Commercial High-Efficiency Windows Measure Package Completion

Final Report

ET24SWE0005

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Executive Summary

The Commercial High-Efficiency Windows Measure Package Completion project will continue the measure package development process that began under the completed CalNEXT project ET23SWE0018. The goal of both ET23SWE0018 and this project, ET24SWE0005, is to submit the measure for California Public Utilities Commission (CPUC) approval and subsequent implementation in California (CA). This project provides measure package development support to the California Technical Forum (Cal TF) which will submit the measure package to the CPUC. The project team responded to initial Cal TF feedback on the draft measure packet, tracked ModelKit updates relevant to the project, and joined Cal TF modeling meetings.

During the development of the ET23SWE0018 project, four Title 24 2022 prototypes (OfficeLarge, OfficeSmall, RetailLarge, and SchoolSmall) were used to calculate the savings since the Database for Energy Efficiency Resources (DEER) commercial prototypes were not released. For new construction, the proposed Title 24 2025 mandatory requirements were used as the baseline. For retrofits, 1985 vintage DEER prototype values were used.

The first set of commercial prototypes were released in March 2024. After running the first set of simulations, a few bugs and typos were identified and resolved. A few versions have been released in the past three months based on the Cal TF team's input and comments.

The result from simulation runs using the DEER EnergyPlus™ prototypes (1985 vintage) were used to calculate the savings.

To address existing buildings, the DEER revision will include the weighted-average prototypes. These weighted-average prototypes will be used as the baseline for the final report. There are two sets of T24_weight_averaged_ex code files, one for hotels and another code file for non-hotel commercial buildings. The commercial prototype set also includes two industrial prototype buildings, manufacturing — light industrial (MLI) and manufacturing — biotech (MBT).

For new construction, the DEER prototype set uses the Title 24 2025 mandatory requirement as the baseline. Given anticipated implementation of this windows measure in January 2025, the default new construction prototype is revised with Title 24 2025 code requirements since there are no code files for 2022 hotel commercial buildings, as was discussed in the Cal TF staff meeting and EnergyPlus weekly call. This is still unresolved. This final report includes the savings based on the Title 24 2025 mandatory code for all commercial buildings.

Abbreviations and Acronyms

Acronym	Meaning
AOE	Add-on Equipment
CA	California
CalBEM	California Building Energy Modeling
Cal TF	California Technical Forum
CPUC	California Public Utility Commission
CZ	Climate Zone
DEER	Database for Energy Efficiency Resources
EE	Energy Efficiency
eTRM	Electronic Technical Reference Manual
IDF	Input Data Files
IOU	Investor-Owned Utility
NR	Normal Replacement
TRC	Total Resource Cost
SCE	Southern California Edison
SHGC	Solar Heat Gain Coefficient
MPP	Measure Package Plan

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Introduction

The Commercial High-Efficiency Windows Measure Package Completion project will continue the measure package development process that began under the completed CalNEXT project ET23SWE0018 - Commercial Windows Market Study and Measure Package Development, with the goal of producing a measure package ready for California Public Utilities Commission (CPUC) approval and subsequent use in California. This project provides measure package development support to the California Technical Forum (Cal TF), which will submit the measure package to the CPUC. The CalNEXT team continues to support these efforts by reviewing and editing the measure package, communicating with Cal TF, and communicating with the California investor-owned utilities (IOUs). Once the CPUC reviews and approves the measure package, the measure will be added to the California (CA) Electronic Technical Reference Manual (eTRM) as a measure package.

Background

Windows can be a significant source of heat gain and loss. Research estimates windows account for 30 to 45 percent of envelope heat transfer. High-efficiency windows are a fuel-neutral measure which is reflected in both electric and gas savings, for customers and utilities. Highly efficient windows with a reduced U-factor and solar heat gain coefficient (SHGC) have not been widely adopted in the commercial market. Installing highly efficient windows can provide meaningful energy savings for consumers as well as reasonable incremental payback periods.

Project ET23SWE0018, recently completed through CalNEXT, developed a draft measure package for commercial high-efficiency windows. This Commercial High-Efficiency Windows Measure Package Completion project is a continuation of findings from ET23SWE0018. Findings included a drafted measure package, which this project will use to move the measure further toward technology transfer completion by submitting to Cal TF.

Objectives

The overall objective of this project is to submit the measure for CPUC approval. This project will complete most of the remaining technology transfer steps needed for the commercial high-efficiency windows measure package. Southern California Edison (SCE) requested that CalNEXT proceed with this work to help advance technology transfer for the commercial windows measure package. This measure package will support IOU programs that include building envelope measures. The commercial high-efficiency windows measure package is considered a gas exempt measure through Decision 23-04-035. The CPUC has directed IOUs to facilitate the creation of new measure packages for gas exempt measures.

Methodology and Approach

Measure Package Development

The methodology used for this project follows the requirements of the measure package review process for CA, including the utilization of the CA eTRM measure log for receiving and providing feedback. This measure package utilizes the Database for Energy Efficiency Resources (DEER) commercial building prototypes for energy modeling. The project team obtained energy savings modeling assumptions from relevant industry information from the commercial windows market characterization performed in CalNEXT project ET23SWE0018, DEER commercial building prototypes, and the CA Energy Code. The measure package follows the Cal TF process for submitting and approving measure packages. The Cal TF website provides details on each step of the process: http://www.caltf.org/submit-a-measure. An overview of the process is listed below:

1. Submit a measure proposal form.
2. Submit a measure development plan.
3. Complete a draft measure packet.
4. The measure is reviewed by lead IOU, then CalTF.
5. Cal TF affirms the measure.
6. The measure is submitted for CPUC approval.

Building Energy Modelling

The CPUC maintains a set of commercial building prototypes that define the building geometry; window area and placement; thermal properties; heating, ventilation, and air-conditioning (HVAC) type(s); schedules; and more. High-level building descriptions and characteristics are listed in Table 1. The commercial building prototypes were transitioned to DEER commercial building prototypes using EnergyPlus as part of the California Building Energy Modeling (CalBEM) stakeholder group's Benchmarking Database project. The CalBEM commercial models documentation is the best current source of documentation for the DEER commercial prototype models.

DEER_EnergyPlus_deer_prototype-system-User_Guide_2024222_DEER_Prototype_System_User_Guide_v2 is intended to be a living document that will be updated for clarity and accuracy over time. Any new prototype-related guidance developed by the CPUC or the program administrators (PAs) will be incorporated into future versions. The current version and start date are indicated on the Change Log page. The document can be accessed here.

For completed CalNEXT project ET23SWE0018, the simulations were run in local machines using the cloned CPUC GitHub EnergyPlus input data files (IDFs). The drafted window measure package was modeled using a building energy simulation software tool developed by the CPUC. The DEER prototypes were previously built for eQUEST/DOE-2© using batch file processing controlled by the MASControl3© batch control software package. The CPUC GitHub repository houses the current modeling system developed for transitioning DEER prototype building simulation models from DOE2-

eQUEST to EnergyPlus. The GitHub tool reuses most of the scripts developed by the previous DEER Ex Ante team to manipulate MASControl3 outputs.

The current DEER Prototype System includes tools to run a batch of energy simulations in the EnergyPlus™ modeling tool. The batch process is managed by Big Ladder Software's Modelkit framework, and simulation post-processing is performed using Python and PostgreSQL scripts. For commercial prototypes, EnergyPlus version 22.2 was used for simulation.

The GitHub folder structure used to house the DEER prototypes is set up to enable batch simulations in Modelkit. The results of a particular simulation are in a case folder nested within a cohort folder, within a climate zone folder, within a measure_bldgtype_vintage folder, within a measure folder. The post-processing scripts subtract the results of two simulation cases (a pre- and a post-) to obtain energy savings that are ultimately stored in the eTRM as a permutation. A cohort may contain multiple pre-cases such as a standard baseline and an existing baseline, as well as multiple post-cases such as measure offerings with different seasonal energy efficiency ratio (SEER) ratings. A DEER table will be maintained that includes all the rows from the post-processing file, "DEER_EnergyPlus_Modelkit_Measure_list_working.xlsx," which manages the savings calculations from pre- and post-case measure simulations.

Table 1: DEER Prototypes — MASControl3/eQUEST-DOE2 (Old) and ModelKit/EnergyPlus (New)

BldgTyp	Description	MASControl3/ eQUEST-DOE2©	ModelKit/ EnergyPlus©
Com	Commercial	Weighted average	Weighted average
Asm	Assembly	Pre-DEER2026	DEER2026+
ECC	Education - Community College	Pre-DEER2026	DEER2026+
EPr	Education - Primary School	Pre-DEER2026	DEER2026+
ERC	Education - Relocatable Classroom	Pre-DEER2026	DEER2026+
ESe	Education - Secondary School	Pre-DEER2026	DEER2026+
EUD	University Dormitory	Pre-DEER2026	DEER2026+
EUn	Education - University	Pre-DEER2026	DEER2026+
Fin*	Financial Institution	N/A	DEER2028+

BldgTyp	Description	MASControl3/ eQUEST-DOE2©	ModelKit/ EnergyPlus©
Gro	Grocery	Pre-DEER2026	DEER2026+
HGR	Hotel Guest Room	Pre-DEER2026	DEER2026+
Hsp	Health/Medical - Hospital	Pre-DEER2026	DEER2026+
Htl	Lodging - Hotel	Pre-DEER2026	DEER2026+
Lib*	Library	N/A	DEER2028+
Mtl	Lodging - Motel	Pre-DEER2026	DEER2026+
Nrs	Health/Medical - Nursing Home	Pre-DEER2026	DEER2026+
OfL	Office - Large	Pre-DEER2026	DEER2026+
OfS	Office - Small	Pre-DEER2026	DEER2026+
Rel*	Religious	N/A	DEER2028+
RFF	Restaurant - Fast-Food	Pre-DEER2026	DEER2026+
RSD	Restaurant - Sit-Down	Pre-DEER2026	DEER2026+
Rt3	Retail - Multistory Large	Pre-DEER2026	DEER2026+
RtL	Retail - Single-Story Large	Pre-DEER2026	DEER2026+
RtS	Retail - Small	Pre-DEER2026	DEER2026+
SCn	Storage - Conditioned	Pre-DEER2026	DEER2026+
SUn	Storage - Unconditioned	Pre-DEER2026	DEER2026+
WRf	Warehouse - Refrigerated	Pre-DEER2026	DEER2026+

*New CalBEM proposed building type

Table 2 provides information on commercial prototype building characteristics that were used in the building energy modeling of the measure.

Table 2: Prototype Building Characteristics

Building Type	Building Type Code	Modeled?
Assembly	Asm	
Community College	ECC	
Primary School	EPr	
Relocatable Classroom	ERC	
Secondary School	ESe	
University	EUn	
Grocery	Gro	
Hospital	Hsp	
Nursing Home	Nrs	
Hotel	Htl	
Motel	Mtl	Yes
Manufacturing Biotech	MBT	
Manufacturing Light Industrial	MLI	
Office - Large	OfL	
Office - Small	OfS	
Restaurant - Fast-Food	RFF	
Restaurant - Sit-Down	RSD	
Retail - Multistory Large	Rt3	
Retail - Single-Story Large	RtL	
Retail - Small	RtS	
Storage - Conditioned	SCn	
Storage - Unconditioned	SUn	
Warehouse - Refrigerated	WRf	No
Greenhouse	GHs	

Vintage Era	Vintage	Vintage Code	Modeled
Existing (Ex)	1975	Before 1978	No
	1985	1987–1992	
	1996	1993–2001	
	2003	2002–2005	
	2007	2006–2009	
	2011	2010–2013	
	2015	2014–2016	
	2017	2017–2019	
	2020	2019–2022	
	2023	2023–2024	
	T24_weight_averaged_ex		Yes
New (New)	2025	New Construction	

Energy Modeling Inputs

Baseline Energy Use Simulation

Modeling was performed using the DEER commercial prototypes for all CA climate zones and commercial building types. Table 3 provides the assumptions for U-factors and SHGC used in the modeling. Baseline efficiency for retrofits, secondary windows, and new constructions were assumed to be the DEER commercial prototype baseline U-factor.

Table 3: Baseline Parameters

Parameter	Parameter Description	Measure Value/Assumption
U-factor	Thermal conductance of the window	DEER existing building weighted average prototype with modified default value of 1.03, for normal replacement (NR) and add-on equipment (AOE) Title 24 2025 mandatory code requirement as modeled in DEER prototype, for new construction (NC)
SHGC	Solar heat gain coefficient	DEER existing building weighted average prototype default, for NR and AOE Title 24 has no SGHC requirement, so 0.41 was modeled to reflect the market

Measure Case Energy Simulation

Modeling was performed using the DEER commercial prototypes for all CA climate zones and commercial building types. The U-factors and SHGC values were modified per Table 4, and all other values were unchanged.

Table 4: Measure Parameter Modifications

Parameter	Parameter Description	Measure Value/Assumption
U-factor (for NC, NR, and AOE)	Thermal conductance of the window	Primary Windows: 0.29 Secondary Windows: 0.45
SHGC (for NC)	Solar Heat Gain Coefficient	Climate Zone 1, 0.41 All other climate zones, 0.23
SHGC (for NR and AOE)	Solar Heat Gain Coefficient	0.55

Measure Permutations

With the energy modeling results uploaded to the eTRM, the project team built the measure permutations. The permutations account for climate zone, building type, and measure application type as the primary differentiating inputs.

After initial permutation development, several negative savings permutations were observed. The measure developer is investigating the negative savings and has found the following preliminary reasons for negative savings that will be adjusted through remodeling:

- The negative savings in heating-dominated climates are due to lower SHGC values.
- For secondary windows, the default SHGC values were used in the draft report. In the final version, the SHGC values were revised in alignment with available Attachments Energy Rating Council (AERC)-certified product listing and the SHGC requirement in the Northwest Regional Technical Forum (RTF) ComSecondaryGlazingSystems_v3_1
- For the initial submission, four prototypes were modeled with a set of recommended values based on 1985 vintage. The current DEER prototypes use weighted average values for existing buildings which had impacts on the final savings.
- For the initial submission, Title 24 2022 prototypes with proposed Title 28 mandatory values were used as the baseline. This was revised to Title 24 2025 prescriptive requirements as instructed in the Cal TF staff meetings and the DEER prototype user documentation. This decreased savings due to the higher efficiency base case. The final modeling was done based on the Title 24 2025 mandatory requirement since the majority of the commercial projects pursue the performance path.

Cost Effectiveness Testing

After building the measure permutations, the project team evaluated the cost-effectiveness of the measure. The measure premutation input file was downloaded from the eTRM and uploaded to the California Energy Data and Reporting System (CEDARS) Cost Effectiveness Tool (CET) and the resulting output was then uploaded to the eTRM measure package. Table 5 provides a summary of the test results, which represent averages across the 2,304 permutations for this measure.

Table 5: Cost-Effectiveness Results

Total System Benefit (TSB)	TRC	Net kWh	Net Therm
$11,629	0.37	10,070	0

Findings

Energy Modeling Results

Error! Reference source not found.he attachment “Permutation Savings” provides the results of building energy modeling of high- efficiency windows for all CA climate zones and building types. For existing buildings, the weighted average code files generated by DEER were used. For new

construction, Title 24, Part 6 Energy Code[1] requirements were utilized as modeled in the DEER new construction prototype.

In working with the recently released new DEER prototypes, the team has seen certain permutations reflect negative savings. To reduce the impact of SHGC on existing building's negative savings, the SHGC was modified to minimize the negative impact and reflect the available products in the market. The conditioned storage prototype building still has negative savings in multiple climate zones since this is a heating-dominated prototype.

Stakeholder Feedback

Energy Solutions spoke with Willdan, the third-party implementer operating the California Energy Design Assistance (CEDA) program about the draft measure package, to inform them of the measure offerings and measure application types that will be included in the measure package. They expressed support for the new construction, retrofit, and secondary windows measure offerings.

During the CPUC's review of our measure package plan, they had two questions. The first related to the base case assumptions, and these have been outlined in the base case section of the measure characterization. The second was about the impact of window orientation on savings. In response, a sensitivity analysis was conducted during the windows market characterization project.

Conclusion

eTRM Review Process

The completed measure packet has been sent to Cal TF for measure review and affirmation. Once measure affirmation is complete, the SCE measure development team will submit the measure package to the CPUC for final review and approval.

The measure package has had all IOU comments responded and has been submitted to CalTF for affirmation. CalTF review is in the final stages, and Measure Package submission to the CPUC is imminent.

[1] 2022 Building Energy Efficiency Standards, Title 24, Part 6 Energy Code, CEC, https://www.energy.ca.gov/sites/default/files/2022-12/CEC-400-2022-010_CMF.pdf

Appendix A: Draft Measure Package

Appendix B: Savings Permutations