5 Simplified M&V Guidelines for Application of Window Films

5.1 Overview

The installation of window films decreases the window shading coefficient (SC) and reduces the solar heat transmitted to the building space. During months when perimeter cooling is required in the building, this measure decreases cooling energy use.

The simplified M&V guidelines developed for this measure are applicable for window films applied to south- and west-facing windows only. The measure demand and energy savings are calculated based on the window-film area; change in shading coefficient; and cooling equipment efficiency. Savings for window film measures may be estimated using the Window Films Worksheet (FA.10) available for download on the Entergy Standard Offer Program Web site at www.ENTERGYefficiency.com.

The following steps comprise the simplified M&V procedure for window film installations.

1. Collect data characterizing the existing south and west windows including: shading coefficient, type of interior shading devices, and presence of exterior shading from buildings or other obstacles. Identify the type and rated efficiency of the cooling equipment in the building.
2. Document the installed window-film shading coefficient and window application area for the south and west windows.
3. Based on the characteristics of the existing windows, newly installed window-films, and cooling equipment; determine the annual demand and energy savings using the window-film calculation spreadsheet.

5.2 Pre-installation M&V Activities

5.2.1 Pre-installation Site Survey

The goal of the pre-installation site survey is to identify the existing south and west window characteristics. At a minimum, the surveys should include the following data for the south and west windows:

- Existing window description;
- Existing window shading coefficient;
- Window area by cardinal orientation;
- Description of interior shading devices;
- If applicable, an estimate of combined window-interior shading coefficient determined from 1997 ASHRAE Fundamentals, Chapter 29, Tables 24-29;
- Description of exterior shading; and

- Description of building cooling equipment.

This information will be included as part of the Initial Application (IA). For window film measures, the IA should be submitted after the project site has been identified. Submitting the IA prior to site identification could result in significant under or over estimation of savings since variations in window area and shading characteristics between sites are large.

5.2.2 Pre-installation Inspection

After the FA is submitted, Entergy or its contractor will conduct a pre-installation inspection to verify that the Sponsor has properly documented the baseline characteristics of the building, including: window area by orientation, shading devices, and cooling equipment type. The M&V administrator will inform the Project Sponsor of any necessary corrections to be made to the pre-installation survey based on the results of the inspection. Removal or demolition of existing shading devices and equipment or installation of new films, shading devices, and equipment cannot commence until the pre-installation inspection is completed.

5.3 Post-Installation M&V Activities

5.3.1 Post-installation Survey

The Sponsor should provide manufacturer's data for the window films; specifically the National Fenestration Rating Council (NFRC) shading coefficient for the installed window films. The area of the window films applied for each different solar orientation must also be specified. These data are required as part of the Installation Report (IR).

5.3.2 Post-installation Inspection

Entergy or its contractor will conduct a post-installation inspection to verify the documented characteristics of the building, windows, shading, cooling equipment, and window films. The M&V administrator will inform the Project Sponsor of any necessary corrections to be made to the pre-installation survey based on the results of the inspection. If the project is comprised of many small installations, Entergy will inspect a randomly selected sample of the window-film installations completed by the Sponsor.

5.4 Calculation of Energy Savings

The window film demand and energy savings result from a reduction in demand and energy use of cooling equipment. For evaluating savings, a calculation worksheet is available for download on the Entergy Standard Offer Program Web site. The savings estimates rely on tabulated values of solar heat gain factors (SHGF) as published in the 1997 ASHRAE Fundamentals, Chapter 29, Table 17. The ASHRAE data represent the amount of solar radiation that is transmitted through single-pane clear glass for a cloudless day at 32^{o} N Latitude for the 21st day of each month by hour of day and solar orientation. The solar gain values are translated to electric energy savings by considering the cooling equipment efficiency. In the calculation, the cooling equipment efficiency equals the rated efficiency of the installed equipment or the ASHRAE Standard 90.1-1989 minimum cooling equipment efficiency (see the Cooling Equipment Standard Efficiency Tables), whichever is more efficient.

To determine the coincident, peak summer demand savings associated with window films, the highest, hourly, ASHRAE SHGF value that occurs during the summer peak period is

identified for each of the south and west building orientations. These data nearest the Entergy service territory are presented in Table 5.1. The building demand savings are determined from the maximum of these peak SHG values for the applicable window orientations.

To determine cooling energy savings associated with window films, the ASHRAE SHGF data are aggregated into daily totals for weekdays during the months of April through October. These totaled, SHG values are presented in Table 5.1. In the table, orientations that are symmetrical relative to the southern sky have the same SHGF values.

Table 5.1: Solar Heat Gain Determined for 32°N Latitude

Orientation	Solar heat gain (Btu/ft^2-year)	Peak hour solar heat gain (Btu/hr-ft^2-year)
SE	158,323	59
SSE	133,894	119
S	120,095	164
SSW	133,894	189
SW	158,323	219
WSW	168,978	228
W	162,388	220
WNW	139,995	208
NW	106,876	176

The data from Table 5.1 are used to determine the demand and energy savings associated with the window film measure using the equations below. Equation 5.1 presents the demand savings calculation. Demand savings are determined for the window orientation that results in the highest savings. Demand savings by orientation are <u>not</u> additive.

Equation 5.1: Calculation of peak demand savings for window films

$$kW_{savings,o} = \frac{A_{film,o} \times SHGF_o \times \left(SC_{pre,o} - SC_{post,o}\right)}{3413 \times COP} \quad (a)$$

$$kW_{savings,peak} = kW_{savings,o,max} \quad (b)$$

Where:

$kW_{savings,o}$	=	Peak demand savings per window orientation.
$kW_{savings,peak}$	=	Peak summer demand savings.
$A_{film,o}$	=	Area of window film applied to orientation (ft^2).
$SHGF_o$	=	Peak solar heat gain factor (Btu/hr-ft^2-yr) for orientation of interest from Table 5.1 on vertical glazing at 32°N latitude.
SC_{pre}	=	Shading coefficient for existing glass/interior-shading device.
SC_{post}	=	Shading coefficient for new film/interior-shading device.
COP	=	Cooling equipment COP or SEER based on ASHRAE Standard 90.1-1989 or actual COP of equipment, whichever is greater.
3413	=	Conversion factor (Btu/kW).

Equation 5.2 presents the annual energy savings calculation for window films. The total annual energy savings is equal to the sum of the savings determined for each orientation, as shown below.

Equation 5.2: Calculation of annual cooling energy savings

$$kWh_{savings,o} = \frac{A_{film,o} \times SHGF_o \times \left(SC_{pre,o} - SC_{post,o}\right)}{3413 \times COP} \quad (a)$$

$$kWh_{savings} = \sum kWh_{savings,o} \quad (b)$$

Where:

SHG_o	=	Solar heat gain factor (Btu/yr) for orientation of interest from Table 5.1.

The following is an example of the savings calculations for a window film project.

Example

Window films are installed on an office building in Beaumont. The building does not have interior shading devices. The building is not self-shaded or shaded externally by neighboring buildings. The window shading characteristics, film surface area, and SHGFs are presented below. The SHG and SHGF values are based on the data presented in Table 5.2. Cooling is provided to the building by a 600 ton, water-cooled, centrifugal chiller. The ASHRAE 90.1-1989 rated COP for this type of chiller is 5.2, as specified in the Entergy Standard Cooling Equipment Tables.

Orientation	South	West
Area (ft^2)	10,000	10,000
Window SC (baseline)	0.95	0.95
Window SC (w/films)	0.35	0.35
Interior Shading	None	None
SHG (Btu/ft^2-yr)	120,095	162,388
Peak SHGF ($Btu/hr\text{-}ft^2$-yr)	164	220

The energy savings for installing the window films can be found using the information provided and Equations 5.2 (a) and (b). Due to the absence of interior shading devices in the building, the window shading coefficients are used in the savings calculation. The energy savings for the south and west films are equal to:

$$kWh_{savings,s/w} = \frac{10{,}000 \times 120{,}095 \times (0.95 - 0.35)}{3{,}413 \times 5.2} + \frac{10{,}000 \times 162{,}388 \times (0.95 - 0.35)}{3{,}413 \times 5.2}$$

$$kWh_{savings,s/w} = 40{,}601 + 54{,}899 = 95{,}500\ kWh$$

The demand savings for installing the window films can be found using the information provided and Equations 5.1 (a) and (b). Due to the absence of interior shading devices in the building, the window shading coefficients are used in the savings calculation. The demand savings for the south and west films are equal to:

$$kW_{savings,s} = \frac{10{,}000 \times 164 \times (0.95 - 0.35)}{3{,}413 \times 5.2} = 55.5\ kW$$

$$kW_{savings,w} = \frac{10{,}000 \times 220 \times (0.95 - 0.35)}{3{,}413 \times 5.2} = 74.4\ kW$$

$$\therefore \quad kW_{savings,peak} = kW_{savings,w} = 74.4\ kW$$