



APPLIANCE OR PLUGLOAD
REFRIGERATORS and FREEZERS,
RESIDENTIAL
SWAP001-01

CONTENTS

Measure Name	2
Statewide Measure ID.....	2
Technology Summary	2
Measure Case Description	2
Base Case Description	4
Code Requirements	4
Normalizing Unit	8
Program Requirements.....	8
Program Exclusions.....	10
Data Collection Requirements	10
Use Category.....	10
Electric Savings (kWh)	10
Peak Electric Demand Reduction (kW)	12
Gas Savings (Therms)	12
Life Cycle	17
Base Case Material Cost (\$/unit).....	17
Measure Case Material Cost (\$/unit)	18
Base Case Labor Cost (\$/unit)	18
Measure Case Labor Cost (\$/unit)	18
Net-to-Gross (NTG)	19
Gross Savings Installation Adjustment (GSIA)	19
Non-Energy Impacts.....	19
DEER Differences Analysis.....	19
Revision History	20

MEASURE NAME

Refrigerators and Freezers, Residential

STATEWIDE MEASURE ID

SWAP001-01

TECHNOLOGY SUMMARY

This measure includes residential ENERGY STAR refrigerators, freezers, and refrigerator-freezers, summarized below.

- A *refrigerator* is a cabinet that is designed for the refrigerated storage of food, including but not limited to solid food and wine, beer, and other beverages, at temperatures $> 32^{\circ}\text{F}$, and that has a source of refrigeration requiring an energy input. It may include a compartment for the freezing and storage of food at temperatures $\leq 32^{\circ}\text{F}$, but it does not provide a separate low-temperature compartment designed for the freezing and storage of food at temperatures below 8°F .¹
- A *freezer* is a cabinet that is designed as a unit for the freezing and storage of food, beverages, or ice at temperatures $\leq 0^{\circ}\text{F}$ and that has a source of refrigeration requiring an energy input.
- A *refrigerator-freezer* is a cabinet that: 1) consists of two or more compartments with at least one of the compartments designed for the refrigerated storage of food, including but not limited to solid food and wine, beer, and other beverages, at temperatures above 32°F ; 2) has at least one of the compartments designed for the freezing and storage of food or ice at temperatures below 8°F that may be adjusted by the user to a temperature of $\leq 0^{\circ}\text{F}$; and 3) has a source of refrigeration requiring an energy input.

Qualifying models are more efficient than standard-efficiency units due to improvements in insulation and compressors.

MEASURE CASE DESCRIPTION

The measure case is defined as a refrigerator that is ENERGY STAR-qualified and at least 10% more efficient than the federal standard. The measure case is presented in two efficiency tiers, detailed below. ENERGY STAR (Version 5.0) models, are at least 10% more efficient than the federal standard).² ENERGY STAR Most Efficient (2016) models are at least 15% above the federal standard and use less than 637 kWh per year.³

¹ California Energy Commission (CEC). 2010. *2010 Appliance Efficiency Regulations*. CEC-400-2010-012. Table A-3.

² ENERGY STAR. 2015. "ENERGY STAR® Program Requirements Product Specification for Residential Refrigerators and Freezers - Eligibility Criteria Version 5.0." Effective September 15, 2014.

³ ENERGY STAR. 2016. "ENERGY STAR Most Efficient Recognition Criteria: Refrigerator-Freezers." Effective January 2016.

Measure Case Specification for ENERGY STAR (Version 5.0)

Configuration	Ice	Size (ft ³)
Freezerless Refrigerator	No Ice	Compact (< 7.75)
		Small (11 - 23)
Refrigerator/Freezer Bottom Freezer	No Ice	Compact (< 7.75)
		Small (8 -16.5)
		Large (≥ 16.5)
	With Ice	Large (≥ 16.5)
Top Freezer	No Ice	Compact (< 7.75)
		Small (10-15)
		Medium (15 - 20)
		Large (≥ 20)
	With Ice	Medium (15 - 20)
Side Freezer	No Ice	Medium (15 - 23)
		Large (≥ 23)
	With Ice	Medium (15 - 23)
		Large (≥ 23)
Upright Freezer	Manual Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)
	Automatic Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)
Chest Freezer	Manual Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)
	Automatic Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)

Measure Case Specification for ENERGY STAR Most Efficient

Configuration	Ice	Size (ft ³)
Refrigerator/Freezer	No Ice	Average size
Bottom Freezer	No Ice	Medium (≤ 18.0)
		Large (18.1 - 22.5)
		X-Large (> 22.5)
	With Ice	Medium (≤ 18.0)
		Large (18.1 - 22.5)
Top Freezer	No Ice	X-Large (> 22.5)
		Medium (≤ 18.0)
		Large (18.1 - 22.5)
	With Ice	X-Large (> 22.5)
		Medium (≤ 18.0)
		Large (18.1 - 22.5)
Side Freezer	No Ice	X-Large (> 22.5)
		Large (18.1 - 22.5)
		Medium (≤ 18.0)

Configuration	Ice	Size (ft ³)
	With Ice	Medium (≤ 18.0)
		Large (18.1 - 22.5)
		X-Large (> 22.5)
Refrigerator	Weighted	Any Size

Measure Case Specification for ENERGY STAR +5% Freezers

Configuration	Ice	Size (ft ³)
Upright Freezer	Manual Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)
	Automatic Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)
Chest Freezer	Manual Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)
	Automatic Defrost	Small (< 13)
		Medium (13-16)
		Large (> 16)

BASE CASE DESCRIPTION

The base case technology for this measure is defined as a refrigerator or refrigerator-freezer that meets the minimum federal efficiency standards (see Code Requirements).

CODE REQUIREMENTS

Applicable state and federal codes and standards for refrigerators are summarized below. The standards are based upon the size, configuration, and functionality of the refrigerator:

- Size: Adjusted volume (AV) is the sum of the fresh food compartment, net of the freezer compartment volume. Volumes are calculated in accordance with 10 CFR 430 Appendix A.
- Configuration: Side-by-Side, Top Freezer, Bottom Freezer, Single Door Refrigerators, Built-In Refrigerators, Chest Freezer, and Upright Freezer
- Defrost: Automatic or Manual
- Ice Maker: No-ice Maker, Automatic, Through-the-Door

Applicable State and Federal Codes and Standards for ENERGY STAR Refrigerators

Code	Applicable Code Reference	Effective Date
CA Appliance Efficiency Regulations – Title 20 (2015)	Section 1605.1, based on the Federal Regulations for Refrigerators (see “Federal Standards” below).	July 1, 2015
CA Building Energy Efficiency Standards – Title 24	None.	n/a
Federal Standards	U.S. Department of Energy (DOE) Standards for Residential Refrigerators and Freezers. The National Appliance Energy Conservation Act (NAECA) dictates minimum energy consumption standards for both commercial and non-commercial refrigerators and freezers. (See following table).	Sept. 15, 2014

The minimum federal standards cover all product classes, only a subset of the product classes are included in this measure and are shown below.

U.S. DOE Federal Standards for Residential Refrigerators and Freezers

Product Class	Maximum Annual Energy Consumption (AEC) (kWh/yr)	
	Based on Adjusted Volume (AV) (ft ³)	Based on Adjusted Volume (L)
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	7.99 AV + 225.0	0.282 av + 225.0
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	8.07 AV + 233.7	0.285 av + 233.7
3A. All-refrigerators—automatic defrost.	7.07A V + 201.6	0.250 av + 201.6
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	8.51AV + 297.8	0.301av + 297.8
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	8.85 AV + 317.0	0.312 av + 317.0
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	9.25 AV + 475.4	0.327 av + 475.4
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	8.40 AV + 385.4	0.297 av + 385.4
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	8.54 AV + 432.8	0.302 av + 432.8
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
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

Product Class	Maximum Annual Energy Consumption (AEC) (kWh/yr)	
	Based on Adjusted Volume (AV) (ft ³)	Based on Adjusted Volume (L)
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	$11.80AV + 339.2$	$0.417av + 339.2$
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	$11.80AV + 339.2$	$0.417av + 339.2$

ENERGY STAR (Version 5.0) qualifying models are at least 10% more efficient than the federal standard, in adherence with the DOE test procedures at 10 CFR 430, Subpart B, Appendix A and Appendix B. The calculations of the maximum annual energy consumption for each product class is provided below.

ENERGY STAR Version 5.0 Annual Energy Consumption Allowance ⁴

Product Class	Maximum Annual Energy Consumption (kWh/yr)
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	$7.19 AV + 202.5$
1A. All-refrigerators—manual defrost.	$6.11 AV + 174.2$
2. Refrigerator-freezers—partial automatic defrost.	$7.19 AV + 202.5$
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	$7.26 AV + 210.3$
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	$8.24 AV + 238.4$
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$7.26 AV + 294.3$
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	$8.24 AV + 322.4$
3A. All-refrigerators—automatic defrost.	$6.36 AV + 181.4$
3A-BI. Built-in All-refrigerators—automatic defrost.	$7.22 AV + 205.7$
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without through-the-door ice service.	$7.66 AV + 268.0$
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	$9.20 AV + 321.7$
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$7.66 AV + 352.0$

⁴ ENERGY STAR. 2015. "ENERGY STAR® Program Requirements Product Specification for Residential Refrigerators and Freezers - Eligibility Criteria Version 5.0." Effective September 15, 2014.

Product Class	Maximum Annual Energy Consumption (kWh/yr)
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	9.20 AV + 405.7
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	7.97 AV + 285.3
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	8.46 AV + 303.2
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	7.97 AV + 369.3
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	8.46 AV + 387.2
5A. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with through-the-door ice service.	8.33 AV + 436.3
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	8.85 AV + 458.3
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	7.56 AV + 355.3
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	7.69 AV + 397.9

ENERGY STAR Most Efficient qualifying models are at least 15% more efficient than the federal standard and use less than 637 kWh per year (with the exception of top-freezers), in adherence with the DOE test procedures at 10 CFR 430, Subpart B, Appendix A and Appendix B. Only full-sized refrigerator-freezer models are eligible to achieve this classification. The calculations of the maximum annual energy consumption for each product class are provided below.

ENERGY STAR Most Efficient (2016) Annual Energy Consumption Allowance ⁵

Product Class	Maximum Annual Energy Consumption (kWh/year)
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	$AV \leq 65.6, E_{ann} \leq 6.79 \cdot AV + 191.3$ $AV > 65.6, E_{ann} \leq 637$
2. Refrigerator-freezers—partial automatic defrost.	$AV \leq 65.6, E_{ann} \leq 6.79 \cdot AV + 191.3$ $AV > 65.6, E_{ann} \leq 637$
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	$AV \leq 53.0, E_{ann} \leq 7.23 \cdot AV + 253.1$ $AV > 53.0, E_{ann} \leq 637$

⁵ ENERGY STAR. 2016. "ENERGY STAR Most Efficient Recognition Criteria: Refrigerator-Freezers." Effective January 2016.

Product Class	Maximum Annual Energy Consumption (kWh/year)
4-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker	$AV \leq 53.0, E_{ann} \leq 7.23 \cdot AV + 253.1$ $AV > 53.0, E_{ann} \leq 637$
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$AV \leq 41.4, E_{ann} \leq 7.23 \cdot AV + 337.1$ $AV > 41.4, E_{ann} \leq 637$
4I-BI. Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	$AV \leq 41.4, E_{ann} \leq 7.23 \cdot AV + 337.1$ $AV > 41.4, E_{ann} \leq 637$
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	$AV \leq 48.8, E_{ann} \leq 7.52 \cdot AV + 269.5$ $AV > 48.8, E_{ann} \leq 637$
5-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	$AV \leq 48.8, E_{ann} \leq 7.52 \cdot AV + 269.5$ $AV > 48.8, E_{ann} \leq 637$
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service	$AV \leq 37.7, E_{ann} \leq 7.52 \cdot AV + 353.5$ $AV > 37.7, E_{ann} \leq 637$
5I-BI. Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service	$AV \leq 37.7, E_{ann} \leq 7.52 \cdot AV + 353.5$ $AV > 37.7, E_{ann} \leq 637$
5A. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with through-the-door ice service	$AV \leq 28.0, E_{ann} \leq 7.86 \cdot AV + 416.7$ $AV > 28.0, E_{ann} \leq 637$
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service	$AV \leq 28.0, E_{ann} \leq 7.86 \cdot AV + 416.7$ $AV > 28.0, E_{ann} \leq 637$
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service	$AV \leq 35.3, E_{ann} \leq 7.26 \cdot AV + 380.5$ $AV > 35.3, E_{ann} \leq 637$
7-BI Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service	$AV \leq 35.3, E_{ann} \leq 7.26 \cdot AV + 380.5$ $AV > 35.3, E_{ann} \leq 637$

NORMALIZING UNIT

Each.

PROGRAM REQUIREMENTS

Measure Implementation Eligibility

All combinations of measure application type, delivery type, and sector that are established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

Measure Application Type	Delivery Type	Sector
Normal replacement	UpDeemed	Res
Normal replacement	DnDeemed	Res
Normal replacement	DnDeemDI	Res
New construction	UpDeemed	Res
New construction	DnDeemed	Res
New construction	DnDeemDI	Res

Eligible Products

The product eligibility requirements for the ENERGY STAR and ENERGY STAR Most Efficient tiers are provided below. See Measure Case Description for a full list of refrigerator model specifications.

Energy Efficiency Requirements for ENERGY STAR Refrigerators

Measure	Requirements
ENERGY STAR Version 5.0 (10% above the federal standard)	<ul style="list-style-type: none"> – Must be on the ENERGY STAR qualifying list. – ENERGY STAR qualified refrigerators are 10% more efficient than models that simply meet the federal minimum standard for energy efficiency. – Refrigerators smaller than 7.75 ft³ are classified as compact refrigerators.
ENERGY STAR Most Efficient (15% above the federal standard)	<ul style="list-style-type: none"> – Must be on the ENERGY STAR qualifying list and be indicated as meeting the ENERGY STAR Most Efficient criteria. – ENERGY STAR Most Efficient qualified refrigerators are 15% more efficient than models that meet the federal minimum standard for energy efficiency. – ENERGY STAR Most Efficient qualified refrigerators must use less than or equal to 637 kWh per year. – Top freezers do not have to meet the 15% requirement; only the ≤ 637 kWh/year requirement.

Eligible Building Types

Eligible building types include any residential single family, multifamily, and residential double-wide mobile homes.

Eligible Climate Zones

The measure is applicable in all California climate zones.

PROGRAM EXCLUSIONS

Ineligible Products

Ineligible products for ENERGY STAR refrigerators (10% above federal standard) include:

- Keg/beverage centers and wine coolers/chillers.
- Refrigerators larger than 7.75 ft³ and 36 inches or more in height do not qualify for a compact refrigerator rebate.

Ineligible products for ENERGY STAR Most Efficient refrigerators (15% above federal standard) include:

- Compact refrigerators, all-refrigerators, and freezers.
- Keg/beverage centers and wine coolers/chillers.

DATA COLLECTION REQUIREMENTS

Data collection requirements are to be determined.

USE CATEGORY

Appliance and plug load (AppPlug)

ELECTRIC SAVINGS (kWh)

The unit energy consumption (UEC) and unit energy savings (UES) for residential refrigerators and freezers are based upon several sources, depending on the tier and product class. For reference, the source of the average energy consumption (AEC) for base case and measure case product classes are provided in Code Requirements. The derivation of the UES for each efficiency for refrigerators and freezers are explained below.

ENERGY STAR Refrigerators

The Database for Energy Efficient Resources (DEER) 2020 provides unit energy savings (UES) for standard sized refrigerators in the following size categories: mini, small, medium, large, and very large. However, to retain consistency with the classification of prior program cycles, the standard sized refrigerator measure offerings are split into three size categories (same as DEER 2015): large, medium, or small. Therefore, the DEER 2020 size categories (and therefore unit energy savings) do not align and must be recalculated with the size categories defined for the measure offerings shown in the Measure Case Description section.

The average total volume of each size category is equal to the average of the lower and upper range of the applicable size category. The average total volume is cross-walked to the adjusted volume for the applicable refrigerator product class using the methodology in the DOE Technical Support Document.

Using the adjusted volume (AV), the federal mandated maximum annual energy consumption (AEC) of the base case model can be calculated from the equations in the Code Requirements. The AEC of an ENERGY STAR refrigerator (measure case model) can be calculated by applying the AV to the ENERGY STAR or ENERGY STAR Most Efficient AEC equations in the Measure Case Description, respectively to determine eligibility.

The UES is calculated as the difference between the federal code (baseline) AEC and the ENERGY STAR (measure case) AEC. This difference was then converted to DEER-equivalent savings by applying a “DEER basis factor” drawn directly from DEER 2014 (“RE-Appl-RefgCond-basis”).

$$UES_{kWh} = (AEC_{base} - AEC_{ES}) \times DEER \text{ basis factor}_{kWh}$$

$$UES_{kW} = (AEC_{base} - AEC_{ES}) \times DEER \text{ basis factor}_{kW}$$

$$UES_{therms} = (AEC_{base} - AEC_{ES}) \times DEER \text{ basis factor}_{therms}$$

ENERGY STAR Most Efficient Refrigerators

The UES of an ENERGY STAR Most Efficient standard sized refrigerator was calculated the same way as the ENERGY STAR refrigerators, except that the total volume is calculated as an average of volumes in the ENERGY STAR-qualified products list.

Compact Refrigerators

The UES of an ENERGY STAR compact refrigerator was calculated as an average of the DEER 2020 savings values for small and mini compact refrigerator categories.

Chest and Upright Freezers

The UES values for all freezers were directly drawn from DEER 2020 or were scaled from DEER 20200. In addition to DEER, values from the U.S. Department of Energy Compliance Certification Management System (CCMS) database were also referenced.⁶ The CCMS provides model-level UEC values for all models sold in the U.S.⁷ While the CCMS is the most comprehensive database of models available, this analysis deferred to existing DEER values if they were available.

Basic Tier

Consistent with the freezer measure offerings established for this measure, DEER classifies Basic Tier freezers into 12 classes based on configuration (upright or chest), and capacity (small: < 13 ft³, medium: 13-16 ft³, or large: >16 ft³). The UES for Basic Tier freezers were drawn directly from the DEER database.

Advanced Tier

Advanced Tier freezers are identified with 5% lower energy consumption than the ENERGY STAR maximum allowance. Note that the ENERGY STAR specification requirement is 10% lower energy consumption than the federal maximum annual energy consumption allowance (i.e., 90% of the federal maximum). This means that for this measure, Advanced Tier are defined as ENERGY STAR +5% as 95% of the ENERGY STAR maximum, or 95% of 90% of the federal maximum (which is equal to 85.5% of the federal standard maximum, or 14.5% lower than the federal standard maximum).⁸

⁶U.S. Department of Energy (DOE), Energy Efficiency and Renewable Energy. 2015. “Appliance & Equipment Standards Program | CCMS. Refrigerators, Refrigerator-Freezers, and Freezers.” [https://www.regulations.doe.gov/certification-data/CCMS-4-Refrigerators Refrigerator-Freezers and Freezers.html#q=Product_Group_s%3A%22Refrigerators%2C%20Refrigerator-Freezers%2C%20and%20Freezers%22](https://www.regulations.doe.gov/certification-data/CCMS-4-Refrigerators%20Refrigerator-Freezers%20and%20Freezers%22). Accessed in 2015.

⁷Refrigerators and freezer specifications for both ENERGY STAR and Federal Standards do not report modal power and usage, but instead report values as UEC (in kWh per year).

⁸This is in contrast to adding the 5% to the 10% lower than the federal maximum (15% lower than the federal maximum).

Advanced Tier (ENERGY STAR +5%) freezers are not included in DEER. As such, the UES values for units in this tier were established by scaling from the UES values in DEER for the Basic Tier. The UES values in DEER are for ENERGY STAR freezers, or freezers that consume 10% less energy than the federal standard. Since the Advanced Tier is defined as ENERGY STAR + 5%, or 14.5% less than the federal standard, the UES values are calculated by multiplying the DEER UES values by a factor of $\frac{10\%}{14.5\%}$ or 1.45.

PEAK ELECTRIC DEMAND REDUCTION (KW)

Peak demand reduction for all refrigerators and freezer were calculated with the same methodology as energy savings, presented in the Electric Savings section.

GAS SAVINGS (THERMS)

Gas energy savings is calculated with the same methodology as electric energy savings, presented in the Electric Savings section.

Summary of Refrigerator Annual Unit Energy Consumption Sources, by Product Class

Product Class	Base Case AEC Source	Measure Case ENERGY STAR Tier AEC Source	Measure Case ENERGY STAR Most Efficient Tier AEC Source	Configuration	Ice	Size
1. Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	DEER 2017			Refrigerator/Freezer	No Ice	Any
1A. All-refrigerators—manual defrost.	Not used					
2. Refrigerator-freezers—partial automatic defrost.	Not used					
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker.	2014 DOE Federal Standard	ENERGY STAR Version 5.0	15% better than Energy Star	Refrigerator/Freezer	No Ice	Any
3-BI. Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker.	Not used					
3I. Refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	Not used					
3I-BI. Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service.	Not used					
3A. All-refrigerators—automatic defrost.	2014 DOE Federal Standard	Energy Star Version 5.0		Freezer-less Refrigerator	No Ice	Any
3A-BI. Built-in all-refrigerators—automatic defrost.	Not used					
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	2014 DOE Federal Standard	Energy Star Version 5.0	ENERGY STAR Most Efficient 2016	Side Freezer	No Ice	Any
4-BI. Built-in refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker.	Not used					
4I. Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	Not used					
4I-BI. Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service.	Not used					

Product Class	Base Case AEC Source	Measure Case ENERGY STAR Tier AEC Source	Measure Case ENERGY STAR Most Efficient Tier AEC Source	Configuration	Ice	Size
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	2014 DOE Federal Standard	Energy Star Version 5.0	ENERGY STAR Most Efficient 2016	Bottom Freezer	No Ice	Any
5-BI. Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker.	Not used					
5I. Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	Not used					
5I-BI. Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service.	Not used					
5A. Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	2014 DOE Federal Standard	Energy Star Version 5.0	ENERGY STAR Most Efficient 2016	Bottom Freezer	With Ice	Any
5A-BI. Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service.	Not used					
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service.	2014 DOE Federal Standard	Energy Star Version 5.0	15% better than Energy Star	Top Freezer	With Ice	Any
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	2014 DOE Federal Standard	Energy Star Version 5.0	ENERGY STAR Most Efficient 2016	Side Freezer	With Ice	Any
7-BI. Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service.	Not used					
8. Upright freezers with manual defrost.	DEER 2017			Upright Freezer	Manual Defrost	Any
9. Upright freezers with automatic defrost without an automatic icemaker.	DEER 2017			Upright Freezer	Automatic Defrost	Any
9I. Upright freezers with automatic defrost with an automatic icemaker.	Not used					

Product Class	Base Case AEC Source	Measure Case ENERGY STAR Tier AEC Source	Measure Case ENERGY STAR Most Efficient Tier AEC Source	Configuration	Ice	Size
9-BI. Built-in upright freezers with automatic defrost without an automatic icemaker.	Not used					
9I-BI. Built-in upright freezers with automatic defrost with an automatic icemaker.	Not used					
10. Chest freezers and all other freezers except compact freezers.	DEER 2017			Chest Freezer	Manual Defrost	Any
10A. Chest freezers with automatic defrost.	DEER 2017			Chest Freezer	Automatic Defrost	Any
11. Compact refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost.	DEER 2014			Refrigerator/Freezer	No Ice	Compact (<7.75 cu ft)
11A. Compact all-refrigerators—manual defrost.	DEER 2014			Freezer-less Refrigerator	No Ice	Compact (<7.75 cu ft)
12. Compact refrigerator-freezers—partial automatic defrost.	Not used					
13. Compact refrigerator-freezers—automatic defrost with top-mounted freezer.	DEER 2014			Top Freezer	No Ice	Any
13I. Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker.	Not used					
13A. Compact all-refrigerators—automatic defrost.	Not used					
14. Compact refrigerator-freezers—automatic defrost with side-mounted freezer.	Not used					
14I. Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker.	Not used					
15. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer.	DEER 2014			Bottom Freezer	No Ice	Compact (<7.75 cu ft)
15I. Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker.	Not used					
16. Compact upright freezers with manual defrost.	Not used					

Product Class	Base Case AEC Source	Measure Case ENERGY STAR Tier AEC Source	Measure Case ENERGY STAR Most Efficient Tier AEC Source	Configuration	Ice	Size
17. Compact upright freezers with automatic defrost.	Not used					
18. Compact chest freezers.	Not used					

LIFE CYCLE

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

The EUL and RUL specified for high-efficiency refrigerators are specified below. Insofar as the RUL is only applicable to the first baseline period for a retrofit measure with an applicable code baseline, it is not applicable for this measure.

Effective Useful Life and Remaining Useful life

Parameter	Refrigerators - All Models	Freezers - All Models	Source
EUL (yrs)	14.0	11.0	California Public Utilities Commission (CPUC), Energy Division. 2008. "EUL_Summary_10-1-08.xls." -
RUL (yrs)	4.7	3.7	

BASE CASE MATERIAL COST (\$/UNIT)

The base case material cost for equipment *delivered via direct install* is equal to \$0.

The base case material costs for *all other delivery types* were derived from cost models developed for the 2010-2012 Measure Cost Update study conducted by Itron, Inc.⁹ The following measures were out of scope of the cost models and were therefore assigned other values, as follows:

- Measure "ENERGY STAR with no Freezer (11 ft³ - 23 ft³) Refrigerator" was assigned the base case cost for "ENERGY STAR Top Mount Freezer, no Ice - Small (10-15 ft³) Refrigerator."
- Compact models were assigned a base case cost of \$175, from the ENERGY STAR Residential Refrigerator Calculator.
- Measure "ENERGY STAR Most Efficient - Average Size Refrigerator/Freezer" was calculated as the average of ENERGY STAR Most Efficient bottom, top and side mount freezer (large size) base case costs. A web-harvesting analysis was conducted in 2016 (see PGECOAPP128) to derive an average base case cost for this measure.
- Measures for upright and chest freezers had assigned base case costs calculated as the average cost of non-ENERGY STAR certified models for that category. A web-harvesting analysis was conducted in 2016 to derive an average base case cost for this measure.

⁹ Itron, Inc. 2014. *2010-2012 W0017 Ex Ante Measure Cost Study Final Report*. Prepared for the California Public Utilities Commission.

MEASURE CASE MATERIAL COST (\$/UNIT)

The DEER 2016 Refrigerator and Freezer Cost Workbook was used to calculate measure case refrigerator model costs for *all delivery types*. The following costs were out of scope of the cost models and were therefore assigned the indicated values:

- Measure “ENERGY STAR with no Freezer (11 ft³ - 23 ft³) Refrigerator” was assigned the measure case cost for “ENERGY STAR Top Mount Freezer, no Ice - Small (10 ft³-15 ft³) Refrigerator”
- Compact models were assigned a measure case cost of \$185, based on a \$10 incremental cost from the ENERGY STAR Appliance Savings Calculator.
- Measure “ENERGY STAR Most Efficient - Average Size Refrigerator/Freezer” was calculated as the average of ENERGY STAR Most Efficient bottom, top and side mount freezer (large size) measure case costs. A web-harvesting analysis was conducted in 2016 (see PGECOAPP128) to derive an average measure cost for this measure.
- Measures for upright and chest freezers had assigned measure costs calculated as the average cost of ENERGY STAR certified models for that category. A web-harvesting analysis was conducted in 2016 to derive an incremental cost for this measure. The analysis found that, after account for features that were “like-for-like”, the incremental measure cost for standalone freezers was not statistically different from zero.

BASE CASE LABOR COST (\$/UNIT)

The base case labor cost for equipment *delivered via direct install* is equal to \$0.

The base case labor cost for *all other delivery types* was derived using the cost assumptions are specified below and are the same for the base case and measure case models. The labor rate adopted for the costs analysis was drawn from the Database for Energy Efficient Resources and is associated with the DEER Labor Rate ID “R-App”.

Labor Cost Assumptions

Parameter	All Full-size Models	All Compact Models	Source
Labor Rate (\$/hr)	\$48.60	\$48.60	The source for this data/information is unknown.
Labor Hours (hrs)	1.5	0.5	Professional judgement.

MEASURE CASE LABOR COST (\$/UNIT)

The measure case labor cost for equipment *delivered via direct install* will be derived as the average installation cost submitted by one or more implementation contractors. The actual installation cost can vary by contractor, the date when the work occurred, and by the volume of each specific contractor’s business. Contractor costs are confidential information and are based upon contractually agreed upon pricing as established in their purchase order with the program administrator. Therefore, the program administrator program tracking systems are the only source for the labor installation cost data. The program administrator will utilize the actual program cost to evaluate the cost-effectiveness of the measure.

For *all other delivery types*, a high efficiency model does not require additional installation labor compared to a base case model. See Base Case Labor Cost.

NET-TO-GROSS (NTG)

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. These NTG values are based upon the average of all NTG ratios for all evaluated 2006 – 2008 residential programs, as documented in the 2011 DEER Update Study conducted by Itron, Inc. These sector average NTGs (“default NTGs”) are applicable to all energy efficiency measures that have been offered through residential programs for more than two years and for which impact evaluation results are not available. Additionally, a NTG ratio has been established for program-qualified high efficiency refrigerators units that are incentivized at the midstream delivery channel.

Net-to-Gross Ratios

Parameter	All Models	Source
NTG – residential default (downstream)	0.55	Itron, Inc. 2011. <i>DEER Database 2011 Update Documentation</i> . Prepared for the California Public Utilities Commission. Page 15-4, Table 15-3.
NTG – other delivery channels	0.20	Pacific Gas and Electric (PG&E). 2017. <i>Work Paper PGECOAPP128 Retail Products Platform Revision #3</i> . March 29. Page 90.

GROSS SAVINGS INSTALLATION ADJUSTMENT (GSIA)

The gross savings installation adjustment (GSIA) rate represents the ratio of the number of verified installations of the measure to the number of claimed installations reported by the utility. This factor varies by end use, sector, technology, application, and delivery method.

Gross Savings Installation Rate Adjustments

Parameter	All Models	Source
GSIA	1.0	California Public Utilities Commission (CPUC), Energy Division. 2013. <i>Energy Efficiency Policy Manual Version 5</i> . Page 31.

NON-ENERGY IMPACTS

Non-energy impacts for this measure have not been quantified.

DEER DIFFERENCES ANALYSIS

This section provides a summary of the Database for Energy Efficient Resources (DEER)-based inputs and methods, and the rationale for inputs and methods that are not DEER-based. Notably, the size designations defined for the measure offerings do not align with those in DEER. Therefore, the rated energy savings obtained from the DOE annual energy use equations are multiplied by “DEER-basis factor.”

DEER Difference Summary

DEER Item	Comment
Modified DEER methodology	Yes
Scaled DEER measure	Yes
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER eQUEST Prototypes	No
DEER Version	DEER 2020, READI v2.5.1
Reason for Deviation from DEER	DEER assumes different size ranges and efficiency levels
DEER Measure IDs Used	n/a
NTG	DEER: The value of 0.55 is associated with NTG ID: <i>Res-Default>2</i> for downstream delivery. The value of 0.20 is not associated with NTG ID; thus, the ID <i>NonRes-sAll-mRfg-DG</i> is used as a proxy for this value.
GSIA	The value of 1.0 is associated with GSIA ID: <i>Def-GSIA</i>
EUL/RUL	The EUL value of 14.0 years is associated with EUL ID: <i>Appl-ESRefg</i> The EUL value of 11.0 is associated with EUL ID: <i>Appl-ESFrzr</i>

REVISION HISTORY

Measure Characterization Revision History

Revision Number	Date	Primary Author, Title, Organization	Revision Summary and Rationale for Revision Effective Date and Approved By
01	10/31/2017	Jennifer Holmes Cal TF Staff	Draft of consolidated text for this statewide measure is based upon: PGECOAPP124, Revision 2 (January 14, 2015) SCE13AP001, Revision 3 (November 24, 2015) WPSDGEREAP0001, Revision 0 (June 15, 2012) PGECOAPP128, Revision 6 (April 9, 2018) Consensus reached among Cal TF members.
	12/31/2018	Jennifer Holmes Cal TF Staff	Final revisions for submission of Version 01.
	12/31/2018	Jia Chang Huang PG&E	Submitted revision 01 of the state-wide paper to WPA
	06/03/2019	Jia Chang Huang PG&E	Added PG&E implementation IDs to EAD Table including chest freezers. Corrected description for upright freezers, ES+5%
	07/05/2019	Tai Voong PG&E	Resubmit revision 01 to the WPA site with no significant modifications
	02/25/2020	Adan Rosillo PG&E	Added PG&E measure IDs; AP018, AP019, AP020, AP021, AP022, AP023, AP037, AP038, AP039, AP040, AP041, and AP042 to the EAD Table - Implementation Tab. Revised word document and update references to DEER versions. No energy savings nor base/measure costs were affected by this update.