OUT WITH THE OLD, IN WITH THE NEW

Why Refrigerator and Room Air Conditioner Programs Should Target Replacement to Maximize Energy Savings

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NRDC
THE EARTH'S BEST DEFENSE
Natural Resources Defense Council
November 2001

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Executive Summary

After years of great success improving the efficiency of refrigerators and room air conditioners (RACs), the market transformation community has reached a crossroads with these products. Due to the increased stringency of federal appliance standards for both products, it is now difficult to save significant amounts of energy by simply persuading consumers to buy new appliances that are more efficient than the standards require. In fact, the annual energy saved by buying a new Energy Star-compliant refrigerator instead of a standard one is roughly the same as what can be saved by one compact fluorescent lamp, roughly 50 to 100 kWh/yr

In response, utilities and regional organizations have begun to shift the emphasis of their appliance programs. The most advanced programs are taking inefficient older units out of service, recycling them in an environmentally sound manner, and replacing them with efficient new models. This greatly increases energy savings and cost effectiveness, while providing a wide range of environmental benefits, including reductions in emissions of air pollutants, ozone- depleting chemicals, groundwater contaminants, and greenhouse gases.

To put the recent efficiency gains into perspective, the typical EER of a room air conditioner in use in a home in 1990 was about 7.5. Today's Energy Star-labeled units have EERs of about 10.7 – a 43% improvement. Even more dramatic progress has been made with refrigerators. Current models use 70% less electricity than units made in 1974, and about 50% less electricity than the current average of all refrigerators in use in homes today.

Given the existing stock of inefficient residential refrigerators and RACs and the availability of dramatically more energy efficient models today, the authors pursued this research in an attempt to provide utility program managers, consultants, energy advocates and policy makers with the tools needed to design the next generation of refrigerator and RACs programs. This paper provides:

- Information on the historic energy consumption and standard levels for refrigerators and RACs

- Market assessments of existing refrigerators and RACs

- An overview of the appliance recycling industry and issues related to recycling and early retirement programs.

- Cost effectiveness estimates and perspectives on various program options

- An overview of existing utility incentive programs that target efficient new refrigerators and RACs, as well as replacement or retirement of older units.

- Policy options and program design recommendations for expanding the success of appliance recycling programs.

Key findings from the paper include:

- Residential refrigerators and room air conditioners (RACs) currently consume about 155 billion kwh of electricity per year -- a full 15% of all residential electricity in the United States. As the current generation of new refrigerators and RACs replace existing units, the nation will achieve significant energy savings. Efforts to accelerate consumer replacement of their functioning units combined with proper recycling of the existing units will result in earlier energy savings, reduced emissions from power generating plants, and significant consumer electric bill savings.

- Early replacement and retirement recycling programs for operating residential refrigerators and RACs are currently offered only in very limited parts of the country. The quantity of units collected annually in existing utility sponsored programs is approximately: 300,000 primary refrigerators, 200,000 secondary refrigerators, and 75,000 RACs. As these programs produce energy savings at 2 to 4 cents per kWh, there should be considerable interest for these programs in parts of the country with high electric rates and/or those that are facing capacity shortfalls.

- Comprehensive recycling of operating second refrigerators, and primary room air conditioners and refrigerators is worth immediate consideration by utilities and market transformation groups throughout the country. The environmental impacts from CFC emissions alone are profound, but rarely captured in utility cost-effectiveness considerations for appliance recycling. Regulators should mandate that all appliance recycling programs recapture CFCs from both cooling systems and insulating foam, either for destruction or re-use.

- Programs should link recycling of old units to the purchase of efficient new ones, rather than treating them as two separate program types. Replacement programs that offer a "trade-in" or "swap" incentive are particularly promising. They offer numerous opportunities for creative partnerships with manufacturers, retailers, delivery companies, and recyclers, who already have a strong financial reason to encourage their customers to replace their appliances early.

- The existing infrastructure for comprehensive appliance recycling is still quite small, and limited to a few regions of the country with strong appliance efficiency or recycling programs. However, new facilities can be built rapidly in new regions in response to stable, regional, multi-year funding commitments.

- Since manufacturers and retailers gain near-term incremental sales and increased profits from programs that encourage earlier purchases of new models and removal of functioning models from the overall market, utilities should explore ways for these entities to contribute funds to support recycling programs. Leverage opportunities include: manufacturer rebates, retailer offering and funding pick-up of existing models, placing consumer education pieces encouraging early replacement and retirement, etc.

- The efficiency community should explore new means of co-funding appliance recycling programs, including a recycling "deposit" charged on the sale of new appliances. These and other mechanisms could allow solid waste and hazardous waste agencies to jointly support the appliance programs now funded almost solely by utilities.

- Appliance efficiency programs should pay incentives proportionate to net energy saved, not to appliance cost or features. Many of the incentives paid in 2001 for the purchase of new Energy Star appliances were very high relative to expected energy savings

- Efficiency programs should do more to emphasize the non-energy benefits (enhanced performance, quiet operation, convenience, etc.) of new Energy Star appliances when marketing replacement programs to owners of older appliances. These attributes are often more highly valued by most buyers than energy savings alone.

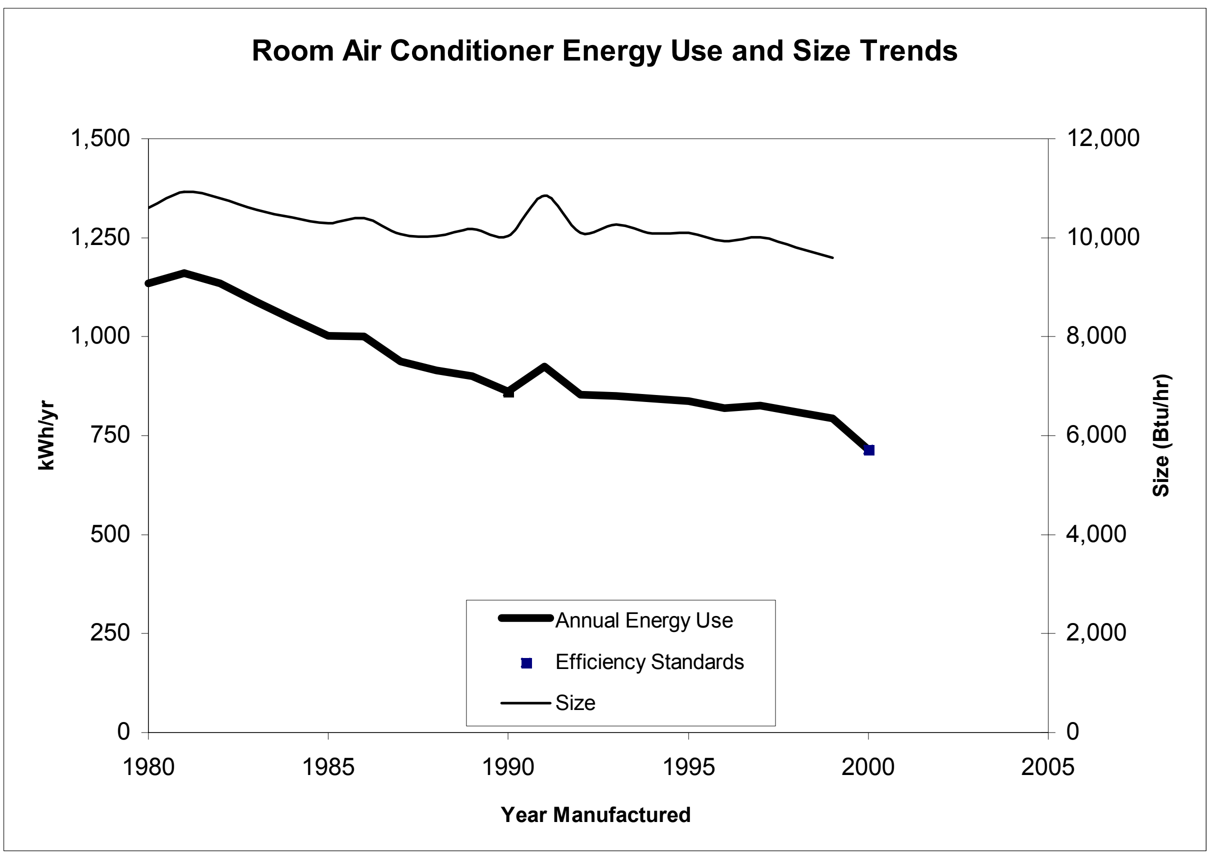
- Programs should explore a range of new construction opportunities, since home purchase and moving are the leading reasons for the purchase of new appliances.

Introduction

Residential refrigerators and room air conditioners (RACs) consume about 155 billion kwh of electricity per year -- a full 15% of all residential electricity in the United States. The yearly economic and environmental impacts of that consumption are enormous -- $12.5 billion of electricity bills and more than 116 million tons of carbon dioxide emissions.[1] In fact, consumers spend about twice as much each year to operate their refrigerators and RACs as they spend purchasing new ones.[2] There are significant opportunities to reduce those costs through energy efficiency improvements.

Though refrigerators and RACs have been sold in the U.S. since the 1930s, significant attention was not paid to their energy efficiency until the last 25 years. Federal and state efficiency standards have been tightened repeatedly for both products, with the most recent rounds taking effect in 2000 and 2001. At the same time ENERGY STAR® labeling programs, tax credits, and more than a decade of utility incentive programs have further accelerated progress. Current models of these appliances are far more energy efficient than older models, while providing improved convenience and level of service.

Figure 1



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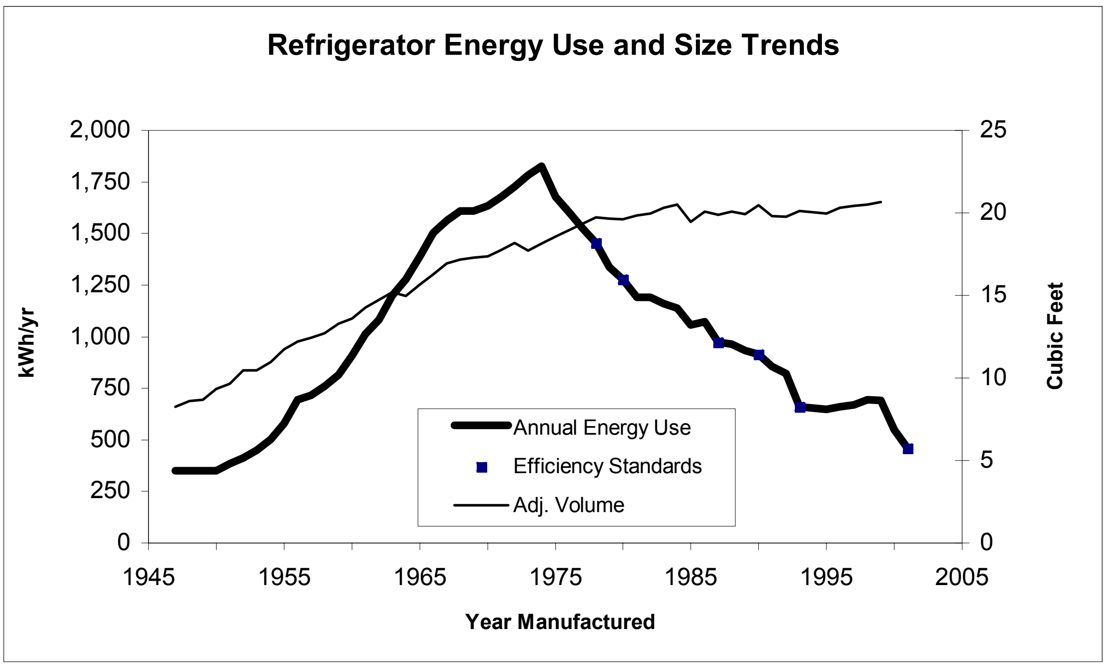
[1] U.S. Department of Energy, Energy Information Administration, *A Look at Residential Energy Consumption in 1997*, November 1999, p. 17.

An Energy Efficiency Rating, or EER measures room air conditioner efficiency (higher EERs represent greater efficiency). The typical EER of a room air conditioner in use in a home in 1990 was about 7.5.[3] Today's ENERGY STAR-labeled units have EERs of about 10.7 – a 43% improvement (Figure 1).

Progress has been even more dramatic with refrigerators (Figure 2).[4] Current models use 70% less electricity than units made in 1974, and about 50% less electricity than the current average of all refrigerators in use in homes today.[5]

Figure 2



As a result, the energy savings that consumers gain from buying a new ENERGY STAR-compliant fridge or RAC compared to a basic new model that just meets the mandatory DOE appliance standards are no longer very significant. Compared to the DOE standards, the average savings are about 40 to 110 kwh/year for an ENERGY STAR room air conditioner and about 45 to 80 kwh/year for an ENERGY STAR refrigerator. That is only about $3 to $9 worth of savings a year at national average electric rates. Nevertheless, efficient products have achieved substantial market share in particular regions in a short period of time.[6]

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[2] *AHAM Fact Book 2000*, p. 10. AHAM quotes manufacturer sales, which may be lower than consumer sales due to retailer markup.
[3] Lawrence Berkeley National Laboratory, *Technical Support Document for Energy Conservation Standards for Room Air Conditioners, Sep 1990*
[4] Data for both charts assembled from Association of Home Appliance Manufacturers (AHAM), *Fact Book 2000*. The 2001 refrigerator forecast was estimated by David Goldstein of NRDC.
[5] Association of Home Appliance Manufacturers
[6] D&R International, www.energystar.gov/opie/library/studiesreports/esappsalesdata/state2001.htm

On the other hand, the dramatic improvements in efficiency that have been made over time make early replacement and comprehensive recycling of older units comparatively more attractive. Enormous energy savings can be gained by removing functioning second refrigerators from the market. Persuading consumers to replace primary refrigerators made prior to 1993 with new, ENERGY STAR-labeled units can yield impressive savings as well, and is surprisingly cost-effective.[7]

Research Methods

NRDC retained Ecos Consulting to look deeper into the issues related to early retirement for refrigerators and air conditioners. Key questions we addressed include:

- What is the energy savings potential of early retirement programs?
- What programs are currently being run and how are they doing?
- What program designs should utilities and other sponsors consider using in future programs?
- What infrastructure is needed to accommodate increased collection and recycling capacity? What policy options exist to help fund this?

What follows are the key findings from our research. This work drew heavily from a survey we conducted of 12 room air conditioner and 25 refrigerator efficiency programs run across the country. .

Though central air conditioners, freezers, clothes washers, and dishwashers also present compelling energy savings opportunities through early retirement, we were not able to examine them in the limited scope of this research. This work was funded by a grant from the U.S. Environmental Protection Agency, and the views expressed herein are solely those of the authors.

Most of the data contained in this report were obtained directly from the staff of utilities operating incentive programs or the managers of various private recycling firms. While we had hoped to locate utility regulators who had independently verified program results through measurement and evaluation studies, very little such current information was available. The Consortium for Energy Efficiency provided valuable input on a wide range of topics. We are particularly indebted to the useful prior research conducted by Everett Shorey and Tom Eckman for the Pew Center on Climate Change and recommend their recent report to all readers of this one.[8]

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[7] James Cavallo, "Eight-Year-Olds Burn Energy," *Home Energy*, July/August 2001, pp. 10-13.
[8] Everett Shorey (Shorey Consulting) and Tom Eckman (Northwest Power Planning Council), *Appliances & Global Climate Change: Increasing Consumer Participation in Reducing Greenhouse Gases*, prepared for the Pew Center on Global Climate Change, October 2000.

Data on program scale, scope, expenditures and results, where available, were tabulated into a database for analysis. In general, program managers were frequently reluctant or unable to provide much information about program cost effectiveness or specific aspects of recycling costs they considered proprietary.

Why Focus on Room Air Conditioners and Refrigerators?

We examined these two appliances in particular for a number of reasons. Of all the types of major home appliances, they are the most likely to be found in quantities of two or more per household. In 1999, U.S. consumers purchased over 9 million refrigerators and nearly 6.3 million room air conditioners, so the opportunity to save energy by influencing those purchasing decisions is significant.[9] In addition:

- Both products have traditionally been substantial consumers of residential electricity;

- Stringent new federal efficiency standards for both products led to sizable cuts in the energy use of new products now sold in stores;

- Both products are long-lived, large, and unwieldy. In addition, they contain components that must at the end of their life be dismantled and recycled carefully to avoid burdening landfills and releasing chemicals that are toxic or ozone-depleting;

- Programs for both products can either offer incentives for the purchase of an efficient new model, encourage people to retire an inefficient old model, or both.

At the same time, there are key differences between the products:

- In total, Americans have three times as many refrigerators as RACs in use in their homes and they use a total of six times as much electricity as RACs.[10]

- Refrigerators are nominally "on" at all times, though their load varies slightly throughout the day. RAC use is driven by user-determined thermostat settings and local climate conditions, and can vary from less than 250 hours per year to more than 2,500 hours in different parts of the country.

- When RACs are operating, however, they contribute a far greater peak load to the utility system than refrigerators. They can draw from 600 to 3000 watts during peak compressor operation, compared to 100 to 400 watts for refrigerators.[11]

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[9] *AHAM Fact Book 2000*, p 10.
[10] Energy Information Administration, *A Look At Residential Energy Consumption in 1997, p. 17.*
[11] James Cavallo and James Mapp, "Monitoring Refrigerator Energy Usage," *Home Energy*, May/June 2000, pp. 32-36; and *No-Regrets Remodeling*, Energy Auditor and Retrofitter, 1997, p. 97.

- Most importantly, the difference in energy efficiency between new and old refrigerators is far greater than the efficiency difference between new and old room air conditioners.

Program Types

Utilities operate a number of different types of programs regarding these appliances. The most basic type is an ***upgrade*** program, which simply encourages people to purchase more efficient appliances than the standard model at the point of sale. The inducements to upgrade may be in the form of rebates to purchasers, point-of-purchase materials, payments to dealers or their salespeople, or co-operative advertising dollars. Upgrades have been the dominant program type for more than a decade. They ignore the fate of the old appliance being replaced by the customer.

A second program type is a ***replacement and recycling*** program. In its most basic form, this program type is exactly like the first one, -- it provides an efficiency incentive when a customer comes to the store to buy a new appliance. But it also provides incentives and convenient pickup for the old refrigerator or air conditioner, provided it is in working condition. Those units are then fully dismantled and recycled at an approved facility. Some replacement and recycling programs will only pay incentives if customers both recycle their old model and purchase an energy efficient new one. Other programs pay separate incentives for either action by itself.

Some replacement programs wait until customers come to the store to buy a new model before marketing the availability of recycling services for the old unit. Other programs actively seek to persuade customers to replace and recycle their inefficient appliances early, before they would normally begin shopping for a new appliance. This is often called an ***early replacement*** program – a slight variant of the standard *replacement and recycling* program.

A third program type is a ***retirement*** program. These programs primarily target second refrigerators, though could also be applicable to spare room air conditioners. These programs do not seek to replace the old unit with another one, but rather aim simply to permanently pull the old model out of use and recycle it, saving all of the energy that model was consuming for the number of years of its remaining life. These programs are most amenable to co-funding by solid waste organizations, since some second appliances are not operational (and thus not eligible for utility funding), yet could be made operational with a simple repair and returned to service.

There are slightly different groups of consumers and correspondingly different program elements in each case, as Shorey and Eckman pointed out (Table 1) in their appliance paper. [12] Note that “considerers” are prime targets for all replacement programs, while “satisfieds” can also be targeted in early replacement programs. They are happy with their

[12] Shorey and Eckman, *Appliances and Global Climate Change,* pp. 11-12.

current, functional appliance, but may respond to marketing messages identifying the benefits of a newer, more energy efficient unit.

Decision	Target Group	Major Program Elements
Upgrade to More Efficient Appliance	Buyers	• Point-of-sale information including Energy Star® logos • Energy labels (on appliances) and data on energy use in electronic "catalogs" • Sales representative training and incentives
Avoid Postponement of Appliance Replacement	Considerers	• Point-of-sale information including Energy Star® logos • Easy-to-use cost and savings analyses, especially for potential online buyers • Sales representative training and incentives
Early Replacement	Considerers Satisfieds	• Mass communications Bill stuffers Consumer Reports • Cost and savings analyses • Rebates/Store Credits for appliance retirement
Appliance Retirement	All households	• Mass communications Bill stuffers Consumer Reports • Rebates • Pick-up and recycling programs

Table 1

What Is Comprehensive Appliance Recycling and Why Is It Important?

Environmental Benefits

The principal environmental benefits from energy efficiency programs usually result from reduced electricity consumption and the related fossil fuel combustion at power plants. So, for example, saving a kilowatt-hour of electricity typically prevents the release of about 1.5 pounds of carbon dioxide, as well as other various air pollutants, from power plants. This represents one of the most compelling aspects of efficiency programs – they prevent pollution while simultaneously saving money. But utility programs that focus on replacing and comprehensively recycling old appliances can prevent pollution in a number of additional, valuable ways, by:

- Preventing the release of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), which help destroy the ozone layer and accelerate global climate change, from cooling systems and insulation
- Capturing toxic materials from lubricating oil and capacitors that could contaminate surface and ground water
- Recovering and reusing metals, plastics, and other potentially valuable materials that make up the bulk of the appliance and would otherwise waste valuable landfill space

Different Recycling Approaches

Though hundreds of entities around the country offer appliance "recycling" services, very few provide comprehensive recycling or appliance retirement. Many retailers, for example, define recycling simply as reuse or resale. When customers purchase a new appliance, the retailer will offer to pick up the old unit and haul it away in the delivery truck for a surcharge of roughly $15. These units are frequently resold in the used marketplace, where they continue to consume energy and pose environmental risks. According to 1996 market research surveys, only about 20 to 30% of new appliances are purchased because the old one died or was too costly to repair, so it is clear that most new appliance purchases do not automatically result in the permanent dismantling of the older model.[13]

Other retailers may dispose of the units in landfills or take them directly to scrap yards, which usually prevents their reuse in homes but perpetuates the risks of toxic material leakage and ozone depletion. Old appliances can be thought of both as an opportunity to recover valuable materials for reuse and as an assortment of potentially hazardous materials that require special handling.

The coolant in an old refrigerator is usually a CFC like R-12 or an HFC like HFC-134A. Approximately 8-12 ounces of these chemicals are normally found in the cooling system. About 2 to 2.5 pounds of the CFC R-11 were used as the blowing agent for the polyurethane insulating foam found in refrigerators made between the 1970s and early 1990s. Room air conditioners normally contain an HCFC called R-22 in their cooling system.

Not only are these chemicals powerful ozone depleters, but they are also extremely potent greenhouse gases. Pound for pound, CFCs are roughly 4,000 times more powerful than carbon dioxide (CO_2) in their contribution to global warming.[14] As a result, capturing two to three pounds of CFCs from a refrigerator[15] in the recycling process may provide as much global warming benefit as an efficiency program saving 5,000 to 8,000 kwh!

Federal law now requires the removal of CFC, HCFC and HFC refrigerants from the cooling system prior to appliance disposal or recycling, so the ozone depletion risk is already diminishing.[16] EPA also regulates the removal and disposal of capacitors, while the Department of Transportation and various state agencies impose additional

[13] *AHAM Fact Book 2000*, p. 25, citing NFO Research Inc., *Home Appliance Saturation and Length of First Ownership Study*, 1996.
[14] Hilary R. French, "Learning from the Ozone Experience," in *State of the World 1997*, Worldwatch Institute, 1997, p. 158.
[15] DOE-funded research conducted by Dimitrios Karvelas at Argonne National Laboratory indicates that some of the CFC-11 used to blow the polyurethane foam is lost over time from the insulation before it is recycled. In addition, much of what remains is chemically bound to the foam in a way that makes it difficult to recover through grinding. As a result, high temperature incineration may have certain environmental and cost advantages over recapturing and reusing the CFCs.
[16] HCFCs like R-22 have much lower ozone depleting potential and are weaker greenhouse gases than CFCs like R-11 and R-12. As manufacturers continue to switch from CFCs to HCFCs to more benign coolants and foaming agents in new appliances, the risk to the global atmosphere will diminish further.

requirements regarding the handling and transport of other related toxics.[17] Anecdotal evidence suggests that these laws are not yet being fully enforced and followed, however, adding to the value of proper recycling.

Even among true recyclers, there are wide variations in the scope of demanufacturing processes employed and the resultant materials that are recycled. Most of the recyclers that work with utilities provide trucks and drivers to retrieve appliances from customers and haul them to recycling centers. To prevent any chance of appliance reuse, they cut the cords and disable the cooling controls of operating appliances before loading them on the truck.

All recyclers generally target the most readily removable and valuable components for resale -- steel, copper, and aluminum. An average refrigerator contains 123 pounds of steel and a room air conditioner contain 43 lbs, so it is not surprising that all appliances together represent 10% of the volume of steel processed by the recycling industry.[18]

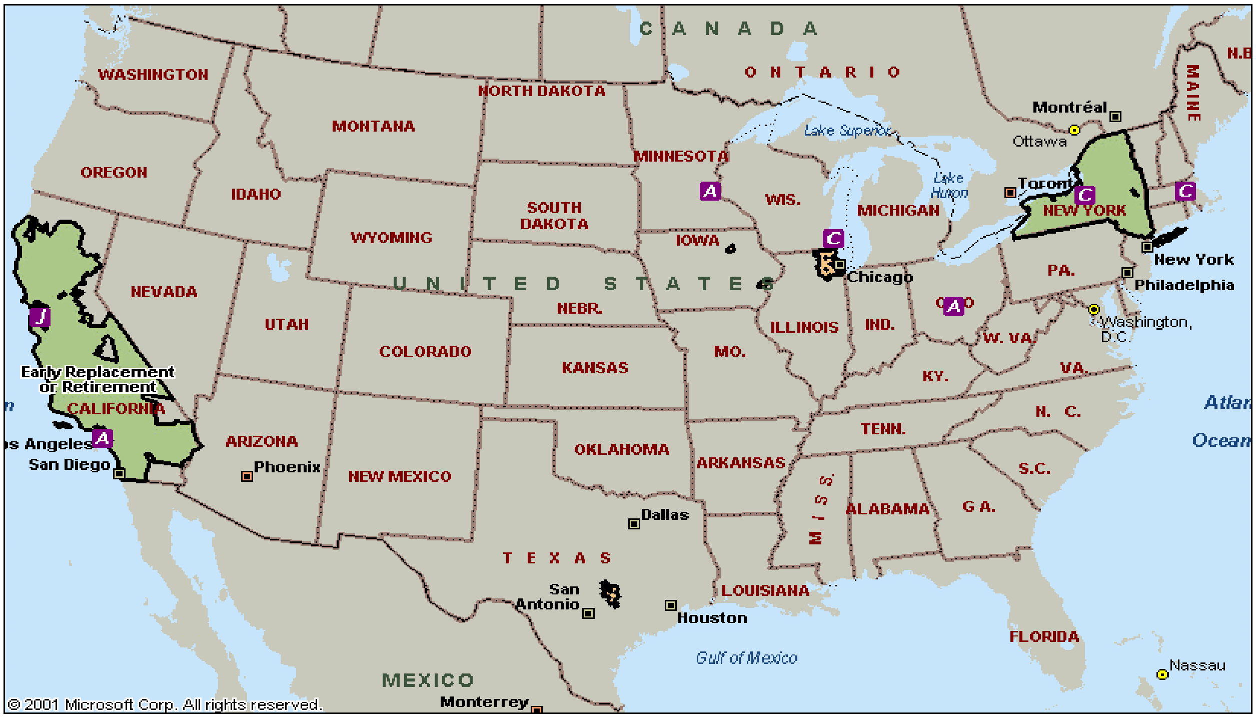
In many cases, they will also recover compressor oil, which may be contaminated and require special handling. Conservation Services Group (CSG) has tested compressor oil for 32 different contaminants, however, and found CFCs in some cases but no PCBs.[19] Recyclers often also recover old capacitors from air conditioners, which can contain toxic PCBs and need to be managed in accordance with federal and state hazardous waste laws regarding collection, handling, storage, transportation, and high temperature incineration.

Service Providers

We identified three recyclers that provide comprehensive services to utilities. These recyclers operate facilities in California, Oregon, Washington, New Mexico, Minnesota, Wisconsin, Ohio, New York, and Massachusetts, as indicated in Figure 3. Given that old refrigerators are in use throughout the country and old RACs are found in large concentrations in the country's warmest areas, these maps reveal the enormous potential for expanding infrastructure to capture additional energy savings and environmental benefits.

[17] Personal communication, Bruce Wall, ARCA, September 2001.
[18] Based on tear-down study of new appliances in 1997, Appliance Recycling Information Center.
[19] Personal communication, Dennis Flack, Conservation Services Group, October 2, 2001.

Figure 3 (Room AC – top map, Refrigerators – bottom map)



Early Replacement or Retirement

Early Replacement or Retirement

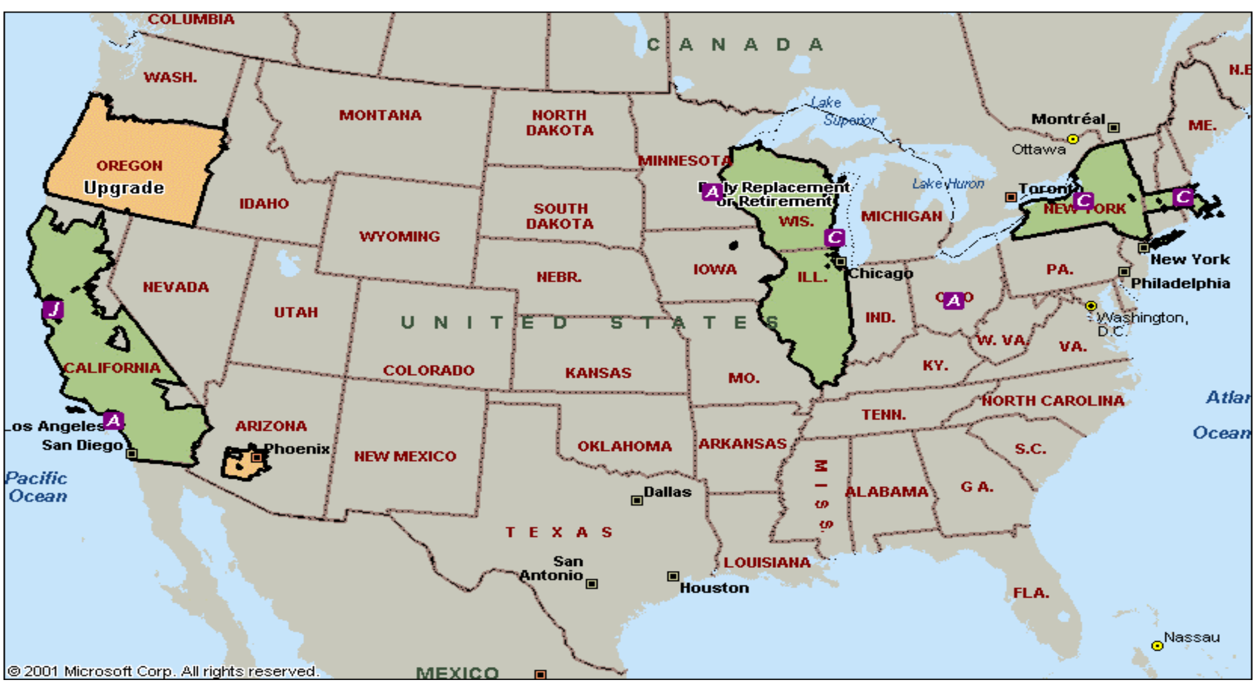
Upgrade

Name of Recycler by City

A ARCA

C CSG

J Jaco Environmental



As noted above, all recyclers remove ozone-depleting chemicals from the cooling system Each comprehensive recycler differs slightly in its approach to plastics and CFCs from insulating foam:

- Jaco Environmental recycles most of the plastics, but incinerates the CFCs at customers' request to prevent their reuse and eventual leakage to the atmosphere.[20]
- CSG does not recycle the plastic or the CFC-11 (which it believes should not be reused in other applications from which they may eventually leak). It is operating facilities originally built by Planergy.
- Appliance Recycling Centers of America (ARCA) recycles some plastics and uses a vacuum extraction process to recycle the CFC-11 for reuse at customers' request. Otherwise, they landfill the panels.

Costs

There are advantages and disadvantages to each approach, and costs vary as well, leading to increasing competition among recyclers. The cost of collecting old appliances from customers and recycling them at a comprehensive facility depends on a number of factors, including the length of the contract, the number of appliances to be recycled, the scope of the actual recycling process, customer density in the program area, distance to the recycling facility, and any related outreach or marketing services to be provided by the contractor. Challenges of logistics and storage often make it necessary for recycling companies to delay pickup until they can locate a large concentration of appliances in a particular area and fully load their trucks. This helps minimize their costs, but can be inconvenient to customers eager to get rid of their appliances. This is especially true for customers who just bought and received their new appliance and are not able to store their old functioning model conveniently, particularly in apartments and multifamily residences where storage space is lacking.

Across the range of service providers, we found that pickup and recycling charges to utilities generally run between $50 and $100 for room AC units and between $75 and $200 for refrigerators. The actual amounts paid by specific utilities were rarely provided to us, given the competitive nature of individual bids by different companies.

One case where specific cost data are available is the current program at SMUD. It pays about $215 for the first refrigerator recycled in a particular home and about $195 for the second unit at the same location, recognizing lower transportation costs. Of these totals, $25 goes to advertising, $50 to a consumer rebate, and $25 to a surcharge for CFC retrieval from foam and incineration.[21] That implies an actual transport and recycling cost (which includes the recycling company's profits) of around $100 per unit.

[20] Jaco also operates facilities in New Mexico, Washington State, and Oregon that resell operational appliances to overseas markets and recycle non-operational appliances.
[21] Personal communication, Michael Dunham, Jaco Environmental, September 24, 2001.

According to SMUD's recycling services provider, Jaco Environmental, transportation costs are a significant and often overlooked factor – about 20% of total program costs. It costs $1.20/mile to operate a truck with a capacity of 80 refrigerators, so both labor and fuel charges are impacted by a program with dispersed customers. Likewise, program costs go up when refrigerators must be collected from a region with no recycling center and trucked or sent by rail a substantial distance. In the same way that power plants are often located near coal mines and paper mills near forests, it may eventually make sense to establish appliance recycling centers near major metropolitan areas to cost-effectively mine a now discarded resource.

Room Air Conditioner Findings

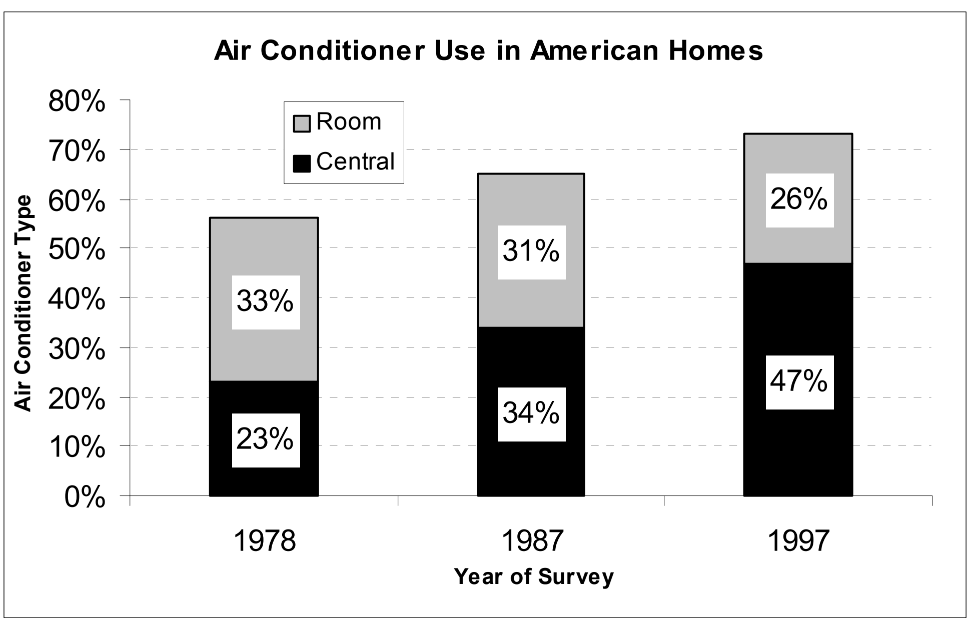
Our key findings include:

- Utility programs that simply encourage customers to buy ENERGY STAR units instead of standard ones frequently deliver small energy savings (approximately 40 to 110 kWh/yr) and are often not cost effective.

- Programs linking incentives for the purchase of a new ENERGY STAR unit with the comprehensive recycling of an old functioning one save far more energy and are usually more cost effective.

- Early replacement programs can become more successful when co-sponsored/funded by other stakeholders. Such programs benefit solid and hazardous waste agencies, and forward thinking agencies responsible for air quality will value the avoided CO_2 and CFC emissions. Manufacturers and retailers may also be willing to co-fund, given the boost to near-term sales.

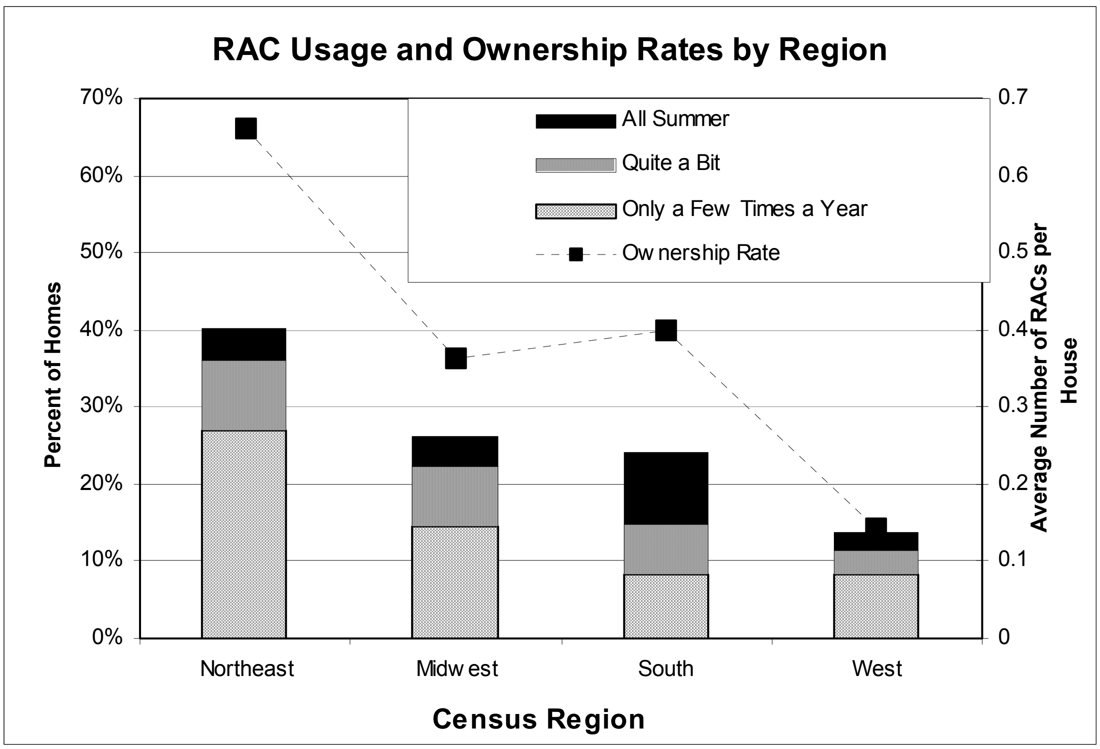
Figure 4



Market Assessment

New RAC efficiency has improved by roughly 30% over the last two decades, while average size (cooling capacity) has declined about 10%. Unit sales peaked in the 1970s and have varied between 2.6 and 6.5 million units per year since 1989. Even though the number of air conditioned homes has been rising steadily – from 56% in 1978 to 73% in 1997 – the percentage of homes containing RACs has actually fallen over that period, from 33% to 26% according to DOE (Figure 4).[22] Still, on a national basis the total number of units in use today is about 80% higher than it was in 1970, and nearly 40% of the homes with room air conditioners have two or more.[23]

Figure 5



It is not possible to accurately predict room air conditioner energy consumption simply from climate data. In fact, the hottest regions of the country are much more likely to have central air conditioning, and thus have a lower need for RACs. Ironically, the part of the country where room air conditioners are most likely to be found (the Northeast) is also the region where they are least likely to be used regularly (Figure 5). This presents a cost-effectiveness paradox – the units easiest to find will often save the least energy, and vice versa. Peak savings can still be valuable, however, especially in capacity-constrained areas with hot summers.

[22] AHAM data suggest a slightly different picture: 25% of homes having an RAC in 1970, 32.4% in 1990, and 30.7% in 1996.

[23] Data source for Figures 5 and 6: Energy Information Administration, *A Look At Residential Energy Consumption in 1997.*

Newer homes are far more likely to have central AC, leaving RACs to provide spot cooling in the warmest rooms or the majority of cooling in older, low-income, or multi-family housing. This is especially true in houses built before ducting was commonly provided for central air conditioning, and would be cost-prohibitive to retrofit (see Figures 6 and 7). From a program design point of view, this suggests that to the extent possible, program designers should try to target older homes.

Figure 6

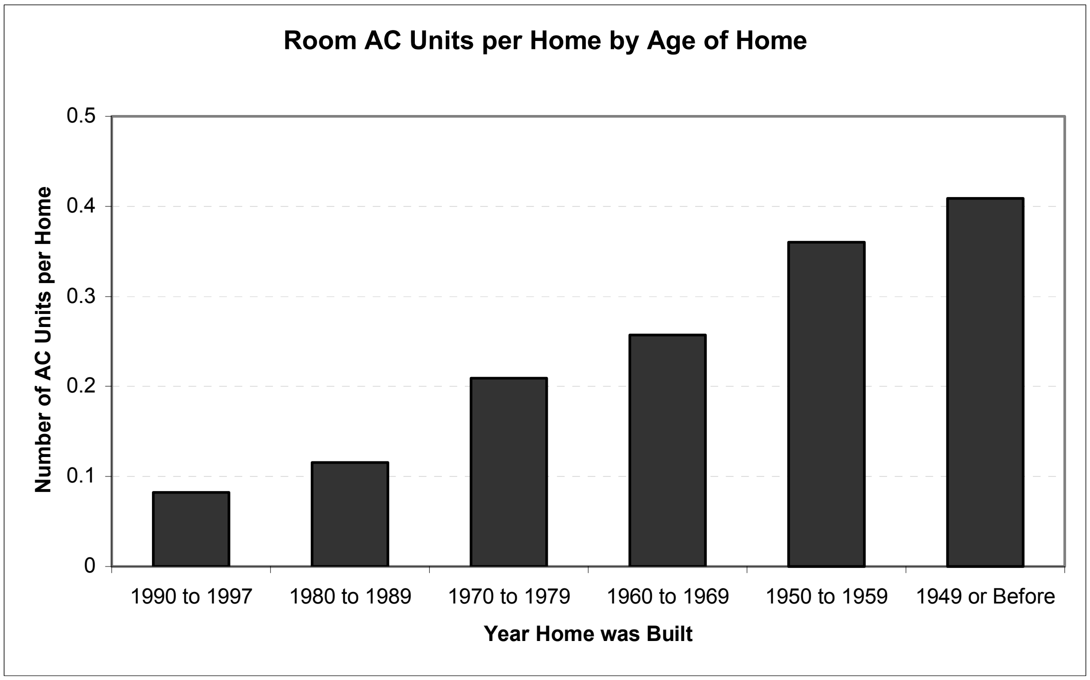
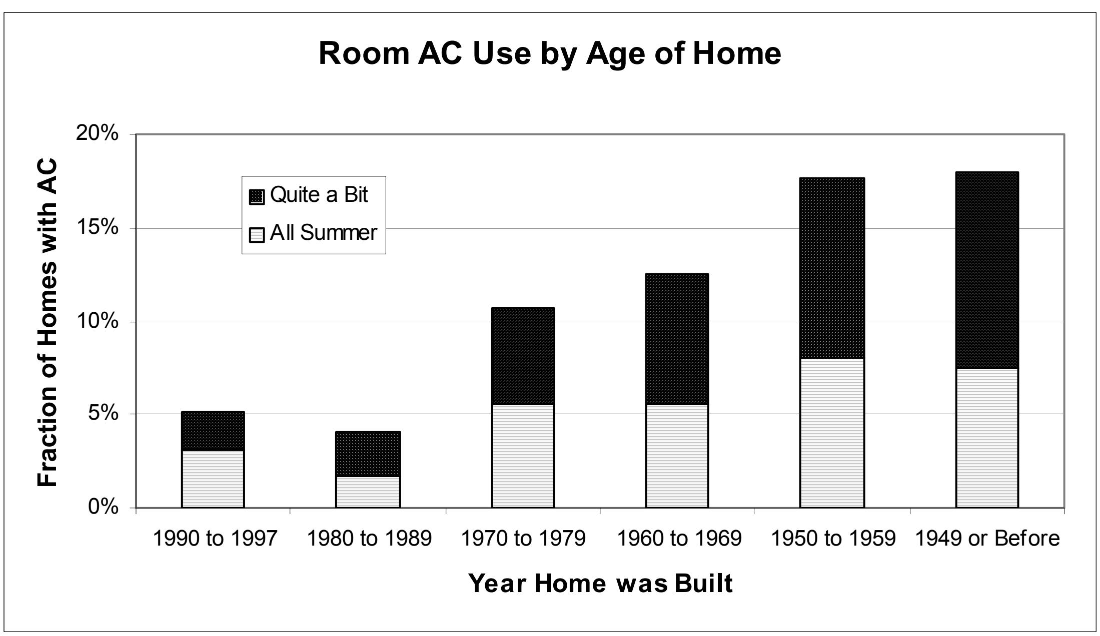


Figure 7



Upgrade Programs

The programs we surveyed were:

Table 2

Organization	City	State	Program Type
Anaheim	Anaheim	CA	Unknown
Austin Power	Austin	TX	Upgrade
Muscatine Power and Water	Muscatine	IA	Upgrade with Removal Requirement
NYSERDA	Albany	NY	Early Replacement/ Retirement
Pacific Gas & Electric	San Francisco	CA	Upgrade/ Optional Recycling
Pasadena Water and Power	Pasadena	CA	Unknown
Riverside Public Utilities	Riverside	CA	Early Replacement/ Retirement
San Diego Gas & Electric	San Diego	CA	Early Replacement/ Retirement
Southern California Edison	Rosemead	CA	Early Replacement/ Retirement
TXU Energy	Dallas	TX	Unknown
Waverly Light and Power	Waverly	IA	Upgrade

Most of the utility programs targeting room air conditioners encourage consumers to buy ENERGY STAR labeled models instead of typical ones. Some programs set their sights even lower when ENERGY STAR units initially proved difficult to find. This was almost certainly a less cost effective strategy than waiting for the ENERGY STAR units to become available, but was done in order to satisfy immediate short term policy objectives to quickly obtain peak demand savings.

Unfortunately, the average annual electricity savings realized per unit from buying an ENERGY STAR room air conditioner are only about 10% compared to standard new models, and few units are available that save much more energy than that. (This should grow with time as manufacturers introduce additional models and technologies). ENERGY STAR yields about 75 kwh/year of savings on average compared to a standard new model, though the range of possible savings can be enormous with variations in climate, unit size, and customer behavior.

Table 3 indicates predicted payback times in years for consumers purchasing an ENERGY STAR-labeled RAC instead of a standard new model of equivalent size. ENERGY STAR labeled models have an EER 1.0 higher than a standard new model. Combinations of unit size, usage, incremental cost, and utility rates needed to yield a payback period of less than six years are shaded. Not surprisingly, annual hours of full load (compressor) usage have a major influence on cost effectiveness. Areas of the country with 500 hours of usage or less – most of the northern states from coast to coast – face a tough cost effectiveness challenge unless units are large and incremental costs are low. No value is assigned to peak savings, since this chart examines paybacks strictly from a consumer perspective.

Table 3
New Room Air Conditioner Cost Effectiveness
(Table indicates payback times in years. Shaded areas are paybacks of less than 6 years)

			Incremental Cost											
			$25			$50			$100			$150		
Size	Usage	Savings	Residential Electricity Rate ($/kWh)											
(Btu/hr)	(Hours/yr)	(Kwh/yr)	$0.07	$0.10	$0.13	$0.07	$0.10	$0.13	$0.07	$0.10	$0.13	$0.07	$0.10	$0.13
<6,000	500	26.5	13.5	9.4	7.3	27.0	18.9	14.5	53.9	37.7	29.0	80.9	56.6	43.5
	1,000	53.0	6.7	4.7	3.6	13.5	9.4	7.3	27.0	18.9	14.5	40.4	28.3	21.8
	1,500	79.5	4.5	3.1	2.4	9.0	6.3	4.8	18.0	12.6	9.7	27.0	18.9	14.5
	2,000	106.0	3.4	2.4	1.8	6.7	4.7	3.6	13.5	9.4	7.3	20.2	14.2	10.9
6,000 to 7,999	500	33.7	10.6	7.4	5.7	21.2	14.8	11.4	42.4	29.7	22.8	63.5	44.5	34.2
	1,000	67.4	5.3	3.7	2.9	10.6	7.4	5.7	21.2	14.8	11.4	31.8	22.2	17.1
	1,500	101.2	3.5	2.5	1.9	7.1	4.9	3.8	14.1	9.9	7.6	21.2	14.8	11.4
	2,000	134.9	2.6	1.9	1.4	5.3	3.7	2.9	10.6	7.4	5.7	15.9	11.1	8.6
8,000 to 13,999	500	52.0	6.9	4.8	3.7	13.7	9.6	7.4	27.5	19.2	14.8	41.2	28.9	22.2
	1,000	103.9	3.4	2.4	1.9	6.9	4.8	3.7	13.7	9.6	7.4	20.6	14.4	11.1
	1,500	155.9	2.3	1.6	1.2	4.6	3.2	2.5	9.2	6.4	4.9	13.7	9.6	7.4
	2,000	207.9	1.7	1.2	0.9	3.4	2.4	1.9	6.9	4.8	3.7	10.3	7.2	5.6
14,000 to 19,999	500	81.9	4.4	3.1	2.3	8.7	6.1	4.7	17.4	12.2	9.4	26.2	18.3	14.1
	1,000	163.8	2.2	1.5	1.2	4.4	3.1	2.3	8.7	6.1	4.7	13.1	9.2	7.0
	1,500	245.7	1.5	1.0	0.8	2.9	2.0	1.6	5.8	4.1	3.1	8.7	6.1	4.7
	2,000	327.6	1.1	0.8	0.6	2.2	1.5	1.2	4.4	3.1	2.3	6.5	4.6	3.5

ENERGY STAR models can cost (MSRP) $25 to $150 more than standard models, with the higher priced models often including extra features as well (filtration, remote control, electronic timers, etc.). However, ENERGY STAR labeled models from Friedrich and Whirlpool at recent trade shows were nearly the same price as standard models. A customer will be able to recoup even an extra $50 to $100 of purchase costs over 3 to 6 years due to electric bill savings if hours of use, RAC size, and electric rates are all high. But it is very tough to get cost effective results if incremental costs are more than $100, especially for small-sized units.

Most importantly, this leaves little "room" for utilities to pay rebates, advertising, and admin costs and still have a cost effective program. Information programs may make the most sense in this case, keeping costs to a minimum and leveraging existing ENERGY STAR labeling infrastructure. Programs that rebate a fixed percentage of ENERGY STAR- labeled products' purchase price regardless of usage, size, or electric rates are not likely to be cost effective.

Replacement Programs

This picture improves significantly with programs that also recover old, operational RACs for recycling. An ENERGY STAR RAC can save an average of 460 kwh/year compared to a 20 year old model and about 230 kwh/year compared to a 10 year old model. However, the data needed to estimate average remaining hours of useful life for old models are sketchy. The average length of RAC ownership by the original purchaser is 6.9 years, but only 19%

of new models are purchased because the old one failed or was too expensive to repair.[24] It seems likely, in fact, that the typical *service* life of a RAC may be 15 to 20 years, lending some credibility to common utility assumptions that an operating old RAC has at least five years of remaining life.

Data gathered from NYSERDA's program suggest that there are additional benefits of replacing and recycling older RACs. 50% of RACs recycled in New York had PCBs in their capacitors. In addition, 1 in 10 had a significant restriction to the air flow caused by an old filter, birds nest, or other obstruction. This suggests that at least some older units suffer from a lack of proper servicing and maintenance, and are therefore performing below their rated efficiency levels.

About 70% of the units recycled had an EER listed on their nameplate. The average of those listings was 8.0, with only a small number of units listed at 9.0 or higher.[25] By contrast, most current ENERGY STAR models operate at an EER of approximately 10 to 11. It is likely that the unlabeled units were older and had an even lower EER than 8.0, which suggests that replacement programs are able to increase efficiency by about 30 to 50%.

RAC Conclusions

The utilities we surveyed generally paid incentives of $25 to $50 for the purchase of an efficient model, though some are willing to pay up to $100 for the purchase of very expensive models. Programs that linked payments to the purchase price of the new unit instead of the amount of energy saved are likely to see undesired market effects and lower cost effectiveness.

Bounties paid for still-in-use models tend to be similar, but only in NYSERDA's program did we find a linkage between the two incentive types ($75 for early retirement + ENERGY STAR purchase). Programs that only pay incentives if customers both recycle an operational old model and purchase an ENERGY STAR labeled new model are likely to have the best shot at cost effectiveness.

However, such programs may pay fewer total rebates for new units. The Electric and Gas Industries Association (EGIA) encountered a problem with this type of linkage in a program it operated in Anaheim, CA. Some salespeople were reluctant to mention the need for recycling to get a utility incentive, for fear that customers would find it to be too much of a hassle and not make a purchase. Rather than risk losing the sale, they would encourage customers to buy a standard unit.[26] The solution, it seems, is not to abandon the proven benefits of replacement and recycling, but for utilities to make the linkage sufficiently lucrative to overcome expected resistance from consumers or salespeople.

[24] *AHAM Fact Book 2000,* p. 25, citing *Home Appliance Saturation and Length of First Ownership Study*, 1996, NFO Research Inc.
[25] Personal communication, Dennis Flack, CSG, October 2, 2001.
[26] Personal communication, Tim Michel, EGIA, October 2001.

It may also prove more cost effective for utilities to partner with retailers to recover the old units rather than attempt to "go it alone." In most cases, the retailers deliver and install new ones and could be co-funded to follow utility protocols to ensure that operational old units are truly recycled instead of simply being returned to service. In other cases, utilities could co-sponsor turn-in events with retailers for old RACs light enough for customers to carry and transport. As with torchieres, customers bringing back an old model would qualify for free recycling and a discount toward the purchase of an efficient new one.

Low income programs have a more straightforward option available – swapping an appropriately sized ENERGY STAR model for the old one at low or no cost. However, programs willing to expend this much money per household may find that packages of related measures are more cost effective. For example, if RACs of a particular size are needed to keep one room in a house or apartment comfortable, it would be logical to investigate shade tree, window film/covering, and insulation options as well, to find the most cost effective combination of measures that meet occupant comfort needs.

It is probably also worth exploring opportunities to include small businesses, hospitality, and institutional/governmental customers in RAC recycling programs, since old units are often found in large numbers in those building types.

It makes sense to do some demographic targeting in the marketing and outreach for these programs. Zip codes with a substantial fraction of homes built since 1980 are likely to be poor targets for a mailing, for example. Other demographic variations are not so obvious. According to DOE, households with an annual income of less than $10,000 are twice as likely to have a RAC that is less than five years old than households with an income of $50,000 or more.[27] Programs targeting households with the disposable income to purchase new appliances may or may not reach the households most likely to have older ones to replace.

In general, under-sizing RAC units leads to far greater efficiencies (and often comfort) than over-sizing them (which results in a lack of dehumidification), so program sponsors should leverage existing efforts by retailers and ENERGY STAR to encourage buyers to size new units appropriately. In fact, it appears that declining average cooling capacity has had nearly as great of an impact on reducing annual energy consumption of RACs as improvements in their EER, so proper sizing is very important.

Free-ridership and energy saving "give-back" are very legitimate concerns with room air conditioner programs. Upgrade programs that generously assume all newly purchased ENERGY STAR models are substituting one-for-one for existing ones are likely to see higher energy consumption than they expect. In some cases, utility promotions and incentive dollars will encourage people to buy an additional new room air conditioner who might not otherwise have done so. Every customer of this type adds enough new electric load to negate the savings from roughly 10 customers that were already planning to buy a RAC and upgrade to ENERGY STAR.

[27] Analysis by Travis Reeder from income and RAC data contained in Energy Information Administration, *A Look at Residential Energy Consumption in 1997*.

Likewise, incentives may drive at least some customers toward larger or more fully-featured units which, though efficient for their type, may use more energy in total than the properly sized, basic unit they were planning to buy. The solution may be programs that link incentive payments to the *difference* between old RAC energy consumption and new, using locally tailored estimates for hours of operation. Customers could be told through program marketing to expect an incentive payment within a certain range, and be encouraged to call with information about their old model or visit a website to find out just how much they can save. This could be a challenge to implement with the oldest models, unless a database of EERs by model number and year can be created and made widely available.

Finally, the lack of metered data and usage studies for room air conditioners by region is a serious impediment to the forecasting of savings and the determination of cost effectiveness. Though DOE assumes 750 hours of annual usage for all room air conditioners sold, actual usage may vary from a few dozen hours per year in some homes and climates to virtually continuous usage for 6 to 8 months of the year in others. Each program implementer should work with data from their region and customers rather than assume similarity to national averages.

Refrigerator Findings

Our key findings from reviewing utility programs include:

- Programs focusing only on new refrigerators are probably even less cost effective than new room air conditioner programs, and provide less of a peak savings benefit than RAC programs do.

- Retirement and comprehensive recycling of functioning second refrigerators is almost always worth doing.

- Verifying that units are operational may be key to their participation in a *utility* program, but should not prevent their inclusion in a properly run recycling program with broader funding from other government agencies (solid and hazardous waste, air boards ,etc.).

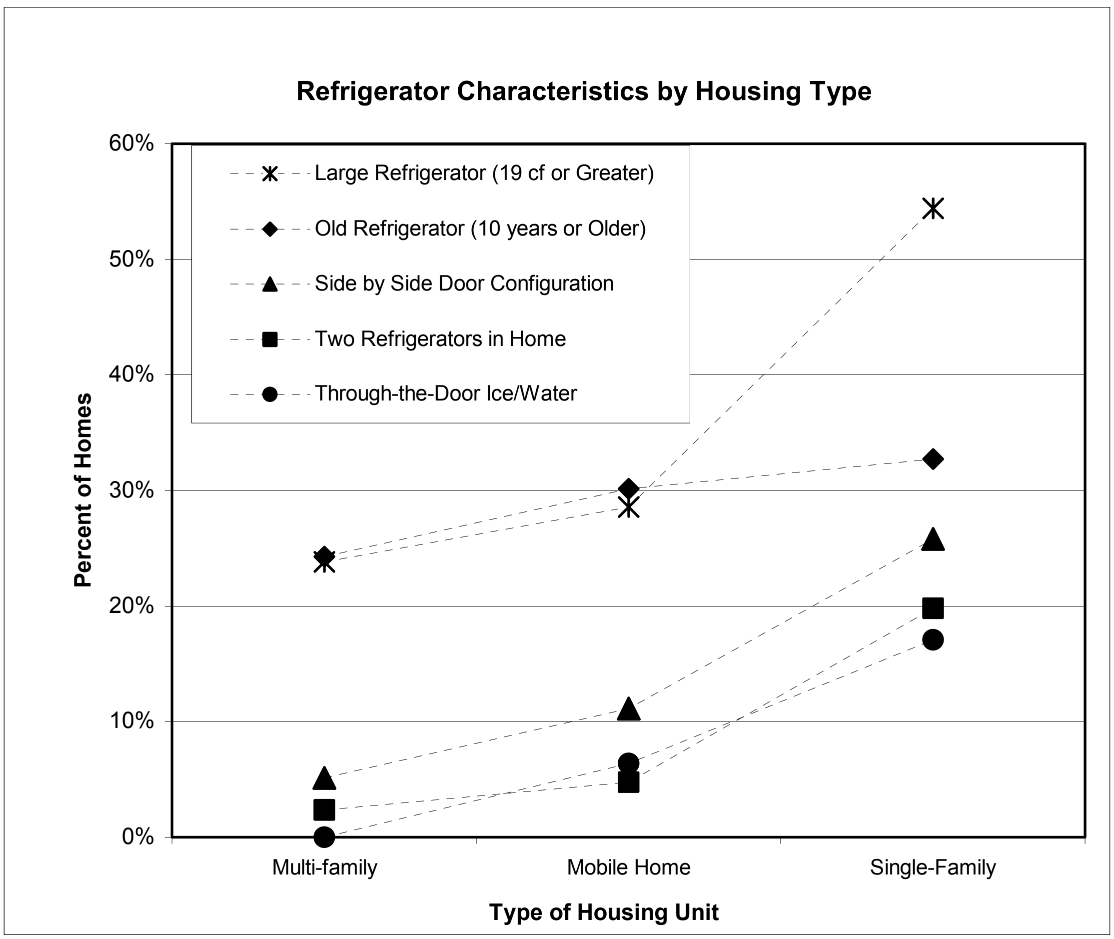
- Early retirement and comprehensive recycling of primary refrigerators has already proven cost effective when the units are at least eight years old. Linking incentive payments to the purchase of an efficient replacement model maximizes cost effectiveness.

Refrigerator Market Assessment

Refrigerators have the highest saturation levels of any major appliance in America. Between 98 and 100% of all households have at least one, and approximately 18% of those have two or more.[28] Refrigerator unit sales in the U.S. have risen steadily since 1989, from about 6.5 million units to 9.5 million units per year.

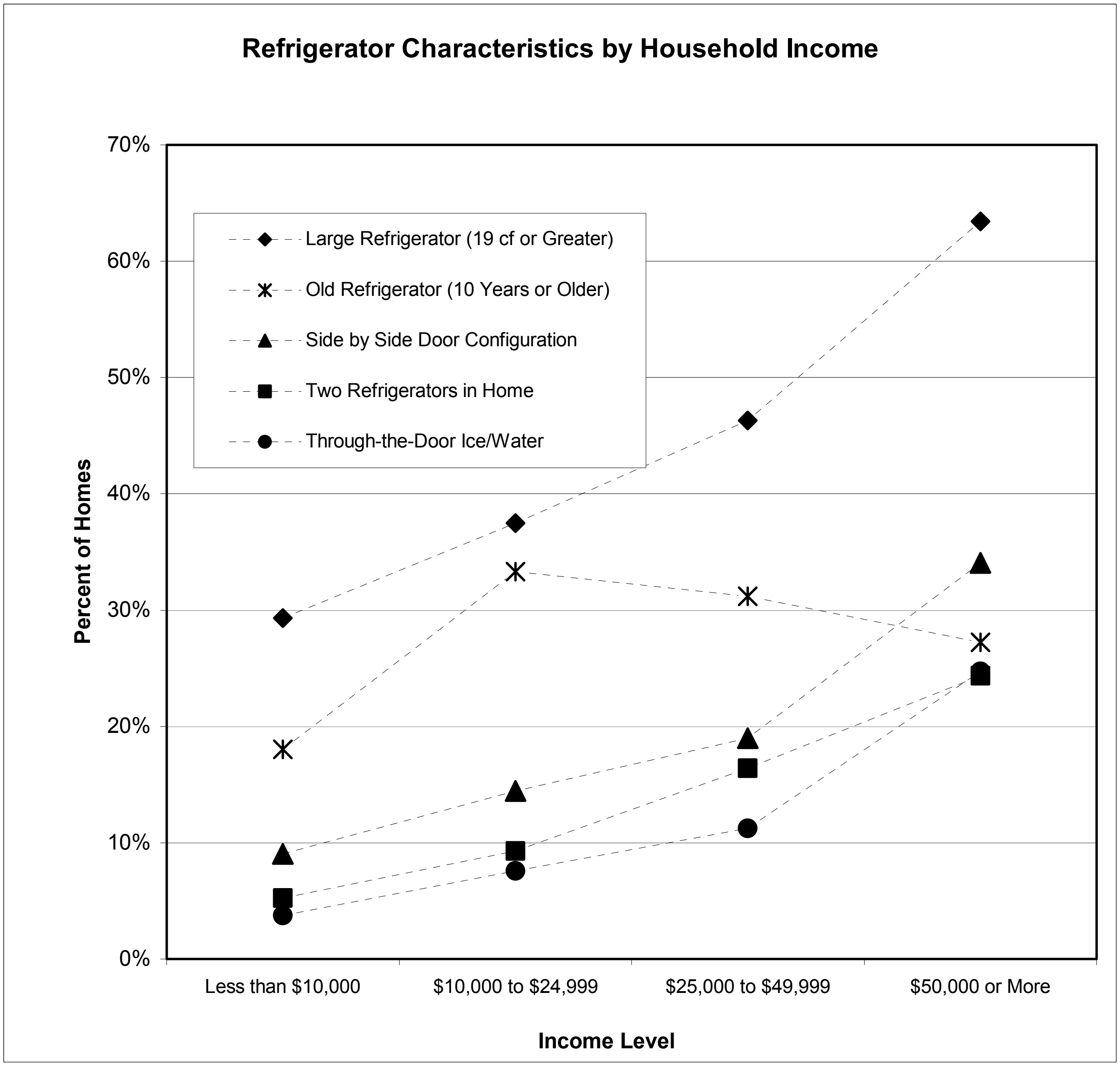
Average new refrigerator energy consumption has fallen by more than 70% since 1974, and is returning to levels not seen since the 1940s. On the other hand, average refrigerator size continues to climb, and is more than double what it was in 1950. Energy-consuming amenities like through-the-door ice and chilled water are also becoming increasingly popular. Refrigerator characteristics vary significantly by housing type and household income, as shown in Figures 8 and 9.

Figure 8



[28] AHAM reports that this splits out as 13.4% with full size refrigerators, 3.1% with compact refrigerators, and 6.5% with built-in refrigerators/freezers.

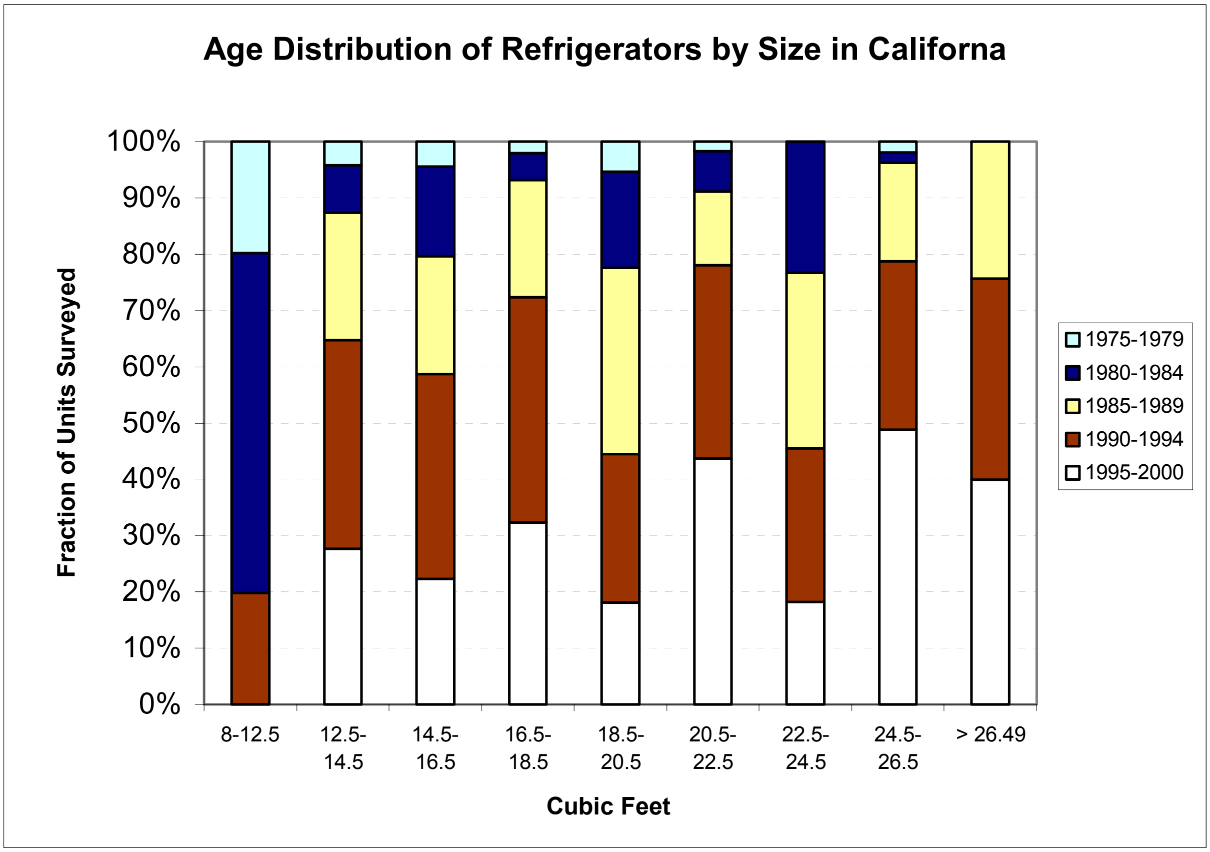
Figure 9



This demographic information provides important clues about targeting efficiency programs. Single-family homes at the highest income level are most likely to have the number and type of refrigerators that consume the most energy, with the exception that old refrigerators are more likely to be found in middle-income houses than either high income or low income. The age of the housing is also a strong predictor of refrigerator age. While only 8 percent of homes built between 1990 and 1997 contained a refrigerator at least 10 years old, 35% of homes built before 1950 contained one.

RLW Analytics looked in more detail at the size and age of refrigerators in California homes. As shown in Figure 10, 80% of very small refrigerators still in use are at least 17 years old, while more than 75% of the largest units were made since 1990. This can confound utility program cost-effectiveness, of course, when the programs are seeking to replace the largest, oldest units with more efficient models. However, California has been running appliance recycling programs in portions of the state for roughly a decade, which has undoubtedly shifted the population of remaining units somewhat compared to the national average. Indeed, RLW found that only 13% of the refrigerators in California homes were manufactured prior to 1985.

Figure 10



Upgrade Programs

The programs we examined through our survey are listed in Table 4.

Most of the utility programs targeting refrigerators encourage consumers to buy an ENERGY STAR labeled model instead of a standard efficiency one. This corresponds to a 10% improvement in efficiency (it was 20% before the federal standards moved to a higher efficiency level in 2001).

Some non-utility programs, like Oregon's tax rebates, specifically target units at least 15% more efficient than federal standards. Savings at those levels range from about 45 to 100 kwh/year. There are variations in this amount in different climates, and refrigerator energy use definitely increases with room temperature, but this has not yet been translated into specific guidelines or adjustment factors for different regions.

Table 4

Organization	City	State	Program Type
Alameda Power & Telecom	Alameda	CA	Upgrade With Recycling Requirement
Anaheim	Anaheim	CA	Unknown
Boston, City of	Boston	MA	Early Replacement/ Retirement
EPUD	Eugene	OR	Upgrade with Removal Requirement
Eugene Water & Electric Board	Eugene	OR	Upgrade
Illinois Department of Commerce and Community Affairs	Springfield	IL	Upgrade With Optional Early Replacement or Retirement
Imperial Irrigation District		CA	Unknown
Lancaster Township	Lancaster	PA	Recycling
Lodi Electric Utility	Lodi	CA	Unknown
Muscatine Power and Water	Muscatine	IA	Upgrade with Removal Requirement
NYSERDA/ Key Span Energy	All	NY	Early Replacement/ Retirement
Oregon Office of Energy	All	OR	Upgrade
Pacific Gas & Electric	San Francisco	CA	Upgrade/ Optional Recycling
Palo Alto Utilities	Palo Alto	CA	Unknown
Pasadena Water and Power	Pasadena	CA	Unknown
Redding Electric Utility	Redding	CA	Upgrade
Riverside Public Utilities	Riverside	CA	Early Replacement/ Retirement
Roseville Electric	Roseville	CA	Upgrade
Salt River Project (SRP)	Phoenix	AZ	Unknown
San Diego Gas & Electric	San Diego	CA	Early Replacement/ Retirement
Silicone Valley Power	Santa Clara	CA	Upgrade
Southern California Edison	Rosemead	CA	Early Replacement/ Retirement
Waverly Light and Power	Waverly	IA	Upgrade
Wisconsin Energy Conservation Corporation	Madison	WI	Upgrade

Table 5 indicates predicted simple payback times in years for consumers purchasing an efficient refrigerator instead of a standard new model of equivalent type and size. We considered two levels of efficiency upgrade: 10% better than standards (ENERGY STAR) and 15% better than standards. The various combinations of unit size and type, efficiency, incremental cost, and utility rates needed to yield a payback period of less than six years are shaded.

ENERGY STAR models can cost (MSRP) $25 to $150 more than standard models, with the higher priced models often including extra features as well (water filtration, through-the-door ice and water, etc.) that increase energy usage. A customer may be able to recoup the extra cost in 4 to 6 years at high efficiency levels and high electric rates, but this becomes virtually impossible at incremental costs of $100 or more. Moreover, the units that are only 10% better than standards are almost never cost effective unless their incremental cost is less than $50.

However, as with RACs, there is little if any “room” for utility expenditures on rebates, advertising, and admin costs, if the intent is to keep new refrigerator programs cost effective. Not surprisingly, many utilities we surveyed lumped some of these expenditures together with broader appliance efficiency efforts, assessing cost effectiveness very narrowly (and optimistically).

Table 5
New Refrigerator Cost Effectiveness
(Table indicates payback times in years. Shaded areas are paybacks of less than 6 years)

			Incremental Cost											
			$25			$50			$100			$150		
Energy Reduction		Savings (Kwh/yr)	Residential Electricity Rate ($/kWh)											
			$0.07	$0.10	$0.13	$0.07	$0.10	$0.13	$0.07	$0.10	$0.13	$0.07	$0.10	$0.13
10%	Top Mount Freezer w/o through-the-door-ice >20.4 AV	49.2	7.3	5.1	3.9	14.5	10.2	7.8	29.1	20.3	15.6	43.6	30.5	23.5
	Top Mount Freezer w/o through-the-door-ice <20.5 AV	45.2	7.9	5.5	4.3	15.8	11.1	8.5	31.6	22.1	17.0	47.4	33.2	25.5
	Side Mount Freezer with through-the-door ice 19.5-22.4 AV	61.8	5.8	4.0	3.1	11.6	8.1	6.2	23.1	16.2	12.4	34.7	24.3	18.7
	Side Mount Freezer with through-the-door ice >22.5 AV	64.8	5.5	3.9	3.0	11.0	7.7	5.9	22.0	15.4	11.9	33.0	23.1	17.8
	Bottom Mount Freezer w/o through-the-door ice	55.1	6.5	4.5	3.5	13.0	9.1	7.0	25.9	18.1	14.0	38.9	27.2	20.9
15%	Top Mount Freezer w/o through-the-door-ice >20.4 AV	73.7	4.8	3.4	2.6	9.7	6.8	5.2	19.4	13.6	10.4	29.1	20.3	15.6
	Top Mount Freezer w/o through-the-door-ice <20.5 AV	67.9	5.3	3.7	2.8	10.5	7.4	5.7	21.1	14.7	11.3	31.6	22.1	17.0
	Side Mount Freezer w/o through-the-door ice 19.5-22.4 AV	92.7	3.9	2.7	2.1	7.7	5.4	4.1	15.4	10.8	8.3	23.1	16.2	12.4
	Side Mount Freezer w/o through-the-door ice >22.5 AV	97.3	3.7	2.6	2.0	7.3	5.1	4.0	14.7	10.3	7.9	22.0	15.4	11.9
	Bottom Mount Freezer w/o through-the-door ice	82.7	4.3	3.0	2.3	8.6	6.0	4.7	17.3	12.1	9.3	25.9	18.1	14.0

Replacement and Retirement Programs

Cost effectiveness can improve dramatically with programs that also recover old, operational refrigerators for recycling. Some programs mainly try to capture the old primary fridge for recycling at the time a new model is purchased and delivered, though they may offer an optional pickup for a secondary fridge as well. Other programs exclusively target second refrigerators, so they contain no program element to simultaneously encourage the purchase of an efficient new model.

Only a tiny fraction of programs surveyed create an explicit link between the purchase of a new ENERGY STAR model *and* the recycling of an operational older one. In these cases, the utility only pays its incentives if both conditions are met, greatly increasing the likelihood of cost effectiveness.

An ENERGY STAR refrigerator can save an average of 700 kwh/year compared to a functioning 20 year old model and about 350 kwh/year compared to a functioning 10 year old model. As with RACs, then, it becomes important to accurately assess years of remaining life to determine total likely savings. The average length of refrigerator ownership by the first purchaser is about 8.7 years. However 31% of new refrigerators are purchased because the old unit failed or was too expensive to repair. Typical service life of a refrigerator may well be 20 to 25 years according to *Appliance* magazine and LBNL, though a unit would likely have multiple owners during that period and undergo some repairs.

One of the great variations in refrigerator replacement programs has been the assumption of annual energy use of retrieved units. Databases are now widely available that tabulate the *rated* energy consumption of refrigerators by model number and age. Other variables can influence those ratings sharply. On the one hand, models are likely to use more than their initial rated consumption as they age, if operated full time, opened regularly, and used in a warm room. In fact, *Home Energy* reported that old refrigerators very commonly use at least 20% more than initial rated electricity consumption, and occasionally up to 225% more.

But second refrigerators are often opened infrequently and placed in cool areas like basements, or areas that may vary from cool to warm, like garages. Each 1 degree F drop in room temperature, according to *Home Energy*, cuts refrigerator energy use by about 2%. Hours of operation are also tough to predict. Many second refrigerators may only be plugged in during warm weather -- often simply to cool beverages -- and during extended visits by guests. Measured savings from refrigerator retirement programs reflect these factors, often indicating unit savings of about 500 kwh/year.[29]

Both ARCA and CSG have compiled extensive databases of the actual consumption of retrieved old refrigerators, but they were not made available for analysis in the compilation of this report. Our interviews with utilities and program service providers suggest that average estimates of annual consumption of second refrigerators range from about 1,200 to 3,000 kwh/year. Likewise net savings estimates (the difference between the consumption of an old refrigerator and the new one that replaces it) range from 213 to 1400 kwh/year. Couple this with variations in the assumption of remaining lifetime, and it is not surprising that cost effectiveness claims are all over the map. Opportunities exist to narrow this range of uncertainty significantly by comparing measured data from old refrigerators in different parts of the country, and standardizing assumptions based on the latest findings.

Table 6 indicates the simple cost of saved energy in a variety of different refrigerator replacement or retirement program scenarios. Note that savings per year generally increase with the age of the refrigerator, but years of remaining life decrease. As a result, there is no one particular age of refrigerators to target to maximize cost effectiveness.

Incentive payments by utilities vary wildly, from $25 to $500(!) per refrigerator, usually varying by refrigerator size or price, and sometimes by efficiency level. For example, 14 programs we surveyed offered at least one incentive level at $75, while 10 programs offered incentives at levels of $50 and again at $100. As with RACs, program designs that offer rebates of 10 to 20% of the new refrigerator purchase price are likely to be the least cost effective. In one case, a program pays incentives of $500 for premium units costing $4,000 to $5,000. This yields modest net savings, if any, over their other refrigerator choices and costs as much as 50 to 100 compact fluorescent lamps!

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[29] Personal communication, Dave Hewitt, September 2001.

Table 6
Expected Cost of Saved Energy for Refrigerator Replacement/Retirement Programs
(Table indicates $/kwh, with scenarios costing $0.04/kwh or less highlighted)

Replaced Refrigerator Age (Years)	Expected Energy Savings (kWh/yr)	10% Free Ridership					
		Total Program Cost to Utlility Per Refrigerator					
		$100	$150	$200	$300	$400	$500
15	400	$0.056	$0.083	$0.111	$0.167	$0.222	$0.278
13	400	$0.040	$0.060	$0.079	$0.119	$0.159	$0.198
10	400	$0.028	$0.042	$0.056	$0.083	$0.111	$0.139
5	400	$0.019	$0.028	$0.037	$0.056	$0.074	$0.093
15	600	$0.037	$0.056	$0.074	$0.111	$0.148	$0.185
13	600	$0.026	$0.040	$0.053	$0.079	$0.106	$0.132
10	600	$0.019	$0.028	$0.037	$0.056	$0.074	$0.093
5	600	$0.012	$0.019	$0.025	$0.037	$0.049	$0.062
15	800	$0.028	$0.042	$0.056	$0.083	$0.111	$0.139
13	800	$0.020	$0.030	$0.040	$0.060	$0.079	$0.099
10	800	$0.014	$0.021	$0.028	$0.042	$0.056	$0.069
5	800	$0.009	$0.014	$0.019	$0.028	$0.037	$0.046
15	1000	$0.022	$0.033	$0.044	$0.067	$0.089	$0.111
13	1000	$0.016	$0.024	$0.032	$0.048	$0.063	$0.079
10	1000	$0.011	$0.017	$0.022	$0.033	$0.044	$0.056
5	1000	$0.007	$0.011	$0.015	$0.022	$0.030	$0.037
15	1200	$0.019	$0.028	$0.037	$0.056	$0.074	$0.093
13	1200	$0.013	$0.020	$0.026	$0.040	$0.053	$0.066
10	1200	$0.009	$0.014	$0.019	$0.028	$0.037	$0.046
5	1200	$0.006	$0.009	$0.012	$0.019	$0.025	$0.031
15	1400	$0.016	$0.024	$0.032	$0.048	$0.063	$0.079
13	1400	$0.011	$0.017	$0.023	$0.034	$0.045	$0.057
10	1400	$0.008	$0.012	$0.016	$0.024	$0.032	$0.040
5	1400	$0.005	$0.008	$0.011	$0.016	$0.021	$0.026
15	1600	$0.014	$0.021	$0.028	$0.042	$0.056	$0.069
13	1600	$0.010	$0.015	$0.020	$0.030	$0.040	$0.050
10	1600						
5	1600						
15	1800	$0.012	$0.019	$0.025	$0.037	$0.049	$0.062
13	1800	$0.009	$0.013	$0.018	$0.026	$0.035	$0.044
10	1800						
5	1800						
15	2000	$0.011	$0.017	$0.022	$0.033	$0.044	$0.056
13	2000						
10	2000						
5	2000						

Bounties paid for refrigerators vary greatly, even within the same state. ARCA participated in one program in southern California in 2001 offering $35 per unit with a substantial marketing budget, while running a different program in other parts of the state with a $75 bounty and a much smaller marketing budget. Imperial Irrigation District offers one of the few programs we encountered that creates an explicit linkage between the two – a 20% rebate on the new purchase and a $120 credit for the old refrigerator.

Program implementers also report significant variations in response rates between urban and rural customers. CSG found an average of 1.42 refrigerators per household in the Niagara Mohawk service territory, which contained a disproportionately high percentage of wealthy, single-family homes. However, this is not always a good predictor of customer response. A similar program that it ran in Vermont turned up large numbers of second refrigerators and standalone freezers, but a very lower percentage of interested participants. Many of the residents were gardeners, hunters, and berry pickers, and felt a strong need to have and use the additional cold storage capacity.[30]

Refrigerator Conclusions

Programs targeting refrigerators built in the 1970s and early 1980s are likely to generate the most energy savings per year, though years of remaining life will be shorter than with newer refrigerators. Programs targeting early retirement of refrigerators only eight years old have already consistently proven cost effective. A website or telephone line allowing potential participants to check the age and expected energy usage of their refrigerator, based on a model number and description, would greatly increase the ability to target those customers effectively.

Second refrigerators are almost always worth recycling, even if non-operational, because the cost to repair and return them to service is often far less than the impact they could have on electric load if used for a number of additional years. If utility programs can create the infrastructure to locate and retrieve such units, it would be worthwhile to find state, county, and local government entities involved in solid waste issues that could fund the recycling of non-functioning units.

Low income programs have proven successful by simply swapping, at low or no cost, an ENERGY STAR model for an operational older unit which they then recycle. Demographic targeting, similar to that suggested for room air conditioner programs, is likely to increase program effectiveness across a range of incomes.

Inducements to participate in these programs can take the form of financial incentives to customers or dealers, marketing assistance, convenience (in the form of free pickup), or partnership with dealers and manufacturers to leverage existing marketing and pickup programs. There is no one correct approach. Some utilities feel that “money talks,” and that the best inducement is a substantial payment to refrigerator owner. Others feel that

[30] Personal communication, Dennis Flack, CSG, October 2001.

program budgets are more effectively channeled primarily toward advertising and consumer education.

Illinois' Department of Commerce and Community Affairs has successfully leveraged manufacturer incentives and marketing from Maytag, as shown in Figure 11. Visitors to Maytag's website are automatically notified about opportunities to take advantage of additional incentives from the state of Illinois, if applicable.

Figure 11

Policy Recommendations

Federal and state standards, federal labeling programs, and utility programs have made tremendous progress in improving appliance efficiency. But our past victories have given birth to a present dilemma. The annual energy savings achievable from convincing a customer to buy a new ENERGY STAR room air conditioner or refrigerator instead of a standard new model are roughly the same as the annual savings from a compact fluorescent bulb or fixture. Yet the appliances themselves are far more expensive, require much greater rebates and delivery hassles, and only offer a savings opportunity to a fraction of the customer base in any one program year.

Environmental Dimensions

Comprehensive recycling of second refrigerators and operating primary room air conditioners and refrigerators is worth immediate consideration by utilities and market transformation groups throughout the country. Concerns about the cost of comprehensive recycling are understandable but not a reason to dismiss the option. At the local, state, and federal level, there are countless efforts underway to reduce solid waste impacts in landfills, prevent hazardous waste releases into the environment, and prevent ozone depletion. Utilities that can partner with those programs to capture the non-energy benefits can better afford to use their own scarce dollars to maximize energy savings. Barring that, state regulators should assign fair externality values to the pollutants and credit the benefit side of cost/benefit calculations for the programs accordingly, or assign larger energy savings values to programs that prevent other greenhouse gas emissions.

The real challenge may be to find creative new ways of funding such partnerships between solid waste organizations, air quality regulators, and utilities. At least three states (Maine, North Carolina, and South Carolina) impose mandatory advance disposal fees on the sale of new appliances. That money accumulates in a fund that can be used to pay for disposal or, as opportunities arise, for future appliance recycling. Other countries have carried this concept even further, imposing on manufacturers the legal responsibility for recycling at the end of their useful life the products they have sold. This would have substantial merit in the U.S. as well, giving manufacturers a powerful incentive to build products that are easy to recycle.

Some states like Ohio have had significant success with a very low-budget statewide promotion for free appliance recycling. This program has no link to energy efficiency incentives or other payments to consumers, and offers no pickup from the customers' location, yet has exhibited very high response rates from the public.

At least 18 states already prohibit the disposal of appliances in landfills, and another 12 require landfills to separate white goods for recycling. Even with that, comprehensive recycling (including removal of CFCs from foam) is still a small part of the equation. Only 6 to 9% of buyers of new RACs in 2001 took their old one to a recycling facility, and only 12 to 17% of new refrigerator buyers did.[31] The three comprehensive recyclers we surveyed recycle about 80,000 room air conditioners and 500,000 refrigerators per year.

Another environmental consideration for future recycling efforts may be carbon credits. As the world moves to formalize a possible cap and trading arrangement for carbon emissions, the saved carbon dioxide from appliance programs could well have a substantial economic value. This could either be shared by all parties that co-fund the programs, or assigned to one party contractually.

[31] NFO WorldGroup, *Home Appliance Saturation and Length of First Ownership Study*, prepared for AHAM, May 2001, pp. 31-37

Partnerships

Manufacturers and retailers have a strong financial interest in the early retirement of existing appliances. It accelerates their opportunity to make another sale. Utilities should pilot test efforts that leverage their marketing dollars to achieve greater results. Utilities should also consider linking with existing retail delivery and appliance retrieval efforts to reduce costs and add more rigor to recycling practices (this is one case where "recycle" is greatly preferable to "reuse" from a societal standpoint). A precedent already exists for manufacturers and retailers to offer free delivery or free installation on a promotional basis. A natural extension of such promotions could be to offer a discount on the purchase of a new ENERGY STAR model if the customer allows the old functioning unit to be picked up on the delivery truck and recycled.

To the extent utilities need to fund their own infrastructure for appliance pickup, they should attempt to collect refrigerators and room air conditioners at the same time, so only one visit per household is needed in most cases.

Opportunities for Utility Regulators

There are a number of regions in the country that have strong funding for energy efficiency programs but no comprehensive appliance recycling infrastructure. Substantial investments are necessary on the part of recyclers to construct and maintain state-of-the-art facilities for recovering CFCs, hazardous materials, and metals from old appliances. Utilities and their regulators can do a great deal to encourage additional recycling by making multi-year commitments across broader geographic areas. This will, in turn, encourage further competition on the part of the recyclers, which will bring other program benefits. The comprehensive recyclers told us they can build a new facility from scratch or relocate an existing one in 30 to 90 days, so replacement and retirement programs should not be perceived as something that requires an enormous lead time to establish.

More regulatory oversight and monitoring are clearly needed regarding the expenditure of public benefit funds by utilities. Many small municipal utilities have recently received dramatic increases in funding available to encourage purchases of ENERGY STAR products. Unfortunately, they do not have the staff resources to fully analyze program designs or conduct follow-up audits, so end up making simplistic assumptions that steer funds toward non-cost effective programs. Greater energy savings could be achieved with limited budgets in many cases by funding other types of programs entirely. At the very least, studies are needed in each region that assess hours of use and evaluate program energy savings and cost effectiveness.

It is important to recognize that refrigerator and RAC efficiency levels are not measured on the simple basis of kwh/year. Instead, the federal standards and ENERGY STAR thresholds for both products are scaled to the size, features, and functionality of the units. As a result, some or most of the expected net energy savings can be lost if the consumer purchases a larger or more feature-laden unit than the one they originally intended to purchase.

Early retirement and recycling programs for operating residential refrigerators and RACs are currently offered only in very limited parts of the country. The quantity of units collected annually in existing utility sponsored programs is approximately: 300,000 primary refrigerators, 200,000 secondary refrigerators, and 75,000 RACs. As these programs produce energy savings at 2 to 4 cents per kWh, there should be considerable interest for these programs in parts of the country with high electric rates and/or those that are facing capacity shortfalls. [32]

Improving Program Designs

If the goal is simply to save kilowatt-hours at the lowest possible cost, program resources are poorly targeted. If the goal is long term market transformation, there are still valid reasons to link the promotion of efficient new models to the recycling of old ones.

New product purchase incentives should be linked to the energy saved, not the price paid. Otherwise, incentives reward retailers that charge more for the same product and encourage sales people to "upsell" to the more expensive models. Such incentives also send distorted signals to consumers regarding the value of one energy savings opportunity relative to another.

At the same time, surveys indicate that consumers attach far greater value to appliance performance, capacity and reliability than they do to energy efficiency or rebate availability.[33] As a result, early retirement/replacement programs may gain more consumer interest by marketing superior performance of newer models than by touting energy savings only. This can create substantial challenges in retail programs, since energy-intensive options like side-by-side doors and through-the-door ice in refrigerators and filtration and remote controls in room air conditioners often form the basis of salespeople's "upsell" to their customers. In addition, the first models to qualify for ENERGY STAR after a change in specifications are often the high-end models that contain those features. We expect that greater savings will be achievable in future years, as ENERGY STAR compliant models become available in a wide range of sizes and price points.

More demographic targeting is clearly needed in these programs. The greatest energy savings result from maximizing the *difference* between the energy consumption of the unit being recycled and the new one being purchased. There are particular combinations of income, housing type, residence location, and occupant age that are most likely to predict high refrigerator energy use. Programs that focus on those segments of the market first are likely to get the most bang for the buck. Effective marketing will target not just those people visiting appliance stores and considering buying a new model, but those who own

[32] The number of recycled refrigerators and RACs are based are based on conversations with the major appliances recyclers currently working with utilities. Cost of savings estimates are based on Table 4,:assuming $150-200 utility cost, refrigerator is 5-15 years old, and per unit savings are 600-1000.
[33] Shorey and Eckman, *Appliances & Global Climate Change,* p. 13.

old appliances and might be persuaded by a statement of benefits and opportunities presented by early appliance retirement.

New construction programs have yet to make significant inroads with efficient appliances, yet it is very common for new home buyers to purchase appliances rather than bring their old ones along. Outreach to builders, realtors, and other parties involved in the new home decision-making process is prudent, to find ways to "upsell" buyers to ENERGY STAR-labeled models and perhaps get the incremental costs rolled into an Energy Efficient Mortgage. In at least 20% of the situations where people buy a new appliance, they leave the old one behind at a previous home.[34] Utility programs can take advantage of that fact to target buyers of existing and new homes with educational materials and incentives.

[34] NFO WorldGroup, *Home Appliance Saturation and Length of First Ownership Study*, prepared for AHAM, May 2001, pp. 31-37.

Appendix A

The authors wish to thank the following people who were generous with their time in providing responses to our survey and addressing our follow-up questions:

Norm Ng	Alameda Power and Telecom
Bruce Wall	Appliance Recycling Centers of America
Ken Keating	Bonneville Power Administration
Dave Jackson	City of Redding, CA
Dennis Flack	Conservation Services Group
Sandy Mar	Emerald Peoples Utility District
Bob Lorenzen	Eugene Water and Electric Board
Ron Dombrowski	Illinois Department of Commerce and Community Affairs
Michael Dunham	Jaco Environmental
Rob Lechner	Lodi Electric Utility
Tim Michel	Electric & Gas Industries Association
John Root	Muscatine Power and Water
Charlie Stephens	Oregon Office of Energy
Ila Homsher	Pacific Gas and Electric Company
Anthony Denrio	Palo Alto Utilities
John Hoffner	Pasadena Water and Power
Carla Johannesen	Roseville Electric
Rick Kallett	Sacramento Municipal Utility District
Charlie Harvey	Saint Vincent de Paul
Joyce Keneer	Silicon Valley Power
Cheryl Wynn	Southern California Edison
Karen Dilger	Waverly Light and Power
Sara Van de Grift	Wisconsin Energy Conservation Corporation

We were able to obtain limited data from websites and other sources for programs operated by the following organizations, who did not respond to our research requests:

Austin Energy
Imperial Irrigation District
New York State Energy Research and Development Authority
Riverside Public Utilities
Salt River Project
TXU Energy
United Illuminating Company