Dovetail Partners Consuming Responsibly Report No. 5

Replacing That Old Refrigerator: a Bigger Decision than You Think

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Replacing That Old Refrigerator: a Bigger Decision than You Think

Executive Summary

It is perhaps intuitive that keeping products in service for as long as possible before discarding represents environmental best practice. However, in the case of refrigerators, long life can translate to greater environmental impacts. The apparent contradiction is due to rapid increases in refrigerator energy efficiency which quickly put older units at considerable disadvantage to newer models, even after accounting for energy consumption and environmental impacts linked to production of new units and recycling/disposal of old units. In general if a refrigerator is older than 10-11 years, it is better from an environmental perspective to recycle and replace it with a new unit.

A Problem and Potential Solutions

A 2016 story in London-based newspaper *The Guardian* related interviews with several owners of early 1950s refrigerators who proudly reported continued use of these appliances. Keeping a refrigerator in service for over 60 years is remarkable, and intuition might suggest continued use as beneficial to the environment. However, reality is often counterintuitive.

Home heating and cooling and heating of water consume the greatest portion of household energy. But among household appliances, the refrigerator – if it is more than ten years old – is by far the greatest consumer of energy.

The energy efficiency of refrigerators currently on the market, and especially those with ENERGY STAR ratings, is three to four times that of units sold in the early 1970s, meaning that new units consume only one-third to one-fifth the energy of earlier models. The difference is great enough that it is environmentally beneficial to recycle and replace older refrigerators rather than to keep them in service. However, relegating an older unit to the basement or garage when a new replacement is purchased for the kitchen, a common practice, effectively nullifies the operating cost savings and environmental benefits that accompany a new refrigerator.

It may be worthwhile to take stock of household refrigeration appliances. An important question is whether a second refrigerator or freezer, if you have one, is really needed. Another is the age of the primary refrigerator (and/or second refrigerator). Taking steps to increase energy efficiency and reducing, where possible, refrigeration capacity can yield significant economic and environmental benefits.

Specific things that can be done to reduce the environmental impacts of refrigeration include:

- If currently using a refrigerator that is older than 10-11 years consider replacing with a new more energy-efficient unit.
- When buying a new refrigerator always select a model carrying the ENERGY STAR label and use information contained on the label to guide selection. ENERGY STAR labeled units exceed federal energy efficiency standards by 15% or more. If living in Europe, select models with an "A" rating – the higher the rating the better.
- Determine refrigerator capacity needs before shopping for a new model. Seek to incorporate all refrigeration/freezer needs into a single unit. Refrigerator/freezer capacity should be sufficient to avoid frequent trips to the grocery store, but no larger than necessary.
- Give consideration to refrigerator configuration. Units with the freezer either on the bottom or top are 13-16% more efficient than side-by-side models. Through the door ice makers, while convenient, increase overall energy use by 14-20%.
- Upon replacement, do not move an older model to the basement or garage. Instead, arrange with vendor to have old unit sent to recycling.
- If a second refrigerator is viewed as essential
    - Consider replacing with a new, energy-efficient model
    - Make sure that the power supplied is adequate – especially for a unit located in the garage.
    - Keep the unit as full as possible. Keeping water-filled and frozen plastic milk bottles in the freezer compartment will help to keep the refrigerator cold with minimal running time. Similarly, keeping bottles of water in the refrigerator section will help to minimize compressor operation.[1]

Improving Energy Efficiency Dominates Environmental Impact

Intuition Seldom Reliable in Making Replacement Decisions

Most households make refrigerator replacement decisions when the old refrigerator stops working or needs major repairs, as part of a kitchen remodeling project, or when newer models offer added features. When an old refrigerator is still functional at the time of replacement it is often retired to the garage or basement, or sometimes sold, rather than going to recycling or landfill.

Environmental considerations usually enter the picture at the time of purchase when buyers are presented with the option of buying a high efficiency unit at slightly higher cost than a model with a lower energy-efficiency rating. Rarely is thought given to the environmental impact of keeping vs. discarding an old refrigerator. When impacts are

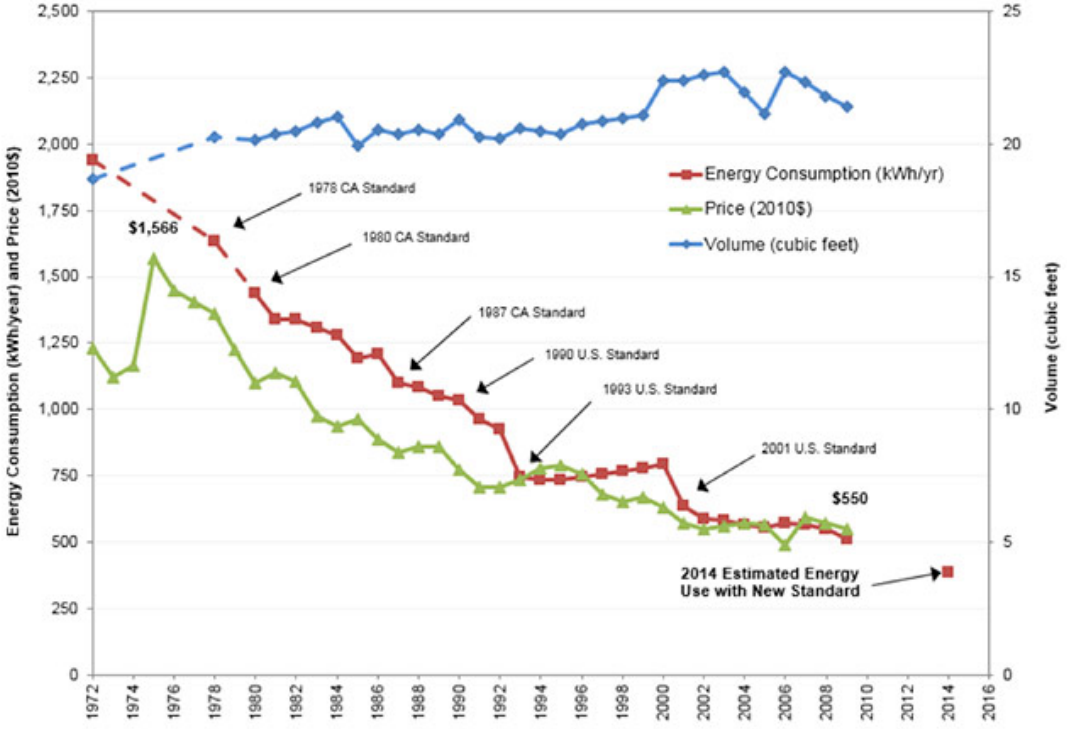
[1] Should an existing second refrigerator have little enough stored in it such that many bottles of ice and water must be added to maintain temperature, rethink need for second refrigeration unit.

considered, intuition tends to suggest that keeping an old unit in service for as long as possible is the best course of action. However, rapid gains in energy efficiency of refrigerators have changed the environmental equation for replacement. Continued use of a refrigerator longer than 10-11 years, or in some cases even less, can translate to expenditure of far more energy, and release of far greater energy-related emissions, than if an older household appliance were retired and replaced with a new model.

Spectacular Increases in Energy Efficiency

Inspired by the 1970s oil embargos,[2] a joint government-industry research and development program was initiated in 1974 with the objective of improving the energy efficiency of home appliances. The effort began to pay off almost immediately (Figure 1), with electricity consumption per refrigerator dropping a third within a decade and by half within 15 years. Efforts inspired by this program resulted in refrigerators that consumed less than 20% of the energy of early 1970s models, even as the average size of refrigerators increased and purchase prices decreased.

Figure 1
Average Household Refrigerator Energy Use, Volume, and Price over Time



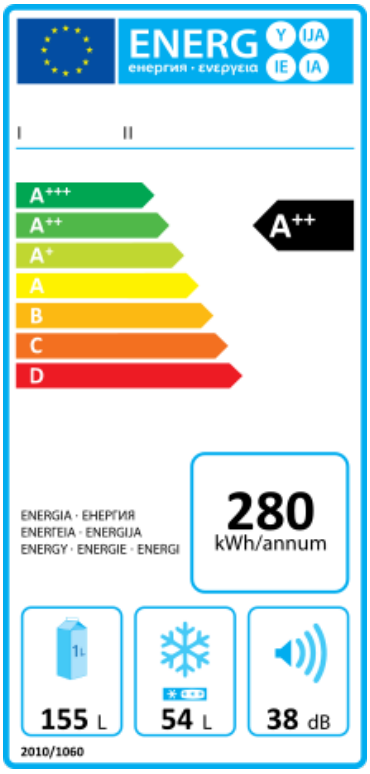
Source: American Council for an Energy Efficient Economy (2014).

[2] The oil embargo of 1973 came about when the members of OPEC voted to cease oil exports to the United States. Over the following six months, the price of oil quadrupled and gasoline shortages ensued.

In 1992 the U.S. Department of Energy, in cooperation with the Environmental Protection Agency introduced the ENERGY STAR program (Figure 2) which provides consumers with simple, unbiased, and credible information on appliance efficiency, and which seeks to leverage gains attributable to federal energy efficiency standards. Full-sized refrigerators that exceed the federal energy standard by 15% or more qualify for the ENERGY STAR label. Full-size freezers that exceed the federal standard by 10% also qualify. According to the EPA the voluntary ENERGY STAR program, which operates in cooperation with numerous industry partners, had by late 2018 saved American consumers more than $450 billion and 3.5 trillion kilowatt hours of electricity since program initiation. It is a spectacular record of success. Canada operates a similar program – EnerGuide.

Figure 2
An Example of the Energy Star Efficiency Rating Label

Figure 3
EU Refrigerator Energy Label



The European Union also established an energy consumption labeling system in 1992. The labeling regulation applies to most energy-using goods at the point of sale or rent, including refrigerators (Figure 3). Energy efficiency classes from A+++ (highest/best) to G (lowest/worst) are indicated on the label along with the annual energy use in kilowatt hours. Depending on the product, consumers find additional information to facilitate evaluating products. For example, refrigerator labels also provide information

about the size of refrigerator and freezer compartments, as well as the maximum noise level. The system allows for labeling of more than electrical appliances, and can even be applied to energy-efficiency labeling of houses and vehicles[3], using appropriate measures of efficiency. The labeling program overall fits into the European Energy Security Strategy of 2014 which aims at moderating energy demand.

In conjunction with this program, the European Commission established a publicly available database, the European Product Registry for Energy Labeling, to inform the public regarding energy efficiency of products on the market, to support market surveillance authorities, and to provide the Commission with up-to-date energy efficiency information for products.[4]

Weighing Economics vs. Environment

Determining when to replace an appliance comes down to two seemingly simple propositions. From an economic point of view, replacement makes sense when the present value of annual savings from reduced energy bills equals the cost of buying a new refrigerator. From an environmental perspective (and for a moment considering only energy-related emissions), replacement is advantageous when energy consumption of the old unit in the year ahead is expected to exceed total energy required to produce a new unit plus annual energy consumption of the new unit in the next year. While energy consumption and associated emissions are only two measures of environmental impact, these two factors are typically dominant impacts.

Replace when:

Economically: [Present value of annual energy savings from new refrigerator] = [Cost of new refrigerator]

Environmentally: (See Figure 5) [CO_2e emissions in year ahead] > [Emissions of new refrig. production] + [Emissions from new refrig. operation]

In almost all instances, replacement decisions based on economics favor longer replacement cycles than those based on environmental considerations.

[3] Motor vehicles are rated in CO_2 emissions and liters of fuel needed for 100 kilometers of travel in city, highway and mixed city-highway driving. Liters/100 km is the standard measurement of fuel efficiency in Europe while in the US it is miles per gallon (mpg).

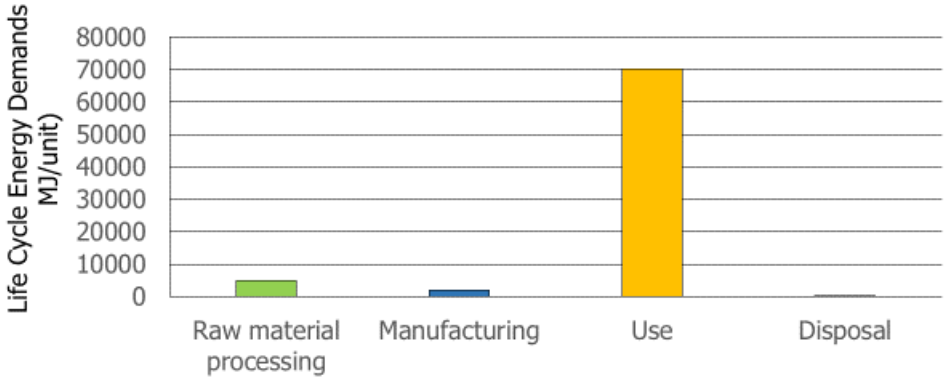
[4] European product registry for energy labelling (EPREL). http://www.energimyndigheten.se/globalassets/om-oss/kalender/eprel---assumptions-v2.80.pdf. Accessed 23 January 2019.

Environmental Assessment

When to Replace

A number of life cycle assessments[5] of the environmental impacts of refrigerator production, use, and disposal have been conducted since 2010. What these all show is that the energy consumed in manufacturing an energy-inefficient refrigerator (including raw material extraction and processing) is a small fraction of the energy consumed in annually operating that refrigerator (Figure 4). Energy-related emissions tend to follow the same pattern, but vary depending upon the proportion of renewable energy in the energy mix.

Figure 4
Life Cycle Energy Demand of New 2008 Refrigerator Over a 10-Year Life

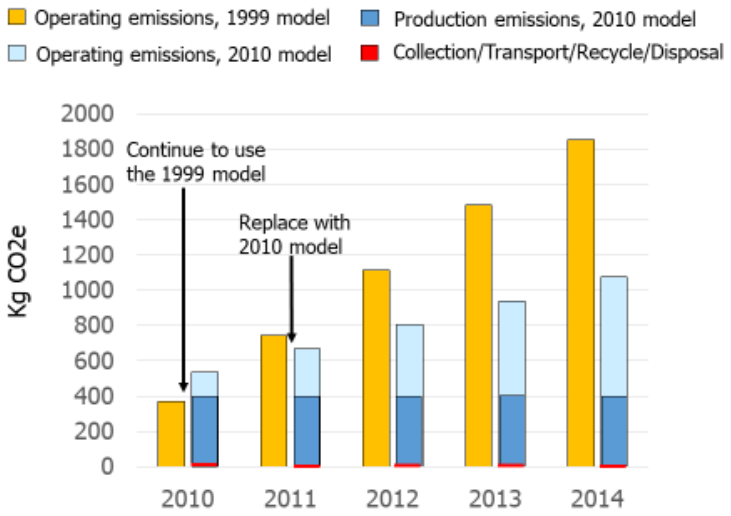


Source: Boustani et al. (2010)

As indicated previously, it becomes environmentally advantageous to trade an older unit for a new one when expected critical emissions (for instance total emissions of methane, carbon dioxide and carbon monoxide) in the year ahead favors the new model (Figure 5). Note in Figure 5 that in 2010 the total of emissions linked to production of the new (2010) refrigerator, plus emissions resulting from refrigerator use, exceeds emissions from continued use of the existing (1999) refrigerator. In 2011, however, overall emissions become greater if the 1999 model is kept in service. In every succeeding year, the environmental disadvantage of retaining the old model increases. Consequently, from an environmental perspective, disposing of the 1999 model would ideally occur in 2011, even though the 1999 model would likely continue to function for an additional 5-10 years beyond 2010 were it to be kept in service.

[5] Life cycle assessment (LCA)-based information yields data about a wide range of environmental impact measures for products or product components such as total energy required in producing a product (referred to as embodied energy), fossil fuel consumption, total resource use, water use, global warming potential, ozone depletion potential, emissions to air, water, and ground, and more. An assessment begins with resource extraction, and encompasses product production, use, and disposal.

Figure 5
CO_2-equivalent Emissions for 1999 Model and 2010 Model Refrigerator –
An Example from an Environmental Assessment in Japan



Source: Japan Electrical Manufacturers' Association (2014)

It could be argued that in a period of very rapid gains in energy efficiency, such as over the past few decades, it could be more favorable to put off replacement for a year or two for introduction of an even more efficient model. However, each gain in efficiency from this point forward is likely to yield less total annual energy savings than earlier years when average energy consumption was higher (i.e., to result in diminishing returns as illustrated in Table 1). Consequently, the more efficient refrigerators become, the greater the influence of manufacturing energy on life cycle energy consumption, and the less favorable an early replacement.

Table 1
Illustration of Diminishing Reduction in Annual Energy Consumption
with Recurring 35% Gain in Refrigerator Energy Efficiency

Model Year	Average Energy Consumption (kWh/yr)	Reduction in annual energy consumption with 35% efficiency gain (kWh/yr)	Energy reduction as a percentage of manufacturing energy*	Number of years required for break-even energy consumption with old unit replacement
1972	1960	686	43	3-4
1990	1050	368	23	5
2008	550	193	12	10-11

* Total manufacturing energy assumed at equivalent of 1600 kWh as per published reports. Value assumed unchanged over the years in accordance with finding that manufacturing energy remaining near steady or slightly rising as average refrigerator becoming larger.

The point at which replacement becomes environmentally beneficial is also influenced by the manner of energy production. In regions where a significant portion of electrical energy is from renewable sources, such as in the Pacific Northwest, the recommended age at replacement is greater than if most or all electricity is fossil-fuel based.

Replace or Repair

Having an older refrigerator repaired or even completely remanufactured[6] can be significantly less expensive than buying new. Doing so can, in addition, save energy and raw materials in the production process in comparison to discarding an old unit and replacing with a new one. However, in view of vastly lower energy consumption of newer models, greatly extending the life of an old technology refrigerator has the effect of magnifying the environmental disadvantage of lower energy efficiency even though energy savings might be realized in the very short term. A 2010 study by the Massachusetts Institute of Technology found that remanufacturing and continued use of 14-year-old unit would result in one-third greater energy consumption over expected life as compared to replacement with a 2008 model.

While repair to keep an old refrigerator in service for an extended time period is not recommended, it is a good idea to periodically check door seals and gaskets, reattaching or replacing as needed. Worn or loose gaskets can result in a loss of energy efficiency over time.

A refrigerator produced to the 2014 standard (still the current standard) is about 29-32% more efficient than one produced during the period 2002-2008. Greater efficiency units built to the 2014 standard translates to a savings of about 160 -175 kWh per year. When energy requirements to produce a new refrigerator and recycle an older one are taken into account, replacement of old with new is found to be environmentally preferable for any unit older than 10-11 years. The State of Minnesota recommends replacement of any refrigerator older than 15 years.

In general, if a refrigerator is older than 10-11 years, it is better from an environmental perspective to replace it with a new unit.

In 2011 the Lawrence Berkeley National Laboratory developed estimates of lifetimes of residential appliances based on national survey data. Average and mean estimates of refrigerator life were 19.8 and 17.7 years. A University of Michigan study at about the same time estimated the average service life at 14 years. Calculations by the authors of the University of Michigan report, which considered the number of U.S. households

[6] Refurbished refrigerators are available in the United States through some major distributors of appliances, such as Sears Outlet and Best Buy Outlet, and in Canada also through Danby Outlet. In addition, there are a number of videos on line that demonstrate DIY renewal.

(126.2 million), the number of second homes (9 million), the percentage of homes which have two or more refrigerators (23%), and the number of refrigerator/freezers discarded in the U.S. each year (9 million), suggest an average service life of 18.2 years. In any event, the average time period refrigerators are actually kept in service is considerably longer than the length of service life that would minimize environmental impacts.

Discard Old Unit or Use as Second Refrigerator

As noted, replacing a ten-year-old or older refrigerator with a new one yields environmental benefits, primarily in the form of a reduction of energy consumption and all resulting emissions. Annual energy consumption is significantly reduced. However, if the old refrigerator is not disposed of, but instead simply moved to the basement or garage for continued use, any energy or economic advantage gained from purchase of the newer, more efficient refrigerator is nullified. Total household energy consumption will go up, not down.

Careful consideration should be given, prior to shopping for a new model, as to how much refrigeration capacity is really needed, with the purchase decision made accordingly. The California Consumer Energy Center points out that one large refrigerator is more efficient and less expensive to operate than two smaller ones. This is especially true if one of the smaller units is kept only partially full.

When a refrigerator is placed in a garage, where summer temperatures can often exceed 100 degrees (38C), this poses another energy efficiency problem, especially when the garage outlet is not linked to a 115 volt, 60 Hz, AC-circuit – which garage (or basement) outlets frequently are not. External heat will cause more frequent running of the motor, particularly if there is insufficient power resulting from use of the wrong circuitry.

Economic Assessment

Several life cycle cost analyses have shown that minimizing costs of a refrigeration unit dictates longer periods of service than when the objective is minimization of environmental impacts. Fundamentally, the reason for the difference is that environmental costs (for instance the cost of removing a ton of carbon from the atmosphere) are not included in the price of energy or of goods in general. Life cycle costing studies tend to show optimum replacement after 16 to 18 years of service.

A simplified refrigerator replacement calculator is available on-line through the ENERGY STAR program (https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator) which can be helpful when considering refrigerator replacement. This tool allows consumers to enter information about their current refrigerator (basic type, capacity, and approximate age) and the state in which they live, and then calculates annual

energy savings that would be realized by purchase of a new unit. Reductions in carbon emissions are also estimated. The program then allows consumers to search specific models that meet the specifications entered, with purchase price and projected annual energy savings information provided.

The replacement calculator has been criticized in that emissions reduction estimates are based only on lower operating energy requirements and do not include energy required in manufacturing or end-of life disposal. This is perhaps justified by the dominance of operating energy over a full life cycle (see again Figure 3). Nonetheless, the calculator is helpful when making purchase decisions.

Summary

Replacement of a refrigerator has significant environmental implications. When to replace, configuration and features of the new model, and what is done with the unit being replaced all weigh heavily on resulting impacts to the environment. Minimization of environmental impact requires replacement prior to the point indicated by economics alone, and careful consideration before making a purchase decision.

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