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Heather Klemick, Elizabeth Kopits, and Ann Wolverton^{1,2}

ABSTRACT: Commercial buildings offer opportunities for companies to reduce energy use that, according to engineering analyses, should save them money while also lowering greenhouse gas (GHG) and other polluting emissions. Supermarket refrigeration is one sector with ample energy-efficiency and emission-reducing investment options. This study explores the evidence of an energy efficiency paradox for supermarket refrigeration technologies that are estimated to reduce energy and emissions while providing net cost savings for firms. We conduct interviews and focus groups with representatives from 44 small, medium, and large US supermarket chains. We focus on the refrigeration system given its dominant role in determining store electricity consumption and GHG emissions. Consistent with the economics literature on the energy-efficiency paradox, we distinguish between market failures, behavioral anomalies, and other factors not accounted for in typical NPV or payback calculations for supermarket refrigeration technologies. Imperfect information and uncertainty about the performance of new technologies were the most pervasive barriers among participants, though split incentives between firms and contractors or employees, liquidity constraints, tradeoffs with other valued system attributes like reliability and customer appeal, and certain behavioral anomalies also play a role among some firms.

Key Words: Energy efficiency paradox, market failures, technology investment barriers, supermarkets

JEL Codes: Q52; Q48; Q58

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I. Introduction

Commercial buildings offer opportunities for companies to reduce energy use that, according to engineering analyses, should save them money while also lowering greenhouse gas (GHG) and other polluting emissions. Supermarket refrigeration is one sector with ample energy-efficiency and emission-reducing investment options. McKinsey & Company (2009) has estimated that net-present-value (NPV) positive energy-efficiency investments in the US food sales industry could reduce energy consumption in the sector by 14 percent (or 40 trillion Btu) in 2020. Consulting and non-governmental studies have highlighted several emission-reducing technologies for supermarket refrigeration systems with payback periods of only a few years that have not been universally adopted (Navigant Consulting 2009, Carbon Trust 2010). In the same vein, analyses of two recent federal efficiency standards for commercial refrigeration equipment estimate that the energy savings for supermarkets and other food sales establishments will outweigh the higher upfront costs by almost \$9 billion over the lifetime of the equipment (US DOE 2014a, US DOE 2014b). These examples are all suggestive of an “energy-efficiency paradox”—the observation that households and businesses often seem to forgo energy-saving investments that have a higher upfront cost than the alternative, but are expected to save money in the long run due to reduced energy costs (Klemick and Wolverton 2013; Jaffe and Stavins 1994).

This study explores the evidence of an energy efficiency paradox for supermarket refrigeration technologies that are estimated to reduce energy and emissions while providing net cost savings for firms. Supermarkets are interesting to study in this context for several reasons. First, they are the most electricity-intensive type of commercial building due to the need to keep food chilled, averaging about 50 kWh per square foot annually (US EPA 2008b).³ The commercial refrigeration system is the biggest energy user within supermarkets, accounting for about 40 to 60 percent of electricity consumption (US EPA 2008a, US EPA 2008b). In aggregate, supermarket refrigeration totals about two to three percent of energy consumption in commercial buildings in the United States, or roughly 0.5 quadrillion Btu (Navigant Consulting 2009). Energy use is of particular interest from a policy perspective because emissions from fossil fuel combustion and industrial processes accounted for almost 80% of total GHG emission increases between 1970 and 2010 (IPCC 2014).

Second, the total climate impact of supermarket refrigeration is even larger when refrigerant gases are considered. Current refrigeration equipment relies on high global warming potential (GWP) hydrofluorocarbons (HFCs) - relative to other greenhouse gases (GHGs), they trap substantially more heat in the atmosphere - as coolants. For the typical US supermarket, GHG emissions more than double when the impact of refrigerant leaks is added to that of electricity consumption (US EPA 2011a). The supermarket industry uses the concept of total equivalent warming impact (TEWI) to gauge the aggregate climate impact of a refrigeration system, accounting for CO₂-equivalent emissions from both refrigerant gases and energy consumption (i.e., direct and indirect emissions). TEWI is particularly important because some advanced refrigeration systems that reduce refrigerant use can have higher energy requirements than conventional systems, eroding some of the net climate benefits of these technologies (ICF Consulting 2005, US EPA 2013).

³ For a typical store, this amounts to about 2 to 3 million kWh of electricity consumption per year.

Third, while supermarkets are large energy users, energy and refrigerant account for a relatively small proportion of expenditures. Product inventory is the overwhelming expense in supermarket budgets (comprising about 75 percent of sales), followed by labor (about 10 percent of sales); energy costs are about one to two percent of sales, and annual refrigerant replacement cost is well under one percent (King et al. 2004, US EPA 2008b, US EPA no date, FMI 2015). This situation contrasts with some other energy-intensive sectors, such as heavy-duty trucking, in which energy can be the largest business expense. However, low profit margins in the industry (also about one to two percent of sales) mean that reducing costs could have a sizable impact on the bottom line (US EPA 2008b). An EPA report notes that “a 10 percent reduction in energy costs for the average supermarket is equivalent to increasing net profit margins by 16 percent” (US EPA 2008a).

Consistent with the economics literature on the energy-efficiency paradox (e.g., Gillingham et al. 2009), we distinguish between market failures, behavioral anomalies, and other factors not accounted for in typical NPV or payback calculations for supermarket refrigeration technologies. Market failures that could lead to sub-optimal firm investments include imperfect information about new technologies’ availability, performance, or other characteristics; split incentives, in which the individual responsible for making investment decisions does not bear the energy or refrigerant costs; and capital or liquidity constraints if a firm cannot obtain the financing to cover higher upfront costs associated with an emission-reducing technology.⁴ Behavioral anomalies, which occur when individuals make decisions inconsistent with rational profit or utility maximization, could inhibit cost-saving if decision-makers are inattentive to energy efficiency or if insufficient coordination among departments within companies leads to organizational barriers. Other factors not typically accounted for in simple NPV analyses that could affect the genuine attractiveness of new technologies for firms include tradeoffs with other important attributes like customer appeal or reliability; store-specific engineering or space considerations; uncertainty about the payoff of a new technology and the option value of delaying an irreversible investment; and a higher opportunity cost of capital than often assumed in engineering calculations.

Evidence of the market failures or barriers most relevant for supermarket refrigeration investments can help guide which policy interventions might be appropriate for addressing them, or may suggest ways to improve payback calculations to include previously unaccounted for costs of adoption. The authors conducted a companion case study on the heavy-duty trucking industry and found that lack of information about technology performance under heterogeneous operating conditions and concern about uncertainty and downside risk were two major factors slowing adoption of fuel-saving technologies (Klemick et al. 2014). Nonetheless, participating fleets had a high level of awareness about emerging fuel-saving technologies and had adopted or experimented with many that have since been mandated by federal regulations.

The literature on commercial buildings also highlights some of the barriers to adoption of energy-saving technologies. For instance, an analysis of German commercial firms found lack of information about energy consumption to be one of the most common barriers to efficiency investments (Schleich and

⁴ Unpriced harmful externalities from GHG emissions undoubtedly also contribute to suboptimal adoption of technologies to reduce emissions. However, they do not enter into firms’ private profit-maximization decisions, so we do not consider the role of environmental externalities in this study.

Gruber 2008). Split incentives (or principal-agent problems) have been widely discussed in this sector, especially landlord-tenant relationships where the building owner is responsible for energy-consuming investments but the tenant pays energy costs (IEA 2007). Analyses of commercial buildings in both the US and Germany have found that energy-efficient investments are more likely in owner-occupied space (Andrews and Krogmann 2009; Schleich and Gruber 2008). However, other studies have shown that energy efficiency investments are fully capitalized into commercial rents and sales prices in US commercial buildings, suggesting that asymmetric information between landlords and tenants (or sellers and purchasers) is not a pervasive barrier (Eichholtz et al. 2013; Papineau 2013). Split incentives between landlords and tenants could occur in supermarkets, though they may be less likely to affect refrigeration system investment decisions since even supermarkets that rent retail space purchase and maintain their own refrigeration equipment. However, there are other types of split incentives that may play a role in refrigeration investment decisions—in particular, split incentives between supermarkets and refrigeration contractors who install and service the system, and between supermarkets and employees who use and occasionally maintain the system.

Regarding behavioral anomalies, survey research has found that anchoring bias can have a large effect on the energy performance goals set by commercial building owners (Klotz et al. 2010). Institutional factors like company size and earnings can affect firms' adoption and payback periods for energy efficient lighting, suggesting that organizational barriers could play a role (DeCanio 1998; DeCanio and Watkins 1998). There could be scope for “rational inattention” to energy and refrigerant consumption if precisely optimizing these factors has a negligible impact on store profits (Sallee 2013). Consistent with this explanation, analyses of German and US commercial buildings found that firms with lower energy use or energy intensity are less likely to adopt energy efficient technologies (Schleich and Gruber 2008; Schleich 2009; Andrews and Krogmann 2009). Loss aversion, which could be relevant to commercial refrigeration given uncertainty in future energy prices and performance of new technologies, has been documented in the context of household investment decisions (Greene 2011; Greene et al. 2013). However, competitive forces and market experience can moderate tendencies toward systematic behavioral failures in firms (Shogren and Taylor 2008; List 2003; List 2004).

Consulting and non-governmental studies of supermarket refrigeration have pointed to potential tradeoffs between energy efficiency or emission reductions and other priorities like customer appeal, reliability, site-specific engineering and space requirements, complexity and training needs, and policy barriers (Carbon Trust 2010, Navigant Consulting). However, a study of UK supermarkets found that several major chains have steadily reduced their energy intensity and GHG emissions over the past decade through voluntary corporate goals and investments in technologies expected to have a positive financial return (Sullivan and Gouldson 2013). A different study based on interviews with UK grocery store managers also found that energy efficiency has become a priority in recent years, though managers focus on investments that meet regulatory requirements and forgo those they perceive as having negative effects on customer appeal (Ochieng et al. 2014).

This research expands the literature on the energy-efficiency paradox in commercial buildings by studying the investment decisions of managers responsible for supermarket refrigeration systems. We conduct interviews and focus groups with representatives from 44 small, medium, and large U.S. supermarket chains. We focus on the refrigeration system given its dominant role in determining store

electricity consumption and GHG emissions. Other uses for electricity in supermarkets not covered in this study range from stand-alone beverage units to space heating and cooling to lighting to food preparation and entail a much broader universe of technology options.

In the remainder of this section of the paper we provide more information about supermarket refrigeration systems, advanced technology options, and regulatory and voluntary programs. Section II describes our interview and focus group methodology, as well as the characteristics of participating supermarkets. Section III delves into our findings on adoption of energy and emission-reducing refrigeration technologies among our sample and whether a “payback gap”—in which firms only adopt technologies whose operating cost savings offset the higher upfront cost in substantially less time than the lifetime of the equipment—appears to exist when making investment decisions. Section IV discusses evidence from our sample on the role of market failures in refrigeration investment decisions. The following section focuses on behavioral and organizational barriers, while section VI discusses other factors not accounted for in typical payback calculations. The final section concludes.

Supermarket refrigeration and advanced technologies

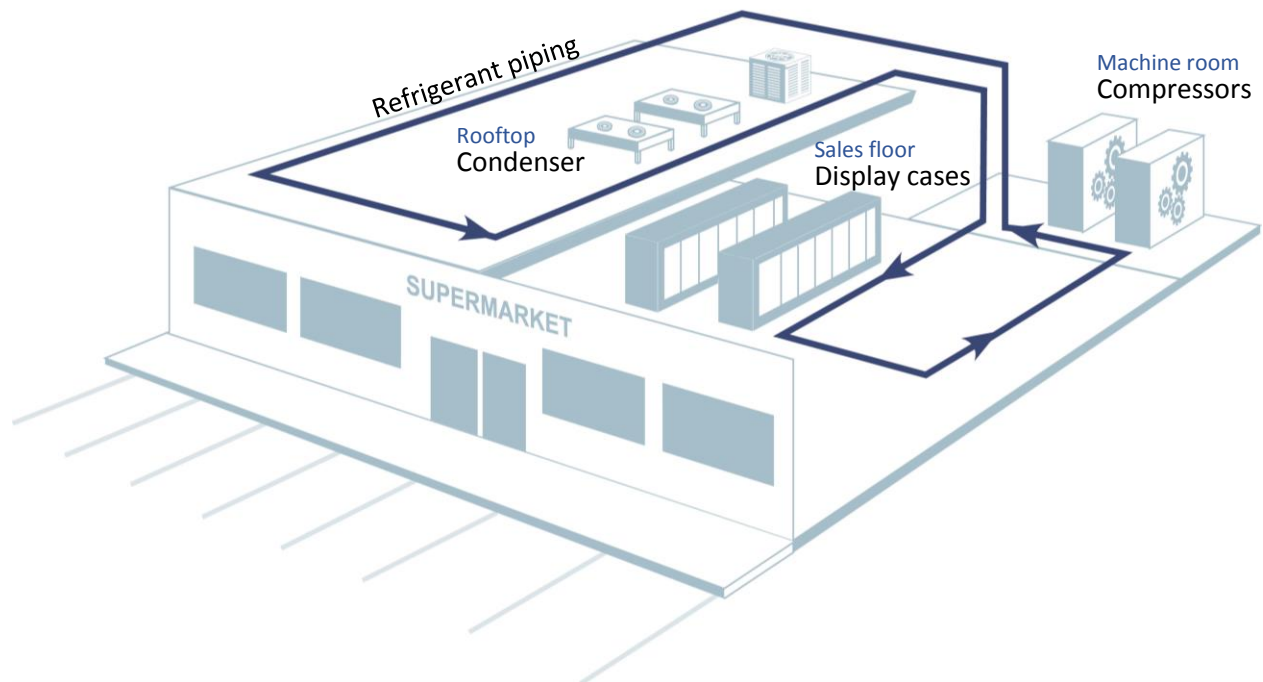
A supermarket refrigeration system consists of many components that act together as one system. Display cases, compressor racks, condensers, and walk-in refrigerators and freezers are the major components (see Figure 1). Walk-ins and compressors are located in the back of the store, with condensers typically on the roof. In the conventional “remote condensing” refrigeration system configuration, an extensive network of piping delivers refrigerant gas from the compressor to the condenser to the display cases and back to the compressor, posing substantial opportunities for refrigerant leaks along the way.^{5,6} While the display cases and compressors together comprise about 85% of the system’s energy consumption, engineering studies have identified “win-win” opportunities within all system components to improve energy efficiency at net cost savings (Navigant Consulting 2009, Carbon Trust 2010). Several of these technologies are listed in Table A and discussed in section II.

Studies have also pointed to potential “win-win” opportunities where supermarkets could save themselves money while reducing emissions from refrigerant gas leaks. Supermarkets on average lose about 25 percent of the refrigerant charge annually due to leaks (US EPA 2011a). Technologies and strategies for leak reduction yield financial gains because the gas is costly to replace, and equipment does not function optimally without the proper refrigerant charge. Thus, while supermarket investments may be characterized by an energy-efficiency paradox, this issue is broader than energy alone given cost-saving opportunities to reduce HFCs and other refrigerant emissions.

⁵ Supermarkets typically have about 60 display cases to house refrigerated and frozen food items (Navigant Consulting 2009).

⁶ This system contrasts with “self-contained” refrigerators—such as ice makers, beverage vending machines, and residential refrigerators—that include all of the components and piping in a single unit. Supermarkets typically house several self-contained units in addition to the walk-ins and central remote-condensing refrigeration system. Our study does not consider investment and maintenance decisions for these units, which use different technologies and may be affected by different investment barriers. For example, beverage vending machines are subject to a split-incentives market failure because they are typically owned and maintained by a bottling company, even though the supermarket bears the electricity expenses (Navigant Consulting 2009, IEA 2007).

Figure 1: Typical Supermarket Refrigeration System Configuration



Source: EPA GreenChill program

Other advanced refrigerant management strategies, such as switching to lower-GWP refrigerants, may not yield net cost-savings for the industry. Thus, slow or minimal adoption of these technologies by supermarkets in the absence of regulatory requirements is not puzzling from an economic perspective and does not represent a paradox. We do not necessarily expect supermarkets to account for the effects of GHG emissions from refrigerant gas—they are an unpriced externality.

Regulatory and Voluntary Programs

Certain commercial refrigeration system components are subject to federal environmental and energy regulations. While energy-efficiency regulations of display cases and walk-ins were updated after the focus group and interviews occurred for this study,⁷ energy efficiency standards do not apply to the system as a whole, and many of the available “win-win” technologies and practices are not currently mandated. This is an important characteristic of the energy-efficiency paradox, as the potential for net cost savings from investing in particular technologies is observed absent regulatory requirements. There

⁷ Our focus groups and interviews were conducted in 2013. The US Department of Energy (DOE) recently issued updated standards for commercial refrigerator and freezer display cases and self-contained units (2014a) and walk-in coolers and freezers (2014b), which take effect in 2017. The standards require technologies such as high-efficiency fan motors, high-efficiency lighting, and improved insulation. Median payback periods for various equipment classes range from about one and a half to seven years. DOE (2014a, 2014b) estimates that the standards together will yield annualized energy savings equivalent to one percent of total 2014 US commercial energy consumption. DOE does not issue standards for remote condensers and compressors, in part due to the high degree of heterogeneity in system design across stores.

are two major voluntary federal programs focused on energy efficiency. EPA and DOE's Energy Star program offers a store certification program for supermarkets but only provides product labels for self-contained (not remote-condensed) refrigeration equipment.⁸ DOE's Better Buildings Alliance, a partnership program to promote energy efficiency, also works with several large supermarket chains to promote energy-saving technologies and practices.⁹

With regard to refrigerants, there are both mandatory and voluntary federal programs in place.¹⁰ EPA does not currently restrict use of HFCs in commercial refrigeration but prohibits venting and requires the repair of systems with leak rates of 35 percent or higher. In 2007, EPA launched the GreenChill voluntary partnership program to reduce supermarket refrigerant emissions by disseminating information about best practices, encouraging corporate goal setting, and certifying individual high-performing stores.¹¹ As of 2014, US EPA (2014) has proposed, but not finalized, a ban on the use of several HFC blends in commercial refrigeration, citing the availability of lower-GWP and zero-ozone-depletion-potential alternatives.

II. Methodology

Since there is limited literature and data on firm capital investment decisions related to energy-efficient and emission-reducing technologies, we relied on focus groups and interviews to collect information.¹² Researchers have used focus groups and interviews to gauge opinions of environmental practices among firms regarding building energy management and design (e.g., Murtagh et al. 2013, Gul and Menzies 2012, Pellegrini-Masini and Leishman 2011, Ryghaugh and Sorensen 2009), as well as heavy-duty trucking companies' energy investment choices (Klemick et al. 2014). Studies using this approach to examine UK supermarkets' voluntary GHG reduction goals and energy efficiency investments include Sullivan and Gouldson 2013 and Ochieng et al. 2014.

We conducted six professionally facilitated focus groups and eight interviews with store and company managers, vice presidents, and owners involved in major purchase and maintenance decisions for refrigeration systems at supermarkets.¹³ A supermarket is defined as a store with over \$2 million in annual sales (FMI 2015) that offers a more diverse set of products than a traditional grocery store but is

⁸ See http://www.energystar.gov/sites/default/files/tools/Supermarkets_0.pdf for more information about the Energy Star supermarket program.

⁹ See <https://www4.eere.energy.gov/alliance/activities/technology-solutions-teams/refrigeration> for more information about the DOE Better Buildings Alliance Refrigeration team.

¹⁰ The US Environmental Protection Agency (EPA) regulates the sale and use of refrigerant gases under the Clean Air Act, consistent with the United States' commitments under the Montreal Protocol. In keeping with EPA's longstanding phase-out of refrigerants with ozone-depletion potential, the refrigeration industry has moved towards HFCs, which have high GWP but do not deplete stratospheric ozone.

¹¹ GreenChill is "an EPA partnership with food retailers to reduce refrigerant emissions and decrease their impact on the ozone layer and climate change." See <http://www2.epa.gov/greenchill> for more information.

¹² See Frechtling and Sharp (1997) for a discussion of the advantages and disadvantages of using focus groups and interviews to collect information.

¹³ Titles varied. Participants had job titles ranging from Director of Refrigeration, Director of Engineering, and Director of Facilities to Refrigeration and Energy Program Manager and Vice President of Store Planning, Owner participation was mainly limited to focus groups with small supermarket companies.

still largely focused on the sale of food-related products. A supermarket typically ranges in size from 20,000 to 80,000 square feet; the median size was about 46,500 square feet in 2010 (FMI 2015). We excluded hypermarkets, which combine a supermarket with a department store (e.g., Walmart), as well as wholesale clubs (e.g., Costco) from consideration since they are much larger in size, sell a much wider range of goods, and dedicate a relatively smaller portion of the store's square footage to refrigeration.

Of the six focus groups, two were with small companies, three were with medium sized companies, and one was with large companies.¹⁴ Individual phone interviews were conducted with representatives from seven large national or regional companies and one small company. Focus group and interview participants were recruited through collaboration with state or national associations and industry experts.¹⁵ Individuals that participated are not a random sample; they are likely more interested in energy and technology issues. To ensure we did not only include supermarkets that are industry leaders for energy- or refrigerant-saving technologies, we recruited both partners and non-partners of EPA's voluntary partnership program, GreenChill. Company affiliation was used to avoid duplication when recruiting but was otherwise masked to protect participant confidentiality with three exceptions. Three interviews were not anonymous: contact was facilitated directly through the GreenChill program, so participants were aware they were participating in an EPA study.¹⁶ We conducted the interviews and focus groups throughout 2013.

The focus groups ranged in size from three to nine participants, with an average of six participants per focus group. Thirty-six of 44 managers recruited ultimately participated in a focus group, which implies a 20 percent attrition rate. There was no obvious pattern with regard to likelihood of participation by company size, most likely because managers were already away from their stores to participate in the affiliated conference. Combined with the interviews, our findings reflect the views of a total of 44 energy and store managers in the retail supermarket industry.

Table 1 summarizes key characteristics of supermarket participants gathered via a questionnaire. Companies in the focus groups and interviews are divided fairly evenly across the three size categories (14 small, 14 medium, and 16 large). All regions are represented among the participants, with some companies having stores in multiple regions. Almost half of the companies in our dataset are primarily located in the Midwest. This is not too surprising given that two of the focus groups were held with Ohio Grocer Association members. Most companies have supermarkets in some combination of urban, suburban, and rural locations. Twenty-five percent of the companies in our data set stated that their electricity consumption varies across states or regions in which they are located.

¹⁴ For the purposes of grouping focus group participants together and summarizing participant data, we define small companies (SM) as those that own 1-5 stores, medium (MD) companies as those that own 6-125 stores, and (LG) large companies as those that own more than 125 stores.

¹⁵ Two focus groups were conducted at a National Grocers Association meeting in Las Vegas, two at an Ohio Grocers Association meeting, and two at the Food Marketing Institute's Energy and Store Development Conference in Baltimore. We used a screener – included in the Appendix – to identify companies that qualified for participation.

¹⁶ Throughout the paper, each focus group (FG) and interview (INT) is labeled numerically and identified by size, measured as number of stores owned by a participating company. In addition, the three non-anonymous interviews with GreenChill partners are identified by the label N-ANOM.

The stores owned by participating companies range widely in age from new to 60 years old. The average is 22 years, with small companies tending to have slightly older stores (on average 26 years). Over 80 percent of participants reported upgrading a refrigeration system within the last three years, and about 60 percent of participants remodel their stores on a five- to ten-year cycle. About a third of the companies are GreenChill partners.

Table 1. Supermarket Participant Summary

| | | Number of participants | % ^A |
|--|----------------|------------------------|----------------|
| Total number of participants (focus groups plus interviews): | | 44 | |
| Company size (number of stores): | 1-5 | 14 | 32% |
| | 6-125 | 14 | 32% |
| | > 125 | 16 | 36% |
| U.S. region: | National | 3 | 7% |
| | Northeast | 10 | 23% |
| | Midwest | 21 | 48% |
| | South and West | 10 | 23% |
| Type of location (categories not mutually exclusive) | Urban | 33 | 75% |
| | Suburban | 22 | 50% |
| | Rural | 31 | 70% |
| Most recent refrigeration system upgrade: | < 3 years | 37 | 84% |
| | 4-7 years | 4 | 9% |
| | 7 + years | 3 | 7% |
| Frequency of store remodel: | 5-10 years | 27 | 61% |
| | 10-20 years | 9 | 20% |
| | It depends | 8 | 18% |
| Electricity consumption varies by state/region? | Yes | 11 | 25% |
| EPA GreenChill partner? | Yes | 14 | 32% |

^A Percentage based on total number of participants.

In addition to the focus groups and interviews with supermarkets, we also interviewed several product and energy managers at a refrigeration supplier company that advises supermarkets on purchasing and installation of new equipment as well as its major components. We did not include this interview in the summary statistics presented in Table 1, since this type of company plays a different role in the refrigeration investment decision-making process, but refer to it when applicable in the results discussion.¹⁷ In general, the supplier interviews echoed major themes from the supermarket focus groups and interviews.

We designed a moderator’s guide and a questionnaire about energy- and refrigerant-saving technologies to guide the focus group and interview discussions. The guide follows a semi-structured funnel design: it begins with broad questions about how companies make supermarket refrigeration investment decisions before discussing the role energy and refrigerant leaks plays in decision-making. We favored open-ended questions but used prompts to facilitate discussion as needed. The ordering

¹⁷ We label the supplier interview as INT SUPPL throughout the results section.

and specific wording of the questions evolved slightly over time to reflect what we learned from previous focus groups and interviews. See Table 2 for examples of questions from the moderator's guide.¹⁸ To compare results across focus groups and interviews, we performed formal content analysis, matching transcript text to pre-defined codes agreed upon by the authors (Radcliff and Best 2005).

Table 2. Sample Questions from Moderator's Guide

How many of you have recently made major investments for a store's refrigeration system that improved energy efficiency? What makes them appealing to adopt? What factors did you consider when deciding whether to adopt them?

Do you think about energy efficiency and refrigerant use together or separately? Does one dominate over the other in investment decisions? Are there trade-offs between them?

Thinking about all the factors you have mentioned so far that affect your investment decision, how do you weigh them against upfront cost? Do you incorporate any of them into an ROI or payback calculation? If not, how do you weigh them against upfront cost and energy savings?

III. Results and Discussion: Evidence of a "Payback Gap"?

Using a simple payback calculation, studies have claimed that supermarkets can achieve significant energy savings by incorporating technologies and components that are currently commercially available with payback periods of seven years or less (for some technologies, substantially less), even though the refrigeration equipment is expected to last much longer (Navigant Consulting 2009, Carbon Trust 2010). We are interested in understanding to what degree supermarket firms in our sample consider such payback calculations and whether there is evidence of a "payback gap" in their investment decisions – i.e., if they require the energy savings to offset the costs of adoption in substantially less time than the technology will be in use.

Among most focus group and interview participants, we found that energy efficiency (or energy consumption) is important to decision making but not necessarily among the top three factors considered when installing a new refrigeration system or making a major upgrade to an existing system. One participant stated, "*It's one of many things. One would be foolish to ignore it. But energy by itself doesn't drive any decision.*" (INT#1, LG) The other factors that were noted, again and again, as most important were upfront cost, maintenance, and customer appeal. As one firm explained, "*...in a supermarket there are a lot of other things to consider too. Energy is certainly an important [factor] but*

¹⁸ Appendices 3 - 5 contain the list of questions to screen candidates for participation, the complete moderator's guide, and the questionnaire, respectively. A separate moderator's guide was used to interview suppliers. While not included in the appendix it is available from the authors upon request.

maintenance and dependability, serviceability and dependability, are two others that are certainly very important.” (INT#8, N-ANON, LG)

We also found evidence of a payback gap among supermarkets that participated in our study.

Participants often noted that the expected payback period is much shorter than the typical remodel cycle or length of ownership of the equipment. This was especially true when retrofitting an existing store. As one interviewee explained: *“We like two-year paybacks, and I’ve gotten some stuff approved with three-and-a-half to four year paybacks. But you’ve got to remember, in the supermarket business, when you go into a store, if you’re talking four years, you may remodel that store in five years. So you really haven’t gained a whole lot. If you can get a year-and-a-half, two years, that’s a good deal.”*

(INT#5, LG) Others agreed: *“...Currently if something doesn’t have a two year or better simple ROI, then we won’t really even look at it.”* One focus group participant explained, *“Your profit margin is so small in grocery, like a penny on the dollar, ...Why would I invest a ton of money in a piece of equipment that’s going to take 10 years to payback, when I can take that money and get a payback in other areas in two years?” (FG#3, MD)*

Several of the interviewees also acknowledged that they have a bit more flexibility when it comes to new stores: *“...if it’s a new store, we’re willing to look a little further [out]. But at this point it’s actually not much more than three to five years.” (INT#4, LG)* Participants in at least one focus group and one interview noted that their payback requirement must be achieved on a store-by-store basis. This is especially true for larger system investments, whereas some stand-alone products (e.g., LED upgrade) are often rolled out to all stores once proven.

The standard length of ownership was reported to vary by type of equipment. Some components were replaced only on an as-needed basis: *“I use equipment until it dies. I think we all do....I use bubble gum, Band-Aids and chewing gum to keep them running.” (FG#5, MD)* Other components, especially in the retail area of the store, are likely refreshed on a regular basis: *“We never arbitrarily replace a refrigeration system. We may do some kind of remodel on a store, or we’ll touch it in some way, shape or form at least every five to seven years. That doesn’t mean that we’re going to touch the mechanical system of the store necessarily.” (INT#3, LG)*

While most participants mentioned that they have specific payback targets or expect a minimum return on investment (ROI) for new investments, other participants mentioned that they do not always have a hard-and-fast requirement. One participant stated, *“We always have a payback calculation but that doesn’t always make the decision for us. Because if [you view it as an] energy savings, it’s a no-brainer. You’re going to do it whether it takes a year and a half, two years, or three years.” (FG#2, SM)*

When we explicitly asked participants why they require refrigeration equipment to pay back well before the end of its useful life, they offered two main explanations. Some pointed to the payback gap as a way to guard against future uncertainty with irreversible investments. Others pointed out that investments in energy-efficient equipment must compete with alternative forms of investment outside of energy efficiency and meet the company’s expected rate of return on capital. These explanations are discussed in more detail in the uncertainty and opportunity cost of capital sections of the paper.

Figure 2: Participant use of refrigeration technologies, by firm size



Existing and Emerging Technologies

As part of the participant questionnaire, we also asked participants about their use of 26 specific practices and technologies that are recognized to potentially improve energy efficiency or reduce refrigerant emissions across key refrigeration system components (condensers, compressors, display cases, piping, and walk-ins), several of which are expected to pay back over relatively short periods of time. A list of these strategies and a summary of responses by firm size is provided in Figure 2.¹⁹

Technologies and practices with the shortest payback periods (typically less than two years) according to published engineering-based estimates include advanced condenser design; high efficiency fan motors; floating head pressure in walk-ins; strip curtains and night blinds; leak detection and repair; recommissioning; cleaning, maintenance and repair; and adjusting store temperatures to be closer to the ambient temperature (Navigant Consulting 2009, Carbon Trust 2010, US EPA 2013). Technologies with very long payback periods (e.g., over 8 years)—or those that may not yield a positive financial return over the lifetime of the equipment—include switching to low-GWP refrigerant alternatives and alternative configurations that reduce the size of the refrigerant charge.

We found that many existing energy saving and new refrigerant technologies and practices are already being adopted by many of the companies in our sample. In many cases, adoption patterns were correlated with expected payback estimates. For example, high efficiency fan motors, recommissioning, cleaning, maintenance and repair, and adjusting store temperature—which all have short payback periods—are among the most widely used practices and technologies. Refrigerant changes and alternative configurations—which may not always yield a positive ROI—are among the least widely used. There are a few exceptions; technologies with relatively short payback periods that are less widely adopted include strip curtains and night blinds, hot gas defrost, and demand defrost controls.

Technology adoption varies by firm size. While adoption rates were noticeably higher among the larger firms in our sample, Figure 2 indicates that this is not true across the board. The technologies with the lowest adoption by the large firms (with usage rates ranging from 56% to 75%) include: hot gas defrost and demand defrost for walk-ins, thicker insulation and strip curtains on display cases, advanced condenser design, and some refrigerant changes. Of these technologies, some respondents said they had tried them but would not use them again (e.g., hot gas defrost, advanced condenser design, and some refrigerant changes), others indicated they would be willing to consider adoption in the future (e.g., thicker insulation on piping and display cases, demand defrost control), and a few noted they would never consider using these technologies (e.g., strip curtains, hot gas defrost, and refrigerant changes).

Adoption rates were lower across the board among the smallest firms in the sample. For example, aside from some advanced lighting options, less than half of the smaller firms used the energy-saving technologies for walk-ins. Similarly, the extent to which companies have tried alternative refrigerant system configurations (e.g., secondary loop, cascade, or distributed compressor systems) appears to

¹⁹ Appendix 1 Tables A-D provide the detailed data in aggregate and by firm size.

vary by company size; only 38% of small firms have tried these new systems, whereas 46% of medium-sized firms, and 88% of the large firms currently use them.

With regard to emerging technologies, some firms expressed a willingness to try or at least experiment with technologies even if the ROI is low or the payback period is long. At least one participant said that they have been experimenting with new refrigerant in case it eventually meets their ROI. Some participants expressed a willingness to try emerging technologies with an extended payback for reasons that are more difficult to quantify: *"We did one project [that], even with incentives, [had] a seven-year payback. But it's also [about] public relations – going green, that kind of thing."* (FG#3, MD) Other participants noted that extra financial incentives might be needed. For instance, *"even if [the technology] has proven itself in that situation, it may not have stood on its own merit. It may have been the utility [rebates] brought it down to a two year payback and, yes, it worked and, yes, it proved out. But if we didn't have that utility rebate, it might have been a three-and-an-half year payback and, at that rate, maybe it didn't pay for itself."* (INT#3, LG) (Rebates are discussed further in the liquidity constraints portion of section IV.)

Payback Calculations

Participants in all the focus groups and interviews stated that their companies make payback calculations, but the level of sophistication varied by firm size and type of investment. Many of the larger firms used spreadsheets or conducted other formal quantitative analysis. One interviewee stated, *"[we] try to include everything that...has real value in the payback calculation."* (INT#4, LG) Another agreed, saying that they *"try to quantify as much as possible. ...It's time/value/money. It's the same financial standard we put on anything we invest in the store."* (INT#1, LG)

One advantage of conducting a quantitative analysis is it allows for a more explicit weighting of factors, such as sustainability and maintenance: *"Sometimes people will come in with an idea that looks good for energy efficiency or it looks good for sustainability or it looks good for maintenance. But for some reason or another it's got a downside. When you run it through a lifecycle analysis, it doesn't look as good."* (INT#2, LG) Another interviewee noted that his firm weighs the cost of repair vs. replacement, while several interviewees mentioned that they account for utility incentives within the payback calculation. Finally, one interviewee noted that the equipment should *"not detract from the customer experience... an investment analyst [has] to put dollar signs to that somehow"* (INT#2, LG). Several participants noted that there are always factors that are hard to monetize, but that *"the intangibles are there as tie-breakers."* (INT#1, LG)

Several focus group participants indicated that while they rely on more sophisticated calculations when contemplating bigger investments they do not apply the same standard to analysis of small-scale investments. *"If it's a \$2,000 repair...I'm not putting a spreadsheet... anything that's beyond that, \$10,000-15,000, we have to look at it very seriously saying, 'Is this really helping us move forward and enough other reasons for us to go?'"* (FG#1, MD) Others, particularly small companies, seemed to regularly rely on qualitative assessment. As one participant noted, *"I look at ROI, but I don't get into deep detail of it. I just get an idea and if it's a long-term investment, then okay, but the shorter the better."* (FG#2, SM) Another mentioned that to *"sit down every decision and put together a nice little*

spreadsheet with a return on investment analysis from my MBA class, that doesn't happen" (FG#1, MD). Others called out specific factors that, while important to consider, they do not explicitly incorporate into a quantitative calculation. For instance, "We don't figure [the cost of maintenance] in dollars. We [ask], are parts easily available, how difficult are they to work on?" (FG#6, SM) Another participant noted, "How do you put a value on [customer appeal]? That appeal that you get is like a new car smell. ...I don't know if it's really quantifiable." (INT#6 LG, N-ANOM)

IV. Evidence of Market Failure

In this section, we review the evidence related to whether market failures pose a barrier to adoption of refrigeration system technologies that improve energy efficiency or reduce refrigerant leaks. Table 3 lists each of the market failure hypotheses and provides illustrative quotations for each: imperfect information, split incentives, and liquidity constraints. We find that while some of these explanations apply in the context of supermarkets, others do not. For instance, all of the focus groups and interviewees discussed imperfect information as a barrier to adoption of energy- and refrigerant-reducing technologies. However, participants expressed mixed views with regard to split incentives and capital or liquidity constraints. We discuss each of these potential market failures in-depth below.

Table 3: Market failure hypotheses

| Potential barrier to investment | Sample quotations |
|---------------------------------|---|
| Imperfect information | <i>"Part of it is your own experiences and knowledge. Part of it is whatever testing [manufacturers] may have to show you. Part of it is talking to others about a particular type of system. If stuff is brand new, then you just don't know. You're going to have to experience for yourself." (INT#1 LG)</i> |
| Split incentives – contractors | <i>"You've bought it and you have somebody else installing it, and a lot of times there's this world of pointing fingers—it's not an equipment problem, it's an installation problem." (FG#1 MD)</i> |
| Split incentives – workers | <i>"[Workers are] trained in the things they can do to reduce energy use...: things like keeping doors on coolers and freezers, the walk-in coolers and freezers shut...Make sure you keep things turned off or turned down whenever possible... Don't overload your cases." (INT#2 LG)</i> |
| Liquidity constraints | <i>"If you have \$100 and that's all you have, you can only do so much, so you select where you think you get the most bang for your dollar. If I have ten projects, and nine of them pay back in one year and another one pays back in two years, I'm going to concentrate on the ones with the quickest payback." (FG#3 MD)</i> |

Imperfect information

Imperfect information is a potential barrier to the adoption of emission-reducing technologies in a variety of contexts. In a companion study to the current article, the authors found that imperfect information about the performance of new fuel-saving technologies contributed to slow adoption among heavy-duty trucking companies (Klemick et al. 2014).

As a first step to consider this hypothesis in the supermarket refrigeration sector, we examine how informed participants are about their energy and refrigerant use. The ability of firms to quantify their current energy and refrigerant consumption at existing stores could affect their ability to assess new technologies. An econometric analysis of German commercial and service industries found that lack of information about energy consumption was one of the most pervasive barriers to energy efficiency (Schleich and Gruber 2008).

Table 4: Participants' energy and refrigerant monitoring

| | | Number of participants | % ^A |
|--|----------------------------------|------------------------|----------------|
| Track energy use: | Yes | 39 | 89% |
| Track refrigerant use: | Yes | 34 | 77% |
| Third-party energy audit: | Yes | 23 | 52% |
| Average refrigerant leak rate (percent): | 0-15% | 8 | 18% |
| | 16-25% | 2 | 5% |
| | Not reported in percentage terms | 4 | 9% |
| | No response/not sure | 30 | 68% |

^A Percentage based on total number of participants.

Table 4 reports summary statistics for energy and refrigerant tracking among interview and focus group participants. It indicates that most, but not all, participants routinely track both refrigerant and electricity use (typically at the individual store level), though energy is monitored more widely than refrigerant use. About half of participants had an energy audit conducted by a government or third-party provider in the past several years,²⁰ though a few participants mentioned that they conducted audits internally instead.

While our small and non-random sample limits us from making statistical inferences about the characteristics of stores that are more likely to track energy and refrigerant use, it is worth noting that these trends vary by firm size. Among our sample of participants, larger companies are somewhat more likely than medium-sized or smaller companies to track energy and refrigerant use. However, a higher

²⁰ According to EnerNOC, an energy audit is an "analysis of energy usage within a building or facility and its contained equipment....Audits include comprehensive lists of energy efficiency measures derived from building and facility performance [and] ...financial analysis for each identified measure. Energy audits can use information from building management systems with the goal of reducing energy usage without negatively impacting the company's everyday practices." See <http://www.enernoc.com/our-resources/term-pages/what-is-an-energy-audit>.

percentage of small firms have had a third party energy audit compared to medium or large firms.²¹ While initially surprising, it may simply be an indication of staffing constraints if small firms have less ability to carry out audits internally.

While most firms in our sample track electricity and refrigerant use, the majority of participants could not report data on average store electricity consumption or refrigerant leak rates when asked on the study questionnaire. Interviewees—who had the opportunity to consult their records when completing the questionnaire, rather than having to rely solely on recall like focus group participants—were more likely to report this information, as were GreenChill partners. Leak rates among reporting participants typically fell well below the industry average of 25% and were closer to the GreenChill partner average of 13% (US EPA 2011b). This result is not surprising given that nine of the fifteen participants reporting leak rates are GreenChill partners.

A few participants noted that store-level tracking of these metrics, while important, is not sufficient to assess the performance of new technologies. One participant explained that, *“There’s so many other things going on in the store, it’s hard to then verify, unless you suddenly spend all this money trying to sub-meter everything.... you’ve got other lights, parking lot lights, fuel stations, ovens, and so many other things going on, it’s hard to measure what impact [a new refrigeration technology] had”* (FG#1 MD). Other supermarkets made investments in more sophisticated tracking systems. One interviewee noted that, *“We monitor all of the energy use down to each store level, sometimes even further into a sub-meter, sometimes to different technologies in the stores.”* (INT#6 LG N-ANOM) Even small companies found that, *“...computers now have the ability to dial out and give you an alarm on your cell phone when there’s a problem, or get the information through a laptop that you can look at and see what’s going on – know if there’s a door open, know if you’ve got somebody who’s got a leak in a case.”* (FG#2 SM) The relatively high prevalence of third-party energy audits among participants, particularly small and medium-sized firms, may also indicate a desire to obtain information on opportunities for reducing energy consumption that is store-specific.

While technologies are available to monitor the energy or refrigerant performance of refrigeration technologies once installed, supermarkets still face the challenge of gathering reliable information about new and emerging technologies that they have not yet tried. We asked study participants about the sources they use and trust when deciding whether to invest in a new technology. Table 5 summarizes the results of these discussions, breaking out responses by company size and mode of data collection.

Information sources mentioned as useful in over half of the interviews and focus group discussions included suppliers/manufacturers, peers, in-house testing, conferences and trade associations, installation and maintenance contractors, and wholesalers or large chains. While

²¹ Seventy-nine percent of 14 small firms, 86 percent of 14 medium firms, and 100 percent of 16 large firms track electricity use, while 57 percent of 14 small firms, 79 percent of 14 medium firms, and 94 percent of 16 large firms track refrigerant use. Sixty-four percent of 14 small firms, 36 percent of 14 medium firms, and 56 percent of 16 large firms have had a third-party energy audit.

suppliers/manufacturers were mentioned most often, participants noted that the information they offer typically is not viewed as definitive. A focus group participant said that, “You expect the manufacturer to provide you with something, and you take it with a grain of salt.” (FG#1 MD)

This skepticism is driven in part by the high degree of heterogeneity across stores, as noted by a participant: “I wouldn’t say there’s any intentful [sic] deception, but refrigeration is very location-specific, as far as what’s going to work. [Manufacturers] advertise a certain capability at a certain set of conditions, and if you happen to be there it works as advertised, but in my case that very seldom happens. It’s good baseline information, but you have to really extrapolate [from it].” (FG#4 LG) Once they obtain basic information from manufacturers, many supermarkets conduct their own in-house testing, as explained by an interviewee: “We’ll get numbers from our vendors. We’ll test for ourselves. Get our own numbers. It’s really our own testing and comparisons that help to drive a decision.” (INT#1 LG) Despite this heterogeneity, many participants viewed information from peers at other supermarket chains as very reliable. One participant stated, “We get a lot of information from our friends in the business, how it worked for them, and would you do it again. And when they say ‘I wouldn’t do it again,’ we definitely don’t do it.” (FG#2 SM)

Table 5. Information sources supermarkets use and trust to gather information about new technologies

| Information sources | Small firms | | Medium firms | | Large firms | |
|--------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| | FG* (2 total) | Int (1 total) | FG* (3 total) | Int (0 total) | FG* (1 total) | Int (7 total) |
| Suppliers/manufacturers | 2/2 | 1/1 | 3/3 | - | 1/1 | 7/7 |
| Peers | 2/2 | 1/1 | 3/3 | - | 1/1 | 5/7 |
| In-house testing | 1/2 | 0/1 | 3/3 | - | 1/1 | 7/7 |
| Conferences & trade associations | 2/2 | 1/1 | 2/3 | - | 1/1 | 5/7 |
| Installation/maintenance contractors | 2/2 | 1/1 | 3/3 | - | 1/1 | 3/7 |
| Wholesalers/larger chains | 2/2 | 1/1 | 3/3 | - | 0/1 | 2/7 |
| Regulators/government/GreenChill | 0/2 | 1/1 | 1/3 | - | 0/1 | 4/7 |
| Trade publications | 2/2 | 1/1 | 1/3 | - | 0/1 | 1/7 |
| Utilities | 2/2 | 0/1 | 1/3 | - | 0/1 | 0/7 |

*Because the views expressed during the focus group discussions could not be attributed to individual participants, each focus group is counted as a single observation for purposes of tabulating results.

Sources mentioned less often include regulators or government, trade publications, and utilities. As with the other information sources mentioned above, these resources are often viewed as a complement to information provided by manufacturers. One focus group participant typically asked, “Is there any independent information outside of the actual manufacturer, whether it be a utility company that has done the study, or California Energy Group, or EPA, or somebody that said, ‘Hey, we tested the doors on the cases and, yes, your load went down 50% on that rack?’” (FG#1 MD) Energy Star, GreenChill, and the Department of Energy all came up as useful information sources, though it is worth noting that they

were highlighted by all of the non-anonymous GreenChill partner interviewees, so this result may be somewhat biased by the mode of data collection.

Table 5 suggests that companies of different sizes rely on different strategies to gather information about new technologies. In-house testing is important for medium and larger firms but used less by small firms, who may lack the resources to implement their own tests. Rather, small firms rely more heavily on conferences and trade associations, contractors, trade publications, and utilities than larger firms. However, participants expressed mixed views about the reliability of information from contractors; they value their hands-on experience but find that contractors are not always familiar with emerging technologies (FG#4 SM; FG#2 SM).

Small and medium-sized firms often look to developments at the largest chain stores to learn about new technologies. A medium-sized firm explained, *“If you’re a major couple-hundred-store player, you’re willing to try some new things.... I will go to [a peer at a larger company] and say, ‘Well, okay, that’s great. I’m glad you’re doing this new. Tell me about what’s worked, because we don’t invest as often as you do.’”* (FG#3 MD) This is perhaps not surprising given that the supermarket industry is highly concentrated, with the top five chains accounting for more than 80 percent of sales (authors calculations using FMI data²²). Furthermore, the wholesalers who supply smaller firms with both food inventory and refrigeration equipment are sometimes owned by the same parent companies as large retail supermarket chains (Navigant Consulting 2009).²³ Wholesalers disseminate information from in-house testing in their retail operations (or the retail operations of their other clients) throughout the industry. A small firm elaborated that, *“The wholesaler that has chain stores and independent stores, they actually have in-house engineers, refrigeration engineers and all that, along with our refrigeration companies, so we look at their advice because they have a lot of stores....”* (FG#6 SM)

Large firms acknowledged their role in generating information used throughout the industry. A representative from a national chain noted that sharing information can benefit their operations if adoption of a new technology becomes widespread enough to drive down installation costs (INT#8, LG N-ANOM). Another participant highlighted the contrast between large and medium firms: *“In a previous position, I worked for a company that’s global. And we tried all kinds of things, but we were not only trying it for our company, we were also trying it for sister companies. But in my role now with over 100 stores, you just can’t afford to make mistakes.”* (FG#5 MD)

The dissemination of information from large supermarket chains throughout the industry suggests that there are learning-by-using externalities in the adoption of refrigeration technologies, creating the scope for market failure leading to sub-optimal levels of investment. At the same time, the supermarket industry displays the characteristics of a “privileged group”—when at least one individual provides a

²² Information on industry and company revenues can be found at <http://supermarketnews.com/2014-top-75-clickable-list> and <http://www.fmi.org/research-resources/supermarket-facts>

²³ For example, Supervalu runs the third-largest grocery wholesale operation in the United States and, until 2013, was also one of the top ten food retailers, operating stores under banners such as Cub Foods, Shoppers, Save-a-Lot, and formerly, Alberton’s, Acme, Shaw’s, and Jewel (Hughlett 2013).

public good because the private benefits outweigh the costs, leading to beneficial spillovers for others in the group (Olson 1965). While the public good may still be underprovided relative to the socially optimal level, the existence of privileged groups has been noted as a partial solution to public goods provision.

Overall, participants offered mixed perspectives about the degree to which imperfect information about new technologies poses a barrier to adoption. Some firms felt that they were able to obtain reliable data to make informed decisions. Others lacked the in-house expertise to evaluate the available information, as illustrated by a medium-sized company: *“Everybody is doing all these different things. You wonder, what’s the supermarket standard? It’s all over the map, which makes it difficult to figure out what [we] should be doing. It sounds like a lot of the systems have different advantages associated with them, and I don’t have the expertise to know what’s best.”* (FG#1 MD)

Several participants noted a trend in the industry towards improved technology options and information in recent years, saying, for example, *“...it’s far more predictable now than it was five years ago. You know you’re going to get energy savings”* (FG#4 SM), and *“It’s probably easier today to get information than it’s ever been. I’ve been around this stuff for 20-plus years and it’s never been this easy.”* (INT#3 LG) However, the diversity of technology options and heterogeneity in store conditions still means that collecting and assessing this information poses a transaction cost to firms, as illustrated by a smaller firm that noted, *“The information is out there; you have to be disciplined and decide when you’re going to go research that.”* (FG#2 SM)

Split incentives

The number of individuals potentially involved in design, upgrade, and maintenance and repair decisions for a supermarket refrigeration system leaves open the possibility of split incentives at various points in the decision-making process. Split incentives can occur when the person that makes capital investment, use, or maintenance decisions for a supermarket’s refrigeration system does not pay the energy or refrigerant costs. A commonly discussed source of split incentives in commercial buildings is when the landlord maintains and upgrades building equipment, but the tenant decides how much energy to use. For a supermarket, split incentives may also occur when workers leave refrigerator doors open or overload display cases, negating energy savings. The result in both instances is commonly recognized in the economics literature as a market failure (Jaffe and Stavins 1994; Gillingham et al. 2009).

In this section, we discuss evidence of three possible split incentive problems for supermarket refrigeration investments: between the supermarket that leases its space and the landowner renting them that space; between the company/store paying for the investment and the contractor installing, repairing, or maintaining the refrigeration system; and between store management who pays the energy bills and the workers who use the refrigeration technology day-to-day.²⁴ We do not classify the

²⁴ Another possible source of split incentives is between the original investor and a second hand buyer of the equipment in the resale market. However, few of our focus group and interview participants buy or sell refrigeration equipment in the resale market. While some participants sometime sell cases into other markets (e.g., to small neighborhood stores), they pointed out that most cases do not have much resale value. One participant stated that they *“usually pay people to haul it out.”* (FG#6, SM) Another participant agreed, saying *“when we’re done with it, it is flat used up. We strip every case down to the copper”* to recycle (FG#4, LG). Buying

potential for company-store miscommunication or a decentralized decision making process within the company as a split incentive, since presumably store and company management share the objective of maximizing store profits. However, it is still possible that organizational inefficiencies interfere with this objective due to behavioral anomalies, which are discussed in a separate section.

Landlord – Tenant Relationship

In the supermarket industry, most major chains lease well over 60 percent of their retail space (Latella 2006). However, unlike many other types of commercial building space, even in leased stores refrigeration system equipment is purchased and maintained by the supermarket rather than the building owner, which minimizes the potential for this type of split incentive. Many companies in our sample have long-term leases (5-7 years) for their stores. Participants in one focus group and three interviews did not mention landlord-tenant relationships. Of those that did, all agreed that in general leasing does not affect refrigeration system investment decisions. A subset of these participants noted, however, that if the store is nearing the end of its lease then it is less likely that they will make a major investment. *“As far as leasing goes, it depends how long you’re planning on being at that location. If you’re planning on leaving, you’re not going to put a bunch of new stuff in there.” (FG#6, SM)* One interviewee noted that when investing in new long lived equipment it may make sense to renegotiate for a longer lease.

Store-Contractor Relationship

Almost all focus group and interview participants—as well as the supplier we interviewed—agreed that, ultimately, the decision of whether to upgrade a piece of equipment or major component of a store’s refrigeration system is up to store or company management. That said, there appears to be the potential for split incentives for many participants. While some participants indicated that they made decisions with very little or no input from contractors, others relied heavily on contractor advice when making these decisions. The supplier we interviewed confirmed that the degree to which a supermarket relies on contractors for advice varies across companies.

Figure 2 presents information on the extent to which participants rely on contractors versus in-house technicians for installation, maintenance, and repair of key components of supermarket refrigeration systems. These activities play a large role in determining the system’s energy consumption and refrigerant leakage. Firms can rely entirely on contractors, entirely on in-house technicians, or use a mix of both. We find that the potential for split incentives between management and contractors exists for focus group and interview participants of all sizes. This is particularly true when installing new equipment, where participating firms tended to rely more heavily on contractor support. The supplier we interviewed confirmed that he is not aware of many companies that have their own in-house installation services.

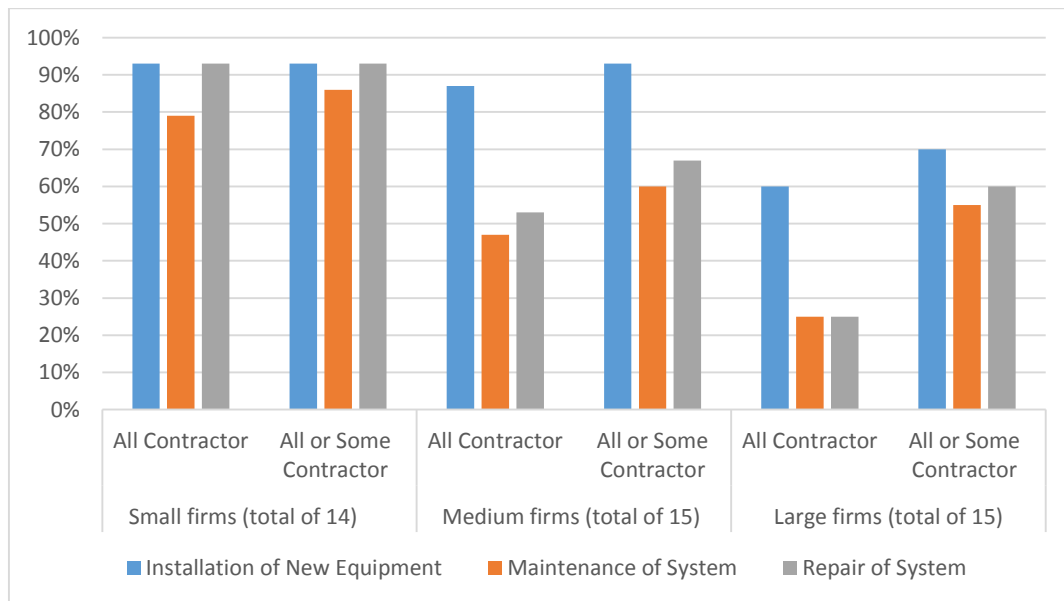
With regard to maintenance and repair, the vast majority of small firms relied entirely on contractors. While about half of the medium-sized firms also only used contractors, the remainder mainly used in-house staff for maintenance and repairs. Only about 25 percent of large firms relied entirely on contractors for repairs, though another 30-35 percent used some contractor support along with their

used cases was even rarer among participants. Most were reticent to do so, given the age of the equipment, though a few companies reuse their own cases (FG#5, MD).

own in-house technicians. The supplier we interviewed agreed that larger firms tend to have in-house technician teams while small firms may not.

Most participants appeared to trust their technicians’ judgement, whether in-house or contractor. One person brought the contractor along when spec’ing new equipment; others used in-house staff to help interpret data or information from the manufacturer for a new piece of equipment. As one small company put it, they rely on *“the guy with the dirty hands who knows a heck of a lot more about it than we do...we make the decision, but they help us.”* (FG#6, SM) As noted previously, small and medium firms frequently mentioned contractors as a valuable source of information about new technologies, while larger firms were less likely to do so. Some participants also noted that contractors may be less pro-active about recommending new technologies if they are unfamiliar with how to maintain them. One participant explained that, *“... my local contractor, I’m reluctant to go to him for advice because I don’t think he has kept up on [new technologies].”* (FG#2, SM)

Figure 2. Whether Participants Contract Out Servicing of Refrigeration System



Participants also noted several strategies that could at least partly mitigate some split incentive problems. For instance, participants noted the importance of working with the same contractor over time to build a relationship. *“We’ve got a company that we’ve used for the last 15 years, and they’re reliable and they take care of us.”* (FG#2, SM) In addition, some participants mentioned that if the contractors know the store’s priorities then they are more likely to look out for equipment that can improve its energy consumption. One participant also mentioned that their company relies on close management oversight of contractor activities: *“If I think [the contractor] charged us too much for a refrigerant, I’ll give them a call and say, ‘Hey, by the way, you charged us twice as much for R22 as anybody else would.’ And just let them know we’re watching.”* (INT#3, LG)

Participants in a few focus groups and interviews commented on how contract structure can affect the degree to which contractors proactively identify repairs and engage in preventative maintenance that could reduce energy use or refrigerant emissions (FG#6, SM; INT#5, LG; INT#7 SM, N-ANOM). In cases where a supermarket pays a flat fee per month for maintenance and repair, whether something breaks or not, there may be a disincentive for the contractor to aggressively address maintenance issues. As one participant put it, you hope *“that your repairs [are] higher than the flat rate you are paying ... We have found that we are usually on the shorter end of that stick.”* (INT#7 SM, N-ANOM) An alternative used by both interviewees is a contract that specifies that the contractor comes to the store on a regular basis for a specified number of hours. This allows the supermarket to save money by addressing less time-sensitive problems during the visit, which ultimately reduces emergency calls (that charge a higher rate for time and materials). One participant stated they want the contractor to visit the stores *“on a monthly or an every-other-week basis to make sure that they do some preventive maintenance.”* (INT#5, LG) This type of contract may still include a flat fee for certain types of repairs and/or preventative maintenance, but it also may specify time and materials rates for more significant problems (FG#6, SM).

It is also possible to build explicit system performance metrics or the cost of replacement refrigerant into the contract, which would incentivize the contractor to proactively reduce refrigerant leaks. One interviewee mentioned that they hold the contractor responsible for refrigerant, while a focus group participant mentioned that his company may switch to a new contractor who covers refrigerant costs as part of the service agreement (FG#6 SM). However, the supplier we interviewed stated that *“Refrigerant...is typically not covered [by the contract] because there are so many variables. The leak could occur in the piping that was installed in the field, the operations group, a stocking individual or somebody in the store operations could have bumped into something with a forklift ...It’s outside of the control of the equipment manufacturer, so [refrigerant is replaced using either] time or materials or a per pound price.”* (INT-SUPPL) Likewise, the cost of energy is not paid by the contractor. Thus, to the extent that contractor actions result in refrigerant leaks or additional energy use, these costs are typically borne by the supermarket, not the contractor.

A number of participants also mentioned the need to carefully monitor installation of new equipment. Some specified performance requirements that must be met after installation; others brought in a third party verifier once installation was completed. One participant leveraged their long-term relationship with the contractor to incentivize better performance: *“We let contractors know we’re only as good as the worst pipe fitter on this job. If you have a bad day, you’re going to give us years of bad days with the leaks if you can’t braze a joint appropriately. We also let them know that, ‘Hey, we’re going to track the service on these stores for leaks and if we have a lot of issues, we don’t ever want you in our store again brazing pipe.’”* (INT#3, LG)

Among participants the preference for in-house staff versus contractors to maintain or repair existing refrigeration equipment was mixed. Some preferred in-house staff because they are more familiar with the equipment and know when something is not working properly, which also means they can focus more on preventative maintenance. However, some noted that finding and keeping a qualified in-house technician is difficult. *“I think we’d prefer to have in-house people everywhere. It’s a challenge ... because there aren’t a whole lot of people that are qualified and interested in that line of work these days.”* (INT#2, LG) The supplier we interviewed also suggested, *“because they have their own in-house people, they can train those people to service and maintain their own equipment,... versus an outside company that may be looking to get the job done as soon as possible.”* (INT-SUPPL)

There appears to be the potential for split incentives in maintenance decisions, particularly in the short run. Some stores allow the contractor to decide when to fix things, particularly in an emergency situation. *"[If] the store reported a problem and ... the contractor gets there and determines that he needs to make a repair right away, then we trust him and we make the repair right away."* (INT#2, LG) However, for *"anything that can wait a day or two, they'll consult with the supervisor that's responsible for that store and they'll decide jointly."* (INT#2, LG) In other cases, the store manager makes the final repair decision even when relying entirely on contractors.

Some participants had monitoring systems that notify the contractor when there is a problem, which prompts the contractor to call and identify an approach to fixing it. Others maintain specific maintenance schedules: *"I pay my refrigeration guy so much money a month and he has to fix everything, and then he's required to do a monthly inspection, which is a two-page checklist inspecting the entire system, including cleaning condensers."* (FG#2, SM) Sometimes, the company also monitors whether each store is getting what they should from the contractor.

Store -Worker Relationships

Split incentives between firms making investments to reduce energy use or refrigerant leaks and workers that undercut those savings when using the equipment was recognized as a common problem among participants. One participant described a common situation with walk-in coolers: *"Usually, [workers] are going in and out of that door and they are usually stocking so their hands are full and it's harder for them to open the door. So it's human nature to prop that door open. And when you do that, you are thinking, 'well, I'm coming right back' but then the customer calls and their priorities change and the door is standing wide open."* (INT#7 LG, N-ANOM)

Recognizing these split incentives, participants used a variety of strategies to try to motivate store workers to reduce energy use or refrigerant leaks. Some invested in training, letting workers know the impact of leaving doors open or overloading cases, for example. However, because of the frequency of staff turnover, stores often have to continue to train workers to avoid problems arising anew. Others offer rewards or tie raises to reducing energy use or refrigerant leaks at a store: *"Some of our biggest energy savings have been because of getting our [workers] involved in the process... we have a little reward system for stores who show the most energy reductions. It builds some bonding, some purpose, and it really drives energy usage down."* (FG#3, MD)

Technology also plays a role in mitigating some of the effects of split incentives (FG#1, MD; FG#5, MD; FG#6, SM; INT#4, LG; INT#6 LG, N-ANOM; INT#7 SM, N-ANOM). Some companies invest in monitoring technology or automatic controls, which then indicate whether they have a problem that needs to be addressed, though training is still important with these systems: *"If an operator is doing something that is going to cause them to use more energy, and a good example of this is leaving freezer doors open for walk-in coolers, then we have alarms in place that notifies them to shut the doors... and if we see this is a continued problem, then the store directors can take some remedial action to make sure the people are trained on the impact of those things."* (INT#6 LG, N-ANOM) Other participants stated that they avoid certain energy saving technologies if they are easy to misuse (e.g., night blinds).

Capital or liquidity constraints

Capital or liquidity constraints represent a potential market failure that could contribute to limited adoption of technologies expected to “pay for themselves” in reduced future operating costs if individuals or firms cannot obtain sufficient funds to cover the higher upfront cost (Gillingham et al. 2009). As discussed in section III, participants in our sample considered upfront cost to be one of the most important factors affecting refrigeration technology investment decisions. While participants varied in their use of cash or external financing for major investments, the majority did not feel that access to financing was a barrier to energy-saving investments as long as the technology was otherwise attractive and met the firm’s payback or ROI requirements. One interviewee explained, *“We have a relatively low cost of money internally. It’s not like we have to go out and finance to make or break a deal. If it was attractive enough, I’m sure that our accountants would jump on it.”* (INT#3 LG)

However, participants in two focus groups and two interviews (FG#3 MD, FG#6 SM, INT#4 LG, INT#7 SM N-ANOM) mentioned access to capital as a barrier to new investments. In particular, a small chain noted that during the 2008-2010 recession, *“The bank wouldn’t give you any money... For two or three years it was very difficult, so that obviously affected what you were going to buy. You had to do it out of cash flow.”* (INT#7 SM N-ANOM) Another small company noted that financial constraints may inhibit investment in new equipment due to staff retention concerns: *“If I’ve just told half the staff there’s no raises because [times] are tough, and then I bring in ...all kinds of new equipment..., the staff is not going to accept that as well when they’re having trouble making ends meet. And, I’m only as good as my staff on the floor.”* (FG#6 SM) The refrigeration supplier we interviewed confirmed that financing can be a barrier to more costly investments for some companies, especially small independently owned firms.

Participants also discussed rebates available from utilities or government programs as a way of easing capital constraints or simply making energy-saving investments more attractive in terms of payback time or ROI. Participants in every focus group and interview mentioned rebates, and many characterized them as a major factor in tipping the scales toward adopting an energy-saving technology. One manager said, *“We always look for rebates when it comes to energy efficiency projects, and often those rebates impact the financials in such a way that it’s a ‘go’ with the rebate, and if for some reason you can’t get the rebate, it’s a ‘no go.’”* (INT#4 LG) Another large chain mentioned that they often roll out energy-saving investments first in states with the most attractive rebate programs (INT#8 LG N-ANOM). These experiences suggest that even though some supermarkets face capital constraints that limit investments in energy-efficient equipment, government and utility subsidies are an effective approach for encouraging adoption in this sector.

V. Evidence of Behavioral and Organizational Inefficiencies

Another possible contributor to the energy-efficiency paradox is the presence of behavioral anomalies or organizational inefficiencies that act as barriers to adoption of energy or refrigerant-reducing refrigeration system technologies. Table 6 presents illustrative quotations from the focus groups and interviews related to potential inefficiencies in company-level decision making, and behavioral anomalies related to loss aversion, inattention, and bounded rationality. We find limited evidence of

organizational inefficiencies within our sample, with the possible exception of budget allocation decisions. Likewise, while we did not find evidence of widespread behavioral anomalies, participants in some of the focus groups expressed views consistent with loss aversion and bounded rationality. We discuss our findings for each of these behavioral hypotheses below.

Table 6. Behavioral Anomaly Hypotheses

| Potential barrier to investment | Sample quotations |
|---------------------------------|---|
| Organizational inefficiencies | <p><i>“Almost everybody here has at least three, maybe even five hats, and so they made me the sustainability guy and the refrigeration guy.” (INT#7 SM N-ANOM)</i></p> <p><i>“Operations typically drives the bus because, obviously, the business is to sell groceries so we’ve got to make sure that the case displays and the things they want are there, and then it’s up to us to try to drive as much efficiency as we possibly can.” (INT#5 LG)</i></p> |
| Loss aversion | <p><i>“In my role now with over 100 stores, you just can’t afford to make mistakes. You can’t even afford to make the wrong investment decisions.” (FG#3 MD)</i></p> |
| Inattention and heuristics | <p><i>“I don’t do any detailed analysis of anything. I just use common sense and consider every factor— everything that’s going to be good about the decision and anything that’s going to be negative, which is the cost.” (FG#2 SM)</i></p> |

Organizational Inefficiencies and Company-Level Decision Making

It is possible that departments within a company that have been assigned different responsibilities (e.g., a sales department, an engineering and operations department, and an accounting department that pays electricity costs) do not communicate effectively and as a result make investment decisions that are not necessarily in the best interest of the firm. Because these divisions operate within the same company, however, we hesitate to label such inefficiencies a market failure in the classic sense. However, they can still interfere with a company’s ability to maximize profits or minimize costs. In general, we heard little from focus group or interview participants to suggest organizational inefficiencies that undercut the profit incentive. However, the supplier we interviewed stated that in his experience working with supermarkets, different departments within the company often have their own budgets and competing priorities, so getting them to work across these departments to fund a project has sometimes been a barrier to investment in the refrigeration system.

Medium and large companies varied in the degree to which they gave their individual stores autonomy to make decisions about upgrades and maintenance to refrigeration systems, though major decisions with significant energy implications were often centrally managed. In cases where stores were granted some degree of autonomy, the company often tried to raise awareness: *“We have folks that are monitoring our stores and taking a look at it from the energy side, and then will reach out to me and say,*

'Hey, this is what we're finding in Store x, and these are the suggested changes that we're going to make.' (INT#5, LG) Another interviewee also described active company-store communication and oversight: *"I'll shoot those guys an email if we have some group leak reduction goals in place and I want to make sure that they're aware of it...And we also review their bills."* (INT#3, LG)

Participants from medium and larger companies also indicated that while they have different departments tasked with maintenance, utility payments, engineering, sustainability, etc., decision making is typically coordinated across these groups for new store designs or major upgrades of refrigeration systems. Sometimes this is done through an explicit mechanism such as reporting to the same company executive or a coordinating team with representation from each department to focus on longer run or big picture issues: *"You've got the energy folks [looking] over the energy bill. The facilities folks and the maintenance folks, they're looking at the maintenance expense. You've got the sustainability folks looking at emission activities. Usually we'd have one broader group, a store development type group, that can be accountable for all those parts..."* (FG#4, LG) Some companies even have cross-department teams that meet regularly to specifically discuss energy issues. *"Each month or two we meet with a team of folks and we entertain new ideas ... that might involve improving energy efficiency, reducing maintenance expenses, weaning ourselves off of HFC refrigerants and HCFC refrigerants."* (INT#2, LG)

A number of participants pointed out to us that cross-department coordination doesn't mean that individuals hold similar opinions on whether a particular technology is a worthwhile investment. A proponent of the investment on energy efficiency grounds may still have to convince others that the investment will not hurt sales or will improve product quality. *"In this business probably more than half the time stuff comes up because some executive thinks it's cheaper to do it another way, and they may be right that it's cheaper upfront, but maybe it's not cheaper in the long run. So we try to be diligent about that and I'm not afraid to tell a senior executive they're wrong. Tell them why, even though it costs less upfront, it's probably not a good deal down the road. We have a team of investment analysis people that can back us up with that."* (INT#2, LG)

Focus groups and interviews with smaller companies generally did not mention cross-company coordination. Instead they pointed out that the same person may pay the electricity bills, make decisions about maintenance, and address sustainability issues. In the words of one participant, *"I am the energy committee. I wear many hats."* (FG#3, MD)

One area where the potential for some disconnect in decision making was acknowledged was in the budget allocation decision for building a new store. Typically, the budget for the entire project is decided based on default assumptions. Only after this decision is made is some amount allocated for refrigeration. However, if the refrigeration design team is interested in a more energy-efficient technology that costs more than the default, they may have to lobby for more funds. But even here, the ability to circle back and discuss whether the investment in energy efficiency is worthwhile may make disconnects less likely.

Loss aversion, inattention, and bounded rationality

Loss aversion or status quo bias is a behavioral pattern that occurs when individuals put greater weight on losses than on gains of an equivalent value when assessing risky options relative to the status quo). This behavior generates results inconsistent with rational utility- or profit-maximization (Tversky and

Kahneman 1992). Loss aversion has been documented among individual consumers (Gerarden et al. 2015), though some evidence suggests that market experience and competition can minimize such behavior among firms (List 2003; List 2004; Shogren and Taylor 2008).

A few participants in five of the focus groups (FG#1, MD; FG#3, MD; FG#4, LG; FG#5, MD; FG#6, SM) discussed investment behavior consistent with loss aversion, evidenced by a particular concern with downside risk. For instance, one participant explained, *"...if [a technology is] still relatively new, I want to assess what's the risk of bad, bad things happening if I do this."* (FG#1, MD) Another participant related this concern to company size: *"...with smaller chains, you don't have as much room for error. You can't make many mistakes because they can have a devastating effect on your company."* (FG#5, MD) Concern about downside risk in particular was not raised in any of the interviews, most of which were with large companies.

Another behavioral anomaly sometimes raised in the energy-efficiency paradox literature for individual consumers is lack of attention to future energy savings when making a purchase decision (Gerarden et al. 2015). If consumers have limited cognitive capacity or attention span and prioritize upfront cost and other product attributes besides energy costs, then they are likely to underinvest in technologies that pay off only after a few years of operation. At the same time, a certain degree of inattention to energy efficiency could be rational given sufficiently high transaction costs of gathering information or sufficiently low returns from precisely optimizing energy efficiency (Sallee 2013).

This logic also could apply to firm, not just household, investment decisions, particularly since energy and refrigerant comprise a relatively small share of supermarkets' budgets (even though the costs can be high in absolute terms). However, we find little evidence of inattention to energy efficiency among our sample of participating supermarkets, particularly regarding their recent investments. One participant said, *"You have to understand that energy is close to 50%, for the refrigeration systems alone, of our utility bill. So it's definitely high on our radar."* (FG#4, LG) Another noted that, *"... the manufacturers of this equipment now know that every supermarket company cares about energy.... We're not going to buy stuff without thinking about it or looking at the energy data."* (INT#2, LG) A different interviewee noted that attention to energy efficiency has improved in recent years due to better information, explaining that, *"For a long time, the before and after energy use for a remodel was in the weeds and [there] really wasn't a lot of thought put in there.... Now it is more structured, and it's there with some backing that shows if we say you are going to get these savings you, you do indeed get that savings."* (INT#6 LG, N-ANOM)

Participants' statements suggest that attention to refrigerant use has lagged behind energy efficiency and has only become salient quite recently. A participant explained, *"We've been doing energy efficiency stuff for 20 plus years... we're just starting the game of managing refrigerant emissions from a greenhouse gas perspective. There's a lot more to be gained, a lot more to be learned."* (INT#2, LG) An interviewee participating in the GreenChill program admitted that when his company first joined, they did not even know what a leak rate was (INT#7 SM, N-ANOM). However, as refrigerant gas replacement costs have risen due to regulatory requirements, finances have made conservation more of a priority. As one participant put it, *"The mindset used to be refrigeration leaks weren't that big a deal. In today's world, for us now, it's hundreds of thousands of dollars."* (FG#1, MD)

A related behavioral anomaly is bounded rationality or heuristic decision-making, which occurs when consumers or decision makers within the firm use simplified rules of thumb when making investment

decisions to avoid the cognitive burden of more complex calculations. Using rules of thumb may or may not lead to mistakes in decision making. When based on a wealth of experience, they can sometimes serve as credible substitutes for more time-consuming processes. Larger supermarket chains in our sample show little evidence that their investments are determined by such rules of thumb, as seen in their discussion of payback and return-on-investment calculations. Participants from large companies explained that *“When I think of lifecycle costs and total cost of ownership, they are the same thing. And energy is a component of that, as well as initial cost, as well as maintenance”* (FG#4, LG), and *“We’re running a for-profit business here, and lifecycle cost is pretty much always applicable.”* (INT#2, LG)

Participants from smaller chains displayed more variability in the sophistication of their investment decisions. A participant from a small firm suggested that, *“You may get different answers to these questions when you go to chain stores and somebody is making decisions for the stockholders...He’s going to analyze it, he’s going to put a pencil to it, he’s going to show the ROI because he has to explain that to somebody else who doesn’t own that store.”* (FG#2, SM) Others in the same focus group clarified that they would not use a spreadsheet for investments of a few thousand dollars, but they would conduct more analysis for technologies costing upwards of \$10,000, a practice that could be consistent with “rational inattention” to energy efficiency.

VI. Evidence of Other Factors Not Accounted for in NPV Calculations

Focus group and interview participants also described a number of barriers to adopting new fuel-saving technologies that do not constitute market failures or behavioral anomalies as typically defined by economists. These factors include tradeoffs between energy efficiency and other attributes such as customer appeal, reliability or maintenance, and refrigerant emissions; regulatory requirements that require particular investments; uncertainty, irreversibility and option value; and the opportunity cost of capital. While sometimes challenging to quantify for inclusion in a NPV calculation, these factors may make a new technology genuinely less attractive or more costly. Table 7 provides illustrative quotations from the focus groups and interviews on these issues.

Table 7: Hypotheses about other factors not accounted for by NPV calculations

| Potential barrier to investment | Sample quotations |
|-------------------------------------|--|
| Store-specific tradeoffs | <i>“Just look at the new technology with transcritical. You wouldn’t put it in Florida and you wouldn’t put it in Georgia. It’s all got to be up north of the Mason-Dixon line, basically. And you wouldn’t typically put evaporative condensers in Las Vegas, you’re not going to drop one in the middle of Minnesota.” (FG#4 LG)</i> |
| Tradeoffs – customer appeal | <i>“One of the reasons operators don’t want doors on the refrigerated cases is that they have this perception that it is going to hurt your sales because now someone has to open the door and they don’t have that impulse buy.... Our take is having doors on your cases provides a competitive advantage over someone who doesn’t because whatever is inside is going to be colder and at a more consistent temperature.” (INT#6 LG N-ANOM)</i> |
| Tradeoffs – maintenance/reliability | <i>“I’ve always felt that the equipment for use in a supermarket needs to be very easily serviced and very direct application. It can be a mistake to make it too complex.” (INT#8 LG N-ANOM)</i> |
| Energy-refrigerant tradeoffs | <i>“Especially when you’re looking at natural refrigerants with GWPs of 1 or even 0 in the case of ammonia, refrigerant emissions will trump energy efficiency every time.” (INT#2 LG)</i> |
| Refrigerant regulations | <i>“We used 407A [refrigerant] as a retrofit. We’ve chosen not to use it as a new refrigerant because if [regulators] decide in five years from now to treat it and 404A exactly the same, what was the point?” (FG#4 LG)</i> |
| Uncertainty and option value | <i>“We don’t mind being on the leading edge, we don’t want to be on the bleeding edge of things.... Six years ago, LED lights in frozen cases, it would be \$300 a door and the quality was terrible. Today, that same light probably costs \$110 and the quality is pretty darn good.” (INT#3 LG)</i> |
| Opportunity cost of capital | <i>“Do you need something more important to you at the time? If you have to borrow the money, what is the cost of money at the time?” (FG#6 SM)</i> |

Tradeoffs with Other Attributes

Store Specific Trade-Offs and Heterogeneity

Participants in all focus groups identified store-specific concerns as one of the top three factors they consider when upgrading a grocery store’s refrigeration system. Interviews were more mixed: Five of the interviews identified store-specific concerns as a top factor while two mentioned them as a relevant but not top factor.

Many participants mentioned that the configuration of the store—what can fit into the physical space and whether a piece of new equipment is compatible with the other components of the system—affects

the types of technologies they consider. As one participant gave an example, *“we may decide because of space requirements what we’re going to put in the back room... there’s one version [of a rack system] that [is] the size of a large refrigerator ... while another type of rack system might take up that whole wall.”* (FG#5, MD) Upgrades to existing stores are therefore more complicated than when building a new store and may preclude investment in some new technologies: *“We have to be a lot more flexible in our solutions for existing buildings... you have structural issues you’re dealing with, and those circumstances drive those decisions.”* (FG#4, LG)

Others focused more on a store’s location: ambient temperature, humidity, and elevation all affect the performance of the refrigeration system and may tilt investment decisions towards or away from particular technologies. Several participants also mentioned that electricity rates in a region may affect the degree to which they consider energy efficient technologies in particular. How often a store is upgraded is also affected by its sales volume; stores in rural areas tend to have fewer new technologies since there is less competition (INT#3, LG). They also often have serviceability concerns (i.e., there may not be technicians familiar with the new technologies to fix them if they break down).

While there was general agreement on their importance, four focus groups and three interviewees had mixed views on whether store-specific factors inhibit investments in energy- or refrigerant-reducing technologies. Two focus groups and four interviewees felt that they do, in fact, inhibit these types of investments. One interviewee did not identify trade-offs with store-specific factors as a concern. Temperature and humidity affect performance of certain technologies, which could be good or bad for energy efficiency or refrigerant use depending on the circumstances. Table 8 summarizes several examples raised by interview and focus group participants. For instance, some systems don’t work well in particular climates (e.g., transcritical CO₂ refrigerant systems); others aren’t really necessary in some conditions (e.g., anti-sweats; demand defrost). One interviewee also noted that because they are a big company with a lot of stores, they want to invest in technologies that work well across a spectrum of climates/stores to save money. This precludes consideration of some energy- or refrigerant-reducing technologies (INT#1, LG).

Table 8: Examples of Store-Specific Tradeoffs that Affect Energy and Refrigerant Savings

| Technology | Tradeoffs |
|--|---|
| Transcritical CO ₂ refrigerant systems | Do not work well in hot, humid climates |
| Display case anti-sweat heater controls | Help in humid climates but are not needed in dry ones |
| Evaporative condensers | Not necessary in hot climates |
| Misting systems (cool air before it gets to condenser) | Only make sense in hot climates |
| Night blinds | In a 24 hour store, cut off customer from product when the store is open but in areas that are susceptible to power outages, they reduce product waste. |
| Motion-activated lighting | May make sense in 24 hour store but if always busy may not result in savings |
| Doors on medium-temperature cases | May be space constraints due to aisle width |
| Hot gas defrost | Doesn't necessarily work well with other advanced technologies |

Regarding space and configuration constraints, some new technologies cannot fit within an existing store footprint (e.g., doors on cases). If a new technology requires changes in the configuration (for example, using a different refrigerant), installation costs also may increase substantially (FG#6, SM) or it may make maintenance of other components of the system more difficult. For instance, *“Sometimes it’s not convenient to place the condenser close enough to the rack if it’s on the sales floor because it might be in the middle of your parking area or you might have to go to the roof, which you may not want to do...Sometimes you make choices on placement based on factors other than just what gives you the lowest refrigerant charge.”* (FG#2, SM) On the other hand, replacing some components of the system may speed up replacement of other components because they are no longer compatible with the new system, which could lead to greater energy savings.

Tradeoffs – customer appeal

Customer appeal and related concerns like food quality were raised as important factors in refrigeration technology investments by participants in every focus group and interview. The purpose of a supermarket is to sell groceries; as one interviewee put it, *“Customer appeal and merchandising and operations are king in our world”* (INT#3, LG). Sales and customer perceptions are of particular importance for investments in display cases, the only major refrigeration system component that customers see. However, energy and refrigeration managers consider indirect impacts on sales—for instance, how certain technologies affect product freshness—when selecting “back of the store” refrigeration components as well.

Indeed, for many participants, impacts on sales typically trump energy efficiency or refrigerant emissions when making investment decisions. An interviewee from a small chain discussed prioritizing the aesthetic appeal of display cases, noting that, *“The energy savings would be the cherry on top, I guess; it would be nice but it wouldn’t be the make or break decision on why we would buy a case.”* (INT#7 SM, N-ANOM)

Despite the priority that managers place on customer appeal when selecting technologies, participants expressed mixed views about whether tradeoffs actually exist with energy efficiency or refrigerant reductions. On the contrary, newer technologies that improve energy efficiency or reduce refrigerant emissions also tend to improve product quality because they maintain a more consistent temperature over time—thus reducing spoilage and “shrinkage,” which occurs when product packaging expands and contracts with temperature fluctuations. Focus groups mentioned glycol secondary loop systems²⁵ and leak detection technology as examples of this synergy between emission reductions and product quality (FG#2, SM; FG#6, SM). Participants also discussed recent advances in the aesthetics of LED lighting in display cases that reduce energy consumption, improve the appearance of food, and avoid spoilage from the heat given off by conventional lightbulbs (FG#1 MD; FG#2 SM; FG#4 LG; FG#6 SM; INT#7 SM, N-ANOM).

The technology that best highlights the relationship between energy efficiency and customer appeal is doors on medium-temperature display cases. While doors on freezer cases have been the industry standard for decades, supermarkets have only recently begun to widely consider doors on refrigerated cases. The use of doors on medium-temperature cases was discussed in all six focus groups and seven out of eight interviews. All seven of these interviewees have begun to adopt refrigerated cases with doors in their stores. At least some participants in every focus group have also installed cases with doors, though others are only starting to consider them or have no plans to invest in the near future.

All participants who discussed doors on cases agree that they yield substantial energy savings. Industry studies have estimated energy savings of about 30 percent (Fricke and Becker 2010; Gary 2010). An interviewee remarked, *“You remember your grandparents told you to keep the door shut. Well, we lost our way over the last 20 years and we’re just getting back to putting doors back on these things again.”* (INT#2, LG) Participants have noticed benefits aside from energy savings as well; several asserted that doors on cases improve product freshness and longevity by maintaining consistent temperatures and enhance customer comfort by lessening the problem of “cold aisles.”

Where views differ is the ultimate impact of doors on product sales. The longstanding perception in the industry has been that doors discourage purchases—particularly impulse buys—by creating a barrier between the product and the customer (INT#6, LG N-ANON; INT#8, LG, N-ANON). A focus group participant explained, *“Years ago, the consensus was the customer wouldn’t take the time and energy to open that door; they were going to walk right by.”* (FG#2, SM) A few European supermarket chains have

²⁵ Secondary loop systems use two chemicals, a primary refrigerant (often an HFC) that circulates in the machine room, and a secondary fluid (typically with a much lower or zero GWP) that is cooled by the primary refrigerant and circulates throughout the store, resulting in drastically lower refrigerant emissions. Secondary loop systems had higher energy requirements than traditional systems in the past, though newer systems may not have an energy penalty (US EPA 2013).

rejected doors on cases for the time being due to concerns about the sales impact (Environmental Investigation Agency 2014). The US chain Supervalu stated publicly that a drop in sales of around two percent would offset the cost savings from doors on cases (Gary 2010).

Many of the energy and refrigeration managers in our study see doors on dairy cases as beneficial to the bottom line on balance due to a combination of energy savings, reduced spoilage, and customer comfort but have encountered skepticism from senior managers concerned that depressed revenues would outweigh cost savings. One interviewee summed up the debate by saying, *“We want to be able to merchandize the product in the fashion that will sell. And so we had to prove to our merchandisers that the doors would not be a barrier for the customers.”* (INT#8, LG, N-ANON) Skepticism has eroded in recent years as more large chains have rolled out doors and a few studies have estimated minimal impacts on sales.²⁶ For some chains, doors on new refrigerator cases have become standard, but retrofitting existing cases with a shorter remaining lifetime does not yield a high enough return to justify investment (INT#4, LG).

Adoption of doors has remained low on cases for particular products—in particular, fresh meat, beer, and wine—where managers expect more sizable sales impacts. A focus group participant explained, *“Now logically you’d think if someone wanted their beer, they would go and open the door, but it did have a significant effect.... We have not gone to the glass door concept on those because of the sales.”* (FG#3, MD) Large-scale publicly available studies examining the impact of refrigerator cases with doors on sales across different regions, store formats, and food products are lacking, making it difficult for chains to assess the tradeoffs quantitatively prior to adoption.

While experiences with doors on cases has been generally positive, participants highlighted a few energy-saving technologies with a perceived negative impact on customer appeal, such as strip curtains (FG#2 SM; INT#8 LG, N-ANOM). Some participants only used them in the back of the store where customers do not see them (FG#2, SM; FG#4, LG). A small chain described the issue by saying, *“It’s just not the sign I want to give to my customers. To me, I feel like those things get really dirty and we’re an upscale gourmet market”* (FG#4, SM). Customer demographics also came into play when stores assessed whether to pursue store certifications like GreenChill; one participant noted that they are more likely to pursue GreenChill certification for stores in high-income and eco-conscious neighborhoods (INT#6 LG, N-ANOM), while other participants expressed uncertainty about the ultimate impact of store certification on sales (FG#1, MD).

Tradeoffs – reliability/maintenance

Participants in all six focus groups and in five interviews ranked reliability among the top three factors when making a major upgrade to a store’s refrigeration system. They discussed reliability in terms of the amount of expected down time, availability of qualified technicians to service and operate the equipment, and access to parts if it is a unique piece of equipment.

²⁶ Studies by Fricke and Becker (2010) and Food Lion (Gary 2010) showed no significant decline in sales from installing doors on dairy and beer cases, but both studies examined only a small number of stores.

Many participants gave examples of specific technologies that are viewed as more energy efficient but are less reliable or require more maintenance than the current alternative, which undercuts the potential for net cost savings. For instance, one participant mentioned that variable speed drives (electronic control devices that adjust electric motor speed) *“create a maintenance issue when they fail or don’t work, and they’re rather expensive. You have to weigh the cost of keeping the variable speed drives operating versus what you save in energy. We haven’t convinced ourselves yet that that’s a good decision.”* (FG#3 MD) Participants in several focus groups and interviews also discussed new compressors in this context (FG#4, LG; FG#6, SM; INT#3, LG; INT#7 SM N-ANOM). One participant explained, *“I can be as energy-efficient as I want, but if I lose one compressor I just threw all that savings out the window.”* (FG#4 LG) The goal for many participants is a store that is *“100% running all the time with minimal breakdowns,”* (INT#5 LG) in which case they may invest very little to improve energy efficiency in those locations that are not experiencing problems.

A related issue is that retrofitting some components of an existing store’s refrigeration system may cause reliability and maintenance issues for other parts of the system. For instance, changing to a new refrigerant may result in additional costs to make an old system work properly or require investment in new equipment. A participant noted *“It’s not as easy as just picking the retrofit refrigerant, [like] moving from 22 to 407A. We’ve done some of that, and now we’re realizing that some pumps are incompatible.”* (FG#4 LG) Participants in several focus groups and interviews also mentioned that hot gas defrost, which used to be the industry standard for defrosting display case evaporators, is hardly used anymore due to incompatibility with other technology advances (FG#2 SM; FG#4 LG; INT#2 LG).

Participants also expressed concern about the ability to service new technologies. Several participants noted that they would not invest in a new energy efficient technology if they didn’t think they could find a trained technician to fix it (FG#2, SM; FG#4, LG; INT#6, LG; INT#7 SM N-ANOM; INT#8, N-ANOM, LG). *“You don’t want to put something in and nobody can service it at midnight when it breaks down.”* (FG#4 LG) Others emphasized a desire for equipment that is not too complex: *“We’re here to sell groceries and we’re pretty good at that. We’re not great at maintaining mechanical systems. So, in large part, we have to be a little bit idiot-proof on our systems. If I’ve got an option of taking a bulletproof compressor that will take use and abuse and misuse versus something that’s a little bit more energy efficient but at the same time is going to require a lot more maintenance, I’m taking the bulletproof one every day, without a second thought.”* (INT#3 LG)

While discussed less frequently, a few focus group participants noted that there are sometimes synergies between new, energy-efficient technologies and reliability or maintenance. For instance, *“The controls on the new racks are much more efficient than what you had on the old single pump systems or even the old racks, and they can do a lot more for you, and they give you a lot better control. You find out problems in a matter of minutes instead of a matter of a day.”* (FG#2 SM) Another participant noted that new technology sometimes *“[can be] swapped very easily across different lines.”* (FG#6 SM)

Tradeoffs – Energy and Refrigerant Use

It is possible that some energy-efficient or refrigerant-reducing technologies are not adopted due to tradeoffs between these two priorities that are not accounted for in a simple present value or payback calculation. In this case, not accounting for potential tradeoffs would make it appear as though companies are foregoing “win-win” opportunities. Three focus groups and one interviewee identified

reducing refrigerant leaks as a key consideration when performing upgrades since repeatedly replacing refrigerant in an old system can be quite costly: *“There’s nothing that will turn your head more to looking at whether or not you should make an investment than having \$8,000 or \$10,000 just get evaporated in your store.”* (FG#5, MD) Participants pointed out that federal regulations have put upward pressure on the prices of high GWP refrigerants (which stores can continue to use in an existing system).²⁷

There is little agreement across focus groups and interviews on the nature of potential synergies or tradeoffs between energy and refrigerant use, however. While some participants stated that they are unaware of potential relationships between refrigerant and energy use, the majority of participants (three focus groups and three interviews) felt that tradeoffs between them generally hinder investment in energy efficient technologies, and the remainder expressed mixed views. As one interviewee stated, *“There’s always a price to pay.”* (INT#5, LG)

Hot gas defrost was raised as one example where tradeoffs could occur (FG#2, SM; INT#6, N-ANOM). While this type of system may be more energy efficient in some situations, it requires a higher refrigerant charge and has a higher likelihood of leaks due to expansion and contraction in the system as well as more piping. On the other hand, secondary loop systems were described as lowering refrigerant emissions but had an energy penalty associated with them (FG#3, MD). Tradeoffs with secondary loop systems were discussed in the context of a potential conflict between DOE and EPA regulations: *“To me, it’s a catch-22 because you’ve got...the DOE wanting you to save energy, and the EPA wanting you to [address] global warming, and the secondary systems, they’re great on the global warming side but on the energy side, they’re not. It’s like we’re caught in the middle. Which direction do you go?”* (FG#3, MD) One participant opined that when there is only a small energy penalty associated with a new refrigerant, it may still be worth adopting to reduce emissions. Another participant commented that, *“the jury [is still out] as far as whether [our own system will] have an energy penalty or not.”* (INT#8, N-ANOM, LG) Related to this mix of views is that performance of some technologies varies with climate (see the store-specific tradeoffs section for more discussion).

That said, several participants noted other examples where synergies between refrigerant and energy spur investments that yield improvements on both counts. Since older equipment tends to have more refrigerant leaks and is less energy efficient, upgrading it will likely improve both, pointing to the potential for a *“win-win”* (FG#2 SM). For instance, new display cases may be more energy efficient and need a smaller amount of refrigerant; automatic controls allow for better monitoring and control of the energy and refrigerant used. Participants explained that if you are leaking refrigerant you are also using a lot of energy (FG#4 LG; INT#6, N-ANOM, LG), making leak detection systems a good investment from both perspectives.

Even though many participants discussed tradeoffs and synergies between energy efficiency and refrigerant use for various technologies and are clearly cognizant of them, the majority of companies still think of and discuss these as separate issues for purposes of decision making. As one interviewee

²⁷ In addition, one interviewee (INT#2, LG) mentioned that several states may end up requiring leak detection monitoring technology for refrigeration systems in the near future.

states, *“they’re pretty much separate animals, both very important.”* (INT#3, LG) Another participant admits that, *“it’s good to think of them together, but I don’t.”* (INT#2, LG) This is the case even though it is often the same group within the company that makes both of these decisions. At least some participants in one focus group (FG#1, MD) and one interviewee disagreed with this perspective, noting that refrigerant and energy use are *“absolutely intertwined.”* (INT#6, N-ANOM, LG) Even among those who think more holistically about refrigerant and energy use, many acknowledged that they have only started to think about them together recently.

Regulatory Requirements

While reducing refrigerant leaks presents potential “win-win” opportunities for companies to reduce costs while lowering emissions, several of the other technologies raised by participants to reduce refrigerant gas emissions entail substantial costs to industry, rather than net cost savings. Indeed, refrigerant changes to lower-GWP alternatives and alternative configurations that reduce refrigerant charge have the longest payback periods (or possibly no positive ROI during the equipment lifetime) among the technologies considered by participants in Appendix Tables A-D. Unsurprisingly, they also have relatively low adoption rates, particularly among small and medium-sized companies (Tables B-C). Economists would expect that absent regulation or a price on emissions, a company’s failure to adopt a low-emissions technology that does not yield cost savings does not represent a paradox. Instead, firms do not incorporate these effects into decision-making due to a classic market failure of unpriced externalities. However, current and anticipated regulatory requirements have spurred several participants to experiment with alternative refrigerants and system configurations.

Participants in four of the focus groups and five interviewees identified the type of refrigerant a system uses and its TEWI as a top factor when evaluating upgrades to a grocery store’s refrigeration system. *“We’re phasing out of the ozone killers [but] refrigerants now have a huge greenhouse gas effect. Eventually we’ve got to evolve to something that doesn’t do either one of those. The search is on for the systems of the future.”* (INT#1, LG) Several participants note that the ranking of refrigerant as a top factor is mostly due to regulatory requirements. An interviewee explained, *“EPA rules and regulations may drive us to change a refrigerant or change to a certain valve configuration or change to a certain case. It may not be the ideal solution for us, it may not be the easiest, and economically it may take a longer payback.”* (INT#5, LG) One interviewee also mentioned California regulations on refrigerants as a further spur to adoption (INT#2, LG). A few forward-leaning participants have even considered low-GWP alternatives such as CO₂ and ammonia, though because these refrigerants are fairly new to the United States they face some federal and state-level bureaucratic barriers to adoption.²⁸

While participants seemed to agree that the effect of current refrigerant regulation on technology adoption is fairly straightforward, several mentioned uncertainty regarding future refrigerant phase-

²⁸ Less attention was paid by participants to the role of state and Federal requirements on adoption of energy-reducing refrigeration technologies. State regulations were mentioned (FG#6, SM; INT#4, LG; INT#8, N-ANOM, LG) as a spur to adoption in the context of requirements to use energy efficient motors (e.g., in California), and promotion of energy efficient options due to mandated utility energy requirements and rebate programs (e.g., in Pennsylvania). Two interviewees (INT#2 LG, INT#6, N-ANOM, LG) discussed the upcoming DOE requirements (finalized in 2014) that could potentially drive future technological changes for display cases.

outs as a factor hindering adoption of some currently allowed high GWP refrigerants. *“The lack of direction or predictability on the regulatory side has led us all to scratching our heads. What do you do? What’s right for right now? Will it be right in eight years? It also makes us slow adopters of new technology.”* (FG#4, LG)

Uncertainty, irreversibility and option value

Firms may rationally avoid or delay investment in a new technology with a certain and high upfront cost when the future payoff is uncertain—whether due to regulatory uncertainty, as just discussed, or other factors. Many participants in our sample expressed a general concern about the risk associated with refrigeration system investments. One focus group participant explained, *“Anything could happen. The environment changes. Things are variable. There’s no way to say – there’s no guarantee what your payback is going to be.”* (FG#6, SM) Another stated that, *“There is a lot of liability associated with running a supermarket chain, so the return on investment has to be commensurate with that liability or risk.”* (INT#8, LG, N-ANOM) Another participant added, *“It’s more important to me whether I can afford the system upfront than whether somebody tells me that I’m going to save so much money over the next 10 years...our business is so day-to-day and so capital intensive, that it’s more important that I make the best decision upfront.”* (FG#5, MD)

Participants frequently noted that uncertainty associated with new refrigeration technologies spurred them to wait for other supermarkets to experiment and adopt first. One participant explained, *“I don’t want to be a beta site. I know somebody else eventually will be a beta site, and they’ll work through all the problems, and I’ll be more than happy to be the second or third generation.”* (FG#1, MD) Several participants expressed a desire to avoid the *“bleeding edge”* and even the *“leading edge”* of new technology (FG#1, MD; FG#4, LG; INT#3, LG; INT#8, LG N-ANOM). This view held true even for some larger chains, such as one participant who said, *“...there’s some uncertainty in what the future is going to look like; you want to hold what you’ve got for a little while, and see who’s doing what”* (FG#4, LG). Other managers highlighted that refrigeration technologies have indeed improved in recent years, justifying the previous reticence to invest; for example, *“...it’s far more predictable now than it was five years ago. You know you’re going to get energy savings.”* (FG#6, SM)

These comments suggest that there is a substantial option value from delayed adoption. Refrigeration system components display certain characteristics that increase the attractiveness of waiting to invest, even if the investments appear to have a positive net present value: They are “lumpy,” long-lived, and irreversible; resale markets are thin or nonexistent; the timing of investments is often flexible; and new technologies entail risk given uncertainty about both future system performance and electricity prices (McDonald and Siegel 1986; Gerarden et al.2015). Previous researchers have noted that this “experience-curve effect” can contribute to the energy-efficiency paradox because individuals expect a technology to improve over time with increased experience (Ansar and Sparks 2009). Participants in five of the six focus groups and half of the interviews made statements consistent with this view.

While this response is rational from the perspective of any individual supermarket chain, it is also potentially indicative of a market failure caused by learning-by-doing or learning-by-using externalities if the benefit of waiting is a function of the cumulative number of systems installed rather than the amount of time the technology has been available. The option value of waiting for performance to improve is related to the imperfect information market failure discussed in section IV; if supermarket

chains wait to learn from others before investing, the level of investment in new technologies will be suboptimal (though recall that while we found this to be the case among small and medium sized firms, large firms in our sample often experiment with new technologies).

Uncertainty about future energy prices could also delay or deter investments in energy efficiency by profit-maximizing firms (Hassett and Metcalf 1993). However, participants in our sample did not perceive uncertain electricity rates as a barrier to investment. While not every focus group or interview discussed electricity rates, some mentioned them as a neutral or motivating factor in relation to energy-efficient investments. One participant said, *“If you buy the more efficient piece of equipment and you own it, you’re in good shape. So when inflation hits, that electricity goes up 30%, which I can’t control, I’m safer with the more efficient piece of equipment.”* (FG#6, SM) This statement suggests that some managers view energy efficiency as a hedge against future economic risks (Metcalf 1994).

Uncertainty about the returns from refrigeration system investments also creates the scope for loss aversion if managers view the returns as riskier than status quo technologies and give greater weight to uncertain losses than gains of an equivalent amount. Such behavior would not be consistent with the assumption of rational profit-maximizing firm behavior. We discuss evidence of loss aversion among our sample in section V.

Opportunity cost of capital

While financial constraints suggestive of capital market failures were not discussed as a pervasive barrier to energy-saving technologies in most focus groups and interviews (section IV), many participants alluded to the firm’s opportunity cost of capital as a potential reason why certain technologies that appear financially attractive based on standard net present value calculations are not always adopted. Most regulatory agencies are required to conduct benefit-cost analysis assuming discount rates of 3 and 7 percent (Office of Management and Budget 1992), which may not reflect the ROI expected by firms.²⁹

Participants in half of the focus groups and more than half of the interviews (FG#3 MD; FG#4 LG; FG#6 SM; INT#1 LG; INT#4 LG; INT#6 LG N-ANOM; INT#8 LG N-ANOM) raised competing uses of capital or particular ROI or payback requirements across other investment opportunities in the firm as a potential explanation for limited investment in emission-reducing or energy-saving technologies. Participants in one focus group explained that they may see a higher return from investments in emerging technologies like barcode scanners, cash registers, security systems, and computer software unrelated to refrigeration (FG#6 SM). Another focus group discussed merchandising investments that make the inventory look more attractive as competing for capital with energy-savings upgrades (FG#4 LG). Interviewees alluded to the need for consistency across projects within the company by stating, *“You have to meet your economic goals, so any projects, any technology that we would evaluate would have to meet a return on investment”* (INT#6 LG N-ANOM), and *“If you’re not making a certain return with all the money you spend, then your stockholders may as well go and put that money in T-Bills”* (INT#8 LG N-ANOM). These statements highlight the importance the discount rate assumed in engineering analyses finding a positive net present value from adopting certain technologies. If a firm’s internal rate of return

²⁹ For reasons of confidentiality, most participants did not volunteer the internal ROI used within their firm for investment decisionmaking.

is higher than the assumed discount rate, then lack of adoption of certain technologies could indicate a rational decision to forgo investment in lieu of other more attractive opportunities available to the firm.

VII. Conclusions

A few caveats are in order when interpreting the results of this study. It was challenging to recruit busy professionals to devote one to two hours of their workday to participate in an interview or focus group without compensation. Thus, the sample of participants may not be representative of the industry at-large. In particular, three interviewees were recruited directly through EPA's GreenChill program and were aware that they were participating in an EPA study, introducing the potential for biased responses. In the preceding sections, we have attempted to highlight the few instances in which the responses from these non-anonymous GreenChill interviewees differed notably from those of other participants. The remaining participants, while balanced between GreenChill partners and non-partners, could still have a greater interest in technology and sustainability issues than supermarkets not participating in the study. Finally, our focus on traditional supermarkets and exclusion of hypermarkets and wholesale clubs limits the generalizability of the results throughout the industry. Nevertheless, the results from interviews and focus group discussions provide insights into firm investment behavior and the barriers to energy-efficient and refrigerant-reducing investments in refrigeration.

The most pervasive barriers to investment in refrigeration technologies across study participants were imperfect information and uncertainty about the performance of new technologies. Supermarkets do not always find manufacturers' and other average estimates of energy consumption (for instance, provided by government or third-party evaluations) reliable due to heterogeneity in climate and store configuration, leading medium and large companies to incur real transaction costs by testing new technologies in-house before rolling them out widely. Participants' statements also suggest that there is a substantial option value from delaying investment to reduce uncertainty by waiting and seeing how their competitors fare with new technologies. However, the dominance of the largest chains in the industry creates a "privileged group" situation in which leading supermarkets find it worthwhile to undertake substantial experimentation, with beneficial spillovers for the remainder of the industry. Several participants also discussed the opportunity cost of capital required by their firms as a barrier to investment in certain technologies expected to yield net positive returns only after several years of reduced energy and operating costs.

Participants expressed mixed views about the importance of several other potential investment barriers. Split incentives between the firm and both staff and refrigeration contractors can affect investment decisions, though firms try to address these split incentives using a variety of approaches, including training, technology, supervision, and in a few cases, contract structure. Capital or liquidity constraints can limit investments by smaller firms in technologies with high upfront costs, though virtually all firms report that government or utility rebates can be a driving factor in adopting new technologies. Participants also discussed potential tradeoffs between energy efficiency and other important technology attributes, including store-specific factors like climate and space constraints, customer appeal, reliability and maintenance, and refrigerant management. While these factors often rank as more important than energy consumption in refrigeration system investments, they are not always a

barrier to more efficient choices; in some instances, these other priorities can spur investment in technologies with lower energy consumption. A few participants indicated that they delay investment in new technologies due to an overriding concern with downside risk regardless of the potential upside, consistent with loss aversion. In addition, a few participants described behavior consistent with heuristic decision-making for refrigeration upgrades that are smaller in scale.

A few potential barriers to energy-efficiency that have been raised in the literature yielded minimal supporting evidence in the interviews and focus groups. Split incentives between landlords and tenants do not appear to affect refrigeration system investments, since supermarkets make these purchase and maintenance decisions regardless of building ownership. In addition, besides the potential for loss aversion discussed above, most participants' investment decisions do not appear consistent with other behavioral anomalies like inattention and coordination problems within firms.

Despite the caveats noted above, these results could be informative to policymakers promoting energy efficiency and refrigerant reductions to reduce GHG emissions from supermarkets. They suggest that information-sharing programs and subsidies or rebates—both approaches that are already used to target this sector—are likely to be effective in accomplishing these objectives. However, it may be worth considering whether the technical information disseminated by EPA and DOE corporate partnership programs could be supplemented to encompass the potential tradeoffs among other refrigeration attributes valued by supermarkets. The example of doors on refrigerated cases provides one such opportunity; despite recent trends toward adoption, a perception remains among a portion of the industry that doors dampen sales. Robust and statistically valid information about the effects of case doors on grocery sales across different store formats, community characteristics, and food and beverage products would provide a public good to the industry, although this type of research may not fall within the purview of existing programs.

A comparison of these results with those from a companion study on the adoption of fuel-efficient technologies among heavy-duty trucking fleets (Klemick et al. 2014) could also yield insights about the energy-efficiency paradox in commercial firms more generally. Imperfect information, uncertainty about technology performance, heterogeneity across firms, and the opportunity cost of capital play a role in both industries in slowing adoption relative to the level that some engineering studies estimate would be optimal. The importance of rebate financing and split incentives was notable for supermarkets but did not appear to be a major factor in decision-making for heavy-duty fleets. We also find that decision-making about energy-saving technologies is relatively sophisticated, and firms are already adopting or experimenting with many available advanced technologies in both industries.

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Appendix 1: Summary of Questionnaire Responses on Use of Supermarket Refrigeration Technologies

Table A. Participant Use of Specific Energy-Saving and Refrigerant Strategies – All Companies

| | Have used but would not again | Have used and would use again | May consider in future | Never | Total responses |
|---|-------------------------------------|----------------------------------|------------------------------|-------|--------------------|
| Compressor | | | | | |
| High-efficiency compressors | 2% | 86% | 12% | 0% | 43 |
| Variable capacity compressor | 2% | 76% | 22% | 0% | 42 |
| Condenser | | | | | |
| Advanced condenser design | 7% | 67% | 26% | 0% | 43 |
| High-efficiency fan motors | 2% | 91% | 7% | 0% | 43 |
| Display cases and piping | | | | | |
| Advanced evaporator design | 3% | 65% | 30% | 3% | 41 |
| High-efficiency fan motors/blades | 5% | 84% | 9% | 0% | 44 |
| Advanced door technologies | 0% | 79% | 19% | 0% | 42 |
| Strip curtains, night blinds | 9% | 64% | 16% | 9% | 44 |
| Anti-sweat controls | 9% | 84% | 5% | 0% | 43 |
| Advanced lighting (e.g., LED) | 5% | 93% | 0% | 0% | 43 |
| Thicker insulation | 3% | 65% | 30% | 3% | 39 |
| Walk-ins | | | | | |
| Hot gas defrost | 17% | 56% | 17% | 10% | 41 |
| Floating head pressure | 3% | 68% | 29% | 0% | 41 |
| Ambient sub-cooling | 3% | 68% | 29% | 0% | 38 |
| Demand defrost control | 0% | 51% | 46% | 3% | 39 |
| Advanced door techs, evaporator fan shutdown | 0% | 75% | 25% | 0% | 41 |
| Strip curtains/plastic door swings | 7% | 73% | 11% | 9% | 43 |
| Advanced lighting (e.g., CFLs) | 0% | 85% | 12% | 0% | 42 |
| Refrigerant | | | | | |
| Refrigerant changes (e.g., 404A replaced by R407A) | 9% | 64% | 20% | 5% | 44 |
| Improved management, leak detection, repair | 2% | 79% | 19% | 0% | 43 |
| Alternative configurations (e.g., secondary loop, cascade, or distributed compressor systems) | 5% | 60% | 33% | 2% | 43 |
| Controls, process changes | | | | | |
| Improved system controls (e.g., electronic expansion valves (EEV), case controllers) | 2% | 70% | 23% | 2% | 44 |
| Re-commissioning | 0% | 71% | 27% | 0% | 42 |
| Maintenance, repair, and cleaning | 5% | 90% | 5% | 0% | 39 |
| Training | 5% | 89% | 7% | 0% | 42 |
| Store temperature, dehumidification | 2% | 88% | 9% | 0% | 43 |

Table B. Participant Use of Specific Energy-Saving and Refrigerant Strategies – Small Companies

| | Have used but would not again | Have used and would use again | May consider in future | Never | Total responses |
|---|-------------------------------------|----------------------------------|------------------------------|-------|--------------------|
| Compressor | | | | | |
| High-efficiency compressors | 0% | 71% | 29% | 0% | 14 |
| Variable capacity compressor | 7% | 64% | 29% | 0% | 14 |
| Condenser | | | | | |
| Advanced condenser design | 0% | 57% | 43% | 0% | 14 |
| High-efficiency fan motors | 0% | 79% | 21% | 0% | 14 |
| Display cases and piping | | | | | |
| Advanced evaporator design | 0% | 50% | 43% | 7% | 14 |
| High-efficiency fan motors/blades | 0% | 86% | 14% | 0% | 14 |
| Advanced door technologies | 0% | 79% | 21% | 0% | 14 |
| Strip curtains, night blinds | 7% | 50% | 29% | 14% | 14 |
| Anti-sweat controls | 7% | 79% | 14% | 0% | 14 |
| Advanced lighting (e.g., LED) | 7% | 93% | 0% | 0% | 14 |
| Thicker insulation | 0% | 57% | 36% | 7% | 14 |
| Walk-ins | | | | | |
| Hot gas defrost | 15% | 46% | 31% | 8% | 13 |
| Floating head pressure | 0% | 33% | 67% | 0% | 12 |
| Ambient sub-cooling | 0% | 38% | 62% | 0% | 13 |
| Demand defrost control | 0% | 46% | 54% | 0% | 13 |
| Advanced door techs, evaporator fan shutdown | 0% | 50% | 50% | 0% | 14 |
| Strip curtains/plastic door swings | 14% | 29% | 29% | 29% | 14 |
| Advanced lighting (e.g., CFLs) | 0% | 71% | 29% | 0% | 14 |
| Refrigerant | | | | | |
| Refrigerant changes (e.g., 404A replaced by R407A) | 0% | 64% | 36% | 0% | 14 |
| Improved management, leak detection, repair | 0% | 69% | 31% | 0% | 13 |
| Alternative configurations (e.g., secondary loop, cascade, or distributed compressor systems) | 0% | 38% | 62% | 0% | 13 |
| Controls, process changes | | | | | |
| Improved system controls (e.g., electronic expansion valves (EEV), case controllers) | 0% | 64% | 36% | 0% | 14 |
| Re-commissioning | 0% | 33% | 67% | 0% | 12 |
| Maintenance, repair, and cleaning | 14% | 79% | 7% | 0% | 14 |
| Training | 14% | 71% | 14% | 0% | 14 |
| Store temperature, dehumidification | 7% | 71% | 21% | 0% | 14 |

Table C. Participant Use of Specific Energy-Saving and Refrigerant Strategies – Medium Sized Companies

| | Have used but would not again | Have used and would use again | May consider in future | Never | Total responses |
|---|-------------------------------------|----------------------------------|------------------------------|-------|--------------------|
| Compressor | | | | | |
| High-efficiency compressors | 0% | 92% | 8% | 0% | 13 |
| Variable capacity compressor | 0% | 67% | 33% | 0% | 12 |
| Condenser | | | | | |
| Advanced condenser design | 8% | 75% | 17% | 0% | 12 |
| High-efficiency fan motors | 7% | 93% | 0% | 0% | 14 |
| Display cases and piping | | | | | |
| Advanced evaporator design | 9% | 55% | 36% | 0% | 11 |
| High-efficiency fan motors/blades | 15% | 69% | 15% | 0% | 13 |
| Advanced door technologies | 0% | 71% | 29% | 0% | 14 |
| Strip curtains, night blinds | 14% | 71% | 14% | 0% | 14 |
| Anti-sweat controls | 23% | 77% | 0% | 0% | 13 |
| Advanced lighting (e.g., LED) | 8% | 92% | 0% | 0% | 13 |
| Thicker insulation | 0% | 80% | 20% | 0% | 10 |
| Walk-ins | | | | | |
| Hot gas defrost | 17% | 67% | 8% | 8% | 12 |
| Floating head pressure | 0% | 70% | 30% | 0% | 10 |
| Ambient sub-cooling | 0% | 71% | 29% | 0% | 7 |
| Demand defrost control | 0% | 38% | 63% | 0% | 8 |
| Advanced door techs, evaporator fan shutdown | 0% | 90% | 10% | 0% | 10 |
| Strip curtains/plastic door swings | 7% | 93% | 0% | 0% | 14 |
| Advanced lighting (e.g., CFLs) | 0% | 92% | 8% | 0% | 12 |
| Refrigerant | | | | | |
| Refrigerant changes (e.g., 404A replaced by R407A) | 14% | 64% | 21% | 0% | 14 |
| Improved management, leak detection, repair | 0% | 71% | 29% | 0% | 14 |
| Alternative configurations (e.g., secondary loop, cascade, or distributed compressor systems) | 8% | 46% | 46% | 0% | 13 |
| Controls, process changes | | | | | |
| Improved system controls (e.g., electronic expansion valves (EEV), case controllers) | 8% | 62% | 31% | 0% | 13 |
| Re-commissioning | 0% | 77% | 23% | 0% | 13 |
| Maintenance, repair, and cleaning | 0% | 91% | 9% | 0% | 11 |
| Training | 0% | 93% | 7% | 0% | 14 |
| Store temperature, dehumidification | 0% | 93% | 7% | 0% | 14 |

Table D. Participant Use of Specific Energy-Saving and Refrigerant Strategies – Large Companies

| | Have used but would not again | Have used and would use again | May consider in future | Never | Total responses |
|---|-------------------------------------|----------------------------------|------------------------------|-------|--------------------|
| Compressor | | | | | |
| High-efficiency compressors | 6% | 94% | 0% | 0% | 16 |
| Variable capacity compressor | 0% | 93% | 7% | 0% | 15 |
| Condenser | | | | | |
| Advanced condenser design | 13% | 69% | 19% | 0% | 16 |
| High-efficiency fan motors | 0% | 100% | 0% | 0% | 16 |
| Display cases and piping | | | | | |
| Advanced evaporator design | 0% | 87% | 13% | 0% | 15 |
| High-efficiency fan motors/blades | 0% | 100% | 0% | 0% | 16 |
| Advanced door technologies | 0% | 93% | 7% | 0% | 15 |
| Strip curtains, night blinds | 6% | 75% | 6% | 13% | 16 |
| Anti-sweat controls | 0% | 100% | 0% | 0% | 16 |
| Advanced lighting (e.g., LED) | 0% | 100% | 0% | 0% | 16 |
| Thicker insulation | 8% | 62% | 31% | 0% | 13 |
| Walk-ins | | | | | |
| Hot gas defrost | 19% | 56% | 13% | 13% | 16 |
| Floating head pressure | 6% | 94% | 0% | 0% | 16 |
| Ambient sub-cooling | 7% | 93% | 0% | 0% | 14 |
| Demand defrost control | 0% | 63% | 31% | 6% | 16 |
| Advanced door techs, evaporator fan shutdown | 0% | 88% | 13% | 0% | 16 |
| Strip curtains/plastic door swings | 0% | 94% | 6% | 0% | 16 |
| Advanced lighting (e.g., CFLs) | 0% | 100% | 0% | 0% | 15 |
| Refrigerant | | | | | |
| Refrigerant changes (e.g., 404A replaced by R407A) | 13% | 69% | 6% | 13% | 16 |
| Improved management, leak detection, repair | 6% | 94% | 0% | 0% | 16 |
| Alternative configurations (e.g., secondary loop, cascade, or distributed compressor systems) | 6% | 88% | 0% | 6% | 16 |
| Controls, process changes | | | | | |
| Improved system controls (e.g., electronic expansion valves (EEV), case controllers) | 0% | 88% | 6% | 6% | 16 |
| Re-commissioning | 0% | 100% | 0% | 0% | 16 |
| Maintenance, repair, and cleaning | 0% | 100% | 0% | 0% | 16 |
| Training | 0% | 100% | 0% | 0% | 16 |
| Store temperature, dehumidification | 0% | 100% | 0% | 0% | 15 |

Appendix 2 – Relevant Quotations

Importance - energy efficiency

“You want your refrigerators and stuff to be invisible to your customers and to your store employees. And you want it to be energy efficient. If you’ve got that, then you’re good.” (FG#1 MD)

“If you do maintenance on your cases on a regular basis, and you’ve done that ever since you’ve had them, the only reason you may want to change the case is for aesthetics or for energy savings. Because cases can last 20-25 years if you take care of them. So it’s not always because the case is broken down It’s just you may want to do it ... to change up the store or for energy savings.” (FG#2 SM)

“If the technology isn’t that earth shattering, doesn’t make that big a difference, we won’t change. If it makes a big difference, we’ll do it.” (FG#2 SM)

“You have to understand that energy is close to 50%, for the refrigeration systems alone, of our utility bill. So it’s definitely high on our radar, but we still have to run the systems in order to maintain the product temperatures. So even though we’re all saving energy, we’re tracking it somewhat separate because we’re always looking at ways to reduce that energy. First and foremost, I’ve got to run the systems in order to have a store open and sell groceries.” (FG#4 LG)

“You can only continue to stay in business as long as you are paying the bills and making a profit. It all comes back to the same thing, we are not mechanical service companies or equipment salespeople or engineers, from that standpoint, we are retailers. We sell food.” (FG#4 LG)

“I’m basing my decision on my kilowatt hour usage, or my KW demand, but not on the cost of electricity. I’m going to squeeze every BTU and kilowatt, whether I’m paying 6 cents or 28 cents.” (FG#4 LG)

“As far as I’m concerned, cost and energy are one and two, but the third factor has got to be what it’s going to cost me to maintain it. Is the compressor something that’s got a decent history, or because of the design of this thing, am I going to be putting money into it every five years? (FG#6 SM)

“It’s one of many things. One would be foolish to ignore it. But energy by itself doesn’t drive any decision.” (INT#1 LG)

“Energy efficiency certainly plays into it, cost certainly plays into it, overall effectiveness and helping us achieve our goals of selling product.” (INT#3 LG)

“It’s probably how it displays the product more than the energy savings. The energy savings would be the cherry on top. I guess it would be nice, but it wouldn’t be the make or break decision on why we would buy a case.” (INT#7 SM N-ANOM)

“If I go to conferences I hear an awful lot about energy efficiency, and sometimes I think we tend to over-emphasize the things that we can measure, that’s easily measured. But I think in a supermarket there are a lot of other things to consider, too. Energy is certainly an important one but maintenance

and dependability, serviceability and dependability are certainly very important, too.” (INT#8 LG N-ANOM)

Importance – refrigerant

“The refrigeration leaks are an area that we can do better at. We [are] getting better measurements in place so we can track how much refrigerant we’re spending each year. Internally, I’m challenging our group to do a better job with that. Since we have internal in-house maintenance, some of those guys are a little older. The mindset used to be refrigeration leaks weren’t that big a deal. In today’s world, for us now, it’s hundreds of thousands of dollars.” (FG#1 MD)

“My biggest fear when I lay in bed at night is that I’m going to have a major refrigeration leak or something happen to the system. Because it’s been proven that the average supermarket loses 25% of its refrigeration every year. One guy loses it all, and one guy, you had no problem, but on the average. Refrigeration is a major headache for all of us. Something is always not working quite right. We always need to tweak things. This case isn’t running quite at the temp we want. This section of freezer doors, we’ve got a little frost on the coil there, we need to get that cleaned out. It’s always something.” (FG#2 SM)

“I’m still waiting on that magic refrigerant to come out that you can just drop it straight in and not have to do much to it.” (FG#3 MD)

“I would say that a lot of grocers are probably looking a lot harder at their backroom equipment now because of the cost of gas. So if there’s a cost to replace the existing gases, we started phasing out the older gases. But I know we’ve had some major leaks in our stores. There’s nothing that will turn your head more to looking at whether or not you should make an investment than having \$8,000 or \$10,000 just get evaporated in your store. That’ll turn your head real quick. In the past, everybody would look at, ‘Well, what’s the case and what’s the customer looking at?’ But now, you’re really forced to look at what’s going on in the back a lot harder because it could be very costly – it’s sort of like having a car. You have a beautiful car, but the engine isn’t running.” (FG#5 MD)

“This goes along with refrigerants, but we financially have just crossed the line where it’s feasible to start retrofitting R22 systems with a newer kind of gas. For us, there’s a financial return on rack systems right now, on the air cooled singles. We’re not quite there, but if the cost of R22 goes up a little bit more, then that would work. So over the last couple of years, we’ve been experimenting with doing that, even though the financial return wasn’t all the way there. We wanted to get it perfected before, so that when it did cross that line, we knew exactly what we were doing and could then move it forward at a more rapid rate. And so, we’re experimenting now with that and also have a goal that in 2015, we would install some sort of, I guess you would call it ‘natural refrigerant system’ where it would be CO₂ or something new.” (FG#5 MD)

“As we’re phasing out of the ozone killers, refrigerants now have a huge greenhouse gas effect. So eventually we’ve got to evolve to something that doesn’t do either one of those. The search is on for the systems of the future.” (INT#1 LG)

“We’ve been doing energy efficiency stuff for 20 plus years, at least here in the New England area ...And we’ve got diminishing returns now. There’s some new technologies that have potential. New lighting technology has potential to have significant impact. But we’re just starting the game of managing refrigerant emissions from a greenhouse gas perspective. There’s a lot more to be gained, a lot more to be learned, and a lot more gains to be had there right now.” (INT#2 LG)

“[Changing refrigerant] would drive us to more of a complete system replacement than what we’ve had in the past, because going from an HCFC to an HFC typically you didn't have to change everything. You probably had to change a bunch of stuff but not everything. Whereas going to a completely natural refrigerant like CO₂ would probably cause a more complete system change-out, and we’re not there yet.” (INT#2 LG)

“Obviously there is a phase out of R22. So every time we go into do a remodel, even if it’s not meant to be a major evolution as far as changing out all of the refrigeration equipment, we would look to see if we could work in a refrigerant upgrade or a change to the system while we are in there to minimize the disruption to the stores.” (INT#6 LG N-ANOM)

“We are constantly looking for the opportunity to go all natural refrigeration in the stores, but with an eye on energy.” (INT#6 LG N-ANOM)

Payback period

“Three years, it’s a no-brainer. If I can make that investment and cash flow it in three years, everything past that is gravy. That just makes it such an easy decision to make.” (FG#1 MD)

“Sometimes this gets baked into a larger remodel or other kind of investment decision with regard to the store. So refrigeration payback is lost in the rest of the payback.” (FG#1 MD)

“In my world—and when I say my world, my region of the country—we’re paying 6-7-8 cents a kilowatt for electricity. Typically the driving force of doing that might be that I have a more efficient system. But typically I can almost gain those efficiencies at the cases and not at the rack. I have yet to see very many times where somebody is going to say, well, we’re going to spend \$100,000 on this rack and we’re going to spend \$75,000 doing the installation, and it’s going to have some sort of payback.” (FG#1 MD)

“We typically don’t add additional sales because that’s such a difficult number to wrap your hands [around]...When I go to our owner and say, ‘I need this much money, and this is the piece of equipment we want to buy, here’s the ROI based on more efficient fans, energy costs, LED lighting.’ We don’t put anything in for additional sales just because that’s so difficult to quantify. We quantify all those other things.” (FG#1 MD)

“I did indicate that we do a return on investment, but there’s really a range on that. Probably 80% of our investment right now is on new stores. So the return on investment isn’t really associated with the refrigeration cases. We’re just looking at the store, the projected sales, how much it would cost, and what our return is on that huge investment. Outside of that, if I’m just going to upgrade for energy

efficiency, I'm going to try to do some quick sort of return on investment... If I know that I can do a two-year payback just on savings, I don't even have to do all that other stuff." (FG#1 MD)

"[Our] rate was typically at 15% or 20% internal rate of return. If you have just that cash on a two year payback, I don't even have to put it in the spreadsheet to know I'm going to hit that rate. But if it starts getting to that three or four year range, I know I might need to say, 'What are all the other variables that are going into this?' Am I having a big savings on year three? It starts getting a little more complicated if it's two or three years, I can go tell everybody this is going to pay back in two or three years when we're done. We don't have to go look at it." (FG#1 MD)

"You just run your numbers and see what the ROI is, and how many years it's going to take to pay it back." (FG#2 SM)

"I look at an ROI, but I don't get into deep detail of it. I just get an idea and if it's a long-term investment, then okay, but the shorter the better." (FG#2 SM)

"We always have a payback calculation but that doesn't always make the decision for us. Because if [you view it as an] energy savings, it's a no-brainer. You're going to do it whether it takes a year and a half, two years or three years. If you view it as an energy savings. If the payback is not in a year and a half, are you going to say then I'm not going to do it? I don't think so." (FG#2 SM)

"The shorter the payback period, the more we're interested in doing it... I don't think that there's ever going to be a situation where an independent retailer is going to spend the money to do an upgrade or a remodel that is not going to have a payback period shorter than his next reinvestment. Because it doesn't make any logical sense from a business standpoint to spend money that you can't recoup before you've got to spend more money to do the same thing again." (FG#2 SM)

"Obviously, we want to make good decisions based on the cost of the equipment, the energy efficiency and, sure, if payback comes into that, we might buy a little bit more expensive piece of equipment than we could because it may be beneficial in the long run as far as the cost of ownership." (FG#3 MD)

"The only stores I didn't roll it out to were stores that we had slated for remodel, replacement, that kind of thing, because if you have a 4.2 year payback, but you're going to remodel in six months, then you'll be replacing that equipment. Obviously, that doesn't make sense." (FG#3 MD)

"We did one project for solar on a rooftop. It did have an extended payback. Even with incentives, it's a seven-year payback. But it's also a public relations – going green, that kind of thing. It also exposes us to the technology, gives us a little chance to play with it, so to speak." (FG#3 MD)

"When I think of lifecycle costs and total cost of ownership, they are the same thing. Energy is a component of that, as well as initial cost, as well as maintenance. As long as we meet the economic reasoning for that application, how we shift those numbers around, if we increase the cost of the upfront cost but we can make that up on something else, maintenance or energy or something like that,

that's okay. It's the big picture that we really look at, not the individual components that say do this versus do that. This is a total ROI, return on investment." (FG#4 LG)

"If it doesn't clear our internal hurdle rate, then it can't move forward." (FG#4 LG)

"I use equipment until it dies." "I think we all do. ...I use them until they die. I use bubble gum, Band-Aids and chewing gum to keep them running." (FG#5 MD)

"We rely on an internal rate of return. There are some things that you have to do. If you have cases that are falling apart and they're not going to last, it doesn't matter whether there's a return. But if we were doing something new or the remodels, they all have to reach a certain level of return or we can't spend the money." (FG#5 MD)

"If you're able to articulate you're spending money for a reason and have the ROI for it, most of the time, that would pretty much be approved. You have to assume you're putting LEDs in because it's going to save energy and in the long run it's better for the company. Other types of systems where you're changing out a case or a system that really doesn't have a clear-cut ROI, you might have to come up with a reason why or you might be able to replace it." (FG#5 MD)

"With equipment, by the time you're done paying it off, the thing's outdated or needs to be replaced again. So what's the point?" (FG#6 SM)

"You do the best you can. Try to quantify as much as possible. The intangibles are there sort of as tie-breakers." (INT#1 LG)

"We're running a for-profit business here, and lifecycle cost is pretty much always applicable. If it passes that filter, then it's definitely worthy of consideration. Sometimes people will come in with an idea that maybe looks good for energy efficiency or it looks good for sustainability or it looks good for maintenance. But for some reason or another it's got a downside to it. So when you run it through a lifecycle analysis filter it doesn't look as good." (INT#2 LG)

"It's got to make money, so it's got to have a good lifecycle cost. And not detract from the customer experience at the very least. If something is going to be good for customers, that's a nice thing. Assuming somebody would have to quantify that, an investment analyst, they've got to put dollar signs to that somehow." (INT#2 LG)

"The net present value calculation is a go/no-go thing....We run it through investment analysis and determine whether it has a positive NPV, and if it does, we put it on the list. Then we try and rank them and allocate budget. My preference is always... investing in things with the best return first." (INT#2 LG)

"The idea is that I'm achieving that [energy] goal by doing cost-effective projects. Nobody is going to give me money to go out and meet my goal if it's not cost effective. So again, it's got to be through investment analysis. They'll tell me if it's got a good enough return, and then I do it. So we have a team

of people that each year we try and fill the funnel with enough cost-effective projects to achieve our goal. And we've been able to do it. We haven't run out of technologies yet." (INT#2 LG)

"We'd ideally like to see a two-year payback. And usually the only way to get there is to have some kind of a utility rebate incentive to help buy that project down." (INT#3 LG)

"As far as the decisions we make, we're a business first and foremost, we're trying to make a buck. So if we can utilize some kind of incentives from a utility, we're certainly going to try and do that. But even if we're not getting a payback, we incorporate a lot of those energy efficiency pieces into our stores in the first place" (INT#3 LG)

"If we didn't have that utility rebate, it might have been a three-and-a-half year payback and, at that rate, maybe it didn't pay for itself. It doesn't meet our internal ROI requirements." (INT#3 LG)

"Our payback, our sweet spot, is two years. We'll look at three, but we typically won't look at over three. I shouldn't say that. In some cases we will, but not always. ... New stores have a little more leeway" (INT#3 LG)

"We look at first cost, and it's not always – that's not the key driver of what we buy, but it's a key driver." (INT#3)

"Every installation would have to stand on its own because utility rates can vary quite drastically, even within states. So every store has to provide for or stand on its own. We would not install something in a store unless its payback was appropriate." (INT#4 LG)

"We try to include everything that we feel has real value in the payback calculation." (INT#4 LG)

"Now this is on a retrofit basis, this isn't for new stores – currently if something doesn't have a two year or better simple ROI, then we won't really even look at it. If it has a two year or better, we will evaluate it and look at it, and then if we like it, carry it forward to senior management and they may or may not approve it. ... If it's a new store, we're willing to look a little further. But at this point it's actually not much more than three to five years." (INT#4 LG)

"We like two-year paybacks, and I've gotten some stuff approved with three-and-a-half to four year paybacks. But you've got to remember, in the supermarket business, when you go into a store, if you're talking four years, you may remodel that store in five years. So you really haven't gained a whole lot. If you can get a year-and-a-half, two years, that's a good deal." (INT#5 LG)

"A lot of our remodels now are sales floor, what the customer sees and wants, and the mechanical side of it stays in the back. And it purely comes down to dollars and cents. There's a ton of equipment that we would leave in our stores that are 20 years old and have never gone back to. And the other piece of it is I don't know how much there is to grab there. Sometimes on the KW side you may have to invest a certain amount of money but never get your money back, or it may take 10 years to do that, and they're not willing to make that investment. Some of these stores are running from a load side as best they can

or as close as they can, and no matter what you do, unless you do a full system replacement, you're not going to generate the type of savings you need to pay back the investment." (INT#5 LG)

"If it's large items or new items we are doing like new refrigeration, we would break that out and give it its own specific return on investment so that the investment team can look at that and see if that is a driving factor in helping or hurting the return on investment of the project." (INT#6 LG N-ANOM)

"I think you will find in any supermarket they are going to have some sort of committee where these things have to meet a minimum return on investment before they do a remodel." (INT#6 LG N-ANOM)

"[Anything with less than a 6-7 year payback] should be adopted but you are probably going to have to sell it internally. Someone [has] to go to bat because if the existing way of doing things is sitting at a 3 year pay back then there is a delta there that you are having to overcome." (INT#6 LG N-ANOM)

"How do you put a value on [customer appeal]? That appeal that you get is like a new car smell... I don't know if it's really quantifiable." (INT#6 LG N-ANOM)

Imperfect information – suppliers/manufacturers

"In terms of getting information, quite frankly, the manufacturers are the ones that are developing. There's a lot of resources there, so we take advantage of that." (FG#1 MD)

"You expect the manufacturer to provide you with something and you take it with a grain of salt what he's actually saying." (FG#1 MD)

"We rely on recommendations from our supplier. But then I have a second person that I use as a consultant that I don't buy anything from. I use him to say, yes, you're on the right [track]..." (FG#1 MD)

"The company that builds the cases offered us a pretty good price to put in CO₂ refrigerant cases as a test... Then they'll use that information to sell that to other people." (FG#2 SM)

"I wouldn't say there's any intentful [*sic*] deception, but refrigeration is very location-specific, as far as what's going to work. They advertise a certain capability at a certain set of conditions, and if you happen to be there it works as advertised, but in my case that very seldom happens. It's good baseline information, but you have to really extrapolate [from it]." (FG#4 LG)

"We're going to always ask for [energy data from manufacturers]. If I get two manufacturers and one of them gives me data that's certified at an ETL test lab and the other guy did it in his garage, I may decide I trust one more than that other." (INT#2 LG)

"They're trying to make a buck, but at the end of the day they also can have really good information to share." (INT#3 LG)

"If it comes from a reputable OEM or a reputable company that we know or have done business with or is nationally recognized, then we are a lot more likely to believe them. We would always do our own diligence and make sure, because even reputable companies could provide information or estimates based on something that just isn't the way we do things. We would always dig in and understand what was in the estimates or calculations and make sure it stood up to our standards." (INT#4 LG)

“Once our OEM stood behind it in terms of putting it in their product and warranting it like the other product, then we were fine with it. Didn’t need to test it.” (INT#4 LG)

“They get into the door with what they tell us, and then we do a verification of that before we put it out there.” (INT#6 LG N-ANOM)

“If we look at a case and they tell us that the case will help you save 15% on energy costs, you have to translate that. They don’t know the case we have now, they are using a national average, we have to take the cases we have now and say, how much energy is that case running?” (INT#7 SM N-ANOM)

“We were given a set of estimates that we looked at to try to justify in our own situation and can't make it work out the same way. Our estimate doesn't look nearly as rosy as the supplier’s does.” (INT#8 LG N-ANOM)

Imperfect information – in-house testing

“Most of the testing is field testing. You put in cases, you try one brand. If it works well for you, then you continue with it, or you try something else if it doesn’t work well for you.” (FG#2 SM)

“We did an ECM [electronically commutated motor] project for placing motors in walk-ins and we did a few test sites, monitored the energy savings. Because it was such a good deal, we rolled it out company-wide.” (FG#3 MD)

“We do a lot of pilots where we will look in a direction, test it in a store, and if it works, then go back and say next year we are going to set money aside to roll this out to all the stores or maybe phase it in over a couple of years.” (FG#5 MD)

“Do some modeling first, pilot one, one store in one place, and a couple of stores in a lot of places. Eventually we’ll roll it out.” (INT#1 LG)

“We’ll get numbers from our vendors. We’ll test for ourselves. Get our own numbers. It’s really our own testing and comparisons that help to drive a decision.” (INT #1 LG)

“We do try new technologies when they come available, and if we like them, they become part of a prototype. We wouldn’t just do it because the OEM supplier said to do it. We would perform our own tests and try it in a store first, and if we like it and we think it delivers the results we need, then it becomes part of the prototype.” (INT#4 LG)

“We look at new and emerging technologies for supermarkets across the board, anything from trash compactors to refrigeration and lighting, and the vast majority of that is spent in refrigeration and lighting. We will evaluate those things and test them and put them in an environment to actually do measurements and verifications to see if it’s something that we feel that works for us.” (INT#6 LG N-ANOM)

“For that store where we installed the new technology, 10 feet away from it, is the existing technology that every supermarket would use... And we switch between one and the other and do a direct comparison.” (INT#6 LG N-ANOM)

Imperfect information – larger companies/wholesalers

“There’s very few warehouses out there that supply any of us that don’t have some help when it comes to buying agreements with the manufacturers or engineering staff that can help you lay out the stores, do the drawings, do the design work, make recommendations.” (FG#2 SM)

“In a previous position, I worked for a company that’s global. We tried all kinds of things, but we were not only trying it for our company, we were also trying it for sister companies. But in my role now with over 100 stores, you just can’t afford to make mistakes. You can’t even afford to make the wrong investment decisions. Right or wrong, we’ll take the plea that somebody on a larger scale proves the technology before we will.” (FG#3 MD)

“If you’re a major couple-hundred-store player, you’re willing to try some new things.... For me, I will go to [a peer at a larger company] and say, ‘Well, okay, that’s great. I’m glad you’re doing this new. Tell me about what’s worked, because we don’t invest as often as you do.’Whereas, a bigger player might say, ‘Well, I’m willing to try this or I’m willing to try that,’ because that’s part of being a bigger player. You have the luxury of doing that kind of thing.” (FG#5 MD)

“For instance, the wholesaler that has chain stores and independent stores - they actually have in house engineers, refrigeration engineers and all that - along with our refrigeration companies. We look at their advice because they have a lot of stores, most of the stores are alike, between the independent and corporate. They have 300 stores and they have the same cases so they can take a look at the efficiency and the cost in all the stores for any type of equipment, and give us advice.” (FG#6 SM)

“Your wholesaler would be on the edge of where they have to be. They’re trying out new systems in different stores, and they’ll see how it works, and then they’ll make a decision on whether they roll them out in their other stores or not. Whereas us single guys, we look to them, we’ll hear maybe what they’re doing, maybe our refrigeration guy will tell us.” (FG#6 SM)

“Food Lion is one of the top bigger companies and they can afford to take two to three stores and make a test out of it. But if you have three stores and you took one-third of your sales and put it into a test. .. Generally what we try to do is learn from somebody else. That’s one reason why I’m in GreenChill. We let the big guys do all the testing.” (INT#7 SM N-ANOM)

“We never want to be on the leading edge. We keep a very close eye on what the Wal-Mart's, the Kroger's, the Whole Foods, what they’re experimenting with. We want to be on the forefront, but we don't want to be on the leading edge. We want to learn from our leaders.” (INT#8 LG N-ANOM)

Imperfect information – peers

“We get a lot of information from our friends in the business, how it worked for them, and ‘Would you do it again?’ And when they say, ‘I wouldn’t do it again,’ we definitely don’t do it.” (FG#2 SM)

"This conference helps us decide where we're going as a group. More importantly, it helps us network, to have that confidence to pick up the phone and ... say, 'Hey, I see you tried this, what do you think of it?' We all fight the same battles, and one of the most valuable things about these conferences are different approaches, because we all basically do the same thing." (FG#4 LG)

"We have an R&D department which means 'Research and Duplicate,' so whatever [my peers] are doing, we tend to do." (FG#5 MD)

"We're sitting around the table with the Safeway guy who does my job, the Target guy who does my job, there's 15 of us that are from chains around the country, and we talk. We see what works. We see what doesn't work. And the relationships at these conferences we get, if I have questions on something, the salesmen will tell you they're great resources, but I pick up the phone and call peer retailers." (INT#3 LG)

"We then share that information [on emerging technologies] so that hopefully some of our competitors jump on board and the volume goes up." (INT#6 LG N-ANOM)

"A lot of time other companies have done it already and done the homework for us. So we rely on their information to say, 'Yup, we know this case is going to work. We want to bring it in.'" (INT#7 SM N-ANOM)

Imperfect information – contractors

"We'll also use our repair company as a source. Obviously, they're out there being trained and are taking care of our systems. And so I rely heavily on them. I've created a really good trustworthy relationship." (FG#1 MD)

"They're the ones that deal with it day to day, so that's where I go." (FG#2 SM)

"The technology has changed so much in the last ten years that I'm reluctant to just go to one person, say my local contractor, for advice because I don't think he has kept up. I'm going to go to several sources for advice in the future, because of possibly some mistakes I've made in the past on refrigeration upgrades. I'm going to be very careful about the choices I make in the future because technology is changing very fast." (FG#2 SM)

"People that I've used in the past with equipment, I take their advice as to whether or not something is beyond repair, needs to be fixed, or whether it could be upgraded. If I've got enough trust for them to be in every day at what I'm paying them an hour, I take their advice as to what they think should go." (FG#6 SM)

"If you trust [your technician], then you'll look at it. 'At another store it seems to be working,' and he'll say, 'I have this in other stores and I've got to fix it all the time. Don't even waste your time on it.' We're not talking about the salesman with the company. We're talking about the guy with the dirty hands. He's seen it and he's got a feel for it. He's the one who's been working on it. He can't tell you numbers but he's got a gut feeling for it, and if he's in there repairing something constantly, these guys will be pretty straight with you." (FG#6 SM)

“They probably have experience with other customers who utilize different systems so it can certainly be a two way communication, or they can tell us they recently put in certain type of technology for another customer and it did work pretty well or it didn’t work at all.” (INT#8 LG N-ANOM)

Imperfect information – other

“The world of refrigeration, commercial refrigeration, is real specialized. There’s a limited number of people that are experts at it. And luckily, I have one of those on the staff and he’s able also to work in partnership with the manufacturers. When we design the system, he’ll question things, give ideas. I try to stay on top of him enough to be able to push him to make us do things better or challenge what we’re looking at or just question, Is there something new we should be evaluating?” (FG#1 MD)

“I’m going to say, is there any independent information outside of the actual manufacturer, whether it be a utility company that has done the study, or California Energy Group or EPA or somebody that said, ‘Hey, we tested the doors on the cases and, yes, your load went down 50% on that rack.’” (FG#1 MD)

“I read that *Supermarket News* held a large focus group discussion with a lot of grocery people. I remember reading through that, and everybody is doing all these different things. You wonder, what’s the supermarket standard? It’s all over the map, which makes it difficult to figure out what [we] should be doing. It sounds like a lot of the systems have different advantages associated with them, and I don’t have the expertise to know what’s best.” (FG#1 MD)

“There’s so many other things going on in the store, it’s hard to verify, unless you suddenly spent all this money trying to sub-meter everything. You have to use a little common sense that if you put a door on a case, you’re going to save something. If you have LED lights that don’t have heat on it right next to your hand, you’re going to use less energy. And trust that their numbers are right. Because it’s hard to measure. Once you put it in the store and you’ve got other lights, parking lot lights, fuel stations, ovens, and so many other things going on, it’s hard to just measure what impact that had.” (FG#1 MD)

“The information is out there, you have to be disciplined and decide when you’re going to go research that...you just have to go get it.” (FG#2 SM)

“The computers now have the ability to dial out and give you an alarm on your cell phone when there’s a problem, or get the information through a laptop that you can look at and see what’s going on – know if there’s a door open, know if you’ve got somebody who’s got a leak in a case. The controls on the new racks are much more efficient than what you had on the old single pump systems or even the old racks, and they can do a lot more for you, and they give you a lot better control. You find out problems in a matter of minutes instead of a matter of a day.” (FG#2 SM)

“You’re going to be talking to your warehouse people, the guys you know in the grocery business who are using that kind of equipment, your refrigeration man, the suppliers. You’re going to get all the information you can before you make a decision to make sure it’s the right one.” (FG#2 SM)

“You know certain brands that you’ve preferred, or we’ve had good service in the past and we lean towards that brand.” (FG#2 SM)

“We made the changes [recommended by an energy audit]. I just don’t know – I feel I may have gotten results, but I couldn’t verify that I got the results.” (FG#2 SM)

“There are a lot of what we like to refer to as snake oils out there, you know, add this additive and drive down your energies by 30 percent—we try to stay away from almost all those things.” (FG#4 LG)

“When pressures drop or compressors are acting funny or running too hot, it sends that information to the technician. You can look at it with your mobile phone, anything. It gives you enough data to know when a baby has a temperature, if your refrigerator is acting funny, send somebody up to look at it. It helps you diagnose things long before the ice cream is on the floor, at 2:00 in the morning.” (FG#6 SM)

“I specifically asked that in the energy audit and they kind of blew it off, but when they did it they were surprised as well.” (FG#6 SM)

“Part of it is your own experiences and knowledge. Part of it is whatever testing [manufacturers] may have to show you. Part of it is talking to others about a particular type of system. If stuff is brand new, then you just don’t know. You’re going to have to experience for yourself.” (INT#1 LG)

“We would typically lean on the suppliers to furnish energy data. That does two things. It tells us what we’re getting and it helps them understand the important of this stuff and they pay more attention to it. So over the years – and DOE has done a lot with this, too - where the manufacturers of this equipment now know that every supermarket company cares about energy. We’re just going to keep asking the questions. Show us the data. Where is your energy data? Whether it’s a DOE efficiency requirement or Energy Star label, or even just data that they determine at the factory. We need to see it. We’re not going to buy stuff without thinking about it or looking at the energy data.” (INT#2 LG)

“We’ll look through *Supermarket News*, we’ll look through the *Refrigeration News*, there’s *Contractor* magazine, there’s any number of mechanical things.... And then if that piques interest, I’ll go online and check it out a little bit further. There’s always something out there.” (INT#3 LG)

“Now with LinkedIn, people will reach out to you that probably would never have reached out before, so we get a bunch of opportunities.” (INT#3 LG)

“We read – that’s one piece. We talk to our peers.... We talk to the sales guys that are coming in. We’ll research via the internet. It’s probably easier today to get information than it’s ever been. I’ve been around this stuff for 20-plus years and it’s never been this easy.” (INT#3 LG)

“We monitor all of the energy use down to each store level, sometimes even further into a sub meter sometime to different technologies in the stores.” (INT#6 LG N-ANOM)

“We have tools we have developed for our consultants, for display cases... They will ...evaluate every fixture for how old it is, and it has a database attached to it that tells us what its current energy use is and what upgrades we have already made and what upgrades are available.” (INT#6 LG N-ANOM)

Split incentives - contractor

“We’re just big enough, got enough staff, enough people that we pretty much drive the decisions on equipment replacement, what we’re going to replace it with, how we’re going to go about converting R22 to other refrigerants.” (FG#1 MD)

“In our case we drive the decision as well. I’ve had very little to no interaction with our contractors. It’s all our internal maintenance staff. And when I have conversations with staff, it’s never, ‘Well, our vendor said this.’ It’s always about he knows this stuff intimately and they make a recommendation based on their knowledge of the situation (FG#1 MD)

“You’ve bought it and you have somebody else installing it and a lot of times there’s this world of pointing fingers—it’s not an equipment problem, it’s an installation problem.” (FG#1 MD)

“Because our stores are spread out over a 70 mile area, we’ve had local contractors that we use to do the maintenance, and we have our own in-house crew that does a lot of it, but there are still certain things that I won’t have them do. A lot of it depends upon your geographic area and what your options are.” (FG#2 SM)

“We have a maintenance contract. I pay my refrigeration guy so much money a month and he has to fix everything, and then he’s required to do a monthly inspection, which is a two-page checklist of inspecting the entire system, including cleaning condensers.” (FG#2 SM)

“We’ve got a company that we’ve used for the last 15 years, and they’re reliable and they take care of us.” (FG#2 SM)

“We’re obviously the final decision [maker] in most cases because we’re the ones who are going to pay the bill. When you write the check, you don’t want to have anybody else making that decision.” (FG#2 SM)

“They give us advice, but pretty much we know, too. We make the last decision actually.” (FG#3 MD)

“If it’s installed correctly, it works fine, but you really have to monitor the installation to make sure the proper expansion loops and everything were put in correctly, because if allowances aren’t made for that, then you definitely have major problems.” (FG#3 MD)

“Our [repair and maintenance is] performed 100% outside. We have very specific maintenance schedules for all the different types of equipment...All that has to be met through checked-off sheets, store stamped and signed from the retail location.” (FG#4 LG)

“Even though I do as much as I can in preventative and projecting, when it actually comes to the question you’re asking – when and who makes the decision – it goes back to the guy with the dirty hands who knows a heck of a lot more about it than I do.” (FG#6 SM)

“We make the decision, but they help us.” (FG#6 SM)

“I couldn’t find anybody that would show up and fix it on the first day without telling me it was fixed and it wasn’t. I had enough of that. I had five different companies in, found the best tech they had, and I hired him. And, generally speaking, I’m fine with that because when he doesn’t have something that isn’t critical, he’s handy enough to do everything else. That was a decision I decided to make, and I’ll know in a year whether or not it killed me, but I don’t mind calling the guy up at 8:00 at night to fix something when it broke and knowing I’m not paying time-and-a-half plus.” (FG#6 SM)

“We’ve had cases before we just bought, and the compressor goes out the year after. You talk to the owner of the company and you’re like, ‘Hey, you guys sold this to me, you’re liable for it as well,’ and they usually take care of you.” (FG#6 SM)

“We let contractors know we’re only as good as the worst pipe fitter on this job. If you have a bad day, you’re going to give us years of bad days with the leaks if you can’t braze a joint appropriately.

“There’s some sort of contract of terms and conditions and there’s some definition of what we want as commissioning. We have a set of best practices that we share and they follow it.” (INT#1 LG)

“You’ve got to have good project managers who are keeping an eye on the installers. You have to have well-defined specs, capable installers, and somebody watching them and calling them on mistakes and make them fix stuff. Good old-fashioned hard work.” (INT#1 LG)

“We have some dedicated design. We have some dedicated maintenance. We have some dedicated energy. In our size we’re specialists, but smaller chains, one guy does everything, so. Some stores don’t even have engineers. They rely on vendors to help them do stuff.” (INT#1 LG)

“We hold [the contractor] accountable to perform the installation contract including things like they need to fully commission the system. They need to start it up properly, draw vacuum, ensure that the controls are working properly, do their point checkouts on the system at least at the rack, which is what we call the central system. We hold them accountable to basically deliver a complete operational system....There’s an in-house team that does installations and then their supervisor is also responsible for all the installation work, whether it’s his crew or an outside contractor...When they’re almost done he checks it out and he works up a list of stuff that’s not done right. Then they fix it, and he goes back when it’s done and he checks it again.” (INT#2 LG)

“Where we have a contractor that we know and trust, it’s not a big deal. But we’d prefer to have in-house people everywhere. It’s a challenge because there aren’t a whole lot of people that are qualified and interested in that line of work these days.” (INT#2 LG)

“We got an alarm or the store reported a problem and we sent a contractor, the contractor gets there and determines that he needs to make a repair right away, then we trust him and we make the repair right away. Anything that has any discretion involved, anything that can wait a day or two, then they’ll consult with the supervisor that’s responsible for that store and they’ll decide jointly.” (INT#2 LG)

“We also let them know that, ‘Hey, we’re going to track the service on these stores for leaks and if we have a lot of issues, we don’t ever want you in our store again brazing pipe.’” (INT#3 LG)

“If there’s something we think they need to know, I’ll shoot them a note. We also review their bills – not all the time, but we used to quite a bit more. If I think they charged us too much for a refrigerant, I’ll give them a call and say, ‘Hey, by the way, you charged us twice as much for R22 as anybody else would.’ And just let them know we’re watching.” (INT#3 LG)

“If you hired the wrong guy you wouldn’t know it for a couple of years in this kind of field.” (INT#3 LG)

“The value to having an in-house team is that folks get to know your locations. When you go to a contractor that’s never been in your store or goes there periodically and doesn’t hit that store once a month maybe, what happens is a learning curve with that. The in-house team knows where that particular piece of equipment is.” (INT#5 LG)

“The understanding we have with our core group of contractors. They know what we want. We have a very tight specification — installation specification and we expect them to adhere to that.” (INT#8 LG N-ANOM)

Split incentives – staff

“We have a fairly [high] staff turnover at several of our locations, and for that reason it’s an ongoing training process.” (FG#2 SM)

“Some of our biggest energy savings have been because of getting our associates involved in the process.... Turning off lights. In the humidity, making sure doors stay shut and are not just left open. And we have a little reward system for stores who show the most energy reductions. It builds some bonding, some purpose, and it really drives energy usage down.” (FG#3 MD)

“And [the electronic controls system] also runs our lighting inside the cases so the employees can’t turn it on at 6:00 in the morning when we open at 8:00.” (FG#6 SM)

“Most of the significant energy use in our stores is managed centrally by our energy management team. The people that work in the store have relatively little opportunity to implement energy use. However, they’re trained in the things they can do to reduce energy use... They sort of embrace it nowadays because they realize it’s part of our sustainability ethic: things like keeping doors on coolers and freezers shut, make sure they keep the doors to the outside shut when you’re in the backroom, make sure you keep things turned off or turned down whenever possible... And don’t overload your cases. There’s certain things they can do to help reduce energy, and they’re trained.” (INT#2 LG)

“If an operator is doing something that is going to cause them to use more energy, and a good example of this is leaving freezer doors open for walk in coolers, then we have alarms in place that notify them to shut the doors and then that is monitored over a period of time and if we see this is a continued problem, then the store directors can take some remedial action to make sure the people are trained on the impact of those things.” (INT#6 LG N-ANOM)

“Usually, they are going in and out of that door and they are usually stocking, so their hands are full and it’s harder for them to open the door while they are doing that. It’s human nature to prop that door open. When you do that, you are thinking, ‘Well, I’m coming right back,’ but then the customer calls and their priorities change and the door is standing wide open. It is more bringing the awareness to them that that impacts the energy use in the store.” (INT#6 LG N-ANOM)

Split incentives – landlord-tenant

“As far as leasing goes, it depends how long you’re planning on being at that location. If you’re planning on leaving, you’re not going to put a bunch of new stuff in there.” (FG#6 SM)

Financing/liquidity constraints

“Our largest town is 13,000 people, and we’ve had personal relationships with all the bankers. We can walk in and finance equipment and be out of there in a very short period of time. They never question what we’re doing. As long as our P&L’s and our cash flow numbers are such that they’re confident they’re going to get paid, it’s our decision.” (FG#2 SM)

“I pay cash for everything so I don’t ever borrow any money, so I make a decision that’s best for the customer, best for the store.” (FG#2 SM)

“When you do a whole store’s worth of changes, with the interest rates where they are today, use some of the bank’s money.” (FG#2 SM)

“If you have \$100 and that’s all you have, you can only do so much, so you select where you think you get the most bang for your dollar. If I have ten projects, and nine of them pay back in one year and another one pays back in two years, I’m going to concentrate on the ones with the quickest payback.” (FG#3 MD)

“Obviously, if you have a pot of money, there’s only so much money in the pot that you have available to do projects with.” (FG#3 MD)

“It’s like an individual buying a car. Would you buy a different kind of car if you had to pay for the car all upfront, or if you had the opportunity to pay for it over six years, or five years?” (FG#4 LG)

“If I’m going to save \$5,000 by writing a check, if I can afford it, I’m going to write the check and save my money right up front versus spreading it out over three years because that isn’t the way I like to operate

my business. Is that a key factor in buying equipment? I would say no. The key factor is the bottom price, because I might be able to get better financing somewhere else.” (FG#6 SM)

“Let’s borrow the money if we can get that paid back in a year, but when it’s your cash out of your checkbook and you’ve had enough slick salesmen to tell you you’ll get a payback in two years and you never see it, you’re a little hesitant.” (FG#6 SM)

“If I’ve just told half the staff there’s no raises because [times] are tough, and then I bring in ...all kinds of new equipment..., the staff is not going to accept that as well when they’re having trouble making their ends meet. I’m only as good as my staff on the floor” (FG #6 SM).

“I don’t want to spend money I don’t have. I’m not confident enough on where the economy is going to say – yes, let me borrow for 15 years or 10 years or 8 years I’ll get my money back. I’m not confident enough with that.” (FG#6 SM)

“The only time financing matters is if the cost is too high, but we have a relatively low cost of money internally. It’s not like we have to go out and finance to make or break a deal. If it was attractive enough, I’m sure that our accountants would jump on it.” (INT#3)

“We haven’t rolled the doors out to our existing store base because financially the company isn’t willing to commit the capital to do that. The capital is tied up in other parts of the company.” (INT#4 LG)

"In '08 '09 and '10, I don't care if you had a million dollars in the bank and you wanted to borrow a dollar, the bank wouldn't give you any money, just flat out wouldn't give you an extra dollar.... for two or three years, it was very difficult so that obviously affected what you were going to buy. You had to do it out of cash flow." (INT#7 SM N-ANOM)

Utility rebates

“I look at the rebate factor, how much money I get back. That’s one of my major concerns is the money on the rebate programs coming back.” (FG#3 MD)

“We always look for rebates when it comes to energy efficiency projects, and often those rebates impact the financials in such a way that it’s a ‘go’ with the rebate, and if for some reason you can’t get the rebate, it’s a ‘no go.’” (INT#4 LG)

“It [utility rebates] often tips the scale I would actually say in today’s climate.” (INT#4 LG)

“I don’t know that a lot of utilities are willing – I don’t think there’s enough money there. Look at how many buildings, how many lighting retrofits they can do across the state as opposed to doing 15 or 20 of my stores.” (INT#5 LG)

“We will do some things in [certain states] that we might not do in [other states] because of the rebates not being there.... because we'll go where we can get the rebates first.” (INT#8 LG N-ANOM)

Tradeoffs – customer appeal

“The industry and operators and merchandisers have gotten past, for the most part, that doors make a better shopping environment, and the customers get it. There's still some holdouts out there who think doors are the gates to hell.” (FG#1 MD)

“There's one caveat I'd throw out there. It's the last holdout on doors. Chilled wines. Typically you don't find those behind doors – seems to be not much emphasis within the industry about putting them behind doors, so no one's pushing for it necessarily, but that's where I think the operators and merchandisers would have a real issue.” (FG#1 MD)

“Where you put meat in short trays with fluorescent tubes running right over top of them, just think what's going on with heat/cold...plus visual presentation of how that looks. We get the right colors in LED lights to make that look very appealing.” (FG#1 MD)

“You hope that you put up a [GreenChill store certification] plaque or it's in a press release that that means something to somebody.” (FG#1 MD)

“We're replacing a seafood case that's only five years old, but we're going to ...replace it with this glycol case because it maintains such even refrigeration. Not just for energy savings or ...the leaks so much, but also for shrink reduction and integrity of the product. ... It maintains that temperature at 33 degrees, and so the whole case – it's safer and the integrity of the product is much better.” (FG#2 SM)

“The display sells the product. Years ago it was a common agreement that door cases didn't make sense in smoked meat, dairy. In today's markets we're seeing everybody going to door cases because the perception with the customer is ... you're going to have a better quality product because it doesn't have the air fluctuation temperature inside the case that you have from the others, and they accept it. Years ago the consensus was the customer wouldn't take the time and energy to open that door, they were going to walk right by. Over time they got used to frozen doors, and now they're getting used to the dairy doors and the mid-temp doors, and it's going to become very common.” (FG#2 SM)

“If you have an ice cream case go down and the ice cream turns soupy, and it refreezes, you're not sure, 'Do I throw it away or is it going to be okay?' Nine times out of ten it's probably going to be okay. But when it refreezes and the consumer gets that home and they pop that lid and it's frosted over the top, it's not 100% quality. They bring it back, or they don't bring it back but they go somewhere else to get it that you'll never know. Once you can get your temperatures constant, your confidence level from your customers has got to come back strong. You never see that savings, but it's got to be huge.” (FG#2 SM)

“I don't find [ammonia as a refrigerant] to be a good choice in a retail environment because if you do have a leak, it's going to empty the store.” (FG#2 SM)

“Where we put doors on cases, a lot of people report the sales stay flat. We've seen, in some instances, a slight uptick. We add energy savings but we also have customers that feel like they're buying product that's safer because it is behind doors. So not every decision is driven strictly by energy.” (FG#3 MD)

“We work for merchandisers, and our companies have to sell product or we don’t have jobs, and we’ve got to maintain that product and display it....We’re on the tail, we’re not out wagging the dog. (FG#4 LG)

“We changed our system to accommodate the changes that were driven by the merchandising team on the sales floor.” (FG#4 LG)

“They have tried to get us to put on glass doors or buy glass door beer cases. When we did that, it doesn’t sell anywhere near as fast as when it’s an open case. Logically you’d think if someone wanted their beer, they would go and open the door, but it did have a significant effect. We’ve got the variety that we want, so we don’t need to find a way to add more and more. But we have not gone to the glass door concept on those because of the sales.” (FG#5 MD)

“The coffin cases are big and they’re ugly and they’re very energy inefficient. They’re expensive to buy, expensive to install, expensive to repair, but they sell products. They sell products because if people can look over and they can see what they want and they can reach down and get it. So we’ll never figure out the answer to this. Maybe somebody already has, but these guys, they’re big players. They’re going for the doors and they’re getting rid of their coffin cases. We’re buying those coffin cases as far as we can... A coffin case is perfect for our business, perfect for us. There are other people in the same type of business that I’m in that believe just the opposite. They’re more interested in saving money on energy than they are in selling additional product. Philosophically, I’m a grocer. And I’m in the business to sell products, and I believe that if I can sell enough product and make enough gross profit that I can cover all of those additional costs of the coffin cases.” (FG#5 MD)

“If you end up selling a spoiled chunk of meat, and you see it on the news, the last place you want to see your name is on the news. So you typically look at the quality of the case in terms of does it hold the temperature or not. It has to hold the temperature. If you look at ... sushi, very high spoilage. You have a very high temperature control around sushi. You want to maintain the product at the right temperature, and when it exceeds it or it goes outside the range, you have to do something about it.” (FG#5 MD)

“With the LED [automatic lighting] technology, having lights off, the customer is not drawn into that aisle, so that wasn’t appealing to us. And our cases are not in the lineups, so they may be an individual case and a customer has to walk by it, they may not go down that aisle. It’s a mental thing.” (FG#6 SM)

“We’ve talked about putting [strip curtains] in a walk-in beer cooler. It’s just not the sign I want to give to my customers. I feel like those things get really dirty, and we’re an upscale gourmet market. I don’t want that. Off the floor if it’s not visible to my customers, yes, it’s great.” (FG#6 SM)

“Customer appeal and merchandising and operations are king in our world and in most retail. If putting doors on cases adversely affected customer appeal, we wouldn’t put doors on cases.” (INT#3 LG)

“You can install a night curtain on an open case, and what that does for you is at night you’re basically putting doors on an open case. After the store closes, if you go in and pull those night shades –it’s not

100% tight fit, but it cuts off a lot of the outside air entering the case. You win from the refrigeration side because you've shut down some of that load, and then you win from the shrink side because you're keeping that product as cold as possible, especially produce and meat." (INT#5 LG)

"The customers have been very vocal about doors on the display cases. We are leading an effort to go in and retrofit and put doors on all display cases and our customers, it's not so much the green aspect, but the stores are so much warmer." (INT#6 LG N-ANOM)

"One of the reasons operators don't want doors on the refrigerated cases is that they have this perception that it is going to hurt your sales because now someone has to open the door and they don't have that impulse buy. That is a double edged sword because our take is having doors on your cases provides a competitive advantage over someone who doesn't because whatever is inside is going to be colder and at a more consistent temperature. When you go in and buy that milk out of an enclosed case, it's going to last longer when you get it home because it hasn't been up and down in temperature. It's going to last longer in the store. If you like to drink beer, it's going to be colder. Stand and watch people sometimes, if it's an open case they get the product out of the back of the case because they know it's colder back there. With doors you don't have to do that. It is the number one complaint from the vast majority of our customers that are super markets are too cold. They want to put their jacket on, run in and get out. By having those doors on you are not spilling out all that cold air." (INT#6 LG N-ANOM)

"If you deploy a technology like putting doors on display cases, we know that changes the whole dynamic where you are not up and down in temperature in those cases. And for things like cartons like milk, you're not having that expansion and contraction so it actually leads to... [fewer] cartons that are going to begin to leak on you. So that is shrink reduction: You're not having to throw that product out." (INT#6 LG N-ANOM)

"We want to be able to merchandize the product in the fashion that will sell. And so we had to prove to our merchandisers that the doors would not be a barrier for the customers." (INT#8 LG N-ANOM)

"We had to show operations how doors would be a benefit because it would provide better refrigeration, temperature continuity and increase the life of the product so there would be less shrink." (INT#8 LG N-ANOM)

Tradeoffs – reliability/maintenance

"You have some tradeoffs [for] new types of refrigerant or doing other controls or electronic kinds of things, floating pressures and suction pressures. Each of those things have some real plusses for energy efficiency, but may be not so good on the compressor itself, the equipment...You have to then value how much better it might be on one side and what are the tradeoffs on the other." (FG#1 MD)

"You mentioned secondary loops earlier or secondary glycol loop. The one time I put it in a store it didn't seem to add any value to the store and just added a ton of cost. So, there's refrigerant replacements and then there's crap." (FG#1 MD)

“The controls on the new racks are much more efficient than what you had on the old single pump systems or even the old racks, and they can do a lot more for you, and they give you a lot better control. You find out problems in a matter of minutes instead of a matter of a day.” (FG#2 SM)

“10-12 years ago [hot gas defrost] was the standard for energy efficient cases. Today it doesn’t work. It causes more problems when that cool gas is going into that steaming hot compressor.” (FG#2 SM)

“We don’t have the installers, the maintenance people, in our area that are familiar enough with it to maintain a system of that type, and therefore we’ve stayed with more traditional refrigerant.” (FG#2 SM)

“We play with variable speed drives a little bit, but it creates a whole other maintenance issue when they fail or don’t work, and they’re rather expensive. You have to weigh the cost of keeping the variable speed drives operating versus what you save in energy. We haven’t convinced ourselves yet that that’s a good decision.” (FG#3 MD)

“I can be as energy-efficient as I want to, but if I lose one compressor I just threw all that savings out the window.” (FG#4 LG)

“For me, the location is important based on the service available. You don’t want to put something in and nobody can service it at midnight when it breaks down.” (FG#4 LG)

“It’s not as easy as just picking the retrofit refrigerant, [like] moving from 22 to 407A. We’ve done some of that, and now we’re realizing that some pumps are incompatible.” (FG#4 LG)

“We don’t figure [the cost of maintenance] in dollars. We figure, are parts easily available, how difficult are they to work on? The newer technology [can be] swapped very easily across different lines.” (FG#6 SM)

“You can go out and buy a whole new lineup, and seven months later the compressor blows and they’ll gladly give you a free one.... But you then lose 24 doors worth of product. In the grocery business you can never put [that] on a sheet of paper: What am I going to lose on a breakdown versus lost sales versus the cost to repair it? Cost for repairing it sometimes is not the worst part of the whole scary, frightening mess.” (FG#6 SM)

“We’re here to sell groceries and we’re pretty good at that. We’re not great at maintaining mechanical systems. So, in large part, we have to be a little bit idiot-proof on our systems. If I’ve got an option of taking a bulletproof compressor that will take use and abuse and misuse versus something that’s a little bit more energy efficient but at the same time is going to require a lot more maintenance, I’m taking the bulletproof one every day, without a second thought.” (INT#3 LG)

“You have some older stores that run probably better than some of our newer stuff, based on the way it was put together. If I have a location, new, old, could be 30 years old or five years old or a year old, it’s going to be based on what the repair looks like. If I’m having a lot of issues in a newer store, that’s

where I'm going to concentrate my efforts to get that place up and running. I don't want any down time; I want 100% running all the time with minimal breakdowns. There are some stores that we don't go near that run and run and run, and we put minimal money into those locations." (INT#5 LG)

"If you are trying something new, we already have a shortage of people that know how to work on the existing refrigeration system, so if these things break, what going to happen then? It's always a huge concern." (INT#6 LG)

"The newest store, believe it or not, has 16 compressors, and 10 of them have failed already in the first six years, and yet our old store that has 40 year old compressors are still running. That shows you how cheap the new stuff is." (INT#7 SM N-ANOM)

"Even if he trained his staff to [maintain a new system] there's going to be a learning curve, and we'd be the learning curve, which means we would be paying the bills if it broke down. They wouldn't be the experts, they probably would call somebody else in so actually that would be part of the equation. If we ever did put a system like that in, I'd have to give our refrigeration guy plenty of notice and find out if he's confident that he can handle it." (INT#7 SM N-ANOM)

"I would add serviceability. I've always felt that the equipment for use in a supermarket needs to be very easily serviced and very direct application. It can be a mistake to make it too complex." (INT#8 LG N-ANOM)

Tradeoffs – energy-refrigerant

"Because of the energy penalties, I'd be very hesitant to use that [secondary loop system] again. I'm open to revisiting maybe different styles or what have you, but I'm hesitant." (FG#3 MD)

"It's a catch-22 on that because you've got the EPA and you've got the DOE. The DOE is wanting you to save energy, and the EPA is wanting you to [reduce] global warming. The secondary systems, they're great on the global warming side but on the energy side, they're not. It's like we're caught in the middle. Which direction do you go?" (FG#3 MD)

"As your system starts to lose refrigerant, your pumps tend to run longer because the cases are not making temp. If it's not caught in a timely manner, you may be wasting energy dollars because of the leaks... with every pound of refrigerant that you lose out of the system, you get less efficiency and more energy consumption. (FG#4 LG)

"We tried secondary systems that were CO₂ or glycol, and we still went back to direct expansion. At the end of the day, it's still a better choice for us for a number of reasons. Our leak rate is lower than average - that worked against introducing new technology - the newer systems were actually consuming more energy than the traditional systems. So we went back to the simple tried-and-true direct expansion." (FG#5 MD)

"We started in the '90s with ozone depletion and moving away from CFCs to HCFCs. Now we're moving from HCFCs to natural refrigerants. In every case there's this question, what will this do to compressor

performance, to compressor efficiency? And then there's this pause because you've got to wait for the compressor manufacturers to go out and test this stuff and publish data. In the meantime there's speculation, we hear it's 5% less efficient or 10% less efficient. Those numbers may or may not be accurate. Until you have good performance data from the manufacturers or from somebody, you don't really know." (INT#2 LG)

"There's certain refrigerant decisions you can make that can adversely affect energy. I think that it has been a little overdramatized in the past, from my experience. But it is an engineering reality that you can't ignore." (INT#2 LG)

"Especially when you're looking at natural refrigerants with GWPs of 1 or even 0 in the case of ammonia, refrigerant emissions will trump energy efficiency every time.... So we have to decide...I get tired of the people saying, 'We can't use that refrigerant because it could be less efficient.' Well, what are we trying to do here, folks? If we really care about greenhouse gas emissions you've got to be looking at this refrigerant." (INT#2 LG)

"Being a seasoned veteran, I am comfortable understanding the interrelationship between refrigerant decisions and energy performance to the point where I'm comfortable thinking about them sort of independently. But on the other hand, we're doing a trans-critical CO₂ pilot project that will start up this summer. And I know – and I'm supposed to present it in the fall – that the first question people are going to ask is, what is the energy performance? And I'm going to have to have that data. So there is a clear interrelationship." (INT#2 LG)

"Refrigerant is tricky right now because a lot of times the stuff that's most energy efficient isn't the best for the environment. R22 from an energy efficiency standpoint is a lot better than a lot of things being touted today. So there's a tradeoff there, and we understand the tradeoff, we understand the ozone depletion and global warming, and it's the right thing to do to get away from those things. But that's a challenge." (INT#3)

"It's the same group of people that work on energy efficiency and whatnot, but I wouldn't say that as we look at the payback on reducing refrigerant leaks, we're not factoring in anything to do with energy, so it's really separate." (INT#4 LG)

"Different refrigerants that operate differently. If you're trying to retrofit, you have to be careful because what will happen is you're going to lose efficiency in your compressor system and you're going to lose efficiency in the refrigerant itself. So you're kind of limited, without doing a huge amount of work to a store, as to how much you can do. We've probably done more maintaining that replacement. From an energy side, that would be last on my list right now." (INT#5 LG)

"One energy savings thing that has been looked at a lot is heat reclaim where you actually take what is generated off of the compressors in your refrigeration systems, and use that to heat your building and heat water. We ... have found you open yourself up to leaking of the refrigerant because there is more piping ... That also results in a larger refrigerant charge to begin with." (INT#6 LG N-ANOM)

“If you are leaking a lot of refrigerant you are using a lot of energy because the systems are designed based on a certain refrigerant charge that’s needed there.” (INT#6 LG N-ANOM)

“It’s still out to the jury as far as whether we do have an energy penalty or not.” (INT#8 LG N-ANOM)

Refrigerant regulations

“Glycol and CO₂ are a couple of items that are being experimented with rather heavily, and there’s been some success with them. But the cooling effect of those is not as good as what you get from some of the CFCs, which is why they were originally used in the first place.” (FG#2 SM)

“The lack of direction or predictability on the regulatory side has really led to us all scratching our heads. What do you do? What’s right for right now? Will be right in eight years? It also makes us slow adopters of new technology.” (FG#4 LG)

“It’s the future regulation we can’t control. It’s a lack of vision that is the issue, not the testing or anything else. ... We’re making 20-year decisions with five-year data....Here’s an example. We used 407A as a retrofit. We’ve chosen not to use it as a new refrigerant because if they decide in five years from now to treat it and 404A exactly the same, what was the point?” (FG#4 LG)

“It’s a mandate. We don’t have any choice but to deal with [refrigerant regulations]. When the government says you can’t have it anymore and they triple the price, you’re forced to make a decision. So do I think about it? Just with anger and frustration.” (FG#6 SM)

“EPA rules and regulations may drive us to change a refrigerant or change to a certain valve configuration or change to a certain case. It may not be the ideal solution for us, it may not be the easiest, and economically it may take a longer payback but it would be a regulatory thing that would drive that.” (INT#5 LG)

Tradeoffs – store-specific factors

“[Small racks like Protocol] create some issues sometimes with refrigerant lines because you’ve got to get access to your condensers. Sometimes it’s not convenient to place the condenser close enough to the rack if it’s on the sales floor because it might be in the middle of your parking area or you might have to go to the roof, which you may not want to do. Most of us know that roof penetrations are never any fun...Sometimes you make choices on placement based on factors other than what gives you the lowest refrigerant charge.” (FG#2 SM)

“We have to be a lot more flexible in our solutions for existing buildings. I don’t think it’s because it’s a new store or because it’s an old store, but you have structural issues you’re going to be dealing with, and those are the circumstances that drive those decisions.” (FG#4 LG)

“Just look at the new technology with transcritical. You wouldn’t put it in Florida and you wouldn’t put it in Georgia. It’s all got to be up north of the Mason-Dixon line, basically. You wouldn’t typically put

evaporative condensers in Las Vegas, you're not going to drop one in the middle of Minnesota." (FG#4 LG)

"We may decide because of space requirements what we're going to put in the back room, whether it be the air cooled singles or some version of a rack system. I know there's one version that one particular manufacturer makes, it's the size of a large refrigerator that can have up to six compressors while another type of rack system might take up that whole wall, so space constraints factor into the decisions that we make." (FG#5 MD)

"Our stores tend to be a larger footprint, so distributed refrigeration systems really don't work well for us." (FG#5 MD)

"In areas that are susceptible to a lot of power outages, [night curtains] works great. The lights go out, you drop all the shades, and you don't have to pull your product. If you know it's going to be a couple of hours getting your power restored, it saves a ton of labor as well." (INT#5 LG)

"There's misting systems to pre-cool the air before it gets to the condenser service...From a cost standpoint it doesn't make a lot of sense because our weather up here is such that... there are not enough days in the year to make it worthwhile. The payback takes too long." (INT#5 LG)

"Now you may get some [stores] that don't have doors because, when we do the decision tree, the store is not capable. Maybe the cases are too old at this point to put the doors on and we know 2 years from now we are going to replace the whole thing. Or it may not [get doors] because of the aisle between the cases facing each other, because there is not enough room with the cases facing each other." (INT#6 LG N-ANOM)

Uncertainty and option value

"Sometimes I can be fed all the information in the world and I'm not going to do it. And the reason is because I don't want to be a beta site. I know somebody else eventually will be a beta site and they'll work through all the problems, and I'll be more than happy to be the second or third generation." (FG#1 MD)

"When people start[ed] putting doors on medium temp cases and the first one said, well, I'm saving 50%. Well, maybe. Then all of the sudden there's four manufacturers and all their spec sheets have about the same energy savings. Then maybe somebody installed it and said, yes, I think this is happening, you start to be more confident in it." (FG#1 MD)

"When you say new technologies, we're like, 'How new?' And we don't like being on that leading edge." (FG#1 MD)

"I'm thinking reliability is necessarily not being the first person to buy the first model of that new case. Seems like sometimes buying that first generation, they can have their kinks not worked out completely. So I wait a year or two and make sure the kinks are worked out, and then get in on it." (FG#2 SM)

"We'll take the plea that somebody on a larger scale proves the technology before we will." (FG#3 MD)

“One of the refrigerant companies came out with a new refrigerant. And they came out and engineered one of our stores, and they were willing to give us all their refrigerant at no cost, but there was a lot of labor involved. I wasn’t willing to step out to spend all of that on a pilot on this refrigerant. I’m sure the cost of the refrigerant, there definitely was some dollar value in there, but still, because it wasn’t proven to me that it was going to work. I wasn’t willing to spend that money.” (FG#3 MD)

“We like to be on the leading edge of technology, we just want other people to do the bleeding part.” (FG#4 LG)

“Let somebody else bite that bullet, be on that leading edge of the technology and let them chase off all their customers.” (FG#4 LG)

“We’re all faced with budget cuts and saving costs across the board; we’re operating on real thin margins. When you’re hit with these things that are coming down the pike, and there’s some uncertainty in what the future is going to look like, you want to hold what you’ve got for just a little while, and see who’s doing what and make sure the decisions you’re making are going to meet your long-term strategy, and it becomes very, very difficult.” (FG#4 LG)

“It’s more important to me whether I can afford the system upfront than it is whether somebody tells me that I’m going to save so much money over the next 10 years...our business is so day-to-day and so capital intensive, that it’s more important that I make the best decision upfront” (FG#5 MD)

“That’s one thing that’s really changed in the last two or three years. They used to come up with all these slick ideas for payback, monitoring systems and this stuff that [was]n’t that effective. But the newer technology has changed hugely. ... You’re using half as big a compressor with smaller lines, LED lighting, which that’s nothing but obvious. LED, it has less heat to it, so it only makes sense that it’s going to be – it’s in a refrigerated case having less heat. The decisions on those paybacks are so much easier right now because they make so much sense.” (FG#6 SM)

“It’s far more predictable now than it was five years ago. You know you’re going to get energy savings.” (FG#6 SM)

“Anything could happen. The environment changes. Things are variable. There’s no guarantee what your payback is going to be. They can tell you it is, but until you see it in action, there’s no way.” (FG#6 SM)

“If you buy the more efficient piece of equipment and you own it, you’re in good shape. So when inflation hits, that electricity goes up 30% which I can’t control, I’m safer with the more efficient piece of equipment. As I look forward down the road, the more efficient you can get, the more that I can control. I cannot control electric rates because that can be driven by God only knows what. That’s a concern that most of us retailers have when our gas and electric bills exceed almost every other thing we pay. It’s the greatest risk we have.” (FG#6 SM)

“There’s a cost associated with changing an entire refrigerant system and at the present time in the US, at least, we haven’t come to grips with that yet. We don’t really understand what the cost is. We know it’s a big number. We think it will probably get smaller over time.” (INT#2 LG)

“We’re at the stage where people are just starting to think about pilot projects to learn more about this. And once that starts happening in two to three years from now, we should have some data from actual case studies that looked at, well, what does it cost to replace an HFC refrigerant system with a CO₂ refrigerant system?” (INT#2 LG)

“We don’t mind being on the leading edge, we don’t want to be on the bleeding edge. We’re not fond of being the first on the block on a mechanical piece that could cost us down the road. Six years ago, LED lights in frozen cases would be \$300 a door and the quality was terrible. Today, that same light probably costs \$110 and the quality is pretty darn good. As that technology has evolved, the quality has gone up, the price point has gone down, it makes sense to get in there. It’s the same way with electrically commutated fan motors, it’s the same way with VFDs if we want to vary the speed on fans, however you want to do it. Any technology, the newer the technology, the more price premium. The more mature that technology and widely adopted that technology, the price point is coming down.” (INT#3 LG)

“There is a lot of liability associated with running a supermarket chain, so the return on investment has to be commensurate with that liability or risk.” (INT#8 LG N-ANOM)

Opportunity cost of capital

“Your profit margin is so small in grocery, a penny on the dollar, you have to get the life of your equipment out. If it takes 10 years to pay back for something, it’s not worth that investment because there’s so many things out there that you can invest your capital dollars in to get a payback within two years. Why would I invest a ton of money in a piece of equipment that’s going to take 10 years to payback, when I can take that money and get a payback in other areas in two years?” (FG#3 MD)

“We don’t look at simple payback. We look at actual internal rate of return. So if we had spent that money on something else, or if it had sat in a bank, it would have earned us such percent. If that can’t meet that or exceed it, then it can’t move forward. Projects compete for money based on that internal rate of return.” (FG#4 LG)

“Do you need something more important to you at the time? If you have to borrow the money, what is the cost of money at the time? I mean, there’s a lot of factors.” (FG#6 SM)

“Technology is not only changing refrigeration and electric. I mean, there’s a lot of technology that’s changing. Computers and software, security systems. We’ve got to address all that too.” (FG#6 SM)

“It’s time/value/money. It’s the same financial standard we put on anything we invest in the store. Refrigeration systems has to have the same kind of investment as a pizza oven or a coffee machine or a soda dispenser. It’s all the same.” (INT#1 LG)

“My preference is always to try and allocate the available budget by investing in things with the best return first. You can use either a payback or a profitability index to determine that.” (INT#2 LG)

“My understanding is the company feels they can do better things with that capital, invest it in other places and get a better payback. It’s the old adage, you only have so much money and nobody has unlimited funds, and somebody’s making decisions on where to apply those available funds.” (INT#4 LG)

“You have to meet your economic goals, so any projects, any technology that we would evaluate would have to meet a return on investment.” (INT#6 LG N-ANOM)

“You have ROI, which is a return on investment, but you have internal rate of return and those type of returns are very important because if you're not making a certain return with all the money you spend, then your stockholders may as well go and put that money in T-Bills.” (INT#8 LG N-ANOM)

“We have other ways we can spend our money, and maybe it's to buy new fixtures that will generate more sales. So we have to weigh that against doing a project that is going to improve our energy efficiency. With limited funds we have to decide which project we're going to do first.” (INT#8 LG N-ANOM)

“We will prioritize those projects so [you start] the ones with the highest returns... At the end of the day if I have \$100 million to spend per year, the board of directors and the shareholders expect a return on that \$100 million.” (INT#8 LG N-ANOM)

Behavioral anomalies – loss aversion

“If it’s still relatively new, I want to assess what’s the risk of bad, bad things happening if I do this. A secondary loop system, that is a huge risk because you’ve got a whole new system, but replacing a few LED lights in a case might be marginal. So I’m going to assess what is the risk of something really bad happening?” (FG#1 MD)

“My biggest fear when I lay in bed at night is that I’m going to have a major refrigeration leak or something happen to the system.” (FG#2 SM)

“In my role now with over 100 stores, you just can’t afford to make mistakes. You can’t even afford to make the wrong investment decisions.” (FG#3 MD)

“With smaller chains, you don’t have as much room for error. You can’t make many mistakes because they can have a devastating effect on your company. I think we’re probably – and I don’t want to speak for anybody else – but we’re probably a lot more cautious in what we will try.” (FG#3 MD)

“You can buy a whole new lineup, and seven months later the compressor blows and they’ll gladly give you a free one....But you [still] lose 24 doors worth of product....Cost for repairing sometimes is not the worst part of the whole scary, frightening mess.” (FG #6 SM)

Behavioral anomalies – inattention and heuristics

“I mean, we ask questions: ‘How old is it? What’s the repair cost? What’s the repair history?’ And stuff like that. There’s usually pretty good data around that information. At the end of the day, I don’t look back and say, ‘Gosh, we’ve been really making a lot of bad decisions about refrigeration.’” (FG#1 MD)

“And how much is it going to cost to do the case, the construction, the electronics? And does it semi make sense? But to say that I sit down every decision and put together a nice little spreadsheet with a return on investment analysis from my MBA class, that doesn’t happen.” (FG#1 MD)

“If it’s a \$2,000 repair, a \$5,000 repair, I’m not putting a spreadsheet.” (FG#1 MD)

“I mean, up to \$2,000 or \$3,000 is a compressor. That’s easy. Anything that’s beyond that, \$10,000-\$15,000, we have to look at it very seriously saying, ‘Is this really helping us move forward and enough other reasons for us to go?’” (FG#1 MD)

“I really didn’t look at [the ROI] for the last install, but it gives me some information with the energy savings that I saw on paper, and the reduction in equipment maintenance that I saw on paper, that I can use that to apply to my next major change.” (FG#2 SM)

“I don’t do any detailed analysis of anything. I use common sense and consider every factor – everything that’s going to be good about the decision and anything that’s going to be negative, which is the cost.” (FG#2 SM)

“You may get different answers to these questions when you go to chain stores and somebody is making decisions for the stockholders...He’s going to analyze it, he’s going to put a pencil to it, he’s going to show the ROI because he has to explain that to somebody else who doesn’t own that store....And even if it was a half a dozen stores, you’re going to be more analytical because you have to be.” (FG#2 SM)

“We’re not going to buy stuff without thinking about it or looking at the energy data.” (INT#2 LG)

“For a long time the before and after energy use for a remodel was in the weeds and not put in there. [There] really wasn’t a lot of thought put in there. People would move that number around to make their return on investment be what they needed it to be. Now it is more structured and it’s there with some backing that shows if we say you are going to get these savings you, you do indeed get that savings.” (INT#6 LG N-ANOM)

“When I first joined GreenChill, I was very concerned; I had no idea what a leak rate was.... So when we did the first year with GreenChill I had to find out what kind of systems we had, what gases were in each system and what my guy was actually doing.” (INT#7 SM N-ANOM)

Organizational inefficiencies

“It’s nice that we’re still able to make our own decisions about what we can put in our stores and what we use, and somebody’s not telling us what we have to use.” (FG#2 SM)

“Our energy committee is composed of merchandising, operations, maintenance, distribution. Everybody has a voice.” (FG#3 MD)

“I am the energy committee. I wear many hats.” (FG#3 MD)

“You’ve got the energy folks [looking] over the energy bill. The facilities folks and the maintenance folks, they’re looking at the maintenance expense. You’ve got the sustainability folks looking at emission activities. Usually we’d have one broader group, a store development type group, that can be accountable for all those parts... and they’re looking at that bigger picture.” (FG#4 LG)

“Our store directors [are] very autonomous. They can use whatever maintenance provider they want to. As much as we would love to mandate certain maintenance practices, we can recommend those best practices, but we can’t necessarily guarantee that those are going to be followed. We have 235 different stores, and we could have 40 different maintenance providers...Some stores have their own maintenance guys, but it’s not as tightly controlled as we would like to see. You really have to have the store manager take some ownership in his store.” (FG#4 LG)

“In this business probably more than half the time stuff comes up because some executive thinks it’s cheaper to do it another way, and they may be right that it’s cheaper upfront, but maybe it’s not cheaper in the long run. So we try to be diligent about that and I’m not afraid to tell a senior executive they’re wrong. Tell them why, even though it costs less upfront, it’s probably not a good deal down the road. We have a team of investment analysis people that can back us up with that.” (INT#2 LG)

“When a store was put together, there were a number of hands that reached in there and took a look at it all. We looked at it from the energy side, we looked at it from what worked best from the refrigeration side or HVAC, and then we looked at what worked best from the operation side. Operations typically drives the bus because, obviously, the business is to sell groceries so we’ve got to make sure that the case displays and the things they want are there, and then it’s up to us to try to drive as much efficiency as we possibly can.” (INT#5 LG)

“I’m actually a store director, and most store directors in bigger companies, all they deal with is what’s going on within the four walls. They don’t worry about refrigeration or anything like that. Almost everybody here has at least three, maybe even five hats, and so they made me the sustainability guy and the refrigeration guy.” (INT#7 SM N-ANOM)

Appendix 3 – Screener (NGA Example)

Date/Time of Interview: _____

Recruiter: _____

General Information/Recruiting Specifications

- Recruit 8-10 participants for each group for a show of 5-6.
- Groups 1 and 2: Small companies (1-10 stores).
- Groups 3 and 4: Medium-sized companies (11-50 stores).

ASK TO SPEAK TO the Owner or President (if a small company), or the Refrigeration or Energy Manager (if a medium-sized company)--someone at the company who makes the purchasing and maintenance decisions for the company's refrigeration systems.

(Introduction to respondent): Hi, I'm _____, with ICF International, a research and consulting firm. We are recruiting participants for several focus group and one-on-one interviews for a research study on how supermarkets make investment decisions related to new and existing commercial refrigeration technologies. (This is NOT a sales call.) We're looking for people who are involved in the day-to-day management of a supermarket refrigeration system and help to make major purchase and maintenance decisions.

Your participation will inform us about supermarkets' experiences, needs, and concerns with the use of these technologies. We highly value the expertise and knowledge that supermarket owners and managers, like you, have learned through operating a business.

I would like to ask you a few questions to see if you qualify. The information is for research purposes only. Your identities will be kept confidential. Do you have a few minutes? **(If they do not have time now, ask when you can call back.)**

(If the respondent asks, the research is being done by the National Center for Environmental Economics at the United States Environmental Protection Agency. The OMB Clearance Number is 2090-0028.)

GET FIRST AND LAST NAME AND DIRECT TELEPHONE NUMBER OF RESPONDENT.

Name: _____

Company: _____

Address: _____

City/State/Zip: _____

Phone: _____

SCREENING QUESTIONS:

1. Which of the following do you do in your position?

a. Participate in decisions about purchasing equipment for your supermarket's refrigeration system (e.g., condensers, compressor racks, walk-ins, and display cases)?

Yes No

a. Participate in decisions about servicing or maintaining equipment of your supermarket's refrigeration system?

Yes No

(The answer to part a must be yes. Otherwise, ask if there is someone else at the company you could talk with that fulfills this role. *Otherwise*, terminate.)

2. How many stores does your company own or operate?

Enter number here _____

- a. 1-10 (small company)
- b. 11-50 (medium-sized company)
- c. 51+ (large company)

3. **[If more than 1 store]** For how many stores are you involved in major purchase and maintenance decisions for their refrigeration systems?

Enter number here _____

4. Are the majority of these stores traditional supermarkets (i.e., annual sales of at least approximately \$2 million)?

- Yes No

5. What state(s) are your stores located in?

Enter states here: _____

(We aren't looking for specific states but want some geographic diversity in each focus group)

6. Are your stores in rural, urban and/or suburban areas? (circle all that apply)

- a. Rural
- b. Urban
- c. Suburban

(We don't have specific regions in mind but want some diversity in each focus group.)

7. What is the average size of your typical supermarket, in square feet?

- a. less than 20,000
- b. 20,000 – 80,000
- c. more than 80,000

8. When did you last purchase/upgrade a refrigeration system for your company, either for a new store or a retrofit?

- a. Within the last 3 years
- b. 4-7 years ago
- c. More than 7 years ago

9. Have you had an energy audit conducted through a government or trade association/third party program in the last several years?

- Yes No

10. Are you a member of EPA's Green Chill program?

- Yes No

[We would like a mix of members and non-members.]

A. WRAP UP TEXT FOR THOSE THAT QUALIFY FOR A FOCUS GROUP:

- If respondent has 1-10 stores, invite them to a small company focus group
- If respondent has 11-50 stores, invite them to a medium-sized company focus group

“I’d like to invite you to participate in a focus group (**if they ask, a focus group is a small group discussion**) with other people like yourself to help us better understand how businesses like yours think about investments in new technologies. The discussion will last about 2 hours. Refreshments and snacks will be provided. The discussion will be held on ____ at _____. We will send the details.”

Will you be able to attend?

Yes No

If no: I’m sorry you’re not able to participate in the focus group. Thank you for your time.

If yes: I’m glad that you will be able to join us! At this point, I need to make sure I have your correct contact information: **enter contact information on last page**. I’m going to [mail/e-mail] you a confirmation letter and directions to the facility.

If for some reason you’re unable to come, please call or email me [*insert contact and phone, email*] as soon as possible.

We look forward to having you participate on [*insert appropriate date and time*]. The session will begin promptly at ____ **am/pm** so please be there at least 15 minutes early to get something to eat and sign a consent form. If you are not there on time, you won’t be invited to join the group late. We look forward to your participation.

B. WRAP UP TEXT FOR THOSE THAT QUALIFY FOR AN INTERVIEW:

- If respondent has more than 75 stores:

“Thank you very much for your time. Based on your responses, we feel you would be most suited to the one-on-one interview format for participating in our study. We plan to conduct these interviews within the next month, most likely over the phone. We would ask you some questions that would help us better understand how businesses like yours think about investments in new technologies. The discussion would last about an hour. Would you be interested in participating in such an interview?”

If yes, enter their contact information below.

Close by saying: We will be back in touch with you in the near future to set up a time. Thank you.

Focus Group Participant POSSIBLE Focus Group Participant Interviewee

Name: _____

Address: _____

Telephone # (Day): _____ (Evening) _____

E-mail Address: _____@_____

Appendix 4 – Moderator’s Guide for Supermarkets

I. WELCOME AND INTRODUCTION (10 minutes)

A. Introduction of the moderator

Good morning/afternoon. My name is <insert name>. I have been hired by an international research and consulting firm located near Washington, DC to moderate this focus group. Our client is interested in hearing your opinions about how supermarkets make investment decisions related to the adoption of new and existing refrigeration system technologies and what factors influence the decision process.

B. What is a moderator?

Before we begin, I want to let you know that I’m not an expert on supermarkets, refrigeration, or the investment decisions you and your companies make. My job as a moderator is to:

- Help guide the flow of conversation
- Make sure everyone’s comments are heard
- Ensure that the questions our client has are covered

You will see me referring to this outline during our session. The outline includes all issues I need to raise with the group, and helps me keep the discussion on track. Since we need to cover all the issues, I may have to break off the conversation to move on to another area. The questions at the end of the guide are just as important as the ones at the beginning.

C. Ground Rules

Before we begin, I’d like to review some ground rules for today’s discussion.

- We are audio and videotaping our discussion today. The tapes will be transcribed and our client will use the transcription to prepare a report. Your names and the companies you represent will never appear in the transcripts or any report that is written.
- Because we are taping the discussion, I ask that you speak loudly and clearly. If I think you are speaking too softly to be heard, I will ask you to speak up.
- Please speak one at a time so everyone has a chance to participate and we can hear you easily on the tape. And please, no side conversations.
- Sometimes I’ll go around the table and ask everyone for their input. At other times, I will just throw a topic open for general discussion.

- Participation -- we would like to hear from everyone in the group, but you don't have to answer every question.
- There are no right and wrong answers. We expect differences in how people see things, and we want to know about these differences. It's important to tell us YOUR thoughts, not what you think others will think, or what you think others want to hear.
- Feel free to disagree or question each other. The purpose of a group session is for us to learn things in group interchanges that we don't get out of one-on-one discussions. If someone says something you disagree with, please let us know.
- Some observers are listening in by phone. They want to hear what you have to say about the topics we'll discuss, but we don't want you to feel constrained by their presence. They have each signed an observer confidentiality form.
- If anyone needs to use the restroom, they are located (specify). There is no need to stop the discussion. Also, about half way through the conversation, we will take a few minutes to complete a questionnaire. During that time, you can also use the facilities or refill water glasses.
- If you have a cell phone, please turn it off or set to vibrate.
- The session will last about two hours.

D. Informed Consent

All participants will have reviewed and signed the informed consent for their participation in the focus group prior to coming into the focus group room. This will be handled by a designated staff at the focus group facility. [Moderator: make sure you have a copy of the form that you can hold up.]

Before coming into the room, you were asked to review and sign an informed consent form. I just want to go over some of the key points on the consent form to make sure we are in agreement.

Review consent form, emphasizing audio- videotaping, confidentiality, and use of first names only.

Does anyone have any questions?

E. Introduction of Participants

Let's start with introductions. Please introduce yourself—first name only—and tell us:

- How long you've been in the industry;

- What's your role is in the company with regard to refrigeration;
- Number of supermarkets (and the regions in which you operate) for which you make refrigeration system decisions;
- When you last made a major refrigeration system upgrade for a store

NOTE TO MODERATOR: Questions 1 and 2 are **warm-up questions** to get the discussion going but should not last more than five minutes.

The main objective is to find out how often they do major upgrades of the refrigeration system (also to use later in ROI or payback discussion), what factors are most important to these decisions and **whether energy efficiency or refrigerants appear** in this list.

Probe on **why** the factors mentioned are important, but no need to understand which rank first, second, or third or get consensus on what ranks in the top three.

II.

OVERVIEW OF SELECTING AND PURCHASING MAJOR REFRIGERATION COMPONENTS (25 minutes)

Just to remind folks, let's limit the discussion today to your commercial refrigeration system and not discuss HVAC or other stand-alone units.

[Moderator: If someone asks for clarification about what we mean by commercial refrigeration system, we mean the compressor, evaporator, receiver, condenser, piping, display cases, and walk-ins. We are excluding beverage merchandisers.]

1. To get us going, what are the top 3 factors you consider when installing a new supermarket refrigeration system or doing a major upgrade? [**Moderator: write factors on newsprint**]

Probe: Why these particular factors?

Probe: [IF ENERGY USE IS NOT MENTIONED] Where does energy efficiency rank? Near the top, middle, or near the bottom?

2. How often do you perform a major upgrade or entirely replace a store's refrigeration system? What factors would lead you to such a decision?
 - a. Do you have a set cycle, or only do a major upgrade when something breaks?

3. Starting from the idea that you want to put a refrigeration system in a new store or replace a major component/perform a major upgrade for an existing supermarket's refrigeration systems ...
 - a. How do you gather information on the components or the system as a whole that you are thinking of replacing? [**Moderator: if necessary mention possible sources:** suppliers, conferences, in-house testing, industry shows, people you know, outside organizations]
 - i. What is the role of the manufacturer in the types of technologies you consider?
 - ii. Wholesalers?
 - iii. Corporate headquarters (when relevant)?
 - iv. Engineers that maintain the system?
 - v. Customers?

NOTE TO MODERATOR: Question 4 relates to **split incentives** between those maintaining the system and those purchasing and/or using the equipment.

4. How many of you contract out installation, commissioning, maintenance, and/or repairs vs. having it done by in-house staff?
 - a. For those of you who contract out part or all of the refrigeration system, what is that relationship like? Does the contractor determine when something needs to be fixed or upgraded, or do you give them direction?
 - b. What about for those of you who do it in-house?
 - c. [**Moderator: May only apply to companies with many stores**] Is there a split between who makes the decisions about the upfront installation of the refrigeration system and who pays for the ongoing maintenance costs and electricity bills?

NOTE TO MODERATOR: For question 5, we'd like to know how the information gathering and decision process applies to **existing systems**, whether it differs for **new systems**, and **whether they resell any components of the system to others**.

5. How do the following factors affect the process we've been discussing:

- a. Does the process differ between your older and newer stores? How about for a new store vs. upgrading an existing store?
- b. By a show of hands, does anyone buy or sell display cases on the secondary market (i.e., used, refurbished)? Is there anything else related to your refrigeration system that you participate in a secondary market for?
- c. **[If participants buy or sell used, ask the following]** How does this affect the process we've been discussing?
- d. How many of your companies lease (vs. own) the buildings for which you make investment decisions? Does this affect your decision process?

III. THE ROLE OF ENERGY EFFICIENCY AND REFRIGERANT USE (40 minutes)

NOTE TO MODERATOR: In this section, we want to know how energy efficiency and refrigerant use fit into purchase decisions – specifically, are there **barriers to energy or refrigerant saving investments**? And, how are energy or refrigerant considerations **weighed against other factors** (e.g. customer access or reliability)?

At the very beginning you all ranked energy efficiency to be [*important, somewhat important, not that important*] when upgrading a supermarket's refrigeration system.

6. How many of you have recently made major investments for a store's refrigeration system that improved energy efficiency? **[Ask them for a few examples]**

- a. **Why** those technologies? What makes them appealing to adopt?

What factors did you consider when deciding whether to adopt them?

- b. How many of you have recently made major investments that reduced refrigerant leaks? **Why** those technologies?

Do you think about energy efficiency and refrigerant use together or separately?
Does one dominate over the other in investment decisions?

Are there trade-offs between them (i.e., some technologies reduce refrigerant use but increase energy use or vice versa)?

- c. Are there energy-saving or leak-reducing technologies you have chosen not to adopt? Can you give an example?

Why did you decide against purchasing these features? What factors did you consider when deciding whether to adopt them?

- d. **[For larger companies]** Are there any new energy or refrigerant-saving technologies you are trying out at some of your stores?

Can you give me some examples that are more and less promising? What would tip the scale toward wider-scale adoption?

7. We've been talking about major investments to reduce energy use and refrigerant leaks. Do you also use maintenance or training (i.e., non-technology based) approaches to reduce energy use or refrigerant leaks? **Why or why not?**

- a. **[If they do not mention]** Do you offer training or incentives to help reduce leaks in the refrigeration system (e.g. bonuses to in-house or contractor technicians)?

I have a list of factors here that you might consider when choosing technologies or strategies to reduce energy use or refrigerant leaks that I want to ask you about.

8. Does _____ factor into your purchase decisions? If yes, how important is it? How might it come into play? **Ask about any factors not already discussed:**

- Customer appeal (e.g. how the food looks, how accessible it is)
- Product quality (e.g. food spoilage) concerns,

- Individual store attributes (e.g., climate, store configuration and size, when busy store times occur; what direction the building faces; building codes)

- Financing
 - o Borrowing constraints,
 - o Utility or state incentives,
 - o Tax credit/depreciation rules

- Energy and/or refrigerant policy
 - o Company-wide energy efficiency or refrigerant policies or approaches

- State or federal energy efficiency or refrigerant legislation
- Reliability issues:
 - Ease of installation,
 - Maintenance and repair concerns (e.g. may need training on new system; risk of down time to maintain)/ability to service)
 - How the new component interacts with the existing system,
 - Warranty issues (e.g., voiding warranty by tweaking the system),
- **[If applicable]** Resale price: Will a buyer pay a premium for used components/display cases that are more efficient?

NOTE TO MODERATOR: The purpose of question 9 is to find out if firms account for **perceived accuracy** of energy use estimates (estimates are sometimes based on “typical” use or are considered unreliable); or **uncertainty in future energy savings** (it’s hard to predict if a new technology will deliver promised savings).

9. I’d now like to ask you about how you estimate and consider energy savings and refrigerant leaks in your decision-making.
- a. You already mentioned some of the sources you use to gather information about new technologies. Do these sources provide reliable estimates for likely energy use and refrigerant leaks?
 - Are there estimates that you don’t believe or bother looking at? Why?
 - b. Do electricity rates affect your investment decision? Do you use potential energy savings from your investment to negotiate revised rates for one or more stores?

NOTE TO MODERATOR: Question 10 is related to how they incorporate these factors into decision-making – do they calculate a **return on investment?** If yes, how are these aspects of the decision factored in?

10. Thinking about all the factors you have mentioned so far that affect your purchase decision, do you weigh them against the upfront cost and incorporate any of them into an ROI or payback calculation?
- a. If so, how?

- b. If not, how do you weigh them against upfront cost and energy savings?

[PROMPT: Examples: maintenance, training, resale value, product quality]

- c. Is this sort of accounting done store-by-store? (Do you consider installing a new technology even if it may not provide the desired financial return in every store you manage?)

IV. OPINIONS ON SPECIFIC TECHNOLOGIES AND PAYBACK (40 minutes)

Before we start the next discussion, please take five minutes to fill out a brief questionnaire.

[HAND OUT QUESTIONNAIRE: Shouldn't take longer than 5 minutes to fill out]

NOTE TO MODERATOR: Questions 11 and 12 dig into particular technologies. **Do not cover the entire list** of technologies from the questionnaire.

Depending on time and responses, we recommend following up on a few technologies in each category. We are interested in **why they did or did not adopt them**. What factors make them more or less appealing? Please drill down a bit, including technologies that have been mentioned briefly in earlier discussion.

Looking at your responses, I notice that the technologies we discussed earlier are [*a bit different from/pretty similar to*] this list, made before the meeting. Let's spend a little time investigating why you think some of them make sense to invest in and others not.

11. I see that some of you considered [*insert specific technology from questionnaire*]. What are the main reasons you considered this technology? **[REPEAT FOR A FEW TECHNOLOGIES BUT NOT ALL]**

- a. If you ended up adopting this technology for one or more stores, what were the main reasons **why**?
- b. If you ended up not adopting this technology in one or more stores, what were the main reasons **why**?

12. (**Skip if they consider all technologies on list**) Many of you indicate that you did not consider [*insert technology*]. What are the main reasons you don't consider them?

NOTE TO MODERATOR: In question 13 we want to know **why** – in spite of what looks like a very short payback (or high ROI) – they aren't adopting them.

13. Some companies have told us that the payback period they need to justify investing in an energy or refrigerant saving technology/feature is less than the amount of time before they perform a major upgrade (for instance, some technologies pay back in 1 -3 years but the refrigeration equipment lasts 10 years).

- i. Is this true for you?
- ii. Why do you need an investment to pay back sooner?

[**Prompt:** If they don't say much or say it's a company rule of thumb, **ask:** Do you know why it's a company rule of thumb? Is it to hedge against uncertainties - e.g., future energy prices, true technology effectiveness?]

Moderator – ask clarifying questions. If none continue to Wrap-Up

V. WRAP-UP (5 minutes)

Today we've discussed what factors into your investment decisions when making major refrigeration system upgrades and how energy efficiency and refrigerant leakage factor into that process. Through this discussion, we've learned that ... **[Fill in with general findings about the investment process.]**

14. Those are the main questions I have for today, but before we finish, I want to check-in with you to see if there's anything we haven't discussed here today that would influence what technologies or other strategies you'd choose for your stores?

I want to take this time to thank you for your input and sharing your expertise. Your time and ideas are valuable to helping us understand your decision making process.

15. Does anyone have any last questions or comments?

Appendix 5 – Questionnaire

1. How many stores refrigeration systems do you manage? _____

2. What is the age range (or ave. age) of your store(s)? _____

3. What state(s) are your stores located in? _____
4. Do you keep track of track energy use at your stores? _____
 - a. If so, do you track use on a store-by-store basis or across all stores? _____
 - b. What is the typical annual electricity consumption (kwh) of one of your stores?

 - c. Does your electricity consumption vary significantly by region/state? _____
5. Do you keep track of refrigerant use at your stores? _____
 - a. If so, do you track use on a store-by-store basis or across all stores? _____
 - b. What is the typical refrigerant leak rate at one of your stores? _____
6. Do you have dedicated refrigeration engineers responsible for the systems? Y____N_____
7. Do you have more experience with refrigeration system decisions for new stores, renovation/major upgrades, repairs, or all of the above? _____
8. How often do you do a store remodel? _____
 - a. Do you typically replace display cases during a store remodel? _____
 - b. Do you do other upgrades to the refrigeration system during a store remodel? _____
 - c. If so, what type of upgrades? _____
9. Do you generally contract out the following services or have them done by in-house staff?
 - c. Installation _____
 - d. Commissioning _____
 - e. Maintenance _____
 - f. Repairs _____

10. Has your company considered or purchased any of the following refrigeration system technologies and energy saving strategies: **(check all that apply)**

| | Has used | | | Never used | |
|---|--------------------------|--------------------------|--------------------------|------------------------------|--------------------------|
| | in store upgrade | in new store | would use again | would consider in the future | would not consider |
| <u>Compressor</u> | | | | | |
| High-efficiency compressors | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Variable capacity compressor | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other, specify: _____ | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <u>Condenser</u> | | | | | |
| Advanced condenser design | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| High-efficiency fan motors | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other, specify: _____ | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <u>Display Cases and Piping</u> | | | | | |
| Advanced evaporator design (e.g., enhanced UA evap coil) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| High-efficiency fan motors/blades | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Advanced door technologies (e.g., low heat doors, auto-door closer) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Strip curtains, nightblinds | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Anti-sweat controls (e.g., ASH controls, hot gas anti-sweat) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Advanced lighting (e.g., LED) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Thicker insulation | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other, specify: _____ | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <u>Walk-ins</u> | | | | | |
| Hot gas defrost | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Floating head pressure | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Ambient sub-cooling | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Demand defrost control | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Advanced door technologies, evaporator fan shutdown | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Strip curtains or plastic door swings | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Advanced lighting (e.g., CFLs) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other, specify: _____ | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <u>Refrigerant</u> | | | | | |
| Refrigerant changes (e.g., RD404A replaced by R407A) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Improved refrigerant management, leak detection, repair | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Alternative configurations (e.g., secondary loop systems, distributed compressor systems) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other, specify: _____ | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <u>Controls and process changes</u> | | | | | |
| Improved system controls (e.g., electronic expansion valves (EEV), case controllers) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Re-commissioning | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Maintenance, repair, and cleaning changes | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Training | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Store temperature, dehumidification | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other, specify: _____ | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |