



## MEASURE CHARACTERIZATION

# High Efficiency Window, Residential

<https://www.caetrm.com/measure/SWBE011/01-draft/>

<b>USE CATEGORY</b> BE - Building Envelope	<b>COMMITTED</b>
<b>STATUS</b> CPUC Request for Information	<b>EFFECTIVE START DATE</b> January 1, 2025
<b>VERSION</b> SWBE011-01-draft	<b>DOWNLOADED</b> July 31, 2024 9:27 AM

# Technology Summary

This measure is the installation of high-efficiency windows with reduced thermal conductance and improved radiant emissivity. The measure applies to residential buildings under new construction and retrofit applications. This measure is only applicable to windows that serve as a barrier between conditioned spaces and outside air. Energy is saved by reducing cooling and heating loads because of reduced energy loss between the building's interior and exterior.

Southern California Edison (SCE) sponsored a project in the Emerging Technology Program to evaluate the energy performance of High-Performance Residential Windows, as indicated in the table below.

## Emerging Technologies

PROJECT NUMBER (TEXT)	PROGRAM FUNDING YEAR (TEXT)
ET23SWE0043	2023-2024

# Measure Case Description

The measure case is defined as the installation of windows that meet the U-factor and solar heat gain coefficient (SHGC) eligibility criteria specified in the ENERGY STAR Program Requirements for Residential Windows, Doors, and Skylights, Version 7.0 <sup>R2810</sup> <sup>R2812</sup>. To map ENERGY STAR climate zones to California climate zones, the project team considered CZ1, CZ3, CZ5, and CZ16 to be North-Central and all other climate zones to be South-Central. The table below shows the requirements for residential windows as listed in the specification.

## ENERGY STAR Residential Windows V7.0 Specification Requirements

CLIMATE ZONE	U-FACTOR	SHGC
Northern	$\leq 0.22$	$\geq 0.17$
North-Central	$\leq 0.25$	$\leq 0.40$
South-Central	$\leq 0.28$	$\leq 0.23$
Southern	$\leq 0.28$	$\leq 0.23$

## Offering ID

MEASURE APPLICATION TYPE	STATEWIDE MEASURE OFFERING ID (TEXT)	MEASURE OFFERING DESCRIPTION (TEXT)
BW	<b>B</b>	<b>ENERGY STAR compliant window, BW</b>
NC	<b>A</b>	<b>ENERGY STAR compliant window, NC</b>

## Base Case Description

The base case for new construction is defined as a standard-efficiency window that meets the 2022 California Building Energy Efficiency Standards (Title 24) mandatory requirements; the U-factor requirement is 0.45 for single family and 0.58 for low-rise multifamily building types, and there are no mandatory requirements for SHGC or mobile home U-factor. <sup>R1557</sup> The DEER Residential Prototypes ([www.github.com/sound-data/DEER-Prototypes-EnergyPlus](https://www.github.com/sound-data/DEER-Prototypes-EnergyPlus)) were utilized for baseline SHGC and mobile home U-factor. A mandatory code baseline was utilized for single family and multifamily new construction as it represented the minimum efficiency required in California new construction by code.

For existing buildings, the DEER Residential Building Prototypes were utilized for baseline efficiency as they represented the CPUC-approved baseline assumptions for building energy modeling of residential windows.

### Base Case Descriptions

MEASURE APPLICATION TYPE	STATEWIDE MEASURE OFFERING ID (TEXT)	EXISTING DESCRIPTION (TEXT)	STANDARD DESCRIPTION (TEXT)
BW	<b>B</b>	<b>Single pane window</b>	<b>Single pane window</b>
NC	<b>A</b>	<b>Single pane window</b>	<b>Single pane window</b>

## Code Requirements

The 2022 Title 24 specifies U-factor requirements for fenestration products, including windows. The requirements for fenestration products installed in single family buildings are listed in Section 150.0(q)1. The requirements for fenestration products installed in multifamily buildings are listed in Section 160.1(e)1.

## Applicable State and Federal Codes and Standards

CODE	APPLICABLE CODE REFERENCE	EFFECTIVE DATE
CA Appliance Efficiency Regulations – Title 20	N/A	N/A
CA Building Energy Efficiency Standards – Title 24	Sections 150.0(q)1, 160.1(e)1	1/1/2023
Federal Standards	N/A	N/A

# Program Requirements

## MEASURE IMPLEMENTATION ELIGIBILITY

All measure application type, delivery type, and sector combinations 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	SECTOR	DELIVERY TYPE
BW	Res	DnDeemDI
BW	Res	DnDeemed
NC	Res	DnDeemDI
NC	Res	DnDeemed
NC	Res	UpDeemed

## ELIGIBLE PRODUCTS

1. Primary windows that meet the criteria specified in the Measure Case Description Section are eligible for this measure. The table below summarizes the minimum SHGC and U-Factor requirements by climate zone.

## California Climate Zone to ENERGY STAR Climate Zone Mapping

CALIFORNIA CLIMATE ZONE	ENERGY STAR CLIMATE ZONE	U-FACTOR	SHGC
CZ1	North-Central	≤ 0.25	≤ 0.40
CZ2	South-Central	≤ 0.28	≤ 0.23
CZ3	North-Central	≤ 0.25	≤ 0.40
CZ4	South-Central	≤ 0.28	≤ 0.23
CZ5	North-Central	≤ 0.25	≤ 0.40
CZ6	South-Central	≤ 0.28	≤ 0.23
CZ7	South-Central	≤ 0.28	≤ 0.23
CZ8	South-Central	≤ 0.28	≤ 0.23
CZ9	South-Central	≤ 0.28	≤ 0.23
CZ10	South-Central	≤ 0.28	≤ 0.23
CZ11	South-Central	≤ 0.28	≤ 0.23
CZ12	South-Central	≤ 0.28	≤ 0.23
CZ13	South-Central	≤ 0.28	≤ 0.23
CZ14	South-Central	≤ 0.28	≤ 0.23
CZ15	South-Central	≤ 0.28	≤ 0.23
CZ16	North-Central	≤ 0.25	≤ 0.40

2. Windows must be certified by the National Fenestration Rating Council.
3. For the building weatherization measure application type, single pane windows and any other existing conditions are eligible (single pane, double pane non vinyl, etc).

## ELIGIBLE BUILDING TYPES AND VINTAGES

This measure is applicable to all residential building types. The existing vintage era (Ex) can be used for all claims of all existing vintages, including recent and old. The new construction measure application type will use the new building vintage.

This measure is applicable to all HVAC system types (only rDXGF and rDXHP savings are provided).

## ELIGIBLE CLIMATE ZONES

The measure is applicable in all California climate zones.

## Program Exclusions

The following equipment is not eligible for this measure:

- Window films or specialty window treatments
- Secondary windows

## Data Collection Requirements

Data Collection requirements are described in DEER Resolutions *E-5152* and *E-5221* with the objectives of: R1503 R2026

1. Better tracking of the installed equipment that received a rebate,
2. Ensuring that eligible measures are submitted in applications,
3. Proper evaluation and application of savings are performed per California EM&V Protocols,
4. Cost effectiveness values are properly/correctly applied for each application/project.

DATA COLLECTION REQUIREMENTS	REQUIRED FOR UPSTREAM	REQUIRED FOR DOWNSTREAM AND DIRECT INSTALL
Site ID - unique identifier for the shipping destination (upstream) or installed location (Midstream/Downstream/DI) of the incentivized equipment (e.g., site address)	Yes	Yes
Quantity per Site – Total units of incentivized equipment located at the site or project	Yes	Yes
Measure equipment ID <sup>1</sup> - A unique identifier for each unit of incentivized equipment	Yes	Yes
Measure equipment model number	Yes	Yes
Measure equipment manufacturer	Yes	Yes

DATA COLLECTION REQUIREMENTS	REQUIRED FOR UPSTREAM	REQUIRED FOR DOWNSTREAM AND DIRECT INSTALL
Measure equipment U-factor	Yes	Yes
Measure equipment SHGC	Yes	Yes
Measure equipment type (primary window, secondary window)	Yes	Yes
Climate Zone	Yes	Yes
Building Type	Yes	Yes

1. If the measure equipment is not serialized, a practical unique identifier may be determined by the Program Implementer and/or the Program Administrator (e.g., Measure equipment manufacturer - Measure equipment model number - Unique Application ID - Site ID - Location within installed site).

2. Refer to guidance below for obtaining base equipment type, building type, and building vintage for upstream and midstream.

For upstream/midstream delivery types, the participant baselines and measure equipment installation details may be unknown. In cases where the manufacturer or distributor may not be aware of the building type of the measure equipment location, the most conservative building type savings should be claimed.

## Electric Savings (kWh)

The electric unit energy savings (UES) of this measure were derived from building energy use simulation results and were calculated as the difference between the baseline and measure building unit energy consumption (UEC). Building energy use and demand were estimated using EnergyPlus Version 9.5.

### Unit Energy Consumption (UEC) Modeling Tool Summary

PLATFORM	ENERGYPLUS
Model Type	PA Modeled
Energy Modeling Engine	EnergyPlus Version 22.2
Energy Modeling Interface	Modelkit-catalist-0.5.0
Batch Processor	DEER Modelkit
Weather Files	CEC CZ2022
GitHub Path to Measure Folder	Not Applicable
Branch Source	Not Applicable
Version Source	Not Applicable

Note: The EnergyPlus input files (\*.idf) will be uploaded to the eTRM platform.

UEC values are expected to change with climate zone, building type, and vintage. Modeling was performed using the DEER Residential Prototypes. Modeling was conducted for all climate zones and residential building types.

## Residential Building Types

BUILDING TYPE	BUILDING TYPE CODE	MODELED
Residential Single Family	SFm	Yes
Residential Multi-family	MFm	Yes
Residential Mobile Home	DMo	Yes

## Non-Mobile Home Vintages

VINTAGE ERA	VINTAGE	VINTAGE CODE	MODELED
Old (Old)	1975	Before 1978	Yes
	1985	1987 - 1992	Yes
	1996	1993 - 2001	No
Median (Ex)	2003	2002 - 2005	No
	2007	2006 - 2009	No
	2011	2010 - 2013	No
	2015	2014 - 2016	No
Recent (Rec)	2017	2017-2019	No
	2020	After 2019	No
New (New)	New	New Construction	Yes

## Mobile Home Vintages

VINTAGE ERA	VINTAGE	VINTAGE CODE	MODELED
Old (Old)	MH72	Before 1976	Yes
	MH85	1976 - 1994	Yes
Median (Ex)	MH00	1995 - 2005	No
	MH06	2006 - 2014	No



VINTAGE ERA	VINTAGE	VINTAGE CODE	MODELED
Recent (Rec)	MH15	After 2014	No
New (New)	New	New Construction	Yes

## Climate Zone

CLIMATE ZONE	CLIMATE ZONE DESCRIPTION	MODELED
1	Eureka Area (CZ01)	Yes
2	Napa Area (CZ02)	Yes
3	Oakland Area (CZ03)	Yes
4	San Jose Area (CZ04)	Yes
5	Santa Maria Area (CZ05)	Yes
6	Los Angeles IAP Area (CZ06)	Yes
7	San Diego Area (CZ07)	Yes
8	Long Beach Area (CZ08)	Yes
9	Los Angeles Downtown Area (CZ09)	Yes
10	Riverside Area (CZ10)	Yes
11	Red Bluff Area (CZ11)	Yes
12	Stockton Area (CZ12)	Yes
13	Daggett-Barstow Area (CZ13)	Yes
14	China Lake Area (CZ14)	Yes
15	El Centro Area (CZ15)	Yes
16	Bishop Area (CZ16)	Yes

## BASELINE ENERGY USE SIMULATION

Modeling was performed using the DEER Residential Prototypes for all climate zones and residential building types. The table below provides the baseline U-factors and SHGC used in the modeling. The DEER Residential Prototype baselines were modified to reflect 2022 California Energy Code Mandatory U-factor requirements for new construction. Baseline efficiency for retrofits was assumed to be the DEER Residential Prototype baseline U-factor. No modifications were made to DEER Residential Prototype SHGC values.

### Baseline Parameters

BUILDING TYPE	DMO	DMO	MFM	SFM	MFM-T24	SFM-T24	DMO	DMO	MFM	SFM	MFM-T24	SFM-T24
YEAR	1972-1985	NEW	1985	1975-1985	2022	2022	1972-1985	NEW	1985	1975-1985	2022	2022
METRIC	U-FACTOR	U-FACTOR	U-FACTOR	U-FACTOR	U-FACTOR	U-FACTOR	SHGC	SHGC	SHGC	SHGC	SHGC	SHGC
CZ1	1.23	0.5	0.66	0.66	0.58	0.45	0.80	0.6	0.52	0.52	0.52	0.52
CZ2	1.23	0.5	0.59	0.59	0.58	0.45	0.80	0.6	0.46	0.46	0.23	0.23
CZ3	1.23	0.5	0.66	0.66	0.58	0.45	0.80	0.6	0.50	0.50	0.50	0.50
CZ4	1.23	0.5	0.60	0.60	0.58	0.45	0.80	0.6	0.47	0.47	0.23	0.23
CZ5	1.23	0.5	0.68	0.68	0.58	0.45	0.80	0.6	0.51	0.51	0.51	0.51
CZ6	1.23	0.5	0.69	0.69	0.58	0.45	0.80	0.6	0.51	0.51	0.23	0.23
CZ7	1.23	0.5	0.68	0.68	0.58	0.45	0.80	0.6	0.51	0.51	0.23	0.23
CZ8	1.23	0.5	0.71	0.71	0.58	0.45	0.80	0.6	0.53	0.53	0.23	0.23
CZ9	1.23	0.5	0.71	0.71	0.58	0.45	0.80	0.6	0.53	0.53	0.23	0.23
CZ10	1.23	0.5	0.68	0.68	0.58	0.45	0.80	0.6	0.52	0.52	0.23	0.23
CZ11	1.23	0.5	0.61	0.61	0.58	0.45	0.80	0.6	0.49	0.49	0.23	0.23
CZ12	1.23	0.5	0.61	0.61	0.58	0.45	0.80	0.6	0.47	0.47	0.23	0.23
CZ13	1.23	0.5	0.74	0.74	0.58	0.45	0.80	0.6	0.56	0.56	0.23	0.23
CZ14	1.23	0.5	0.69	0.69	0.58	0.45	0.80	0.6	0.54	0.54	0.23	0.23
CZ15	1.23	0.5	0.65	0.65	0.58	0.45	0.80	0.6	0.49	0.49	0.23	0.23
CZ16	1.23	0.5	0.64	0.64	0.58	0.45	0.80	0.6	0.50	0.50	0.50	0.50

## MEASURE CASE ENERGY USE SIMULATION

Modeling was performed using the DEER Residential Prototypes for all climate zones and residential building types. The U-factors and SHGC values were modified per the table below and all other values were unchanged.

### Measure Parameter Modifications

PARAMETER	PARAMETER DESCRIPTION	MEASURE VALUE/ASSUMPTION
U-factor	Thermal Conductance of the Window	CZ01,3,5,16 - 0.25 CZ02,4,6-15 - 0.28
SHGC	Solar Heat Gain Coefficient	CZ01,3,5,16 - 0.40 CZ02,4,6-15 - 0.23

## CALCULATION OF UNIT ENERGY SAVINGS

The annual UES was calculated as the difference between the baseline and measure case annual UEC. Results were normalized per square foot of window area <sup>R2792</sup>.

### Annual Unit Energy Savings - Electric

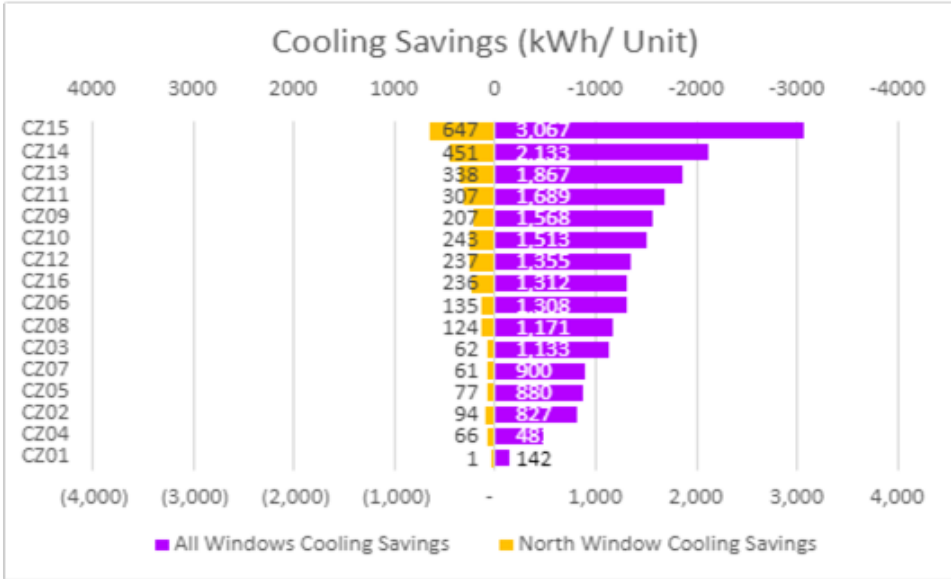
EQUATION (KWH / YR)

$$UEC_{Base\_YrkWh} - UEC_{Meas\_YrkWh}$$

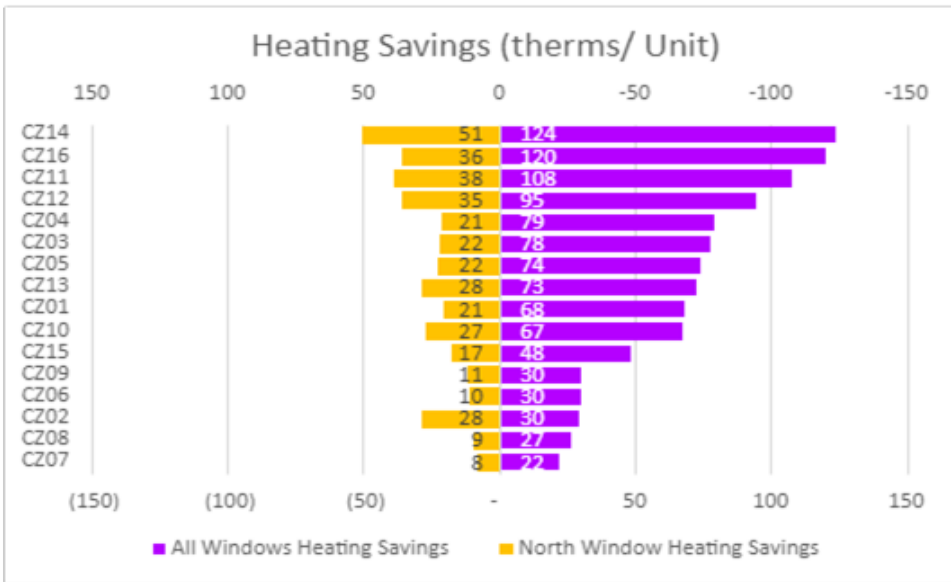
$UEC_{Base\_YrkWh}$  = Annual unit energy consumption - baseline, electric (kWh/yr)

$UEC_{Meas\_YrkWh}$  = Annual unit energy consumption - measure case, electric (kWh/yr)

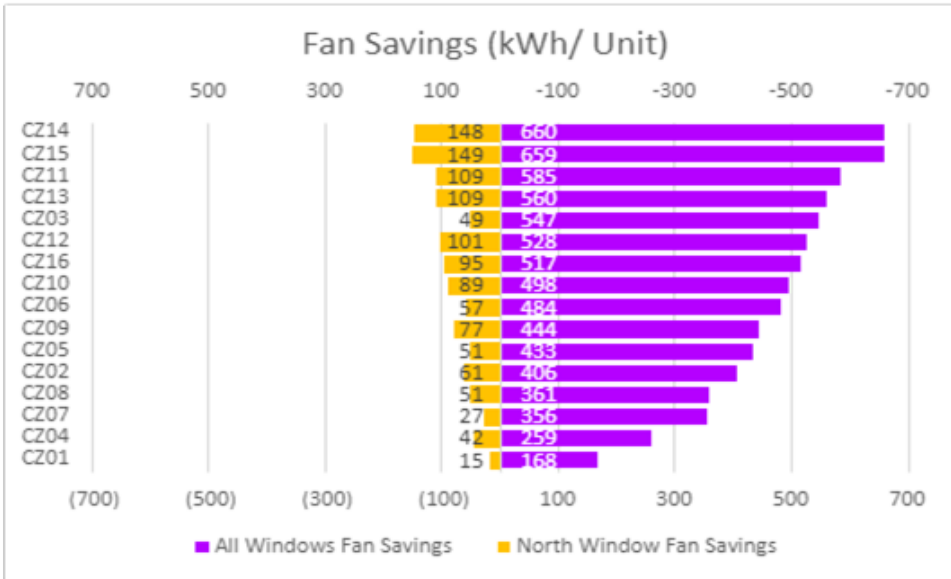
Window directionality was analyzed, and the figures below illustrate the savings of the north wall windows compared to all walls. This provides a sense of the variability in heating and cooling savings for each climate based on directionality. The yellow bars show north wall savings while the purple bars show savings from all walls. Please note that fan savings are separated from cooling system savings.



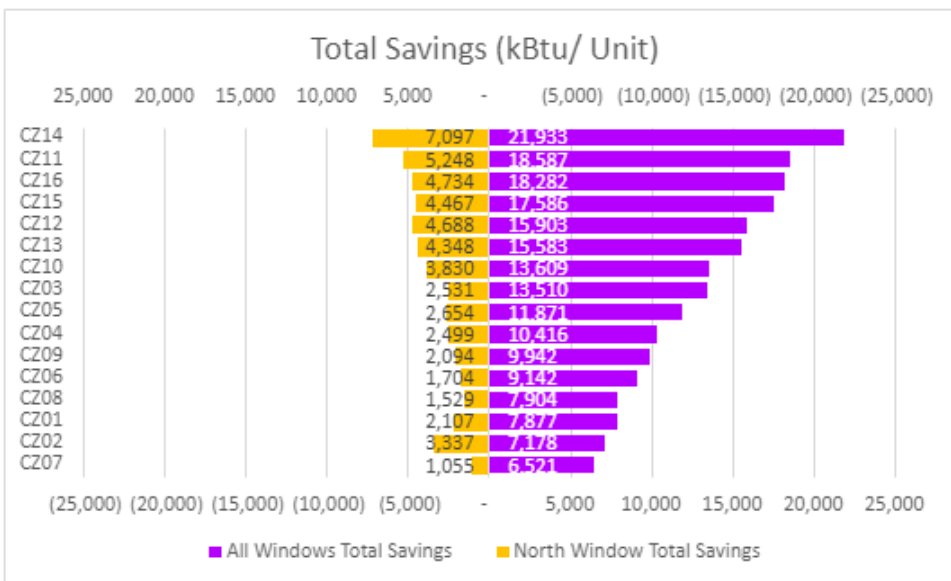
Window Directionality Sensitivity Analysis - Cooling



Window Directionality Sensitivity Analysis - Heating



Window Directionality Sensitivity Analysis – Fan Savings



Window Directionality Sensitivity Analysis - Total Savings

## INPUTS AND ASSUMPTIONS

The modelling input files and weather data files are provided as supplemental inputs <sup>R2791</sup>. The efficiency value assumptions for the base case and measure case can be found in the “Baseline Energy Use Simulation” and “Measure Case Energy Use Simulation” sections. The base case U-factor and SHGC values used are the default values present in the DEER Residential Prototypes. The measure case U-factor and SHGC values were selected based on the requirements specified in the ENERGY STAR Program Requirements for Residential Windows, Doors, and Skylights, Version 7.0 <sup>R2810</sup>.

<sup>R2812</sup>

## Peak Electric Demand Reduction (kW)

Peak demand reduction values were derived using the methodology presented in Electric Savings (kWh). The peak demand reduction was calculated as the difference between the baseline and measure case average hourly peak demand for the 15 hours of the peak period from 4:00 p.m. to 9:00 p.m. during the three consecutive weekday period within the dates of June 1 through September 30 that was defined within each climate zone by having the highest algebraic sum of the average temperature over the three-day period from 12:00 p.m. to 6:00 p.m.

## Gas Savings (Therms)

Gas UES values were derived using the methodology presented in Electric Savings.


## 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.

### Effective Useful Life and Remaining Useful Life

EFFECTIVE USEFUL LIFE ID	EUL DESCRIPTION (TEXT)	SECTOR (TEXT)	EUL YEARS (YR)	START DATE (TEXT)	EXPIRE DATE (TEXT)
BS-Win	<b>High Performance Windows</b>	<b>Res</b>	<b>20.00</b>	<b>2013-01-01</b>	

## Base Case Material Cost (\$/Unit)

The cost data for windows was gathered through a survey of online retailers. Products were grouped into base case and measure case based on U-factor. The material cost was calculated as the average of each group. 

## Measure Case Material Cost (\$/Unit)

See Base Case Material Cost.

## Base Case Labor Cost (\$/Unit)

The labor costs were derived using the 2023 edition of the RSMeans Unit Cost data. The labor cost was calculated as the product of the residential carpenter labor rates and the installation hour for a carpenter to install a window of up to 30 ft<sup>2</sup>. Labor rates were normalized per square foot of window area installed. It was assumed that the base case and measure case labor rates would be the same. R2155

## Measure Case Labor Cost (\$/Unit)

See Base Case Labor Cost.

## Net-to-Gross

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention. The NTG value adopted for this measure is designated specifically for emerging technologies by the California Public Utilities Commission (CPUC). R237

### Net to Gross Ratio

NET TO GROSS RATIO ID	NTG DESCRIPTION (TEXT)	NTG ELECTRIC (RATIO)	NTG GAS (RATIO)	START DATE (TEXT)	EXPIRE DATE (TEXT)
ET-Default	<b>Emerging Technologies approved by ED through work paper review</b>	<b>0.8500</b>	<b>0.8500</b>	<b>2019-01-01</b>	

# 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. This GSIA rate is the current “default” rate specified for measures for which an alternative GSIA has not been estimated and approved. R1270

## Gross Savings Installation Adjustments - Default

GSIA ID	GSIA (RATIO) <span style="color: green;">R1270</span>
Def-GSIA	<b>1.0000</b>

# Non-Energy Impacts

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

# DEER Differences Analysis

This section provides a summary of inputs and methods based upon the Database of Energy Efficient Resources (DEER), and the rationale for inputs and methods that are not DEER-based.

## DEER Difference Summary

DEER ITEM	COMMENT
Modified DEER methodology	No
Scaled DEER measure	No
DEER Base Case	No
DEER Measure Case	No
DEER Building Types	Yes
DEER Operating Hours	Yes
DEER EnergyPlus Prototypes	Yes
DEER Version	N/A




DEER ITEM	COMMENT
Reason for Deviation from DEER	DEER does not contain this type of measure
DEER Measure IDs Used	N/A

## References

- R1270** California Public Utilities Commission (CPUC), Energy Division. 2020. *Energy Efficiency Policy Manual Version 6*. April. Page 34-35.  
[Download](#) (PDF, 1.1 MB)
- R1503** California Public Utilities Commission (CPUC). 2021. *Resolution E-5152*. August 6. [Download](#) (PDF, 1.7 MB)
- R1557** California Energy Commission (CEC). 2021. *2022 Building Energy Efficiency Standards for Residential and Nonresidential Buildings (Title 24, Part 6, and Associated Administrative Regulations in Part 1)*. CEC-400-2022-010-CMF. [Download](#) (PDF, 5.5 MB)
- R2026** California Public Utilities Commission (CPUC). 2022. *Resolution E-5221*. November 3. [Download](#) (ZIP, 1.5 MB)
- R2155** Gordian Group, Inc. (n.d.). "RSMMeans Data Online." Residential Open Shop Labor Rates 2023. National Average Location.
- R237** California Public Utilities Commission (CPUC). 2012. *Decision 12-05-015 in the Order Instituting Rulemaking to Examine the Commission's Post-2008 Energy Efficiency Policies, Programs, Evaluation, Measurement, and Verification, and Related Issues (R.09-11-014)*. Issued May 18.  
[Download](#) (PDF, 1.2 MB)
- R2790** Energy Solutions (ES). 2024. "SWBE011\_Cost Calcs\_2024-04-24.xlsx."  
[Download](#) (XLSX, 26.0 KB)
- R2791** Energy Solutions (ES). 2024. "SWBE011\_Model Input\_2024-04-24.xlsx."  
[Download](#) (ZIP, 1.7 MB)
- R2792** Energy Solutions (ES). 2024. "SWBE011\_Model Results\_2024-04-24.xlsx."  
[Download](#) (XLSX, 28.8 KB)

**R2810** ENERGY STAR. 2021. "ENERGY STAR® Version 7.0 Residential Windows Doors and Skylights Data Package.xlsx" Accessed February 20.

 [Download](#) (XLSX, 46.1 KB)

**R2812** ENERGY STAR. 2022. ENERGY STAR® Program Requirements for Residential Windows, Doors, and Skylights - Partner Commitments. Version 7.0  [Download](#) (PDF, 375.5 KB)

**R2991** .