

**INCORPORATING REFRIGERATOR REPLACEMENT
INTO THE WEATHERIZATION ASSISTANCE PROGRAM**

INFORMATION TOOL KIT

Prepared for:

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INCORPORATING REFRIGERATOR REPLACEMENT INTO THE WEATHERIZATION ASSISTANCE PROGRAM

INTRODUCTION

The U.S. Department of Energy (DOE) recently updated the regulations governing the Weatherization Assistance Program and added certain electric base-load measures, including refrigerator replacement, to the traditional heating- and cooling-related measures installed under the program. To help Weatherization providers successfully add refrigerator replacement to the energy efficiency services they provide, DOE has compiled the following information on estimating potential energy savings, bulk refrigerator purchasing, and sample protocols used in several utility refrigerator replacement programs.

A one-page, “at-a-glance” summary outlines DOE’s auditing, installation, and disposal requirements regarding refrigerator replacement. These initial requirements are likely to be revised and improved over time as the program gains more experience with refrigerator replacements. States that find effective refrigerator replacement protocols that appear to conflict with the DOE requirements presented in the one-page summary should discuss them with DOE.

A database of the estimated energy use of refrigerators manufactured between 1979 and 1992 is included on CD-ROM in several formats including Microsoft Excel, Microsoft Access (97 and 2000), and comma delimited. Although the Weatherization Program currently allows the replacement of only refrigerators and refrigerator-freezers, the database includes information on chest freezers, upright freezers, and other models since many agencies run utility programs that allow replacement of these units.

A special report by Larry Kinney and Rana Belshe, entitled *Refrigerator Replacement in the Weatherization Program: Putting a Chill on Energy Waste*, explores the important issues that are critical to developing and running an effective refrigerator replacement program.

DOE REQUIREMENTS FOR REFRIGERATOR REPLACEMENT — AT A GLANCE

What existing units may be replaced?

- **Refrigerators and refrigerator-freezers** — Only new refrigerators and refrigerator-freezers can be installed with DOE funds. However, agencies may encourage clients to give up other model types such as chest freezers as part of the refrigerator replacement. For example, a client has an inefficient 15-cubic-foot refrigerator-freezer and a stand-alone upright freezer. The agency may replace both units with a new 18- or 21-cubic-foot refrigerator-freezer if the energy savings compared to both the existing units justify the measure.

What new replacement units may be installed?

- **Refrigerators and refrigerator-freezers** — Weatherization Program Notice 00-5 lists the types of refrigerators that may be installed with DOE funds. They are refrigerators and refrigerator-freezers with manual, automatic, or partial automatic defrost. Units must comply with UL-250 and with energy efficiency standards established in the National Appliance Energy Conservation Act of 1987 that are periodically updated. New replacement units may **not** have through-the-door ice or water service since this feature increases energy use.

What are the cost-effectiveness requirements?

- **SIR \$ 1.0** — As with all energy efficiency measures installed with DOE funds, refrigerator replacement must result in a savings-to-investment ratio (SIR) of 1.0 or greater.
- **Economic life time = 15 years** — According to *Appliance* magazine the expected service life of a refrigerator averages 15 years. DOE believes 15 years is an appropriate economic life time to use in life-cycle cost calculations.

What are the metering requirements?

- **Meter at least 10% of units replaced** — It is not required to meter every existing refrigerator that is replaced. Initially, as the program gains experience, DOE will require states to meter at least 10% of the units replaced. Units that can not be located in the AHAM or other refrigerator databases may make up all or most of the 10% requirement.
- **Meter at least 2 hours** — The minimum metering duration required to obtain results accurate enough to make a reliable replacement decision has been debated for several years. DOE believes a two-hour minimum metering duration is an appropriate compromise.

Besides metering, how else can energy use of existing refrigerator be determined?

- **AHAM or other certified database of refrigerator energy use** — The Association of Home Appliance Manufacturers' database, separately or as incorporated into NEAT/MHEA, may be used to estimate the annual energy use of existing refrigerator. The Home Energy on-line database (www.homeenergy.org/consumerinfo/refrigeration/index.php) or the database on the CD-ROM that accompanies this document may also be used. Keep in mind that use of one of these databases does not relieve a state from the 10% metering requirement.

Can I replace refrigerators based solely on age?

- **No** — Although older refrigerators were built to less efficient standards, other factors such as size and manual defrost impact energy use of existing refrigerators. Initially, as the program gains experience, DOE will require agencies to meter or use the AHAM, Home Energy, or accompanying database to estimate the annual energy of existing refrigerators.

What do I do with the existing refrigerator?

- **Take out of service** — Make sure the existing refrigerator removed from the house does not find its way back onto the electric grid.
- **Dispose in an environmentally responsible manner** — All refrigerators replaced must be properly disposed of according to the environmental standards in the Clean Air Act of 1990, section 608, as amended by Final Rule 40 CFR 82, May 14, 1993.
- **Take to a de-manufacturing facility or incorporate disposal requirements in vendor contract** — De-manufacturing facilities like the one in Syracuse, New York, described in the special report by Larry Kinney and Rana Belshe (*Refrigerator Replacement in the Weatherization Program: Putting a Chill on Energy Waste*) exist in certain parts of the country. If none are available locally, specific disposal requirements can be written into the contract with the vendor supplying the new refrigerator. Although this arrangement makes the vendor responsible for the removed refrigerator, states should verify replaced refrigerators are disposed of properly.

ESTIMATING ENERGY SAVINGS

Based on the experience of a number of electric utility appliance management programs, there are two main methods to estimate the savings that result from replacing an existing refrigerator with a new, energy-efficient model. The first involves metering the electricity usage during the client interview/energy audit. The other method utilizes a database of estimated annual electricity usage of most refrigerators manufactured in the past 25 years that is based on data published by the Association of Home Appliance Manufacturers (AHAM). A subset of this data is publicly available from several sources.

Metering

Several meters are commercially available that monitor the electrical usage of plug loads such as refrigerators and other home appliances (see Figure 12 and Table 4 in the attached paper by Larry Kinney and Rana Belshe, and Appendix A of this document). Some models plug straight into the electrical receptacle and the appliance plugs into the meter. Some auditors prefer this configuration to the meters that have their own hard-wired power cord because of the reduced number of wires and cleaner set-up. However, some auditors note that meters that plug directly into the receptacle are often hidden by the refrigerator during metering. They like meters with hard-wired power cords that can be positioned out from behind the refrigerator and can be viewed during metering.

- *How Long Should I Meter?* -- The debate on refrigerator metering centers on how long must a refrigerator be metered to get a reasonably accurate estimate of its annual electricity use. Obviously, longer metering times result in more accurate estimates. Refrigerator metering conducted in a test chamber by Larry Kinney¹ indicates that a one-hour metering duration results in estimates within $\pm 10\%$ of actual usage only 18 out 100 times. Three-hour metering results in estimates within $\pm 10\%$ of actual usage 90 out 100 times. However, some have indicated that a two-hour metering duration is sufficient to make cost-effective refrigerator replacement decisions.

See the attached special report by Larry Kinney and Rana Belshe, entitled *Refrigerator Replacement in the Weatherization Program: Putting a Chill on Energy Waste*, for more information on metering duration. As the authors point out, making a simple “replace/don’t replace” decision requires less accurate data than evaluating program performance. The general consensus based on the experience to date is that one-hour metering is too short to provide estimates of sufficient accuracy and three hours is longer than many Weatherization auditors typically spend in a house. DOE believes a two-hour minimum metering duration is an appropriate compromise.

- *What About Defrost Cycles?* – Defrost cycles can significantly affect the accuracy of refrigerator energy use estimates extrapolated from metering results. If a defrost cycle does not occur during metering, about 8% is typically added to metering results to account for periodic defrost cycles that

¹ Refrigerator metering control chamber tests were conducted when Laurence F. Kinney was with Synertech Systems Corporation, Syracuse, New York. He is currently with Esource/Financial Times Energy, Boulder, Colorado.

occur during normal, long-term operation. If a defrost cycle occurs during metering, the results can not be reliably used.

The ability to determine if a defrost cycle has occurred during metering is essential to deriving accurate estimates of annual energy use from metered data. If demand exceeds approximately 380 watts, the defrost heater has come on. Since the auditor is busy collecting other information and running the blower door during refrigerator metering, it may not be practical to check the meter every five minutes to look for evidence of a defrost cycle. A few commercially available plug load meters record the peak demand experienced during metering. However, their sampling rate is so frequent that the spikes resulting from normal compressor start-up exceed and mask the demand of the defrost heaters. Discussions with some meter manufacturers indicate that their next generation of plug load meters may address this problem.

Alternatively, on many older refrigerators, it may be possible to reliably ensure that the defrost heater will not come on during metering by advancing the defrost timer past the defrost cycle. There are several different styles of defrost timers (see Figure 1) and they can be difficult to locate on a refrigerator. Figure 2 shows some typical mounting locations. Often, they are mounted under a cover plate or in a bracket that hides the components but provides access to the advancement pinion. There are some key exceptions. The defrost timer in Whirlpool or Kenmore refrigerators with flex-tray ice makers is integrated into the ice maker and can not be advanced manually.

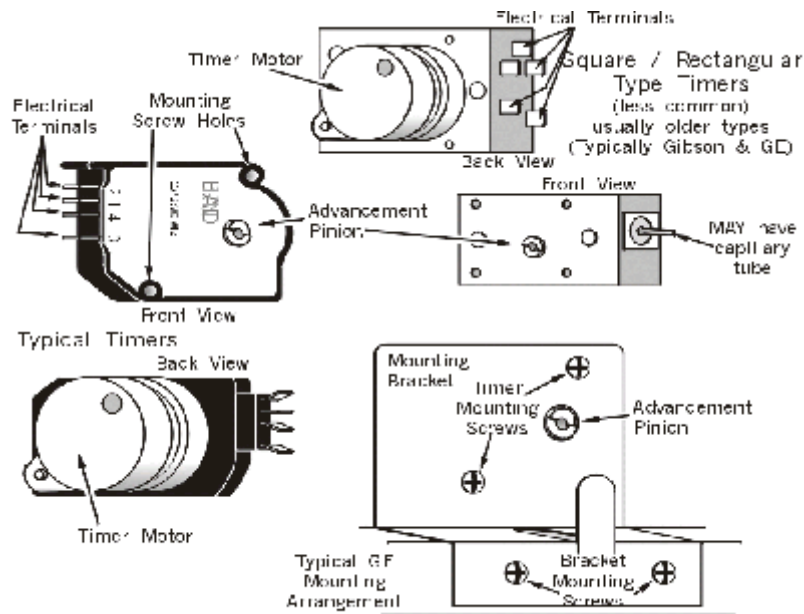


Figure 1 - Typical Defrost Timers (reprinted with permission from “Refrigerator Repair Cheap and Easy!,” Douglas Emley, EB Publishing, Inc., (800-400-3026) January 2000)

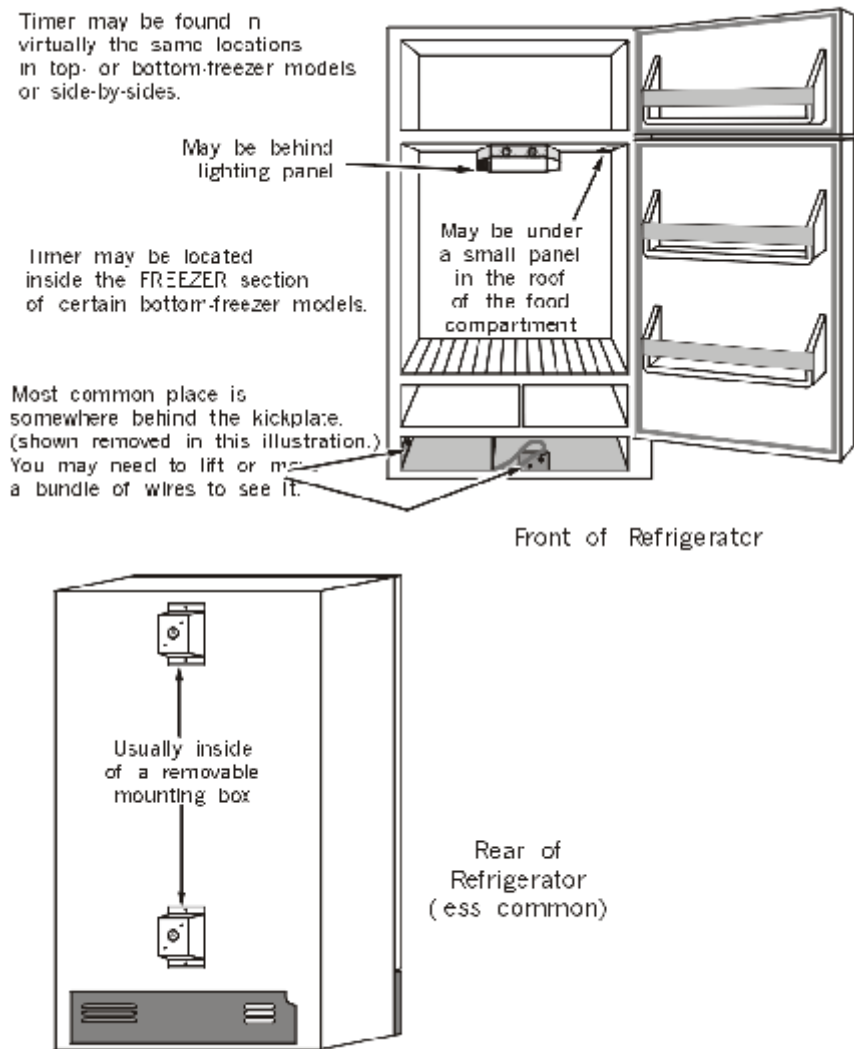


Figure 2 - Defrost Timer Mounting Locations (reprinted with permission from "Refrigerator Repair Cheap and Easy!", Douglas Emley, EB Publishing, Inc., (800-400-3026) January 2000)

After locating the defrost timer, place a screwdriver in the advancement pinion and turn it clockwise (counter-clockwise will damage the defrost timer). Sometimes a fairly firm twist is required. The timer audibly clicks as it advances. At some point in the cycle, the timer will click loudly. Advance the timer 10 to 20 degrees further and you will feel and hear another loud click (see Figure 3). Between the two loud clicks is the defrost part of the cycle. The rest of the timer's rotation is the "run" cycle². By advancing the defrost timer just past the second loud click, you ensure that the defrost heater will not come on during a two- to three-hour metering duration.

² *Refrigerator Repair Cheap and Easy!*, Douglas Emley, EB Publishing, Inc., (800-400-3026), January 2000.

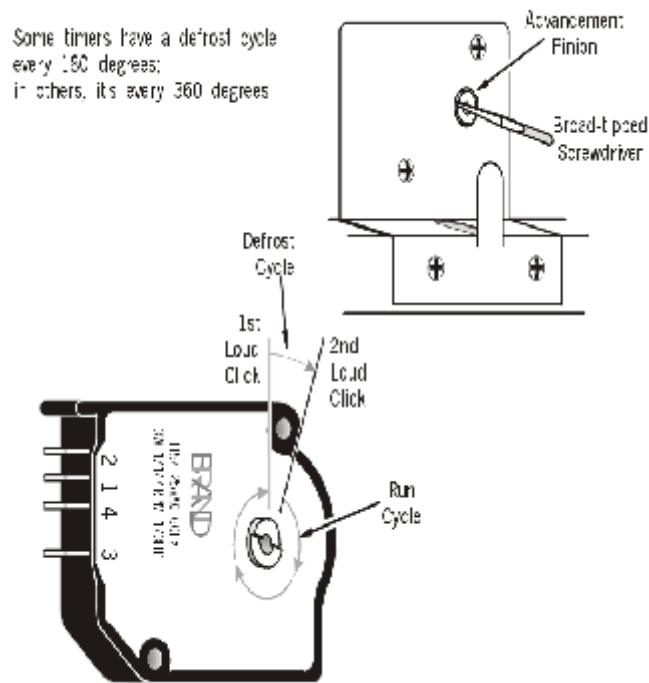


Figure 3 - Advancing the Defrost Timer ((reprinted with permission from "Refrigerator Repair Cheap and Easy!," Douglas Emley, EB Publishing, Inc., (800-400-3026) January 2000)

Compensating for Ambient Temperature -- Changes in temperature of the ambient air surrounding the refrigerator can affect the accuracy of metered results. The difference in temperature between the inside of a refrigerator and ambient affects performance by 2.25%³ to 2.5%⁴ per degree F. If the refrigerator was metered at a time when the kitchen was cooler than normal (possibly due to blower door testing), the correction should be added to the annual estimate extrapolated from the metered data. If the kitchen is normally cooler than it was when the metering was done, subtract the correction. For example, if the refrigerator was tested at an ambient temperature of 68EF and the kitchen is normally at 72EF, multiply measured results by:

$$1 \% (2.5\% \times (72EF - 68EF)) = 1 \% (0.025 \times 4) = 1.1$$

³ Cavallo, James, and James Mapp, "Monitoring Refrigerator Energy Use," *Home Energy* 17(3), (May/June 2000), pp 32-36.

⁴ Kinney, L.F., Lewis, G., Clute, W., "Refrigerator Replacement Demonstration Project," NYSERDA Final Report 98-8, Synertech Systems Corporation, June 98.

Energy Use Data for Existing Refrigerators

The Association of Home Appliance Manufacturers (AHAM) publishes energy data for all certified refrigerators, refrigerator-freezers, and freezers. Of particular interest to the Weatherization Assistance Program is AHAM's *Refrigerator & Freezer Historical Data Set*, which contains energy data for models manufactured from 1973 to 1994. This database lists estimated annual kWh use based on the U.S. Department of Energy (DOE) test procedure. Thus, the AHAM historical database gives the annual energy use of older refrigerators *when they were new*. For this reason, most local agencies administering refrigerator replacement programs for electric utilities add 20% to 30% to the AHAM estimate to account for performance degradation due to age. The National Energy Audit Tool (NEAT) inflates AHAM data on a sliding scale based on refrigerator age as shown in Table 1.

Table 1 – NEAT Adjustments to AHAM Appliance Energy Data for Refrigerator Age	
<i>Refrigerator Age</i>	<i>AHAM Energy Data is Inflated By:</i>
Less than 5 years old	0%
5 to 10 years old	10%
10 to 15 years old	20%
More than 15 years old	30%

The AHAM database is incorporated into NEAT Version 7.1.1. The user enters the manufacturer and model number into the Base Loads/Refrigerator screen and NEAT displays the estimated annual energy consumption based on the DOE test procedure in the “Label Annual Consumption” area of the Base Loads/Refrigerator screen. Although the age of the refrigerator is displayed, the energy use on the Base Loads/Refrigerator screen has not been inflated to account for age. The AHAM data is not age-adjusted until the user runs NEAT. The energy savings and savings-to-investment ratio shown on the “Annual Energy and Cost Savings” and “Energy Saving Measure Economics” output reports are based on the age-adjusted energy use estimate.

There is some debate that the DOE test procedure does not reflect real-life refrigerator use and, therefore, the results may not accurately estimate actual energy use. The test procedure is conducted on empty refrigerators in a 90EF environment. Neither the refrigerator nor the freezer door are opened during the test. A refrigerator fully stocked with food uses less energy than an empty refrigerator. Likewise, a refrigerator in a warm environment uses more energy than one surrounded by cooler ambient air. Obviously, repeatedly opening the refrigerator and freezer doors increases energy use. However, most refrigerator replacement programs that use the historical AHAM data set believe that these conflicting factors tend to offset each other, so that the only necessary adjustment is for age.

In addition to providing the AHAM energy data for existing refrigerators within NEAT, DOE planned to make the data available in other electronic and hard copy formats to facilitate its use in the field. Unfortunately, AHAM and DOE were unable to negotiate the release of AHAM's historical data set (outside NEAT) to the Weatherization network at a reasonable fee. However, DOE was able to secure similar energy data for over 41,000 refrigerators, refrigerator-freezers, and freezers from

Directory of Certified Refrigerators, Freezers, and Refrigerator Freezers published by the California Energy Commission (CEC) from 1979 to 1992 (no directory for 1991 was available). The refrigerator-freezers that are most likely to be replaced as Weatherization measures account for approximately 21,000 records of the total compiled.

This data is provided on the accompanying CD-ROM in several formats including Microsoft Excel®, Microsoft Access® (97 and 2000), and comma delimited. The information for each model includes:

- Manufacturer (for years available),
- Brand,
- Year of manufacture,
- Model number,
- Type (e.g., side-by-side, top freezer),
- Defrost type,
- Fresh food volume,
- Freezer volume,
- Total volume,
- Height,
- Width,
- Depth,
- Low kWh/year,
- High kWh/year,
- Mean kWh/year,
- Date of the CEC directory, and
- Effective date of the appliance efficiency standard with which it complies.

The manufacturer is the company which constructed the appliance. The brand name is the name that appears on the appliance and under which it is sold. In some cases, the brand name is the same as the manufacturer's name. In many cases, it is not. For a few years, the CEC directory did not list the manufacturer, just the brand name. Many models include heaters designed to eliminate condensation around the doors in humid climates. Many models with such anti-sweat heaters include switches to turn the heaters off when not needed. The Low kWh/year and High kWh/year database fields represent the energy consumption of these models with the heaters switched off and on, respectively. The Mean kWh/year is the average of the high and low. Models with no entry in the low and high fields either have no anti-sweat heaters or the heaters can not be switched off.

In addition to the raw data in several formats, the CD-ROM also contains applications in Access® 97 and 2000 format that help Weatherization providers determine the cost-effectiveness of replacing existing refrigerators in eligible households. The annual energy use of the existing refrigerator is estimated by either locating the brand and model # in the database, entering metering results, or entering some other estimate of annual energy use. The annual energy use and installed cost of the new replacement refrigerator is entered by the user or selected from a list of previously entered units. After verifying some economic assumptions, the Access® application calculates the savings-to-investment ratio and tells the user if the particular refrigerator replacement specified meets DOE cost-effectiveness requirements. To simplify the Access® applications, not all of the database fields are shown on the various input and results screens.

James Cavallo⁵ has compiled energy use data for over 18,000 existing refrigerators from publicly available data and posted it on www.homeenergy.org/consumerinfo/refrigeration/index.php. Data from the accompanying CD-ROM will be made available so it can be added to the Home Energy web site as needed.

An application is being developed for personal data assistants (PDAs) using Palm OS that will mirror the Access® analysis tool described above. To keep the file size under 2 MB, only refrigerators and refrigerator-freezers (no chest or upright freezers) over 9 cubic feet are imbedded in the PDA application. DOE will inform the network how obtain the PDA application once the optimal distribution method is worked out.

Historical Energy Efficiency Standards

Most of the electric utility refrigerator replacement programs meter the existing refrigerator, use the AHAM database, or combine these approaches to accurately estimate potential energy savings. However, much of the commercially available energy audit software⁶ use simplified methods to estimate appliance energy use. Refrigerator energy use estimates are often based on historical appliance energy efficiency standards. The user is asked to provide the year the refrigerator was manufactured, the size of the refrigerator in cubic feet, and the freezer configuration (top, bottom, side). The year of manufacture determines what energy efficiency standards were in effect when the appliance was made. The freezer configuration tells the software which equation from the standard should be used, and the size is plugged into that equation. It should be noted that this approach gives the maximum refrigerator energy use allowed under the energy efficiency standard. The actual refrigerator in question is likely to use much less. Appendix B includes a dating chart that can be used to determine the year a refrigerator was manufactured by looking at the model and/or serial number.

BULK PURCHASING

After estimating the energy savings, the other part of the cost-effectiveness equation is cost. Purchasing energy-efficient refrigerators in bulk can minimize measure costs, thereby making the replacement of more refrigerators cost-effective. The local agencies administering electric utility low-income programs in Massachusetts instituted a bulk purchase process to reduce the cost of new energy-efficient refrigerators. Purchase agreements have been negotiated with different appliance retailers throughout Massachusetts. One agency, South Middlesex Opportunity Council (SMOC), administers the refrigerator procurement program. When a refrigerator is to be replaced in a low-income house, the local agency writes up an order and faxes it to SMOC who orders the refrigerator from the retailer covering that area of Massachusetts.

⁵ James Cavallo, Associate Editor of *Home Energy* magazine and Principal at Kouba-Cavallo Associates, Downers Grove, IL.

⁶ The National Energy Audit Tool (NEAT) incorporates the AHAM *Refrigerator & Freezer Historical Data Set*. The Windows version of the Manufactured Home Energy Audit (MHEA) will also use the AHAM data.

Appendix C includes the Partner Guide for the Super-Efficient, Apartment Sized Refrigerator Initiative (SEAR). The SEAR Initiative, developed by the Boston-based Consortium for Energy Efficiency (CEE), uses a bulk procurement approach that produces attractive pricing. CEE has facilitated the installation of more than 130,000 super-efficient refrigerators since the initiative began in 1997. The New York Power Authority (NYPA) was a major force in the development of the SEAR Initiative, committing to a sizable bulk purchase in of 15 cu. ft. refrigerators 1997. With NYPA enabling other purchasers to "piggy-back" onto its order, CEE was able to attract other sponsors into the program. Similarly, the Los Angeles Department of Water & Power served as an anchor buyer for a larger, 18.5 cu. ft. model in 1999.

By stimulating interest from housing authorities around the country, CEE is enabling appliance manufacturers to produce these new-to-the-market, super-efficient models. Through a competitive bidding process, Maytag was awarded the contract for both the 15 cu. ft. and 18.5 cu. ft. models.

DOE is considering additional refrigerator bulk purchasing arrangements to benefit the Weatherization network.

SAMPLE PROTOCOLS

Appendix D includes sample protocols that certain states and local agencies have used to guide the implementation of various refrigerator replacement programs. Please note that many of these protocols are for programs not funded by DOE and, therefore, carry different requirements than the Weatherization Program.

APPENDIX A

REFRIGERATOR METERING EQUIPMENT

REFRIGERATOR METERING EQUIPMENT

PL-100 Plug Load Analyzer

- Power monitor and energy logger
- Displays true RMS voltage and current, true power, apparent power, true power factor, and current crest factor
- Logs minimum and maximum power, voltage, and current over time
- Converts metered usage into annual kWh
- Metered load plugs directly into meter
- Specifications:
 - < Operating Range: 100-140 Volts RMS
 - < 5-2400 Watts
 - < 0-65535 kWh
 - < Voltage, current, wattage measurements: accurate to $\pm 1\%$ of full scale ± 2 in the low-order digit
 - < Dimensions: 5.4" x 1.7" base width 3.5"
 - < Weight: 9 oz.
- Price: \$225
- Contact Information: The Watt Stopper
2800 De La Cruz Blvd
Santa Clara, CA 95050
(408)988-5331
www.wattstopper.com

Line Logger

- Energy logger, accumulates kWh regardless of setting
- Displays line voltage, true power consumption in Watts, and continuously records energy usage in kilowatt-hours
- Displays power, but does not log peak
- Metered load plugs directly into meter
- Specifications:
 - < Operating Range: 80-140 Volts RMS
 - < 0-2400 Watts
 - < 0-9999 kWh
 - < Accuracy: Volts=1% over full range; Watts= 2% nominal + 2deg of (theta) (where $W = VI \cos(\theta)$)
 - < Dimensions: 4½" x 2½" x 1½"
 - < Weight: 8 oz.
- Price: \$249 (1 to 5 units); \$229 (6 or more units)
- Contact Information: Pacific Science & Technology
64 NW Franklin Avenue
Bend, OR 97701
(541)388-4774
www.pacscitech.com
- Also available from: Optimum Energy Products Ltd. #236
16 Midlake Blvd SE Calgary
Alberta Canada T2X 2X7
(877)256-3431
www.electricitymetering.com

Note: List of metering equipment is not comprehensive. To add equipment to this list, contact Alex Moore, D&R International, Ltd., 1300 Spring Street, Suite 500, Silver Spring, MD 20910, Phone: (301)588-9387, Fax: (301) 588-0854, amoores@drintl.com

EML 2000

- Displays instantaneous power (kW), energy (kWh) consumed, and cost of energy calculations
- Displays Watts and Watt-hours for channel 1 or 2, or sum of both
- Two channels allows metering of two 120 Volt loads simultaneously (requires additional current transformer, only one included) or a 240 Volt split phase load
- Accepts electricity rates from user
- Requires use of current transformer, which is included
- Specifications: not available
- Price: \$219 (single unit); \$199 (2 or more units)
- Contact Information: Optimum Energy Products Ltd. #236
16 Midlake Blvd SE Calgary
Alberta Canada T2X 2X7
(877)256-3431
www.electricitymetering.com

ECM-1200

- Displays Watts and Watt-hours for channel 1 or 2, or sum of both
- Two channels allows metering of two 120 Volt loads simultaneously or a 240 Volt split phase load
- Stores average kW
- Displays elapsed time
- Displays cost of metered or projected energy
- Requires use of current transformer, which is included
- Specifications:
 - < Operating Range: 80-145 Volts for phase type=0 (average responding)
160-290 Volts for phase type=1 (average responding)
 - < 0-3200 Watts (maximum per channel)
 - < 0-9999 kWh
 - < 0 to 200 Amps depending on current transformer used (15 Amps with wall plug adapter)
 - < Accuracy: Volts=typically $\pm 1\%$ plus \pm least significant digit; Watts=typically $\pm 2\%$ 120V PF=1) ± 1 least significant digit
- Price: \$400
- Contact Information: Brultech Research, Inc.
12L67 Harbourview Rd.,
Port Colborne, Ontario, Canada, L3K 5V4
1-905-834-7559
www.brultech.com

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Watts up?

- Displays Watts, Watt-hours, and time
- Displays instantaneous power from 1 Watt to 999 kilowatts
- Accepts two different electricity rates and displays cost of energy metered
- Metered load plugs directly into meter
- Specifications:
 - < 0-999,000 Watts
 - < 12.5 Amps
 - < Accuracy: $\pm 5\%$ for loads above 20 watts
 - < Dimensions: 7" x 4" x 2"
 - < Weight: 1½ lbs.
- Price: \$96
- Contact Information: Electronic Educational Devices, Inc.
2345 South Lincoln Street
Denver, CO 80210
1-877-928-8701
www.doubleed.com

Brand Electronics Digital Power Meters

- Five models
- The BE-4-1850 model has four basic displays:
 - < Instantaneous power (Watts) and energy (kilowatt-hours) since meter was last reset;
 - < Elapsed time since meter was last reset;
 - < Cost of energy consumed since meter was last reset and electric rate (cents/kWh) entered by user; and
 - < Estimated monthly energy cost.
- The 20-1850 and 21-1850CI models also include displays that show Amps, Volts, Power Factor, VARS, Volt-Amps, and Peak Watts.
- The 21-1850CI model includes data logging capabilities.
- A dual-range option, 185 Watt / 1850 Watt range, is available for all power meters. This option allows you to accurately measure and display power in 0.1 Watt increments up to 185 Watts. The normal 1850 Watt range displays readings in 1 Watt increments.
- Metered load plugs directly into meter
- Specifications:
 - < Operating Range: 100-140 Volts RMS
 - < 0-1850 Watts
 - < 0-9999 kWh
 - < 0.2-15 Amps RMS (20-1850 and 21-1850CI models)
 - < Accuracy: $\pm 2\%$ ± 2 least significant digit (for 20-1850 model Amps= $\pm 3\%$; VARS and Volt-Amps= $\pm 5\%$; Amps, VARS, and Volt-Amp reading below 0.2 Amps not accurate)
- Price: BE-4-1850 = \$149
BE-4-1850 DR = \$169 (dual range option)
BE-20-1850 = \$249 (BE-4-1850 basic capabilities plus Amps, Volts, Power Factor, VARS, Volt-Amps, and Peak Watts)
BE-20-1850 DR = \$269 (BE-20-1850 with dual range option)
BE-21-1850CI = \$349 (BE-20-1850 with data logging capabilities)
- Contact Information: EnergyTools.com
7800 Talisman Road
Anchorage, AK 99516
1-888-739-3535
www.energytools.com

Note: List of metering equipment is not comprehensive. To add equipment to this list, contact Alex Moore, D&R International, Ltd., 1300 Spring Street, Suite 500, Silver Spring, MD 20910, Phone: (301)588-9387, Fax: (301) 588-0854, amoore@drintl.com

APPENDIX B

REFRIGERATOR DATING CHART

REFRIGERATOR DATING CHART

Refrigerators are listed by brand name, followed by the coding system. If several manufacturers used the same system, they are listed together. Some rules of thumb for easy identification are: (1) Refrigerators that are any color of green, brown, yellow, pink, or blue (actually KitchenAid makes a new unit in cobalt blue); have mechanical handles; have doors held shut with magnetic strips; have rounded shoulders; have a chromed handle; or have exposed "house door" type hinges are at least 10 years old, and (2) the following brands have only been manufactured since around 1984 - Roper, Estate, KitchenAid, Caloric, Modern Maid, and Maytag.

Brand(s)	What to look for	What to avoid	How to decode	Example
Montgomery Wards, Signature (2000)	Serial # - 1 st two digits	n/a	Reverse the digits	56xxxxx = 19 <u>65</u>
Sears, Kenmore, Coldspot	Model # - 1 st & 3 rd digits after (.)	n/a	Combine the digits	xx.6x2xxx = 19 <u>62</u>
Whirlpool	Model # - 1 st 3 letters (pre 1982) Serial # - 2 nd digit (post 1982)	Serials with letters	No need as 1 st two digits Add "198." to it	ABCxxx = pre 1982 x2xxx = 198 <u>2</u>
Amana	Serial # - 1 st digit (pre 1986)	n/a	BLACKHORSE B=1, L=2	Hxxxx = 19 <u>66</u> or 197 <u>6</u> 61 is the oldest
Frigidaire	Serial # - 1 st & 4 th digit (pre 1989)	Serials with no letter in the 4 th space	Add "196, 197, or 198" to the 1 st digit. The letter in the 4 th space is a month code used only on older models.	3xxBxx = 197 <u>3</u> or 198 <u>3</u>
Gibson, Kelvinator	Serial # - 3 rd digit (pre 1989)	n/a	Add "196, 197, or 198" to it	xx3xx = 196 <u>3</u> or 7 <u>3</u> or 8 <u>3</u>
White, Westinghouse	Serial # - 2 nd letter (pre 1989)	Serials without letters	A,V,W=78, B=79, C=80 etc. pre-1978, R=74, U=77 etc.	xLxxx = 19 <u>88</u> 74 is the oldest year
Tappan, O'Keefe & Merritt	Serial # - 7 th digit (pre 1989)	n/a	Add "196, 197, or 198" to it	xx xxx-x8xx = 196 <u>8</u> or 7 <u>8</u> or 8 <u>8</u>
Admiral, Crosley, Norge, Magic Chef, Jenn Air	Serial # - last letter	n/a	A=1950 or 1974 (+14 yrs) B=1951 or 1975, etc.	xxxxxxD = 19 <u>53</u> or 19 <u>77</u>
General Electric (GE)	Serial # - 2 nd letter	n/a	See chart below	xGxxx = 19 <u>50</u> or 19 <u>80</u>
Hotpoint	Same as GE with some exceptions. See GE and Hotpoint exceptions chart below			

GE Decoder Chart: A = 44, 65, 77, 89 B = 45, 66 C = 46, 67 D = 47, 68, 78, 90 E = 48, 69 F = 49, 79, 91 G = 50, 80, 92
 H = 51, 81, 93 J = 52 K = 53 L = 54, 70, 82, 94 M = 55, 71, 83 N = 56, 72 P = 57, 73
 R = 58, 84 S = 59, 85 T = 60, 74, 86 V = 61, 75, 87 W = 62 X = 63 Y = 64 Z = 76, 88

Hotpoint Exceptions: U = 61, V = 62, W = 63, X = 64, Y = 65, Z = 66, A = 67, B = 68

Revised 5/6/94

APPENDIX C

CONSORTIUM FOR ENERGY EFFICIENCY'S SUPER-EFFICIENT APARTMENT-SIZED REFRIGERATOR INITIATIVE

(Reprinted from <http://www.cee1.org/gov/sear/sear-guide-2001.pdf>)

APPENDIX D

SAMPLE REFRIGERATOR REPLACEMENT PROTOCOLS

Note: Keep in mind that many of these protocols are for programs that have historically not been DOE-funded. Therefore, the programs may not have requirements, such as measure cost-effectiveness, that are consistent with DOE regulations. There are presented for information purposes only.

Division of Housing and Community Renewal

MEMORANDUM Energy Services Bureau PPM Addendum 2000-01

TO: Weatherization Subgrantees DATE: 7/28/2000

FROM: J. Delaine Jones

SUBJECT: PPM Addendum 2000-01, Refrigerator Replacement Criteria

Refrigerator Replacement Criteria

During the 2000 program year subgrantees may replace an inefficient refrigerator as a repair measure on a Class B or Class D dwelling unit provided that such replacement is cost effective. The following criteria will provide the basis for such a replacement:

1. The refrigerator to be replaced must have been manufactured before 1993 and must be the primary refrigerator used by the household. In cases where more than one refrigerator is being used, the subgrantee should encourage the client to dispose of the secondary refrigerator(s). The disposal of secondary refrigerator(s) will be considered an eligible activity, however, the client must provide the subgrantee with written permission for this disposal. If the client does not wish to dispose of secondary refrigerator(s), the subgrantee should provide client education regarding the energy cost involved with the operation of this additional refrigerator.
2. All refrigerators that are replaced must be removed from the clients' premises upon delivery of the replacement and properly disposed of in accordance with The Clean Air Act, USC Title 42, Section 7671g. This Act makes it unlawful for any person to dispose of refrigerants in a manner in which they will be allowed to enter the environment.
3. The replacement refrigerator must be an Energy Star-rated⁷ energy-efficient refrigerator with an estimated annual consumption of 600 kWh/yr. or less. It must be a similar style and capacity as the one being replaced, where practical. Refrigerators with advanced options such as an ice maker will not be considered allowable replacements. If there is an additional cost for a custom color, the additional cost is not an allowable weatherization cost but may be paid for by the client.
4. Subgrantees must determine that a replacement will be cost effective before considering a refrigerator replacement as an eligible repair option. To accurately determine the cost effectiveness of replacing a refrigerator, first determine the annual energy consumption of the existing refrigerator and compare this to the estimated consumption of the replacement. The following methodology will provide the basis for this determination:

⁷ The U. S. Department of Energy can provide the most recent Energy Star refrigerator model listing including it's cooling capacity and annual kWh consumption. Phone: (202) 429-0063 or access the web site at <http://www.energystar.gov>

Determining the annual consumption of the existing refrigerator:

- A) Use a cumulative watt hour meter to determine the present usage of the refrigerator. Plug the meter into a wall outlet and plug the refrigerator into the meter. You must document the date, exact time, and the initial reading, when removing the meter you must also record the date, time and reading. The difference in the two readings will be the number of watt hours or kilowatt hours used for the time the refrigerator was metered. If Watt hours are shown they must be converted to kilowatt hours by dividing the number of watt hours by 1000.
- B) The refrigerator must be metered for a minimum of two hours and, wherever possible longer. This should be accomplished during the course of performing the energy audit on the building.
- C) Some older refrigerators had to be manually defrosted, however, most that are currently in use have an automatic defrost cycle. If the automatic defrost cycle is activated during testing, you will not get a true reading of usage. In cases where you have a unit with an automatic defrost cycle, try to return to the refrigerator every 15-20 minutes to determine if it has gone into the defrost mode. A significant increase in watts over a short period of time is a good indicator of defrost mode. If the refrigerator has gone into the defrost mode, the reading cannot be used and the refrigerator must be retested.
- D) The metered usage, in kilowatt hours, must then be converted to an hourly usage by dividing the reading by the number of minutes the refrigerator was plugged in to the meter and then multiplying by 60. This number must then be multiplied by 8766 (the average number of hours in a year) to determine the annual usage.

Determining the cost effectiveness of the replacement:

NOTE: The following cost-effectiveness requirements are not consistent with DOE's cost-effectiveness requirements for Weatherization measures. New York historically has not used DOE funds for their refrigerator replacement program. To replace a refrigerator with DOE funds, the measures must result in a savings-to-investment ratio of one or greater.

- A) If the annual usage of the existing refrigerator is 900 KWh or more, the refrigerator may be replaced.
- B) If the annual usage is less than 900 KWh, use the following method to determine if the replacement will be cost effective.

Subtract the annual usage of the proposed replacement from the annual usage determined above. This will provide the estimated annual energy savings. Multiply this estimated annual energy savings by the client's cost for a kWh of electricity, as determined by the client's electric bill. This represents the estimated annual dollar savings to the client.

- C) Divide the total cost for the replacement refrigerator by the estimated annual dollar savings to the client to arrive at the payback period. (This replacement cost must include materials, labor, program support, and disposal costs). If the payback period is less than 15 years, (average refrigerator life) the refrigerator may be replaced.

Following is a sample calculation:

1. A refrigerator is metered for two and a half hours (150 minutes) and the meter shows usage of 0.250 kilowatts.
2. Convert to hourly usage = $0.250 \text{ kW} \div 150 \text{ minutes} = 0.00167 \text{ kW/min.} \times 60 \text{ min/hr} = 0.1002 \text{ kWh / hr.}$
3. Annual usage = $0.1002 \text{ kWh} \times 8766 \text{ hr/yr} = 878 \text{ kWh / yr.}$
4. The annual usage of an equivalent Energy Star rated replacement is 576 kWh / yr.
5. $878 - 576 = 302$ estimated annual savings in kWh.
6. $302 \text{ kWh} \times \$0.14 \text{ per kWh} = \42.28 estimated annual dollar savings to client.
7. The total replacement cost for the Energy Star replacement is \$600. Divided by \$42.28 this equals a payback period of 14.19 years. Therefore it is cost effective to replace this refrigerator since the payback period is less than 15 years.

NOTE: The above calculation is based on 14 cents per kilowatt hour. The same scenario at 13 cents per kilowatt hour or less would not be cost effective.

**From the REACH Measure Criteria Reference Guide
developed by the Redwood (California) Community Action Agency Energy Center**

5. REFRIGERATOR REPLACEMENTS

The following criteria apply to replacement refrigerators.

5.1 ELIGIBILITY FOR REPLACEMENT

- To qualify for replacement, the existing refrigerator must have been manufactured before January 1987 (see Refrigerator Dating Chart).

5.2 MATERIALS

- New refrigerators shall:
 - < be the same size as the replaced unit,
 - < not exceed 18 cubic feet in size,
 - < be frost free, and
 - < have a minimum 1 year warranty.

5.3 INSTALLATION

- Electrical Requirements
 - < The electrical outlet shall:
 - A) provide the voltage specified on the ID plate of the new refrigerator,
 - B) be properly grounded and/or protected with a properly functioning GFIC device, and
 - C) be located within reach of the refrigerator without the use of an extension cord.
 - < Outlet and cover plate shall be in good condition with nothing visibly wrong (e.g., not cracked or broken, and no sparks, smoke, burn marks, etc.).
- Structural Requirements
 - < Location shall meet refrigerator manufacturer's specifications for space and clearances.
 - < The floor must be level and structurally adequate to properly support the new refrigerator.
 - < Doors and hallways in the dwelling must be sufficient to allow removal of the existing refrigerator and installation of the new one.
- The contractor shall:
 - < deliver and install the new refrigerator,
 - < level the unit to ensure proper operation,
 - < ensure that door hinges are on the appropriate side,
 - < instruct the customer on refrigerator operation,
 - < deliver warranties and operating manuals to the customer, and
 - < set temperature controls appropriately.

5.4 DISPOSAL

- The contractor shall:
 - < remove all packing materials from the customer's premises,
 - < remove the old refrigerator from the customer's premises, and
 - < properly dispose of all replaced refrigerators.

UTAH POWER PROGRAM PARAMETERS

Local Agency Responsibilities

Implement the 2000–2001 Weatherization Assistance Program Guidelines for each Utah Power home weatherized and provide the additional services listed below:

Refrigerators

6. Determine approximate age of existing refrigerator.
7. On units that are suspected to be at least eight to ten years old, test unit with a Digital Power Meter for a minimum of 72 hours.
8. Record all data from Digital Power Meter on inspection sheet.
9. Those units with a total monthly average operational cost of \$7.96⁸ or greater (based on KWH price of 7.5 cents) are eligible for replacement.
10. Weatherization program coordinator will make the final determination on refrigerator replacements based on data collected and availability of funds.
11. Refrigerators will be replaced with an approved model procured through a bulk purchase program.
12. Refrigerators will be removed from premises and recycled according to EPA guidelines.
13. Refrigerators not replaced will receive the following:
 - a. Thorough cleaning of evaporator coils.
 - b. Provide adequate ventilation.
 - c. Test and readjust interior temperature
 - d. Client education on proper refrigerator usage and client handout entitled: “Tips for Lowering Your Refrigerator Energy Usage.”
 - e. Installation of Power Planner.
14. Replacement refrigerators in rental units will be the property of the individual who owned the original refrigerator.

Sample Customer Letter (Utah)

Date:

Dear: (client's name)

It has been determined that you are eligible to receive a replacement refrigerator from the Utah Weatherization Assistance Program as part of the Utah Power Low-Income conservation program. Your new refrigerator is free of charge to you.

Your refrigerator will be replaced with a Whirlpool 18.2 Cubic Foot model # ET18HPXJW. This model is white, freezer on top and has Spillmizer™ glass shelves. This make and model is the only type we will be ordering. Your new refrigerator will be delivered to your home by RC Willey Co. Below is a list of requirements you must follow in order to receive your new refrigerator.

1. Notify us as soon as you know the date and time for delivery.
2. There must be an adult present in the home to take delivery.
3. Your old refrigerator will be removed by RC Willey Co. ***This is required by Utah Power as part of the program. You may not keep your old refrigerator.*** If your old refrigerator is not there for RC Willey to pick up, they will not deliver the new refrigerator. Please have the old refrigerator cleaned out and ready to go.
4. You will need to sign a receipt to take delivery.

If you purchased the old refrigerator, than the new refrigerator is also yours. However, if your home/apartment/mobile home is a rental unit and came with a working refrigerator, the new one must remain in the unit in the event you move out. Your landlord will be notified when we replace the refrigerator. Your landlord will ***not*** be able to keep the old refrigerator.

Congratulations from our energy conservation team on being an energy saver. Enjoy the benefits of your new refrigerator.

Sincerely,

(local agency name)

MEMORANDUM OF UNDERSTANDING (Utah)

By signature with this agreement the dealer indicated here agrees to the conditions set forth below:

Dealer/Business Name: _____

Dealer Contact Person: _____

Telephone Number: _____

Business Address: _____

General Conditions

1. Dealer will deliver to Weatherization client's home the appliance ordered by local Weatherization Program operating agency.
2. Dealer certifies the appliance was an Energy Star appliance at the time of purchase.
3. Dealer will remove the existing appliance and will perform, or contract for appropriate disposal of the appliance (including removal and recycling of Freon) and assuring future use is prevented.
4. Dealer will provide normal back-up service after the sale.
5. Dealer agrees to make these same models available to the public.

Signature _____
Authorized Representative Date

UTAH POWER WEATHERIZATION PROGRAM

REFRIGERATOR REPLACEMENT REQUEST

AGENCY REQUESTING REPLACEMENT _____ Date _____

Agency Phone #() _____ Contact Person _____

Client Name _____

Address _____ City _____ Phone () _____

Digital Power Meter av./month reading @ 6.6 cents KWH _____

Existing Ref. C.F. capacity _____ Width _____ Height _____ Depth _____

Replacement is 29½ wide X 65 ½ high X 31 ½ deep. Will it fit the existing space? _____

Delivery directions _____

Best Delivery Time/Day of week etc. _____

Special instructions _____

