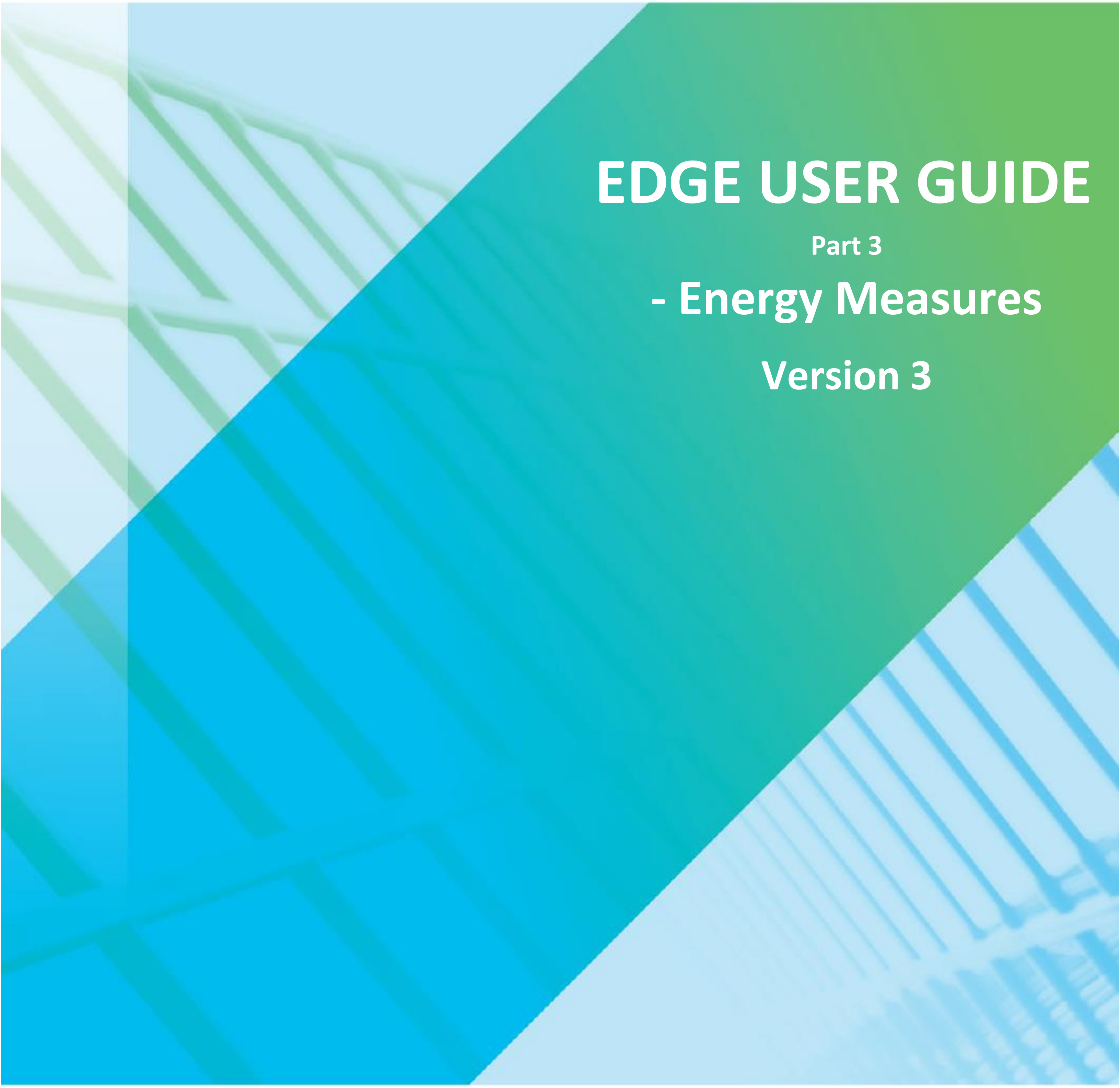

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EDGE USER GUIDE

Part 3

- Energy Measures

Version 3

Date of Release: November 27th, 2024

Official Document

Contents

Introduction

EDGE (Excellence in Design for Greater Efficiencies) is a standard, a green building certification and an online app of the International Finance Corporation (IFC). This document is part of a series of documents aimed at the global harmonization of EDGE buildings certification process for version 3.

In these documents, "Must" and "Shall" are used to prescribe obligatory actions. "Should" implies a recommendation, but it is not required. Lastly, "May" grants permission or suggests that an action is permissible, providing flexibility or discretion to the *project team*.

The target group for this document are *project teams*, EDGE experts, EDGE auditors, EDGE certifiers and anyone interested in learning more about the certification.

The **Part 3—User Guide Energy Measures** document offers detailed instructions on the requirements, intention, and high-level methodology used to calculate the impact of each energy measure. Furthermore, it advises on the process for achieving compliance with each energy efficiency measure (EEM).

From January 1st, 2025, this document invalidates and substitutes the Energy Efficiency Measures section EDGE Version 3.0.a.

Table 1 shows the relative position of this document within the set of EDGE user guides.

Table 1: Position of this document within the EDGE V3 modules.

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Note 2: All guidance and user guide documents are complimentary information to the EDGE protocol documents.
Note 3: In the case of any discrepancy, the EDGE protocol document takes precedence</td></tr>
</table>

To share feedback with the EDGE team, please send suggestions along with relevant documentation to edge@ifc.org.

Glossary

AHU	Air Handling Unit
ARI	Air-conditioning and Refrigeration Institute
ASHRAE	American Society of Heating Refrigerating and Air-conditioning Engineers
Btu	British thermal unit
cfm	Cubic feet per minute (ft^3/min)
CIBSE	Chartered Institution of Building Services Engineers
COP	Coefficient of Performance (W/W)
EER	Energy Efficiency Ratio (Btu/W)
EDGE	Excellence in Design for Greater Efficiencies
EPI	Energy Performance Index (kWh/m^2/year)
GIA	Gross Internal Area
GJ	Giga Joules
HVAC	Heating, Ventilation and Air-conditioning
ISO	International Organization for Standardization
kW	Kilowatt
kWh	Kilowatt-hour
LLF	Lumen Loss Factor
MJ	Megajoules
PED	Primary Energy Demand
ppm	Parts per million
SC	Solar Coefficient
SHGC	Solar Heat Gain Coefficient
sqm	Square Meter
STP	Sewage Treatment Plant
TR	Tonnage of Refrigeration
VLT	Visible Light Transmission
VAV	Variable Air Volume
VFD	Variable Frequency Drive
VSD	Variable Speed Drive

W	Watt
Wh	Watt-hour
WFR	Window-to-Floor Ratio
WWR	Window-to-Wall Ratio

Efficiency Measures Overview

This section provides an overview of the policies related to energy efficiency measures in EDGE.

Base Case

The Base Case is the standard benchmark against which the proposed design is compared for EDGE certification. The base case values shown in the App are used to calculate the base case performance of a building.

EDGE defines the Base Case or "EDGE Baseline" as the 'standard construction practice currently prevalent in a region (e.g., city, district, state) over the previous 3 years for the specific building type being evaluated'.

- In a region which has mandatory building energy, water, or materials codes, and where these codes are implemented in most of the new buildings being built in last 3 years, the relevant code may serve as the Baseline. If the code is sufficiently implemented in a few cities or states, and not the rest, their baselines can be different.
- In a region where no such codes exist, or where they do exist but are not sufficiently enforced, EDGE uses the standard practices followed by the local construction industry as the Baseline. For example, if most low-income homes in a region have walls constructed using concrete blocks, the base case material selection would reflect this. These assumptions may be different for different income category homes, and across different building types, such as offices, hotels, and shopping malls.

To maintain the simplicity of EDGE, the Baseline incorporates broad trends and practices and does not delve into the details of a specific building or technology unless that represents the normal/typical practice.

Baseline Types

The base case varies by building type and by location. Each location in EDGE is assigned one of the following four (4) baselines:

1. Country-customized baseline: Countries with distinct building materials or a strong national building energy or water code are reflected in the EDGE baseline.
2. City-Customized baseline: Countries with uneven implementation of building energy code in cities, with some cities more stringent than others; or where cities have distinct building patterns because of weather variation have a baseline customized at the city level.
3. Global EDGE baseline: A global set of baseline parameters is used as the baseline for countries with emerging economies following typical global practices.
4. ASHRAE 90.1-2016: Some advanced economies that follow a higher standard of construction have been assigned the ASHRAE 90.1-2016 baseline. Distinctions in aspects such as insulation are based on climate zones as per the ASHRAE standards.

Efficiency Measures

The selection of energy efficiency measures can have a significant impact on the resource demand of a building. When measures are selected, EDGE makes default assumptions on the typical improved performance over the base case. The results are shown in charts that compare the base case building with the improved case.

The default values seen when selecting the measures are purely informative and must be overwritten with actual values by editing the user input fields.

While some measures such as onsite renewable energy and the collection of rainwater are not technically efficiency measures, they reduce the use of grid electricity and treated potable water respectively, contributing to the 20% efficiency savings target required to reach the EDGE standard. Other innovative measures impacting energy or water savings can be reported using a proxy measure and will be evaluated on a case-by-case basis.

The current document focuses on the energy efficiency measures.

Energy

The energy chart shows a breakdown of the end uses that consume energy. The units are kWh/m²/year. This includes the energy from all fuels – including electricity, natural gas and diesel – converted to kilowatt-hours. Hovering on the bar graph sections displays more information about each section. Note that Figure 1 shows 'Virtual Energy' for cooling and fans because the building does not include a cooling system.

EDGE currently uses delivered energy (i.e., energy delivered to the building minus on-site renewable energy) as the measure of efficiency, as it is a more consistent global indicator rather than primary energy, which relies on the regional characteristics of the grid. *Project teams* needing to calculate Primary Energy Demand (PED), may refer to ***Part 1 – Building Certification Guidance, Annex 4: Primary Energy Demand.***

Virtual Energy

The use of Virtual Energy is a key concept in EDGE. When there are no plans for HVAC systems to be installed in a building at the time of certification, EDGE calculates the energy that will be required to ensure human comfort on the premise that if the building design does not provide proper internal conditions and the space is uncomfortably hot or cold, eventually mechanical systems will be added to the building (in the form of individual air conditioning units, for example) to compensate for the lack of a space-conditioning system. This future required energy for comfort is demonstrated in EDGE as "virtual energy," articulated separately for ease of understanding.

Note: *Virtual Energy is defined as "assumed system" according to ISO 52000-1:2017,*

While this virtual energy is not reflected in the utility costs, it is used by EDGE to determine the 20% improvement in energy efficiency required by EDGE. Therefore, virtual energy must be reduced in the same way that actual energy is reduced.

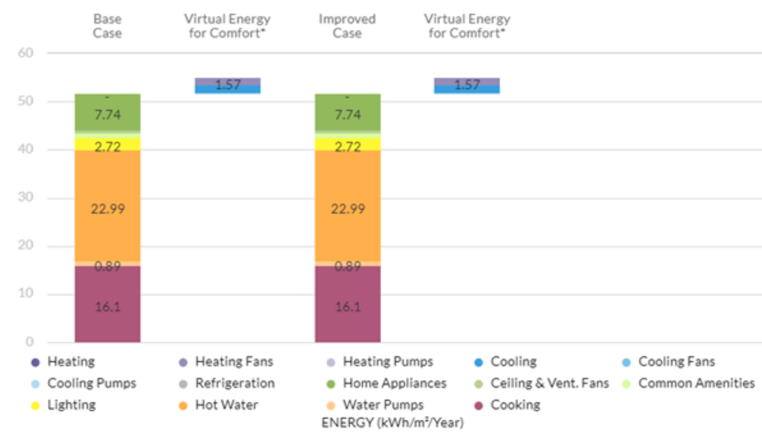


Figure 1. Sample Energy chart from the Apartments typology.

The categories in the Energy Chart vary depending on the building type. A description of the categories follows.

- Heating Energy, Cooling Energy, Pump and Fan Energy: These reflect the energy used in the space conditioning systems for all activity areas. When a cooling or heating system is not specified, but the building requires it to maintain comfort, the estimated heating or cooling energy and its related fan & pump energy show up as "virtual energy" on the Energy Chart.
- Cooking: Includes cooking energy required for food preparation.
- Water Pumps: Water Pumps, STP Pumps.

- Home Appliances: Plug loads from common appliances (Applicable to Homes)
- Hot Water: Energy consumed by the hot water system. Heating with any fuel type is converted to kWh.
- Laundry: This is the energy involved in washing and drying clothes (Applicable to all typologies except Industrial, Offices, Education and Retail)
- Lighting: This is the energy used for the lights internally and external (Landscape, External car parking, and Swimming pool lighting areas).
- Refrigeration: For to industrial and retail, this is the energy used by industrial refrigeration equipment for cold and frozen storage. For gest accommodation, it includes the refrigerators available for guests.
- Common Amenities: This includes the energy consumption of sewage treatment plant (STP), water treatment plant (WTP), gray water treatment plant, water pumps for recreational facilities (such as a swimming pool), and the lift as applicable.

Special Ruling Requests (SRR)

While the prescribed measures are designed to cover most situations, there may be cases where a project team has a compelling reason for non-compliance. In such instances, a Special Ruling Request (SRR) may be submitted. Each SRR should be based on standards, national codes, or validated numerical solutions, and must be verifiable and aligned with industry best practices. SRRs must be submitted to the IFC for approval via edge@ifc.org. Please note that even if an SRR is approved by the IFC, it is still subject to auditor verification to ensure that the assumptions align with the actual onsite installations.

Individual Measures in EDGE

The Individual Measures Section in the user guide describes each measure included in EDGE, indicating the intent of the measure, how it is assessed, potential technologies and strategies to incorporate the measure, and what assumptions have been made to calculate the base case and improved case.

Requirement Summary

A summary of the system or level of performance required to claim that a measure has been incorporated into the *subproject*.

Intention

What the measure aims to achieve and why it is measured in a certain way in EDGE.

Approach/Methodologies

The approach used to assess the design is provided with an explanation of the calculations and terminology used.

Note that EDGE makes default assumptions for a base case building. The key baseline values are displayed in the EDGE App. The base case is taken from either typical practice or performance levels required by applicable local codes and standards. An assumption is also made for the improved case, so that when a measure is selected the predicted performance of the building is improved.

It is mandatory to override the improved case assumptions in EDGE with actual values representing predicted performance for the actual building design, allowing actual improvements to be recognized.

Potential Technologies/Strategies

The possible solutions and technologies that might be considered by the design team to meet the requirements of the measure.

Relationship to Other Measures

EDGE calculates the impact of user-selected measures by taking a holistic view of the building project and assessing the impact on inter-related aspects of energy, water, and materials (also known as integrated analysis). For example, a higher window-to-wall ratio may increase energy use and increase embodied carbon of the building envelope if the windows have higher embodied carbon compared to the wall material. Another example is hot water; a reduction in hot water use would decrease the consumption of both water and the energy used to heat the water. Such inter-relationships between measures are listed in this section to clarify EDGE calculations and support the overall design process.

Compliance Guidance

The compliance guidance provided for each measure indicates the documentation that will be required to demonstrate compliance for EDGE certification. Documentation requirements vary according to the technology being assessed. The documents required to prove compliance are specified in each individual measure section of this User Guide.

Because available evidence depends on the current stage in the building design process, EDGE provides compliance guidance for each measure at both the design and post-construction stages.

If the required evidence is not available during the design stage, a signed declaration of intent can be provided by the project administrator, except for Core & Shell, refer to ***Part 1 - EDGE Building Certification Guidance*** for more information. Note that at the post-construction stage, this declaration must be signed by the client, or a designated client representative as defined in the certification agreement. During the post-construction stage, more rigorous documentation is required. However, a common-sense approach is recommended to verify that the measure has indeed been installed as per the specifications claimed. For example, some measures require purchase receipts to demonstrate compliance. If these are not available, similar locally used documents such as drawings or invoices may be used instead to verify the construction details.

In the case of EDGE *subprojects* that are going directly into Post-Construction phase, the compliance requirements of both design and post-construction stages are expected to be met, except where a post-construction requirement replaces the design stage requirement.

In most cases, a minimum of 90% of a particular specification must comply for certification, unless specifically stated. If the auditor has reason to believe that a measure should be recognized, then proper justification should be provided for the certifier's review. Approval of such justification is at the discretion of the certifier.

EEM01 – Windows-to-Wall Ratio

Requirement Summary

The Window to Wall Ratio (WWR) represents the ratio of the total window area to the total wall area of the building's envelope, i.e. the external layer that separates the thermally conditioned indoor spaces from the exterior. For home typologies, the WWR refers to the weighted average unit.

If detailed wall and glazing details for each orientation are available, the user shall use the detailed entry calculator to input this information. Walls and glazing areas of all applicable orientations must be entered when the detailed entry calculator is used, if some fields are left blank the tool considers that façade area with default values.

The calculator must be used in EDGE when the *project team* submits for certification. Direct entries in the user field are not acceptable.

Intention

The sun is a powerful light source but is also a source of significant heat gain. Therefore, it is important to balance lighting and ventilation benefits of glazing with the impacts of heat gain on cooling needs and/or passive heating. Finding the correct balance between the transparent (glass) and the opaque surface in the external façades helps to maximize daylight while minimizing unwanted heat transfer, resulting in reduced energy consumption. The design goal should be to meet minimum illumination levels without significantly exceeding the solar heat gains in temperate and warm climates, as well as to make the most of passive heating in cold climates in wintertime.

Windows generally transmit heat into the building at a higher rate than walls do. In fact, windows are usually the weakest link in the building envelope as glass has much lower resistance to heat flow than other building materials. Heat flows out through a glazed window more than 10 times faster than it does through a well-insulated wall. While glazed areas are desirable to admit solar radiation in cold climates during the day, windows in warmer climates can significantly increase the building's cooling loads.

Approach/Methodologies

This measure uses the Window to Wall Ratio (WWR), which is defined as the ratio of the total area of the window or other glazing area (including mullions and frames) divided by the total wall area, including the window area.

The calculations for all window and wall areas must be entered in the window to wall ratio calculator in EDGE for any submission.

The WWR is calculated with the following equation:

$$\mathrm{WWR}\ (\%) = \frac{\sum \text{External Glazing area}\ (\mathrm{m}^2)}{\sum \text{Exposed Gross Facade area}\ (\mathrm{m}^2)}$$

Note: *Subprojects* located in South Africa, the measure EEM01 will display a non-editable Window to Floor Ratio (WFR). This is based on user entered data in the measure for the calculation of the ratio of the window area to the net floor area. The metric is provided only for *subprojects* located in South Africa, which require South Africa National Standards (SANS) reporting.

Definitions:

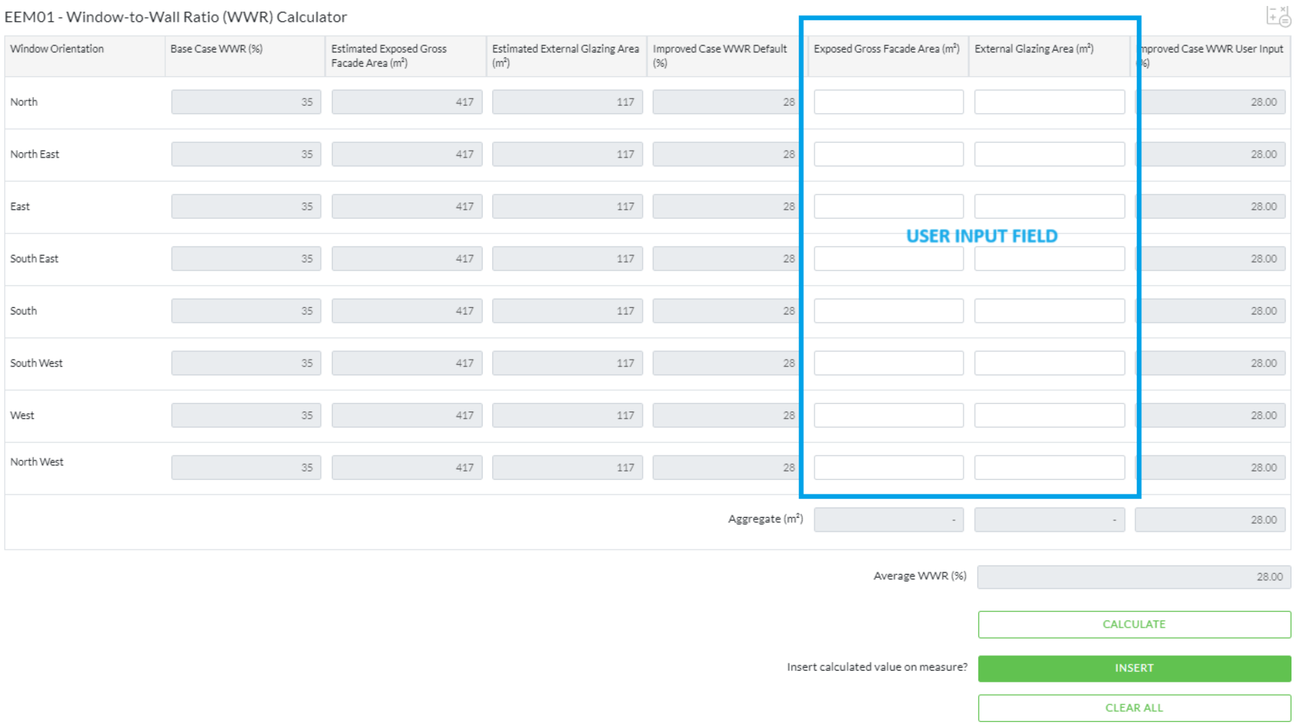
External Glazing area is the area of glass including frames and mullions on all façades regardless of orientation. For homes, it refers to the area of a weighted average unit.

Exposed Gross façade area is the sum of the area of the exterior walls that divide the thermally conditioned indoor spaces from the exterior for all orientations, which includes walls, windows, doors, mullions, and frames. Double façade systems are counted once. For homes, it refers to the area of a weighted average unit.

Where***:***

$$\textit{Exposed Gross façade area} \geq \textit{External Glazing area}$$

The improved case WWR must be calculated and entered for each façade separately, i.e., for the North Façade the % WWR of the North façade only should be entered. This will impact the solar gain in each façade and impact the cooling and heating load. Calculations must be entered into the EDGE App as per Figure 2.



EEM01 - Window-to-Wall Ratio (WWR) Calculator

Window Orientation	Base Case WWR (%)	Estimated Exposed Gross Facade Area (m²)	Estimated External Glazing Area (m²)	Improved Case WWR Default (%)	Exposed Gross Facade Area (m²)	External Glazing Area (m²)	Improved Case WWR User Input (%)
North	35	417	117	28			28.00
North East	35	417	117	28			28.00
East	35	417	117	28			28.00
South East	35	417	117	28			28.00
South	35	417	117	28			28.00
South West	35	417	117	28			28.00
West	35	417	117	28			28.00
North West	35	417	117	28			28.00
				Aggregate (m²)	-	-	28.00

Figure 2. EDGE App calculator User Input Field

Windows and walls facing internal courtyards or gaps between buildings (open to outside air) should be included in the WWR calculations.

Figure 3. Courtyard of a building[1]

When dealing with an internal courtyard, determining the window to wall ratio requires calculating the total internal wall and glazing area for each orientation. Total wall area then includes the wall area facing the courtyard, as well as the external building wall area. A similar methodology shall be used to find the total glazing area. Note: internal courtyards are not included in external building length, hence inputs for building lengths in the design tab remains the same.

For buildings with curtain walls, spandrel panels (opaque insulated glass panels) should be included as external walls in the WWR calculations.

Figure 4. Window to Wall Ratio of Building with Curtain Wall Glass [2]

In the EDGE calculator, the actual WWR for the design case must be entered in the system. While a higher WWR may have a negative impact on energy savings, it may be compensated for by other energy saving measures.

<u>Exclusions from WWR Calculations</u>

The following examples should be excluded from the calculations of WWR:

a. Walls that feature windows or ventilation openings that lead exclusively into covered internal shaft (for example, as seen for bathrooms in residential *buildings* in certain regions)
b. Façade sections that do not separate thermally conditioned indoor spaces from the exterior, such as parapets.
c. External walls that are not exposed to the outdoors. For example, underground walls, earth-bermed walls or walls that are in immediate contact with an adjacent building. For walls in basements that are partially exposed, any segment of the wall or window that is not covered should be taken into account.
d. External walls of spaces that are always considered as thermally unconditioned[3]:
    - Highly ventilated spaces. Defined as spaces with a continuous ventilation capacity of at least 3 liters per second for every square meter of the space's floor area.

[1] *Image credit: MIT News, https://news.mit.edu/2020/building-14-courtyard-undergoing-renovation-0922*

[2] *Image credit: MIT News, https://news.mit.edu/2018/mit-nano-building-open-0924*

[3] Thermally unconditioned spaces as defined in ISO 52016-1:2017

- Spaces with large openings, characterized as having one or more permanent openings that are equal to or exceed an area of 0.003 square meters per square meter of the space's floor area.

<u>Notes on EDGE App Entries:</u>

a. For buildings modelled across multiple *subprojects*, the recommended method is to calculate an average WWR for the whole building and use that in every *subproject*. Modeling each *subproject* with its own WWR is also acceptable, but unless a significant difference exists between the *subprojects*, e.g. some containing double height spaces or significantly different glass areas, this approach is not recommended. For example, if the average WWR of a residential building is 35%, such value may be used for all unit types regardless of their individual WWR.
b. There may be energy variations both in the base and improved case when using the calculator for entering directly window and glazing areas compared to the value obtained without the calculator. This difference arises due to the underlying assumptions of wall area, which can vary between the EDGE default calculation and the specific values entered by the user. Therefore, using the detailed entry calculator allows for a more accurate representation of the building's energy performance.

Potential Technologies/Strategies

Envelope heat transfer is a function of the thermal resistance of the external materials, the area of the building façade, and the temperature difference between the exterior and interior of the building. The primary causes of heat transfer are radiation and conduction through windows. The size, number and orientation of windows have a significant effect on the building's energy use for thermal comfort purposes (heating or cooling).

A building with a higher WWR will transfer more heat than a building with a lesser WWR. If the WWR is higher than the default value, then other measures such as shading or a lower solar heat gain coefficient (SHGC) of the glass should be considered to offset the energy loss. In cold climates, when the WWR is higher than the default, the insulation of glass using double or triple glazing should be considered.

With regards to daylight, two basic strategies are available for using the sun for lighting while minimizing heat gain. The first is to use a small window opening (15% WWR) to illuminate a surface inside the space that then spreads the light out over a large area. The second is to use a moderately sized window (30% WWR) that "sees" an exterior reflective surface but is shaded from the direct sun. To increase the daylight availability, the selection of higher visible light transmittance (VLT>50) for the glass is also important.

In cold climates, direct solar radiation passes through the glass during the day, passively heating the interior. If sufficient thermal mass is used, this heat is then released, helping to keep the room comfortable later in the day. In this climate type, the glass placement that is most desirable is at the elevation with the greatest exposure to sunlight. However, in warm and temperate climates, the WWR should be lower as the reduction of glass leads to a reduction in the overall cooling load and reduced need for air conditioning.

Relationship to Other Measures

When the calculator of this measure is used, the following measures are affected:

- The material areas in MEM05 and MEM10
- The walls areas of reflective facade in EEM03
- The effectiveness of external shading in EEM04
- The walls U-values in EEM08
- Glass area in EEM09 calculator shall be consistent with the calculation in this measure

- The effectiveness of EEM22 – Efficient lighting for Internal Areas will be impacted due to changes in daylight availability

Compliance Guidance

Preliminary Stage Certification

- EEM01 calculator and/or Calculation of “Glazing Area” and “Gross Facade Area” for each façade of the building, and the average area weighted WWR; and
- Elevation drawings showing glazing dimensions and general building dimensions.

Post Construction Stage Certification

At the post-construction stage, it is important to ensure that the WWR has been maintained to achieve the energy savings indicated in the EDGE results. Compliance is achieved when the design team demonstrates that the WWR in all elevations is equal or lower than the claimed specification, using the formula explained in “Potential Technologies/Strategies” above.

At the post-construction stage, the following must be used to demonstrate compliance:

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- As-built façade drawings; or
- Date-stamped photographs of the building interior and exterior showing all the elevations.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence of construction details, such as existing building drawings, calculations, onsite measurements and photos, where relevant, taken during renovation shall be submitted.

EEM02 – Reflective Roof

Requirement Summary

EDGE will calculate the impact of any improvement beyond the base case. This measure tends to demonstrate energy savings in warm climates.

Intention

SRI defines how much visual light and heat is being reflected and not absorbed.

Specifying a higher reflectance finish for the roof can reduce the cooling load in air-conditioned spaces and improve thermal comfort in non-air-conditioned spaces. Due to the reduction in surface temperature, the service life of the finish also improves, and the impact on the urban heat island effect[4] can be reduced.

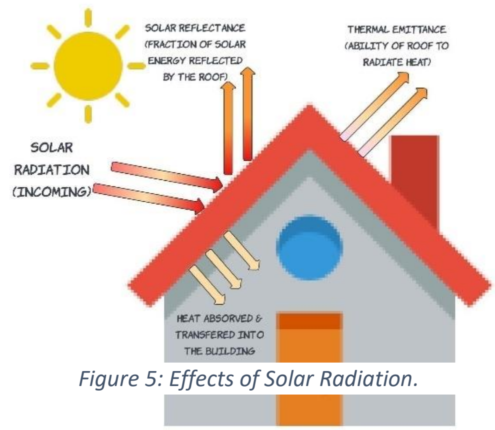


Figure 5: Effects of Solar Radiation.

Approach/Methodologies

The SRI calculation in the EDGE App is based on the methodology defined in the ASTM E1980 standard.

EDGE App uses the solar reflectance index (SRI) of the roof finish as the indicator of performance. **Solar Reflectance Index** is a composite value accounting for a surface's solar reflectance and thermal emittance. SRI is defined so that a standard black surface (solar reflectance 0.05, thermal emittance 0.90) is 0 and a standard white surface (solar reflectance 0.80, thermal emittance 0.90) is 100. SRI values for highly reflective roofs have been engineered to go above 100. The SRI for a specific roofing material and finish can be acquired from the product manufacturer. It is often indicated in the product data sheet or laboratory test results published on manufacturers' websites.

The detailed entry table provides the user with the option to enter up to four different types of roof reflectivity (SRI) values. The calculation considers the weighted average value, based on the area, of these entered values. Should there be more than four different SRI values, *project teams* may perform their weighted average calculations. If a portion of the roof is a Green Roof, the SRI value in EDGE will only apply to the portion that is not the green roof.

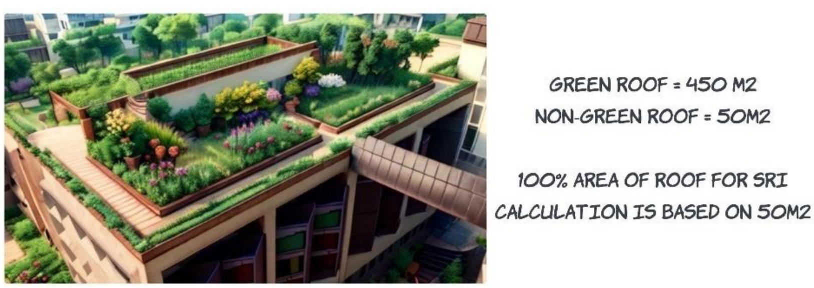


Figure 6. SRI calculation in EDGE – Excludes all Green Roof Area

The EDGE App accepts values ranging from 10 to 135. Should the values fall below or above the range, *project teams* shall use either the minimum or maximum values as applicable.

[4] A city's core temperature is often significantly higher than its surrounding area due to the retention of heat from the built environment.

When solar reflectance and thermal emittance is available, *project teams* may compute the SRI using the Berkeley National Laboratory's SRI calculator (https://coolcolors.lbl.gov/assets/docs/SRI Calculator/SRI-calc10.xls) with a roof surface temperature of 50.8 °C.

Potential Technologies/Strategies

High solar reflectance is the most important property of a cool surface. Color is the key factor in the solar reflectivity of the material or finish. In **warm climates**, a white finish is ideal to maximize reflectivity. A very light color would be the next best choice. Cool roof coatings can significantly increase the reflectance of a roof, even for dark colors, and therefore increase the SRI. SRI captures both solar reflectance and thermal emittance. High SRI values may be achieved by virtue of the material, color, coating, or a combination of those. Table 2 provides an indication of the SRI values for different roof finishes but is meant only as a guide. Manufacturers' published values must be used in the EDGE assessment.

For existing buildings, if manufacturer data is not available, EDGE reference values may be used if the roofing material in the table corresponds to the material used on site.

Table 2. Solar reflectance Index (SRI) values for typical roofing materials[5]

Roofing Materials	SRI
Bitumen	
Firestone SBS Bitumen on White	28
Smooth Bitumen	1 (use 0)
White Granular Surface Bitumen	28
Asphalt Shingles[6]	
White Asphalt	26
Light Gray	22
Light Gray – with cool coating	44
Gray	4
Beachwood Sand	19
Light Brown	18
Saddle Tan	14
Black or Dark Brown	1
Black – with cool coating	41
Blue	16
Blue – with cool coating	50
Coral	14

[5] Source: Adapted from the LBNL Cool Roofing Materials Database. These values are for reference only and are not for use as substitutes for actual manufacturer data.

[6] https://heatisland.lbl.gov/resources/asphalt-shingles

Roofing Materials	SRI
Terracotta-colored	36
Terracotta-colored – with cool coating	56
Green	18
Green – with cool coating	53
Chocolate	9
Chocolate – with cool coating	46
Metal Roof	
Metal roof – Uncoated	68
Bare Aluminum	56
New, Bare Galvanized Steel	46[7]
Metal roof – with Cool Coating	92
White Metal Roof	82
Built-up Roof	
Dark Gravel on Built-Up Roof	9
Light Gravel on Built-Up Roof	37
White-Coated Gravel on Built-Up Roof	79
Roof Tiles	
Red Clay Tile	36
Red Concrete Tile	17
Unpainted cement Tile	25
White Concrete Tile	90
Light Beige-coated Concrete Tile	76
Light Brown-coated Concrete Tile	48
Earth Brown Fiber Cement Tile	27
Pewter Gray Fiber Cement Tile	25
EPDM	
EPDM[8]- Gray	21
EPDM – White	84
EPDM - Black	-1 (use 0)

[7] https://heatisland.lbl.gov/resources/metal-roofing

[8] https://heatisland.lbl.gov/resources/roofing-membranes

Roofing Materials	SRI
T-EPDM	102
Roof Coatings[9]	
White Coating (2 coats, 20 mils*)	107
White Coating (1 coat, 8 mils*)	100
No Pigment Coating (1 coats, 18 mils*)	40
No Pigment Coating (2 coats, 36 mils*)	64

** mil is equal to .001 inches or .0254 millimeter*

Buildings in cold climates that do not need cooling will not benefit from a high Solar Reflectance Index (SRI) roof. This is because the roof reflects heat away, which can increase the need for heating energy. In temperate climates, where *buildings* require both heating and cooling, energy savings from a high SRI roof will only occur if the reduction in cooling energy use is greater than the increase in heating energy use.

Relationship to Other Measures

The impact that the solar reflectivity of the roof has on the energy consumption of a building is dependent upon the insulation levels and the approach used to cool the building, as well as the efficiency of any cooling systems.

The solar reflectivity of the roof finish has a decreased effect on the internal heat gains as the insulation levels are increased. Super-insulated buildings may not benefit significantly from roof finishes with a high solar reflectivity. Higher solar reflectivity values will have no effect on the energy consumption in passively cooled buildings, but may have an impact on virtual energy and, therefore, EDGE results due to occupant comfort.

As the efficiency of the cooling system increases, the solar reflectivity will have a decreasing impact on energy consumption.

Compliance Guidance

At both the design and post-construction stage, it is important to ensure that the value obtained for the roof material/finish is the solar reflectivity of the finish rather than an alternative indicator of performance. The values that may be provided by a manufacturer include the solar reflectance index (SRI), visible solar reflectance, the emittance, or gloss units, which are not the same as solar reflectivity.

<u>Preliminary Stage Certification</u>

- Building plans and calculations marking the area of major roof types if more than one type of roof is present; and
- Building design drawings showing the roof finish(es). Where the finish is white, this measure may be awarded without further evidence when a data sheet is not available.
- If finish is not white, provide one of the following with the solar reflectance Index of the roof surface clearly indicated,
    - Roof specifications; or
    - Manufacturer’s data sheets, or
    - Bill of quantities.

[9] https://heatisland.lbl.gov/resources/roof-coatings

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the roof(s) showing the claimed products on site; or
- Purchase receipts showing the installed products.

Existing building documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence, such as existing building drawings and photos, where relevant, taken during renovation shall be submitted.

EEM03 – Reflective Walls

Requirement Summary

Buildings in **warm climates** may claim energy savings if the solar reflectance index (SRI) of the external wall finish is greater than the local base case. EDGE will calculate the impact of any improvement beyond the base case.

Intention

Specifying a higher SRI finish for the walls can reduce the cooling load in air-conditioned spaces and improve thermal comfort in non-air-conditioned spaces. Due to the reduction in surface temperature, the service life of the finish also improves, and the impact on the urban heat island effect[10] can be reduced.

Approach/Methodologies

EDGE uses the solar reflectance index (SRI) of the exterior finish as the indicator of performance. SRI represents a combination of the reflective properties of the surface when subject to incident solar radiation (total solar reflectivity), and the emittance properties of the surface (thermal emittance). Unlike Visible Solar Reflectance, SRI includes the full solar spectrum.

Solar Reflectance Index is a composite value accounting for a surface's solar reflectance and thermal emittance. SRI is defined so that a standard black surface (solar reflectance 0.05, thermal emittance 0.90) is 0.0 and a standard white surface (solar reflectance 0.80, thermal emittance 0.90) is 100. SRI values for highly reflective surfaces have been engineered to go above 100. The SRI for a specific material and finish can be acquired from the product manufacturer. It is often indicated in the product data sheet or laboratory test results published on manufacturers' websites. SRI is typically expressed as a fractional value between 0 and 1. It can also be expressed as a percentage.

Potential Technologies/Strategies

The key consideration of the material used on the façade is its color and potential solar reflectivity.

Table 3 provides an indication of the ranges for different materials but is meant only as a guide. Manufacturers' published values must be used in the EDGE assessment. If manufacturer data is not available, the EDGE reference values may be used as an exception.

Table 3: Solar reflectivity of typical wall finishes. Ranges are taken from various manufacturers' website

Wall Materials	SRI
Metal – with Cool Coating	92
White Metal	82
Red Clay Brick	36
Red Concrete	17
Unpainted cement	25
White-painted Concrete	90

For existing buildings, if manufacturer data is not available, EDGE reference values may be used if the roofing material in the table corresponds to the material used on site.

[10] A city's core temperature is often significantly higher than its surrounding area due to the retention of heat from the built environment.

Relationship to Other Measures
The impact that the solar reflectivity of the walls has upon the energy consumption in a building is dependent on the insulation levels, as well as the approach used to cool the building and the efficiency of any cooling systems.

The solar reflectivity of the wall finish has a decreased effect on the internal heat gains as the insulation levels are increased. Super-insulated buildings may not benefit significantly from wall finishes with a high solar reflectivity. Higher solar reflectivity values will have no effect on the energy consumption in passively cooled buildings but may have an impact on the EDGE rating due to occupant comfort.

As the efficiency of the cooling systems increases, the solar reflectivity will have a decreasing impact on reducing the energy consumption. This measure may have negative impacts in heating dominating climates.

A highly reflective surface might cause glare and should be taken into consideration by the *project team*.

Compliance Guidance
At both the design and post-construction stage it is important to ensure that the value obtained for the wall material/finish is the solar reflectivity of the finish rather than an alternative indicator of performance. Other values that may be provided by a manufacturer include the solar reflectance index (SRI), visible solar reflectance, the emittance or gloss units, which are not the same as solar reflectivity.

Preliminary Stage Certification

- Building plans or elevations highlighting the area of major external wall types if more than one type of external wall is present; and
- Building design drawings showing the wall finish(es). Where the finish is white, this measure may be awarded without further evidence;
- If finish is not white, provide one of the following with the solar reflectivity Index of the wall surface clearly indicated,
    - Wall specifications; or
    - Manufacturer's data sheets, or
    - Bill of quantities.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the wall(s) showing the claimed products on site; or
- Purchase receipts showing the installed products.

Existing Building Documentation

- If the documents required above are not available, other evidence of construction details, such as existing building drawings or photos, where relevant, taken during renovation shall be submitted.

EEM04 – External Shading Devices

Requirement Summary

This measure may be claimed if external shading devices are provided on the building's exterior. Adaptive shading elements are not considered shadings for this measure.

Intention

External shading devices are provided on the building façade to protect the glazed elements (glass windows and doors) from direct solar radiation to reduce glare and to reduce radiant solar heat gain in cooling dominated climates. This method is more effective than internal shading devices such as blinds. This is because radiant solar gain occurs in the form of short wavelengths that can pass through glass; however, radiation absorbed by surfaces in the room is emitted as long-wavelength radiation, which cannot escape back out through the glass because almost all window glass is opaque to long-wavelength radiation. This traps the radiant solar gain inside the room. This phenomenon is known as the greenhouse effect.

Approach/Methodologies

The EDGE tool assumes no shading devices on all windows of the building.

The shading factor, which affects the amount of solar radiation entering the building, is influenced by several factors such as the building's latitude, window orientation, and the size of the shading device. The tool calculates the shading factor by using the default values mentioned above. If the user entry is provided in the built-in calculator those inputs are considered for shading factor calculation.

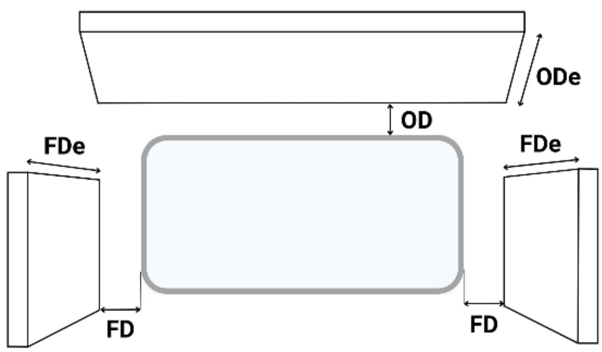


Figure 7. Illustration of the dimensions used to calculate the shading factor.

The picture illustrates the terminologies used in the calculator.

- **ODe**=Overhang Depth (m)
- **FDe**=Fin Depth (m)
- **OD**=Overhang Distance: Overhang projection depth (m)
- **FD**=Fin Distance: Distance from window edge to vertical fin (m)

Users can model 3 types of shading devices in each orientation and weighted average value is considered for calculation.

The EDGE tool considers only the user's input values when the detailed entry calculator is selected. If information about other window orientations is not provided, the shading factor for those orientations will be assumed to be zero.

Alternative Compliance Pathway

For buildings with complex shading devices, building simulation software such as Climate Studio, DL-Light (Watt extension), Design Builder, IES-VE, or any other equivalent software may be used to model and calculate the Annual Average Shading Factor (AASF).

The AASF is used to assess the effectiveness of shading devices. It is calculated using the following formula:

$$\text{AASF} = 1 - \frac{\text{Total annual solar heat gain from a window with shading (kWh)}}{\text{Total annual solar heat gain from a window without shading (kWh)}}$$

The shading factor is expressed as a decimal value between 0 and 1. A higher AASF indicates greater cooling energy savings.

Process to Estimate AASF Using Building Simulation Software:

1. **Create Two Models:**
   - **Model 1:** A building model without shading devices.
   - **Model 2:** A building model with shading devices.
2. **Perform Full-Year Simulations:**
   - Run a full-year energy simulation for each model.
   - Report the annual total solar heat gain from all windows in kilowatt-hours (kWh) for both models.
3. **Calculate AASF:**
   - Use the reported values to calculate the AASF using the formula provided above.

Submission Requirements:

Project teams following the alternative compliance pathway shall submit the following to the International Finance Corporation (IFC) at edge@ifc.org prior to submitting for certification:

- Descriptions of the models with and without shading devices.
- Annual total solar heat gain from all windows for both models.
- Calculations of the AASF.
- Simulation report detailing the methodology and results.

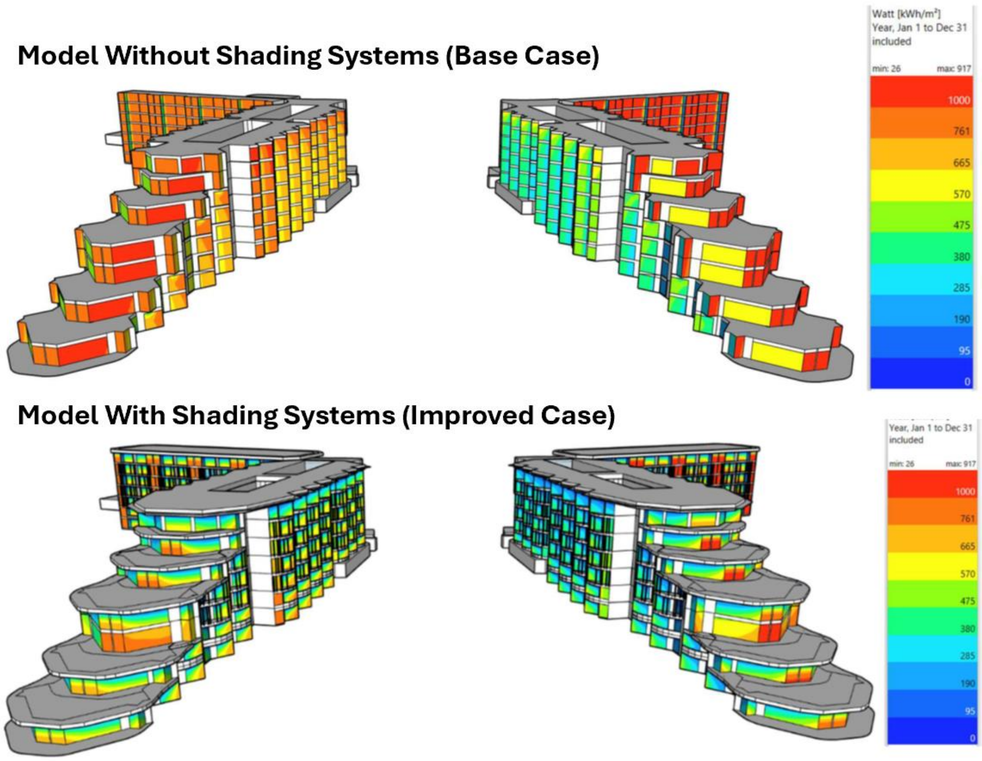
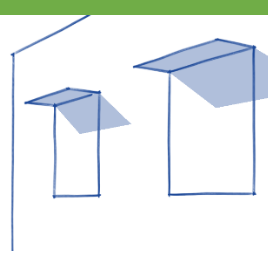
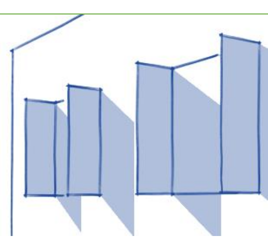


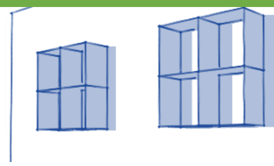
Figure 8. Simulation models used to estimate the Total Annual Solar Heat Gain. Image courtesy of ISD Engineering.

Potential Technologies/Strategies

Three basic types of solar shading are used most: horizontal, vertical, and combined (egg crate). Table 4 shows a summary of the shading types and descriptions.

Table 4: Shading types and descriptions.

Shading Type	Image	Description
Horizontal shading devices (overhangs)		These are useful for building façades where the sun's rays are at a high angle of incidence, in short, where the sun appears high in the sky. Examples include summer mid-day sun on either the northern or southern façades of a building for higher latitudes, or east and west façades for equatorial latitudes.
Vertical shading devices (fins)		These applications are useful where the sun's rays are at a low angle of incidence (where the sun appears low in the sky). Examples include eastern sun on eastern façades, western sun on western façades, and winter sun on southern or northern façades in high latitudes.

Shading Type	Image	Description
Combined shading devices (egg crate)		"Egg crate" devices are used for conditions where different times of the year warrant different shading needs.
Moveable shading devices – louvres or shutters	 	These devices are used to control sunlight during the day as well as reduce heat losses at night. They are moveable and may be mechanical or manual. They often provide maximum shading as they fully cover the window. These shading devices also protect from inclement weather (hail, wind, or rain) as well as provide privacy and security.

The effectiveness of a shading device varies depending on the location towards the equator (latitude) and the orientation of the window. Table 5 shows the usually recommended shading strategies for different orientation at the design stage.

Table 5: Shading strategies for different orientations at the design stage.

Orientation	Effective Shading
Equator-facing	Fixed Horizontal Device
East	Vertical Device/Louvres (moveable)
Pole-facing	Not required
West	Vertical Device/Louvres (moveable)

Relationship to Other Measures

External shading reduces the heat gain through solar radiation, therefore a glazing type with a higher solar heat gain coefficient may be selected without a significant negative impact. As external shading cuts the solar heat before it hits the glazed element, it reduces radiative heat gain compared to a treated glass without shading, thus offering better thermal comfort conditions.

Shading reduces heat gain and, therefore, cooling loads. The extent of the savings achieved in cooling energy from shading will be impacted by the efficiency of the cooling system. With a more efficient cooling system, the magnitude of savings from shading alone will be less, even though the combined savings will be greater.

In heating mode, the heating consumption may be increased when external shading is incorporated, due to the reduction of solar heat gains in winter, if shading is not well designed. Well-designed shading cuts out the summer sun but allows in the winter sun which is at a lower altitude.

Compliance Guidance

Preliminary Stage Certification

- All façade elevation drawings highlighting the provision of horizontal and vertical shading devices; and
- Window details clearly showing the depth of the shading device and the calculation of the proportion.
- For alternative compliance path, an approved SRR from IFC is required.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of all facades showing the shading devices on site; or
- Purchase receipts showing the installed products.
- For alternative compliance path, an approved SRR from IFC is required.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence of construction details, such as existing building drawings, calculations, and photos, where relevant, taken during renovation shall be submitted.

EEM05 – Insulation of Roof

Requirement Summary

This measure utilizes the U-value or thermal conductivity of materials as the performance indicator, with the inclusion of insulation leading to an improvement in the U-value. The U-value should be entered in accordance with the guidelines provided in the Approach/Methodologies section.

To demonstrate energy savings from this measure, it is necessary to prove that the U-value of the complete roof specification is better (lower) than the base case. In partial *building* certifications, if the space above is permanently thermally conditioned, the *project team* may input a U-value of 0.01 W/m²K.

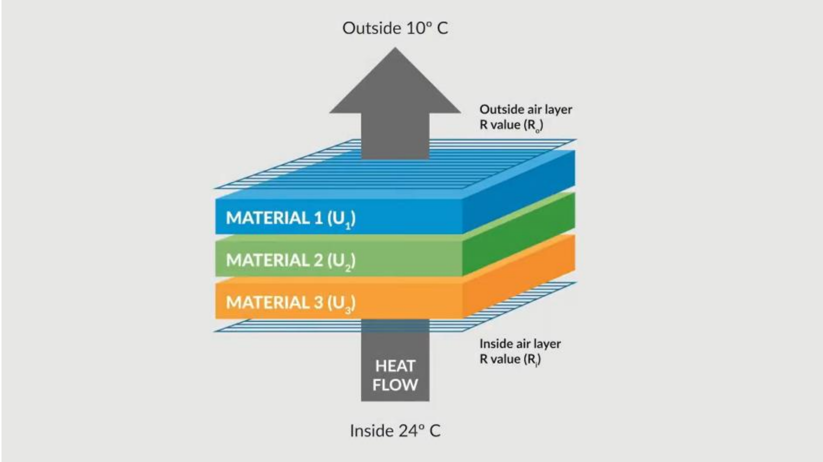
Intention

Insulation is used to prevent heat transmission from the external environment to the internal space (for warm climates) and from the internal space to the external environment (for cold climates). Insulation aids in the reduction of heat transmission by conduction[11], so more insulation implies a lower U-value and better performance. A well-insulated building has lower cooling and/or heating energy requirements.

Please note that many modern insulating materials, such as certain foam-based insulations, as well as air cavities that improve the sustainability and energy efficiency of buildings also spread fire more easily compared to traditional materials such as concrete and wood. The *project team* is encouraged to take proper fire safety precautions in the selection of these materials and the associated design details such as fire stops.

Approach/Methodologies

This measure uses U-value, which is defined as the quantity of heat that flows through a unit area in unit time, per unit difference in temperature; it is expressed in Watts per square meter Kelvin (W/m²K). U-value is an indication of how much heat is transmitted through a material (thermal transmittance), see Figure 9: The U-value is an indication of how heat is transmitted through a material.Figure 9.



$$U=1/(R_o+1/U_1+1/U_2+1/U_3+R_i)$$

Figure 9: The U-value is an indication of how heat is transmitted through a material. Source: EDGE Buildings Channel.

[11] Conduction is the process by which thermal energy moves within an object or between connected objects.

The U-value, which is the performance indicator of this measure, is the reciprocal of the total thermal resistance[12] (1/∑R) of the roof, which is calculated from the individual thermal resistance of each component/layer of the roof.

Simplified method of calculating the U-value

The U-value is calculated in accordance with the "simplified method" as defined in ISO 6946, with the formula:

$$U - value = \frac{1}{R_{si} + R_{se} + R_1 + R_2 + \cdots}$$

Where:

R_{si} is the resistance of the air layer on the inner side of the roof.

R_{se} is resistance of the air layer on the external side of the roof.

$R_1 + R_2 + \cdots$ is the Resistance of each material layer within the roof.

The resistance of a roof material is derived by the following formula:

$$R = \frac{d}{\lambda}$$

Where:

d is the thickness of the layer of material (m).

λ is the thermal conductivity[13] in W/m K

As seen in the formula above, the insulating capacity is a direct function of the thickness of the material. The actual thickness required will depend on many other factors, including the fixing method, roof construction and position of the insulation within the material layers. The U-value calculation must not include the green roof portion.

Roof U-value Calculator

EDGE provides a built-in calculator for calculating the U-value of a roof with multiple layers of materials layered on top of each other.

When submitting for certification *project teams* must either use the U-Value calculator (Figure 10), validated calculation software/spreadsheets or energy modelling software. The former two methods are recommended for non-conventional assemblies (e.g. when materials are not in continuous layers or there are metal penetrations that punctuate the roof)

[12] Thermal resistance is a measure of how much heat loss is reduced through the given thickness of a material. Thermal resistance is expressed as the R, which is measured in square meters Kelvin per Watt (m^2K/W).

[13] Thermal conductivity is a standardized measure of how easily heat flows through any specific material, independent of material thickness. It is measured in Watts per meter Kelvin (W/m K) and is often expressed as the "K Value" or "λ".

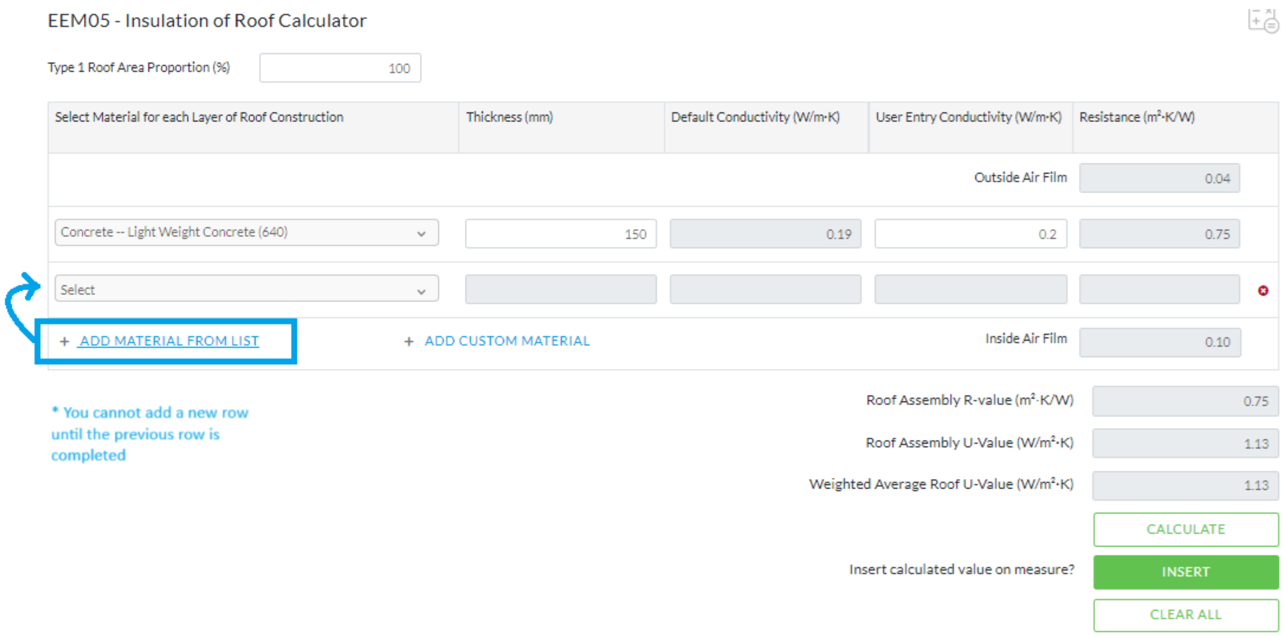


Figure 10. EEM05 – Insulation of Roof Calculator

When using the U-Value Calculator, EDGE users must consider the following:

- Roof Area Proportion must be entered in percentage (%) of roof area.
- Thickness of the material must be entered in mm.
- Thermal conductivity of the material in W/m.K must be entered under *User Entry Conductivity.*
- All fields in each row must be completed before a new material can be added.
- Customized Materials may be used when the *building* material is not part of the list of materials. Laboratory certificate containing the Thermal Conductivity should be provided, alternatively, a standard indicating the thermal conductivity for that specific material may be referenced.
- "Air Gap" in the list of material is an insulating air gap and cannot be selected for gaps larger than 100mm. For gaps >100mm, this must not be entered into EDGE.

Note 1: *The EDGE App accepts U-values within the range of 0.01 to 8. If the roof assembly U-value falls outside the range (i.e., U > 8W/m2K, a value of 8 W/m2K may be entered).*

Note 2*: If more than five roof types are present in the building, project teams may focus on modelling the 90% of the roof, by area. If this method is not enough, project teams may combine similar roofs into one by providing a technical justification as part of the documentation submitted.*

<u>*Documentation Relief for Existing Buildings*</u>

For existing buildings with insufficient records on the roof section, the *project team* may follow these steps:

1. Identify the predominant material of the roof. If there are multiple layers, the *project team* may choose to identify each layer.
2. Measure the roof thickness. If the thickness cannot be measured, the *project team* must use the base case thickness from measure MEM04.
3. Enter the material and thickness information into the EEM05 calculator to determine the existing U-value of the roof.

Potential Technologies/Strategies

Insulating the roof is potentially the most cost-effective way to reduce the energy used for heating a building. Therefore, in cold or temperate climates there is a strong case for maximizing the insulation before designing the heating ventilation and air conditioning equipment. In hot climates insulating the roof can reduce heat gain, but the effect is relatively minor.

Different types of insulation are available, and the appropriate type will depend on the application as well as cost and availability. Insulation types can be grouped into four main categories, see Table 6.

Table 6. Insulation Types and typical conductivity range

Insulation Type	Description	Typical Conductivity Range (*λ - K Value)*
Matting, Blanket, or Quilt Insulation	This type of insulation is sold in rolls of different thicknesses and is typically made from mineral wool (fiber made from glass or rock). Some common uses include insulating empty lofts, stud walls, and under suspended timber floors. Other materials such as sheep's wool are also available.	0.034 – 0.044
Loose-fill Material	Loose-fill material, made of cork granules, vermiculite, mineral wool, or cellulose fiber is usually poured between the joists to insulate lofts. It is ideal for loft spaces with awkward corners or obstructions, or if the joists are irregularly spaced.	0.035 – 0.055
Blown Insulation (Only for Roof insulation and Insulation of Exterior Walls)	Blown insulation is made from cellulose fibers or mineral wool. Spray foam insulation is made from Polyurethane (PUR). Blown insulation should only be installed by professionals, who use special equipment to blow the material into a specific, sectioned-off area, to the required depth. The material may remain loose if used for loft insulation but can also bond to a surface (and itself) for insulating stud walls and other spaces.	0.023 – 0.046
Rigid Insulation Boards	Rigid insulation boards are mostly made from foamed plastic such as polystyrene, polyurethane (PUR), or polyisocyanurate (PIR), which can be used to insulate walls, floors, and ceilings. PUR and PIR board are among the best insulation materials commonly used, and so are useful where space is limited. Rigid board must be cut to size, so fitting is often a skilled job.	0.02 – 0.081

The range of thermal conductivity may be used by auditors and reviewers to check for reasonableness of the *project team's* claims about insulation properties. The range may also be applied as a substitute in the rare case when manufacturer data is not available.

Relationship to Other Measures

- ***Impact on Materials Savings***: The use of insulation is selected shall cause an increase in the embodied carbon in MEM09 Roof Insulation due to the addition of insulation material, reflected as a negative improvement.

- ***Impact on heating / cooling loads***: By increasing the level of insulation the heating and/or cooling loads will generally be reduced. Increasing the levels of insulation could therefore reduce the energy demand for cooling and heating, leading to energy savings that compensate for the negative impacts in the materials section.

Compliance Guidance

To claim savings from this measure, it is necessary to demonstrate that the U-value of the complete roof specification is better (lower) than the Base Case. If the EDGE default for the improved case U-value is used, then it is only necessary to demonstrate that insulation has been or will be installed, and that its U-value does not exceed the default improved case value.

Preliminary Stage Certification

- Building plans highlighting the area of major roof types if more than one type of roof is present; and
- Detailed drawing(s) showing the layers of roof materials and any U-value specifications; and
- Calculation of overall roof U-value using either the calculator provided in the EDGE measure or external calculations; and
- Manufacturer's data sheets for the specified building materials; or
- Bill of quantities with the specifications for any roof insulation materials clearly highlighted.
- Laboratory certificate containing the Thermal Conductivity of the customized material should be provided as applicable.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the roof(s) taken during construction at a point when any insulation materials claimed were visible on site; or
- Purchase receipts showing the installed products.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence of construction materials and thicknesses, such as existing building drawings, on site measurements, and photographs, where relevant, shall be submitted.

EEM06 – Insulation of Ground/Raised Floor Slab

Requirement Summary

This measure refers to the U-value or thermal conductivity of materials as the indicator of performance, in which the use of slab-on-grade insulation may improves the U-value. The U-value must be entered following the guidelines in the Approach/Methodologies section. Note that the corresponding insulation measure must also be selected in the Materials tab, and the actual insulation type and thickness entered.

If the *project team* does not utilize the U value calculator, it is necessary to confirm that the U-value was calculated in accordance with *ISO 13370 Thermal performance of buildings — Heat transfer via the ground – Calculation Method*, as shown in the Approach/Methodologies section below.

Intention

Insulation is used to prevent heat transmission from the external environment to the internal space (for warm climates) and from the internal space to the external environment (for cold climates). Insulation aids in the reduction of heat transmission by conduction[14], so more insulation implies a lower U-value and better performance. A well-insulated building has lower cooling and/or heating energy requirements.

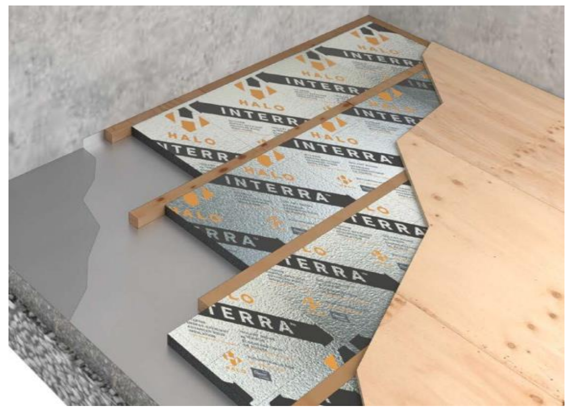


Figure 11. Insulation of Concrete Floor (Image from https://buildwithhalo.com/)

Please note that many modern insulating materials, such as certain foam-based insulations, as well as air cavities that improve the sustainability and energy efficiency of buildings also spread fire more easily compared to traditional materials such as concrete and wood. The *project team* is encouraged to take proper fire safety precautions in the selection of these materials and the associated design details such as fire stops.

Approach/Methodologies

This measure uses U-value, which is defined as the quantity of heat that flows through a unit area in unit time, per unit difference in temperature; it is expressed in Watts per square meter Kelvin (W/m²K). U-value is an indication of how much thermal energy (heat) is transmitted through a material (thermal transmittance). The U-value, which is the performance indicator of this measure, is the reciprocal of the total thermal resistance[15] (1/∑R) of the floor, which is calculated from the individual thermal resistance of each component/layer of the floor.

EDGE considers slab-on-ground well insulated floors which include any floor consisting of a slab in contact with the ground over its whole area, whether supported by the ground over its whole area and situated at or near the level of the external ground surface.

To calculate the ground/raised floor slab U-value component, it is first required to calculate the characteristic dimension of floor. The formula is defined as:

$$B = \frac{A}{0.5\ x\ P}$$

Where:

[14] Conduction is the process by which thermal energy moves within an object or between connected objects.

[15] Thermal resistance is a measure of how much heat loss is reduced through the given thickness of a material. Thermal resistance is expressed as the R, which is measured in square meters Kelvin per Watt (m²K/W).

B is the characteristic dimension of floor, in m;

A is area of floor, in m^2;

P is the exposed perimeter, in m.

Then calculate the thermal transmittance for a well-insulated floor according to the formula below:

$$U_{fg;sog} = \frac{1}{\left(R_{si} + R_f + R_{se} + \frac{d_{w;e}}{\lambda_g}\right) + R_{g;eff}}$$

Where:

$U_{fg;sog}$ is the thermal transmittance of the floor slab, including that of any all-over insulation layers above, below or within the floor slab, and that of any floor covering, in W/m2·K;

$d_{w;e}$ is the full thickness of the walls, including all layers, see figure below, in m;

λ_g is the thermal conductivity of the ground, in W/m·K;

R_{si} is the thermal resistance of internal surface, in m2·K/W;

R_{se} is the thermal resistance of external surface, in m2·K/W;

$R_{g;eff}$ is the effective thermal resistance of the ground, in m2·K/W, defined as:

$$R_{g;eff} = \frac{0.457xB}{\lambda_g}$$

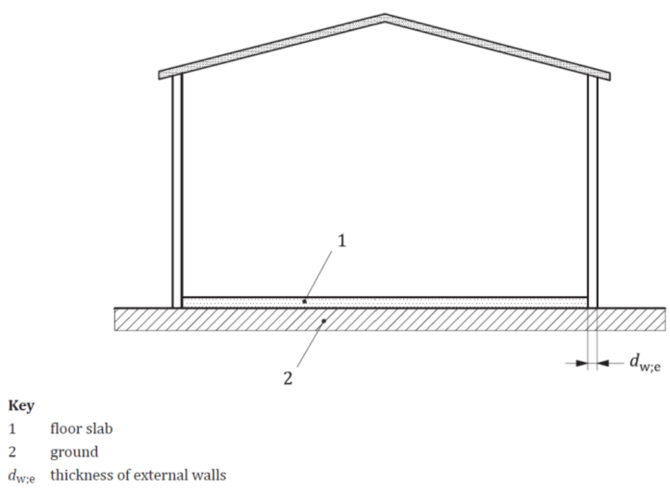


Figure 12: Schematic Diagram of Slab-on-ground Floor.

<u>Edge Insulation</u>

In the tool, there are two types of edge insulation that shall be modeled based on the *building's* applicability: horizontal edge insulation and vertical edge insulation. When using the tool, the user is required to input the U-value of the floor material.

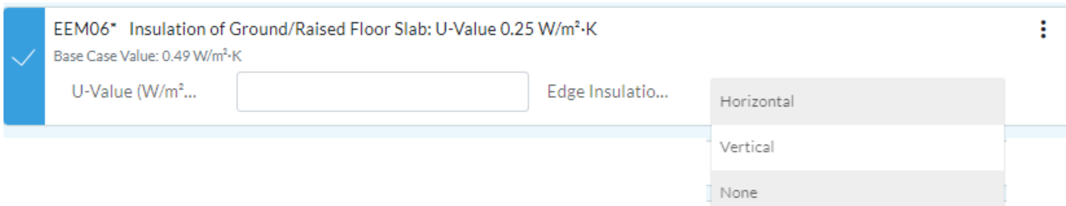
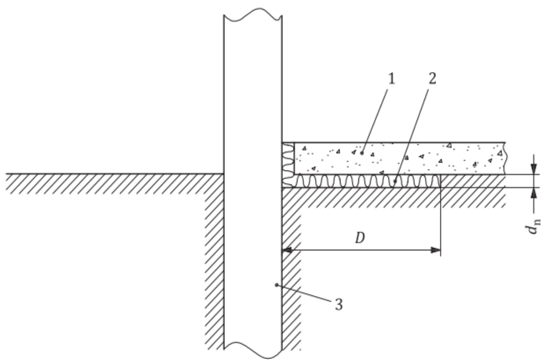


Figure 13. Building edge insulation – Horizontal, Vertical or None

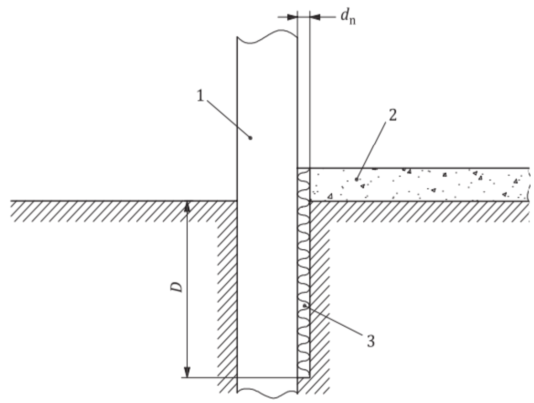
1)Horizontal edge insulation



Key

1 floor slab
2 horizontal edge insulation
3 foundation wall
d_n thickness of the edge insulation (or foundation)
D width of horizontal edge insulation

2) Vertical edge insulation



Key

1 foundation wall
2 floor slab
3 vertical edge insulation
d_n thickness of the edge insulation (or foundation)

The tool then calculates the corrected U-value, considering the specific type of edge insulation chosen (horizontal or vertical). This calculation helps determine the thermal performance and effectiveness of the selected edge insulation method in maintaining energy efficiency and indoor comfort.

Buildings that do not have ground floor insulation added, “none” must be selected.

Customized Material

In cases where the floor material is not listed among the available options, users have the choice to select the customized material option. In such instances, it becomes mandatory for the user to manually enter the U-value of the custom material into the designated user entry field. Laboratory certificate containing the Thermal Conductivity of the customized material must be provided, alternatively, standards for similar materials may be referenced and provided as part of the documentation.

Documentation Relief for Existing buildings

For existing buildings with insufficient records on the building floor slab section, the *project team* may follow these steps:

1. Identify the predominant material of the floor slab. If multiple layers are present, the *project team* may choose to identify each layer.
2. Measure the floor slab thickness. If thickness cannot be measured, the *project team* must use the base case thickness from measure MEM01.
3. Enter the material and thicknesses into the EEM06 calculator to determine the existing U-value of the floor slab.

Note: *The EDGE App accepts U-values within the range of 0.01 to 8. If floor slab U-value falls outside the range (i.e., U > 8W/m2K,) a value of 8 W/m2K may be entered.*

Potential Technologies/Strategies

Insulating the floor reduces the energy used for heating a building in a cold or temperate climate. There is a strong case for maximizing the insulation before designing the heating, ventilation, and air conditioning equipment.

Different types of insulation are available. Insulation types can be grouped into four main categories, see Table 6 in the above section. The appropriate type of insulation for a floor will depend on whether it is on grade or underground, for which waterproof insulation boards are best practice.

The range of thermal conductivity may be used by auditors and reviewers to check for reasonableness of the project team's claims about insulation properties. As a last resource, the table may also be used as a substitute in the rare case when manufacturer data is not available.

Relationship to Other Measures

Selecting this measure will show an increase in the environmental impact in the materials section due to the addition of insulation material (reflected as a negative percent improvement).

However, by increasing the level of insulation the heating and/or cooling loads will be reduced. Increasing the levels of insulation could therefore reduce the cost and environmental impact of the heating and cooling plant, leading to energy savings that compensate for the negative impacts in the materials section while providing thermal comfort.

Compliance Guidance

Preliminary Stage Certification

- Building plans highlighting the area of major on-grade floor slab types if more than one type is present; and
- Detailed drawing(s) showing the layers of on-grade floor slabs materials and any U-value specifications; and
- Calculation of overall on-grade floor slabs U-value using either the calculator provided in the EDGE measure or external calculations; and
- Manufacturer's data sheets for the specified building materials; or
- Bill of quantities with the specifications for any floor insulation materials clearly highlighted.
- Laboratory certificate containing the Thermal Conductivity of the customized material should be provided as applicable.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the floor(s) taken during construction at a point when any insulation materials claimed were visible on site; or Purchase receipts showing the installed products.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence of main construction materials and thicknesses, such as existing building drawings and photographs, where relevant, shall be submitted.

EEM07 – Green Roof

Requirement Summary

To meet the requirements of this measure, the *building* must have a roof that is specifically covered with a layer of growing media and vegetation. It is important to note that the use of artificial turf does not fulfill the criteria for this measure.

Intention

The presence of soil and vegetation on a roof provides insulation and shade, effectively reducing heat transfer through the roof. Additionally, transpiration from the vegetation contributes to a cooling effect. Green roofs also offer the added benefit of improving stormwater retention, thereby reducing surface water runoff.

Approach/Methodologies

When evaluating a green roof, the following factors are considered in EDGE

- **Growing Media Depth** – This is the thickness of the soil or other growing media.
- **% Green Roof Area** – Percentage of the roof covered by the green roof.

Note: *EDGE assumes a leaf area index of 5[16]. The value cannot be edited.*

Based on the above, the tool calculates the U-value for green roof, which is then used as the overall roof U-value of the building. The tool will automatically calculate the weighted average U-value for the roof considering EEM05 and EEM07 inputs.

Calculation Example:

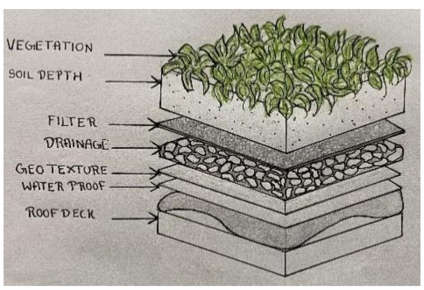


Figure 14. Green Roof

$$U\ Value\ of\ Roof = \frac{1}{Green\ Roof\ Thermal\ Conductivity + Roof\ Thermal\ Conductivity}$$

Potential Technologies/Strategies

There are three main types of green roofs[17]:

1. **Extensive Green roofs** – Green roofs with 8-15 cm of lightweight growing medium and low-maintenance ground-cover plants. These are ideal for large flat commercial rooftops and apartments.

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[16] For more information about this concept direct to https://www.sciencedirect.com/topics/engineering/leaf-area-index

Leaf Area Index - an overview | ScienceDirect Topics

[17] Image credit: © British Columbia Institute of Technology, https://commons.bcit.ca/greenroof/faq/what-are-the-different-types-of-green-roofs/

2. **Intensive Green Roofs** – Also known as rooftop gardens, these are fully landscaped with 20-30 cm or more of growing medium and require regular maintenance. Plants with invasive root systems should be avoided.
3. **Semi-intensive Green Roofs** – These are a combination of extensive and intensive green roofs and typically adopted to reap the environmental benefits of a green roof within a reasonable budget.

Relationship to Other Measures

This measure has direct relation with the calculation of the U-value in EEM05 – Insulation of Roofs.

Compliance Guidance

Preliminary Stage Certification

- Building plans highlighting the area of green roof; and
- Section drawing(s) showing the layers of roof materials

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the green roof after installation; and
- Contractor invoice for As Built details of the installed roof.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence of construction details, such as existing building drawings, calculations and photographs, where relevant, shall be submitted.

EEM08 – Insulation of Exterior Walls

Requirement Summary

This measure refers to the U-value or thermal conductivity of materials as the indicator of performance, in which the use of insulation improves the U-value of the exterior walls. The U-value must be entered following the guidelines in the Approach/Methodologies section. Note that the corresponding insulation measure must also be selected in the Materials tab, and the actual insulation type and thickness entered.

For multiple exterior wall types with different U-values, the detailed entry calculator in the app may be used.

Intention

Insulation is used to prevent heat transmission from the external environment to the internal space (for warm climates) and from the internal space to the external environment (for cold climates). Insulation aids in the reduction of heat transmission by conduction[18], so more insulation implies a lower U-value and better performance. A well-insulated building has lower cooling and/or heating energy requirements.

Please note that many modern insulating materials, such as certain foam-based insulations, as well as air cavities that improve the sustainability and energy efficiency of buildings also spread fire more easily than traditional materials such as concrete and wood. The *project team* is encouraged to take proper fire safety precautions in the selection of these materials and the associated design details such as fire stops.

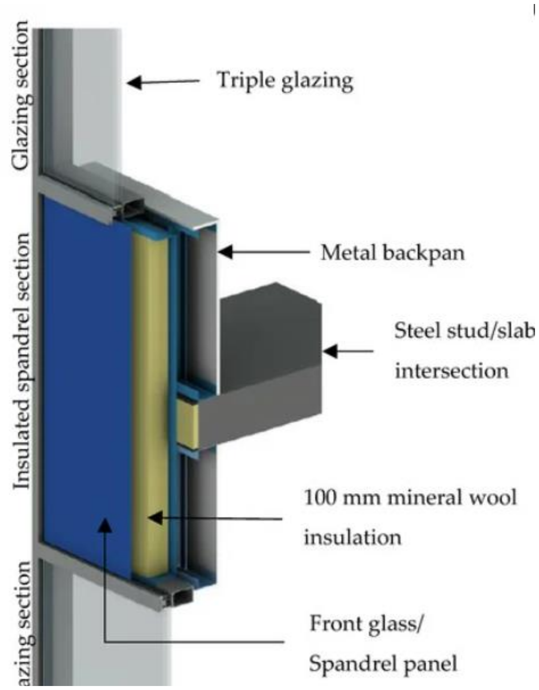

Figure 15. Insulation of Wall section of a Curtain Wall. Image credit: MDPI, Journal Article, In situ Experimental Investigation of Slim Curtain Wall Spandrel Integrated with Vacuum Insulation Panel, by Fred Edmond Boafo.

Approach/Methodologies

This measure uses U-value, which is defined as the quantity of heat that flows through unit area in unit time, per unit difference in temperature; it is expressed in Watts per square meter Kelvin (W/m²K). U-value is an indication of how much thermal energy (heat) is transmitted through a material (thermal transmittance). The U-value, which is the performance indicator of this measure, is the reciprocal of the total thermal resistance[19] (1/∑R) of the external walls, which is calculated from the individual thermal resistance of each component/layer of each external wall.

<u>Simplified method of calculating the external wall U-value</u>

See *Approach/Methodologies* in the *EEM05 – Insulation of Roof*.

<u>External walls U-value calculator</u>

EDGE provides a built-in calculator for calculating the U-value of a roof with multiple layers of materials layered on top of each other.

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[18] Conduction is the process by which thermal energy moves within an object or between connected objects.

[19] Thermal resistance is a measure of how much heat loss is reduced through a given thickness of a material. Thermal resistance is expressed as the R, which is measured in square meters Kelvin per Watt (m²K/W).

When submitting for certification *project teams* must either use the insulation of Exterior Walls Calculator (Figure 16), validated calculation software/spreadsheets or energy modelling software. The former two methods are recommended for non-conventional assemblies (e.g. when materials are not in continuous layers or there are metal penetrations that punctuate the roof)

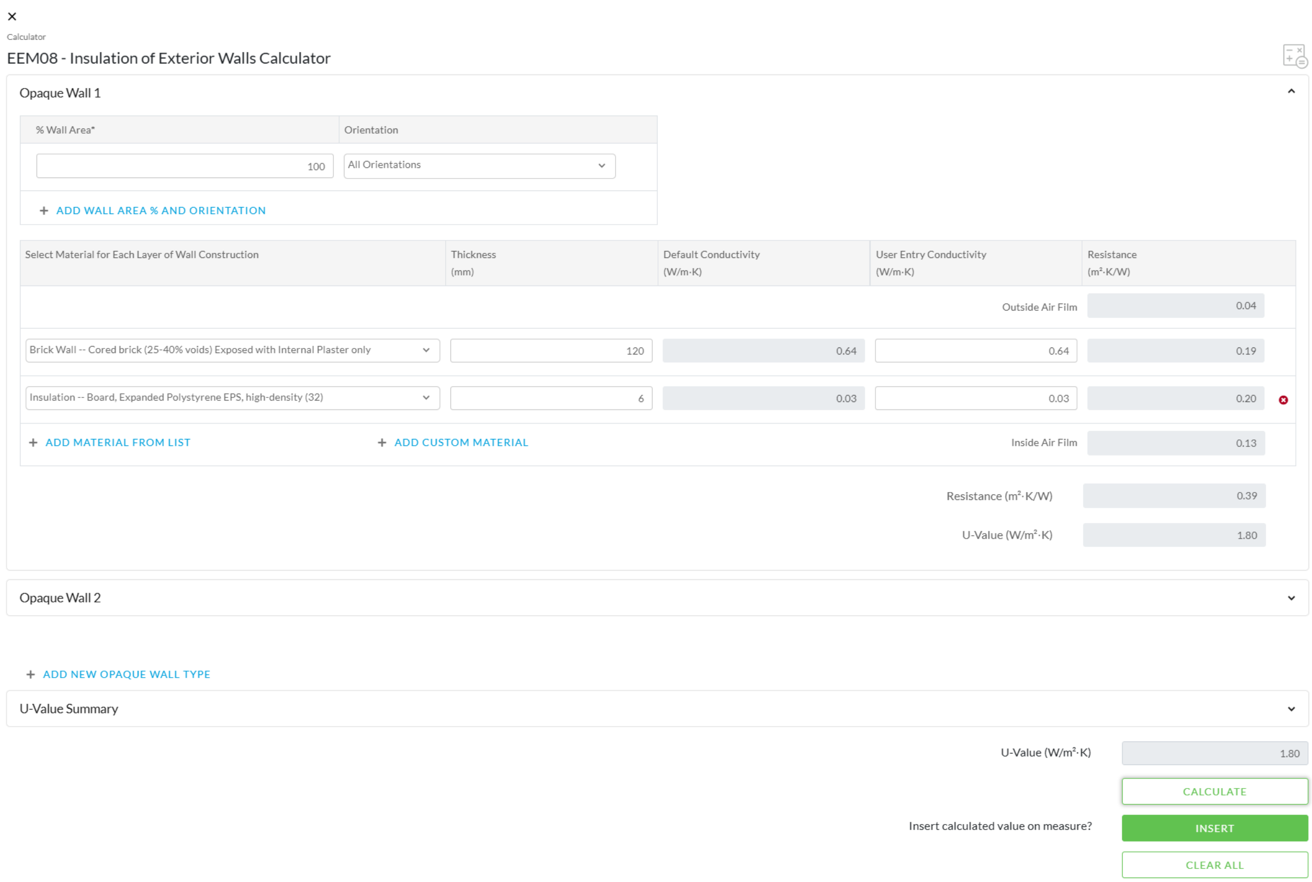


Figure 16: Insulation of Exterior Walls Calculator.

Detailed Calculator Description:

- **Number of Opaque Wall Types:** The calculator allows the user to model up to five different types of opaque walls. Opaque walls are walls that do not have transparent elements like windows or glass panels.
- **Specified U-Value and Orientation:** For each of the five opaque wall types, the user can input the layer-by-layer materials used and the tool calculates the U-value. Additionally, the calculator considers the orientation of the wall (e.g., north-facing, south-facing, etc.).
- **Wall Area Portion:** The user can also specify the portion of the total wall area for each of the 5 opaque wall types. This allows the calculator to account for variations in wall compositions within the building envelope.
- **Default Improved Case U-Value:** If the calculator does not have a specific U-value mentioned for a particular orientation, it will consider a default improved case U-value.
- User-Selected Material U-Value: If the user specifies a U-value for a particular orientation and wall type, the calculator will use the user-selected U-value for that portion of the wall area and for remaining wall area it uses the default improved case U-value.

By entering these parameters, the calculator can assess the overall energy performance of the building walls. The tool will consider the different U-values and wall areas for various orientations, helping users make informed decisions about the building's insulation and energy efficiency.

Note 1: *The EDGE App accepts U-values within the range of 0.01 to 8. If the wall assembly U-value falls outside the range (i.e., U > 8W/m2K,) a value of 8 W/m2K may be entered.*

Note 2*: If more than five wall types are present in the building, project teams may focus on modelling the 90% of the walls, by area. If this method is not enough, project teams may combine similar walls into one by providing a technical justification as part of the documentation submitted.*

Regarding the data input of this measure, EDGE users must consider the following:

- If this measure is not selected the assigned wall U-value will depend on the selection of the Exterior Wall Material.
- Changing the wall material will change the heat transfer through the wall which will impact the building's energy use.
- If a customized material is selected in the Embodied Carbon section for wall materials, it is crucial to ensure that the corresponding U-value of that customized material is mandatorily entered in the user field of EEM08.
- Failing to provide the correct U-value can lead to inaccurate calculations of the building's energy performance.
- Customized Materials may be used when the *building* material is not part of the list of materials. Laboratory certificate containing the Thermal Conductivity should be provided, alternatively, a standard indicating the thermal conductivity for that specific material may be referenced.
- "Air Gap" in the list of material is an insulating air gap and cannot be selected for gaps larger than 100mm. For gaps >100mm, this must not be entered into EDGE.
- Spandrels glass may be modeled as "Curtain Wall | Aluminum Frame and Opaque panels".

Documentation relief for existing buildings

For existing buildings with insufficient records on the building wall section, the *project team* may follow these steps:

1. Identify the predominant material of the wall. If multiple layers are present, the *project team* may choose to identify each layer.
2. Measure the wall thickness. If thickness cannot be measured, the *project team* must use the base case thickness from measure MEM05.
3. Enter the material and thicknesses into the EEM08 calculator to determine the existing U value of the wall.

Potential Technologies/Strategies

Insulating the external walls is potentially the most cost-effective way to reduce the energy used for heating a building. Therefore, in **cold or temperate climates** a strong case may be made for maximizing the insulation before designing the heating ventilation and air conditioning equipment. In **hot climates** insulating the wall can reduce heat gain, but the effect is relatively minor.

Different types of insulation are available, and the appropriate type will depend on the application as well as cost and availability. Insulation types can be grouped into four main categories, see Table 6 in the above section. Auditors and reviewers may use the ranges of thermal conductivity to check for reasonableness of the *project team's* claims about insulation properties. The range may also be applied as a substitute in the rare case when manufacturer data is not available.

Project teams may use Table 7 as guidance to determine the thickness of insulation required to achieve a U-value of 0.45 W/m² K, a value considered relatively acceptable in most thermal zones.

Table 7: Thickness of insulation required to achieve a U-value of 0.45 W/m² K

Insulation Type	Thickness (mm) Approximate values to achieve a U-value of 0.45W/m² K	Thermal Conductivity (W/m K)
Vacuum Insulated Panels	10 - 20mm	0.008
Polyurethane (PU)	40 - 80mm	0.020 - 0.038
Polyisocyanurate (PIR)	40 - 60mm	0.022 - 0.028
Phenolic Foam (PF)	40 - 55mm	0.020 - 0.025
Expanded Polystyrene (EPS)	60 - 95mm	0.030 - 0.045
Extruded Polystyrene (XPS)	50 - 80mm	0.025 - 0.037
Wool and Fiber	60 - 130mm	0.030 - 0.061

Relationship to Other Measures

Selecting this measure will show an increase in the environmental impact in the materials section due to the addition of insulation material (reflected as a negative percentage impact).

The level of insulation will have a direct impact in the heating and/or cooling energy.

Compliance Guidance

Preliminary Stage Certification

- Building plans highlighting the area of major exterior wall types if more than one type of wall is present; and
- Detailed drawing(s) showing the layers of exterior wall materials and any U-value specifications; and
- Calculation of overall exterior wall U-value using either the calculator provided in the EDGE measure or external calculations; and
- Manufacturer's data sheets for the specified building materials showing the brand and product name and insulating properties of any insulation; or
- Bill of quantities with the specifications for any exterior wall insulation materials clearly highlighted.
- Laboratory certificates containing the Thermal Conductivity of the customized materials should be provided.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the exterior wall(s) taken during construction at a point when any insulation materials claimed were visible on site; or
- Purchase receipts showing the installed products.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence of construction materials and thicknesses, such as existing building drawings, on site measurements, and photographs, where relevant, shall be submitted.

EEM09 – Efficiency of Glass

Requirement Summary

This measure must be selected in all *subprojects*, even when the U-value of the actual glass in the building is worse (higher) than the base case value. The same principle is applicable to the Solar Heat Gain Coefficient (SHGC), i.e., if the SHGC is different from the base case assumption, whether better or worse, the actual SHGC must be entered.

Transparent polycarbonate sheets for vertical walls are included in this measure.

Intention

The benefits of glazing with lower U-values, are similar to the ones described in EEM05 – Insulation of Roofs.

For glazing, the addition of a Low-E coating to glazing reduces the heat transfer from one side to the other by reflecting thermal energy. Low-E coatings are microscopically thin metal or metallic oxide layers that are deposited on a glass surface to help keep heat on the same side of the glass from which it originated. In **warm climates** the intention is to reduce heat gain, and in **cold climates** the intention is to reflect interior warmth back indoors.

By selecting double or triple glazing, which has an improved thermal performance as well as a coating (tinted glass or Low-E) the heat transfer is reduced further than with low-E coating alone, and an even lower SHGC may be achieved.

Approach/Methodologies

Double or triple glazing or Low-E coating reduces the Solar Heat Gain Coefficient (SHGC) and thermal conductivity (U-Value) of the glazing. A third value is Visible Transmittance (VT) which can be impacted by the coatings.

EDGE considers the center of the glass U-value (i.e. without considering the window frame), and the user must enter only the U-value of the glass. The U-value of the frames will be considered based on the window frame material selected in measure MEM07.

If documentation is not available, plastic panels (structured sheets) and polycarbonate must use a use U-value of 4.1 W/m^2 K, SHGC of 0.46 and a VT of 0.27.

Note: *The EDGE App accepts U-values within the range of 0.01 to 8. If the window assembly U-value falls outside the range (i.e., U > 8W/m^{2}K,) a value of 8 W/m^{2}K may be entered.*

In cases where multiple glass types are used, a weighted average must be applied, which can be calculated using the built-in calculator in EDGE app, Figure 17.

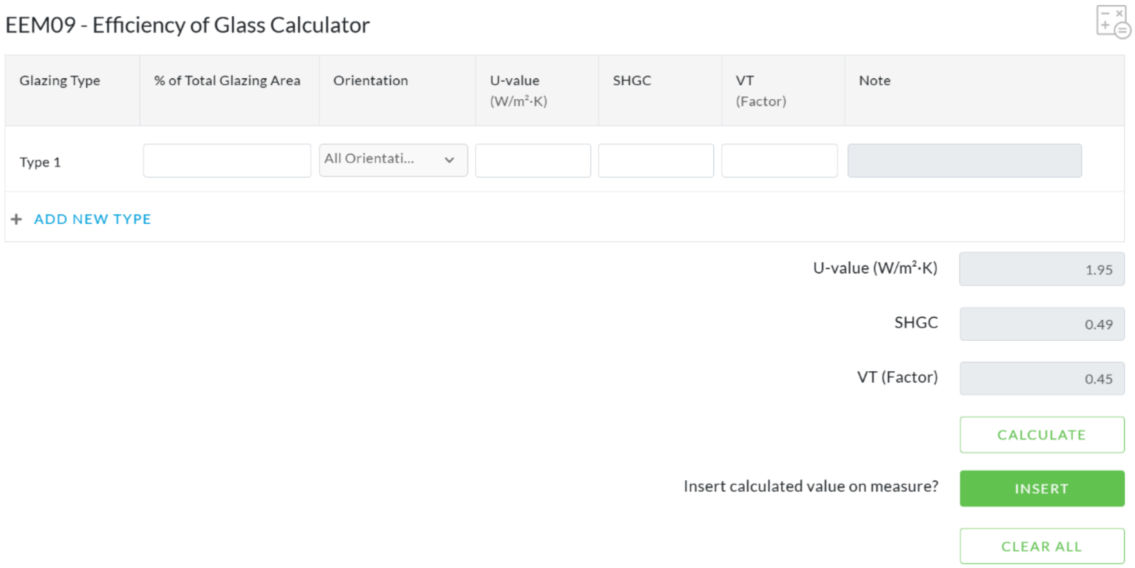


Figure 17: EEM09 - Efficiency of Glass Calculator.

Detailed calculator description:

The EDGE app allows users to model nine different types of glass U-values, SHGC and VT. Each type of glass has a specific thermal transmittance (U-value), which represents how effective it is as an insulator. These U-values might vary depending on factors like the glass thickness, coatings, and other properties.

- **Portion of Glass Area with Assigned U-Value:** The user can also specify what portion of the total glass area for each orientation should have the assigned U-value. This feature is valuable when different areas of the building require different levels of thermal performance based on their orientation and environmental factors.
- **Orientation-Specific Glass Selection:** For each orientation (e.g., north-facing, south-facing, etc.), the user can assign a specific type of glass with its corresponding U-value. This allows the app to account for variations in thermal performance based on the building's orientation and exposure to sunlight.
- **U-Value:** Also knows as thermal transmittance, is thermal transmittance (U-value) of glass is defined as the rate of heat transfer through a glazing system per unit area and per unit temperature difference between the indoor and outdoor environments.
- **SHGC:** Is defined as the ratio of the total solar energy transmittance (g-value) of the glazing to the incident solar radiation, representing the fraction of solar energy that passes through the glass and contributes to the heat gain inside a building. To convert Solar Coefficient (SC) to SHGC, a factor of 0.87 may be used.
- **Visible transmittance (VT):** Also known as Visible light transmission (VLT) indicates the fraction of incident visible light that passes through the glass. The higher the number, the greater the amount of light that is passing through the glass. It can be expressed as 0 to 1 or as a percentage. A glass type with VT 0.5 lets in 50% of the visible light. A glass type with VT 0.75 lets in 75% of the visible light. Coatings reduce the VT of high-performance glass as compared to clear glass. Therefore, VT is a useful metric to compare two glass types that may have similar U-values and SHGC. Higher VT is desirable in most areas where daylighting is desired.

  Note: *VT does not have an impact on energy use, only when EEM 24 is selected for daylighting.*

Potential Technologies/Strategies

Low-E coating is applied to different sides of the glazing depending on the climate. In single-pane windows, the coating may be applied inside or outside depending on the coating. For double pane windows, the coating is usually applied on the outer surface of the inner pane in **cold climates** to allow useful solar radiation to pass through to passively heat the interior, and to reduce the ability for infrared radiation to reflect out. In **warm climates**, the coating is usually applied on the inner surface of the outer pane, as this helps to reflect the solar radiation back outside before it enters the air cavity.

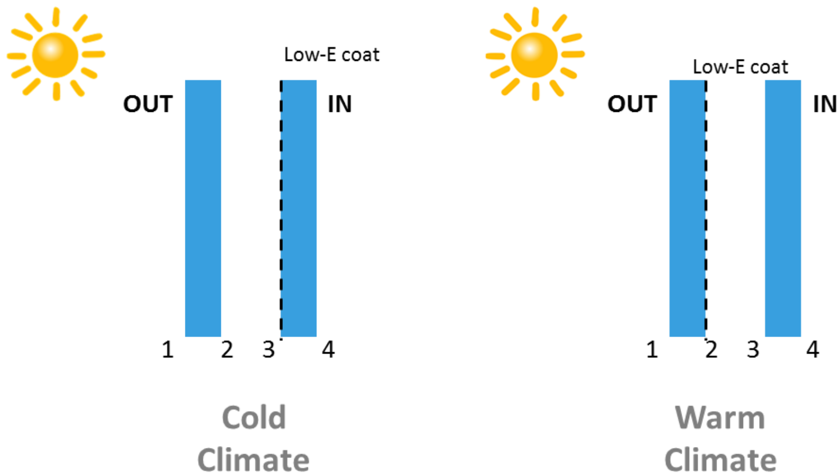


Figure 18. Recommended position of the low-e coating for double-pane glass

Two types of Low-E coating are available: hard coat and soft coat. Only hard coat (pyrolytic coating) should be used in single-glazed units as it is more durable than soft coat (sputter coating).

Care must be taken in **cold climates**, because as the U-Value is reduced, the SHGC is reduced even further for many glass types. Low SHGC reduces heat gain from the sun and increases heating requirements during the sunlit hours. In those cases, a window with a double or triple layer glass resulting in low U-value but with a higher solar heat gain coefficient (SHGC) may be the right selection.

Relationship to Other Measures

EDGE considers the U-value of the geometrical center of the glass, i.e. the user must enter only the U-value of the glass. The EDGE App then calculates the overall U-value of the glass by considering the window frames materials selected in measure MEM07.

Project teams must maintain consistency with the external glazing area (including frames and mullions) reported in EEM01 - Window-to-Wall Ratio (WWR) Calculator.

Compliance Guidance

Preliminary Stage Certification

- Manufacturer's data sheets showing the U-value for the glass, the solar heat gain coefficient (SHGC) of the glass and VT; and
- A list of different types of windows included in the design (window schedule).

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and

- Date-stamped photographs of the glazing units installed; or
- Purchase receipts showing the brand and product installed.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If the documents required above are not available, other evidence of construction details, such as existing building drawings and photographs, where relevant, shall be submitted.

EEM10 – Air Infiltration of Envelope

Requirement Summary

This measure may be claimed if the air infiltration of the building envelope is reduced below the baseline. This reduction may be demonstrated either through the results of a blower door test or through improved construction details.

Intention

By reducing air infiltration, the load on the air conditioning system may be reduced significantly.

Approach/Methodologies

Air infiltration in a building can be represented in an energy model by air changes per hour (ACH) of the entire air volume in a building. It can be represented by average leakage through the envelope measured in volume per unit time per unit surface area.

EDGE uses ASHRAE 90.1-2016 building envelope infiltration method section C3.5.5.3 Air Leakage.

The EDGE App calculates the air leakage rate of the building envelope (I75Pa) at a pressure differential of 75 Pa as a function of floor area.

Total area of the building envelope (m^2), including the lowest floor, any below-grade walls or above-grade walls, and roof (including vertical fenestration and skylights) is considered as envelope area.

Air leakage rate of the building envelope is expressed as L/s·m^2 at a fixed building pressure differential of 75 Pa.

Passive House Standard for air tightness of the building and Blower door test results can be submitted to claim the measure.

This measure includes a detailed calculator where the user may select different strategies to reduce the air leakage in walls, joints, and entrances. The following formulas are used to convert the data to L/s-m^2:

To convert from Air Changes per Hour (ACH) to L/s-m^2:

$$Air\ infiltration\ \left(\frac{L}{s\ \ m^2}\right) = \frac{Floor - to - floor\ height\ (m)\ x\ ACH}{3.6}$$

To convert from m^3/hr to L/s-m^2:

$$Air\ infiltration\ \left(\frac{L}{s\ \ m^2}\right) = \frac{Air\ infiltration\ (\frac{m^3}{hr})}{3.6\ x\ Floor\ area\ (m^2)}$$

Where:

$Floor\ area\ (m^2)$ is the floor area is the area where the air infiltration test is being conducted.

Potential Technologies/Strategies

Bulk air leakage can occur through poor joints and gaps and when windows and doors are opened. In addition, the entire surfaces of walls and roofs can allow air exchange at a slow and steady rate because most building materials are pervious to air and moisture molecules. Air molecules are smaller than water molecules, so materials that resist moisture (vapor barriers) may still allow air exchange. Effective air barriers require higher levels of impermeability (lower ‘perm’ rating – a measure of permeability) compared to vapor barriers.

Strategies to reduce air leakage include:

- Continuous air barrier on all exterior opaque surfaces (walls, roof, floor if raised). This can be an airtight wrap made of special paper with very low permeability to air, or a rubberized paint with similar properties. Insulation boards with special coatings that serve the same purpose are also available and reduce construction time in buildings that are installing exterior insulation anyway.
- Sealed window and door frames and joinery details. The gap between a window or door frame and the wall can be a source of bulk leakage.
- Sealed envelope penetrations (pipes, ducts, cables)
- Sealed and taped envelope junctions (wall corners, wall, and roof joints)
- Self-closing external doors
- Entrance vestibule to limit the air exchange when opening doors
- Air curtains on external doors which mechanically push air down creating a barrier between the inside and the outside air to limit the air exchange when opening doors
- Door sweeps that cover any gap between the door and the floor

Other air sealing trouble spots applicable for this measure are described in Figure 19.

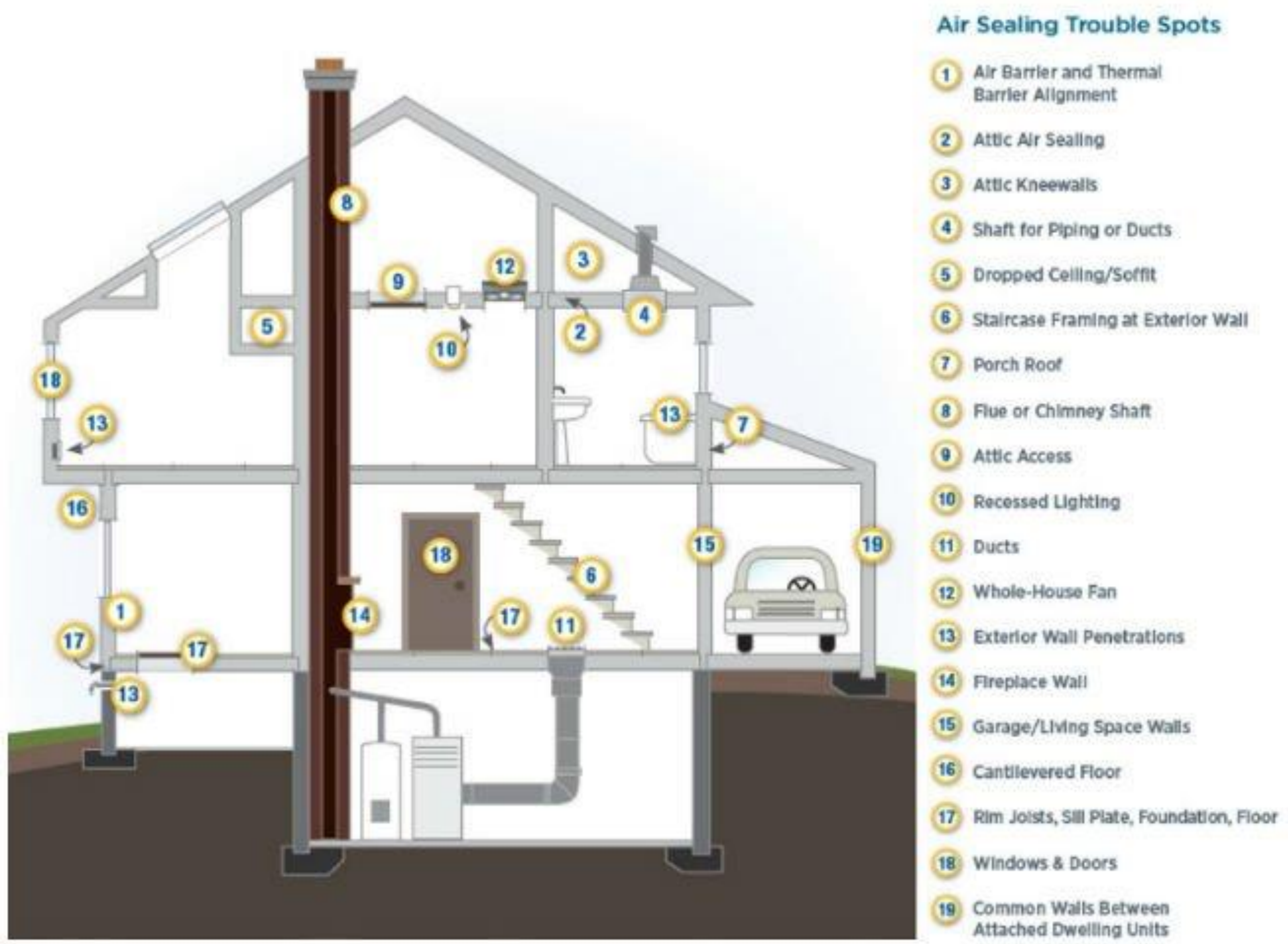


Figure 19. Example of Air sealing common trouble Spots. Source: https://www.energy.gov/energysaver/air-sealing-your-home

Relationship to Other Measures

A reduction in air leakage will reduce cooling and heating energy use which may impact the effectiveness of EEM13 – Cooling System Efficiency and EEM16 – Space Heating System Efficiency.

Compliance Guidance

Preliminary Stage Certification

- Drawings and/or specifications for airtightness to be confirmed during construction using a blower door test; or
- For each item below that is present in the building, show schematics/detailed drawings and manufacturer's data sheets showing air flow ratings for all materials intended for use to achieve the airtightness:
  - **a.** Continuous air barrier on all exterior opaque surfaces (walls, roof, floor if raised) with airtightness ratings
  - **b.** Sealed window and door frames and joinery details
  - **c.** Sealed envelope penetrations (pipes, ducts, cables)
  - **d.** Sealed and taped envelope junctions (wall corners, wall and roof joints)
  - **e.** Self-closing external doors
  - **f.** Entrance vestibule
  - **g.** Air Curtains on external doors
  - **h.** Door Sweeps

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Provide whole building blower door test reports by accredited testing agencies showing air leakage rates in as-built conditions; or
- For each item below that is present in the building, provide date-stamped photographs taken during construction showing the make and model matching the specifications or data sheets as applicable:
  - **a.** Continuous air barrier on all exterior opaque surfaces
  - **b.** Sealed window and door frames and joinery details
  - **c.** Sealed envelope penetrations (pipes, ducts, cables)
  - **d.** Sealed and taped envelope junctions (wall corners, wall and roof joints)
  - **e.** Self-closing external doors
  - **f.** Entrance vestibule
  - **g.** Air Curtains on external doors
  - **h.** Door Sweeps

  or
- Purchase receipts for each applicable item showing the make and model matching the specifications or data sheets as applicable.

Existing Building Documentation

- Provide whole building blower door test reports by accredited testing agencies showing air leakage rate.

EEM11 – Natural Ventilation

Requirement Summary

This measure may be claimed if the space has cooling energy requirements (including virtual cooling energy), and natural ventilation strategies are used in that space. For all enclosed space connected to an HVAC system, there must be an auto-shut off HVAC control that switches the HVAC system off while the room is being naturally ventilated, except for residential buildings.

Permanent openings do not count as natural ventilation.

The table below shows the spaces that must be naturally ventilated for each building type to claim the natural ventilation measure. Each row in the table represents a separate measure in the calculator of this measure.

Table 8:Natural ventilation by building type & space type.

Building Type	Natural ventilation spaces in EDGE
Homes	Bedrooms, Living Room, Kitchen
Serviced Apartments, Hotels & Resorts	Corridors
	Guest Rooms
Retail	Corridors, Atrium, and Common Areas
Industrial	Office Space, Receiving Area, Shipping Area, Production Area, Inventory Area, Kitchen & Food Prep, Kitchenette, Packaging, Receiving & Shipping
Offices	Offices, Corridors and Lobby
Hospitals	Corridors
	Lobby, Waiting, and Consultation Areas
	Patient Rooms
Education	Corridors
	Classrooms

Note 1: *Auto-shut off is mandatory in all building types except residential typologies.*

Note 2: *Industrial buildings may claim natural ventilation operable louvres and active systems that can regulate incoming air.*

Intention

A well-designed natural ventilation strategy can improve occupant comfort by providing access to fresh air as well as reducing cooling energy requirements, resulting in lower capital and maintenance costs.

Approach/Methodologies

EDGE natural ventilation calculations based on the CIBSE Applications Manual AM10 for the natural ventilation calculation methodology. The detailed calculation methodology is beyond the scope of this document but part of the ***Methodology document series***.

A detailed entry is available in the calculator for a *project team* to select the ventilation type for each functional area. The *project team* may identify if the space type is naturally ventilated and enter the percentage opening of the façade of each space type (Area of Opening/ Gross Wall Exterior Area). *Project teams* should also identify if the space is a single sided ventilation or crossflow ventilation, considering the following descriptions:

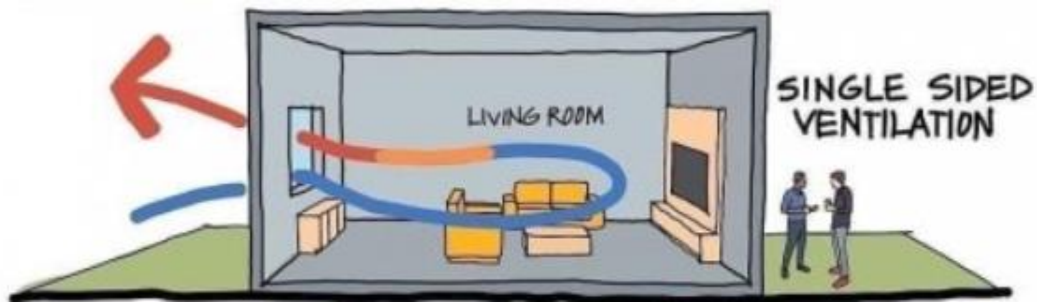


Figure 20. Single Sided Ventilation. Image credit: U.S. Department of Energy (https://www.energy.gov/energysaver/natural-ventilation)

- **Single sided Ventilation**: Ventilation airflow in this case is driven by room-scale buoyancy effects, small differences in envelope wind pressures, and/or turbulence. Consequently, driving forces for single-sided ventilation tend to be relatively small and highly variable. Compared to the other alternatives, single-sided ventilation offers the least attractive natural ventilation solution but, nevertheless, a solution that can serve individual spaces.

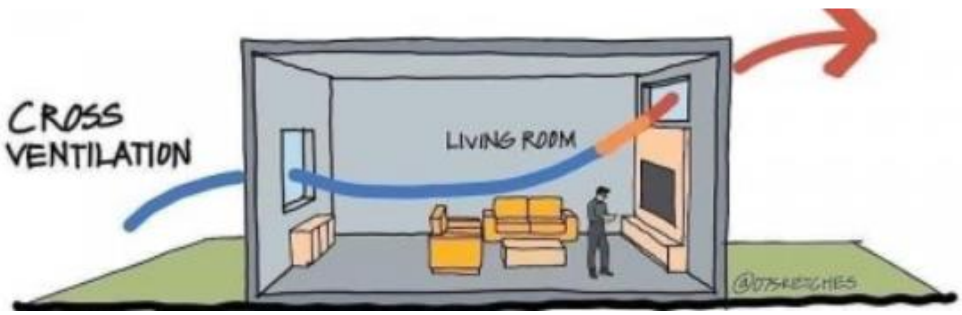


Figure 21. Cross Flow Ventilation. *Image credit: U.S. Department of Energy (https://www.energy.gov/energysaver/natural-ventilation)*

- **Crossflow ventilation**: The crossflow ventilation system typically requires two or more openings, such as windows or vents, positioned on opposite sides of the building. The openings allow air to enter from one side and exit from the other, creating a continuous flow of fresh air. Multiple rooms connected to each other through dedicated ventilation grills and with external openings in opposite sides may count towards this measure. If one or more opening(s) does not have direct access to outdoors, the adjacent space to the opening(s) should have a permanent opening of at least the same size of the sum of the openings connected to the space.

The EDGE base case assumes that ventilation is delivered using mechanical means, while the improved case may assume that natural ventilation provides cooling during the hours when the temperature outside is suitable.

Note: *Natural ventilation savings does not apply to areas that do not require conditioning. (i.e., "No Conditioning Required" selected in the Detailed Loads Input).*

For buildings with cooling system, the savings will be reflected in the main Energy consumption graph (in kWh/m^2/yr) for Cooling energy and any associated energy uses.

<u>Alternative Compliance Pathway</u>

To estimate cooling energy savings from natural ventilation strategies using external tools, follow these steps:

1. **Create Two Models:**
   - **Base Model:** A building model with permanently closed windows/skylights.
   - **Improved Model:** A building model with openable windows/skylights.

2. **Perform Full-Year Simulations:**
    - Run a full-year energy simulation for each model.
    - Report the annual total cooling energy consumption in kilowatt-hours (kWh) for both models.
    - Calculate the energy savings by comparing the base model to the improved model.
3. **Demonstrate Occupant Thermal Comfort:**
    - Ensure the simulation shows an 80% acceptance rate for thermal comfort during 90% of the time in regularly occupied spaces, in accordance with the adaptive method in the ASHRAE 55-2023[20] standard.
    - For existing buildings, indoor temperature measurements taken during at least the winter and summer seasons during occupied times, can be used to demonstrate the same 80% acceptance rate during 90% of the time, in accordance with the adaptive method the ASHRAE 55-2023 standard.
4. **Submit Documentation:**
    - Compile the calculations and simulation report, including:
        - Descriptions of the base and improved models.
        - Annual total cooling energy consumption for both models.
        - Energy savings comparison.
        - Evidence of compliance with ASHRAE 55 (either through simulation results or on-site measurements).
    - Submit the report to the International Finance Corporation (IFC) at edge@ifc.org prior to submitting for certification.

The requirements for auto shut offs linked to openings, except for residential *buildings*, still apply. Failure to demonstrate thermal comfort will result in the rejection of the EEM1- Natural ventilation measure.

Potential Technologies/Strategies

Potential technologies and strategies to achieve natural ventilation in commercial and industrial buildings include:

- **Operable Windows:** Manually or automatically controlled windows to allow fresh air in and stale air out.
- **Ventilation Louvres:** Adjustable louvres to control airflow and maintain desired ventilation rates.
- **Atriums and Lightwells:** Central open spaces that facilitate vertical air movement and enhance natural ventilation.
- **Wind Towers:** Structures that capture and direct wind into the building for cooling and ventilation.
- **Stack Ventilation:** Utilizing temperature differences to create a natural airflow from lower to higher parts of the building.
- **Cross Ventilation:** Designing openings on opposite sides of the building to allow air to flow through and ventilate spaces.
- **Solar Chimneys:** Using solar energy to heat air in a chimney, creating an upward airflow that draws fresh air into the building.
- **Night Purge Ventilation:** Using cooler night air to ventilate and cool the building, reducing the need for mechanical cooling during the day.
- **Automated Control Systems:** Sensors and controls to optimize the operation of natural ventilation systems based on environmental conditions.

[20] Project teams may refer to CBE Thermal Comfort Tool for more information. https://comfort.cbe.berkeley.edu/

Please notice that, regardless of the strategy selected, a form of integration between the HVAC system and the natural ventilation system is mandatory to claim this measure in all non-residential *buildings*, e.g. a mechanism for switching off the HVAC system when the natural ventilation active. Strategies related to integrating fresh air as part of the HVAC system, EEM20 - Economizers may be the right measure.

Relationship to Other Measures

Natural ventilation can significantly reduce the cooling (virtual) energy.

Compliance Guidance

Preliminary Stage Certification

- Typical floor plans for every floor showing the layouts of the naturally ventilated spaces and the location of openings
- Calculations within or outside the EDGE App showing that the minimum natural ventilation requirements have been met.
- For alternative compliance path, an approved SRR from IFC is required.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs showing that the plan layouts and location of openings as specified at the design stage have been constructed.
- For alternative compliance path, an approved SRR from IFC is required.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of construction details, such as existing building drawings, calculations and photographs, where relevant, shall be submitted.

EEM12 – Ceiling Fans

Requirement Summary

The incentive for this measure may be obtained if ceiling fans have been installed in all the applicable rooms as per the minimum performance requirements. The EDGE base case assumes the absence of specified ceiling fans. Note that this measure is not applicable in the Retail Typology.

EDGE improved case requires the covered floor area to be covered by ceiling fans. This is not the same as area of ceiling fan. Refer to Table 9 for information about the areas not encompassed by different building types.

Table 9: Spaces excluded with Ceiling Fans, by Building Type.

Building Type	Spaces that don't require ceiling fans installed
Hotels & Resort	Laundry, Kitchen, Corridors, Linen, and Store
Education	Restroom, Corridor, Indoor Carparking, Labs
Healthcare	Corridor, Kitchen, M&E Room, Datacenter, Laundry, ICU, Operating Rooms, Diagnostic Centers, Indoor Carparking, Central Sterile supply department, Storage
Homes& Apartment	Kitchen, Toilet, Utility, Balcony, Enclosed Garage, Staircase
Industrial	M&E Rooms, Indoor Car Parking

For *buildings* where the utilization of ceiling fans varies, the detailed data entry allows users to individually select spaces. Users can input the percentage of area covered by ceiling fans. This entry guides the tool in calculating ceiling fan energy consumption and the resultant reduction in cooling energy.

Intention

Ceiling fans increase air movement, aiding human comfort by promoting the evaporation of perspiration (evaporative cooling).

Approach/Methodologies

The measure may be claimed if ceiling fans have been installed in all the required rooms in line with the guidance above. The assumption is that the efficiency of the ceiling fans installed is 60W/fan. The EDGE base case assumes that no ceiling fans are specified*.

**Exception*: In countries where ceiling fans are required by code or are common practice [21], ceiling fans are assumed to be present in the base case. In these cases, the power consumption of the base case fans is assumed

[21] The methodology documentation will contain the list of these specific regions.

to be 60W/fan. *Buildings* located in these countries can claim the ceiling fan measure by installing efficient ceiling fans, where the improved case ceiling fan has a power consumption of 40W/fan or better.

Potential Technologies/Strategies

Ceiling fans are normally used to reduce cooling energy requirements by creating greater air movement in rooms. The increased air movement results in occupants feeling comfortable at a relatively higher temperature set point. To have this effect, the fan must be installed with the raised edge of the blade on the leading edge. The movement of the fan pulls the air towards the ceiling. In cooling mode, the effect is on perceived comfort.

Relationship to Other Measures

The installation of ceiling fans to reduce cooling requirements improves occupant comfort without actively cooling the air. Ceiling fans are therefore only beneficial in spaces that have a demonstrable cooling load.

Compliance Guidance

Preliminary Stage Certification

- Mechanical and electrical layout drawings showing the location and number of ceiling fans; and
- Manufacturer's data sheets showing the energy consumption and diameter of ceiling fans selected.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the ceiling fan(s) taken during and after installation showing the make and model; or
- Purchase receipts for the ceiling fans showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of construction details, such as existing building drawings, calculations, and photographs, where relevant, shall be submitted.

EEM13 – Cooling System Efficiency

Requirement Summary

If the *building* includes a cooling system, the actual coefficient of performance (COP) of a system must be entered into the calculator (even if the COP is lower than Base Case). Savings may be achieved if the air conditioning system provides a COP greater than the Base Case.

For certification, *project teams* must use the calculator provided and fill in the information regarding installed capacity (kW) and system efficiency (COP, EER or Efficiency %).

Core & Shell *subprojects* may refer to ***Part 1 - EDGE Building Certification Guidance, Annex 2: Core & Shell Measures*** for more information.

Intention

In many cases, a cooling system will not be fitted as part of the original build, which increases the risk that future occupants will deal with any insufficient cooling later by installing air-conditioning units that may be inefficient and are poorly sized and installed. By carefully designing the installation of an efficient cooling system into the *building*, the energy needed to deliver the required cooling can be reduced in the longer term.

Approach/Methodologies

EDGE uses the Coefficient of Performance (COP/EER) to measure the efficiency of air conditioning systems. The COP is the total output of cooling energy per electricity input. The COP for cooling is defined as the ratio of the rate of heating energy removal to the rate of electrical energy input, in consistent units, for a complete air conditioning system or some specific portion of that system under designated operating conditions. The formula to calculate COP is explained below. For consistency the ARI conditions should be used for comparison of COP values.

$$\text{COP} = \frac{Q\ out}{W\ in}$$

Where:

Q_{out} = heating energy removal (kW)

W_{in} = electrical energy input (kW)

The tool calculates the cooling energy considering the default COP based on the selected system or the user entry COP which is entered by the user. For large buildings, more than one system may be installed. If these air conditioning systems have different COPs, the weighted average COP should be calculated. Backup systems that are not regularly used, must not be accounted for.

In some cases, the cooling system could be centralized, serving a combination of buildings/dwellings within the development. The central cooling plant may be within the *project boundary* and controlled by the *project owner;* in which case the technical specifications must be submitted. However, when the plant for the cooling system is out of *project boundary* or not controlled by the EDGE client, then a contract with, or letter from the management company in charge of the plant must be provided, stating the efficiency of the system, as part of the documentation for the post-construction stage.

If air conditioning is not specified, any cooling load will be displayed as "virtual energy."

Calculation Methodology

The ASHRAE 90.1-2016 methodology for the HVAC system design for base case. The base case system is calculated based on the building type, Number of Floors, and Gross Conditioned Floor Area.

EDGE Baseline Cooling System:

Table 10 shows the EDGE base case cooling system per building type and climate zone.

Table 10: Source: ASHRAE 90.1-2016 Table G3.1.1-3 Baseline HVAC System Types.

Building type, Number of Floors, and Gross Conditioned Area	Climate Zones 3B, 3C, and 4 to 8	Climate Zones 0 to 3A
Residential	System 1 -PTAC	System 2-PTHP
Public Assembly<11,000m² **Public Assembly>11,000m²**	System 3 -PSZ-AC System 12-SZ-CV-HW	System4-PSZ-HP System 13- SZ-CV-ER
Retail and 2 floors or fewer	System 3 -PSZ-AC	System4-PSZ-HP
Other Residential and 4 or 5 floors or fewer and < 2300 m² **or** **5 floors or fewer and 2300 m² to 14,000 m²**	System 3 -PSZ-AC	System4-PSZ-HP
Other Residential and 3 floors or fewer and < 2300 m³	System 5-Packaged VAV with reheat	System 6-Packaged VAV with PFP boxes
Other residential and more than 5 floors or>14,000 m²	System 7-VAV with reheat	System 8-VAV with PFP boxes

Baseline System Description:

Table 11. Source: ASHRAE 90.1-2016 Table G3.1.1-4 Baseline System Description.

System No.	*System* Type	Fan *Control*	Cooling Type [a]	Heating Type [a]
1. *PTAC*	*Packaged terminal air conditioner*	Constant volume	Direct expansion	Hot-water *fossil fuel boiler*
2. *PTHP*	*Packaged terminal heat pump*	Constant volume	Direct expansion	Electric heat pump
3. PSZ-AC	Packaged rooftop air conditioner	Constant volume	Direct expansion	*Fossil fuel* furnace
4. PSZ-HP	Packaged rooftop heat pump	Constant volume	Direct expansion	Electric heat pump
5. Packaged *VAV* with *reheat*	Packaged rooftop *VAV* with *reheat*	*VAV*	Direct expansion	Hot-water *fossil fuel boiler*
6. Packaged *VAV* with PFP boxes	Packaged rooftop *VAV* with parallel fan power boxes and *reheat*	*VAV*	Direct expansion	*Electric resistance*
7. *VAV* with *reheat*	*VAV* with *reheat*	*VAV*	Chilled water	Hot-water *fossil fuel boiler*
8. *VAV* with PFP boxes	*VAV* with parallel fan-powered boxes and *reheat*	*VAV*	Chilled water	*Electric resistance*
9. Heating and *ventilation*	Warm air furnace, gas fired	Constant volume	None	*Fossil fuel* furnace
10. Heating and *ventilation*	Warm air furnace, electric	Constant volume	None	*Electric resistance*
11. SZ–*VAV*	Single-zone *VAV*	*VAV*	Chilled water	See note (b).
12. SZ-CV-HW	*Single-zone system*	Constant volume	Chilled water	Hot-water *fossil fuel boiler*
13. SZ-CV-ER	*Single-zone system*	Constant volume	Chilled water	*Electric resistance*

The EDGE App displays the base case system type (Table 11) as well as the Coefficient of Performance (COP) of the baseline system as per methodology in ASHRAE Section G3.1.2 General Baseline HVAC System Requirements. Savings may be achieved if the air conditioning system provides a COP greater than the Base Case.

The EDGE App calculator requires the following information:

I. Improved Case Cooling System Selection
II. Cooling Distribution System
III. Installed Capacity
IV. Cooling System Efficiency
V. Secondary Cooling System details (Optional)

***Project teams* must provide all inputs, including installed capacity and system efficiency, regardless if only one Primary Cooling System is being modeled.**

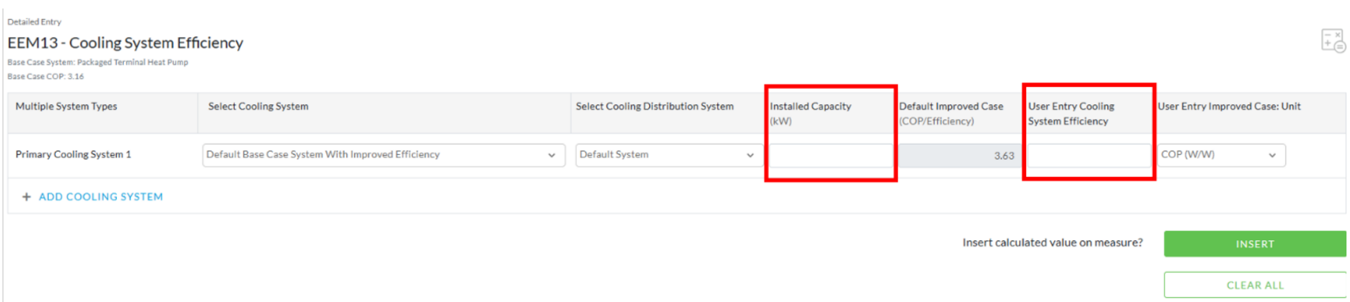


Figure 22: EEM13 – Cooling System Efficiency Calculator. Project teams shall include to the inputs are marked in red.

I. Improved Case Cooling System:

Following describes the different type of cooling system the tool considers for the EDGE Improved case.

A. Default Base Case System with Improved Efficiency

EDGE considers 15% improvement in the system efficiency if the default base case system with improved efficiency is selected.

B. 2-stage Evaporative Cooling System

A 2-stage Evaporative Cooling System employs a two-step process to cool air. In the first stage, outside air is pre-cooled by passing through a moistened medium, reducing its temperature. The second stage involves further cooling by passing the pre-cooled air through another evaporative unit, effectively enhancing cooling efficiency and energy savings. This system is ideal for hot and dry climates and providing eco-friendly cooling solutions.

The user has the option to choose the fuel type (Diesel, LPG, Natural Gas, Generator waste heat and Process waste heat)

C. **Absorption Chiller Double Effect, Indirect Fired**

It employs a two-stage process where a refrigerant, typically water, is heated indirectly using an external heat source. This heat-driven process results in efficient cooling, making it suitable for large-scale applications such as industrial and commercial cooling, and it offers advantages in energy efficiency and environmental sustainability.

Utilizing an Absorption Chiller is advisable in scenarios with a substantial amount of waste heat available. This technology effectively harnesses excess heat for cooling purposes, resulting in efficient energy utilization, and contributing to sustainable practices.

The user has the option to choose the fuel type (Diesel, LPG, Natural Gas, Generator waste heat and Process waste heat)

D. **Water Cooled: Absorption Double Effect, Direct Fired**

A Water-Cooled Absorption Double Effect Chiller, Direct Fired, is an advanced cooling system that operates using the principle of absorption refrigeration. In this setup, it utilizes a double-effect process where the refrigerant, often water, is heated directly through combustion to facilitate efficient cooling. Water is used as the cooling medium to remove heat from the system, making it suitable for large-scale applications in industrial and commercial settings.

The user has the option to choose the fuel type (Diesel, LPG, Natural Gas, Generator waste heat and Process waste heat)

E. **Air Cooled Absorption Chiller, Single Effect**

An Air-Cooled Single Effect Absorption Chiller is a cooling system that utilizes the principle of absorption refrigeration. In this setup, a single-stage process is employed where a refrigerant, usually water, is chilled through the absorption of heat from the surrounding air. This method provides efficient cooling without the need for water consumption, making it a suitable choice for various cooling applications, including air conditioning and industrial processes, while also offering energy-saving benefits.

The user has the option to choose the fuel type (Diesel, LPG, Natural Gas, Generator waste heat and Process waste heat)

F. **Water Cooled Absorption Chiller, Single Effect**

A Water-Cooled Single Effect Absorption Chiller is a sophisticated cooling system that employs the principle of absorption refrigeration. In this configuration, a single-effect process is used, where heat is applied to a refrigerant, often water, causing it to evaporate and absorb heat from the surrounding environment. The resulting vapor is then condensed using a cooling water source, effectively cooling the space.

G. **DX Split System**

DX Split System is a type of air conditioning setup where the cooling process involves a direct expansion (DX) refrigeration cycle.

EDGE can model 2 types of DX system Air cooled and Water-Cooled DX Split system. These systems are suitable for small scale applications like individual houses. Water Cooled DX Split systems are more efficient than the Air-Cooled DX Split System.

H. Air Cooled Screw Chiller

An Air-Cooled Screw Chiller is a cooling system designed for large-scale applications. It utilizes screw compressors to circulate refrigerant, absorbing heat from the surrounding air. This absorbed heat is then released outdoors, resulting in effective cooling for industrial and commercial spaces.

Air cooled chillers are less efficient than the water-cooled chillers.

I. Air Cooled, DX Unitary Single package Heat Pump

An Air-Cooled DX Unitary Single Package Heat Pump is a versatile heating and cooling system contained within a single unit. It operates using a direct expansion (DX) refrigeration cycle, which allows it to extract heat from the outdoor air for heating or release heat outdoors for cooling. This all-in-one system is suitable for residential and small commercial spaces which requires both space heating and cooling requirement.

J. Applied Heat Pump

An applied heat pump is a versatile heating and cooling system that transfers heat between indoor and outdoor environments. This technology extracts heat from a source, such as the ground, air, or water, and then releases it into a space to provide warmth or removes heat to offer cooling.
These systems are environmentally friendly.

Following types of applied heat systems may be modelled using EDGE:

- Applied Heat Pump, Brine to Air, Ground Loop
- Applied Heat Pump, Brine to Water, Ground Loop
- Applied Heat Pump, Water to Air, Groundwater
- Applied Heat Pump, Water to Water, Ground Loop
- Applied Heat Pump, Water to Water, Water Loop

K. Direct Evaporative Cooling System

A Direct Evaporative Cooling System is an efficient cooling method that uses the natural process of water evaporation to lower air temperature. In this system, warm outdoor air is passed through moistened pads or surfaces, causing the water to evaporate and cool the air before it is circulated indoors. This eco-friendly approach is particularly effective in dry climates, providing cost-effective cooling while introducing fresh, humidified air into the space.

L. Packaged Terminal Air Conditioner & Package Terminal Heat Pump

A Packaged Terminal Air Conditioner (PTAC) and a Packaged Terminal Heat Pump (PTHP) are self-contained heating and cooling units frequently encountered in hotels, apartments, and individual rooms. These units are mounted within an exterior wall and offer both cooling and heating functions. While a PTAC employs a refrigeration cycle to achieve its temperature control, a PTHP operates using a heat pump cycle, allowing it to efficiently provide both cooling and heating capabilities.

M. VRF

Variable Refrigerant Flow (VRF) Systems are innovative heating and cooling solutions used in buildings to provide efficient and customizable climate control. These systems use a single outdoor unit that connects to multiple indoor units, allowing for individualized temperature settings in different zones. VRF systems use refrigerant to transfer heat between the indoors and outdoors, enabling simultaneous heating and cooling in various areas. With their flexibility, energy efficiency, and precise temperature management, VRF systems are widely adopted for both residential and small and medium scale commercial applications, enhancing comfort and reducing energy consumption.

EDGE has the capability to model the following types of VRF systems:

- VRF Air Cooled, Cooling & Heating
- VRF Ground Source
- VRF Water Cooled, Cooling and Heating
- VRF, Air Cooled Cooling Only

N. Water Cooled Chillers

A water-cooled chiller is an advanced cooling system designed to remove heat from a building or industrial process using water as the primary cooling medium. In this setup, warm water from the process or building is circulated through the chiller, where heat is absorbed and transferred to a separate water loop. This second loop is cooled through a heat exchange process and then recirculated, creating a continuous cycle of cooling. Water-cooled chillers are efficient and versatile solutions for large-scale cooling applications, offering enhanced energy efficiency and temperature control.

Following types of Water-Cooled Chillers may be modelled using EDGE:

- Water Cooled Centrifugal Chiller
- Water Cooled Screw Chiller
- Water Cooled Heat Recovery Chiller

O. District Cooling

Packaged Terminal Air Conditioner & Package Terminal Heat Pump

Note: *If the project team uses more than one type of cooling system, the user can model the same using detailed entry table. The user has the option to choose 3 types of cooling system in the building.*

II. Improved Case Distribution System:

A cooling distribution system is a network of components and conduits designed to efficiently deliver chilled air or water throughout a building. This system ensures that cooled air or water reaches different spaces and equipment that requires cooling for optimal temperature control. It typically includes components such as chillers, pumps, pipes, valves, and air handling units, working together to deliver the desired cooling effect to various areas while maintaining energy efficiency and occupant comfort.

Following distribution systems may be modelled using EDGE:

a. **Default System:** This is calculated based on the building type, building load, building area and base case system type.

b. **Constant air volume**: Constant air volume (CAV) refers to a type of HVAC system where the supply of air remains consistent regardless of the changing demands for heating or cooling within a building. In a CAV system, the air handling unit maintains a fixed airflow rate, delivering a steady volume of conditioned air to the occupied spaces. While CAV systems are straightforward and relatively simple to design, they may not be energy efficient.

c. **Variable Air Volume:** Variable air volume (VAV) is an HVAC system design that adjusts the supply of conditioned air to different areas or zones within a building based on the specific heating or cooling requirements. In a VAV system, the airflow rate can be varied to match the thermal needs of each zone, allowing for precise temperature control and energy efficiency. VAV systems are known for their flexibility and ability to optimize comfort while conserving energy.

d. **Fan Coil Unit**: A fan coil unit (FCU) is a compact HVAC device commonly used to provide localized heating and cooling within a building. It consists of a coil, which is connected to a hot or cold-water source, and a fan that circulates air over the coil to transfer heat to or from the air. Fan coil units are typically installed in individual rooms or zones and are controlled independently to achieve personalized temperature control. They are versatile, efficient, and well-suited for applications in hotels, apartments, offices, and other spaces requiring localized climate management.

e. **Displacement Ventilation System:** In this system, cool air is introduced at low velocity near the floor, creating a buoyancy effect that encourages the warmer, polluted air to rise and be extracted at ceiling level. This system improves the efficiency of chiller or cooling generation systems. This type of distribution system will work for all Water-cooled chiller, Air Cooled Chiller, Applied Heat Pumps, 2-Stage evaporative system, Direct evaporative systems, and Absorption Chillers.

f. **Radiant System:** A radiant cooling distribution system is an innovative HVAC method that uses chilled water pipes or panels embedded in a building's surfaces, such as ceilings, walls, or floors, to cool indoor spaces. This system operates by absorbing excess heat from occupants and other heat sources, providing a comfortable and energy-efficient cooling effect. This system improves the efficiency of chiller or cooling generation systems and reduces the Air Handling Unit capacities drastically.
Note 1: This type of distribution system will work only for all Water-cooled chiller, Air Cooled Chiller, Applied Heat Pumps and Absorption Chillers.
Note 2: Thermally Activated Building Structures (TABS) systems may be modelled as Radiant Systems.

III. Installed Capacity (kW)

The cooling equipment's capacity is determined based on the peak day of the year. In cases where the actual installed equipment's efficiency (COP/EER) differs, the user must input a weighted average of both the capacity and efficiency/COP/EER of the system, not SEER, to accurately reflect its performance.

IV. Improved Case Cooling System Efficiency

The improved case cooling system shall utilize the nominal efficiency – COP or EER. *Project teams* shall not use the seasonal efficiency (Seasonal COP or Seasonal EER) of the system.

V. Secondary Cooling System

The secondary cooling system is specifically for the areas such as hub room, or datacenters that have a distinct system to ensure consistent and reliable cooling. It is expected that these areas require constant (24 hr / 7 days a week) air conditioning and is separate from the main cooling system.

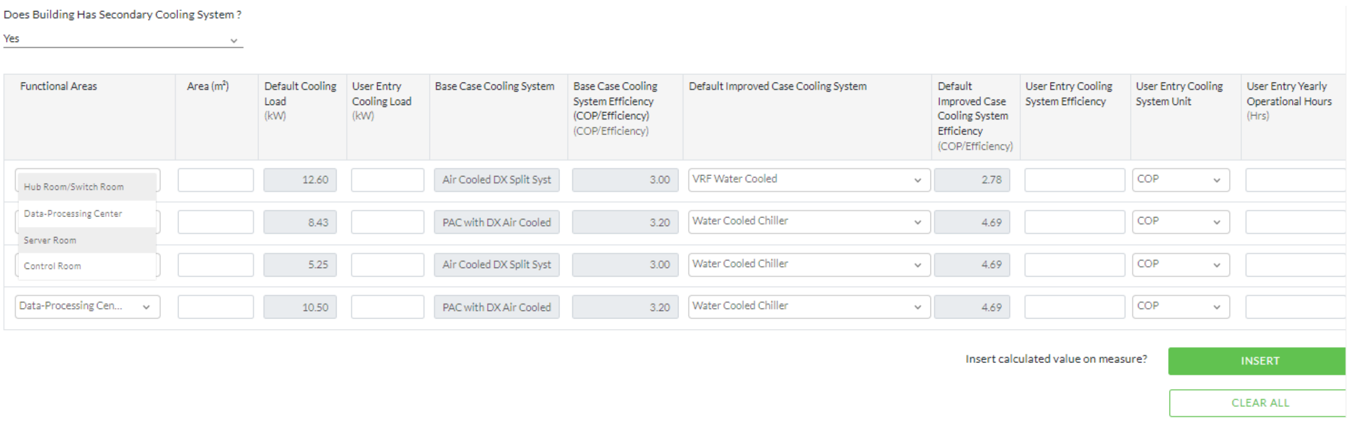


Figure 23. EEM13 Calculator - Secondary Cooling System.

The secondary cooling system cannot be integrated with the main cooling system in order to maintain the dedicated cooling needs. When a secondary cooling system is selected, the same details (e.g. installed capacity, system efficiency etc.) must be entered into the calculator. It is expected that due to the continuous operational usage of these system, there will be an increase in energy usage.

Note: Cold/frozen/ fruits & vegetable storage areas, as defined in the Area and Loads Breakdown in the Design tab, are part of the primary cooling systems.

Potential Technologies/Strategies

Simple air-conditioners fitted in windows and through-the wall unitary air-conditioners are the most common type of air-conditioners used in individual residential units. Apartment buildings may use packaged air-conditioners located on roof tops with ducted air flow. However, these are the least efficient types of systems. Various air-conditioning systems are available that achieve higher cooling efficiency, including split air-conditioners, multi-split air conditioners, VRF systems and chillers.

Table 12. Improved Case System in EDGE.

Improved Case System	COP/Efficiency Range
Default Base Case System with Improved Efficiency	EDGE considers 15% improvement in the system efficiency if the default base case system with improved efficiency is selected.
2-stage Evaporative Cooling System	110%
Absorption Chiller Double Effect, Indirect Fired	0.7 to 1
Water Cooled: Absorption Double Effect, Direct Fired	0.7 to 1
Air Cooled Absorption Chiller, Single Effect	0.7 to 1
Water Cooled Absorption Chiller, Single Effect	0.7 to 1
DX Split System	3.04 to 3.27

Air Cooled Screw Chiller	2.99
Air Cooled, DX Unitary Single package Heat Pump	2.97 to 3.34
Applied Heat Pump	3.57 to 5.27
Direct Evaporative Cooling System	80% efficiency
Packaged Terminal Air Conditioner & Package Terminal Heat Pump	4.14 to 4.24
VRF	2.78 to 3.52
Water Cooled Chiller	4.45 to 6.1
District Cooling	4.5

Relationship to Other Measures

- The efficiency of cooling systems will not impact other measures but will impact the total energy use of the cooling system. In addition, when a water-cooled chiller is selected as an energy efficiency measure, total water consumption is increased for both the base and the improved case, as the chiller will require water to operate.
- EEM14 – Variable Speed Drives must be consistent with the cooling type and distribution system.
- EEM16 – Space Heating System Efficiency may be also selected for systems that provide both heating and cooling.

Compliance Guidance

Preliminary Stage Certification

- Mechanical and electrical layout drawings showing the location of the external and internal components of the space cooling equipment for all floors; and
- Equipment Schedule or Manufacturer's data sheets (with the project-specific info highlighted & noted) for the space cooling system specifying efficiency information.
- For systems including more than one type or size of space cooling system, the design team must provide the weighted average efficiency calculations, calculated either within or outside the EDGE App.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the space cooling equipment taken during or after installation showing the make and model; or
- Purchase receipts for the space cooling equipment showing the make and model; or
- Contract with the management company showing the efficiency of the space cooling system, if the system is under separate management or off-site.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of system details, such as existing building drawings, calculations and equipment nameplate photographs, where relevant, shall be submitted.

EEM14 – Variable Speed Drives

Requirement Summary

In the cooling system, if Variable Speed Drive (VSD) motors are employed for fans and pumps, they utilize modulating technology to adjust motor speeds. This applies to various components such as chiller, cooling tower fans, chilled water pumps, condenser pumps, space heating's hot water pumps, domestic water pumps, sludge recycling pumps, STP blowers, and air handling units. These motors, often in the form of variable-frequency drive (VFD) or adjustable-frequency drive systems, respond to real-time demand, optimizing energy consumption and system performance.

Intention

The aim is to encourage the *project team* to specify VSDs, as energy consumption will be reduced, and therefore the utility costs. VSD fans offer improved system reliability and process control. The lifetime of system components is increased because of lesser use at full capacity leading to lesser wear and tear with less maintenance needed.

Approach/Methodologies

Cooling systems need to operate at the maximum (peak) load only at certain times. For most of the hours in a day, they only need to operate at part loads. VSDs on fans control and regulate the fan speeds depending on the load on the cooling system, as opposed to constant speed fans, thus reducing energy consumption. Variable Speed Drive (VSD) motors use an electronic device to modulate the speed of the fan motors based on actual heating/cooling demand. The power demand of motors is directly proportional to the cube of the motor speed. So, even a 20% reduction in motor speed cuts down power consumption by about half[22].

VSDs are not typically part of the baseline. This measure will show savings only if an air conditioning system is selected, and VSDs applies to various components such as chiller, cooling tower fans, chilled water pumps, condenser pumps, space heating's hot water pumps, domestic water pumps, sludge recycling pumps, STP blowers, and air handling units.

By default, the measure is applicable to all the above-mentioned components and if the user must model it for particular components, then the user can use the detailed entry to select the VSD for individual system types.

Note: *If the base case system has VSD then this measure will not have any impact on the energy savings.*

Potential Technologies/Strategies

VSDs offer a high degree of control and are extremely versatile. They are available both as integrated and standalone devices that can be connected to the fan and pump motor.

In chillers, the air used to cool the water is pulled through the cooling tower by electric motor-driven fans. These fans can be electronically controlled with Variable Speed Drive (VSD) motors. A VSD motor regulates the speed and the rotational force of the fan by varying the motor input frequency and voltage.

[22] http://www.ecmweb.com/power-quality/basics-variable-frequency-drives

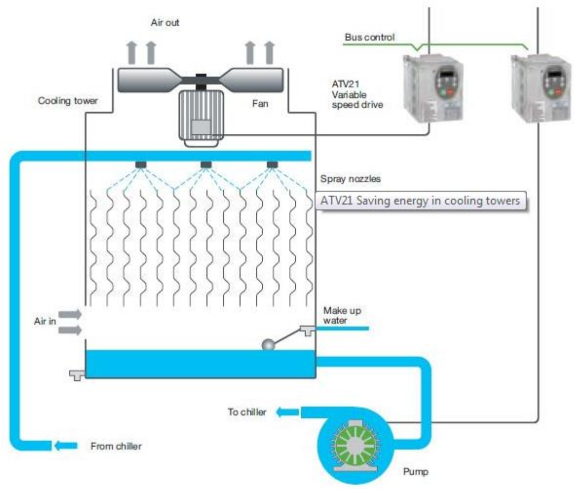


Figure 24. Schematic of cooling tower and VSDs system. Source: Image credit: Joliet Technologies, L.L.C. 2014 and Schneider Electric SE. 2014

Variable Speed Drive (VSD) pumps use electronics to control the power used by the motor of the pump to adjust the speed of the flow into an HVAC system in response to the demand. VSDs offer a high degree of control and are extremely versatile. They are available as standalone devices that are connected to the motor of the pump except for motors below 15kW, which are embedded or integrated into the motor.

Relationship to Other Measures

When VSDs for the fans of the cooling towers is selected as an energy efficiency measure, the cooling system selected must be Air Conditioning with Water Cooled Chiller to show the savings. Reduced fan energy will also reduce the heat loss from fan motors and, therefore, the load on the cooling energy.

When VSDs for the pumps is selected as an energy efficiency measure, it is required that the HVAC system selected are either air or water-cooled chillers, heat pumps or absorption chillers for savings to show. Reduced pump energy use will also reduce the heat loss from pump motors and, therefore, the load on the cooling energy.

Compliance Guidance

Preliminary Stage Certification

- Mechanical and electrical layout drawings/documents highlighting the use of VSDs; and
- Manufacturer's data sheets for the mechanical equipment showing VSD specifications.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the equipment with VSD(s) taken during or after installation showing the make and model; or
- Purchase receipts for the equipment with VSD(s) showing the make and model.

Existing Building Documentation

- The same documentation applicable for ***Post Construction Stage Certification*** may be presented.

EEM15 – Fresh Air Pre-Conditioning System

Requirement Summary

This measure may be claimed if a device has been installed in the ventilation system to pre-condition the fresh air entering the system to reduce the temperature difference between the outside air and the inside conditioned air.

Intention

Reducing the temperature difference between the outside air entering the building and the inside conditioned air helps to reduce the load on the space conditioning system. This helps to reduce fossil fuel consumption, and lower operating costs. Buildings that use energy for heating or cooling the fresh air supply have the potential to benefit from the application of devices to pre-condition the ventilation air.

Approach/Methodologies

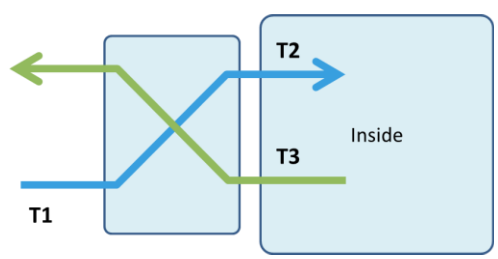
Fresh air can be pre-conditioned using several techniques such as sensible heat recovery (most common), total heat recovery, including sensible, and latent heat (the device is also known as enthalpy wheel), or indirect evaporative cooling. All these methods use very little energy to pre-condition the air and provide useful heat for space heating and in some cases for space cooling.

When buildings include an HVAC system and the main load of the building is due to space heating/ space cooling, installing heat recovery on the ventilation system reduces energy consumption by preheating/precooling the incoming fresh air with the outgoing exhaust air.

To qualify, the design team must demonstrate that the HVAC system has a heat recovery or indirect evaporative cooling device on the fresh air supply system. EDGE uses Temperature Transfer Efficiency (TTE) as the measure of efficiency, which is either quoted by the manufacturer. If manufacturer information is not available, the *project team* shall report the average of at least two TTE calculations with the maximum and minimum air flow rates respectively with the following formula:

Temperature Transfer Efficiency (TTE):

$$\mu t = \frac{T2 - T1}{T3 - T1}$$



Where: μ_t = Temperature Transfer Efficiency (%)

T_1 = Outside air temperature **before** heat exchanger (ºC)

T_2 = Air temperature **after** heat exchanger (ºC)

T_3 = Exhaust air temperature **before** heat exchanger (ºC)

No pre-conditioning system is included in the Base Case. The improved case default is a sensible heat recovery device with a Temperature Transfer Efficiency (TTE) of 65%. If the actual TTE value is different than 65%, the rated value must be entered in EDGE.

Potential Technologies/Strategies

A. Heat Recovery – Sensible or Total

Heat recovery aims to collect and reuse the heat arising from a process that would otherwise be lost. This is ideal for colder climates but works for warmer climates also. As air contains moisture, the heat contained within the air can be sensible heat (transfers the temperature only) or latent heat (includes the transfer of water vapor). Some energy recovery devices only transfer sensible heat and some transfer both sensible and latent heat (also called "total heat recovery" or "enthalpy wheel"). The latter are desirable in almost all climates except the very humid.

Sensible Heat Recovery occurs when the temperature of the cooler air stream exchanges heat with the temperature of the warmer air stream. Moisture level is not impacted unless condensation occurs.

Total Heat Recovery occurs when the moisture is also allowed to transfer along with the heat transfer. This is ideal where the inside air is being artificially humidified and introducing fresh air would drop the moisture levels.

B. Indirect Evaporative Cooling

Indirect evaporative cooling aims to precondition incoming hot air in a warm climate using the principle that evaporation causes cooling. Traditional evaporative cooling can result in uncomfortably high moisture levels. "Indirect" evaporative cooling takes advantage of the cooling effect from evaporation without adding moisture to the incoming air. The device accomplishes this by wetting the exhaust air from the cooled indoor space with water, cooling it further in the process. Incoming air is passed over this moist cooled exhaust air via heat exchangers that transfer the heat but do not transfer the moisture. The exhaust air becomes moist and warm and is ejected out, while dry, cooled air is supplied to the space.

Note: *An Air Handling Unit that recirculates air is not considered as heat recovery system and cannot claim savings for this measure.*

Relationship to Other Measures

Heat recovery from exhaust air reduces the heating load in heating mode and therefore decreases consumption in "Heating Energy." The same principle applies to the cooling load if the building is predominantly in cooling mode; then the reduction is in "Cooling Energy." The energy due to "Fans" also decreases slightly as less air is moved. However, in climates where both heating and cooling seasons occur, savings appear in the "heating energy," but the "cooling energy" increases due to some heat trapped during midseason.

Compliance Guidance

<u>Preliminary Stage Certification</u>

- Mechanical and electrical drawings showing the location of the pre-conditioning system, such as a heat recovery wheel, and indicating the percentage (%) of total air passing through the system; and
- Manufacturer's data sheets for the device specifying the Temperature Transfer Efficiency (TTE); or
- A calculation to demonstrate efficiency in case the manufacturer's data does not specify the TTE.

<u>Post Construction Stage Certification</u>

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As Built conditions;
- Photos / Evidence of at least two TTE conducted on-site (Only in the case of TTE information that is not available); and
- Date-stamped photographs of the installed device showing the make and model; or

- Purchase receipts for the device showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM16 – Space Heating System Efficiency

Requirement Summary

If the *building* includes a heating system, the actual efficiency (%) or coefficient of performance (COP) of the system must be entered into the calculator (even if the Efficiency/COP is lower than Base Case). Savings may be achieved if the heating system provides an Efficiency/COP greater than the Base Case.

For certification, *project teams* must use the calculator provided and fill in the information regarding installed capacity (kW) and system efficiency (COP, EER or Efficiency %).

Core & Shell *subprojects* may refer to ***Part 1 - EDGE Building Certification Guidance, Annex 2: Core & Shell Measures*** for more information.

Intention

Globally, space heating is one of the largest energy uses in buildings and often it is provided with fossil fuels. The specification of an efficient space heating system will reduce the energy required to satisfy the heating load for a building, and the resulting emissions.

Approach/Methodologies

To claim savings, the heating system must be able to demonstrate an efficiency level greater than the base case. The *project team* may enter either a percentage efficiency or a COP or EER in EDGE. Seasonal efficiencies (SCOP or SEER) may **not** be used.

$$COP = \frac{EER}{3.41}$$

Design Tab Inputs:

In the design tab, the *project team* must select the appropriate space heating fuel type. Where multiple systems with different efficiency ratings are specified, the dominant fuel type must be selected.

Energy Tab EEM16 Inputs:

Project teams must enter the space heating system type, installed capacity and its efficiency rating in the Energy page. The *project team* must also specify the heating distribution system (Constant Air Volume, Variable Air Volume, Fan Coil Unit or Radiant System).

Note: *The default distribution varies based on the type of heating system selected.*

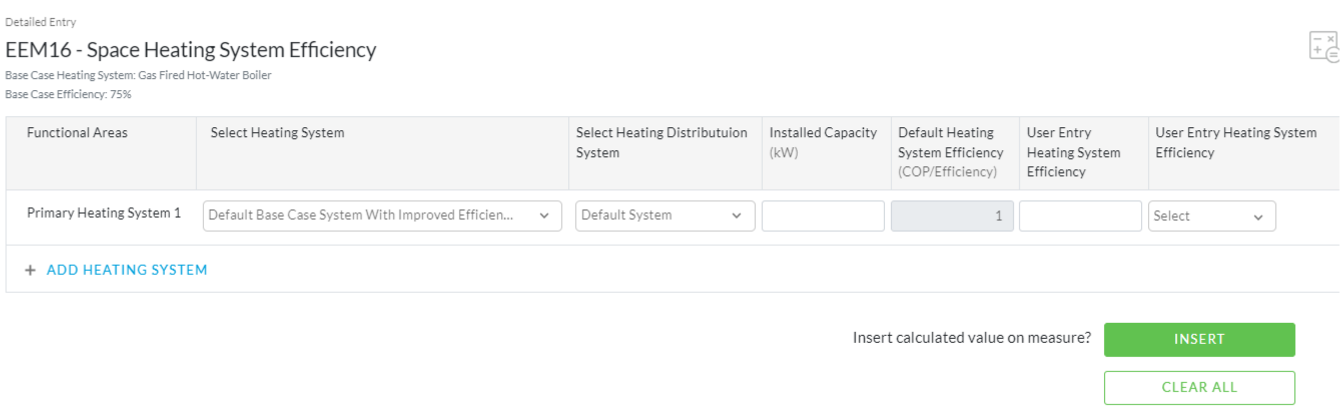


Figure 25. EEM16 – Space Heating System Efficiency - Calculator

For *buildings* with multiple systems, the weighted average efficiency must be calculated to account for not only the capacity but also the expected run time. Backup systems that are not regularly used, must not be accounted for.

Potential Technologies/Strategies

EDGE has the following space heating system types available.

1. **Heat Pumps** – These typically use electricity, but gas-fired heat pumps are also available. Heat pumps may be packaged or split.

2. **Condensing Boilers** – These typically run on natural gas and achieve 97% efficiency or higher. They utilize the latent heat in the waste gases' water vapor which is generated by the combustion process. Condensing boilers have a larger heat exchanger that recovers more heat and sends cooler gases up the flue. Additional heat is extracted from the water vapor from combustion; the heat extraction converts the vapor into liquid or "condensate". This condensate is removed through the drain or the flue. The types of condensing boilers available in the market are as follows:

Table 13: Types of Condensing Boiler.

Type / method	Description
Heat-only boilers	▪ Conventional boilers ▪ Provide both space heating and hot water ▪ Hot water storage cylinder and cold-water top-up tanks are required, plus a loft tank for feed and expansion
System boilers	▪ The pump and expansion vessel are built-in, does not need a loft tank. ▪ Designed to generate space heating and service hot water, the latter stored in a separate hot water storage tank.
Combination boilers or 'Combi'	▪ Combines a high-efficiency water heater and a central heating boiler in a compact unit. ▪ Heats water instantaneously on demand. ▪ Does not need a loft tank or storage cylinder. ▪ Good water pressure, as water is directly from the mains. ▪ Economical to run
Modulated control boilers	▪ New generation ▪ More efficient because of the modulated controls

To achieve the best results, care must be taken not to oversize the boiler, since maximum levels of efficiency are achieved at a full load. In larger buildings with a centralized plant, like an education building, a modular system made up of an array of smaller boilers may be appropriate. Smaller boilers can be used so that when the system is under partial load, individual boilers within the array can still operate at full load. To minimize the cost of a boiler installation, the heat loads must be minimized before sizing the system.

3. **Electric Resistance** - In electric resistance heating systems, the resistive element is typically made of materials with high electrical resistance, such as nichrome or stainless steel. When an electric current flows through the resistive element, it encounters resistance, causing the electrons to collide with atoms and generating heat in the process.
   Electric resistance heating can be used in various applications, including space heating, water heating, and industrial processes. Common examples of electric resistance heating systems include electric baseboard heaters, electric furnaces, electric radiant floor heating, and electric water heaters.
   While electric resistance heating is relatively simple and easy to install, it can be less energy-efficient compared to other heating methods, such as heat pumps or gas-fired systems. This is because electric

resistance heating relies solely on converting electrical energy into heat, without any energy conversion or extraction from an external source.

4. **Conventional Boiler** - A conventional boiler is primarily used for heating water for domestic or commercial heating and hot water supply. It operates by heating water in a storage tank or cylinder and distributing it to various points of use. Conventional boilers are commonly found in older homes and require separate components for heating and hot water, such as a hot water cylinder and cold-water storage tank.

5. **Furnace** - A furnace heating system is a type of central heating system that uses a furnace as its primary heat source. It is commonly found in residential and commercial buildings and is designed to provide warmth and comfort during colder months.
   Furnace heating systems can be controlled by a thermostat, allowing users to set desired temperatures and regulate the operation of the furnace. They are known for their ability to provide consistent and reliable heating, and they can be compatible with various types of heating distribution systems, such as forced-air systems or hydronic systems with radiators or baseboard heaters.

6. **Steam Boiler** – A steam boiler is designed to produce steam for various industrial applications. It is commonly used in power plants, refineries, chemical plants, and other industrial settings. Steam boilers generate steam by heating water in a boiler vessel, which then expands and exits the boiler as high-pressure steam. This steam can be used for heating, power generation, or other industrial processes.

7. **Generator Waste Heat**. This measure can be claimed if an on-site power generator fueled by Diesel or Natural Gas provides power to the building, and a recovery technology is installed to capture the waste heat for space heating. Heat recovery collects and reuses the heat that would otherwise be lost. Waste heat may also be generated by electric generators. The following image shows different sources of waste heat and the uses of the recovered waste heat, the list is non-exhaustive:

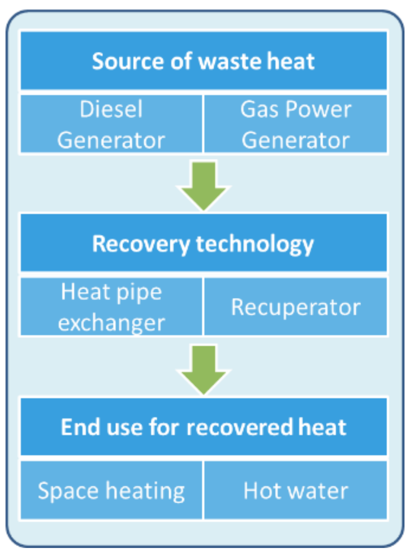


Figure 26. Typical Sources of Waste Heat and Recovery Option. This list is non exhaustive. Source: Heat is Power Association. Trade association of Waste Heat to Power (Not-for-Profit organization)

The *project team* must select the appropriate fuel under *Generator*, and input the appropriate value for *% of Electricity Generation Using [Fuel]*. Justification and documentation must be provided for these key assumptions.

Relationship to Other Measures

The efficiency of heating systems will not impact other measures but impact the total energy use of the heating system. A heating system will have a smaller impact on savings if the building walls and windows have been optimized.

- EEM14 – Variable Speed Drives must be consistent with the heating distribution system.
- EEM13 – Cooling System Efficiency may be also selected for systema that provide both heating and cooling.

Compliance Guidance

Preliminary Stage Certification

- Mechanical and electrical layout drawings showing the location of the external and internal components of the space heating equipment for all floors; and
- Equipment Schedule or Manufacturer's data sheets (with the project-specific info highlighted & noted) for the space heating system specifying efficiency information.
- For systems including more than one type or size of space heating system, the design team must provide the weighted average efficiency calculations, calculated either within or outside the EDGE App.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the space heating equipment taken during or after installation showing the make and model; or
- Purchase receipts for the space heating equipment showing the make and model; or
- Contract with the management company showing the efficiency of the space heating system if the system is under separate management or off-site.

Existing Building Documentation

- The same documentation applicable for ***Post Construction Stage Certification*** may be presented. If some of the documents required above are not available, other evidence of system details, such as existing building drawings, calculations and equipment nameplate photographs, where relevant, shall be submitted.

EEM17 – Room Heating Controls with Thermostatic Valves

Requirement Summary

This measure may be claimed if the radiators for space heating are fitted with thermostatic valves to control the room temperature.

Intention

The intent of this measure is to reduce space heating demand. Space heating with radiators is typically provided in buildings with a central heating plant or district heating supply. When these radiators are not fitted with thermostatic valves, a common problem is that some spaces get uncomfortably hot even in winter and the occupants need to manually control radiators or open windows to regulate the room temperature. This results in significant wasted heat. The use of thermostatic valves will reduce this wasted heat.

Approach/Methodologies

When windows are opened on cold days to regulate the temperature in a space, the space heat that has already been generated is simply wasted. To recover this wasted heat, there is additional load on the space heating system.

To model this measure in EDGE, simply select the measure. EDGE models the savings automatically if the radiant heaters have temperature control at room level, thus reducing the load on the heating system.

Potential Technologies/Strategies

Thermostatic valves are installed on radiators, which can be set to regulate the amount of heat being delivered to the space. This may be achieved by throttling the hot water or steam in the radiators.

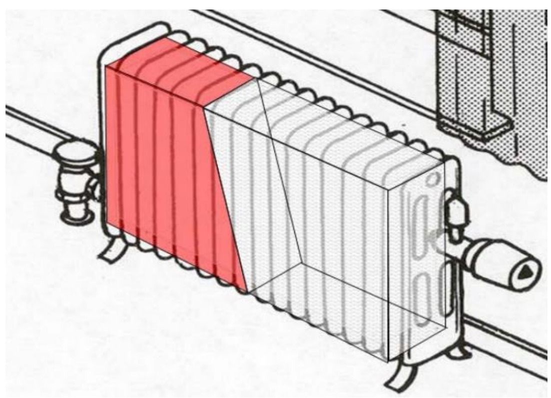


Figure 27: A radiator with a Thermostatic radiator valve (TRV). Source: U.S. Department of Energy https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/thermostatic_radiator_valve.pdf

Relationship to Other Measures

This measure only impacts the space heating energy use.

Compliance Guidance

<u>Preliminary Stage Certification</u>

- Mechanical system schematics showing the make and model, specifications, and location of the thermostatic radiator valves in the building; and
- Manufacturer's data sheets for the thermostatic radiator valves specified.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed thermostatic valves showing the make and model; or
- Purchase receipts for the thermostatic valves showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM18 – Domestic Hot Water

Requirement Summary

This measure focuses on the efficiency of domestic hot water systems. This measure is mandatory, meaning it must be selected.

Project teams must fill out all the fields in the calculator for this measure.

Core & Shell *subprojects* may refer to ***Part 1 - EDGE Building Certification Guidance, Annex 2: Core & Shell Measures*** for more information.

Intention

Providing hot water with high efficiency will reduce fuel consumption and related carbon emissions from water heating.

Approach/Methodologies

There are several different methodologies for calculating the efficiency of a water heating system.

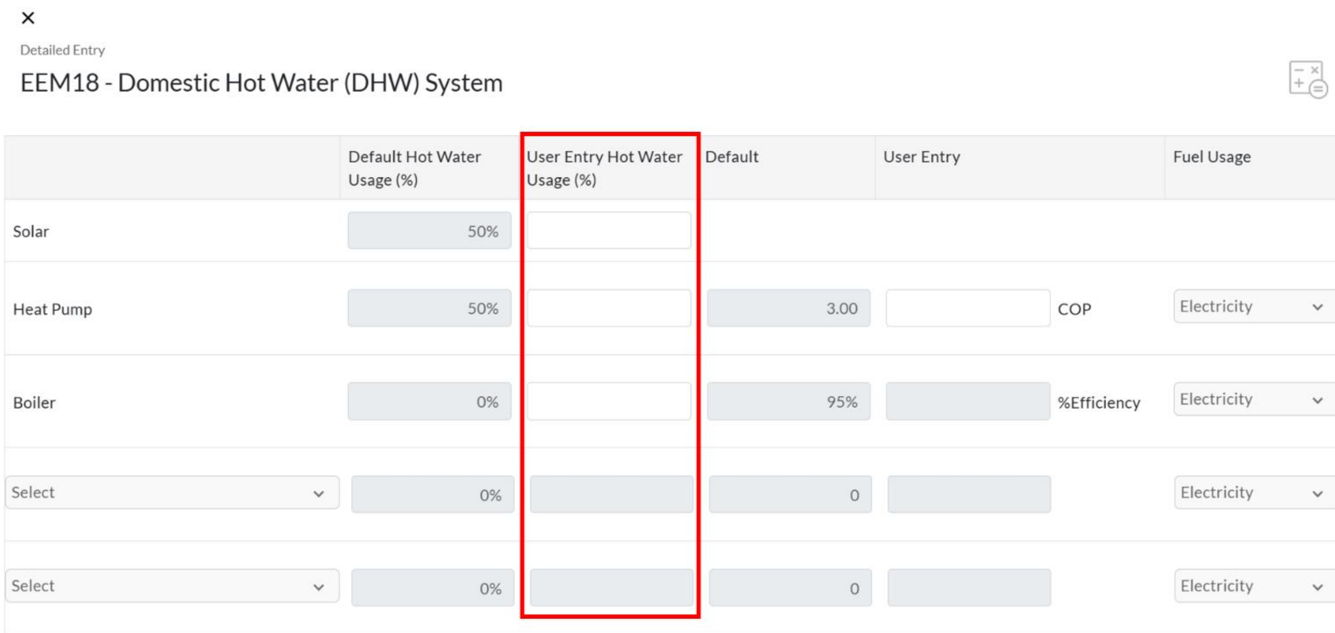
From EDGE App V3.1 onwards, the efficiency of the base case hot water system does not depend on the fuel selection in the design tab.

For the improved case, the tool defaults to assuming a solar hot water heater meeting 50% of the demand, coupled with a heat pump fulfilling the remaining 50%. If the *building's* hot water supply differs from this scenario, users can utilize the detailed entry table. The tool accommodates several system types, including Solar Hot Water Heater, Heat Pump, Boiler, Instantaneous Hot Water Heater, and District Hot Water Supply System.

In countries where regulations mandate the use of solar water heaters as part of the baseline, the corresponding country-specific value is adopted for baseline hot water energy reduction [23],. In such cases, the improved case will not exhibit any savings unless the usage surpasses the established baseline norms. In scenarios where usage exceeds the specified norms, savings will be calculated based on the additional solar energy employed.

Project teams must enter the proportion of hot water demand in the improved case delivered by each technology using the calculator for this measure, highlighted in red in Figure 28. The EDGE App uses this percentage to calculate the amount of energy needed, for solar collectors the subsection below can be followed to calculate solar hot water contributions.

[23] The methodology documentation will contain the list of these specific regions.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Detailed Entry

EEM18 - Domestic Hot Water (DHW) System

	Default Hot Water Usage (%)	User Entry Hot Water Usage (%)	Default	User Entry		Fuel Usage
Solar	50%					
Heat Pump	50%		3.00		COP	Electricity
Boiler	0%		95%		%Efficiency	Electricity
Select	0%		0			Electricity
Select	0%		0			Electricity

Figure 28: EEM18 - Domestic Hot Water (DHW) System calculator.

If the *building* does not have a hot water system installed but has the infrastructure in place to install one, the project team should report the same system type and efficiency as the base case.

If no hot water systems are expected to be installed at all, the project team may select *none* in the *fuels* section of the *design tab*.

Solar Hot Water Heater Contribution Calculation

To calculate the contribution of a Solar Thermal Hot Water Heater, including electric resistance geysers coupled with solar PV, to the overall hot water heating system, *project teams* shall follow these steps using the provided formula and, when required, the assumptions:

Step-by-Step Calculation:

1. Get the energy generation of the solar hot water system EPI in kWh/m²/yr ($EPI_{solar\ hot\ water\ system}$).
    - This may be provided from the manufacturer in kWh/year and apply a matching factor according to **Annex 1: Solar Hot Water Energy Calculation**, or
    - Follow steps in **Annex 1: Solar Hot Water Energy Calculation.**
2. Determine the improved case EPI of a Heat Pump with COP of 1 in kWh/m²/yr ($EPI_{Improved\ case\ COP=1}$).

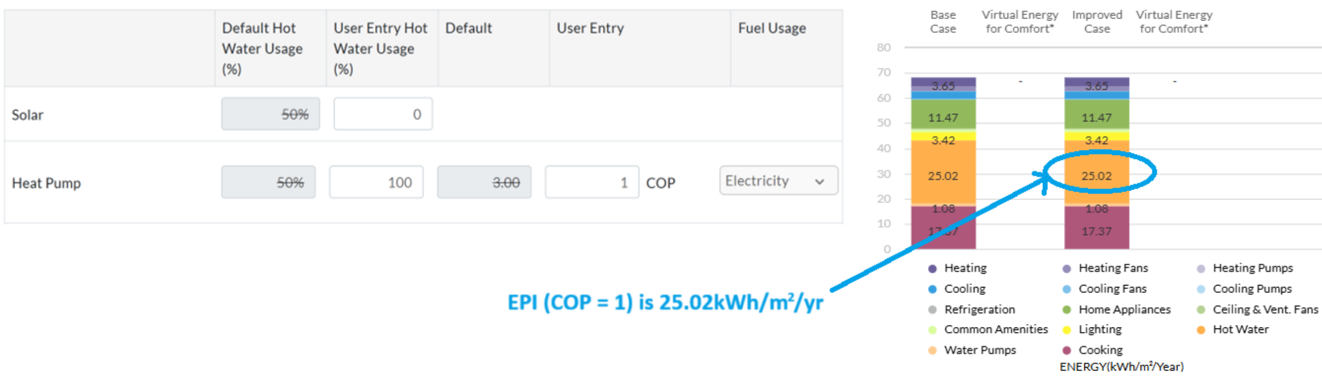


Figure 29: How to estimate the improved case EPI with COP =1

3. Determine the percentage contribution of the solar hot water heater.

$$Contribution\ from\ Solar\ Hot\ Water\ (\%) = \frac{EPI_{solar\ hot\ water\ system}}{EPI_{Improved\ case\ COP=1}}$$

The contribution from solar hot water percentage that is calculated can then be entered into the Solar *User Entry Hot Water Usage (%)* in EEM18. The remaining percentage (100% - *Contribution from Solar Hot Water %)* can then be entered in the other sections, according to the *building* characteristics.

Potential Technologies/Strategies

A. Heat pump water heaters (HPWH)

HPWH use electricity to take the heat from surrounding air and transfer it to the water in an enclosed tank. This process is like the heat transfer process in a refrigerator but in reverse. Heat pump water heaters can be used with dual functionality in hotels for example to cool the kitchen, laundry, or ironing area and to generate hot water. Because they move heat rather than generate heat, heat pumps can provide efficiencies greater than 100%.

The efficiency of a heat pump is indicated by the Coefficient of Performance (COP). It is determined by dividing the energy output of the heat pump by the electrical energy needed to run the heat pump at a specific temperature. The higher the COP, the more efficient the heat pump. Typical heat pump water heaters are two to three times more efficient than standard electric water heaters.

The fuel utilized for the instantaneous water heater can be chosen from the available fuel type options listed.

Table 14: Processes of various heat pump types.

Type	Process
Heat Pump Water Heaters	A low-pressure liquid refrigerant is vaporized in the heat pump's evaporator and passed into the compressor. As the pressure of the refrigerant increases, so does its temperature. The heated refrigerant runs through a condenser coil within the storage tank, transferring heat to the water stored there. As the refrigerant delivers its heat to the water, it cools and condenses, and then passes through an

	expansion valve where the pressure is reduced, and the cycle starts over.
Air-source Heat Pumps ("Integrated" units)	These systems are called "integrated" units because they integrate the heating of domestic water with a house space-conditioning system. They recover heat from the air by cooling and transferring heat to domestic hot water. Water heating can be provided with high efficiency with this method. Water heating energy can be reduced by 25% to 50%.
Ground-Source Heat Pumps	In some Ground-Source Heat Pumps, a heat exchanger, sometimes called a "desuperheater," removes heat from the hot refrigerant after it leaves the compressor. Water from the home's water heater is pumped through a coil ahead of the condenser coil, in order that some of the heat that would have been dissipated at the condenser can be used to heat water. Excess heat is always available in the summer cooling mode and is also available in the heating mode during mild weather when the heat pump is above the balance point and not working to full capacity. Other ground-source heat pumps provide domestic hot water (DHW) on demand: the whole machine switches to providing DHW when it is required. Water heating is easier with ground-source heat pumps because the compressor is located indoors. They generally have many more hours of surplus heating capacity than required for space heating, because they have constant heating capacity. Like air-source heat pumps, ground-source heat pumps can reduce water heating consumption by 25% to 50%, as some have a desuperheater that uses a portion of the heat collected to preheat hot water and can automatically switch over to heat hot water on demand.

B. Boilers

Even the most efficient boilers can only achieve a maximum efficiency of around 98%. This is because some energy (heat) is inevitably lost through the flue gases and the main body of the boiler. Additionally, a lack of regular maintenance can further reduce a boiler's efficiency.

The most common types of boilers available on the market use electricity, natural gas, or LPG (liquefied petroleum gas) as fuel. However, for greater efficiency, it is worth considering emerging technologies such as hybrid systems, condensing boilers, heat pumps, and combined heat and power (CHP) boilers.

It is possible to list up to two boilers using the calculator, each boiler may have its own efficiency and fuel usage. For example, both electric and natural gas boilers can be modelled.

C. Instantaneous Hot Water System

An instantaneous water heater, also known as a tankless water heater, is a compact and energy-efficient device used to provide hot water on demand. Unlike traditional water heaters that store and continuously heat a large volume of water, an instantaneous water heater heats water only when it is needed. Cold water passes through a heating element or coil, quickly raising its temperature to the desired level as it flows through the unit. This technology eliminates the standby heat loss associated with storage tanks, resulting in energy savings and a continuous supply of hot water.

The fuel utilized for the instantaneous water heater may be chosen from the available fuel type options listed.

D. District Hot Water System

A District Hot Water System is a centralized heating infrastructure designed to provide hot water to multiple buildings or units within a specific area. In this system, a central energy source, such as a power plant or heating facility, generates hot water and distributes it through a network of pipes to various connected locations. This approach offers efficiency and cost benefits by consolidating heating resources and reducing the need for individual equipment and maintenance.

District hot water systems are commonly used in urban areas, residential complexes, and commercial developments to streamline heating operations and promote energy conservation. When a district hot water system is selected, the base system and efficiency are similar to other fuel-based systems. However, the fuel used for the district hot water system must be reported by choosing from the available fuel type options listed.

The final operational CO2 emissions will be influenced by the fuel selection for the district hot water system, as these emissions are considered on-site emissions.

Relationship to Other Measures

This measure is inextricably linked to hot water consumption, which EDGE estimates based on the number of occupants, the efficiency of the hot water boiler, and the flow rates of the kitchen, showers, laundry and hand basin faucets. The size of the required system can therefore be reduced significantly by specifying low-water-use showers, washing machines, dishwashers, faucets and other measures that reduce hot water demand (WEM01, WEM02, WEM08, WEM09, WEM10, and WEM11), as well as any water heating recovery technology.

This measure reduces both 'Water Heating' and 'Other' categories of energy use due to the reduction of pumping requirements for water.

Compliance Guidance

Preliminary Stage Certification

- Mechanical and electrical layout drawings showing the location of the water heating equipment for all floors, clearly showing any solar or heat pump water heaters; and
- In the case of solar water heating, briefly describe the system including the type of solar collector, the capacity of the storage tank of the boiler and its location, and the size, orientation and installed angle of the panels.
- Equipment Schedule or Manufacturer's data sheets (with the project-specific info highlighted & noted) for the water heating system(s) specifying efficiency information.
- For systems including more than one type or size of water heating system, the design team must provide the weighted average efficiency calculations, calculated either within or outside the EDGE App.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and

- Date-stamped photographs of the water heating equipment taken during or after installation showing the make and model; or
- Purchase receipts for the water heating equipment showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of construction details, such as existing building drawings, calculations and photographs, where relevant, shall be submitted.

EEM19 – Domestic Hot Water Preheating System

Requirement Summary

This measure may be claimed if a heat recovery device is installed to capture and reuse waste heat with at least 30% efficiency. If this measure is selected, the assumptions for fuel type and system type must also be verified.

Intention

Recovering waste heat to preheat the water supplied to the hot water system helps buildings to reduce the design capacity of water heaters, and lower associated fossil fuel consumption, operating costs, and pollutant emissions. For example, hospitals that use a power generator as a significant source of electricity and energy for hot water can reap benefits from the use of heat recovery systems such as lower maintenance, quieter operation, and higher availability of hot water, as well as reducing energy costs and carbon emissions from lower fuel consumption.

Approach/Methodologies

Waste heat is recovered from a source such as gray water, a heat recovery chiller, or a power generator. In the case of gray water, the efficiency of heat recovery device should be input. In the case of a generator providing waste heat, the fuel used for electricity generation and the percentage of annual electricity provided by the generator should be marked in the Design page under the Fuel Usage panel. The default fuel is Diesel. It can be changed to reflect the actual fuel powering the generator. The basis of fuel selection and percentage electricity generation must be included in the measure documentation.

To qualify, the design team must demonstrate that the Hot water system has a 'heat recovery' device. The EDGE base case assumes no heat recovery from gray water, while the improved case assumes that all the hot water discharge passes through a heat recovery system with 30% efficiency (can be updated by the user), therefore a portion of the hot water demand is covered by the recovery of the waste heat.

In the case of heat recovery from a generator, the default fuel is assumed to be Diesel. The fuel selection may be changed in the Design page to reflect the actual fuel powering the generator.

Note: *Pre-heating swimming pool hot water is not considered in this measure.*

Potential Technologies/Strategies

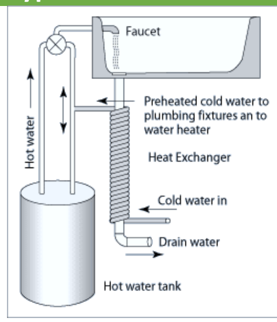
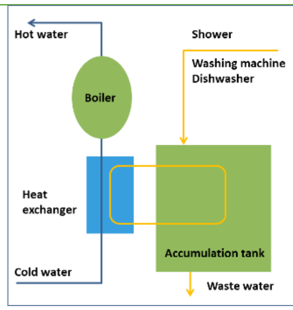
Heat recovery in buildings aims to collect and reuse the process heat waste that would otherwise be lost. Sometimes, the rejection of this heat is intentional, such as in air conditioning, where the purpose is to remove heat from a space. But using a recovery technology, such waste heat can be used to preheat the water feeding the hot water system.

EDGE offers three options for heat recovery. Other options may be modeled by using one these three as a proxy.

A. Gray Water Heat Recovery

A drainpipe carrying warm gray water (drain water from showers, washbasin, laundry, spa area) can be fitted with a heat exchanger to absorb that waste heat into the incoming cold-water pipes leading directly to water fixtures or to preheat the water being supplied to the hot water heater. Various commercial solutions are available for gray water heat recovery, ranging from non-storage systems (shower-only recovery) to centralized heat recovery, which connects more equipment and augments the possibilities for use of the recovered energy. The following table shows some of the solutions:

Table 15: Gray Water Heat Recovery Solutions.

Types		Description
Spiral design (non-storage)		Hot water runs through a series of narrow spirals in which it is forced to spin alongside the walls of the heat recovery pipe. The cold water then comes as a counter flow in a spiral pipe swirled around the outside. This design requires small gaps (2cm) to avoid plugging. It is commonly used in residential and small hotels or hospitals. Instead of a spiral system, tubular or rectangular heat exchanger systems can also be used.
Accumulation tank (centralized)		Gray water from different sources is accumulated in a tank, which has an electrical coil (close loop) that transfers the heat to the cold water passing through the gray-water heat recovery unit outside the tank.
Parallel heat exchanger (centralized)		This is ideal for larger buildings such as hospitals, as it collects the gray water in one pipe that passes through the heat exchanger. It is like spiral design but used centrally rather than in each unit.

B. *Heat Recovery from Chiller*

Chillers reject large amounts of heat from the condenser using air or water. In water-cooled chillers, water that has been warmed up from the heat rejection process can be used to preheat the incoming water supply for water heating.

C. *Generator Waste Heat*

Electricity generators are typically fueled by diesel and operate at relatively low efficiencies, therefore creating a significant amount of waste heat. This waste heat can be captured using heat exchangers to preheat the water supply for the water heating systems.

Relationship to Other Measures

This measure reduces water heating energy, independently of the domestic hot water system used in EEM19.

Compliance Guidance

Preliminary Stage Certification

- Mechanical and electrical layout drawings showing the location and specifications of the water preheating technology, such as heat recovery from gray water or laundry wastewater, chiller or generator; and
- Manufacturer’s data sheets for the recovery technology used and its efficiency; and

- Calculation to demonstrate that the waste heat covers the percentage of the demand for hot water calculated by the EDGE app.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the heat recovery equipment taken during or after installation showing the make and model; or
- Purchase receipts for the heating recovery equipment showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of construction details, such as existing building drawings or photographs shall be submitted.

EEM20 - Economizers

Requirement Summary

This measure may be claimed if the HVAC system includes economizers.

The economizer evaluates outside air temperature and even humidity levels. When the exterior air levels are appropriate, it uses the outside air to cool the building. HVAC economizers use logic controllers and sensors to get an accurate read on outside air quality. As the economizer detects the right level of outside air to bring in, it utilizes internal dampers to control the amount of air that gets pulled in, recirculated, and exhausted from the building.

Intention

Cooling energy use can be reduced in buildings when outside air conditions are suitable to cool the building with little or no need for mechanical cooling.

Approach/Methodologies

EDGE software uses monthly average outdoor air temperatures based on the *building* location to estimate the suitability of an economizer for the *subproject*.

An air-side economizer brings outside air into a building and distributes it to the servers. Instead of being re-circulated and cooled, the exhaust air from the building is simply directed outside. If the outside air is particularly cold, the economizer may mix it with the exhaust air, so its temperature and humidity fall within the desired range for the equipment.

A water-side economizer uses the evaporative cooling capacity of a cooling tower to produce chilled water and can be used instead of the chiller during the winter months. Water-side economizers are best suited in climates where the wet bulb temperature is lower than 55°F (12.8 °C).

Critical areas with special needs for indoor air quality, such as Operation Theatres (OT) and/or the Intensive Care Units (ICU) in hospitals, are exempt from the requirement of air-side economizers. Waterside economizers can still be used in these areas.

Following are the temperature setpoints for air-side and water-side economizers.

Table 16: Temperature setpoints for air and water-side ecomomizers. Applicable to EDGE version 3.1.

Temperature Setpoint	Type of Economizer
15 °C	Air-side Economizer
25° C	Water-side Economizer

When the outdoor dry bulb temperature is less than or equal to the setpoint, the economizer is activated.

Potential Technologies/Strategies

Two types of economizers are commonly used.

A. Air-side Economizers

The effectiveness of air-side economizers is highly dependent on the outside air temperature and humidity levels, which are measured through an outdoor sensor in the economizer system. Under suitable conditions, the outside air damper is fully open, and the cooling compressors are turned down or shut off.

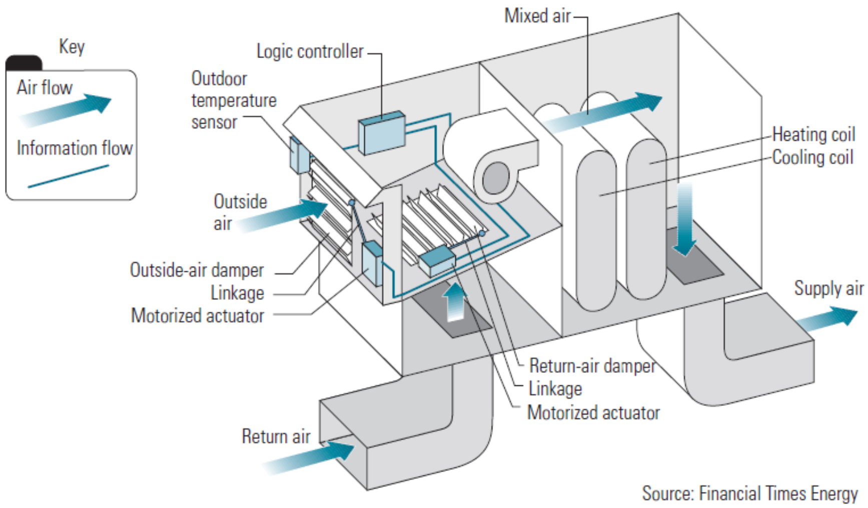


Figure 30. Components of an air-side economizer system[24]

A decision on the inclusion of economizers should be based on analysis of outdoor air temperature and humidity in comparison to the desired indoor temperatures. While this measure has potential to reduce cooling energy significantly in some locations, increased capital and operating costs are possible if the system is not designed and maintained properly.

Air-side economizers should typically be avoided in following circumstances:

- Especially corrosive climates, such as near an ocean
- Hot and humid weather
- Scarcity of sufficiently trained maintenance staff

B. Water-side Economizers

A water-side economizer uses the evaporative cooling capacity of a cooling tower to produce chilled water. Such an economizer can be used instead of a chiller at a data center during the winter months. Water-side economizers offer cooling redundancy because they can provide chilled water if a chiller goes offline. This can reduce the risk of cooling system down time.

[24] Source: Financial Times Energy, Image courtesy of Energy Design Resources (www.energydesignresources.com),

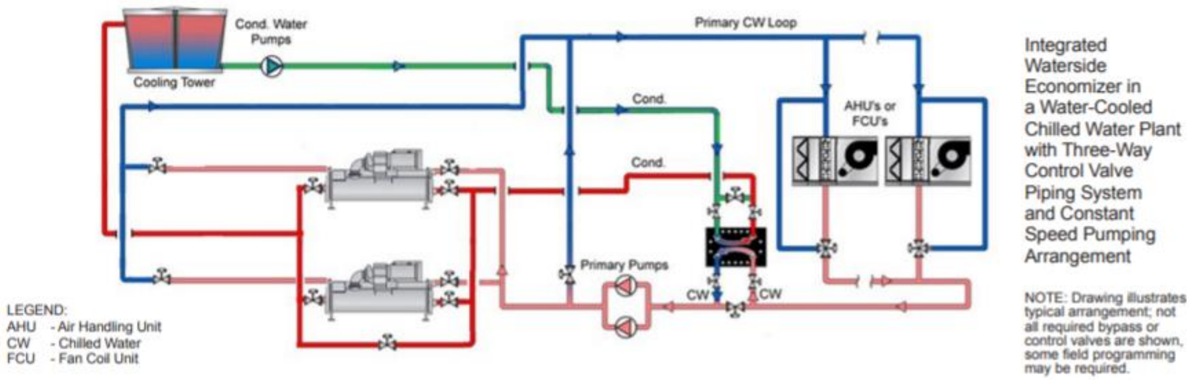


Figure 31. Integrated Water-Side Economizer in a Water-cooled Chilled Water plant with 3-way Control Valve Piping System and Constant Speed Pumping System. Image courtesy Carrier Corporation.

Relationship to Other Measures

Economizers reduce the need for mechanical cooling. Therefore, while the overall savings will increase, savings from improvement in cooling efficiency by itself will be reduced.

Compliance Guidance

To demonstrate compliance, the design team must describe the specified system and provide documentation to support the claims.

Preliminary Stage Certification

- System schematics showing the location, brand and model of the economizers; and
- Manufacturer's data sheets for the economizers specified.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the economizers taken during or after installation showing the make and model; or
- Purchase receipts for the economizers showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of construction details, such as existing building drawings and photographs, where relevant, shall be submitted.

EEM21 – Demand control ventilation using CO_2 sensors

Requirement Summary

To claim this measure, the mechanical ventilation in the core conditioned areas of the building shall be controlled by CO_2 sensors. Demand Control Ventilation Using CO_2 Sensors is an energy-efficient strategy employed in HVAC systems.

Intention

Mechanical ventilation introduces fresh air into the space. By installing CO_2 sensors in core areas, mechanical ventilation can be switched off when it is not required, thus consuming lesser energy. While the primary benefit of the CO_2 sensors is the reduction of energy bills, the following are the other associated benefits:

- Improved and consistent indoor air quality,
- Occupant comfort,
- Reduced greenhouse gas emissions, and
- Extended equipment life due to less demand on the HVAC system.

It is recommended that the control system take frequent measurements of CO_2 levels to adjust the ventilation supply to maintain proper indoor air quality.

Approach/Methodologies

This approach involves the use of carbon dioxide (CO_2) sensors to monitor indoor air quality. When CO_2 levels rise beyond setpoint, indicating higher occupancy or activity, the ventilation system adjusts the airflow rate to ensure a fresh and comfortable environment. By matching ventilation rates to actual occupancy, this system optimizes energy usage, enhances indoor air quality, and contributes to a healthier and more sustainable indoor environment.

The base case assumption is that the mechanical ventilation is provided at a fixed rate. To claim savings, at least 70% of the areas in the calculator, Figure 32, must have CO_2 sensors to control ventilation.

×

Calculator

EEM21 - Demand Control Ventilation Using CO_2 Sensors

Functional Areas	Default Improved Case Areas with Demand Control Ventilation	User Entry Improved Case Areas with Demand Control Ventilation
General Sales Area	Yes	Yes
Electronics Area	~~Yes~~	No
Food Sales	~~Yes~~	No
Office	~~Yes~~	No
Corridors and Lobby	Yes	Yes
Kitchen & Food Preparation	~~Yes~~	No

Figure 32: Calculator used to determine the core areas with demand control ventilation using CO_2 sensors.

Potential Technologies/Strategies

The amount of mechanical ventilation can be controlled to only provide fresh air to spaces at the time that it is required. This reduces the energy consumed by the HVAC system. Traditional ventilation systems are designed to provide a constant volume of fresh air based on maximum occupancy[25]. However, at partial occupancy levels, energy is wasted to condition outside air provided through the mechanical ventilation system even when it is not needed. The level of Carbon Dioxide (CO_2) in the air exhaled by people serves as a useful indicator of the room's occupancy levels, and therefore its ventilation needs.

CO_2 sensors are therefore a type of controls based on demand for the mechanical ventilation system, which reduce energy consumption while ensuring good air quality. The savings vary depending on the configuration of the HVAC system. For constant volume air-handling units (AHUs), the savings occur at the primary systems (boilers, chillers, air-conditioners, etc.), while for variable-air-volume (VAV) AHUs, the savings occur not only at the primary systems but also at the terminal boxes that include reheat[26]. The following image explains the way CO_2 sensors operate in both cases:

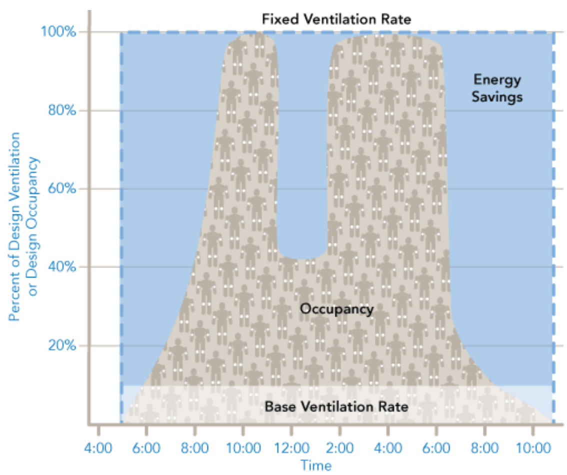


Figure 33: Energy savings due to CO2 sensors. Source Design brief: Demand-controlled ventilation, Energy Design Resources. 2007. http://energydesignresources.com/media/1705/EDR_DesignBriefs_demandcontrolledventilation.pdf

The following specifications are recommended for the selection of the CO_2 sensor equipment:

- Range: 600-1,000 ppm,
- Ability to collect and record data at regular intervals, typically every 10 minutes,
- Can be calibrated, as per manufacturer's indications.

Relationship to Other Measures

CO_2 sensors are controls for the mechanical ventilation system that can reduce the amount of cooling or heating energy, as well as fan energy, used by the HVAC system as less outside air is moved into the building. In addition, if the building uses a water-cooled chiller for the AC, then a reduction in the water consumption is also achieved.

[25] Commercial HVAC, Manitoba Hydro. 2014. https://www.hydro.mb.ca/your_business/hvac/ventilation_co2_sensor.shtml

[26] Design brief: Demand-controlled ventilation, Energy Design Resources. 2007. http://energydesignresources.com/media/1705/EDR_DesignBriefs_demandcontrolledventilation.pdf?tracked=true

Compliance Guidance

Preliminary Stage Certification

- HVAC layout drawings showing the location of the CO_2 sensors for the ventilation system including the mounting height; and
- Manufacturer specifications of the sensors.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the CO_2 sensors taken during or after installation showing the make and model; or
- Purchase receipts for the CO_2 sensors showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of system details, such as existing building drawings and photographs, where relevant, shall be submitted.

EEM22 – Efficient Lighting for Internal Areas

Requirement Summary

There will be a positive impact in energy savings if the light bulbs used in the *building* are highly efficient.

This measure becomes mandatory if internal lighting is provided in the *building.* The *project team* shall report the lighting characteristics of at least 90% of the available lighting within the GIA.

Core & Shell *subprojects* may refer to ***Part 1 - EDGE Building Certification Guidance, Annex 2: Core & Shell Measures*** for more information.

Note: *Lighting power from display lighting is excluded, although highly efficient lighting solutions are highly encouraged for this category of lighting. For example, lighting used for display merchandise in Retail buildings.*

Intention

Efficient lamps, that produce more light with less power compared to standard incandescent bulbs, reduce the building's energy use for lighting. Due to the reduction in waste heat from efficient lamps, heat gains to the space are also lowered, which in turn reduces cooling requirements. Maintenance costs are also reduced as the service life of these types of bulbs is longer than that of incandescent bulbs.

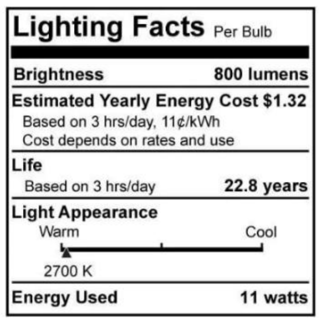


Figure 34: Lighting Label example.

Approach/Methodologies

Lighting efficiency at the building level can be expressed in one of two ways in EDGE, either as lighting power density (W/m^2) or as luminous efficacy (lm/W).

- ***Luminous efficacy*** - in lumens, per watt of power drawn (lm/W) is the measure of the production of visible light output. A higher luminous efficacy translates to greater energy savings. For example, a 40W light bulb has a power draw of 40W and produces about 450 lumens[27], the lighting efficacy of this 40 W lamp would be 450÷40 or 11.25 lm/W. A higher luminous efficacy results in higher energy savings.
- ***Lighting Power Density*** (LPD) – in watts/square meter (W/m^2) is the amount of power drawn per square meter. A lower LPD results in higher energy savings.

[27] http://clark.com/technology/lightbulbs-watt-to-lumen-conversion-chart/

Figure 35. EDGE Calculator – Two options: (1) Luminous Efficacy; (2) Lighting Power Density.

The baseline assumption for lighting power density (LPD) involves the utilization of lighting fixtures predominantly equipped with lamps that possess an efficacy of at least 65 lumens per watt (65 lm/W). This baseline assumption is established in accordance with the recommended lux levels for various building spaces as defined by the Chartered Institution of Building Services Engineers (CIBSE)[28], while also considering the Lumen Loss Factor (LLF).

Note: *EDGE baseline LPD is calculated based on CIBSE and NBC (India) lux level and luminous efficacy of 65 lm/W. If the ASHRAE baseline is available and selected the Building HVAC System section of the design Tab in the EDGE app, it will display LPD values based on ASHRAE 90.1.2016.*

Space-by-space input can also be entered into EDGE using the detailed entry calculator if the *project team* needs to differentiate the lighting efficiency between space types in a building.

EEM22 - Efficient Lighting for Internal Areas Calculator

Functional Areas	Base Case LPD (W/m²)	Default Improved Case LPD (W/m²)	User Entry Improved Case LPD (W/m²)
Office Space	8.2	5.9	
Receiving Area	4.1	3.0	
Shipping Area	6.2	4.4	
Production Area	15.4	11.1	
Inventory Area	3.1	7.4	
Mechanical & Electrical Room	10.3	2.2	
Kitchen & Food Preparation	10.3	7.4	
Indoor Car Parking	1.5	1.1	
Cold Storage Area	6.2	4.4	

SAVE

CLEAR ALL

Figure 36. EEM22 Calculator – Space-by-space inputs.

Potential Technologies/Strategies

Fluorescent (e.g., T8 and T5) and LED bulbs are available with various high-performance specifications.

Although the efficacy of bulbs from different manufacturers will differ, the table below gives an approximate range of efficacies that can be expected for different bulb technologies.

[28] https://www.cibse.org/knowledge-research/knowledge-resources/engineering-guidance/top-tips/cibse-top-tips-2-lighting-in-buildings-2015

Table 17: Typical range of efficacies for different lamp types. Data from the 2011 Buildings Energy Data Book, Table 5.6.9, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy Source: https://www.eia.gov/consumption/commercial/reports/2012/lighting/

Lamp Type	Typical Range of Efficacy (Lumens/Watt)	Rated lifetime (hours)
Incandescent – Tungsten Filament (conventional bulbs)	10-19	750-2,500
Halogen lamp	14-20	2,000-3,500
Tubular Fluorescent (T5, T8 and T12)	25-92	6,000-20,000
Compact Fluorescent (CFL)	40-70	10,000
High Pressure Sodium	50-124	29,000
Metal Halide	50-115	3,000-20,000
Light Emitting Diode (LED)	50-100	15,000-50,000

Relationship to Other Measures

Using more efficient bulbs reduces the heat gain from lighting, thereby reducing cooling loads. Another related measure is daylighting; better daylight design can reduce the need for artificial lighting during the daylit hours.

The selection of lighting efficiency will impact the effectiveness of EEM24 – Lighting Controls.

Compliance Guidance

Preliminary Stage Certification

- Electrical layout drawings showing the location and type of all interior lighting fixtures; and
- Lighting schedule listing the type and number of lamps specified for all fixtures; and
- Manufacturer's data sheets or calculations showing that the lamps meet the minimum lumens per watt threshold.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed lighting; it is not necessary to take photos of every single installed lamp, but the auditor is responsible for checking and verifying a reasonable proportion; or
- Purchase receipts for the lighting;
- For Core & Shell *subprojects*, the signed tenants fit out guides for commercial buildings / binding lease agreements or similar provisions.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence such as building audits will be accepted. Photographs alone will not be sufficient for this measure.

EEM23 – Efficient Lighting for External Areas

Requirement Summary

External lighting areas refer to outdoor spaces that require illumination for various purposes, including safety, security, and aesthetics. The requirements for this measure are the same as for the previous measure ***EEM22 – Efficient Lighting for Internal Areas*** except that they apply to external areas; so, any reference to interior lighting should be replaced with exterior lighting.

The spaces considered for external lighting include:

- Landscape area;
- External car parking area; and
- Swimming pool area.

All the above-mentioned areas that have permanent lighting for the purposes listed above, shall be accounted as "Area with external lighting (m^2)" and reported in the field with the same name. If multiple lighting types exist, a weighted average by external area is required.

For EDGE V3.0, Lighting in the external carparking area, should be reported separately in the design tab in *Area with Exterior Lighting*. Both *Area with Exterior Lighting* and *External Parking* area must be completed for this to be accounted for EEM23.

For EDGE V3.1 onward, *External Parking* in EEM23 includes lighting for external car parking area. For areas with no lighting for parking, these areas do not have to be included.

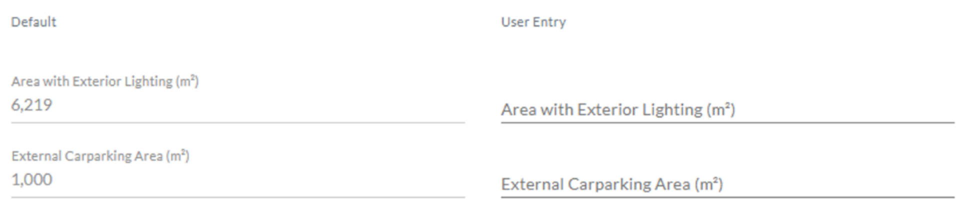


Figure 37: Exterior lighting and External Carparking Area fields in the Design tab.

Note: *Decorative façade, non-permanent landscape lighting, and street lighting are not considered as part of the exterior lighting calculations, or in any other measure calculation.*

Intention

Same as EEM22 – Efficient Lighting for Internal Areas.

Approach/Methodologies

Same as EEM22 – Efficient Lighting for Internal Areas.

Potential Technologies/Strategies

Same as EEM22 – Efficient Lighting for Internal Areas.

Relationship to Other Measures

This measure does not have a relationship with any other measure, e.g. EEM24 – Lighting Controls.

Compliance Guidance

Same as EEM22 – Efficient Lighting for Internal Areas.

EEM24 – Lighting Controls

Requirement Summary

This measure may be claimed if lighting in all the required rooms is controlled using technologies such as occupancy sensors, timer controls, or daylight sensors.

Manual lighting controls do not qualify for this measure.

Intention

By installing lighting controls in rooms, lighting usage is reduced. Occupancy sensors reduce the possibility for lights to be left on when the room is unoccupied and photoelectric sensors reduce it when sufficient natural light is available. Reduced lighting use leads to a reduction in energy consumption.

Approach/Methodologies

No calculations are involved in the assessment of this measure. To claim that it has been achieved, the lighting in all the required rooms must be connected to lighting controls. In the case of lighting controls for daylighting, all ambient lighting in “daylight zones” which have access to exterior windows, or skylights, must be connected to an automatic daylight control system using photosensors.

Daylight calculation in EDGE is based on the methodology outlined in ISO 10916-2014.

Project teams shall enter data into the EDGE calculator for this measure.

Potential Technologies/Strategies

Occupancy sensor controls are effective in saving lighting energy in spaces that have varying occupancy over the working hours. If many of the spaces in a building are expected to be unoccupied during some hours of the day, such as a conference room or a classroom, this measure may be considered.

Selection of the type of sensor and its location is critical for this measure. The sensor should be situated so that it can “see” all the occupants in the room. If the room is small enough, this could be done by placing the sensor in one corner of the room near the ceiling. For larger rooms, multiple sensors may be required.

Relationship to Other Measures

As lighting controls help to reduce unnecessary use of lighting which produces heat, cooling loads are reduced. Both “Lighting” and “Cooling Energy” are reduced in the energy graph, while “Heating Energy” is increased.

The amount of savings achieved with a daylighting measure will be affected by the Window to Wall Ratio entered in EEM01 – Windows-to-Wall Ratio.

Compliance Guidance

Preliminary Stage Certification

- Electrical layout drawings showing the location and type of all lighting controls; and
- Lighting schedule listing the specifications for all controls, if applicable; and
- Manufacturer’s data sheets for the lighting controls.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed controls; it is not necessary to take photos of every single installed control, but the auditor is responsible for checking and verifying a reasonable proportion; or
- Purchase receipts for the controls.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of construction details, such as existing building drawings, calculations and photographs, where relevant, shall be submitted.

EEM25 – Skylights

Requirement Summary

This measure may be claimed if a building utilizes natural daylight from skylight(s) to light up the interior, reducing the use of artificial lighting during daytime hours.

For industrial typologies, this measure becomes mandatory if skylights are present in the *building.*

Intention

The intent of this measure is to reduce the use of electricity for artificial lighting by using natural daylight. The use of daylight for lighting interior spaces requires only a part of the roof to be transparent and can save significant amounts of electricity usage for lighting, especially in spaces that are used mostly in the daytime.

Approach/Methodologies

The skylight(s) must be well distributed to provide maximum daylight penetration in the building.

To claim this measure, the design team must demonstrate that transparent elements in the roof allow sufficient daylight to achieve the required lighting level in the interior of the space of the top floor area, and that the lights in this area are equipped with dimming or shut-off controls such as daylight-responsive controls.

Daylight calculations using skylights in EDGE are based on the methodology outlined in ISO 10916.

The base case assumes no skylights in the building. When this measure is selected, the improved case with skylights assumes that a default area of 5% of the roof area is a Daylight Zone served by skylights, with a default Solar Heat Gain Coefficient (SHGC) of 0.5 and a U-value of 3.56 W/m^2.K. *Project teams* shall edit the default improved case according to the project-specific information.

Selecting the measure also reveals the editable fields for:

- Total Skylight Area (m^2)
- SHGC of the Fenestration
- U-value of the Fenestration
- Orientation of the Skylight
- Slope of the Skylight
- Type of Daylight Control System

Exceptions for measure:

- Areas designated as security or emergency areas that are required to be continuously lighted
- Interior exit stairways, interior exit ramps and exit passageways
- Emergency egress lighting that is normally off
- Display/accent lighting must have dedicated controls independent of the general lighting controls

Potential Technologies/Strategies

Natural daylight may be introduced into the building using windows in the roof, that is, skylights. Glass skylights are typically used, but daylight can also be introduced through other transparent or translucent materials such as transparent plastic panels or translucent insulation panels.

Figure 38. Skylight example - Source: yourhome.gov.au

If documentation is not available, plastic panels (structured sheets) and polycarbonate must use a use U-value of 4.1 W/m^2 K, SHGC of 0.46 and a VT of 0.27.

Relationship to Other Measures

Besides impacting the use of artificial lighting, the use of skylights will impact the heat gain through a roof which will impact the energy use for space conditioning. The area of skylights and their thermal properties (Solar Heat Gain Coefficient or SHGC and U-value) must be optimized to avoid excessive heat gain. Reduction in electricity usage for artificial lighting by using skylights must be balanced with the potential increase in cooling energy use.

Compliance Guidance

Preliminary Stage Certification

- Building plans and sections showing the Daylight Zones with the location and size of skylight(s) and any obstructions; and
- Manufacturer's data sheets showing the U-value for the skylight (including glass and frame) and the solar heat gain coefficient (SHGC) of the glass; and
- Lighting plans showing the photosensitive lighting controls in the Daylight Zones.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed skylights and associated photosensitive lighting controls; or
- Purchase receipts for the skylights and associated photosensitive lighting controls.

Existing Building Documentation

- The same documentation applicable for ***Post Construction Stage Certification*** may be presented. If some of the documents required above are not available, other evidence of construction details, such as existing building drawings and photographs, where relevant, shall be submitted.

EEM26 – Demand Control Ventilation for Parking using CO Sensors

Requirement Summary

To claim this measure, most of the mechanical ventilation in indoor parking areas shall be controlled by CO sensors. At least 70% of the parking ventilation system should be controlled by CO sensors to claim this measure.

Intention

Mechanical ventilation introduces fresh air into the space. By installing CO sensors in at least 70% of the parking areas, mechanical ventilation shall be switched off when it is not required, thus consuming lesser energy. While the primary benefit of the CO sensors is the reduction of energy bills.

It is recommended that the control system take frequent measurements of CO levels to adjust the ventilation supply to maintain proper indoor air quality.

Approach/Methodologies

No calculations are involved in the assessment of this measure. The improved case assumes that CO sensors are installed on fresh air systems to control the fresh air based on the demand. To claim that this measure has been achieved, the *project team* must demonstrate that the indoor parking areas have CO sensors to control ventilation, covering at least 65% of the building car parking area.

The base case assumption is that the mechanical ventilation in the parking area is provided at a fixed rate.

Potential Technologies/Strategies

The amount of mechanical ventilation can be controlled to only provide fresh air to spaces at the time that it is required. This reduces the energy consumed by the HVAC system. Traditional ventilation systems are designed to provide a constant volume of fresh air based on maximum occupancy. However, at partial occupancy levels, energy is wasted to condition outside air provided through the mechanical ventilation system even when it is not needed. The level of Carbon Monoxide (CO) in the air serves as a useful indicator of the parking area's air quality, and therefore its ventilation needs.

CO sensors are therefore a type of controls based on demand for the mechanical ventilation system, which reduce energy consumption while ensuring good air quality. The savings vary depending on the configuration of the HVAC system. For constant volume air-handling units (AHUs), the savings occur at the primary systems (boilers, chillers, air-conditioners, etc.), while for variable-air-volume (VAV) AHUs, the savings occur not only at the primary systems but also at the terminal boxes that include reheat. The following image explains the way CO sensors operate in both cases:

The following specifications are recommended in National Ambient Air Quality Standards (NAAQS) for the selection of the CO sensor[29]:

1. 8 hr. averaging time: CO level 9ppm
2. 1 hr. averaging time: CO level 35ppm

Relationship to Other Measures

CO sensors are controls for the mechanical ventilation system that can reduce the amount of cooling or heating energy, as well as fan energy, used by the HVAC system as less outside air is moved into the indoor parking area.

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[29] https://www.epa.gov/naaqs/carbon-monoxide-co-air-quality-standards

Compliance Guidance

Preliminary Stage Certification

- HVAC layout drawings showing the location of the CO sensors for the parking ventilation system including the mounting height; and
- Manufacturer specifications of the sensors.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the CO sensors taken during or after installation showing the make and model; or
- Purchase receipts for the CO sensors showing the make and model.

Existing Building Documentation

- The same documentation applicable for ***Post Construction Stage Certification*** may be presented.

EEM27 – Insulation for Cold Storage Envelope

Requirement Summary

To demonstrate effectiveness of highly insulated colds storage areas. This measure applies to retail and industrial typologies.

This measure applies to cold, frozen and fruits & vegetables storage areas, that are reported in the *Area and Loads Breakdown*. For these areas the U-values of the insulating elements shall be entered in the detailed entry of this measure, Figure 39. These U-values shall not be considered as part of EEM05 – Insulation of Roof, EEM06 – Insulation of Ground/Raised Floor Slab and EEM08 – Insulation of Exterior Walls.

Intention

Minimize the energy consumed by refrigeration rooms installed in industrial and retail buildings, to reduce the operational emissions and costs.

Approach/Methodologies

This measure is applicable for Industrial and Retail typologies with frozen/cold/fruits & vegetables storage areas.

The assumed base for cold areas is:

- Internal Wall U-Value: 0.28 W/m^2.K
- External Wall U-Value: 0.28 W/m^2.K
- Floor U-Value: 0.29 W/m^2.K
- Roof U-Value: 0.3 W/m^2.K
- Glass U-Value: 5.75 W/m^2.K
- Glass SHGC: 0.7

For the improved case, project teams must overwrite the default improved case entries shown in Figure 39, as applicable. If the U-values are not provided by the manufacturer, the project team shall calculate them in accordance with the method described in EEM06 – Insulation of Ground/Raised Floor Slab.

Detailed Entry

EEM27 - Insulation for Cold Storage Envelope

	Default Entry	User Entry	
Internal Wall U-Value	0.15		W/m²·K
External Wall U-Value	0.16		W/m²·K
Floor Slab U-Value	0.15		W/m²·K
Roof U-Value	0.15		W/m²·K
Glass U-Value	5.75		W/m²·K
Glass SHGC	0.25		

Figure 39: Detailed entry for EEM27 – Insulation for Cold Storage Envelope.

Potential Technologies/Strategies

The U-value indicates the thermal performance of the following components of the cold storage area:

- Exterior walls
- Internal walls
- Floor slabs
- Roof slabs, and
- Window Glass

A lower U-value will provide greater savings, especially in cooling dominated locations.

Relationship to Other Measures

This measure is only linked to cold/frozen/ fruits & vegetable storage room areas.

This measure does not have a link with EEM28 – Efficient Refrigeration for Cold Storage.

Compliance Guidance

Preliminary Stage Certification

- Plans of the cold storage space highlighting the envelope elements such as types of wall, floor slab, roof, and glass; and
- Detailed drawing(s) showing the materials used in the envelope with U-value specifications; and
- Calculations of U-value for each element; and
- Manufacturer's data sheets for the specified insulation and glass showing the brand and product name and insulating properties.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the envelope elements taken during construction at a point when any insulation materials claimed were visible on site; or
- Purchase receipts showing the installed products.

Existing Building Documentation

- The same documentation applicable for ***Post Construction Stage Certification*** may be presented. If the documents required above are not available, other evidence of construction details, such as existing building drawings shall be submitted.

EEM28 – Efficient Refrigeration for Cold Storage

Requirement Summary

This measure must be claimed if the *building* has refrigeration equipment. To demonstrate energy savings, *project teams* may purchase refrigerated cases, fridges and refrigerators that achieve recognized appliance ratings.

Energy from refrigeration equipment is reflected as refrigeration load in the energy bar plot.

Intention

Minimize the energy consumed by refrigeration equipment installed in the buildings, such as supermarkets and small food retail, to reduce the operational emissions and costs.

Approach/Methodologies

EDGE uses ASHRAE 90.1-2016 commercial Refrigerator and Freezers minimum efficiency requirement table 6.8.1-12 calculation methodology for the base case.

The improved case has the option to model the equipment types as per *ASHRAE 90.1-2016* commercial Refrigerator and Freezers minimum efficiency requirement table 6.8.1-13, also as per table below.

Table 18. Refrigeration Equipment (ASHRAE Table 6.8.1-13)

Equipment Type	Equipment Class
Horizontal Transparent Door Remote Condensing Medium Temperature	HCT.RC.M
Vertical Open Remote Condensing Medium Temperature	VOP.RC.M
Semi Vertical Open Remote Condensing Medium Temperature	SVO.RC.M
Horizontal Open Remote Condensing Medium Temperature	HZO.RC.M
Vertical Transparent Remote Condensing Medium Temperature	VCT.RC.M
Service Over Counter Remote Condensing Medium Temperature	SOC.RC.M
Vertical Open Self Contained Medium Temperature	VOP.SC.M
Semi Vertical Open Self Contained Medium Temperature	SVO.SC.M
Horizontal Open Self Contained Medium Temperature	HZO.SC.M
Vertical Solid Doors Remote Condensing Medium Temperature	VCS.RC.M
Horizontal Solid Doors Remote Condensing Medium Temperature	HCS.RC.M
Vertical Open Remote Condensing Low Temperature	VOP.RC.L
Horizontal Open Remote Condensing Low Temperature	HZO.RC.L
Horizontal Open Remote Condensing Low Temperature	VCT.RC.L
Horizontal Open Self Contained Low Temperature	HZO.SC.L
Semi Vertical Open Remote Condensing Low Temperature	SVO.RC.L
Horizontal Transparent Door Remote Condensing Low Temperature	HCT.RC.L

Equipment Type	Equipment Class
Vertical Solid Doors Remote Condensing Low Temperature	VCS.RC.L
Horizontal Solid Doors Remote Condensing Low Temperature	HCS.RC.L
Service Over Counter Remote Condensing Low Temperature	SOC.RC.L
Vertical Openself Contained Low Temperature	VOP.SC.L
Semi Vertical Open Self Contained Low Temperature	SVO.SC.L
Vertical Transparent Door Self Contained Ice Cream	VCT.SC.I
Vertical Solid Doors Self Contained Ice Cream	VCS.SC.I
Horizontal Transparent Door Self Contained Ice Cream	HCT.SC.I
Vertical Open Remote Condensing Ice Cream	VOP.RC.I
Semi Vertical Open Remote Condensing Ice Cream	SVO.RC.I
Horizontal Open Remote Condensing Ice Cream	HZO.RC.I
Vertical Transparent Door Remote Condensing Ice Cream	VCT.RC.I
Horizontal Transparent Door Remote Condensing Ice Cream	HCT.RC.I
Vertical Solid Doors Remote Condensing Ice Cream	VCS.RC.I
Horizontal Solid Doors Remote Condensing Ice Cream	HCS.RC.I
Horizontal Solid Doors Remote Condensing Ice Cream	HCS.RC.I
Service Over Counter Remote Condensing Ice Cream	SOC.RC.I
Vertical Open Self Contained Ice Cream	VOP.SC.I
Semi Vertical Open Self Contained Ice Cream	SVO.SC.I
Horizontal Open Self Contained Ice Cream	HZO.SC.I
Service Over Counter Self Contained Ice Cream	SOC.SC.I
Horizontal Solid Doors Self Contained Ice Cream	HCS.SC.I

To account for refrigeration equipment loads, by default, EDGE assumes a refrigeration system volume of 10m^3.

Buildings with refrigeration equipment loads shall use the detailed entry option after selecting the measure and enter the project-specific refrigerated volume. Buildings without refrigeration equipment loads are required to enable the measure and enter 0 in the Volume m^3 to completely remove them.

Note 1: The refrigeration equipment load is not linked to any of the cold storage areas defined in the Area Loads Breakdown.

Note 2: Dedicated chiller for cold storage rooms (frozen/cold/fruits & vegetables areas), are not considered refrigeration loads for this measure. These shall be modelled as part of EEM13 – Cooling System Efficiency.

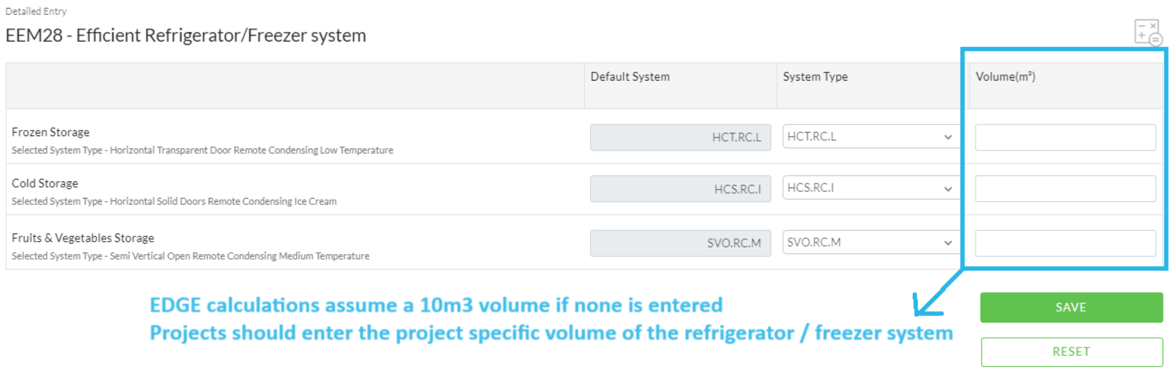

Figure 40. EEM28 Efficient Refrigerator / Freezer System backend assumption.

Potential Technologies/Strategies

Refrigeration equipment is mostly used in supermarkets and small food retail, where up to half of the energy consumption is dedicated to the refrigeration systems (display cases and storage coolers).

Relationship to Other Measures

Claiming this measure reduces energy use for refrigeration equipment only.

This measure does not have a link with *EEM27 – Insulation for Cold Storage Envelope or cold/frozen/ fruits & vegetable storage room modeling*.

Compliance Guidance

Preliminary Stage Certification

- Summary list of the refrigerated cases to be installed in the building, including quantity, energy use, and proof of certification by *Energy Star*, *EU Energy Efficiency Labeling Scheme, Energy Technology Product List (ETL),* or equivalent; and
- Manufacturer's specifications of the refrigerators/freezers.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed refrigerators/freezers showing the make and model; or
- Purchase receipts for the refrigerators/freezers showing the make and model.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM29 – Efficient Refrigerators and Clothes Washing Machines

Requirement Summary

This measure is only applicable to residential typologies (homes and apartment), hotels, resorts, serviced apartments and hospital typologies.

The measure may be claimed if **all** the refrigerators and clothes washing machines installed are energy efficient. If the *building* only has partial installation or partial provision of efficient refrigerators and clothes washing machine, the *project team* cannot claim this measure.

This may be demonstrated by purchasing refrigerators and clothes washing machines that achieve recognized appliance ratings as described in the Approach/Methodologies section below.

Centralized washing machines can be included in this measure if all occupants have access to them and the ratio of home units to washing machines does not exceed 15:1. This guideline does not apply to hotels and resorts.

Note: *Hotel and hospital typologies are available from EDGE App version 3.1 onwards.*

Intention

Minimize the energy consumed by refrigerators and clothes washing machines installed.

Approach/Methodologies

The base case assumes standard refrigerators and clothes washing machines. EDGE uses the following recognized appliance rating systems, but is not necessarily limited to:

- Energy Star rated; or
- Minimum 'A' rating under the EU Energy Efficiency Labelling Scheme; or
- Equivalent level in a comparable rating scheme[30] to the ones above

Figure 41. Example of the Energy Star Rating. Source: https://www.energyrating.gov.au/consumer-information/understand-energy-rating-label

[30] If other rating schemes are used, evidence describing how the refrigerator or clothes washing machine meets or exceeds the equivalent requirements under the Energy Star or EU labelling scheme must be submitted.

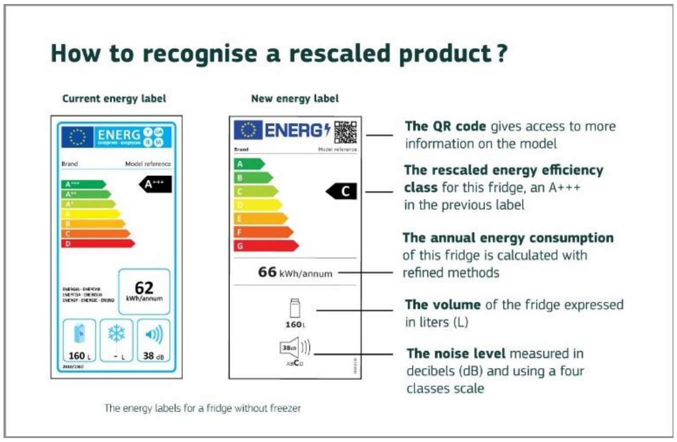

Figure 42. Example of the EU Energy Efficiency Labelling Scheme Source: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_818

This measure may be claimed only if the buildings are fitted with efficient refrigerators and clothes washing machines at the time of certification.

Potential Technologies/Strategies

Table 19. Energy efficient appliances features.

Appliance	Overview	Key Features for Efficiency
Refrigerators 	After heating and cooling, refrigeration appliances are the biggest energy consumption in a household, as they are working continuously.	An efficient refrigerator should: ▪ Be small. Consider refrigerators with a capacity of 14 to 20 cubic feet (>4 people). ▪ Have a high efficiency compressor (350kWh/year or less). ▪ A model with the freezer on top (not a bottom-mounted freezer or side-by-side model). ▪ Not have an automatic icemaker and/or through-the-door ice dispenser. ▪ Have automatic moisture control rather than an “anti-sweat" heater.
Clothes Washing Machines 	About 60% of the energy used by a washing machine goes towards water heating; therefore, models that use less water also use less energy.	Efficient clothes washing machine should: ▪ Be the right size for the house. ▪ Have several wash cycles. ▪ Have improved water filtration. ▪ Have a dryer with a moisture sensor. ▪ Have a model with a high Modified Energy Factor (MEF) and a low Water Factor (WF).

Relationship to Other Measures

Energy reduction due to appliances is expected by both energy efficient refrigerators and clothes washing machines. Clothes washing machines also show reductions in energy due to hot water as well as lower water consumption.

Compliance Guidance

<u>Preliminary Stage Certification</u>

- Summary list of the refrigerators and clothes washing machines to be installed in the building, including quantity, energy use, and proof of certification by *Energy Star*, *EU Energy Efficiency Labeling Scheme, Energy Technology Product List (ETL),* or equivalent; and
- Manufacturer's specifications of the refrigerators and clothes washing machines.

<u>Post Construction Stage Certification</u>

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed refrigerators and clothes washing machines showing the make and model; or
- Purchase receipts for the refrigerators and clothes washing machines showing the make and model.

<u>Existing Building Documentation</u>

- The same documentation applicable for *<u>Post Construction Stage Certification</u>* may be presented. If some of the documents required above are not available, other evidence related to equipment specifications should be submitted.

EEM30 – Submeters for Heating and/or Cooling Systems

Requirement Summary

To claim this measure, the *project team* must demonstrate that dedicated meters for the heating and cooling systems have been installed in at least 70% of the thermally conditioned areas.

Intention

The intent is to reduce the energy used for space conditioning by increasing the awareness of it.

Approach/Methodologies

The Base Case assumes that no submeters are installed. EDGE’s Improved Case assumes 5% savings in the category — Heating, Cooling, or both — for which submeters are installed.

Potential Technologies/Strategies

Installing submeters on individual pieces of equipment or electrical circuits is a simple and standard process. It can assist in measurement and verification of HVAC assets.

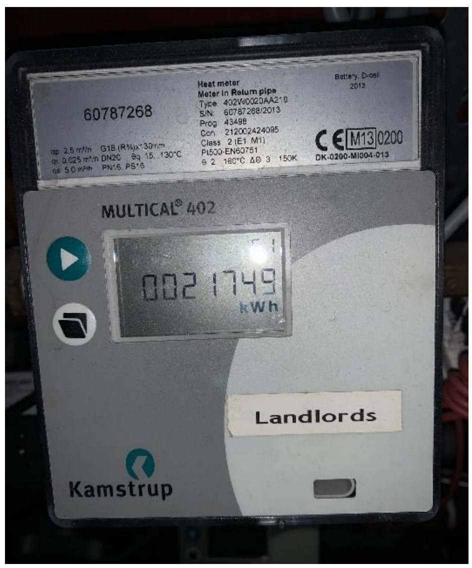

Figure 43: An example of a heat meter dedicated to the landlord-controlled area.

Relationship to Other Measures

This measure is independent and does not have any direct interactions or dependencies with other measures, however, it only has an effect when cooling and/or heating energy exists.

Compliance Guidance

Preliminary Stage Certification

- Electrical drawings/specifications showing the type of electricity meters and the connection with the mains; and
- Manufacturer’s data sheets of the meters; or
- Technical specifications for an equivalent online system.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed meters showing the make and model; or

- Purchase receipts for the meters showing the make and model; or
- Purchase receipts for subscription(s) to an equivalent online system.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented. If some of the documents required above are not available, other evidence of meter details, such as photographs shall be submitted.

EEM31 – Smart Meters for Energy

Requirement Summary

For residential buildings, this measure can be claimed if smart metering is provided in all units of the subproject. The smart meter must display usage data for the last hour, last day, last 7 days, and last 12 months, and a display with offline capabilities must be accessible within each unit.

For non-residential buildings, owners may either subscribe to an online monitoring system or install an Energy Information System (EIS) capable of storing, analyzing, and displaying hourly energy meter data. While public display of the data is optional, storing at least three years of energy-related data is mandatory to claim this measure. This measure does not apply to Core & Shell *subprojects*.

Note that this measure cannot be claimed when 'prepaid meters' are installed as they are not considered smart meters under EDGE.

Intention

In residential *subprojects*, the objective is to decrease energy demand by promoting greater awareness of energy consumption. Smart meters enable end-users to gain a better understanding of their energy usage and actively participate in responsible energy management within the building. These meters can display measurements and provide recommendations to facilitate informed decision-making.

In non-residential buildings, the benefits of installing EIS include better demand-side management, improving equipment performance by signaling the need for preventive maintenance or repairs and optimizing operational efficiency.

Approach/Methodologies

By installing smart meters in a residential building, end-users gain access to real-time feedback that can lead to energy savings of up to 3%. Smart meters provide a more detailed breakdown of energy consumption compared to conventional meters, enabling users to identify areas for improvement. The base case assumes the use of conventional meters, while the improved case involves the installation of smart meters with display in each residential unit.

Figure 44: Clamp on power meter.

To be eligible for claiming this measure in non-residential buildings, except Core & Shell, it is required that the building is equipped with an Energy Information Systems (EIS) capable of storing, analyzing and displaying energy hourly meter data. The EIS shall cover the main energy consuming systems and at least 80% of the electricity consumption of the *building or* tenant space, for the case of owner-occupied subprojects. The installation the EIS must be completed at the time of certification. The presence of an EIS helps to track energy use, identify energy-saving opportunities, communicate energy metrics with occupant and allow measurement and verification (M&V) reporting.

Technologies/Strategies

Residential: Smart metering is designed to provide occupants with information on a real-time basis about their domestic energy consumption. This may include data on how much electricity they are consuming, the costs, and the impact of their consumption on greenhouse gas emissions.

In order to qualify for this measure, it is necessary for all meters to have the capability to measure and display on screen the energy consumption on an hourly, weekly, or monthly basis. Meters may be accessed online but must also have offline capabilities for areas with low / poor internet connectivity.

Nonresidential typologies: Energy Information Systems (EIS) and Building Management Systems (BMS) offer significant benefits for optimizing building operations. EIS provides real-time monitoring of energy consumption, enabling cost savings, improved decision-making, and enhanced sustainability through detailed analytics and predictive maintenance. BMS enhances operational efficiency by automating control of HVAC, lighting, and security systems, leading to reduced energy use, lower operational costs, and improved occupant comfort and productivity. Both systems support data-driven decision-making, scalability, and remote monitoring, contributing to more sustainable, efficient, and intelligent building management.

For best results it is recommended that separate smart meters be used for different end-uses, e.g., lighting, cooling, heating, hot water, and plug loads.

Advanced or High-energy performance Building Automation and Control (BAC) may claim savings in **EEM34 – Additional Energy Savings Measures** as an SRR by following the method 1 (detailed) or method 2 (factor-based) described in BS EN ISO 52120-1:2022 instead of this measure.

Relationship to Other Measures

The energy savings from the measure are reflected in a fixed percentage reduction across the various energy use. This measure increases end user awareness, which in the long term can help to significantly reduce energy consumption from appliances, heating, cooling, and hot water.

Compliance Guidance

Preliminary Stage Certification

- Electric drawings/specifications showing the make and model of the smart energy meters and the connection with the electric system; and
- Manufacturer's data sheets of the meters; or
- Technical specifications for an equivalent online system.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed meters showing the make and model; or
- Purchase receipts for the meters showing the make and model; or
- Purchase receipts for subscription(s) to an equivalent online system.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM32 – Power Factor Corrections

Requirement Summary

This measure may be claimed when power factor correction devices, such as voltage stabilizers, are installed on the incoming current into the building.

Intention

Power factor correction (PFC) refers to a set of techniques employed to enhance the power factor and power quality of a device or system. The primary objective of PFC is to improve energy efficiency and reduce electricity expenses by adjusting the power factor to a value closer to 1. By doing so, PFC minimizes reactive power and optimizes the utilization of electrical power, resulting in reduced energy losses and improved overall system performance.

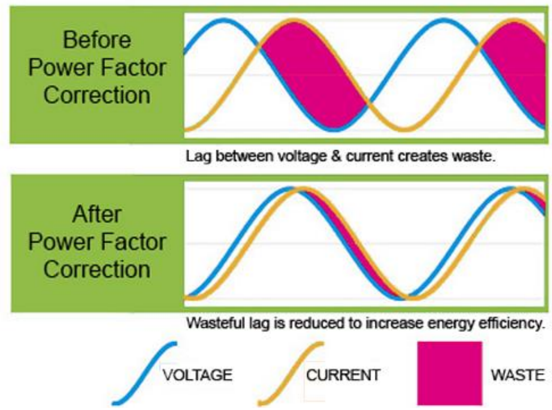

Figure 45. Effect from using a Power Factor Correction Device

Approach/Methodologies

EDGE assumes that power correction devices improve the performance of the electrical equipment by improving the quality of power delivered.

Potential Technologies/Strategies

Several types of power correction devices are available. These include:

- **Capacitors**: Capacitor banks are the most common power factor correction devices. They introduce reactive power to the system, which compensates for lagging (inductive) loads and improves the power factor.
- **Static Var Generator (SVG):** When the load is generating inductive or capacitive current, it makes load current lagging or leading the voltage. SVG detects the phase angle difference and generates leading or lagging current into the grid, making the phase angle of current almost the same as that of voltage on the transformer side, which means fundamental power factor is unit.
- **Synchronous Condensers:** Synchronous condensers are rotating machines that can provide or absorb reactive power as needed. They act as a source or sink of reactive power and are particularly useful in high-power applications.
- **Passive Filters:** Passive filters consist of combinations of inductors, capacitors, and resistors that are tuned to specific frequencies to filter out harmonic currents and improve the power factor.
- **Tuned Harmonic Filters:** These filters are designed to target specific harmonic frequencies in the system, helping to mitigate harmonic distortion and improve power factor simultaneously.
- **Thyristor Switched Capacitors (TSCs):** TSCs use thyristor switching to connect or disconnect capacitor banks, allowing for precise and fast power factor correction.
- **Detuned Reactors:** Detuned reactors are designed to limit the flow of harmonic currents without affecting the fundamental frequency power factor. They may be used in combination with capacitors for harmonic filtering.
- **Active Harmonic Filters:** These devices actively monitor the harmonic currents in the system and inject equal and opposite harmonic currents to cancel out harmonics, while also contributing to power factor correction.

Note: *A surge protector is not considered as a solution / strategy for this measure.*

Relationship to Other Measures

This measure does not impact other measures in EDGE.

Compliance Guidance

<u>Preliminary Stage Certification</u>

- Electrical drawings/specifications including the make and model of the power factor correction devices; and
- Manufacturer's specifications of the power correction devices.

<u>Post Construction Stage Certification</u>

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed power factor correction devices showing the make and model; or
- Purchase receipts for the power factor correction devices showing the make and model.

<u>Existing Building Documentation</u>

- The same documentation applicable for *<u>Post Construction Stage Certification</u>* may be presented.

EEM33 – Onsite Renewable Energy

Requirement Summary

This measure may be claimed if a renewable source that generates electricity — such as solar photovoltaic (PV) panels, Wind Turbine, Small Hydro or other[31] — is used to displace fossil-fuel-based energy and if the energy generated from it is used for operation of the building. The renewable energy source must be located within the *project perimeter* — i.e., installed on the building or on-site — to claim savings.

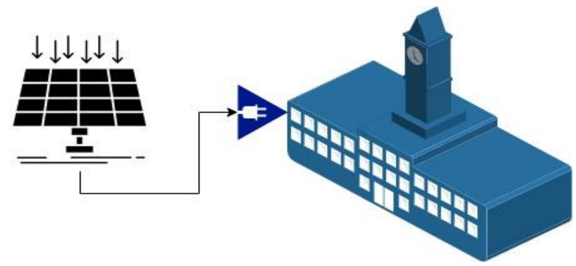

Figure 46: Renewable Energy located nearby.

Alternatively, *Buildings* with dedicated nearby renewable energy facilities may claim the on-site renewable energy measure in EDGE. The renewable energy source must be either directly or community owned. An example of this is when solar panels are installed at a nearby site specifically to serve a particular *building*[32].

The amount of renewable energy for the *building* must be measurable and/or metered.

If claimed, this measure must be implemented only after EEM01 to EEM32 and *EEM34 Other Energy Saving Measures*.

Intention

The intent of this measure is to reduce the use of electricity generated from fossil fuels such as coal and gas. The use of renewable energy reduces the primary energy, e.g. combustion of fossil fuels, required to produce electricity and its resulting emissions. For example, installing solar photovoltaic panels reduces the amount of electricity required from the grid.

Approach/Methodologies

To claim this measure, the *project team* shall indicate the percentage of electricity demand offset with renewable energy generated on-site, expressed as a percentage of the annual electricity use of the improved case that is met by the renewable system. The inputs shall be accessed from the detailed entry table, as showed in Figure 50

The total annual electricity consumption of the improved case is calculated automatically by EDGE. The project team must be able to demonstrate that the renewable electricity source can deliver at least the percentage of electricity consumption claimed by the *project team*.

When an entire development is being certified in one phase, the renewable electricity source can be centralized to serve multiple buildings or dwellings within the development. In such cases, the renewable energy generation must be located within the *project boundary* or be owned and managed by a company controlled by the site owner. For projects divided into multiple *subprojects*, the annual renewable energy must be calculated and then divided by the total annual electricity consumption of all subprojects. This resulting value can be used across the entire project to determine the annual energy use offset for each subproject.

Please notice that EDGE only reduces the electricity component in a subproject (refer to calculations in Figure 48 and Figure 49).

[31] For a full definition, consult BS EN ISO 52000-1:2017 3.4.10 renewable energy.

[32] BS EN ISO 52000-1:2017 defines three types of locations: on-site, nearby and distant.

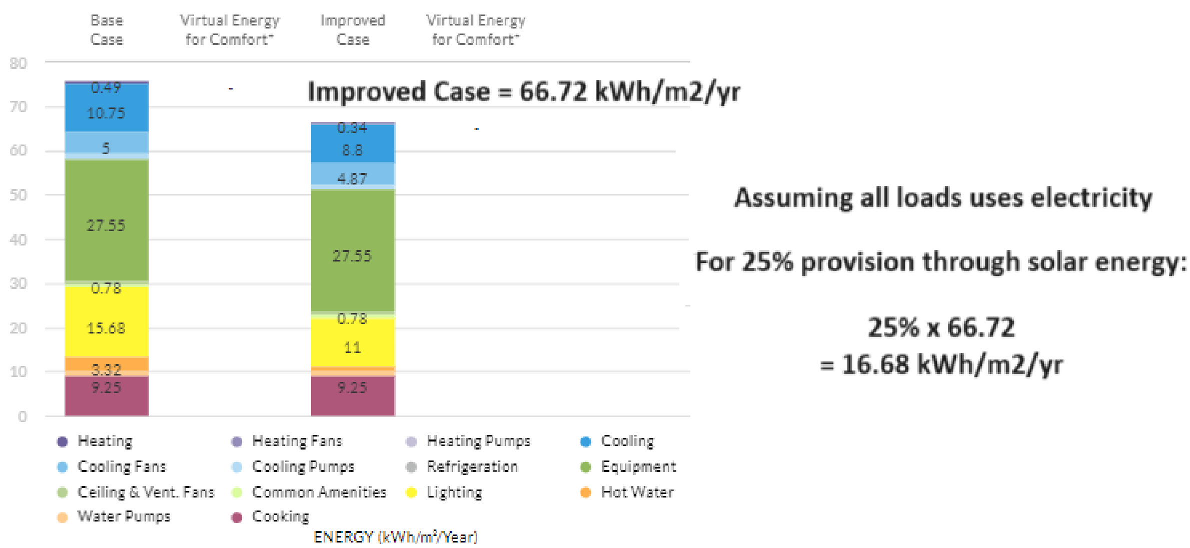

Figure 48. EEM33 Renewable Entry Calculations for buildings with only Electricity usage

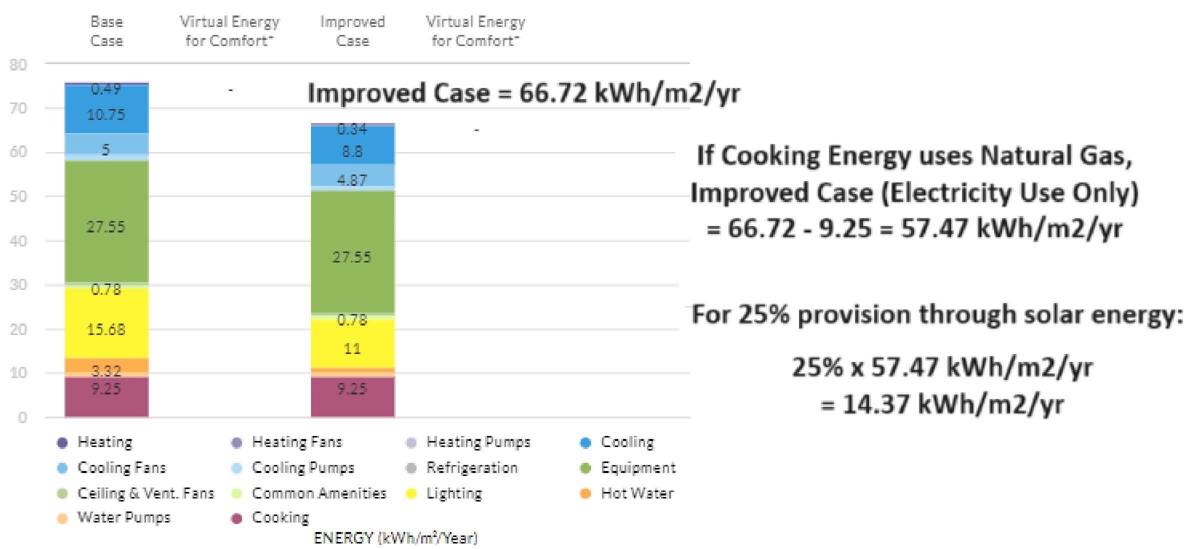

Figure 49. EEM33 Renewable Energy Calculations for buildings with Electricity and Natural Gas (for cooking loads)

<u>*Nearby Renewable Energy (Shared Facilities)*</u>

Project teams claiming this measure energy using nearby renewable sources (i.e., outside the *building site*) must demonstrate ownership and control of the renewable energy system. This can be done by either owning the system or having a long-term contract of at least 15 years for purchasing the renewable energy.

If dedicated building submetering is not available, the project team must adopt a worst-case scenario allocation method and claim the minimum expected provision of renewable energy over the next 15 years.

To meet the intention of the renewable energy measure, the allocation method for estimating the minimum expected provision must be:

- **Documented**: Clearly document the chosen allocation method and the rationale behind it.
- **Transparent**: Ensure that all stakeholders understand and agree to the allocation method.
- **Verifiable**: Maintain records and data to verify that the allocation method is being applied correctly and consistently.

Potential Technologies/Strategies

Solar PV Panels

Many types of solar photovoltaic systems are available, and different technologies convert solar energy into electricity with varying levels of efficiency. Design teams should ensure that the specified system achieves the maximum efficiency possible for the available capital.

In the case of homes and apartment typology, the greyed out Annual Energy Use field corresponds to the Annual Energy Use (from Renewable Energy) per home/apartment unit, which includes the energy consumption of common areas allocated to each unit.

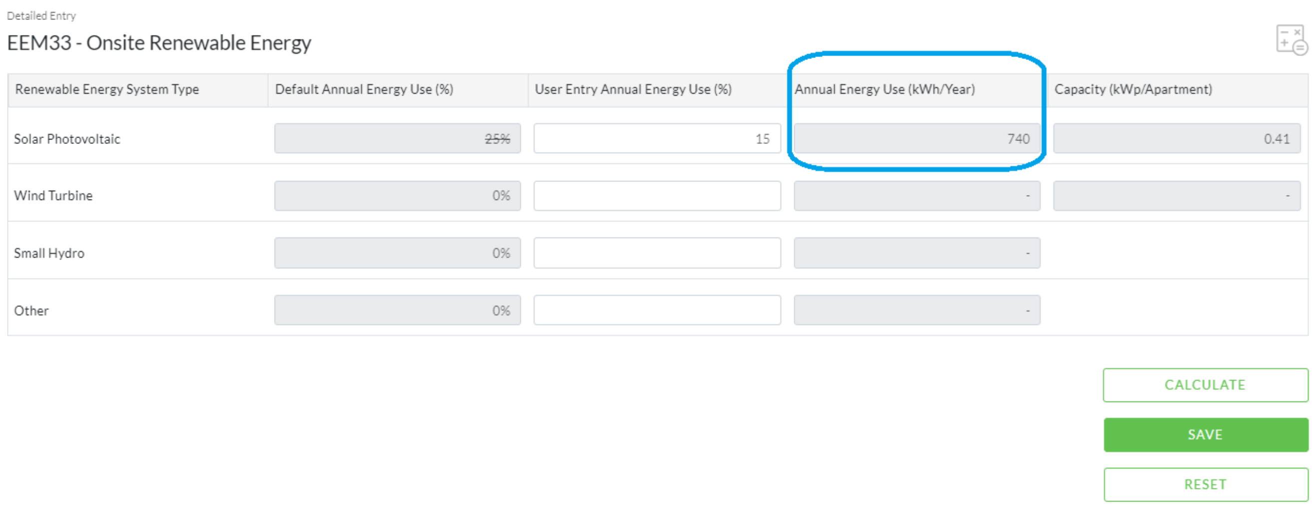

Figure 50. EDGE App calculator - Annual Energy Use (from Renewable Energy) per Apartment

Note 1: *It is possible to use the global solar atlas (https://globalsolaratlas.info/map) and PVWatts (https://pvwatts.nrel.gov/pvwatts.php) to model the required capacity in more detail.*

Note 2: *Please be aware that the percentage of savings is applied on the electricity use of the building. Which heavily depends on your fuel selection, rather than in the total EPI or EUI.*

Note 3: *When using multiple typologies in residential typologies, all metrics are given for the entire subproject. Except for the case of single typology in homes, where metrics are given in terms of units.*

Note 4: *For the case of residential typologies that have individual meters, the installed capacity of on-site electricity generation shall be capable of feeding into the grid to account for the entire capacity.*

Wind Turbine

Small wind turbines ranging in size from 400 watts to 20 kilowatts can be operated on buildings in suitable locations with sufficient wind speeds and local codes that allow wind turbines to be installed locally.

It is possible to use the global wind atlas (https://globalwindatlas.info/en) to model energy yield of the wind turbines.

Small hydro

Small hydro is the development of hydroelectric power on a scale suitable for local community and industry, or to contribute to distributed generation in a regional electricity grid. Exact definitions vary, but a "small hydro" project is less than 50 megawatts (MW), and can be further subdivide by scale into "mini" (<1MW), "micro" (<100 kW) or "pico" (<10 kW).

Other

If the *building* uses other renewable energy sources that also generate electricity, the *project team* may claim savings using EDGE app calculator by selecting “others”, e.g. hydrogen energy and fuel cells.

Project teams using non-electricity renewable sources, for e.g., biomass, for on-site energy generation, may claim savings using EEM34 – Additional Energy Savings Measures.

Relationship to Other Measures

To maximize the percentage contribution from renewable sources of electricity, the electricity demand must first be minimized by reducing energy consumption.

Compliance Guidance

Preliminary Stage Certification

- Briefly describe the system type
- Supporting calculation showing the proposed system will deliver sufficient electricity to achieve the claimed proportion of total demand, including product efficiency and system size; and
- Manufacturer’s data sheets for the proposed system including peak and average production wattage.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and
- Date-stamped photographs of the installed system; or
- Purchase receipts of the system; or
- Contract with the energy management company if the system is owned by a third party.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM34 – Additional Energy Savings Measures

Requirement Summary

This measure may be used to claim energy savings from strategies and technologies that are not included in the list of EDGE measures. The *project team* must file a Special Ruling Request (SRR) to get approval to claim the savings.

If claimed, this measure must be implemented, after EEM01 to EEM32 and before *EEM33 Onsite Renewable Energy*, *EEM35 Offsite Renewable Energy Procurement* and *EEM36 Carbon Offsets.*

Intention

The intent of this measure is to invite *project teams* to save energy using strategies and technologies beyond the measures listed in EDGE.

Approach/Methodologies

The specific approach would depend on the strategies and technologies applied. But in every case, the *project team* must provide the following:

1. Describe the Base Case and Improved Case scenarios for a specific *subproject* with evidence.
2. Provide the evidence and calculations that demonstrate the expected savings.
3. Present the resulting savings:
    a. In the form of kWh/m^2/year savings; and
    b. As a percentage of the annual energy use, by the applicable types (e.g., hot water savings, cooling savings, etc.).

Users can consult the **Part 1 – Building Certification Guidance** (or equivalent) document for detailed guidance as to what constitutes a valid case for an SRR, or how to use it for claiming savings derived from dynamic simulation results.

Potential Technologies/Strategies

These will be based on the energy saving strategy deployed.

Compliance Guidance

Preliminary Stage Certification

- Drawings showing the design intent; and
- Evidence and calculations showing the percentage of energy savings compared to the EDGE baseline; and
- Approved SRR documentation from IFC.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the documents to clearly reflect As-Built conditions; and/or
- Date-stamped photographs of the installed system; and/or
- Purchase receipts of the system; and/or
- Contract documents if the system is owned by a third party; and
- Approved SRR documentation from IFC.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM35 – Offsite Renewable Energy Procurement

Requirement Summary

The measure may be claimed if a long-term contract (e.g., 15 years or more) has been signed for the procurement of new off-site renewable energy that is specifically allocated for the *building*. Renewable energy is assumed as carbon-free energy that is generated without the use of fossil fuels, such as that sourced from solar, wind, geothermal, aerothermal, hydrothermal and tidal, hydropower, or biomass resources[33]. This measure can be claimed once the subproject achieves at least 40% energy savings and does not contribute to additional energy savings, but it reduces the total Operational CO_2 of the *subproject*.

If claimed, this measure must be implemented, after EEM01 to EEM34 and before *EEM36 Carbon Offsets.*

Intention

Investment in off-site renewable energy supports the creation of new clean energy resources on the electrical grid. This allows *project teams* to access renewable energy even if they are in a dense urban environment and do not have sufficient open space or solar access to generate energy on site. Supporting off-site renewable energy can accelerate the reduction of greenhouse gas emissions associated with the energy sector. Additionally, by increasing renewable energy capacity on the grid, these resources may become more accessible or affordable for a greater number of electricity consumers.

Refer to the current **Part 1 – Building Certification Guidance** for eligible offsite renewable providers.

Approach/Methodologies

To claim this measure, the design team must specify the quantity of off-site renewable energy that was contractually procured for the *building*. If an entity associated with the *building* has already made general procurements of off-site renewable energy at an organization level, it must be demonstrated that a specific allocation was made for the exclusive use of the building. Off-site renewable energy procurements are typically transacted in blocks of energy units over the course of a year, such as kilowatt hours or equivalent BTU of electricity. When off-site renewable energy procurements are entered into the EDGE app, the quantity is compared to the annual electricity use to give a percentage offset in the net carbon emissions plot, Figure 51.

[33] For a full definition, consult BS EN ISO 52000-1:2017 3.4.10 renewable energy.

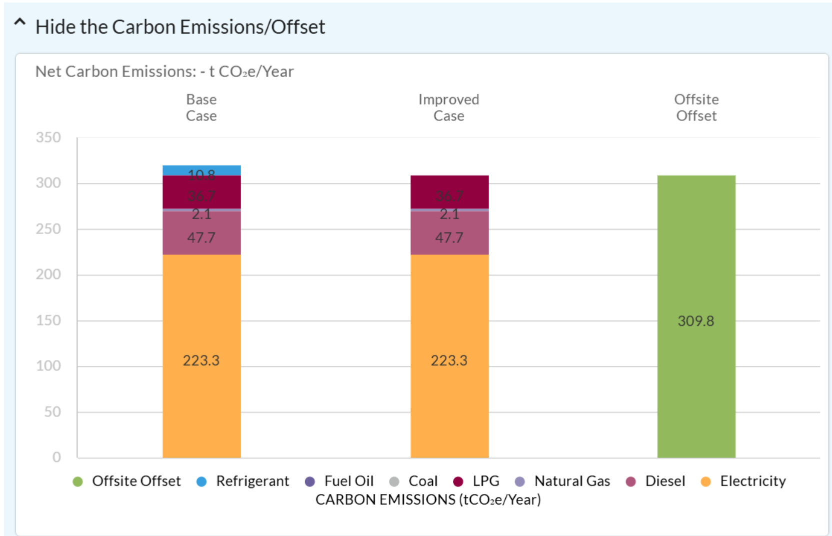

Figure 51: Off-site electricity is reflected in the net carbon emissions plot.

Potential Technologies/Strategies

Off-site renewable energy may be procured from a variety of sources that are typically regionally dependent. In some countries, utility providers have established formal programs to support renewable energy development through a premium rate that is charged directly to the consumer's electricity bill, known as "green power" purchasing. Alternatively, third-party providers may have established individual projects or other community-based cooperatives to allow collective procurement of renewable energy at the local level. Where regional renewable energy resources do not exist, *project teams* may also consider procurement of renewable energy certificates (RECs) or other transferrable credits that may be sourced from a broader range of locations. These credits essentially transfer the value of renewable energy generated from the system owner to a consumer on the open market.

Project teams should refer to their local jurisdiction or regulatory authority for a definition of acceptable forms of renewable energy.

Relationship to Other Measures

Off-site renewable energy procurements may be made in combination with other measures that reduce the use of fossil fuel or carbon-based energy resources for building construction and operations. These may include energy efficiency measures that improve the passive performance of a building, such as increased insulation or higher efficiency glass; the reduction of fossil fuel energy use in active systems, such as through high efficiency equipment; or the replacement of fossil-fuel based electricity from the grid with on-site generated renewable energy. The goal of combining these energy use reduction and replacement measures would be to utilize renewable energy for all energy demands on site.

Compliance Guidance

The design team must be able to provide documentation of the origin and type of off-site renewable energy procurements, including the name of the provider. This documentation must include a copy of a signed contract or other formal agreement to confirm allocation of the of the off-site renewable energy.

Note: *Off-site renewable energy procurements must be associated with new projects that are retired from the market after the energy is procured.*

Preliminary Stage Certification

No documentation is required at the design stage.

Post Construction Stage Certification

- Copy of contract or other formal document stating the quantity and term of renewable energy provided to the project; and
- Description of the form of renewable energy that is procured and its origin or project name; and
- Documentation that it meets the definition of any applicable local authority.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM36 – Carbon Offsets

Requirement Summary

The measure may be claimed if a contract has been signed for investment in a carbon offset project. Carbon offsets represent funding for third-party action to reduce or recapture carbon emissions that would otherwise be emitted to the atmosphere. This measure can be claimed once the subproject achieves at least 40% energy savings and does not contribute to additional energy savings, but it reduces the total Operational CO_2 of the *subproject*.

Eligible carbon offsets projects, compliance guidance and contract conditions shall align with ***Part 1 – Building Certification Guidance***.

If claimed, this measure must be implemented after EEM01 to EEM35.

Intention

Investing in carbon offsets reduces the net impact of building construction and operations on the atmosphere. By putting a value on carbon emissions reduction, the market is incentivized to implement additional measures to mitigate carbon emissions impact.

Approach/Methodologies

To claim this measure, the design team must specify the amount of carbon offsets that have been procured with a signed contract. Typically, each carbon offset unit represents the mitigation of one metric ton of carbon dioxide or equivalent greenhouse gas. When carbon offsets are claimed in the EDGE app, the offset value is compared to the total estimated carbon emissions of the improved case in order to calculate the total offset percentage.

Eligible carbon offsets projects and contract conditions shall align with ***Part 1 – Building Certification Guidance***.

Potential Technologies/Strategies

Many different carbon offset products are available from providers that represent projects across a range of sectors and regions. While the most common carbon offset projects are related to funding new renewable energy installations, such as solar or wind energy, several other projects are available related to energy efficiency upgrades, methane or carbon capture and sequestration and forestry restoration. The EDGE tool does not make restrictions on the type or origin of carbon offsets, though project teams may choose to procure specific offset products based on their desired impact (e.g. support clean energy development) or a preference for locally based projects. While the EDGE tool recognizes carbon offsets equally based on the equivalent metric tons of CO_2, the cost of individual carbon offsets may vary depending on regional availability and project type.

Relationship to Other Measures

Carbon offsets may be applied in combination with other measures that reduce the emissions associated with building construction and operations. These may include energy efficiency measures that improve the passive performance of a building, such as increased insulation or higher efficiency glass; the reduction of fossil fuel energy use in active systems, such as through high efficiency equipment; or the replacement of fossil-fuel based electricity from the grid with on-site generated or off-site procured renewable energy. Together, carbon reduction measures may be combined with carbon offsets to achieve Zero Carbon for the building.

Compliance Guidance

The design team must be able to provide documentation of the origin and type of carbon offset procured, the organization issuing the offset, and evidence of third-party verification by the appropriate regulatory authority. Finally, a copy of a signed contract must be provided to confirm execution of the carbon offsets.

Project teams must revise ***Part 1 – Building Certification Guidance*** for additional compliance guidance.

Preliminary Stage Certification

No documentation is required at the design stage.

Post Construction Stage Certification

- Documentation of the carbon offset provider, stating formal certification or other third-party verification by an appropriate authority; and
- Description of carbon offset project, including the methods by which carbon reductions are made; and
- Copy of contract or other formal document stating the number of offsets procured in equivalent metric tons of CO_2.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

EEM37 – Low Impact Refrigerants

Requirement Summary

The measure may be claimed if a *building* is using refrigerants with low Global Warming Potential. This measure does not contribute to additional energy savings, but it reduces the Refrigerant Global Warming Potential of the *subproject*. This measure can be claimed once the subproject achieves at least 40% energy savings.

Intention

Conventional refrigerants have high Global Warming Potential (GWP), and refrigerants that end up in the atmosphere through leakage or mismanagement at the end of life have a disproportionate impact on global warming. The intent of this measure is to reduce the amount of conventional refrigerants being used in buildings. GWP is measured using a 100-year value for comparison, where the 100-year GWP of carbon dioxide (CO_2) is taken as 1. The GWP of the most commonly used refrigerant used today, R-22, has almost 2,000 times the potency of carbon dioxide. So, just one pound (about half a kilogram) of R-22 is nearly as potent as a ton of carbon dioxide in its ability to cause global warming.

Approach/Methodologies

To claim this measure, the design team must describe the system sizes (kW), their refrigerant type, refrigerant charge (kg/KW), and leakage (%) in the detailed entry in the EDGE App. This measure only impacts the carbon emissions from refrigerants, as shown in Figure 52.

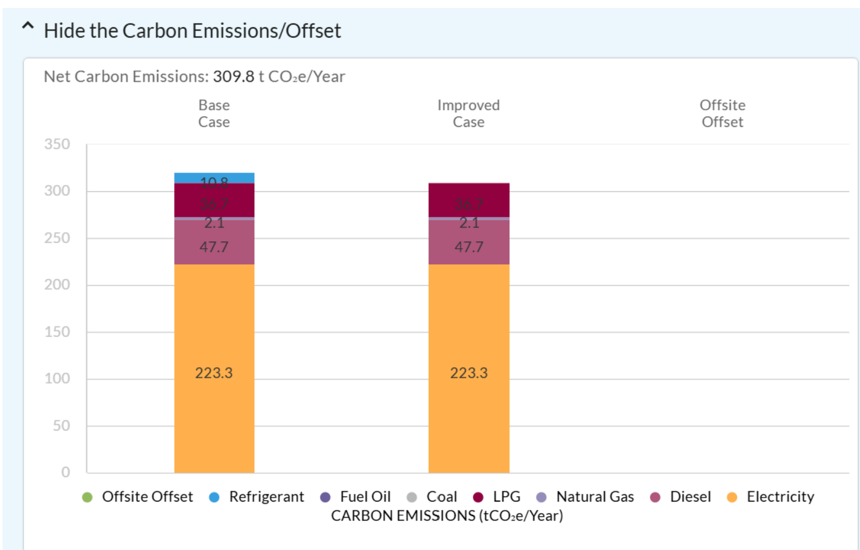

Figure 52: Carbon emissions reductions due to low impact refrigerants.

Potential Technologies/Strategies

Potential solutions include:

1. The replacement of HCFCs and HFCs-based systems and materials with the ones using substances with low GWP (with 100-year GWP values below 700) for mechanical systems utilizing refrigerants, such as air-conditioning systems or cold storage in retail stores and warehouses. For example, in the refrigeration and air conditioning systems, refrigerant alternatives may include: HFOs, blended HFCs, ammonia, and CO_2 (it might be noted that changing a refrigerant may require changing the refrigeration system itself).
2. Not-In-Kind (NIK) solutions, such as an improved system design that reduces refrigerant use, evaporative coolers (swamp coolers) that do not use refrigerants (because the water acts as a coolant); and

3. Effective maintenance procedures to minimize leakage.

Table 20 provides a quick reference of GWP of the refrigerants that may be used for air conditioning, heating-only heat pumps, and mechanical refrigeration.

Table 20: Refrigerant and their associated GWP

Refrigerant Types	Refrigerant Name	Refrigerant Charge	GWP
-	-	kg/kW	-
CFC	CFC-11	0.01	4,660.00
CFC	CFC-12	0.00	10,200.00
CFC	CFC-13	0.01	5,820.00
HCFC	HCFC-22	0.07	1,810.00
HCFC	HCFC-141b	0.04	782.00
HCFC	HCFC-142b	0.06	1,980.00
Blend	R-404A	0.13	3,922.00
Blend	R-407C	0.30	1,774.00
Blend	R-410A	0.25	2,088.00
Blend	R-432A,B,C	0.63	3.00
Blend	R-436A, B	0.98	3.00
Blend	R-444A	1.15	92.00
Blend	R-446A	1.12	460.00
Blend	R-447A	0.88	582.00
Blend	R-448A	0.37	1,387.00
Blend	R-449A	0.37	1,397.00
Blend	R-449C	0.41	1,251.00
Blend	R-450A	0.86	601.00
Blend	R-451A	0.85	140.00
Blend	R-451B	0.85	150.00
Blend	R-452A	0.24	2,140.00
Blend	R-452B	0.74	698.00
Blend	R-452C	0.23	2,220.00
Blend	R-454A	1.10	239.00
Blend	R-454B	1.10	466.00
Blend	R-454C	0.86	148.00
Blend	R-455A	0.86	148.00
Blend	R-456A	0.75	687.00
Blend	R-457A	0.76	139.00
Blend	R-459A	1.12	460.00
Blend	R-459B	1.12	144.00
Blend	R-460A	0.24	2,103.00
Blend	R-460B	0.38	1,352.00
Blend	R-463A	0.34	1,494.00
Blend	R-465A	0.14	145.00
Blend	R-466A	0.70	733.00
Blend	R-513A	0.81	631.00
Blend	R-513B	0.86	596.00
Blend	R-516A	0.00	141.00

Refrigerant Types	Refrigerant Name	Refrigerant Charge	GWP
HFC	HFC-134a	1.15	1,430.00
HFC -	HFC-32	0.76	675.00
HC	R-441A	0.86	6.00
HC	Propane (HC-290) (R-290)	0.07	3.00
HC	HC-1270	0.03	3.00
CO2	CO2 (Carbon Dioxide) (R-744)	0.19	1.00
HFO	HFO-1234yf	0.58	4.00
HFO	HFO-1234ze	0.37	1.00
HFO	HFO-1234zd	0.30	5.00
HFO	HFO-1336mzz	0.30	9.00
Water	R-718(Water)	1.00	-
NH3	R-717(Ammonia)	-	-

Relationship to Other Measures

Low-impact refrigerants, often referred to as environmentally friendly refrigerants, have a significantly lower global warming potential (GWP) compared to traditional refrigerants like CFCs, HCFCs, and HFCs. By using these refrigerants, we can reduce greenhouse gas emissions and mitigate climate change.

Compliance Guidance

Preliminary Stage Certification

- Documentation of the proposed system sizes for all equipment types in the *building* that use refrigerants including refrigerators, freezers, or air conditioning systems, and
- The types and amounts of refrigerant charge for these systems; and
- The associated global warming potential.

Post Construction Stage Certification

- Documents from the design stage if not already submitted. Include any updates made to the design stage documents to clearly reflect as-built conditions; and
- Date-stamped photographs of the system or
- Purchase receipts of the system and refrigerants.

Existing Building Documentation

- The same documentation applicable for *Post Construction Stage Certification* may be presented.

Annex 1: Solar Hot Water Energy Calculation

Two methods for generating hot water using solar energy are described:

1. **Solar Thermal Hot Water Systems**: These systems use solar energy directly to heat the water.
2. **PV-Based Solar Water Systems**: These systems first convert solar energy into electricity, which is then used to heat the water.

Solar Thermal Hot Water System

To calculate the contribution of a solar hot water system:

1. **Determine the Effective Area of Solar Collectors:**
    a. For flat plate collectors, use the actual aperture area of the flat plate.
    b. For evacuated tube collectors, use the effective tube area, if not available, multiply the total tube area (tube # x Length of tube X Circumference of tube) by a factor of 0.6.
2. **Calculate the Solar Energy Contribution (Q_{solar}):**
    a. Use the formula: $Q_{solar} = Area * I * \eta * f_{match}$
    b. Where:
        i. $Area$ is the effective area of the solar collectors (m²).
        ii. I is the solar irradiance on the collector surface (kWh/m²/year) using the global horizontal irradiation from the Global Solar Atlas (https://globalsolaratlas.info/map).
        iii. η is the efficiency of the solar collector (dimensionless, expressed as a decimal). If not available by the manufacturer, assume:
            1. Flat Plate Collector Efficiency: 40%,
            2. Evacuated Tube Collector Efficiency: 50%.
        iv. f_{match} is the matching factor as defined in ISO 52000-1, if not calculated. Assume the following:
            1. for systems with storage capable of meeting daily water demand, $f_{match} = 1.0$,
            2. for instant systems, $f_{match} = 0.2$
3. **Divide Q_{solar} by the Gross Internal Area (GIA):**
    a. This step normalizes the solar energy contribution by the size of the building, making it comparable with total Domestic Hot Water Energy in the bar plot.
    b. Use the formula: $EPI_{solar\ hot\ water\ system} = \frac{Q_{solar}\left(\frac{kWh}{year}\right)}{GIA\ (m^2)}$
    c. The resulting value is the $EPI_{solar\ hot\ water\ system}$ in kWh/m^2/year
    d. Note that the GIA value used here must align with the GIA value used for $EPI_{Improved\ case\ COP=1}$ to ensure consistency in the calculation.

The PV-based Hot Water System Contribution Calculation

To calculate the contribution of an electricity-based hot water system:

1. **Determine energy generation from the PV system in ideal conditions ($Q_{solar\ before\ matching\ factor}$):**

    a. Use the PVWatts calculator (https://pvwatts.nrel.gov/pvwatts.php) to estimate the energy contribution, Figure 53. If efficiency is not provided by the manufacturer, use the default system losses.

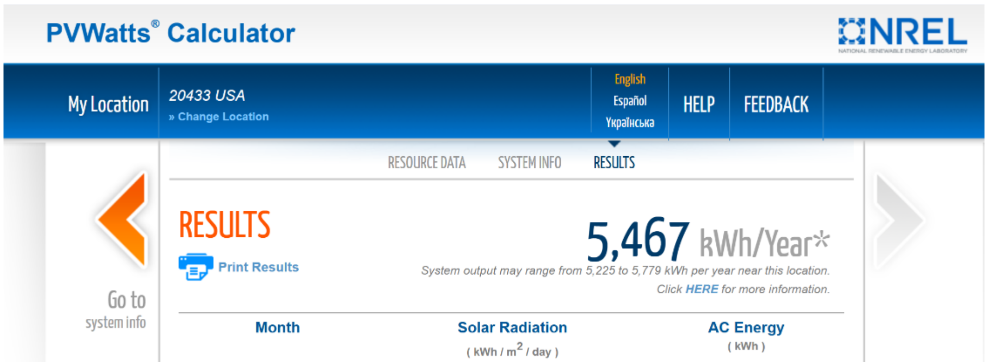

Figure 53: PVWatts calculator results example.

2. **Multiply by a matching factor:**

    a. Use the formula: $Q_{solar} = Q_{solar\ before\ matching\ factor} * f_{match}$

    b. f_{match} is the matching factor, as defined in ISO 52000-1, if not calculated. Assume the following:

        1. for systems with storage capable of meeting daily water demand, $f_{match} = 1.0$,

        2. for instant systems, $f_{match} = 0.2$

3. **Divide Q_{solar} by the Gross Internal Area (GIA):**

    a. Use the formula: $EPI_{solar\ hot\ water\ system} = \frac{Q_{solar}\left(\frac{kWh}{year}\right)}{GIA\ (m^2)}$

    b. This step normalizes the solar energy contribution by the size of the building, making it comparable with total Domestic Hot Water Energy in the bar plot.

    c. The resulting value is the $EPI_{solar\ hot\ water\ system}$ in kWh/m^2/year

    d. Note that the GIA value used here must align with the GIA value used for $EPI_{Improved\ case\ COP=1}$ to ensure consistency in the calculation.

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