Cool Savings Program Report

Prepared by: Michael Fung
Jennifer Wang
San Francisco Department of the Environment
1455 Market St. Suite 1200
San Francisco, CA 94103

SF Environment
Our home. Our city. Our planet.
A Department of the City and County of San Francisco

Technical Contributors: Denis Livchak
Adam Cornelius
Fisher Nickel
12949 Alcosta Blvd. Suite 101
San Ramon, CA 94583

FISHER NICKEL Inc.

Program Background

San Francisco has over 5,000 businesses that depend on refrigeration equipment for their operations. These include restaurants, coffee shops, convenience stores, supermarkets, warehouses, hotels/motels, hospitals and convalescent homes. For small and medium businesses, which in San Francisco generally do not have air conditioning, refrigeration represents the highest percentage of their electricity load. Most of the equipment operates 24 hours a day making it impossible for these businesses to avoid expensive peak demand electricity rates and high energy bills overall.

An overriding barrier to a successful refrigeration replacement program is the high cost of equipment. Basically, many small businesses are reluctant to invest in equipment with a long payback period when they are unsure of their ability to remain in business over the long term. Customer response to high purchase/replacement prices has led to conditions that can pose even greater barriers, specifically:

- Business owners often keep equipment far beyond its useful life. Many of these units have been found in such state of disrepair that normal energy efficiency measures (EEMs) such as gasket replacement, door closers, motor upgrades, and controls, that have been offered in previous utility programs cannot be installed to significantly reduce energy use.
- Certain types of refrigeration and restaurant equipment is leased or provided for free by major companies such as Pepsi, Coca Cola, Haagen-Dazs, etc., so the customer does not have control over the efficiency of the equipment installed.
- With the high rate of business failures and frequent turnover, particularly in the restaurant industry, the older equipment can continue to get recirculated in the marketplace.

This combination of factors contributes to excessive energy use sector-wide, but it also creates a financial burden for businesses, which bear the high monthly utility costs of operating the equipment.

San Francisco Department of the Environment (SFE) partnered with the Food Service Technology Center (FSTC) to study the possibilities for transforming the market so that newer, more efficient refrigeration equipment can become a more cost-effective option for San Francisco businesses, especially restaurants and convenience stores. The pilot project (Cool Savings Program) focused on two specific categories of refrigeration equipment: reach-in refrigerators and freezers and ice machines. The project also studied ice machines to test an integrated demand-side management approach that would involve making ice during the utility's off-peak hours.

Stand-alone reach-in refrigerators and freezers and ice machines were targeted for this study because they are the most common refrigeration units in small and medium businesses in San

Francisco. They are also easy to replace and install with new energy efficient units widely available through local restaurant supply stores.

Program Summary

The objective of the Cool Saving Program was to quantify the potential energy savings from early retirement of older, inefficient stand-alone commercial refrigeration equipment (reach-in refrigerators and freezers and ice machines), assess ice machine load shifting opportunities, and provide baseline efficiency information for future efficiency programs based on the data collected.

The partnership between SFE and FSTC was ideal as FSTC staff was able to provide their technical expertise on refrigeration equipment and testing procedures while SFE staff was able to leverage their experience in energy efficiency assessments, knowledge of the business environment in San Francisco as well as their existing relationships with customers through the San Francisco Energy Watch Program, to reach out to potential participants in the Cool Savings Program.

The Cool Savings Program used a four-pronged approach to collect the data needed to assess the potential energy savings and gather input for the possibility of future refrigeration replacement programs.

- Conducted customer surveys with business owners and operators to determine:
    - The barriers they face to upgrading their refrigeration equipment
    - The major factors that influence their purchase decision on refrigeration equipment
    - The type of incentive that would motivate them to replace their existing refrigeration equipment with more energy efficient equipment
- Conducted refrigeration equipment surveys to get a profile of the various types of refrigeration equipment being used by different businesses in San Francisco and the operating conditions of the equipment
- Monitored the energy use of self-contained reach-in refrigerators and freezers and ice machines (targeted equipment) and other non-targeted refrigeration equipment to determine a baseline energy use of the existing refrigeration equipment
- Offered a 50% buy-down to customers to facilitate the replacement of existing reach-in refrigerators and freezers and ice machines with new high efficiency models to obtain pre and post installation energy use data

Working with Third-Party Vendors, the Cool Savings Program staff was able to coordinate the delivery and installation of new Energy Star qualified high-efficiency refrigeration equipment and verify that the existing equipment was properly recycled.

The goals of the Cool Savings Program were to:

- Characterize energy use of existing stand-alone reach-in refrigerators and freezers and ice machines
- Categorize stand-alone refrigeration energy use by type, size, and age of equipment
- Quantify the energy use of replacement energy-efficient equipment and determine the energy and energy cost savings associated with replacing existing equipment with new high efficiency equipment
- Estimate average energy use of existing equipment based on acquired data and forecast the energy savings potential if customers were to upgrade their refrigeration equipment
- Create a profile of the refrigeration equipment in various types of businesses in San Francisco
- Collect customer survey data to determine how business owners make decisions regarding the purchase of refrigeration equipment

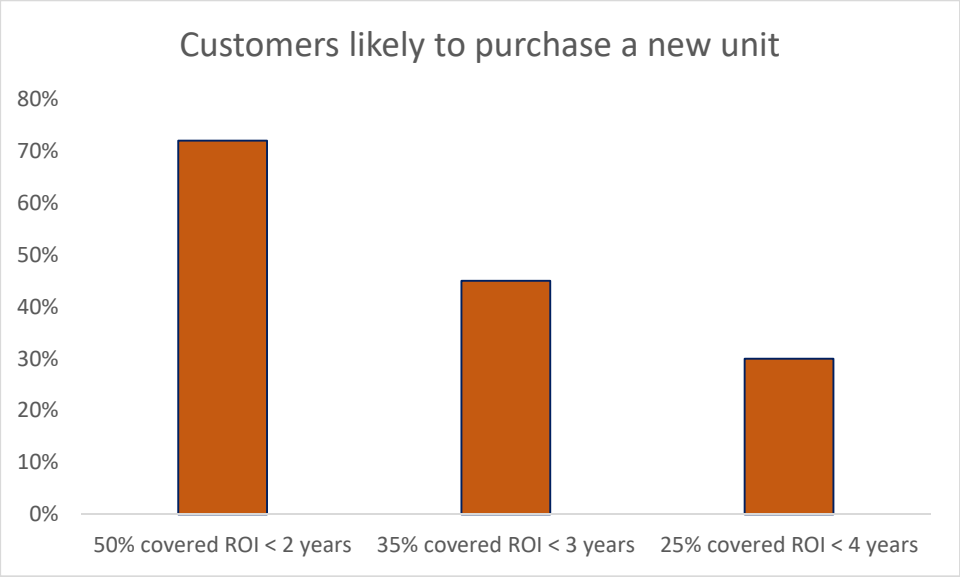
Program Results

Customer Surveys

Customer surveys were collected from 117 different businesses in the city. Business owners and decision makers were often not available when we visited some businesses, making it extremely challenging to collect the surveys in a time-efficient manner. A review of the survey results showed:

- Out of 117 responses, 68 customers (58%) indicated that they would conduct their own research prior to purchasing new refrigeration equipment
- The top factors influencing a customer's purchase decision of new refrigeration equipment were "Cost" and "Energy Efficiency". The condition of the unit (new or used) was also an important factor.
- Customers were presented with three different hypothetical rebate offerings and asked how likely they were to purchase new refrigeration equipment based on the rebates offered:
    - For a rebate that covered 50% of the new unit and had a simple payback of less than 2 years, 72% of the customers indicated that they would "Definitely" or "Very Likely" purchase the new unit
    - For a rebate that covered 35% of the new unit and had a simple payback of less than 3 years, 45% of the customers indicated that they would "Definitely" or "Very Likely" purchase the new unit
    - For a rebate that covered 25% of the new unit and had a simple payback of less than 4 years, only 30% of the customers indicated that they would "Definitely" or "Very Likely" purchase the new unit

The graph below shows the percentage of customers who indicated they very “Definitely” or “Very Likely” to purchase a new refrigeration unit based on rebate percentage of total cost.



- When customers were presented with the scenario of a broken down refrigeration unit with repair costs that were less than the cost of replacing the unit
    - 68% of the customers indicated they would have the existing unit repaired
    - 27% of the customers indicated they would purchase a new more expensive energy efficient unit to replace the existing unit
    - A small percentage of the customers indicated that would try to lease or purchase a used unit to replace the existing unit
- When customers were asked about how simple payback would affect their decision to purchase new energy efficient refrigeration equipment
    - 43% of the customers indicated they would purchase new energy efficient refrigeration equipment if the payback was between 1-2 years
    - 36% of the customers indicated they would purchase new energy efficient refrigeration equipment if the payback was between 2-4 years
    - 15% of the customers indicated they would purchase new energy efficient refrigeration equipment if the payback was between 4-5 years
    - A small percentage of the customers indicated they would purchase new energy efficient refrigeration equipment if the payback was greater than 5 years

One interesting point was that many customers did not initially think about the purchase of new refrigeration equipment from a perspective of simple payback (return on investment). When presented with this scenario, these customers thought it to be an interesting consideration, but many indicated that they would still base their purchase decision on other factors.

Refrigeration Equipment Survey

The refrigeration equipment survey conducted at over 105 businesses in San Francisco tabulated over 500 different pieces of refrigeration equipment. While stand-alone reach-in refrigerators and freezers were the most common type of refrigeration equipment, ice machines, refrigerated prep tables and under-counter refrigerators were common in restaurants/cafes, and a variety of glass-top freezers and walk-in refrigerators were common in convenience stores.

Table 1 shows the number of businesses that had at least one of each type of the following equipment

Equipment Type	Number of Businesses
Solid-Door Reach-In Refrigerator	37
Solid-Door Reach-In Freezer	44
Glass-Door Reach-In Refrigerator	67
Glass-Door Reach-In Freezer	14
Ice Machine	36
Refrigerated Prep Table	29
Under-Counter Refrigerator	24
Under-Counter Freezer	6
Glass-Top Freezer	17
Chest Freezer	9
Deli Case	12
Walk-In Cooler	25
Open Front Display Case	4
Refrigerated Beer Dispenser	4

Based on talking to the business owner and looking up the serial numbers for the refrigeration equipment, we were able to obtain the age of 392 pieces of existing equipment.

Table 2 shows the number of pieces of equipment in each age group

Equipment Age	Number of Refrigeration Equipment	Percentage of Total	Average Age
Less than 5 Years	42	10.7%	2.12 years
Between 5 and 10 Years	126	32.1%	7.71 years
Between 10 and 15 Years	112	28.6%	12.04 years
Between 15 and 20 Years	50	12.8%	17.56 years
Greater than 20 Years	62	15.8%	25.61 years

The average age of the existing equipment was 12.4 years, which is higher than the expected life of 12 years for this type of refrigeration equipment. The equipment survey showed that

224 pieces of refrigeration equipment (over 57%) is over 10 years old and reinforces the fact that a lot of the old equipment gets recirculated in the marketplace even after it is past its expected life.

Energy Use Data for Existing Equipment

Energy consumption data was collected for over 150 existing refrigeration units from 80 different businesses in the city. These businesses included convenience stores, restaurants, bars, cafes, hotels, and religious institutions.

In addition to the targeted reach-in refrigerators and freezers and ice machines, energy consumption data was also collected for a range of other refrigeration equipment including: chef bases, chest freezers, cooler-freezer combo units, deli cases, glass-top freezers, refrigerated prep tables, and under-counter refrigerators and freezers. Each unit was monitored for a minimum of two weeks.

During the extent of the Cool Savings Program, energy consumption data was collected for 104 existing reach-in refrigerators and freezers.

Table 3 shows the average daily energy consumption of the existing reach-in refrigerators and freezers:

Number of Doors	Door Type	Number of Refrigerators Measured	Avg. Refrigerator (kWh/day)	Number of Freezers Measured	Avg. Freezer (kWh/day)
1	Solid	8	6.12	14	11.88
	Glass	10	7.28	0	N/A
2	Solid	25	8.43	16	22.68
	Glass	18	10.25	0	N/A
3	Solid	0	N/A	1	36.52
	Glass	10	13.44	1	42.84
4	Solid	0	N/A	0	N/A
	Glass	1	30.57	0	N/A

Although, the reach-in refrigerators and freezers vary slightly in internal volume, in general the 2-door units have twice the internal volume of the 1-door units and the 3-door units have three times the internal volume of the 1-door units. Based on this and the average energy use data, the existing two-solid-door refrigerators consumed 31% less energy than two single-solid-door refrigerators and the two-glass-door refrigerators consumed 29.6% less energy than two single-glass-door refrigerators. The three-glass-door refrigerators consume 38.5% three single-glass-door refrigerators. The four-glass-door refrigerator was old (over 20 years) and not well maintained, therefore its energy use was significantly higher than expected. The data also shows that existing two-solid-door freezers consumed 4.5% less energy than two single-solid-door freezers. The average energy consumption data for single-solid-door freezer included data for 3 freezers that are designed to not have a condenser fan motor. This significantly

reduced the energy consumption for these units. If these units were removed from the data set, the average energy consumption for single-solid-door freezers would be 17.6% higher at 13.97 kWh/day, which would result in the average two-solid door freezer consuming 18.8% less energy than two single-solid-door freezers.

As part of the Cool Savings Program, energy consumption data was also collected for 19 existing ice machines. The existing ice machines varied in size with rated capacities from 250 lbs of ice/day to 1800 lbs of ice/day. The existing ice machines had an estimated energy consumption ranging from 5.33 kWh/100 lbs of ice to 10.35 kWh/100 lbs of ice. There were two ice machines that were outliers to this set of data. The energy consumption of these outliers were 2.43 kWh/100 lbs of ice and 13.25 kWh/100 lbs of ice.

The ice machine that consumed only 2.43 kWh/100 lbs of ice was a water-chilled unit installed in a hotel with a chiller loop providing cold water for cooling the ice machine. The energy required to provide the cold water to the ice machine for cooling was not accounted for in the estimated energy consumption of this ice machine. The ice machine that consumed 13.25 kwh/100 lbs of ice was the largest ice machine of the group measured. Although larger ice machines are generally more efficient and use less energy per 100 lbs of ice, it was determined that the ice machine was malfunctioning and the compressor was on the verge of failure, thus the extremely high energy consumption.

Reach-in and Ice Machine Replacements

In order to obtain energy consumption data for new reach-in refrigerators, freezers, and ice machines, the Cool Savings Program offered qualifying customers a facilitation payment of approximately 50% of the retail price to replace their existing glass or solid door reach-in refrigerators, solid door freezers, or self-contained ice machines with new high efficiency equipment. By the end of the program, 20 reach-in refrigerators (13 solid door, 7 glass door), 10 reach-in freezers, and 5 ice machines were replaced through the Cool Savings Program. Although, the original goal was to have 10 ice machines replaced through the program, we came across many challenges with finding customers wanting to replace their ice machines. This was mainly due to the fact that many ice machines were leased and the high payback periods for ice machines (over 5 years in most cases) even with 50% off the retail price.

Energy savings for the new reach-in refrigerators, freezers and ice machines ranged from 13% to 76%, with an average energy savings of 44%. Out of the 35 units replaced, 21 of the new units (60%) resulted in energy savings of over 40%. The 44% average energy savings equated to an average of 3,150 kWh/year savings or $567/year (@ $0.18/kWh).

Table 4 shows the potential energy savings based on the data collected for pre and post installation of the new reach-in refrigerators and freezers:

Number of Doors	Door Type	Avg. Refrigerator Energy Use	Avg. Refrigerator Energy Savings	Avg. Freezer Energy Use	Avg. Freezer Energy Savings

		kWh/day	kWh/day	% Savings	kWh/day	kWh/day	% Savings
1	Solid	6.12	3.05	49.8%	11.88	7.69	64.7%
	Glass	7.28	3.48	47.8%	N/A	N/A	N/A
2	Solid	8.43	5.19	61.6%	22.68	8.85	39.0%
	Glass	10.25	4.67	45.6%	N/A	N/A	N/A
3	Solid	N/A	N/A	N/A	36.52	16.78	45.9%
	Glass	13.44	7.58	24.8%	42.84	19.33	45.1%

Energy savings for the new ice machines averaged 33% for the 5 ice machines replaced through the Cool Savings Program. Most business owners decided to replace their ice machines due to occasional ice shortages and having to purchase additional ice elsewhere. Once the energy savings were normalized for ice consumption, the average energy savings was 25%.

Table 5 shows the average energy consumption of the existing ice machines and the new ice machines.

	Average Ice Machine Size Monitored (lbs ice/day)	**Average Energy Usage (kWh/day)**	**Average kWh/100 lbs of ice**	**% Savings**
Old Ice Machines	473	20.41	7.37	N/A
New Ice Machines	525	17.88	5.66	25%

Of the five ice machines replaced through the Cool Savings Program, 3 of the ice machines were replaced with similar size units, 1 of the ice machines was replaced with a larger unit and 1 was replaced with a smaller unit.

Load-Shifting ice production to off-peak hours helps customers avoid using electricity during the most expensive peak hours on weekdays (12:00 noon to 6:00 pm). The ice machine that was replaced with a larger unit had its duty cycle reduced from close to 100% to 69%, allowing it to be load-shifted to make ice during the off-peak hours. Despite being replaced by ice machines of similar size, 2 of the ice machines had their duty cycles reduced from over 92% to 56% and 66%. This allowed these ice machines to also be load-shifting to not make ice during the utility's peak demand period.

Although the other 2 ice machines replaced through the Cool Savings Program had duty cycles of 60% and 56% and were candidates for load-shifting, the business owners decided not to load-shift the ice making to off-peak hours for the following reasons:

- 24-hour diner that did not want to worry about running out of ice
- Hotel that did not want ice machine operating during the late night hours because of noise

In general, it was determined that ice machines with a duty cycle less than 70% were potential candidates for load-shifting.

Other Program Findings

Coil Cleaning Energy Reduction

Most people realize that proper maintenance would help their refrigeration equipment operate properly and more efficiently. As part of the Cool Savings Program, we were able to quantify this assumption with regards to the one of the most common maintenance issues that can be easily performed by business owners. Dirt and dust buildup on condenser coils can greatly degrade the efficiency of refrigeration equipment. The dust buildup on the condenser coils acts as a layer of insulation that reduces the unit's ability to reject heat removed from the refrigeration unit. This results in the compressor working harder to keep the same internal temperature in the reach-in refrigerators and freezers.

Energy consumption was recorded for 10 different reach-in units before and after cleaning of the condenser coils. The range of reduction in energy consumption was 2% to 49% after condenser coils were cleaned, with the average reduction being 17%. The wide range in energy savings is accounted for by the various stages of cleanliness of the condenser coils. In some cases, the dust buildup was only on the surface of the condenser coil and only minimally reduced air flow and the unit's ability to reject heat. However, in the case where there was a 49% energy reduction, the condenser coil had a thick blanket of dust that completely covered the coil preventing any air flow and greatly reducing the unit's efficiency

AHRI Data Comparison

The California Energy Commission (CEC) requires all commercial reach-in refrigerators and freezers sold in California to be listed in their database, which includes estimated energy use based on Air Conditioning, Heating, and Refrigeration Institute (AHRI) data. The reach-in refrigerators are tested in independent laboratories to the ASHRAE 72 Standard, which is designed to mimic conditions found in the field. However, actual energy usage of the refrigeration units in the field can differ greatly depending on different internal and ambient temperatures, the number of door openings per day, how long the doors are left open, and the quantity and temperature of the items placed inside the reach-in units. When comparing the energy consumption of the new reach-in refrigerators and freezers installed through the Cool Savings Program to the AHRI data, the difference between the actual energy consumption of the new units to AHRI data ranged from -39% to +51%, with the average difference being 6% greater than AHRI data. This result shows that the AHRI data is a good estimate for the average energy consumption of refrigeration equipment, but it may not be accurate for a particular single unit.

Project Conclusions

Although over 70 customers were eligible to replace their existing refrigeration equipment with new high efficiency equipment at a 50% discount, only 35 customers chose to take advantage of this offer. If the new equipment was purchased at the retail price, only 6 customers (17.1%) would have a simple payback of less than 5 years based on energy savings alone. For the type equipment studied in the Cool Savings Program, PG&E offers rebates between $75-$600 (3-11% of retail price), depending on the type of equipment purchased. When the PG&E rebate is taken into consideration, 8 customers (22.9%) would have a simple payback of less than 5 years. With the 50% discount offered through the Cool Savings Program, 23 customers (65.7%) had a simple payback of less than 5 years.

With the high cost of new energy efficient equipment and the fact that many business owners are unsure of their ability to remain in business over the long term, small business owners are reluctant to invest in equipment with a long payback period and would rather continue to pay higher energy bills in the short term.

Potential Future Efficiency Program

Higher Rebate for Replacing Existing Equipment

For the equipment studied as part of the Cool Savings Program, PG&E currently offers rebates ranging from $75-$600. Based on the Deemed energy savings associated with the rebates, this results in a cost of $0.13-$0.17/kWh in energy savings. Since there is no requirement that the customer receiving this rebate remove their existing equipment, the Deemed energy savings can be assumed to be the incremental energy savings when compared to standard efficiency equipment. The data collected through the Cool Savings Program showed an average energy savings of 3,150 kWh/year, significantly higher than the average Deemed energy savings of 1,298 kWh/year for the new equipment installed.

A potential Direct-Install Efficiency program could provide a calculated incentive for replacing the existing refrigeration equipment with new high efficiency equipment. The incentive would be calculated based on the measured energy consumption of the existing refrigeration equipment and the AHRI rated energy consumption for the new equipment. Such a program would be able to claim the full energy savings associated with replacing the existing refrigeration unit by verifying that the existing equipment is removed and properly recycled. If we applied a $0.15/kWh cost to the potential energy savings for the units replaced through the Cool Savings Program, the incentive provided would have been more than double the Deemed rebate amount for 18 of the 35 customers and 12 of the 35 customers (34.3%) would have had a simple payback less than 5 years. This increased rebate could help motivate more customers to replace their old inefficient refrigeration equipment. In addition, staff associated with this Direct-Install program could educate the customer on energy efficiency and the benefits of having new high-efficiency refrigeration equipment (energy savings, manufacturer's warranty, etc.).