

IMPACTS OF CEE'S SUPER-EFFICIENT APARTMENT-SIZED REFRIGERATOR INITIATIVE

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Definition of Issues

Refrigerators account for a significant portion of energy consumption in multi-family residences with units in excess of 10 years old consuming upwards of 1100 kWh/yr. per unit. In public housing, little incentive exists to install energy saving measures as the U.S. Department of Housing and Urban Development (HUD) typically compensates housing authorities for energy bills. The Consortium for Energy Efficiency's (CEE) Super-Efficient Apartment-Sized Refrigerator Initiative was designed to address a market deficiency to bring economically and technically viable refrigerators to the market. Secondly, by clearly demonstrating the actual energy savings due to refrigerator replacements, the effort seeks to take advantage of an under-utilized HUD program that provides incentives for installation of efficiency upgrades ultimately to the benefit of housing authorities across the country.

Background and Approach

In June of 1995, utilities, government, housing authorities and other national players voluntarily met to encourage refrigerator manufacturers to develop and produce a new-to-the-market, super-efficient, apartment-sized refrigerator. With an ultimate goal of driving down the energy costs of the single largest energy-consuming appliance in the multi-family sector, the consortium implemented a national bulk procurement initiative to pull super-efficient products into the market. The result of this effort is a tremendous success story that produced a new-to-the-market, super-efficient, 15 cu. ft. refrigerator that is 31 percent more efficient than the federal energy standard, and a first year demand for the product in excess of 70,000 units.

Relevance for Program Management

This paper identifies the players, concepts, conditions, and marketing efforts that led to the new product introduction and the significant attributable energy savings to be experienced over the life of the new units. Upon providing a clear understanding of the foundation of the initiative, the paper highlights the installation of the new units in New York City and evaluates the associated energy and financial savings for the New York City Housing Authority (NYCHA). Finally, the paper closes with an evaluation of utility impacts, emphasizing demand savings, customer satisfaction, and public relations benefits - all of

which are increasingly important in the newly competitive marketplace.

Introduction

In 1995, CEE and the New York Power Authority, (NYPA - as the lead purchaser) teamed with the US Department of Energy and other CEE members to encourage the development and sale of an economically justifiable "super-efficient" 14 - 15 cu. ft. refrigerator. With consultation from refrigerator manufacturers, the group developed a request for proposal (RFP) for the procurement of "super-efficient" refrigerators (defined as approximately 10 percent more efficient than the most efficient unit currently available in the market at the time). In exchange for a competitively priced "super-efficient" product, the group offered:

- a minimum purchase order for 20,000 units;
- a minimum individual order quantity to maximize manufacturer shipping economies and minimize manufacturer administrative expenses; and
- the national promotion, marketing, and sales of the new product by a not-for-profit organization and its partners, bringing tremendous third party credibility to the product offering as well as positive name recognition for the manufacturer.

Through a competitive bidding process, the bulk procurement effort selected a 14.4 cu. ft. General Electric unit for installation during 1996. However, GE limited the 1996 offering to the New York Power Authority's (NYPA) request for 20,000 units. The GE unit represented one of only two models at the time in the desired size range (the other is manufactured by Whirlpool) that out performed federal energy standards by 20 percent or more. By the close of 1996, GE had delivered all 20,000 units.

For 1997 delivery, however, the effort successfully enticed Maytag to offer a new-to-the-market, 15 cu. ft. super-efficient refrigerator that exceeds federal energy standards by more than 30 percent. With the super efficient Magic Chef refrigerator in production in the fall of 1996, CEE and its supporters generated requests for more than 71,000 Maytag Magic Chef units, with additional requests continuing to come in even after the official No-

vember 30, 1996 request period had expired. Instrumental to the generation of product requests was the introduction of life-cycle costing methods to public procurement officials as well as breakthroughs with HUD in the application of efficiency incentive regulations. These successes promise to have lasting effects on significantly influencing procurement decisions toward energy efficiency products. The long term goals of the initiative include:

- Educate institutional markets on the benefits afforded by energy efficient refrigerators as well as the practices necessary to secure associated proceeds
- Encourage procurement officials to transfer their life cycle costing experience to the procurement of other energy consuming appliances
- Encourage an adequate supply and purchase of apartment-sized refrigerators that are approximately 30 to 40 percent more efficient than the 1993 federal standard.

Background

Approximately 1.5 million refrigerators are sold in the U.S. every year in the 12 to 15 cu. ft. capacity, with an

estimated 20 million units in use. Of the 1.5 million purchased every year, approximately 50 to 75 percent are purchased through bulk purchase agreements placed directly with manufacturers.

To maximize the impact of the initiative, large procurers were primary targets for participation. Housing authorities represented a sizable initiative target, accounting for 1.4 million residences across the U.S. Major apartment management firms and Department of Defense properties were the next most logical targets; however, due to procurement practices (mainly the desire to have units installed on an ad hoc basis) and manufacturer concerns over alienation of existing delivery channels, initiative participation was limited to publicly assisted properties and their agents.

Roles of Primary Initiative Partners

Many key allies played a significant role in the success of this initiative including CEE member utilities, the U.S. Department of Energy, the New York City Housing Authority, state energy offices, and the U.S. HUD. Primary roles are shown in Table 1:

Organization	Role
Consortium for Energy Efficiency	Managed and marketed the national procurement opportunity
US Department of Energy	In addition to providing general assistance to CEE, validated energy savings in NYC, marketed the national procurement opportunity, provided technical assistance to key housing authority participants, and interfaced with HUD
New York Power Authority	In addition to providing general assistance to CEE, anchored the national procurement effort on behalf of the New York City Housing Authority (a key customer), coordinated the installation of new units and the recycling of replaced units, and evaluated energy savings
New York City Housing Authority	Electric Customer of NYPA's and recipient of super-efficient refrigerators procured through the initiative. NYCHA supported the national effort through HUD relations and its public endorsement

Table 1. Partner Roles.

Initiative Phases

There are five important phases of the initiative, each of which focus on distinct market players and their respective roles in the procurement process for refrigerators. The phases are as follows:

1. Effectively demonstrate the appeal of a national bulk procurement opportunity to manufacturers in hopes of minimizing ini-

- tiative unit costs and maximizing unit efficiency characteristics.
2. Develop marketing materials, promote the effort nationally, and contact large volume purchasers and influencers in several states to deliver on the order volume expectations of manufacturers.
3. Ensure product delivery for those entities requesting units to realize the energy savings from the new refrigerators and demonstrate concretely, the benefits of pro-

- curing appliances based upon life cycle costing.
4. Evaluate changes in procurement practices in terms of specifying life cycle costing as a means for product selection.
 5. Monitor market impacts of the initiative in terms of new product releases, inquiries from housing authorities as to other energy efficient product offerings available, new standards, manufacturer emphasis on producing and selling energy efficient products and other relevant areas.

Benefits to Initiative Participants

Instrumental to the success of the initiative was that each program participant, whether a housing authority, manager of low income properties, utility, or an agent of a low income property, had to clearly recognize the benefits of participation. Benefits by major participant category include:

Housing Authorities and Low Income Properties

- Competitive or advantageous purchase price of the unit
- Energy saving benefits for those authorities that pay energy costs
- HUD program incentives that relieve financial burdens in terms of capital and/or financing
- Reductions in contract administration costs due to NYPA contract activities
- Positive public relations and personal appeal due to energy savings, air quality enhancement, and additional service to tenants
- Potential partnering with local utilities
- Participating in a national effort to further energy efficiency
- Demonstration of progressive actions
- Complementary with modernization activities

Utilities

- Complement existing utility DSM rebate programs. Utilities can participate by using existing rebate programs as a vehicle to encourage bulk purchases via the NYPA contract. For instance, utilities might consider paying all or a portion of the incremental cost difference between a super-efficient refrigerator and a refrigerator that only meets the minimum federal standard. In this manner, the incentives of two complementary programs

- work to encourage a purchase decision in favor of energy efficiency.
- Provide a cost-effective opportunity for utilities to promote efficient apartment-sized refrigerators. The CEE program would help minimize individual utility administrative costs as NYPA is administering the contract. In addition, utility rebate or financing programs would be further leveraged due to anticipated unit price concessions obtained through the NYPA purchase order.
- Create an opportunity for utilities to provide value to key customers. Housing authorities are major customers of utilities and this program provides an opportunity for utilities to provide real value to these important customers.
- Provide utilities with a DSM opportunity aimed at the multi-family sector. In the past, the multi-family housing market has often not taken full advantage of utility DSM programs. This was likely due in part to the fact that the procurer of major multi-family housing appliances was not the end user. This program allows utilities to reach out to this important market.
- Provide utilities flexibility in program participation. The program is structured to allow significant flexibility in terms of both resource allocation and timing. Participation in refrigerator procurement can take place in any year or years of the NYPA effort with no obligation for additional orders, and various incentive programs can be tailored for any duration.
- Accelerate the entry of super-efficient refrigerators into the marketplace and help establish a viable market for highly-efficient apartment-sized refrigerators. The uniform product specifications and the anticipated volume of the order will likely help reduce the price premium for more efficient refrigerators due to economies of scale. To the extent that the program accomplishes this objective, the likelihood of success at the retail level is also enhanced.
- Create positive public relations and personal appeal due to energy savings, air quality enhancement, and additional service to tenants.
- Share in a national effort to transform the apartment sized refrigerator market and the publicly assisted housing sector for all appliance purchases.

Regarding the benefits to core initiative partners, NYCHA has received new refrigerators on an accelerated schedule while avoiding the operational expense of their purchase and installation. NYCHA is able to infuse the money normally spent replacing refrigerators to other building improvements. Residents of public housing receive a new appliance, typically larger than their current refrigerator and with automatic defrost. NYPA receives goodwill and a long-term relationship with their third largest customer.

DOE and HUD expect this program to serve as a model for many similar programs being undertaken in the near future. HUD and the U.S. taxpayers win because they receive energy cost savings in excess of the program cost over the lifetime of the replacement refrigerators. DOE and other initiative sponsors win through spurred voluntary development of new, super-efficient refrigerators. DOE and EPA also benefit from reduced emission levels. Finally, U.S. industry and the economy win because jobs and economic growth are promoted by the accelerated replacement with the new, super-efficient models.

Many market factors contributed to the realization of program success and associated benefits. These include:

- Large Anchor Buyer (NYPA)
- Relatively Limited Number of Buyers Comprised Significant Volume
- Direct Purchase from Manufacturer
- Flexibility in RFP
- Proposed Federal Energy Standards
- Potential for HUD Subsidy Through Performance Funding System
- Consumer Accepted Technology - Generally Viewed as a Commodity Product
- Timing Consistent with Manufacturer Plant Renovation
- Potential Opportunity for Other Appliance Sales with Participants

Evaluation of Energy Savings from 1996 Efforts/Projection for 1997

The following analysis describes the energy cost savings achieved from the replacement of 20,000 refrigerators in the first year of the NYPA/NYCHA program (1996), as well as preliminary results and projects for the 1997 effort in New York City.

In 1996, NYPA competitively procured 20,000 of the most cost-effective refrigerators available, selecting a 14.4-ft³ top-freezer automatic-defrost refrigerator rated at 499 kWh/yr. NYCHA then signed a contract with NYPA for the purchase, installation, and financing of the new refrigerators as well as the recycling of materials from the old units. HUD agreed to reimburse NYCHA for the refrigerator purchase and installation costs pending the demonstration of energy savings resulting from the new units.

HUD also agreed on a metering approach to isolate energy savings.

Field monitoring activities included:

- short-term metering of total energy consumption for the old refrigerators in use by NYCHA occupants for a period of approximately one week, for a sample of existing refrigerators (n=256) and the GE high-efficiency replacement refrigerators (n=74)
- collecting refrigerator model numbers and snapshot data (at the beginning and end of the metering period) of key drivers for refrigerator consumption, including: indoor and refrigerator compartment temperatures, compartment temperature control settings, and visually-estimated food loadings in each compartment
- supplementing the energy consumption data with a small sample metered with data loggers (n=30) to collect much more detailed 15-minute interval consumption data, including ambient air temperatures, refrigerator and freezer compartment temperatures, defrost cycles, and door openings and durations, as a basis for understanding these key effects as well as peak load impacts.

No formal sampling scheme was established; residents were recruited for metering on an ad hoc basis. Thus, the sample is not random in a formal statistical sense, but it is felt that a reasonably representative sample of the occupant's refrigerator usage was obtained.

Tests were also conducted in an environmental chamber to verify that the new refrigerators achieved their rated performance under the conditions of the DOE label rating test, and to ascertain their efficiency as a function of ambient and compartment temperatures.

NYPA provided 15-minute total building electric demand records for 10 NYCHA developments in order to determine the time of day of building peak demands.

NYPA also conducted a compliance survey to determine how many refrigerator controls were at various settings both before and after a campaign to lower them in response to settings that were found to result in colder than needed temperatures in the new units.

Analysis Procedure

The analysis activities were directed toward achieving a single objective: estimating the annual energy and cost savings to NYCHA (at current NYPA electric rates) achieved by replacing existing refrigerators with the new GE model during calendar year 1996. Achieving a more generalizable understanding of savings as a function

of refrigerator label ratings, occupant effects, indoor and compartment temperatures, and characteristics (such as size, defrost features, and vintage) is the subject of data collection and analysis efforts for 1997. Therefore, except for the peak load impacts, the measured data utilized was primarily weekly energy consumption and snapshot data.

The analysis accounts for four effects not directly represented in the raw data:

- Refrigerator consumption is largely proportional to the temperature difference between the compartments and the ambient indoor air, and indoor temperatures during week-long metering periods do not represent annual average conditions.
- Part way through the metering period it was discovered that the new refrigerators were operating several degrees colder than the existing refrigerators, and the manufacturers' default control setting was lowered to compensate for this.
- Many more models of existing refrigerators were replaced than could be metered with any meaningful sample, and the efficiency of the existing refrigerators, as evidenced by their DOE-label ratings, varies widely (by more than a factor of two).
- The refrigerators' share of the building's peak load (upon which electricity demand charges are based) is less than their share of the average building energy consumption, because consumption by other appliances increases more during peak periods than does the energy consumption of refrigerators. So, cost savings for peak demand reduction must be accounted separately, instead of computed based on a blended-rate (the total electric bill for energy and demand charges divided by the number of kWh).

The analysis consists of five basic processes:

1. Adjust the measured consumption of each of the refrigerators from the indoor and compartment temperatures during the metering period to that which would occur under annual average conditions for the public housing population as a whole.
2. Construct a relationship between refrigerator consumption and DOE-label rating so that consumption can be estimated for refrigerator models not represented in the metered sample.
3. Use this relationship to estimate savings for each refrigerator replaced, and estimate

savings attributable to changing the new refrigerators' control settings.

4. Estimate the consumption of refrigerators during the hours of peak building demand, and use it to compute the peak demand cost savings.
5. Use the records of the number of refrigerators of each model demanufactured to compute an average total-per-unit savings for the program in 1996.

Results of 1996 efforts at NYCHA units

- As part of NYPA's effort, the internal control settings of installed units were adjusted from the factory setting of 5 down to a setting of 2. At a setting of 2, the annual energy savings are estimated at 653 kWh/yr, or \$44 per year per refrigerator when demand costs are included. If residents adjust settings upward, as observed by sampling conducted by NYPA to an average setting of 3.1, energy savings are estimated at 575 kWh/yr. per refrigerator.
- NYCHA pays \$0.0354/kWh and \$22.31/kW each month of the year in demand charges. NYCHA considers its energy cost based on an effective blended rate of \$0.085/kWh. However, based upon an evaluation of refrigerator load requirements relative to NYCHA's peaks, a more representative blended rate of \$.068/kWh was computed.
- The new refrigerators are significantly larger than the average replaced unit (14.4 ft³ compared to 12.6 ft³). This provides considerable qualitative benefits to the residents. It should be noted that savings would be even higher if the new refrigerators were the same size as the existing units.
- Another similar qualitative amenity provided by the new refrigerators is automatic defrost. Most of the old units were manual defrost models. A simple comparison of the difference in historical DOE-label ratings for refrigerators of this size provides an estimate of the energy consumed by the defrost cycle at approximately 140 kWh per year.
- Previous studies of refrigerators showed average label ratios (actual consumption to DOE-label rating consumption) of about 0.9 whereas in this study the new and existing units are at 1.3. These studies are of single-family dwellings, having much cooler ambient air temperatures on average, have larger refrigerators, and may

have fewer occupants and/or fewer home during the day. The difference in temperature explains approximately 75% of the difference in the label ratios.

For 1997, the Magic Chef units being installed are expected to outperform the 1996 GE units. In a lab test of 5 Magic Chef units, the units on average outperformed the label rating of the 1996 GE unit by 18 percent - 408 kWh/yr. vs. 499 kWh/yr.