



Northwest Energy Efficiency Alliance (NEEA) Retail Products  
Portfolio (RPP) Methodology Documentation for Residential  
Refrigerators and Freezers

Table 1: Report Summary

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<b>Product</b>	Refrigerators and Freezers
<b>Last Updated:</b>	October 31, 2018
<b>Last Revised By:</b>	Ari Mytelka, Energy Solutions
<b>Report Generated:</b>	November 27, 2018

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## 1. Introduction

This automatically-generated document reports the methodologies and assumptions used to calculate the sales-weighted unit energy consumption (UEC) of **residential refrigerators and freezers** (by product class) for the Northwest Energy Efficiency Alliance (NEEA) Retail Products Portfolio (RPP, also used interchangeably with 'Retail Products Platform') Program<sup>[5]</sup>. Since NEEA uses these calculated values to track and estimate long-term energy savings, it is important that the methodologies and assumptions are well-documented, transparent, and reproducible. This document is generated using R Markdown. The values reported in this document are retrieved from the same R source code used to calculate energy savings and thus reflect the actual values used as of the report generation date. Manual revisions to this document shall be tracked in Appendix Section A.1

## 2. Methodology

To calculate the sales-weighted, volume-normalized UEC of each product category and efficiency tier, NEEA performs the following steps:

1. Acquire RPP sales data from RPP data provider (web portal)
2. Identify model attributes (product configuration and energy efficiency metric)
3. Modify/adjust the efficiency metric for NEEA-specific regional characteristics
4. Calculate UEC for each model
5. Weight model UECs by sales
6. Normalize for average volume by product class and efficiency tier

The following sub-sections will discuss steps 1 through 4 and 6.

### 2.1 Sales Data

Sales data for the RPP program is managed on <http://www.retailproductsplatform.com>. NEEA and other program sponsors have access to only the masked and aggregated data. For the purposes of energy savings calculations, NEEA uses the `sales_by_model` dataset, which contains the brand and model number of each product sold through participating retailers, and the quantity of units sold for that model in a given month (aggregated by month).

### 2.2 Model Attributes

In order to determine the energy usage characteristics for each refrigerator/freezer model, each model number (for a given brand) was mapped to models in the ENERGY STAR® Qualified Products List<sup>[3]</sup>, U.S. Department of Energy Compliance Certification Management System<sup>[6]</sup>, and California Energy Commission Modernized Appliance Efficiency Database<sup>[1]</sup>. If there was conflict between the values reported by the three sources for a given refrigerator model, the values listed in the ENERGY STAR® Qualified Products list were used. If a model was not qualified for ENERGY STAR®, the values listed by the California Energy Commission were used. The table below shows the attributes used for determining volume-normalized Unit Energy Consumption (UEC):

Table 2: Table of Attributes

Attribute	Equation Variable	Source(s)
Adjusted Volume (cu. ft.)	$AV$	[1][3][6]
Annual Energy Use (kWh/yr)	$AEC$	[1][3][6]
DOE Product Class	-	[3][6]
U.S. Federal Standard (kWh/yr)	$FedStd$	[1][3]

## 2.3 Calculations

The volume-normalized UEC in kWh per year (kWh/yr) for each product class and tier was determined using model data. Each model's UEC is reported as the Annual Energy Use (AEC), and the U.S. Department of Energy (DOE) sets a maximum allowed AEC as a function of the adjusted volume and product class of the unit<sup>[1]</sup>:

$$FedStd = k * AV + c$$

*FedStd*, The DOE's maximum allowed annual energy consumption in kWh/year

*k*, The adjusted volume coefficient for allowable energy consumption, see Appendix Section A.3 for values by product class

*AV*, Adjusted volume of the refrigerator or freezer in cubic feet

*c*, The constant for allowable energy consumption, see Appendix Section A.3 for values by product class

From the AEC and federal standard requirement, the model's percent less energy use than the federal requirement can be determined, and then the volume-normalized UEC is calculated by multiplying that value by the average federal standard maximum AEC for the product class:

$$UEC_{norm} = \left( \frac{FedStd - AEC}{FedStd} \right)_{tier} \times FedStd_{class}$$

*UEC<sub>norm</sub>*, Energy used per year, normalized over the product class and efficiency tier for volume

$\left( \frac{FedStd - AEC}{FedStd} \right)_{tier}$ , Percent less energy used than the standard, averaged over class and tier

*FedStd<sub>class</sub>*, Federal standard maximum allowed energy consumption in kWh/yr, averaged over product class

The efficiency tier is determined based on qualification for the **ENERGY STAR® v5** and **ENERGY STAR® Most Efficient 2017-2018** measure levels. To qualify for **ENERGY STAR® v5**, a product must use at most **90%** of the federal allowable maximum unless it qualifies under the Connected Product Criteria, in which case an additional **5%** allowance is permitted<sup>[2]</sup>. To qualify for ENERGY STAR® Most Efficient, an ENERGY STAR® refrigerator (freezers are ineligible) must use less than **637** kWh/year and either have a top-mounted freezer configuration or use at most **85%** of the federal allowable maximum<sup>[4]</sup>. For freezers, units that use at most **85%** of the federal requirement are also classified at a higher efficiency tier.

The product class is determined based on the listed product class if a match was found in the DOE Compliance Certification Management System or the ENERGY STAR® Qualified Product List. If no match was found on those lists, the product class is determined based on the model attributes described in the California Energy Commission Modernized Appliance Efficiency Database (see Appendix Section A.2 for the code to classify models from listed attributes).

## 3. Sources

[1] California Energy Commission Modernized Appliance Efficiency Database. <https://cacertappliances.energy.ca.gov>

[2] ENERGY STAR® Final Version 5.0 Residential Refrigerators and Freezers Specification. <https://www.energystar.gov/sites/default/files/specs//private/ENERGY%20STAR%20Final%20Version%205.0%20Residential%20Refrigerators%20and%20Freezers%20Program%20Requirements.pdf>

[3] ENERGY STAR® Qualified Products List. <https://www.energystar.gov/productfinder/>

[4] Refrigerator-freezers ENERGY STAR® Most Efficient 2018 Final Criteria. <https://www.energystar.gov/sites/default/files/Refrigerator-Freezers%20ENERGY%20STAR%20Most%20Efficient%202018%20Final%20Criteria.pdf>



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[5] Retail Products Platform Sales Data. <http://www.retailproductsplatform.com>

[6] U.S. Department of Energy Compliance Certification Management System. <https://www.regulations.doe.gov/certification-data>

[7] U.S. Department of Energy Direct Final Rule for Residential Refrigerators, Refrigerator-Freezers, and Freezers (2011). <https://www.regulations.gov/document?D=EERE-2008-BT-STD-0012-0133>

[8] U.S. Department of Energy Technical Support Document for Residential Refrigerators, Refrigerator-Freezers, and Freezers (2011). <https://www.regulations.gov/document?D=EERE-2008-BT-STD-0012-0128>

## Appendix

### A.1. List of Revisions

Date	Description	Author
October 31, 2018	Original Publication	A. Mytelka, Energy Solutions

### A.2. R Functions

#### DOE Product Class Determination Function

```
for (i in 1:nrow(MASTER_PRODUCT)) {

  if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] == "Wine Chiller")) {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <-
      "non-federally-regulated wine chiller"
  }

  # compact units
  else if (isTRUE(MASTER_PRODUCT[i,"Compact Refrigerator"] == "TRUE") |
    isTRUE(MASTER_PRODUCT[i,"Total Volume (Cu. Ft.)"] <= 7.75)) {
    if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] == "Chest Freezer")) {
      MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "18"
    } else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
      "Upright Freezer")) {
      if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Defrost Type"] == "Manual")) {
        MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "16"
      } else {
        MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "17"
      }
    }
  } else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Internal Freezer")) {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "11"
  } else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Defrost Type"] == "Manual")) {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "11A"
  } else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Defrost Type"] ==
    "Partial Automatic")) {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "12"
  } else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Top Freezer w/o Ice thru door") |
    isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Top-Mounted Freezer")) {
    if (isTRUE(MASTER_PRODUCT[i,"Automatic Ice Maker"] == "TRUE")) {
      MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "13I"
    } else {
      MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "13"
    }
  }
  } else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Side-Mounted Freezer") |
    isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
```

```

        "Side-by-Side w/o Ice thru door")) {
    if (isTRUE(MASTER_PRODUCT[i,"Automatic Ice Maker"] == "TRUE")) {
        MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "14I"
    } else {
        MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "14"
    }
} else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Bottom-Mounted Freezer") |
    isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Bottom Freezer w/o Ice thru do") |
    isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Bottom Freezer w/o Ice thru door")) {
    if (isTRUE(MASTER_PRODUCT[i,"Automatic Ice Maker"] == "TRUE")) {
        MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "15I"
    } else {
        MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "15"
    }
} else {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- "13A"
}
}

# standard-size units
else {
    if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Defrost Type"] == "Manual")) {
        if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] == "All-Refrigerator")){
            MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 1A"
        } else {
            MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 1"
        }
    } else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Defrost Type"] ==
        "Partial Automatic")) {
        MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 2"
    } else if ((isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
        "Bottom-Mounted Freezer") &&
        isTRUE(MASTER_PRODUCT[i,"Through-The-Door Service"] == "TRUE")) |
        isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
        "Bottom Freezer w/Ice thru door")) {
        if (isTRUE(MASTER_PRODUCT[i,"Built-In Refrigerator"] == "TRUE")) {
            MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 5A-BI"
        } else {
            MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 5A"
        }
    }
} else if ((isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Bottom-Mounted Freezer")
    && !isTRUE(MASTER_PRODUCT[i,"Through-The-Door Service"] == "TRUE"))
| isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Bottom Freezer w/o Ice thru do") |
    isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
    "Bottom Freezer w/o Ice thru door")) {

```

```

if (isTRUE(MASTER_PRODUCT[i,"Automatic Ice Maker"] == "TRUE")) {
  if (isTRUE(MASTER_PRODUCT[i,"Built-In Refrigerator"] == "TRUE")) {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 5I-BI"
  } else {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 5I"
  }
} else {
  if (isTRUE(MASTER_PRODUCT[i,"Built-In Refrigerator"] == "TRUE")) {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 5-BI"
  } else {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 5"
  }
}
} else if ((isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
  "Side-Mounted Freezer") &&
  isTRUE(MASTER_PRODUCT[i,"Through-The-Door Service"] == "TRUE")) |
  isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
  "Side-by-Side w/Ice thru door")) {
  if (isTRUE(MASTER_PRODUCT[i,"Built-In Refrigerator"] == "TRUE")) {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 7-BI"
  } else {
    MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 7"
  }
} else if ((isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
  "Side-Mounted Freezer") &&
  !isTRUE(MASTER_PRODUCT[i,"Through-The-Door Service"] == "TRUE")) |
  isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
  "Side-by-Side w/o Ice thru door")) {
  if (isTRUE(MASTER_PRODUCT[i,"Automatic Ice Maker"] == "TRUE")) {
    if (isTRUE(MASTER_PRODUCT[i,"Built-In Refrigerator"] == "TRUE")) {
      MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 4I-BI"
    } else {
      MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 4I"
    }
  } else {
    if (isTRUE(MASTER_PRODUCT[i,"Built-In Refrigerator"] == "TRUE")) {
      MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 4-BI"
    } else {
      MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 4"
    }
  }
}
} else if (isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
  "Top-Mounted Freezer") &&
  isTRUE(MASTER_PRODUCT[i,"Through-The-Door Service"] == "TRUE")) {
  MASTER_PRODUCT[i,"DOE Product Class (CEC)"] <- " 6"
} else if ((isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
  "Top-Mounted Freezer") &&
  !isTRUE(MASTER_PRODUCT[i,"Through-The-Door Service"] == "TRUE")) |
  isTRUE(MASTER_PRODUCT[i,"Refrigerator Style"] ==
  "Top Freezer w/o Ice thru door")) {

```







Table 4: U.S. DOE Coefficients for the Federal Standard Requirement by Product Class

DOE Product Class	AV Coefficient	Equation Constant
1	7.99	225
1A	6.79	193.6
2	7.99	225
3	8.07	233.7
3-BI	9.15	264.9
3I	8.07	317.7
3I-BI	9.15	348.9
3A	7.07	201.6
3A-BI	8.02	228.5
4	8.51	297.8
4-BI	10.22	357.4
4I	8.51	381.8
4I-BI	10.22	441.4
5	8.85	317
5-BI	9.4	336.9
5I	8.85	401
5I-BI	9.4	420.9
5A	9.25	475.4
5A-BI	9.83	499.9
6	8.4	385.4
7	8.54	432.8
7-BI	10.25	502.6
8	5.57	193.7
9	8.62	228.3
9I	8.62	312.3
9-BI	9.86	260.9
9I-BI	9.86	344.9
10	7.29	107.8
10A	10.24	148.1
11	9.03	252.3
11A	7.84	219.1
12	5.91	335.8
13	11.8	339.2
13I	11.8	423.2
13A	9.17	259.3
14	6.82	456.9
14I	6.82	540.9
15	11.8	339.2
15I	11.8	423.2
16	8.65	225.7
17	10.17	351.9
18	9.25	136.8