



Commercial Baseline Study

HVAC Market Assessment

Final Report

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SECTION 1

Introduction

1 Introduction

This report presents the comprehensive findings from the Heating Ventilation and Air Conditioning (HVAC) market assessment. The HVAC market assessment is one of four assessments conducted by Opinion Dynamics (the “Market Evaluation Team”) as part of NYSERDA’s Commercial Statewide Baseline Study. The main goal of the HVAC market assessment was to characterize the market for commercial unitary air conditioning (AC) systems in New York State. This assessment was designed to (1) help NYSERDA set more accurate baselines for

energy efficiency programs, (2) aid public and private innovation in the commercial marketplace, and (3) support estimation of the potential for additional energy efficiency opportunities in New York.

To do so, the Market Evaluation Team worked with NYSERDA to develop eleven key research objectives and related metrics for this study. The Team grouped the eleven research objectives into six categories, listed in Table 1 below.

Table 1 | Key Research Objectives by Category

Category	Research Objectives
Commercial Unitary AC Market in New York	<ul style="list-style-type: none">• Penetration and average quantity/saturation of existing unitary AC equipment• Characteristics (age, capacity, and efficiency level) of existing equipment• Penetration and average quantity/saturation of energy efficient unitary AC
Market Channels	<ul style="list-style-type: none">• Key market actors• Factors influencing equipment decisions• Distributor stocking practices
Energy Efficiency Technology Trends	<ul style="list-style-type: none">• New and emerging HVAC technologies used to improve efficiency• Market actor practices and attitudes towards energy efficient systems and technologies
Installation and Maintenance Practices	<ul style="list-style-type: none">• Contractor and customer installation and maintenance practices
Market Trends	<ul style="list-style-type: none">• Unitary AC market trends over the past three years
Market Barriers	<ul style="list-style-type: none">• Market barriers to unitary systems installation

The findings from this research are presented in Section 2. The Market Evaluation Team developed these results based on 43 in-depth interviews with market actors, and data collected through a telephone/online survey and onsite visits with commercial customers, conducted as part of the Commercial Baseline Study.



SECTION 2

Market Characterization
and Assessment Results

2 Market Characterization and Assessment Results

2.1 Commercial Unitary System Market in New York

The HVAC market assessment focuses on unitary systems. The study defines unitary systems as air conditioning systems that include an evaporator/cooling coil, a compressor, and a condenser. They can be package or split systems. Rooftop units (RTUs) are a common type of package system that are usually installed on the roof. They are typically configured with constant speed supply fans that provide

ventilation at a set rate to meet ventilation needs when the building is fully occupied. Constant speed fans cannot adjust the ventilation rate for periods when the building is not fully occupied and there is a reduced need for ventilation. Split systems are air conditioning or heat pump systems that house the evaporator, compressor, and condenser in separate units that are connected by refrigerant piping.

AC SYSTEMS VS. HEAT PUMPS

There are two main types of split and package systems: air conditioner and heat pump. AC systems only provide cooling while heat pumps provide cooling and heating. In addition to functioning like a typical AC, heat pumps provide heat by reversing the direction of the refrigeration cycle to release heat into the conditioned space. Heat pumps are a newer technology and tend to be more energy efficient than AC systems.

In addition to characterizing the existing commercial unitary system market in New York State, the Market Evaluation Team also targeted emerging HVAC technologies such as variable refrigerant flow (VRF). Most VRF systems are heat pumps. They use refrigerant as a cooling and heating medium and are able to

operate in part-load conditions allowing them to be more efficient than standard air conditioning systems that provide more constant temperatures and humidity levels. Some VRF systems include heat recovery mechanisms that allow for simultaneous heating and cooling of different zones.

Engineer & Architect Interviews

“I think unitary systems have a higher growth rate than other type of system [sic] out there in New York. I think they’ve got the lion’s share of the market.”

The following sections characterize the commercial unitary system market in New York State in terms of equipment penetration, average quantities/saturation, and characteristics.

2.1.1 Penetration

Results of the Commercial Baseline Study show that 62% of businesses in New York State have unitary systems.¹ More businesses have split systems (36%) than package systems (29%).² Twelve percent of businesses have unitary heat pumps. Based on these penetration rates, more than 226,000 businesses in New York have at least one unitary system.³ As such, the energy savings potential from unitary HVAC systems in New York may be substantial.

Figure 1 presents the penetration of split and package systems by system type. Overall, AC systems are far more common than heat pumps. For split systems, the penetration of ACs is more than double the penetration of heat pumps (26% vs 12%). VRFs, a subset of split system heat pumps, are found in 2% of businesses in New York. In contrast, AC systems dominate the share of package systems compared to heat pumps (28% vs 2%).

PENETRATION, AVERAGE QUANTITY, AND SATURATION

PENETRATION is a percentage that represents the proportion of businesses that have one or more of a particular piece of equipment. It is calculated by dividing the number of businesses with one or more of a piece of equipment by the total number of respondents to that question.

AVERAGE QUANTITY refers to the mean number of a particular piece of equipment among businesses that have the equipment. It is calculated by dividing the total number of a particular piece of equipment by the total number of businesses that have the equipment.

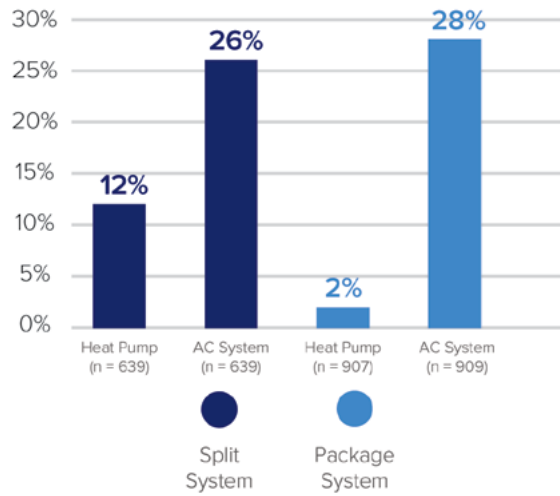
SATURATION is a number that represents how many of a particular piece of equipment are present, on average, among all businesses. It is calculated by dividing the total number of a particular piece of equipment by the total number of respondents to that question (including businesses that do not have the equipment).

¹ The unit of analysis of the NYSERDA Commercial Baseline Study is the “business,” which is defined as a unique company/organization at a unique location.

² Note that some businesses have both types of system. As a result, the sum of the penetration values of the two system types is greater than the overall penetration value.

³ Based on Commercial Baseline Study results, there are over 367,000 businesses in the segments included in the study (i.e., office, retail, grocery, warehouse, lodging/hospitality, food service, health services/hospitals, and education).

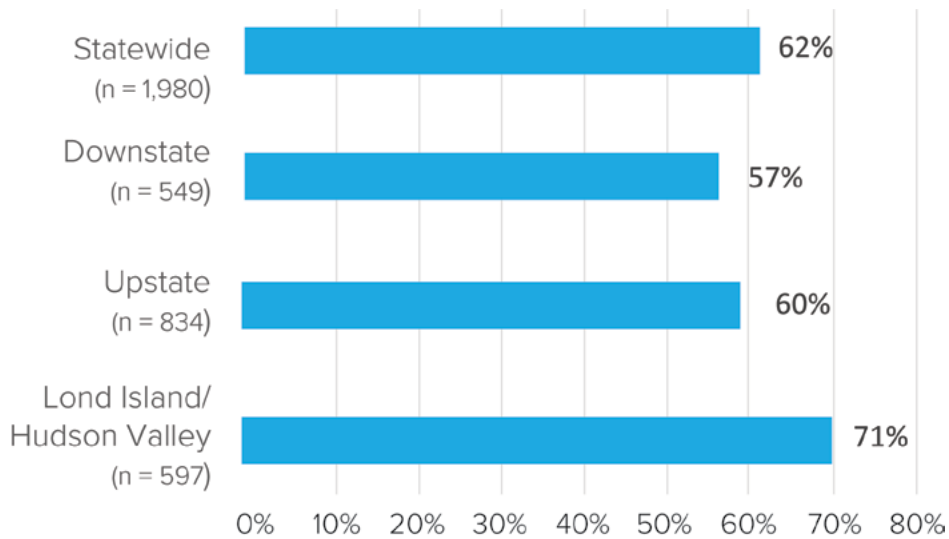
Figure 1 | Penetration of Unitary Systems by Type



The penetration of unitary systems varies by geographic region (see Figure 2). Penetration is the highest in the Long Island/Hudson Valley region (71%), followed by the Upstate (60%) and Downstate (57%)

regions. According to market actors, unitary systems are less common in taller buildings, most prevalent in the Downstate region, that tend to use chillers and cooling towers to cool multiple floors vertically.⁴

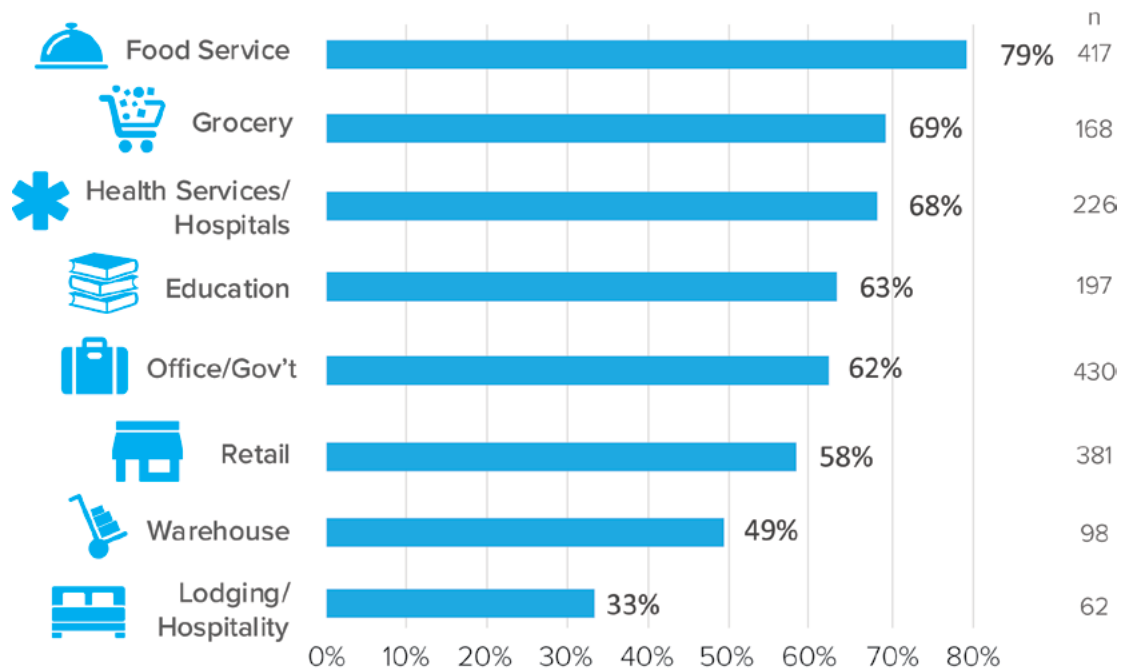
Figure 2 | Penetration of Unitary Systems by Region



⁴ Based on Commercial Baseline Study results, the mean number of stories of commercial buildings in the Downstate region is 4.8 compared to 1.7 in the Upstate region and 1.6 in the Long Island/Hudson Valley region.

There are also notable differences in the penetration of unitary systems by business segment, with the food service segment having the highest penetration (79%, see Figure 3). Penetration is the lowest in the lodging/hospitality segment (33%) where packaged terminal air conditioners – single, self-contained units installed through a wall – are a popular choice due to their smaller size, low cost, and ease of installation.

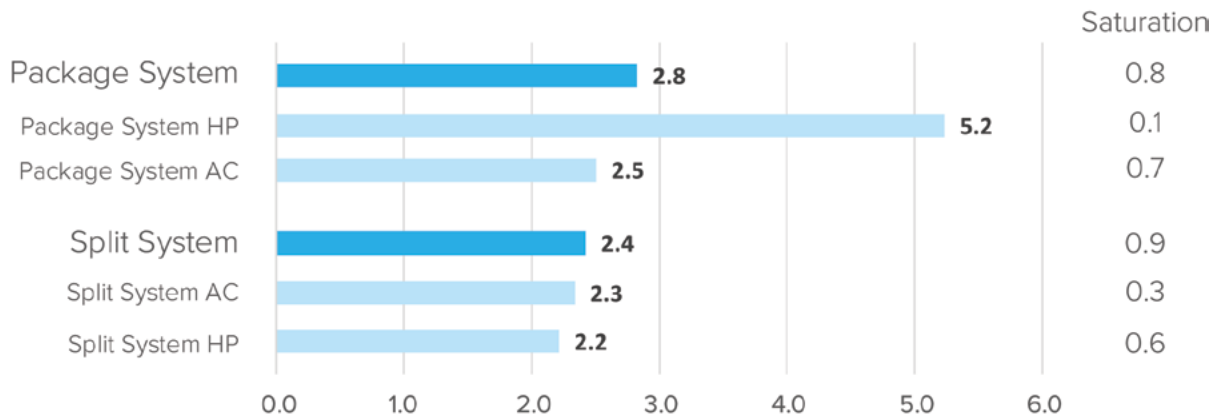
Figure 3 | Penetration of Unitary Systems by Segment



2.1.2 Average Quantity/Saturation

On average, New York businesses have 5.2 unitary systems (saturation of 1.7) and similar numbers of split and package systems (2.8 and 2.4, respectively; see Figure 4). Two-thirds of split systems are AC systems while the vast majority of package systems are AC systems.

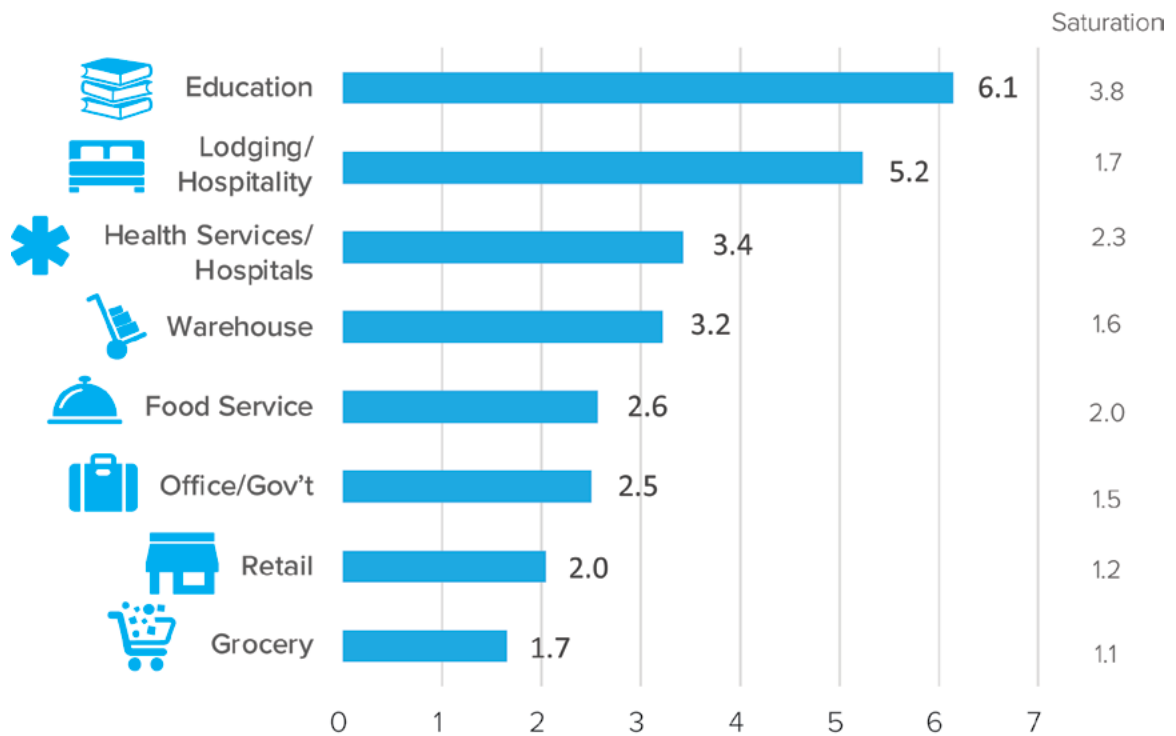
Figure 4 | Average Quantities and Saturation of Unitary Systems by Type



Since size is a key driver of the number of HVAC units, medium/large businesses have more unitary systems (4.7 per business; saturation of 3.6) than smaller businesses (0.6 per business; saturation of 1.2), and segments with larger businesses have more unitary systems than segments with smaller businesses. For example, the

average square footage of businesses in the education segment is nearly four times the square footage of an average business in New York (44,592 square feet compared to 12,705 square feet), and the education segment has the highest average quantity of unitary systems, with 6.1 per business (saturation of 3.8).

Figure 5 | Average Quantities and Saturation of Unitary AC by Segment



2.1.3 Characteristics of Unitary AC

The baseline study also gathered data on key unitary equipment characteristics that impact energy consumption including age, cooling capacity, and cooling efficiency. Table 2 provides a summary of mean values at the statewide level. A comparison of package and split system shows:

- Package systems tend to be slightly older than split systems (12.0 years compared to 10.2 years).
- Because package systems generally serve larger spaces than split systems, their cooling capacity is more than double the size of split systems.
- The average efficiency of package systems is slightly lower (10.8 EER) than that of split systems (11.5 EER). This difference is correlated with system age (newer systems tend to be more energy efficient), system capacity (cooling efficiency decreases with increasing capacity), and system type (heat pumps tend to be more efficient than AC systems and account for a larger share of split systems than package systems).

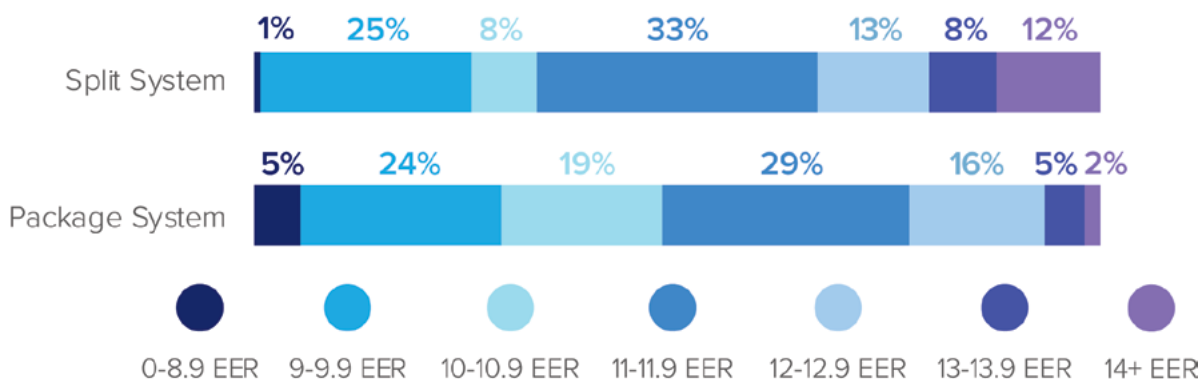
Table 2 | Characteristics of Split and Package Systems

	Split Systems		Package Systems	
	Mean	n	Mean	n
Age of Units (Years)	10.2	247	12.0	181
Cooling Capacity (Tons)	3.2	276	8.7	171
Cooling Efficiency (EER)	11.5	218	10.8	117



Figure 6 provides additional detail on the cooling efficiency of split and package systems: 33% of split systems have an efficiency rating of 12 EER or higher, compared to 23% of package systems, and 12% of split systems have an efficiency rating of 14 EER or higher, compared to only 2% of package systems.

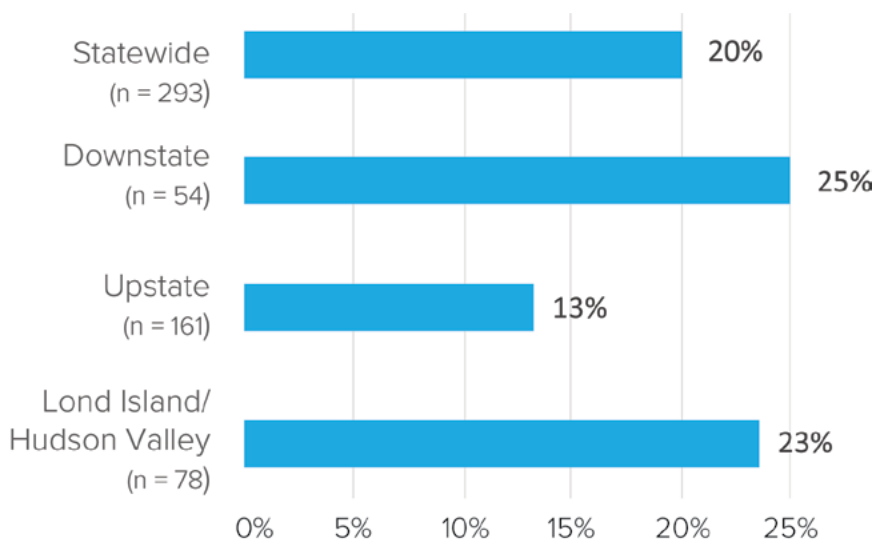
Figure 6 | Split and Package System Cooling Efficiency



Another useful way to assess cooling efficiency is relative to efficiency thresholds, such as ENERGY STAR® and Consortium for Energy Efficiency (CEE) standards. The Market Evaluation Team classified units observed as part of the Commercial Baseline Study as “efficient” based on ENERGY STAR® minimum energy efficiency criteria for unitary equipment (based on equipment type, ranges of cooling capacity, and heating section type).⁵ In cases where ENERGY STAR® specifications were not available, the Team used the 2019 Consortium for Energy Efficiency (CEE) Tier 1 standards.⁶

Based on this analysis, 20% of businesses in New York State have at least one energy efficient unitary system. Penetration of energy efficient unitary equipment varies by geographic region, with 25% of businesses in the Downstate region but only 13% in the Upstate region having efficient systems (Figure 7).

Figure 7 | Penetration of Energy Efficient Unitary AC Systems by Region

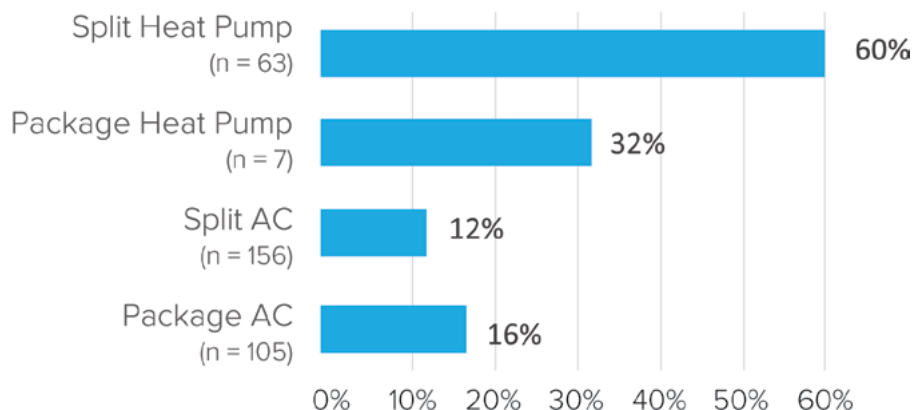


⁵ ENERGY STAR® Program Requirements for Light Commercial HVAC, Version 3.1, March 2017.

⁶ Consortium for Energy Efficiency (CEE), 2019 Commercial Unitary Air Conditioning and Heat Pumps Specification.

As a percentage of all units, split heat pumps have the highest share of energy efficient units while split AC systems have the lowest share (60% compared to 12%, respectively; see Figure 8).

Figure 8 | Share of Energy Efficient Unitary Equipment by Type



2.2 Market Channels

The commercial unitary market in New York State is highly competitive for manufacturers. Market actors characterized manufacturers of split and package systems as competing within two tiers: higher-end (with higher price points) and lower-end (with lower price points). In addition to prices, higher-end or lower-end is associated with the quality of equipment, reliability, technical support, availability of parts, and brand reputation. Market actors identified higher-end manufacturers as Trane®, Carrier®, York®, Daikin®, and Lennox® while lower-end manufacturers

include Goodman® and Rheem®.

Figure 9 provides the estimated market shares for the top six manufacturers of split and package systems in New York State based on market actor interviews. Trane and Carrier are the top manufacturers in New York State and account for up to 80% of the total market share. The New York State market shares align closely with market share reported in a recent rooftop market characterization study conducted in the Northwest region.⁷

Figure 9 | Top Manufacturers of Split and Package Systems



⁷ Evergreen Economics. February 16, 2017. Rooftop HVAC Market Characterization Study. Northwest Energy Efficiency Alliance.

2.2.1 Demand for New HVAC Equipment

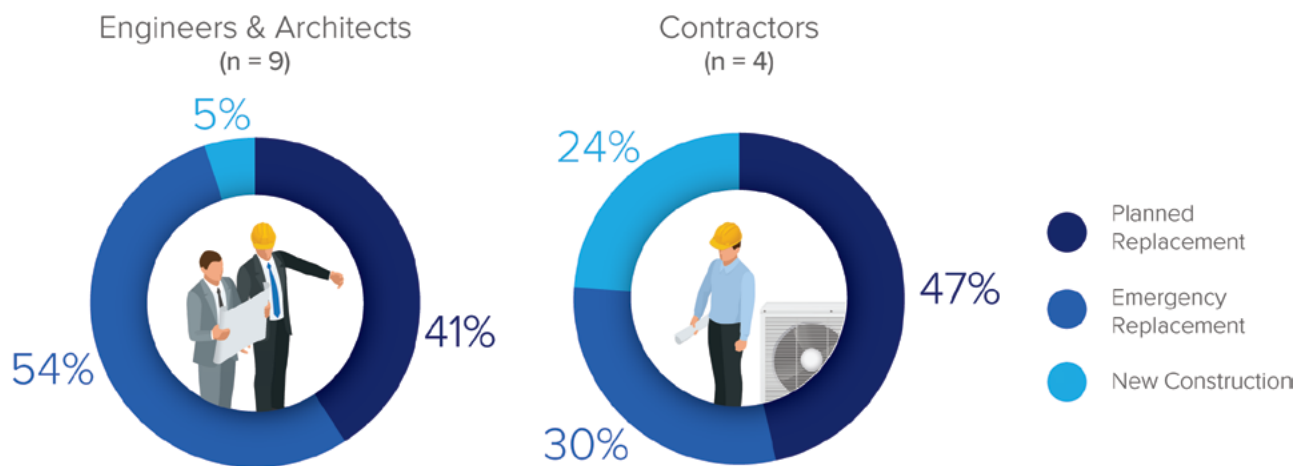
Demand for new HVAC equipment falls into three categories:

- New construction projects involve installing new HVAC equipment in new buildings.
- Planned replacement includes the replacement of existing equipment that is nearing the end of useful life, replacement of equipment that does not fit the functionality of the new space following renovation,⁸ and early retirement of older inefficient equipment.

- Emergency replacement involves the immediate replacement of existing equipment that has failed.

Figure 10 presents the distribution of projects for each demand type as reported by four engineers/architects and nine contractors.⁹ The interviewed contractors reported working on all types of projects while the engineers and architects reported rarely worked on emergency replacement projects.

Figure 10 | Sources of Demand for New HVAC Equipment



⁸ For this study, The Market Evaluation Team considered major renovations as planned replacement projects.

⁹ Note that results are based on a small number of market actors and are largely influenced by the types of services they provide.

2.2.2 Factors Influencing Equipment Decisions

According to market actors, the factors influencing equipment decisions vary considerably for each category of demand. HVAC system design and installation for new construction and planned replacement projects tend to follow a “plan and spec” or “design build” approach:

PLAN AND SPEC: The end-user hires an engineering or architectural firm to design and specify HVAC equipment based on budget, building structure, cooling and heating needs, minimum efficiency levels, and comfort. The specified HVAC equipment goes through a competitive bidding process where mechanical contractors respond to requests for proposal (RFPs) and submit quotes for installing the equipment and related services. Contractors will sometimes meet with end-users and conduct site meetings to better-understand customer needs. When the pricing for the specified equipment exceeds the project budget, engineers will have to redesign the system, or contractors will re-bid the project based on their own designs. Decision-making for these installations is generally driven by price, indicating initial cost as a main barrier to the adoption of higher efficiency equipment.

DESIGN BUILD: The end-user hires a design-build firm that has in-house engineers and contractors to design and install the HVAC system. This streamlined process allows contractors to execute projects in a more cost-effective and timely manner. These firms tend to be focused on building strong relationships with clients and have more input in the decision-making process.

Engineers and contractors indicated that for most replacement projects (both planned and emergency) it is easier and less costly to replace the existing HVAC equipment with equipment of the same type (e.g., to replace a rooftop unit with another rooftop instead of removing existing ductwork to install a ductless VRF system). Two contractors said that rooftop installations can be completed in as little as two days whereas VRF systems are more complex and may require up to two weeks to install. The additional installation time adds considerably to the project cost and increases the burden placed on customer’s time and business operations when replacing existing equipment.

Contractors also noted that when replacing a standard rooftop unit with a higher efficiency unit, they would typically need to install a curb adaptor due to differences between the standard and higher efficiency unit in terms of equipment size and construction. The curb adaptor will properly support the weight of the new RTU and connect the unit with the existing supply and return ducting. Adding a curb adaptor to the project scope increases project costs and may delay installation if the necessary curb adaptor is not stocked by distributors.

⁵ A rating of 5, 6, or 7 on a scale of 1 to 7, where 1 means “not a barrier” and 7 means “very large barrier.”

Not surprisingly, all interviewed market actors named initial cost as the primary factor that drives customer decisions. Upfront cost is especially important for new construction projects where building owners or developers are highly focused on completing the building projects within budget. One contractor reported that without incentives, higher efficiency models are on average 10% to 15% more expensive than standard models.

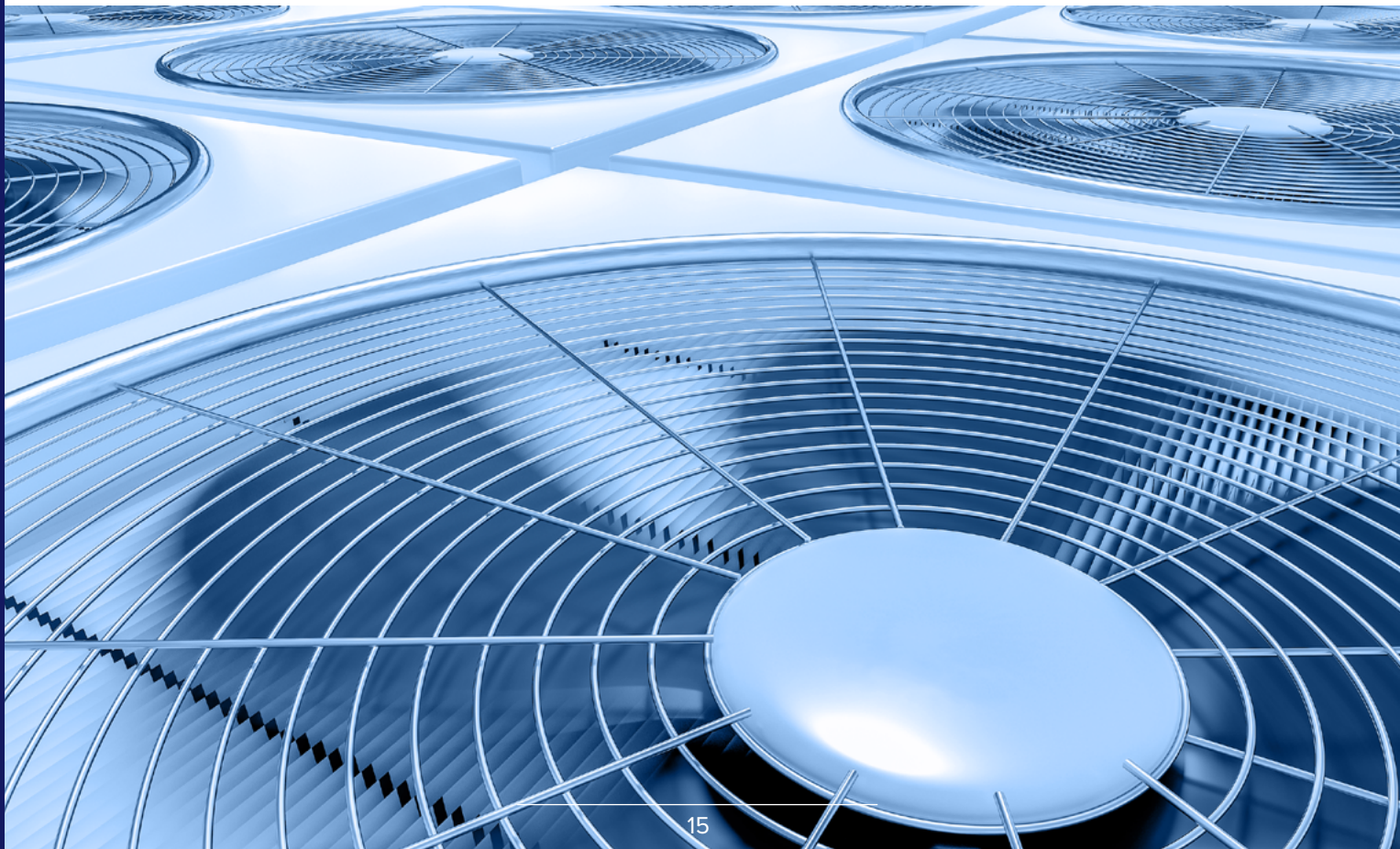
Split incentives are another barrier to the adoption of higher efficiency HVAC

systems, identified by four interviewed market actors. Split incentives occur when building owners make capital investment decisions that can impact tenants who are responsible for paying energy bills. Building owners may be less inclined to invest in higher efficiency HVAC equipment if tenants benefit from energy savings.

As expected, customers also care about reliability and ease of maintenance of HVAC systems. Finally, customers are also concerned with visibility, noise, and comfort level of the equipment.

Contractor Interviews

“[I]f the math makes sense that’s probably what’s going to drive most of the decision making process so incentives for [customers] to purchase a higher efficiency piece of equipment and be rewarded by making that choice is [sic] probably been the single most contributing factor.”



2.2.3 Distributor Stocking Practices

Commercial unitary equipment is typically distributed through wholesale distributors or manufacturer representatives. Based on our interviews with manufacturers and distributors, stocking practices are largely based on historical sales, code compliance, customer and market needs, and available incentives. The distributor market is divided into those who sell a mixture of code-compliant and higher efficiency (above code) equipment and those who sell exclusively or almost exclusively minimum efficiency equipment. Companies that stock higher efficiency products are interested in providing customers (mostly contractors) with value-based services, such as in-house technical support. In contrast, distributors who primarily stock baseline efficiency equipment are mostly focused on lower prices driving a higher volume of sales.

Of the five distributors interviewed for this study, one distributor stocked 100% baseline unitary equipment while the other four reported that between 87% and 98% of the units in stock were baseline efficiency. On average, the interviewed distributors stocked 93% of their inventory with baseline equipment and only 7% with higher efficiency products. When asked about the motivation behind this stocking practice, distributors reported that contractors typically prefer standard equipment over higher efficiency products because they are cheaper. In addition, higher efficiency products are difficult to stock because they tend to come in different capacities and configurations and can require highly customized installations.

Contractor Interviews

“We find people are interested [in higher efficiency equipment], but the lead time on the high efficiency equipment is longer than the people can wait, so we end up settling for the lower efficiency.”

Market actors reported that because distributors do not have a large selection of energy efficient units in stock, there is a longer lead time for higher efficiency equipment. If a contactor wants to purchase a unitary AC system that is not stocked by the distributor, they would have to create a special order that would require an average of eight weeks to deliver from the

factory. These stocking practices present a barrier to energy efficiency in emergency replacement projects where customers are looking to replace the failed equipment immediately. One contractor reported that the turnaround time for emergency replacements is usually three days and cannot exceed a week.

2.3 Energy Efficiency Technology Trends

Understanding new and emerging HVAC technologies used to improve the efficiency of unitary systems can help NYSERDA target specific opportunities to affect market change. The Market Evaluation Team asked market actors

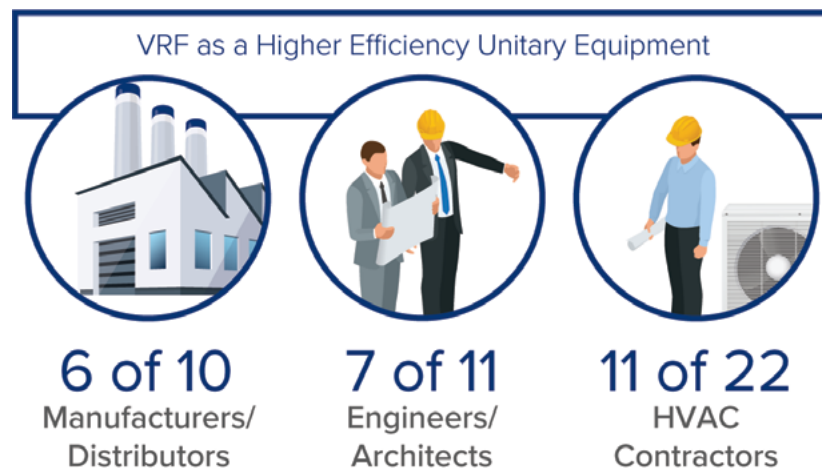
about higher efficiency unitary equipment such as variable refrigerant flow (VRF), as well as technologies used to improve the efficiency of existing unitary systems, such as HVAC controls.

2.3.1 VRF Technology

Based on Commercial Baseline Study results, only 2% of New York businesses currently have VRF technology. However, more than half of the interviewed market

actors (24 of 43) identified VRF as a growing HVAC technology in the New York State commercial market (see Figure 11).

Figure 11 | VRF Technology



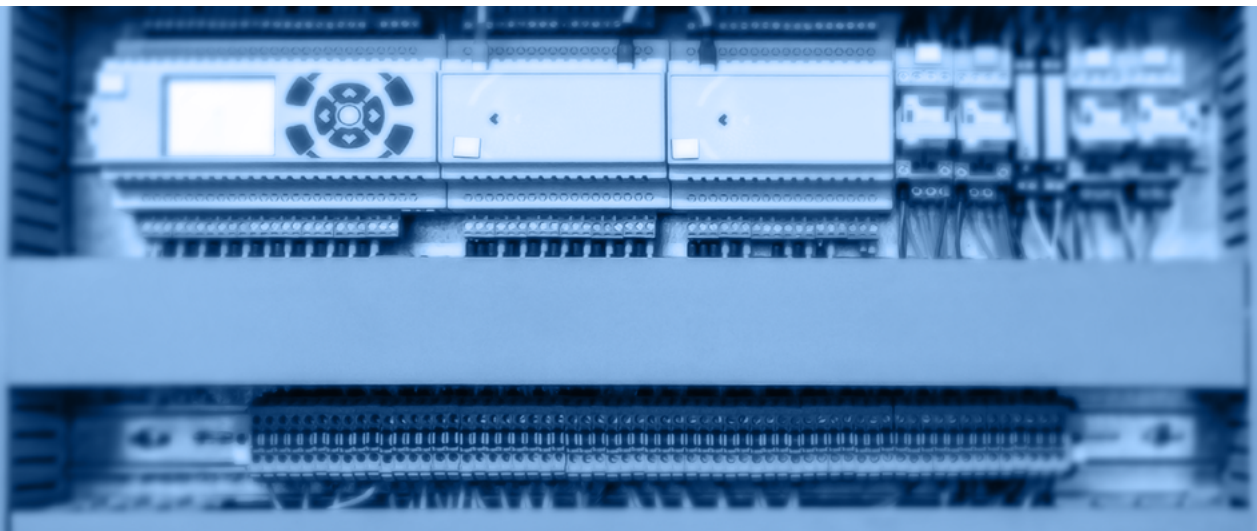
In general, engineers and contractors expressed positive views of VRF technology and highlighted the level of efficiency, comfort, and controllability provided by VRF systems. Two market actors estimated that VRF systems can achieve on average 25% energy savings compared to conventional AC systems.¹⁰ VRF systems are quiet and allow building occupants to control each room individually which further increases occupant comfort. Since VRF systems do not require ductwork like RTUs, end-users will have additional usable space such as higher ceilings. Finally, according to five interviewed manufacturers and contractors, VRF systems are easier to maintain as the systems tend to have less components compared to RTUs. The general

maintenance practice for VRF systems is to clean filters quarterly and outdoor coils once a year whereas most RTUs require tuning and cleaning of equipment at least two times a year.

While VRF systems have been a dominant technology in Asia and Europe, they are an emerging, but growing, technology in New York State and nationwide. Several HVAC market studies – such as the forthcoming Northeast Energy Efficiency Partnership (NEEP) study,¹¹ a Northwest Energy Efficiency Alliance study,¹² and a Bonneville Power Administration study¹³ – reported that VRF technology has become increasingly popular with customers in the US.

HVAC Manufacturer Joint Ventures

Top manufacturers such as Trane® and Carrier® have established joint ventures with leading VRF manufacturers to meet the strong demand for VRF. On January 17, 2018, Trane® announced a joint venture with Mitsubishi Electric® for ductless and VRF heating and cooling systems. Similarly, Carrier® established a joint venture with Toshiba® on August 23, 2018.



¹⁰ Savings depend on cooling fuel type and hours of use.

¹¹ Badger, Chris. "NEEP VRF Market Transformation Strategies Report." 2019 Air Source Heat Pump Market Transformation Workshop.

¹² Evergreen Economics. February 16, 2017. *Roof-top HVAC Market Characterization Study*. Northwest Energy Efficiency Alliance.

In addition, utilities and state agencies in the Northeast have begun to recognize the substantial opportunity for VRF and are supporting the adoption of VRF through incentive programs:

- The Mass Save® Upstream Commercial and Industrial (C&I) HVAC Program has paid over \$1 million dollars in incentives to support the installation of nearly 1,000 VRF systems in commercial and industrial facilities.¹⁴
- The Massachusetts Clean Energy Center (MassCEC) launched a commercial VRF Program in May 2017 to develop the VRF market and decarbonize heating in commercial buildings. This program has awarded nearly \$6 million in incentives across 107 projects.¹⁵
- In New York State, the Consolidated Edison C&I Energy Efficiency Program offers incentives for VRF systems.¹⁶

Engineer & Architect Interviews

“[VRF systems] are enormously popular and the easier they are to install, the more likely it is that contractors will want to install them.”

Four out of ten interviewed distributors and manufacturers reported rapid growth of the VRF market in New York State due to increased awareness and competition. According to one manufacturer, sales of VRF systems have doubled in the last 3 to 4 years with an average annual growth of 20%. One leading HVAC distributor in New York estimates that their VRF business is increasing by 30% each year. The growing market presence of VRF systems has created competition among VRF manufacturers and distributors that is driving innovation of new features, and education and training targeted at end-

users and contractors. One interviewed manufacturer reported that the number of VRF manufacturers has grown from 3 to 12 in the past few years. Based on interviews with engineers and contractors, VRF technology is becoming more popular and accepted in the New York City metropolitan area and Long Island. However, two engineers and one contractor explained that VRF technology is less accepted in upstate New York, which experiences extreme low temperatures more frequently. VRF may not provide sufficient heating when temperatures fall below zero degrees Fahrenheit.

¹³ Bonneville Power Administration. April, 2016. *HVAC Market Intelligence Report*.

¹⁴ Kyle Coumas. “*Mass Save and National Grid Rhode Island C&I Upstream HVAC Program Insights*.” 2019 Air Source Heat Pump Market Transformation Workshop.

¹⁵ Peter McPhee. “*MassCEC VRF Program: Lessons Learned from 2 Years in the Field*”. 2019 Air Source Heat Pump Market Transformation Workshop.

¹⁶ *The Consolidated Edison Commercial and Industrial Energy Efficiency Program Manual 2019, V1.1*.

According to a 2016 Consortium for Energy Efficiency (CEE) report,¹⁷ VRF manufacturers include Mitsubishi® Electric, Daikin®, Fujitsu®, GD Midea Heating & Ventilating Equipment Co. Ltd., Lennox®, LG®, Panasonic®, SANYO®, Samsung®, and Carrier®. Market actors did not provide market shares for VRF manufacturers but identified the leading manufacturers of VRF technology in New York State as Mitsubishi®, Daikin®, and LG®.

Some of the main barriers to VRF technology experienced by engineers and contractors are high upfront cost, poor heating performance at very low temperatures, difficult reconfiguration once installed, inability to provide fresh air intake, and complex installations. VRF systems typically cost more than traditional unitary equipment and require custom engineering that further increases upfront cost. Two engineering firms located in upstate New York expressed negative experiences with VRF installations that were insufficient

in providing heating at below-zero temperatures and required a secondary backup heating source. When customer heating and cooling needs change, engineers indicated that it is difficult to reconfigure or expand an existing VRF system because refrigerant lines are sized very specifically. Another challenging aspect of designing VRF systems is the need to provide fresh air intake which is required by New York State building codes in commercial spaces. VRF systems do not provide ventilation on their own and require a separate ventilation system to be installed. A common solution to the issue is the installation of energy recovery ventilators (ERVs) to supply fresh air. Finally, market actors indicated that VRF systems are complex and more challenging to install due to additional system components such as refrigerant piping. Therefore, it is crucial that contractors have the proper education and training in order to install the systems correctly.

Contractor Interviews

“I would say the [HVAC contractor] industry as a whole, a lot of people are out there performing services that aren’t properly trained for it.”

¹⁷ Jensen, Bjorn. January 12, 2016. [High Efficiency Commercial Air-Conditioning and Heat Pumps Initiative](#). Consortium for Energy Efficiency (CEE), accessed August 23, 2016

2.3.2 HVAC Controls

HVAC controls are auxiliary devices that facilitate the efficient use of HVAC equipment by adjusting equipment setpoints and runtimes to better match HVAC supply and demand within a facility.

MAJOR TYPES OF HVAC CONTROLS

Manual On/Off Controls require the user to turn the equipment on when in use and off when not in use.

Manual Thermostats allow the user to set the temperature by manually turning a dial or moving a lever; the temperature setting only changes when the user adjusts the thermostat.

Programmable Thermostats use the built-in calendar and clock to adjust the temperature according to programmed settings by day and time but are not Wi-Fi-connected. These thermostats are also called “setback thermostats” or “clock thermostats.”






Smart/Wifi Thermostats have all functionalities of a programmable thermostat but can also connect to the Internet, allowing the user to remotely adjust the temperature. Some automatically tailor settings based on occupant preferences, heating system type, and/or outdoor temperature.

Energy Management Systems (EMS) consist of centralized hardware and software. They are used for monitoring and/or controlling heating, ventilation, air conditioning, and lighting at a building-wide level to optimize energy use and occupant comfort.



Businesses in New York use various types of technology to control HVAC equipment, ranging from manual on/off switches to energy management systems (EMS). More than half of businesses (53%) have programmable thermostats, but very few have advanced controls such as Smart/Wifi Thermostats or EMS (see Table 3).

Table 3 | Penetration of HVAC Controls

	Has Equipment	Used for Cooling	Used for Heating
 Manual On/Off	18%	15%	8%
 Manual Thermostat	39%	25%	35%
 Programmable Thermostat	53%	47%	48%
 Smart/Wifi Thermostat	5%	4%	4%
 Energy Management System (EMS)	3%	2%	2%
Other	2%	1%	1%

The main technology recommended by engineers and contractors to improve the efficiency of existing systems is HVAC controls. Nine interviewed contractors and engineers reported recommending WiFi thermostat controls and HVAC controls integrated into building management systems (BMS). Three contractors estimated energy savings from installing controls ranging from 10% to 50%, with an average of 24%. One engineer recommended training building operators to properly use the controls to prevent them from accidentally overriding the programming and to ensure long-term effectiveness of controls.

One distributor reported that the HVAC controls market is changing because manufacturers are developing new plug

and play BMS software instead of software that has traditionally been proprietary. In addition, many manufacturers are creating Fault Detection Diagnostics (FDD) to monitor system operation, identify issues affecting occupancy comfort and energy efficiency, and provide recommendations for corrective action. According to an Institute for Building Efficiency report,¹⁸ traditional BMS systems use alarms to notify building operators of issues after they have occurred, but building operators would have to complete their own analyses to determine the cause of the issues. In contrast, FDD systems identify non-critical irregularities (e.g., faulty sensors) that can affect system performance, so facility managers can detect a problem before it happens.

Manufacturer & Distributor Interviews

“The whole advancement of electronics both on the control side and on the diagnostics and equipment monitoring side is really going to help drive the efficiency.”



¹⁸ Managan, Katrina. October, 2013. Fault Detection and Diagnostics. Enabling techno-commissioning to ease building operation and improve performance. Institute for Building Efficiency, an initiative of Johnson.

2.3.3 Recommending Higher Efficiency Technology

End-users rely on engineers and contractors to provide HVAC solutions that meet their unique needs. Therefore, engineers and contractors are important market actors who can influence the end-user to invest in higher efficiency unitary solutions. The Market Evaluation Team asked engineers/architects and contractors about the degree to which they offer or sell higher efficiency energy efficient systems and technologies and recommend standard efficiency equipment only as a second option.

Compared to contractors, engineers are more likely to recommend higher efficiency systems and different types of unitary systems. Customers hire engineering firms for value engineering and to apply their expertise to more complex projects. According to interviewed engineering firms, approximately 65% of customers incorporate some type of higher efficiency technology recommended by engineering firms.

Contractors are less likely to recommend higher efficiency systems and technologies compared to engineers because they want to be competitive in their bidding price and are often working with clients who are looking to complete a project quickly. Interviewed contractors reported a wide range of customers – between 10% and 100%, with an average of 51% – that adopt higher efficiency technologies when they are recommended by the contractor. Study findings indicate that while contractors play an important role in influencing customer decisions for the replacement market, they are generally not pushing for higher efficiency options.

According to four market actors, “old school” engineers and contractors who have been in the HVAC business for a long time tend to stay with the traditional “tried and true” unitary equipment and are less likely to recommend newer technology such as high efficiency equipment, controls, or VRF systems.

Contractor Interviews

“I’m an old school contractor. I still look at the split systems and ... the rooftop units. It’s what we know; it’s what we’re best at; so I always try and push that first.”

2.4 Installation and Maintenance Practices

Contractors follow mandatory statewide codes including the Uniform Fire Prevention and Building Code (Uniform Code)¹⁹ and the New York State Energy Conservation Construction Code (NYSECCC)²⁰ for all HVAC projects. Certain types of projects may require contractors to follow additional guidelines. For example, contractors follow Article 28 of the Public Health Law²¹ and Facility Guidelines Institute's (FGI) Guidelines for construction projects in the healthcare segment (e.g., hospitals, medical offices, nursing homes, etc). ENERGY STAR[®] also provides quality installation practices for contractors installing ENERGY STAR[®]-certified HVAC equipment.

In addition to HVAC codes and standards, contractors can also receive training from manufacturers and distributors on how to install specific HVAC equipment. One contractor reported having an in-house

training facility that staffs a North American Technician Excellence (NATE)-certified trainer to train employees. The contractor also stated that their employees are a part of a national training certification for heating and air conditioning.

In terms of maintenance practices for HVAC equipment, contractors generally follow guidelines from manufacturers. The specific maintenance needs may vary depending on the specific needs of the system. Maintenance services can occur from two to four times a year. Typical services include replacing air filters, cleaning evaporator and condenser coils, cleaning drain lines and pans, and inspecting and replacing other parts that are showing wear and tear. Contractors emphasized that lack of regular maintenance can result in equipment failures that can be costly to repair due to the unplanned downtime of equipment.

Maintenance Checklist:

- ✓ Change air filters
- ✓ Clean evaporator & condenser coils
- ✓ Clean drain lines & pans
- ✓ Check condition of fans & belts
- ✓ Check thermostat & controls
- ✓ Check temperature readings
- ✓ Check electrical connections
- ✓ Check refrigerant charge



¹⁹ New York State Department of State, *2016 Uniform Code Supplement*, March, 2016.

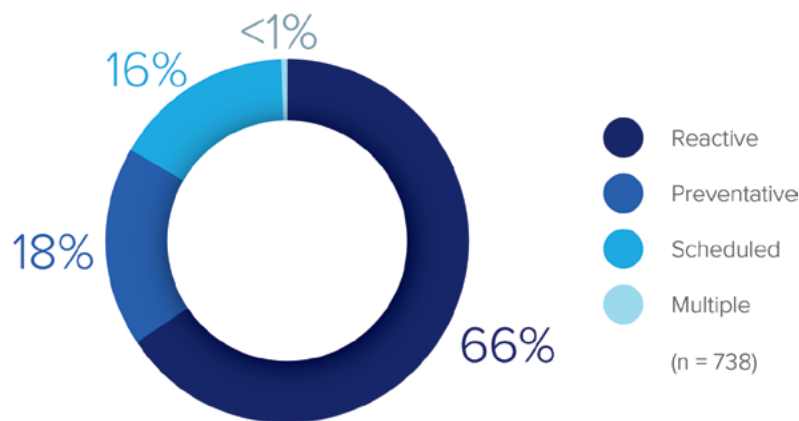
²⁰ New York State Department of State, *2016 Supplement to the New York State Energy Conservation Construction Code*, March, 2016

²¹ New York State Department of Health, Public Health Law, Article 28.

²² Facility Guidelines Institute, *State Adoption of the FGI Guidelines*

In contrast to contractors' recommendation for regular maintenance, most customers wait until their HVAC systems break down before calling for repairs: Two-thirds (66%) of New York businesses have a reactive approach to equipment maintenance, i.e., they service or repair equipment when it breaks (see Figure 12). About a third of businesses have either a preventative (staying ahead of potential issues before they become more significant) or scheduled (following all manufacturer recommendations) maintenance approach. Less than one percent of customers have multiple maintenance approaches.

Figure 12 | Customer Maintenance Practices

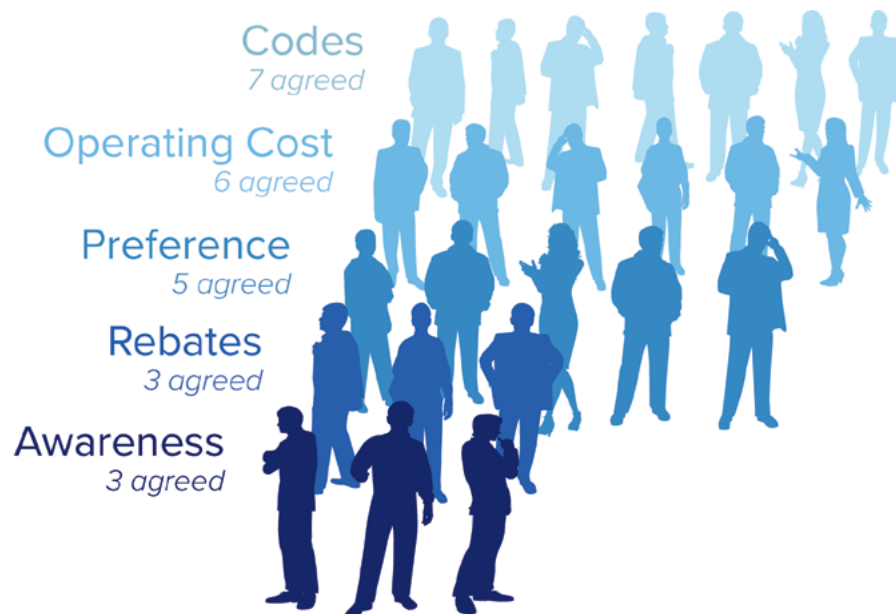


2.5 Market Trends

Market trends help characterize growth in the HVAC industry and can help NYSERDA focus on where to direct resources to influence market transformation.

The Market Evaluation Team asked market actors if the overall sales of higher efficiency unitary AC systems have increased, decreased, or stayed the same over the past three years. Out of 21 market actors who responded to this question, 86% said that sales have increased due to a variety of factors, including more stringent federal efficiency standards, consumer preferences, operating cost, utility rebates, and increased contractor and consumer awareness (see Figure 13).

Figure 13 | Factors that Influenced Increase in Sales of Efficient Equipment



Interviewed market actors agreed that federal regulations and the New York State Energy Conservation Construction Code are the largest factor in driving the market adoption of higher efficiency systems. Engineers and contractors also reported that rebates are crucial in motivating customers to select higher efficiency options beyond the code requirements. The incentives help engineers and contractors offer higher efficiency systems as attractive investments with three to five-year paybacks.

However, some contractors find rebates time-consuming and difficult to complete and describe the paperwork as “exhaustive.” There is also limited awareness of rebate opportunities among contractors.

Contractor Interviews

“It always helps to have the utility company incentivize the customer to go higher efficiency. That’s the single biggest thing that we see. Every time we have a customer in front of us they’re asking, ‘What incentives are there available to us? If we go higher efficiency, can we get that premium paid for?’”

Contractor awareness and knowledge of higher efficiency equipment also influence the market adoption of higher efficiency unitary systems. Finally, consumers are becoming more aware of their energy use, and seek to reduce costs and be sustainable or eco-friendly.

Only one interviewed contractor thought that overall sales of higher efficiency equipment have stayed the same due to relatively consistent upfront costs and energy prices. Two interviewed market actors thought that sales have decreased due to (1) customers becoming more aware of other areas where they can cost-effectively save energy, such as lighting upgrades, which can compete with energy efficient HVAC projects; and (2) a slower economy and a lack of new construction projects in the contractor's service area.

Contractor Interviews

"A lot of contractors don't take advantage of [rebates] because they're not aware of it."

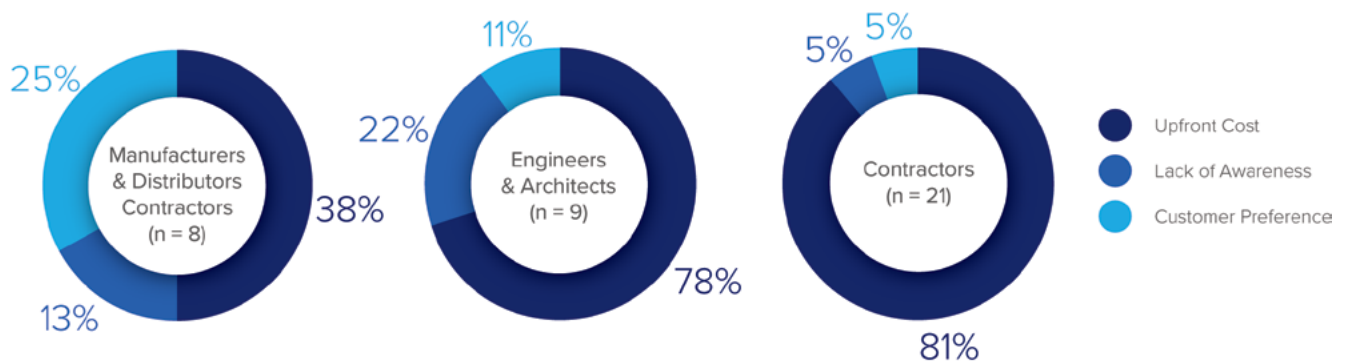


2.6 Market Barriers

As previously discussed, barriers to higher efficiency unitary systems include split incentives, distributor stocking practices, lack of awareness of VRF technology, VRF installation challenges, and limited number of contractors promoting higher efficiency technology. Figure 14 presents

the top three market barriers reported by 8 manufacturers/distributors, 9 engineers/architects, and 21 contractors. Not surprisingly, a majority of market actors (71%) reported upfront cost as the main barrier.

Figure 14 | Top Three Market Barriers



Market actors identified additional barriers that varied depending upon each market actor's perspective. Two out of the five manufacturers expressed federal regulations as the main market barrier. In 2018, the Department of Energy increased efficiency levels of commercial unitary air conditioners and heat pumps by 10% and is scheduled to increase efficiency levels by an additional 25% to 30% in 2023.²³ Meeting these efficiency requirements would require manufacturers to incorporate more efficient components (compressors, coils, and condenser fans) or add efficient technology that would increase the size of the equipment. Manufacturers find it challenging to increase efficiency of the equipment while maintaining competitive prices. Another concern is that while manufacturers are busy complying with

higher efficiency standards, it takes time away from designing other competitive advantages, such as adding new features, for their products.

The main barrier for distributors is understanding complex code compliance regulations and adjusting their inventory to meet new codes and standards. New York City was one of the first areas in the country to adopt the new American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1-2013 and 2015 International Energy Conservation Code (IECC) standards which became effective on October 3, 2016.²⁴ One distributor said that the new regulations are not clear and found it challenging to determine what equipment to stock.

²³ Appliance Standards Awareness Project. *Commercial CAC and HP (65,000 Btu/hr to 760,000 Btu/hr)*.

²⁴ U.S. Department of Energy. *Building Energy Codes Program*.



SECTION 3

Findings and
Recommendations

3 Findings and Recommendations

Based upon these market assessment results, the Market Evaluation Team has identified several key areas where

NYSERDA may be able to promote efficiency within the commercial HVAC market.

3.1 Contractor Training in VRF Market

Market actors see VRF technology as a significant energy savings opportunity for many projects. While the technology is proven and has claimed a large share of the market overseas, only 2% of businesses in New York State have VRF technology. Interviewed market actors identified a number of barriers to its widespread adoption in New York, which are causing the market to transform slowly. Opportunities may exist for NYSERDA to play an influential role in moving the market forward more quickly. One of the

main barriers identified through the market actor interviews is the lack of contractor awareness of VRF technology and its benefits. The Market Evaluation Team recommends that NYSERDA sponsor programs and collaborate with leading VRF manufacturers such as Mitsubishi®, Daikin®, and LG® to train contractors on how to install VRF technology. Contractor awareness will help increase customer awareness of VRF technology, and properly trained contractors will ensure that VRF systems are installed correctly.

3.2 Upstream and Midstream Incentives

NYSERDA should consider investigating the feasibility of upstream and midstream HVAC programs. One of the main barriers to energy efficiency identified by contractors is the lack of readily available higher efficiency commercial unitary equipment. Upstream and midstream incentive programs may help overcome this market barrier. Compared to a typical

downstream program, where rebates are provided directly to the customer or contractor, upstream or midstream models involve partnering with manufacturers and/or distributors to provide price markdowns on customer's purchases of efficient unitary equipment. This approach has increased installation of higher efficiency systems through programs in other states.²⁵

²⁵ According to a 2016 Southwest Energy Efficiency Project (SWEET) report [Gellar, Howard and Quaid, Maureen. May, 2014. Upstream Utility Incentive Programs: Experience and Lessons Learned. Southwester Energy Efficiency Project (SWEET)], Pacific Gas & Electric (PG&E) has deployed upstream market programs for commercial and industrial equipment since 1998. PG&E has found the upstream delivery model to be successful because it can focus on a relatively small number of market actors (manufacturers and distributors). PG&E's program observed increased market penetration, up to 900% increase, when the utility shifted from downstream to upstream delivery. In 2013, utilities in Massachusetts launched an upstream HVAC program through Mass Save®. The program paid \$400,000 in incentives to achieve just over 1 million kWh of gross annual savings.

Another advantage of upstream and midstream programs is that they can help overcome the initial cost barrier without the burden of completing sometimes

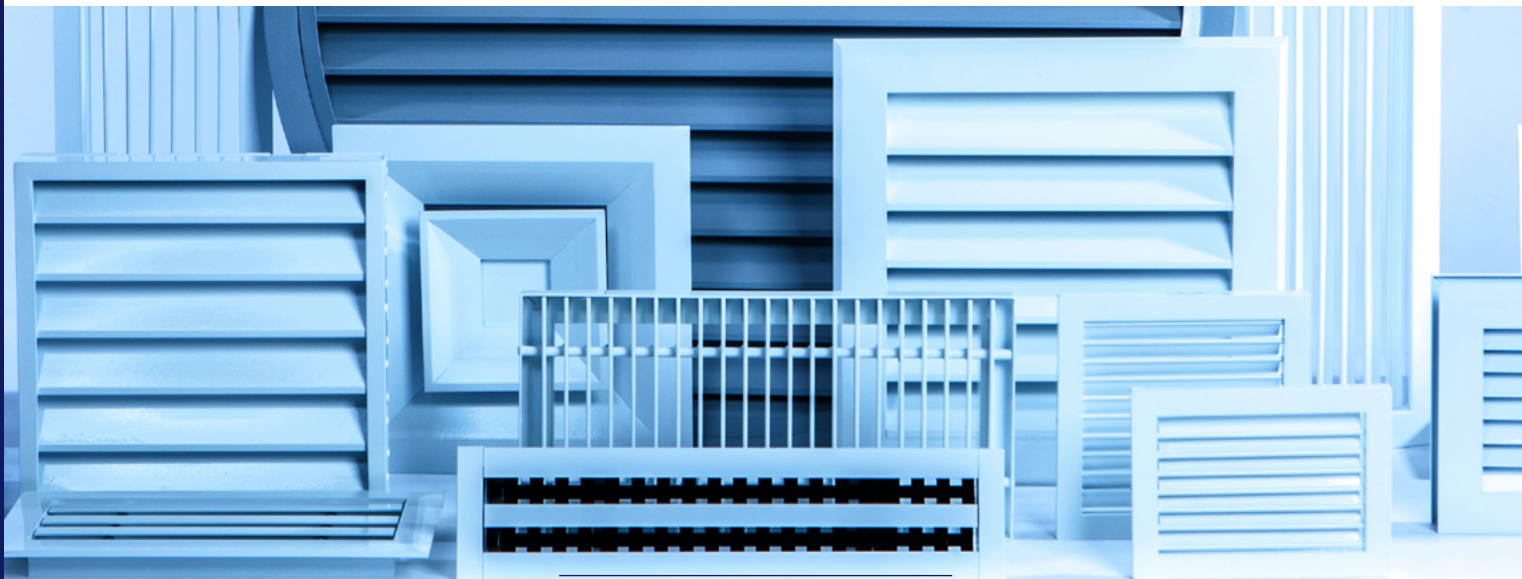
cumbersome rebate applications, which often take too long to process and can discourage some contractors from recommending qualifying equipment.

3.3 Commercial HVAC Maintenance Programs

Based on interviews with engineers and contractors, planned and emergency replacement projects represent over half of all commercial unitary projects. Contractors also reported that customers in the planned replacement market, particularly building owners and tenants, are more willing to invest in higher efficiency equipment to reduce operating costs compared to real estate developers who are the primary customer segment for new construction projects. Longer sales cycles also allow engineers and contractors to recommend higher efficiency equipment and technologies that are not stocked by manufacturers and distributors.

NYSERDA can influence the market adoption of higher efficiency unitary equipment in the replacement market through commercial HVAC maintenance

programs. Most commercial customers in New York State (66%) have a reactive maintenance program, which indicates a substantial opportunity for enhanced maintenance programs. Maintenance programs can foster a partnership between engineering firms and contractors who then provide maintenance services and recommendations to install higher efficiency retrofits. Engineering firms will benefit from designing the system and performing energy analyses while contractors can offer more complex systems that benefit the owner. One example of such a partnership is PG&E's Commercial HVAC Quality Maintenance Program, which offers incentives to customers who enroll in a three-year air conditioning quality maintenance service agreement and install optional unit retrofits.





SECTION 4

Methods

4 Methods

To explore the research topics of this market assessment, the Market Evaluation Team conducted the following research activities: (1) secondary research and (2) in-depth interviews with HVAC market actors. In addition, this market assessment leveraged results of the customer survey and on-site visits conducted in support of the Commercial Baseline Study.

Table 4 summarizes the research questions for this assessment and which research activities were used to address them.

Table 4 | Key Research Objectives and Data Collection Methods

Objective	Research Questions	Secondary Research	Market Actor Interviews	Commercial Baseline Study
Commercial Unitary AC Market Characteristics	<ul style="list-style-type: none"> • What is the penetration and average quantity/saturation of existing unitary AC equipment? • What are the characteristics (age, capacity, and efficiency level) of existing unitary equipment? • What is the penetration and average quantity/saturation of energy efficient unitary systems? 	●	●	●
Market Channels	<ul style="list-style-type: none"> • Who are the key market actors and what role do they play? • What factors influence customers decision-making for HVAC equipment? • What are distributor stocking practices? 	●	●	
Energy Efficiency Technology Trends	<ul style="list-style-type: none"> • Are there new and emerging HVAC technologies used to improve efficiency? • What is the level of contractor practice of recommending energy efficient systems 	●	●	●
Installation and Maintenance Practices	<ul style="list-style-type: none"> • What are contractor’s installation practices? • What are the maintenance practices among contractors and customers? 	●	●	●
Market Trends	<ul style="list-style-type: none"> • What factors have influenced or are currently influencing sales of energy efficient unitary AC systems? • Has the overall sales of efficient unitary AC systems increased, decreased, or stayed the same over the past three years? 	●	●	
Market Barriers	<ul style="list-style-type: none"> • What are the market barriers to the installation of unitary AC systems? 	●	●	

The following subsections provide additional detail about the research activities used for this market assessment.

4.1 Secondary Research

The Market Evaluation Team reviewed existing literature to support this market assessment, including research on the size of the market for commercial unitary AC systems, energy efficient technologies, market actors, and market barriers to the installation of efficient unitary systems and technologies. Based on this secondary

research, three types of market actors are active in the commercial HVAC market in New York State and collectively influence the market adoption of higher efficiency unitary equipment: manufacturers and distributors, engineering and architectural firms, and HVAC contractors.

4.2 Market Actor Interviews

The Market Evaluation Team conducted in-depth interviews with 43 market actors, including 5 manufacturers and 5 distributors of unitary systems, 10 engineering and 1 architecture firms,²⁶ and 22 HVAC contractors. The interviews included both structured questions to gather quantitative data and open-ended questions that covered a variety of topics related to the research objectives.

The Market Evaluation Team compiled the sample frame for these interviews from a variety of sources, including a purchased list of businesses in New York State and

recommendations from the NYSERDA Market Team. The Market Evaluation Team also applied a “snowball” sampling approach where interviewed market actors were asked to identify and recommend other important firms and individuals who the Market Evaluation Team should speak to as part of the study. The Market Evaluation Team targeted market actors in the sample frame based on annual revenue and geographic location of the firms, such that the interviews covered as much of the New York State commercial unitary AC market as possible.

4.3 Baseline Study Survey and Onsite Visits

The Market Evaluation Team used primary data collected through telephone/online surveys and onsite visits, as part of the Commercial Baseline Study, to inform this market assessment. The Commercial Baseline Study provided information on the penetration and average quantities/saturation of unitary systems in NY State, characteristics of existing equipment,

penetration and average quantities/saturation of energy efficient unitary systems, and customer maintenance practices.

The methodologies for the baseline study survey and onsite visits are described in detail in Volume 1 of the overall Commercial Baseline Study report.

²⁶ While architectural and engineering firms often work on the same commercial HVAC project, architects focus on aesthetics and noise control of the HVAC equipment. They rely on engineers for all HVAC design and specifications. Therefore, most of the architects contacted were not able to provide relevant input to help characterize the market for this study.

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