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LEED® Application Guide

Tubular Daylighting Devices
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SOLATUBE®

Acknowledgements

This LEED® Application Guide was prepared for Solatube International, Inc. by Laurie C. Fisher, AIA & LEED® Accredited Professional, and Kristopher Baker, P.E. & LEED® Accredited Professional. Solatube International, Inc. greatly appreciates the efforts of Ms. Fisher and Mr. Baker to review the USGBC LEED® V2.1 and LEED® V2.2 Green Building Rating System documentation and apply their technical and design knowledge to develop a unique guideline for applying Solatube International's Daylighting Systems to buildings in the early phases of design in an effort to achieve desired LEED® V2.1 and LEED® V2.2 points.

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Introduction

The LEED® Green Building Rating System is a voluntary, consensus-based, market-driven building rating system. It evaluates environmental performance from a whole-building perspective, providing a definitive standard for what constitutes a "green" building.

The rating system is organized into five environmental categories: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources and Indoor Environmental Quality. An additional category, Innovation & Design Process, addresses sustainable building expertise as well as design measures not covered in the other five categories. LEED® is a performance-oriented system where points are earned for satisfying performance criteria. Different levels of green building certification are awarded based on the total points earned.

LEED® documentation requires detailed information that is often only available in later design phases or once the project has gone to bid. If changes or adjustments need to be made, it is often too late in the design process to make them and can result in cost overruns and possibly even losing the LEED® point.

This document has been created for the design professional who is considering LEED® Certification for his or her built project, and would like to evaluate early in the design process the impact that a Solatube installation would have on that certification.

Using typical scenarios and simple formulas, this guide provides the project designer with an "at-a-glance" picture of how Solatube Daylighting Systems (which is a Tubular Daylighting Device (TDD)), contribute to credits in multiple LEED® categories. (Tubular Daylighting Device is a new product category instituted by the National Fenestration Rating Council and Construction Specification Institute.)

LEED® Categories

While a Solatube installation has a significant and straight-forward impact on the credits earned in the Energy & Atmosphere and Indoor Environmental Quality categories, we have also identified other potential Solatube contributions that may surprise the design team in the Materials & Resources category.

LEED® V2.2 went into effect in January 2006, impacting several of the credits covered in this guide; therefore we discuss the implications of a Solatube Daylighting System installation in both V2.1 and V2.2. Although this guide focuses on the LEED® NC (New Construction) credits, it should be noted that similar impacts can be had on LEED® EB (Existing Buildings) and LEED® CI (Commercial Interiors) projects. Solatube Daylighting Systems are an ideal way to green a building remodel or tenant improvement project. The LEED® NC Version 2.1 & 2.2 categories covered in this document are as follows:

- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation & Design Process

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How to Use This Document

When the design team first sits down to the table and begins reviewing the LEED® Point Checklist, it is usually before any design work has even begun, or if it has, the project is still in a very conceptual phase of the design process.

At this point in the project, it is difficult for the design team to assess achievability of points that are based on cost, weight of materials, or energy conservation without developing a conceptual project baseline. Typically, the true number of credits that are realistically obtainable remain a mystery until the final moments of construction document production. This guide can even aid the design team in setting daylighting goals and energy targets for the entire project.

Solatube Daylighting Systems Design Estimate

Prior to assessing the impact of a Solatube product installation on LEED Certification or benchmarking, it is necessary to determine an initial estimate of the appropriate number of Solatube products needed for your project. This quantity will become the basis for determining the impact of the Solatube product installation on all LEED® credit opportunities. If an initial layout has already been configured, skip this design estimate and use the actual number of Solatube products in the design.

The simple guidelines below will gauge the approximate number of Solatube products your project will require. This methodology attempts to account for proper daylighting by addressing the needs for an adequate quantity of daylight, as well as a high quality of daylight distribution. These guidelines are not a substitute for proper Solatube product design; a design professional or Solatube International must be consulted to ensure proper application and performance for each project.

The following three steps are used to establish a guideline for Solatube product applications. These guidelines assume that you are using one of the configurations of the 21" diameter Solatube SolaMaster model; please note that if you are using a smaller diameter model, your resulting LEED® point total may be different.

1. Determine the Standard Solatube Density (SSD) from Table 1 below. The SSD is dependant upon building type and the desired interior illuminance level.
2. Adjust the SSD for the project's specific geographical region. First determine the applicable region from Figure 1, then multiply the SSD by the Design Location Adjustment Factor (DLF) found in Table 3.
3. Confirm that the Maximum Solatube Density (MSD) from Table 2 has not been exceeded; if the adjusted SSD is higher than the MSD, then use the MSD value from Table 2. MSD values are based on Solatube minimum spacing criteria which are a function of the ceiling height and building type.

Table 1 - Standard Solatube Density (SSD)

Table 1 - Standard Solatube Density (SSD) (Square Feet/Solatube 21" Diameter)							
Building Type	**Desired Illuminance Level, footcandles**						
	10	15	20	30	40	50	75
Open Office			400	267	200	160	
Private Office			237	158	119	95	
Conference Center			427	284	213	171	114
Classroom				239	180	144	96
Retail				154	116	93	62
Health Clinic	880	587	440	293	220	176	117
Gymnasium	776	517	388	259	194	155	103
Industrial Workspace	804	536	402	268			
Warehouse	764	509	382				

* Values computed using Solatube proprietary analysis algorithms for the 2,400 most illuminant hours per year. Analysis algorithms are based on ray-trace analyses, Typical Meteorological Year solar data, and the Lumen Method illuminance calculations.

Table 2 - Maximum Solatube Density (MSD)

Table 2 - Maximum Solatube Density (MSD) (Square Feet/Solatube 21" Diameter)						
Building Type	**Ceiling Height, feet**					
	9	10	11	12	15	20
Open Office	108	144	185	231	400	784
Private Office	95	127	163	203	352	689
Conference Center	129	172	221	276	479	938
Classroom	129	172	221	276	479	938
Health Clinic	95	127	163	203	352	689
Retail	129	172	221	276	479	938
Industrial Workspace	129	172	221	276	479	938
Gymnasium	169	225	289	361	625	1225
Warehouse	264	352	452	564	977	1914

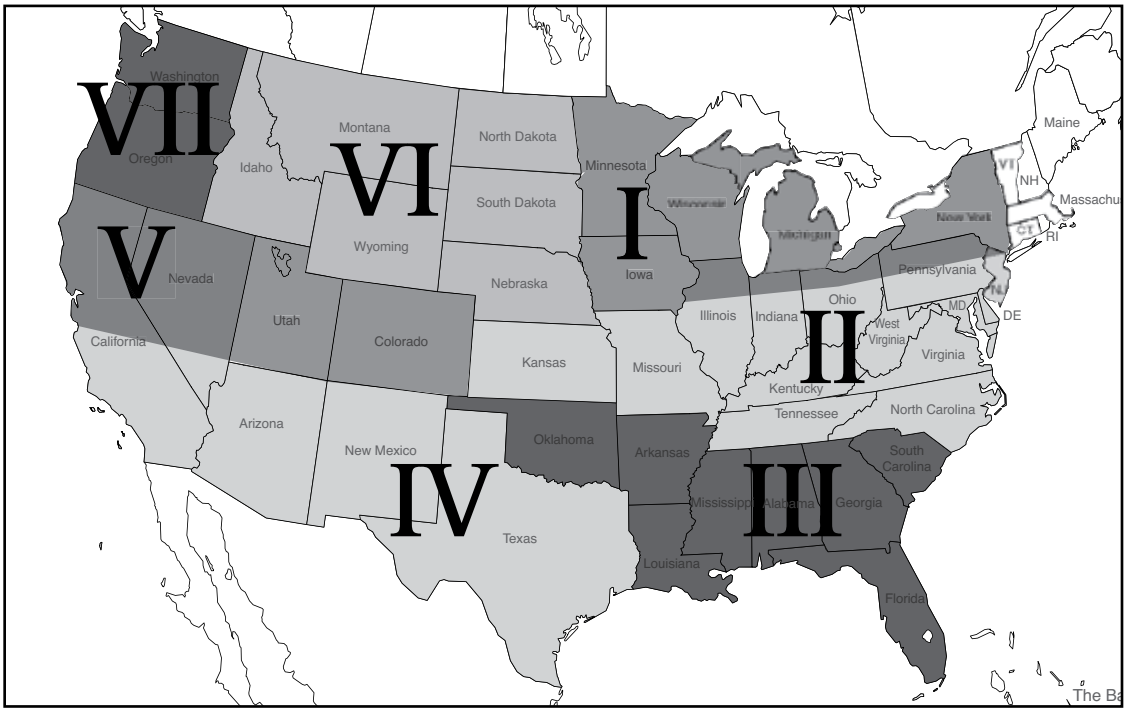
* Values computed using Solatube proprietary analysis algorithms for the 2,400 most illuminant hours per year. Analysis algorithms are based on ray-trace analyses, Typical Meteorological Year solar data, and the Lumen Method illuminance calculations.

Table 3 - Geographical Design Location Adjustment Factor (DLF)

Table 3 - Geographical Design Location Adjustment Factor (DLF)	
Location	**DLF**
Region I	0.66
Region II	0.81
Region III	0.84
Region IV	1.00
Region V	0.86
Region VI	0.78
Region VII	0.57

*Regions categorized based on Solatube calculations. Differences are primarily due to variances in latitude and cloud cover.

Figure 1 – Geographical Design Region



Example

160,000 nsf/200,000 gsf office building with mostly open plan offices and 10' ceilings with a desired illuminance level of 35 fc in Chicago, Illinois.

1. SSD is 233 sqft/Solatube Daylighting System from Table 1. For 35 fc, interpolate between the data for 30 & 40; (200+267) / 2 = 233.
2. The Geographical Design Location Adjustment Factor (DLF) is 0.66 from Table 3 & Fig. 1, so the Adjusted SD is 233 * 0.66 = 154
3. From Table 2, the MSD is 144, so the applicable Design SD is 144.
4. To determine the Solatube Daylighting System quantity estimate: 160,000 / 144 = 1,112 Solatube units for this project.

Important Note:

Please be aware that these values are subject to change as your project advances and consulting professionals begin to perform the official calculations that are necessary for the LEED® submittal. The use of this document is by no means a guarantee for the award of any LEED® point. This guide has been prepared independently of the US Green Building Council.

SS	WE	EA	MR	EQ	ID
Prerequisite					

SS	WE	EA	MR	EQ	ID
Credit 1					

Energy & Atmosphere

1-10 Points

Minimum Energy Performance

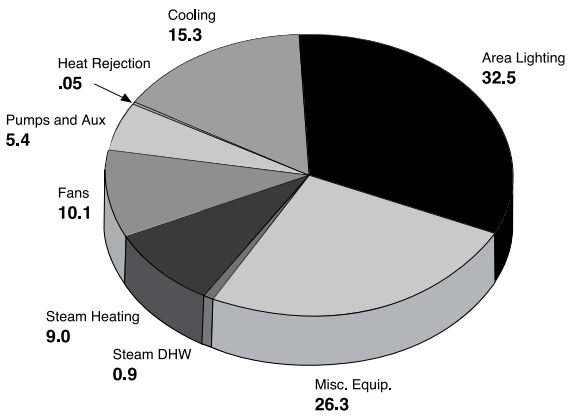
The goal with EA Prerequisite 2 and EA Credit 1 is to reduce design energy cost compared to the energy cost budget of the systems regulated by certain standards and codes. Both the prerequisite and the credit in this category reference an energy performance standard, either ASHRAE/IESNA Standard 90.1-1999 or the local code or standard if it is more stringent. For example, in California, state law requires adherence to the Title 24 code; since Title 24 is more stringent than the ASHRAE standard, Title 24 standards are used as the reference point for the calculations of these credits. In California, adherence to Title 24 automatically satisfies the EA Prerequisite 2.

The prerequisite simply states that the project must meet these standards. LEED® prerequisites are required for any level of certification.

Optimize Energy Performance

EA Credit 1 awards points according to what extent, in percentage points, that the project beats these standards (either ASHRAE/IESNA Standard 90.1-1999 or the local code or standard if it is more stringent). The range of performance optimization is from 5% to 60% better than the standard, and the points awarded range from 1 to 10, respectively. It becomes apparent that savings in this category can go far to achieving LEED® certification.

Figure 2 – US Commercial Electricity Consumption by End Use



Lighting accounts for roughly 1/3 of all electricity consumed in the US. As is illustrated in the pie chart (Figure 2), lighting energy is typically 25-40% of the building energy consumption in commercial construction, and as such, provides a superb opportunity for significant energy savings. Proper daylighting with Solatube Daylighting Systems displaces the use of electric lighting equipment typically between 1,500 and 3,000 hours per year. This is often significantly

SS | WE | **EA** | MR | EQ | ID

Prerequisite

SS | WE | **EA** | MR | EQ | ID

Credit 1

1-10 Points

more energy savings than can be achieved by applying energy-efficient lighting, which merely reduces the energy consumption of the lighting system.

To best estimate the energy savings from a Solatube product installation, a simple algorithm and look up tables have been generated. To complete this estimate, you will need to know the following data:

- Actual Solatube Design Density (ASDD) – This value is determined by the designer or by the simple Design Estimate approach, and is recorded as Square Feet/Solatube.
- Project Region – The region can be determined from the Regional Map in Figure 1 of the Design Estimate section at the beginning of this document.
- Project Building Type – Open office, classroom, retail, etc.
- Interior Illuminance Level – The acceptable minimum interior illuminance level, in footcandles.
- Lighting Schedule – The schedule of operation of the lighting system includes start time, stop time, as well as lighting diversity.[1]
- Lighting Type – Lighting type incorporates the efficiency of the existing or planned lighting system. For new construction, there are 3 levels: Title-24, ASHRAE 90.1-1999, or ASHRAE 90.1-2004. For existing buildings, lighting efficiency levels are based on building age: less than 5 years old, 5-15 years old, and more than 15 years old. Actual lighting power densities and lighting technologies are described in the appendix.
- Lighting Control Type - either a simple on/off control or dimming from dimming ballasts.
- Lighting Power Density (LPD) – Actual LPD are best, however, Table 8 lists the maximum LPD thresholds as defined by ASHRAE 90.1 and California's Title 24, as well as rough estimates for existing buildings based on the age of the installed lighting system.

The following process describes the method to determine the approximate energy savings from the Solatube product design and installation. Using the above collected data, table values can be applied to the following algorithm (Equation 1):

kWh Savings = SDH • GEA Factor • SchFctr • LPD • area / 1000 **Eq. 1**

Where, SDH = *Standard Displaced Hours* (from Tables 4 or 5)
GEA Factor = *Geographical Energy Adjustment Factor* (from Table 6)
SchFctr = *Type of Schedule Factor* (from Table 7)
LPD = *Lighting Power Density in Watts/sf* (from actual design or Table 8)
Area = *Net Daylit Area*

[1]Diversity refers to the percentage of lights that are on at any given time. Often in private offices, lighting is off while unoccupied, while open offices are generally illuminated regardless of the occupancy.

1. Determine *the Standard Displaced Hours* (SDH) from Table 4 or 5 based on the Building Type, Actual Solatube Design Density (ASDD), Minimum Acceptable Illuminance Level, and Lighting Control Type. Table 4 includes data for simple on/off controls, while Table 5 includes data for dimmable systems.
2. Determine *Geographical Energy Adjustment Factor* (GEA Factor) from Table 6 and Figure 1 for the specific project location and lighting control type. Note that this is a different geographical adjustment than the DLF used in estimating the Solatube Design Density.
3. Determine the *Type of Schedule Factor* (SchFctr) from the list of standard schedules in Table 7. This will adjust the savings for unoccupied daylit hours.
4. Determine the *Lighting Power Density* (LPD) either from the lighting design or from the data in Table 8.
5. Apply the determined factor values to Equation 1 to calculate the estimated annual energy savings due to the Solatube Daylighting System design.

Table 4 - Standard Displaced Hours (SDH) On/Off Controls

Table 4 - *Standard Displaced Hours* (SDH) – On/Off Controls

	Minimum Illuminance Level	Actual Solatube Design Density (ASDD)								
		64	80	100	120	144	196	256	324	400
Open Office	30	3450	3200	3100	2950	2750	2300			
	40	3250	2975	2825	2575	2325	1825			
	50	3050	2725	2525	2250	1950	1400			
Private	30	3050	2700	2500	2250	1950	1375			
Office	40	2750	2275	2075	1775	1425				
	50	2400	1925	1700	1325					
Conference	25		3350	3250	3100	2950	2550	2150	1750	1350
Center	50	3050	2725	2525	2250	1950	1400			
	75	2575	2100	1900	1550	1175				
Classroom	30	3375	3125	3025	2825	2575	2125	1675		
	45	3050	2725	2525	2250	1950	1400			
	60	2750	2300	2100	1775	1450				
	75	2425	1925	1725	1350					
Health Clinic	30	3025	2675	2475	2200	1900	1325			
	45	2550	2050	1850	1500	1100				
	60	2100	1525	1275						
	75	1725	1075							
Retail	30	3500	3300	3200	3050	2850	2425	2025	1600	1175
	45	3225	2950	2800	2550	2300	1800	1250		
	60	2975	2575	2400	2125	1825	1225			
	75	2725	2250	2075	1750	1400				
Industrial	15				3450	3325	3075	2800	2450	2100
Workspace	45	3100	2750	2575	2300	1975	1375			
	75	2450	1950	1725	1325					
Gymnasium	10						3450	3275	3050	2850
	20				3325	3175	2875	2500	2125	1775
	30				2975	2750	2300	1850	1350	
Warehouse	5								3500	3375
	10						3375	3175	2975	2725
	15				3425	3325	3050	2775	2425	2075

SS | WE | **EA** | MR | EQ | ID

Prerequisite

SS | WE | **EA** | MR | EQ | ID

Credit 1

1-10 Points

Table 5 - Standard Displaced Hours (SDH) Dimming Controls

Table 5 - *Standard Displaced Hours* (SDH) - Dimming Controls

	Minimum Illuminance Level	Actual Solatube Design Density (ASDD)								
		64	80	100	120	144	196	256	324	400
Open Office	30		3525	3425	3325	3175	2850			
	40	3575	3375	3300	3125	2950	2600			
	50	3400	3150	3025	2825	2600	2175			
Private	30	3375	3150	3000	2825	2600	2175			
Office	40	3225	2925	2775	2550	2300	1800			
	50	3075	2725	2575	2325	2025	1450			
Conference	25		3600	3525	3400	3275	3000	2750	2450	2150
Center	50	3400	3150	3025	2825	2600	2175	1700	1200	
	75	3050	2725	2550	2300	2025	1425			
Classroom	30		3450	3375	3225	3050	2725	2375	2025	1625
	45	3400	3150	3025	2825	2600	2175	1700	1200	
	60	3175	2850	2700	2475	2200	1675	1125		
	75	2950	2575	2425	2150	1825	1175			
Retail	30		3575	3500	3375	3250	2950	2650	2325	2000
	45	3525	3325	3225	3050	2850	2475	2075	1650	1175
	60	3350	3050	2925	2725	2500	2050	1525	1075	
	75	3150	2825	2675	2425	2175	1625	1100		
Health Clinic	30		3125	2975	2800	2575	2125			
	45	3025	2675	2500	2250	1950	1325			
	60	2725	2275	2100	1775	1375				
	75	2425	1925	1700	1275	1000				
Industrial	15					3600	3400	3225	2975	2750
Workspace	45	3425	3200	3050	2850	2625	2200	1700	1175	
	75	2975	2600	2450	2150	1825	1175			
Gymnasium	10							3550	3400	3250
	20				3600	3475	3275	3000	2750	2475
	30				3325	3200	2875	2525	2175	1800
Warehouse	5									3625
	10							3500	3350	3150
	15					3600	3400	3200	2950	2725

Table 6 - Geographical Energy Adjustment Factor (GEA)

Table 6 - *Geographical Energy Adjustment Factor (GEA)*

Location	GEA Factor	
	On/Off Controls	Dimming Controls
Region I	0.78	0.89
Region II	0.81	0.86
Region III	0.88	0.93
Region IV	1.09	1.09
Region V	0.97	1.02
Region VI	0.87	0.95
Region VII	0.73	0.88

Table 7 - Type of Schedule Adjustment (SchFctr)

Table 7 - *Type of Schedule Adjustment (SchFctr)*

Schedule Description	SchFctr
7:00am - 6:00pm 5 Days; 10:00am-2:00pm 1 Day	0.80
8:00am-5:00pm, 5 Days	0.70
24 hours 7 days	1.00
6:00am-4:00pm, 5 Days	0.70
6:00am-11:00pm, 6 Days	0.86

Table 8 - Typical Lighting Power Density (LPD)

Table 8 - Typical *Lighting Power Density* (LPD)							
	ASHRAE 90.1, Version		Title-24, Version		Older Construction, Year of Lighting Installation		
	1999	2004	2001	2005	1995	1990	1985
Open Office	1.3	1.1	1.3	1.2	1.6	1.8	2.1
Private Office	1.5	1.1	1.3	1.2	1.8	2.1	2.4
Conference Center	1.5	1.3	1.5	1.4	1.8	2.1	2.4
Classroom	1.6	1.4	1.6	1.2	1.9	2.2	2.6
Health Clinic	1.6	1.5	1.4	1.2	1.9	2.2	2.6
Retail	2.1	1.7	2.0	1.7	2.5	2.9	3.4
Industrial Workspace	2.1	1.2	1.2	1.1	2.5	2.7	2.9
Gymnasium	1.9	1.4	1.0	1.0	2.3	2.7	3.0
Warehouse	1.1	0.9	0.6	0.6	1.3	1.4	1.5

Note on Daylight Sensors

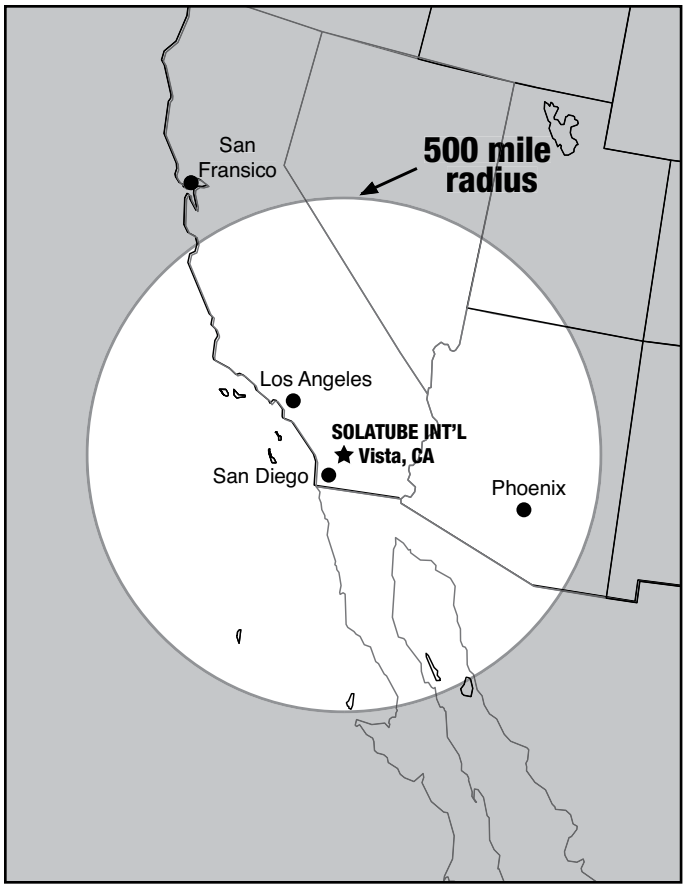
It is important to mention that the use of daylight sensors is critical to the ultimate reduction of energy consumption in any Solatube Daylighting System or other daylighting installation. Daylight sensors are small, inexpensive units that are connected to the lighting circuit and the lighting control system. When the sensors detect a pre-determined level of daylight in the space, electric lights are automatically shut off. Various applications are available, ranging from a simple cut-off method to more complex combinations that can respond to more subtle changes in lighting levels.

The use of sensors is critical to guarantee energy savings because without them, electric lights can remain on unnecessarily for extended periods of time. In a daylit space, occupants will not notice whether the electric lighting is turned on or off. This can result in disastrous excesses in energy use; obviously not what we strive for when pursuing LEED® certification!

Materials & Resources

Regional Materials

The requirement for MR-Credit 5.1 (LEED® V2.1) is that a minimum of 20% of the materials and products in your project are manufactured locally (within a 500 mile radius of the jobsite). If your jobsite lies within the 500 mile radius circle drawn on the map to the right (Figure 3), the entire cost of your Solatube installation can contribute to MR-Credit 5.1.



Based upon various Solatube Product case studies, we have found that, depending on the use and density of the installation, in most cases Solatube products accounted for as much as one third of MR-Credit 5.1.

Unfortunately, this credit has been significantly altered for LEED® V2.2. Under LEED® V2.2, this credit requires that materials not only be manufactured within the 500 mile radius, but that they also be harvested/extracted within that 500 mile radius as well. Solatube International cannot provide the required supporting documentation for this credit under LEED® V2.2 due to the very nature of material supply from metal and plastic providers.

Solatube Product Cost: (per unit) (based on approximate MSRP, does not include labor)

21-C Suspended Ceiling (21 in/530 mm Daylighting System):	$726.08
21-O Open Ceiling (21 in/530 mm Daylighting System):	$384.10
Daylight Dimmer:	$244.58

1-2 Points

Indoor Environmental Quality

Controllability of Systems

In LEED® V2.1, EQ-Credit 6 is actually divided into two parts, 6.1 and 6.2, although there is only one point offered. IQ-Credit 6 requires that a building's occupants have the ability to control various systems in their own personal environment by zoning the building into perimeter and non-perimeter spaces. EQ-Credit 6.1 deals with "perimeter" spaces (spaces located within a 15' offset from a perimeter wall) while EQ-Credit 6.2 addresses "non-perimeter" spaces.

The two major differences between the two classifications are that 6.1 requires a certain number of operable windows, and the quantity of system controls (lighting & HVAC) are determined on a per-square-foot basis, while 6.2 does not address windows and requires that system controls be provided for at least half of the zone's occupants (based on ASHRAE occupancy zone definitions).

In LEED® V2.2, the calculation is quite different. EQ-Credit 6.1 now applies solely to lighting controls, and EQ-Credit 6.2 applies to thermal comfort. The EQ-Credit 6 is now worth two points. EQ-Credit 6.1 (V2.2) simply requires that lighting controls are provided for 90% of the building occupants.

When using Solatube products in your project, specify a Daylight Dimmer unit for each TDD. By providing dimmer controls as a part of the required number of lighting controls stated in EQ Credits 6.1 & 6.2, you can satisfy a large part of EQ-Credit 6.

1 Point

Daylighting and Views

EQ Credit 8.1, daylighting of 75% of the regularly occupied spaces, is generally a difficult credit to obtain, however, through the application of a Solatube product installation, this credit is simple to achieve. The primary method of compliance for this credit requires a 2% daylight factor. Many daylighting designers consider this level of daylight to be unnecessary. For example, this would require a minimum of 200 footcandles being produced throughout 75% of Solatube International's offices on a beautiful Southern California summer day, far in excess of today's 35-50fc standard for ambient illumination.

In response to this concern, the US Green Building Council has developed an alternate compliance method. This alternate method requires a lighting simulation model to show that the daylighting design provides a minimum of 25 footcandles at solar noon of the equinox (March 21st) under clear sky conditions. All properly designed Solatube product installations, with the exception of some warehouse applications, will achieve these minimum lighting levels, and thus will achieve the LEED Credit. Table 9 lists the maximum Solatube Density Thresholds that cannot be exceeded in order to qualify.

Table 9 - Solatube Density Threshold for Daylighting Calculations

Table 9 - *Solatube Density Threshold* for Daylighting Calculations

	Geographical Location						
	Region I	Region II	Region III	Region IV	Region V	Region VI	Region VII
Open Office	475	500	475	525	475	450	425
Private Office	275	300	275	325	275	275	250
Conference Center	525	525	525	575	500	500	475
Classroom	425	450	425	475	425	400	400
Health Clinic	275	275	275	300	275	250	250
Retail	525	550	550	600	525	500	475
Industrial Workspace	450	475	450	500	450	425	400
Gymnasium	475	475	475	500	450	450	425
Warehouse	450	450	450	475	425	425	400

1-4 Points

Innovation & Design Processes

Innovation in Design

Oftentimes, the ID Credit 1 can be satisfied by creating interactive, educational installations relating to a building's operations. A Solatube product installation can educate a building's occupants as to not only the amount of energy they conserve, but also about what are reasonable lighting levels for a space.

By proposing an installation of light and energy meters, a building's occupants can see in real time how their building is performing. By understanding the energy conserved, and how effective daylighting is functionally, users become more aware of their own behavior even when they leave the building.

Include Solatube products in any interactive, educational metering system and it might earn your team an ID point!

Summary

We hope that you have found this LEED® Application Guide for Solatube Daylighting Systems useful in the preliminary design and sustainable strategic planning of your LEED® project. Solatube products are an effective, relatively easy way to score LEED® points in a variety of categories.

Solatube International, Inc. wishes you the best of luck in the certification of your project. Please contact one of our representatives for further information about Solatube Daylighting Systems and how they will fit in your project.

For More Information…

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