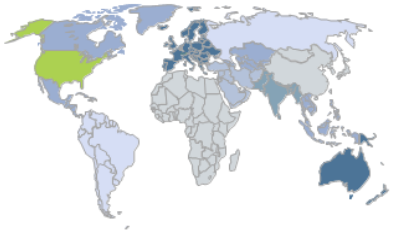
# Mapping Document



| | |
|---|---|
| Country: | USA |
| Technology: | Domestic refrigerated appliances |
| Sub Category: | Refrigerators, refrigerator-freezers and freezers |

## Introduction

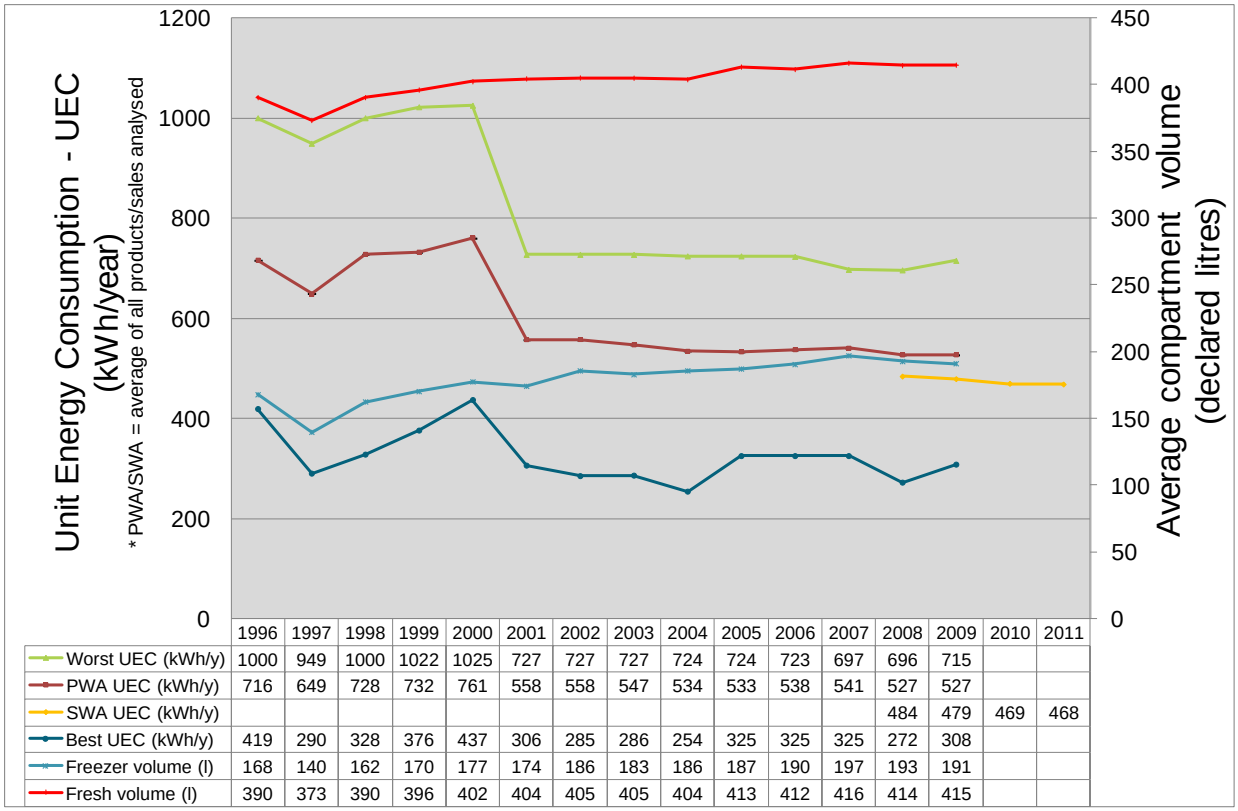
The first stage in the Mapping and Benchmarking process is the definition of the products, i.e. clearly setting the boundaries that define the products for use in data collection and analysis. This ensures that comparison between the participating countries is done against a specific and consistent set of products.

The summary definition for this product is:

| M&B Category | Description |
|---|---|
| **Refrigerator only and refrigerators with freezer compartments** | The primary compartment is for fresh storage in the temperature range 5°C >= T> 0°C *and*<br>• The unit has no freezer compartment, *or*<br>• The unit has a freezer compartment of any temperature rating but a volume of less than 14 litres, *or*<br>• The unit has a frozen food compartment of any volume that is rated as 0°C >= T > -15°C |
| **Refrigerator/Freezer** | The primary compartment for fresh storage in the temperature range 5°C >= T> 0°C *and* the primary frozen food compartment is greater than 14 litres and has a rated temperature T <= -15°C |
| **Freezer only** | A unit where *all* compartments have a temperature rating T <= -15°C |

The detailed product definition can be found at the Annex website:
http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=13

# Unit Energy Consumption of new refrigerator freezers in the USA

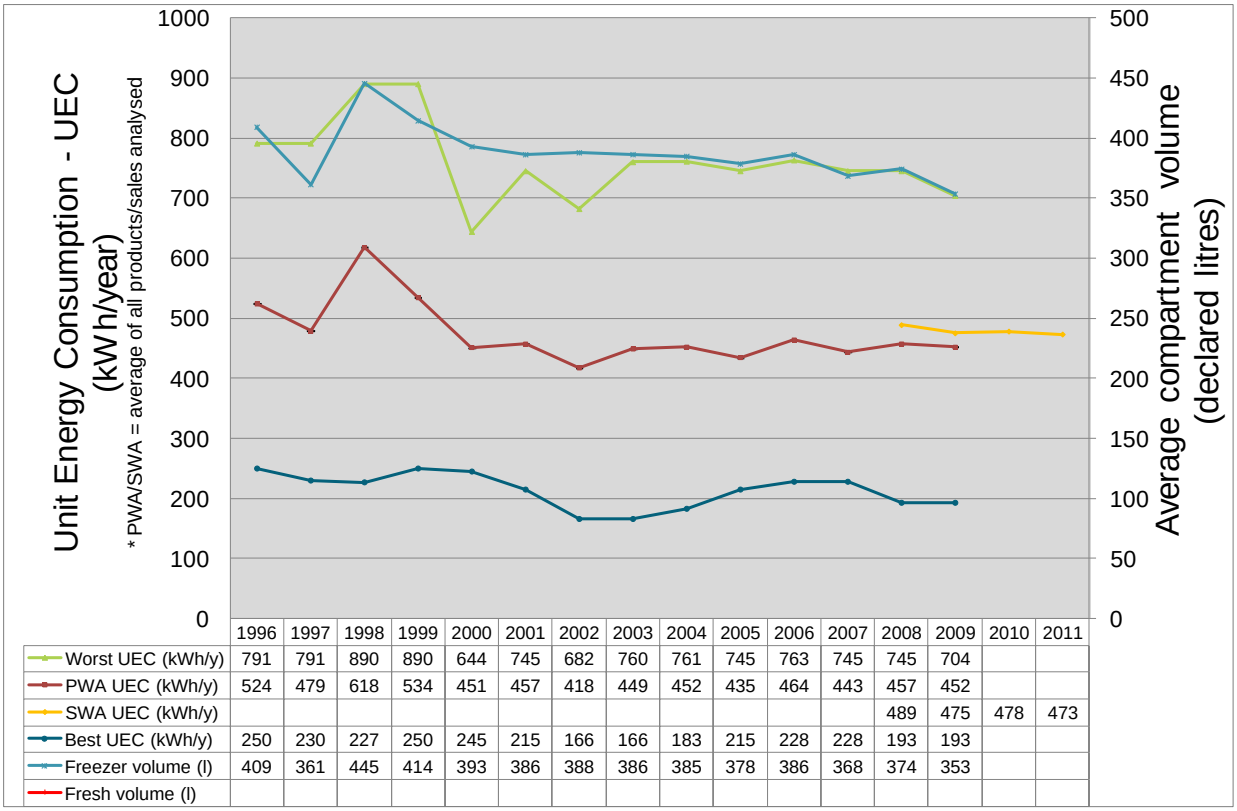



| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Worst UEC (kWh/y) | 1000 | 949 | 1000 | 1022 | 1025 | 727 | 727 | 727 | 724 | 724 | 723 | 697 | 696 | 715 | | |
| PWA UEC (kWh/y) | 716 | 649 | 728 | 732 | 761 | 558 | 558 | 547 | 534 | 533 | 538 | 541 | 527 | 527 | | |
| SWA UEC (kWh/y) | | | | | | | | | | | | | 484 | 479 | 469 | 468 |
| Best UEC (kWh/y) | 419 | 290 | 328 | 376 | 437 | 306 | 285 | 286 | 254 | 325 | 325 | 325 | 272 | 308 | | |
| Freezer volume (l) | 168 | 140 | 162 | 170 | 177 | 174 | 186 | 183 | 186 | 187 | 190 | 197 | 193 | 191 | | |
| Fresh volume (l) | 390 | 373 | 390 | 396 | 402 | 404 | 405 | 405 | 404 | 413 | 412 | 416 | 414 | 415 | | |

***Key notes on Graph (see notes section 1)***

- The majority of data presented is drawn from a database collated by Home Energy Magazine (HEM). The HEM database contains no sales information and so Unit Energy Consumption (UEC) is presented as a product weighted average (PWA) of all products in the in the HEM database. The sales weighted average (SWA) UEC is drawn from The NPD Group, Inc./Retail Tracking Service.
- Both datasets are considered representative of the USA market. However, it should be noted that it is unclear what proportion of the market the HEM data set covers, but is considered representative of the entire market as data is consistent with other comprehensive data sources where data overlaps. Further the NPD Group, Inc. database only has a UEC value for between 19-38% of products listed, although this represents 85-91% of sales in that database (overall the NPD Group, Inc. data is believed to cover approximately 3.5m of the 9m refrigerated appliances sold in 2008).
- The 'Worst UEC' is the UEC of the product at the 'worst 5%' point of a ranked list of products in the dataset.

# Unit Energy Consumption of new freezers in the USA




| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Worst UEC (kWh/y) | 791 | 791 | 890 | 890 | 644 | 745 | 682 | 760 | 761 | 745 | 763 | 745 | 745 | 704 | | |
| PWA UEC (kWh/y) | 524 | 479 | 618 | 534 | 451 | 457 | 418 | 449 | 452 | 435 | 464 | 443 | 457 | 452 | | |
| SWA UEC (kWh/y) | | | | | | | | | | | | | 489 | 475 | 478 | 473 |
| Best UEC (kWh/y) | 250 | 230 | 227 | 250 | 245 | 215 | 166 | 166 | 183 | 215 | 228 | 228 | 193 | 193 | | |
| Freezer volume (l) | 409 | 361 | 445 | 414 | 393 | 386 | 388 | 386 | 385 | 378 | 386 | 368 | 374 | 353 | | |
| Fresh volume (l) | | | | | | | | | | | | | | | | |

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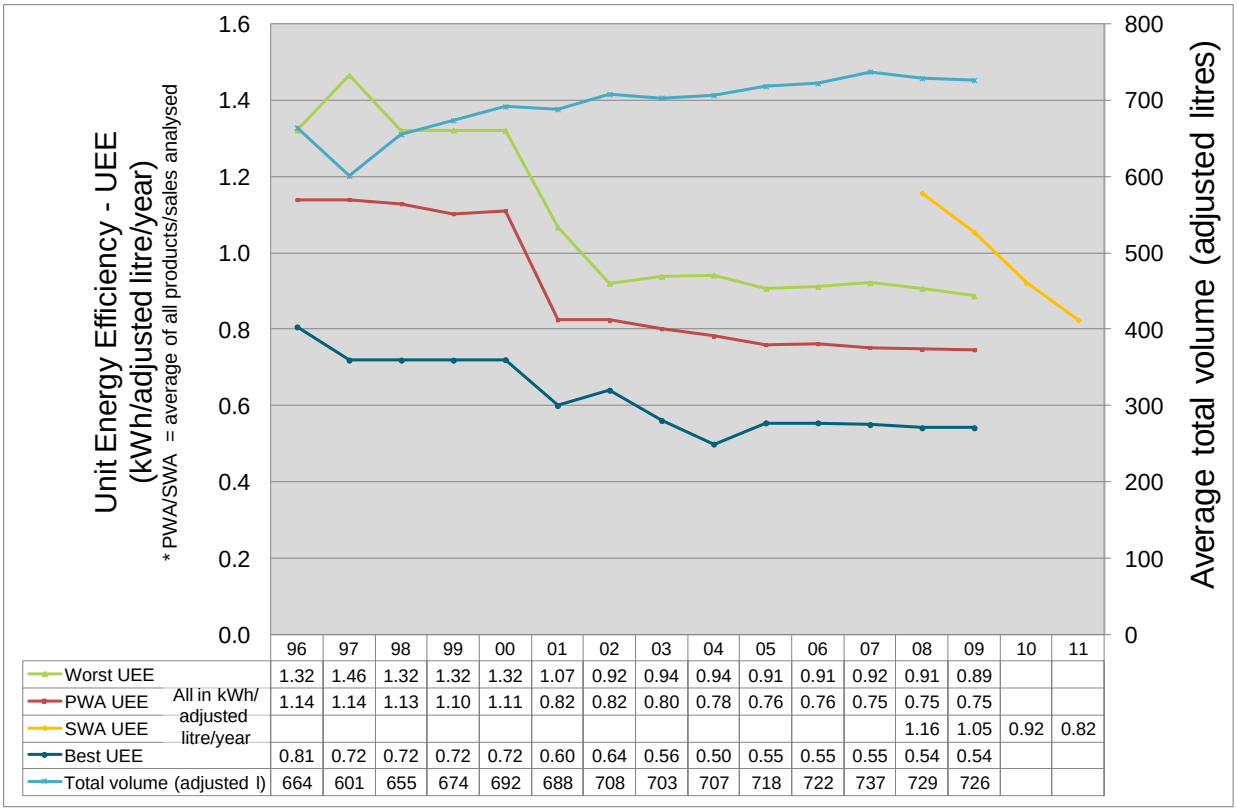
- The 'Worst UEC' is the UEC of the product at the 'worst 5%' point of a ranked list of products in the dataset.

# Unit Energy Consumption of new refrigerators and refrigerators with freezer compartments in the USA

It was not possible to distinguish with sufficient certainty which products in the USA datasets met the Annex Criteria for refrigerators and refrigerators with freezer compartments. Consequently the results for this sub-category are insufficiently robust and are not reported. However, this market segment represents a very small proportion of the overall US refrigerated appliance market.

# Unit Energy Efficiency of new refrigerator freezers in the USA




| | | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Worst UEE | All in kWh/ adjusted litre/year | 1.32 | 1.46 | 1.32 | 1.32 | 1.32 | 1.07 | 0.92 | 0.94 | 0.94 | 0.91 | 0.91 | 0.92 | 0.91 | 0.89 | | |
| PWA UEE | | 1.14 | 1.14 | 1.13 | 1.10 | 1.11 | 0.82 | 0.82 | 0.80 | 0.78 | 0.76 | 0.76 | 0.75 | 0.75 | 0.75 | | |
| SWA UEE | | | | | | | | | | | | | | 1.16 | 1.05 | 0.92 | 0.82 |
| Best UEE | | 0.81 | 0.72 | 0.72 | 0.72 | 0.72 | 0.60 | 0.64 | 0.56 | 0.50 | 0.55 | 0.55 | 0.55 | 0.54 | 0.54 | | |
| Total volume (adjusted l) | | 664 | 601 | 655 | 674 | 692 | 688 | 708 | 703 | 707 | 718 | 722 | 737 | 729 | 726 | | |

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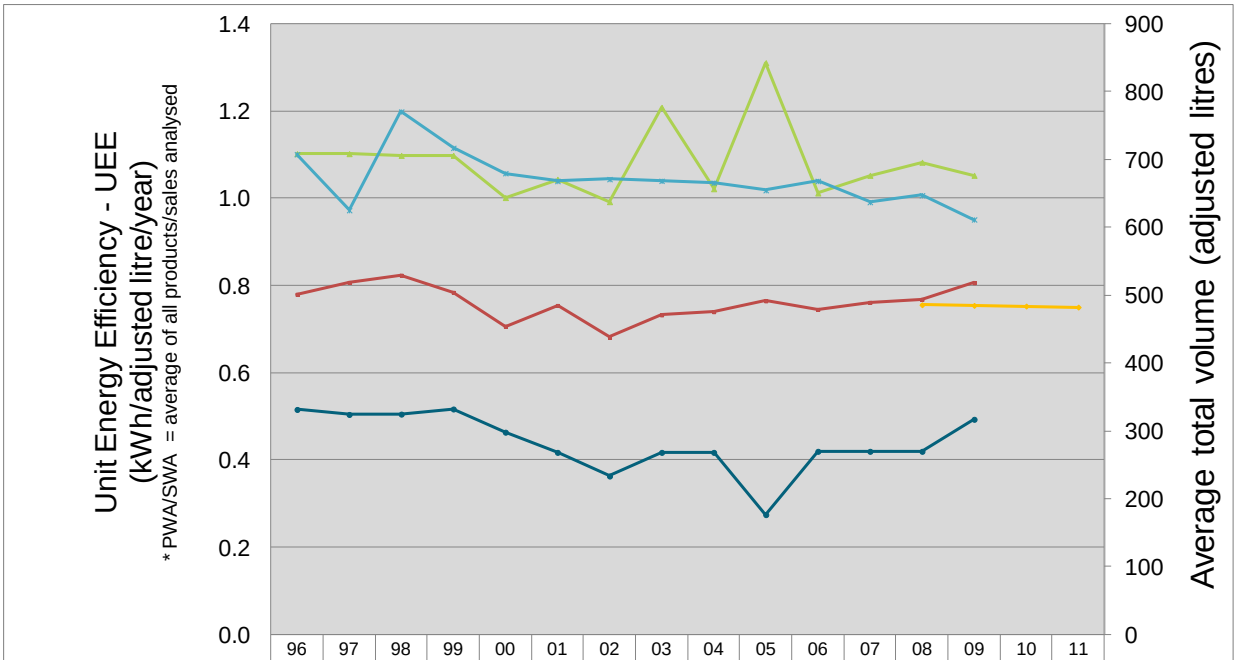
- The total volumes shown are based on HEM model level data and calculated using the temperatures and methods defined in the local test methodology/regulations.
- The PWA UEE is calculated using the total volume in adjusted litres for each model. The SWA UEE data follows the same methodology but is based on the NPD Group, Inc. volume data (sales weighted total volumes from the NPD Group, Inc. data are not shown).
- Both datasets are considered representative of the USA market. However, it should be noted that it is unclear what proportion of the market the HEM data set covers, but is considered representative of the entire market as data is consistent with other comprehensive data sources where data overlaps. Further the NPD Group, Inc. database only has a UEC value for between 19-38% of products listed, although this represents 85-91% of sales in that database (overall the NPD Group, Inc. data is believed to cover approximately 3.5m of the 9m refrigerated appliances sold in 2008).
- Also, note that the values for SWA UEE (the NPD Group, Inc.) and PWA UEE (HEM) vary significantly. This appears to be a result of consumers purchasing products with an average UEE that is worse than that of the average product on sale in the market. However, this cannot be confirmed due to the limited product coverage of the NPD Group, Inc. UEC data.
- The 'Worst UEE' is the UEE of the product at the 'worst 5%' point of a ranked list of products in the dataset.

# Unit Energy Efficiency of new freezers in the USA




| | | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Worst UEE | All in kWh/ adjusted litre/year | 1.10 | 1.10 | 1.10 | 1.10 | 1.00 | 1.04 | 0.99 | 1.21 | 1.02 | 1.31 | 1.01 | 1.05 | 1.08 | 1.05 | | |
| PWA UEE | | 0.78 | 0.81 | 0.82 | 0.78 | 0.71 | 0.75 | 0.68 | 0.73 | 0.74 | 0.76 | 0.75 | 0.76 | 0.77 | 0.81 | | |
| SWA UEE | | | | | | | | | | | | | | 0.76 | 0.75 | 0.75 | 0.75 |
| Best UEE | | 0.52 | 0.50 | 0.51 | 0.52 | 0.46 | 0.42 | 0.36 | 0.42 | 0.42 | 0.27 | 0.42 | 0.42 | 0.42 | 0.49 | | |
| Total volume (adjusted l) | | 708 | 625 | 770 | 717 | 680 | 668 | 671 | 668 | 666 | 655 | 668 | 637 | 647 | 611 | | |

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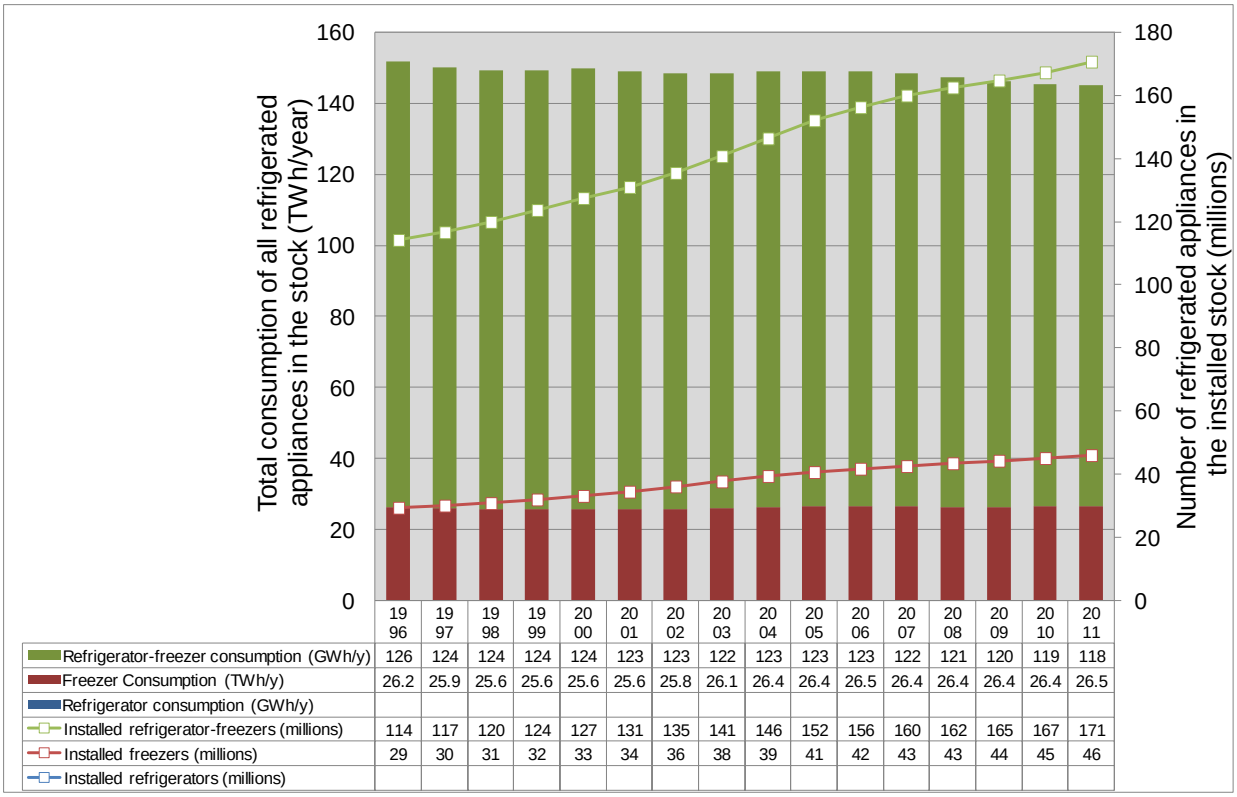
It was not possible to distinguish with sufficient certainty which products in the USA datasets met the Annex Criteria for refrigerators and refrigerators with freezer compartments. Consequently the results for this sub-category are insufficiently robust and are not reported. However, this market segment represents a very small proportion of the overall US refrigerated appliance market.

# Energy Consumption of the installed stock of refrigerated appliances in the USA




| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Refrigerator-freezer consumption (GWh/y) | 126 | 124 | 124 | 124 | 124 | 123 | 123 | 122 | 123 | 123 | 123 | 122 | 121 | 120 | 119 | 118 |
| Freezer Consumption (TWh/y) | 26.2 | 25.9 | 25.6 | 25.6 | 25.6 | 25.6 | 25.8 | 26.1 | 26.4 | 26.4 | 26.5 | 26.4 | 26.4 | 26.4 | 26.4 | 26.5 |
| Refrigerator consumption (GWh/y) | | | | | | | | | | | | | | | | |
| Installed refrigerator-freezers (millions) | 114 | 117 | 120 | 124 | 127 | 131 | 135 | 141 | 146 | 152 | 156 | 160 | 162 | 165 | 167 | 171 |
| Installed freezers (millions) | 29 | 30 | 31 | 32 | 33 | 34 | 36 | 38 | 39 | 41 | 42 | 43 | 43 | 44 | 45 | 46 |
| Installed refrigerators (millions) | | | | | | | | | | | | | | | | |

***Key notes on Graph (see notes section 2)***

- The refrigerator-freezer data shown includes all refrigerators, refrigerators with freezer compartments and refrigerator-freezer combination units. Further, the data combines both compact and full sized units.
- Similarly, freezer data combines compact and full sized units.

# Major Policy Interventions (*see notes section 3)*

The USA has three primary federal policy[1] interventions related to refrigerators and freezers:

- Minimum Energy Performance Standards: Based on the 1987 National Appliance Energy Conservation Act, which established the first uniform national efficiency standard for residential refrigerators and gives the Department of Energy the ability to place establish or amend energy standards on various consumer products.. The current standards for refrigerators are defined in: *"10 CFR Part 430.32: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Refrigerators, Refrigerator-Freezers, and Freezers"*.

  MEPS for refrigerators and freezers first took effect in 1990 with revisions in 1993 and 2001. Strengthened standards were announced in 2011 with an effective date 2014.

- Mandatory Labelling: EnergyGuide, which provides and indication of comparative energy consumption and an estimate of costs to the consumer. First introduced in 1980, with a redesigned label (featuring more prominently displayed costs estimates being announced in 2007).

- Voluntary Labelling: Energy Star which seeks to help consumers identify higher performing products that meet a range of performance standards. In the case of cold appliances, this is typically 10-20% above the minimum requirement.

  Energy Star was introduced for refrigerators in 1998, and expanded to cover all refrigerator and freezer appliances on 1 January 2003. The most recent addition of the Energy Star criteria were issued on 3 August 2007 and came into effect on 28 April 2008. In 2009, it was estimated that at least 35% of US refrigerators carried the Energy Star label[2].

In addition there are a large number of regional, state and local policy interventions by a large number of bodies. Such intervention range from state based MEPS through major procurement activities (eg utility DSM programmes), often driven by requirements in states such as California and/or based on Energy Star qualified products.

[1] The majority of policy information sourced from APEC-ESIS http://www.apec-esis.org/countrysummary.php?country=USA&ID=262
[2] http://www.energystar.gov/index.cfm?c=manuf_res.pt_appliances#asd

## Cultural Issues (*see notes section 4)*

Overall number of refrigerators installed in US homes in 2009 was 124 million. 26 million households (from a total of 111.1 million households) had more than one refrigerator. Detailed information on energy use within US households, with associated trends and drivers can be found in the Energy Information Administration's "Residential Energy Consumption Survey Home Energy Uses and Costs"[3].

On average, actual refrigerator unit energy consumption in use is similar to tested/declared data[4].

[3] Residential Energy Consumption Survey (RECS)
[4] Energy use of US residential refrigerators and freezers: function derivation based on household and climate characteristics. Jeffery Greenblatt & Asa Hopkins & Virginie Letschert & Michael Blasnik. Springer Science+Business Media B.V. 2012. www.springerlink.com/content/4gjk4714h86884q0/

# *Section 1.* Unit Energy Consumption and Unit Energy Efficiency Graphics

## *1.1 Test methodologies and Product Definitions*

### 1.1.1 *Product Definitions*

(Source: 10 CFR 430, Section 430.2)

***Built-in refrigerator/refrigerator-freezer/freezer*** means any refrigerator, refrigerator-freezer or freezer with 7.75 cubic feet or greater total volume and 24 inches or less depth not including doors, handles, and custom front panels; with sides which are not finished and not designed to be visible after installation; and that is designed, intended, and marketed exclusively (1) To be installed totally encased by cabinetry or panels that are attached during installation, (2) to be securely fastened to adjacent cabinetry, walls or floor, and (3) to either be equipped with an integral factory-finished face or accept a custom front panel.

***Compact refrigerator/refrigerator-freezer/freezer*** means any refrigerator, refrigerator-freezer or freezer with total volume less than 7.75 cubic foot (220 liters) (rated volume [as determined in accordance with the applicable DOE test procedure]).

***Electric refrigerator*** means a cabinet designed for the refrigerated storage of food, designed to be capable of achieving storage temperatures above 32 °F (0 °C) and below 39 °F (3.9 °C), and having a source of refrigeration requiring single phase, alternating current electric energy input only. An electric refrigerator may include a compartment for the freezing and storage of food at temperatures below 32 °F (0 °C), but does not provide a separate low temperature compartment designed for the freezing and storage of food at temperatures below 8 °F (−13.3 °C).

***Electric refrigerator-freezer*** means a cabinet which consists of two or more compartments with at least one of the compartments designed for the refrigerated storage of food and designed to be capable of achieving storage temperatures above 32 °F (0 °C) and below 39 °F (3.9 °C), and with at least one of the compartments designed for the freezing and storage of food at temperatures below 8 °F (−13.3 °C) which may be adjusted by the user to a temperature of 0 °F (−17.8 °C) or below. The source of refrigeration requires single phase, alternating current electric energy input only.

***Freezer*** means a cabinet designed as a unit for the freezing and storage of food at temperatures of 0 °F or below, and having a source of refrigeration requiring single phase, alternating current electric energy input only.

(Source: 10 CFR 430, Subpart B, Appendix A1)

***All-refrigerator*** means an electric refrigerator which does not include a compartment for the freezing and long time storage of food at temperatures below 32 °F (0.0 °C). It may include a compartment of 0.50 cubic feet capacity (14.2 liters) or less for the freezing and storage of ice.

Note:

1) The US Department of Energy (DoE) does not currently have standards for wine chillers or other consumer refrigeration products that are not designed to be capable of reaching compartment temperatures below 39 °F (3.9 °C). However, the DOE is planning on conducting a rulemaking to establish test procedures and energy conservation standards for such products in the future.

2) DOE also does not currently regulate as consumer products refrigerators or refrigerator-freezers with total refrigerated volume exceeding 39 cubic feet (1104 liters) and freezers with total refrigerated volume exceeding 30 cubic feet (850 liters), or refrigeration products that are designed to be operated without doors, that do not incorporate a compressor and condenser as an integral part of the cabinet assembly, or that are designed solely for use in recreational vehicles and other mobile equipment. However, some of these products, namely large refrigeration products and units without doors or with remote condensing units, are regulated as commercial equipment.

### *1.1.2 Test Methodology*

#### *1.1.2.1 Summary of Changes*

The US Department of the Environment (DOE) has finalized a new test method, which will become mandatory for product testing in 2014 when new energy conservation standards for household refrigerators and freezers become applicable to all products (see section 1.2). Because this method incorporates a number of changes to the test settings, it will result in an increase in a measured energy use for most classes of products.

The most significant change in measured energy use results from a lowering of the standardized compartment temperatures for refrigerators and refrigerator-freezers, which will yield an expected increase in measured energy use of approximately 12% to 18%, depending on the product type. The impact on all-refrigerators, for which DOE increased the standardized compartment temperature, will be a slight decline in measured energy use, and there will be no impact on freezers, as the compartment temperature for those products is unchanged. DOE also made an adjustment to the standards for a procedural change in the calculation of refrigerated volume. Unlike the change to the compartment temperatures, this adjustment does not result in a change in measured energy use.

In addition to the compartment temperature changes, DOE also adjusted the test cycle to account for the extra energy use by products with “precooling” prior to defrost and added a requirement that will capture energy use by heated special compartments. Because these changes only affect products that have these particular features, DOE made adjustments to the standards on a shipment-weighted basis in order to account for the percentage of products in each affected class that are likely to have them.

#### *1.1.2.2 Test Methodology*

The U.S. DOE test procedures for refrigerators and refrigerator-freezers are contained in Appendix A1 to Subpart B of 10 CFR Part 430. The test procedures for freezers are in Appendix B1 of the same subpart. These procedures are based in large part on the test methods in the Association of Home Appliance Manufacturers (AHAM) procedure HRF-1-1979, with numerous modifications over the years to address new technical developments (e.g. variable defrost). These procedures involve, at the most basic level, a closed-door test conducted in a 90 ˚F (32.2 ˚C) ambient test chamber that provides a representative test cycle, which is extrapolated mathematically to provide an energy consumption value for a 24-hour period in kilowatt-hours (kWh). For comparison with the DOE energy standards, this 24-hour value is multiplied by 365 days per year to yield a final energy consumption value in kWh per year.

The current procedures use a method that is designed to “bound” standardized internal compartment temperatures. The test is begun by conducting a test with all temperature

controls at the median position of the temperature dial(s) (or average value of the coldest and warmest settings for electronic controls), and the measured average temperatures are compared to the required "standardized" temperatures for each compartment. If one or both of the resulting temperatures are warmer than the standardized temperatures, a second test is performed with all temperature controls at the coldest position of the temperature dial(s); but if they are both colder, then the second test is performed at the warmest positions of the temperature dial(s). By bounding the standardized temperature, the method allows for interpolating the results of these measurements to determine the energy consumption at the standardized temperature rather than requiring iteration of temperature settings to achieve an exact match of internal temperatures with the standardized temperatures, which could greatly extend the test time.

The measurements are made for test periods defined based on characteristics of the product under test, such as the product's defrost system type and the presence of features such as dual evaporators or dual compressors. Energy consumption per 24-hour test cycle is calculated for each temperature control setting based on the energy use measurements and durations of the defined test periods. The energy use at the standardized temperatures per 24-hour test cycle is finally calculated using interpolation based on the compartment temperatures measured during the tests.

Starting September 15, 2014, when the revised energy conservation standards for these products will apply, manufacturers will be required to test and rate their products according to the revised DOE test procedure in Appendix A for refrigerators and refrigerator-freezers and Appendix B for freezers. There is a summary of the significant changes at the end of this section of the document. The principle elements that have changed which will affect energy consumption are the standardized compartment temperatures for the test, which were adjusted to be more closely in line with expected consumer use and international test methods, modification of existing test cycles to better capture energy use for defrost of products with more sophisticated control systems, and the addition of ice maker energy use for products with automatic ice makers. DOE also updated the volume measurement method to conform to AHAM HRF-1-2008.

The initial conditions and product set-up, standardized temperatures, and the other characteristics of the tests according to the current test procedures are listed below:

#### *1.1.2.3 Test Conditions:*

***Ambient Temperature during the Test:*** 90 ˚F (32.2 ˚C) +/- 1 ˚F, measured at locations 10 inches (25.4 cm) out from the centers of the two sides of the unit at a height of 36 inches (91.5 cm).

***Set-up and Establishment of Operating Conditions:*** Test units are to be set up and operating conditions maintained in accordance with the requirements of AHAM HRF-1-1979, unless otherwise specified by DOE. In general, this requires the following:

- ***Vertical ambient temperature gradient:*** maintained to no more than 0.5 ˚F per foot (0.9 ˚C per meter) during test and measured during test at locations 10 inches (25.4 cm) out from the centers of the two sides of the unit, and from 2 inches (5.1 cm) above the floor or supporting platform to a height of 1 foot (30.5 cm) above the top of the unit.
- ***Radiation:*** Shields are to be provided to prevent direct radiation from the test unit to or from any heated or cooled surfaces whose temperature differs from the air temperature by more than 10 ˚F (5.6 ˚C).
- ***Ambient relative humidity:*** Not controlled during the test.

- ***Air circulation:*** unit under test is shielded from direct air currents with a velocity of more than 50 feet per minute (0.254 meters per second)
- ***Power supply:*** units are tested using a power supply of 115V +/- 1% and 60 Hz
- ***Unit setup:*** units are set up for testing in accordance with the printed instructions supplied with the cabinet by the manufacturer, although built-in products are not installed in a built-in condition for the test. All the product's chutes and throats required for the delivery of ice are freed of packing, covers, or other blockages that may be fitted for shipping or when the icemaker is not in use. Other specific conditions are:
  - Baffles: open unless otherwise specified in manufacturer's instructions
  - Automatic icemakers: inoperative (but not turned off)
  - Butter conditioners: set to lowest energy usage position (if adjustment is provided)
  - Convenience lights, radios, clocks, hygienic lamps, and similar devices are set at their lowest energy usage positions when adjustment is provided
  - Features that are electrically powered, manually initiated, and automatically terminated within 168 hours (such as customer operated dispensers, fast chill compartments, electric door openers, etc.) are operated at their lowest energy usage position
  - Compartments which are convertible from refrigerator to freezer are operated in the highest energy usage position
  - Other temperature controllable compartments (such as crispers or meat keepers) are considered special compartments and are tested at the coldest temperature setting
  - Evaporators in manual defrost models are not defrosted prior to each test unless accumulated frost exceeds ¼ inch (0.6 cm) in average thickness.
  - Ice trays and ice buckets in models with non-automatic ice making are removed from the freezer compartment. Ice bins of units with automatic ice makers are not removed.
- ***Clearance to wall:*** the space between the back of the cabinet and a vertical surface (the test room wall or simulated wall) is the minimum distance in accordance with the manufacturer's instructions
- ***Water lines and filters:*** connection of these components is not required
- ***Anti-sweat heaters:*** If the test unit has an anti-sweat heater switch it should be tested twice, on during one test and off during a second test, and the results are averaged. In the case of an electric refrigerator-freezer with variable anti-sweat heater control, the standard cycle energy use is calculated by way of a formula given elsewhere in the procedure, which uses values for anti-sweat heater watts supplied by the manufacturer for each of several humidity conditions.
- ***Defrost controls:*** operative during the test
- ***Run-in period prior to testing:*** a week is recommended, but in no case is it less than 24-hours of compressor run time.

***Steady-state conditions:*** *temperature measurements in all measured compartments taken at four minute intervals or less during a stabilization period are not changing at a rate greater than 0.042 °F (0.023 °C) per hour during representative periods described in the procedure which depend upon compressor cycles.*

### *1.1.2.4 Test Control Settings:*

***Standardized Compartment Temperatures:***

- All-Refrigerator: 38 ˚F (3.3 ˚C) fresh food compartment temperature
- Refrigerator: 15 ˚F (-9.4 ˚C) freezer compartment temperature, 45 ˚F (7.2 ˚C) fresh food compartment temperature
- Refrigerator-Freezer: 5 ˚F (-15 ˚C) freezer compartment temperature, 45 ˚F (7.2 ˚C) fresh food compartment temperature
- Freezer: 0 ˚F (-17.8 ˚C)

**Treatment of Separate Auxiliary Compartments:** DOE defines such a compartment as a freezer compartment or a fresh food compartment of a refrigerator or refrigerator-freezer having more than two compartments that is not the first freezer compartment or the first fresh food compartment. Access to a separate auxiliary compartment is through a separate exterior door or doors (or a drawer) rather than through the door or doors of another compartment. Separate auxiliary compartments may be convertible (e.g., from fresh food to freezer), and are to be tested in their highest energy usage position. For separate auxiliary convertible compartments tested as freezer compartments, the median setting shall be within 2 °F (1.1 °C) of the standardized temperature, and the warmest setting shall be above 10 °F (−12.2 °C). For separate auxiliary convertible compartments tested as fresh food compartments, the median setting shall be within 2 °F (1.1 °C) of the standardized temperature, and the coldest setting shall be below 40 °F (4.4 °C). For compartments where control settings are not expressed as particular temperatures, the measured temperature of the convertible compartment rather than the settings shall meet the specified criteria.

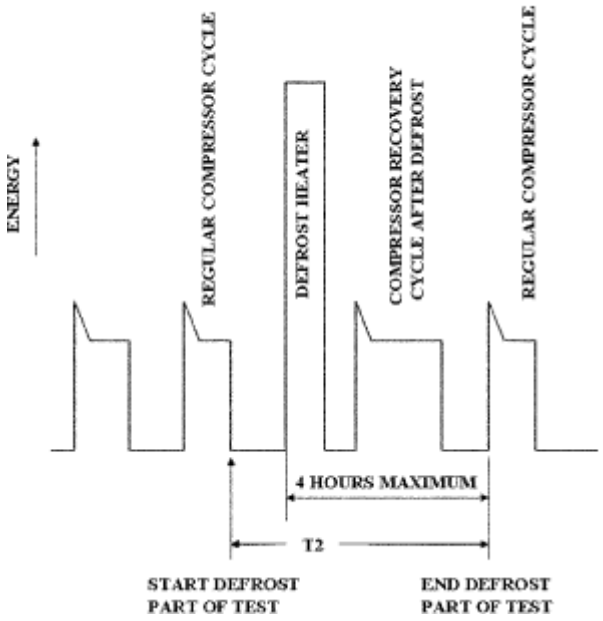
### *1.1.2.5 Test Periods:*

***Units with Manual Defrost:*** the test time period starts after steady-state conditions have been achieved and is no less than 3 hours in duration. During the test period, the compressor motor must complete two or more whole compressor cycles. (A compressor cycle is a complete “on” and a complete “off” period of the motor). If no “off” cycling occurs, as determined during the stabilization period, the test period is 3 hours.

***Units with Automatic Defrost:*** the test time period starts after steady-state conditions have been achieved and is from one point during a defrost period to the same point during the next defrost period, for example from the time of initiation of the defrost heater during one defrost cycle to the next initiation of the defrost heater. If the model being tested has a long-time automatic defrost system (i.e. where successive defrost cycles are separated by 14 hours or more of compressor-operating time) or variable defrost control (i.e., in which successive defrost cycles are determined by an operating condition variable or variables other than solely compressor operating time), the alternative procedure described below may be used.

***Units with Long-time or Variable Automatic Defrost:*** This test consist of two parts. The first part is the same as the test for a unit having no defrost provisions (manual defrost). The second part starts when a defrost cycle is initiated when the compressor “on” cycle is terminated prior to start of the defrost heater and terminates at the second turn “on” of the compressor or 4 hours from the initiation of the defrost heater, whichever comes first. See figure 1 below.

Figure 1
Long-time Automatic Defrost Diagram




***Units with Dual Compressor Systems with Automatic Defrost:*** DOE has a special provision for the small minority of models with separate compressor systems for the refrigerator and freezer sections, each with its own automatic defrost system. The procedure is essentially a variation of the two-part method for units with long-time automatic defrost.

### *1.1.2.6 Test Measurements:*

### *Compartment Temperature:*

Compartment temperatures for the fresh food and freezer compartments are determined for each test for each evaluated temperature control setting. The compartment temperature at a given time is equal to the average of all temperature sensor readings taken in that compartment at that time. Temperature sensor locations are prescribed, based on the compartment geometric details, as indicated in HRF-1-1979 Figure 7-1 for fresh food compartments and Figure 7-2 for freezer compartments,

Compartment temperatures are time-averaged over one or more complete compressor cycles. For products that require a two-part test, such as those with long-time automatic defrost and variable defrost models, the procedure uses the compartment temperatures measured in the first part of the test period, but if no compressor cycling occurs, the compartment temperature are the average of the measured temperatures taken during the last 32 minutes of the test period.

If there are separate auxiliary compartments (e.g. a second fresh food or freezer compartment with its own external door), the fresh food and freezer compartment temperatures are volume-weighted averages of the compartment temperatures measured separately as described above for the primary and separate auxiliary compartments. The formulas for calculating these averages are in the appendix to this document.

### *1.1.2.7 Changes Implemented for the Appendix A and Appendix B Procedures*

The following are important differences between the existing test procedures, and the procedures in Appendix A and Appendix B that will become required for testing in 2014.

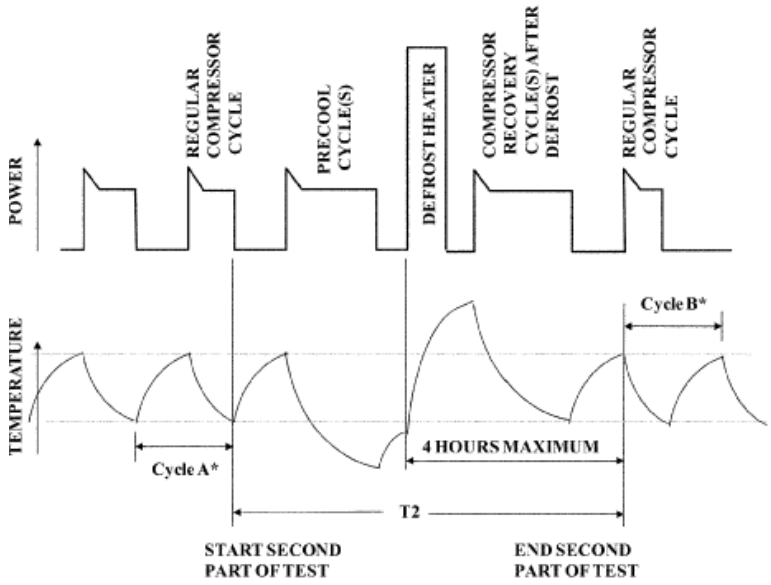
***Standardized compartment temperatures:***

- All-refrigerator: 39 °F (3.9 °C) fresh food compartment temperature;
- Refrigerator: 15 °F (−9.4 °C) freezer compartment temperature, 39 °F (3.9 °C) fresh food compartment temperature;
- Refrigerator-Freezer: 0 °F (−17.8 °C) freezer compartment temperature, 39 °F (3.9 °C) fresh food compartment temperature.
- In the existing procedure, the values are 38 for all-refrigerators, 15/45 for refrigerators, and 5/45 for refrigerator-freezers. The standardized temperature for freezers (0 ºF) did not change.

***Temperature Settings for Separate Auxiliary Convertible Compartments:*** The settings for these features were adjusted to be consistent with the new standardized compartment temperatures.

***Modification of the Test Period of Long-Time Automatic Defrost and Cycling Compressors:*** The test period was extended to capture “pre-cooling energy” prior to the defrost, and to ensure that the defrost part of the test does include pre-cooling energy and the energy used in temperature recovery. See figure 1 below.

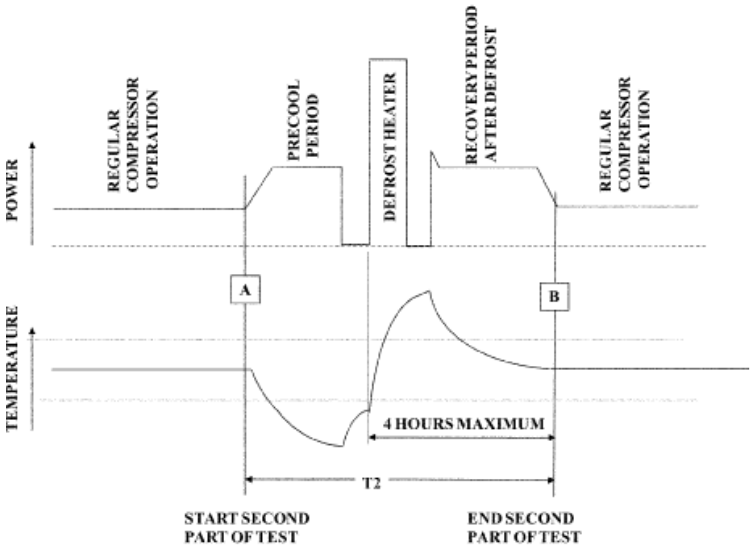
Long-time Automatic Defrost Diagram for Cycling Compressors




*Average compartment temperature during cycles A & B must be within 0.5 °F of the average temperature for the first part of the test. This requirement does not apply for cycle B if the 4 hour limit is reached.

***Modification of the Test Period for Long-Time Automatic Defrost and Non-Cycling Compressors:*** This method was added to allow for a method of testing products with variable speed compressors that do not cycle. See figure 2 below.

Long-time Automatic Defrost Diagram for Non-Cycling Compressors




*Average compartment temperature at times A & B must be within 0.5 °F of the average temperature for the first part of the test. This requirement does not apply for time B if the 4 hour limit is reached.

***Products with automatic ice makers:*** For the derived energy calculation, a standard energy consumption value was added to the formulas to account for automatic ice makers. In each case, the same formulas for "E" are used, but a value designated "IET" is added to the end of each. IET is equal to 0.23 (in kilowatt-hours per cycle) for products with an automatic ice maker and zero for products without an automatic icemaker. This value is equal to approximately 84 kilowatt-hours per year, which is accounted for in the energy standards by increasing the energy standards for products with automatic icemakers by 84 kilowatt-hours.

***Additional provision for Heated Special Compartments:*** for special compartments in which temperature control is achieved using the addition of heat (including resistive electric heating, refrigeration system waste heat, or heat from any other source, but excluding the transfer of air from another part of the interior of the product) for any part of the controllable temperature range of that compartment, the product energy use shall be determined by averaging two sets of tests. The first set of tests shall be conducted with such special compartments at their coldest settings, and the second set of tests shall be conducted with such special compartments at their warmest settings. The requirements for the warmest or coldest temperature settings of this section do not apply to features or functions associated with temperature control (such as fast chill compartments) that are initiated manually and terminated automatically within 168 hours.

***Adjustment factors for calculating adjusted volume:*** in order to account for the changes in standardized compartment temperatures, DOE also modified the adjustment factors that are used to calculate adjusted volume for the purposes of comparing energy use measurements with the energy conservation standards. The new adjustment factors are:

- Refrigerators other than all-refrigerators: 1.47 (from 1.44 in the old procedure)
- Refrigerator-freezers: 1.76 (from 1.63 in the old procedure)
- Freezers: 1.76 (from 1.73 in the old procedure)
- The volume adjustment factor for all-refrigerators remains the same at 1.0.

***Clearance to the Wall During Testing:*** Under the existing procedure, DOE specifies that the space between the back of the cabinet and a vertical surface (the test room wall or simulated wall) shall be the minimum distance in accordance with the manufacturer's

instructions. For the revised procedure, DOE added a maximum allowed distance of 2 inches from the plane of the cabinet's back panel to the vertical surface, and provided that if permanent rear spacers extend further than this distance, the appliance shall be located with the spacers in contact with the vertical surface.

## *1.2 Product Classifications and Performance Requirements*

The following product classifications and MEPS levels have been in effect since 1 July 2001 and remain in force until September 15, 2014 (10 CFR 430, Section 430.32(a). Note that there are a few additions to this listing (eg category 10A), but these additions are for a very limited number of products.

| Product class | Energy standard equations for maximum energy use (kWh/yr) |
|---|---|
| 1. Refrigerators and refrigerator-freezers with manual defrost | 8.82AV+248.4<br>0.31av+248.4 |
| 2. Refrigerator-freezers—partial automatic defrost | 8.82AV+248.4<br>0.31av+248.4 |
| 3. Refrigerator-freezers—automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerator—automatic defrost | 9.80AV+276.0<br>0.35av+276.0 |
| 4. Refrigerator-freezers—automatic defrost with side-mounted freezer without through-the-door ice service | 4.91AV+507.5<br>0.17av+507.5 |
| 5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without through-the-door ice service | 4.60AV+459.0<br>0.16av+459.0 |
| 6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service | 10.20AV+356.0<br>0.36av+356.0 |
| 7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service | 10.10AV+406.0<br>0.36av+406.0 |
| 8. Upright freezers with manual defrost | 7.55AV+258.3<br>0.27av+258.3 |
| 9. Upright freezers with automatic defrost | 12.43AV+326.1<br>0.44av+326.1 |
| 10. Chest freezers and all other freezers except compact freezers | 9.88AV+143.7<br>0.35av+143.7 |
| 11. Compact refrigerators and refrigerator-freezers with manual defrost | 10.70AV+299.0<br>0.38av+299.0 |
| 12. Compact refrigerator-freezer—partial automatic defrost | 7.00AV+398.0<br>0.25av+398.0 |
| 13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer and compact all-refrigerator—automatic defrost | 12.70AV+355.0<br>0.45av+355.0 |
| 14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer | 7.60AV+501.0<br>0.27av+501.0 |
| 15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer | 13.10AV+367.0<br>0.46av+367.0 |

| Product class | Energy standard equations for maximum energy use (kWh/yr) |
|---|---|
| 16. Compact upright freezers with manual defrost | 9.78AV+250.8<br>0.35av+250.8 |
| 17. Compact upright freezers with automatic defrost | 11.40AV+391.0<br>0.40av+391.0 |
| 18. Compact chest freezers | 10.45AV+152.0<br>0.37av+152.0 |

*AV: Adjusted Volume in $ft^3$; av: Adjusted Volume in liters (L).*

Note:

1. There is also a product class 5A standard in effect prior to 2014 for certain refrigerator-freezers with automatic defrost and through-the-door ice that were granted exception relief by DOE's Office of Hearings and Appeals. The standard is 5.0AV + 539.0 kWh per year. DOE also granted exception relief for a manufacturer of chest freezers with automatic defrost, designated as class 10A. The standard for the products granted relief is 14.76AV + 211.5 kWh per year.

The following product categorisations and MEPS levels apply to products manufactured starting on September 15, 2014.

| Product class | Equations for maximum energy use (kWh/yr) | |
|---|---|---|
| | Based on AV ($ft^3$) | Based on av (L) |
| 1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost | 7.99AV + 225.0 | 0.282av + 225.0 |
| 1A. All-refrigerators—manual defrost | 6.79AV + 193.6 | 0.240av + 193.6 |
| 2. Refrigerator-freezers—partial automatic defrost | 7.99AV + 225.0 | 0.282av + 225.0 |
| 3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker | 8.07AV + 233.7 | 0.285av + 233.7 |
| 3–BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker | 9.15AV + 264.9 | 0.323av + 264.9 |
| 3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service | 8.07AV + 317.7 | 0.285av + 317.7 |
| 3I–BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service | 9.15AV + 348.9 | 0.323av + 348.9 |
| 3A. All-refrigerators—automatic defrost | 7.07AV + 201.6 | 0.250av + 201.6 |
| 3A–BI. Built-in All-refrigerators—automatic defrost | 8.02AV + 228.5 | 0.283av + 228.5 |
| 4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker | 8.51AV + 297.8 | 0.301av + 297.8 |
| 4–BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker | 10.22AV + 357.4 | 0.361av + 357.4 |
| 4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service | 8.51AV + 381.8 | 0.301av + 381.8 |
| 4I–BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service | 10.22AV + 441.4 | 0.361av + 441.4 |

| Product class | Equations for maximum energy use (kWh/yr) | |
|---|---|---|
| | Based on AV ($ft^3$) | Based on av (L) |
| 5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker | 8.85AV + 317.0 | 0.312av + 317.0 |
| 5–BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker | 9.40AV + 336.9 | 0.332av + 336.9 |
| 5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service | 8.85AV + 401.0 | 0.312av + 401.0 |
| 5I–BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service | 9.40AV + 420.9 | 0.332av + 420.9 |
| 5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service | 9.25AV + 475.4 | 0.327av + 475.4 |
| 5A–BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service | 9.83AV + 499.9 | 0.347av + 499.9 |
| 6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service | 8.40AV + 385.4 | 0.297av + 385.4 |
| 7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service | 8.54AV + 432.8 | 0.302av + 432.8 |
| 7–BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service | 10.25AV + 502.6 | 0.362av + 502.6 |
| 8. Upright freezers with manual defrost | 5.57AV + 193.7 | 0.197av + 193.7 |
| 9. Upright freezers with automatic defrost without an automatic icemaker | 8.62AV + 228.3 | 0.305av + 228.3 |
| 9I. Upright freezers with automatic defrost with an automatic icemaker | 8.62AV + 312.3 | 0.305av + 312.3 |
| 9–BI. Built-In Upright freezers with automatic defrost without an automatic icemaker | 9.86AV + 260.9 | 0.348av + 260.9 |
| 9I–BI. Built-in upright freezers with automatic defrost with an automatic icemaker | 9.86AV + 344.9 | 0.348av + 344.9 |
| 10. Chest freezers and all other freezers except compact freezers | 7.29AV + 107.8 | 0.257av + 107.8 |
| 10A. Chest freezers with automatic defrost | 10.24AV + 148.1 | 0.362av + 148.1 |
| 11. Compact refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost | 9.03AV + 252.3 | 0.319av + 252.3 |
| 11A.Compact all-refrigerators—manual defrost | 7.84AV + 219.1 | 0.277av + 219.1 |
| 12. Compact refrigerator-freezers—partial automatic defrost | 5.91AV + 335.8 | 0.209av + 335.8 |
| 13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer | 11.80AV + 339.2 | 0.417av + 339.2 |
| 13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker | 11.80AV + 423.2 | 0.417av + 423.2 |
| 13A. Compact all-refrigerators—automatic defrost | 9.17AV + 259.3 | 0.324av + 259.3 |
| 14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer | 6.82AV + 456.9 | 0.241av + 456.9 |
| 14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker | 6.82AV + 540.9 | 0.241av + 540.9 |
| 15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer | 11.80AV + 339.2 | 0.417av + 339.2 |
| 15I. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker | 11.80AV + 423.2 | 0.417av + 423.2 |
| 16. Compact upright freezers with manual defrost | 8.65AV + 225.7 | 0.306av + 225.7 |
| 17. Compact upright freezers with automatic defrost | 10.17AV + 351.9 | 0.359av + 351.9 |
| 18. Compact chest freezers | 9.25AV + 136.8 | 0.327av + 136.8 |

AV = Total adjusted volume, expressed in $ft^3$, as determined in appendices A and B of subpart B of 10 CFR 430.
av = Total adjusted volume, expressed in Liters.

Note:

1. Product classes with automatic icemakers have a standard "adder" for the icemaker. This is equivalent to 84 kWh/year, as explained at the end of the test procedure section below. DOE is planning a test procedure rulemaking to establish a laboratory-based test procedure to determine icemaking energy use to replace this 84 kWh adder. After development of this icemaking test procedure, the 84 kWh adder used in the standards table above will likely be adjusted for consistency with test results for available products.

## *1.3 Data sources and limitations*

All product weighted data and best/worst products are based on the ***Home Energy*[5] magazine** (HEM) refrigerated appliances database. The HEM database is believed to be representative in part because the results are consistent with other databases and data that should be representative. For example, HEM is consistent with FTC data for the years the FTC database covers (which should include all refrigerators in compliance with federal regulation) and with the AHAM (Association of Home Appliance Manufacturers) sales weighted energy use data, which is an average over all refrigerators sold in the US.

The sales weighted data was purchased (by the US DoE) from **The NPD Group, Inc./Retail Tracking Service** (formerly *National Purchase Diary*)[6]. This data is originally sourced as actual sales data from retailers and distributors. It is estimated that the data covers approximately 40% of US sales (the NPD Group, Inc. data in 2008 reports sales of 3.5m compared with a total US market of approximately 9m).

The number of models and sales analysed by product category are presented in the tables below.

***Refrigerator freezers (Home Energy Magazine):***

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Products in dataset | 301 | 696 | 2811 | 2163 | 2260 | 934 | 888 | 4629 | 4179 | 2284 | 2557 | 1983 | 2494 | 3468 |
| Products analysed | 301 | 695 | 2811 | 2163 | 2260 | 933 | 887 | 4625 | 4169 | 2282 | 2555 | 1980 | 2488 | 3459 |
| % products included | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

***Refrigerator freezers (The NPD Group, Inc.):***

| | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Products in dataset | 5252 | 5295 | 4898 | 4589 |
| Products analysed | 979 | 1269 | 1615 | 1742 |
| % products included | 19% | 24% | 33% | 38% |
| Sales in dataset ('000s) | *Confidential Commerical data* | | | |
| Sales analysed ('000s) | *Confidential Commerical data* | | | |
| % Sales included | 85% | 90% | 91% | 89% |

***Freezers (Home Energy Magazine):***

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Products in dataset | 480 | 638 | 472 | 140 | 145 | 285 | 382 | 871 | 987 | 205 | 458 | 338 | 338 | 168 |
| Products analysed | 480 | 638 | 472 | 140 | 145 | 285 | 381 | 871 | 986 | 205 | 458 | 338 | 337 | 168 |
| % products included | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

[5] http://www.homeenergy.org/
[6] https://www.npd.com/wps/portal/npd/uk/home.

***Freezers (The NPD Group, Inc.):***

| | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Products in dataset | 342 | 366 | 353 | 303 |
| Products analysed | 92 | 96 | 116 | 94 |
| % products included | 27% | 26% | 33% | 31% |
| Sales in dataset ('000s) | *Confidential Commerical data* | | | |
| Sales analysed ('000s) | *Confidential Commerical data* | | | |
| % Sales included | 92% | 96% | 95% | 92% |

## *1.4 Data manipulations and specific limitations*

### *1.4.1 Overview of the mapping and benchmarking process*

There are essentially 4 stages to the mapping and benchmarking process for domestic refrigerated appliances as detailed below:

| Stage: | Description |
|---|---|
| 1. Data Cleaning and Pre-processing | • Removal of duplicate entries<br>• Pre-processing to align all terminology and reported test values to be consistent between countries<br>• Assigning of local, mapping and benchmarking and EU categories<br>• Etc |
| 2. Production of mapping outputs | • Production of mapping outputs based on local test methodologies |
| 3. Normalisation of test data | • Calculation of adjusted volumes<br>• Assignment Unit Energy Consumption to individual compartments<br>• Normalisation for test temperature differentials |
| 4. Production of Benchmarking outputs | • Post processing of benchmarking results<br>• Production of benchmarking report |

The details of this process are described in three supporting documents that accompany this mapping report:

1. The **product definition** describes the exact characteristics of the product being analysed; the energy metrics that will be calculated; the technological, usage and other characteristics that will be considered; and any other policy or cultural information that will be collected
2. The **summary of approach** provides an overview of the mapping and benchmarking process for analyzing domestic refrigerated appliances for all countries and regions.
3. The **actions and assumptions** report details the specific steps that were necessary to allow the data submitted from a specific country or region to be included in the mapping and benchmarking process as described in the product definition and summary of approach. A separate “actions and assumptions” report has been created for each of the datasets used in this USA mapping document.

All these documents can be found at the annex website:

http://mappingandbenchmarking.iea-4e.org/matrix

by clicking on the "X" in the matrix table that aligns with the *USA* and *Domestic refrigerated appliances 2012*.

### 1.4.2 Specific cautions for this data

Please refer to the actions and assumptions document described in Section 1.4.1.

## 1.5 Alternative data sets

### 1.5.1 Alternative data sources and limitations

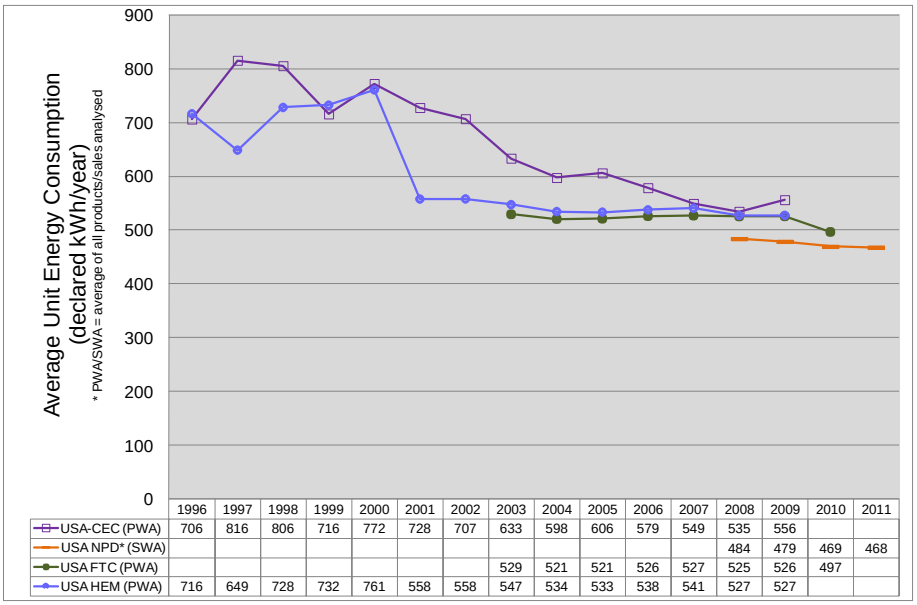
This mapping report is based on 2 datasets selected by USA government officials and experts to be the *most* representative of the USA market. However, an additional datasets were analysed from the Federal Trade Commission (FTC)[7] and the California Energy Commission (CEC)[8]. To provide full transparency, and to potentially assist future researchers and analysts, a summary comparison of the other data sets is provided below.

The analysis of the FTC and CEC databases follows exactly the same methodology used for the HEM and the NPD Group, Inc. datasets as outlined in sections 1.4.1, and similar "Actions and Assumptions" reports have been produced for the FTC and CEC datasets (available by following the link shown at the bottom of section 1.4.1). The graphics below show the comparative results of all datasets analysed for each of the primary metrics presented in the Benchmarking report, along with the summary tables of models analysed in the FTC and HEM databases by product category.

It should be noted that while all datasets are considered representative of the overall USA market[9], there are inevitably differences in outcomes due to limitations in the methodology for capture and storage of product data by each source. It is particularly important to note that resultant analysis of the sales weighted UEE (based on the NPD Group, Inc. data), and the product weighted UEE data from all sources, including the NPD Group, Inc. dataset itself, vary significantly. This appears to be a result of consumers purchasing products with an average UEE that is worse than that of the average product on sale in the market. However, this cannot be confirmed due to the limited product coverage of the NPD Group Inc. UEC data.

[7] http://www.ftc.gov/bcp/conline/edcams/eande/appliances/index.htm
[8] http://www.energy.ca.gov/appliances/database/
[9] The CEC database should in principle include all refrigerators sold in California (which should be almost all refrigerators sold in the US). The issue associated with the CEC database is a known number of errors, in particular duplications. While significant effort has been made to remove duplications, experts in the USA believe the CEC data set is still less representative than the HEM data set. The FTC data set should include all refrigerators in compliance with federal regulation, so it should be very representative, but it covers a shorter time frame than CEC or HEM. Note also that HEM, FTC, and CEC are all simple product lists and only the NPD Group Inc. data has sales weighted information (refer to section 1.3 for a summary of limitations of the NPD Group Inc. and HEM data sets).

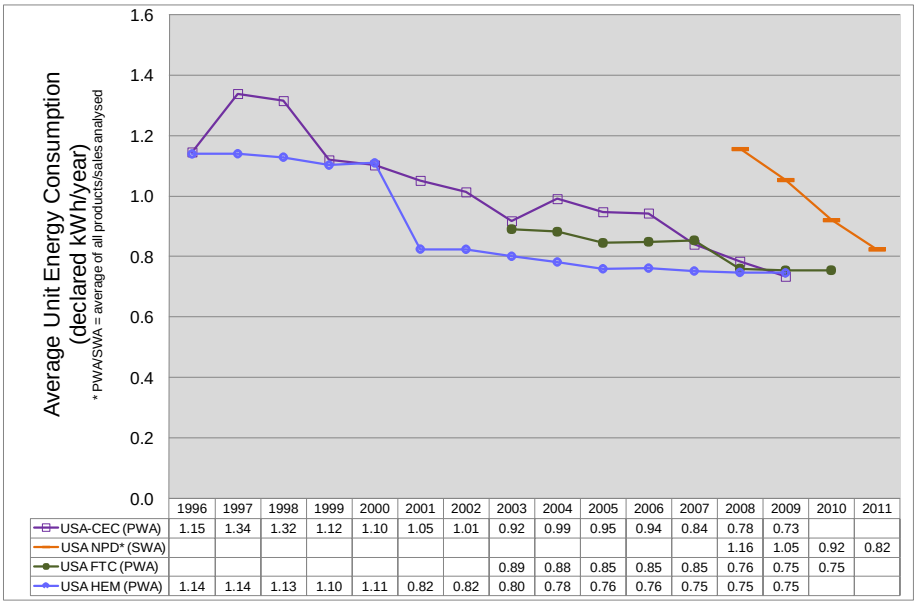
# Unit Energy Consumption of Refrigerator Freezers in the USA




| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USA-CEC (PWA) | 706 | 816 | 806 | 716 | 772 | 728 | 707 | 633 | 598 | 606 | 579 | 549 | 535 | 556 | | |
| USA NPD* (SWA) | | | | | | | | | | | | | 484 | 479 | 469 | 468 |
| USA FTC (PWA) | | | | | | | | 529 | 521 | 521 | 526 | 527 | 525 | 526 | 497 | |
| USA HEM (PWA) | 716 | 649 | 728 | 732 | 761 | 558 | 558 | 547 | 534 | 533 | 538 | 541 | 527 | 527 | | |

* Source: The NPD Group, Inc./Retail Tracking Service

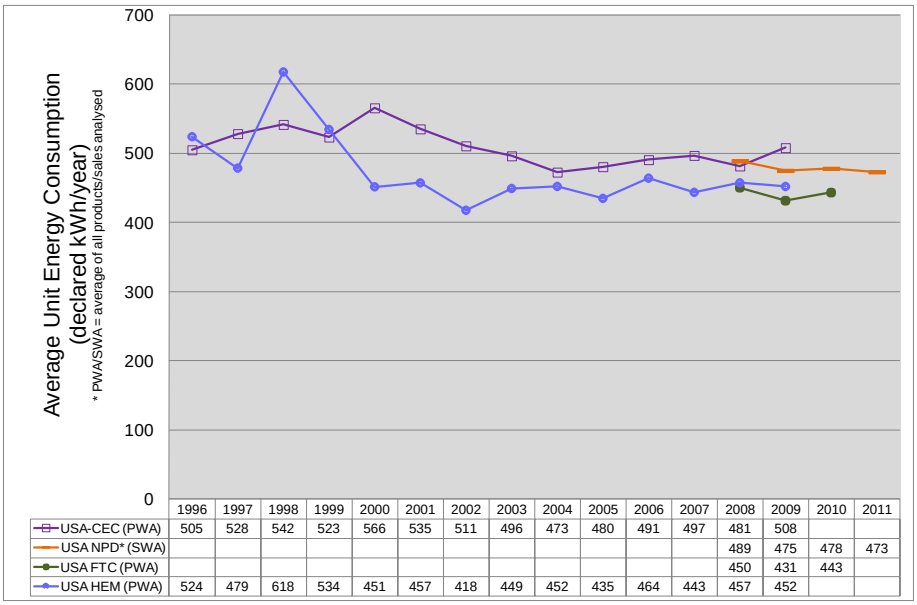
# Unit Energy Efficiency of Refrigerator Freezers in the USA




| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USA-CEC (PWA) | 1.15 | 1.34 | 1.32 | 1.12 | 1.10 | 1.05 | 1.01 | 0.92 | 0.99 | 0.95 | 0.94 | 0.84 | 0.78 | 0.73 | | |
| USA NPD* (SWA) | | | | | | | | | | | | | 1.16 | 1.05 | 0.92 | 0.82 |
| USA FTC (PWA) | | | | | | | | 0.89 | 0.88 | 0.85 | 0.85 | 0.85 | 0.76 | 0.75 | 0.75 | |
| USA HEM (PWA) | 1.14 | 1.14 | 1.13 | 1.10 | 1.11 | 0.82 | 0.82 | 0.80 | 0.78 | 0.76 | 0.76 | 0.75 | 0.75 | 0.75 | | |

* Source: The NPD Group, Inc./Retail Tracking Service.
Other data from:
CEC: California Energy Commission
FTC: Federal Trade Commission
HEM: Home Energy Magazine

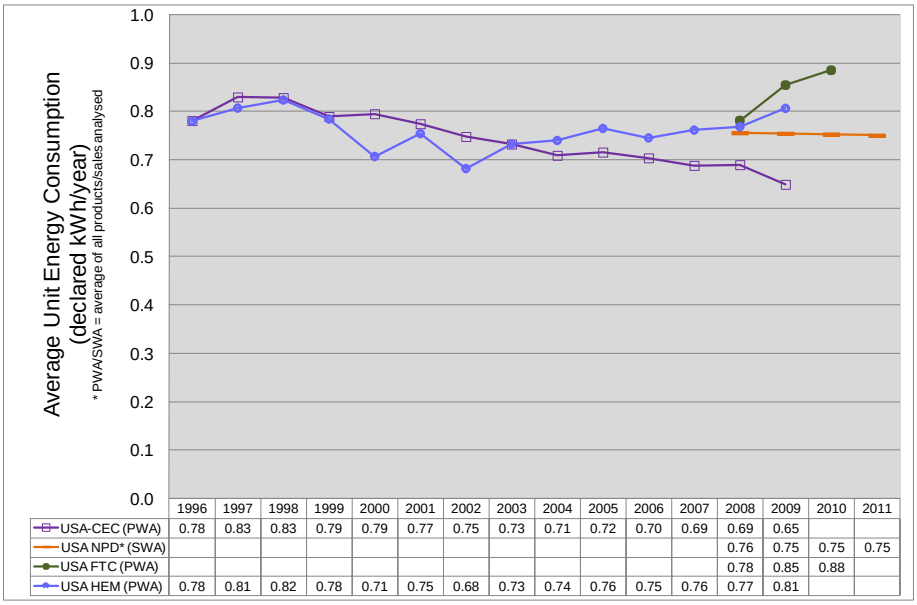
## Unit Energy Consumption of Freezers in the USA




| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USA-CEC (PWA) | 505 | 528 | 542 | 523 | 566 | 535 | 511 | 496 | 473 | 480 | 491 | 497 | 481 | 508 | | |
| USA NPD* (SWA) | | | | | | | | | | | | | 489 | 475 | 478 | 473 |
| USA FTC (PWA) | | | | | | | | | | | | | 450 | 431 | 443 | |
| USA HEM (PWA) | 524 | 479 | 618 | 534 | 451 | 457 | 418 | 449 | 452 | 435 | 464 | 443 | 457 | 452 | | |

* Source: The NPD Group, Inc./Retail Tracking Service

## Unit Energy Efficiency of Freezers in the USA




| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USA-CEC (PWA) | 0.78 | 0.83 | 0.83 | 0.79 | 0.79 | 0.77 | 0.75 | 0.73 | 0.71 | 0.72 | 0.70 | 0.69 | 0.69 | 0.65 | | |
| USA NPD* (SWA) | | | | | | | | | | | | | 0.76 | 0.75 | 0.75 | 0.75 |
| USA FTC (PWA) | | | | | | | | | | | | | 0.78 | 0.85 | 0.88 | |
| USA HEM (PWA) | 0.78 | 0.81 | 0.82 | 0.78 | 0.71 | 0.75 | 0.68 | 0.73 | 0.74 | 0.76 | 0.75 | 0.76 | 0.77 | 0.81 | | |

* Source: The NPD Group, Inc./Retail Tracking Service.
Other data from:
CEC: California Energy Commission
FTC: Federal Trade Commission
HEM: Home Energy Magazine

The number of models analysed by product category are presented in the tables below.

***CEC Refrigerator freezers:***

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Products in dataset | 2046 | 6327 | 7147 | 4030 | 1855 | 2279 | 2065 | 1031 | 932 | 465 | 363 | 483 | 639 | 448 |
| Products analysed | 2046 | 6327 | 7147 | 4030 | 1855 | 2279 | 2065 | 1031 | 932 | 465 | 363 | 483 | 639 | 448 |
| % products included | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

***FTC Refrigerator freezers:***

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| Products in dataset | 2583 | 2130 | 2197 | 2728 | 2103 | 2609 | 3581 | 1543 |
| Products analysed | 2582 | 2130 | 2197 | 2728 | 2103 | 2609 | 3578 | 1543 |
| % products included | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

***CEC Freezers:***

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Products in dataset | 1451 | 2831 | 3276 | 2431 | 584 | 826 | 943 | 343 | 339 | 313 | 324 | 297 | 264 | 174 |
| Products analysed | 1450 | 2830 | 3276 | 2431 | 584 | 826 | 943 | 343 | 339 | 313 | 324 | 297 | 264 | 174 |
| % products included | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

***FTC Feezers:***

| | 2008 | 2009 | 2010 |
|---|---|---|---|
| Products in dataset | 371 | 226 | 118 |
| Products analysed | 371 | 226 | 118 |
| % products included | 100% | 100% | 100% |

# *Section 2.* Energy Consumption of the installed stock of refrigerated appliances graphic

## *2.1 Data sources and limitations*

*Sources:* Stock and Energy Consumption projections generated by Lawrence Berkeley National Laboratory based on National Impact Assessment Spreadsheets used in US Standards Development.

# Section 3. Major Policy Interventions

## 3.1 Minimum Energy Performance Standards

The U.S. government established a mandatory compliance program in the 1970s requiring that certain types of new appliances bear a label to help consumers compare the energy efficiency among similar products.

Minimum standards of energy efficiency for many major appliances were established by the U.S. Congress in the National Appliance Energy Conservation Act (NAECA) of 1987, and in the National Appliance Energy Conservation Amendments of 1988. Standards for some fluorescent and incandescent reflector lamps, plumbing products, electric motors, and commercial water heaters, heating, ventilation and air conditioning (HVAC) systems were added in the Energy Policy Act of 1992 (EPACT). The U.S. Department of Energy (DOE) is responsible for developing the standards and test procedures for the Appliance Standards Program as well as periodically issues new standards for specific appliances.

In December 2007, the Congress enacted H.R. 6, requiring that DOE complete a rulemaking to consider strengthened standards for residential refrigerators by December 31st, 2010. This is now complete and requires compliance by September 15, 2014 (refer section 1.1 and 1.2 above).

### 3.1.1 Statutory Authority

The Energy Policy and Conservation Act (EPCA) (42 U.S.C. 6291, et seq.) established the Energy Conservation Program for Consumer Products Other than Automobiles, covering major household appliances including residential refrigerators, refrigerator-freezers, and freezers. The National Appliance Energy Conservation Act of 1987 subsequently amended EPCA by establishing energy conservation standards for residential refrigerators, refrigerator-freezers, and freezers. The Energy Independence and Security Act of 2007 (EISA) then required the U.S. Department of Energy (DOE) to review and amend energy conservation standards for residential refrigerators, refrigerator-freezers, and freezers. DOE is currently developing amended standards pursuant to 42 U.S.C. 6295(b)(4).

## 3.2 Mandatory Labelling: EnergyGuide

In 1980, the Federal Trade Commission (FTC) Appliance Labeling Rule became effective, and requires that EnergyGuide labels be placed on all new appliances. The FTC is responsible for the design, implementation and compliance of this program. The National Institute of Standards and Technology (NIST) is responsible for the test procedures.

The EnergyGuide label on refrigerators indicate how much electricity in kilowatt-hours (kWh) a particular model uses in one year.

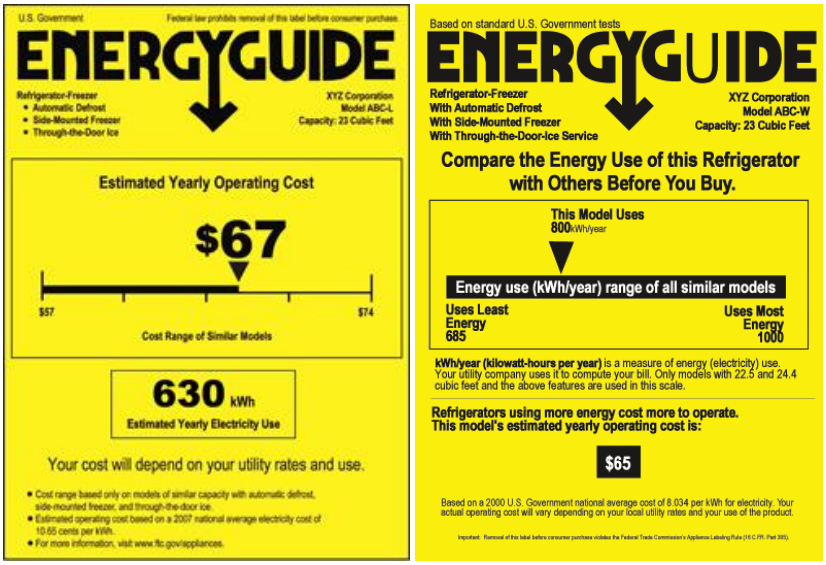
### 3.2.1 The New EnergyGuide Label

The Federal Trade Commission announced in August, 2007 that it has concluded a two-year review of the FTC's Appliance Labeling Rule (16 C.F.R. Part 305) and, after substantial public comment and consumer research, has amended the Rule to improve the design and content of the EnergyGuide label required on most new appliances sold in the United States[10]. The yellow EnergyGuide label, familiar to most appliance shoppers, helps

[10] http://www.ftc.gov/os/2007/08/070807appliancerule.pdf

consumers compare the "operating costs" of competing models and aids them in identifying high-efficiency models that will reduce their energy use.

The new EnergyGuide label displays estimated yearly operating costs prominently for most appliance types. This estimated cost information, appears on the labels in dollars per year and provides consumers with a clear context to compare the energy efficiency of different appliance models. It also helps consumers assess trade-offs between the energy costs of their appliances and other expenditures. The new EnergyGuide label design continues to display energy consumption information (e.g., annual electricity use) as a secondary disclosure for most labeled products.




## 3.3 *Voluntary Labelling: Energy Star*

Energy Star is jointly managed by the Environment Protection Agency (EPA) and the US Department of Energy (DOE) since 1992 as a voluntary, market-based partnership that seeks to reduce air pollution through increased energy efficiency. The program originally covered only computers, monitors and printers, but has now been expanded to cover a wide variety of appliances, equipment, building products and homes and windows. Products that have earned the Energy Star designation prevent greenhouse gas emissions by meeting strict energy-efficiency specifications set by the government.

### 3.3.1 *Labelling Requirement:*

Refrigerator, refrigerator-freezer, and freezer models must be at least 7.75 ft³ in total (refrigerator plus freezer) volume.

To qualify for the label, refrigerator and refrigerator-freezer models which meet above criteria must use 20% less energy than the July 1, 201 MEPS level or minimum federal standards for a refrigerator or refrigerator-freezer of that size and configuration, and freezer models which meet the above criteria must use 10% less energy than the July 1, 2011 MEPS level for a freezer of that size and configuration[11].

[11] The current ENERGY STAR specifications for refrigerators are available at: http://www.energystar.gov/index.cfm?c=refrig.pr_crit_refrigerators


In 2009, it is estimated that at least 35%[12] of refrigerators in the US are qualified to carry the Energy Star Label.

[12] http://www.energystar.gov/index.cfm?c=manuf_res.pt_appliances#asd

## *Section 4.* Cultural Issues

No additional notes.