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C17: Connecticut Commercial & Industrial (C&I) Market Research

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FINAL REPORT

Presented To:

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Executive Summary

C17: Connecticut Commercial and Industrial (C&I) Market Research

The Connecticut Energy Efficiency Board (EEB) Evaluation Committee commissioned market research in 2014 and 2015 to support the goals of the Connecticut Energy Efficiency Fund Commercial and Industrial (C&I) programs. The overall objective of this research was to provide detailed market research regarding four end use categories to the EEB, the EEB Evaluation and C&I Committees, and the Program Administrators. This market research was designed to support targeted and effective strategies to bring about broad and deep energy efficiency savings. This research included an analysis of existing data as well as the collection and analysis of primary data from manufacturers and distributors.

This study addressed the following research questions:

- What are the **four largest energy end-use markets** – defined as a group of products with similar function – with potential to meet the increasing C&I energy savings goals?
- What are the **characteristics of these markets** currently (i.e., size, market actor characteristics, supply chain characteristics, effective marketing channels, and saturation of energy efficient equipment)?

Methods

To address the research questions, the research team used **three complementary phases of data collection and analysis:** (1) a review of customer data from C&I customers in CT, (2) a literature review of secondary data sources, and (3) in-depth interviews with manufacturers and distributors. Originally, this study included surveys with contractors/plumbers and surveys with customers. These latter activities were cancelled and this report is the final wrap-up report for this study.

1. Customer Data Review

The research team analyzed utility and publicly available data to identify end uses on which to focus our research into the commercial and industrial (C&I) market. Based on the magnitude of energy consumed by C&I customers in Connecticut, we identified four end uses for further study:

- **lighting**
- **gas space heating**
- **motors**
- **refrigeration**

2. Secondary Data Review

Following the customer data review, the research team completed an analysis of **end-use specific market data**, including purchased third-party reports as well as recent publicly available reports. The secondary data review was designed to inform primary data collected in later tasks, to allow the research team to better understand the context of the end-use markets selected for research.

3. Manufacturer and Distributor Interviews

In order to gain a more complete understanding of the market for each end-use, the research team conducted **33 in-depth interviews with market actors** involved in the manufacturing and distribution of technologies across the four selected end-uses.

Research Objectives Mapped to Data Collection Activity:

Research Objective	Customer Data Review	Secondary Data Review	Manufacturer and Distributor Interviews
Four most important end-use markets	X	X	
Size of the overall market		X	X
Market actor characteristics		X	X
Supply chain characteristics		X	X
Effective marketing channels identification			X
Saturation of current market in terms of energy efficiency		X	X

Initially, this study also included not just the secondary data review and market actor interviews, but also surveys with market actors and surveys with customers. Collectively, these tasks were part of a systems approach to this study, whereby data from multiple sources would be combined to form a complete picture of the market. Multiple sources can provide confirmation of findings or identify if there is a difference of expert opinion, suggesting that a finding should be changed or qualified. Because this study only had one source of primary data collection, we were unable to make these comparisons to form a complete picture of the market. Nevertheless, several key findings emerged.

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Key Findings*

Lighting

1. The supply chain for lighting is changing. Traditionally, a limited number of large lighting manufacturers have dominated the market; however, the growing demand for LEDs has disrupted the traditional supply chain, and new lighting manufacturers are entering the marketplace.

2. Lighting designers (e.g., architects and engineers) heavily influence purchasing decisions. This influence is exacerbated by the fact that customers tend to buy exact replacements of existing lamps.

3. Market adoption for LEDs is rapidly increasing. While the DOE estimates that 42% of commercial sales and 26% of industrial sales will be LED by 2020, *Freedonia forecasted the LED share to reach closer to 65% of nonresidential energy efficient lighting sales nationwide by 2017* (including program and non-program states). **Manufacturers and distributors reported current CT LED sales at roughly 50% of the commercial market.** One interviewee reported that **industrial LED sales may be even higher** given LEDs being used for high and low bay lighting. When asked about sales in CT going forward, these interviewees stated **LED sales would be 60-90% of CT lighting sales by November 2015, and one interviewee stated LEDs would be 100% of C&I lighting sales by 2017.**

4. While lamp sales are expected to decline, sales of lighting fixtures are expected to increase. Lamp sales are expected to decline as more efficient lamps are installed, because these generally need to be replaced less frequently. The fixture market, on the other hand, is expected to continue to grow as the new construction market expands.

5. Interviewees attributed the majority of current LED sales to rebate programs. Interviewees cited direct relationships between LED sales and rebate levels throughout the country.

6. Ensuring that incentivized products meet product quality standards is very important. Customers' first impressions have a great deal of influence on the market adoption of new technologies. Incenting subpar products could lead customers to avoid efficient lighting in the future, or to associate poor products with the utilities.

7. A small proportion of residential incentivized bulbs are likely being sold out of state by a few small businesses (not participants or lighting retailers). Two (of 11) lighting manufacturer/distributor interviewees described instances that could undermine the lighting programs. One described finding contractors coming from other states going store to store buying the maximum incented bulbs to sell outside CT. Another interviewee noted that a lack of coordination between the residential and commercial lighting program incentives may be driving some businesses to purchase residential (program-incented) bulbs from big box retailers rather than purchasing C&I incented bulbs from CT-based mid-market firms.

Gas Space Heating

1. While some portions of the space heating market are changing rapidly, other portions have not changed substantially in the past few decades. In some cases, gas heating systems are being replaced by electric heat pumps, which have become increasingly popular. Meanwhile, the average efficiency of the combustion component of most packaged rooftop units has not changed significantly.

2. The integration of controls provides an opportunity for efficiency gains with gas space heating equipment. Looking beyond the energy efficiency of the equipment itself, the importance of the control and operation of the equipment emerged as an important concern by interviewees.

3. Interviewees generally agreed that utility programs have a great deal of influence on purchase decisions in the nonresidential gas space heating market. Several interviewees remarked that most end users would not purchase energy efficient equipment without rebates or other incentives.

Motors

1. Major future gains in motor-driven equipment efficiency will come through optimized system design and implementation. Therefore, future opportunities lie in optimizing the efficiency of the system as a whole as it performs mechanical work.

2. Service shops are likely in the best position to influence the efficiency of those motors that are simply being repaired or replaced by industrial customers. It is important to ensure that these service shops are employing best practices for restoring motors to efficient levels.

3. Because motors standards are at maximum efficiency, utility incentives should focus on optimizing motor-driven systems. This could be accomplished by conducting system-wide audits, providing incentives for systems optimization engineering design, incorporating controls and variable speed drives, optimizing pump or fan sizing, optimizing controls, and through other opportunities.

Refrigeration

1. The refrigeration market is concentrated with a few large manufacturers. These manufacturers account for a majority of sales. Distributors often carry multiple brands of equipment and operate on a regional scale.

2. The flow of equipment through the refrigeration supply chain varies based on submarket category (e.g., supermarket, restaurant, retail). The supply chain varies by end-use customer segment with different product categories for each segment.

3. There will continue to be an opportunity to upgrade standard efficiency refrigeration equipment with models that are more efficient, given a market emphasis on repair rather than replacement. New standards for commercial refrigeration equipment are set to take effect in March of 2017, but the market is expected to see the largest growth in sales of refrigeration parts rather than new equipment. This presents an opportunity for efficiency programs.

4. Product availability and price are critical factors in customer decisions about upgrades and replacements for refrigeration equipment, especially for restaurants. Increasing the availability of energy efficient equipment options could help to address concerns of immediate replacement needs, and rebates for more efficient models could help to offset the increased costs.

Remaining Questions*

1. Due to the importance of C&I lighting savings to the portfolio, additional research is warranted to verify and track that the market share of LEDs for C&I buildings may be 100%, or close to that, by 2020 (potentially reducing or ending the opportunity to obtain C&I lighting savings).

2. Research is needed to examine opportunities for efficiency gains from motor-driven systems upgrades among industrial customers. Unfortunately, this study was cancelled prior to collecting any data from contractors or customers that could have provided this information.

3. This research study was originally planned as a comprehensive study to include surveys with contractors, vendors, and C&I customers to understand what are the best leverage points, messages, and strategies for different types of energy efficient equipment, systems, and operation. The study was cancelled prior to undertaking this primary data collection and could not answer the related research questions.

*Abbreviated. See report for full text of Key Findings and Remaining Questions.

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1. INTRODUCTION

The Connecticut Energy Efficiency Board (EEB) Evaluation Committee commissioned market research in 2014 and 2015 to support the goals of the Connecticut Energy Efficiency Fund Commercial and Industrial (C&I) programs. The overall objective of this research was to provide detailed market research regarding four end use categories to the EEB, the EEB Evaluation Committee and C&I Committee, and the Program Administrators at Eversource (previously Northeast Utilities) and United Illuminating (collectively referred to as the Companies). This market research was designed to support targeted and effective strategies to bring about broad and deep energy efficiency savings. This research included an analysis of existing data and the collection and analysis of primary data from manufacturers and distributors.

Note that initially, this study included additional tasks, but at the request of the EEB Evaluation Committee, the research team ended the project early, without completing the remaining activities.[1] Because of this, this report does not contain a complete picture of the market; rather it only summarizes the three activities completed prior to the study's cancellation: a review of customer data, a review of secondary data, and interviews with manufacturers and distributors.

1.1 Research Questions

This study was designed to answer the following research questions:

- What are the four largest energy end-use markets - defined as a group of products with similar function – with potential to meet the increasing C&I energy savings goals?
- What are the characteristics of these markets currently, including:
  - What is the size of the overall market? What are the key technologies that make up this market? How many of each of these technologies is sold annually?
  - Who are the market actors in the supply chain for these markets (including manufacturers, distributors, installers, etc.)? How many of these market actors exist? What are the roles these market actors play in the market? What role do they play in promoting energy efficiency (*e.g.*, stocking energy efficient products, conducting training, raising program awareness, etc.)?
  - What are the effective marketing channels used for these markets? Are particular channels more effective for energy efficient products?
  - What is the market saturation for energy efficient and program eligible technologies in these markets?

Originally, the study was also intended to answer the following questions, but these were **not addressed** under the abbreviated scope approved by the EEB:

- How do Connecticut C&I customers interact with these markets, including:
  - Within each end use category, what are the types of equipment and/or systems most commonly installed at C&I facilities (*e.g.*, what types of motor-driven industrial process equipment is installed in industrial facilities)?

[1] These additional tasks included telephone surveys with 300 contractors, as well as telephone surveys with 370 commercial and industrial customers.

    - How do customers make decisions regarding these products? How does energy efficiency factor into the decision-making process? What non-energy benefits factor into these decisions?
    - For what proportion of projects (by end-use, major technology, and high efficiency/standard efficiency) do customers (1) lead the decision process, (2) ask for input from contractors/vendors and make a joint decision, or (3) ask the vendor and follows vendor's advice?
    - What are the barriers for greater adoption of energy efficiency products within these markets?
    - What methods of financing are commonly used by customers for the purchase of new equipment? What types of financing are acceptable and/or preferable?
    - What is the level of customer awareness and understanding of the technologies that make up these markets?
- How do contractors/vendors serving Connecticut C&I customers interact with these markets, including:
    - What are their perceptions of how customers make decisions regarding these products? How does energy efficiency factor into the decision-making process? What non-energy benefits factor into these decisions? How do these perceptions compare to customers' responses?
    - How much influence do contractors/vendors have on the customer decision-making process?
    - How often do contractors/vendors suggest energy efficient options for new equipment installations? How often do customers purchase the energy efficient option?
    - For what proportion of projects (by end-use, major technology, and high efficiency/standard efficiency) do customers (1) lead the decision process, (2) ask for input from contractors/vendors and make a joint decision, or (3) ask the vendor and follows vendor's advice? How does this compare to the decision-making that customers report?

Table 1-1 shows the data collection activities designed to answer each research question. As originally designed, the study was meant to take a systems approach by collecting data from multiple sources for each question. However, the planned contractor surveys and customer surveys (shown in the two dark grey columns on the right) were not conducted because the project was ended early at the request of the EEB Evaluation Committee and C&I Committee. As a result, and as shown in the table, several questions were not at all addressed, and several were only partially addressed by this study.

Table 1-1: Research Question by Data Source

Research Objective	Customer Data Review	Secondary Data Review	Manufacturer and Distributor Interviews	Contractor Surveys	Customer Surveys
Four most important end-use markets	X	X			
Size of the overall market		X	X	X	
Market actor characteristics		X	X	X	
Supply chain characteristics		X	X	X	
Effective marketing channels identification			X	X	
Saturation of current market in terms of energy efficiency		X	X	X	X
Customer characteristics				X	X
Characteristics of decision-making process				X	X
Adoption barriers				X	X
Need for and acceptance of financing				X	X
Customer awareness and understanding of technologies				X	X

Note. The contractor surveys and customer surveys (shown in the two dark grey columns on the right) were originally planned for this study but were not conducted because the project was ended early at the request of the EEB. As a result, several questions were not at all addressed, and several were only partially addressed by this study.

1.2 Organization of this Report

The next chapter (Chapter 2) summarizes the methodologies used for this study. This is followed by the results of the customer data review (Chapter 3), which identified the four end uses for further study: lighting, gas space heating, motors, and refrigeration. Then, Chapters 4 through 7 present results of the secondary data review and in-depth interviews conducted separately for each of the four selected end use markets. A summary of lessons learned during this study that may be useful for future similar research is contained in Chapter 8, and Chapter 9 provides a summary of key findings for each of the four end-use categories. Finally, the Appendices contain some additional analysis of customer billing data, additional reference tables, and data collection instruments.

2. METHODOLOGY

This chapter describes the methodology used to complete three primary tasks conducted for this study:

- Customer Data Review
- Secondary Data Review
- Market Actor Interviews

2.1 Customer Data Review

In March and April 2014, the research team analyzed utility and publicly available data to identify end-uses on which to focus our research into the commercial and industrial (C&I) market. The research team made the assumption that the end-uses that are currently responsible for the greatest consumption of energy among Connecticut C&I businesses are also those with the highest potential for savings. Consequently, we selected end uses for further study by quantifying and comparing the amount of energy consumed by each end use among C&I customers in Connecticut.

Because available utility data did not include consumption broken down by end use, we searched for public data sources that could be matched to the utility data to estimate these quantities. We ultimately accomplished this by matching utility information about energy use and customer business types to end use and building/business type data available through the Commercial Building Energy Consumption Survey (CBECS)[2] and the Manufacturing Energy Consumption Survey (MECS)[3]. Based on this analysis, the research team selected the following four end-use categories for further analysis:

- Lighting
- Refrigeration
- Motors
- Gas space heating

This task is discussed in much greater detail in Chapter 3, the Customer Data Review Results chapter. That chapter includes a list of all sources used and a detailed review of steps taken to complete the analysis. The results of the analysis show electricity consumption in Connecticut by business activity/manufacturing sector, which may also be useful for other purposes or in other analyses.

2.2 Secondary Data Review

Following the customer data review, the research team completed an analysis of detailed end-use specific market data, including purchased third-party reports as well as recent publicly available data. The secondary data review was designed to inform primary data collected in later

[2] http://www.eia.gov/consumption/commercial/
[3] http://www.eia.gov/consumption/manufacturing/

tasks,[4] to allow the research team to better understand the context of the end-use markets selected for research.

One of the objectives of this task was to understand the characteristics of the selected end-use markets in Connecticut and compare them to similar markets found in New England and nationally. However, the research team found that none of the reports we identified included market data specific to Connecticut; when available, we gathered data specific to the New England or Northeast region. Specifically, these data were reviewed to understand:

- The size of the overall market (in terms of revenue and units sold)
- What portion of the overall market is considered "energy efficient"

To complete the secondary data review, the research team first conducted an online search to identify potential sources of market-specific data available from several third-party vendors including Freedonia[5], AnythingResearch[6], Ibis World[7], and Better Data Better Design/D&R International[8]. We ultimately purchased several Freedonia reports as these were judged to be the most relevant for our research objectives. We combined this with publicly available data from sources such as the Department of Energy (DOE)[9] as well as various industry-specific sources.

The results of the secondary data review, as well as a complete list of sources used, are provided separately by end use category in Chapters 4, 5, 6, and 7.

2.3 Market Actor Interviews

In order to gain a more complete understanding of the market for each end-use, the research team conducted 33 in-depth interviews with market actors involved in the manufacturing and distribution of technologies across the four selected end-uses. The research team conducted all interviews via telephone between October 2014 and January 2015. To compensate respondents for their time and encourage participation, the research team offered respondents a $100 gift card for completing the interview.

The primary purpose of the interviews was to document who are the actors in the supply chain and what are the roles these market actors play in each end use market, as well as to help estimate market size for each of the selected end use categories. Specifically, the interviews were designed to answer the following research questions:

- Who are the market actors in the supply chain for these markets? How many of these market actors exist? What are the roles these market actors play in the market? What role do they play in promoting energy efficiency?

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[4] Initially, these later tasks included not just market actor interviews, but also surveys with market actors and surveys with customers. The secondary data review task was part of a systems approach to this study, whereby data from multiple sources would be combined to form a complete picture of the market. Multiple sources can provide confirmation of findings or identify if there is a difference of expert opinion, suggesting that a finding should be changed or qualified. Because this study only had one source of primary data collection, we were unable to make these comparisons to ensure reliability and form a complete picture.
[5] http://www.freedoniagroup.com/
[6] http://www.anythingresearch.com/industry/
[7] http://www.ibisworld.com/
[8] https://www.betterdatabetterdesign.com/
[9] http://energy.gov/

- What is the size of the overall market? What are the key technologies that make up this market? How many of each of these technologies is sold annually?
- What portions of products sold in these markets are considered energy efficient?
- How do market actors define efficiency, or determine what products are efficient?
- What are the effective marketing channels used for these markets? Are particular channels more effective for energy efficient products?

The interview guide, contained in the Appendix, included common questions across the end uses but also included some questions unique to each end use. Following the interviews, the research team analyzed findings across all interviewees for each end use. Results are provided separately by end-use category in Chapters 4, 5, 6, and 7. The remainder of this section describes the sample design and respondent characteristics.

Market Actor Interview Sample Design

The research team used a "snowball" sampling technique to develop the sample frame for manufacturers and distributors. Snowball sampling is perhaps the most common sampling method used in qualitative studies. The researcher identifies a few index cases that are relevant to the study -- in this case we began with distributors -- and then asks them to help locate additional relevant cases, such as manufacturers. The advantage of this method is that the researcher interviews individuals relevant to the research objectives of the study and then gets a good introduction to the next participant. The disadvantage is that the variation in the sample may be limited because it consists of individuals belonging to the network of the index cases. However, in the case of the supply chain research for this study, these networked connections are exactly what we sought to understand.

Using a snowball sampling approach, we began by speaking with distributors rather than manufacturers. This approach was used for three main reasons. First, because distributors are located towards the middle of the supply chain, they have a great deal of insight into the supply chain both upstream (*i.e.*, from manufacturers), as well as downstream (*i.e.*, to contractors and customers).[10] Thus, there is an efficiency associated with beginning in the middle of the chain. Second, locating distributors for each of the end uses via Internet searches is a relatively easy and cost effective manner of locating these actors. Third, this snowball sampling technique was used to assist the research team in quickly identifying the major players in the marketplace—both in terms of manufacturers and distributors as well as in terms of other actors dealing with energy efficient products.

We began by locating distributors via ThomasNet, an online database that catalogs suppliers (both manufacturers and distributors) for various types of goods and is easily searchable by product category (*e.g.*, "commercial lighting") and by geographic area of interest (*i.e.*, "Connecticut").[11] The value of beginning the search for suppliers using a resource like ThomasNet is it provides a readily-accessible database limited to suppliers and classified by end use category.[12] According to their website: "The platform serves procurement professionals, engineers, plant and facility management and other buyers from corporations, educational

[10] Originally, this study included surveys with contractors and surveys with customers.
[11] ThomasNet is a free online platform and is available at www.thomasnet.com.
[12] According to ThomasNet, the website has over 700,000 commercial and industrial suppliers in its database.

institutions, government agencies, the military and small businesses. It also serves manufacturers, distributors, and service companies throughout North America who want to connect and do business with these buyers." We supplemented our search on ThomasNet with additional online searches using YP[13] and ENERGY STAR[14]. This process yielded an initial sample frame of suppliers serving Connecticut, shown in Table 2-1.[15]

We began our interviews with this initial sample frame. In addition to asking respondents about topics aimed at answering the research questions, we also asked about their competitors and who manufactures the products they supply. These additional questions served to increase the sample frame by identifying additional contacts. This process yielded the final sample frame shown in Table 2-1.

Table 2-1: Sample Frame and Completed Market Actor Interviews

End Use Category	Initial Sample Frame [a]	Final Sample Frame
	N	N
Lighting	16	41
Refrigeration	6	37
Motors	20	33
Gas Space Heating	14	33
Total	**56**	**144**

[a] These numbers do not constitute a comprehensive sample frame – they were only intended to serve as a starting point for the snowball sample.

Completed Market Actor Interviews and Respondent Characteristics

As shown in Table 2-2, the research team completed a total of 33 interviews and spoke with a variety of market actors, including distributors, manufacturers, manufacturer representatives, and one efficiency consultant.[16] Each interview lasted between 30 and 60 minutes, with an average length of 42 minutes. On average, interviews with market actors in the motor and lighting markets (average = 45 to 55 minutes) were more lengthy than those in the gas space heating and refrigeration markets (average = 35 to 40 minutes). This was due to the specialization of market actors in the HVAC and refrigeration market, which is discussed in more detail in the results chapters. Because of the specialization of these market actors, they were less able to answer questions about the market as a whole, and thus the interviews were shorter in duration.

[13] http://www.yellowpages.com/
[14] http://www.energystar.gov/
[15] We also sent this initial list to the Utilities for comment, but no additional contacts were added.
[16] We initially targeted 40 total interviews, with 10 in each end-use category. However, the project was cancelled before we could complete all 40 interviews. Additionally, manufacturers, particularly those in the refrigeration market, were difficult to reach and more frequently declined our requests for interviews. It is unclear why this was the case.

Table 2-2: Types of Market Actor Interview Respondents

End Use	Market Actors				Total
	Distributors	Manufacturers	Manufacturer Representatives	Efficiency Consultant [a]	
Lighting	4	5	2		**11**
Refrigeration	3	1	1		**5**
Motors	4	2	1		**7**
Gas Space Heating	5	3	1	1	**10**
Total	**16**	**11**	**5**	**1**	**33**

[a] While we did not specifically target efficiency consultants, this one contact was recommended by a distributor because of this individual's extensive market knowledge and industry experience.

As shown in Table 2-3, the interviewees played various roles within their companies, including sales managers and executives. The research team also spoke to a number of interviewees that focused on energy efficiency issues, such as utility relationship managers, energy specialists, and compliance managers. The executives and owners tended to represent more local distribution companies, while the managers tended to represent more national manufacturers or distributors.

Table 2-3: Roles of Market Actor Interview Respondents

End Use	Roles				Total
	Sales or Marketing Managers or VPs	Executives; General Managers; Owners	Utility, Energy, or Compliance Managers	Product Manager	
Lighting	5	3	3		**11**
Refrigeration	3	2			**5**
Motors	3	2	1	1	**7**
Gas Space Heating	6	2	1	1	**10**
Total	**17**	**9**	**5**	**2**	**33**

As shown in Table 2-4, the interviewees mostly represented national or international firms. Manufacturers especially tended to be international and national firms, while distributors often represented more local markets. When the research team interviewed firms that sold products throughout the country, the research team typically interviewed staff who managed sales in Connecticut or the Northeast region.

Table 2-4: Geographic Reach of Respondent Firms

End Use	Geographic Reach			Total
	International / National	Regional	State	
Lighting	8	2	1	**11**
Refrigeration	3	2	0	**5**
Motors	6	0	1	**7**
Gas Space Heating	4	6	0	**10**
Total	**21**	**10**	**2**	**33**

3. CUSTOMER DATA REVIEW RESULTS

In March and April 2014, the research team analyzed utility and publicly available data to identify end-uses on which to focus the commercial and industrial (C&I) market research. The team selected four end-uses based on their high potential for energy savings: lighting, refrigeration, motors, and gas space heating. This chapter outlines the process by which the research team selected the four end-uses and summarizes available information about their share of current energy usage in Connecticut.

3.1 Data Sources

The research team used a variety of data sources, which were available at the time we conducted this review, to inform the selection of end-uses for further research. United Illuminating and Northeast Utilities provided an extract of variables for all their C&I customer data for provision of electricity and natural gas. The data used for the end-use consumption estimates included the following:

- Connecticut Light and Power (CL&P, recently a part of Eversource) C&I customer data, including annual electricity usage (kWh) and North American Industry Classification System (NAICS) categorizations from the billing data system[17]
- United Illuminating (UI) C&I customer data including monthly electric and gas usage (CCF) from their billing data system[18]
- 2011 United States Census Data including number of business establishments by NAICS code and zip code[19]
- 2003 Commercial Building Energy Consumption Survey (CBECS) including energy consumption by end-use by building type for the Northeast region (2012 CBECS data were not published until after this analysis was completed)[20]
- 2010 Manufacturing Energy Consumption Survey (MECS) including energy consumption by end-use by NAICS code (manufacturing only)[21]
- 2012 EIA natural gas (MMCF)[22] and electricity (GWh)[23] sales data by state and sector

[17] We used data provided by CL&P, dated June 15, 2013, with individual account data aggregated to the customer level (*i.e.*, "customer groups"). CL&P provided NAICS for their C&I customers, while NAICS was not available in the UI C&I billing data. We did not review Yankee Gas C&I data for this analysis because we did not receive those data until July of 2014, after this task was already completed.
[18] This included UI electric data for November 2011 through November 2012 and CNG and SCG gas data for November 2011 through August 2012. None of these three datasets included NAICS.
[19] 2011 County Business Patterns: ZIP Code Business Statistics. Table CB1100CZ11. http://factfinder2.census.gov
[20] CBECS 2003. File 18: Consumption of Electricity by End Use and File 19: Consumption of Natural Gas by End Use. http://www.eia.gov/consumption/commercial/data/2003/index.cfm?view=microdata
[21] MECS 2010. Table 5.3 Energy Consumed as a Fuel by End Use by Manufacturing Industry with Total Consumption of Electricity (physical units). http://www.eia.gov/consumption/manufacturing/data/2010/
[22] 2012 Natural Gas Consumption by End Use. http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_SCT_a.htm
[23] 2012 Total Electric Industry – Sales (Thousand Megawatthours). http://www.eia.gov/electricity/sales_revenue_price/pdf/table2.pdf

3.2 Methodology

The research team selected end-uses for further study based on their potential for saving energy in the form of electricity and/or natural gas. The research team made the assumption that the end-uses that are responsible for the greatest consumption of energy among Connecticut C&I businesses were also those with the highest potential for savings. Consequently, making the end-use selections involved quantifying and comparing the amount of energy used by equipment in each end-use category among C&I customers in Connecticut. Because available utility data did not include consumption broken down by end-use, we estimated these quantities by matching utility information about energy use and customer business types[24] to end-use and building/business type data available through CBECS and MECS. Because only Connecticut Light & Power (CL&P) electric data contained information about customer business types, we relied primarily on CL&P data for the analysis.[25] Using the steps described below, the research team verified that the subset of Connecticut customers in the CL&P service territory were indeed representative of customers statewide in terms of business types; therefore, the research team felt confident that the end-use selection could be made using only the CL&P data. The research team also used publicly available data about natural gas consumption to inform the decision about whether or not to include gas end-uses in this research.

Step 1: Verify statewide distribution of business types

The research team had access to data including both electricity usage and business type only for customers in the CL&P territory (UI data contained a commercial/industrial designation as well as type of premise, but these variables cannot be mapped to CBECS building classifications - see Step 2 below).[26] To verify that the CL&P data were representative of the entire state of Connecticut, the research team used US Census data to compare the frequency of business types (by NAICS sector) in the CL&P service territory to that in the UI service territory (which includes most of the rest of the state) at the zip code level. To be clear, we used zip-code level Census data, which includes NAICS, to compare the two service territories. We found that the two territories were in fact very similar in terms of the distribution of business types.

Step 2: Map commercial business types to building types

End-use data collected by CBECS is organized by building type rather than by business type (*i.e.,* NAICS code). To make use of CBECS data for this analysis the research team mapped each business type in the CL&P customer data (*i.e.,* NAICS sub-sector codes) to a building type in CBECS. While this mapping method was approximate (business type and building type are not a one-to-one match), we were able to map most of the commercial business types to a building type with some confidence (*e.g.*, it was reasonable to expect that most real estate businesses occupy an office space). The customers that mapped to a building type represented 92% of the

[24] Business type is used in this study as a reference to the classification of business establishment using the national standard of the North American Industry Classification System (NAICS).
[25] Overall, CL&P's C&I electric customers represent about 80% of statewide C&I electricity use. Both CL&P and UI data contained high-level business designations (i.e., commercial or manufacturing/industrial). Examining the proportions in these two categories matched the general 80/20 split by utility. Additionally, looking at number of customers, CL&P represented 72% of unique electric C&I customers, whereas UI represented 28% of unique electric C&I customers. Given these simple tests, the research team assumed that the CL&P NAICS/business type coding was representative of that statewide.
[26] On the other hand, CL&P data contained NAICS, which could be mapped to CBECS building classifications.

total electricity usage. For those business types where an appropriate building type mapping was less apparent (*e.g.*, construction of buildings or rail transportation) we designated a building type of "Other." These along with a small portion of customers with no business type information represented only 8% of total electricity usage among CL&P C&I customers.

For manufacturing business types, no such approximation was necessary because MECS data is organized at the business type (NAICS sub-sector) level; therefore, there was a one-to-one match with manufacturing businesses.

Once the mapping was complete, the research team was able to sum electricity consumption by building type. Table 3-1 below summarizes total electric usage by building activity or manufacturing type for all CL&P customers. As noted above, the research team determined that the proportions of business types in CL&P territory were generally representative of Connecticut as a whole.

Table 3-1: Electricity Consumption by Activity (CL&P only)

Principal Business Activity	Total kWh	% kWh	Customers	% Customers
Non-manufacturing				
Office	3,911,473,147	32%	20,857	37%
Mercantile	939,711,073	8%	5,713	10%
Other	918,098,399	7%	2,714	5%
Food sales	714,767,288	6%	2,522	4%
Education	603,131,229	5%	1,092	2%
Food service	553,617,857	4%	4,137	7%
Service	418,597,584	3%	7,176	13%
Lodging	382,709,885	3%	751	1%
Inpatient health care	319,294,908	3%	75	0%
Public assembly	289,508,358	2%	1,552	3%
Outpatient health care	236,732,029	2%	3,479	6%
Public order and Safety	186,868,461	2%	193	0%
Uncategorized	107,121,637	1%	2,869	5%
Warehouse and Storage	49,753,837	0%	349	1%
Total Non-manufacturing	**9,631,385,691**	**78%**	**53,479**	**94%**
Manufacturing				
Paper	458,145,649	4%	50	0%
Fabricated Metal Products	400,994,590	3%	782	1%
Transportation Equipment	324,323,071	3%	140	0%
Miscellaneous	301,652,268	2%	496	1%
Chemical	186,328,872	2%	103	0%
Machinery	185,280,052	2%	368	1%
Plastics and Rubber Products	150,835,888	1%	110	0%
Computer and Electronic Product	142,055,673	1%	178	0%
Food	115,457,945	1%	144	0%
Primary Metals	108,437,008	1%	54	0%
Electrical Equipment, Appliances, and Components	96,291,346	1%	94	0%
Printing and Related Support Activities	83,936,953	1%	213	0%
Nonmetallic Mineral Products	61,460,090	0%	108	0%
Textile Mills	22,940,318	0%	28	0%
Furniture and Related Products	20,296,840	0%	116	0%
Beverage and Tobacco Products	17,192,109	0%	23	0%
Wood Products	14,295,532	0%	115	0%
Petroleum and Coal Products	10,426,015	0%	13	0%
Textile Product Mills	2,553,685	0%	34	0%
Apparel	1,332,997	0%	15	0%
Leather and Allied Products	1,122,572	0%	7	0%
Total Manufacturing	**2,705,359,475**	**22%**	**3,191**	**6%**
Grand Total	**12,336,745,166**	**100%**	**56,670**	**100%**

Step 3: Estimate electricity consumption by end-use

EMI applied end-use information by building type from CBECS and MECS to the electricity consumption information available from CL&P. Given our finding that the business-type profile of the CL&P territory was representative of the state overall, the research team was able to obtain an estimate of C&I electricity consumption by end-use in the state of Connecticut.

Step 4: Convert statewide gas and electric energy consumption into a single unit

While matching CL&P data to CBECS and MECS data resulted in useful information about electric end-uses, the research team was also interested in the magnitude of gas usage (in terms of energy consumed) relative to electricity usage. This would inform our decision whether or not to include natural gas end uses in our in-depth research. In order to compare the relative magnitude of energy consumed by electricity and gas customers, the research team converted the state's total C&I electricity and gas consumption (based on EIA data for 2012) to MMBtu using the conversion formulas:

1 kWh = 0.003412 MMBtu
1 CCF = 0.1029 MMBtu

As shown in Table 3-2 below, natural gas consumption accounted for somewhat more than half of total C&I energy consumption from natural gas or electricity. Consequently the research team judged that it would be worthwhile to include a gas end-use in our in-depth research.

Table 3-2: Connecticut 2012 Energy Consumption (Gas and Electric)

Sector	Gas			Electric			Total	
	MMCF	MMBtu	%	GWh	MMBtu	%	MMBtu	%
Commercial	42,346	43,574,034	34%	12,976	44,274,112	35%	87,848,146	69%
Industrial	26,258	27,019,482	21%	3,566	12,167,192	10%	39,186,674	31%
Total	**68,604**	**70,593,516**	**56%**	**16,542**	**56,441,304**	**44%**	**127,034,820**	**100%**

3.3 Selected End Uses

Table 3-3 shows the four end uses that the research team selected to pursue for the study. The table also shows the portions of electric and gas consumption that come from each of the four selected end-uses. Based on the steps described above, results indicated that lighting and refrigeration in non-manufacturing sectors and motors in the manufacturing sector represented the highest-consumption electric end-uses in Connecticut. In total, these three end-uses accounted for about 51% of all C&I electricity consumption in the state and about 22% of total energy consumption (in the form of electricity or natural gas).

According to state-level consumption data available from EIA, commercial customers accounted for about 61% of the C&I natural gas consumption in Connecticut. Regional CBECS data further indicated that about 69% of gas consumption in commercial buildings was used for space heating. Consequently, the research team estimated that commercial space heating accounted for about 43% of the total C&I gas consumption and about 23% of the total energy consumption

(in the form of electricity or natural gas). The research team also noted that because this estimate did not include industrial space-heating, the actual portion of C&I gas usage used for space-heating was likely somewhat greater than 43%.[27] The magnitude of energy used for space heating suggests a substantial opportunity for energy savings. Consequently, the research team chose to include gas space heating in our market research along with the electric end-uses mentioned above.

Table 3-3: Energy Usage by Selected End-Uses

Category	Percentage of all C&I Usage		
	Electric kWh	Gas CCF	TOTAL Electric + Gas (Converted to MMBTU)
Lighting (non-manufacturing)	30%	--	13%
Refrigeration (non-manufacturing)	11%	--	5%
Motors (manufacturing) [a]	10%	--	4%
Total Electric	**51%**	**--**	**22%**
Gas space heating (commercial)	--	69%	23%
Total	**51%**	**69%**	**55%**

[a] The "motors" end use was actually listed as "machine drive" in the MECS data and did not include motors that were part of other end uses categorized by MECS (e.g., process cooling and refrigeration). Therefore, the percentages shown in the table actually under-represents the energy use attributable to motors.

In conclusion, the customer data review resulted in focusing our subsequent research on commercial lighting and refrigeration, industrial motors, and natural gas space-heating for both the commercial and industrial sectors. The remainder of this report summarizes market research findings on these four end use categories.

[27] Based on end-use consumption data from MECS and information on manufacturing types in Connecticut from Census data, the research team estimated that facility HVAC accounted for about 24% of natural gas consumption in the state's manufacturing sector. However, some of the gas consumption could come from natural gas-powered ventilation or air conditioning, and specific information about space heating was not available. If the research team assumed that all of this natural gas was used for space heating and that usage in the manufacturing sector was representative of industrial customers generally, then industrial gas space-heating accounted for roughly 9% of C&I gas consumption, and therefore, that space-heating overall accounted for about half (52%) of C&I gas consumption.

4. LIGHTING MARKET RESULTS

To explore the nonresidential lighting market in Connecticut, the research team conducted two tasks. First, we reviewed secondary data sources to develop a high-level understanding of the lighting market. These sources focused on national trends in the lighting market. The research team then conducted interviews with lighting manufacturers, manufacturer representatives, and distributors working within the Connecticut nonresidential lighting market.

Findings from these tasks suggest that the Connecticut nonresidential lighting market is changing quickly. This is largely due to national policies focused on manufacturing more energy efficient lighting and the market adoption of LEDs.[28] As a result, market data is quickly becoming out of date and manufacturers and distributors are struggling to define what efficient lighting means today. These findings are further detailed within this chapter. The remainder of the chapter first presents findings from the secondary data review and then findings from the interviews.

4.1 Secondary Data Review

The research team conducted a review of secondary data sources relating to the lighting market prior to conducting the interviews. The purpose of the secondary data review was to develop a high-level understanding of the lighting market to inform subsequent primary research tasks. In particular, the research team sought to address the following questions:

- What is the size of the overall nonresidential lighting market in Connecticut?
- What portion of the overall Connecticut nonresidential lighting market is considered "energy efficient"?
- What is the path this equipment takes from manufacturing to end user?
- Who are the market actors in the lighting supply chain?
- What are the natural groupings for equipment types within each end use category?
- What types of data are missing from the secondary data sources?[29]

The research team completed the secondary data review during August and September 2014. This review focused on the following six reports available at that time:

1. *Lighting Fixtures: Industry Study #3136*, Freedonia Group (May 2014)[30]
2. *Lamps: Industry Study #3054*, Freedonia Group (October 2013)[31]

[28] These policies include the Energy Independence and Security Act of 2007, which phased out the manufacturing of traditional-wattage incandescent lamps, and a 2009 Department of Energy regulation that effectively banned the manufacturing of T12s.
[29] The original study plan included designing contractor surveys that would include inquiry for these market actors' perspective on the size and operation of the market, how they interacted with customers with regard to the equipment and energy efficiency and to fill gaps from the earlier research tasks. This would have then been followed by C&I customer surveys. These latter activities were cancelled and this report is the final wrap-up report for this study.
[30] Purchased from http://www.freedoniagroup.com/industry-study/3136/lighting-fixtures.htm
[31] Purchased from http://www.freedoniagroup.com/industry-study/3054/lamps.htm

3. *LEDs and High Efficiency Lighting: Industry Study #3068*, Freedonia Group (November 2013)[32]
4. *2010 U.S. Lighting Market Characterization*, US Department of Energy, Energy Efficiency & Renewable Energy (January 2012)[33]
5. *"Lamp Indices,"* National Electric Manufacturers Association (Various dates)[34]
6. *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*, US Department of Energy, Energy Efficiency & Renewable Energy (August 2014)[35]

Sources of data for the Freedonia reports (reports #1 - 3 in the list above) included government publications, trade associations, industry participants, and online databases. The 2012 Department of Energy (DOE) report (#4) was based on a national onsite lighting inventory. The National Electric Manufacturers Association (NEMA) report (#5) was based on surveys of NEMA member companies. The 2014 DOE report (#6) used secondary data sources to forecast future lighting inventories.

All of these reports are nationally focused. However, as part the market actor interviews, interviewees stated that the Connecticut lighting market is similar to the national lighting market. It is important to consider that these reports rely on data collected at least a year prior to publication. Therefore, these reports do not necessarily represent the 2015 market; however, they provide a recent baseline for comparison.

The remainder of this section presents the findings from this secondary data review. It presents results on the following topics:

- Nonresidential lighting market structure,
- Lighting categories,
- The size of the nonresidential lighting market (including the prevalence of energy efficiency and LEDs), and
- Data gaps.

Nonresidential Lighting Market Structure

Understanding the market structure and key market actors is necessary for determining where to best intervene in the supply chain. This section summarizes data as it relates to how the nonresidential lighting market is structured. It first describes the supply chain – that is, how products are developed and how these products make their way to the customer. It then identifies key market actors working within the nonresidential lighting market.

Supply Chain

At the highest level, the nonresidential lighting supply chain generally flows from manufacturers, to distributers, and then to end users. Characteristics of the supply chain are similar between lamps and fixtures; therefore, below we present results for both lamps and fixtures together. All

[32] Purchased tables from http://www.freedoniagroup.com/industry-study/3068/leds-and-high-efficiency-lighting.htm. Because the research team only purchased tables and not the entire report, the research team cannot provide unique page numbers for data references throughout this chapter.
[33] Available at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf
[34] Available at http://www.nema.org/Intelligence/pages/lamp-indices.aspx
[35] Available at http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/energysavingsforecast14.pdf

of the data presented in this sub-section is from the Freedonia lamp and fixture reports (reports #1 and #2 in the list above).

The first step in the supply chain is to develop innovative lamps and fixtures. Lamp and fixtures manufacturers typically develop new products within their own research teams; however, some academic institutions and research laboratories also research and develop new lamp products. Much of the new lamp research is focused on increasing the environmental friendliness of the lamps. Lamp developers specifically focus on increasing energy efficiency and lowering mercury content. Additionally, developers also look to improve other performance characteristics, such as longer life and better light quality.[36]

Once developed, the manufacturing process differs slightly between lamps and fixtures. For lamps, the manufacturing process is relatively complex, but fairly well established. The US market purchases the majority of lamps from manufacturing locations in China and Mexico. Manufacturing of fixtures, on the other hand, depends on the product type, with some fixtures produced automatically on assembly lines and others by hand. Large and small manufacturers also often produce fixtures outside of the US, typically in Mexico, to minimize costs.[37]

Once manufactured, the lamp and fixture distribution is similar but varies by sector and OEM markets. The nonresidential market includes buildings and exterior applications such as highways and streets. According to Freedonia, manufacturers distribute their products to the nonresidential market through distributors and internal sales teams. Distributors are often electrical distributors that sell lamps and other electrical products largely to contractors and nonresidential purchasing professionals. Nonresidential customers can often purchase lamps from distributors through a bidding process.[38] While Freedonia reported that manufacturers also have internal sales teams that work with government and national accounts, interviewees clarified that while this happens, manufacturers still use local distributors to actually stock and sell the product to those customers. Interviewees similarly reported that manufacturers work with external sales representatives to help manage and sell their products to local distributors and customers.

According to Freedonia, professional staff are often responsible for purchasing decisions in nonresidential applications. Such staff include: developers, property managers, electrical contractors, engineering personnel, and maintenance personnel.[39]

Key Market Actors in the Supply Chain

The Freedonia reports also highlighted specific manufacturers of lamps and fixtures. These data show that the lamp market is controlled by a few large manufacturers, but the fixture market is more diversified. With regards to market actors in the lamp market, the top three manufacturers produced 44% of all the lamps sold in the United States in 2012 (including lamps sold in all sectors and original equipment manufacturers, or OEMs). They were General Electric, Osram Licht, and Royal Philips. The following three small- to mid-sized firms comprised an additional 6%

[36] Freedonia Group, *Industry Study #3054 Lamps* (Cleveland, 2013) 224-238 and Freedonia Group, *Industry Study #3136 Lighting Fixtures* (Cleveland, 2014), 260-272.
[37] Ibid.
[38] Ibid.
[39] Ibid.

of the total lamp market: Feit Electric, TCP International, and Ushio. A handful of smaller companies specialize in particular markets, especially with regards to OEMs.[40]

More companies play a role in the fixture market. In 2013, Freedonia reported seven leading fixture manufacturers accounted for 26% of total fixture sales within all sectors and OEMs: Acuity Brands, Royal Philips, Cooper Lighting (Eaton), Hubbell, Osram Sylvania (Osram Licht), Hella, and Koito Group. However, the fixture industry includes hundreds of companies, many of which are small. Products are diverse and serve lots of different needs, including cost, maintenance, aesthetics, and availability.[41]

Lighting Technologies and Categories

Understanding the key technologies that make up the lighting market is essential for determining how to focus energy efficiency strategies and program design. To better understand the types of lighting products sold, and help frame our subsequent interviews, the research team wanted to identify ways by which lighting could be grouped into categories. As shown in Table 4-1, the Department of Energy presents six major technological lamp categories: incandescent, halogen, compact fluorescent, fluorescent, high Intensity discharge (HID), and other (which includes LEDs):[42]

Table 4-1: Lamp Types

Incandescent	Halogen	Compact Fluorescent	Fluorescent	High Intensity Discharge (HID)	Other
• General Service - A-type • General Service-Decorative • Reflector • Misc.	• General Service • Reflector • Low Voltage Display • Misc.	• General Service-Screw • General Service-Pin • Reflector • Misc.	• T5 • T8 < 4 feet • T8 4 feet • T8 > 4 feet • T8 U-shaped • T12 U-shaped • Misc.	• Mercury Vapor • Metal Halide • High Pressure Sodium • Low Pressure Sodium	• LED Lamp • Misc.

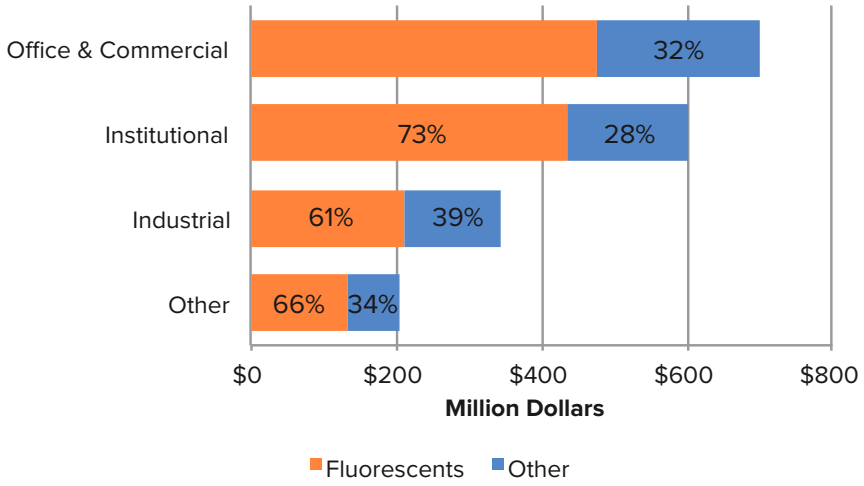
Source: US Department of Energy, Energy Efficiency & Renewable Energy, 2010 U.S. Lighting Market Characterization (Washington DC, 2012) 4.

At an even higher level, Freedonia identified two groups: (1) filament lamps, which include incandescent and halogen lamps, and (2) electrical discharge lamps, which include fluorescent, HID, and other lamps (mostly LEDs).[43] In the nonresidential market, Freedonia reported that different lamp technologies are best suited for different building types. For example, offices tend to rely on fluorescent lamps to light spaces, hotels often use filament lamps for improved aesthetics, and facilities with high bay lighting often use HID lamps.[44] Of electrical discharge

[40] Freedonia Group, *Industry Study #3054 Lamps* (Cleveland, 2013), pp. 214-217.
[41] Freedonia Group, *Industry Study #3136 Lighting Fixtures* (Cleveland, 2014), pp. 247-252.
[42] US Department of Energy, Energy Efficiency & Renewable Energy, *2010 U.S. Lighting Market Characterization* (Washington DC, 2012), p. 4.
[43] Freedonia Group, *Industry Study #3054 Lamps* (Cleveland, 2013)
[44] Freedonia Group, *Industry Study #3054 Lamps* (Cleveland, 2013), p. 190.

lamps, fluorescents are the most common. Figure 4-1shows the prevalence of fluorescent lamps vs. other types of lamps in various nonresidential segments.[45]

Figure 4-1: Percentage of Fluorescents Installed by Nonresidential Segment in 2012 in the United States



Source: Freedonia Group, *Industry Study #3054 Lamps* (Cleveland, 2013), pp. 193-198.

Like lamps, fixtures can further be classified by type. Freedonia defined three fixture categories but they did not provide any specific market data to show the prevalence of these fixture types within the nonresidential sector:[46]

- Non-portable – fixtures that are hard-wired
  - Industrial-type
  - Outdoor lighting
  - Other indoor varieties (including recessed, track, emergency)
- Portable – fixtures that are plugged into a wall, battery powered, or solar powered
- Parts and Accessories
  - Outdoor poles
  - Lamp ballasts (fluorescent and HID)
  - Other

Size of the Nonresidential Lighting Market

This sub-section presents secondary data on the overall size of the nonresidential lighting market, including data relating to lamps and fixtures. It also presents data relating to the prevalence of energy efficient lighting and the prevalence of LED lighting. Freedonia estimated that lamp sales will slow down because they expect more efficient lamps (which generally last longer) to be installed overtime, thereby decreasing the number of lamps sold in the future. The fixture market, on the other hand, is expected to continue to grow over time as the new

[45] Within the nonresidential section of the Freedonia lamp report, Freedonia only compared fluorescents with other lamps. There was no more granularity to show other types of lamp technologies within this report at the sector level.
[46] Freedonia Group, *Industry Study #3136 Lighting Fixtures* (Cleveland, 2014).

construction market is expected to continue growing in the future. The energy efficient lighting market is also growing, although it is unclear exactly what percentage of the market is energy efficient. The LED market in particular has shown large growth in recent years and is expected to remain a prominent type of lamp in the future.

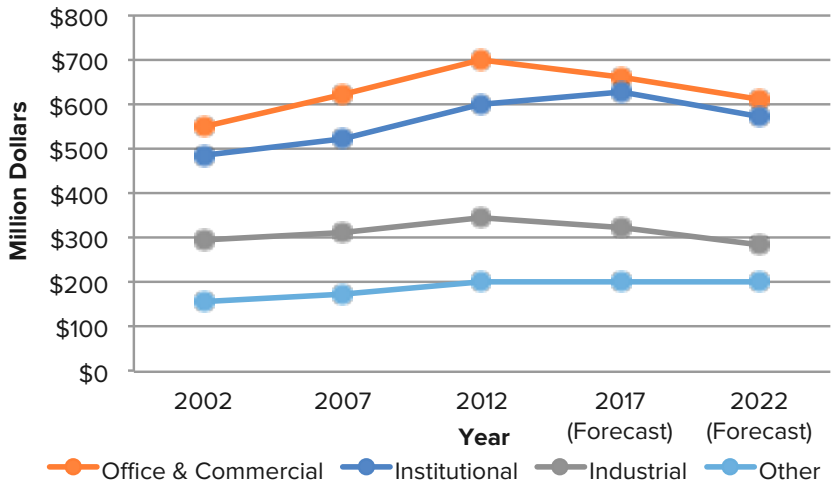
Freedonia did not break down their data by state, however interviewees expected Connecticut to be similar to national trends.

Size of the Nonresidential Lamp Market

This sub-section first presents the size of the lamp market and then the size of the fixture market. Freedonia reported the size of the United States nonresidential lamp market to be valued at $1.9 billion in 2012. Freedonia estimated that the demand for lamps would decrease less than 1% annually to $1.8 billion in 2017. Freedonia predicted decreased lamp sales overtime as lifetime use for lamps is expected to increase with more energy efficient technologies. Freedonia forecasted increased competition from LEDs and increased construction activity within the nonresidential sector would help minimize additional losses that could have occurred. Additionally, Freedonia expected that the 2007 Energy Independence and Security Act (EISA), which phased out the manufacturing of traditional incandescents by 2014, would have limited impact on the nonresidential market since the nonresidential market has not heavily relied on incandescent lamps.[47]

Figure 4-2 shows a breakdown of sales for different segments within the nonresidential sector. As shown, the highest demand is for office and commercial buildings (at $700 million), followed by institutional buildings (at $600 million). In 2012, the office and commercial segment made up the largest share (38%) of lamp sales, followed by institutional buildings (32%), and then industrial buildings (19%). Freedonia expected these trends to be consistent over time.[48]

Figure 4-2: Size of Nonresidential Lamp Market in the United States



Source: Freedonia Group, Industry Study #3054 Lamps (Cleveland, 2013), pp. 189-190.

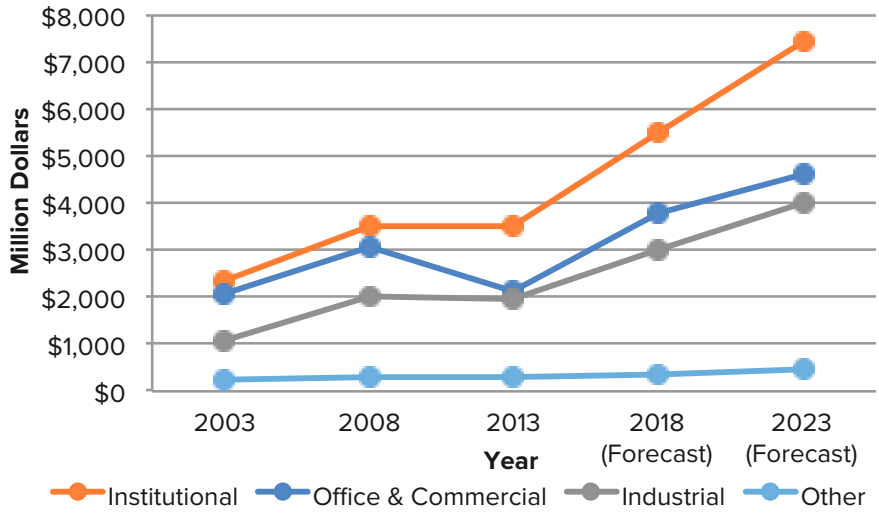
[47] Freedonia Group, *Industry Study #3054 Lamps* (Cleveland, 2013), pp. 189-190.
[48] Ibid.

Size of the Nonresidential Fixture Market

Freedonia reported the nonresidential fixture market to be valued at $7.9 billion in 2013, and they expected sales to annually increase 9.9% to $12.7 billion by 2018. Unlike lamps, Freedonia forecasted the sales of fixtures to increase over time due to the recovery of the nonresidential new construction industry.[49]

As shown in Figure 4-3, institutional settings comprised the largest (44%) market share of fixture sales in 2013, at $3.5 billion. This trend is forecasted to continue over time. Freedonia expected greatest relative growth among the office and commercial segment.[50]

Figure 4-3: Size of Nonresidential Fixture Market in the United States



Source: Freedonia Group, Industry Study #3136 Lighting Fixtures (Cleveland, 2014), p. 173.

Prevalence of Energy Efficiency in the Nonresidential Lighting Market

This sub-section summarizes how much of the lighting sold could be considered energy efficient. The research team used a variety of data sources to examine the prevalence of energy efficient products in the lighting market, including the Freedonia reports and studies published by the Department of Energy. None of the research specifically addressed this question, but they offer data points that can be used to understand trends.

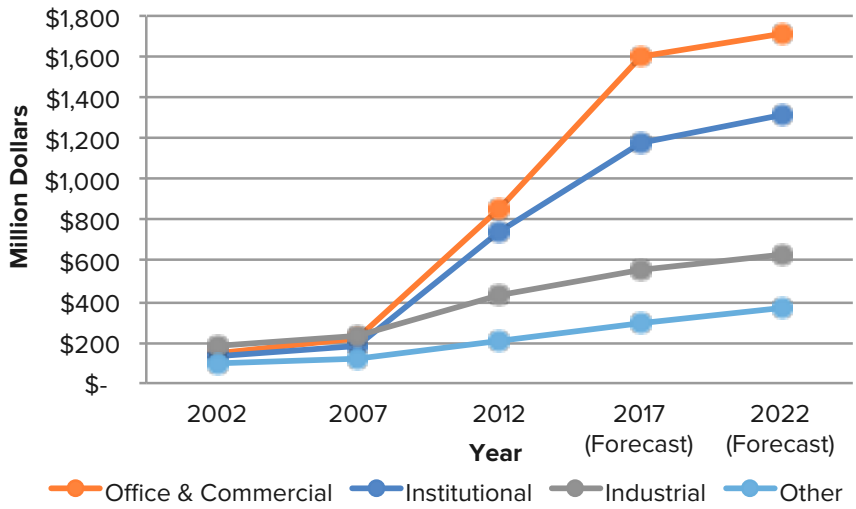
While Freedonia did not clearly define the proportion of energy efficient lighting in the nonresidential sector, they did report sales data on high efficiency lighting. According to these findings, the total high efficiency lighting demand for the nonresidential sector was worth $2.2 billion in 2012. While lamp demand is expected to decline overtime, energy efficient lighting is forecasted to grow to $4 billion in 2022.[51] As shown in Figure 4-4, starting in 2012, Freedonia

[49] Freedonia Group, *Industry Study #3136 Lighting Fixtures*, (Cleveland, 2014), pp. 171-173.
[50] Ibid.
[51] The research team attempted to apply these figures to the overall nonresidential lamp demand but found it difficult to do so. Applying the energy efficiency figure to the lamp data resulted in figures over 100%. Without supplemental text from the Freedonia Industry Study #3068 to explain the data in detail, the research team was not confident in applying the data to the lamp data to calculate an overall percentage of energy efficiency demand in the market.

found that the office and commercial segment is demanding a larger share of energy efficient lighting. They expected this trend to continue in the future.

Freedonia reported that the nonresidential sector is driven to install efficient lighting to help decrease operating costs. Because these types of customers can often realize cost savings, Freedonia suggested that energy efficient lamps are more common in the nonresidential sector compared to the residential sector.[52]

Figure 4-4: High Efficiency Nonresidential Lighting Demand in the United States by Sector

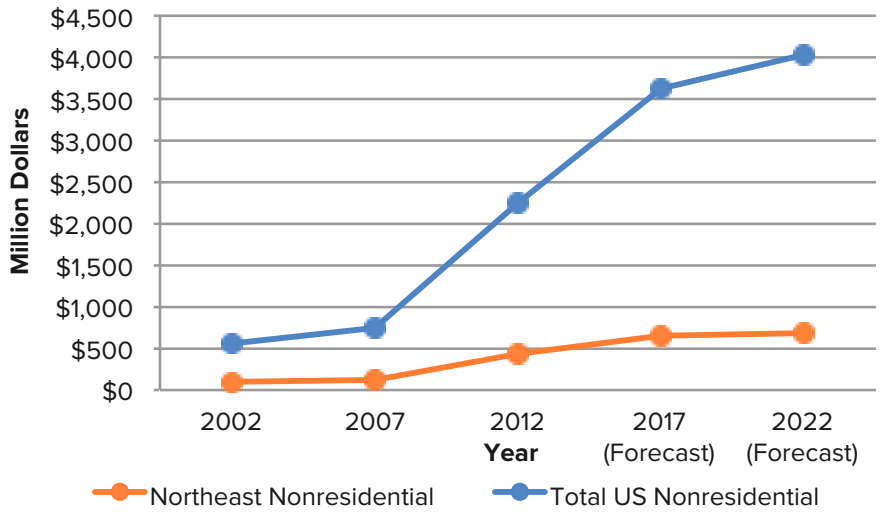


Source: Freedonia Group, Industry Study #3068 LED and Energy Efficient Lighting (Cleveland, 2013).

Although most of the reports reviewed contained data at the national level, there were limited data available specific to the Northeast region. As shown in Figure 4-5, demand for efficient lighting in the Northeast is expected to increase 58% between 2012 and 2017, from $420 million to $665 million. Demand is then expected to plateau somewhat, increasing only 5% between 2017 and 2022, to $700 million. This pattern is similar to that for national nonresidential efficient lighting demand; demand in the Northeast is a relatively consistent proportion of national demand, ranging from 19% in 2012 to 17% in 2022. This is consistent with the idea that national lighting trends are generally similar to those that occur within the Connecticut market (or at least the Northeast market more broadly).

[52] Freedonia Group, *Industry Study #3054 Lamps* (Cleveland, 2013), 190.

Figure 4-5: High Efficiency Nonresidential Lighting Demand in the Northeast



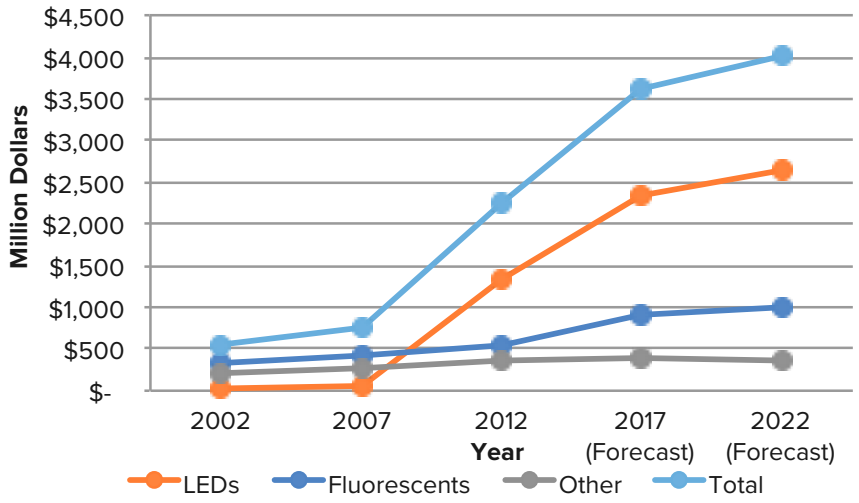
Source: Freedonia Group, Industry Study #3068 LED and Energy Efficient Lighting (Cleveland, 2013).
Note. "Northeast" includes: CT, ME, MA, NH, RI, VT, NJ, NY, and PA.

Prevalence of LEDs in the Nonresidential Lighting Market

Of all technologies, LEDs are showing the greatest gains in the lighting market, and so the research team conducted additional research on LEDs to better understand their market share and any changes that are occurring. In the Freedonia report relating to energy efficient lighting sales, Freedonia identified different types of energy efficient lighting for the nonresidential market, including LEDs, high efficiency fluorescents, and "other." As shown in Figure 4-6, in 2012, Freedonia found that LED sales comprised 60% of the high efficiency lighting sales, at $1.3 billion out of $2.2 billion in total energy efficient lighting sales. This was a dramatic increase from 2007, at which point LEDs only comprised 6% of high efficiency lighting sales, at $45 million out of $750 million in total energy efficient lighting sales. Freedonia forecasted the LED share to reach closer to 65% of nonresidential energy efficient lighting sales in 2017.[53]

[53] Freedonia Group, Industry Study #3068 LED and Energy Efficient Lighting (Cleveland, 2013).

Figure 4-6: Nonresidential Market Share of Energy Efficient Lighting in the United States, by Lighting Type



Source: Freedonia Group, Industry Study #3068 LED and Energy Efficient Lighting (Cleveland, 2013).

A 2014 Department of Energy (DOE) study also explored the role of LEDs in the lighting market. In this study, the DOE compared LED sales to the overall lighting market, not just the energy efficient lighting market. As shown in Table 4-2, DOE predicts that LED sales will grow dramatically in the coming years, from 3% in 2013 to 84% of lighting sales in 2030. In 2015, the DOE expected LED sales in the nonresidential sectors to be 8% and 3%, respectively.[54] This is much lower than what interviewees stated, which was that anywhere from 60% to 100% of sales to nonresidential customers were expected to be LED by 2017 (reported in more detail in section 4.2 under "Prevalence of LED Lighting in Connecticut." This was a national trend that interviewees reported would be expected in the state of Connecticut as well.

Table 4-2: U.S. Department of Energy LED Market Share Forecasts of Lighting Sales in the United States for Buildings and Infrastructure

LED Market Share	2013	2015	2020	2025	2030
Overall	3%	11%	48%	72%	84%
Residential	< 1%	3%	33%	71%	83%
Commercial	2%	8%	42%	69%	82%
Industrial	< 1%	3%	26%	58%	87%
Outdoor	9%	22%	75%	97%	99%

Note. The Department of Energy defined market share as the percentage of sales, measured in lumen-hours.
Source: Department of Energy, Energy Efficiency & Renewable Energy, Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, (Washington DC, 2014), p. 9.

[54] Department of Energy, Energy Efficiency & Renewable Energy, *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications,* (Washington DC, 2014), p. 9.

Data Gaps from Secondary Data Review

The Freedonia and the Department of Energy reports offered a great deal of information relating to national trends. However, these reports did not provide any specific information relating to Connecticut. In addition, as the lighting market is rapidly changing due to policy changes and the introduction of LED technologies, secondary data may be obsolete once published.[55] Therefore, findings that draw on data from 2010-2012 may not necessarily reflect the current market. To address these data gaps, the research team interviewed lighting manufacturers, manufacturer representatives, and distributors active in the Connecticut nonresidential lighting market in 2014. Results of these interviews are presented in the following section.

4.2 Interview Findings

This section presents results from eleven in-depth telephone interviews with lighting manufacturers, manufacturer representatives (who represented multiple manufacturers), and distributors active in the nonresidential market in Connecticut. Unlike the secondary data review, interview findings are specific to the Connecticut nonresidential lighting market.

Interview findings suggest that the nonresidential lighting market is changing rapidly due to new federal lighting standards coming into effect, which eliminated the manufacturing and importing of fluorescent T12s in 2014, and LED technologies becoming less expensive and more widely adopted.[56] Because the market is changing, lighting distributors and manufacturers had less certainty about which technologies should be considered energy efficient, however they agreed that energy efficiency played a key role in selling lamps to nonresidential customers. Additionally, the interviews highlighted the increasing role LEDs are having in the marketplace, even more so than what was presented in the secondary data review.

To conduct the interviews, the research team spoke to eleven lighting manufacturers, manufacturing representatives, and distributors:

- **Five Manufacturers** – All five interviewees represented international lighting manufacturing companies. Two of the manufacturers only produced LED technologies. The other three produced LED and traditional lighting technologies.
- **Two Manufacturer Representatives** – Both interviewees represented the regional sales force for a wide range of lighting manufacturers in the Northeast region.
- **Four Distributors** – The research team spoke to three national distribution agencies and one distributor who worked entirely in Connecticut.

The remainder of this chapter presents feedback the research team collected from the interviews with lighting manufacturers and distributors on the following topics:

- **Nonresidential lighting market structure** – This section includes descriptions of the structure of the supply chain, key market actors, and the relationships between the market actors.

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[55] The policy changes referenced in the sentence relate to both the Energy Independent and Security Act of 2007, which banned the manufacturing of incandescent lamps, and the 2009 Department of Energy regulation banning the manufacturing of fluorescent T12s.

[56] In 2009, the Department of Energy developed a new regulation governing lumens per watt for linear fluorescent and halogen PAR lamps.

- **Lighting categories, applications, and customer segments** – This section discussed the types of lighting products sold today, the use of lighting by nonresidential customers, and the mix of customer segments purchasing lighting.
- **Size of the nonresidential lighting market** – In this section, we present the information obtained regarding the size of the lighting market in Connecticut and the amount of energy efficient technologies sold to Connecticut nonresidential customers.
- **Marketing to nonresidential customers** – This section includes Insight from interviewees on effective means to market energy efficient lighting products to nonresidential customers in Connecticut.
- **Other emergent findings** – Here we discuss additional feedback from interviewees.

Nonresidential Lighting Market Structure

At a high level, the market structure for the nonresidential lighting market comprises a number of actors playing unique roles. Results are similar to what was found in the secondary data review, but are much more granular. The remainder of this sub-section presents an illustration of how the supply chain is organized. It then details the role each market actor plays in the nonresidential lighting market and summarizes key on-going changes in the market structure as a result of LED technologies.

Supply Chain

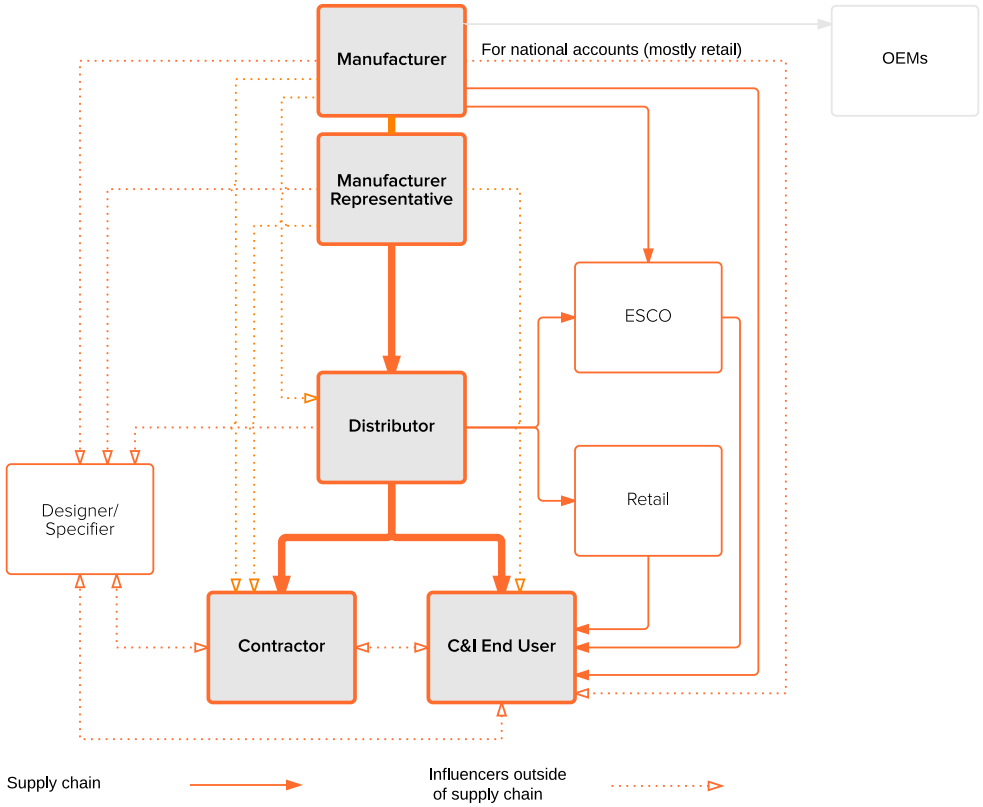
Figure 4-7 presents an image of the nonresidential lighting market in Connecticut and includes:

- Manufacturers
- Manufacturer representatives
- Distributors
- Retail stores
- Contractors/ESCOs
- Lighting designers
- End-users/customers

As shown, the primary supply chain flows from manufacturers, through manufacturer representatives, to distributors, then to contractors and/or ultimately to customers. Outside of this general structure, distributors also sell to energy service companies (ESCOs) and national chain stores, which all manufacturers referred to as "national accounts." Manufacturers reported they could sell directly to large nonresidential customers, but all interviewees reported that this was very rare.

The dotted lines in Figure 4-7 show that a number of different market actors also play a role in influencing customers' purchasing decisions. Manufacturers, manufacturer representatives, distributors, contractors, and specifiers (*i.e.*, lighting designers, architects, and engineers) all play a role in influencing a customer's purchasing decision. Interview findings suggest that the most influential actor varies based on unique relationships and projects.

Figure 4-7: Lighting Supply Market Structure for Nonresidential Applications



Note. Grey/bold coloring depicts primary supply chain. Manufacturer Representatives play an active role in the sales process but do not hold stock, stock is typically sent directly from the manufacturer to the distributor.

Role of Manufacturer

The primary role of the manufacturer is to produce the product. Manufacturers work closely with manufacturing representatives and distributors to carefully calculate how much product they need to produce in order to meet expected customer demand. They also play a role in working directly with end users (particularly national retail chains) or ESCOs to demonstrate lighting products that could be sold nationally or regionally to large end users. At times, manufacturers can work closely with specifiers (*i.e.* lighting designers, architects, and engineers) to make sure specifications are accurate. Through this effort, they can sometimes cater products to end users' needs, but this is rare.

Major Lighting Manufacturers:

GE Lighting, Osram Sylvania, Philips Lighting, TCP International, Cree, Alco, Max Lite, Fan Lite

Manufacturers do not typically distribute products because they do not have floor space or the ability to float costs between the time a product is ordered and when the end user pays for the product. Additionally, most manufacturers do not have their own sales force and instead they rely on independent manufacturing representative agencies to serve as regional sales teams. These manufacturer representatives are discussed next.

Role of Manufacturer Representative

The manufacturer representative plays the role of an independent sales force for manufacturers. One manufacturer representative may represent multiple manufacturers in a particular geographic territory. They work closely between distributors and manufacturers to ensure manufacturers produce the right quantities of products and coordinates where the products need to be shipped. Manufacturers pay manufacturer representatives a commission based on final sales. Each product has its own commission rate, which is based off of a variety of factors determined by the manufacturer.

Major CT Manufacturer Representatives:

Lighting Affiliates,
Vanguard Lighting,
Reflex Lighting
Apex Lighting Solutions,
Langlais Associates

The manufacturer representative also plays a key role in disseminating information on product specifications to distributors, end users, contractors, lighting designers and/or specifiers. In doing so, they play an active role in influencing lighting-related purchasing decisions, even though the actual sale is through the distributor. In some cases, the manufacturer representative might actually generate the sales documentation, but they would still include fees for the distributor to store and deliver the product to the purchaser. When asked how often this happened, manufacturer representative and distributor interviewees provided a range of responses from “rarely” to 70% of the time. This variance is reflective of how different representatives operate, with some solely focusing on facilitating the distribution of the products and others who work more closely with specifiers and/or end users.

Manufacturer and distributor interviewees both valued the role of the manufacturer representative. Manufacturer interviewees reported that independent manufacturing representatives are better suited to perform the sales functions than the manufacturer because manufacturer representatives are based regionally and have strong local relationships with specifiers and contractors. Distributors value the role of the manufacturer representative because they can work directly with one representative, rather than having to work with multiple manufacturers. Based on interview results, there is at least one large manufacturer that still relies on their own sales force rather than a manufacturer representative, however multiple interviewees pointed out that the market was moving towards outsourcing sales forces because it is more cost effective.

Role of Distributor

The distributor acts as the actual sales agent for all lighting manufacturers. They warehouse equipment and coordinate shipping to end users. They have ultimate control over what type of products are available and communicate this to their customers. They also work closely with purchasers to inform them of lighting specifications, stock levels, and lead times. Distributors work closely with manufacturer representatives to manage stock flows. They also work closely with contractors/lighting technicians, ESCOs, designers, and end users. In Connecticut, there are a few influential local distributors as well as national distributors with regional offices. Additionally, there are a growing number of online distribution companies.

The research team asked distributor interviewees about to whom they sold their products, and interviewees provided a wide range of responses. Two distributors said their sales were mostly split between end users and contractors. Another distributor reported that 90% of their business was to contractors, while another said 75% of their business was directly to end users. This

variance is likely due to the fact that distributors can specialize in different types of customers, with some distributors working more closely with contractors/technicians and others working more closely with end users.

Role of Retail Store

In addition to distributors, retail stores can also sell lighting products to nonresidential customers, but interviewees reported these sales represented a very small percentage of the overall nonresidential lighting market. Interviewees considered retail stores to focus on residential customers, but acknowledged that small nonresidential customers (which one interviewee defined as being one to five employees) likely purchase their lighting from retail stores. These types of nonresidential customers would likely be looking for more residential-type lighting, purchasing small quantities of lighting, and they would value the proximity of a neighboring retail shop. Interviewees reported that distributors likely provide better prices than retail shops because distributors' prices can be negotiable. That being said, one manufacturer reported that even if only 10% of businesses purchased their lighting from retail shops, it would still represent a large volume.

Role of Contractor/Lighting Technicians & Energy Service Companies (ESCOs)

Contractors and lighting technicians are the actors who are actually installing the equipment. They often coordinate the sale with the distributor, and as a result, can play an influential role in relaying lighting information from the distributor back to the customers. Contractors and lighting technicians play a larger role in new construction/renovation projects compared to replacement projects.

ESCOs play a similar role to contractors and lighting technicians, as they also install lighting equipment, but ESCOs focus entirely on providing energy efficiency upgrades. Because ESCOs buy products in large quantities, they are more likely to work closely with manufacturers compared to other contractors. However, most manufacturers still require ESCOs to purchase through a distributor, even if the ESCO and manufacturer have a close relationship.

Role of Lighting Designer

Lighting designers, including architects and engineers, specify lighting equipment that will be installed on new construction/renovation projects. They work closely with customers to determine their needs and desires. These actors can be highly influential in what lights are actually purchased (especially with new construction and retrofit projects) because they can direct what lights contractors and lighting technicians install. Additionally, because customers tend to buy replacements of existing lamps, the initial specification can play a large role in dictating future purchases. For example, if a lighting designer specifies a fluorescent lamp, customers are more likely to replace the lamps with fluorescents rather than LEDs.

Role of End User

The nonresidential end user is the ultimate decision maker. They work closely with contractors, lighting technicians, and lighting designers to ensure their needs are met. Large nonresidential end users tend to have dedicated facility staff to make facility decisions, while smaller nonresidential end users tend to rely on owners, managers, or office staff. According to interviewees, when nonresidential end users buy replacements, they are most likely to buy an exact replacement. They are also most likely to order from the company that they worked with in

the past. These results are important in that they suggest original lighting specifications and purchasing decisions play a key role in influencing long-term purchasing behaviors.

Role of Original Equipment Manufacturers (OEMs)

Lighting manufacturers also produce lamps for original equipment manufacturers (OEMs). OEMs purchase a variety of lighting products. The research team did not focus its interviews on OEMs because their products represent very different markets, including computers and automobiles. However, one interviewee stated that some traditional lighting manufacturers are now more focused on OEMs than in prior years. This is because LEDs have changed the traditional lighting market structure. This change is explored in more detail below.

Changing Market Structure

Two of the interviewees explained that the rapid growth in LED technologies in the past few years produced some changes in the market structure. Both interviewees described how LED technologies have allowed new manufacturers to become active in the lighting industry and even outpace the traditional lighting manufacturers that have dominated the lighting market for the last one hundred years. While the traditional lighting manufacturers still play a dominate role in lighting, they have had a harder time shifting production from other technologies to LED technologies because they are heavily invested in fluorescents, halogens, etc. One of the interviewees reported that while the traditional lighting manufacturers will eventually catch up, some of them are deciding not to invest in LED lighting products, but rather focus on producing LED chips for other equipment manufacturers, such as computers, automobiles, and other lighting manufacturers.

The other interviewee defined these changes by describing “pre- and post-LED” models. The “pre-LED” model consisted of three types of manufacturers: those that produced lamps and ballasts, those that produced controls, and those that produced fixtures. In the “post-LED” model, these technologies are sold in one package, thereby displacing manufacturers that focus only on lamps, controls, or fixtures. This adjustment is allowing for new manufacturers to enter into the market place. This changing market structure will need to be monitored so the dominant manufacturers can be targeted for energy efficiency programs.

Lighting Categories, Applications, and Customer Segments

This sub-section summarizes findings relating to what types of lighting technologies are sold and what types of customers purchase lighting products. The research team asked interviewees about the lighting products they sell to better understand what types of lamps are sold to Connecticut nonresidential customers. This sub-section first presents the different types of lighting categories identified by the interviewees. It then presents the various types of lighting applications identified by the interviewees and concludes by presenting feedback on nonresidential customer segments.

Lighting Categories

Interviewees identified the following high-level categories of lamps:

- Fluorescent
- Compact Fluorescents

- LED
- HID
- Incandescent
- Halogen

These findings confirm results from the secondary research, but highlight the increasing prevalence of LEDs, as LEDs were considered an "other" in the secondary research findings. That being said, interviewees, particularly distributors, did not frame their discussion around lighting categories, but rather framed their discussion around lighting applications. It tended to be easier for interviewees to frame their responses around how customers use complete lighting products, including fixtures and lamps, rather than specific technology classifications.

Lighting Applications

Nonresidential customers use lamps in a variety of ways. For the purpose of the interviews, the research team focused on lighting in and around buildings, rather than OEM applications. Interviewees categorized lighting differently, with some interviewees defining lamps by interior and exterior uses and some interviewees defining lamps by fixture types. By analyzing all of the interviewees' responses, the research team identified the following categories:

- Exterior lighting
  - Parking – for parking lots and/or garages
  - Roadway – for roads (public and private)
  - Walkway – for pedestrians getting to/from buildings
  - Area & Sight – for pedestrians at building entrances and to highlight landscaping or building features
- Interior lighting
  - Linear and Troffers– found mostly commonly in commercial settings; many distributors called the lamps used in linear lighting as "tube lighting"
  - Recess Downlights and Screw-Ins– includes a variety on non-linear lighting that is recessed into the ceiling or surface mounted; examples include desk lamps, track lighting, sconces
  - High/Low Bay – found most commonly in industrial settings and big box stores; these applications rely on fixtures that use deflectors to direct light outward depending on the ceiling heights; typically high bay lighting is used in facilities with ceilings higher than 20 feet, while low bay lighting is used in facilities with ceilings less than 20 feet.
  - Emergency – found throughout facilities to direct occupants to exits.

Customer Segments

The research team asked interviewees about the key end use customer segments in the lighting market in Connecticut. Interviewees, for the most part, could not answer this question because they did not keep track of customers by segments. However two interviewees highlighted the following nonresidential customer segments within the nonresidential sectors in Connecticut:

- Schools & universities
- Retail

- Health care
- Grocery stores
- Jewelry stores
- Restaurants
- Small offices
- Large offices
- Municipalities
- Warehouses

Interviewees agreed that Connecticut businesses follow national trends and that one could estimate the breakdown of sales by looking at census data. Census data, as shown in Table 4-3, indicates retail and health care businesses to be the most prevalent business type in Connecticut. With this reasoning, retail and health care businesses would comprise the highest amount of lighting sales within Connecticut. These data, however, do not take into consideration differences in business size or lighting needs. Using only census data, therefore, reduces the influence certain businesses, such as universities or facilities with high lighting needs, have on the lighting market. An analysis of Connecticut utility billing data (see Chapter 3) showed that the business type that is largest in terms of energy consumption is office, but the second largest is mercantile (or retail). The comparison is complicated by the fact that "office" is not a category in the census data.

Table 4-3: Frequency of Commercial Establishments in Connecticut

Business Types	Total Establishments	Percent
Retail Trade	12,623	14%
Health Care and Social Assistance	10,315	12%
Other Services (except Public Administration)	9,322	11%
Professional, Scientific, and Technical Services	9,245	10%
Accommodation and Food Services	8,287	9%
Construction	7,860	9%
Finance and Insurance	6,159	7%
Administrative and Support and Waste Management and Remediation Services	5,210	6%
Wholesale Trade	4,374	5%
Manufacturing	4,357	5%
Real Estate and Rental and Leasing	3,142	4%
Information	1,631	2%
Arts, Entertainment, and Recreation	1,605	2%
Transportation and Warehousing	1,601	2%
Educational Services	1,354	2%
Management of Companies and Enterprises	743	1%
Utilities	157	< 1%
Agriculture, Forestry, Fishing and Hunting	85	< 1%
Mining, Quarrying, and Oil and Gas Extraction	74	< 1%
Industries not classified	66	< 1%

Source: US Census 2012. http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl

Size of the Nonresidential Lighting Market

One of the primary objectives for conducting the interviews was to better understand the size of the lighting market in Connecticut and how efficient it is. The results highlight a market that is becoming more efficient due to policy changes and the wide adoption of LED technologies. Results showed, however, that interviewees had limited understanding of the total market size in Connecticut. They also defined energy efficiency differently, resulting in a varied understanding of the prevalence of energy efficient lighting in Connecticut. This section first summarizes the information obtained regarding the overall size of nonresidential lighting in Connecticut. It then presents results on how interviewees defined energy efficiency, the prevalence of energy efficient lighting in Connecticut, and the prevalence of LED lighting in Connecticut.

Market Size in Connecticut

Interviewees did not know the size of the nonresidential lighting market in Connecticut, stating that their feedback would be a complete guess. Interviewees attributed this to the fact that they were only familiar with their own business and/or that they specialized in a particular customer segment or region and didn't have familiarity with the entire nonresidential lighting marketing in Connecticut.

The research team also asked interviewees to provide a breakdown of sales based on key lighting applications to better understand what types of lamps were sold. Three interviewees were not willing or able to share the information, but the remaining eight interviewees provided their responses. As shown in Table 4-4, responses were not consistent. Two interviewees mostly sold linear lighting, three interviews sold 40%-50% linear, and three interviewees sold less than 40% linear. Breakdowns between nonlinear lighting applications varied even more and many interviewees could not provide any additional detail.

Table 4-4: Lighting Sales by Application

Interviewee ID [a]	Exterior				Interior				
	Parking	Roadway	Walkway	Area and Site/ Wall pack	Linears and Troffers [b]	Recessed Downlight and Screw-in Bulbs [b]	High Bay	Low Bay	Emergency
Interviewee #2	20%	15%	3%	40%	4% - 11%	13% - 30%	4%	4%	5%
Interviewee #3	35%	5%	15%	45%	40%	0% - 30%	5%	5%	1%
Interviewee #4					45%	55%			
Interviewee #5					50%				
Interviewee #6					85%				
Interviewee #7					25%				
Interviewee #9	20%				40%		25%		
Interviewee #11					"mostly"				

Note: While responses should add to 100%, interviewees estimated numbers and values did not always accurately add up. In addition, some interviewees could only estimate valued for certain lighting applications and did not provide estimates on other applications.
[a] Interviewees not included in this table did not respond to this question.
[b] The research team presents ranges where interviewees provided multiple categories associated with the application shown in the table.

Mixed Definitions of Energy Efficient Lighting Technologies

To understand the extent of lighting sales considered energy efficient, the research team needed to first understand how each interviewee defined energy efficiency. To put their definitions into perspective, Table 4-5 shows energy efficiency codes and standards for lighting. As shown in the table, Energy Star only specifies LEDs and CFLs as energy efficient, while the Federal Energy Code and the utilities also promote standard fluorescent T8s and T5s as energy efficient lighting products.

Table 4-5: Lighting Codes and Standards

Source	Standard/Code
2015 Energy Star Specification [a]	LEDs; CFLs
2015 Federal Energy Code [b]	CFLs, fluorescent T8s or smaller, or lamps with a minimum efficacy based on lamp wattage (> 40 watts, 60 lumens/watt; 15 - 40 watts, 50 lumens/watt; < 15 watts, 40 lumens/watt)
Design Light Consortium Qualified Product List [c]	Variable based on application and light output
2015 Connecticut Utility Rebates [d]	Fluorescent T8s, fluorescent T5s, LEDs, CFLs, HIDs

[a] http://www.energystar.gov/products/certified-products/detail/light-bulbs
[b] http://www.energycodes.gov/sites/default/files/becu/2015_IECC_commercial_requirements_ lighting.pdf
[c] https://www.designlights.org/content/qpl/productsubmit/categoryspecifications
[d] https://www.cl-p.com/downloads/Lighting.pdf?id=4294986546&dl=t

Interviewees mostly expressed similar energy efficiency definitions as that defined by codes and standards, however unique responses varied. While all of the interviewees stressed LEDs as the main energy efficient technology on the market today, they differed on what other products were considered energy efficient. Table 4-6 shows how each interviewee responded to these questions. Note that when discussing fluorescent tube T8s, interviewees referred to standard T8s, super T8s (also known as high-performance T8s), and low-wattage T8s (which have different specifications than super T8s) -- we refer to the latter two types as "high-efficiency" T8s in the table. There are also linear LED T8s, which are contained in the category "LED" in the table.

Table 4-6: Energy Efficient Nonresidential Lighting Technologies

Interviewee ID	What Lamps are Energy Efficient?	What Lamps are Not Energy Efficient?
Interviewee #8	LED; otherwise depends on existing equipment	CFL and high pressure sodium are “almost antiquated”
Interviewee #9	Most commonly LED, CFL but anything on Energy Star or Design Lights Consortium (DLC) counts	Any type of fluorescent T8, HID
Interviewee #10	LED but also others not specified	(not specified)
Interviewee #11	Anything meeting 45 lumens/watt (LED, Fluorescents, HID)	(not specified)
Interviewee #7	LED, fluorescent T5	High efficiency fluorescent T8s
Interviewee #4	LED, CFL, High efficiency fluorescent T8s (and lower)	Standard fluorescent T8s
Interviewee #3	LED, CFL, fluorescent T5 (and lower)	Any type of fluorescent T8 is "debatable"
Interviewee #6	LED, HID, high efficiency fluorescent T8s (and lower)	(not specified)
Interviewee #5	LED, CFL, standard fluorescent T8 (and better)	Fluorescent T12, halogen, incandescent
Interviewee #2	LED, CFL, HID, any type of fluorescent T8 (and lower)	(not specified)
Interviewee #1	LED, CFL, Any type of fluorescent T8 (and lower)	(not specified)

Besides LEDs, all but one of the interviewees reported CFLs to be energy efficient. This one interviewee reported that CFLs were “almost antiquated” but did not go so far as to say they were not energy efficient. Seven of the interviewees specifically included fluorescents in their definition of energy efficiency, but they differed on whether fluorescent T8s were considered efficient. Four interviewees reported that standard fluorescent T8s were not considered energy efficient, two of which also reported that high efficiency fluorescent T8s (defined as either low wattage T8 or super T8) were not considered efficient. Another interviewee included standard fluorescent T8s as energy efficient because their company's fluorescent T8 lamps met the new federal efficiency requirements of being 45 lumens/watt. When asked if any technologies were not energy efficient, interviewees agreed that fluorescent T12s were not energy efficient, but held various views on other technologies.

Interviewees also discussed energy efficiency in a dynamic, context-specific manner. Two of the interviewees reported that any lighting product could be considered energy efficient so long as it is more efficient that the customer’s current product. For example, if a customer has fluorescent T12s in place, then standard fluorescent T8s are efficient. But if a customer has standard fluorescent T8s installed, than standard fluorescent T8s are not efficient. Similarly, interviewees reported that they would market LEDs as being energy efficient, but if their customers could not afford LED lamps, then they would sell the following products as energy efficient alternatives: fluorescents, HID, CFLs, and induction lamps.

Prevalence of Energy Efficient Lighting in Connecticut

Although interviewees defined energy efficiency differently, in general, they considered a high percentage of sales to be energy efficient. As shown in Table 4-7, all interviewees reported a high volume of sales to be energy efficient by stating that everyone wants to be energy efficient because they want to save money. Five interviewees viewed 100% of current sales to be energy efficient, four interviewees reported at least 75% of sales to be energy efficient, and the other two interviewees reported a range depending on either the application or project type.

Table 4-7: Percentage of Sales that are Energy Efficient as of 2014

Interviewee	% Lamps that are Energy Efficient
Interviewee #1	100%
Interviewee #3	100%
Interviewee #4	100%
Interviewee #7	100%
Interviewee #10	100%
Interviewee #9	60%-100% depending on existing or new construction
Interviewee #6	99%
Interviewee #11	90%
Interviewee #2	15% - 85% depending on the application [a]
Interviewee #5	80%
Interviewee #8	75% [b]

[a] This interviewee estimated that sales for most applications were over 50% efficient. Applications with the least efficiencies were commercial linear lighting and commercial non-linear recess lights.
[b] This data was not supported during follow-up questions when the interviewee reported that 99% of commercial sales were energy efficient and 99% of industrial sales were energy efficient. This difference in sales data may be accounted for if the interviewee limited their definition of what was considered energy efficient when answering this question.

The research team asked interviewees about whether energy efficient sales differed by segment and/or technology application. There were no clear distinctions with regards to both of these questions. Because the majority of respondents thought sales were energy efficient, they did not express any difference between sectors. Table 4-8 shows how interviewees did not view either sector as buying more or less energy efficient products.

Table 4-8: Portion of Sales that are Energy Efficient by Sector

Interviewee [a]	Commercial	Industrial
Interviewee #2	85%	High, but less than 85%
Interviewee #3	40% LED (60% other) [b]	40% LED (60% other) [b]
Interviewee #4	100%	100%
Interviewee #7	100%	100%
Interviewee #8	40% LED (60% other) [b]	70% LED (30% other) [b]
Interviewee #9	New Construction: 100% LED Replacement: 60% LED (40% other) [b]	100%
Interviewee #10	100%	100%
Interviewee #11	90% Minimum	90% Minimum

[a] Interviewees not included in this table did not respond directly to this question.
[b] Interviewees reported that the "other" could include energy efficient and non-energy efficient technologies.

As shown in Table 4-9, there was great variability when it came to technology application, but the research team found no clear findings across all the interviewees. This was perhaps due to the fact that the interviewees could specialize in different market needs. One interviewee confirmed this when they stated that manufacturers work with different distributors because each distributor can specialize in applications and/or sectors. That being said, findings generally suggest that energy efficient lighting is found across all technology applications.

Table 4-9: Percentage of 2014 Sales that were Energy Efficient, by Application

Interviewee	Exterior				Interior				
	Parking	Roadway	Walkway	Area and Site/ Wall pack	Linear	Recess Downlight and Screw-in Bulbs	High Bay	Low Bay	Emergency
Interviewee #2	85%	55%	85%	55%	15%-20%	25%	15%	15%	70%
Interviewee #3	100%	100%	100%	100%	100%	100%	100%	100%	100%
Interviewee #4	100%	100%	100%	100%	100%	100%	100%	100%	100%
Interviewee #5					80%				
Interviewee #6					99%				
Interviewee #7	100%	100%	100%	100%	100%	100%	100%	100%	100%
Interviewee #8	70%-100%	70%-100%	70%-100%	70%-100%	70%-100%	70%-100%	100%	100%	100%
Interviewee #10	100%	100%	100%	100%	100%	100%	100%	100%	100%
Interviewee #11	90%	90%	90%	90%	90%	90%	90%	90%	90%

Prevalence of LED Lighting in Connecticut

Since interviewees considered the majority of sales to be energy efficient, the research team began asking interviewees to specifically comment on the LED market. Interviewees believed the LED market is rapidly expanding and estimated that LED sales will continue to increase. Four interviewees provided the following estimates of LED growth in the nonresidential sector:

- 60% LED by Nov 2015
- 90% LED by Nov 2015
- 100% LED by 2017
- Approaching 80% (but no time line specified)

These estimates are all much higher compared to those reported in the Department of Energy report, which estimated 42% of commercial and 26% of industrial sales will be LED by 2020.[57]

Collectively, interviewees provided a number of benefits of LEDs to help explain why the market was rapidly moving to LEDs. They explained that LEDS:

- Are very efficient,
- Require less maintenance than other technologies (which is particularly important for high bay/low bay applications),
- Last longer,
- Do not get hot,
- Do not break as easily,
- Do not change color over time, and
- Do not include mercury.

When asked what percentage of current sales are LED, interviewees provided a range of responses, from 15% to 100% of nonresidential sales, depending on the application and customer type. The research team asked six interviewees about the prevalence of LED sales to nonresidential customers. Table 4-10 shows that five of the six interviewees estimated that roughly half of lighting sales were LED in 2014.

[57] Department of Energy, Energy Efficiency & Renewable Energy, *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications,* (Washington DC, 2014), p. 9.

Table 4-10: Percentage of 2014 Sales that were LED

Interviewee [a]	% Lighting Sales that are LED
Interviewee #1 [b]	50%+
Interviewee #2	15% - 85%
Interviewee #3	40%
Interviewee #8	55%
Interviewee #10	50%
Interviewee #11	40%

[a] Interviewees not included in this table were not asked this question.
[b] This interviewee estimated that 50% of their sales were LED and 50% of sales were for traditional fixtures whereby any lamp, including LEDs, could be installed in the fixtures.

The research team also asked whether LED adoption differed between commercial and industrial customers. While interviewees reported that both sectors purchased energy efficient equipment, the percentage of LED sales between the sectors differed. Interviewees commonly reported that 40 to 50% of commercial sales are LED, but there was less consensus around sales to industrial customers, with estimates ranging from 40% to 100%. One interviewee thought the industrial percentage was higher than the commercial percentage because these customers tended to purchase high bay and low bay lamps, which have higher maintenance costs, thereby making LEDs more cost effective. Another interviewee stated LED sales to be lower for industrial customers because the common alternative, HID lamps, were already so efficient.

One interviewee reported that LED sales differed by customer segment. This interviewee experienced higher LED sales with hotels (particularly in lobby and hallway applications), retail, and restaurant sectors. This interviewee also noted that smaller offices more typically converted their lighting fixtures for LED lamps and/or used LED replacement lamps, while industrial customers more typically purchased new LED fixtures. This difference was largely due to the fact that industrial customers often use high bay fixtures, whereby it is more cost effective to replace everything at once rather than replacing equipment in a piecemeal fashion.

Some manufacturers are now producing retrofit linear LED T8 lamps, which are LED tubes than can be installed in fixtures traditionally used for fluorescents. If a customer does not use a retrofit LED lamp, then they need to replace or retrofit their existing fixture. One interviewee thought once retrofit LEDs became more readily available the market would see an even larger growth in LED sales. At the moment, however, there seems to be some confusion in the marketplace about the quality of retrofit LED lamps. One interviewee expressed concern over these products because they could create fires, void fixture warranties, and they did not necessarily work with dimmable switches. Other interviewees did not mention any concerns with retrofit LEDs, however, they did state that customers more commonly change to LED fixtures rather than buying retrofit LEDs. They attributed this to the fact that retrofit LEDs are more expensive and not always reliable. Presumably, once retrofit LEDs became more reliable and more cost effective, the market share of LEDs could increase even more.

Marketing Lighting to Connecticut Nonresidential Customers

The research team asked interviewees about effective means to market lighting products and energy efficient lighting. All interviewees agreed that energy efficiency played an important role

in marketing lighting products in 2014. The interviewees also all mentioned that effective marketing is often dependent on developing and maintaining good relationships with customers and influencers. This section first describes how manufacturers and distributors market their products. The section concludes by describing the role Connecticut utility companies play in promoting energy efficient lighting technologies from the perspective of the manufacturers, manufacturing representatives, and distributors.

Marketing Techniques

Manufacturers, manufacturer representatives, and distributors play active roles in promoting their products to the electrical industry by marketing to distributors, ESCOs, contractors, sales representatives, and national accounts. They market lighting by a variety of means including indirect techniques such as information on their website and advertisements in newsletters to more direct techniques with specific customers via emails, phone calls, and relationship building. Table 4-11 shows a matrix of marketing techniques used by manufacturers, manufacturer representatives, and distributors. Manufacturers tend to focus on indirect marketing efforts to a national audience and direct marketing to large buyers and distributors. Manufacturer representatives and distributors, on the other hand, utilize more targeted marketing techniques and focus their marketing efforts on local contractors and end users.

Table 4-11: Marketing Techniques to Sell Lighting Products by Manufacturers, Manufacturer Representatives, and Distributors

Actor		Manufacturers	Manufacturer Representatives	Distributors
Audience		Distributors Designers/Specifiers Large Buyers (ESCOs, Contractors, National Accounts)	Distributors Designers/Specifiers	Contractors End Users
Primary Marketing Technique	Information on Website	X		
	Newsletter Advertisements	X		
	Email Blasts	X		
	Booths at Trade Shows	X		
	Educational Seminars	X	X	X
	Demonstrations	X	X	X
	Emails	X	X	X
	Phone Calls	X	X	X
	Relationship Building		X	X

Promoting Energy Efficiency

All of the interviewees stressed that energy efficiency was always part of their sales pitch. The interviewees were largely in agreement that the person working mostly closely with the customer would be best positioned to sell energy efficiency because they can influence the customer's

decision. However, they also acknowledged that the distributor, in particular, is well positioned to influence the market because they determine stock availability and customers are most likely to buy readily available products rather than waiting for a custom order. One interviewee also explained that distributors were best positioned to sell energy efficiency to customers because they can receive larger profits from higher priced products, such as LEDs, compared to less efficient and inexpensive traditional lighting products. Comparatively, contractors don't want to sell LEDs because LEDs have less maintenance and less burn out, so it reduces their business.

One interviewee stressed that "copy catting" can be very effective, especially in the LED market where product quality remains variable. Once a manufacturer or distributor can show that the lights are working well for a particular customer, it easier to sell the product to others.

The interviewees stressed the importance of how to best message energy efficient products. Interviewees stressed that while cost effectiveness is always an important factor, messaging should focus on lighting quality and how current products are better than older technologies. When selling LEDs in particular, one interviewee described three important messages: LEDs improve light quality, decrease maintenance costs, and use no mercury.

Role of Utility Programs

The interviewees agreed that the utility programs are highly influential in whether customers buy energy efficient lighting. They stressed the importance of both the rebate programs and the utility outreach efforts. Additionally, interviewees said that because LEDs are new, utilities can play an effective role in supporting LEDs through rebates to encourage more customers to purchase LEDs.

The interviewees believed that the majority of LED sales continue to be due to rebate programs, citing direct relationships between LED sales and rebate levels throughout the country. One interviewee said that when the Connecticut utilities started rebating LEDs, LED sales went up 70-80% in the state. Similarly, another interviewee representing a national manufacturer said that they focus their sales in areas with the best utility programs. They have not been focusing in Connecticut because the rebates are not as good as rebates in other states, citing programs in Massachusetts and New York.

One interviewee explained that they thought upstream programs were more effective than downstream programs because in upstream programs, customers do not need to provide the upfront costs nor do they need to fill out the paperwork. Upstream programs, therefore, allow smaller businesses, who do not have staff to complete the paperwork, to buy energy efficient equipment at reduced prices.

Other Emergent Findings

While the research team focused its research on characterizing the lighting market in Connecticut, some interviewees provided additional findings worth documenting. This section presents these findings, including:

1. LED product quality,
2. Direct install lighting programs, and
3. Instances where interviewees found market actors operating contrary to program intent and where a small proportion of residential incentivized bulbs are being sold out of state by small businesses (not lighting retailers, participants, or non-participants).

Two interviewees expressed concern about LED lamps made in China. These interviewees said the lamps do not perform to specifications (*i.e.*, the lifetime is shorter than expected or the color is off). They also mentioned that these lamps are sold in major retail stores. These interviewees expressed concern that when customers purchase these lamps and experience poor performance, then they associate that poor performance with all LEDs. If widespread, this could ultimately impact the market acceptance for LEDs. Additionally, it may be difficulty to confirm whether lamps installed actually met utility requirements because some foreign manufacturers were incorrectly printing labels on LED lamps that said the lamps met Energy Star or DSL specifications when they didn't.

One interviewee stated that some utilities offer direct install LED programs, but use cheap LEDs that do not provide quality lighting. This interviewee reported to have customers who received LEDs through a utility direct install program but did not like the quality of light and were asking for new non-LED lights. This interviewee needed to convince the customer that the LEDs that the utility provided were poor quality and that other LEDs provided better light quality and could still reduce costs. To convince the customer that other LEDs provided better light quality, this interviewee provided a demonstration to the customer to show off other LED products. The customer ultimately bought the LED lamps that the interviewee demonstrated.

Lastly, two interviewees described instances of businesses (in Connecticut and from outside Connecticut) operating contrary to program intent in ways that could undermine the utility lighting programs. One interviewee stated that they found a small proportion of residential incentivized bulbs being sold out of state through small businesses from out of state going store to store in Connecticut purchasing the maximum numbers of incented bulbs. The interviewee also stated that sales of these program-incented bulbs could be seen online (e.g., on eBay or Craigslist), potentially available to Connecticut and non-Connecticut purchasers.[58] A second lighting mid-market actor reported that some firms that had historically purchased lighting through Connecticut-based mid-market lighting firms are instead purchasing incented bulbs from big box stores because of the strong residential lighting program rebates. In other words, the incentives for the C&I upstream lighting program and the residential upstream lighting program were not coordinated to account for lighting distributors in Connecticut, and ended up accidentally harming Connecticut market actors.[59]

[58] Reported by a distributor with 90% of sales to Connecticut businesses.
[59] Reported by a manufacturer representative working in the New England region.

5. GAS SPACE HEATING MARKET RESULTS

The research team performed two separate but related phases of research to better characterize the C&I natural gas space heating market within Connecticut. In the first phase, we scanned available secondary data sources to better understand the industry-wide trends affecting gas space heating equipment on a national level. In the second phase, we performed in-depth interviews with manufacturers, manufacturer representatives, distributors, and an energy efficiency consultant to better understand the gas space heating market within the state of Connecticut.

While characterization of the gas space heating market is complicated by the diversity of technologies and applications for this equipment, several trends emerged during our analysis. Our findings from both phases of this research suggest that while parts of the gas space heating market are changing rapidly due to the rising popularity of technologies like heat pumps,[60] other parts of the market are changing very slowly, with only minimal improvements in efficiency over the past few decades (*e.g.*, the combustion component of rooftop units). In the following sections, we first report on our review of existing secondary data sources and then discuss the results of the market actor interviews.

5.1 Secondary Data Review

The research team conducted a review of secondary data sources relating to the gas space heating market prior to interviewing market actors. The purpose of the secondary data review was to develop a high-level understanding of the C&I gas space heating market to inform subsequent primary research tasks. In particular, the research team sought to address the following questions:

- What is the size of the overall commercial and industrial gas space heating market in Connecticut?
- What portion of the overall Connecticut commercial and industrial (C&I) gas space heating market is considered “energy efficient”?
- What is the path this equipment takes from manufacturing to end user?
- Who are the market actors in the gas space heating supply chain?
- What are the natural groupings for gas space heating equipment types?
- What types of data are missing from the secondary data sources?[61]

We completed the secondary data review during August and September 2014, focusing on several reports that were available during that time:

1. *HVAC Equipment Study #2813*, Freedonia Group (November 2011)

[60] While our research indicates that most heat pumps are not gas-powered, we found that in some cases electric heat pumps are displacing technologies that *are* gas-powered.

[61] The original study plan included designing contractor/plumber surveys that would include inquiry for these market actors’ perspective on the market on size and operation, how they interacted with customers with regard to the equipment and energy efficiency and to fill gaps from the earlier research tasks. This would have then been followed by C&I customer surveys. These latter activities were cancelled and this report is the final wrap-up report for this study.

2. *Characterization of the U.S. Industrial/Commercial Boiler Population,* Energy and Environmental Analysis (2005)[62]
3. *Industry Statistical Profile,* Air Conditioning, Heating and Refrigeration Institute (2014)
4. *The Future of Natural Gas,* MIT Energy Initiative (2011)[63]

The Freedonia Group report (#1 in the list above) included government publications, trade association publications, and analysis of government and industry datasets. The 2005 Energy and Environmental Analysis report (#2 above) relied on information available mostly from government datasets, including CBECS and MECS data. The Industry Statistical Profile (#3 above) consists of data collected from manufacturers in the HVAC industry. *The Future of Natural Gas* study (#4 above) referenced a number of primary and secondary data sources.

In this section, we present the findings from this secondary data review covering the following topics:

- Nonresidential gas space heating market structure,
- Classification of gas space heating technologies,
- Estimates of the size of the nonresidential gas space heating market, and
- Data gaps.

Nonresidential Gas Space Heating Market Structure

Characterizing the overall market structure and understanding the roles of key market actors is critical to determining where interventions may be most effective. We begin with a description of the supply chain – that is, how products are developed and how these products make their way to the customer. We then identify key market actors working within this supply chain and describe their roles. The information in this section is from the Freedonia report listed above, except where otherwise noted.

Supply Chain

At a very basic level, the primary flow of nonresidential gas space heating equipment commonly begins with a manufacturer, is sold to a distributor or wholesaler, continues on to a contractor, and finally proceeds to the end-user (customer). However, the equipment may take one of several paths to get from each stage to the next. For the larger manufacturers that employ their own internal sales force, this equipment is sold directly to distributors or even to contractors. For manufacturers lacking a sales force, the equipment is typically sold via a third party representative to a distributor/wholesaler.[64]

Although differences exist between the supply chains for different technologies (*e.g.*, rooftop units versus boilers), the basic underlying structure is fairly consistent across technology categories. Some manufacturers (such as Goodman Global Holdings) will sell products through an internal distribution network through company stores.[65] In some cases, particularly for more complex systems used by industrial facilities, manufacturers may sell equipment directly to the

[62] Available at http://www.energy.gov/eere/amo/downloads/characterization-us-industrialcommercial-boiler-population-final-report-may-2005
[63] Available at http://mydocs.epri.com/docs/summerseminar11/presentations/03-02_moniz_mit_natural_gas_v1.pdf
[64] Freedonia Group, HVAC Equipment Study #2813, p. 222.
[65] Freedonia Group, HVAC Equipment Study #2813, p. 222.

end-use customer – however, this type of sale is a minority of the overall sales in the market, as most standard systems are sold through third-party agents and distributors.[66]

Unlike some other technologies that can be purchased directly by end-users, most types of nonresidential gas space heating equipment can only be purchased by certain market actors (for example, many distributors will sell only to licensed contractors). Thus, unlike supply chains for other consumer products, conventional retailers do not have a significant presence in the market for nonresidential gas space heating equipment. An exception to this is the case when a light commercial[67] customer may purchase residential-type equipment from a "big-box" store such as Home Depot.[68]

Key Market Actors in the Supply Chain

Gas space heating equipment is manufactured worldwide by a handful of large firms and a number of smaller firms; however, the bulk of U.S. market share is accounted for by American companies. Some manufacturers produce a wide variety of different gas space heating technologies while others focus on only a few specific types of technologies (*e.g.*, boilers). Among the bigger manufacturers, gas space heating equipment may represent only a small fraction of the types of HVAC equipment produced, with many firms also producing electric-based HVAC technologies.

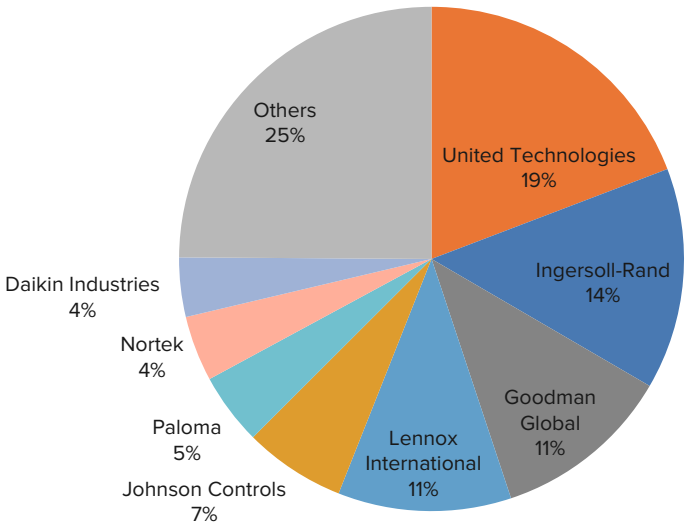
The Freedonia Group reports that for the HVAC market overall (gas and electric), eight firms accounted for 75% of the U.S. HVAC equipment sales in 2010.[69] These firms include:

- Carrier (United Technologies)
- Trane (Ingersoll-Rand)
- Goodman Global Holdings
- Lennox International
- York International (Johnson Controls)
- Rheem (Paloma)
- Nortek
- Daikin/McQuay International

Figure 5-1 shows the relative market share for the overall HVAC market for these eight manufacturers as of 2010.

[66] Freedonia Group, HVAC Equipment Study #2813, p. 223.
[67] The term light commercial is not strictly defined in this report.
[68] Freedonia Group, HVAC Equipment Study #2813, p. 223.
[69] Freedonia Group, HVAC Equipment Study #2813, p. 211.

Figure 5-1: Domestic HVAC Equipment Market Share (2010, $13.1B)



Source: Adapted from Freedonia Group, HVAC Equipment Study #2813, p. 213.

Manufacturers will typically target either the residential or nonresidential market. And although many manufacturers will produce equipment but not provide other services, some of the larger manufacturers (such as Ingersoll-Rand) will offer maintenance and other services to customers as a way of securing customer loyalty.[70]

Some manufacturers have devised creative business arrangements by which they can streamline their distribution practices. For instance, the distributor WATSCO has acquired a number of smaller distributors over the past two decades, expanding their network in existing markets. In 2009, WATSCO formed a joint venture with the manufacturer Carrier to distribute Carrier products throughout North America.[71] The resulting entity, called Carrier Enterprise, is owned 70% by WATSCO and 30% by Carrier.

Gas Space Heating Technologies and Categories

Natural gas is used by a wide variety of heating and cooling systems. While a comprehensive classification of all gas space heating technologies is difficult due to the large number of technologies utilizing natural gas as a primary or auxiliary fuel source, such technologies may be grouped into several broad categories:

- **Furnaces** (which use heated air as the circulating medium). Note that furnaces may also be electric or use heating oil instead of natural gas. Older warm air furnaces relied on gravity for the air return but newer models use a fan.

[70] Freedonia Group, *HVAC Equipment Study #2813,* p. 209.
[71] WATSCO. Available at: http://www.watsco.com/about-us/our-business/

- **Boilers** (where water is heated and then circulated). Boilers come in three main configurations: cast iron boilers, fire tube boilers (used mostly in small industrial applications), and water tube boilers (not typically used for space heating).[72]
- **Gas-fired Infrared (IR) Heaters**. These are used to generate heat where typical central heating is impractical, via the transmission of IR waves. IR heaters heat surfaces, not air. They are typically used in automobile garages and airplane hangars.[73]
- **Gas-fired Absorption Units**. Gas-fired absorption units use an ammonia/water absorption cycle to provide heating (and cooling). These units do not necessarily need to be powered by natural gas, though many are. May also be referred to as gas-fired absorption heat pumps.[74]

Table 5-1 shows a breakdown of the major types of gas space heating technologies along with any relevant efficiency metrics. Other types of HVAC equipment (such as air source heat pumps), may utilize natural gas as a fuel source; however, a majority of these units are electric-powered.

[72] PSE&G, Gas Technologies. Available at: https://www.pseg.com/business/small_large_business/convert/gas_technology.jsp
[73] Ibid.
[74] California Energy Commission. Gas Fired Heat Pump for Heating and Refrigeration in Food and Beverage Industry (2005).

Table 5-1: Gas Space Heating Technology Classification

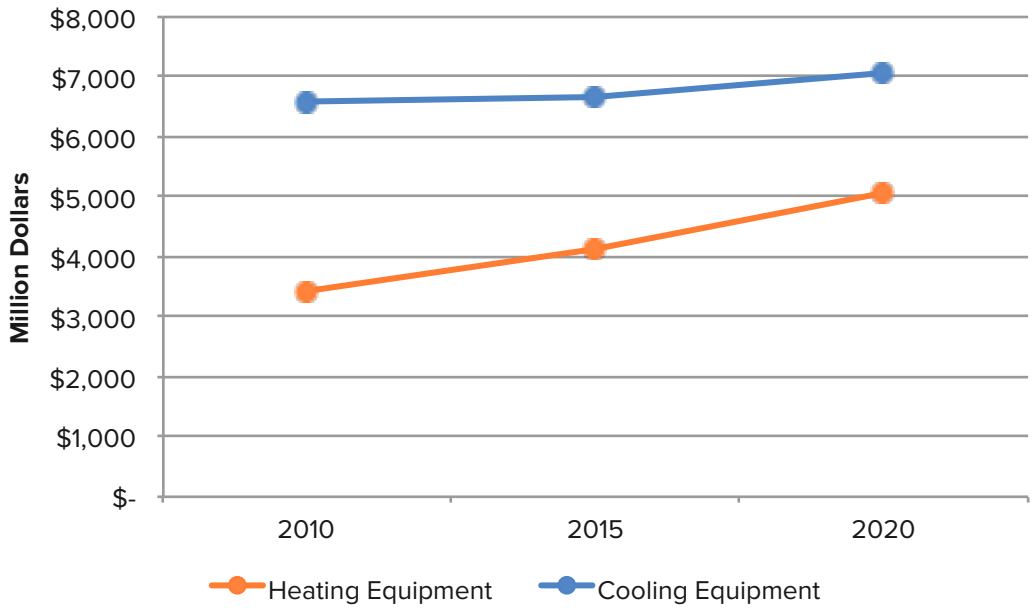
Technology Type	Notes	Classification	Relevant Efficiency Classification Metric and Value
Gas furnaces for heating	• Natural gas or propane • Can be classified as conventional (AFUE 80%-83%), mid-efficiency (AFUE 83%-88%/90%), or high efficiency (>88%/90%) [a, b] • It is also possible to combine condensing and non-condensing models into a "hybrid" system	Non-condensing / low or mid-efficiency	AFUE < 90%[(a)] (some use 88%) [b]
		Condensing / high efficiency	AFUE ≥ 90%[(a)] (some use 88%) [b]
Gas boilers for heating	• Small (< 300 MBH) or large (≥ 300K MBH) [c] • Packaged or field-erected • Can be single-zone or multi-zone • Can be steam or hot water (hot water may also be referred to as *hydronic*) • Hot water boilers are typically more efficient than steam boilers • Minimum efficiency is 80%/82% (steam/hydronic)	Steam (noncondensing)	Efficiency < 82% [d]
		Steam (high efficiency, noncondensing)	Efficiency ≥ 82% [d]
		Hot water (noncondensing)	Efficiency < 85% [d]
		Hot water (high efficiency, noncondensing)	Efficiency ≥ 85% [d]
		Hot water (condensing)	Efficiency ≥ 90% [d]
Gas-powered infrared Heaters	• Can be classified by intensity	Low-intensity (closed flame)	Up to 90% efficient [f]
		High-intensity (open flame)	Up to 100% efficient [f]
Gas-fired absorption units	• Gas-powered absorption heaters use heated water for space heating in larger buildings. May eliminate the need for a boiler. [e]	Comes in various compressor configurations (reciprocating, screw, and centrifugal).	Efficiencies may be measured by resource coefficient of performance (resource COP). [f]

[a] Kubba, Sam. Handbook of Green Building Design and Construction: LEED, BREEAM, and Green Globes. Butterworth-Heinemann, 2012, p. 412.
[b] Durkin, Thomas, P.E. Boiler System Efficiency. ASHRAE Journal, July 2006. Vol. 48, p. 52.
[c] MBH = 1,000 BTU/hr
[d] National Grid. High Efficiency Heating. Available: http://www.nationalgridus.com/niagaramohawk/non_html/ee_conference/Heating.pdf
[e] Green Globes. Gas-fired Chiller/Heaters. Available at: http://www.greenglobes.com/advancedbuildings/_frames/fr_t_heat_gasfired_chiller.htm
[f] For example, see: https://www.reverberray.com/about-infrared/types-of-infrared-heaters/
[g] DOE. Absorption Heat Pumps. Available: http://energy.gov/energysaver/articles/absorption-heat-pumps

Size of the Nonresidential Gas Space Heating Market

In this subsection we present secondary data on the overall size of the nonresidential domestic gas space heating market. We also present data on estimates of the level of energy efficiency within this market. Because the HVAC market is highly dependent on current economic conditions (which impact construction and renovation investment), the size of the market may fluctuate year to year. In many locations (such as Connecticut) where the existing building stock is relatively large compared to the amount of new construction, much of the demand for HVAC equipment comes from replacement of non- or poorly working equipment and retrofits in existing buildings rather than the construction of new buildings. When the U.S. economy took a downturn in the late 2000s, the HVAC market suffered as well. As the U.S. economy has rebounded, however, the market has begun to grow again from a low point in 2010 with demand projections for all types of nonresidential HVAC equipment calling for modest growth through 2020 (Figure 5-2).[75]

Figure 5-2: Projections for Electric and Gas Nonresidential HVAC Demand in the United States to 2020



Source: Freedonia Group, *HVAC Equipment Study #2813,* p. 200.

It is difficult to estimate the size of the market solely for gas space heating equipment. This is partially because units may be purchased from a number of different sources and partially because some types of equipment have both electrical and gas components (*e.g.*, packaged rooftop units). Despite these limitations, there are some additional statistics that are helpful in estimating the market size for various types of HVAC equipment. By applying estimates of the percent of HVAC shipments that use natural gas and estimates of the overall size of the HVAC market, Table 5-2 presents an approximation of the market size for natural gas space heating units nationally projected through 2020. It is important to note that these values include both

[75] Freedonia Group, *HVAC Equipment Study #2813,* p. 177.

residential and nonresidential units, and thus these estimates represent an absolute upper bound if only considering the nonresidential sector.

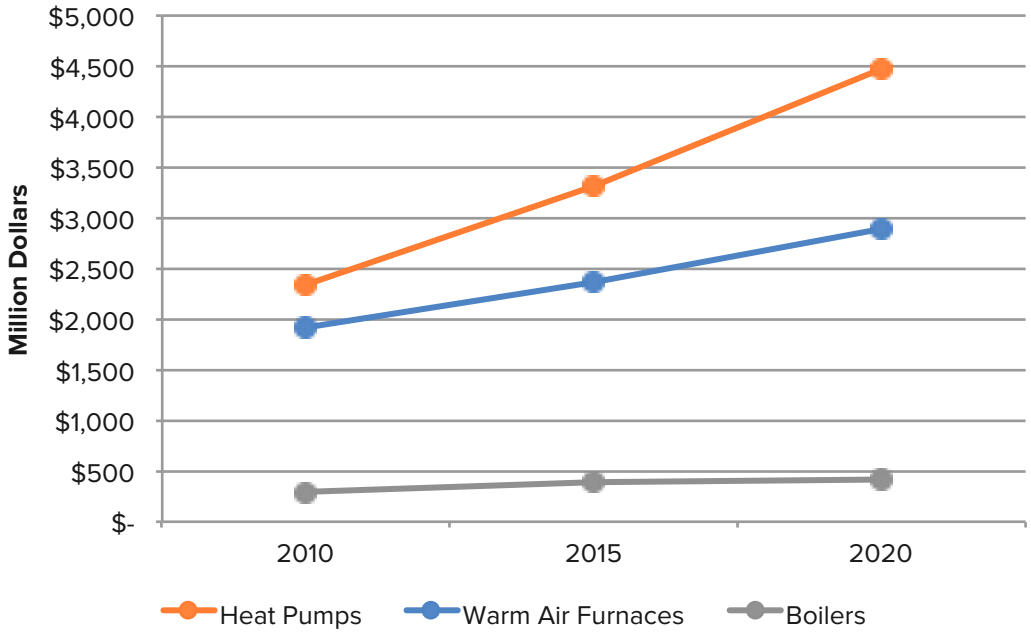
Table 5-2: Natural Gas Residential and Nonresidential HVAC Equipment Demand in the United States

Item	2010	2015	2020
Total HVAC equipment demand	$13,050M	$16,750M	$20,200M
% Natural gas powered	15.90%	16.20%	17.00%
Natural Gas HVAC Equipment (row 1 * row 2)	$2,075M	$2,720M	$3,430M

Source. Adapted from Freedonia Group, HVAC Equipment Study #2813, p. 68.
Note. These values technically include both heating and cooling equipment, although gas is generally used for heating rather than cooling.

Figure 5-3 shows a breakdown of three major types of HVAC equipment (heat pumps, warm air furnaces, and boilers) with projections to 2020. Here we see that sales of warm air furnaces (of which many are gas-fired) are expected to increase over the next five years, although they will likely not keep up with the impressive demand seen for heat pumps (most of which are not gas-powered). Demand for boilers is projected to remain relatively static over this same time period.

Figure 5-3: Heating Equipment Shipments in the United States, 2010 - 2015



Source: Freedonia Group, HVAC Equipment Study #2813, p. 84.

Prevalence of Energy Efficiency in the Nonresidential Gas Space Heating Market

Very little reliable secondary data is available regarding the overall saturation of energy efficient gas space heating units. Such a calculation is complicated by inconsistent definitions for what is considered efficient, and by the fact that what was considered "efficient" ten years ago may now be considered to be only mid-efficient or not efficient at all. Instead, the research team relied on

the in-depth interviews to help inform estimates of energy efficiency in the gas space heating market (discussed in subsection 5.2).

Data Gaps from Secondary Data Review

The reports cited in this section provided ample information on national market trends and the overall market structure. However, these reports provided very little specific information relating to Connecticut, and only limited information related to specific types or categories of equipment. In many cases, the reports focus on the broader category of HVAC equipment and do not distinguish between gas and electric technologies. To better understand how the Connecticut market may differ from the national market, and to obtain more detailed information regarding different types of gas space heating equipment, the research team interviewed upstream market actors[76] active in the Connecticut nonresidential gas space heating market. We present the results of these interviews in the following section.

5.2 Interview Findings

This section presents the results of the ten in-depth interviews conducted with gas space heating manufacturers, distributors, and consultants serving Connecticut. Although not all interviewees were physically located in the state of Connecticut, all of them were active in selling to the Connecticut market.

Results suggest that the efficiency of some types of gas space heating equipment continue to improve at a rapid pace, while the efficiency of other types of equipment has not changed significantly in the past several decades (*e.g.*, the gas side of non-condensing packaged rooftop units). Newer technologies such as "mini-split" heat pumps (which are typically electric) are becoming popular among some light commercial users and may in some instances be displacing the need for gas-powered units. There was also an indication that in recent years there has been a significant emphasis on the sophisticated *control* of gas space heating systems (and other types of systems) instead of focusing solely on the efficiency of the actual units.

The research team spoke to ten upstream market actors including three manufacturers, five distributors, one manufacturer representative, and one efficiency consultant / energy services company (ESCO).

- **Three manufacturers** – All three manufacturers were part of international organizations, and together represented a substantial portion of the production market for gas space heating equipment used in nonresidential applications.
- **Five distributors** – The five distributors all had locations within the state of Connecticut. Three of the five distributors were part of regional organizations that included other locations within New England; two distributors were part of national organizations.
- **One manufacturer representative** – The single manufacturer representative included in these interviews was part of a regional organization that included other locations in New England, New York, and Canada. This firm represents multiple manufacturers and works with a number of contractors.

[76] As described in the next section, in this study, "upstream market actors" included manufacturers, manufacturer representatives, distributors/wholesalers, and a consultant/ESCO.

- **One efficiency consultant** – The research team included a single efficiency consultant in this round of interviews to help shed light on the overall supply chain. This consultant also self-identified as an energy services company (ESCO).

The remainder of this chapter presents information gleaned from the in-depth interviews with gas space heating upstream market actors, touching on the following topics:

- **Market structure** – This section includes descriptions of the nonresidential supply chain structure, key market actors, and the interactions between them.
- **Technology categories, applications, and customer segments** – This section discusses the specific types of technologies currently used in nonresidential applications, and describe some of the major customer segments using this equipment.
- **Nonresidential market size** – In this section, we present information on the information obtained regarding the overall market size for commercial gas space heating equipment in CT.
- **Marketing to nonresidential customers** – This section includes information on how gas space heating equipment is typically marketed by the different market actors.
- **Other emergent findings** – Here we discuss other emergent findings that arose during the interviews with market actors.

Nonresidential Gas Space Heating Market Structure

The market structure for gas space heating equipment is generally similar across the different technology categories of gas space heating, although the path that the equipment takes from manufacturer to end user may vary greatly depending on the precise application and end user segment. In this section we present an illustration of the market structure for gas space heating equipment in nonresidential settings, and then discuss the roles of each of the market actors included in this structure.

Supply Chain

Figure 5-4 shows a schematic representation of the overall supply chain structure for nonresidential gas space heating equipment applications in Connecticut. The major market actors included in this diagram are:

- Manufacturers
- Manufacturer representatives
- Distributors
- Contractors
- ESCOs
- Designers/specifiers
- Retailers
- End-users/customers

For most technology categories, there is a single primary path from the manufacturer to the distributor, and then from the distributor to a contractor (who installs the equipment for the end user). In many cases, there is also a manufacturer (or technical) representative that advises the distributor on the types of equipment to purchase, essentially serving as a liaison between a

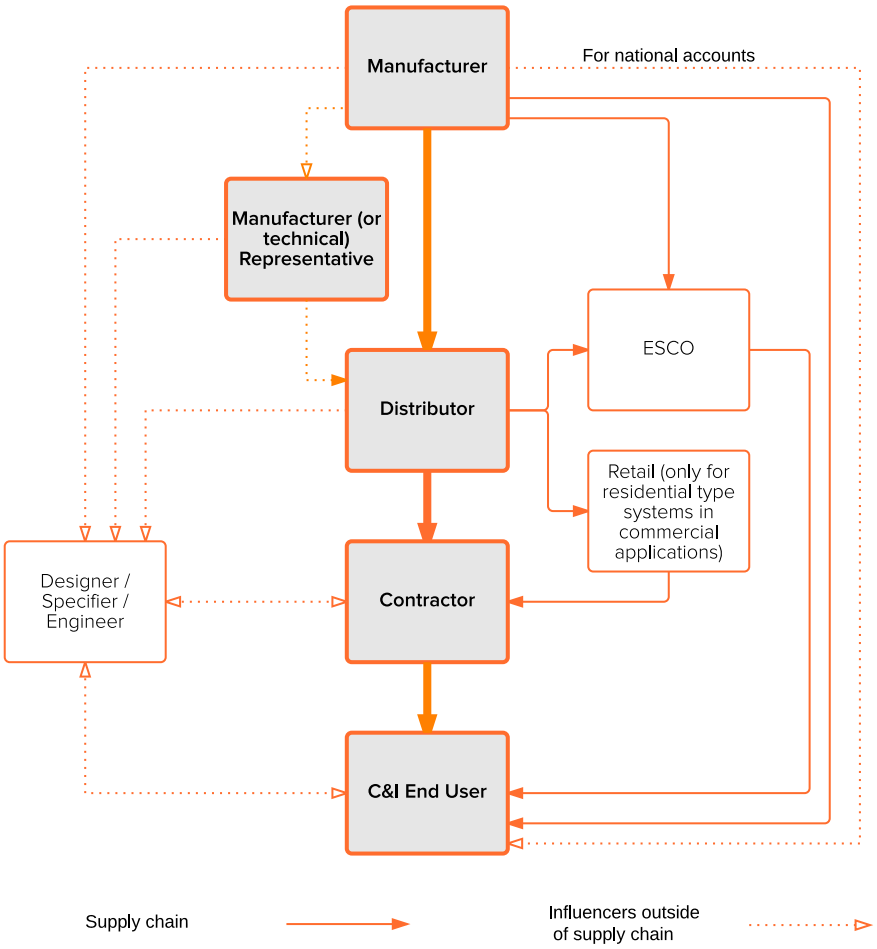
number of manufacturers and distributors. These representatives do not typically hold equipment stock, however.

For some national accounts, equipment is occasionally sold directly from the manufacturer to the end user; however, this path represents a minute fraction of the more popular path from manufacturer → distributor → contractor → end user.

Outside the flow of actual equipment, there are a number of influencers who have some impact on the market. These influencers include:

- Designers/specifiers (including engineers) who work with clients on new construction projects.
- ESCOs that work directly with the end use customers on whole-system or whole-building applications.
- Retailers, in some rare circumstances, may play a small role in instances where residential HVAC equipment is used for light commercial purposes.

Figure 5-4: Gas Space Heating Supply Market Structure for Commercial and Industrial Applications



Note. Grey/bold coloring depicts primary supply chain. Manufacturer Representatives play an active role in the sales process but do not hold stock, stock is typically sent directly from the manufacturer to the distributor.

In the following sections, we briefly summarize the roles of each of the major players shown in the simplified supply chain model above.

Role of Manufacturer

In the nonresidential gas space heating market, manufacturers are responsible for producing gas space heating equipment and then working with manufacturers' representatives (discussed below) or their own internal sales force to sell the equipment to distributors. Many of the larger manufacturers are national or international organizations and do not always have the local knowledge necessary to makes sales directly to contractors, thus the need for manufacturer representatives and distributors. For custom built-up systems[77], the manufacturer may occasionally work with designers and engineers to make sure the equipment is correctly specified.

Major Manufacturers:

Carrier
Trane
Lennox
Johnson Controls
United Technologies
Daikin/Goodman
Modine
Reznor
Aeon
Weil-Mclain
Mitsubishi
Luxaire

Manufacturers do not typically distribute products directly to contractors or other end users because manufacturers lack the physical infrastructure necessary for this purpose (*i.e.*, floor space) as well as the ability to address the financial aspects of these transactions (*e.g.*, extending credit). All three manufacturers interviewed for this study reported making a majority of their sales to distributors; two of the three manufacturers utilized a third party representative in this process while one manufacturer did not.

Role of Manufacturer Representative

The manufacturer representative is a technical resource that serves as an intermediary between manufacturers and distributors. Because many manufacturers lack local connections, they rely instead on the manufacturer representative as their local guide. The manufacturer representative interfaces with both manufacturers and distributors to ensure that the right amount and the right type of equipment will be stocked in response to customer demand. The manufacturer representative may serve multiple manufacturers and multiple distributors, thus acting as a central hub through which equipment sales are made. Based on interview results, there is at least one large manufacturer that still relies on their own sales force rather than a manufacturer representative; however this appears to be an exception to the rule.

Major CT Distributors:

F.W. Webb
Carrier Northeast
Plimpton & Hills
Sid Harvey Industries
Torrco
Shetucket
Bender Plumbing
United Refrigeration
Bell Simons
ABCO
Johnstone Supply

Role of Distributor

The distributor is responsible for buying and stocking equipment from manufacturers, and then selling this equipment to licensed contractors (in most cases). In some situations, they coordinate shipping from the warehouse to the end use customer. In Connecticut, there are regional distributors as well as local branches for national distributors.

[77] As opposed to packaged units, "built-up" systems are custom designed. These systems often require a greater degree of design and engineering rigor to install or replace.

The distributors interviewed by the research team were fairly consistent in the type of customers to whom they sell a majority of their stock, with all of them reporting a majority of sales going directly to licensed contractors. Several distributors reported that on occasion they sell equipment directly to an end user (such as a large institutional or national retail client), but agreed that these types of sales do not happen frequently.

Role of Retail Store

In the nonresidential gas space heating market, there are few retailers, if any, because customarily it is only licensed contractors who are able to purchase this equipment. In some cases, residential HVAC equipment may be purchased from a "big box" store such as Home Depot and then used in a commercial setting – but this appears to represent a very small fraction of the overall sales in this market. This finding corroborates the research team's assessment of the secondary data sources described in the previous section.

Role of Contractor/ESCO

The contractor (which in some cases is also an energy services company or ESCO) is responsible for purchasing equipment from a distributor (or manufacturer) and installing this equipment for the end use customer. Contractors must be licensed in order to purchase and install most gas space heating equipment for the nonresidential sector, and may also self-identify as an HVAC contractor or mechanical contractor.

ESCOs play a similar role as contractors and technicians because they install HVAC equipment, but ESCOs focus on providing *energy efficient* upgrades. Because ESCOs buy products in large quantities, they are more likely to work closely with manufacturers compared to other contractors. However, most manufacturers still require ESCOs to purchase through a distributor, even if the ESCO and manufacturer have a close relationship.

Role of Designer/Specifier/Engineer

For new construction projects and "add-on" projects, there is often a designer or engineer who is involved with choosing the type of equipment that will be installed. This is in contrast to replacement or retrofit jobs, where many times the new equipment will simply be a newer version of the model that was being replaced. In many cases, the contractor will work with a designer or engineer to install or replace a system; however, interviewees did not specify the precise frequency with which this happens.

Role of End User

The end user purchases the equipment typically from the contractor, although in some cases they may purchase directly from the manufacturer (*e.g.,* national accounts or large institutions). While it is true that the end user is the final decision-maker, in many cases they rely heavily on input from the contractor or engineer when making decisions regarding HVAC equipment due to the highly complex technical considerations involved in the installation.

Gas Space Heating Categories, Applications and Customer Segments

This section first presents a classification scheme for the different types of gas space heating categories identified by the interviewees. It then presents the various types of applications

identified by the interviewees and concludes by describing the major commercial and industrial customer segments.

Gas Space Heating Equipment Categories

There is a wide range of technologies that have a gas heating component and are used in nonresidential facilities, the most significant of which include:

- Gas-fired furnaces
- Gas-fired boilers
- Packaged units (typically rooftop units, or RTUs) with a gas-heating component
- Gas-fired unit heaters
- Gas-fired air-turnover units[78]
- Gas-fired make-up air units[79]
- Gas-fired infrared (IR) heaters

Most manufacturers typically focus on some subset of these equipment categories; most do not manufacture all types.

Gas Space Heating Applications

Gas space heating comprises a single application (comfort/space heating), although in the case of packaged units, the gas space heating equipment is integrated with equipment that also performs cooling (air conditioning). Thus, when a customer buys a packaged unit, they make decisions based on both the heating and cooling performance specifications.

Customer Segments

The research team asked interviewees about the major end use customer segments to whom they sell their equipment. Because manufacturers and distributors typically only sell to licensed contractors, the type of end use customer is not always apparent to these suppliers. However, most suppliers do have some knowledge of the type of projects for which their equipment is used. These types of projects for the nonresidential sector can be roughly divided into the following segments and sub-segments:

- Retail
- Office
    - Small office buildings
    - Large office buildings
- Institutional/municipal/government
    - Schools
    - Hospitals

[78] Air-turnover units are typically used in large internal spaces (like warehouses) where a temperature differential exists because hot air rises to the top of the room. These units redistribute warmer air from the upper layers to lower layers, ensuring a more consistent vertical temperature gradient.

[79] Make-up air units heat or cool outside air and deliver it to an indoor space (as opposed to many other types of gas HVAC units which simply recirculate indoor air). Make-up air units come in a variety of configurations, including both direct and indirect gas-fired units. Make-up air units may be required in applications such as hospitals where recirculation of indoor air is not always possible due to health concerns.

    - Universities
    - Government buildings
- Industrial/manufacturing
    - Warehouses and other storage facilities

It was difficult for interviewees to estimate the relative sizes for each of these segments. However, several interviewees indicated that the retail and office segments comprised the bulk of their sales, while institutional and industrial clients made up the balance.

Size of the Nonresidential Gas Space Heating Market

One of the primary objectives for conducting the interviews was to better understand the size of the gas space heating market in Connecticut and how efficient it is. There was a very large range of estimates for the overall annual CT market was $80M – $300M, though estimates differed greatly between respondents, and several interviewees did not provide a numerical estimate. Several interviewees also mentioned that the market has been growing steadily over the past few years, following a lull during the recession of the late 2000s. The *efficiency* of the overall market was even more difficult for interviewees to estimate due to the large variety of equipment types included in this category. However, there was an indication that customers continue to purchase equipment that is not considered high efficiency (such as noncondensing RTUs).[80]

This section first summarizes the information obtained regarding the size of the gas space heating market in Connecticut. It then presents results on how interviewees defined energy efficiency, followed by estimates of the prevalence of energy efficient gas space heating in Connecticut.

Market Size in Connecticut

The research team asked interviewees to estimate the total market size for nonresidential gas space heating equipment in Connecticut. Interviewees' estimates for annual market sizes in CT are listed below:

- **Overall market: $80M – $300M.** One manufacturer indicated he thought the overall market was about $300M annually, with $100M accounted for by unitary systems and $200M accounted for by built-up systems. A distributor said he believed the overall market would be closer to $80M annually. A third interviewee (also a distributor) said he thought the overall market was somewhere in between these two bounds. Other interviewees did not feel they could provide a numerical answer because they did not have sufficient knowledge of the overall market to make such an estimate.
- **Packaged rooftop unit market: $35M-$40M.** One manufacturer specializing in RTUs indicated he believed the CT market for RTUs to be in the $35M-$40M range.

The research team also asked about the relative proportion of their sales by equipment type. Four interviewees reported they were unable to estimate this value. Of the interviewees who did provide estimates, most reported working primarily with packaged RTUs, and a few also reported

[80] Contractor surveys would have allowed us to attempt to narrow this range and derive a better estimate of the CT market size. The remaining components of this study were cancelled. It may prove helpful to derive the size of the CT C&I gas space heat market in any future related research or evaluation study.

working with furnaces or other types of equipment. Table 5-3 shows that in general, packaged RTUs accounted for the largest proportion of equipment types with which interviewees typically worked, though some also worked with other products types, primarily furnaces and boilers.

Table 5-3: Relative Breakdown of Gas Space Heating Equipment Sales by Type

Interviewee ID	Furnaces	Boilers	Packaged Units / RTUs	Other
Interviewee #1	-	-	Majority	Some
Interviewee #2	-	0%	Majority	Some
Interviewee #5	-	-	95%	-
Interviewee #6	30%	-	30%	40% mixed
Interviewee #8	-	-	Mostly	-
Interviewee #10	50% split between furnaces & boilers		50%	-

Note. Some interviewees could only estimate values for certain equipment types and did not provide estimates on other types. Interviewees not included in this table did not respond to this question.

Definitions of Energy Efficient Gas Space Heating Technologies

It is not possible to apply a single blanket definition of energy efficiency to all product categories in the gas space heating market because of significant variation between equipment types. The line between what is energy efficient and what is not energy efficient is also blurred because some types of packaged systems are considered to be efficient on the cooling (electric) side but not the heating (often gas) side. Nor do ENERGY STAR specifications cover many types of C&I gas space heating equipment. As shown in Table 5-4, interviewees' definition of efficiency was primarily based on whether or not a unit was a condensing unit (it is typically only possible to exceed 90% efficiency through use of a condenser).

Table 5-4: Definition of Efficiency by Equipment Type

Technology Type	What is Considered Efficient?
Gas-fired furnaces	Condensing; > 90% efficiency
Gas-fired boilers	Condensing; > 90% efficiency
Packaged units / RTUs	For gas equipment, > 90% efficiency
Unit heaters	Condensing
IR heaters	> 90% efficiency

Note. None of the interviewees provided efficiency definitions for air-turnover units or make-up air units.

Prevalence of Energy Efficient Gas Space Heating in Connecticut

Although interviewees' definitions of energy efficiency closely agreed with each other, interviewees reported a wide range of estimates for the percent of equipment sales that are energy efficient. Table 5-5 presents ranges for specific types of gas space heating equipment estimated by interviewees. As shown, the percentage of energy efficient gas furnaces ranged from 40% to 60%, and the percentage of gas-fired boilers ranged from 40% to 80%. Interviewees indicated that none of their sales of packaged RTUs were efficient on the heating (gas) side, with

several commenting they did not even know if such units were available. Two interviewees provided estimates for the overall percentage of gas space heating sales that are efficient, ranging from 10% to 65%.

Table 5-5: Percentage of Sales that are Energy Efficient as of 2014

Interviewee	% Sales that are Energy Efficient				
	Gas furnaces	Gas boilers	Packaged units / RTUs	Unit heaters	Overall
Interviewee #1	-	-	0% [a]	0% [b]	-
Interviewee #2	-	-	0% [a]	-	-
Interviewee #3	-	-	0% [a]	-	-
Interviewee #4	10%	15%-20%	Very small	8%-10%	-
Interviewee #5	15%-20%	-	0% [a]	-	-
Interviewee #6	60%	80%	0% [a]	70%	-
Interviewee #7	-	-	[c]	-	-
Interviewee #8	40%	40%	0% [a]	Very small	-
Interviewee #9	-	-	-	-	10% [d]
Interviewee #10	-	-	-	-	65%

Note. Several interviewees did not provided numerical estimates for all categories. Two interviewees provided overall estimates, but did not provide category-specific estimates. No estimates were given for air-turnover units or make-up air units.
[a] In this context, "efficiency" only pertains to the gas (heating) component of the unit, not the electric (cooling) component.
[b] Interviewee did not know if high efficiency units even exist.
[c] Interviewee noted that customers never ask about efficiency on heating side (it is not typically a consideration), only cooling side for packaged units/RTUs.
[d] Interviewee clarified that this was based on the equipment itself and did not factor in any efficiency gains from controls that were implemented in conjunction with the equipment.

Marketing Space Heating Equipment to Connecticut Nonresidential Customers

The research team asked interviewees about effective means to market gas space heating technologies. This section first describes how manufacturers and distributors market their products. The section concludes by describing how interviewees thought that the Connecticut utility companies could best promote energy efficient gas space heating technologies, from the perspective of manufacturers and distributors.

Marketing Techniques

All interviewees reported playing active roles in promoting their products by marketing to other market actors in the industry. Manufacturers tend to focus their marketing efforts on large buyers and distributors, while distributors focus their marketing efforts on contractors and end users. Interviewees also reported that manufacturers rely heavily on existing relationships with contractors and distributors.

On the whole, the manufacturer representatives and distributors we interviewed mentioned the importance of training and education for *contractors* since it is the contractor that often makes recommendations to the end use customer. While every distributor indicated they held training and education seminars for contractors, one distributor complained that it was often difficult to get contractors to show up for these trainings unless they were covering popular new technologies (such as mini split systems). For these newer technologies, he said it was easy to attract contractors because of the demand among their customer base.

Manufacturer interviewees reported marketing heavily to contractors, although they also reported marketing directly to the end user (particularly larger national accounts). One distributor referenced a particularly successful residential marketing campaign by the manufacturer Modine, which was aimed primarily at end users. Another interviewee (a manufacturer) mentioned that while they focused most of their efforts on educating and informing contractors, he thought that utilities may best benefit from targeting business owners directly in order to stimulate demand for more efficient technologies from the end users (with the expectation that contractors would react to this demand accordingly).

Promoting Energy Efficiency

Interviewees varied in their assessment of the opportunities for promoting energy efficiency in marketing efforts. Distributors do not always promote products based on efficiency, because as one interviewee explained, contractors can get products with equal efficiency ratings from a number of different sources – as one distributor stated, contractors consider the *convenience*, *availability*, and *support services* provided with the purchase to be more important.

In some situations, energy efficiency does not factor into marketing efforts because there are no efficient products to promote. Two manufacturer interviewees reported that for packaged RTUs, there are no efficient options on the heating (gas) side, and thus marketing is limited to efficiency on the cooling side. One interviewee said he believed the heating efficiency of these units had not increased in 20-30 years. Another interviewee mentioned that some of his commercial customers had started to switch from more traditional, less efficient packaged units (which often feature a gas component) to newer, more efficient "mini split" systems (which do *not* typically feature a gas component).

Role of Utility Programs

Interviewees generally agreed that utility programs have the ability to greatly influence customer decision-making in the nonresidential gas space heating market. Several interviewees referenced current rebate programs and suggested that without them, most end users would *not* be purchasing efficient equipment. Two distributors mentioned that the point-of-sale (POS) rebates were highly effective in incentivizing contractors to purchase higher efficiency equipment.

> "I would expect that the contractor is going to get it to the masses. I'm sure the utilities have relationships with large users, which probably have high usage but also slight reductions would dramatically change the gas companies' providing of gas. So maybe it's a two-pronged approach [targeting both contractors and end users]."

One distributor interviewee expressed concern that utility programs were in some cases trying to push additional paperwork onto distributors and contractors, though he did not reference any program in particular. He thought that too much additional overhead would end up being detrimental to the distributor, and suggested that the purchasing party be

responsible for the rebate paperwork. He believed this approach would be particularly effective for situations in which a building owner (the purchasing party) rents out space to a tenant who pays their own utility bills. In this situation, the building owner does not stand to reap cost savings from more efficient equipment (because the owner does not pay the utility bills) and thus may not be interested in installing high efficiency equipment without an up-front rebate or other financial incentive.

Another interviewee expressed concern that utility efficiency programs look only at individual components of a building's overall energy use instead of taking a more holistic "systems approach." He believed that while this approach may have some benefits, it would ultimately miss out on some of the bigger energy savings measures.

In the opinion of one interviewee, the role of the utility should be to provide long term financing options for more efficient equipment, allowing the customer to pay off the cost of the equipment over the span of its life. This type of option would help mitigate customers' concerns regarding the incremental first cost of more expensive systems. The interviewee did not provide further specifics on the details of such a strategy.

Other Emergent Findings

For the gas space heating market for C&I customers, interviewees agreed that there is typically not a traditional *retailer* involved in the supply chain. Because HVAC equipment is typically installed by a licensed contractor, contractors go straight to the distributor to purchase the equipment, thus obviating the need for a storefront facility. Several interviewees did mention that distributors sometimes open showrooms to display products, and that these are geared primarily toward contractors rather than end users.

Interviewees noted that several of the larger manufacturers have for some time offered downstream services in addition to providing just the equipment. For manufacturers such as Trane and Carrier, these services may include installation and service options by employees of those companies. One interviewee mentioned that this type of behavior can cause "heartburn" among smaller contractors who purchase equipment from a manufacturer and then find out they are bidding against the manufacturer on a job. From the larger manufacturers' point of view, however, offering these types of services affords benefits derived from being involved at every stage of the supply chain.

Two interviewees mentioned that they thought incorporating better equipment controls into HVAC systems could have an impact on energy consumption without swapping out the actual equipment. One interviewee referenced demand-control ventilation (DCV), a control technology that uses sensors to detect how many people are in a space and thus how much ventilation is required. When rooms have fewer people than their intended occupancy levels, sensors then alert the ventilation system to dial back, resulting in less wasted energy. Another interviewee (a distributor) mentioned that much of the marketing in recent years has focused on better control of systems as opposed to the actual efficiency of the equipment itself.

6. INDUSTRIAL MOTORS MARKET RESULTS

Due to federal mandates, the majority of industrial motors will meet maximum energy efficiency levels in 2016. Therefore, future gains in motor-driven equipment efficiency will come through optimized *system* design and implementation. These efficiency improvement opportunities will be largely associated with the mechanical elements in motor-driven systems rather than the motors themselves. Such system-level optimized designs focus on applying the proper type and size of motor, mechanical equipment, and controls to deliver only the power required for the application.

This study was originally designed to collect more in-depth information on industrial motors *systems* through surveys with contractors and customers; however the remainder of the study was cancelled prior to conducting these surveys. The distributors and manufacturers we interviewed generally did not have insight into the applications of motors by the end-user. Thus, this chapter serves to provide a common understanding of the current motors market rather than providing detailed information on motors systems. First, the secondary data review summarizes national trends in the motors market and provides background information on the federal standards for motor efficiency. Next is a summary of the interviews with manufacturers and distributors working within the Connecticut industrial motors market. These interviews provide a more in-depth review of the motors supply chain, confirm the imminent efficiency of motors and the need to focus future efforts on motors systems, and provide additional information on marketing and customer decision-making.

6.1 Secondary Data Review

The research team conducted a review of secondary data sources relating to the industrial motor market prior to interviewing manufacturers and distributors. The purpose of the secondary data review was to develop a high-level understanding of the industrial motor market to inform subsequent primary research tasks. In particular, the research team sought to address the following questions:

- Who are the market actors in the motors supply chain?
- What is the path this equipment takes from manufacturing to end user?
- What is the size of the overall industrial motors market in Connecticut?
- What are the natural groupings for equipment types within each end use category?
- What portion of the overall Connecticut industrial motors market is considered “energy efficient”?
- What types of data are missing from the secondary data sources?[81]

The research team completed the majority of the secondary data review during August and September 2014. We also completed some additional secondary research in February 2015 to

[81] The original study plan included designing contractor surveys that would include inquiry for these market actors’ perspective on the size and operation of the market, how they interacted with customers with regard to the equipment and energy efficiency and to fill gaps from the earlier research tasks. This would have then been followed by C&I customer surveys. These latter activities were cancelled and this report is the final wrap-up report for this study.

follow up on findings from the market actor interviews. This review focused on the following documents:

1. *Electric Motors: Industry Study # 3007*, Freedonia Group (March 2013).[82]
2. *2013 Energy Savings Potential and Opportunities for High-Efficiency Electric Motors in Residential and Commercial Equipment*, US Department of Energy (DOE) (May 2013).[83]
3. *Motor Efficiency, Selection, and Management: Guidebook for Industrial Efficiency Programs,* Consortium of Energy Efficiency (September 2013).[84]
4. "Motor Market Update" Presentation by Alex Chausovsky of Industrial Automation at *Motor Summit 2014, Zurich Switzerland* (October 2014).[85]
5. "A Summary of Motor Efficiency in the United States," Presentation by Rob Boteler of Emerson Motor Technologies at *2007 Motor Summit,* Zurich Switzerland (April 2007).[86]
6. Various policy-level summaries published by Baldor Electric.[87]

All of these reports were nationally focused, and interviewees confirmed that the Connecticut industrial motors market generally mirrors national trends. It is important to consider that these reports typically rely on data collected at least a year prior to publication. Therefore, these reports do not necessarily represent the 2015 market; however, they provide a recent baseline for comparison.

The remainder of this section presents the findings from this secondary data review. It presents results on the following topics:

- Industrial motors market structure,
- Industrial motors categories
- The size of the industrial motors market (including the prevalence of energy efficient motors), and
- Data gaps.

Industrial Motors Market Structure

Understanding the market structure and key market actors is necessary for determining where to best intervene in the supply chain to improve energy efficiency. This section summarizes data as it relates to how the industrial motors market is structured. It first describes the supply chain – that is, how products are developed and how these products make their way to the customer. It then identifies key market actors working within the industrial motors market.

Supply Chain

The supply chain for electric motors consists of a variety of distribution channels. According to the Freedonia Group report, manufacturers typically sell motors through their own sales teams or distributors. For original equipment manufacturer (OEM) applications, sales staff are typically technically trained and work with customers to design customized motor-driven equipment. The

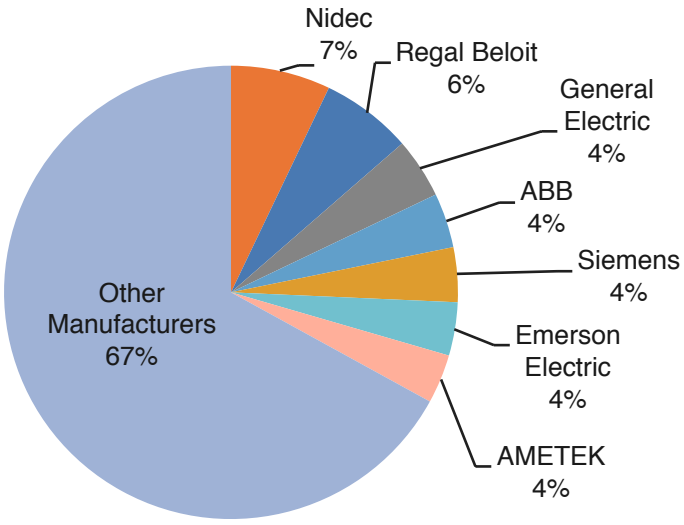
[82] Purchased from http://www.freedoniagroup.com/industry-study/3007/electric-motors.htm
[83] http://energy.gov/sites/prod/files/2014/02/f8/Motor%20Energy%20Savings%20Potential%20Report%202013-12-4.pdf
[84] http://www.motorsmatter.org/CEEMotorGuidebook.pdf
[85] http://motorsummit.ch/data/files/MS_2014/mittwoch/530_ms14_chausovsky.pdf
[86] http://motorsummit.ch/data/files/MS_2007/1/4_Boteler.pdf
[87] http://www.baldor.com/pdf/doe-integral-hp-motor-rule.pdf and http://www.baldor.com/pdf/integral-hp-rule-webinar-slides.pdf

Internet has changed the way in which motor manufacturers market and advertise their products. Many motor manufacturers now market their motors on their websites. Websites are often searchable and typically present the following specifications: horsepower, power source, torque, and voltage. Some websites also offer online chat functions, making their sales teams available to customers on an as-needed basis.[88]

Key Market Actors in the Supply Chain

The Freedonia Group reports that one-third (33%) of 2012 industry revenues are concentrated among the seven largest suppliers to the US electric motor market. The top seven suppliers, as shown in Figure 6-1, include: Nidec, Regal Beloit, GE, ABB, Siemens, Emerson Electric, and AMETEK. Note that these data represent the entire motors industry and do not focus on industrial motors specifically.

Figure 6-1: 2012 United States Total Electric Motor Market Share by Company



Source: Freedonia Group, Industry Study #3007 Electric Motors (March 2013), p. 134.

Motor Categories

Understanding the key technologies that make up the motors market is essential for determining how to focus energy efficiency strategies and program design. To better understand the types of industrial motors available in the market, and help frame our subsequent interviews, the research team wanted to define how secondary sources categorized motors and what types of motor applications exist. First, types of motors are summarized, followed by a summary of motor applications.

[88] Freedonia Group, *Industry Study #3007 Electric Motors* (March, 2013) 134-146.

Types of Motors

As shown in Table 6-1, the Freedonia Group defined three major types of electric motors: AC motors, DC motors, and hermetic motors. Motor categories include fractional motors, which are less than one horsepower, and integral motors, which are one horsepower or more.

Table 6-1: Types of Industrial Motors

Type of Motors	Categories
AC Motors	Fractional AC Motors (Single Phase, Poly Phase) Integral AC Motors (Induction, Synchronous)
DC Motors	Fractional DC Motors (Brushed, Brushless) Integral DC Motors (Brushed, Brushless)
Hermetic Motors [a]	Fractional Integral

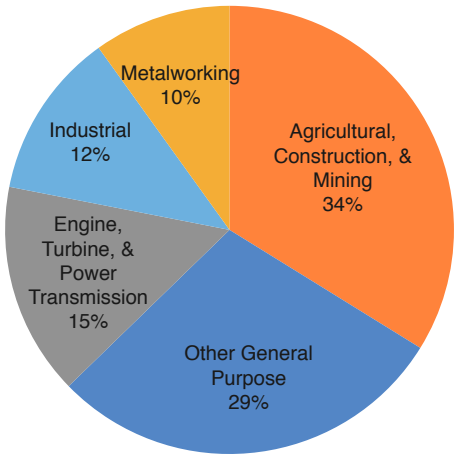
Source: Freedonia Group, Industry Study #3007 Electric Motors (March 2013), p. i – iii.
[a] Hermetic motors are sealed for special uses such as cooling and refrigeration equipment and environments containing explosive gases.

Motor Applications

Motors are found in a variety of equipment. The Freedonia Group identified six types of motor applications: motor vehicles, heating and cooling equipment, machinery, household appliances, aerospace and other transportation equipment, and commercial and service industry equipment. Of these groups, machinery motors is most applicable to the industrial motors market and so the research team explored the machinery applications in more detail.

Within the machinery category, the Freedonia Group described a variety of motor applications: agricultural, construction, mining, engine, turbine, power transmission, industrial, metalworking, and other. As shown in Figure 6-2, industrial machinery comprised 12% of the machinery motors shipped within the United States.

Figure 6-2: 2012 US Machinery Motor Shipments By Application Type



Source: Freedonia Group, *Industry Study #3007 Electric Motors* (March 2013), p. 111.
Note. It is unclear how "Industrial" machinery was differentiated from the other types of machinery shown, such as Metalworking or Mining.

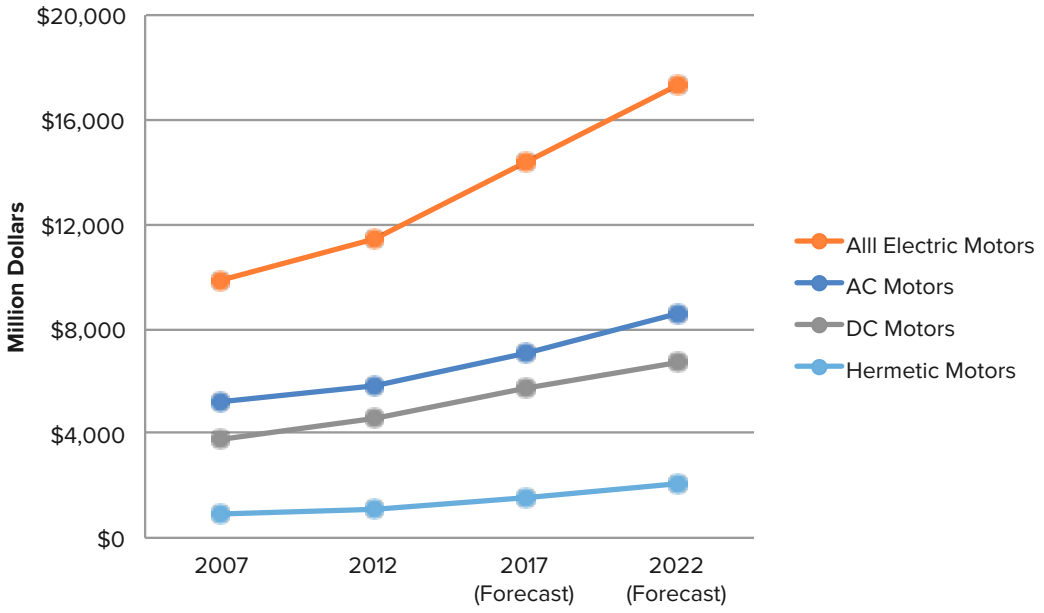
Size of the Industrial Motors Market

The size of the industrial motors market is somewhat difficult to estimate based on documentation reviewed by the research team. That being said, the secondary data pointed to information that could be used to infer the size of the industrial motors market. In this sub-section, the research team presents available data on the overall size of the motors market and the prevalence of energy efficient motors.

Overall Size of Motors Market

According to the Freedonia Group, the 2012 overall electric motor market, which includes motors for automobiles and OEMs, was worth $11.5 billion (in 2005 dollars), as shown in Figure 6-3. The market continues to increase, with an estimated worth of $17.3 billion in 2022. The Freedonia Group broke down motors between alternating current (AC) motors, direct current (DC) motors, and hermetic motors (as shown in Table 6-1). As shown in Figure 6-3, AC motors comprised the largest amount of demand, valued at $5.8 billion in 2012 (or 51% of all motor demand).

Figure 6-3: Total Electric Motor Demand in the United States Over Time

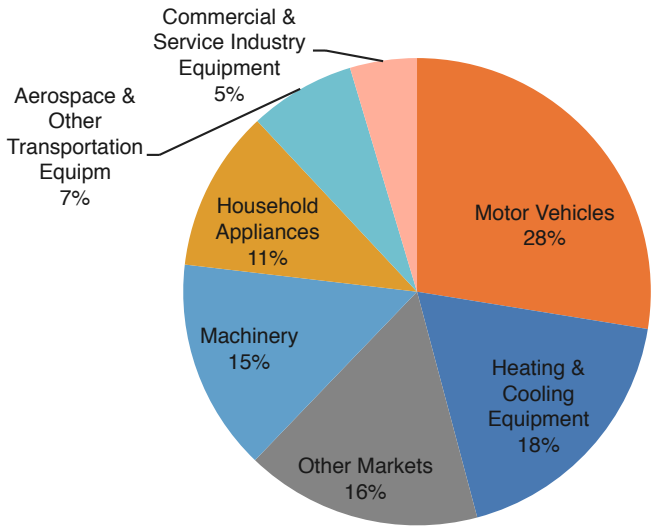


Source: Freedonia Group, Industry Study #3007 Electric Motors (March 2013), p. 3.

While data presented in Figure 6-3 represents the entire motors market, Figure 6-4 shows motor demand broken down by application. The Freedonia Group reported that motors are most often sold for motor vehicles, heating, and cooling equipment. While the data is not broken down by sector, one could estimate the size of industrial motor sales by referring to data for machinery applications. As shown in Figure 6-4, motors for machinery comprised 15% of the motors market in 2012, which equates to $1.7 billion. The Freedonia Group predicts electric motor demand for machinery to increase 3.4% annually to $2.0 billion in 2017. They predicted this growth based on improving economic conditions within the United States that would result in increased industrial equipment demand. This growth is less than the growth forecasted for other types of motors, due

to increasing overseas competition constraining growth in the domestic industrial manufacturing segment.

Figure 6-4: Electric Motor Demand in the United States by Application in 2012 (Total = $11.5 Billion)

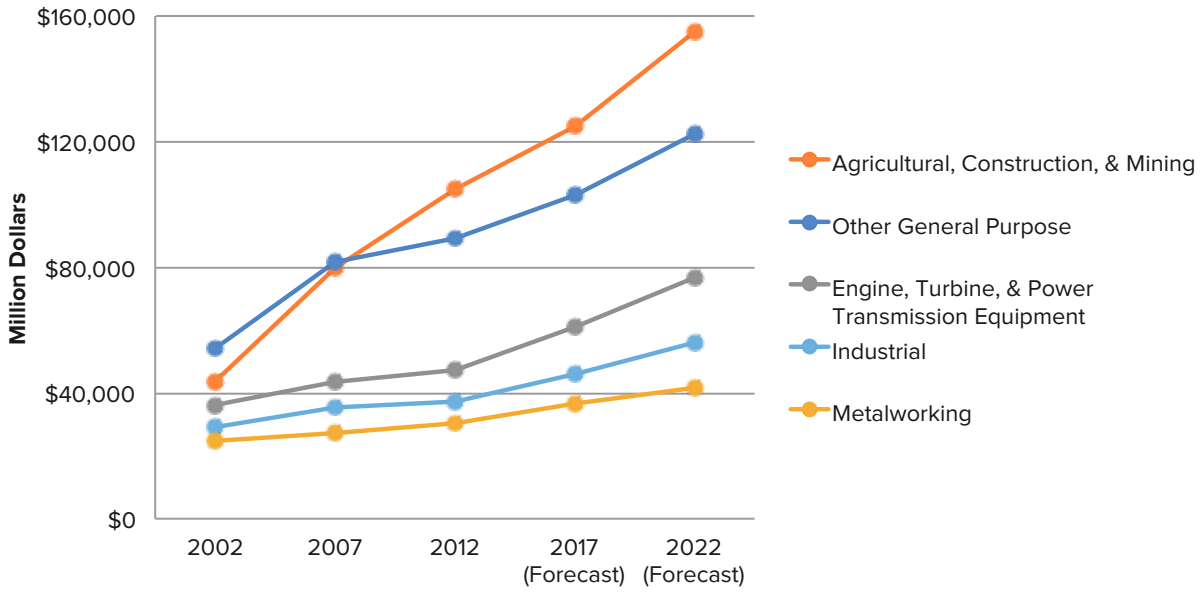


Source: Freedonia Group, Industry Study #3007 Electric Motors (March 2013), p. 88.

When looking specifically at the machinery motors group category, the Freedonia Group reported shipment data by motor applications. Within the industrial machinery category, the Freedonia Group reported $37.2 billion in shipments in 2012 and projected shipments to increase to $45.8 billion in 2017 (Figure 6-5).[89]

[89] Freedonia Group, Industry Study #3007 Electric Motors (March 2013) 109-113.

Figure 6-5: Motor Shipments for Machines by Application in the United States Over Time



Source: Freedonia Group, Industry Study #3007 Electric Motors (March 2013), p. 113.

Prevalence of Energy Efficient Motors

To understand what portion of the motors market is energy efficient, the research team first examined how secondary data defined energy efficiency. Within the motors market, energy efficiency tends to be defined by national standards. By 2016, the majority of industrial and commercial electric motors will be mandated by DOE to be high efficiency. Depending on the motor size, minimum efficiency levels are as high as 96.2% under these standards. To better understand the energy efficient standards, which vary for integral and fractional horsepower motors, the research team defines each standard below.

Energy Efficient Integral Horsepower Motor Standards

Since 1977, the U.S. Department of Energy (DOE) has regulated the energy efficiency level of commercial and industrial electric integral motors, defined as more than one horsepower. Over time, standards increased in efficiency levels and covered more types of integral horsepower motors. The Energy Policy Act (EPAct), as amended by the Energy Independence and Security Act of 2007 (EISA 2007, enacted in 2010), defines energy efficiency levels for integral horsepower motors.90 According to these rulings, integral horsepower motors must meet minimum efficiency levels that range from 74% to 96.2%, depending on the specific motor type and level of horsepower. These percentages are based on efficiency standards set by the National Electrical Manufacturers Association (NEMA). These standards are published in a NEMA document called "NEMA MG 1 (2006)."91 Within this document are two tables, Table 12-11 and Table 12-12, which list efficiency levels for integral horsepower motors (these are presented in the Appendix). These tables differ in that they cover different motor types, and Table 12-12 presents

[90] Consortium for Energy Efficiency, Motor Efficiency, Selection, and Management: Guidebook for Industrial Efficiency Programs (September 2013), 7.
[91] This documentation is available from NEMA at http://www.nema.org/Standards/Pages/Motors-and-Generators.aspx

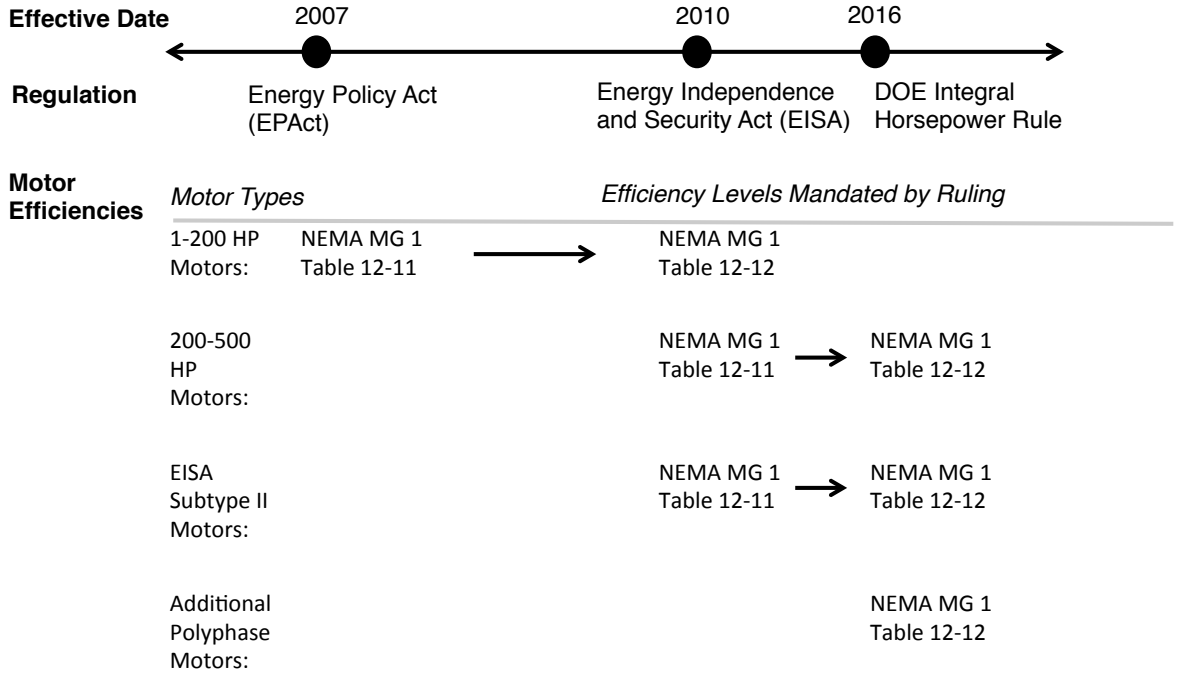
slightly higher efficiency levels for some motor types. The secondary data all refer to these standards as NEMA MG 1 Tables 12-11 and Table 12-12. NEMA MG 1 Table 12-11, which NEMA developed in 1997, is considered the standard efficiency for motors.92 NEMA MG 1 Table 12-12 is considered premium efficiency and was developed in 2001. Within both of these tables, NEMA presents a range of efficiency levels based on the following motor characteristics:

- Horsepower – unit of measurement of power.
- Framing – motors can be "open framed" or "closed framed"; opened framed motors are open to the air, while closed framed motors are enclosed.
- Number of poles – for AC motors, the number of poles sets the full (unloaded) speed of the motor for a given electrical frequency.

In 2014, the DOE passed another ruling, the Integral Horsepower Motor Rule, which did two things.[93] First, it expanded the regulation to include a number of other groups of electric motors that DOE had not previously regulated. Secondly, the ruling brought all regulated motors to the same efficiency level. According to one of the interviewees, the goal of this final ruling was to stabilize efficiency at the NEMA Premium level and close loopholes in the previous two regulations. The 2014 ruling has a compliance date of June 1, 2016. Figure 6-6 shows the historical development of regulations covering integral motors. As shown, the efficiency levels and types of integral motors have expanded over time.

[92] Boteler, "A Summary of Motor Efficiency in the United States," Presentation at 2007 Motor Summit (April 2007).
[93] http://www.baldor.com/pdf/doe-integral-hp-motor-rule.pdf

Figure 6-6: Historical Development of Federal Energy Efficiency Levels for Integral Motors



Source: Created based on data from Consortium of Energy Efficiency, Motor Efficiency, Selection, and Management: Guidebook for Industrial Efficiency Programs (September 2013) 7 and summary of DOE Integral Horsepower Motor Rule available at http://www.baldor.com/pdf/doe-integral-hp-motor-rule.pdf
Note. EISA subtype II motors are defined in the Appendix. Additional polyphase motors included within the Integral Horespower Rule were not previously covered by the subtype II motor list or motors included in NEMA MG 1 Tables 12-11 and 12-12. Additional polyphase motors also include custom motor configurations. While this ruling brings most integral motors to efficiency levels within NEMA MG 1 Table 12-12 levels, 1-200 horsepower fire pump motors remain at the NEMA MG 1, Table 12-11 efficiency level.[94]

Energy Efficient Fractional Horsepower Motor Standards

In 2010, the DOE also developed efficiency standards for small and fractional motors (less than one horsepower), which had previously not been regulated. These regulations take effect in March 2015. This regulation will mostly impact HVAC motors given that they make up the majority of products in this size class, but it also impacts motors used for machine drive applications. Like integral motors, the minimum efficiency levels required by the standard are dependent on the motor type and horsepower, and range from 62.2% to 86.9%. This regulation applies to single-phase and three-phase motors built in a two-digit NEMA frame and rated from ¼ to 3 horsepower.[95]

Prevalence of Energy Efficiency in the Industrial Motors Market

At the time of conducting this research, the 2014 Integral Horsepower Rule had not taken affect. Therefore, only the 2007 EPAct and 2010 EISA regulations had been enacted. Based on these regulations, CEE identified 634 motors that were more efficient than the EISA regulation and

[94] http://www.baldor.com/pdf/integral-hp-rule-webinar-slides.pdf
[95] Balder Electric provides a summary with more information on motors covered under the small motors act: http://www.baldor.com/pdf/integral-hp-rule-webinar-slides.pdf.

listed them on their website.[96] Because this list only focuses on the 2007 EPAct and 2010 EISA regulations, it does not specify how many motors will be more efficient than the standard once the Integral Horsepower Regulation takes effect in 2016. Data presented at the latest Motor Summit in 2014 showed that 94% of low voltage motors sold in the United States and Canada met NEMA Standard Efficiency and NEMD Premium Efficiency Standards, which equates to the EPAct and EISA standards respectively.[97] These data also show that 1% of low voltage motors sold were *above* these standards.[98] That being said, industrial motors are not typically low voltage motors and, therefore it is unclear what percentage of motors in the industrial market exceeds the standards.

Assuming that the industrial motors market is transformed or will soon be transformed, almost all future efficiency improvement opportunities lie with the mechanical elements in motor-driven systems rather than the motors themselves. Such system-level optimized designs focus on applying the proper type and size of motor, mechanical equipment, and controls to deliver only the power required for the application. Many industrial applications have varying loads, and modern speed control technologies (*i.e.*, ASDs or adjustable speed drives, VSDs or variable speed drives) can match motor speed, torque and power to the load cost-effectively.[99,100] Notably, many fluid flow devices, such as pumps and fans are subject to cubic "affinity laws," which make proper speed matching a great energy saver. Additionally, for a fluid flow machine, matching the design flow and pressure can help optimize its nominal efficiency.

Data Gaps from Secondary Data Review

The secondary data reviewed did not provide any data on the motors market within Connecticut specifically. Additionally, while the research team attempted to focus its research on industrial motors, the secondary data did not explicitly present data by sector.

6.2 Results of Interviews with Motors Distributors and Manufacturers

To further investigate the motor market, the research team interviewed seven motor distributors and manufacturers selling equipment in Connecticut. Unlike the secondary data review, interview findings are specific to the Connecticut industrial motors market.

Results indicate that motors are sold by manufacturers and distributors and that current standards are energy efficient. Interviewees suggested that remaining energy efficiency opportunities exist through auditing and optimizing existing equipment and by focusing on the efficiency of motor *systems*.

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[96] http://library.cee1.org/content/cee-premium-efficiency-motors-list
[97] Chausovsky, "Motor Market Update," Presentation at 2014 Motor Summit (October 2014), p. 12.
[98] Ibid.
[99] Motor Efficiency, Selection and Management: A Guidebook for Industrial Efficiency Programs, Pacific Gas & Electric Company and Consortium for Energy Efficiency (2011), pp. 18, 27 - 28. Available at: http://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/agriculture/industrial_guidebook.pdf
[100] Applications of variable speed drive (VSD) in electrical motors energy savings. Renewable and Sustainable Energy Reviews, 16, 543-550). Saidur, R., Mekhilef, S., Ali, M. B., Safari, A., & Mohammed, H. A. (2012). Available at: http://www.academia.edu/2169234/Applications_of_variable_speed_drive_VSD_in_electrical_motors_energy_savings

To collect these data, the research team conducted interviews with the following seven experts:

- **Two manufacturers** – Both manufacturers represented global electrical motor manufacturers and sales teams.
- **One manufacturer representative** – This interviewee represented an independent sales representative that contracts with a manufacturer to sell electrical motors.
- **Four distributors** – Two interviewees represented global distributors that offered maintenance, repair, wholesale distribution, and retail sales. Another interviewee represented a national distribution company that offered wholesale and retail distribution. The fourth interviewee represented an independent motor distributor and retailer.

The remainder of this chapter presents feedback the research team collected from the interviews with motor manufacturers and distributors on the following topics:

- **Industrial motor market structure** – This section contains a description of the supply chain, key market actors, and the proportion of sales through each market actor.
- **Motor categories, applications, and customer segments** – This section discusses the types of motor categories and applications, the mix of customer segments purchasing motors.
- **Size of the industrial motor market** – In this section, we present the information obtained regarding the size of the motor market in Connecticut, how market actors define energy efficient motors, and the portion of energy efficient motors sold to Connecticut industrial customers.
- **Marketing to Connecticut industrial customers** – This section includes insight from interviewees on effective techniques to market energy efficient motors to industrial customers in Connecticut.
- **Other emergent findings** – Here we discuss additional feedback from interviewees.

Industrial Motors Market Structure

The industrial motors market includes manufacturers, manufacturer representatives, distributors, service shops, and end users. Each actor has its own specific role in the supply chain. This section first presents an image of the supply chain and then describes each role in depth. It also identifies major motor manufacturers and distributors selling equipment in Connecticut.

Supply Chain

The structure of the supply chain for industrial electric motors, particularly for machine drive and power transmission electric motors, is described in this section. The supply chain illustrated in Figure 6-7 also shows OEM and HVAC motors, which are not the focus of this research but make up a significant portion of the supply chain. Interviewees indicated this structure is consistent across the various product categories described later in this chapter.

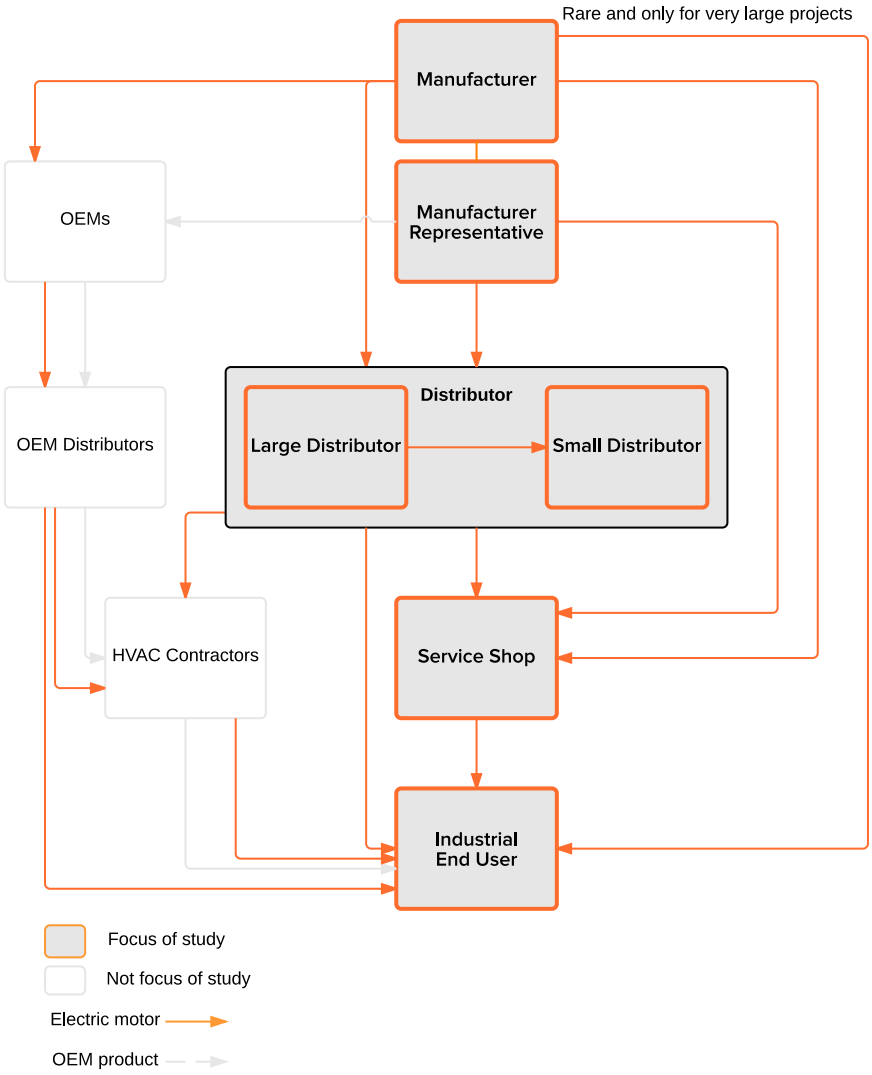
Each of the market actors that serve a role in bringing electric motors to the end use customer are shown in Figure 6-7. As shown, products originate with the manufacturer. Manufacturers then work with manufacturing representatives or their own sales teams to sell motors primarily to distributors. Manufacturers also sell to service shops and in rare instances to customers. As described below, distributors can play many roles, but typically sell either to service shops, who

contract with customers to install and maintain customers' motors, or distributors, who sell directly to customers. Some distributors also serve as warehouses and will sell to other distributors.

Manufacturers also sell electric motors to OEMs. As shown in Figure 6-7, OEMs then install motors into a new product, such as industrial production equipment, and then sell the equipment to a distributor who, in turn, sells the equipment to contractors and end users. OEMs also sell replacement motors for existing equipment through similar channels.

Each actor's unique role and interaction with other market actors are described in the remainder of this section. Market actors include the manufacturer, manufacturer representatives, large and small distributors, original equipment manufacturers (OEMs), service shops, contractors (for which HVAC equipment is a major segment of the market - not a focus of this chapter), and end users.

Figure 6-7: Motor Supply Market Structure for Industrial Applications



Role of Manufacturers

The electric motor manufacturer is a national or international organization that supplies products to customers through a network of regional warehouses and district offices. Some manufacturers use a combination of direct sales and outsourced sales forces called manufacturer representatives, while some exclusively use only one of these sales staffing approaches. Most manufacturer products reach the end use customer through distributors. Manufacturers rarely sell directly to the end use customer except in rare cases for large projects. For example, one manufacturer said they sold directly to large petrochemical projects. Manufacturers sell directly to original equipment manufacturers (OEMs), and dedicate key account managers to handle these relationships.

Major Motor Manufacturers:

Baldor Electric
Nidec US Motors
Regal Beloit (Marathon, Century, Leeson)
Dayton
WEG
USEM

Role of Manufacturer Representatives

Manufacturer representatives, or “manufacturer reps,” are regionally located independent firms contracted as commissioned sales representatives to provide an outsourced regional sales force for the manufacturer. Unlike in the lighting market, motor manufacturer representatives only represent one manufacturer per product category; while they only represent one motor manufacturer, they may sell a wide variety of other non-motor products and represent those manufacturers accordingly. Manufacturer representatives sell to OEMs, service shops, and large and small distributors with warehouses located within their region.

Role of Distributors

Distributors may be part of a large national or international organization or a small local independent company. Distributors sell motors from regionally located warehouses operated by the distributor, and in some cases also provide installation, service, and repair services. Their primary business may be as a power transmission distributor, electrical apparatus distributor, industrial equipment and products distributor, and/or service shop. Large and small distributors source their supply directly from the manufacturer, while smaller distributors may also source supplies through larger distributors as either a main source or only in emergencies. Some distributors sell wholesale only, while others sell a combination of wholesale and retail. Wholesale products are sold to other distributors and service shops, while retail products are sold directly to end use customers. Retail sales are made through online e-commerce, regionally located branch stores (which also serve as mini-warehouses), or through national agreements with large industrial companies that have a large number of facilities.

Major Motor Distributors:

Kaman Industrial Technology
Grainger
Applied Industrial Technology
Motion Industries
Fastenal

Role of Original Equipment Manufacturers (OEM)

Original equipment manufacturers (OEMs) are typically large national or international organizations that design motors into their equipment. OEMs source motors directly from the manufacturer or the manufacturer representative and typically have a direct account. According to one manufacturer, these motors are usually not stock products, but custom designed for use in the specific equipment. OEMs represent a diverse set of industries including aerospace or

defense, air handler manufacturers, pump manufacturers, winch manufacturers, and industrial process equipment manufacturers (*e.g.* packaging, dryers, presses, food processing, etc.). Some OEMs sell replacement motors directly to end use customers; however, this is uncommon. The exception is when OEMs also manufacture motors. Examples of OEMs that also manufacture motors are Mitsubishi, Hitachi, Fuji, and Siemens.

Role of Service Shops

Service shops are usually local independently owned companies. Service shops sell replacement motors for retail and also offer motor repair services such as motor cleaning and rewinding. Service shops source their motors from manufacturers or distributors and sell directly to the end use customer. Service shops often contract with customers to install and maintain motors over time at customers' facilities.

Role of End Use Customers

Among industrial end use customers, the purchaser is often an in-house or contracted maintenance manager or a staff person overseeing a facility including warehouses and factories. Independently run companies contract with one or several local motor service centers, which provide sales, installations, and repair services. If the facility is staffed with in-house engineers and installers, they may order the motor online or by phone from a major distributor and perform the installation themselves. For facilities that are part of a large national organization, they may procure motors through a national account with a large distributor.

Proportion of Sales through Market Actors

The research team attempted to calculate the portion of sales that flow through each portion of the supply chain; however, the research team found it challenging to estimate because responses varied among distributors and manufacturers, and also varied based on whether the interviewee was a manufacturer or distributor. Responses also varied based on how interviewees categorized equipment. As a result, the research team presents findings from each of the five interviewees who addressed this question to provide some indication of the range of responses.

Distributor sales

- One major national distributor reported that 60% of their sales are for maintenance, repair, and overhaul (MRO) applications and 40% are for new installations, with original equipment manufacturer (OEM) sales making up 5% to 10% of that.
- Another major distributor reported that 60% of their sales are for MRO applications and 40% are for OEM applications.
- One small independently owned distributor did not sell to OEMs, and the majority of their business was for MRO applications. Of the MRO sales, 20% to 30% of sales were to industrial customers and 70% to 80% of sales were to HVAC customers.

Manufacturer sales

- One major manufacturer reported they sold 50% to distributors and 50% to OEMs.
- Another major manufacturer sold 40% to distributors and 60% to OEMs.

Motor Categories, Applications, and Customer Segments

This sub-section presents a description of motor categories and their applications. It also presents information on what types of industrial customers purchase motors. As described below, interviewees categorized motors in many different ways. Additionally, interviewees segmented end use customers by the type of purchases they made.

Motor Categories and Applications

To better understand the motors market, the research team asked interviewees to define categories of motors. This sub-section presents these results as they relate to motors that focus on power transmission or machine drive motor applications. For reference, power transmission or machine drive refers to "the direct process end use in which thermal or electric energy is converted into mechanical energy," such as process cooling and refrigeration, process heating, or electrochemical processes; this does not include motors that are found in equipment that is wholly contained in another end use.[101] Interviewees indicated that electric motors for use in machine drive applications are typically AC (alternating current) general purpose, integral horsepower motors that are three phase (although smaller horsepower motors are common too, which usually use single phase). The remainder of this sub-section presents categories of motors and information on customer segments that rely on industrial motors.

Motor categories

The research team found that market actors divided electric motors into two high-level motor categories, AC (alternating current) and DC (direct current) motors, with AC motors making up the majority of the motor market. Because AC motors make up the majority of the motors used in industrial applications, they are the focus of this study. From those high-level motor categories, market actors split out AC motors by two broad use categories, industrial drive and power transmission applications.

Market actors further described AC motors using three characteristic groupings including phase (*e.g.*, single phase, three phase, poly phase), motor technology (*e.g.*, shaded pole, capacitor start capacitor run, etc.), and application (either general use, drip-proof, sealed, or a special use including extreme duty, explosion proof, etc.). Any individual motor can be described by using one of each of the following three characteristics:

- Type by phase (the number of electrical waves used by a motor)
  - Single phase
  - Three phase
  - Poly phase
- Type by technology
  - AC Induction Motor
    - Shaded pole (SP)
    - Capacitor Start (CS)
    - Capacitor Start Capacitor Run (CSCR)
  - AC Synchronous Motors (*e.g.*, Permanent Magnet Synchronous Motor (PMSM))

[101] As defined by the Manufacturing Energy Consumption Survey (MECS). See http://www.eia.gov/consumption/manufacturing/terms.cfm#m

- Type by application
    - General purpose
    - Cooling tower
    - Fan motors
    - Sanitary
    - Severe duty
    - Extreme duty
    - Explosion proof

In addition, any single AC motor can be further described by assigning a value for each of the following attributes:

- Attributes
    - Horsepower
        - Fractional horsepower (HP < 1)
        - Integral horsepower (HP >= 1)
    - Enclosure
    - Mounting
    - Voltage
    - RPM
    - Service factor
    - Shaft diameter

Interviewees also described how motors are controlled by a number of different types of motor drives and controls. Adjustable speed drives, of which there are many types, control AC motor speeds and/or torque by varying the motor input frequency and voltage. Manufacturers interviewed all said they sell adjustable speed drives. Most distributors interviewed offer adjustable speed drives, although some only sell them paired with a controllable motor and do not sell drives and controls on their own. Adjustable variable speed drives and controls can be coupled with AC induction type motors or permanent magnet synchronous type motors (PMSM) to provide customized control and energy savings. Energy savings occur because adjustable variable speed drives can reduce motor speeds when operations are not in use or are decreased from normal operations. Because motors themselves are generally considered energy efficient, focusing on ASDs is key for increasing the energy efficiency of motors systems.

Customer Segments

Interviewees segmented end use customers by the type of purchase they made, such as MRO, OEM, or HVAC. Some market actors grouped HVAC with OEM (assuming these were for new installations), and others grouped HVAC with MRO (assuming these were for repair and replace installations). When asked exclusively about MROs, motor manufacturers and distributors stated that they sell products to all types of industrial buildings, including warehouses and factories. The buyer is typically a facility manager (in-house staff or third party management).

Size of the Industrial Motors Market

One of the research objectives was to understand the size of the industrial motors market in Connecticut and understand the portion of the market that could be considered energy efficient. Interviewees, however, found difficulty in answering both questions. This was likely due to interviewees not having data to answer the question and because interviewees could not consistently distinguish HVAC and OEM motors from MRO motors to understand the size of the machine drive motor market. Furthermore, manufacturers and distributors did not generally have insight into the end-use applications for the motors they sell. That being said, the research team did find that market actors believed that nearly all motors being sold today could be considered energy efficient based on current standards and policies.

Total Size of Motor Market in Connecticut

The research team was not able to confidently estimate the total size of the industrial motor market in Connecticut, as most manufacturers were not willing to share sales information or did not have granular enough data available to provide state-level values or values specific to machine drive applications. However, one manufacturer representative did share that they estimated there was $100 million in total market wide motor sales in Connecticut for all types of motors, referencing a report through the PTDA (Power Transmission Distributors Association).[102] One major national distributor estimated that $1 million or 15% of their total electric motor sales were in Connecticut. This was not an insignificant number given that the distributor has 200 national offices, serving New York, Massachusetts, Pennsylvania, and California as its primary markets. Another major multinational distributor estimated $6 to $7 million of its motor sales were in Connecticut. Both figures do not separate HVAC from machine drive applications. Lastly, a small independent distributor located in Connecticut said 70% of their business was done within the state, however this was mostly for HVAC motor sales. They reported that 20-30% of their total motor sales were in machine drive applications, although they mostly sold those motors out of state.

How Market Actors Define Energy Efficient Motors

To understand the prevalence of energy efficient industrial motors, the research team needed to first identify how interviewees defined energy efficiency. The research team found that, like the standards, interviewees defined energy efficiency differently for integral horsepower motors and fractional motors. Interviewees also consistently relied on national standards to define motor efficiencies (see the secondary research section of this chapter for a definition of the energy efficient motor standards).

Portion of Energy Efficient Motors in Connecticut by Product Type

Once the research team understood how interviewees defined energy efficient products, the research team asked interviewees about the portion of motors sales they considered to be energy efficient. Most manufacturers, however, were not willing to share sales information or did not have granular enough data available to provide state level values or values specific to machine drive applications. However, two interviewees provided indicators by fractional and integral motor categories.

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[102] We were unable to obtain any reports through PDTA, because these are made available only to association members.

For integral motors, one distributor selling into the Connecticut market estimated that 1% to 2% of total electric motors sold into Connecticut were above NEMA premium efficiency, the minimum federal efficiency standard for most integral motors with 1 to 500 horsepower. They caveated this response by saying it was difficult to estimate this because products were generally not marketed or tracked as above NEMA premium efficiency. Another manufacturer said that there was a category of motors that was above NEMA premium efficiency, permanent magnet synchronous type motors (PMSM), but these motors were expensive and outside the scope of a standard general use motor and used for niche applications (*e.g.*, cooling towers).

Marketing Motors to Connecticut Industrial Customers

Manufacturers play the primary role in marketing motors to industrial customers. As a result, they also play a primary role in promoting energy efficiency to market actors. This sub-section describes marketing techniques used to sell motors and techniques used to promote energy efficient motors.

Marketing Techniques

Manufacturers play a key role in promoting energy efficiency in the electric motor market for industrial applications. They are the sole source for product, design, installation literature, and information used to educate market actors throughout the supply chain. Manufacturers are the only market actor investing heavily in advertisements and promotion and utilize channels such as plant maintenance or industry-specific trade magazines, trade shows, and direct trainings to distributors. Distributors said that they rely on training and collateral resources provided by manufactures to educate their staff and customers, rather than generating materials themselves.

Promoting Energy Efficiency

One manufacturer said their efficiency messaging is mostly directed towards MRO applications via the distributor channel and less towards OEMs. They said that although some OEMs do try to differentiate themselves by energy efficiency, most tend to look for the least expensive solution because they don't have to pay for the operation of the equipment. They said that OEMs will likely change their practices because of the new efficiency regulations for small and fractional motors mandating improved performance for pumps, fans, and compressors. However, another manufacturer mentioned some OEMs have been adopting high efficiency motors prior to the small motors ruling based on their improved speed and noise control, and not necessarily for the efficiency gains.

One manufacturer said their most effective channel for promoting efficient products have been through their training and engineering summits where they sell, explain, and show products to engineers who can then go back up the chain in their organizations to the purchasing decision makers. This manufacturer said they have national training staff that travel around the country to distributors and end use customers and are effective at influencing their customers to buy efficient motors.

Market actors indicated that utilities no longer provide incentives for the adoption of efficient motors because most motors for use in industrial applications are mandated to be efficient by

federal minimum efficiency standards. However, a 2013 list of CEE member motor programs[103] indicates there are 22 prescriptive programs for motors with 18 programs providing rebates for motors at or above NEMA premium, and 4 programs incentivizing motors listed on the CEE's premium efficiency motor list. That being said, it appears the industry believes rebates are essentially non-existent and interviewees did identify new energy efficient opportunities that utilities could support. These opportunities are described in the next sub-section of this chapter.

Other Emergent Findings

While not a focus of the interviews, market actors provided information on additional energy efficiency opportunities within the motors context. They also provided feedback on energy efficiency program ideas that can help meet these opportunities, including how to influence end users and how to better utilize service centers.

Remaining Energy Efficiency Opportunities

Due to the broad set of regulations now covering a large portion of the industrial and commercial electric motor market, from small fractional to large integral motors, manufacturers stated that any additional energy savings associated with motors will stem from energy management measures that improve system-wide efficiencies. Examples include conducting system-wide audits, incorporating controls and variable speed drives, optimizing controls, and performing more in-depth monitoring of energy usage.

One manufacturer recommended that if there was any additional work to be done on improving motor energy efficiency, the best thing to do would be to fully understand the federal regulations and look for opportunities around the edges where the government was only mandating to go to a certain efficiency or was not covering a certain motor type and help fill in the gaps. They emphasized however, that motor efficiencies provide minute incremental improvements, whereas system level optimization provides a larger opportunity for capturing additional energy savings.

One manufacturer said that remaining energy efficiency opportunities are with drives for motors, where the payback without incentives can be six to eight months. The manufacturer estimated that there are over 350 drive incentive programs nationwide, where customers can get $40 to $50 per HP, and the 2013 list of CEE member motor programs indicates there are 50 programs providing ASD (adjustable speed drive) rebates. However, the interviewee stated that the programs are underutilized because customers are not aware of them. This interviewee reported a generous program in Maine that paid for the motor, drive, and installation. However, this interviewee believed that incentives on their own do not address some of the most important barriers, such as risk aversion.

This manufacturer saw risk aversion as an important barrier because decision makers are hesitant to adopt new equipment and practices that could potentially fail and lead to production line down time. This manufacturer believed that one of the more successful programs was in the Northwest, where a group of knowledgeable engineers called circuit riders were hired to consult with customers and facility managers at universities and industrial and commercial buildings. The program targeted a list of users and helped them make motor system energy improvements, guiding them through the process, calculating benefits, and helping to facilitate discussions with

[103] http://www.motorsmatter.org/CEE_MMSprogram_summary_public.xlsx

internal decision makers. Circuit riders can educate both the facilities managers and decision makers that drives are more reliable than they used to be twenty years ago, and that downtime can be minimized by phasing in the new technology during regular maintenance schedules. Another example provided was the Arkansas Energy Office and DOE Energy Assessment Office at University of Arkansas, which holds quarterly meetings with end users about how they can save energy with their industrial process equipment and increase productivity.

Influencing End User Decision Making

One manufacturer said that end users usually purchase a motor upon motor failure at which time federal regulations will automatically mandate the use of high efficiency motors. Although end users have the option to repair instead of replace failed motors, manufacturers indicated this is uncommon. This interviewee reported that on average, small motors were always replaced, and only some large motors, defined as 100 to 200 horsepower, were repaired. Interviewees indicated that while motors can last over twenty years, on average a motor is used for eight years. This is because a twenty-year old motor is less efficient than a newer motor, and a newer motor costs the same or less than what it would take to repair the motor. The manufacturer suggested that a large opportunity exists to encourage early retirement of old inefficient motors with high operational hours. Offering technical assistance to customers can help customers identify these motors and develop the financial justification and reports to help influence decision makers in the organization.

One manufacturer emphasized a need to specifically bridge the gap between procurement decision makers and engineers who maintain and operate the motors. This interviewee emphasized that those with purchasing power are rewarded for saving on first costs, and therefore they select equipment that is not usually the most efficient. This could mean that purchasers disregard situations like high efficiency motors where the purchase price is only about 2% of life cycle costs while operational costs are 98% of lifecycle costs. Like what the interviewee described above, this interviewee also suggested that technical assistance can generate technical reports that plant maintenance and engineering staff could take to procurement staff and high level management to demonstrate the benefits of new motors. Technical assistance could include energy audits, walk-throughs, guidance on utilizing incentives, and calculating financial paybacks.

Service Centers

Although interviewees indicated that the repair of motors is limited to large motors, some interviewees said there may be opportunities to influence the quality and efficiency of these repairs. One interviewee cited the Proven Efficiency Verification (PEV) program,[104] which was established to certify motor service centers that employ best practices for restoring motors to efficient levels. The certification involves baseline testing on the motor, damaging the motor, and then sending the motor back to the service center for repairs, which must return the motor to original performance and efficiency levels. One market actor recommended promoting the expansion and adoption of this program to impact larger motors in the industrial market. The 2013 list of CEE member motor programs indicates there are 10 programs incentivizing motor rewinds utilizing the Green Motors Practice Group initiatives. The service center trade

[104] http://www.advancedenergy.org/programs/proven-efficiency-verification-for-motor-repair

association, EASA (Electrical Service Apparatus Association), is the industry's association for motor repair and supply shops and they list all members on their website.[105]

[105] http://www.easa.com

7. REFRIGERATION MARKET RESULTS

In this chapter, we present findings from our research on the Connecticut commercial and industrial refrigeration market. To explore this market, the research team conducted two tasks. First, we reviewed secondary data sources to develop a high-level understanding of the US refrigeration market. Second, we conducted interviews with manufacturers and distributors working within Connecticut to better understand characteristics of the refrigeration market in the state.

Findings from these tasks reveal the complexity of the refrigeration market and suggest that the refrigeration market is primarily *regional* in structure. Market actors, from manufacturers to distributors to end-use customers, tend to specialize is sub-market sectors. Examples include supermarket refrigeration, restaurants and retail refrigeration, and large industrial refrigeration. As a result, interviews with manufacturers and distributors tended to focus on the single sub-market sector they were most familiar with. In addition, most manufacturing and distribution occurs at either a regional or national level; few market actors are dedicated only to Connecticut. The remainder of this chapter will present these findings, first from the secondary data review and then from the interviews with manufacturers and distributors.

7.1 Secondary Data Review

This first section provides a review of secondary data sources relating to the nonresidential market prior to interviewing market actors. The purpose of the secondary data review was to develop a high-level understanding of the refrigeration market to inform subsequent primary research tasks. In particular, the research team sought to address the following questions:

- What is the size of the overall nonresidential refrigeration market in Connecticut?
- What portion of the overall CT nonresidential refrigeration market is considered “energy efficient”?
- What is the path this equipment takes from manufacturing to end user?
- Who are the market actors in the refrigeration supply chain?
- What are the natural groupings for equipment types within each end use category?
- What types of data are missing from the secondary data sources?[106]

The research team completed the secondary data review during August and September 2014. This review focused on the following three reports available at that time:

1. Commercial Refrigeration Equipment: Industry Study #3159, Freedonia Group (May 2014)[107]
2. Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Navigant Consulting, Inc. (September 2009)[108]

[106] The original study plan included designing contractor surveys that would include inquiry for these market actors’ perspective on the size and operation of the market, how they interacted with customers with regard to the equipment and energy efficiency and to fill gaps from the earlier research tasks. This would have then been followed by C&I customer surveys. These latter activities were cancelled and this report is the final wrap-up report for this study.
[107] Purchased from http://www.freedoniagroup.com/industry-study/3159/commercial-refrigeration-equipment.htm

3. Buildings Energy Data Book, available online, U.S. Department of Energy (accessed August, 2014)[109]

All of these reports are nationally focused. Sources of data for the Freedonia report (the first source in the list above) included government publications, trade associations, industry participants, and online databases.[110] The report from Navigant Consulting sponsored by the U.S. Department of Energy, includes references from additional Freedonia Group studies. The third resource reviewed by the research team was the Buildings Energy Data Book, available online, that provides market technology categories and descriptions. It is important to consider that these reports rely on data collected at least a year prior to publication, and may not necessarily represent the 2015 market; however, they provide a recent baseline for comparison.

The remainder of this section presents the findings from this secondary data review. It presents results on the following topics:

- Nonresidential refrigeration market structure,
- Refrigeration categories,
- Size of the nonresidential refrigeration market, and
- Data gaps.

Nonresidential Refrigeration Market Structure

Understanding the market structure and key market actors is necessary for determining where to best intervene in the supply chain. This section summarizes data as it relates to how the nonresidential refrigeration market is structured. It first describes the supply chain – that is, how products make their way from the manufacturer to the customer. It then identifies key market actors working within the nonresidential refrigeration market.

Supply Chain

The nonresidential refrigeration supply chain generally flows from manufacturers, to distributers, and then to end-users. Characteristics of the supply chain are similar across most nonresidential refrigeration product categories. In the supply chain, distributors play an important role providing refrigeration equipment to a wide variety of end users. These independent distributors often carry multiple brands of equipment. In most cases, it is much easier for manufacturers to sell to a distributor who is capable of large bulk purchases than to the end-user. However, large-scale refrigeration sales to industrial customers or supermarket/restaurant chains may be completed directly from the manufacturer to the end-user.[111]

Key Market Actors in the Supply Chain

The nonresidential refrigeration market comprises a large number of active manufacturers, with a greater proportion of these firms focusing on the commercial sector. According to Freedonia,

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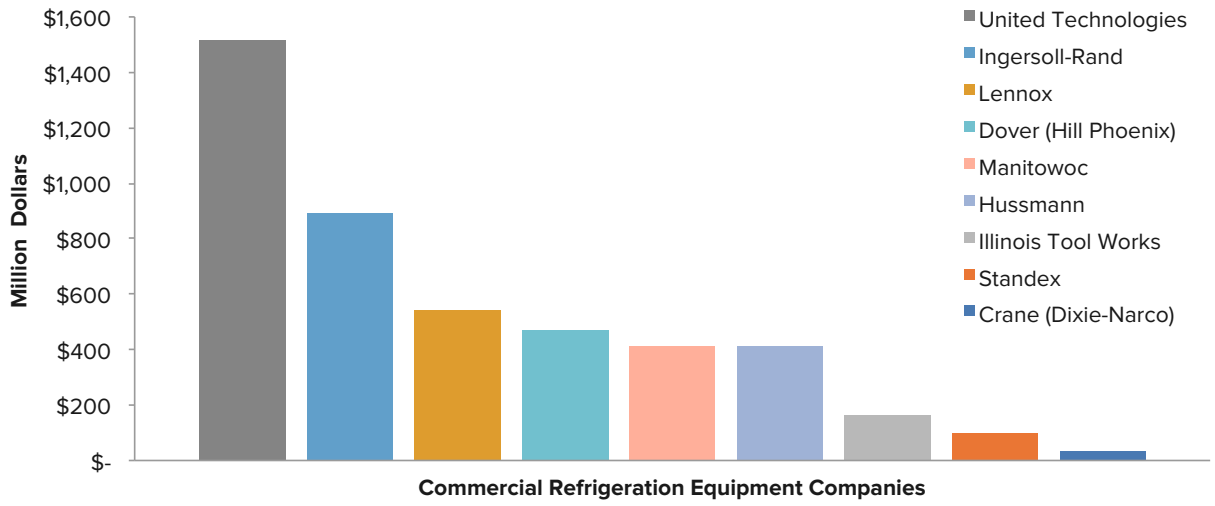
[108] Available at http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/commercial_refrig_report_10-09.pdf
[109] Available at http://buildingsdatabook.eren.doe.gov/Glossary.aspx#cr
[110] The Freedonia report focused primarily on commercial refrigeration equipment, not industrial equipment. However, in some cases the lines between what is considered commercial and what is considered industrial were not well defined.
[111] Freedonia Group, *Industry Study #3159* (May 2014), p. 134.

over 100 individual firms manufacture nonresidential refrigeration equipment for the US market.[112] Despite the number of individual firms in the market, there are only a few large manufacturers. Many of these larger firms also provide HVAC equipment or *residential* refrigeration equipment, and in many cases, nonresidential refrigeration is typically subsumed by the HVAC industry work from these companies.

Figure 7-1 below illustrates the largest refrigeration equipment companies in the US according to domestic refrigeration sales in 2013.[113] Two firms, United Technologies and Ingersoll-Rand, accounted for 26% of all US commercial refrigeration sales in 2013. However, it should be noted that both of these companies manufacture refrigerated transport systems as a substantial portion of their business; the proportion of their business attributed to transport was not specified by Freedonia.

Figure 7-1: Sales of Top Nine U.S. Commercial Refrigeration Equipment Companies



Adapted from Freedonia Group, Commercial Refrigeration Equipment: Industry Study #3159 (May 2014).

Refrigeration Categories

Understanding the key technologies that make up the refrigeration market is essential for determining how to focus energy efficiency strategies and program design. To help maintain consistency in classifying refrigeration products into categories, the research team elected to use the same six major technological categories used by the US Department of Energy for refrigeration.[114] As shown in Table 7-1, the categories are limited to commercial refrigeration applications, including: supermarket refrigeration, walk-ins, reach-ins, refrigerated vending machines, ice machines, and beverage merchandisers/refrigeration. Note that the secondary data focused on commercial refrigeration applications and did not include industrial equipment.

[112] Freedonia Group, *Industry Study #3159* (May 2014) p. 127.
[113] Commercial refrigeration equipment sales figures include refrigerated transport systems.
[114] Available at: http://buildingsdatabook.eren.doe.gov/Glossary.aspx#cr

Table 7-1: Commercial Refrigeration Technology Categories

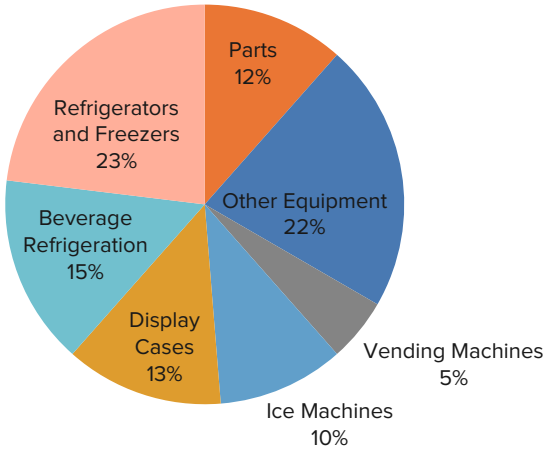
Technology	Definition
Supermarket Refrigeration	The complete supermarket refrigeration system including display cases, compressor racks, condensers, and walk-ins.
Walk-Ins	A refrigeration or freezer unit (within a building) that is large enough to walk into.
Reach-Ins	Upright, self-contained refrigerated cases with solid or glass doors whose purpose is to hold frozen and/or refrigerated food products.
Refrigerated Vending Machines	Upright, refrigerated cases whose purpose is to hold cold beverages and/or food products and vend them in exchange for currency or tokens.
Ice Machines	Machines used to provide a variety of ice types used in the food service, food preservation, hotel, and healthcare industries.
Beverage Merchandisers/Refrigeration	Self-contained, upright, refrigerated cabinets that are designed to hold and/or display refrigerated beverage items for purchase without an automatic vending feature.

Source: U.S. Department of Energy, Buildings Energy Data Book.

Size of the Nonresidential Refrigeration Market

A review of secondary data provided an estimate of the overall size of the commercial refrigeration market in the U.S. According to the Freedonia report, sales in the commercial refrigeration market in 2013 alone were more than $7 billion, excluding refrigerated transport systems.[115] Major categories of commercial refrigeration, as illustrated in Figure 7-2, include refrigerators and freezers, beverage refrigeration, display cases, ice machines, vending machines, parts, and "other" equipment. The "other" category includes cryogenic equipment and liquid chillers, as well as smaller refrigeration products like compressor racks, dairy coolers, and egg refrigerators.

Figure 7-2: Relative Demand by Commercial Equipment Category in 2013 (Total = $7.1B)

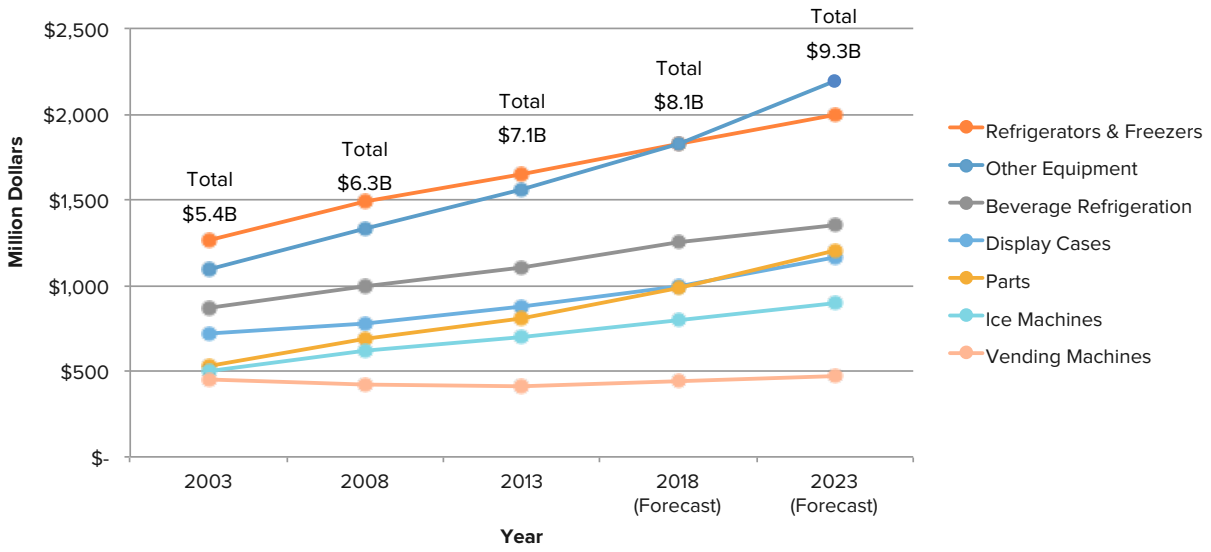


Source: Adapted from Freedonia Group, Commercial Refrigeration Equipment: Industry Study #3159 (May 2014).
Note. The "Other Equipment" category includes cryogenic equipment and liquid chillers, as well as smaller refrigeration products like compressor racks, dairy coolers, and egg refrigerators.

[115] The Freedonia report focused primarily on commercial refrigeration equipment, not industrial equipment. However, in some cases the lines between what is considered commercial and what is considered industrial were not well defined.

As shown in Figure 7-3, demand for commercial refrigeration equipment increased by 2.7% annually over a 10-year period, from $5.4 billion in 2003 to just over $7 billion in 2013. The commercial refrigeration market is expected to continue growing at the same pace and increase to $9.2 billion by 2023. Among all categories within the commercial refrigeration segment, refrigeration parts are projected to increase the most, at a rate of 4.1% annually through 2018. This expected growth in sales is due to users opting to repair existing equipment in order to avoid the rising costs of new replacement commercial equipment. The "other" category of refrigeration equipment should also see a relatively large (3.2%) increase in sales annually. Sales of beverage refrigeration, display cases, and ice machine equipment are all expected see an annual increase of 2.6% to 2.7%. Future demand for refrigerators and freezers is expected to be more modest, at 2% annually, due to the substantial availability of used equipment on the market. Similarly, vending machines are estimated to only increase at a modest (1.4%) rate through 2018.

Figure 7-3: Projections of Commercial Refrigeration Demand in the United States to 2023



Source: Adapted from Freedonia Group, Commercial Refrigeration Equipment: Industry Study #3159 (May 2014).
Note. The "Other Equipment" category includes cryogenic equipment and liquid chillers, as well as smaller refrigeration products like compressor racks, dairy coolers, and egg refrigerators. Totals for each year are shown in billions ($B).

Prevalence of Energy Efficiency in the Commercial Refrigeration Market

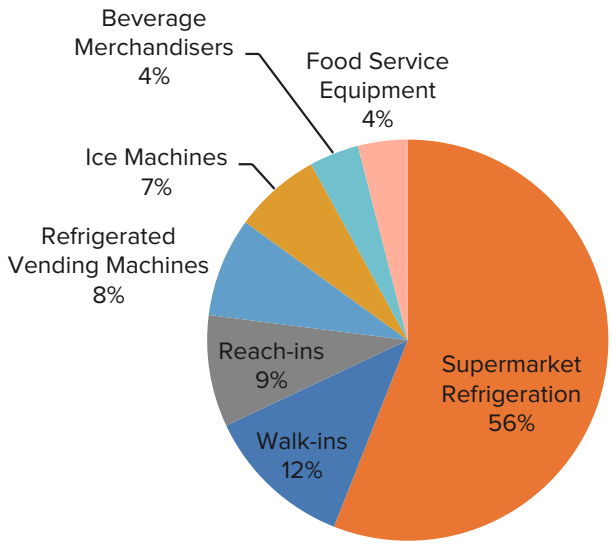
Despite the difficulty estimating the overall portion of energy efficient units in the commercial refrigeration market, there are signs that efficiency improvements will likely continue. Federal energy requirements have become increasingly stringent over the last few years, which have helped to drive efficiency improvements in a number of equipment categories. In addition, in early 2014, the DOE published updated rules for energy conservation standards of commercial refrigeration equipment.[116] Freedonia estimated that when the new standards take effect, refrigerators will become 40-65% more efficient and commercial freezers will become 40-86%

[116] Available at: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/52#standards

more efficient, depending on equipment class and size.[117] These rules are set to take effect in March of 2017.

As shown in Figure 7-4, the supermarket category accounts for more than half (56%) of the total energy consumed by all nonresidential refrigeration applications. Product categories within supermarket refrigeration include compressor racks, display cases, condensers, and supermarket walk-ins.

Figure 7-4: Annual Primary Energy Usage of Commercial Refrigeration in the US by Equipment Type



Source: Energy Savings Potential and R&D Opportunities for Commercial Refrigeration, Navigant Consulting, Inc. (September 2009).

Data Gaps from Secondary Data Review

The reports reviewed for this study offered a great deal of information relating to national trends. However, these reports did not provide any specific information relating to the Northeast region or Connecticut specifically. To address these data gaps, the research team interviewed market actors active in the Connecticut nonresidential refrigeration market in 2014. Results of these interviews are presented in the following section.

7.2 Interview Findings

This section provides results from in-depth telephone interviews with five active commercial refrigeration distributors and manufacturers who serve Connecticut. We contacted a variety of market actors, but were only able to complete interviews with those who interface with the commercial food service refrigeration market. We initially had targeted 10 completed interviews, but given the difficulty in reaching these market actors, and the abbreviated timeline of this study,

[117] Freedonia Group, Industry Study #3159 (May 2014), p. 35.

we were only able to complete 5 interviews. Specifically, the research team spoke with the following market actors:

- **Two Wholesale Restaurant Distributors** – Both interviews were with independent family-owned wholesale restaurant equipment distributors that sell to Connecticut and elsewhere.
- **One Refrigeration Equipment Manufacturer** – The manufacturer is a provider of commercial refrigeration equipment.
- **One Refrigeration Manufacturer Representative** – The Massachusetts-based company represents different manufacturers of restaurant equipment across the entire New England region.[118]
- **One Supermarket Service and Equipment Distributor** – The interview was with a representative of a supermarket services and commercial equipment supplier throughout the New England region.

The remainder of this section presents feedback the research team collected from interviewees on the following topics:

- **Commercial and industrial refrigeration market structure** – This section includes descriptions of the structure of the supply chain, key market actors, and the relationships between market actors.
- **Refrigeration product categories and customer segments** – This section discusses the types of refrigeration products sold today and the mix of customer segments utilizing these refrigeration products.
- **Size of the commercial refrigeration market** – In this section, we present the information obtained regarding the size of the refrigeration market in Connecticut and the amount of energy efficient technology sold to commercial and industrial customers.
- **Marketing energy efficient refrigeration** – This section includes insight from interviewees on effective means to market energy efficient refrigeration products to commercial and industrial customers in Connecticut.
- **Other emergent findings** – Here, we discuss other emergent findings that arose during the interviews.

Nonresidential Refrigeration Market Structure

This section presents an illustration of how the supply chain is organized. It then details the role each market actor plays in the commercial and industrial refrigeration market.

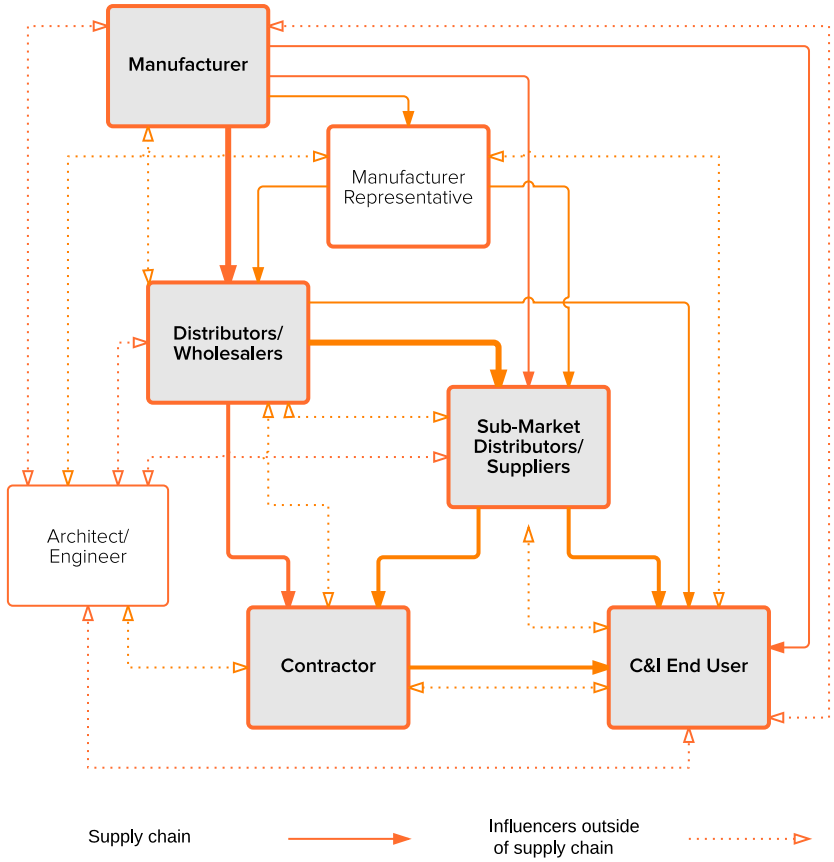
Supply Chain

Overall, the refrigeration supply chain follows a traditional distribution model,[119] with products transferring from manufacturers through distributors to end-use customers. However, with the advent of the Internet and with a more globally connected marketplace, the supply chain relationship has become much more complicated. The level of complexity is dependent upon the end-use customer segment and product application.

[118] New England region includes: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.
[119] In a traditional distribution model, manufacturers supply distributors who ultimately sell to end-use customers.

The dotted lines in Figure 7-5 illustrate that a number of different market actors also play a role in influencing customers' purchasing decisions. Manufacturers, distributors/wholesalers, sub-market distributors/suppliers, contractors, designers, and specifiers all play a role in influencing a customer's purchasing decision. Interview findings suggest that the most influential actor varies based on unique relationships and projects.

Figure 7-5: Refrigeration Market Structure for Commercial and Industrial Applications



Role of Manufacturer

The primary role of the manufacturer is to produce the refrigeration equipment. Manufacturers primary sell equipment to distributors/wholesalers that are able to make large product purchases. Occasionally, manufacturers sell directly to sub-market distributors/suppliers and end-use customers (*e.g.*, chain restaurants, large retailers) who are able to purchase large quantities directly. For large industrial equipment sales, manufacturers work closely with end-use customers, architects, and engineers to develop equipment that meet necessary specifications.

Major Refrigeration Manufacturers:

True
Traulsen
Delfield
Beverage Air
Arctic Air
Hussman
Kaiser-Warren
Arneg
Zero Zone

In some circumstances, manufacturers partner with other manufacturers to provide a full-range of products and services across diverse target segments. For example, products supplied for supermarkets in the retail food service market include everything from display cases, walk-in coolers, and freezers, to the evaporators, condensing units, and racks used to mount them. Interviews with manufacturers revealed that because of non-compete agreements, different manufacturers work together to provide various refrigeration products to the market.

Role of Distributors/Wholesalers

Major Distributors:

United Refrigeration
Johnstone Supply
FW Webb

In the refrigeration market, the distributor/wholesalers act as the primary sales agent for products developed by the major manufacturers. They warehouse products and coordinate distribution and shipping to smaller sub-market distributors/suppliers, contractors, and end use customers. They also work with designers to ensure the desired product mix is available.

Interviews with distributors highlighted that while manufacturers used to have a distributor for every state, the model has changed and most manufacturers sell primarily to larger regional distributors/wholesalers. As a result, the need for local distributors has reduced and refrigeration equipment supply for the foodservice industry is primarily concentrated among just a few large distributors – typically those that can purchase a minimum order amount (*e.g.*, $10 million/annually) or quantities (*e.g.*, 36 pieces) of products from the manufacturer. These larger distributors sell directly through the Internet to end-use customers and contractors, along with supplying products to local sub-market distributors/suppliers through various channels. The local sub-market distributors/suppliers primarily purchase from large distributors rather than manufacturers, and then in turn only sell to end-use customers and contractors.

Another change reported by interviews with sub-market distributors is that the distribution model for profits has changed. Now, the more the distributor sells of a manufacturer's product, the greater the percentage of profit (5-15%) that they get to keep.

"In Connecticut, there used to be only 2-3 major distributors to compete with. Now the Internet has leveled the playing field."

- Restaurant Supply Distributor

Role of Contractor

In the refrigeration market, contractors are the actors who actually install the equipment. For smaller retail and independent restaurants, they often are the intermediary between the customer and the distributor. As such, they can play an influential role in relaying refrigeration information from the distributor and information about energy efficient options back to the customers. For larger retail customers and chain restaurants, decisions about refrigeration may be handled directly by the customer (although a contractor would likely still install the equipment).

Role of End User

The commercial and industrial end users include a broad mix of customers who are the ultimate decision makers for products. The sub-market category they are part of often determines which market actors they will work most closely with. For example, within the food service sector,

restaurant chains mostly buy direct from manufacturers through contracts arranged by chain restaurant corporate representatives, whereas independent restaurants and convenience stores either work with contractors, or in some circumstances directly with distributors. The supermarket sub-market is another example of end-users who may purchase directly from manufacturers. Large industrial customers typically purchase direct from manufacturers because many products need to meet specific custom specifications.

Refrigeration Product Categories and Customer Segments

As the research team investigated the refrigeration market, it became clear that the market is multifaceted, consisting of a combination of *product categories* and *end-use customer segments*. There are often product categories that overlap customer segment groups, but the supply chain for each sub-market group may be very distinct from one another.

To simplify categorizing the broad range of products produced for the refrigeration market, the research team used the technology grouping definitions provided by the US DOE, Building Energy Data Book (detailed in Table 7-1) as a starting point. The following commercial customer segments were developed with additional information gained through interviews with manufacturers and distributors.

- **Supermarkets** – This category consists of both chains and independently owned supermarkets. Technology categories include supermarket refrigeration (including display cases, compressor racks, condensers, and walk-ins) and refrigerated vending machines.
- **Restaurants** – This category includes both chains and independently owned commercial restaurants. Technology categories include: walk-ins, reach-ins, ice machines, and beverage merchandise refrigeration.
- **Small Retail** – This category mostly consists of small businesses like liquor stores, convenience stores, flower shops, gas stations, etc. Technology categories for this segment include: walk-ins, reach-ins, ice machines, and beverage merchandise refrigeration.
- **Large Retail** – These customers include bulk membership businesses (e.g., Costco, Sam's Club) that have many systems similar to supermarkets, but on a larger scale. Technology categories for this segment include: supermarket refrigeration, walk-ins, reach-ins, ice machines, beverage merchandise refrigeration, and refrigerated vending machines.
- **Hotels** – Customers in the hotel industry are unique because they have not only restaurant refrigeration equipment, but also ice and refrigerated vending machines.
- **School & Hospital Kitchens** – This category includes customers who have facilities as complex as large hotels or as simple as small independent restaurants. Typical products include: walk-ins (occasionally), reach-ins, ice machines, beverage merchandise refrigeration, and refrigerated vending machines.

Size of the Commercial Refrigeration Market

Two of the primary objectives for conducting the interviews were to better understand the size of the commercial refrigeration market in Connecticut and to identify the prevalence of energy efficiency within the market. This section summarizes the limited information interviewees could

provide on the overall size of the market. It then presents findings on how interviewees defined energy efficiency and addresses the prevalence of energy efficiency in commercial refrigeration. The research team did not speak with anyone that was knowledgeable about industrial refrigeration.

Market Size in Connecticut

Interviewees commented that they had limited visibility into the size of the total refrigeration market. This was especially true when asking solely about the market size in Connecticut. This is the result of two factors: (1) most distributors and manufacturers focus on a specific commercial sub-market (*e.g.*, supermarket refrigeration), and (2) sales tracking and distribution is not driven and conducted at a state-level.

Among the five interviewees with whom the research team spoke, only one wholesale restaurant distributor provided an estimate of the commercial refrigeration market size in Connecticut – estimating that it is at least $100 million annually. The other four interviewees had limited knowledge of the total market size in either Connecticut or regionally.

Prevalence of Energy Efficient Refrigeration in Connecticut

Interviews with refrigeration market distributors and manufacturers provided insight into how energy efficient equipment is defined. For much of the market, energy efficiency is defined by ENERGY STAR ratings. Unofficially though, interviewees also included any refrigeration product that has similar efficiency ratings, even if not ENERGY STAR approved. Distributors commented that because it is very expensive for manufacturers to get products ENERGY STAR rated/approved, some dedicate only a selection of models or a line of models to meet that rating, even though the output and energy performance of the other models developed may be just shy of meeting specifications.

Neither of the distributors interviewed were able to provide estimates of energy efficiency across the entire commercial refrigeration market in Connecticut, but they did comment that among the largest manufacturers it is likely that most, if not all, models – even those not ENERGY STAR rated/approved – would qualify if submitted for formal testing. The distributor selling in the supermarket sector reported that 95% of supermarket refrigeration products sold in Connecticut and the Northeast are energy efficient. On the other hand, one restaurant supply distributor estimated that only 5% of restaurant equipment in Connecticut is energy efficient.

Interestingly, the manufacturers that we spoke with reported a much lower rate of refrigeration products sold that are energy efficient. The one manufacturer interviewed reported that of total sales, approximately 60% of refrigeration products are energy efficient, and that the remaining 40% of products would be considered standard efficiency. The manufacturer representative, who sells refrigeration products from a broad variety of manufactures, estimated that only about 15% of the total refrigeration sales are for energy efficient products. One possible explanation for the variance among respondents is that some manufacturing brands produce a higher percent of energy efficient products. In addition, distributors are typically a licensed distributor for only a few brands, so the extent of efficient products sold will depend on which brand they carry.

Supermarkets are a refrigeration sub-market that is currently investing heavily in energy efficiency. The manufacturer interviewed explained that supermarkets are one customer

segment that is actively looking for any way to save money. This is because the majority of the energy usage at supermarkets can be attributed to the refrigeration system, and because supermarket profit margins are traditionally low.[120] Any measure that will help them save on costs over the long run are looked at and reviewed seriously.

> "Supermarkets are willing to spend a little more money up front to save more later."
>
> - Manufacturer

Marketing Energy Efficient Refrigeration to Connecticut Nonresidential Customers

Another objective of the interviews with distributors and manufacturers was to better understand the most effective channels to market energy efficiency in refrigeration products. Perspectives on the importance of marketing energy efficiency varied across interviewees. One of the primary channels for marketing reported by interviewees was through industry magazines and trade publications. The reason offered is that it is difficult to reach the right end use customer directly, so they have to go through the various sub-market trade associations. They also reported that trade shows used to be an effective avenue for marketing, but in recent years, they have not experienced a good return on investment. Instead, manufacturers and distributors claim that focusing on visiting dealers and end-users is a much more effective approach. Another avenue that is used and extremely cost effective is through manufacturer emails to distributors and end-use customers. One interviewee also offered the suggestion that any energy efficient marketing for refrigeration provided by utilities should focus on educating the end-user (often restaurant and retail customers) to increase demand of energy efficient products.

Other Emergent Findings

In addition to addressing the primary research objectives, interviewees also provided insight into a variety of other aspects of the refrigeration market, including: customer purchase decisions, customer project types, training, impact of rebates, and financing energy efficient replacements.

Customer Purchase Decisions

According to interviewees, customers in food service portion of the market face two key challenges for investing in energy efficient products: *product availability* and *price*. First, product availability is a key concern because any downtime due to replacing inoperative equipment can be extremely costly to the business. Because demand for immediate repairs/replacement is so high, the product available through the distributor today takes precedent over the product that is more energy efficient and not immediately available.

Second, when critical equipment needs to be replaced immediately, resulting in thousands of dollars of unexpected costs, the long-term cost of ownership (efficiency) concerns are often out-weighed by upfront cost. Adding to that, interviewees reported that restaurant owners typically fall into two categories: customers who want high quality efficient products and are willing to pay

[120] While interviewees did not specifically mention low profit margins for supermarkets, it is an important aspect of the context for this market. For example, see http://www.marketplace.org/topics/business/groceries-low-margin-business-still-highly-desirable/.

for it if available, and customers who just want the least expensive products available now regardless of long-term costs. The more price sensitive the customer, the greater the likelihood that the less expensive product available now will be purchased.

Customer Project Types

Interviews with distributors revealed that there are two primary project types driving purchases of refrigeration equipment: *new construction projects* and *retrofit/ replacement projects.* For new construction projects, equipment required is almost completely based on architect specs and not through recommendations from the distributors. Among retrofit/ replacement projects, decisions for purchase by contractors and nonresidential customers are primarily determined by what is in stock at the distributor. As a result of this factor, one distributor reported trying to always stock two or three selections for customers in each product category, including an energy-efficient option, but customers will be limited to just those without a special order being placed.

Training

There are a broad range of education and trainings provided for contractors and nonresidential customers. The manufacturing representative commented that they recently built an extensive showroom and innovation center for trainings. This includes an operating refrigeration system in the training center that allows customers hands-on interaction with the products. In addition, they keep a training manager on staff who manages training initiatives and travels for onsite training at customer locations. Training is offered by both manufacturers and wholesaler distributors.

Impact of Rebates

Interviewees reported that energy efficient rebates are very important in the decision-making process. One distributor reported that the availability of rebates for energy efficient models is one of the first questions that they are asked by end use customers. Another distributor reported that the incentive rebate program in Connecticut has been beneficial, despite having a limited qualified products list, and helps to steer more restaurant customers to purchase energy-efficient models. One point of contention discussed is that there are not incentives offered for distributors who promote products that will help utilities and their programs. The focus for distributors instead is on promoting products that will help their own business and customer needs at the time. Therefore, distributors will only focus on promoting energy-efficient products when there is a clear business reason.

Financing Energy Efficient Replacements

Financing was also reported as a strategy that could be an effective approach to increasing energy efficient purchases. Interviewees reported that low-interest loans are already being utilized by smaller independent stores, but that there is limited need or interest among chains that have greater access to capital.

8. LESSONS LEARNED FOR FUTURE SIMILAR RESEARCH

This chapter includes a summary of methodological challenges the research team encountered in conducting this study. It includes a description of the key barriers we encountered as well as solutions we identified to overcome these barriers. These solutions may be valuable in the future if similar research is conducted. These challenges are organized by data source below.

8.1 Customer Data

The research team had to make some compromises in quantifying customers' energy use by end-use category. This task was conducted in order to prioritize end-use categories for further research. One approach would have been to assume the same distribution of energy use by end use as documented in the Commercial Building Energy Consumption Survey (CBECS)[121] and Manufacturing Energy Consumption Survey (MECS)[122] data across all facility types.[123] However, that would not account for the possibility that Connecticut C&I customers may have different characteristics and thus different energy usage patterns compared to the average facility. To account for this, as described in Chapter 3, we mapped commercial business type data (*i.e.*, NAICS) contained in the billing data to building types contained in the CBECS data.[124] This mapping was relatively straightforward, but did result in a small percentage of business types that could not be confidently matched to a single building type. We then matched this to electricity consumption by end-use based on building type in CBECS and MECS. For electric customer data, only Connecticut Light & Power (CL&P, recently a part of Eversource) billing data contained NAICS; our solution was to use CL&P data only, since it represented the majority of Connecticut (CT) electric customers.[125]

The customer billing data provided by the utilities did not always contain valid peak demand data, so the research team was unable to use peak demand for sampling purposes. While this research was cancelled prior to conducting customer surveys, we did begin to develop a sample frame and stratification plan. As part of this, we examined energy and demand usage in order to stratify survey targets by size (*e.g.*, small commercial vs. large commercial). As small business programs are defined by demand usage, we wanted to define the population of small commercial customers using the same criteria. However, of 56,757 unique electric customers, 1,221 were missing kW, 4,143 had a kW value of zero, and 1 had a negative kW value. Overall, nine percent of electric customers did not have valid kW data available in the billing data. For this reason, as described in Chapter 3, we used kWh instead to classify small vs. large commercial customers.

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[121] http://www.eia.gov/consumption/commercial/
[122] http://www.eia.gov/consumption/manufacturing/
[123] CBECS and MECS data are broken out by region. However, out of over 5,000 CBECS records, only 217 are from buildings located in the New England region. Of over 5,000 MECS records, only 302 are from the New England region. Although we could have assumed the same distribution of energy use by end use for New England buildings only, there is risk of inaccuracy with this approach by relying on relatively small sample sizes.
[124] MECS is already organized by NAICS, allowing a one-to-one match with billing data.
[125] Yankee Gas data also contained NAICS, but we completed this analysis before the gas data were sent to us.

8.2 Secondary Data

All except the most recent secondary reports were "out-of-date," especially for quickly moving markets; therefore it was important to collect primary data to understand the current state of the market. Some markets (particularly lighting) are moving so quickly that published reports are quickly out of date. For this reason, the research team found speaking with market actors was particularly valuable to understand the real time information on the market share of energy efficient equipment in Connecticut. As part of this process, it was important to define what is meant by "efficient equipment" in speaking with manufacturers and distributors, as different individuals used different definitions. For example, for the lighting end-use category, we found that 4 of 11 interviewees did not consider standard fluorescent T8s as energy efficient, and two of these also did not consider high efficiency fluorescent T8s (defined as either fluorescent low wattage T8s or fluorescent super T8s) as energy efficient. Because of this issue, we prompted interviewees for data specifically on LEDs, a technology that most market actors agreed is energy efficient.

To obtain data specific to Connecticut, research will need to be conducted with customers and contractors that serve the state. Throughout this research, it was very difficult to obtain market data specific to Connecticut. None of the published secondary data or reports contained state-specific information, and very little information was available specific to the Northeast or New England region. Even manufacturers and distributors had difficulty reporting information specific to Connecticut. The data we obtained were valuable for providing information on national market trends, but state-specific data was challenging to obtain.

8.3 Manufacturer/Distributor Data

In constructing a sample frame for manufacturers and distributors, it was important to select interviewees based on location and influence (*i.e.*, size or market share). One option we considered when constructing the sample frame was to use Dun & Bradstreet (D & B) data.[126] However, these data only allow the user to select contacts physically located in the state, and do not account for businesses that serve Connecticut but may be located out-of-state. For example, distributors often have regional sales offices, so selecting only distributors located in Connecticut would exclude those located in nearby states that may also serve Connecticut. Coupled with the complexity of the end-use markets examined as part of this research, creating a comprehensive sample frame of manufacturers and distributors for the purposes of conducting the in-depth interviews was not practical. For these reasons, as described in Chapter 2, we used a “snowball” sampling technique, beginning with distributors located via ThomasNet and supplemented with referrals and additional online sources.[127] ThomasNet allows the user to search for companies within Connecticut, or to search for companies *serving* Connecticut, which included companies located out of state. It also included phone numbers and additional information such as a list of products and brand names offered. The snowball sampling approach allowed us to assemble a list of influential market actors.

An additional challenge we encountered in conducting interviews with manufacturers and distributors was the inability of many interviewees to provide estimates of market size. This was

[126] http://www.dnb.com/all-products/find-dnb-marketing-solutions.html/; http://www.hoovers.com/
[127] http://www.thomasnet.com/

true on a number of levels. First, as stated previously, many found it difficult to provide estimates specifically for the state of Connecticut, as they often work in multiple, adjacent states. Second, distributors often focus on specific components of the market; for example, refrigeration distributors may focus solely on food service equipment. Thus getting comprehensive information on the market as a whole was very challenging. Conversely, for other end use categories, manufacturers and distributors did not have insight into equipment applications (e.g., motors distributors generally were not aware of the breakdown of motors across different industrial applications). Finally, manufacturers and distributors were generally not able to estimate how equipment sales are broken out by fuel type. For this study, this was problematic for the gas space heating category, as interviewees found it difficult to report on equipment that was specifically designed for use with natural gas, as opposed to electricity or other fuel types.

8.4 Contractor Data

Although the study was cancelled prior to conducting contractor surveys, we did begin the process of constructing a sample frame for the surveys. Defining the population for research with contractors serving CT businesses proved to be a challenging endeavor. As with the manufacturer/distributor data, one option would have been to use D & B data to construct the sample frame. This is a common practice. However, as stated previously, the research team wished to include businesses that serve Connecticut but may be located in another state (to ensure a comprehensive and unbiased population). Thus, we reviewed the state licensure list as a potential data source. Contractors are required to be licensed by the State of Connecticut to perform certain types of mechanical and electrical work; therefore we considered this list to be comprehensive -- a major advantage compared to D & B data.[128] As shown in Table 8-1, for the preliminary sample frame developed using this approach, 17% were located outside of Connecticut (most commonly in Massachusetts, New York, and Rhode Island). A second advantage to using this approach is the ease with which the total contractor population can be quantified for statistical purposes.

However, the primary disadvantage with using this source was that the licensure lists did not contain phone numbers. Furthermore, the list of licensees for electrical and heating/piping/cooling work only included individuals' names and addresses and did not include firm names, making it difficult to match each licensee to a business phone number.[129] Lastly, the licensure lists do not show any indication of firm size. Ideally, this study would target larger contractors as they complete the majority of the work and would have more insight into the market. In the future, this could be resolved by matching the firms with D & B data, which contain information on firm size. We did not complete this step because the study was cancelled prior to finalizing our sample frame for the contractor surveys. One further caveat is that all of the contacts would need to be screened to determine if they conduct work in the specific end use category in which we were interested.

[128] The exception is that the list does not contain contractors that may be operating without a license. See https://www.elicense.ct.gov/.
[129] The major and mechanical contractors contained firm name, so these could more easily be matched to a database such as D & B or YP (http://www.yellowpages.com/) to obtain phone numbers.

Table 8-1: Preliminary Sample Frame for Contractor Surveys by Contractor/License Type, including Portion Located Outside of Connecticut

Contractor/License Type	N	%	n Outside CT	% Outside CT
Major contractors	1,362	8%	693	51%
Mechanical contractors	85	< 1%	10	12%
Electrical licenses (E1 only) [a]	5,241	32%	676	13%
Heating, Piping and Cooling licenses [a]	9,883	60%	1,356	14%
TOTAL	**16,571**	**100%**	**2,735**	**17%**

Note. This table shows the initial sample frame development that the research team completed in anticipation of completing surveys with contractors. As shown, some contractors may be located outside of Connecticut but still work in the state. This project was cancelled prior to fully completing development of the sample frame.
[a] These lists contained only individuals' names and addresses, and did not contain firm names, meaning it would be nearly impossible to match these contacts to a business phone number.

9. KEY FINDINGS & REMAINING QUESTIONS

Initially, this study included not just the secondary data review and market actor interviews, but also surveys with market actors and surveys with customers. Collectively, these tasks were part of a systems approach to this study, whereby data from multiple sources would be combined to form a complete picture of the market. Multiple sources can provide confirmation of findings or identify if there is a difference of expert opinion, suggesting that a finding should be changed or qualified. Because this study only had one source of primary data collection, we were unable to make these comparisons to form a complete picture of the market. Nevertheless, several key findings emerged. This chapter summarizes the key findings that resulted from our market research activities across four end-use equipment categories. This chapter also includes a description of remaining questions that will require further research to fully answer.

9.1 Key Findings

This section includes key findings for each of the four end-use categories: lighting, gas space heating, motors, and refrigeration.

Lighting

The research undertaken for this study showed that the Connecticut nonresidential lighting market is changing quickly. This is largely due to national standards that mandate more energy efficient lighting and the rapid market adoption of LEDs. As a result, market data is quickly becoming out of date and manufacturers and distributors are struggling to define what efficient lighting means today. Key findings for the lighting market are summarized below:

1. **The supply chain for lighting is changing.** Traditionally, a limited number of large lighting manufacturers have dominated the market; however, the growing demand for LEDs has disrupted the traditional supply chain, and new lighting manufacturers are entering the marketplace. As part of this disruption, those manufacturers who are able to offer all three components together may displace those that focus only on lamps, controls, or fixtures.
2. **Lighting designers (e.g., architects and engineers) heavily influence purchasing decisions.** This influence is exacerbated by the fact that customers tend to buy exact replacements of existing lamps. Therefore, whether installed in new construction or a replacement/retrofit, the lighting that is specified by designers heavily influences the lamp type that will be installed for years to come.
3. **Market adoption for LEDs is rapidly increasing.** While the DOE estimates that 42% of commercial sales and 26% of industrial sales will be LED by 2020, *Freedonia forecasted the LED share to reach closer to 65% of nonresidential energy efficient lighting sales nationwide by 2017* (including program and non-program states). **Manufacturers and distributors reported current CT LED sales at roughly 50% of the commercial market.** One interviewee reported that **industrial LED sales may be even higher** given LEDs being used for high and low bay lighting. When asked about sales in CT going forward, these interviewees stated **LED sales would be 60-90% of CT lighting sales by November 2015, and one interviewee stated LEDs would be 100% of C&I lighting sales by 2017.** Once linear LED T8 lamps become more reliable and cost effective for retrofits,

the market share of LEDs may increase dramatically. (Please see the Remaining Questions section below, as the rapid transformation of the C&I lighting market could raise critical questions and require program changes by the end of the 2016-2018 planning period.)

4. **While lamp sales are expected to decline, sales of lighting fixtures are expected to increase**. The Freedonia Group estimated that lamp sales will decline as they expect more efficient lamps (which generally last longer) to be installed over time, thereby decreasing the number of lamps sold in the future. The fixture market, on the other hand, is expected to continue to grow over time as the new construction market is expected to expand in the future.
5. **Interviewees attributed the majority of current LED sales to rebate programs.** Interviewees cited direct relationships between LED sales and rebate levels throughout the country. One interviewee reported that LED sales increased 70% to 80% in Connecticut once utilities began offering LED rebates. Another interviewee reported focusing their sales in areas with the best utility incentives, stating that they have not focused LED sales efforts in Connecticut because the rebates were less than in other states.
6. **Ensuring that incentivized products meet product quality standards is very important.** Customers' first impressions have a great deal of influence on the market adoption of new technologies, and incenting subpar products could lead customers to not try efficient lighting in the future, or to associate poor products with the utilities. Two interviewees expressed concern with LED lamps made in China by reporting that some lamps do not perform to specifications, thereby impacting customers' perceptions of LEDs and undermining utility efforts to support LED products. Utilities, therefore, must ensure that only quality LED lamps that perform to specifications are included in incentive programs. There is an opportunity for utilities to work with national or regional organizations, the EPA, and/or DOE to identify mislabeled products and enforce penalties.
7. **A small proportion of residential incentivized bulbs are likely being sold out of state by a few small businesses (not participants or lighting retailers).** One interviewee described two practices by which bulbs may be leaving the state, and another noted that a lack of coordination between the residential and commercial lighting program incentives may be driving some businesses to purchase residential (program-incented) bulbs from big box retailers rather than purchasing C&I incented bulbs from Connecticut-based mid-market firms.

Gas Space Heating

The nonresidential gas space heating market comprises a wide variety of equipment types. Concurrent with the rising popularity of technologies like heat pumps, some parts of the gas space heating market are changing rapidly. Other parts of the market are changing very slowly, with only minimal improvements in efficiency over the past few decades (*e.g.*, the combustion component of rooftop units). Key findings for the gas space heating market are summarized below:

1. **While some portions of the space heating market are changing rapidly, other portions have not changed substantially in the past few decades.** In some cases, gas heating systems are being replaced by electric heat pumps, including mini-split systems, which have become increasingly popular in recent years. Though sales of warm-air furnaces

are expected to increase in the next five years, the demand for heat pumps is increasing at a much greater rate. Conversely, the average efficiency of the combustion component of most packaged rooftop units has not changed significantly in the last few decades.

2. **The integration of controls provides an opportunity for efficiency gains with gas space heating equipment.** Looking beyond the energy efficiency of the equipment itself, the importance of the control and operation of the equipment emerged as an important concern by interviewees. Interviewees noted that in order for a particular piece of equipment to operate efficiently, it must be operated properly. Well-implemented controls can assist and encourage this process with many C&I customers. The Operations and Maintenance Program currently offers custom incentives for operations and maintenance improvements.
3. **Interviewees generally agreed that utility programs have a great deal of influence on purchase decisions in the nonresidential gas space heating market.** Several interviewees remarked that most end users would not purchase energy efficient equipment without rebates or other incentives. Outside of utility programs, some distributors may focus more attention on differentiating themselves by promoting the convenience, availability, and support services rather than energy efficiency; therefore there is an opportunity to influence distributors to promote efficiency. In addition, interviewees indicated that long-term financing would be helpful in promoting more efficient equipment purchases. However, there was some concern that requiring distributors to perform additional administrative work to process rebate paperwork would negatively impact their business.

Motors

Due to federal mandates, the majority of industrial motors sold will meet maximum energy efficiency levels by 2016 and future energy efficiency opportunities will focus on optimizing existing motors systems. Key findings for the industrial motors market are summarized below:

1. **Major future gains in motor-driven equipment efficiency will come through optimized system design and implementation.** Interviewees believed that nearly all motors sold today could be considered energy efficient based on current standards and policies. Therefore, future opportunities lie in optimizing the efficiency of the system as a whole as it performs mechanical work. Such system-level optimized designs focus on applying the proper type and size of motor, mechanical equipment, and motor controls to deliver only the power required for the application.
2. **Service shops are likely in the best position to influence the efficiency of those motors that are simply being repaired or replaced by industrial customers.** Service shops sell replacement motors for retail and also offer motor repair services such as motor cleaning and rewinding. It is important to ensure that these service shops are employing best practices for restoring motors to efficient levels.
3. **Because motors standards are at maximum efficiency, utility incentives should focus on optimizing motor-driven systems.** This could be accomplished by conducting system-wide audits, providing incentives for systems optimization engineering design, incorporating controls and variable speed drives, optimizing pump or fan sizing, optimizing controls, and performing more in-depth monitoring of energy usage. Additional opportunities include: providing incentives for motor drives, linked to system configuration, promoting early retirement of older motors, and offering technical

assistance to plant managers to demonstrate the benefits of energy efficient motor system to procurement staff.

Refrigeration

Findings indicate that the efficiency of refrigeration equipment in the Connecticut commercial refrigeration market is influenced by the broader availability of efficiency models through regional distribution and access to online purchasing. As a result, improvements in energy efficiency of refrigeration equipment will be impacted most by national efficiency standards requirements, such as ENERGY STAR. Key findings for the refrigeration market are summarized below:

1. **The refrigeration market is concentrated with a few large manufacturers.** The market is large, with over 100 individual firms manufacturing nonresidential equipment in the US market. The research team identified over 60 different distributors, manufacturers, and manufacturer representatives serving Connecticut. However, the market is highly concentrated, as there are only a few large manufacturers that account for a majority of sales, and distributors often carry multiple brands of equipment and operate on a regional scale.
2. **The flow of equipment through the refrigeration supply chain varies based on submarket category (e.g., supermarket, restaurant, retail).** The supply chain for refrigeration equipment varies by end-use customer segment with different product categories for each segment. Commercial refrigeration equipment is organized into six basic customer segments: supermarkets, restaurants, small retail, large retail, hotels, and schools and hospital kitchens. Refrigeration equipment is typically sold by manufacturers to distributors and suppliers, who then sell to end use customers. However, manufacturers will sell directly to end use customers that are able to make bulk purchases of equipment that meet a minimum threshold (*e.g.*, large commercial supermarket and restaurant chains). In addition, distributors' role in the refrigeration market supply chain can range from large wholesalers who sell to smaller distribution warehouses to distribution supply houses that sell directly to contractors, designers, and end use customers.
3. **There will continue to be an opportunity to upgrade standard efficiency refrigeration equipment with models that are more efficient given a market emphasis on repair rather than replacement.** New standards for commercial refrigeration equipment are set to take effect in March of 2017. However, the commercial refrigeration market is expected to see the largest growth in sales of refrigeration *parts* rather than new equipment, as users opt to repair rather than replace existing equipment. The availability of energy efficient products is dependent on the particular manufacturing brands that a distributor/ supplier is licensed to sell, so there may be opportunities to influence the types of equipment that distributors carry, in addition to influencing the decision to replace rather than repair equipment.
4. **Product availability and price are critical factors in customer decisions about upgrades and replacements for refrigeration equipment, especially for restaurants.** First, any downtime due to inoperative equipment can be extremely costly for businesses. In addition, restaurant owners are extremely price sensitive, so reduced upfront costs for replacement equipment typically outweigh the increased long-term cost savings. Increasing the availability of energy efficient equipment options could help to address concerns of immediate replacement needs, and rebates for more efficient models could help to offset the increased costs.

9.2 Remaining Questions

Based on the findings from this study, and also because of the study's reduced scope, the research team identified some remaining questions that are important for the Connecticut utilities and program planners to explore further in order to fully understand C&I customers and how to best target energy efficiency/peak demand programs.

- **Additional research is warranted to verify and track that the market share of LEDs for C&I buildings may be 100%, or close to that, by 2020.** We only completed interviews with one of the three market actor groups originally planned for this study: the lighting manufacturers, manufacturer's representatives, and distributors; we did not complete surveys with contractors/designers or customers, due to the reduced scope of the study. The complete transformation of the C&I lighting market in Connecticut to LEDs could mean there would be no opportunity for obtaining C&I program lighting savings in the last year of the 2016-2018 Plan and none beyond that. Surveys with lighting designers, lighting contractors, and C&I customers should be conducted to determine the proportion of lighting purchases that are currently LED. While current LED sales may be heavily influenced by incentives, as prices come down and retrofit linear LED T8 lamps became more reliable, there will likely to increased adoption even without utility incentives. Due to the importance of C&I lighting savings to the portfolio, the research with contractors/designers and customers is needed to verify or modify this critical information. A critical question to answer is whether the C&I lighting market in CT will be transformed before the completion of the 2016-2018 program cycle.
- **Research is needed to examine opportunities for efficiency gains from motors systems upgrades among industrial customers.** Unfortunately, this study was cancelled prior to collecting any data from contractors or customers that could have provided this information. Future research should examine the types of systems in place, the age of installed motors, and the frequency of motor rewinds. This could help identify the extent to which system-wide audits, controls and/or variable speed drives may be effective, and the industrial customer segments that may benefit most from these services.
- **This research study was originally planned as a comprehensive study to include surveys with contractors, vendors, and C&I customers to understand what are the best leverage points, messages, and strategies for different types of energy efficient equipment, systems, and operation.** The study was cancelled prior to undertaking this primary data collection. That work would have quantified the level of influence that contractors, manufacturer's representatives, distributors, and in-house staff have on equipment purchasing decisions, for different types of equipment. It could be important to know how decision-making varies by type of equipment to customize different program packages for specific C&I customers and to develop marketing messages targeting specific channels or customer situations.

APPENDIX A: SUMMARY OF CUSTOMER BILLING DATA

This research included an analysis of available customer data in preparation for fielding customer surveys. Although the customer surveys were canceled, we have included the results of this analysis here. First is a summary of electric customer data, and this is followed by a summary of gas customer data.

A.1 Summary of Electric Customer Data

Connecticut Light and Power (CL&P) and United Illuminating (UI) provided annual electric customer data to the research team; these data included all C&I accounts in the respective service territories. Because the research team planned to use customer contact information for data collection via telephone survey, our data processing focused on unique customers rather than individual accounts to avoid calling the same individuals more than once.

Connecticut Light and Power (CL&P)

We received both account level and customer level data from CL&P. In the customer level data file, each "customer group" appeared to share a business name and, in most cases, a NAICS segment code. According to CL&P analysts, aggregation was conducted manually. The research team further combined 142 of these groups[1] to avoid duplicate contacts. This process resulted in 56,519 unique CL&P customers, accounting for a total of 12,323,044,203 kWh in annual usage.

United Illuminating (UI)

UI electric customer data included annual usage data at the account level. Data processing involved aggregating usage data across each customer's separate accounts. Using a business partner number provided in the data,[2] the research team identified 21,474 unique customers. Full-year usage data were available for 18,566 of these customers (86%). These customers accounted for 2,700,792,027 kWh in annual usage.

Population of Electric Customers

Of all 77,993 unique electric customers, CL&P customers accounted for 72 percent of the cases (56,519 customers) and 21,474 UI customers made up the remaining 28 percent. Table A-1 summarizes consumption data by customer sector.[3] As described above, full year usage data were unavailable for 2,908 customers. The remaining 75,085 customers for which full-year usage data were available accounted for nearly 15,024 GWh in annual electricity consumption. Overall, median consumption was 19,680 kWh, although this was much higher for industrial customers, at 97,280 kWh.

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[1] Data were aggregated by customer account number, the variable name "CUSTOMER_ACCT".
[2] This variable was labeled "BusinessPartner."
[3] Customer types for CL&P data were identified by a rate code, "rc_cd," For UI data, a variable called "RevenuClass" specified whether customers were Commercial or Industrial. Using these fields, we were able to classify 96% of customers. The remaining 4% are shown as "Unclassified."

Table A-1: Summary of Unique Customer Population: Electricity Consumption by Sector (n = 77,993)

Sector	Usage (kWh)				N	
	Mean	Median	Standard Deviation	Sum	Full-year Available	Incomplete
Commercial	151,123	19,360	1,507,760	10,367,810,555	68,605	2,802
Industrial	1,237,909	97,280	6,626,923	4,220,032,592	3,409	106
Unclassified	141,971	8,500	4,117,693	435,993,082	3,071	0
Total	**200,091**	**19,680**	**2,194,301**	**15,023,836,230**	**75,085**	**2,908**

Note. The research team manually classified some customers based on business name and other indicator variables as available: 14 customers labeled "Citizen" were reclassified as "Commercial"; 116 customer labeled as "Town" were reclassified as "Commercial"; 2 customers labeled as Northeast Utilities were reclassified as "Industrial."

As shown in Figure A-1, the vast majority of customers fall into the commercial category. A small number of customers were not classified as either commercial or industrial in the utility data.

Figure A-1: Unique Electric Customer Population by Sector (n = 77,993)

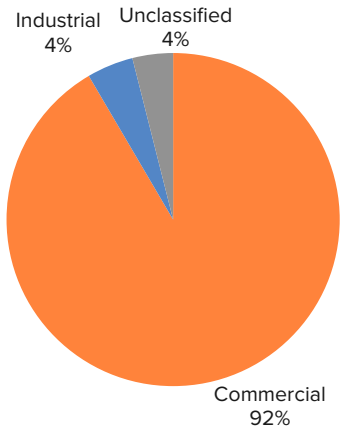
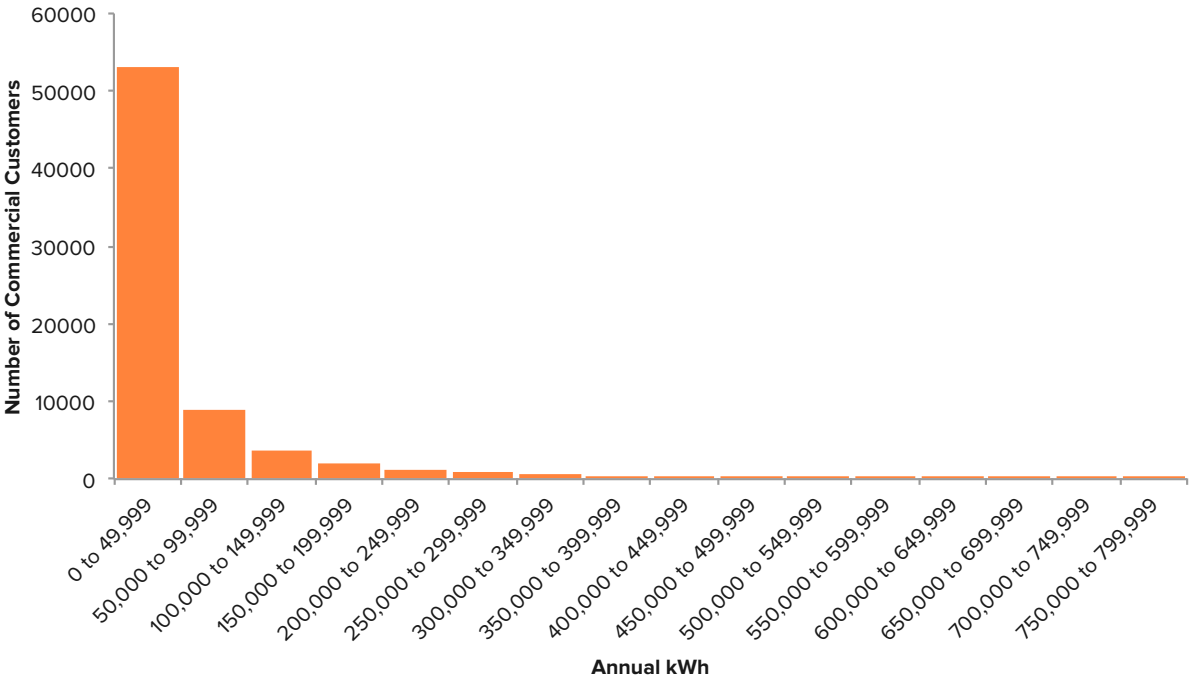


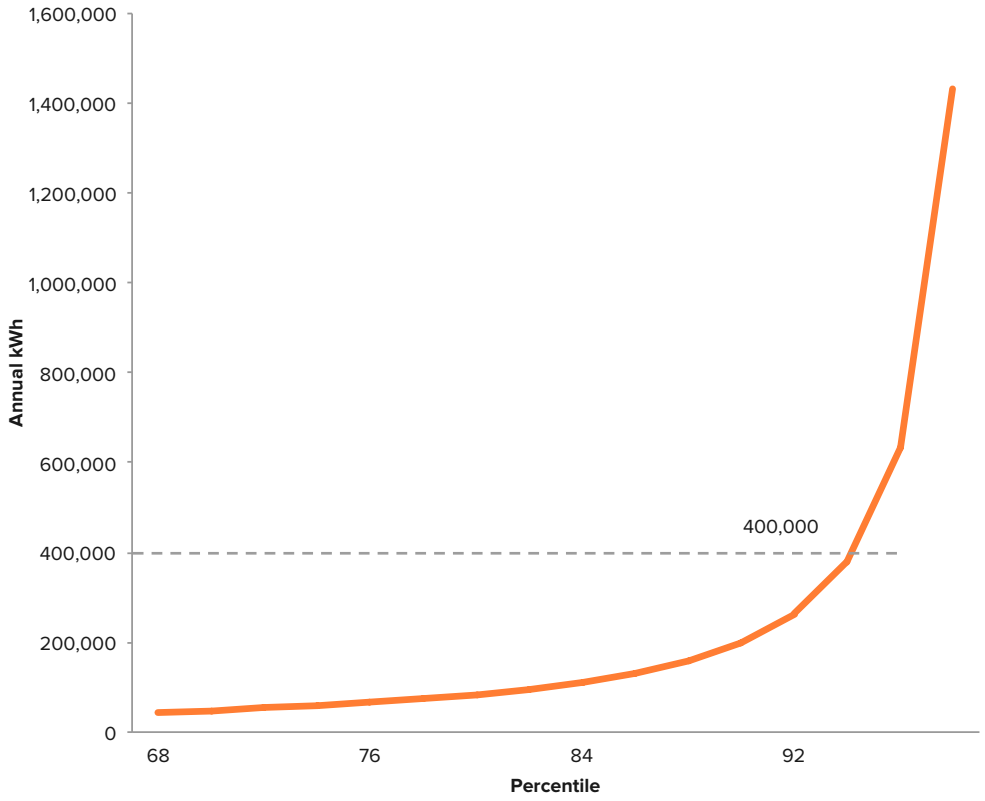
Figure A-2 shows the distribution of electricity consumption. Note that the figure excludes the 2,908 cases for which consumption data were unavailable as well as 4 customers with negative consumption figures. Due to the highly skewed distribution, we only show customers with annual consumption of less than 800,000 kWh (this excludes 2,459 customers).

Figure A-2: Unique Customer Population: Annual kWh Consumption (n = 72,622)



We further examined the distribution of electricity consumption to determine how categories for small commercial and large commercial customers would be defined for purposes of the survey. Figure A-3 shows a portion of the cumulative distribution of electricity consumption. Qualitative assessment of the data suggests a natural division of the data at about 380,000 kWh or the 94th percentile. Above this threshold, consumption varies considerably. The research team chose this natural break point to define customers as either Small or Large based on their annual consumption; however we rounded up to 400,000 kWh to be consistent with the value used by at least two other utilities to determine qualification for small business programs. We defined customers with less than 400,000 kWh annual consumption as Small and those with 400,000 Kwh or higher as Large.

Figure A-3: Cumulative Distribution of Electricity Consumption (kWh)



Using the size categories defined above, we categorized customers into three segments: Small Commercial, Large Commercial, and Industrial/Manufacturing. Table A-2 summarizes consumption data for each type. Note that this analysis excludes 3,071 unclassified customers.

Table A-2: Summary of Consumption by Customer Segment (n = 72,120)

Segment	N	Annual Consumption (kWh)			
		Mean	Median	Standard Deviation	Sum
Small Commercial	65,284	42,543	17,651	63,849	2,777,412,967
Large Commercial	3,321	2,285,576	861,120	6,488,971	7,590,397,588
Industrial/Manufacturing	3,515	1,237,909	97,280	6,626,923	4,220,032,592

A.2 Summary of Natural Gas Customer Data

The research team obtained C&I natural gas customer data from the UIL Holdings Corporation utilities, Connecticut Natural Gas (CNG) and Southern Connecticut Gas (SCG), as well as from Yankee Gas, a Northeast Utilities company. With the exception of a municipal utility, these three utilities represent all C&I gas customers in Connecticut.

UIL Holdings (CNG and SCG)

UIL gas customer data included monthly usage data at the account level. Data processing involved aggregating usage data across the 12 months of the year (November 2011 to October 2012) and across each customer's separate accounts. Using a business partner number,[4] we identified 21,902 unique customers. Full-year usage data were available for 74% of customers, accounting for 399,873,691 CCF in annual usage.

Yankee Gas

Yankee gas customer data included annual usage data at the account level. In reviewing the data, the research team identified and eliminated 9,204 duplicate entries in the provided file.[5] We aggregated usage data to the customer level using a customer identification number.[6] This resulted in 34,022 unique customers, accounting for 1,686,314,977 CCF in annual gas consumption. Full-year usage data were available for all customers.

Population of Gas Customers

Using the customer data provided by UIL and Yankee Gas, the research team identified 55,924 unique customers in Connecticut. Table A-3 shows consumption by sector. Full year usage data were unavailable for 5,506 customers. The remaining 50,418 customers accounted for 2,086,188,668 CCF in annual natural gas consumption. Median consumption was 3,243 CCF, although again, this was higher for industrial customers, at 7,881 CCF. Although the 12 unclassified customers had very high consumption, we could not confidently classify them as either industrial or commercial.

Table A-3: Summary of Unique Customer Population: Gas Consumption by Type (n = 55,954)

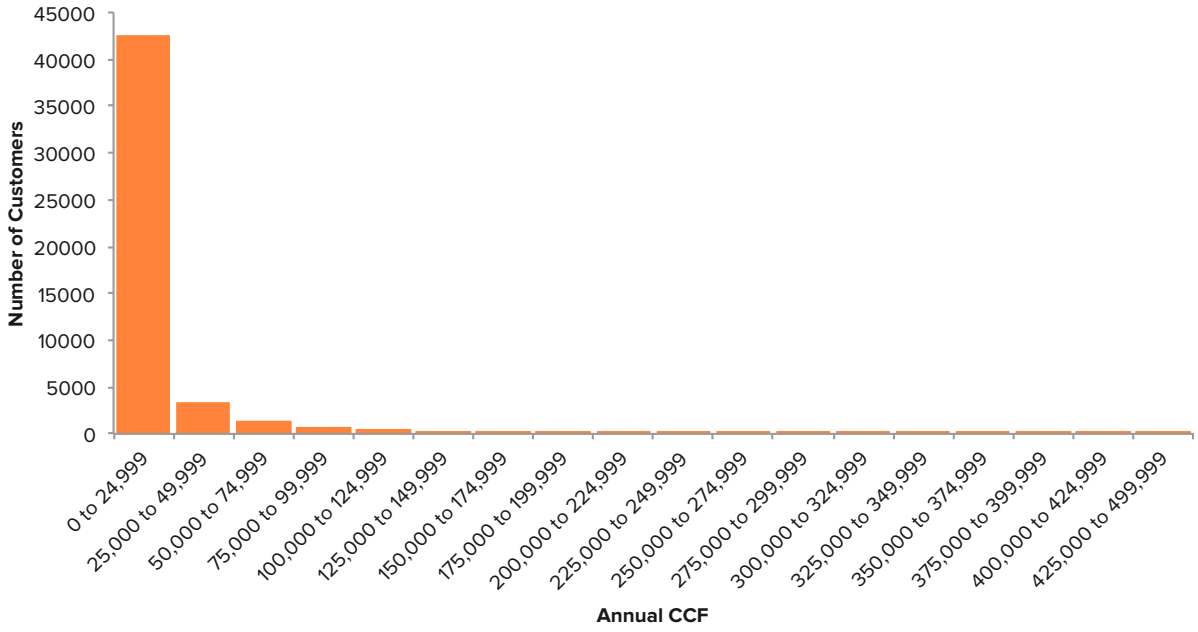
Type	Usage (CCF)				N	
	Mean	Median	Standard Deviation	Sum	Full-year Available	Incomplete
Commercial	25,772	3,034	289,719	1,213,354,787	47,080	5,038
Industrial	239,862	7,881	2,353,554	797,781,692	3,326	468
Unclassified	6,254,349	2,144,093	9,876,082	75,052,189	12	0
Total	**41,378**	**3,243**	**690,641**	**2,086,188,668**	**50,418**	**5,506**

Note. The research team manually classified some customers based on business name and other indicator variables as available: 4 customers labeled "Gas Company Use" were classified as "Industrial"; 23 customers labeled "Northeast Utilities" were classified as "Industrial"; 15 customers identified as "Marketer Services" or "Other Non-service" were left unclassified. (The “Marketer Services” customers were heating oil dealers.)

The distribution of natural gas consumption is shown in Figure A-4. Note that this analysis excludes 499 customers with consumption of 450,000 CCF or more.

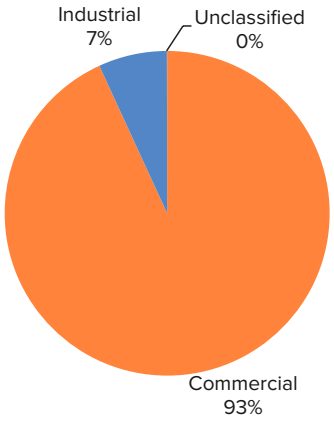
[4] This variable was labeled "BusinessPartner."
[5] In these cases, rows identified as duplicates shared ALL of the following identical fields with another row in the dataset: Customer ID number, account number, service account number, and annual CCF usage total.
[6] The variable "CU_ID."

Figure A-4: Unique Customer Population: Annual Gas Consumption (n = 49,919)



As shown in Figure A-5, the majority of gas customers are commercial customers. Industrial customers represent only 7% of the customer population and a very small portion were not classified.

Figure A-5: Unique Gas Customer Population by Sector (n = 55,954)



APPENDIX B: ADDITIONAL DETAIL ON MOTOR EFFICIENCY

This appendix contains detailed tables showing required efficiency levels for motors set by the National Electrical Manufacturers Association (NEMA). It also contains additional information for a subset of motors not covered by the standards set by NEMA; these were covered by the Energy Independence and Security Act (EISA) of 2007.

B.1 NEMA MG 1 Tables 12-11 and 12-12

According to the Energy Policy Act (EPAct), as amended by the Energy Independence and Security Act of 2007 (EISA 2007, enacted in 2010), integral horsepower motors must meet minimum efficiency levels that range from 74% to 96.2%. These percentages are based on efficiency standards set by NEMA, in a document called "NEMA MG 1 (2006)."[1] Within this document are two tables that list efficiency levels for integral horsepower motors, shown here in Table B-1 and Table B-2.

Table B-1 shows NEMA MG 1 Table 12-11, developed in 1997 and considered the standard efficiency for motors.[2] Table B-2 shows NEMA MG 1 Table 12-12, developed in 2001 and considered premium efficiency. Within both of these tables, NEMA presents a range of efficiency levels based on the horsepower (HP), framing (open or enclosed), and number of poles.

[1] This document is available from NEMA at http://www.nema.org/Standards/Pages/Motors-and-Generators.aspx
[2] Boteler, "A Summary of Motor Efficiency in the United States," Presentation at 2007 Motor Summit (April 2007).

Table B-1: NEMA MG 1, Table 12-11 (Standard Efficiencies)

HP	NOMINAL FULL LOAD EFFICIENCY							
	OPEN FRAME				ENCLOSED FRAME			
	2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	4 POLE	6 POLE	8 POLE
1	N/A	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1 1/2	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0
5	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
7 1/2	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15	89.5	91.0	90.2	89.5	90.2	91.0	90.2	88.5
20	90.2	91.0	91.0	90.2	90.2	91.0	90.2	89.5
25	91.0	91.7	91.7	90.2	91.0	92.4	91.7	89.5
30	91.0	92.4	92.4	91.0	91.0	92.4	91.7	91.0
40	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0
50	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7
60	93.0	93.6	93.6	92.4	93.0	93.6	93.6	91.7
75	93.0	94.1	93.6	93.6	93.0	94.1	93.6	93.0
100	93.0	94.1	94.1	93.6	93.6	94.5	94.1	93.0
125	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150	93.6	95.0	94.5	93.6	94.5	95.0	95.0	93.6
200	94.5	95.0	94.5	93.6	95.0	95.0	95.0	94.1
250	94.5	95.4	95.4	94.5	95.4	95.0	95.0	94.5
300	95.0	95.4	95.4	N/A	95.4	95.4	95.0	N/A
350	95.0	95.4	95.4	N/A	95.4	95.4	95.0	N/A
400	95.4	95.4	N/A	N/A	95.4	95.4	N/A	N/A
450	95.8	95.8	N/A	N/A	95.4	95.4	N/A	N/A
500	95.8	95.8	N/A	N/A	95.4	95.8	N/A	N/A

Source: http://www.marathonelectric.com/docs/MG1EffCharts.pdf

Table B-2: NEMA MG 1, Table 12-12 (Premium Efficiencies)

HP	NOMINAL FULL LOAD EFFICIENCY							
	OPEN FRAME				ENCLOSED FRAME			
	2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	4 POLE	6 POLE	8 POLE
1	77.0	85.5	82.5	N/A	77.0	85.5	82.5	N/A
1 1/2	84.0	86.5	86.5	N/A	84.0	86.5	87.5	N/A
2	85.5	86.5	87.5	N/A	85.5	86.5	88.5	N/A
3	85.5	89.5	88.5	N/A	86.5	89.5	89.5	N/A
5	86.5	89.5	89.5	N/A	88.5	89.5	89.5	N/A
7 1/2	88.5	91.0	90.2	N/A	89.5	91.7	91.0	N/A
10	89.5	91.7	91.7	N/A	90.2	91.7	91.0	N/A
15	90.2	93.0	91.7	N/A	91.0	92.4	91.7	N/A
20	91.0	93.0	92.4	N/A	91.0	93.0	91.7	N/A
25	91.7	93.6	93.0	N/A	91.7	93.6	93.0	N/A
30	91.7	94.1	93.6	N/A	91.7	93.6	93.0	N/A
40	92.4	94.1	94.1	N/A	92.4	94.1	94.1	N/A
50	93.0	94.5	94.1	N/A	93.0	94.5	94.1	N/A
60	93.6	95.0	94.5	N/A	93.6	95.0	94.5	N/A
75	93.6	95.0	94.5	N/A	93.6	95.4	94.5	N/A
100	93.6	95.4	95.0	N/A	94.1	95.4	95.0	N/A
125	94.1	95.4	95.0	N/A	95.0	95.4	95.0	N/A
150	94.1	95.8	95.4	N/A	95.0	95.8	95.8	N/A
200	95.0	95.8	95.4	N/A	95.4	96.2	95.8	N/A
250	95.0	95.8	95.4	N/A	95.8	96.2	95.8	N/A
300	95.4	95.8	95.4	N/A	95.8	96.2	95.8	N/A
350	95.4	95.8	95.4	N/A	95.8	96.2	95.8	N/A
400	95.8	95.8	95.8	N/A	95.8	96.2	95.8	N/A
450	95.8	96.2	96.2	N/A	95.8	96.2	95.8	N/A
500	95.8	96.2	96.2	N/A	95.8	96.2	95.8	N/A

Source: http://www.marathonelectric.com/docs/MG1EffCharts.pdf

B.2 Energy Independence and Security Act Subtype II Motors

The Energy Independence and Security Act (EISA) of 2007 included an additional subset of motors not covered within the NEMA MG 1 Tables 12-11 and 12-12. Subtype II includes motors that are configured in one or more of the following ways:

- Close-coupled pump motor (pump impeller is mounted directly to the motor shaft)
- Footless (defined a flange mounted motor without provisions for feet)
- 8-pole
- Maximum of 600 V and is not rated at:
  - 230 V+/10% or 460 V+/10% (or both)
  - Cannot be operated on 230 or 460 volts (for both)
  - Rated other than 209 (418) through 256 (512) volts (e.g., 575 V)[3]

3 http://www08.abb.com/global/scot/scot234.nsf/veritydisplay/fa66577bfbcd2dfcc1257beb0032b699/$file/PM327_USA_EISA_requirements_EN_revB_2013_lowres.pdf

APPENDIX C: DATA COLLECTION INSTRUMENTS

This appendix contains the in-depth interview guide used to conduct interviews with manufacturers and distributors. It also contains a preliminary topic guide that was developed for the surveys that were originally planned with contractors/designers; these surveys were canceled prior to developing a more thorough interview guide.

C.1 Market Actor Interview Guide

Note: END USE = Lighting, refrigeration, motors (focus on machine drive industrial process applications[1] including compressed air), gas space heating.

Section A: Introduction/Screener

A1. Hello, this is [**NAME**]**.** We are looking to complete interviews on behalf of the state of Connecticut to help them better understand the [**END USE**] industry. This is not a sales call.

A2. Who is the person at your business that is most familiar with sales in the [**END USE**] market?

A3. Would I be able to speak with him/her?
1. Yes [continue]
2. No [Thank and terminate]

A4. My company, EMI Consulting, was hired by the Connecticut Energy Efficiency Board, Northeast Utilities, and United Illuminating to conduct market research. The purpose is to obtain information on the [**END USE**] market for commercial and industrial customers in Connecticut, such as the structure of the market, how it operates, the role and proportion of energy efficient products, and decision-making in this market.

We are interested in asking you some questions about your understanding and perspective of the market for products sold in your industry as it applies to commercial and industrial end users (not residential). The interview will last approximately 45 minutes and for your time and feedback we are offering a $100 Amazon gift card.

A5. Would you be interested in participating?
1. Yes [Continue]
2. No [Thank and terminate]

[1] Machine drive refers to "the direct process end use in which thermal or electric energy is converted into mechanical energy. Machine drive does not include motors that are found in equipment that is wholly contained in another end use" (such as process cooling and refrigeration, process heating, or electrochemical processes).

A6. Do you have time to conduct the interview now?
1. Yes [Skip to B1, start interview]
2. No [Skip to A7, schedule]

A7. Is there a day/ time that would work best for you?

Section B: Firmographics

First, I have just a couple of questions about your firm. Please note that I will keep your individual responses anonymous.

B1. How would you classify your company's primary business activity?

B2. What is your role in the company?

B3. Is your firm independent or part of a national organization?

- What proportion of your sales of [END USE] are to Connecticut businesses?

Section C: Product Categories and Applications

Now I'm going to ask you about the different types of product categories and applications.

C1. What are the major categories for products in the commercial and industrial [**END USE**] market? What are the key products within each of the categories? [**IF NEEDED:** "Categories" refers to how you would group together different products based on common features or criteria (e.g., technology, size, energy consumption).]

C2. What are the major applications for commercial and industrial [**END USE**] customers? What are the key products in each of the applications? [**IF NEEDED:** "Applications" refers to how products are used by customers.]

C3. What are the key end-use customer segments for **the** [**END USE**] market? What would you estimate is the proportion of the market each customer segment represents? [**IF NEEDED**: "Customer segments" refer to categories of different types of customers who purchase and use [**END USE**] products.]

Section D: Market Actors

Now I have some questions about the supply chain for the [**END USE**] market. If possible, I would like you to focus your responses on the market in the state of Connecticut, particularly as it applies to commercial and industrial customers. (*Periodically remind the respondent of this request*).

D1. How is the supply chain structured?

- How does equipment get from the manufacturer to the end use customer?
- Who are the key actors in the [**END USE**] market -- such as manufacturers, distributors, suppliers, retailers, contractors?
- Is it different across the different types of products mentioned previously?

D2. How does your company interact with the various actors?

D3. Who are the major distributors & suppliers for this [**END USE**] market?

D4. Are there many manufacturers who make this type of product or only a few?

- Who are the most significant manufacturers?
- Do you have a manufacturing representative or contact that you could refer me to?

D5. Are there any contractors or retailers that are highly active in the commercial and industrial sector that you would recommend we talk to?

D6. [**Distributors:**] Who are your primary customers? [OR: Who do you typically sell to?] What percentage of your business (in terms of sales) goes to each of those groups?

- OEMs? To retailers? To contractors/installers? Engineers/designers? To commercial/industrial end users? Other market actors? (Specify _____)

D7. [**Manufacturers:**] What percentage of your sales goes to distributors? To OEMs? To retailers? To contractors/installers? To commercial/industrial end users? Other market actors? (Specify _____)

Section E: Market Size

The rest of my questions are about the size of the [**END USE**] market.

E1. What would you estimate is the overall annual volume/size of the commercial and industrial [**END USE**] market in Connecticut (Probe for $ and units)?

E2. What percent of your firm's total business would you estimate is accounted for by products in the [**END USE**] market?

- What percent of your firms' [**END USE**] sales are within the state of Connecticut?
- For your firm, how are sales in the [**END USE**] market divided by percentage into the major product categories (reference categories mentioned in Section C)?
- For your firm, how is volume (units sold) divided by percentage into the major product categories?

E3. [**FOR GAS SPACE HEATING ONLY**] Of the boilers you sell that are installed in industrial facilities, what percentage would you estimate are used for space heating (vs. other process uses)? In *commercial* facilities?

E4. I want to understand what portion of [**END USE**] technologies you sell are energy efficient. Thinking about the… (INSERT CATEGORY - e.g., linear lighting, small commercial freezers, etc.) products you sell, what proportion are energy efficient, using the following definition…"

[Ask only the questions below that apply to the appropriate end use.]

LIGHTING:

- Linear lighting: reduced wattage T8s, high performance T8s, T5s, linear LEDs
- Non-linear: CFL bulbs, LED bulbs, induction lighting, HID

REFRIGERATION:

- Residential-style refrigerators and freezers that may be used in offices and small businesses: ENERGY STAR
- Small commercial ice machines, refrigerators, and freezers: ENERGY STAR[2]

MOTORS:

- NEMA Premium motors (mandatory as of Dec 2010)
- Adjustable/variable speed drives

GAS SPACE HEATING:

- Boilers: At least 90% thermal efficiency/AFUE
- Furnaces: At least 90% thermal efficiency/AFUE

E5. **(FOR ANY CATEGORIES OR PRODUCTS THAT WE DO NOT HAVE GOOD ENERGY EFFICIENCY DEFINITIONS:)**

For _____, how do you define "energy efficient" equipment? What are the criteria you use? What portion of the (CATEGORY) products you sell are energy efficient?

REFRIGERATION:

- Refrigerated warehouses/distribution centers
- Ammonia systems
- Supermarket refrigeration
- Reach-ins (open-case and closed-case)
- Walk-ins

[2] http://www.energystar.gov/ia/products/downloads/Refrigerator_and_Freezer_Fact_Sheet.pdf

- Ice machines
- Vending machines
- "Beverage handlers"

GAS SPACE HEATING:

- Gas heat pumps/ absorption pump
- Unit heaters (warehouses, factories)
- Infrared heaters

E6. What percent of [**END USE**] purchases for commercial and industrial buildings are energy efficient? Of this, what portion is for commercial and what portion is for industrial buildings?

Section F: Marketing and Opportunities for Energy Efficiency

Again, focusing on Connecticut commercial and industrial customers (to the extent possible)…

F1. Do you market [**END USE**] to customers (can be distributors, contractors, or end-use customers)? If so: How?

- What type and how much marketing occurs between the different levels in the supply chain? (Such as manufacturer to distributors; distributor to contractors; contractor to end-use customers; and to market actors farther down in the chain.)
- Do you provide education and training to your customers?
- In your opinion, what marketing activities are the most effective at influencing your customers' purchases for **[END USE]**? Who is doing this marketing?

F2. [**SKIP IF THEY DO NOT DO MARKETING**] To what extent is your marketing geared towards energy efficiency?

- What are your companies' common methods for helping end users understand the value of these energy efficient products as compared to less efficient options?
- What solutions and products are most commonly promoted as energy efficient?

F3. Where in the supply chain does it make the most sense to market energy efficient products within the [**END USE**] market?

- In your opinion, which marketing channels are most effective for promoting energy efficient products?

F4. From your perspective, which types of market actors currently have a role or should have a role in promoting energy efficient products in the [**END USE**] market?

F5. How do you think the <gas/electric> utilities should best promote energy efficient technologies to commercial and industrial customers in CT?

- How much impact, as a percent of current sales, would these activities have on [**END USE**] sales?

Section G: End-Use Specific Questions

[Ask only the questions below that apply to the appropriate end use.]

Lighting

G1. Our understanding is that a key differentiator between the residential and non-residential market is that in the non-residential sectors, the buying decision is generally made by a professional, for instance: a building manager, electrical contractor, or maintenance professional. Is that consistent with your experience and understanding of the market?

G2. We also understand that large non-residential customers typically purchase lighting directly from manufacturers, while smaller customers purchase products from distributors.

- Is that consistent with your experience and understanding of the market?
- Do you have a sense of the percentage of commercial or industrial customers who purchase lighting directly from a retailer, rather than a manufacturer or distributor?

Refrigeration

G3. Do you see major differences between the markets for refrigeration equipment in commercial settings versus industrial settings? [Remind them we are not interested in the transportation sector.]

G4. Do you have a sense of the percentage of commercial or industrial customers who purchase refrigeration equipment directly from a retailer?

G5. I have a couple of questions specifically about customers that are supermarkets:

- Are there instances in which a supermarket chain would work directly with manufacturers rather than through the traditional supply chain (e.g., distributors)?
- Do supermarkets hire contractors to install this equipment or do they generally do it in-house?

Motors

I have a few more questions remaining -- and I want to remind you that I would like you to focus on motors for industrial process machine drive and compressed air.

G6. With costs of variable speed drives decreasing over the last 10 years, they are starting to become a cost-effective method for reducing energy consumption in variable-load applications. Are you seeing this trend and do you foresee it continuing? If not, why?

- Would you say VSDs are already standard practice for certain types of customers (e.g., large data centers)? Which types?

G7. To help us understand the replacement motor market, can you offer your best estimate for the percentage of motors sold into the OEM market versus the motor replacement market?

G8. Are you aware of what types of customers and applications are responsible for the majority of motor replacement purchases?

- What are the most common products sold for replacement applications?
- Is the motor replacement market growing?

G9. Can you offer some insight into customer decision-making? More specifically, when a motor fails, can your provide your best estimate for how commonly an end user replaces the equipment, versus purchases a replacement motor, versus pursues motor repair?

- Does this vary across motor size, applications or some other variables?
- Are there large differences in this decision in different C&I customer segments? Which ones & how much are they different?
- What are the key considerations when customers are making this decision?

Gas Space Heating

G10. Our understanding is that retailers are not typically involved in the supply chain of this market, except for light commercial equipment at big box retailers.

- Is that consistent with your experience and understanding of the market?
- Do you have a sense of the percentage of commercial or industrial customers who purchase gas space heating equipment directly from a retailer?

G11. (If not mentioned previously:) How common are gas-powered infrared space heaters in the commercial and industrial market in CT?

G12. (If not mentioned previously:) Have you seen evidence that larger manufacturers are also supplying downstream services for their equipment, such as design, installation, and/or maintenance?

Section H: Closing

H1. Now that we are finished with the formal interview questions, do you have any additional comments or questions? Is there anything additional that would be useful for us to consider or know in our study of the **[END USE]** market?

H2. Lastly, can you please provide your email address so I can send your Amazon gift card? _____

H3. Thank you very much for taking the time to provide your perspectives on the market, who the key actors are, and how the supply chain works. If we come up with any additional questions, do you mind if I send you an email or give you a quick call?

C.2 Preliminary Topic Guide for Contractor/Designer Survey

Section A. Screening Questions

1. Does the respondent fit into one of the appropriate market actor categories for this survey? (i.e., contractors or retailers)
2. Does your firm sell, install, service, and/or provide [END USE] products?
3. For contractors: Does your firm work with commercial customers? Industrial customers?
4. Does your firm work with customers in the state of Connecticut?

Section B: Firmographics

1. Determine role/position of respondent.
2. Verify type of company (i.e., contractor or retailer).
3. Collect company size information for descriptive purposes (e.g., number of full time employees).
4. For contractors, determine type of work: retrofit versus new construction.
5. Determine % sales/project work in the CT market.

Section C: Market Characteristics and Supply Chain Structure

- Objectives for this section:
  - Goal 2.1a: How many of each of these technologies are sold annually? (i.e., How is volume - units sold - divided by percentage into the major product categories?)
  - Goal 2.1b: What portion of products sold in these markets is considered energy efficient?
  - Goal 2.2a: What are the roles these market actors play in the market?
  - Goal 3.3: What is the market saturation for energy efficient technologies in these markets?

1. Who are contractors/retailers purchasing these products from (e.g., manufacturers, distributors, manufacturer reps)?
2. What are the approximate number of units sold annually for each of these major categories? (Or may ask for percent of overall sales by category.)
3. Using previously specified efficiency metrics – for each key technology category, what portion of the annual sales volume is considered energy efficient?
4. What is the current market saturation of energy efficient products in the end use category?

Section D: Customer Characteristics / Customer Awareness

- Objectives for this section:
  - Goal 3.1: What are the characteristics of the customers purchasing these products? (i.e., who are the contractors selling to?)
  - Goal 3.6: What is the level of customer awareness and understanding of the technologies that make up these markets?

1. What are the major end use customer types that you sell/provide services to? (i.e., hospitals, small office, retail, industrial, etc.)
2. How aware are customers of energy efficient products/options in the end use category?

Section E: Customer Decision-Making and Adoption Barriers (including Financing)

- Objectives for this section:
  - Goal 3.2: How do customers make decisions regarding these products? How does energy efficiency factor in the decision-making process? What non-energy benefits factor into these decisions?
  - Goal 3.4: What are the barriers for greater adoption of energy efficiency products within these markets?
  - Goal 3.5: What methods of financing are commonly used by customers for the purchase of new equipment? What types of financing are acceptable and/or preferable?

1. What are customers' top priorities when selecting new equipment?
2. To what extent do end use customers factor energy efficiency into their decisions?
3. What non-energy benefits, if any, do customers include in their decision-making process?
4. What prompts customers to purchase energy efficient products in this end use category? Are these drivers different for new construction versus retrofits/remodeling?
5. What are the primary factors preventing customers from installing more energy efficient equipment in this end use category?
6. How willing are customers to take out loans to finance purchases of new equipment?
7. What financing mechanisms (e.g., PACE) and sources do end use customers use to finance these purchases?

Section F: Marketing of Energy Efficiency

- Objectives for this section:
  - Goal 2.2b: What role do these market actors play in promoting energy efficiency (e.g., stocking energy efficient products, conducting training, and raising program awareness)?
  - Goal 2.3: What are the effective marketing channels used for these markets? Are particular channels more effective for energy efficient products?

1. What types of marketing and/or outreach efforts (for EE) do these market actors currently participate in, if any?
2. Are certain marketing approaches more effective for promoting EE than others?

Section G: Closing

1. Thank survey respondent and collect email address for gift card distribution.