them at all."*

There was no general agreement among the different participant groups about whether the terms Tier 1 or Tier 2 were the best way to distinguish the two levels of NEEA's Efficient RTUs in this study, and the table below presents options for alternative naming conventions suggested by three participants.

Table 6: Alternative Naming Options for Standard and Efficient RTUs

Participant Type	Standard Efficiency (Code)	Tier 1	Tier 2
ESCO	Standard	High Efficiency	Ultra High Efficiency
ESCO	Good	Better	Best
Contractor	N/A	Standard	More Efficient

Recommendations

- Create a broader set of documents that appeal to messages and needs of multiple customers and program advocates with more side-by-side comparisons between standard and Efficient RTUs to highlight the benefits and messages that appeal to specific market segments.
- Expand the messaging around program benefits to include details about economic and non-efficiency benefits such as improved controllability and reliability, systems integration, pay-back timelines, health and comfort, and environmental impacts.
- Be clear and transparent about best-case scenarios and use these documents as an opportunity to educate participants that the technologies are foolproof.

Research Objective #2

Learn incremental price to customer (equipment and labor) to replace existing HVAC with Tier 1 and Tier 2 units with heat- or energy-recovery ventilation, relative to a code minimum RTU, to inform intervention design and the baseline adoption curve.

As shown in Table 7 below, the recruitment team received submissions from three contractors for a total of eight bids including three standard RTU replacement units, three Tier 1 replacement units, and two Tier 2 replacement units. In order to ensure consistency between the several quotes, contractors received detailed building plans along with a set of general assumption to consider when preparing their bids (See Appendix G).

Each contractor was required to submit bids in the following manner:

- **Required Bid #1:** Replace the existing RTU with a similar unit (like for like replacement).
- **Required Bid #2:** Replace the existing RTU with either a Tier 1 or a Tier 2 unit based on the specifications provided in the "Efficient RTU System Requirements" (See Appendix E).
- **Optional Bid #3:** Replace the existing RTU with the other Tier that was not used in the second bid above.

The table below lists the breakdown of pricing for each bid submitted. Manufacturers have not been identified by name, but for comparison purposes, the table does show where a specific Make of RTU has been provided for one or more quotes.

Table 7: Bid Pricing

Participant / Unit Type	Make of RTU	RTU Price	Labor	Parts & Materials	Total	Permits
Participant 1 / Standard RTU	Manufacturer A	$18,125	$16,695	$4,160	$38,980	Included in materials column
Participant 2 / Standard RTU	Manufacturer A	$19,850	$20,852	$7,711	$48,413	$996
Participant 3 / Standard RTU	Manufacturer D	$15,516	$2,900	$4,753	$23,169	Included in materials column
Participant 1 / Tier 1 RTU	Manufacturer B	$140,700	$24,795	$4,830	$170,325	Included in materials column
Participant 2 / Tier 1 RTU	Manufacturer C	$42,995	$20,852	$15,640	$79,487	$2,535
Participant 3 / Tier 1 RTU	Manufacturer B	$68,221	$2,900	$4,753	$75,874	Included in materials column
Participant 1 / Tier 2 RTU	Manufacturer B	$201,460	$27,670	$4,830	$233,960	Included in materials column
Participant 2 / Tier 2 RTU	Manufacturer C	$53,260	$20,852	$18,105	$92,217	$2,997

As Table 7 illustrates, there is a range of pricing in the marketplace regardless of the RTU product efficiency:

- The standard efficiency units have a range of $25,244 between the most and least expensive unit.
- Tier 1 units have a range of $94,451 for comparably equipped units.
- Tier 2 units have a range of $141,743 for comparably equipped units.

The table below lists the incremental price to customer for upgrading from a Standard RTU to a Tier 1 or Tier 2 RTU. Incremental price to customer is based on the pricing data shown in Table 7 above.

Table 8: Incremental Price to Customer

Participant	Base RTU Price	Tier 1 Price	Incremental Price / Tier 1 Upgrade
Participant 1	$38,980	$170,325	$131,345
Participant 2	$49,409	$82,022	$32,613
Participant 3	$23,169	$75,874	$52,705
Participant	**Base RTU Price**	**Tier 2 Price**	**Incremental Price / Tier 2 Upgrade**
Participant 1	$38,980	$233,960	$194,980
Participant 2	$49,409	$95,214	$45,805

As Table 8 illustrates, the average price to customer to upgrade from a Standard RTU to a Tier 1 is $72,221, and the average price to upgrade from Standard RTU to a Tier 2 is $120,393.

There are several market factors impacting the incremental price to customer of both standard and Efficient RTUs.

Tier 1 & Tier 2 RTUs are generally custom, made-to-order products. One contractor told us that, "*Over the last 18 months product pricing has increased up to 20% due in large part to the lack of materials needed to manufacturer the equipment.*" He went on to say, *"Low availability of key materials like microchips, copper, and sheet metal have negatively impacted product manufacturing by driving up prices for products needed to manufacture RTU."*

All participants noted that the pre-COVID-19 turnaround for equipment orders was in the range of 8–12 weeks for a standard RTU, but today it is closer to 18–24 weeks with some distributors claiming as many as 30 weeks out for custom-built RTUs.

We heard from contractors and distributors that these delays are affecting property owners whose equipment is failing and they are paying service contractors a premium to keep their equipment functional while waiting for new equipment to ship. With replacement parts impacted by the supply chain issues, installers find themselves robbing parts from retired equipment to help keep old units running. Installers commented that it is actually a good time to promote the benefits of high efficiency due to lower O&M costs.

While structural upgrade estimates were largely excluded from the bids we solicited, participants stated that costs to install Efficient RTUs could increase due to structural and visual code requirements. One contractor explained that Efficient RTUs, *"Generally weigh more which can trigger structural enhancements costing $5,000 - $10,000 for upgrades."* He also went on to state, *"If the new RTU is too large and it's visible from the road, it could require screening and that's a $15,000-$20,000 potential cost."*

The two highest bids the research team received were from large firms which could be a contributing factor toward higher labor and product mark-up costs due to higher overhead expenses associated with larger firms. Because no work was actually awarded in this research project and the threat of losing the work did not exist, the quotes we received may have been less competitive than in an actual competitive bidding process. In a competitive bidding process, one contractor commented, *"Ultimately it's price and competition. If there are three to four bidders that are going for a project, you want to give them a price that will win the work. Start talking about efficiency upgrades after the bid is won."* From a property owner's standpoint, multiple bids for projects of this nature will help them manage the first cost and gives them leverage to negotiate.

In a strong economy, particularly as the heating and cooling seasons approach and contractors have a backlog of jobs needing to get completed, one ESCO pointed out that, *"Price could depend on how much work contractors have. Materials and labor amount aren't the only influencers."*

Suppliers offer pricing that is based, in part, on how much product the installer purchases from them. One ESCO stated, *"Having good relationships with [supplier] reps are important for pricing."* However, we didn't see strong evidence of this in the quotes that were submitted. Larger mechanical contractors who specialize in commercial equipment said that they have tremendous buying power due to their purchasing volume. However, there was a broad range of price points when comparing quotes; a smaller contractor's estimates fell well below their larger counterparts.

Lastly, there is little demand for Efficient RTUs. As one distributor noted, *"Owners aren't even thinking about a replacement until the old units fail and have to install whatever units suppliers have in stock which are rarely Efficient RTUs."*

Recommendations

- Create a communication platform to engage business owners and educate them about the benefits of considering several estimates from both large and small companies in order to determine the best pricing for RTU upgrades.
- Promote the establishment of a network of ESCO-like service companies to conduct audits to advise building owners of their replacement options.
- Work with existing trade ally networks and HVAC program implementors to promote a strategy that incorporates planned replacements for older, less efficient units.
- Continue outreach to manufactures and distributors to expand product availability and training support for installation contractors throughout their distribution channels.

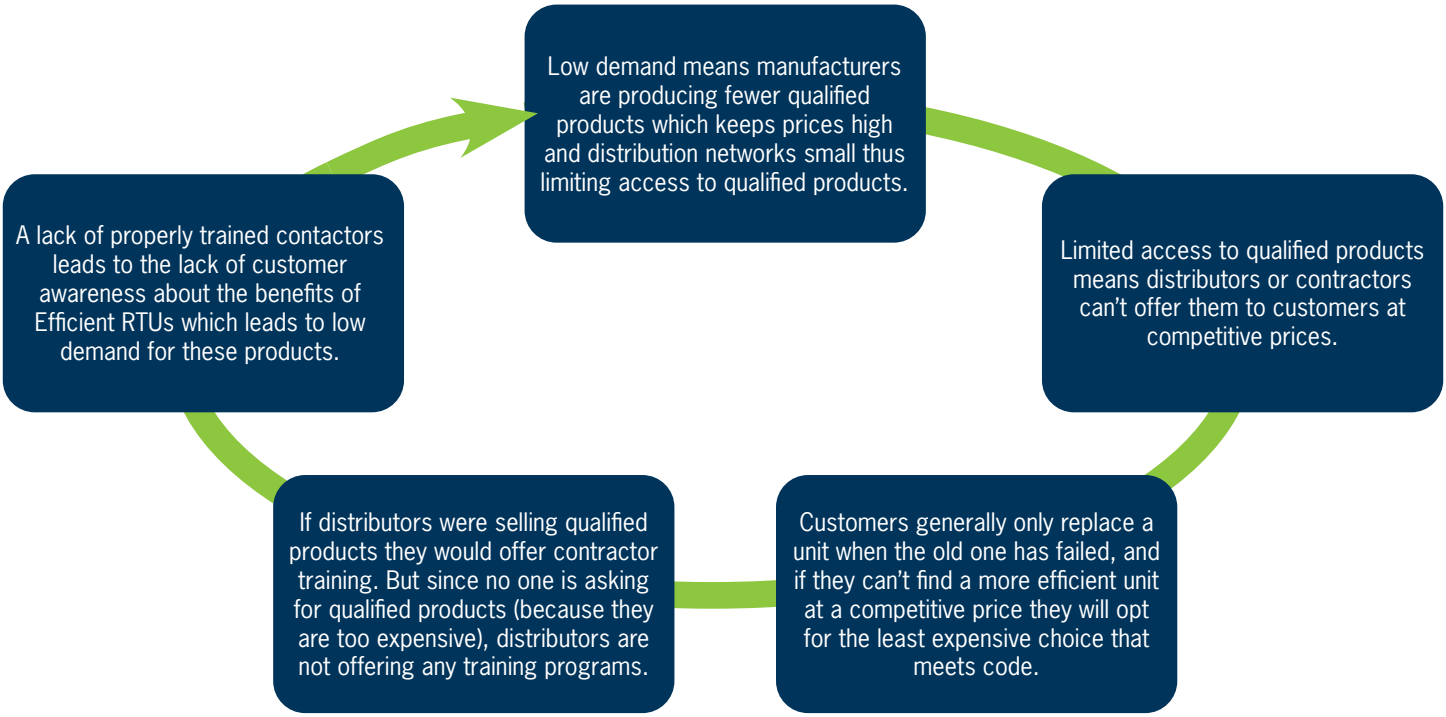
Research Objective #3

Identify barriers to adoption for Tier 1 and Tier 2 units with heat- or energy-recovery ventilation to inform intervention design.

Contractors, distributors, ESCOs, and program administrators all pointed to high first cost as the principal barrier to more widespread adoption of Tier 1 and Tier 2 units. Each participant we interviewed noted that, even before the current supply chain disruptions, limited product availability contributed to general lack of product awareness by suppliers making it difficult for customers to know they exist. These actions keep demand for the product low and as a result, pricing remains out of reach for most customers. As illustrated in Figure 1, each of these barriers are interrelated and identifying strategies that result in increased demand will help to bring prices down and foster an environment of improved product adoption.

This cycle represents a summary of how participants characterized the current state of the HVAC market as it relates to more widespread adoption of Tier 1 and Tier 2 units.

Figure 1. Cycle of Barriers



1 Participants identified high first costs as their biggest challenge when trying to promote or sell Efficient RTUs.

> ***"In almost every case, price and payback is the reason whether to move forward or to not."***
> **—ESCO**

In every interview, high first-cost was identified as the largest barrier for commercial RTU replacements, and, for the most part, their feedback was consistent. It focused on ways to spur demand to increase supply, which, in their experience, leads to competitive pricing. The solution they all noted was to push for code changes that would incentivize manufactures to put more product out into the marketplace at competitive prices. Until that happens, few customers have the capital reserves to consider purchasing an above code unit. One contractor told us bluntly that, *"There's not a snowball's chance that I could sell a 10-ton unit for $75,000."*

The principal factor causing the price to be so high is related to the unit itself and the likely structural upgrades that are required if it doesn't fit the existing footprint of the unit it is replacing. According to one ESCO we interviewed, *"As soon as the new unit is 1 pound heavier than the unit it is replacing, it requires structural calculations."* He went on to say that, "*A Tier 2 is always heavier, but a Tier 1 varies from manufacturer to manufacturer."* In addition, if the dimensions of the unit are too large and visibility is an issue, screening may be required, triggering even further upgrade costs.

Of the three contractors who participated, only one had a significant increase to labor between the standard replacement, Tier 1 and Tier 2 upgrades. Otherwise, labor cost differences across all upgraded units were small, as were projections of O&M costs. When we began the interview process, there was an assumption that O&M would be much more expensive for Efficient RTUs than the units they were replacing. However, we learned during the interviews with contractors that this is not always the case. O&M costs can vary from a 30% increase (according to one contractor) to being only nominally more expensive for an Efficient RTU. One contractor even told us that he offers free O&M for the first year for every product they sell. Additionally, as one ESCO noted, *"Materials/labor amount aren't the only influencers; price could depend on how much work contractors have and having good relationships with manufacturing reps are important for pricing."*

When asked, "What questions or concerns do you think customers will have when evaluating the choice to upgrade to an Efficient RTU?" One contractor simply replied, *"Cost and budget."* A second installer stated that, *"In almost every case, price and payback are the reasons that customers decide whether to move forward or to not."*

Moreover, according to one program administrator, *"If the new tech is comparably priced, offers better performance, better indoor quality, easier to install and maintain for the contractor – you may not even need an incentive. People will just want it."*

2 Lack of product availability is one of the main reasons prices for Efficient RTUs remains high.

> ***"If there is only limited product availability prices will remain high."***
>
> **—DISTRIBUTOR**

When considering product availability, distributors pointed to a lack of storage space to carry the Efficient RTUs, which they perceived would take up more space than a standard RTU. While many have showrooms, they have always relied on quick delivery times to overcome limited warehouse space. However, in the case of Efficient RTUs there is little interest in keeping those units on the showroom floor. One distributor asked, *"Why bring it in and have units lingering there that won't sell, and after a year I have to discount the price like a car?"*

One distributor told us, *"We only sell what we stock and standard units can be sold the same day. I'm not going to be promoting Efficient RTUs."*

Referring to the current supply chain issues, one contractor told us that before COVID-19 he could get products in a week and a half, but now he's seeing delays for a 5–10-ton standard RTU up to 30 weeks. He went on to say that, *"I won't put brand in a proposal letter because I don't know if I'll get that brand in time."*

One distributor told us that, *"If a customer wants it, they stock it. Contractors drive what distributors stock."*

3 Contractors and end-use customers not being educated about the benefits of upgrading to a more Efficient RTU.

> ***"We live in a good climate for it, but no one understands the technology."***
>
> **—DISTRIBUTOR**

Poor customer awareness of Efficient RTUs often drive decision makers to continue purchasing the same code minimum standard models rather than upgrading to new, more efficient options.

All participants pointed out that developing relationships with customers is critical in understanding their needs and helping them understand their options. One program administrator pointed out that *"Helping building owners see the 'big picture' is important when promoting the advantages of Efficient RTUs."* For the right building owner, controls integration and connectivity is an important feature and showing them how Efficient RTUs integrate into the entire building's system can help drive sales. As one contractor told us, *"If building owners are responsible, then this is the best chance to get energy efficiency on the roof."* Another contractor pointed out that, *"The non-energy benefits are starting to become part of the conversation, but not something they typically did in the past."* These changes are making it easier to upsell a builder by speaking to the advantages of more than just energy savings. One program administrator noted that, *"People are becoming a little more aware of efficiency and the ability to control an energy-consumptive technology remotely through Demand Response programs or Time of Use rates. This might influence people to purchase more high-efficiency units."*

One effective strategy that program administrators use when engaging with building owners is to educate them about their options to promote early retirement for older, less efficient units which are nearing the end of their lifetime. *"Promoting early retirement helps building owners see the value in replacing a standard RTU early with an Efficient RTU and gives them time to work with their supplier and track down units they want."* – Program Administrator

***"People are more interested in customer service than efficiency."* - Distributor**

Being able to convey key messages that speak to a broader cross-section of customer interests (both service oriented and technical) can help contractors sell Efficient RTUs to more than just a single customer type. (See Table 5 above.)

One program administrator explained, *"There are different levels of owners, so having a clear and consistent message that speaks to multiple building owners is really important. Some owners are interested in the technology and the benefits of things like indoor air quality and have some experience with RTUs. They know how to ask the right questions. Some owners only care about having a reliable system that can heat and cool their building. They don't care about indoor air quality and only want lower utility bills."*

One ESCO that we interviewed noted that being able to speak to the *"return on investment and payback is a question a lot of clients are asking about."* Clients want to know why they should be paying *"this much up front,"* and having a pool of properly trained contractors, or ESCOs, who can answer those types of questions for a broad range of customers, can be instrumental in helping building owners overcome the barrier of price. The ESCOs that we interviewed said they catered to larger commercial building owners including school districts, colleges, hospitals, or other government buildings, but the professional guidance ESCOs provide to these larger building owners would benefit any property owner of any size. Promoting professional engineering services that support smaller building owners can have a significant impact in advancing the adoption of Efficient RTUs.

Moreover, educated contractors can demonstrate that these technologies are foolproof and communicate the value and benefits of these more efficient units so they can answer the fundamental question of *"what people are getting for the money. Customers want to know about payback and product performance."* Other participants noted that this is an issue up and down the supply chain. One contractor, in preparing his bid for a Tier 1 unit for this study, found that even at the manufacturing level the salespeople he spoke to could not explain why the units were so much more expensive or what exactly anyone was getting for their money.

As one program administrator told us, *"Educating building owners on what it looks like when they need to replace an RTU, what the economic and non-efficient benefits are, and how an efficient unit will help them,"* can help move the market toward the adoption of more efficient products.

Recommendations

- Continue building strong partnerships with manufacturers and encourage development of Efficient RTU products. With limited manufacturers building Efficient RTUs, the product is difficult to obtain.
- Develop and execute an outreach and education campaign. Not only do Efficient RTUs lack customer awareness, the entire range of market actors involved in a potential sale including product distributors, architects, engineers, and installers needs to be educated on the range of benefits Efficient RTUs offer in order to gain traction among building owners and property managers.
- Offer support for small to mid-sized commercial property owners. Promote packages that offer free energy audits or more general engineering and technical support to commercial building owners to prompt a call to action and drive proactive replacements among property owners and managers interested in efficient HVAC options.

Research Objective #4

Determine each tier's value propositions for HVAC contractors and ESCO engineers to inform intervention design.

ESCOs and HVAC contractors are at the front lines when it comes to actively selling and installing Efficient RTUs. When hired, ESCOs strictly manage the design phase of an RTU replacement, choosing the best-fitting equipment while keeping efficiency in mind. Contractors will install the equipment, although many of them are hired to take care of the design phase as well. We asked both ESCOs and contractors about how they value Tier 1 and Tier 2 RTUs, and how they use those value propositions to promote the benefits of Efficient RTUs (See Appendix F) to their customers. The common value propositions among our participants are ranked in order of importance below.

1 Improved indoor environment is a commonly used selling point for both ESCO and HVAC contractors

"It's not hard to sell efficiency. It's hard to sell efficiency if you're ONLY trying to sell efficiency."- Contractor

Contractors and ESCOs found significant value in non-efficiency benefits of RTUs, specifically highlighting the impact of heat- and energy-recovery ventilation. Tier 2 RTUs with ERVs provide a comfortable indoor environment and reduce drafting. ESCOs particularly like ERV technology because it enables them to confidently deliver the comfort standards they promise to their customers. A standard unit does not have air mixing capabilities like a Tier 2 RTU with an ERV, so ESCOs often urge their customers to purchase units with ERVs to ensure their comfort standards. Similarly, one contractor claimed that poor indoor comfort is a leading reason for employees leaving jobs. Warehouses, shops, and manufacturing facilities with harmful particulates put employees at risk without proper ventilation and filtration. Both Tier 1 and Tier 2 units are equipped with MERV 13 filtration and produce healthy indoor air quality. Additionally, ERV capabilities on Tier 2 units enhance air quality even further.

ESCOs work directly with contractors and manufacturers to help building owners and property managers identify new technologies and evaluate the benefits and costs of upgrading their HVAC systems to include more energy-efficiency products, like Efficent RTUs.

2 Energy savings resulting from high performance can provide a full payback on the initial cost of Efficient RTUs

***"There has to be motivation for building owners to even consider the unit. Economic value is the number one value in doing that."* – Program Administrator**

Contractors and ESCOs both noted the importance of illustrating the low life-cycle cost of Efficient RTUs. Efficient RTUs of both Tiers employ low-leakage dampers and R-12 insulation that eliminate costs related to air leakage and heat escape. Tier 2 RTUs with ERVs provide further efficiency by warming incoming outside air with used warm air and recovering energy stored in humidity. ESCOs claimed that Efficient RTUs will often see full payback at the end of its lifecycle, and a contractor claimed a five- to seven-year payback after incentives are applied. ESCOs are already using tools that show customers how Efficient RTUs will reduce the customer's utility bill and how that will contribute to final payback.

3 Efficient RTUs are highly configurable

***"A Tier 2 RTU won't solve all your problems - it also depends on how you commission it."* – ESCO**

Despite some concern from contractors that the weight of Efficient RTUs would trigger building structure adjustments, a contractor we spoke to said that nearly all modern RTU replacements require building structure adjustments and that this isn't specific to Tier 1 and Tier 2 RTUs, even with their additional capabilities. New baseline RTUs that are designed to meet code are still heavier than the existing RTUs that were installed 15–20 years ago. ESCOs, who are designing the retrofits, embrace the flexible configuration of select Efficient RTU models. Tier 1 and Tier 2 RTUs have configurable cabinet spaces that reduce the structural changes needed to install, benefitting both ESCOs and installing contractors.

ESCOs play a critical role in the adoption of higher efficiency units because they exist at the intersection of the upgrade process with the key decision makers:

- ✔ ESCOs work with building owners, structural engineers, and architects who evaluate their recommendations and decide whether to move ahead with one of their recommendations
- ✔ ESCOs work with manufacturers, distributors, and contractors who supply and install the products
- ✔ ESCOS work with utilities or other efficiency organizations who support and help fund energy efficiency projects

4 Green technology boosts a company's image

"Companies want high efficiency equipment because it looks good. Selling image is a way to win them over."

ESCOs and contractors both mentioned that their clients valued having sustainability attached to their company name. During the design phase, ESCOs have been asked how Efficient RTUs look on top of buildings and if they are eye-catching from an aerial or street view. ESCOs said that climate awareness is more common in emerging companies with young leadership, so they now use image as a selling point when working with enthusiastic clients.

5 Lead times are faster for some Efficient RTUs due to current supply chain disruptions (specific to COVID-19)

We heard from contractors and ESCOs that shipping times for new RTUs are up to 30 weeks, and in some cases even longer, due to COVID-19-related supply chain issues. One contractor we spoke to mentioned that shipping times for efficient Aaon units are as low as six weeks and are sparking interest in customers that need a quick turnaround. He mentioned that if supply chain disruption continues, we may observe more Aaon installations solely because of the prompt shipping times.

Recommendations

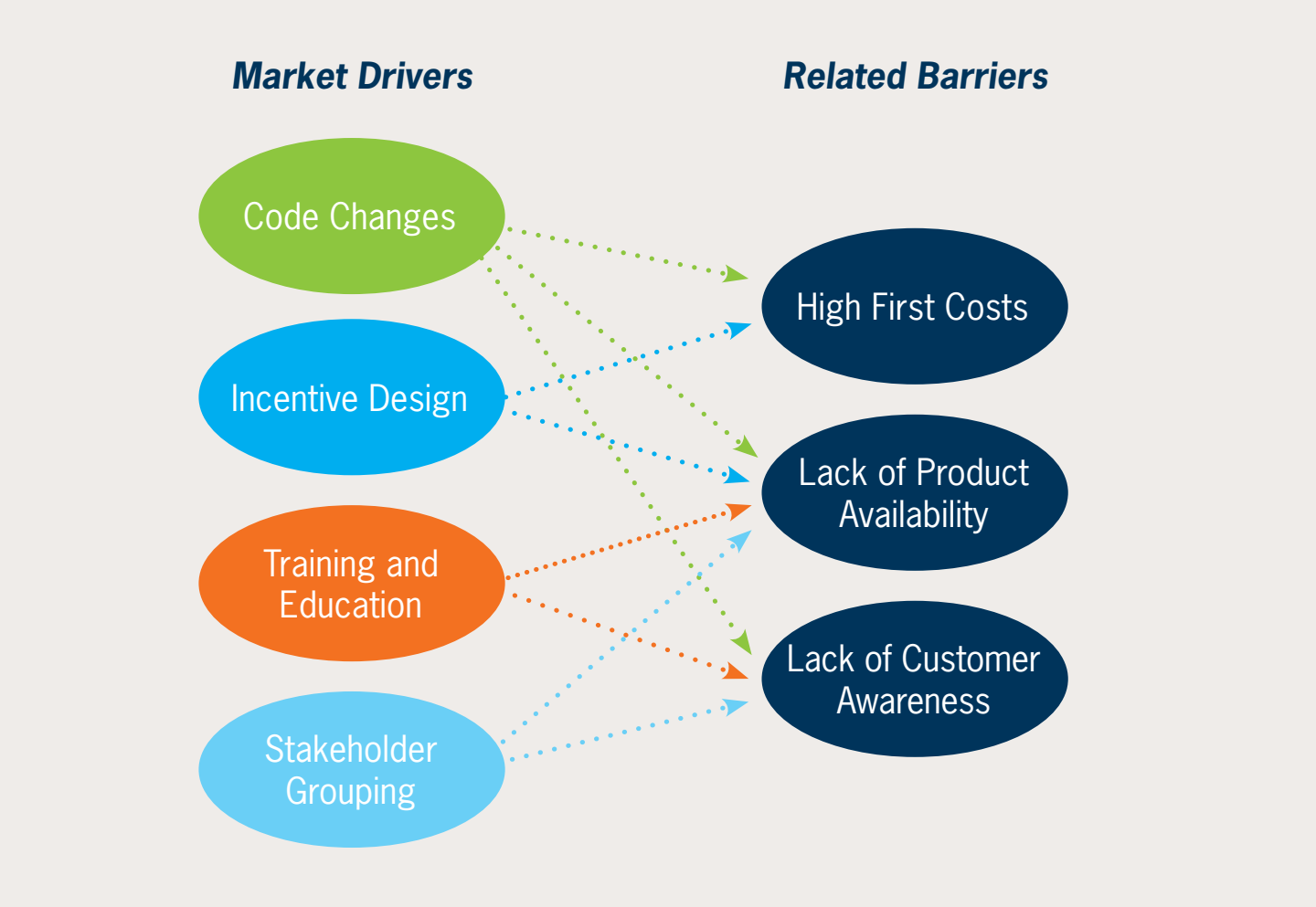
- Integrate value propositions identified by ESCOs and HVAC contractors into NEEA's Efficient RTU promotional documents.
- Develop tools and messages that highlight all the benefits of Tier 1 and Tier 2 RTUs.
- Document the scenarios that show the high-performance capabilities of Efficient RTUs and how that contributes to energy savings and payback.
- Demonstrate how Efficient RTUs are highly configurable and can simplify the replacement process.
- Identify businesses who align green technology with their brand image and engage them as early adopters of Efficient RTUs.

Research Objective #5

Identify drivers of new system adoption/behavior change learned from a prior RTU program (specifically the federal Department of Energy's Advanced RTU program) to inform intervention design.

We spoke to three former HVAC program administrators, two of whom worked on the Department of Energy's Advanced RTU Campaign. We asked them to help us identify effective program strategies, successful delivery models, and important market factors for rolling out a high-efficiency HVAC program in today's small commercial market. The most prominent market transformation drivers identified were building codes, incentive design, training and education, and stakeholder groupings. The figure below outlines which market driver effects each barrier our participants identified:

Figure 2. Market Drivers and Barriers



While this section is primarily focused on recommendations and experience from program administrators, we also received input from contractors and distributors. As the market actors on the receiving end of the program, they provided insights on what factors can transform the commercial HVAC market.

1 Code changes bind market actors to action

Nearly every participant we spoke to said that the leading driver of Efficient RTU adoption would be building code changes. Most RTUs are engineered to meet code baselines, and even if they claim to exceed code baselines, they do not reach Tier 1 or Tier 2 qualifications. Building owners will face fines, contractors will face demerit, and manufacturers will need to make and distribute equipment that meets the new baseline. Code has the ability to apply pressure and get more Tier 1 and Tier 2 RTUs into the market.

2 Incentives have the best shot at market adoption when placed in the right hands

The purpose of incentives is to move new technology into markets, but their success is directly related with who is receiving them. There were contrasting arguments amongst our participants about who should be receiving incentives. The majority said a midstream model providing incentives to distributors is the most effective way to move markets because it provides distributors with resources to keep efficient units in stock and provides end-users with a quick turnaround time. However, when asked about the midstream approach, distributors said that they did not want to deal with the incentives because they are difficult to manage and report. Although there are contrasting opinions, all participants agreed that incentives are a key factor in new system adoption if they are executed effectively.

3 Training and education can lead the push for adoption of more advanced HVAC systems

Building owners and property managers rely on contractors and distributors to be knowledgeable and informed about new products. Contractors and distributors are unlikely to recommend or install high-efficiency HVAC systems if they are not educated and up to date on the latest advancements. Building owners will not overcome the initial cost barrier without understanding what they are paying for and how it will pay them back in the long term. Having a strategy to maintain a constant flow of information towards industry actors will change how they think about new technologies. Contractor networks, industry events, and industry media are all effective methods of educating market actors. Our participants identified ASHRAE and BOMA as leading organizations to help the advancement of Efficient RTUs.

4 Coalitions of business leaders can drive consumer awareness about Efficient RTUs and their benefits

The Federal Advanced RTU Campaign targeted the Better Buildings Alliance (BBA) as the participants for the program. The BBA is an alliance of business leaders in sustainability, which program staff felt was very impactful. Program administrators found that a coalition of educated business leaders was effective in communicating efficiency goals to the market. Buildings with ENERGY STAR® distinction (and the like) are good starting points for building progressive coalitions. Additionally, program administrators said that business coalitions that self-identify as leaders in sustainability serve as motivators for other business to adopt “green” business practices. Coalitions of business leaders, whether local, regional, or national, have the ability to increase awareness of Efficient RTUs.

Recommendations

- Work with state and city governments to advance building codes and force efficiency into the market. More efficient building codes will require distributors to keep Efficient RTUs in stock and available for customers, as well as reduce lead times from RTU replacements. Increased competition among manufacturers and distributors will drive prices down, overcoming the current initial cost barrier.
- Put incentive dollars at the midstream level and make it easy to receive incentives. Customers are looking for quick replacements most of the time and motivating distributors to keep Efficient RTUs in stock will drive up the rate of installations. If incentives are passed down to the customers, it also narrows the price gap between standard and Efficient RTUs.
- Work with industry organizations to promote Efficient RTUs with events and deliverables. Present at ASHRAE or BOMA events and take out ads in their magazines and newsletters. Use them as resources to get marketing materials to ESCOs and contractors, who are choosing RTUs for their customers.
- Continue working with regional and national organizations that support the alignments and advancement of the efficiency codes and standards like the Department of Energy (DOE), Energy Trust of Oregon (ETO), Energy Star, and Consortium for Energy Efficiency (CEE).
- Work with local governments and businesses to form sustainability coalitions. When businesses come together to promote efficiency, local distributors will react to changes in demand and stock more efficient equipment.

Appendix A. Detailed Methodology

NEEA provided D+R an initial list of approved installation contractors from which D+R would recruit candidates for that portion of the study. NEEA and D+R also collaborated to identify the other market actors needed to complete this research: distributors, manufacturers, program administrators, and ESCOs. Recruitment efforts began by phone in early October 2021.

Participants were evaluated based on their familiarity with the commercial RTU market, their ability to provide feedback for the research objectives, and their willingness to participate in a one-hour interview between November and December 2021. Candidates who met those criteria were selected for participation and received a program package including NEEA's proposed marketing materials and RTU specifications. Contractors would also receive guidelines for how to submit their bids.

Outreach candidates included the following groups who each play a key role in the adoption and promotion of Efficient RTUs:

- HVAC contractors who work with suppliers to design and install HVAC systems on commercial buildings.
  - Participating contractors were required to submit a bid for a like-for-like replace of a standard efficiency 10-ton RTU along with a Tier 1 or Tier 2 replacement bid. They would also be asked to provide a third bid for the advanced RTU that was not included in the first bid package.
  - Contractors were also asked to participate in a one-hour interview to review the bid, and discuss the Research Objectives (1, 2, 3, and 5) and help assess NEEA's proposed marketing materials for Tier 1 and Tier 2 RTUs that they would receive along with the building specifications via email.
- Commercial HVAC suppliers – These are manufacturers and distributors who sell, stock, and/or distribute HVAC systems.
  - Participating manufacturers and distributors were asked to participate in a one-hour interview to discuss the Research Objectives (1, 3, and 5) and help assess NEEA's proposed marketing materials for Tier 1 and Tier 2 RTUs that they would receive via email.
- ESCOs who propose energy efficiency upgrades to existing building owners. ESCOs are hired by building owners to propose energy efficient upgrades, including HVAC, and thus influence building owners' decision making for HVAC.
  - Participating ESCOs were asked to participate in a one-hour interview to discuss the Research Objectives (1, 4) and help assess NEEA's proposed marketing materials for Tier 1 and Tier 2 RTUs that they would receive via email.
- RTU program administrators (from prior federal programs).
  - Participating program administrators were asked to participate in a one-hour interview to discuss the Research Objectives (1, 3, and 5) and help assess NEEA's proposed marketing materials for Tier 1 and Tier 2 RTUs that they would receive via email.

All contributors were compensated for participating in the study and were eligible to receive a $100.00 referral bonus for each candidate referred to the study.

The table below identifies the amount of compensation the research study offered to participants.

Table A1: Participant Compensation

Target Group	Research Objective	Data Collection Process	Gift Card Value
Contractors	2	Baseline Bid & Tier 1 Bid	$ 750.00
Contractors	2	Tier 2 Bid	$ 250.00
Contractors	4	Focus Group	$ 150.00
ESCO	4	Focus Group	$ 250.00
Distributor	1,3,5	Interviews	$ 250.00
Manufacturer	1,3,5	Interviews	$ 250.00
Program Administrator	1,3,5	Interviews	$ 250.00
All		Referral	$ 100.00

Following the recruitment process, D+R had not secured commitments from any manufacturers for the study so that group was not included in the interview process. Additionally, it took longer than expected to recruit ESCOs, so to expedite the data collection process interviews were conducted with that target group.

D+R conducted interviews with 11 participants including 3 contractors, 2, distributors, 3 program administrators, and 3 ESCOs.

Appendix B. Initial Participant Outreach

Contractors

"My name is [ ] and I'm an analyst at D+R International. We are conducting a market research study for Commercial Roof Top Units, and we are looking for Commercial HVAC Installation Contactors to participate in our study."

- If they are not Installation Contractors, "thank you…"
- If they are, "We need your help evaluating some commercial RTU specifications. We are offering contractors $750 to $1000 for participating in our research study."

"As part of the process, we are looking for contractors to submit 2-3 sample bids for a commercial project using different makes and models of RTUs. While the building is real, the bids are only being used for research purposes. We will provide you with detailed building specifications as well all the information you will need to submit your bids. We would also interview you about your bids and opinions about the RTUs."

"We can schedule time to go over this in more detail but wanted to find out if this is something you would be interested in participating in AND if you would be able to complete the bidding process in the next four to five weeks. If so, we can set up some time after this call to go over the project in a bit more detail."

If not, "thank you…"

If yes, …

"That's great. We appreciate your support and will be providing you building specifications as well as some other marketing materials to help complete the study. Following the bid process, we will set up time to go over your bids and ask the interview questions to help round out our research. The interview process should not take more than one hour."

"There may also be an opportunity after the bidding process to participate in an online focus group where you can earn another $150. We can discuss this during the bidding process."

[For clarity on the gift cards] Contractors will receive gift cards in the amount of $750 for providing two bids (one for a standard RTU replacement and second for an upgraded RTU). We will offer another $250 for contractors who submit a third replacement bid for an additional upgraded RTU, for a total of $1,000.

Get their email address and confirm contact information. Schedule a time to follow up with them for questions and to keep their bid on track.

Distributors and Manufacturers

"My name is [ ] and I'm an analyst at D+R International. We are conducting a market research study on Commercial Roof Top Units."

"We need your help reviewing some commercial RTU specifications. We are looking for commercial HVAC manufacturers and distributors who can evaluate the RTU specifications and provide opinions about them during an interview. We are offering individuals a $250 gift card if they participate in our research study."

"We are looking to schedule informal interviews in the next two or three weeks to seek feedback on the RTU specifications."

"We can schedule time to go over this in more detail, but wanted to find out if this was something you would be interested in participating in."

If no, "thank you…"

If yes, …

"That's great. We appreciate your support. We will be

providing you with the specifications as well as some marketing materials to help complete the study. Once you have a chance to review the documents, we will set up a time for an informal interview to get your feedback on the materials. The Interview process should not take more than an hour."

Get their email address and confirm contact information. Schedule a time to follow up with them for questions.

Program Administrators

"My name is [ ] and I'm an analyst at D+R International. We are conducting a market research study on Commercial Roof Top Units."

"We need your help reviewing some commercial RTU specifications. We are looking for program administrators with experience implementing an RTU program, ideally including high efficiency measures, who can evaluate the RTU specifications and provide opinions about them during an interview. We are offering individuals a $250 gift card if they participate in our research study."

"We are looking to schedule informal interviews in the next two or three weeks to seek feedback on the RTU specifications."

"We can schedule time to go over this in more detail, but wanted to find out if this was something you would be interested in participating in."

If no, "thank you…"

If yes, …

"That's great. We appreciate your support. We will be providing you with the specifications as well as some marketing materials to help complete the study. Once you have a chance to review the documents, we will set up a time for an informal interview to get your feedback on the materials. The Interview process should not take more than an hour."

Get their email address and confirm contact information. Schedule a time to follow up with them for questions.

ESCOs and Contractors

"My name is [ ] and I'm an analyst at D+R International. We are conducting a market research study on Commercial Roof Top Units."

"We need your help reviewing some commercial RTU specifications. We are looking for mechanical engineers or anyone who specifies commercial HVAC systems at ESCOs who can evaluate the RTU specifications and provide opinions about them during a focus group. We are offering individuals a $250 gift card if they participate in our research study."

"We are looking to schedule a focus group in the next two or three weeks to seek feedback on the specifications.

"We can schedule time to go over this in more detail, but wanted to find out if this was something you would be interested in participating in."

If no, "thank you…"

If yes, …

"That's great. We appreciate your support. We will be providing you with some specifications as well as some marketing materials to help complete the study. Once you have a chance to review the documents, we will be scheduling a time for the focus group to get your feedback on the materials. The focus group should not take more than an hour.

Get their email address and confirm contact information. Schedule a time to follow up with them for questions.

Appendix C. Interview Discussion Guides

Contractors

Research Objective 1:

Question #1: Do NEEA's specification documents do a good job of calling out the differences / benefits between a standard and an Efficient RTU?

Question #2: Was there anything unclear in the RTU specifications?

Question #3: Would additional information be beneficial to understand anything in the document?

Question #4: In your experience, what distinguished an RTU from other rooftop equipment that is known as an RTU?

Question #5: Does the term "Efficient RTU" accurately describe the category of equipment in the spec docs?

Research Objective 2:

All questions here will come directly from the bids and the information submitted from contractors.

Question #1: How do you think operations & maintenance costs compare between typical RTUs (specifically the "baseline" like for like bid one) and Efficient RTUs? What is your estimate for the annual cost or O&M for the baseline vs. the Efficient RTUs [NOTE: If a dollar amount is not possible, they can estimate percentage difference)?

Question #2: What are the main drivers in the differences between in the bids you provided? Does it just come down to labor, materials, etc…?

Research Objective 3:

Question #1: What questions or concerns do you think you will have when evaluating the choice to upgrade to an Efficient RTU?

Question #2: What questions or concerns do you think customers will have when evaluating the choice to upgrade to an Efficient RTU? How will factors like sizing, budget, or maintenance influence the decision-making process?

Question #3: What problems have you faced trying to sell or install efficient HVAC equipment?

Question #4: What challenges do you foresee that might prevent you from actively promoting and installing Efficient RTUs?

Research Objective 5:

Question #1: How have you motivated customers to purchase a more Efficient RTU for the first time, or any higher efficiency equipment for that matter?

Distributors

Research Objective 1:

Question #1: Do NEEA's specification documents do a good job of calling out the differences / benefits between a standard and an Efficient RTU?

Question #2: Was there anything unclear in the RTU specifications?

Question #3: Would additional information be beneficial to understand anything in the document?

Question #4: In your experience, what distinguished an RTU from other rooftop equipment that is known as an RTU?

Question #5: Does the term "Efficient RTU" accurately describe the category of equipment in the spec docs?

Research Objective 3:

Question #1: What questions or concerns do you think you will have when evaluating the choice to upgrade to an Efficient RTU?

Question #2: What questions or concerns do you think customers will have when evaluating the choice to upgrade to an Efficient RTU? How will factors like sizing, budget, or maintenance influence the decision-making process?

Question #3: What problems have you faced trying to sell or install efficient HVAC equipment?

Question #4: What challenges do you foresee that might prevent you from actively promoting and installing Efficient RTUs?

Research Objective 5:

Question #1: How have you motivated customers to purchase a more Efficient RTU for the first time, or any higher efficiency equipment for that matter?

Program Administrator

Research Objective 1:

Question #1: Do NEEA's specification documents do a good job of calling out the differences / benefits between a standard and an Efficient RTU?

Question #2: Was there anything unclear in the RTU specifications?

Question #3: Would additional information be beneficial to understand anything in the document?

Question #4: In your experience, what distinguished an RTU from other rooftop equipment that is known as an RTU?

Question #5: Does the term "Efficient RTU" accurately describe the category of equipment in the spec docs?

Research Objective 3:

Question #1: How did you promote high efficiency HVAC equipment?

Question #2: What were the biggest challenges you faced when rolling out a program with high efficiency HVAC equipment?

Question #3: What challenges do you foresee for any market actor promoting a new Efficient RTU program in the future?

Research Objective 5:

Question #1: What did you find to be the most effective design and delivery strategies in rolling out a program that offered high efficiency measures?

Question #2: Was your delivery model as effective as it could have been (upstream vs. midstream vs. downstream) or would it have been better with another approach?

Question #3: What market factors do you believe need to be in place to deliver a successful high efficiency program? Why are these important?

Question #4: What recommendations, if any, did your evaluators have for future program design?

ESCOs and Contractors

Research Objective 1:

Question #1: Do NEEA's specification documents do a good job of calling out the differences / benefits between a standard and an Efficient RTU?

Question #2: Was there anything unclear in the RTU specifications?

Question #3: Would additional information be beneficial to understand anything in the document?

Question #4: In your experience, what distinguished an RTU from other rooftop equipment that is known as an RTU?

Question #5: Does the term "Efficient RTU" accurately describe the category of equipment in the spec docs?

Research Objective 4:

Question #1: Based on the materials reviewed, what benefits or selling points would you use to convince a customer to upgrade to a Tier 1 or Tier 2? Any that you would add or remove?

Question #2: Do the benefits of a more Efficient RTU outweigh any risks (real or perceived)?

Question #3: What is the role of ESCOs in advancing new HVAC technologies?

Question #4: What factors do you think will play a key role in deciding whether commercial customers will be inclined to select a more efficient unit (Size of the building, purpose of use, etc.?)

Appendix D. NEEA Stimuli Documents - Efficient-RTU Flyer Diagrams

BETTERBRICKS
Powerful Energy Ideas. Delivered by NEEA.

ALL ROOFTOP UNITS (RTUs) ARE CONVENIENT, BUT MOST ARE WASTEFUL

Rooftop units (RTUs)—HVAC appliances installed on building roofs—supply heating and/or cooling to meet the thermal comfort requirements of commercial buildings. Inherently convenient, RTUs package heating, cooling and ventilation equipment together in a space that is accessible to technicians without taking up precious real estate. However, most RTUs are using much more energy than necessary.

EFFICIENT GAS ROOFTOP UNITS REDUCE ANNUAL HVAC ENERGY USE BY UP TO 40%

Efficient gas RTUs, incorporate a combination of energy-saving features, including secondary condensing heat exchangers, high insulation values, improved cabinet design, low-leakage dampers, and heat or energy recovery. These easy-to-install systems are available now to replace existing RTUs and reliably deliver energy savings in Northern climates.

Efficient gas RTUs can take a variety of forms to boost overall efficiency in a variety of ways. One approach uses secondary condensing heat exchangers to capture a greater percent of the gas combustion energy. The secondary heat exchanger transfers additional energy from the flue gas into the supply air stream, resulting in lower flue temperatures and additional energy captured from the condensation of water vapor in the flue gas.

Other types of efficient gas RTUs provide comparable efficiency results without requiring a condensing system at all. These systems incorporate additional energy-saving measures including insulation and higher performance dampers to save considerable energy at small incremental costs. Additionally, heat and energy recovery equipment can provide up to 40% total HVAC energy savings when installed in an efficient gas RTU that introduces outside air.

COMMON APPLICATIONS FOR EFFICIENT GAS RTUs

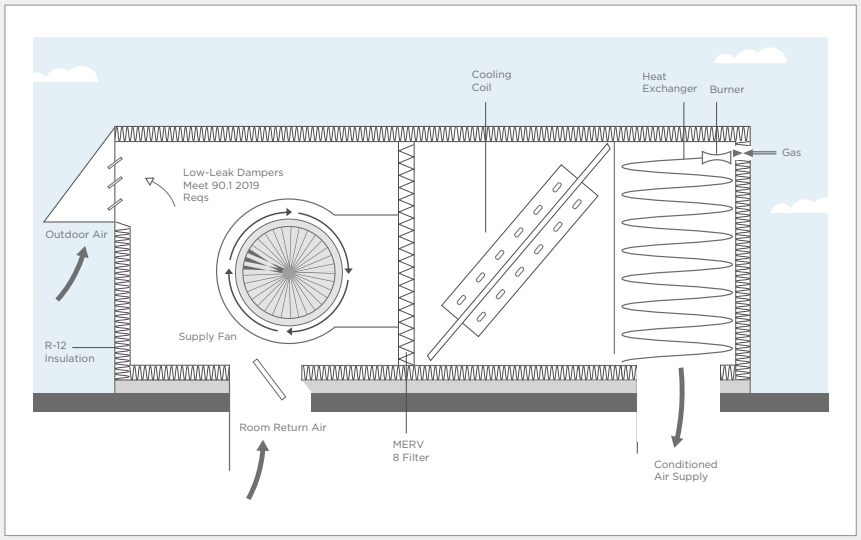
- Small to medium commercial buildings, under 3 stories
- Retail, small office, grocery and schools
- Buildings with existing RTUs

THE BETTER AND BEST EFFICIENT GAS RTUs

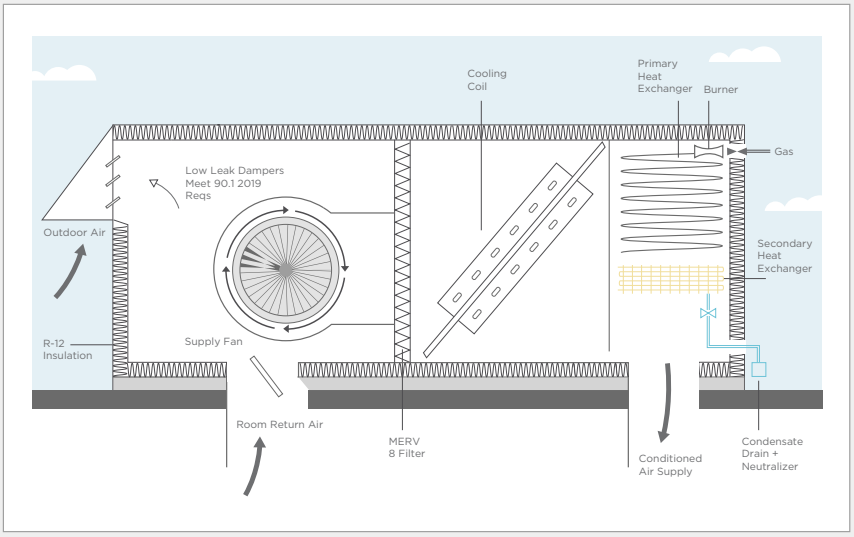
Based on field and lab testing completed by the Northwest Energy Efficiency Alliance (NEEA), efficient gas RTUs can be grouped into two categories, or tiers, based on their energy performance:

TIERS BASED ON PERFORMANCE	
Tier 1 units provide better efficiency than standard RTUs.	These units have at least 80% Thermal Efficiency (TE) and additional energy efficiency gains via increased insulation and reduced damper leakage making them up to 15% more efficient than a standard RTU (depending on climate zone and building type).
Tier 2 units are the highest performing RTUs available.	These units include everything in Tier 1, and either a) the furnace is a condensing gas furnace, or b) the unit includes heat or energy recovery with an energy recovery ventilator (ERV). These upgrades can result in units that are up to 40% more efficient than a standard RTU (depending on climate zone and building type). Tier 2 units are particularly ideal for buildings with higher occupancies and/or higher than average heating needs.

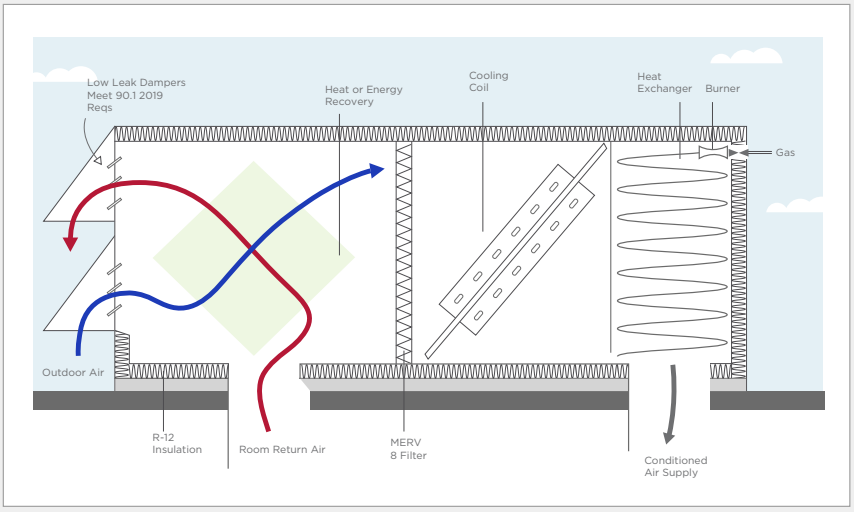
Tier 1



Tier 2: Condensing



Tier 2: Heat Recovery



Note: These drawings are for illustration purposes only and do not reflect the exact system design and component of every available model. Contact your manufacturer for exact system schematics.

To learn more about this and other efficient HVAC solutions, visit: **betterbricks.com/solutions/hvac.**

Appendix E. NEEA Stimuli Documents - Efficient-RTU Requirements

- REVISED SEPTEMBER 3, 2021 -

BETTERBRICKS
Powerful Energy Ideas. Delivered by NEEA.

Efficient Gas Rooftop Units for Commercial Buildings

System Requirements and Compliant Equipment

Introduction

Throughout the United States, rooftop units (RTUs) supply heating and/or cooling to meet the thermal comfort requirements of commercial buildings. In the Northwest states of Idaho, Montana, Oregon and Washington more than 400,000 RTUs exist, and more than half include a standard gas furnace module with 80% thermal efficiency. The Northwest Energy Efficiency Alliance's (NEEA) research indicates higher performance RTUs exist that utilize condensing heat exchangers, heat or energy recovery ventilators, or improved cabinet design.

Thermal efficiencies greater than 90% are possible by using secondary heat exchangers that capture a greater percent of the combustion energy. The flue gas temperatures of these systems are low enough to result in condensation of the water vapor in the combustion exhaust gases which delivers more heat to the supply air stream for a given amount of fuel combustion, boosting overall efficiency.

Additionally, other energy-saving measures can be incorporated into RTU design that can achieve comparable results without the need for a condensing system. NEEA's research indicates insulation and higher performance dampers save considerable energy at small incremental costs. Heat and energy recovery equipment can also be installed on RTUs that introduce outside air and provide up to 40% total HVAC savings.

The highest-performing RTUs incorporate a combination of energy-saving features, including condensing heat exchangers, high insulation values, low-leakage dampers, and heat or energy recovery.

For additional information and resources, visit: betterbricks.com/solutions/hvac.

Disclaimer: *This document, along with the equipment list and any guidance and recommendations included herein, are only intended to assist the recipient in evaluating energy efficient HVAC system options; it should not be used in lieu of professional design or engineering services. Moreover, this document and its contents are provided "as is" without any warranty or representation regarding quality, accuracy, non-infringement, or usefulness. Under no circumstances are NEEA or NEEA's funders liable for any direct, indirect, special,*

Purpose and Scope

This specification provides guidance to manufacturers and market actors for developing and delivering efficient gas RTUs that reliably deliver heating energy savings in Northern climates and are easy to install as a direct replacement for existing RTUs. The end goal of this effort aims to make efficient RTUs common practice for all commercial replacement and new construction RTUs.

Equipment Types

This specification covers commercial packaged RTU with gas-fired furnaces that may or may not also provide ventilation air and/or cooling, in addition to space heating.

Also covered by this specification are specialized RTUs with the primary function of providing outside air to a building that are capable of heating and other air treatment of the outside air. Such systems include dedicated outdoor air systems (DOAS) which provide 100% outdoor air for building ventilation to maintain indoor air quality and make-up air units (MAU) which provide 100% outdoor air to offset exhausted or exfiltrated air to prevent negative pressure within a building.

Applications

Heating capacity and percent of outside air processed through the RTU are the primary application differences to support the heating and indoor air quality needs of commercial buildings. Outside ventilation air can vary from 0-100%. The RTUs with larger outside air percentages (>60%) include DOAS and MAUs.1 However, the majority of RTUs supply around 30% outside air or less for ventilation. The capacity of these units varies widely, but in the Northwest 80% of installed units have a capacity of 10 tons or less.[2]

Climate

This specification intends to ensure high performance in heating dominant climates,[3] or locations in North America within the International Energy Conservation Code climate zones 4 or higher,[4] herein referred to as "Northern climates."

Valuing Efficiency in RTUs (CSA P.8 Standard)

The most common efficiency metric used for commercial furnaces in the United States, thermal efficiency, focuses on the burner efficiency and therefore does not account for a variety of efficiency opportunities in RTUs. CSA Group, an international standards organization, is developing a new metric to better value efficiency in RTUs. This new metric serves as a valuable tool for NEEA and other efficiency entities to set meaningful performance targets for programs and guidelines.

CSA P.8 is a standard for thermal efficiencies of industrial and commercial gas-fired packaged furnaces published by the CSA Group. The CSA P.8 standard (Edition 3.0) is undergoing revisions which will include both a test procedure and a calculation method to calculate a new efficiency metric, the Total Heating Season

[1] Past NEEA research indicates DOAS and MAUs make up 6% of the installed RTUs and 12% of the installed RTU capacity in the Northwest.
[2] Northwest Energy Efficiency Alliance's 2014 Commercial Building Stock Assessment

Coefficient of Performance ($TCOP_{HS}$). $TCOP_{HS}$ includes factors that influence total equipment efficiency and energy consumption to better represent the energy an RTU will actually consume during the heating season.

These factors include burner efficiency, total enclosure heat losses, fan energy consumption, and heat gains from heat recovery. The new $TCOP_{HS}$ metric establishes a realistic, consistent point of comparison that includes all of the most important elements of RTU design that affect energy consumption. The performance path of this specification includes $TCOP_{HS}$ targets to allow for more flexible options in meeting each tier. While the CSA P.8 standard is not final at the time of this document, NEEA includes this performance path option to encourage manufacturers to adopt the $TCOP_{HS}$ metric early.

System Requirements

The following system requirements include two Efficient RTU Tiers. Additionally, each Tier can be met through one of two paths:

1. **A prescriptive path** defining specific RTU characteristic requirements.
2. **A performance path** using the CSA P.8 efficiency metric, $TCOP_{HS}$, to allow a manufacturer to meet efficiency requirements in the method best suited to their product line. While the CSA P.8 standard is not final at the time of this document, the calculation method is available for manufacturers to start using.

	Tier 1	Tier 2
Prescriptive Path	All Tier 1 efficient RTU requirements	Tier 1 efficient RTU requirements plus condensing furnace or heat/energy recovery
Performance Path (Draft)	$TCOP_{HS}$ > 0.70	$TCOP_{HS}$ > 0.80

Tier 1 Requirements

Tier 1: Prescriptive Path Requirements	
Thermal Efficiency	>=80% Thermal Efficiency[5]
Insulation	Cabinet shall be thermally insulated: • All panels (Door liners, top panels, divider panels, and mullions) adjacent to conditioned air, including the base, shall be fully insulated with a minimum of R-12 • Insulation exposed to supply air must either be cleanable foil-faced with sealed edges or be sealed within double-wall cabinet to ensure no insulation fibers enter the airstream

Outdoor and Return-Air Mixing Dampers	Damper leakage rate shall be no greater than the rate described in ASHRAE/IESNA 90.1-2019 Table 6.4.3.4.3
Tier 1: Performance Path Requirements	
$TCOP_{HS}$ (Draft)	>0.70, as measured by CSA P.8 – Edition 3.0

Tier 2 Requirements

The Tier 2 prescriptive path shall be met by meeting all of the Tier 1 requirements and having one of the following addition efficiency options:

1. A heat or energy recovery ventilator, or
2. A condensing heat exchanger

Tier 2: Prescriptive Path Requirements (in addition to Tier 1 Requirements)	
Condensing Furnace Requirements	
Thermal Efficiency	>=90% Thermal Efficiency[6] (condensing heat exchanger)
Heat or Energy Recovery Requirements	
Heat or Energy Recovery	The unit must be equipped with a heat or energy ventilator that that allows for energy recovery (sensible or total) between the exhaust and ventilation air steams
Tier 2: Performance Path Requirements	
$TCOP_{HS}$ *(Draft)*	>0.80, as measured by CSA P.8 – Edition 3.0

Other Requirements

- General
  - Unit shall meet Federal minimum standards and any other applicable local energy codes and standards.
  - Unit shall comply with all UL, NFPA, and local safety code requirements.

- Indoor Air Quality
  - Unit shall be equipped with a filter that has a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 as follows:
    - 2-inch Minimum MERV 7, Factory-Installed for use during construction
    - 2-inch pleated Replacement Set: Minimum MERV 8

- Filter compartment shall have a hinged, gasketed, access panel on one side of cabinet to allow for easy filter removal.

Design and Installation Guidelines

The following guidelines are not mandatory requirements to meet this specification but offer best practices for sizing and installation of RTUs.

- Sizing
  - The unit load and sizing should be calculated in accordance with the section "Load and Energy Calculations" from the most recent version of the ASHRAE Fundamentals Handbook.[7]
  - Unit should include roof curb or curb adapter appropriate for installation.

- Installation
  - For Condensing RTUs Only: Condensate Management
  - RTUs installed with a condensing heat exchanger should follow condensate management best practices specific to the application and location, identified in the report, "Condensing Gas Rooftop Unit Installation Tips and Best Practices," available at https://betterbricks.com/resources/condensing-gas-rooftop-unit-c-rtu-installation-tips-and-best-practices.

- REVISED SEPTEMBER 3, 2021 -

Compliant Equipment

The following currently available Efficient Gas RTU equipment meets the minimum equipment performance requirements based on the Prescriptive Path tables above:

Manufacturer	Product Line / Model #	Customization Required
Tier 1		
Aaon	RQ	
Aaon	RN	
Aaon	RZ / RZ-A	With optional low leakage damper included
Daikin Applied	Rebel Applied / DPSA	
Daikin Applied	Rebel (16-28 tons cooling capacity sized units) / DPS	With optional low leakage dampers included
Greenheck	RVE (DOAS)	
Modine	Atherion (DOAS) / B/C/D	
Tempeff	RG (DOAS)	
Tier 2: Heat Recovery		
Aaon	RQ	With optional ERV included
Aaon	RN	With optional ERV included
Aaon	RZ / A	With optional low leakage dampers and ERV included
Daikin Applied	Rebel Applied / DPSA	With optional ERV included
Daikin Applied	Rebel (16-28 tons cooling capacity sized units) / DPS	With optional low leakage dampers and ERV included
Greenheck	RVE (DOAS) / RVE	ERV is standard a component
Tempeff	RG (DOAS)	ERV is standard a component
Tier 2: Condensing		

Appendix F. List of Efficient RTU Benefits

Efficient RTU Benefits List

Generic benefits:

Engineered for performance

High performance design

Highly flexible and configurable

Customizable cabinet provides design flexibility and eliminates the need for transition curbs

Improved thermal comfort

Maximum energy efficiency

Energy efficient humidity control and dehumidification

High quality ventilation at the highest efficiency

Energy recovery wheels save cooling and heating costs

Low total lifecycle cost

Frost resistant

Low maintenance

Long-term performance

High efficiency filtration (MERV 13 efficiency rating)

Low-leakage dampers (meets 90.1 2019 and California Title 24)

Insulated cabinet reduces sound and improves energy efficiency

Double-wall construction provides strength and durability

Manufacturer Features/Benefits

Aaon (RQ and RN)	AAON RQ series rooftop units are engineered for performance, flexibility, and serviceability. Double wall rigid polyurethane foam insulated cabinet construction and direct drive backward curved plenum fans allow RQ series units to have quiet, energy efficient airflow with high static pressure capabilities. • Variable capacity and two step R-410A scroll compressors for load matching cooling and improved part load efficiency. • Multiple methods of humidity control including: High Capacity Cooling Coils and Modulating Hot Gas Reheat Humidity Control which provides energy efficient dehumidification, even with low sensible heat loads, without the temperature swings common with on/off reheat systems. • Modulating gas heat and SCR electric heat provide energy efficient, consistent supply air temperature heating and improved occupancy comfort. • Factory installed, sensible or enthalpy, gear driven economizer allows for free cooling. • Multiple high efficiency filtration options, with up to a MERV 14 efficiency rating. • Factory installed total and sensible AAONAIRE® energy recovery wheels save cooling and heating dollars. • Polymer e-coated coils are available to extend the life of the coils and protect them in corrosive environments. • Interior corrosion protection option protects interior components of the unit in corrosive environments. • ECM driven condenser fans for head pressure control, reduced power consumption and lower sound levels at off design RQ ambient conditions. AAON RN and RQ Series roof top units continue to lead the packaged rooftop equipment industry in performance and serviceability. Double wall rigid polyurethane foam insulated cabinet construction and direct drive backward curved plenum fans allow RN and RQ Series units to have quiet, energy efficient airflow with high static pressure capabilities. RN and RQ Series units also feature lockable hinged doors which provide service access to all sections of the unit. AMCA Certified and Labeled Low Leakage Dampers—Gear driven economizer eliminates the excess play and bind that occurs with linkage type economizers. Standard AMCA Certified and Labeled AAON Low Leakage Dampers meet the California Title 24 damper air leakage requirement.

Daikin Applied Rebel Applied / DPSA	Rebel Applied is an all-encompassing packaged rooftop solution that rises above its class with industry leading high-performance design, maximum energy efficiency, lowest lifecycle cost, and unlimited configurability. It features a modular, high-performance cabinet design that is unique to the market and delivers a reimagined product solution that enables engineers and contractors to design around their exact application. This is especially true of new construction and retrofit applications that require maximum energy efficiency, lowest total lifecycle cost, and unlimited configurability. Gain unprecedented configuration flexibility to fit new or retrofit applications, replacing Daikin and competitor rooftop units with Rebel Applied's no-transition curb and modular design - up to 37% shorter and 30% lighter than legacy applied rooftops. Turn to Rebel Applied for unmatched thermal comfort, humidity control, and dehumidification in your commercial and industrial applications. Rebel Applied is changing the landscape in the retrofit market. Its highly customizable modular cabinet gives you the flexibility to design around the exact application. It eliminates the need for transition curbs for many existing units in the field and is an ideal solution for retrofit applications. ***Highest Performance Design*** Capitalize on high-performance cabinetry featuring a Class 6 leakage rating at +/- 6" of static pressure (based on ASHRAE Standard 111) and a thermally broken design that eliminates energy-robbing direct conduction paths. ***Maximum Energy Efficiency*** Get superior efficiencies with EERs exceeding 11.0 and IEERs up to 17.0 by incorporating the latest in advanced technologies, such as EC motors and high efficiency scroll compressors that enable Rebel Applied to far exceed minimum energy efficiency requirements through 2023. ***Lowest Total Lifecycle Cost*** From installation through lifecyle maintenance, save money, time, and energy by qualifying for utility rebates with factory pre-commissioned controls, refrigeration monitoring sensors, ECM fans that eliminate belt/bearing maintenance, and Intelligent Equipment® controls for remote monitoring. ***Unlimited Configurability*** Gain unprecedented configuration flexibility to fit new applications or retrofit applications, replacing Daikin and competitor rooftop units with Rebel Applied's no transition curb, modular design that is up to 37% shorter and 30% lighter than legacy applied rooftops.

Greenheck RVE (DOAS)	A dedicated outdoor air system (DOAS) is a unit supplying cooled, dehumidified outside air to the building in summer and heated outside air in the winter. The system can also include a total energy wheel. An energy recovery wheel offers up to 80% total effectiveness reducing the heating and cooling capacity requirement of the DOAS unit significantly. Pre-engineered rooftop ventilators condition and deliver 100% outside air or mixtures of outdoor air and return air to a building. This unit is ideal for 100% outdoor air, variable air volume and single zone applications. The ERCH combines the benefits of the total energy wheel with supplemental cooling and/or heating. The result is a product that is specifically designed to condition 100% outdoor air to desired supply conditions. Model ERCH offers a wide variety of configurable options from intake and discharge orientations to factory tested and proven control sequences. Model ERT offers the benefits of a total energy wheel and cooling coil with a wrap-around heat pipe and/or heating. The result is a unit designed to be the most efficient product for conditioning humid outdoor air to near room conditions. DOAS systems offer control options for efficient operation including integration into building management systems. These controls come pre-programmed from the factory and are easily configured in the field. ***An Inverter Compressor*** An inverter compressor option is available from 3 to 70 tons. The inverter compressor provides many benefits. • Improved part load efficiency • Integrated Energy Efficiency Ratio (IEER) up to 22.1, with an average improvement over a digital scroll compressor of 15 to 20% • Reduced sound levels • Precise temperature and humidity control I ***An Air-source Heat Pump*** An air-source heat pump is available from 5-30 tons. This heating and cooling option offers: • High efficiency with an inverter compressor (standard feature) • Lead EC outdoor fan motor (standard feature) for modulating head pressure control • Coefficients of Performance (COP) ranging from 3-4, contributing to lower annual energy costs A ***High Turndown Furnace*** A high turndown furnace option is available on models RV and RVE. This high turndown is industry-leading technology for the tubular-style heat exchanger market. • Up to 16:1 turndown per furnace • Precise temperature control • Fully modulating control • Less cycling during part-load conditions • Commissioning sequence for easy start-up

Modine Atherion	The Modine dedicated outdoor air unit is the ideal solution to effectively and efficiently meet the challenge of conditioning high volumes of outside air for ventilation, regardless of your geographic location. Whether you are in the humidity-soaked air of the Southeast, in the drier, milder air of the West, or the wide four-season-variation of the upper Midwest and Northeast, the unit can be customized to meet your outside ventilation air requirements. With the Energy Recovery Exhaust option, your system is highly effective at recapturing energy from the building exhaust airstream, potentially saving thousands in annual energy costs. ***Refrigeration Circuit*** • Modulating digital scroll compressors standard for superior temperature control and part load efficiency with turndown as low as 12.5% for B- and C-Cabinet and 6.25% for D-Cabinet. • Modulating variable speed head pressure control regulates refrigerant pressure over a wide range of ambient conditions, provides energy savings, and if equipped, maximizes hot gas reheat capacity for excellent dehumidification at part load conditions. • Electronic expansion valve(s) provides superior superheat control and energy savings. • PF™ microchannel condenser coils from the company that invented them – Modine, reduces weight and refrigerant volumes. ***Heating*** • Modulating 81% thermally efficient natural gas heat is by far the most common heating system selected. This option includes a stainless steel heat exchanger as standard to ensure long life with up to 100°F temperature rise. ***Controls*** • Programmable microprocessor based system provide a wide range of application driven control strategies. • Controls are optimized for the equipment to maximize energy efficiency and performance through superior control and sequencing of all system components. • Easy-to-follow menu driven system that includes user level, service level, and manufacturer level password protection. • Operating hours by system (i.e. compressors, supply fan, etc.) along with easy to understand warnings and alarms greatly simplify equipment preventative maintenance. • Advanced diagnostic capability with real time display of refrigerant pressures, sensor temperatures, and sub cooling and superheat temperatures all but eliminates the need for a gauge set during troubleshooting. • Every unit undergoes rigorous end-of-line testing to verify proper operation of all systems prior to shipping.

	Construction • Robust 2" double-wall construction and standing roof seam for strength and durability (insulated on roof, walls, AND floor). • Pre-painted G90 galvanized steel with an attractive finish verified capable of withstanding a minimum 2,500 hour salt spray and fog atmosphere exposure in accordance with ASTM B117 test procedures • Full-length, piano-hinged access doors for accessibility and easy-to-open quarter-turn latches • Stainless steel, double-sloped drain pan prevents corrosion and avoids standing water for improved IAQ • Ultra-Low Leak AMCA Class 1A dampers. Leakage rate 3cfm/ft2 exceeds many stringent code requirements. • Energy efficient direct drive supply air plenum fans on neoprene vibration isolators with high total static pressure capability. • 2" MERV 10 fresh air filters standard

Tempeff RG (DOAS)	***Sensible Effectiveness*** Tempeff North America products employ Dual Core regenerative technology that offers up to 95% sensible effectiveness. Other available technologies offer a maximum of approximately 50% to 75% effectiveness under ideal circumstances, and much lower real effectiveness in colder temperatures due to frost. The Dual Core design is significantly more energy efficient in all conditions, thus payback periods are extremely attractive. ***Latent Recovery*** In winter modes condensation will form on the exhausting heat exchanger. When the cycle changes the outdoor air is passed over the heat exchanger, and that moisture is added back to the airstream. This reduces the need for adding humidity to the conditioned space. In many cases up to 70% latent recovery can be obtained. ***Frost Resistant*** Most heat recovery technologies suffer from the same basic drawback. In cold temperatures frost will form on the exhaust side of the heat exchanger, dramatically reducing the heat recovery effectiveness. If a defrost cycle is not employed, frost will build up until the entire heat recovery device becomes inoperable. During the defrost cycle the heat recovery device is usually bypassed, or put into a mode where effectiveness is significantly reduced so that the frost can melt. Thus in times where heat recovery is needed the most (ambient temperatures are coldest) the effectiveness of the device is the lowest. As a result, most technologies require additional heat capacity for these times, usually sized as if there is no heat recovery device at all to ensure the building does not experience periods where cold air is being introduced (during defrost cycles). In turn real effectiveness is greatly reduced increasing operating costs, equipment costs, and life cycle costs. The Dual Core design prevents frost build up in a typical application. With the Dual Core heat exchanger, one heat exchanger is always delivering conditioned air to the space. In many cases additional heat is not necessary for the ventilation air, due to the real effectiveness of the system! As a result operating costs, equipment cost, installation cost and overall life cycle costs are significantly reduced compared to traditional heat recovery technology ***Low Maintenance*** With few moving parts, maintenance of the system is very low. Due to cycling nature of the heat exchangers dust rarely builds up on the heat exchangers, thus frequent cleaning is not required. ***Long Term performance*** In a third party audit of a 17 year old installation, performed by CIT Energy Management AB, it was found that the efficiency of the equipment was the same as the day it was installed (90% measured temperature efficiency). Thus owners of Tempeff equipment can rest assured that they will enjoy the high performance of their system for a long time.

Appendix G. Assumptions Regarding Contractor Bids

HVAC Contractor Responsibilities:

1. Like for like base unit, Tier 1 unit & Tier 2 unit as referenced in System Requirements
2. Complete installation
    a. If the Efficient RTUs weighs more than the baseline we would want to know how much more that costs
    b. If roof load calculations are needed, it is okay to estimate what those could cost rather than actually doing the calculations.
    c. If they do feel they need to provide roof load calculations, itemize that in the bid so we can see cost.
3. Compliant Equipment PDF supplied with this document
4. No ductwork involved
5. Curb adapter roof sealant
6. Plenum connections
7. All condensate drainage and connection to existing sanitary waste
    a. Since we are not asking for bids for CRTUs, this should not be necessary.
8. Mechanical permitting
    a. This will depend on jurisdiction.
9. Refrigerant and oil recovery and disposal
    a. Assume all of the products are being replaced are at the end of their life so this cost should be inevitable and not included in the incremental cost.
    b. No need to Cost this out.
10. Local controls
11. System commissioning
12. Controls integration to existing EMS
13. Air balancing?
    a. Only if it's necessary
14. Commercial load calculation? (This is a time intensive exercise)
    a. We are assuming that what is already there is right-sized and so re-calculating isn't needed.
15. Economizer adjustments and settings
16. ERV/HRV adjustments and settings
17. Specifications and drawings of equipment to be submitted with bid

General Contractor Responsibilities:

18. Disposal of existing equipment
19. Providing disconnect and electrical connection to the disconnect
20. Heavy equipment services (i.e., crane)