**Work Paper WPSDGEREAP001**

**Revision 0**

**San Diego Gas & Electric**

Energy Efficiency Engineering

**Energy Star**

**Refrigerators**

### Core Measure Summary Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| General Measure Information | | | | | | | | PT | 1st Baseline Period | | | | 2nd Baseline Period | | | | TOU | IR |
| Measure Name | Measure RunID | Solution Code | CZ | Building Type | Load Shape | EUL | Unit Definition | Program Type (NEW, ROB, RET) | Gross Unit Annual Electricity Savings (kWh/unit) | User Entered kW Savings per unit (kW/unit) | Gas Savings (Therms) | 1st Baseline Useful Life | kWh Saving per unit (kWh/unit) | kW Savings per unit (kW/unit) | Gas Savings (Therms) | 2nd Baseline Useful Life | % TOU | Installation Rate |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 6 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 7 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 8 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 9 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 10 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 13 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 14 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 15 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | To be Exported by MMDB | AP-39992 | 16 | Residential-Single Family | DEER:RefgFrzr\_HighEff | 14.0 | Unit | ROB | 114.65 | 0.02502 | 0.00 | 14.0 | N/A | N/A | N/A | N/A | 0 | 1 |

Note: **For the complete list of Measures, refer to the attached calculation spreadsheet**

### Costing and NTG Summary Table

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| General Measure Information | | | | PT | NTG | | | 1st Baseline Period | 2nd Baseline Period | IMC | DIM |
| Measure Name | Solution Code | CZ | Unit Definition | Program Type (NEW, ROB, RET) | NTG Non-Res. | NTG Res. | NTG Multi Family | Gross Measure Cost per unit | Gross Measure Cost per unit | Incremental Measure Cost per unit | Delivery & Incentive Method |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 06 | Unit | ROB | 0.XX | 0.55 | 0.55 | $26.10 | N/A | $26.10 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 07 | Unit | ROB | 0.XX | 0.55 | 0.55 | $30.00 | N/A | $30.00 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 08 | Unit | ROB | 0.XX | 0.55 | 0.55 | $28.08 | N/A | $28.08 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 09 | Unit | ROB | 0.XX | 0.55 | 0.55 | $28.89 | N/A | $28.89 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 10 | Unit | ROB | 0.XX | 0.55 | 0.55 | $27.12 | N/A | $27.12 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 13 | Unit | ROB | 0.XX | 0.55 | 0.55 | $26.82 | N/A | $26.82 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 14 | Unit | ROB | 0.XX | 0.55 | 0.55 | $26.37 | N/A | $26.37 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 15 | Unit | ROB | 0.XX | 0.55 | 0.55 | $28.08 | N/A | $28.08 | Financial Support / Down-Stream Incentive - Deemed |
| 447 kWh/yr Energy Star Bottom Mount Freezer - small (8-16.5 ft3) Refrigerator replacing 518 kWh/yr rated Refrigerator | AP-39992 | 16 | Unit | ROB | 0.XX | 0.55 | 0.55 | $29.61 | N/A | $29.61 | Financial Support / Down-Stream Incentive - Deemed |

Note: **For the complete list of Measures, refer to the attached calculation spreadsheet**

# Document Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Revision #** | **MM/DD/YY** | **Author/Affiliation** | **Summary of Changes** |
| 0 | 6/15/2012 | Charles Harmstead (SDGE) | Adopted from SCE workpaper Energy Star Refrigerators WPSCREAP0001 Rev 5 Dated April 19, 2012. Revised NTGR to DEER 2011. (Added CZ7, updated August 30, 2012). |

# Section 1. General Measure & Baseline Data

## 1.1 Measure & Delivery Description

### 1.1a Measure Description

This work paper details the E3 Calculator inputs for the purchase and installation of Refrigerators that meet Energy Star requirements (*ES*-Refrigerator) instead of Federal Minimum Code efficiency (*Fed Min*-Refrigerator) requirements including full-size refrigerator-freezers eligible for Most Efficient recognition in 2012.

Refrigerator configurations and size details for both full size and compact refrigerators are shown in .

**Table 1 Measure Details: Refrigerator Configurations**

|  |  |  |  |
| --- | --- | --- | --- |
| Solution Code | Refrigerator Configuration | | Total Volume  (cubic feet) |
|  |  | | |
| AP-39992 | Small | Bottom Mount Freezer | 8 - 16.5 |
| AP-Hold1 | Medium | Bottom Mount Freezer | 18.0 and smaller  (ES 2012\*) |
| AP-Hold2 | Medium w/ICE\*\* | Bottom Mount Freezer | 18.0 and smaller  (ES 2012\*) |
| AP-68842 | Large | Bottom Mount Freezer | 16.5 or greater |
| AP-Hold3 | Large | Bottom Mount Freezer | 18.1 – 22.5  (ES 2012\*) |
| AP-Hold4 | Large w/ICE\*\* | Bottom Mount Freezer | 18.1 – 22.5  (ES 2012\*) |
| AP-10114 | Large w/ICE\*\* | Bottom Mount Freezer | 16.5 or greater |
| AP-Hold5 | X-Large | Bottom Mount Freezer | Larger than 22.5  (ES 2012\*) |
| AP-Hold6 | X-Large w/ICE\*\* | Bottom Mount Freezer | Larger than 22.5  (ES 2012\*) |
|  |  | | |
| AP-19411 | Small | Top Mount Freezer | 10 - 15.0 |
| AP-29410 | Medium | Top Mount Freezer | 15 - 20 |
| AP-Hold7 | Medium | Top Mount Freezer | 18.0 and smaller  (ES 2012\*) |
| AP-Hold8 | Medium w/ICE\*\* | Top Mount Freezer | 18.0 and smaller  (ES 2012\*) |
| AP-39094 | Medium w/ ICE\*\* | Top Mount Freezer | 15 - 20 |
| AP-45521 | Large | Top Mount Freezer | 20 or greater |
| AP-Hold9 | Large | Top Mount Freezer | 18.1 – 22.5  (ES 2012\*) |
| AP-Hold10 | Large w/ICE\*\* | Top Mount Freezer | 18.1 – 22.5  (ES 2012\*) |
| AP-Hold11 | X-Large | Top Mount Freezer | Larger than 22.5  (ES 2012\*) |
| AP-Hold12 | X-Large w/ICE\*\* | Top Mount Freezer | Larger than 22.5  (ES 2012\*) |
|  |  | | |
| AP-80244 | Med w/ ICE\*\* | Side Mount Freezer | 15 - 23 |
| AP-Hold13 | Medium | Side Mount Freezer | 18.0 and smaller  (ES 2012\*) |
| AP-Hold14 | Medium w/ICE\*\* | Side Mount Freezer | 18.0 and smaller  (ES 2012\*) |
| AP-12333 | Large w/ ICE\*\* | Side Mount Freezer | 23 or greater |
| AP-Hold15 | Large | Side Mount Freezer | 18.1 – 22.5  (ES 2012\*) |
| AP-Hold16 | Large w/ICE\*\* | Side Mount Freezer | 18.1 – 22.5  (ES 2012\*) |
| AP-74421 | Med | Side Mount Freezer | 15 - 23 |
| AP-98888 | Large | Side Mount Freezer | 23 or greater |
| AP-Hold17 | X-Large | Side Mount Freezer | Larger than 22.5  (ES 2012\*) |
| AP-Hold18 | X-Large w/ICE\*\* | Side Mount Freezer | Larger than 22.5  (ES 2012\*) |
|  |  | | |
| AP-90011 | Compact | Bottom Mount Freezer | 7.75 or less |
| AP-29187 | Top Mount Freezer | 7.75 or less |
| AP-87223 | Refrigerator Only | 7.75 or less |
|  |  |  |
| AP-79111 | Refrigerator/Freezer | 7.75 or less |
|  |  | | |
| AP-40945 | Refrigerator Only | Freezerless | 11- 23 |
|  |  |  |  |
| AP-Hold19 | Refrigerator Only | Freezerless | 11.95 (Average)  (ES 2012\*) |
| AP-Hold20 | Refrigerator/Freezer | Refrigerator/Freezer | 15.52 (Average)  (ES 2012\*) |

\* Refers to the Energy Star Most Efficient 2012 Refrigerators

**\*\*** “ICE” refers to the presence of through-the door ice service.

Requirements for qualifying ES Refrigerators are shown below in

Table **2**

**Table 2 Energy Star Refrigerator Specifications**

|  |  |  |
| --- | --- | --- |
| **Equipment** | **Volume** | **Energy Star Criteria** |
|
| Full Size Refrigerators | 7.75 cubic feet or greater | At least 20% more energy efficient than the minimum federal government standard (NAECA). |
| Compact Refrigerator and Freezer | Less than 7.75 cubic feet, and 36 inches or less in height | At least 20% more energy efficient than the minimum federal government standard (NAECA). |
| Full Size Refrigerators – ES Most Efficient 2012 | 7.75 cubic feet or greater | At least 30% more energy efficient than the minimum federal government standard (NAECA). |

### 1.1b Delivery and Incentive Mechanism

This work paper describes energy impact, and cost values for Replace on Burn-out (ROB), and New Installations (NEW) Program Type/Install Type.

NEW measures are installation of equipment that has never been installed before. The installation of equipment that has never been installed does not include equipment that is added to an existing system that improves the performance.

ROB measures replace existing equipment with more energy efficient equipment on failure of the existing equipment. ROB is also a blanket install type applied to certain types of technologies that are typically held long past their effective useful lives such as appliances and large process equipment.

The delivery method is Financial Support – Downstream Incentive – Deemed.

### 1.1c Measure Requirements

Energy and Demand impacts described in this work paper are for non-commercial refrigerators operating in residential buildings. Applicable measures shall comply with the 2010 State of California Code of Regulations, Title 20 [[[1]](#endnote-1)] and shall have a minimum performance as detailed by the Energy Star rating.

Further, eligibility criteria for ES Most Efficient 2012 refrigerator-freezers include the following:

1) Product must be ENERGY STAR qualified consistent with applicable ENERGY STAR Partner Commitments and the requirements set forth in the ENERGY STAR Program Requirements Product Specification for Residential Refrigerators and Freezers, Version 4.1. Product performance must be certified by an EPA-recognized certification body.

2) Product must use less than or equal to 481 kWh per year and be at least 30% more efficient than federal requirements NAECA (as summarized further in the report), as determined by ENERGY STAR specified federal test procedures.

## 1.2 DEER Differences Analysis

This specific measure is included in the Database for Energy Efficient Resources (DEER) Version 2008.2.05 [49]; however the measure savings in DEER is outdated as the ENERGY Star requirements for full-size refrigerators changed from 15% better than code, to 20% better, and later to 30% better than code in 2012 [[[2]](#endnote-2)].

In addition since energy and demand savings for compact refrigerators are not available in DEER, the DEER savings values are not used.

## 1.3 Code Analysis

The National Appliance Energy Conservation Act (NAECA) dictates minimum energy consumption standards for both commercial and non-commercial refrigerators and freezers. These are consequentially referenced in the 2010 State of California Code of Regulations, Title 20 [277].

The maximum energy consumption for refrigerators, refrigerator-freezer, and freezers that are consumer products, as well for determination of baseline energy, are shown in . The energy consumption in this table is what the Energy Star 20% and 30% above federal minimum is calculated against.

Table 3 Standards for Non Commercial Refrigerators, Refrigerator-Freezers,

and Freezers – Manufactured on or After July 1, 2001

|  |  |
| --- | --- |
| Appliance (Product Class) | Maximum Energy Consumption (kWh/year) |
| Refrigerators and Refrigerator-Freezers with manual defrost | 8.82AV + 248.4 |
| Refrigerator-Freezer – partial automatic defrost | 8.82AV + 248.4 |
| Refrigerator-Freezers – automatic defrost with top-mounted freezer without through-the door ice service and all refrigerators – automatic defrost | 9.80AV + 276.0 |
|
| Refrigerator-Freezers – automatic defrost with side-mounted freezer without through-the door ice service | 4.91 AV + 507.5 |
|
| Refrigerator-Freezers – automatic defrost with bottom-mounted freezer | 4.60AV + 459.0 |
| Refrigerator-Freezers – automatic defrost with top-mounted freezer with through-the-door ice service | 10.20AV + 356.0 |
|
| Refrigerator-Freezers – automatic defrost with side-mounted freezer with through-the door ice service | 10.10AV + 406.0 |
|
| Upright Freezers with manual defrost | 7.55AV + 258.3 |
| Upright Freezers with automatic defrost | 12.43AV + 326.1 |
| Chest Freezers and all other Freezers except Compact Freezers | 9.88AV + 143.7 |
| Compact Refrigerators and Refrigerator-Freezers with manual defrost | 10.70AV + 299.0 |
| Compact Refrigerator-Freezers – partial automatic defrost | 7.00AV + 398.0 |
| Compact Refrigerator-Freezers – automatic defrost with top-mounted freezer and compact all refrigerators – automatic defrost | 12.70AV + 355.0 |
| Compact Refrigerator-Freezers – automatic defrost with side-mounted freezer | 7.60AV + 501.0 |
| Compact Refrigerator-Freezers – automatic defrost with bottom-mounted freezer | 13.10AV + 367.0 |
| Compact Upright Freezers with manual defrost | 9.78AV + 250.8 |
| Compact Upright Freezers with automatic defrost | 11.40AV + 391.0 |
| Compact Chest Freezers | 10.45AV + 152.0 |
| AV = adjusted total volume, expressed in ft3, as determined in 10 CFR, Part 430, Appendices A1 and B1 of Subpart B (2008), which is: [1.44 x freezer volume (ft3)] + refrigerator volume (ft3) for refrigerators; [1.63 x freezer volume (ft3)] + refrigerator volume (ft3) for refrigerator-freezers; [1.73 x freezer volume (ft3)] for freezers. | |
| **Note:** Maximum energy consumption standards for refrigerator-freezers with internal freezers are same as those for refrigerator-freezers with top-mounted freezers. | |

Similarly, summarizes eligibility (energy) criteria for Energy Start Most Efficient 2012 refrigerator-freezers required to be at least 30% most efficient than the minimum federal government standard (NAECA) and to have an annual energy consumption not exceeding 481 kWh.

Table 4 Standards for (ES Most Efficient 2012) Non Commercial Refrigerators, Refrigerator-Freezers, and Freezers – Manufactured on 2012

## 1.4 Measure Effective Useful Life

DEER08 documentation provides EUL and RUL information to be used for the 10-12 program cycle on [www.deeresources.com](http://www.deeresources.com). The DEER documentation “Summary of EUL-RUL Analysis for the April 2008 Update to DEER” provides the RUL value as a flat 1/3 of the EUL value.

To obtain the EUL value, the DEER08 documentation, EUL\_Summary\_10-1-08.xls, was consulted [213]. below identifies the value/methodology used for the measures in this work paper.

Table 5 DEER08 EUL Value/Methodology

|  |  |  |  |
| --- | --- | --- | --- |
| Market | Enduse | Measure | EUL (Years) |
| Residential | Appliances | High Efficiency Refrigerator | 14 |

## 1.5 Net-to-Gross Ratios for Different Program Strategies

Although this workpaper is for *ES-*Refrigerators, which are (currently) by definition 20% and 30% better than code, and the DEER NTG was established for units 15% beyond code, in absence of recent impact studies, the below referenced DEER NTG is considered applicable for the purpose of this work paper.

The NTG value was obtained from the DEER 2011. The relevant NTGR for this measure is shown in below.

Table 6 Net-to-Gross Ratio

|  |  |  |
| --- | --- | --- |
| NTGR ID | Delivery Method\* | NTG\* |
| RES-DEFAULT>2 | Any | .55 |

\*Denotes that the column is taken from the DEER NTG Table.

## 1.6 Time-of-Use Adjustment Factor

As directed by the CPUC in decision 06-06-063 dated June 29, 2006, time-of-use (TOU) adjustment factors are to be applied for residential A/C and commercial A/C (packaged and split-system direct-expansion cooling) measures only. Since this is not an A/C measure, the TOU adjustment factor is 0. The specific TOU adjustment factors are inherent in the avoided-cost calculation performed in the E3 calculator.

# Section 2. Energy Savings & Demand Reduction Calculations

## Energy Savings Calculations

Since the DEER does not provide the most updated energy and demand impacts for Energy Star Refrigerators, the Energy Star Qualified Refrigerator list was utilized to determine the average energy savings from the replacement of a *Fed Min*-Refrigerator with an *ES-*Refrigerator.

The *ES*-Refrigerator configurations covered in this workpaper include:

* Top Mount Freezer
* Bottom Mount Freezer
* Side Mount Freezer (or Side-by-Side)
* Freezerless (Refrigerator Only)
* Compact

*ES-*Refrigerators were further grouped based on the total volume, and the capability to produce ice through the door. below shows a sample of the *ES-*Refrigerators groupings.

Table 7 ES Refrigerator Groupings

|  |  |  |
| --- | --- | --- |
|  | Refrigerator  Configuration | Total Volume  (fresh + freezer) |
| **Small** | Top Mount Freezer | 10 - 15.0 |
| **Medium** | Top Mount Freezer | 15 - 20 |
| **Medium w/ ICE** | Top Mount Freezer | 15 - 20 |
| **Large** | Top Mount Freezer | 20 or Larger |

**Note:** Top Mount refers to the location of the freezer space. In this case the freezer space is above the fresh space (i.e. refrigerated space).

The ES Qualified Refrigerator list provides the maximum energy usage for each *ES*-Refrigerator based on freezer configuration and total unit volume. In addition, the list provides maximum allowable energy consumption of a comparable *Fed Min*-Refrigerator.

The estimated energy savings for each refrigerator grouping was determined as the difference between the Fed Min-Refrigerator and an ES Refrigerator. shows the estimated energy savings for a small top mount refrigerator.

Table 8 ES Refrigerator Estimated Energy Savings

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Avg Volume | Refrig Config | ES Refrig kWh | Fed kWh | Ave. kWh Savings |
| **Small** | 12.438 | Top Mount | 325.849 | 414.967 | 89.118 |

Further, incremental energy savings estimates for ES Most Efficient 2012 Refrigerator-Freezers from comparable appliances meeting federal standards were found by comparing maximum annual energy use (kWh/year) between federal standard compliant appliances and Most Efficient 2012 appliances using corresponding eligibility criteria.

Table 9 provides sample of energy savings estimation on selected (Medium Refrigerator) measure.

As mandated by the CPUC’s Energy Division during collaboration meetings in April 2012, an adjustment factor was introduced to adjust the energy savings for the most efficient 2012 Energy Star measures from that determined by taking the difference of the Energy Star standard and the Federal minimum. This factor accounts for differences in operating conditions and other undefined factors that were utilized in the DEER simulations.

This factor is obtained from the DEERV3.02 Res workbook and can be seen in attachment 4 [E]. These factors vary by climate zones and are applied to these new measures only.

Table 9 ES Most Efficient 2012 Refrigerator Estimated Energy Savings

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Size | Freezer  Mount | Ice TTD | Adjusted  Volume (ft3) | Total  Volume (ft3) | Baseline ES  (Federal Standard),  kWh/Year | Measure ES  2012,  kWh/Year | Energy Savings, kWh/Year |
| Medium  (18 ft3 and less) | Bottom | No | 18.14 | 15.68 | 542.4 | 379.7 | 162.7 |

TTD= Ice through the door.

## Demand Reduction Calculations

Peak demand savings are based on the load shapes contained in the California Energy Commission’s (CEC) peak demand forecasting model. Methodology for estimating demand reductions is the same for all appliances – appliances manufactured prior 2012 (ES) and appliances manufactured on 2012 (ES Most Efficient 2012). The demand/energy factor (kW/kWh) estimated to calculate demand savings herein was average at 0.000152964 kW/kWh using load shapes per the latest DEER 2008 for the Energy Star Most Efficient Refrigerators and Estimates for all other demand reduction are based on a 0.00021823 kW/kWh factor which had been previously used and frozen.See Attachment 3 [[[3]](#endnote-3)] for detail estimation of the demand/energy factor.

describes methodology for estimating electric demand reduction on all measures. Further, summarizes demand reduction results on one of the sample measures (e.g., Small Top-Mount Refrigerator).

**Equation 1- Sample Calculation for Small Top Mount Energy Star Refrigerator**

Table 10 ES-Refrigerator Estimated Demand Reduction

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Avg Volume | Refrig Config | Ave. kWh Savings | Ave. kW Reduction |
| **Small** | 12.438 | Top Mount | 89.118 | 0.019448 |

provides a summary of the energy savings and demand reduction for ES Refrigerator configurations. Similarly, provides a summary of the energy savings and demand reductions for ES Most Efficient 2012 Refrigerator configurations covered in this work paper.

See Attachment 2 [[[4]](#endnote-4)] and Attachment 4 [[[5]](#endnote-5)] for details calculations on energy and demand reductions for all measures contained within this work paper.

Table 11 ES Refrigerator Estimated Energy Savings and Demand Reduction

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Configuration | Solution Code | Ave. Volume | Refrig. Config. | ES Refrig kWh | Fed kWh / Baseline kWh | Ave. kWh Savings | Ave. kW Reduction |
| **Small** | AP-39992 | 12.037 | Bottom Mount | 409.282 | 523.930 | 114.648 | 0.025020 |
| **Large** | AP-68842 | 21.190 | Bottom Mount | 454.918 | 574.705 | 119.787 | 0.026141 |
| **Large w/ ICE** | AP-10114 | 25.171 | Bottom Mount | 535.449 | 688.006 | 152.557 | 0.033293 |
|  |  |  |  |  |  |  |  |
| **Small** | AP-19411 | 12.438 | Top Mount | 325.849 | 414.967 | 89.118 | 0.019448 |
| **Medium** | AP-29410 | 17.902 | Top Mount | 372.493 | 478.089 | 105.596 | 0.023044 |
| **Medium w/ ICE** | AP-39094 | 18.300 | Top Mount | 407.000 | 569.180 | 162.180 | 0.035393 |
| **Large** | AP-45521 | 21.000 | Top Mount | 410.853 | 517.329 | 106.475 | 0.023236 |
|  |  |  |  |  |  |  |  |
| **Med w/ ICE** | AP-80244 | 21.965 | Side Mount | 533.672 | 678.119 | 144.447 | 0.031523 |
| **Large w/ ICE** | AP-12333 | 25.439 | Side Mount | 565.671 | 724.355 | 158.684 | 0.034630 |
| **Med** | AP-74421 | 19.356 | Side Mount | 496.000 | 624.037 | 128.037 | 0.027941 |
| **Large** | AP-98888 | 24.806 | Side Mount | 525.462 | 657.343 | 131.881 | 0.028780 |
|  |  |  |  |  |  |  |  |
| **Compact** | AP-90011 | 5.000 | Compact BtMount | 411.378 | 519.236 | 107.857 | 0.023538 |
| AP-29187 | 3.373 | Compact TopMount | 284.260 | 409.539 | 125.279 | 0.027340 |
| AP-87223 | 4.365 | Compact RefrigOnly | 302.705 | 398.162 | 95.457 | 0.020832 |
| AP-79111 | 3.411 | Compact Refrig/Frzr | 275.563 | 354.423 | 78.861 | 0.017210 |
|  |  |  |  |  |  |  |  |
| **Refrigerator Only** | AP-40945 | 16.597 | Freezerless | 335.172 | 438.653 | 103.481 | 0.02258 |

Table 12 ES Most Efficient 2012 Refrigerator Estimated Energy Savings and Demand Reduction

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Size | Freezer  Mount | Adjusted  Volume (ft3) | Total  Volume (ft3) | Baseline ES (Federal Standard),  kWh/Year | Measure 2012 ES,  kWh/Year | Energy Savings, kWh/Year [1]\* | Demand Factor, kW/kWh | Demand Savings, kW/Year |
| Medium (18 ft3 and less) | Bottom | 18.14 | 15.79 | 542.4 | 379.7 | 162.7 | 0.00015296 | 0.0249 |
| Medium (18 ft3 and less) | Bottom | 18.14 | 15.79 | 542.4 | 440.8 | 101.7 | 0.00015296 | 0.0155 |
| Medium (18 ft3 and less) | Side | 18.14 | 15.79 | 596.6 | 417.7 | 178.9 | 0.00015296 | 0.0274 |
| Medium (18 ft3 and less) | Side | 18.14 | 15.79 | 589.2 | 412.4 | 176.8 | 0.00015296 | 0.0270 |
| Medium (18 ft3 and less) | Top | 18.14 | 15.79 | 453.8 | 317.6 | 136.1 | 0.00015296 | 0.0208 |
| Medium (18 ft3 and less) | Top | 18.14 | 15.79 | 541.0 | 378.7 | 162.3 | 0.00015296 | 0.0248 |
| Large (18.1 to 22.5 ft3) | Bottom | 22.49 | 19.28 | 562.5 | 393.7 | 168.7 | 0.00015296 | 0.0258 |
| Large (18.1 to 22.5 ft3) | Bottom | 22.49 | 19.28 | 562.5 | 456.0 | 106.4 | 0.00015296 | 0.0163 |
| Large (18.1 to 22.5 ft3) | Side | 22.49 | 19.28 | 617.9 | 432.7 | 185.3 | 0.00015296 | 0.0283 |
| Large (18.1 to 22.5 ft3) | Side | 22.49 | 19.28 | 633.1 | 443.2 | 189.9 | 0.00015296 | 0.0291 |
| Large (18.1 to 22.5 ft3) | Top | 22.49 | 19.28 | 496.4 | 347.5 | 148.9 | 0.00015296 | 0.0228 |
| Large (18.1 to 22.5 ft3) | Top | 22.49 | 19.28 | 585.4 | 409.8 | 175.6 | 0.00015296 | 0.0269 |
| X-Large (Larger than 22.5 ft3) | Bottom | 30.46 | 22.56 | 599.1 | 419.4 | 179.7 | 0.00015296 | 0.0275 |
| X-Large (Larger than 22.5 ft3) | Bottom | 30.46 | 22.56 | 599.1 | 481.0 | 118.1 | 0.00015296 | 0.0181 |
| X-Large (Larger than 22.5 ft3) | Side | 30.46 | 22.56 | 657.1 | 460.1 | 197.0 | 0.00015296 | 0.0301 |
| X-Large (Larger than 22.5 ft3) | Side | 30.46 | 22.56 | 713.6 | 481.0 | 232.6 | 0.00015296 | 0.0356 |
| X-Large (Larger than 22.5 ft3) | Top | 30.46 | 22.56 | 574.5 | 402.2 | 172.4 | 0.00015296 | 0.0264 |
| X-Large (Larger than 22.5 ft3) | Top | 30.46 | 22.56 | 666.7 | 466.7 | 200.0 | 0.00015296 | 0.0306 |
| Refrigerator only | N/A | 13.83 | 13.83 | 370.4 | 259.2 | 111.1 | 0.00015296 | 0.0170 |
| Refrigerator/Freezer | N/A | 17.96 | 11.07 | 406.8 | 284.7 | 122.1 | 0.00015296 | 0.0187 |

*Note: [1] Incremental energy savings from Federal Standard (e.g., reduction on maximum allowable annual energy consumption between federal standard and Most Efficient 2012 appliance)*

*\*Please note that these savings values do not include the reduction factor used from the DEERV3.02 res workbook as mandated by the ED.*

# Section 3. Load Shapes

The difference between the base case load shape and the measure load shape would be the most appropriate load shape; however, only end-use profiles for some sectors are available. Therefore, the closest load shape chosen for this measure is the DEER:RefgFrzr\_HighEff load shape.

See for a list of all Building Types and Load Shapes. See the KEMA report [31] for a more thorough discussion regarding the load shapes for this measure.

Table 13 Target Sectors and Load Shapes

|  |  |  |
| --- | --- | --- |
| **Building Type** | **E3 Alt. Building Type** | **Load Shape** |
| Residential Single Family | RES | DEER:RefgFrzr\_HighEff |
| Residential Multi-family | RES | DEER:RefgFrzr\_HighEff |
| Residential Mobile Home - Double-Wide | RES | DEER:RefgFrzr\_HighEff |

# Section 4. Base Case & Measure Costs

## 4.1 Base Case Cost

**NEW/ROB**

The base case equipment cost is the purchase price of refrigerators that meet minimum Federal and State of California appliance standards. Base equipment cost is estimated at $1,150, based on *average retail price* in 2008 from national retail data [[[6]](#endnote-6)]. For compact refrigerator the same source is utilized and the estimated average cost is $175. Slightly variations on retail price against the *average retail price* are expected on latest 2012 Energy Start appliances.

## 4.2 Gross Measure Cost

**NEW/ROB**

In the case of NEW and ROB the equipment being replaced is assumed to have failed in place or is past its useful life so the customer is in the situation of having to purchase new equipment. The customer is then faced with either purchasing standard efficiency or code baseline equipment versus energy efficient equipment.

For **NEW** and **ROB**, Gross Measure Cost (GMC) is represented by the equation below:

*GMC = (Measure Equipment Cost + Measure Labor Cost) –*

*(Base Case Equipment Cost + Base Case Labor Cost)*

Since the customer will be spending money to replace equipment anyway, the gross cost for the energy efficient measure is the premium paid above the non-efficient or code baseline equipment.

The measure case labor and base case labor are assumed to be the same value reducing the equation to the following:

*GMC = Measure Equipment Cost – Base Case Equipment Cost*

The measure costs are estimated at $1,180 [F], based on *average* *retail price* of a qualified model in 2008 from a national retailer. For compact refrigerator the same source is utilized and the estimated average cost is $195.

The complete Gross Measure Cost with the climate zone multiplier factored in for each climate zone is presented in this work paper.

## 4.3 Incremental Measure Cost

**NEW/ROB**

For this measure category, the incremental measure cost is used strictly for providing insight to program managers to assist in determining rebates for deemed measures. For retrofit measures the incremental measure cost is NOT used for reporting in the cost effectiveness calculations.

The incremental measure cost (IMC) is the measure material cost minus the base material cost or ($1,180.00-$1,150.00) and turns out to be $ 30.00. Labor cost is assumed to be the same both in the basecase and the measure case. Following the same equation, the IMC for compact size refrigerators is estimated at $20.The incremental measure cost with the climate zone multiplier factored in for each climate zone is presented in this work paper

# Attachments

1.



2.

3. 

4. 

5.

# References



[31]

[49]

[132]

[213]

[277]

1. California Energy Commission, Title 20 2010 Appliance Efficiency Regulations. <http://www.energy.ca.gov/2010publications/CEC-400-2010-012/CEC-400-2010-012.PDF>. 1605.1 (o) Table O [↑](#endnote-ref-1)
2. US. Environmental Protection Agency and US Department of Energy <http://www.energystar.gov/index.cfm?c=refrig.pr_crit_refrigerators> [↑](#endnote-ref-2)
3. Attachment 3 - ES Refrigerators ImpactID MMDB.xlsx [↑](#endnote-ref-3)
4. Attachment 2 – ES Refrigerators Calculation\_V2.xls [↑](#endnote-ref-4)
5. Attachment 4 - ES Most Efficient 2012 RF.xlsx [↑](#endnote-ref-5)
6. Energy Star. (Site accessed on 4/23/2012). Savings Calculator spreadsheet. http://www.energystar.gov/index.cfm?fuseaction=find\_a\_product.showProductGroup&pgw\_code=RF [↑](#endnote-ref-6)