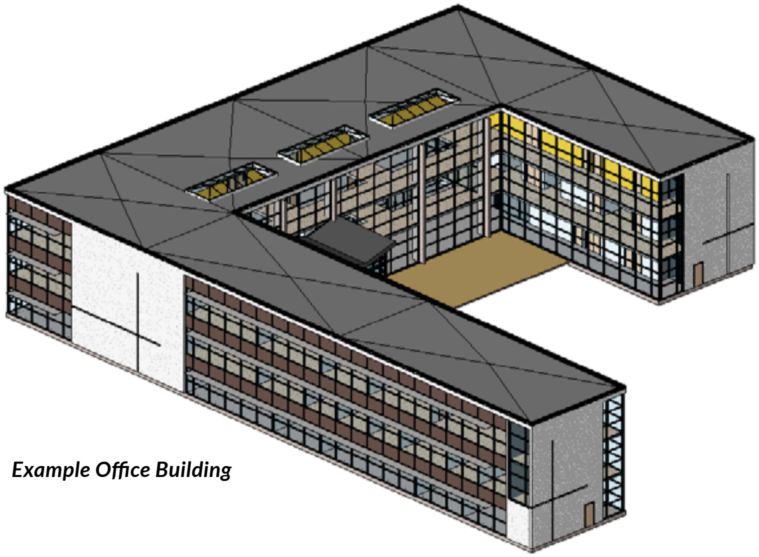
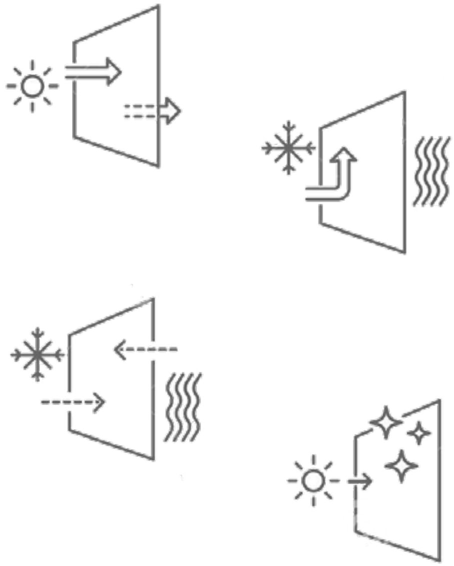
IMPACT OF GLAZING PROPERTIES ON ENERGY USE INTENSITY AND DAYLIGHT QUALITY



Example Office Building

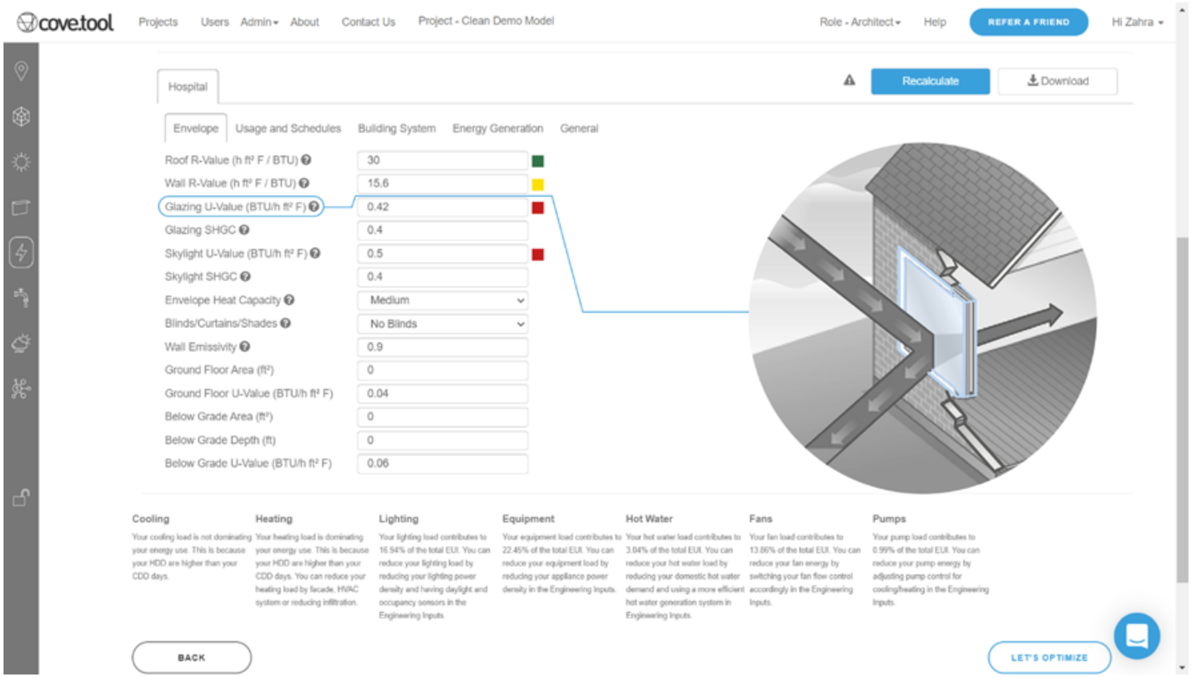


One of the main characteristics of contemporary architecture is the predominant use of glass, a material that has become one of the fundamental elements of modern architecture. The reason is simple, glass brings many qualities to spaces. It establishes a visual connection to the outdoor environment, increases the quality of spaces by allowing daylight into the building, aesthetically enhances the architectural design, and increases the building's energy efficiency if used wisely. This popularity of glass in contemporary architecture has led to significant advancements in glass technology and performance. Now, the glass industry offers a wide range of products with various material properties and functions. Common types of glazing that are used in architectural applications include clear and tinted glass, tempered glass, and laminated glass as well as a variety of coated glasses, all of which can be glazed singly or as double, or even triple glazing units.

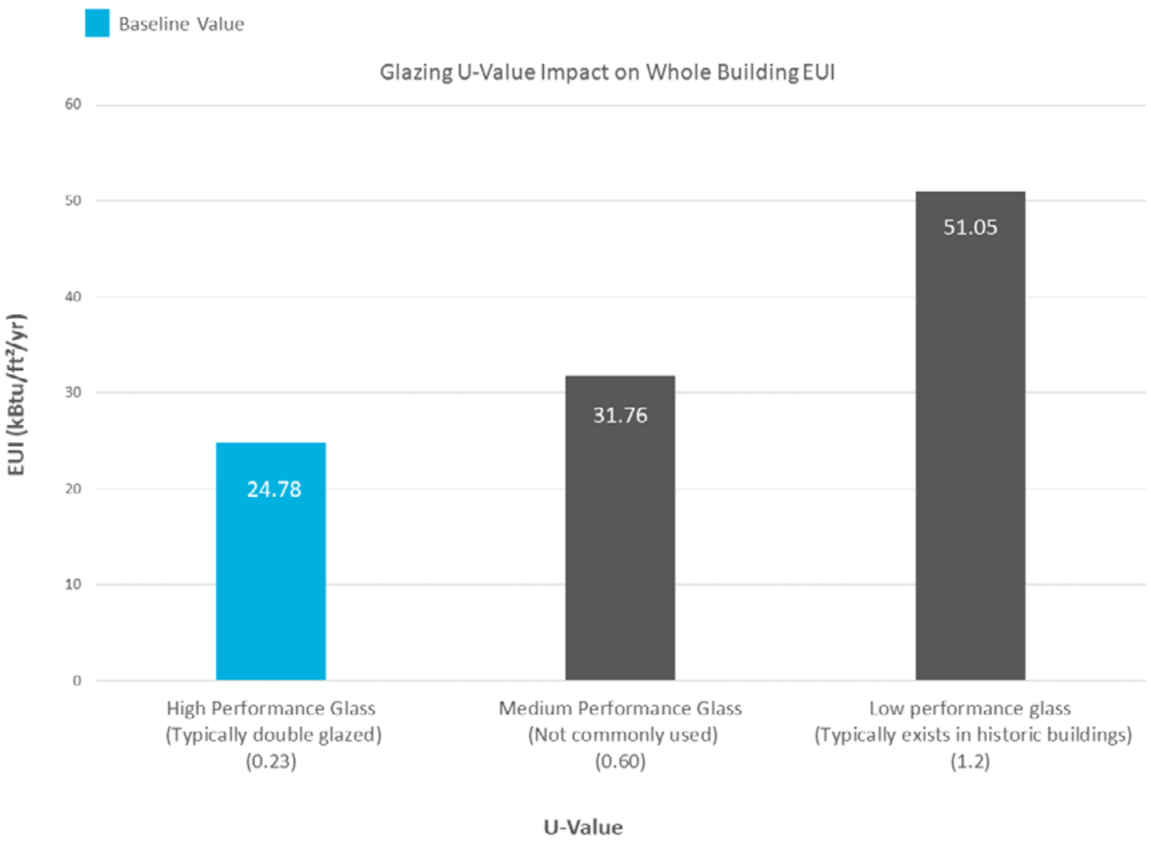
This E-book studies the energy and daylight impact of selecting different types of glass products based on their performance properties. The project studied (image above) showcases an office building, located in Atlanta with 63% window to wall ratio and an area of 53,000 sqft. To study the impact of modifying the glass on the envelope, the base glass type selected is modified to have better and worse thermal conductance (u-value), solar heat gain coefficient (SHGC) and visual transmittance levels (VT). The study highlights the impact of changes in glass properties on the energy use intensity and daylight quality of this office project.

Impact of Thermal Conductance (U-value):

Before we understand how thermal conductance can impact building energy performance, it is helpful to understand what it actually means. Thermal conductance (U-Value) is defined as the measure of the ability of a material to transfer the heat per unit time through the unit area of the material. U-value quantifies the rate of heat flow due to conduction, convection and radiation caused by the temperature difference between the maintained space and the outside environment. The unit of U-value in IP system is BTU/hr.ft2. °F and in SI system is Watts/m2.K.
Since U-value reflects the insulating capacity of glass, it should be determined based on the climate zone of a project. In the hot/warm climate (ASHRAE climate zones 1,2,3 and 4), the Solar Heat Gain Coefficient (SHGC) has precedence over U-value as the heat coming in is considerably higher than the heat transferred out of the space. On the other hand, the cold climates (ASHRAE climate zones 5,6,7 and 8) benefit from having a lower U-Value for windows as it is important to retain the heat inside the maintained space from flowing outside.
The range for U-values generally varies from 0.2 to 1.3 in IP system where the lower value is considered superior as it indicates the limited loss of heat from the space. Based on industry practice, for a building in Atlanta, a glass with U-Value of 0.2 - 0.35 is considered to be an efficient glass product.



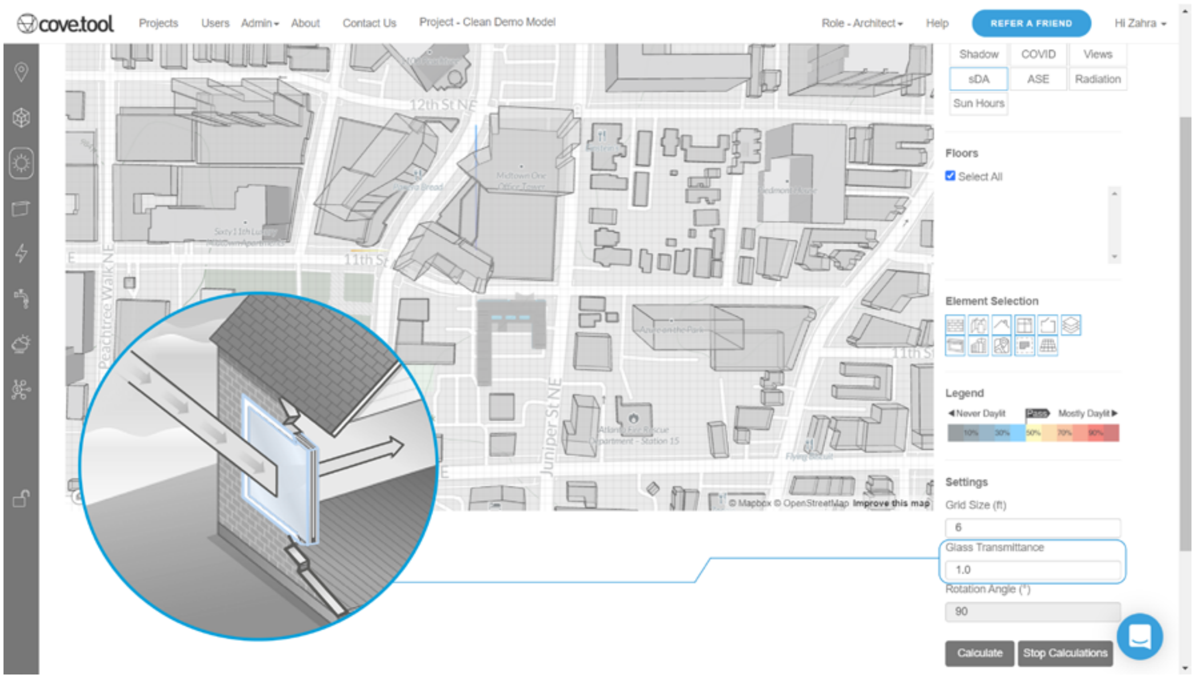
When studying the impact of modifying U-Value on the glazing of the office project, we are able to see that it has a pretty considerable impact. As seen in the graph below, increasing the U-Value from efficient to in-efficient can increase the total building energy use intensity by 105%. For a 53,000 sqft. building this equates to about 40,400$ in utility bills and 185.4 tons of additional carbon emissions.



Impact of Visible Light Transmittance (VT):

The percentage of the visible solar light that passes through the glazing is called Visible Transmittance (VT). Therefore, VT is a useful measure to maximize the sunlight entering the spaces where needed and minimize it where it causes glare and visual discomfort. An opening without any glazing on the building envelope would have 100% VT and an opaque wall has 0% VT since light cannot pass through it at all. The common values for Visible Transmittance may vary from 35% to 80 % for tinted and coated windows. Un-tinted windows may have the Visible Transmittance as high as 90%.

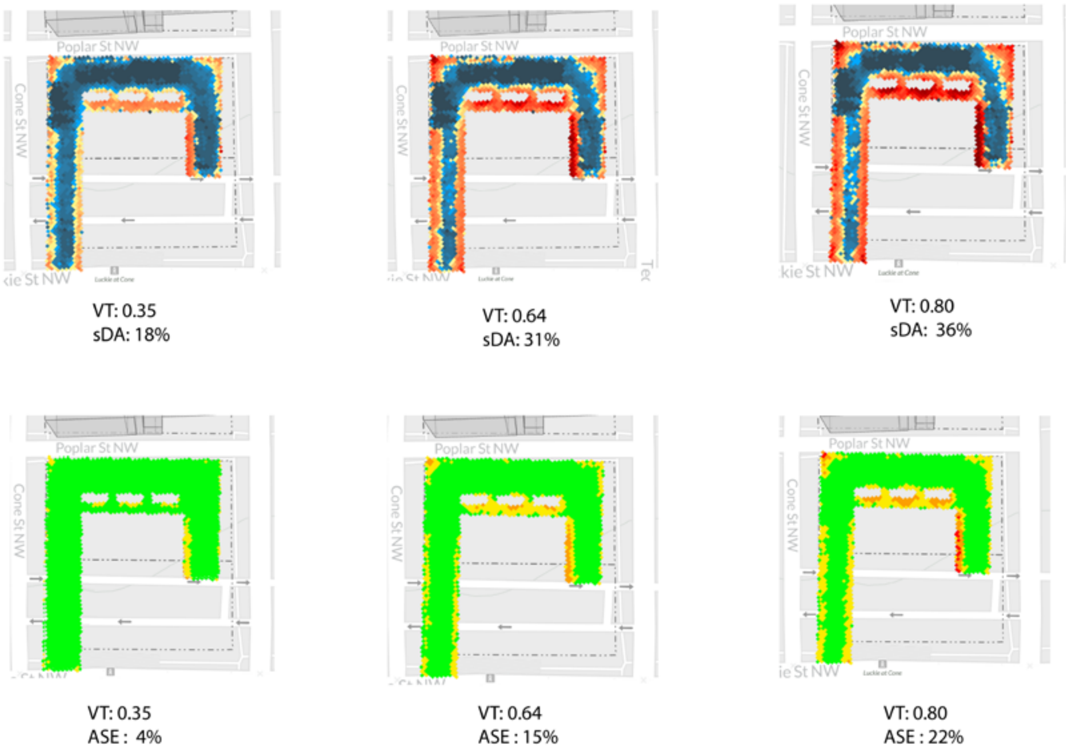
Choosing the right Visible Transmittance value is one of the important design decisions as it directly affects the daylight quality of spaces. As the Visible Transmittance value increases the amount of daylight into spaces also increases. VT value can be determined according to the climate zone, window orientation, and dimension. In hot/warm climate zones (ASHRAE 1,2,3 and 4), the lower VT value should be chosen since the higher VT value leads to glare and overheating of the space. And for the cold climates (ASHRAE Zones 5,6,7 and 8), the higher values for VT are desired as it helps to reduce the heating load of the system.



The following graphics demonstrate the Daylight (Spatial Daylight Autonomy sDA) and Glare (Annual Solar Exposure ASE) impact associated with different Visibility Transmittance values for the glazing in the office building. As expected, increasing the visibility transmittance of glass results in admitting more daylight into the spaces which consequently increases the sDA and ASE percentages.

The graph below shows that increasing the VT from 35% to 80% can have a 18% impact in the overall sDA. This is a fairly considerable impact since increasing VT is a much more cost effective way of bringing in daylight as compared to adding more glazing to the project. The graph also showcases that allowing more sunlight into the floor plate, does have an impact on its glare, bringing it up form 5% to 22%. This highlights the importance of studying both the glare and the daylight map collectively to drive design decisions. Based on the data below, a designer would likely chose a glass with 64% VT for the example office project in Atlanta to get the daylight benefit without creating significant glare challenges.

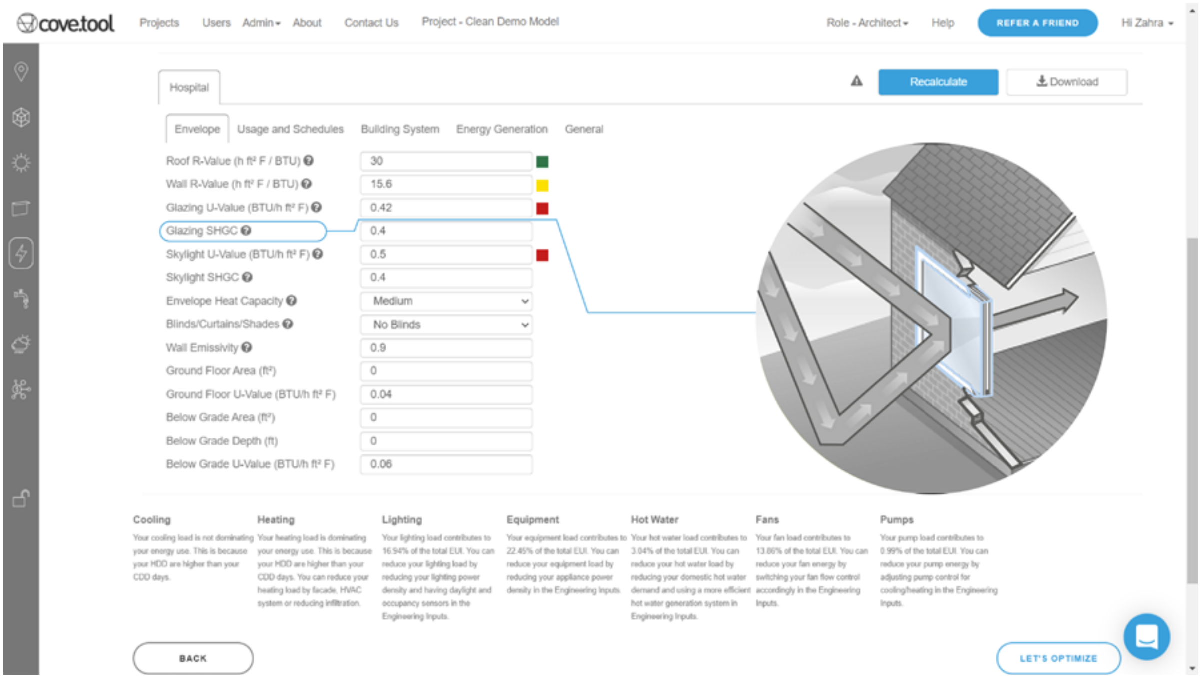
Impact of glazing's visibility transmittance on Daylight (sDA) and Glare (ASE)



Impact of Solar Heat Gain Coefficient (SHGC):

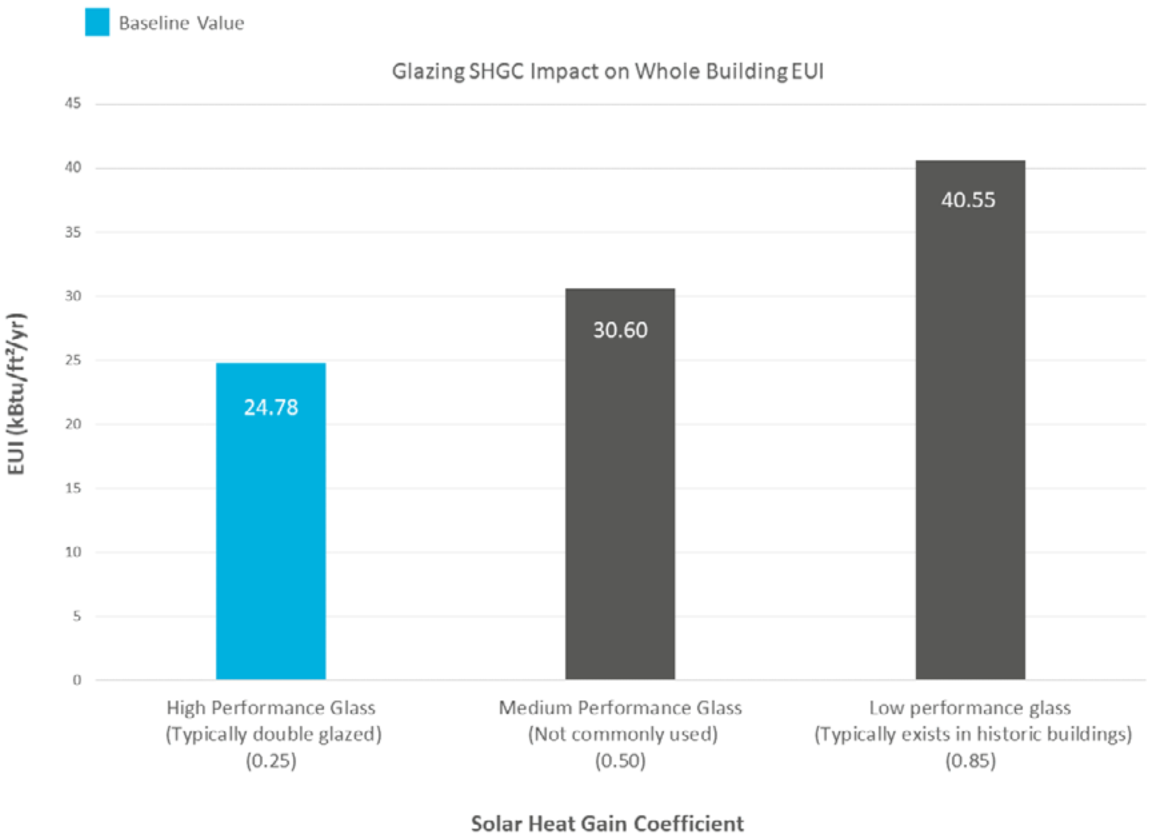
The Solar Heat Gain Coefficient (SHGC) is the fraction of the total incident sunlight that is being transmitted through the glazing material. SHGC is a dimensionless number that ranges between 0 and 1. The glazing with 0 SHGC value indicates total resistance to the heat and 1 SHGC value indicates that total heat from sunlight passes through the glazing into the maintained space. Solar heat radiation can work against or in favor of whole-building energy consumption depending on the building location. Therefore, choosing glass with the right SHGC value can save a considerable amount of energy by reducing the cooling load in hot climates and heating load in cold climates.

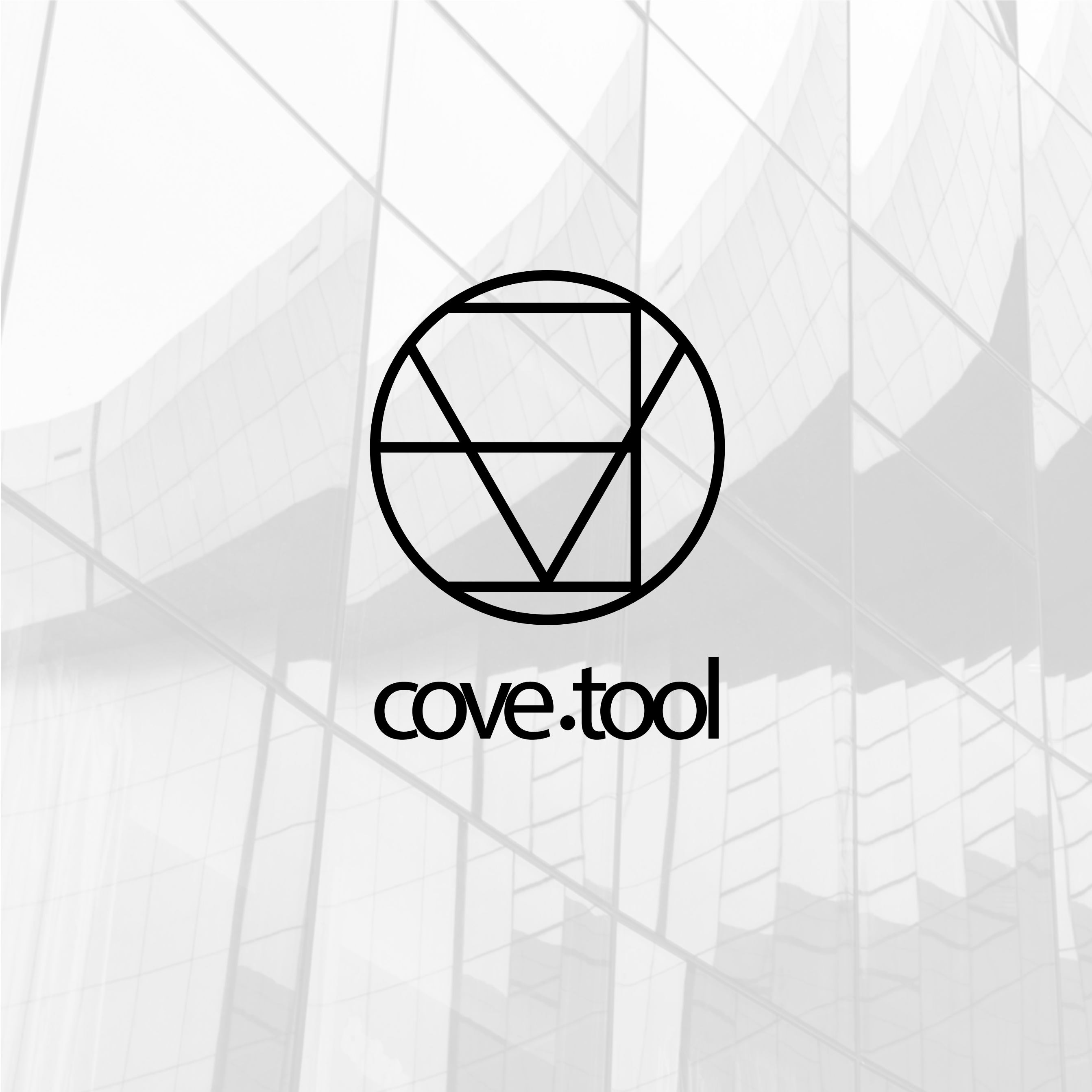
Typical values for glazing SHGC varies from 0.2 to 0.9 depending upon the type of glass used, tinting, coating type, number of panes, etc. For the hot/warm climate zones (ASHRAE zones 1,2,3 and 4), selecting higher SHGC for glazing results in higher cooling loads for the building. Therefore, a low SHGC value typically less than 0.4 is desired for hot climate zones (where cooling loads are significantly higher).
For the cold climate zones (ASHRAE zones 5,6,7 and 8), the higher SHGC values for glazing are preferred as they permit more solar heat into the space. Integrating this passive solar heating strategy helps to reduce the heating loads for the overall system.



The graph below indicate the EUIs associated with different glass SHGC values used in the office project. As seen in the graph, increasing the SHGC from efficient to in-efficient can increase the total building energy use intensity by 63%. For a 53,000 sqft. building this equates to about 24,250$ in utility bills and 111.3 tons of additional carbon emissions.

With buildings contributing to almost 40% of all carbon emissions, each decision made to the glass type and the property selection has a drastic and long lasting impact.
Understanding the key property parameters and how they can be modified to reduce the overall energy use and increase the amount of daylight is key to performance driven design. With energy regulations becoming stringent across the world, and glazing leading to a significant impact on performance, using iterative testing can be a cost effective way to design a building that meets the budget constraints.

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