PARAMETRIC PERFORMANCE-DRIVEN PASSIVE SOLAR DESIGNED FACADE SYSTEMS

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Master of Science in Architecture

by
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ABSTRACT

Parametric Performance-driven Passive Solar Designed Facade Systems
Thomas Paul Shorey Jr.

Buildings in the United States account for nearly 68% of all U.S. energy consumption due to their reliance on electrical lighting and mechanical systems. Beginning in the 20th century, emphasis on developing the glass curtain wall created increased energy demands on lighting and mechanical systems. Consequently, the building's curtain wall is a direct cause of significant energy loads. This research project investigated how current parametric design tools and energy analysis software are used during a performance-driven passive solar design process to develop facade systems that lower the energy use intensity (EUI) of a building and increase natural daylight to an acceptable illuminance level (lux). Passive solar shading strategies were employed to realize the proposed design process through a proof of concept project that retrofits the facade of an outdated office building in a hot-mediterranean climate. Incremental steps were taken using parametric software (Revit Architecture 2015) to increase the passive solar and daylighting performance capabilities of the facade system and Autodesk Green Building Studio was employed to measure, compare and contrast the results of each design.

Keywords:

Climate Responsive Design, Parametric Design, Performance-based Design, Performance-driven Design, Passive Design, Computational Design, Sustainable Design, Form Finding and Facade Design.

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The love and support of my wife
Stephanie Shorey
made this research possible.

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Before the advent of air conditioning, architects of the late 19th century needed to give considerable attention to site conditions and passive design strategies to create comfortable built environments. Whenever possible, buildings were oriented to capture prevailing wind as a source of natural cross ventilation. Windows were offset deep into exterior walls resulting in overhangs that would block out the sun during the summer and allow the sun to enter in during the winter. These strategies allowed the building to be naturally heated and cooled. Additionally, materials with substantial thermal mass and insulation properties were used in the design of the building facades, which helped to minimize interior-exterior heat exchange.

Figure 1.1.1: Images of the Monadnock Building [1]

[1] Murry, Scott. *Contemporary Curtain Wall Architecture*. New York, New York: Princeton Architecture Press, 2009. Print.

The Monadnock Building by architect Daniel H. Burnham is an interesting example of an office building where passive techniques assisted to create a comfortable interior environment. Upon its completion in 1891, the Monadnock was the tallest building in the world. At a time when steel frame construction was becoming increasingly popular as the most efficient method for constructing high-rise office buildings, Burnhan and his client went against popular practice and used the increasingly outdated method of load-bearing masonry to construct the Monadnock Building.[2] This type of construction requires the wall thickness to increase in relation to the building's height; as a result, this 16 story office building required massive 72 inch thick walls at its base (Figure 1.1.1.).[4] Nevertheless, this type of construction offered some passive design advantages. For example, the building's massive masonry walls not only provided a substantial amount of thermal mass and insulation, they also allowed the windows to sit deep within the building's facade, providing protection from the high summer sun while allowing the low winter sun to enter. Burnham also placed opposing operable windows along the building's long axis; this encouraged natural cross ventilation and provided passive cooling (Figure 1.1.2.). Today, many consider the Monadnock as a building that punctuates the end of an important architectural era and marks the beginning of architecture's shift away from solid masonry towards steel and glass construction. Similarly, the Monadnock Building also represents a movement away from passive design thinking, towards the more energy dependent designs of the Modern era.

[2] Murry, Scott. *Contemporary Curtain Wall Architecture*. New York, New York: Princeton Architecture Press, 2009.

During the early 20th century, solid load-bearing masonry method were replaced with modern steel frames. Shorter construction time, cheaper material cost, and taller office buildings were some obvious financial benefits that fueled this shift to steel frame construction. The steel frame also offered some important architectural features.

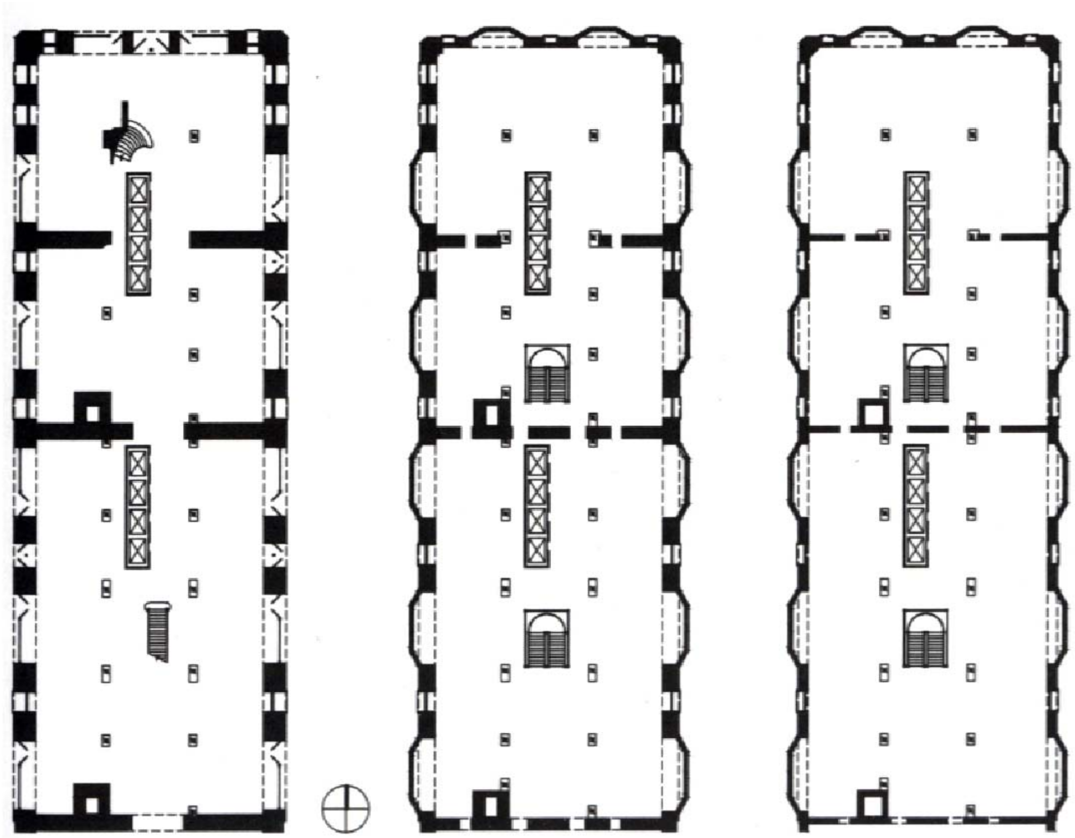

Figure 1.1.2: Floor Plans of the Monadnock Building [3]

By freeing the exterior walls from their structural role, the steel frame made it possible for architects to design floor to ceiling glass curtains walls that offered ample natural light and unobstructed views. Unfortunately, this new building type did not offer sufficient thermal insulation and required a substantial amount of mechanical heating and air-conditioning to maintain a comfortable work environment. In the years that followed,

3 Murry, Scott. *Contemporary Curtain Wall Architecture*. New York, New York: Princeton Architecture Press, 2009.

the demand for office buildings steadily increased, building technologies improved, engineering developed, and the demand for bigger, taller office buildings grew. As a result, the demand for air-conditioning systems also grew. In 1937, all the major air conditioning manufacturers Carrier, Frigidaire, General Electric, Westinghouse and York more than doubled their sales of air-conditioning systems that were installed in new office buildings.[4] Due to the office building's new demand for complex air-conditioning systems, came a growing need for electrical lighting, and a greater reliance on energy.

Many consider the United Nations Secretariat Building by Harrison, Le Corbusier, and Niemeyer to be one of the first high-rise office buildings in the United States to fully realize the modernist vision of steel and glass construction. At the time, many referred to this building's curtain wall as "The World's Largest Window" because it featured a 280 foot wide by 500 foot high glass wall (Figure 1.1.3.).[5] The short sides of this building were clad in solid Vermont marble, while the long sides were mostly made up of "tinted heat-absorbing" glass panels that were suspended two feet nine inches (Figure 1.1.4.) beyond the building's perimeter and oriented to maximize day lighting and views.[6] Unfortunately, the orientation that offered the desired views took precedence over the building's optimal solar orientation. Le Corbusier warned his co-designers to provide "brise-soleil" (sun shading devices) for these exposed glass facades. However, Harrison decided to address the increased cooling demand, due to the building's orientation, by commissioning Carrier to design one of the most sophisticated air-

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[4] Arnold, David. "Air Conditioning in Office Buildings after World War II." *ASHRE Journal*, July 1999.

[5] Murry, Scott. *Contemporary Curtain Wall Architecture*. New York, New York: Princeton Architecture Press, 2009.

conditioning systems of the time.[6] This complex system included more than the typical one intermediary floor of services, it required “three-at the sixth, sixteenth and twenty-eighth levels, each distributing conditioned air upwards and downwards to the

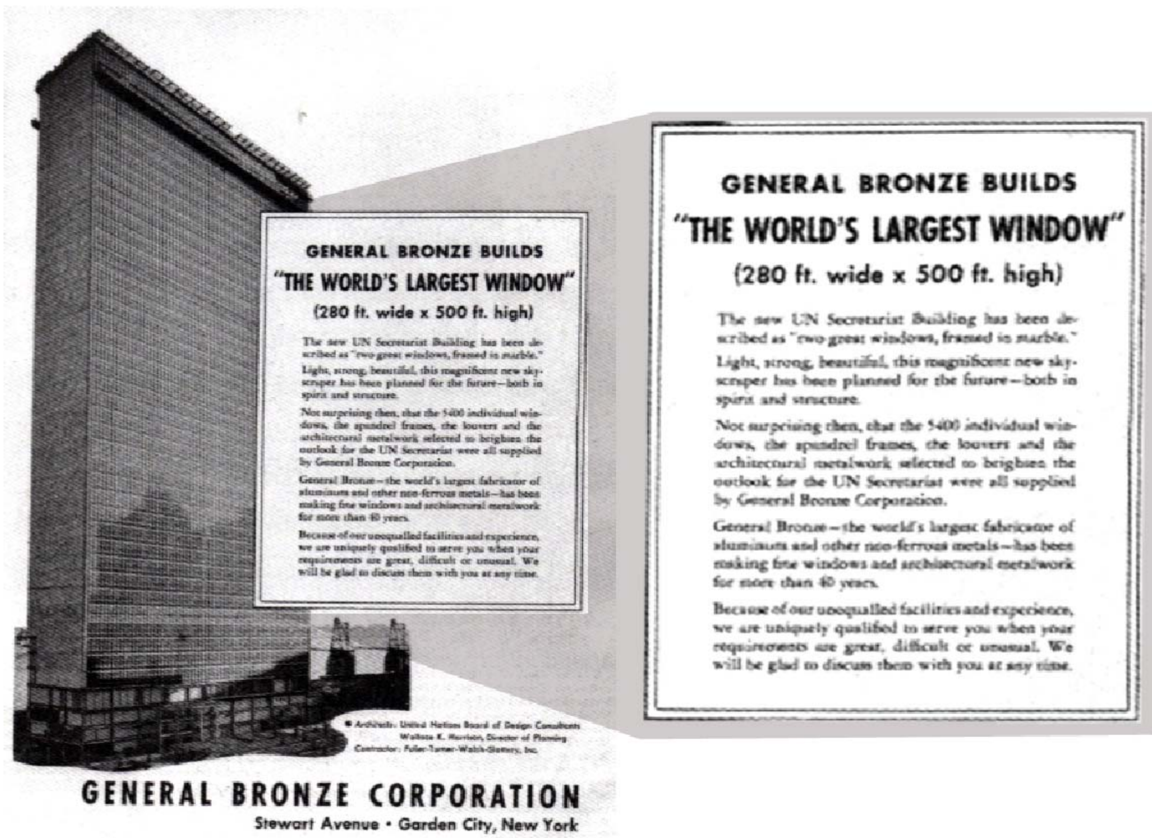

Figure 1.1.3: Media Image of the United Nations Secretariat Building [7]

intervening floors, plus a final plant floor at the top of the block serving the floors immediately below, and another in the basement, to serve the entrance areas and council chambers.”[7] Still, during the building’s first summer in use, office workers found that it was necessary to keep the blinds drawn for the entire day, reducing the natural light and views that the initial design intended.[6] Keeping the blinds drawn all day long not only

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[6] Banham, Reyner. *Architecture of the Well-Tempered Environment*. Chicago: The University of Chicago Press, 1969.

[7] Murry, Scott. *Contemporary Curtain Wall Architecture*. New York, New York: Princeton Architecture Press, 2009.

obstructed the views, but also increased the building's reliance on artificial lighting, which raised the building's demand for energy. Though clearly flawed in its design, the United Nations Secretariat Building nevertheless marks an important step forward in the development of the glass curtain wall system.[8] Unfortunately, it also represents the beginning of a design era that disregarded passive design strategies and marked a large step towards the trend to design energy dependent office buildings.

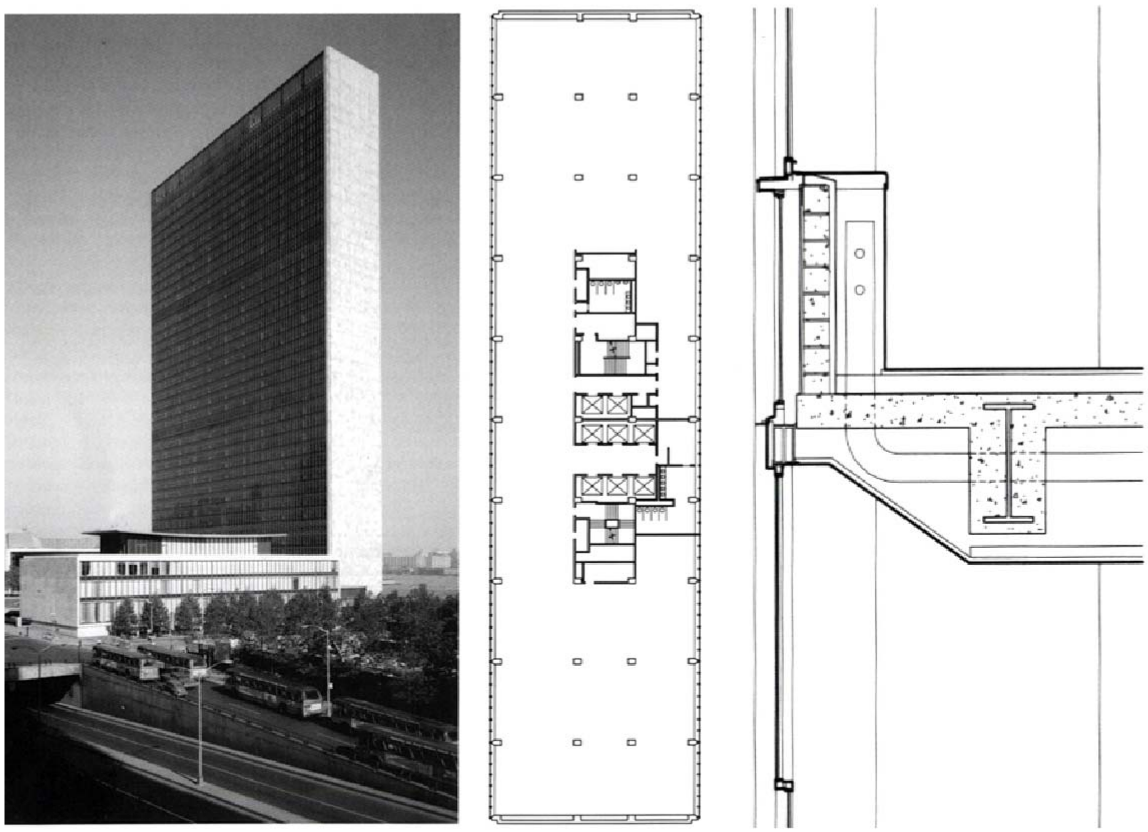

Figure 1.1.4: Image, Plan, and Section of United Nations Secretariat Building [9]

[8] Murry, Scott. *Contemporary Curtain Wall Architecture*. New York, New York: Princeton Architecture Press, 2009.

[9] Murry, Scott. *Contemporary Curtain Wall Architecture*. New York, New York: Princeton Architecture Press, 2009.

Throughout the remainder of the 20th century, the modern glass office building continued to grow in footprint, height, and number; ending with the predictable speculative high-rise buildings of the 1990's. Unfortunately, as the demand for these large glass office buildings increased, the United States demand for energy also increased.

1.2. The Problem

The United States represents only 5% of the world's total population,[10] yet it consumes more than 25% of the world's total energy (Figure 1.2.1.).[11] Of that 25%, the building sector is responsible for about 68% of the total energy consumed in the United States (Figure 1.2.2.).[12]

Figure 1.2.1: Diagram of the World and United States Population

Today the U.S. is the major consumer of energy in the world. In view of these statistics and with finite energy sources diminishing, it is clear that something must be done to make buildings in the United States more energy efficient.

[10] "www.census.gov: U.S. & World Population Clocks." Accessed November 21, 2012.

[11] "www.eia.gov: International Energy Statistics." Accessed November 21, 2012.

[12] "www.epa.gov: Why Build Green? | Green Building |US EPA." Accessed November 21, 2012.

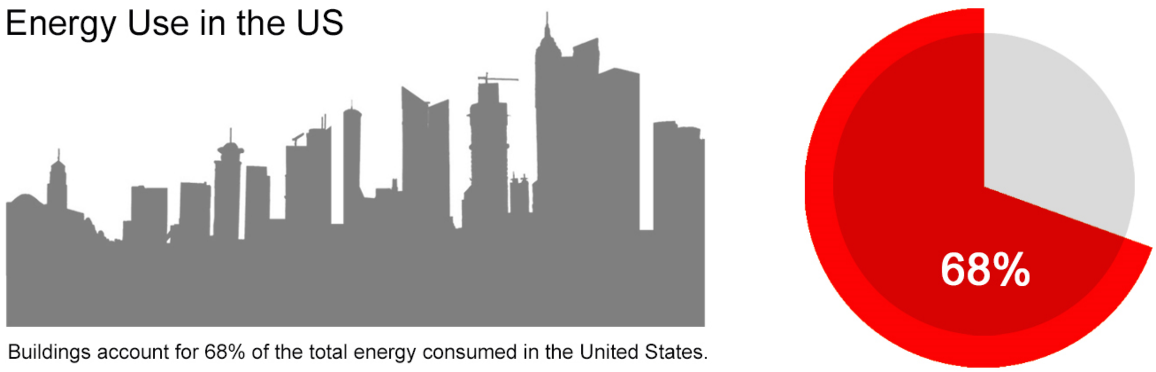

Figure 1.2.2: Diagram of the Building Sectors Energy Use in the U.S.

1.3. Architecture 2030 and the 2030 Challenge

As a response to the current climate and energy crisis, architect Edward Mazria created a non-profit independent organization called Architecture 2030 in 2002.[13] The organization pursues “the dramatic reduction in global fossil fuel consumption and GHG (Greenhouse Gas) emissions of the built environment by changing the way cities, communities, infrastructure, and buildings, are planned, designed, and constructed and; the regional development of an adaptive, resilient built environment that can manage the impacts of climate change, preserve natural resources, and access low-cost, renewable energy resources.”[14] In 2012, Architecture 2030 extended a challenge to building designers called the 2030 challenge. The 2030 Challenge sets a higher standard for current architectural and construction professionals by encouraging them to implement reduced target performance values for all new and renovated buildings.

[13] “www.architecture 2030.org: Architecture 2030: Why?” Accessed January 17, 2014.

[14] “www.architecture 2030.org: Architecture 2030: Why?” Accessed January 17, 2014.

This quote from the Architecture 2030 website includes many of the new standards set by the 2030 Challenge:

"All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 60% below the regional (or country) average/median for that building type.

At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 60% of the regional (or country) average/median for that building type.

The fossil fuel reduction standard for all new buildings and major renovations shall be increased to: 70% in 2015, 80% in 2020, 90% in 2025 and Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate." [15]

Figure 1.3.1 graphically demonstrates the 2030 Challenge's standard for reducing fossil fuel within Architecture 2030's given time frame.

One way architects and builders can meet these higher building standards, is by lowering the energy use intensity (EUI) of all new and renovated buildings. Energy use intensity is a unit of measurement that quantifies a building's energy use. Energy use intensity describes the amount of energy consumed per year by a building relative to its floor area. EUI is calculated by dividing the total amount energy consumed in one year (kBtu) by the total floor area of the building (kBtu/ft^2/year). Generally, a low EUI signifies good energy performance. Architects and builders could lower a building's energy use intensity by optimizing the performance of building's facade, lighting, and mechanical systems. [16]

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[15] "www.architecture 2030.org: Architecture 2030: Why?" Accessed January 17, 2014.

[16] ASHRAE, AIA, IESNA, U.S. Green Building Council, and U.S. Department of Energy. "Advanced Energy Design Guide for Small to Medium Office Buildings," 2011.

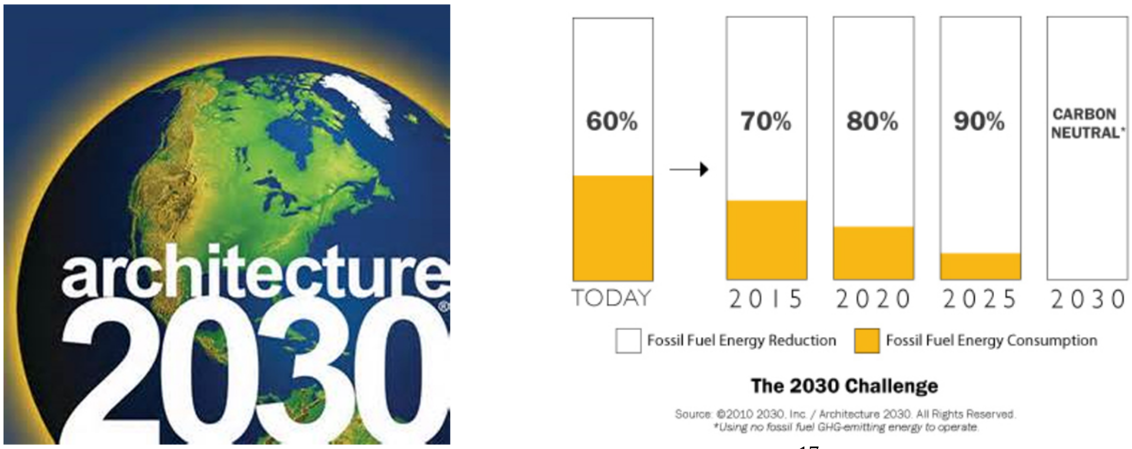

Figure 1.3.1: Architecture 2030 Logo and Diagram of the 2030 Challenge [17]

1.4. Energy Star Target Finder

An important step to lowering a building's energy use intensity (EUI) is setting a target or goal for energy performance. The 2030 Challenge encourages architects and builders to strive to lower a building's energy use "60% below the regional average/median for that building type." Median source and site EUI can be found at www.energystar.gov with the Energy Star Portfolio Manager Target Finder. [18] These values are based on data from the national building energy consumption survey. The key parameters affecting the EUI values are; location (state, city, and address), primary and secondary function (building type), gross floor area (square feet), number of buildings on the property, weekly hours of operation, number of computers, number of occupants during regular operational hours, percentage of the building that is cooled, and percentage of the building that is heated. These parameters are entered into the Energy Star system

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[17] "www.architecture 2030.org: Architecture 2030: Why?" Accessed January 17, 2014.

[18] "www.energystar.gov: ENERGY STAR Portfolio Manager Target Finder." Accessed February 7, 2014.

in order to determine the median EUI for a specific building type. Figure 1.4.1 is a sample graph and table output that can be generated with the Energy Star Target Finder. 60% of the median EUI can then be set as a target EUI to meet the 2030 Challenge target for "today" (2014).

Design Target*	Median Property*
97	50
96.7	241.8
38.4	96.1
62,416,317.6	156,040,794.0
24,806,485.2	62,016,213.0
745,304.01	1,863,260.02
1,922.9	4,807.2

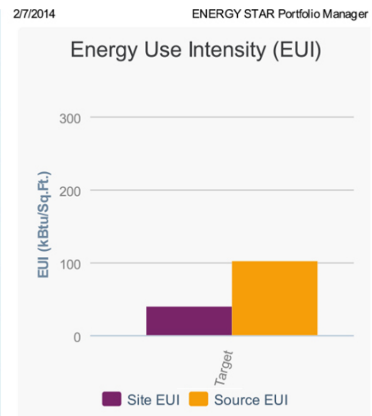

Figure 1.4.1: Sample Energy Star Target Table and Graph [19]

1.5. Significance

Buildings in the United States account for nearly 68% of all the United States' energy consumption, due to their reliance on electrical lighting and mechanical systems. During the 20th century, as the modern curtain wall developed, office buildings grew in footprint and in height. Consequently, building's energy loads increased significantly. These dated buildings are now major contributors to the enormous amount of energy the consumed in the U.S. Unfortunately, the amount of energy and finite materials required to demolish and reconstruct these outdated buildings, is simply not a sustainable solution. A more sustainable approach is to retrofit or renovate these dated buildings to be more energy efficient.

[19] "www.energystar.gov: ENERGY STAR Portfolio Manager Target Finder." Accessed February 7, 2014.

The 2030 Challenge and Energy Star Target Finder are setting the bar for higher, more sustainable energy targets of all new and renovated buildings. This research project investigated how current parametric design tools and energy analysis software are used during a performance-driven design process to develop new facade systems for outdated buildings that will lower their energy use intensity and increase their natural daylighting capabilities to acceptable illuminance levels in order to reduce the building's electrical lighting and mechanical energy demand.

2. CONTEMPORARY FACADE DESIGN

2.1. Parametric Design

In Webster's Dictionary, the word parameter is defined as: a rule or limit that controls what something is or how something should be done. Parametric design can be thought of as a design process that establishes rules or parameters to define a form or a particular function. Current designers and architects are using parametric software to design products and buildings. Parametric software facilitates the generation of complex geometry that is governed by, rules, parameters, variables and algorithms. The use of rules, parameters, and algorithms creates a geometric hierarchy that allows designers and architects to explore a variety of possible design solutions with considerably less modeling time. Today these techniques are widely used by architects to develop innovative forms and patterns in facade systems. Figure 2.1.1 shows an example of a parametrically design facade by Zaha Hadid. Parametrically designed facade systems will often vary in form as a reaction to the surrounding environmental condition.

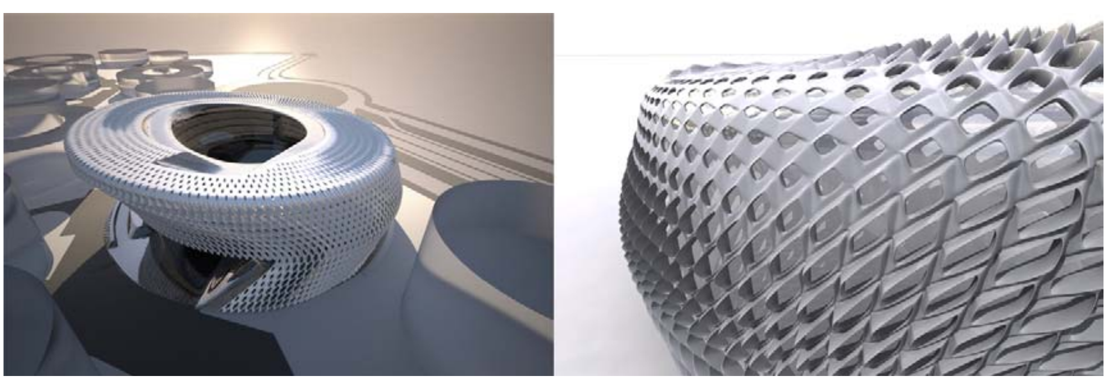

Figure 2.1.1: Parametric Design by Zaha Hadid [20]

[20] "www.patrikschumacher.com: Parametric Patterns." Accessed June 7, 2014.

The facade or envelope design in Figure 2.1.1 features a skin that permits a gradual variation of sunlight to penetration through the patterning of apertures that are spaced over the curved surface, combining functional and formal variation.

2.2. Performance-driven Design

Performance-driven design is an emerging approach to architecture that uses performance design objectives as guiding principles during the design process. This type of architecture places performance objectives above or next to form-making and utilizes digital technologies to create performance simulation models that produce both quantitative and qualitative values that can be used during the early stages of the design process.[21] Analysis software is often used in a performance-driven process to simulate acoustics performance, day lighting levels, heating and cooling loads, structural loads, and many other performance values related to design. Access to these values during the early phases of design allows the designer to better understand the results and consequences of their design decisions. Aesthetic decisions can be made simultaneously with performance objectives, resulting in a more integrated design. This approach to architectural design can give designers and architects access to data that is vital to the energy performance of a building. This data can be gathered and organized to inform design decisions for current and future projects, in order to continually refine the designer's approach to sustainable design. Figure 2.2.1 displays a solar analysis study of the London City Hall by Norman Foster + Partners. This example demonstrates how the form of the building evolved during the design process into a shape that would minimize solar gain. This performance-driven process resulted in a building geometry that

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[21] Kolarevic, Branko. *Performative Architecture: Beyond Instrumentality*. Routledge, 2005.

minimized direct sun exposure and actually self-shaded the lower floors. As a result, the building's cooling and energy demands were reduced.

Figure 2.2.1: London City Hall by Foster + Partners [22]

2.3. Passive Solar Design

Passive design exploits naturally occurring climate conditions and material characteristics to produce work. Typically the work that an architectural design requires is the heating, cooling, and lighting of enclosed spaces. [23] Passive solar design uses building elements such as windows, walls, roofs, floors, and overhangs to distribute or redirect the sun's energy to heat, cool and light a space. Generally, passive design solutions are static (few moving parts) in nature and require little to no mechanical systems to condition spaces. Solar orientation, glazing, thermal mass, insulation, natural daylighting, natural ventilation and shading are all integral strategies involved in designing an effective passive solar solution. Some aspects of passive design that are

[22] "www.fosterandpartners.com: Foster + Partners." Accessed June 7, 2014.

[23] "www.wiki.naturalfrequency.com: | Passive Design | Archived Ecotect WIKI." Accessed May 23, 2013.

specific to facade systems are solar orientation, glazing, shading / solar gain, and daylighting.

Orientation

Orientation is a critical factor when passively designing a building. A well oriented building can dramatically reduce a building's solar heat gain during the hot summer months and allow for maximum solar heat gain during the cold winter months. If the building is oriented properly the eastern and western sides of the building that are exposed to the low-angle summer sun in the morning and afternoon will be minimized.[24] Buildings should be oriented and planned so that the majority of the spaces face towards the equator.[25] Figure 2.3.1 shows a building with an optimal solar orientation.

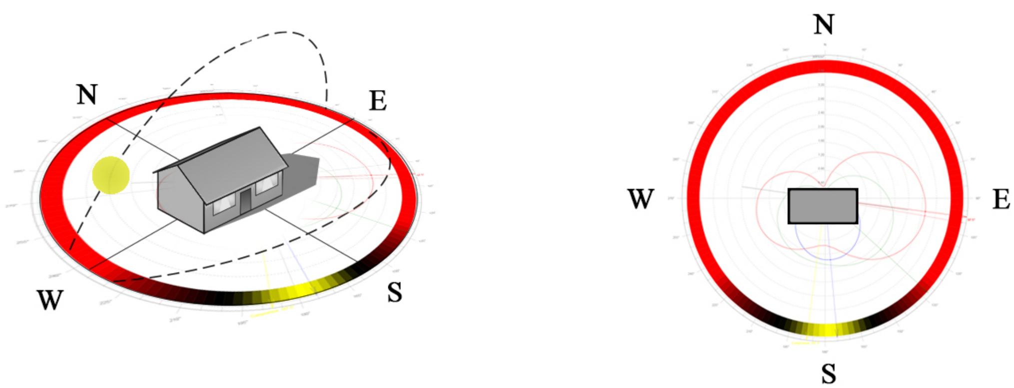

Figure 2.3.1: Solar Orientation Diagram

Glazing

Window placement and type is also critical to passive design and should be carefully considered. Glazing plays a crucial role in heat gain and loss. Glazing type can have a significant impact on energy use intensity.[26] Care should be taken when deciding

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[24] "www.wiki.naturalfrequency.com: | Passive Design | Archived Ecotect WIKI." Accessed May 23, 2013.

[25] "www.wiki.naturalfrequency.com: | Passive Design | Archived Ecotect WIKI." Accessed May 23, 2013.

[26] "www.wiki.naturalfrequency.com: | Passive Design | Archived Ecotect WIKI." Accessed May 23, 2013. h

the percentage and position of glass on a facade. Eastern and western facing windows are often difficult to shade and are vulnerable to low-angled summer sun, and therefore should be kept to a minimum in warm climates. Northern facing windows can usually be maximized without resulting in solar gain and can provide substantial natural daylighting. When properly designed with shading devices, southern facing windows can provide daylighting, solar gain during the cool winter months and block out the sun during the summer months.

Shading / Solar Gain

A well-designed passive solar shaded building will provide a passive sun shading device that minimizes solar gain during the summer and allows for sufficient solar gain during the winter. A shading system should be placed along the equator side of the long axis to provide adequate protection from high-angled summer sun and allow the low-angled winter sun to shine into the building when its warmth is required in winter (Figure 2.3.2.).[27] Shading windows from solar heat gain is one of the best design strategies to passively cool a building and reduce the need for cooling from a HVAC system, requiring less energy.[28] Solar gain through thermal mass is another passive design strategy that can be employed to reduce a building's energy use. Thermal mass can be integrated into the floor and or wall assemblies of a building. Thermal mass can help to stabilize internal temperature by acting as a heat source in the evenings and a heat sink

[27] "www.wiki.naturalfrequency.com: | Passive Design | Archived Ecotect WIKI." Accessed May 23, 2013.

[28] Grondzik, Walter T., Alison G. Knok, Benjamin Stein, and John S. Reynolds. *Mechanical and Electrical Equipment for Buildings*. Hoboken, New Jersey: John Wiley & Sons Inc., 2010.

during the day (Figure 2.3.3.). This lowers the need for the use of HVAC equipment.

Figure 2.3.2: Solar Shade Diagram

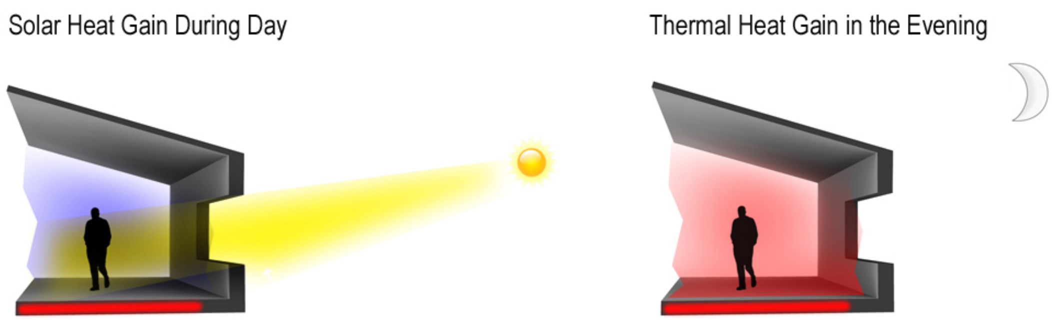

Figure 2.3.3: Solar Gain Thermal Mass Diagram

Daylighting

Providing natural light is also important in a passive design process because it helps to minimize the need for electrical lighting resulting in less energy use. Light shelves can be an effective technique to enhance natural lighting through windows located along the building's facade that is parallel to the equator. If the windows are protected from direct summer sun angles, a light shelf can reflect indirect light upward towards the ceiling, providing diffuse natural light to the interior of the building and greatly reduce the building's need for electrical lighting. Figure 2.3.4 demonstrates how a light shelf can reflect diffused light deep into a space and provide natural daylighting.

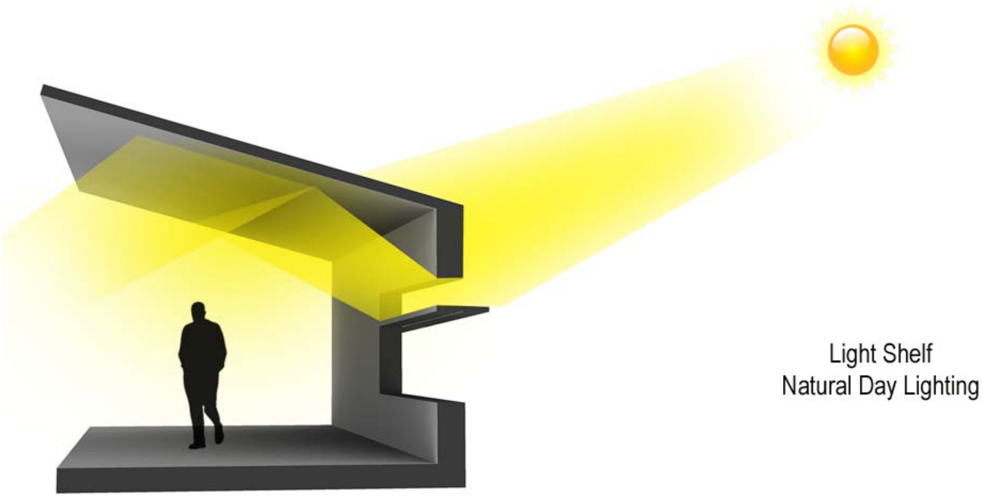

Figure 2.3.4: Light Shelf Diagram

2.4. Parametric Performance-driven Passive Solar Design

Parametric performance-driven passive solar design integrates parametric, performance-driven and passive solar design into one process. Parametric software is used in combination with analysis software (performance-driven software) with a design objective to exploit passive solar design strategies in an integrated design process that will lower a building's energy use by maximizing its passive solar and daylighting capabilities.

Decisions made during this design process are in direct connection with the site and its surrounding environment. Using parametric software and energy analysis software, the designer finds ways to utilize the site's natural properties (sun path, prevailing wind etc…) to lower the building's need for energy. The flexible nature of parametric software allows for incremental changes to be made to the design; each change can be evaluated using analysis software to determine if the passive solar and daylighting design targets are being met. As a result, multiple iterations of a design can be modeled and evaluated to achieve the desired performance goals. Figure 2.4.1 shows the evolution of a parametrically modeled building form in order to maximize its self-shading capabilities and integrate a passive solar shading system into the facade in order to increase the building's passive cooling capabilities.

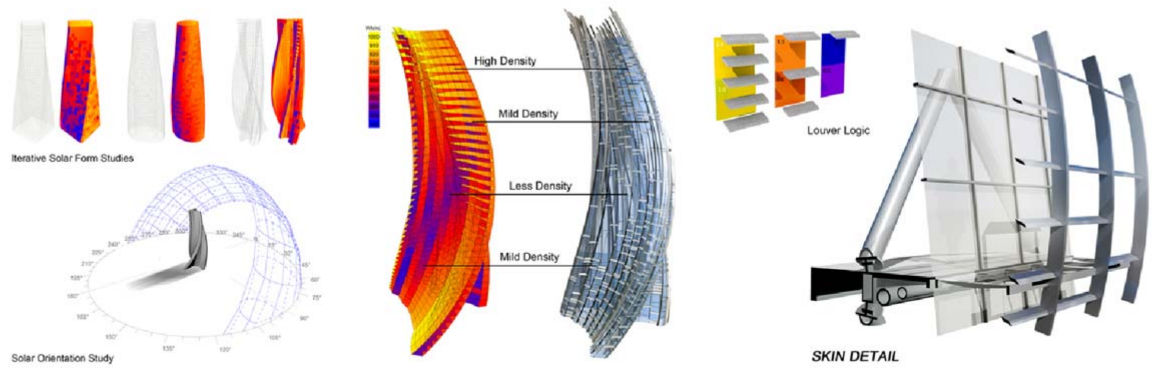

Figure 2.4.1: Parametric Form Designed by Thomas Shorey

2.4.1. Performance-driven Passive Design Precedent Federal Building, San Francisco, Ca.

An interesting example of performance-driven passive solar design is the Federal Building in San Francisco, California (Figure 2.4.1.1.). The building was designed by architect Thom Mayne, owner of Morphosis and engineered by ARUP. Construction was completed in 2007 and the building's program includes 18 floors and 600,000 square feet of office space. A study of this innovative building reveals an integrated design process that combines performance-driven goals and passive solar design strategies.

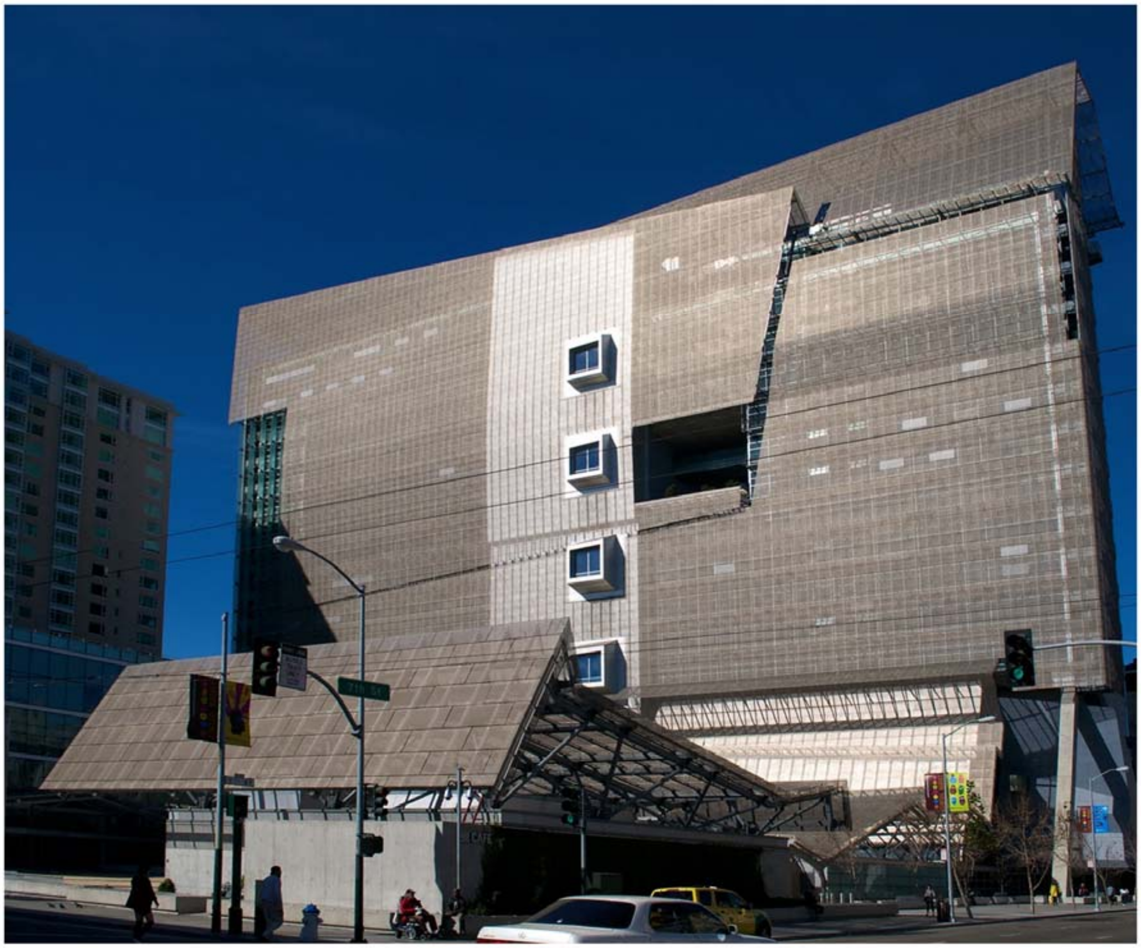

Figure 2.4.1.1: Federal Building, San Francisco, CA.[29]

Reducing heating, cooling, and lighting loads were the main performance objectives throughout the entire design process. This performance-driven process resulted in one of the first naturally ventilated modern office buildings on the west coast. The building's shape and orientation were designed to maximize natural air flow and provide cross ventilation to its occupants'.[30] The building's narrow footprint facilitates ample natural daylighting to the majority of the interior office spaces. An impressive 85

[29] "www.morphopedia.com: | Morphopedia |" Accessed Oct 06, 2013.

[30] "www.morphopedia.com: | Morphopedia |" Accessed Oct 06, 2013.

percent of the building’s workspace lighting needs are met with natural light. Figure 2.4.1.2 demonstrates the building’s narrow design and natural ventilation capabilities.

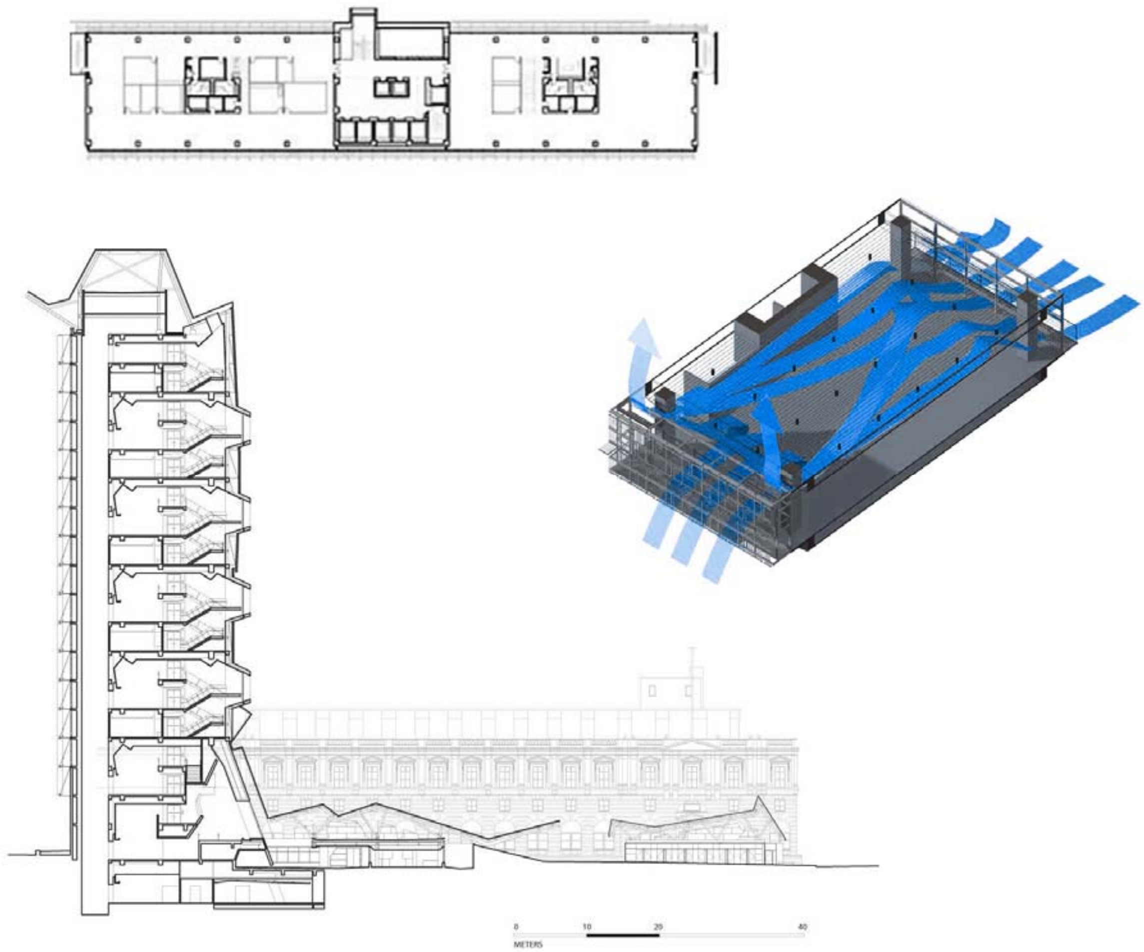

Figure 2.4.1.2: Federal Building Ventilation Diagram [31]

Minimizing the use of mechanical systems was a major focus during the performance-driven design process. In order to reduce the number of floors that required mechanical heating and cooling, the spaces that had a concentration of people and equipment were programmed to fit into the first five floors of the building and are the only floors that are mechanically cooled. This design strategy left the remaining thirteen upper floors to be passively cooled through cross ventilation. Cross ventilation was made possible through a

[31] “morphopedia.com: | Morphopedia |” Accessed Oct 06, 2013.

"living skin" on the windward side that automatically adjusts to allow the building to "breathe."[32] Figure 2.4.1.3 displays images, section and details of the building's innovative breathable skin.

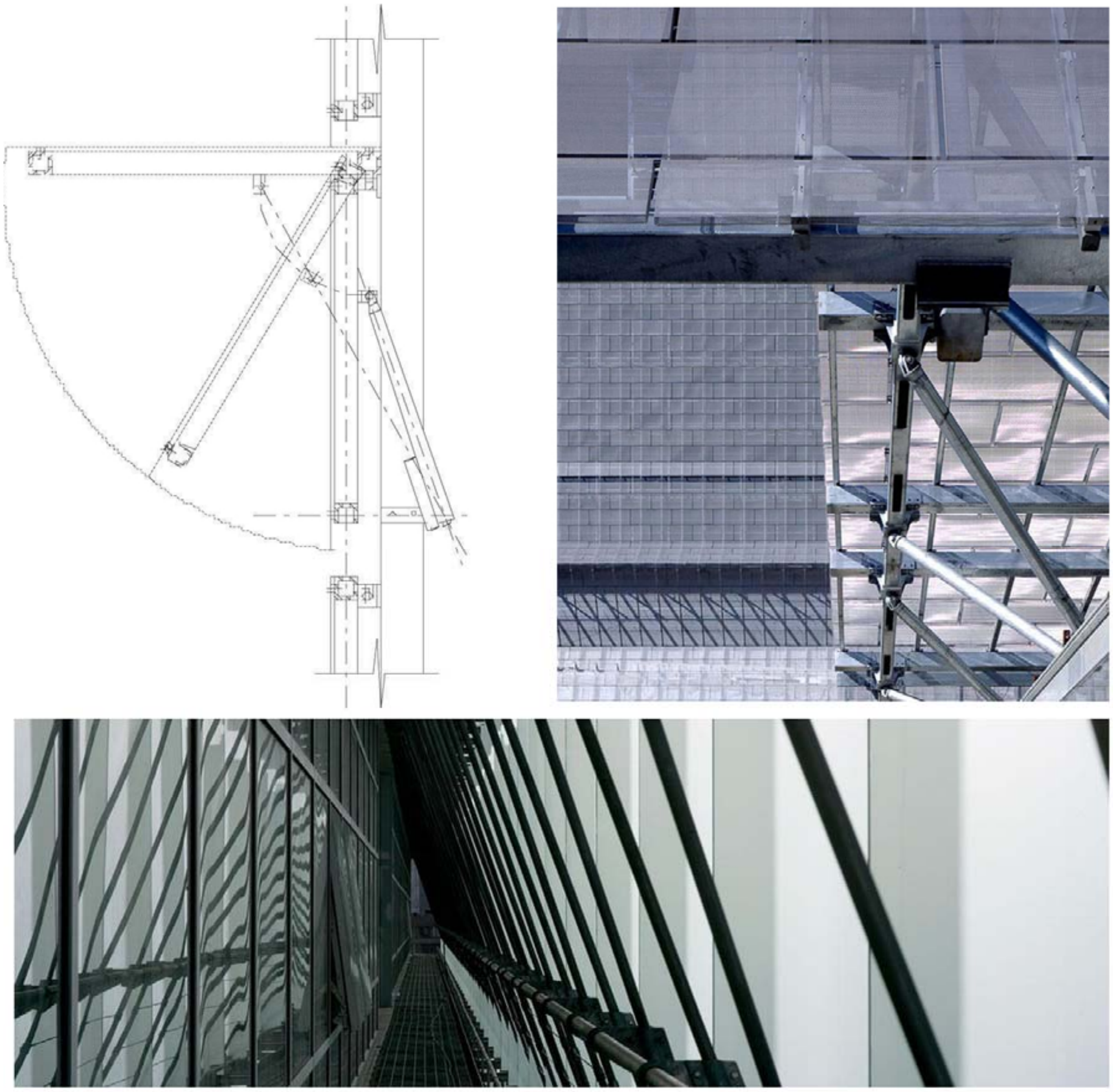

Figure 2.4.1.3: Federal Building Breathable Facade Design [33]

[32] "www.morphopedia.com: | Morphopedia |" Accessed Oct 06, 2013.

[33] "www.morphopedia.com: | Morphopedia |" Accessed Oct 06, 2013.

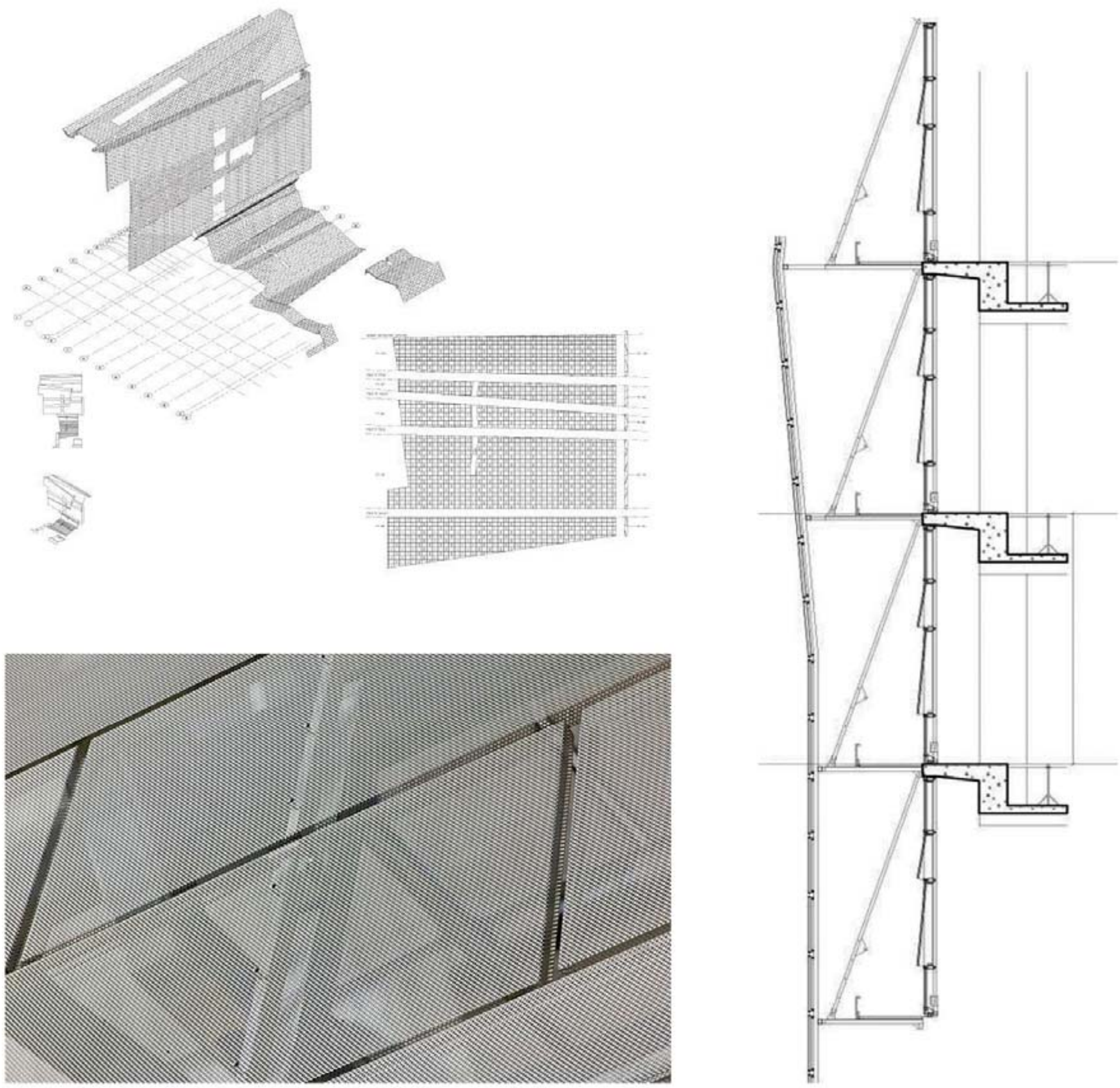

Figure 2.4.1.4: Federal Building South Facing Facade Design [34]

Skip stop elevators were also used to reduce the mechanical energy load. Skip stop elevators stop at every other floor to help reduce the energy demands of the elevator system.

Passive solar design strategies were also employed during the design of the exterior facade system of the building. The south facade is shaded from the summer sun by operable perforated metal screens. Figure 2.4.1.4 shows the building's south facade

[34] "www.morphopedia.com: | Morphopedia |" Accessed Oct 06, 2013.

design. The building facade design reduces solar gain during the warm summer months, while still allowing passive cross ventilation to freely pass through. The northwestern facade also incorporates passive design strategies and features as series of transparent vertical shading devices that block out the low-angled evening sun without reducing natural daylighting opportunities or obstructing the view (Figure 2.4.1.5.).

Figure 2.4.1.5: Federal Building North Facing Facade Design.[35]

[35] "www.morphopedia.com: | Morphopedia |" Accessed Oct 06, 2013.

These features, combined with a number of other energy-saving elements, significantly reduced the overall energy consumption of the Federal Building when compared to other conventional commercial office buildings in the United States. The San Francisco Federal Building's tower only uses 33% of the energy used by a typical California large office building and saves enough electricity to power over 600 homes per year (Figure 2.4.1.6.).[36]

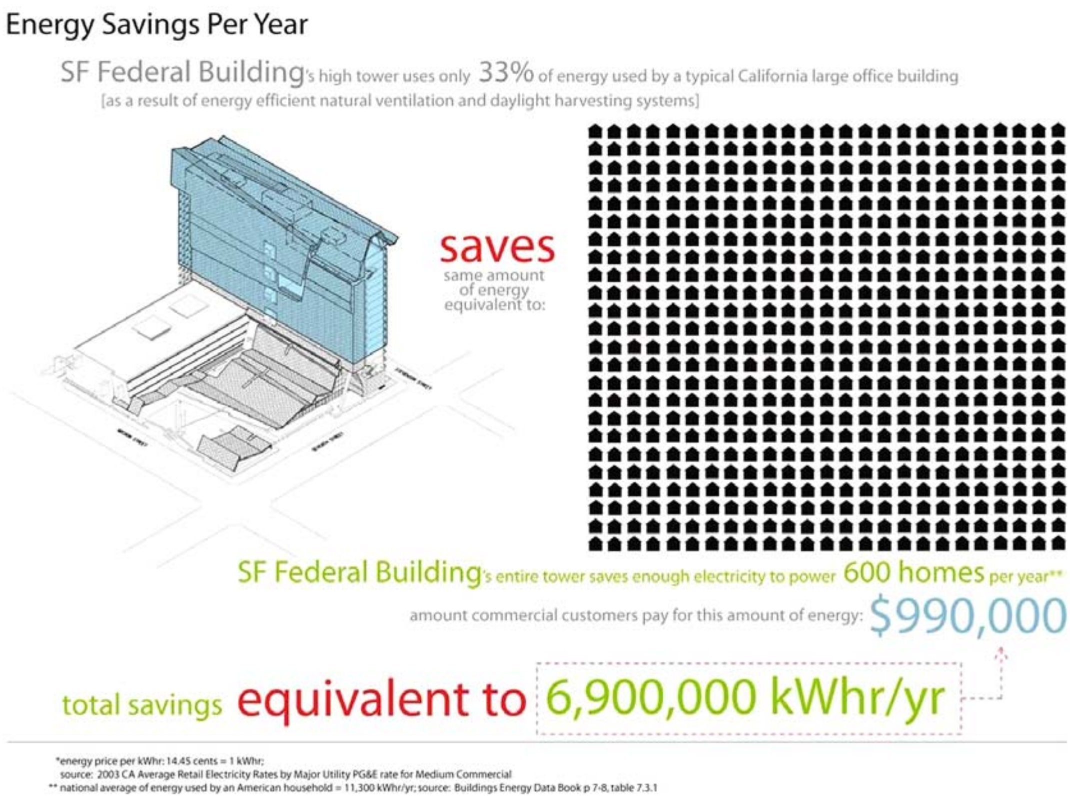

Figure 2.4.1.6: Federal Building Energy Savings Diagram [37]

Although this innovative building design was successful at lowering energy use, it was unsuccessful at providing a comfortable work environment to its occupants. The General Services Administration commissioned a nationwide post occupancy survey of

[36] "www.morphopedia.com: | Morphopedia | Accessed Oct 06, 2013.

[37] "www.morphopedia.com: | Morphopedia | Accessed Oct 06, 2013.

22 federal building's that included the San Francisco Federal Building. The study was commissioned to determine the employee satisfaction level with their work space. The San Francisco Federal Building received the lowest score of just 13% employee satisfaction and well below the average in thermal comfort and lighting categories. [38]

2.4.2. Performance-driven Parametric Design Precedent Pinnacle Building, London, UK

Figure 2.4.2.1: The Pinnacle Building, London, UK [39]

[38] Kim M. Fowler; Emily M. Rauch; Jordan W Henderson; Angela R. Kora (June 2010). *Re-assessing Green Building Performance*. Pacific Northwest National Laboratory. Retrieved 15 August 2012.

[39] Littlefield, David. *Space Craft: Developments in Architectural Computing*. London: RIBA Publishing, 2008.

The Pinnacle Building in London, United Kingdom is a complex example of a facade system that was developed through a performance-driven parametric design process (Figure 2.4.2.1.). The building was designed by the architecture firm Kohn Pedersen Fox (KPF) and is a 100 story building with more than 1,000,000 square feet of office space. This innovative building is sure to become an architectural icon upon its completion.

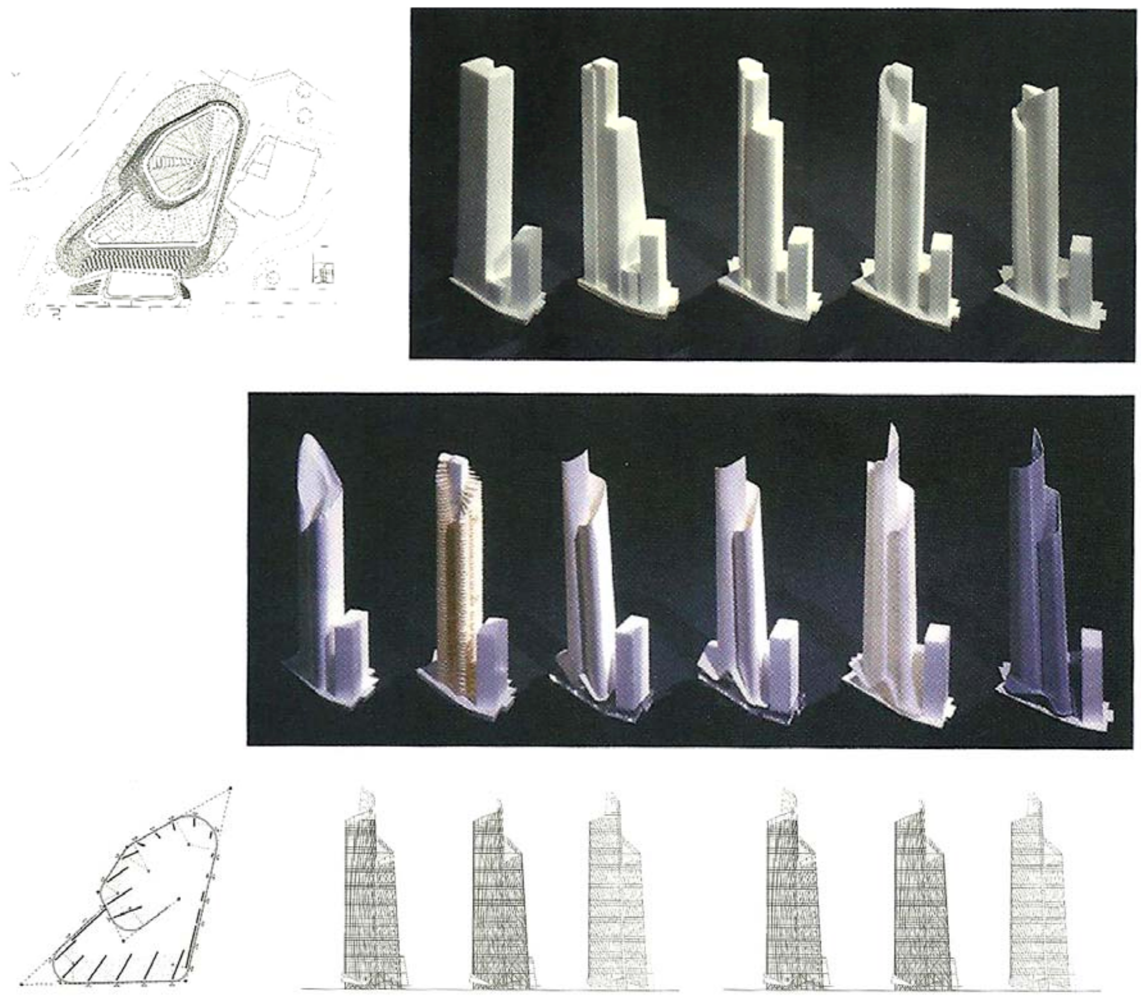

Figure 2.4.2.2: The Pinnacle Building Design Models [40]

[40] IBID. London: RIBA Publishing, 2008.

"The geometric approach is based on a number of simple constraints, while including flexibility in the design process. The need for flexibility means that the focus in the design process moves away from design of the object toward designing the system that designs the object. The tower is therefore built on a sequence of parametric dependency models, always responding to the demands of the process." [41]

During conceptual design, the building form was generally developed manually resulting in simple forms, cubes, cylinders, and prisms (Figure 2.4.2.2.). The form of the building made it difficult for the design team to find a "coherent geometric schema allowing for a tapering building where each face slopes differently to be built from simple geometry, capable of simple construction." [42] In order to realize the complex design, the form had to be parametrically modeled. In other words, rather than modeling the various floors individually using elementary modeling techniques (scale, rotate, etc...), the model was built parametrically with a system of rules that defined the arc lengths and radii to serve as the underlying "system that designs the [overall] object." [43] During the parametric form finding process, engineers also used the model to perform aerodynamic analysis in order to understand how the tower would perform under a wind load (Figure 2.4.2.3.).

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[41] IBID. London: RIBA Publishing, 2008.

[42] IBID. London: RIBA Publishing, 2008.

[43] IBID. London: RIBA Publishing, 2008.

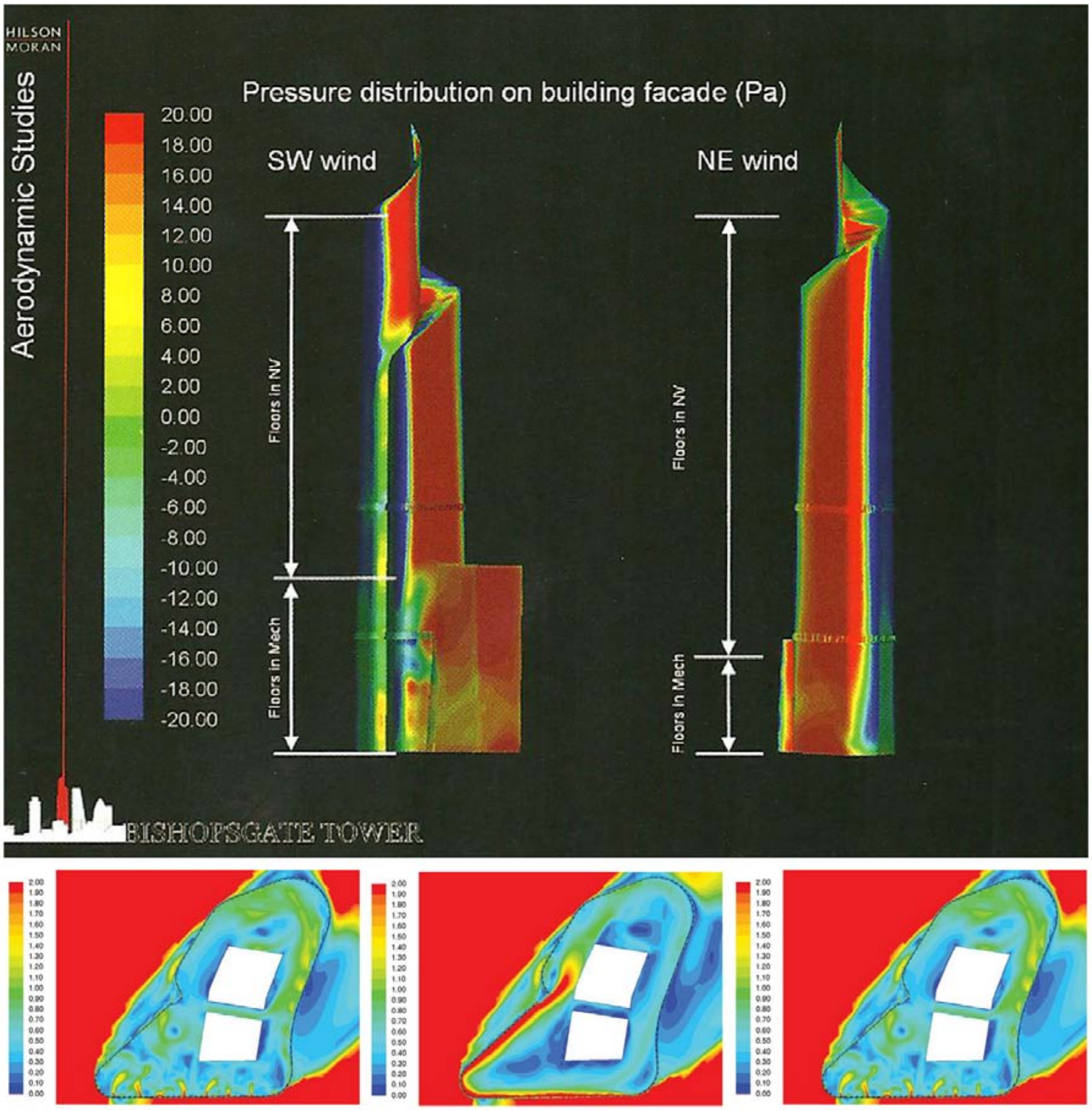


Figure 2.4.2.3: The Pinnacle Building Wind Load Studies [44]

44 IBID. London: RIBA Publishing, 2008.

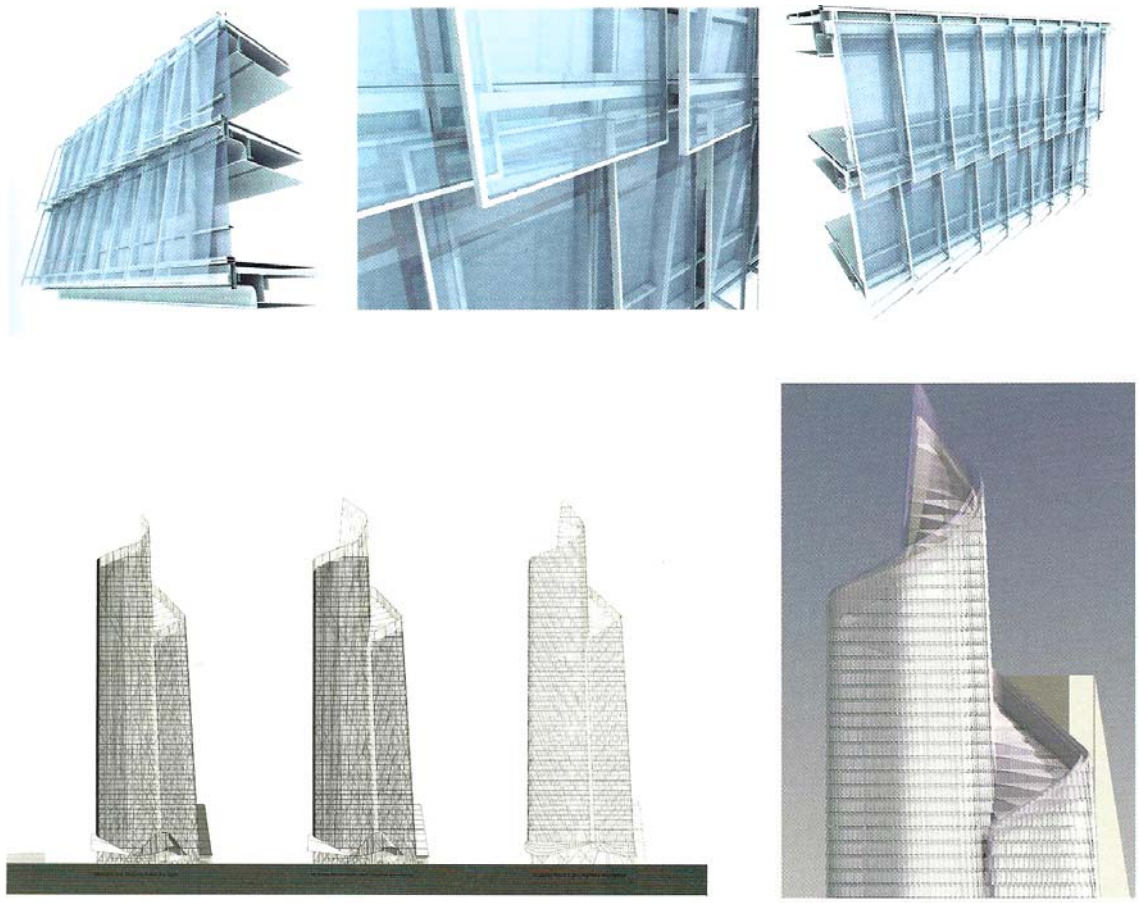


Figure 2.4.2.4: The Pinnacle Building Facade Drawings [45]

The facade development presented a similar challenge to the form development. The goal was to create a facade that would taper with the form of the floor plates, yet remain constructible using simple rectangular panels (Figure 2.4.2.4.). However, by nature, a rectangular panel does not conform to a tapered triangular form. A parametric definition was therefore essential to develop the logic that allowed the rectangular panel to populate the tapered face in a horizontal fashion (Figure 2.4.2.5.).

[45] IBID. London: RIBA Publishing, 2008.

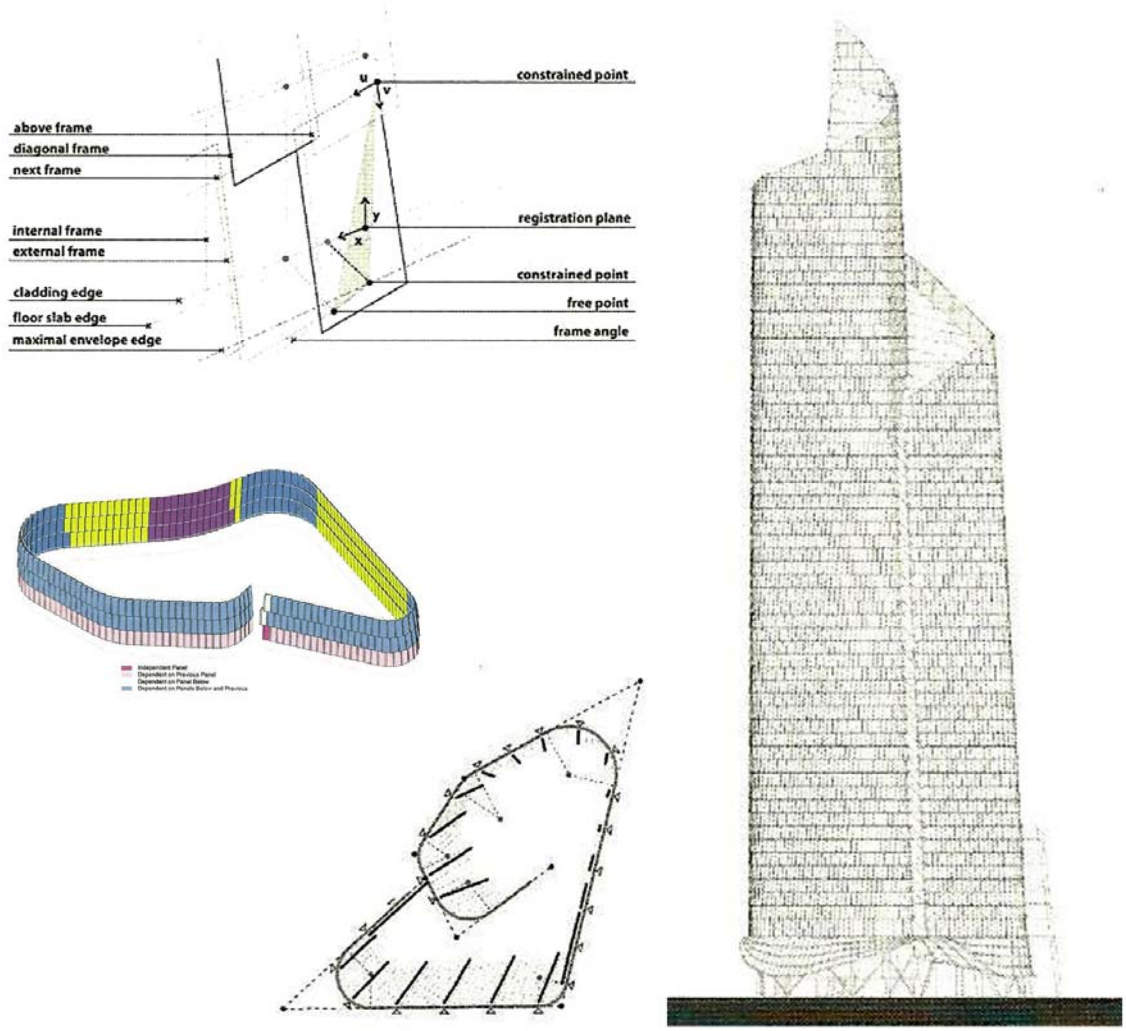


Figure 2.4.2.5: The Pinnacle Building Facade Diagrams [46]

As the facade system was being solved parametrically, daylighting analyses were also being performed to ensure that the daylighting performance goals were being met. The flexibility of the parametric process allowed for various iterations to be analyzed and resulted in an optimization daylighting strategy (Figure 2.4.2.6.).

[46] IBID. London: RIBA Publishing, 2008.

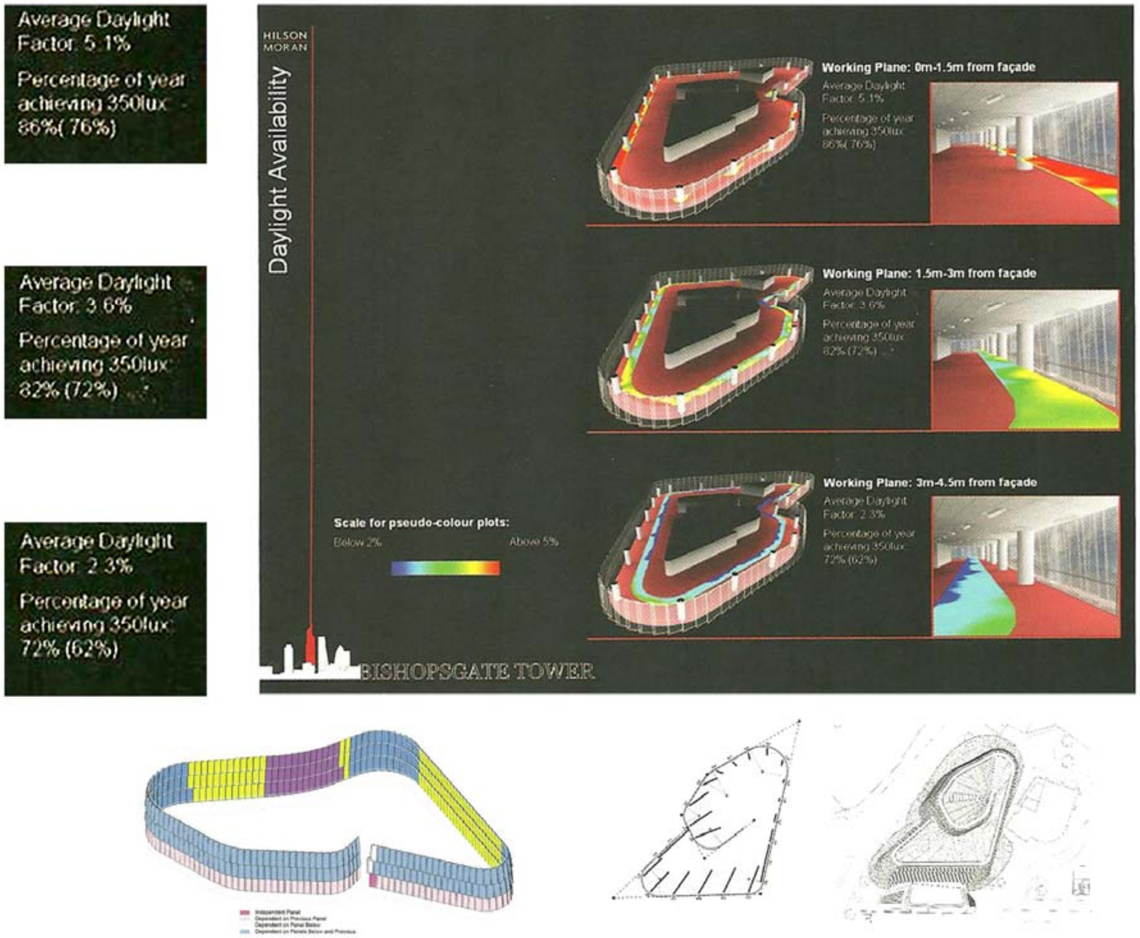


Figure 2.4.2.6: The Pinnacle Building Daylight Studies [47]

2.5. Contemporary Facade Design Conclusions

The Federal Building and Pinnacle Building are both successful examples of a parametric performance-driven and performance-driven passive design process that achieved reduced energy use in newly constructed buildings. During the design process designers used parametric software, integrated with performance-driven objectives to achieve lower energy use. These same design strategies should be used to retrofit outdated buildings. Integrating parametric design with performance-driven objectives and

[47] IBID: RIBA Publishing, 2008.

passive design strategies will help designers to meet the Architecture 2030 Challenge to reduce energy use of buildings and eventually lower the United States' demand for energy.

3. THESIS STATEMENT / RESEARCH QUESTIONS

3.1. Thesis Statement

A parametrically modeled, performance-driven passive solar deigned facade system will facilitate an incremental improvement in the energy use intensity (EUI) and illuminance levels (lux) of an existing office building.

3.2. Main Research Question

How much can a parametrically modeled, performance-driven passive solar designed facade system (glazing, shading devices, and light shelves) lower the energy use intensity (EUI) of an existing building while maintaining appropriate illuminance levels (lux)?

3.2.1. Research Sub-Questions

1. What is the impact of the percentage of glazing in a facade system on energy use intensity?

2. What is the impact of the type of glazing in a facade system on energy use intensity?

3. What is the relationship between glazing percentage and glazing type in terms of energy use intensity?

4. What is the impact of a passive solar designed, horizontal and slanted vertical louvers shade system on energy use intensity?

5. What is the impact of a parametrically modeled passive solar designed egg-crate and slanted vertical louvers shade system on energy use intensity?

6. How do passive solar horizontal and slanted vertical louvers compare to a parametrically modeled passive solar egg-crate and slanted vertical louvers in terms of energy use intensity?

7. What is the impact of using day lighting controls on energy use intensity?

8. What is the impact of the percentage of glazing in a facade system on illuminance levels (lux)?

9. What is the impact of shading devices on illuminance levels (lux)?

10. What is the impact of light shelves on illuminance levels (lux)?

11. How is an occupant's view impacted by a facade system's percentage of glazing, shading devices, and light shelves?

12. What combination of glazing percentage, glazing type, shade device type, and light shelf creates the lowest energy use intensity while maintaining appropriate visual comfort and maximum view (percentage)?

4. METHODOLOGY

4.1. Proof of Concept Project

The thesis statement and research questions were tested through a proof of concept project. The proposed performance-driven passive solar design process was used to design a retrofit facade system for an outdated office building in a hot mediterranean climate. Performance targets for energy use intensity (EUI) were based on the 2030 Challenge and targets were set with the Energy Star Target Finder. Performance targets for illuminance levels (lux) were established by referencing acceptable illuminance level charts, published by the Illuminating Engineering Society of North America (IESNA). The project and facade systems were modeled using a current parametric modeling software (Revit Architecture 2015) at the time of this research. Incremental parametric changes were then made to the facade systems; then the existing and post-design energy use intensity and illuminance levels were measured using current energy analysis software (Autodesk Green Building Studio). The data was then compared and contrasted to determine how the performance-driven passive solar designed facade systems impacted the building's energy use intensity (EUI), illuminance levels (lux), and percentage of view.

4.1.1. Site and Building Selection

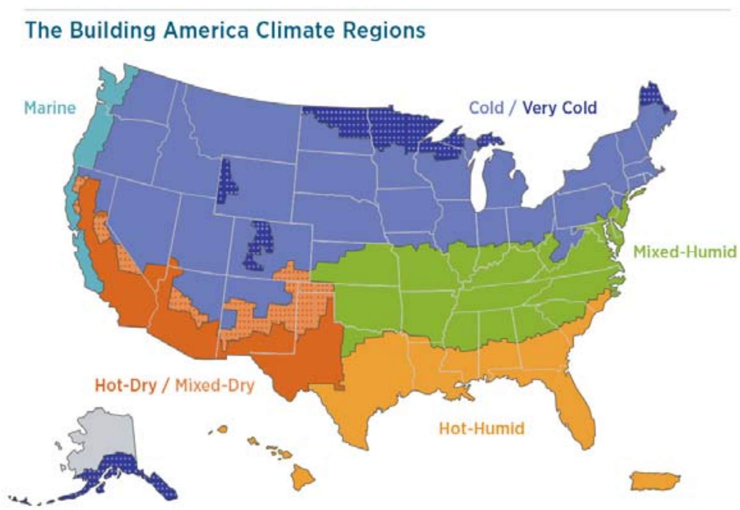
The building that was selected for this proof of concept project is the Natural Resources Agency Building (formally known as the Retirement Building) at 1416 9th Street in Sacramento, California, near the State Capitol (Figure 4.1.1.1.). The existing building is an 18 story high-rise office complied in 1964.

Figure 4.1.1.1: Site Location Diagram Images from Google Earth

4.1.2. Site and Building Analysis

Site Analysis

Sacramento, California, is considered a hot-mediterranean climate in climate zone 3B (Figure 4.1.2.1.). This climate type is known to have cool damp winters and hot dry summers. The site analysis for this project was performed in Autodesk's climate analysis software Ecotect Analysis 2011,[48] and includes all of the following data, tables, graphs and analysis found in the chapter. According to Figure 4.1.2.2 the average annual temperature is 61.0 °F (16.1 °C). The monthly daily average temperature ranges from 46.4 °F (8.0 °C) in December to 75.5 °F (24.2 °C) in July (Figure 4.1.2.2.).



Building America	IECC
Subarctic	Zone 8 (only found in Alaska)
Very Cold	Zone 7
Cold	Zones 5 and 6
Mixed-Humid	4A and 3A counties above warm-humid line
Mixed-Dry	Zone 4B
Hot-Humid	2A and 3A counties below warm-humid line
Hot-Dry	Zone 3B
Marine	All counties with a "C" moisture regime

Figure 4.1.2.1: Climate Zone Map [49]

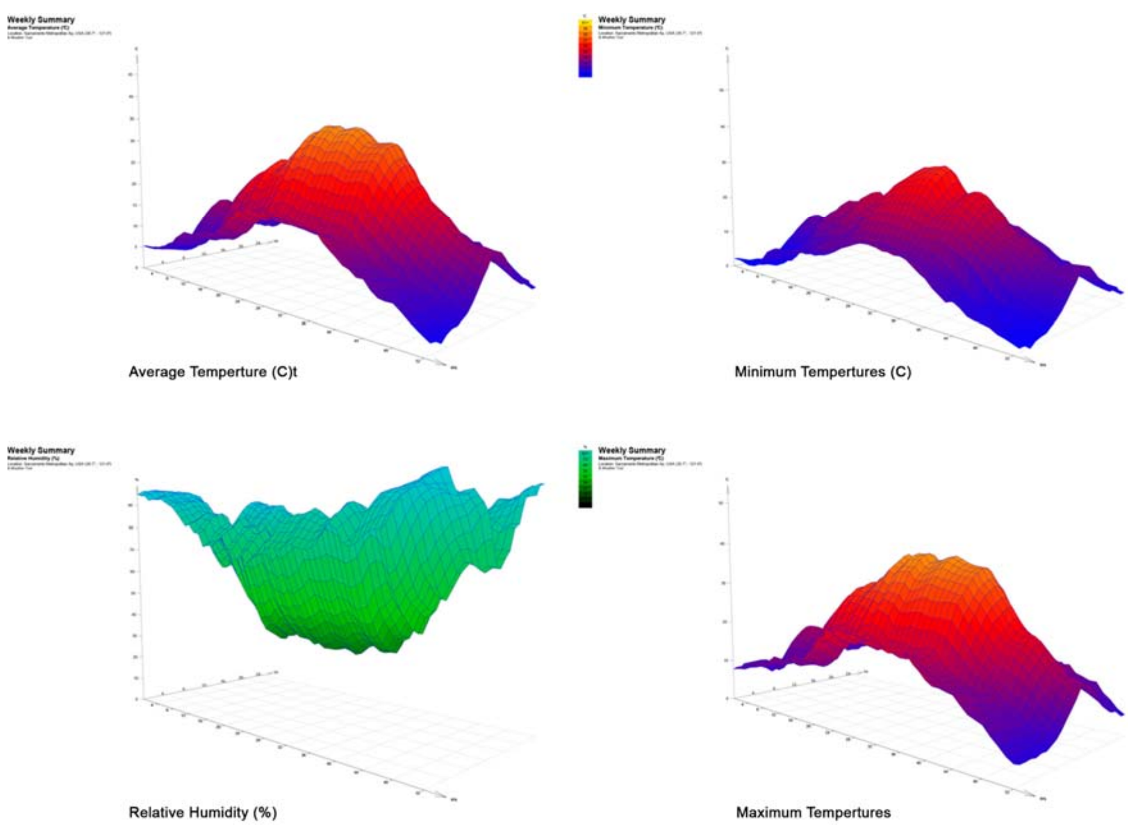


Figure 4.1.2.2: Temperature Graphs Autodesk Ecotect Analysis 2011 Weather Tool [50]

[49] "www.energycodes.gov: The Building America Climate Regions." Accessed Dec. 10, 2014.
[50] Autodesk Ecotect Analysis 2011 Weather Tool. Software.

The average maximum temperature during summer is 89.4 °F (31.9 °C). 73 days out of the year exceed 90 °F (32 °C) and 14 days out of the year exceed 100 °F (38 °C) (Figure 4.1.2.2.). The average minimum temperature during the winter is 43.9° F (6.6 °C) (Figure 4.1.2.2.). There are 15 days where the temperature drops to 50° F (10 °C), and 15 nights that freeze per year. The average relative humidity is 82.6%. According to Figure 4.1.2.3 the average relative humidity in the summer is 77.6%.

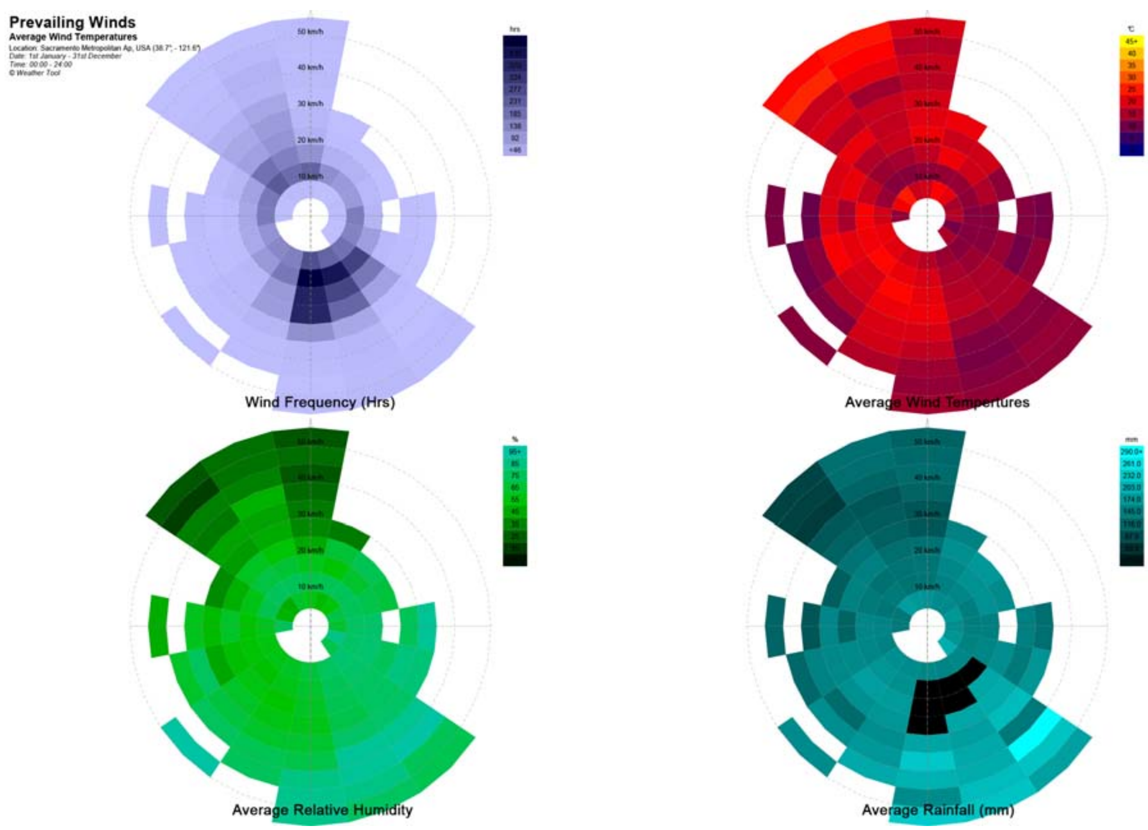


Figure 4.1.2.3: Wind Rose, Average Wind, Average Relative Humidity, and Average Rainfall Graphs Autodesk Ecotect Analysis 2011 Weather Tool [51]

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[51] Autodesk Ecotect Analysis 2011 Weather Tool. Software.

The rainiest months typically occur from October to April (Figure 4.1.2.3.). The average annual precipitation is 18.52 inches. Average high rainfall is 3.67 inches, during January. There is generally no measurable precipitation during the summer months. The summer temperatures and humidity tend to drop in the evening, a result of the prevailing delta breeze, predominantly from the northwest year-round.

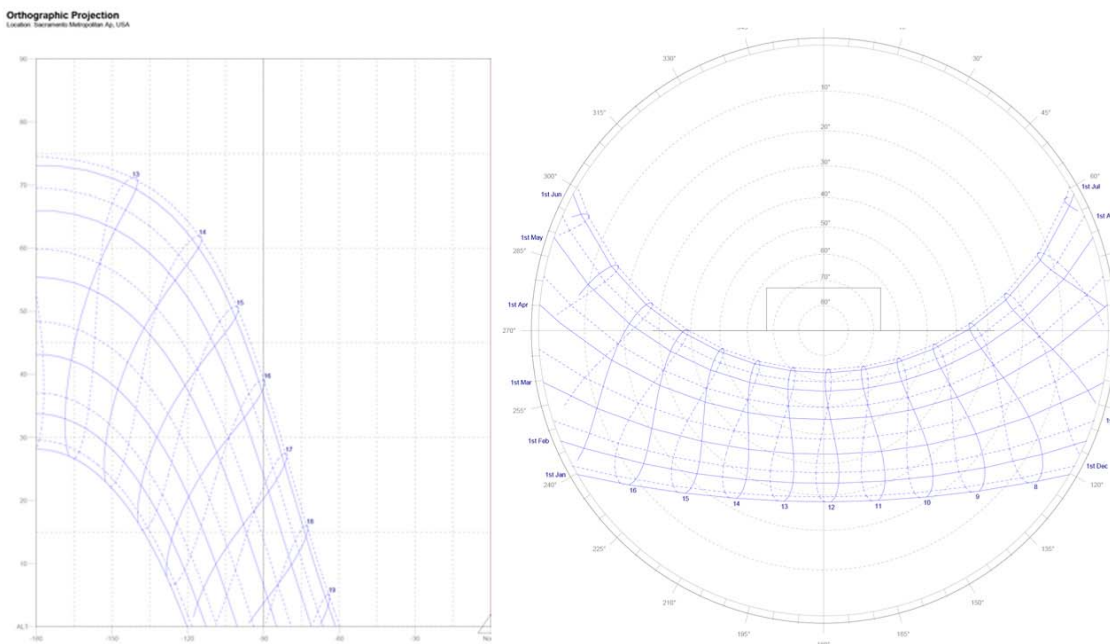


Figure 4.1.2.4: Sun Angles Autodesk Ecotect Analysis 2011 Weather Tool [52]

[52] Autodesk Ecotect Analysis 2011 Weather Tool Software.

The year-round sun angles are reflected in Figure 4.1.2.4. The sun angles found on these carts were used in the design of the various shading charts that were designed during this project. The optimal solar orientation for this site is 97.5° from north and is reflected in Figure 4.1.2.5.

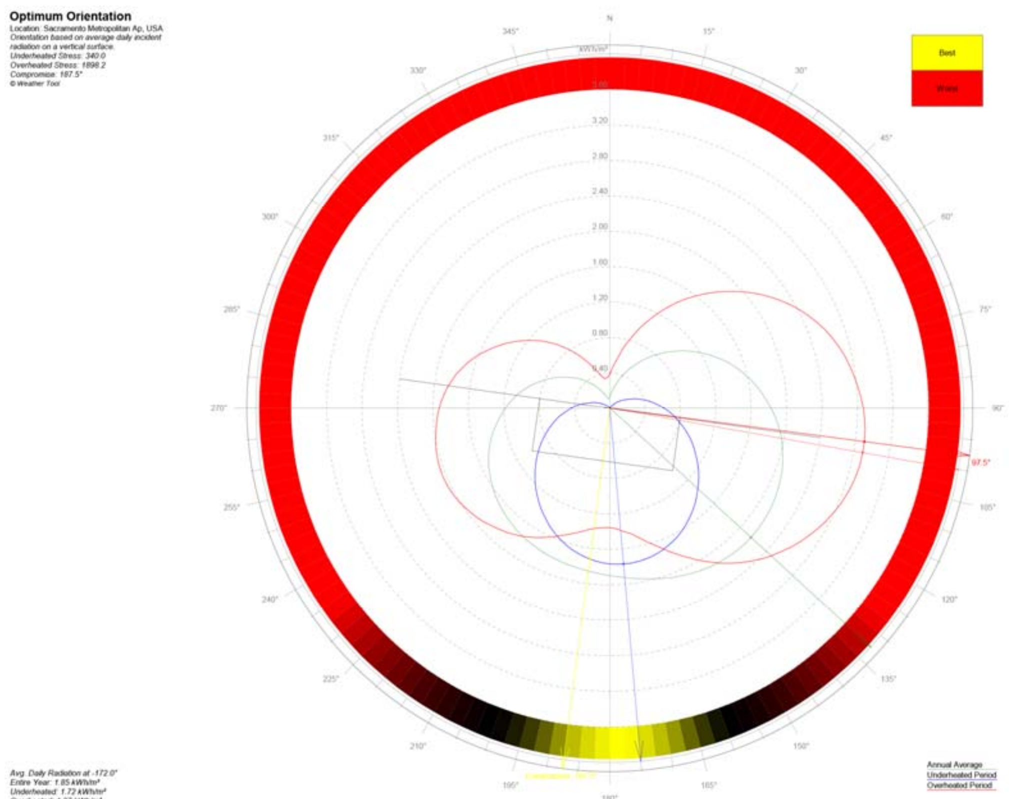
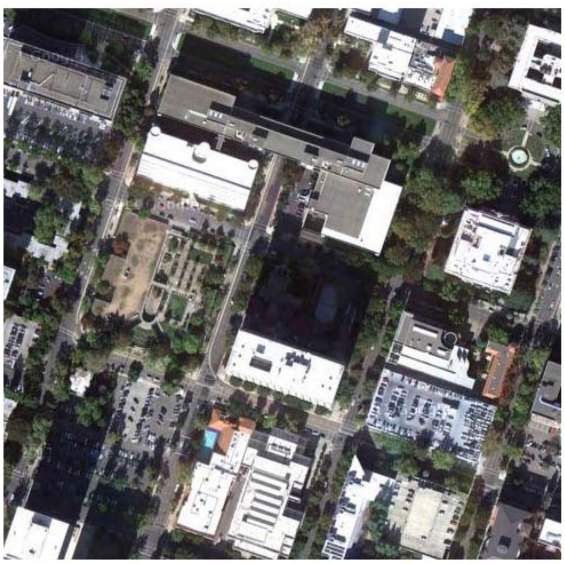


Figure 4.1.2.5: Optimal Solar Orientation Autodesk Ecotect Analysis 2011 Weather Tool [53]

[53] Autodesk Ecotect Analysis 2011 Weather Tool Software.

Building Analysis

The selected building was designed well for the time period in which it was built. The building is oriented 90 degrees from north, only 7.5 degrees off of the recommended optimal solar orientation (Figure 4.1.2.6.). The building's single pane glazing, typical for this time period, was properly sized and placed to minimize solar gain and loss during the summer and winter months. Although this building was well designed, it nevertheless offers many opportunities for improved passive solar and day-lighting performance.



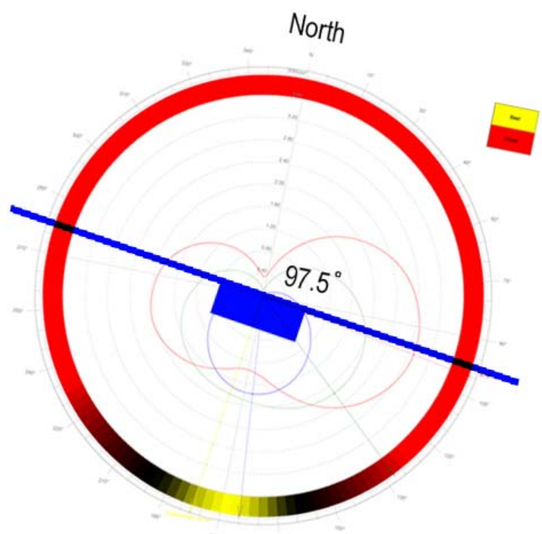


Figure 4.1.2.6: Optimal Solar Orientation Diagram Autodesk Ecotect Analysis 2011 Weather Tool [54]

Figure 4.1.2.7 shows that the building's form easily accommodates passive design strategies. Since, the building's solar orientation is nearly optimal, there is potential to effectively heat and cool the building through passive techniques. Furthermore, the building's thin shape provides opportunities for natural day lighting.

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[54] Autodesk Ecotect Analysis 2011 Weather Tool. Software.

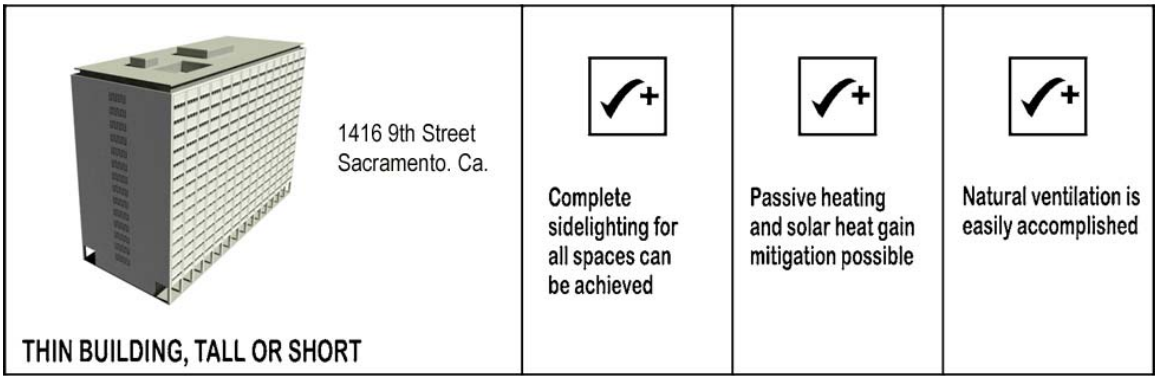

Figure 4.1.2.7: Building Shape Diagram

This building could also benefit from upgraded glazing and appropriate shading systems that will block out the majority of the average summer sun while allowing some of the low winter sun to enter into the space and provide passive heating and cooling. A passive ventilation system could also lower the building's energy use. However, ventilation is outside of the scope covered in this research and was not considered as an option in the design process.

4.2. Early Design Process

Two digital processes were experimented with during the design phase of this project. The first process integrated the modeling software Rhinoceros and parametric modeling plug-in Grasshopper with a plug-in called Geco to create a feedback loop from Autodesk Ecotect 2011 to Rhinoceros (Figure 4.2.1.). This feedback loop facilitated the display of Ecotect analysis data to appear in the Rhinoceros interface (Figure 4.2.2.).

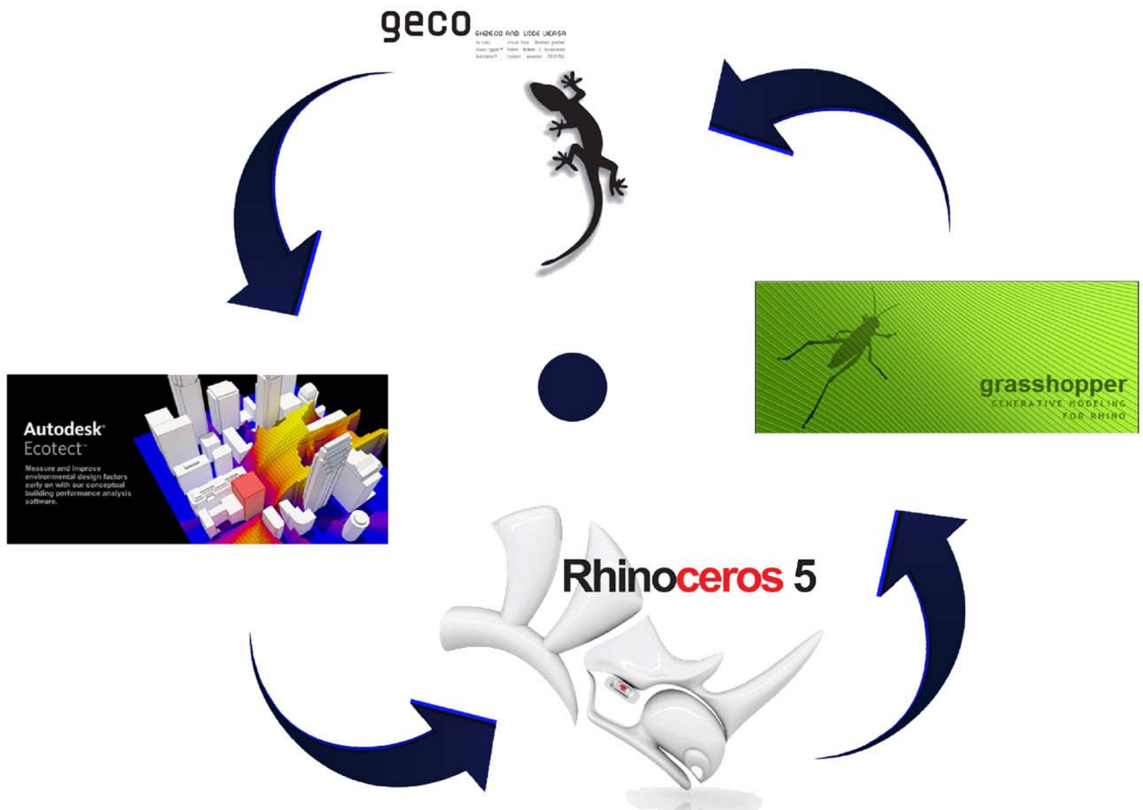

Figure 4.2.1: Early Conceptual Design Workflow Diagram

Figure 4.2.2 shows images from the first design process using Rhinoceros, Grasshopper, Geco and Ecotect. Figure 4.2.3 shows the various apertures that were tested in this early design process to determine if a particular shape was more or less effective at reducing solar gain while maintaining appropriate day lighting levels. The rectangular aperture proved to outperform the other apertures. It is important to note, that many of the concepts learned in this early design process eventually informed the geometric direction that was taken for the design of the parametrically modeled egg-crate shade device. However, the data gathered during this early phase is not documented in this research.

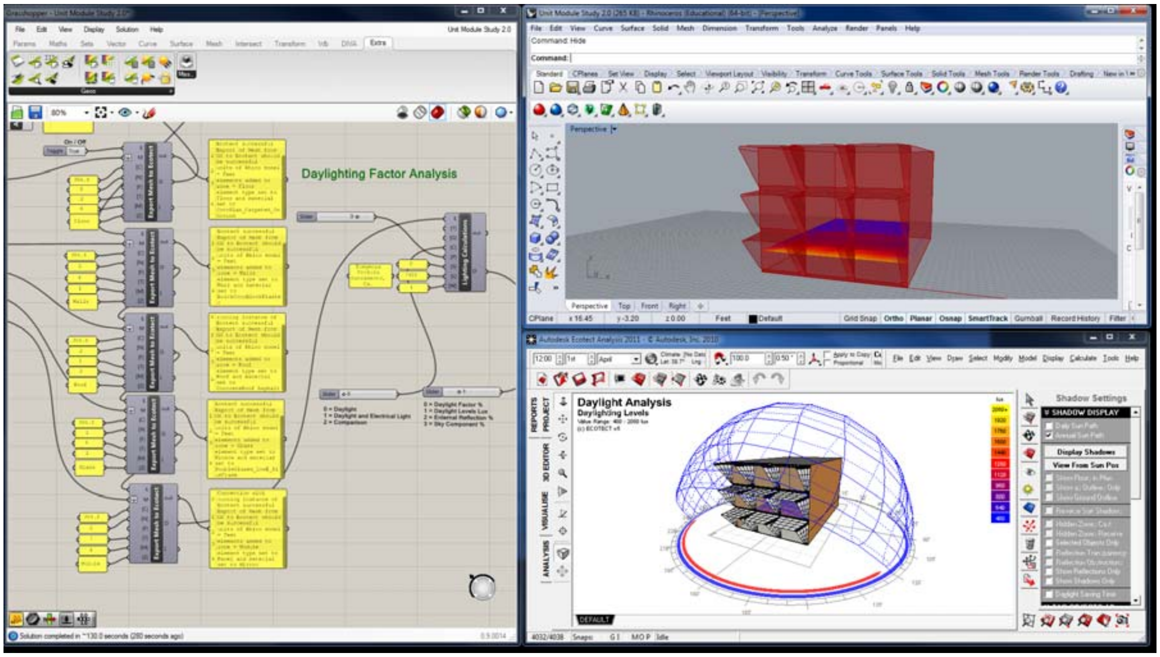

Figure 4.2.2: Rhino, Grasshopper, Geco, Ecotect Workflow Screen Shot

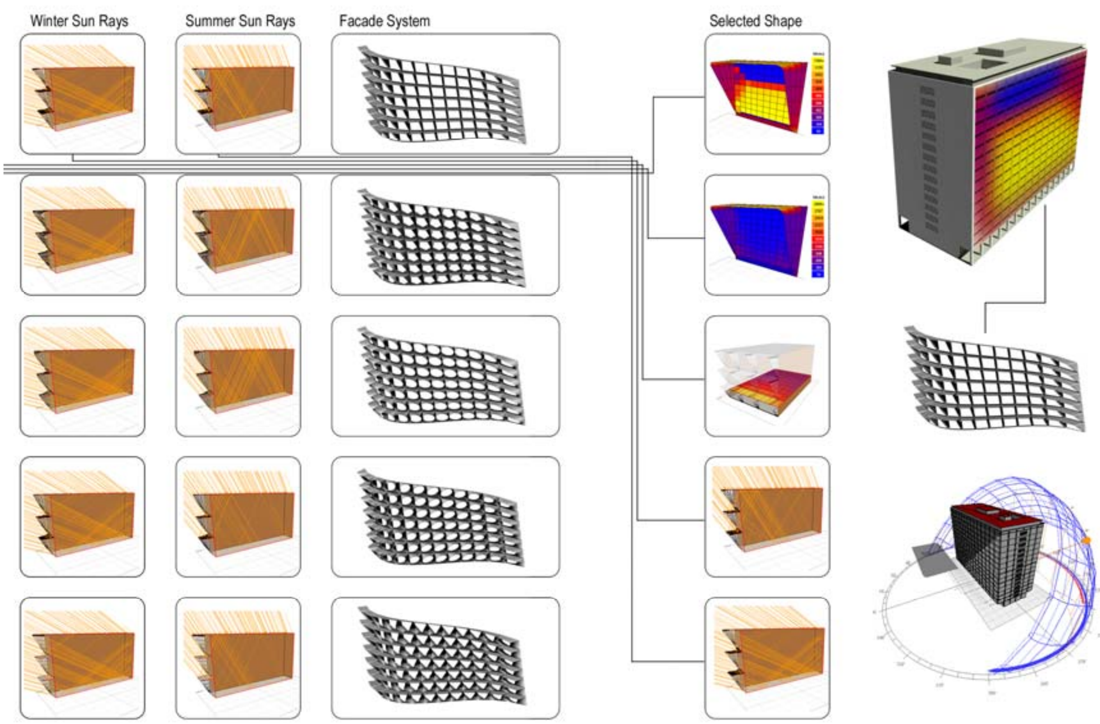

Figure 4.2.3: Early Conceptual Design Diagram

The initial design process that employed Rhinoceros, Grasshopper, Geco, and Ecotect was simply too time consuming, requiring 1-2 hours per iteration. For this reason, the actual studies for this project were done in Revit Architecture 2015 and Green Building Studio (Figure 4.2.4.). Figure 4.2.4 demonstrates the second design process that employed Autodesk Revit 2015 and the energy analysis software Green Building Studio.

Figure 4.2.4: Conceptual Design Workflow Programs

4.3. Revit Architecture 2015 & Green Building Studio

The Energy Model for this project was created in Autodesk Revit 2015 and the energy simulation was performed in the cloud based analysis software Green Building Studio. Since Green Building Studio is a cloud based program, the analyses are processed by Autodesk servers, which greatly reduces the computation time. This process required 1-2 minutes per iteration.

It should be noted, that there are currently no federal standards verifying absolute precision of energy modeling software. The current state of energy modeling software is insufficiently accurate to predict actual energy use of a building. [55] Autodesk Revit 2015 and Green Building Studio are accurate at determining if one strategy is more or less effective than another and is the focus of this research. [56]

[55] ASHRAE, AIA, IESNA, U.S. Green Building Council, and U.S. Department of Energy. "Advanced Energy Design Guide for Small to Medium Office Buildings," 2011.

[56] Vandezande, James, Eddie Krygiel, and Phil Read. *Mastering Autodesk Revit Architecture 2014*. Indianapolis, India: John Wiley & Sons, Inc., 2013.

4.3.1. Revit Element Model

The first step was to create an accurate Revit Element Model, based on the original construction documents (Figure 4.3.1.1.) of the selected building. The Revit Element Model was modeled after the information found in the original plans, sections, and details. The building manager was also contacted on various occasions to answer questions regarding materiality, mechanical and electrical systems, occupancy use, and building schedule.

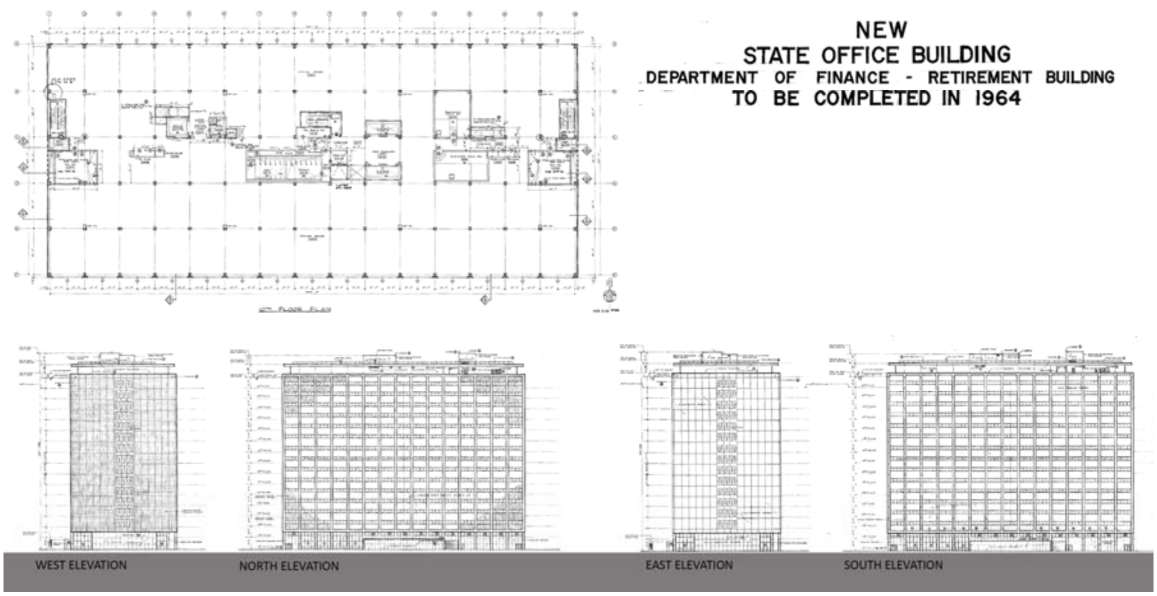

Figure 4.3.1.1: Original Construction Documents

Table 4.3.1.1 represents the Conceptual Construction Settings used to create the Revit model. Figure 4.3.1.2 are images of the Revit Element Model.

Baseline Analysis 1 Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Mass Exterior Wall	High Mass Construction – No Insulation	Ceramic Finish Over Precast Conc. Panel
Mass Interior Wall	Lightweight Construction – No Insulation	Gyp. Bd. Over Metal Studs @ 16" O.C.
Mass Exterior Wall - Underground	High mass Construction – Typical Mild Climate Insulation	Concrete Foundation w/ Weather Barrier
Mass Roof	Typical Insulation – Cool Roof	Typical Cool Roof Over Light Weight Construction.
Mass Slab	High Mass Construction – No Insulation	Concrete Slab
Mass Glazing	Single Pane – Tinted	Tinted Single Pane
Mass Skylight	Single Pane – Tinted	Not Applicable
Mass Shade	Basic Shade	Default Revit 2014
Mass Opening	Air	Default Revit 2014

Table 4.3.1.1: Baseline Analysis 1 Construction Settings

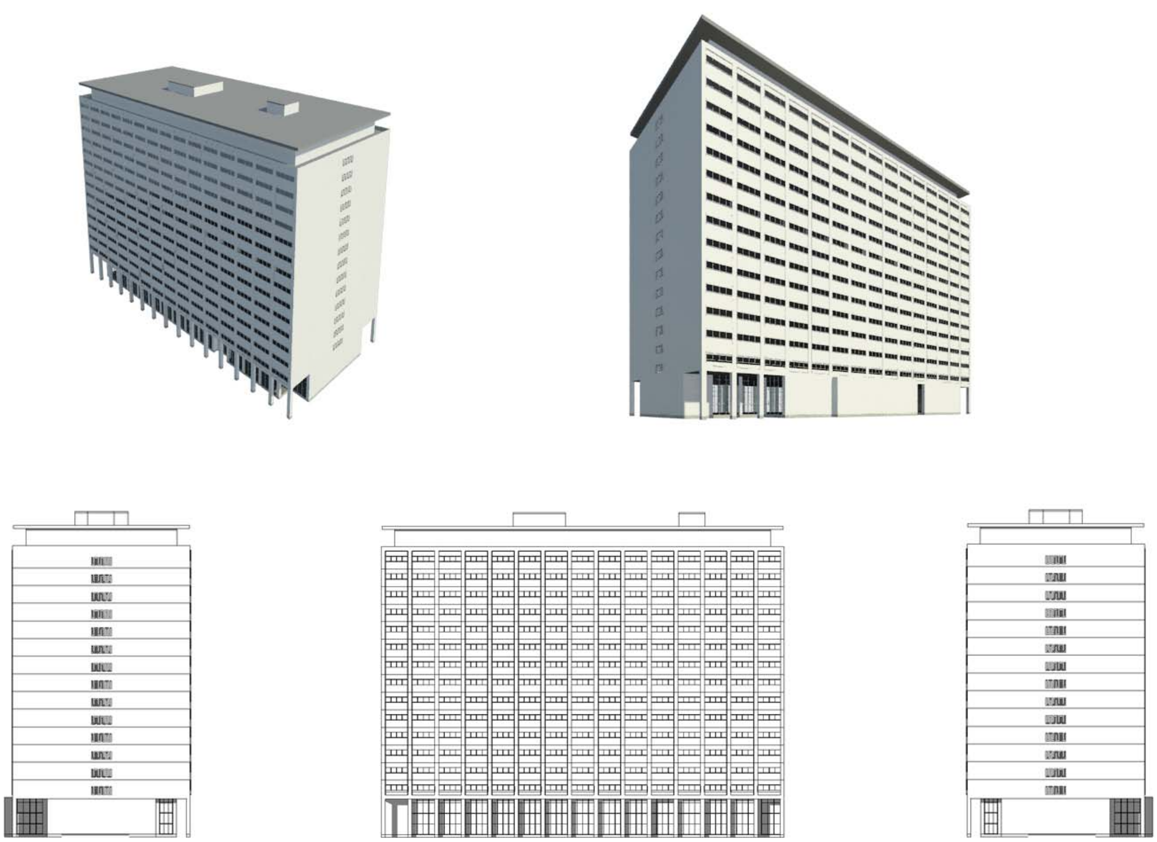

Figure 4.3.1.2: Perspective and Elevation Views of the Revit Element Model

4.3.2. Revit Energy Model

Unlike the architectural element model (Figure 4.3.1.2.), the energy model does not embody the exact appearance of the building it represents, but rather a simplified version of the building that acts as a graphic representation of the parameters inputted into the model. For example, in an energy model it is more important that one accurately inputs the percentage, orientation and type of glazing, than it is to perfectly locate the individual glass panes on the facade.

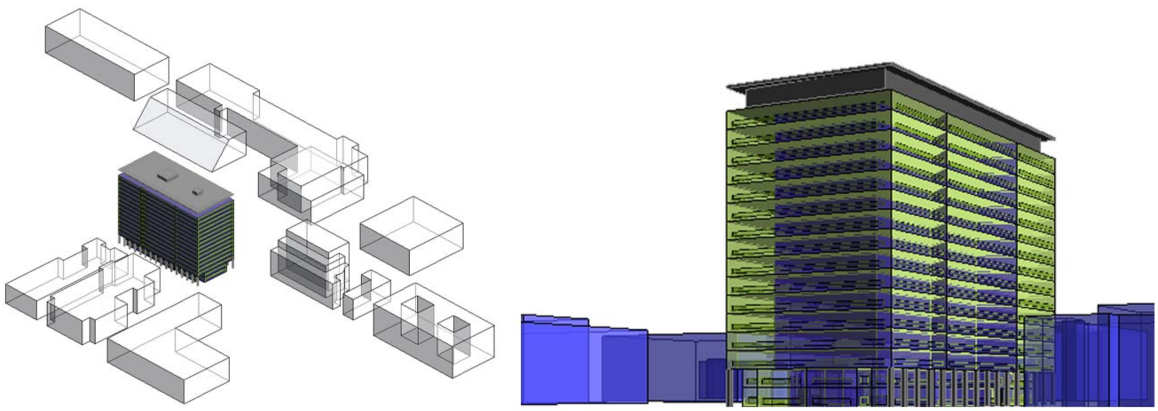

Figure 4.3.2.1: Revit Energy Model Process Image

Figure 4.3.2.1 shows the Revit Energy Model and the surrounding context. Similar to the Revit Element Model, the Revit Energy Model was based on the dimensions from the original construction documents (Figure 4.3.1.1.). The model was then digitally located using the internal Internet Mapping Service in the Location Weather and Site dialogue box. The location was set to the exact address at 1416 9th Street, Sacramento, CA 95814, USA. At Latitude: 38.581573486 and Longitude: -121.494400024 (Figure 4.3.2.2.). The Weather Station that was selected was station 59386 located approximately 0 miles (less than a mile) away from the site.

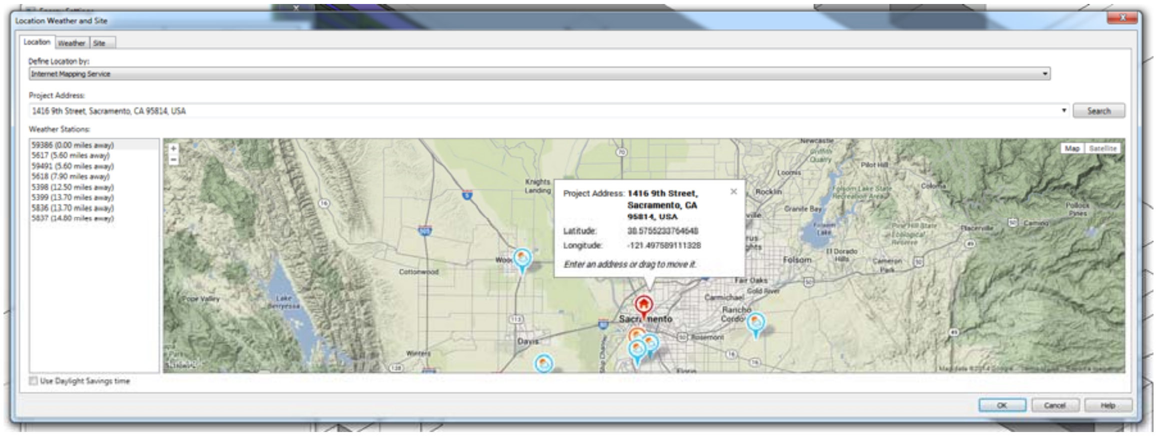

Figure 4.3.2.2: Revit Project Location Window

The surrounding buildings were located and modeled based on the current information found in Google Earth. The model of the existing building and its surrounding structures were modeled as accurately as possible given the information at hand. Brummel, Myrick & Associates (BMA), a Mechanical Engineering firm located in San Luis Obispo, California, was consulted during this process to ensure that informed decisions were made while inputting the parameters that represent the energy model.

The Building Type was defined as an Office due to the building primary function, the secondary functions were set to Lobby and Electrical / Mechanical. Revit calculated the gross floor area of the building as 645,330 square feet. The Number of Occupants during hours of operation was set to 2,431, the default Green Building Studio setting for buildings of this type and size. Export Category was defined as Spaces per recommendation found at Help: Revit Users website.[57] Export Category is Spaces rather that Rooms because it allows the designer to input more specific parameters for the individual spaces. The Export Complexity was set to Simple with Shaded Surfaces because the energy model was created as a mass. Include Thermal Properties, was set to

[57] Autodesk Ecotect Analysis 2011 Weather Tool. Software.

“No” because the model is not an element base model. Project Phase is not applicable to this discussion, however it may be worth noting that this project has been digitally organized into two phases: existing and new construction. The Silver Space Tolerance and Analytical Space Resolution were defined as 1’- 0” and 1’- 6” as the default setting in Revit per recommendation found at Help: Revit Users website.[58] The Silver Space Tolerance represents the gap between spaces and rooms that is tolerated by the energy simulation. Although this setting was set to 1’- 0”, it should be noted that the model was created with strict tolerances (+/- 1”). The Core Offset was set 45’-0” and the Divide Perimeter Zones were both set to “Yes” to represent the typical zones used in a heating / cooling load calculation. The Target Percentage Glazing (30%) and Target Sill height (3’- 0”) were set based on the original construction documentation. The Glazing is Shaded, Shade Depth, and Target Percentage Skylights options were not applicable to the existing condition of the building, so they were not used. The HVAC System was set to be 4-Pipe Fan Coil System, Chiller 5.96 COP, Boilers 84.5 eff (Determined via communication with the Building Manager) setting based on the building type and size. Outdoor Air Information was not considered for this analysis. Building Infiltration Class was set to “None” on all analysis in order to focus the study on the effects of the facade (glass, shading, and light shelf) on the energy needs of the building. The energy settings, parameters and variables that were used to create the Revit Energy Model are found in Table 4.3.2.1.

[58] “www.help.autodesk.com: Help: Revit Users.” Accessed February 8, 2014.

Baseline Analysis 1 Energy Parameters

Parameter	Variable
Location	1416 9th St. Sacramento, California
Building Type	Lobby (Ground Floor), Office (2nd-16th Floors), Electrical/Mechanical (17th Floor)
Gross Floor Area (Total)	645,330 square feet
Number of Occupants (Operational Hours)	2,431 (Calculation by Green Building Studio)
Export Category	Spaces
Export Complexity	Simple with Shading Surfaces
Include Thermal Properties	No
Project Phase	Not Applicable (Each Iteration was Modeled Separately)
Silver Space Tolerance	1'- 0" (default Revit 2014)
Analytical Space Resolution	1'- 6" (default Revit 2014)
Core Offset	45'- 0" (Derived from Original Construction Documents)
Divide Perimeter Zones	Yes
Target Percentage Glazing	30% (Calculated in Revit)
Target Sill height	Typ. 3'- 0" / Input per Elevations
Glazing is Shaded	No
Shade Depth	Not Applicable
Target Percentage Skylights	0%
Skylight Width & Depth	Not Applicable
Building Operation Schedule	12/6 Facility
HVAC System	4-Pipe Fan Coil System, Chiller 5.96 COP, Boilers 84.5 eff (Consulted with BMA)
Outdoor Air Information	Not Applicable

Table 4.3.2.1: Baseline Analysis 1 Energy Settings

The baseline energy use intensity and illuminance level (lux) analysis were then analyzed in Green Building Studio with the settings established in the in Sections 4.3.1 and 4.3.2.

4.3.2.1. Baseline EUI Values and Potential Energy Savings

The resulting energy use intensity (EUI) for the baseline Analysis 1 was 51.9 kBtu/s.f./yr. Figure 4.3.2.1.2 shows that there are potential energy savings in lighting efficiency, plug load efficiency, occupancy sensors, window glass with daylight controls, window glass, skylight glass with daylight controls, daylight controls, and building orientation. Lighting efficiency, plug load efficiency, occupancy sensors, skylight glass with daylight controls, and building orientation are outside of the scope of the project because they are not directly related to the facade retrofit, so they are not discussed in this research. Window glass with daylight controls, window glass, and daylight controls do, however, relate to the facade and are the focus of this research as areas of potential energy savings. Figure 4.3.2.1.1 shows the original facade design used during all of the baseline analysis.

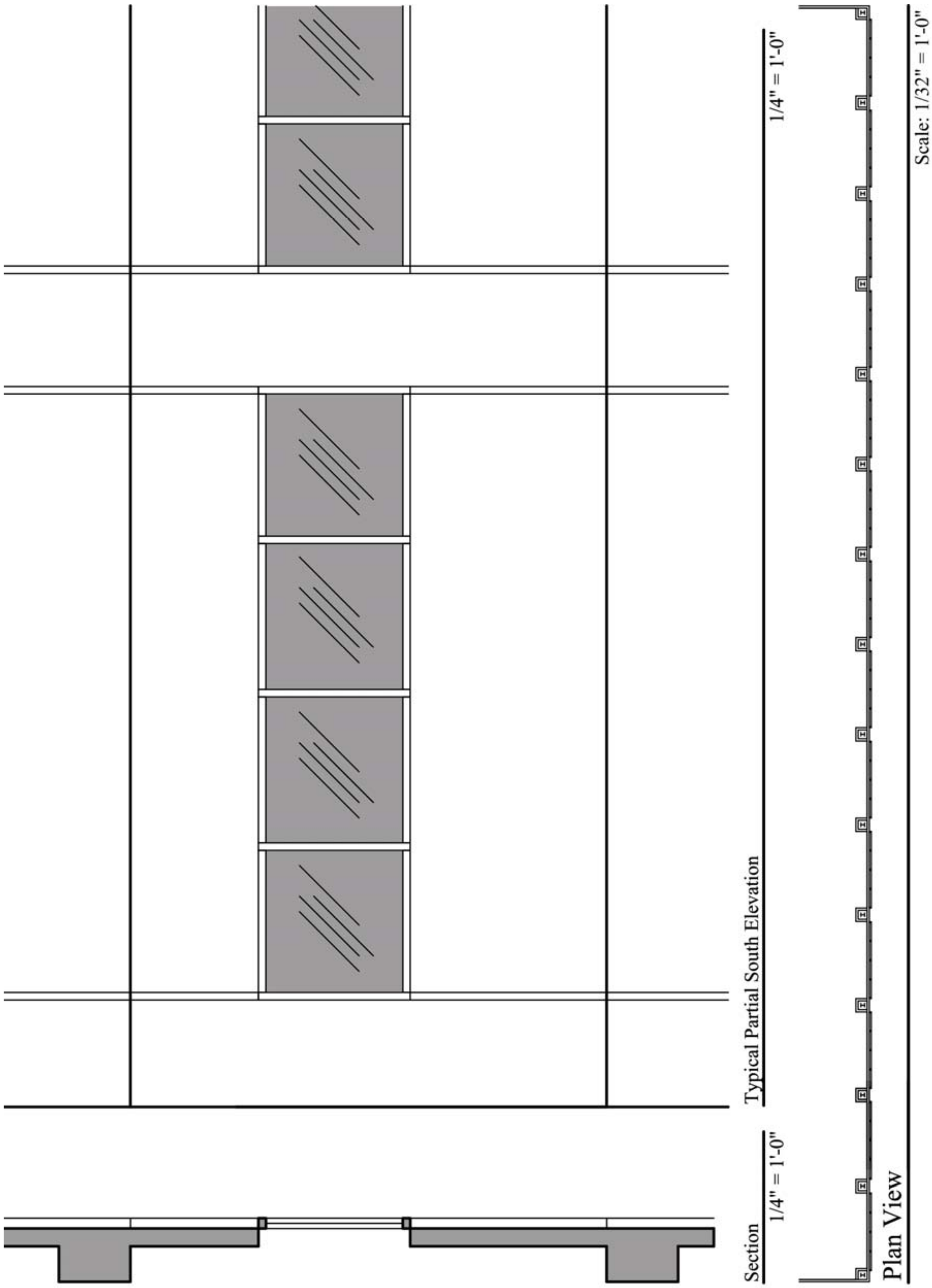

Figure 4.3.2.1.1: Documentation of the Design for the Baseline Analysis 1

Analysis 1 Synthesized EUI Report

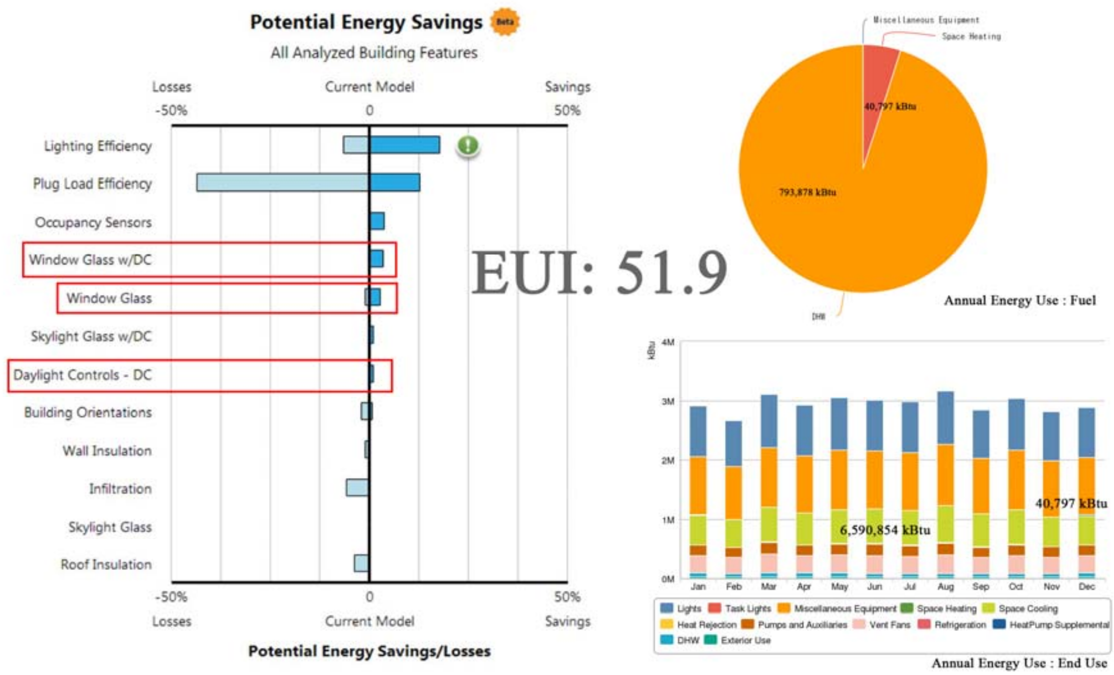

Figure 4.3.2.1.2: Analysis 1 Synthesized EUI Report

4.3.3. Revit Daylight Model

The daylight model was created in Revit Architecture 2015 as a Revit Element Model. The building was modeled as close to the original construction documents as possible. Materials were all defined as close to the original building as possible using the information at hand. Then a 5’ x 20’ grid of office desktops were modeled to be at 2’-6” above the finished floor. These desktops were used to gather illuminance levels (lux) data at the typical working surface. The Daylight and Illuminance Renderings were taken in Green Building Studio from the 10th floor looking towards the southeast corner of the building. All renderings were taken at noon on the summer solstice, winter solstice, spring equinox and fall equinox. Lux values were then assigned to the Illuminance Rendering using Adobe Photoshop RGB values.

4.3.3.1. Baseline Daylight Analysis

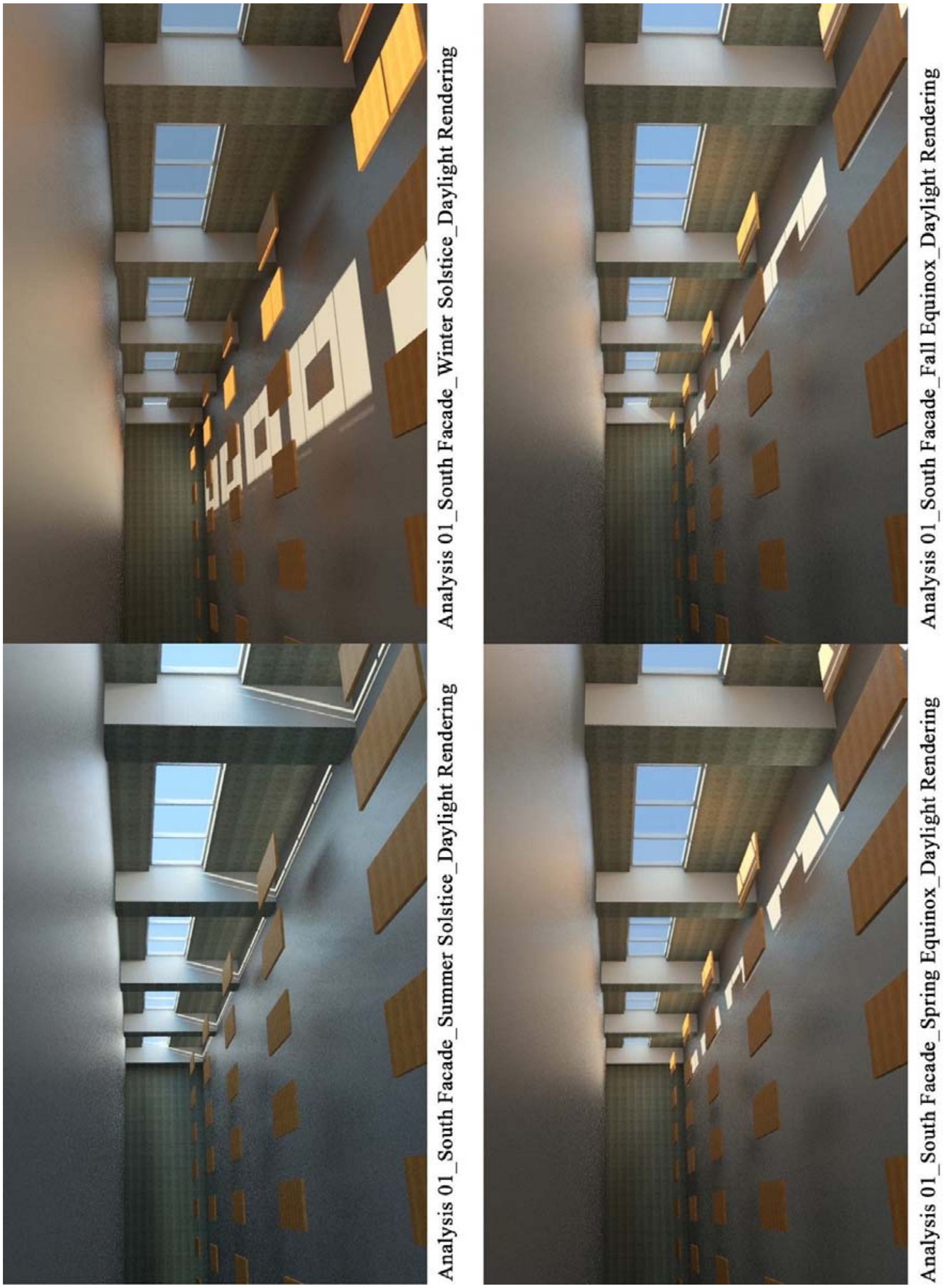

Figure 4.3.3.1.1: Analysis 1 Daylight Renderings

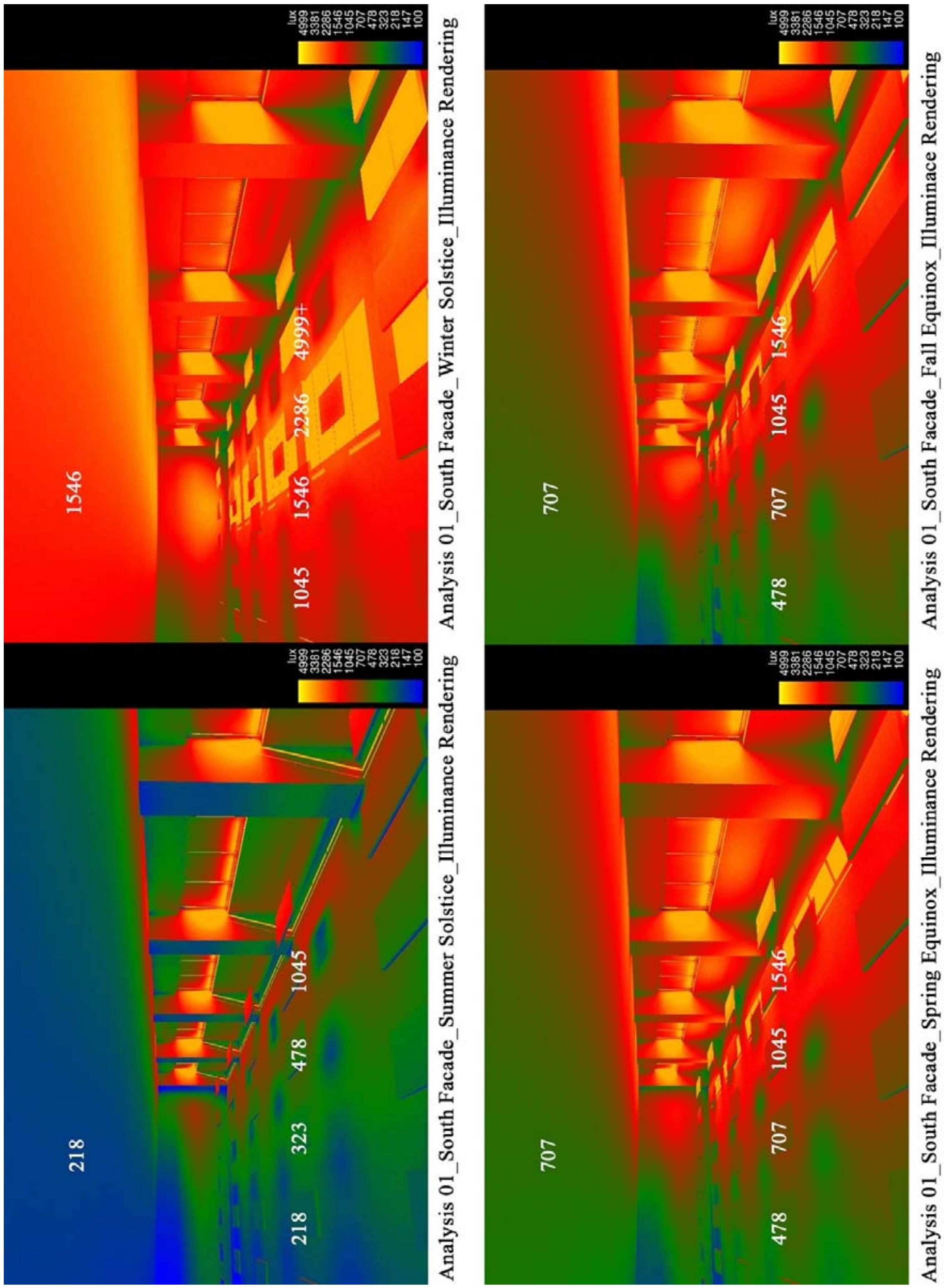

Figure 4.3.3.1.2: Analysis 1 Illuminance Renderings

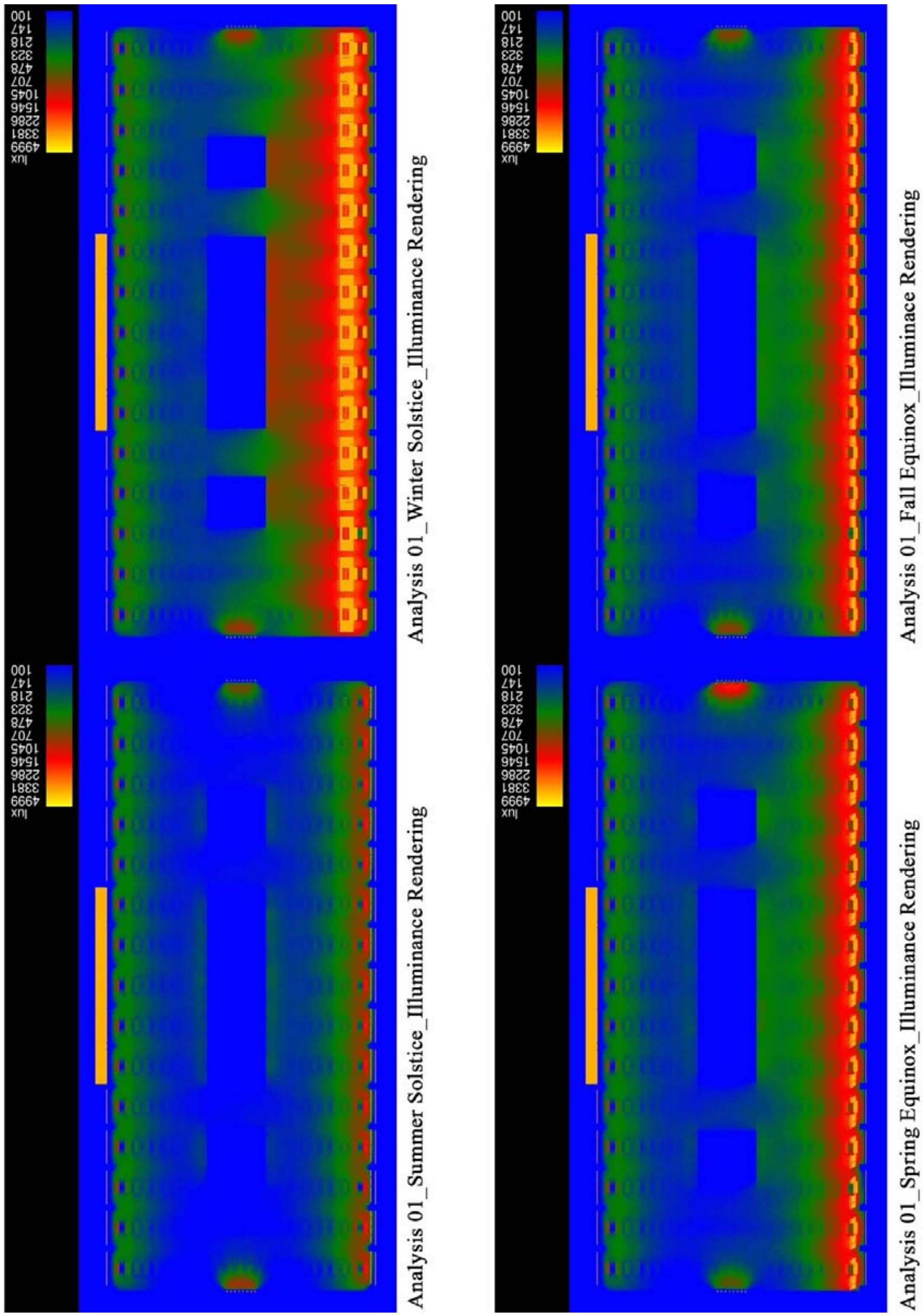

Figure 4.3.3.1.3: Analysis 1 Illuminance Plan Renderings

Figures 4.3.3.1.1 - 4.3.3.1.3 are the baseline illuminance levels in lux used to compare and contrast the effectiveness of the designs in the sections that follow.

4.4. Energy Use Intensity (EUI) 2030 Targets

The targets in this section were established based on the 2030 Challenge by calculating 60% of the median source and site energy use intensities for properties that are "relative to similar" in size and use of the selected office building.

Energy Star Location Data

Median source and site EUI were found with the Energy Star Portfolio Manager Target Finder. [59] These values are based on data from the National Building Energy consumption survey. The key parameters affecting the EUI values are; location (state, city, and address), primary and secondary function (building type), gross floor area (square feet), number of buildings on the property, weekly hours of operation, number of computers, number of occupants during regular operational hours, percentage of the building that is cooled, and percentage of the building that is heated. Table 4.4.1 indicates the variables that were entered into the Energy Star Target Finder. Figure 4.4.1 is an example of an Energy Star output graph and Table 4.4.2 shows the actual output values specific to this research from Energy Star Target Finder.

[59] "www.energystar.gov: ENERGY STAR Portfolio ManagerTarget Finder." Accessed February 7, 2014.

Energy Star Location Data

Parameter	Variable
Location	1416 9th St. Sacramento, California
Primary Function	Office (Building Type) and Lobby
Gross Floor Area (Total)	645,330 square feet
Number of Building on Property	One
Weekly Hours of Operation	72 hours
Number of Computers	1500
Number of Occupants (Operational Hours)	2,431 (default Green Building Studio calculation)
Estimated Design Energy	Default Calculation (based properties of similar size)
Percentage of Building Cooled	50% or more
Percentage of Building Heated	50% or more

Table 4.4.1: Energy Star Location Data

ENERGY STAR

Design Target*	Median Property*
97	50
96.7	241.8
38.4	96.1
62,416,317.6	156,040,794.0
24,806,485.2	62,016,213.0
745,304.01	1,863,260.02
1,922.9	4,807.2

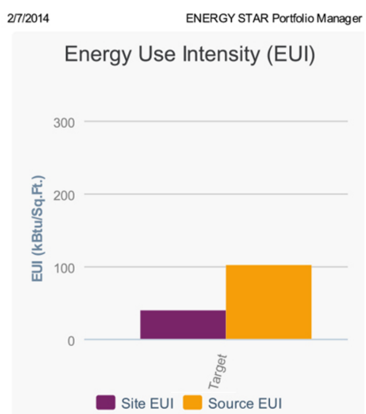

Figure 4.4.1: Sample Energy Star Output Graph [60]

[60] "www.energystar.gov: ENERGY STAR Portfolio ManagerTarget Finder." Accessed February 7, 2014.

Energy Star Output Data

Metric	Median Property
Source EUI (kBtu/ft^2)	254.9
Site EUI (kBtu/ft^2)	101.3
Source Energy Use (kBtu)	164,494,617.0
Site Energy Use (kBtu)	65,371,929.0
Energy Cost ($)	1,964,081.58
Total GHG Emissions (MtCO2e)	5,067.3

Table 4.4.2: Energy Star Output Data

The following data in Table 4.4.3 demonstrates the projected site and source energy use intensity values that meet the 2030 challenge targets:

Metric	Benchmark E.S.T.F.	Targets 2030 Ch. 2014 60%	Targets 2030 Ch. 2015 70%	Targets 2030 Ch. 2020 80%	Targets 2030 Ch. 2025 90%	Targets 2030 Ch.
Source EUI (kBtu/ft)	254.9	102.0	76.5	51.0	25.5	C.N.
Site EUI (kBtu/ft)	101.3	40.5	30.4	20.3	10.1	C.N.

E.S.T.F. = Energy Star Target Finder; 2030 Ch. = 2030 Challenge; C.N. = Carbon Neutral

Table 4.4.3: 2030 Challenge Targets

4.5. Illuminance Levels (lux) Standard Targets

Illuminance = Light Falling on a surface.

The amount of light falling on a surface is "illuminance." Illuminance is measured in lux (metric unit = lumen/m^2) for the purposes of this project. These levels are usually measured at the level of a working surface in a building.

The current accepted authority on appropriate illuminance levels is the Illuminating Engineering Society of North America (IESNA). The IESNA publishes a Handbook and a supplemental Recommended Practice Guides that provides tables for appropriate illuminance levels for a variety of spaces and uses. The Illuminating Engineering Society of North America (IESNA) recommends interior spaces with a moderate demand for visual acuity performing computer work, reading, writing and general office work should maintain a level of 750 lux.[61] Figure 4.5.1 describes the appropriate illuminance levels for various acuity demands and interior functions. While 750 lux is considered to be the optimal illuminance level for an office space, 500-800 lux fall within an acceptable visual comfort range for an interior work space.

[61] Illuminating Engineering Society of North America (IESNA), www.sustainability workshop.autodesk.com, Accessed February 8, 2014.

Standard Maintained Illuminance (lux)	Foot-candles	Characteristics of Activity	Representative Activity
50	5	**Interiors rarely used for visual tasks** *(no perception of detail)*	Cable tunnels, nighttime sidewalk, parking lots
100 - 150	10-15	**Interiors with minimal demand for visual acuity** *(limited perception of detail)*	Corridors, changing rooms, loading bay
200	20	**Interiors with low demand for visual acuity** *(some perception of detail)*	Foyers and entrances, dining rooms, warehouses, restrooms
300	30	**Interior with some demand for visual acuity** *(frequently occupied spaces)*	Libraries, sports and assembly halls, teaching spaces, lecture theaters
500	50	**Interior with moderate demand for visual acuity** *(some low contrast, color judgment tasks)*	Computer work, reading & writing, general offices, retail shops, kitchens
750	75	**Interior with demand for good visual acuity** *(good color judgment, inviting interior)*	Drawing offices, chain stores, general electronics work
1000	100	**Interior with demand for superior visual acuity** *(accurate color judgment & low contrast)*	Detailed electronics assembly, drafting, cabinet making, supermarkets
1500 -2000+	150-200+	**Interior with demand for maximum visual acuity** *(low contrast, optical aids & local lighting will be of advantage)*	Hand tailoring, precision assembly, detailed drafting, assembly of minute mechanisms

Figure 4.5.1: Guidelines for Illumination Levels [62]

[62] Illuminating Engineering Society of North America (IESNA), www.sustainability workshop.autodesk.com, Accessed February 8, 2014.

4.6. Proof of Concept Project Targets

EUI

The target values for this study were based on the 2030 Challenge for the year 2014. This target includes, targets for source energy use intensity and site energy use intensity. Source energy use intensity represents the amount of raw fuel required to operate a building. Site energy use intensity represents the amount of heat and electricity required to power a building. The average source energy use intensity for a comparable building in the same climate zone is 254.9, a 60 % reduction of the source energy use intensity is 102.0 kBtu/ft^2 (Figure 4.6.1.). Similarly, the average site energy use intensity for a comparable building in the same climate zone is 101.3 and a 60 % reduction of the site energy use intensity is 40.5 kBtu/ft^2 (Table 4.6.1.). For the purposes of this research, site energy use intensity will be the primary focus because a facade system effects a building's heating and electrical demand.

Targets

Site Energy Use Intensity Target	**Source Energy Use Intensity Target**
40.5 (kBtu/ft^2)	102.0 (kBtu/ft^2)

Table 4.6.1: EUI Target Values

Illuminance (lux)

For the purposes of this research, the optimal level of illuminance were defined as 750 lux at the typical working surface of 2'-6." Illuminance levels that range from 500-800 lux was taken as falling within the acceptable visual comfort range.

4.7. Analysis Flow Chart and Matrix

In order to study the effects of glazing, shade, daylight controls, and light shelves on energy use intensity and illuminance levels, the following flowchart and matrix were developed to systematically address each incremental design option. The matrix below gives a numeric designation and/or alphanumeric designation to each analysis scenario. Each analysis is discussed and identified using designations found in Figure 4.7.1.

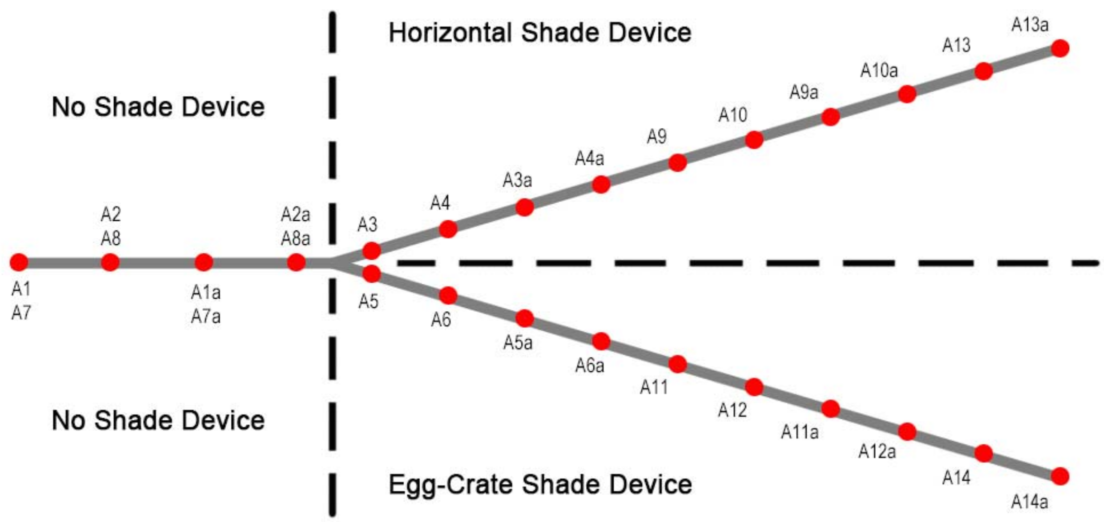

Figure 4.7.1: Analysis Flow Chart Diagram

Analysis Matrix

Energy Use Intensity Matrix Analysis Label	Existing Building 30% Glass	Updated Building Curtain Wall at South and North Façade 90% Glass	Existing Building 30% Glass & D.C.	Updated Building Curtain Wall at South and North Façade 90% Glass & D.C.
Single Pane Tinted				
Single Pane Tinted Glass	1	2	1a	2a
Horizontal Shade Device & S.P. Glass	3	4	3a	4a
Egg-crate Shade Device & S.P. Glass	5	6	5a	6a
H.P. Clear Double Pane				
Double Pane Clear H.P. Glass	7	8	7a	8a
Horizontal Shade Device & H.P. Clear Glass	9	10	9a	10a
Egg-crate Shade Device & H.P. Clear Glass	11	12	11a	12a
Light Shelf				
Horizontal Shade Device, H.P. Clear Glass & L.S.	NA	13	NA	13a
Egg-crate Shade Device H.P. Clear Glass & L.S.	NA	14	NA	14a

Abbreviation Ledged
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC
D.C. = Daylighting Controls
L.S. = Light Shelf

Table 4.7.1: Analysis Matrix

5. PERFORMANCE-DRIVEN PASSIVE SOLAR DESIGN PROCESS

The passive solar shade systems were designed and modeled in the parametric platform Autodesk Revit 2015 and were analyzed in Autodesk Green Building Studio. The shade systems were then optimized to reduce solar gain during the summer and permit solar heating during the winter. During conceptual design, horizontal, slanted vertical, and egg crate style shading devices were all considered (Figure 5.1.). For the purposes of this research, it was determined that two shading systems were appropriate for the shading of the south facade, a passive solar designed horizontal louver and a parametrically modeled passive solar designed egg-crate. The east and west facades were shaded with slanted vertical fins in combination with both the horizontal and egg-crate shade devices. Due to the passive design nature of this research, movable (dynamic) shade devices were not explored.

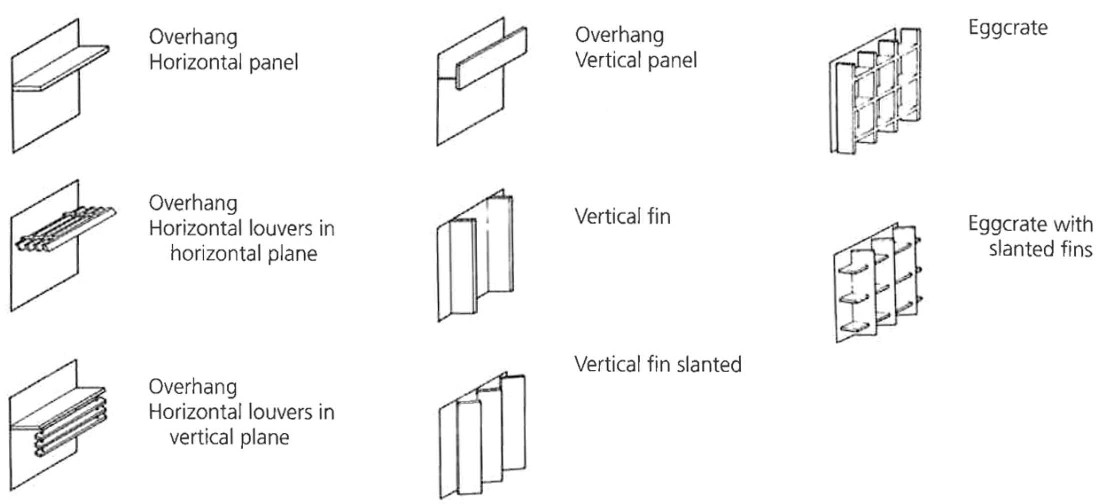

Figure 5.1: Shading Device Diagram [63]

[63] Lechner, Norbert. *Heating, Cooling, Lighting - Sustainable Design Methods for Architects*. Canada: John Wiley & Sons Inc., 2009.

5.1. Passive Solar Design of the Horizontal and Slanted Vertical Shade Device

To design the horizontal shade device, the overheated and under heated periods of the year for this building were determined, using the Balance Point Temperature (BPT). A buildings Balance Point Temperature is the external temperature when heat gains and heat loss of the building are equal. The BPT for a building depends on whether it is an Envelope Dominated Building (EDB) or an Internally Dominated Building (IDB). Medium to large size office buildings are generally designated as Internally Dominated Buildings. However, communication with the building manager revealed that this building requires mechanical cooling during the summer and some mechanical heating during the winter. The baseline energy use intensity report in Figure 4.3.2.1.2 also confirmed that this building requires some mechanical heating in the winter. In order to lower the building's need for mechanical heating and cooling, the proposed facade system must block out summer sun to reduce solar gain and allow for some solar gain during the winter. Therefore, the shading devices were designed for an Internally Dominated Building (IDB) with the need for some solar gain during the winter.

The balance point temperature for an IDB is 60 ° F. [64] Therefore, overheated periods for this project were defined as temperatures above 60 ° F and under heated periods were defined as temperatures below 50 ° F. An analysis of the average temperatures for Sacramento, California revealed the overheated time periods are May – October and the under-heated time periods are December – February. The sun path diagram in Figure 4.1.2.4 was then used to determine the sun's angles during the overheated and under heated time periods. It was determined that any angles greater than

[64] Lechner, Norbert. *Heating, Cooling, Lighting - Sustainable Design Methods for Architects*. Canada: John Wiley & Sons Inc., 2009.

59.8° degrees represent the overheated periods and angles below 48.4° represented the under heated periods. Blocking or allowing these angles minimizes the building's need for mechanical cooling or heating. The last overheated day for this site occurs in October. The sun path diagram revealed that the suns altitude to be approximately 50° during the last day of the overheated time period (Figure 5.1.1.). 50° was then used to design the shade depth for all of the horizontal shading devices.

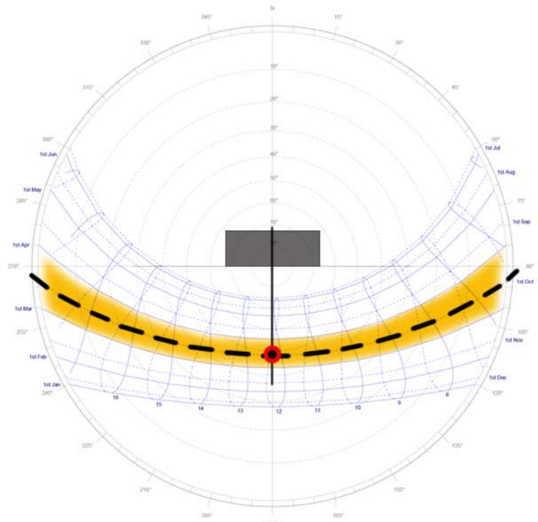

Figure 5.1.1: Sun Angle Overheated Period Diagram [65]

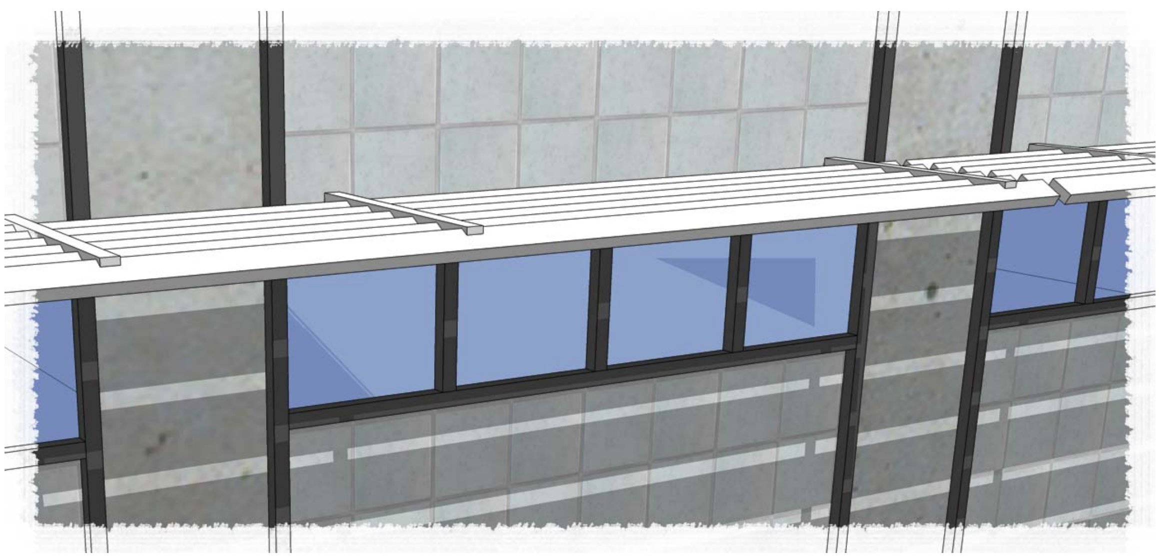

Figure 5.1.2: Horizontal Shade Device Design

[65] Autodesk Ecotect Analysis 2011 Weather Tool. Software.

Figure 5.1.3: Horizontal Shade Device Perspective

Figures 5.1.2 shows the basic design of the horizontal shade device and Figure 5.1.3 shows a perspective view of the horizontal shade device placed onto facade of the existing building and energy model.

It is not possible to fully shade east and west windows from the summer sun with a fixed passive design shade device. However, a slanted vertical fin design will shade east and west windows from direct sun from 7 A.M. to 5 P.M. (solar time) for the whole year.[66] The slanted vertical shade devices for this project were designed by first determining the latitude in Sacramento, California, which is 38.581573486 (per Section 4.3.2. Revit Energy Model) and the critical sun angle “D” which is 9.5° (per Figure 5.1.4.). 9.5° was then used to design the depth of the slanted vertical shading devices for the east and west facades (Figure 5.1.5.).

Table 9.13 Shade Line Angle for Slanted Vertical Fins*

Latitude	Angle D
24	18
28	15
32	12
36	10
40	9
44	8
48	7

*This table is for vertical fins slanted toward the north on east or west windows. Designs based on this table will provide shade from direct sun for the whole year between 7 A.M. and 5 P.M. (solar time). This table can also be used to design vertical fins on north windows for the same time period.

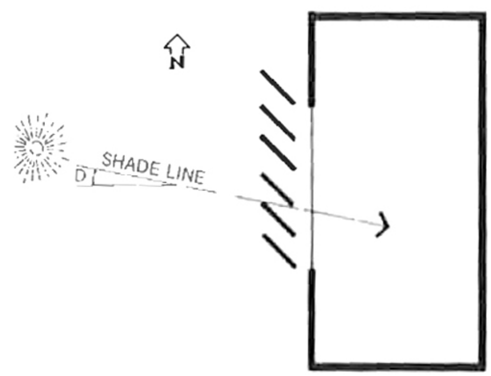

Figure 5.1.4: Shade Line Angle for Slanted Vertical Fins Chart [67]

[66] Lechner, Norbert. *Heating, Cooling, Lighting - Sustainable Design Methods for Architects*. Canada: John Wiley & Sons Inc., 2009.

[67] Lechner, Norbert. *Heating, Cooling, Lighting - Sustainable Design Methods for Architects*. Canada: John Wiley & Sons Inc., 2009.

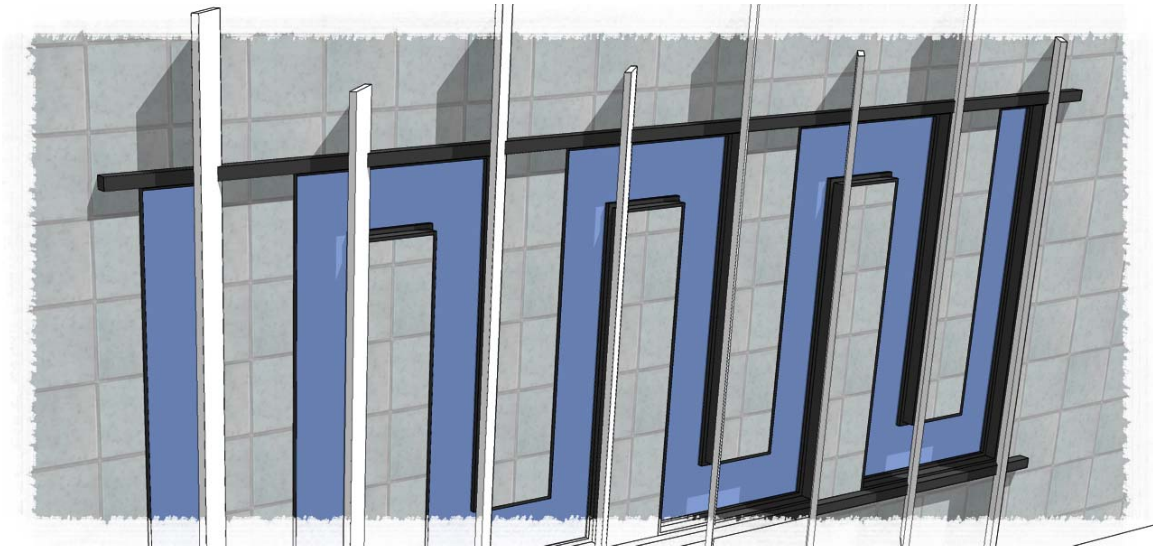
Figure 5.1.5: Slanted Vertical Fins Design

5.1.1. 30% Glazing Design

The 30% glazing design was used in Analysis 3 and Analysis 9. One 3’-6” horizontal shading device at the window head height of each floor and slanted vertical shading devices at the east and west windows. The slanted vertical fins are at 45° from the surface of the glazing and 1’- 4” deep. Refer to Figures 5.3.2 and 5.3.8 for drawings of the 30% glazing design and the slanted vertical fins design.

5.1.2. 90% Glazing Design

The 90% glazing design was used in Analysis 4 and Analysis 10. Two 4’- 9” horizontal shading device at the center and window head height of each floor and slanted vertical shading devices at the east and west windows. The slated vertical fins are at 45° from the surface of the glazing and 1’- 4” deep. Refer to Figures 5.3.3 and 5.3.9 for drawings of the 90% glazing design and the slanted vertical fins design.

5.1.3. 90% Glazing with Light Shelf Design

The 90% glazing design was used in Analysis 13. Two 4'- 9" horizontal shading device at the center and window head height of each floor and slanted vertical shading devices at the east and west windows. The slanted vertical fins are at 45° from the surface of the glazing and 1'- 4" deep. Refer to Figures 5.3.12 for drawings of the 90% glazing design and the slanted vertical fins design.

5.2. Parametric Solar Design of the Egg-Crate Shade Device

The passive solar egg-crate design was created in Autodesk Revit 2015. Revit is considered a parametric modeling software because all points, vectors, and surfaces created in Revit are interrelated.[68] The egg-crate facade was created by combining two families: an adaptive component and curtain wall family. An adaptive component is a family that can be inserted into a mass. Its shape can be modified by the application of parameters or can be dynamically "pushed or pulled."[69]

Six adaptive points were created to begin to define the geometry of the module. Numeric designations and parameters were assigned to each point to allow for maximum flexibility and manipulation in form. These adaptive points were then connected with lines and arcs that define the shading elements.

Parameters were then assigned to the lines in the horizontal plane to define the module's variable height and width (Figure 5.2.1.). The lines in the slanted vertical plane were assigned parameters to define the "shade depth" and "light shelf depth," surfaces were then created by lofting together the lines and arcs. The completed adaptive

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[68] "www.help.autodesk.com: Help: Revit Users." Accessed February 8, 2014.

[69] "www.help.autodesk.com: Help: Revit Users." Accessed February 8, 2014.

component was then inserted in the curtain wall family (Figure 5.2.2.). Curtain wall families are predefined families with built in parameters. The parameters define the density of the curtain walls panels. Numeric values were entered to define its density in both the U and V directions (Figure 5.2.2.). Then the adaptive points were assigned to the curtain wall nodes to create the parametric curtain wall system. The parameters defined in the adaptive component combined with the built in parameters of the curtain wall family allowed for limitless variation in the curtain wall's density, curve, height, length, and depth.

The curtain wall family was then inserted into the Revit Energy Model, then applied to the south facade and incrementally adjusted to perform the applicable analysis described in Figure 4.7.1. Similarly, the same curtain wall family was inserted in the Revit Element Model and adjusted to perform the various illuminance and daylight renderings.

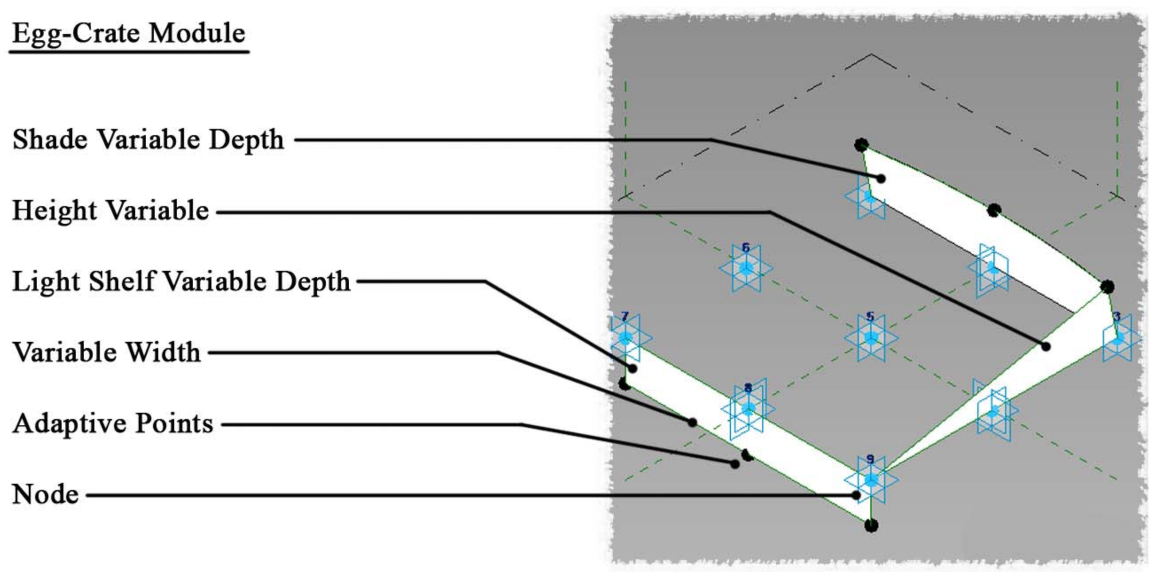


Figure 5.2.1: Parametric Module Design

Figure 5.2.3 shows the basic design of the egg-crate shade device and Figure 5.2.4 shows a perspective view of the egg-crate shade device placed onto the facade of the existing building and energy model.

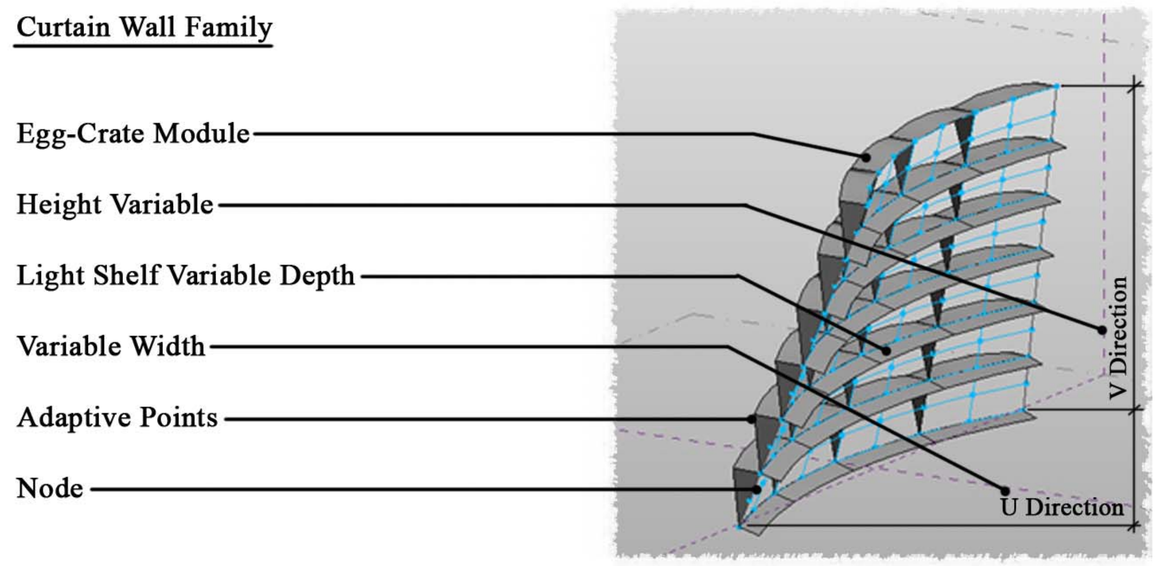


Figure 5.2.2: Parametric Revit Family and Facade System Design

Figure 5.2.3: Egg-Crate Shade Device Design

The same slanted vertical fins described in Section 5.1 were used for the east and west facades of the analysis that employed the egg-crate shade device.

Figure 5.2.4: Egg-Crate Shade Device Perspective

5.2.1. 30% Glazing Design

The 30% glazing design was used in Analysis 5 and Analysis 11. One 3'- 6" egg-crate shading device at the window head height of each floor and slanted vertical shading devices at the east and west windows. The slanted vertical fins are at 45° from the surface of the glazing and 1'- 4" deep. Refer to Figures 5.3.4 and 5.3.10 for drawings of the 90% glazing design and the slanted vertical fins design.

5.2.2. 90% Glazing Design

The 90% glazing design was used in Analysis 6 and Analysis 12. Four 2'- 3" egg-crate shading devices were evenly distributed at each floor and slanted vertical shading devices at the east and west windows. The slanted vertical fins are at 45° from the surface of the glazing and 1'- 4" deep. Refer to Figures 5.3.5 and 5.3.11 for drawings of the 90% glazing design and the slanted vertical fins design.

5.2.3. 90% Glazing with Light Shelf Design

The 90% glazing design was used in Analysis 14. Four 2'- 3" egg-crate shading devices were evenly distributed at each floor and slanted vertical shading devices at the east and west windows. The slanted vertical fins are at 45° from the surface of the glazing and 1'- 4" deep. Refer to Figure 5.3.13 for drawings of the 90% glazing design and the slanted vertical fins design.

5.3. Analysis Variables and Design Documentation

The following tables show the parameters input for the Analyses 1-14. In order to reduce the repetition of information, the parameters that are not shown in each table are assumed to be the same setting and parameters that are in the baseline Analysis 1.

Analysis 1 - 30 % Single Pane Tinted Glass Analysis 1

Analysis 1 is the existing baseline condition as described in Sections 4.3.1 and 4.3.2.

Analysis 2 - 90 % Single Pane Tinted Glass

Energy Settings

Parameter	Variable
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”

Table 5.3.1: 90 % Single Pane Tinted Glass Analysis 2 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Same Settings	Conceptual Construction

Table 5.3.2: 90 % Single Pane Tinted Glass Analysis 2 Construction Settings

Analysis 3 - 30 % Single Pane Tinted Glass with Horizontal Shade Device

Energy Settings

Parameter	Variable
Target Percentage Glazing	30% (Calculated in Revit)
Target Sill height	Typ. 3’- 0” / Input per Elevations
Glazing is Shaded	Yes
Shade Depth	3’-6”

Table 5.3.3: 30 % Single Pane Tinted Glass with Horizontal Shade Device Analysis 3 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Same Settings	Conceptual Construction

Table 5.3.4: 30 % Single Pane Tinted Glass with Horizontal Shade Device Analysis 3 Construction Settings

Analysis 4 - 90 % Single Pane Tinted Glass with Horizontal Shade Device

Energy Settings

Parameter	Variable
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”
Glazing is Shaded	Yes
Shade Depth	4’-9”

Table 5.3.5: 90 % Single Pane Tinted Glass with Horizontal Shade Device Analysis 4 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Same Settings	Conceptual Construction

Table 5.3.6: 90 % Single Pane Tinted Glass with Horizontal Shade Device Analysis 4 Construction Settings

Analysis 5 - 30 % Single Pane Tinted Glass with Egg-Crate Shade Device

Energy Settings

Parameter	Variable
Target Percentage Glazing	30% (Calculated in Revit)
Target Sill height	Typ. 3’- 0” / Input per Elevations
Glazing is Shaded	Yes
Shade Depth	3’-6”

Table 5.3.7: 30 % Single Pane Tinted Glass with Egg-Crate Shade Device Analysis 5 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Same Settings	Conceptual Construction

Table 5.3.8: 30 % Single Pane Tinted Glass with Egg-Crate Shade Device Analysis 5 Construction Settings

Analysis 6 - 90 % Single Pane Tinted Glass with Egg-Crate Shade Device

Energy Settings

Parameter	**Variable**
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”
Glazing is Shaded	Yes
Shade Depth	2’-3”

Table 5.3.9: 90 % Single Pane Tinted Glass with Egg-Crate Shade Device Analysis 6 Energy Settings

Construction Settings

Mass Model	**Constructions**	**Actual Assembly per Con Docs**
Same Settings	Same Settings	Conceptual Construction

Table 5.3.10: 90 % Single Pane Tinted Glass with Egg-Crate Shade Device Analysis 6 Construction Settings

Analysis 7 - 30 % Double Pane Glass

Energy Settings

Parameter	**Variable**
Target Percentage Glazing	30% (Calculated in Revit)
Target Sill height	Typ. 3’- 0” / Input per Elevations

Table 5.3.11: 30 % Double Pane Glass Analysis 7 Energy Settings

Construction Settings

Mass Model	**Constructions**	**Actual Assembly per Con Docs**
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.12: 30 % Double Pane Glass Analysis 7 Construction Settings

Analysis 8 - 90 % Double Pane Glass

Energy Settings

Parameter	Variable
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”

Table 5.3.13: 90 % Double Pane Glass Analysis 8 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.14: 90 % Double Pane Glass Analysis 8 Construction Settings

Analysis 9 - 30 % Double Pane Tinted Glass with Horizontal Shade Device

Energy Settings

Parameter	Variable
Target Percentage Glazing	30% (Calculated in Revit)
Target Sill height	Typ. 3’- 0” / Input per Elevations
Glazing is Shaded	Yes
Shade Depth	3’-6”

Table 5.3.15: 30 % Double Pane Tinted Glass with Horizontal Shade Device Analysis 9 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.16: 30 % Single Pane Tinted Glass with Passive Solar Shade Device Analysis 9 Construction Settings

Analysis 10 - 90 % Double Pane Glass with Horizontal Device

Energy Settings

Parameter	Variable
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”
Glazing is Shaded	Yes
Shade Depth	4’-9”

Table 5.3.17: 90 % Double Pane Glass with Horizontal Shade Device Analysis 10 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.18: 90 % Single Pane Tinted Glass with Horizontal Shade Device Analysis 10 Construction Settings

Analysis 11 - 30 % Double Pane Glass with Egg-Crate Shade Device

Energy Settings

Parameter	Variable
Target Percentage Glazing	30% (Calculated in Revit)
Target Sill height	Typ. 3’- 0” / Input per Elevations
Glazing is Shaded	Yes
Shade Depth	3’-6”

Table 5.3.19: 30 % Double Pane Glass with Egg-Crate Shade Device Analysis 11 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.20: 30 % Double Pane Glass with Egg-Crate Shade Device Analysis 11 Construction Settings

Analysis 12 - 90 % Double Pane Glass with Egg-Crate Shade Device

Energy Settings

Parameter	**Variable**
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”
Glazing is Shaded	Yes
Shade Depth	2’-3”

Table 5.3.21: 90 % Double Pane Glass with Egg-Crate Shade Device Analysis 12 Energy Settings

Construction Settings

Mass Model	**Constructions**	**Actual Assembly per Con Docs**
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.22: 90 % Double Pane Glass with Egg-Crate Shade Device Analysis 12 Construction Settings

Analysis 13 - 90 % Double Pane Glass with Horizontal Shade Device with Light Shelf

Energy Settings

Parameter	**Variable**
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”
Glazing is Shaded	Yes
Shade Depth	4’-9”

Table 5.3.23: 90 % Double Pane Glass with Horizontal Shade Device with Light Shelf Analysis 13 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.24: 90 % Double Pane Tinted with Horizontal Shade Device with Light Shelf Analysis 13 Construction Settings

Analysis 14 - 90 % Double Pane Glass with Egg-Crate Shade Device with Light Shelf

Energy Settings

Parameter	Variable
Target Percentage Glazing	90% (Calculated in Revit)
Target Sill height	6”
Glazing is Shaded	Yes
Shade Depth	2’-3”

Table 5.3.25: 90 % Double Pane Glass with Egg-Crate Shade Device with Light Shelf Analysis 14 Energy Settings

Construction Settings

Mass Model	Constructions	Actual Assembly per Con Docs
Same Settings	Double Pane Clear - High Performance, LowE, High Tvis, Low SHGC	Conceptual Construction

Table 5.3.26: 90 % Double Pane Glass with Egg-Crate Shade Device with Light Shelf Analysis 14 Construction Settings

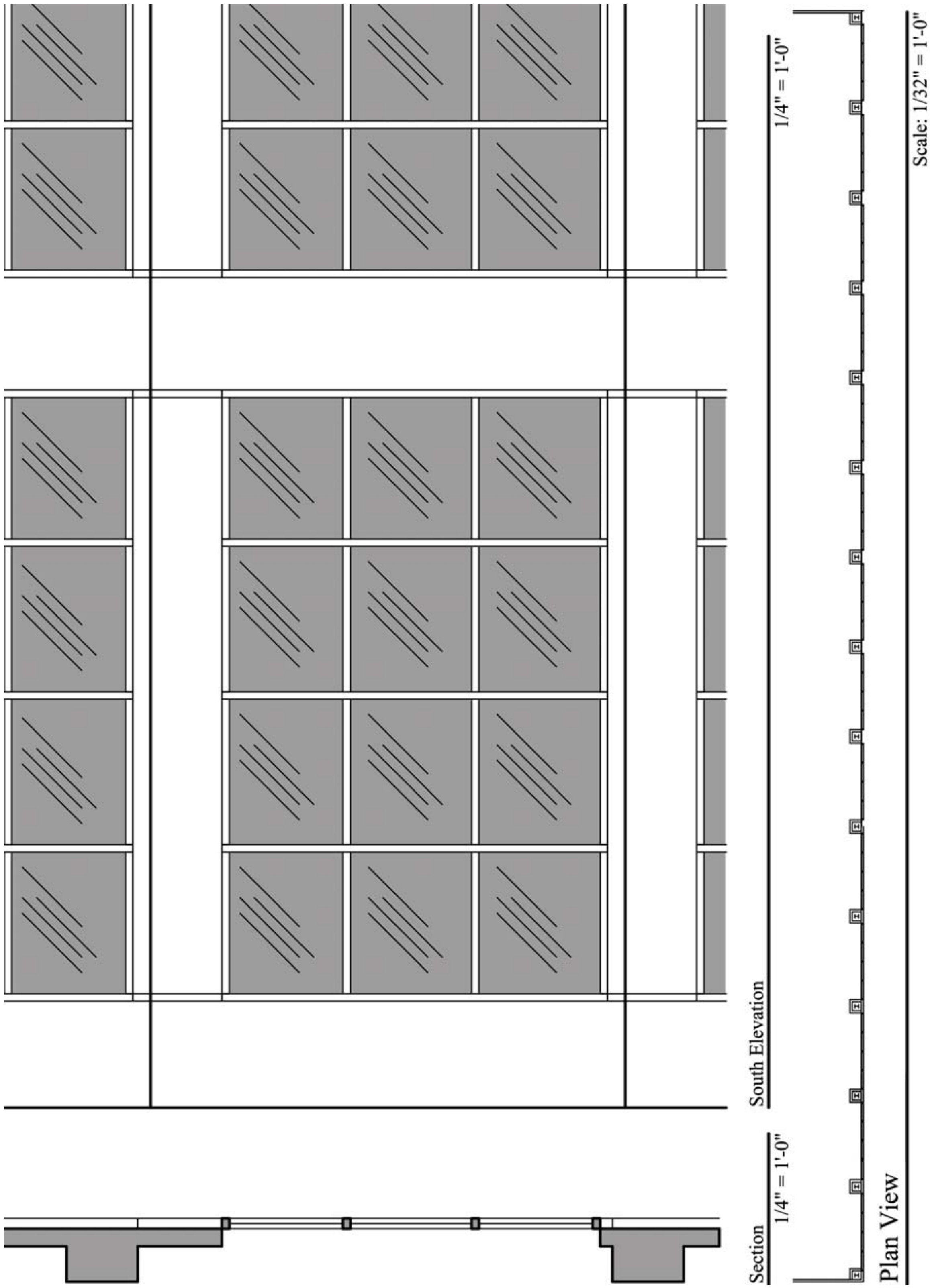


Figure 5.3.1: Documentation of the Design for Analysis 2

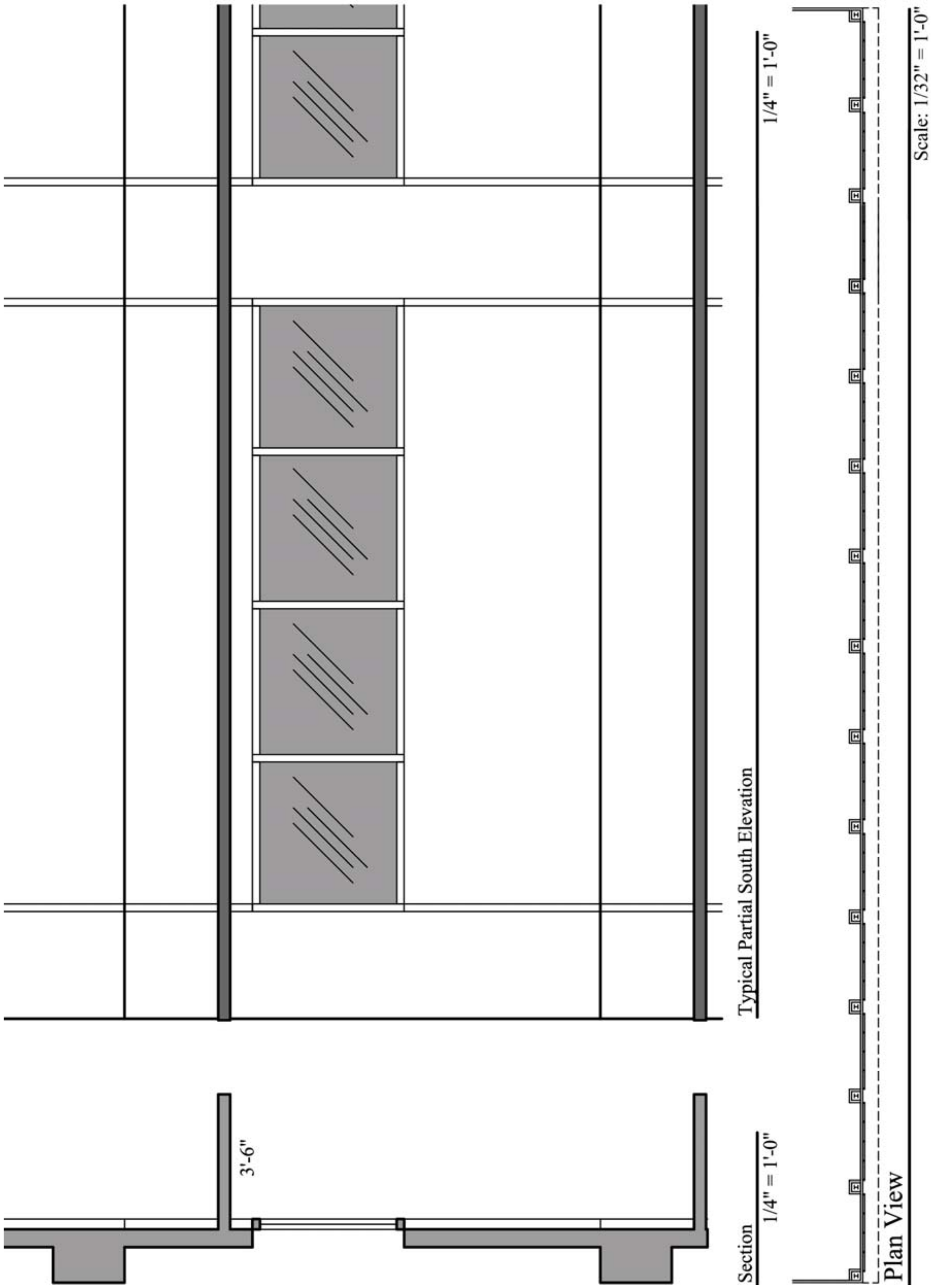


Figure 5.3.2: Documentation of the Design for Analysis 3

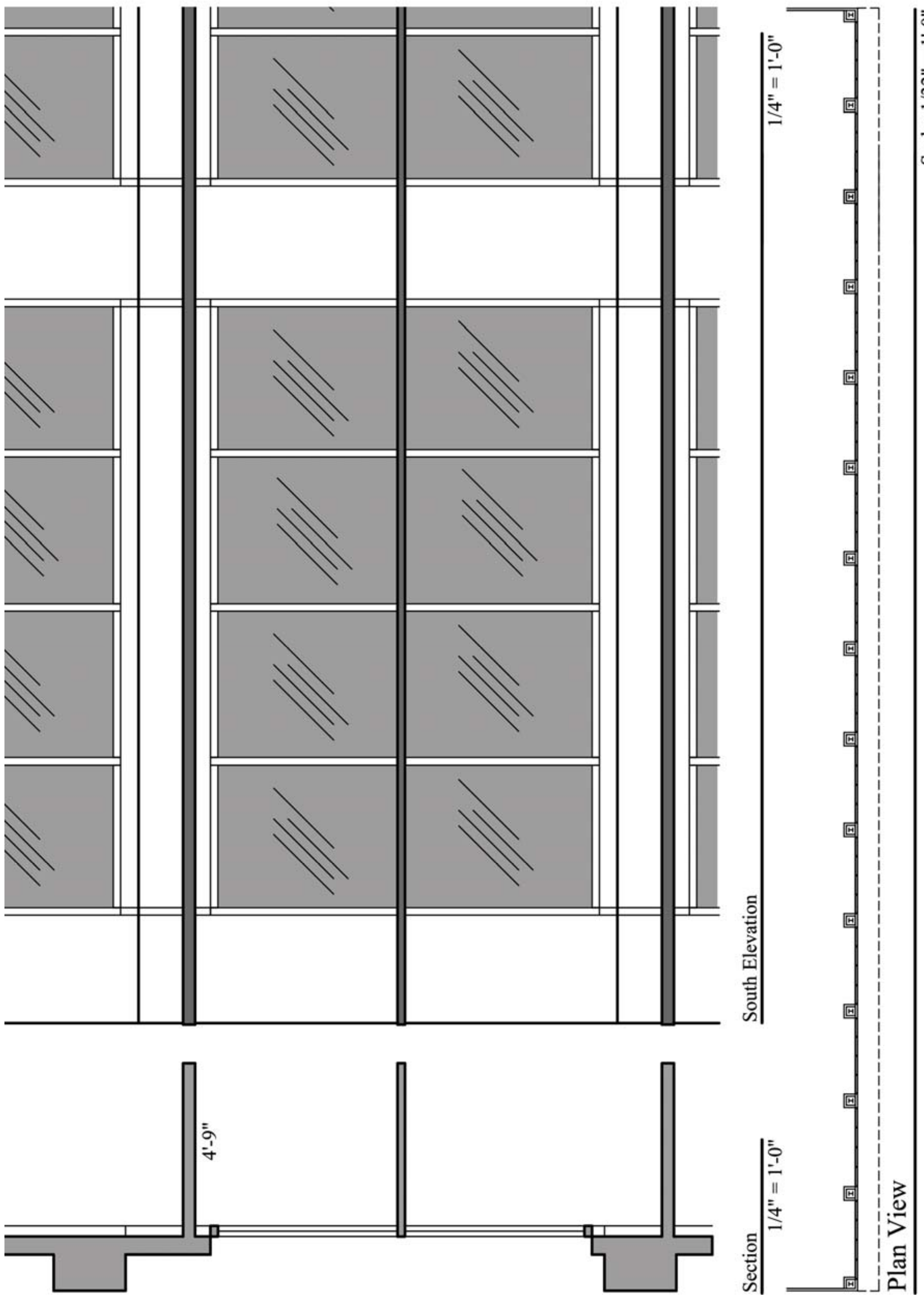


Figure 5.3.3: Documentation of the Design for Analysis 4

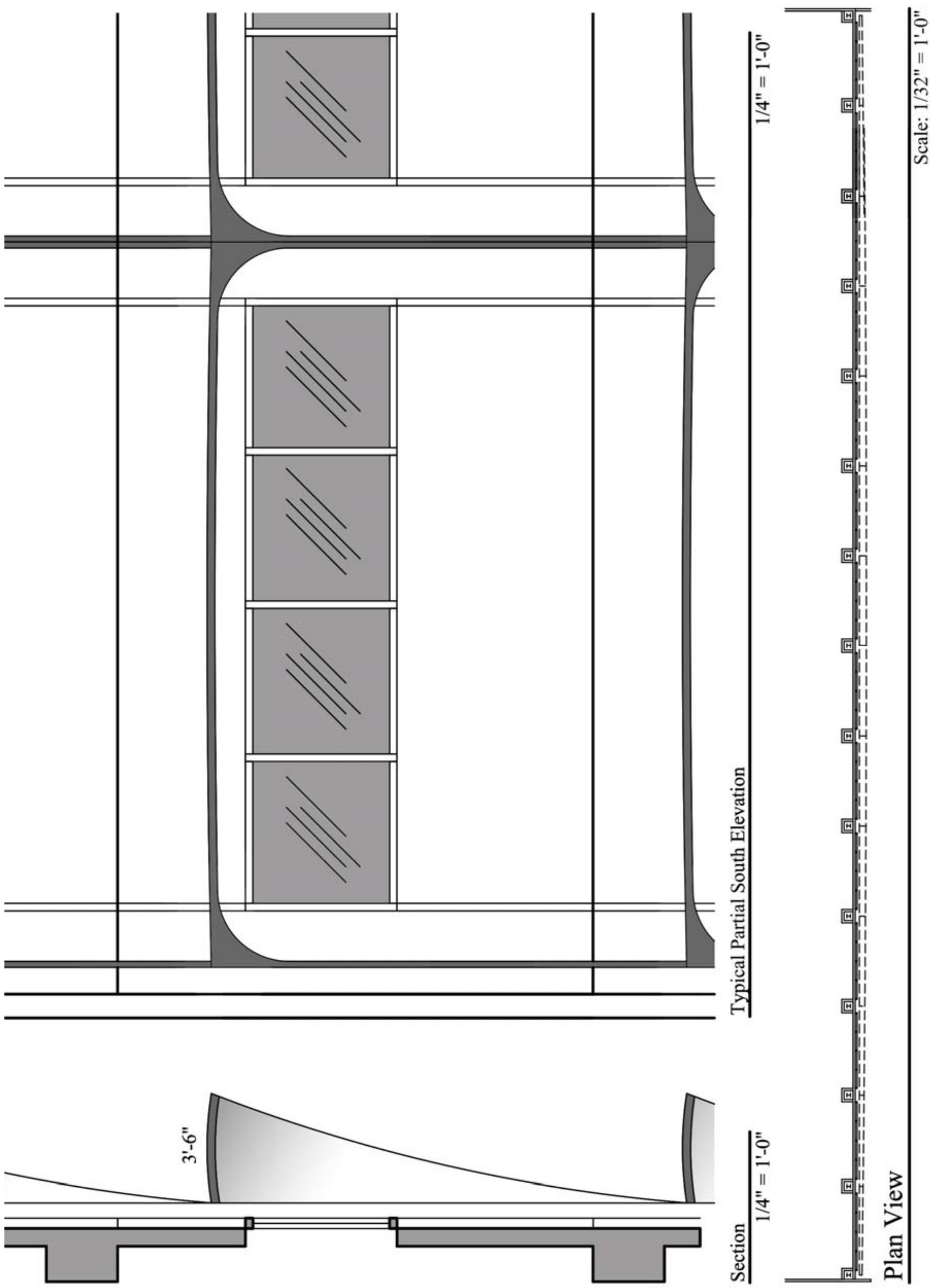


Figure 5.3.4: Documentation of the Design for Analysis 5

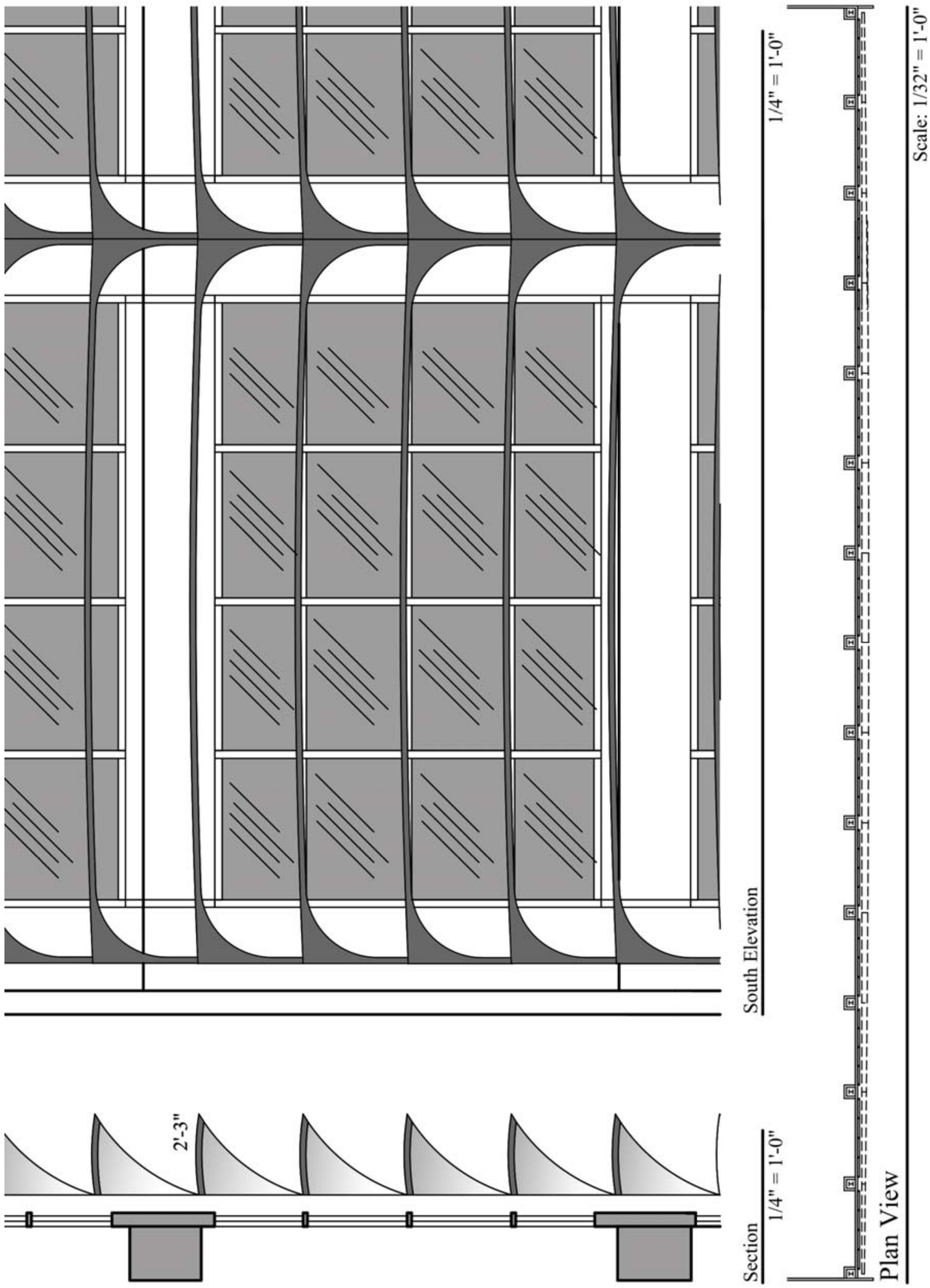


Figure 5.3.5: Documentation of the Design for Analysis 6

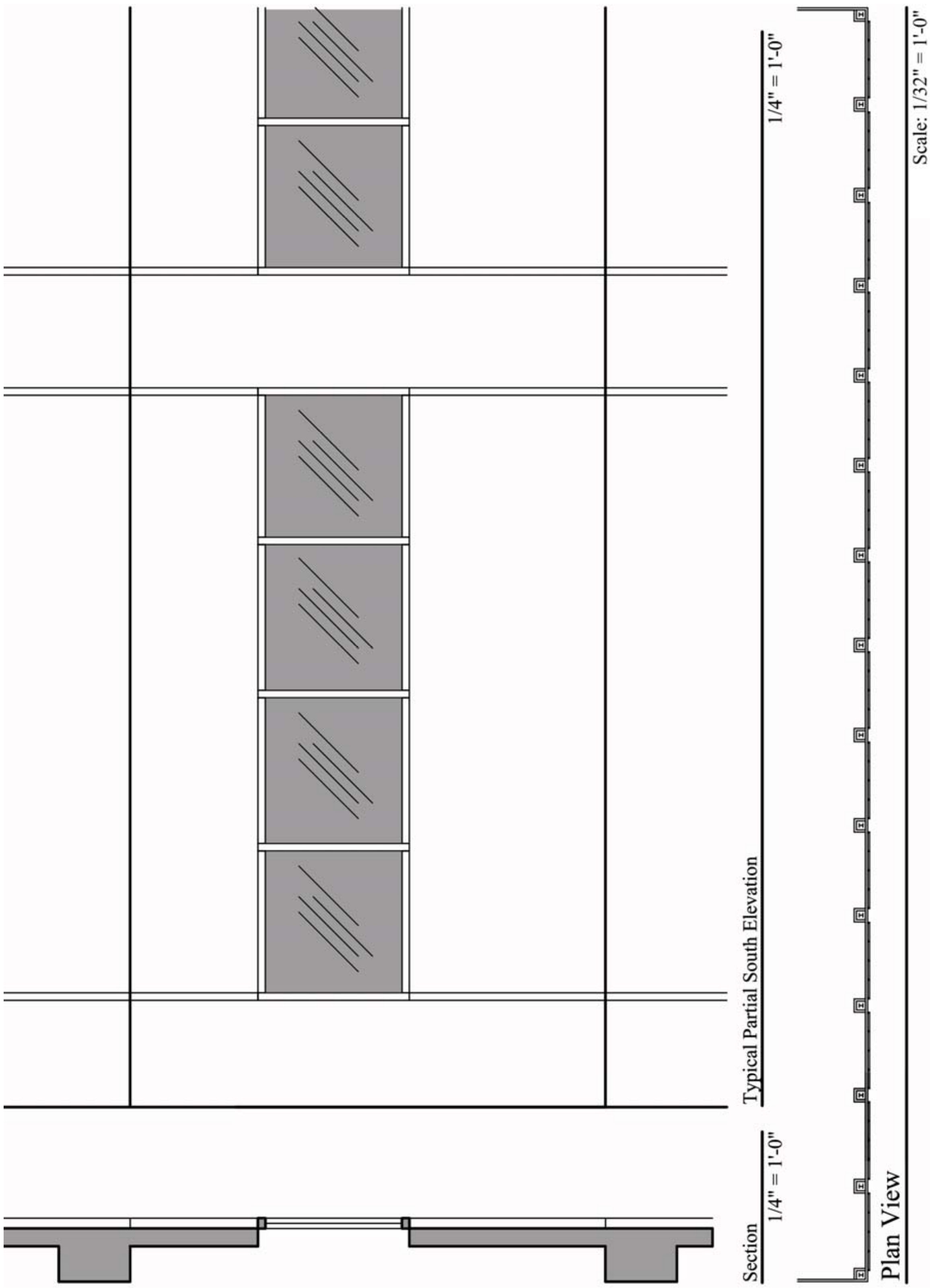


Figure 5.3.6: Documentation of the Design for Analysis 7

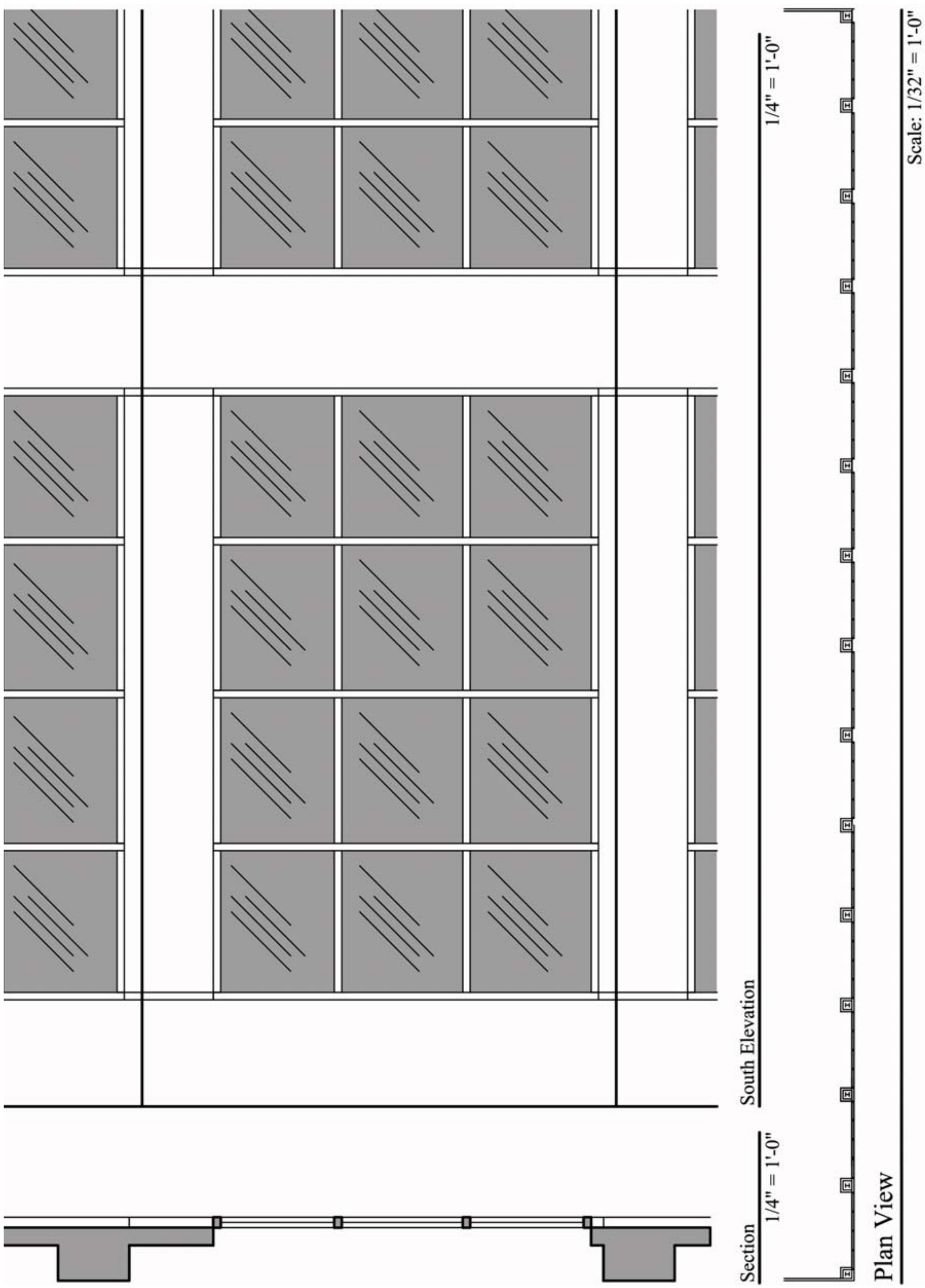


Figure 5.3.7: Documentation of the Design for Analysis 8

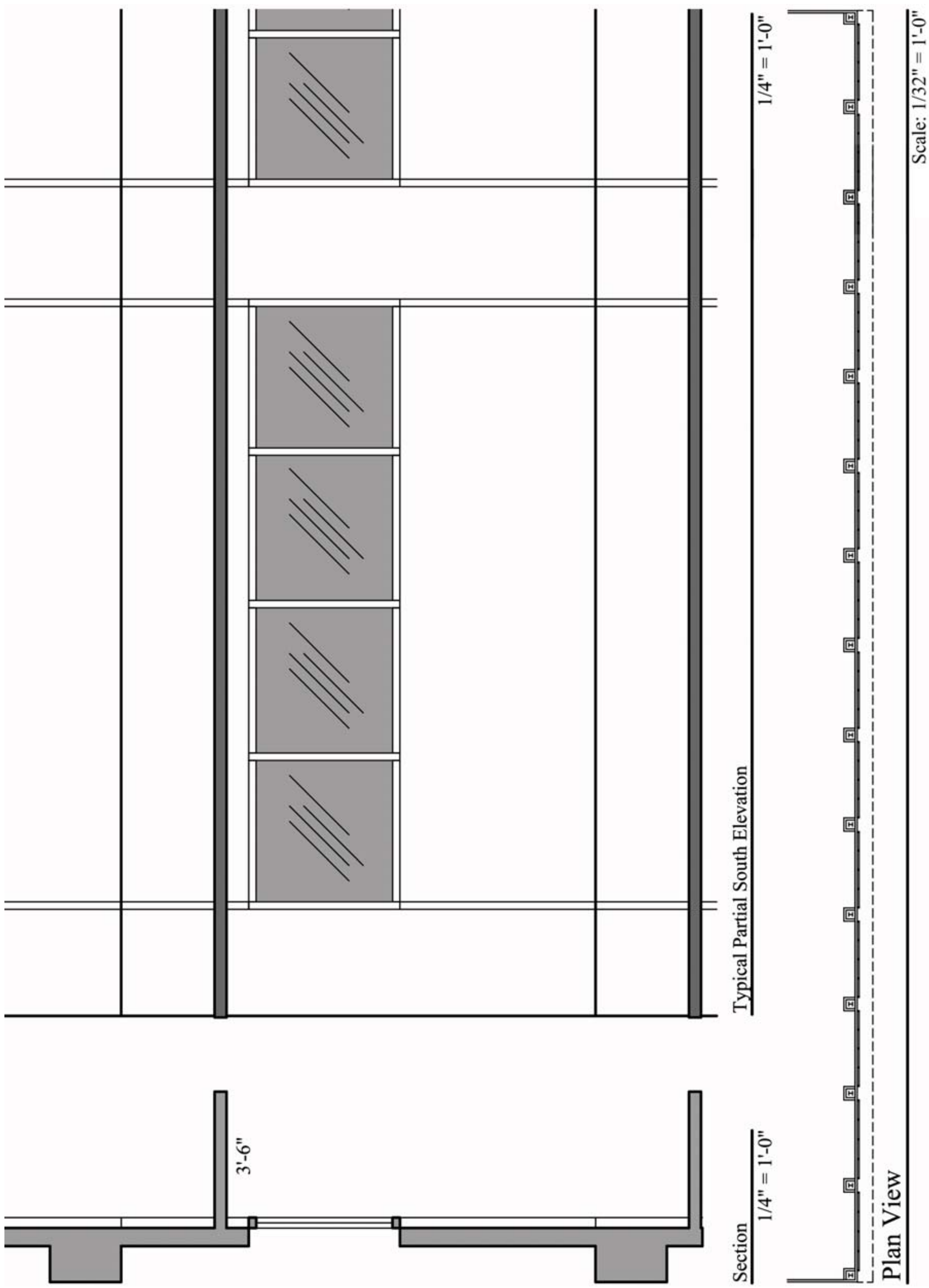


Figure 5.3.8: Documentation of the Design for Analysis 9

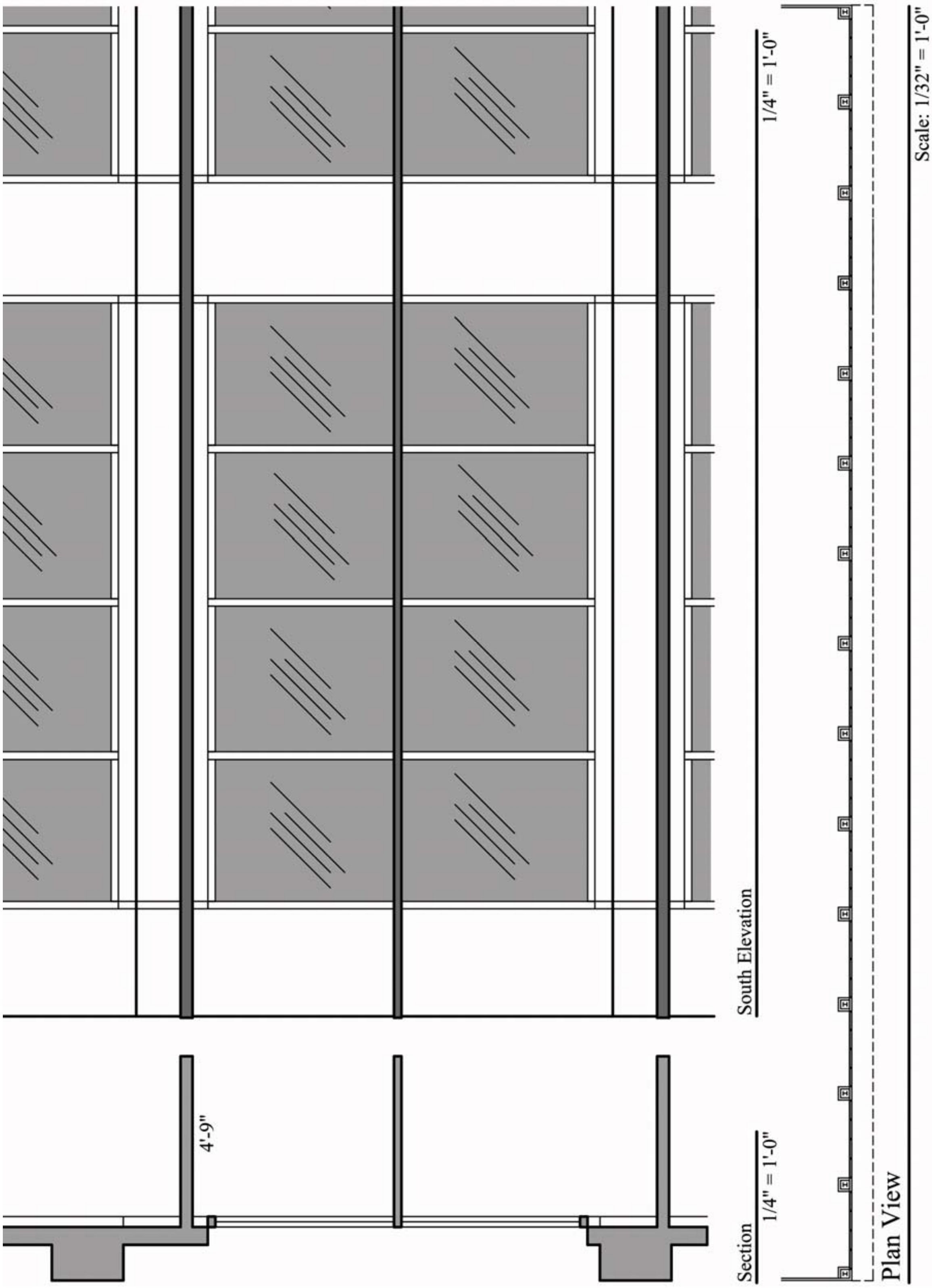


Figure 5.3.9: Documentation of the Design for Analysis 10

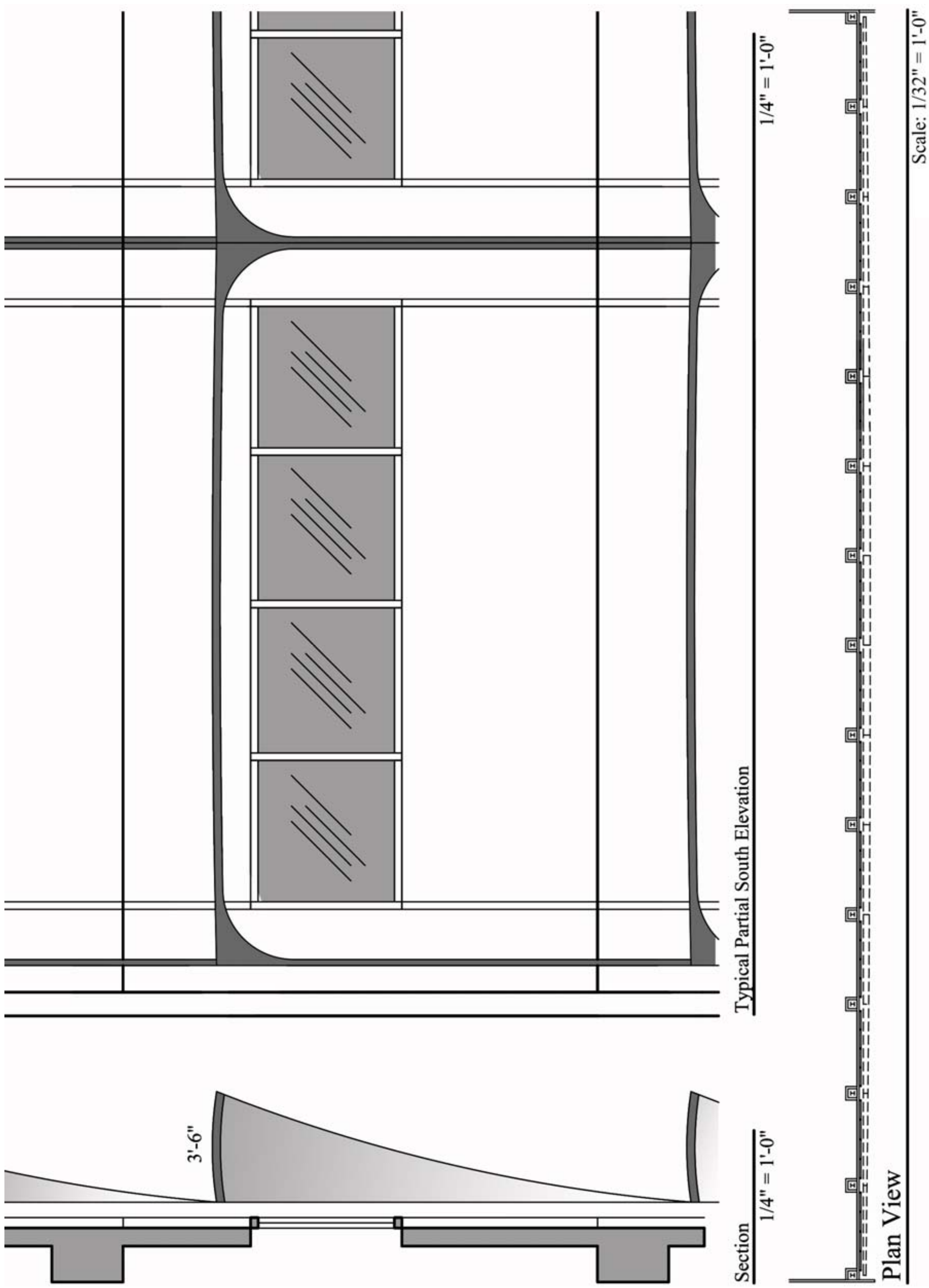


Figure 5.3.10: Documentation of the Design for Analysis 11

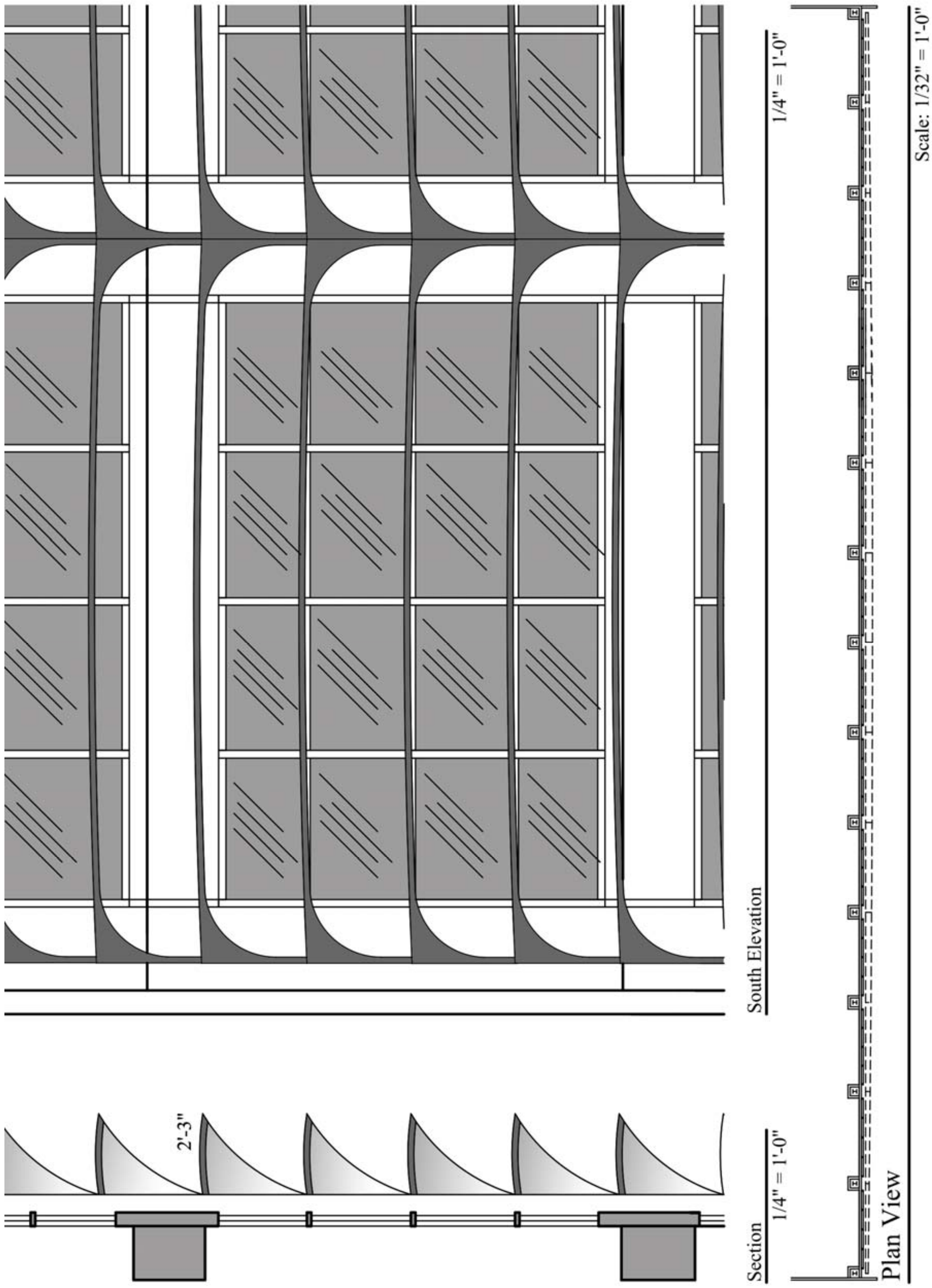


Figure 5.3.11: Documentation of the Design for Analysis 12

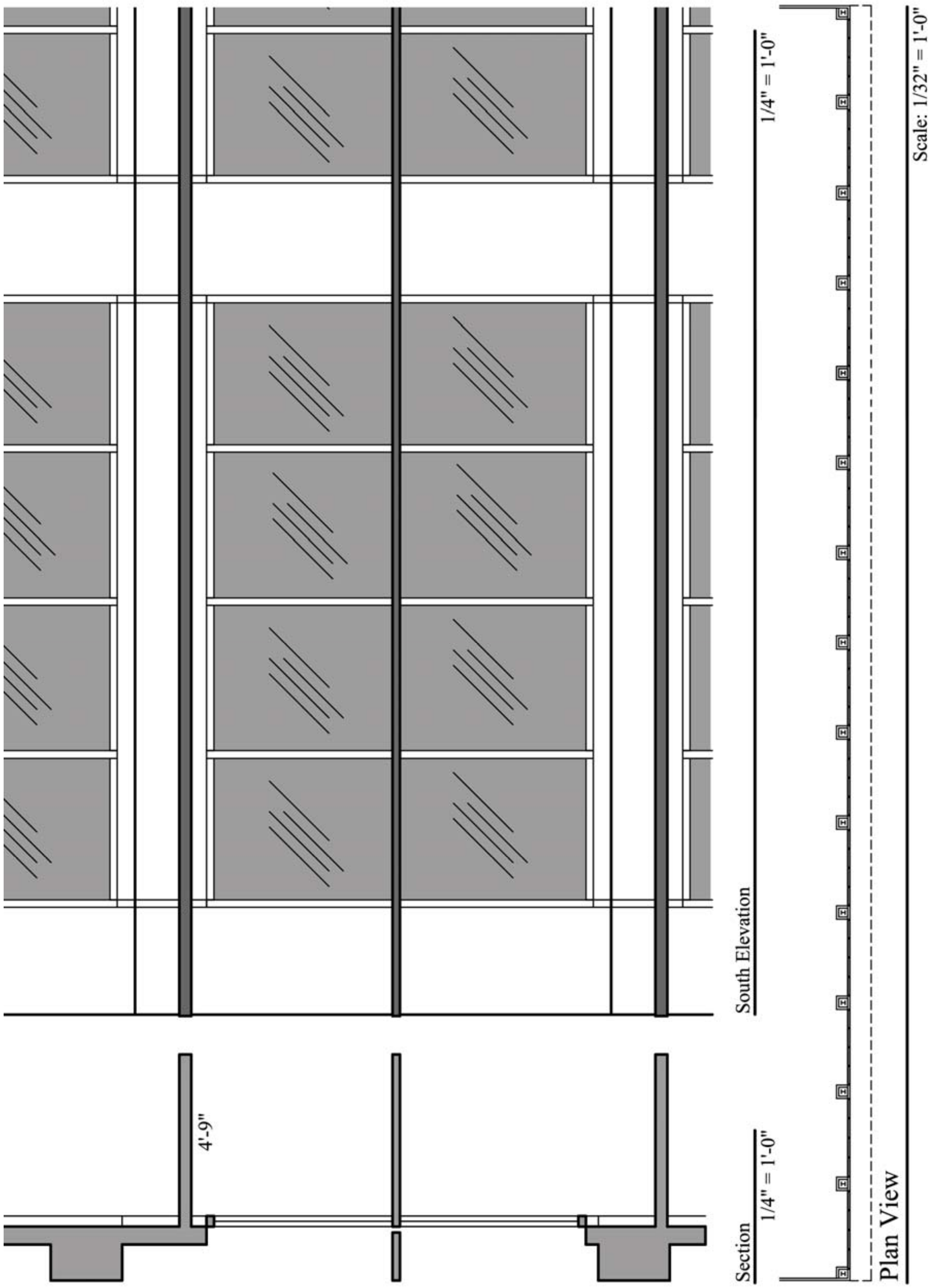


Figure 5.3.12: Documentation of the Design for Analysis 13

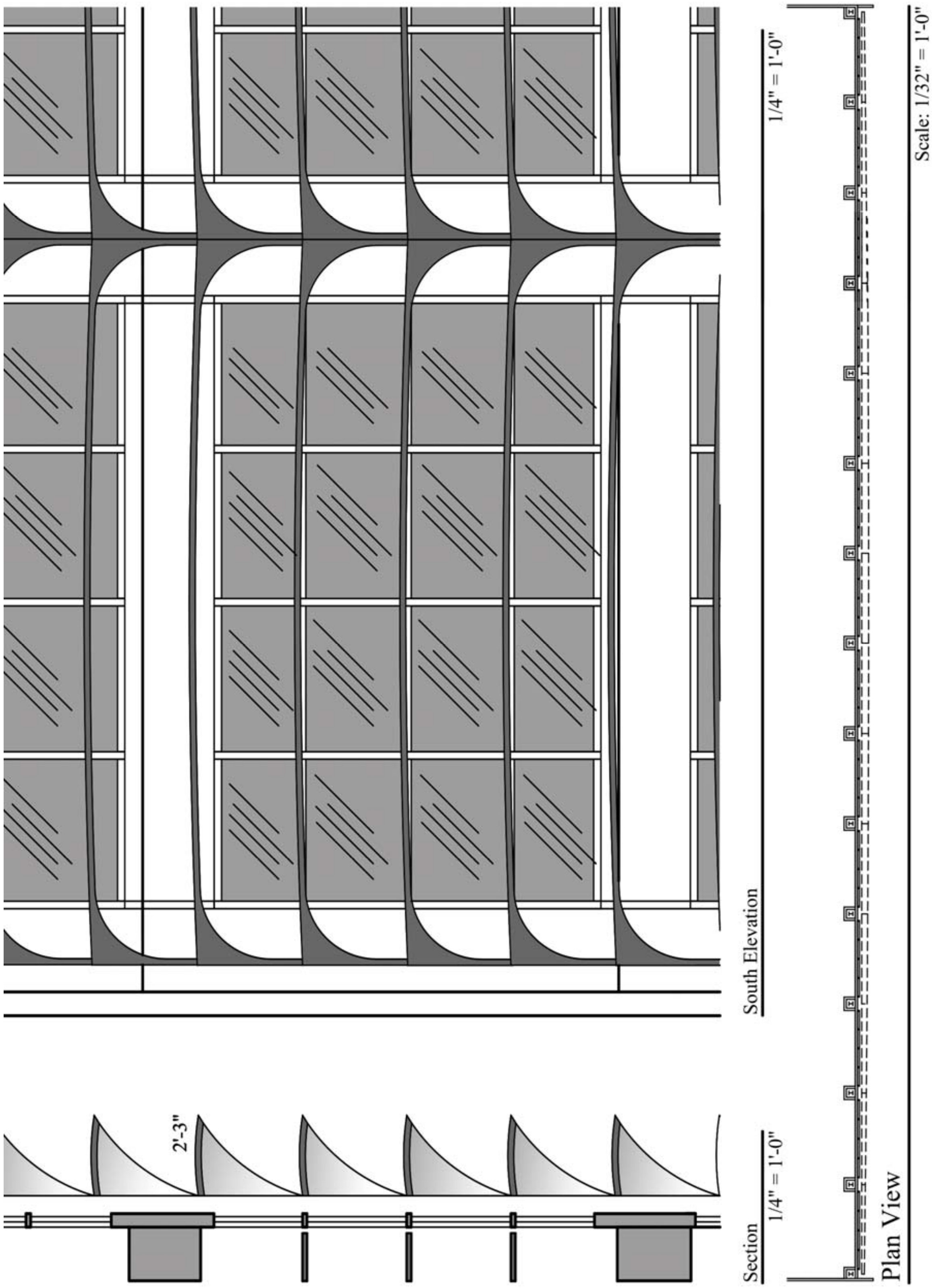


Figure 5.3.13: Documentation of the Design for Analysis 14

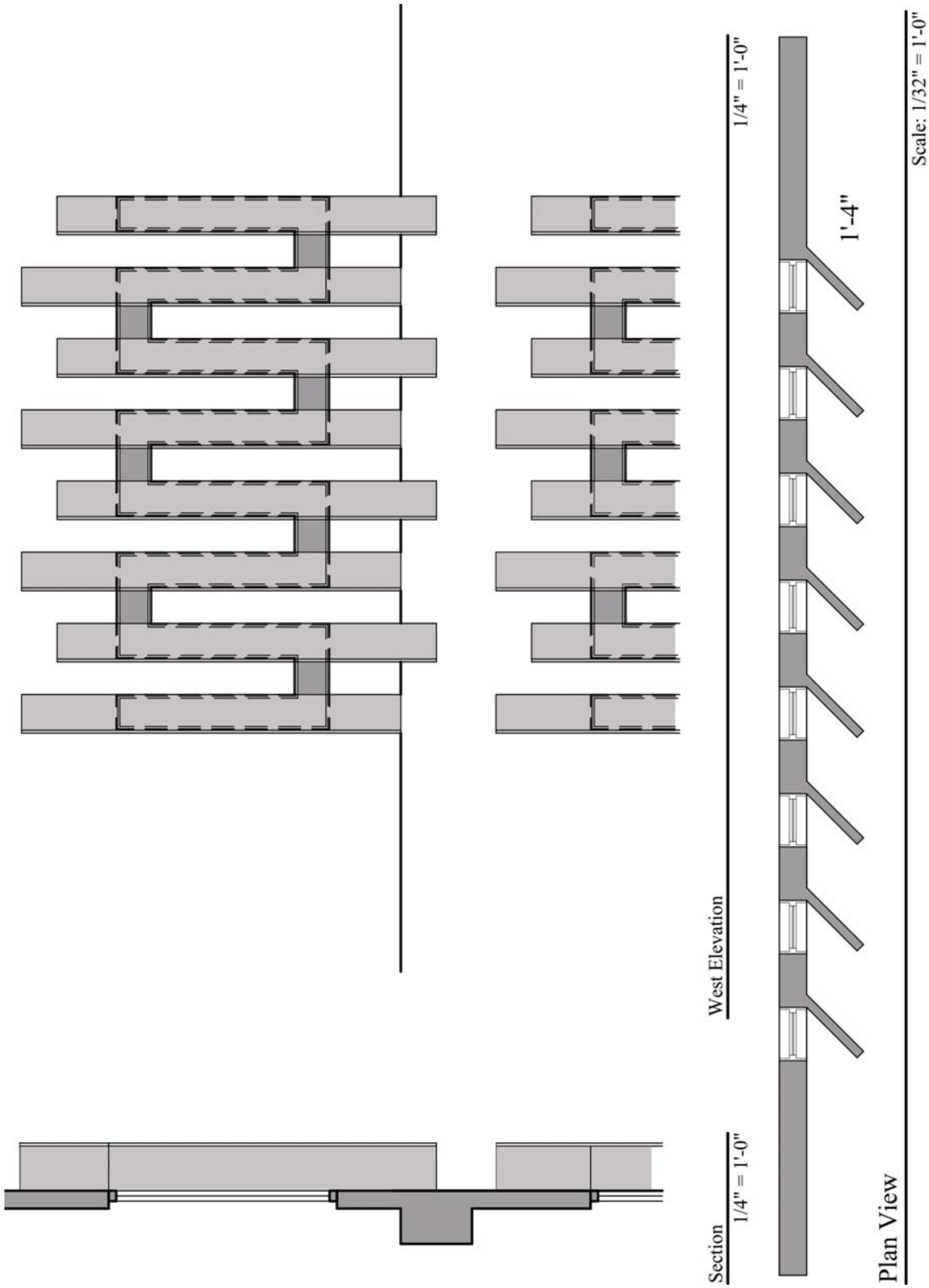


Figure 5.3.14: Documentation of the Design of the Slanted Vertical Fins

6. ANALYSIS

Section 4.7.1 displays the twenty eight different scenarios that were analyzed during the course of this research. In order to objectively compare and contrast the data that were generated by this research, each analysis was numerically or alphanumerically designated and grouped. The groups were organized into sets of analyses that were analyzed under similar conditions that effect energy use intensity (EUI). Group A was composed of analyses that had the conceptual construction setting of single pane tinted glass in common. Group B was made up of analyses that had the conceptual construction setting of single pane tinted glass and energy setting of daylight control "on" in common.

Analysis Matrix

Energy Use Intensity Matrix Analysis Label	Existing Building 30% Glass Group A	Updated Building Curtain Wall at South and North Façade 90% Glass	Existing Building 30% Glass & D.C. Group B	Updated Building Curtain Wall at South and North Facade 90% Glass & D.C.
Single Pane Tinted				
Single Pane Tinted Glass	1	2	1a	2a
Horizontal Shade Device & S.P. Glass	3	4	3a	4a
Egg-crate Shade Device & S.P. Glass	5	6	5a	6a
H.P. Clear Double Pane	Group C		Group D	
Double Pane Clear H.P. Glass	7	8	7a	8a
Horizontal Shade Device & H.P. Clear Glass	9	10	9a	10a
Egg-crate Shade Device & H.P. Clear Glass	11	12	11a	12a
Light Shelf		Group E		Group F
Horizontal Shade Device, H.P. Clear Glass & L.S.	NA	13	NA	13a
Egg-crate Shade Device H.P. Clear Glass & L.S.	NA	14	NA	14a

Table 6.1: Analysis Matrix Diagram

Group C was composed of analyses that had the conceptual construction setting of high performance double pane glass in common. Group D was made up of analyses that had the conceptual construction setting of high performance double pane glass and energy setting of daylight control “on” in common. Group E was composed of analyses that had the conceptual construction setting of high performance double pane glass in common as well as light shelf models “on” while being analyzed. Group F was made up of analyses that had the conceptual construction setting of high performance double pane glass, energy setting of daylight control “on” and light shelf models “on” while being analyzed. Refer to Table 6.1 for a graphic display of the analysis groups.

In each of the sections that follow, energy use intensity and illuminance levels will be considered as they relate to each analysis scenario and group. However, due to the holistic nature of energy use intensity, topics that may not be specific to each section will also be discussed. Table 6.2 shows the EUI results as they relate to their analysis number and groups. Table 6.3 shows all of the results for illuminance levels as they relate to their analysis number and group.

Analysis, Groups and EUI Matrix

Energy Use Intensity Matrix Analysis Label	Existing Building 30% Glass Group A	Updated Building Curtain Wall at South and North Façade 90% Glass	Existing Building 30% Glass & D.C. Group B	Updated Building Curtain Wall at South and North Facade 90% Glass & D.C.
Single Pane Tinted				
Single Pane Tinted Glass	A1 51.9	A2 57.2	A1a 51.5	A2a 56.4
Horizontal Shade Device & S.P. Glass	A3 50.8	A4 52.9	A3a 50.4	A4a 52.2
Egg-crate Shade Device & S.P. Glass	A5 50.4	A6 51.5	A5a 50.1	A6a 50.9
H.P. Clear Double Pane	Group C		Group D	
Double Pane Clear H.P. Glass	A7 50.6	A8 51.4	A7a 50.2	A8a 50.6
Horizontal Shade Device & H.P. Clear Glass	A9 50.4	A10 50.5	A9a 50.0	A10a 49.8
Egg-crate Shade Device & H.P. Clear Glass	A11 50.3	A12 50.1	A11 49.8	A12a 49.4
Light Shelf		Group E		Group F
Horizontal Shade Device, H.P. Clear Glass & L.S.	NA	A13 50.5	NA	A13a 49.8
Egg-crate Shade Device H.P. Clear Glass & L.S.	NA	A14 50.1	NA	A14a 49.4

A# = Analysis # and # = EUI kBtu / sf /yr.

Table 6.2: Analysis, Groups and EUI Matrix

Illuminance Levels Matrix

Energy Use Intensity Matrix Analysis Label	Existing Building 30% Glass	Updated Building Curtain Wall at South and North Facade 90% Glass
Single Pane Tinted		
Glass	A1 21%	A2 22%
Horizontal Shade Device & Glass	A3 10%	A4 26%
Egg-crate Shade Device & Glass	A5 18%	A6 39%
Light Shelf		
Horizontal Shade Device, Glass & Light Shelf	NA	A13 39%
Egg-crate Shade Device, Glass & Light Shelf	NA	A14 53%

A# = Analysis # and % = Percentage of floor area within 500 – 800 lux.

Table 6.3: Illuminance Levels Matrix

6.1. Impact of Glazing on EUI

This section addresses the following research sub-questions:

1. What is the impact of the percentage of glazing in a facade system on energy use intensity?
2. What is the impact of the type of glazing in a facade system on energy use intensity?
3. What is the relationship between glazing percentage and glazing type in terms of energy use intensity?

Section 6.1.1 discusses sub-question 1, regarding the impact of percentage of glazing on energy use intensity. Section 6.1.2 addresses sub-question 2, concerning the impact of type of glazing on EUI. Finally, Section 6.1.3 discusses sub-question 3, the relationship between percentage of glazing and type of glazing in terms of their impact on energy use intensity.

6.1.1. Impact of Glazing Percentage on EUI

What is the impact of the percentage of glazing in a facade system on energy use intensity?

The impact of percentage of glazing was studied by comparing Analysis 1 to 2 and Analysis 7 to 8, from Groups A and C.

<u>Analysis Key:</u>

Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).
Analysis 2 – 90% Single pane tinted glazing.

Analysis 7 - 30% High performance double pane glazing.
Analysis 8 - 90% High performance double pane glazing.

The two percentages of glazing that were considered were 30% and 90%. These percentages were selected because they were considered to be extreme cases that would result in distinguishable data.

The data from this section revealed that all of the non-shaded analysis (Analysis 2 and 8) resulted in an increase in energy use intensities when the percentage of glass increased. In Group A, when Analysis 1 was compared to Analysis 2, single pane non-shaded glass demonstrated a 9.2 percentage point increase in energy use intensity when the percentage of glazing was changed from 30% to 90%. In Group C, when Analysis 7 was compared to Analysis 8, high performance double pane non-shaded glass, it demonstrated a 1.5 percentage point increase in energy use intensity when the percentage of glazing was increased from 30% to 90% (Table 6.1.1.1.).

Impact of Percentage of Glazing on EUI

EUI **kBtu / sf /yr**	**Existing Building** **30% Glass**	**Updated Building Curtain Wall at South and North Façade 90% Glass**
Single Pane Tinted		
Single Pane Tinted Glass	51.9	57.2, Increased by 9.2%
H.P. Clear Double Pane		
Double Pane Clear H.P. Glass	50.6	51.4, Increased by 1.5%

Abbreviation Ledged
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC

Table 6.1.1.1: Impact of Percentage of Glazing on EUI

Analysis 1 Synthesized EUI Report

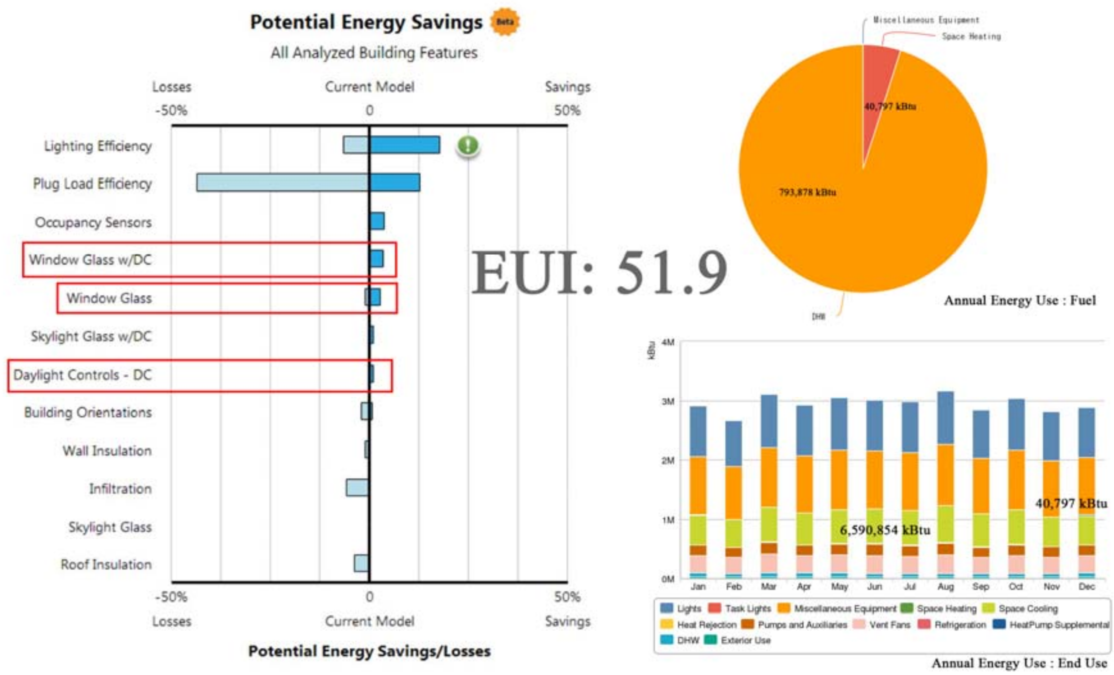


Figure 6.1.1.1: Analysis 1 Synthesized EUI Report

Analysis 2 Synthesized EUI Report

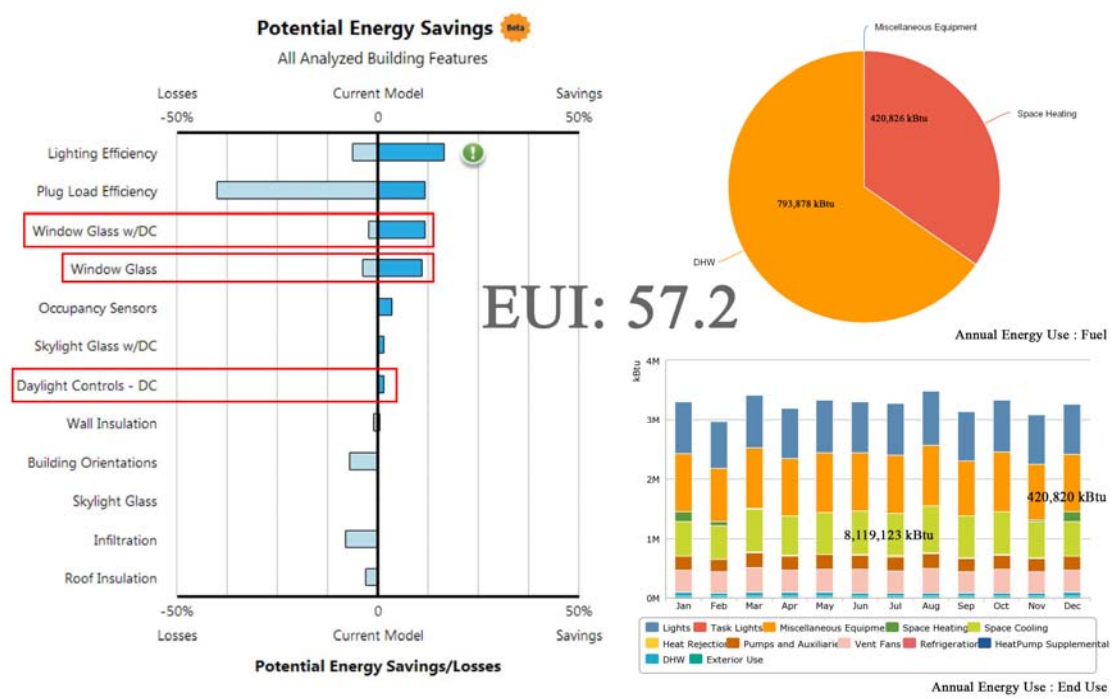


Figure 6.1.1.2: Analysis 2 Synthesized EUI Report

Analysis 7 Synthesized EUI Report

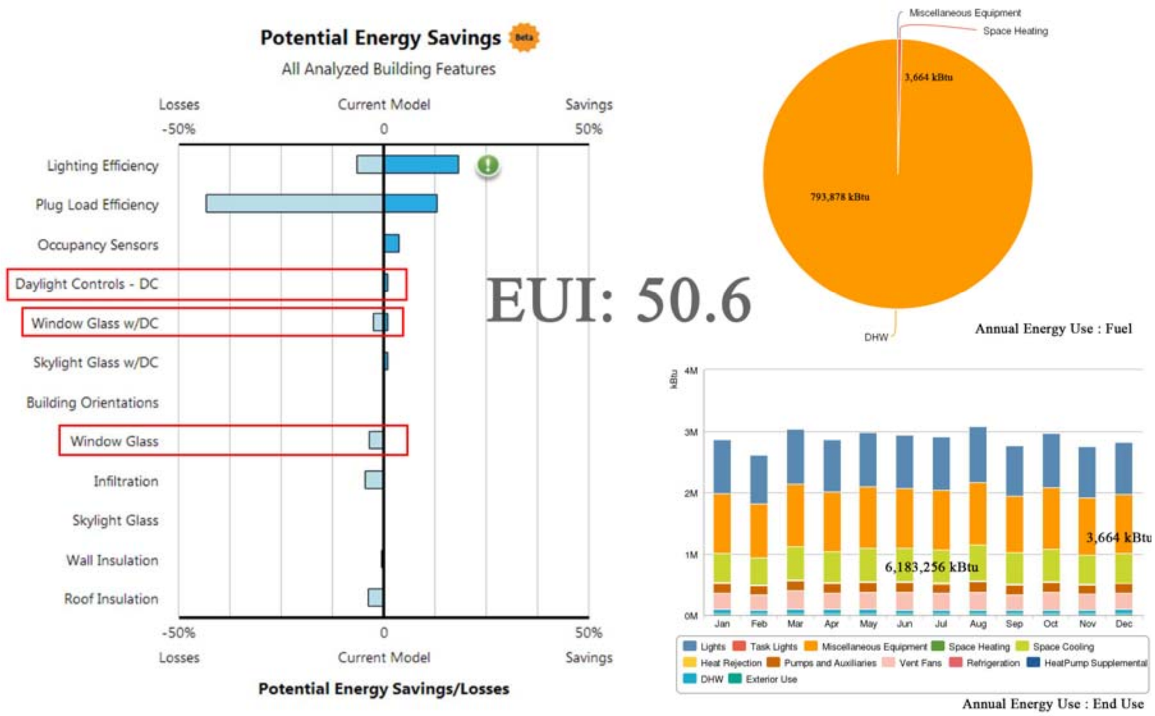


Figure 6.1.1.3: Analysis 7 Synthesized EUI Report

Analysis 8 Synthesized EUI Report

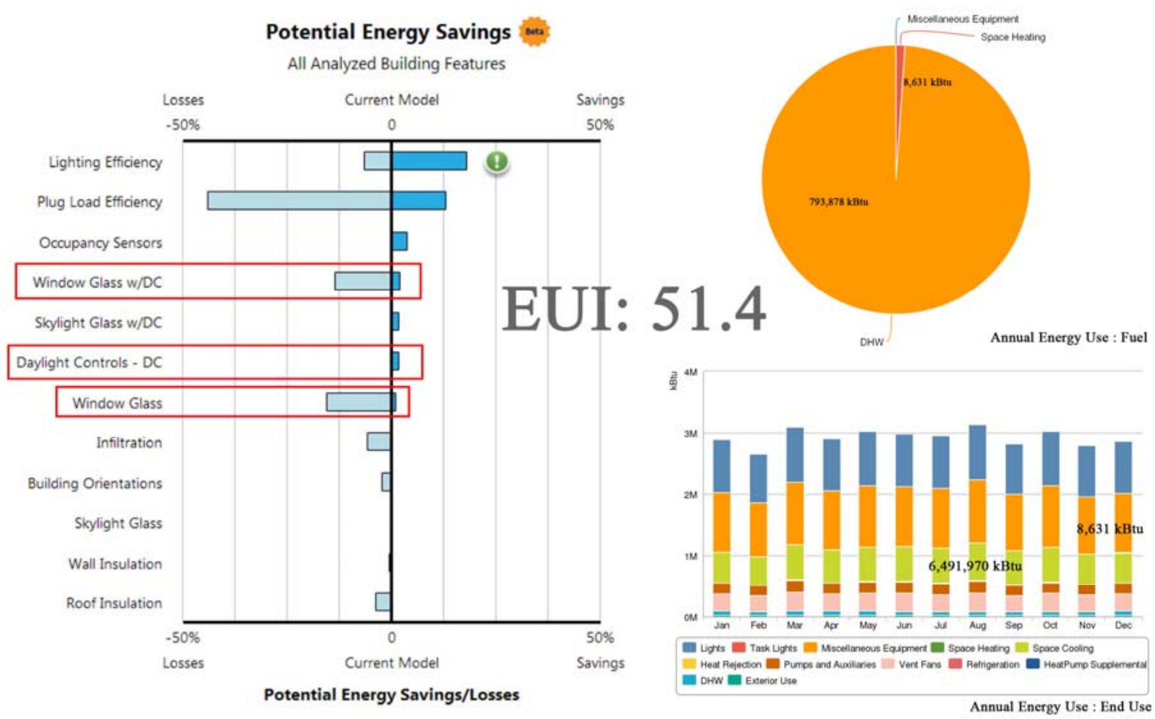


Figure 6.1.1.4: Analysis 8 Synthesized EUI Report

The research in this section demonstrated that when glazing is not properly shaded, increasing the percentage of glazing from 30 to 90% has a negative impact on energy use intensity. The increase in energy use intensity is a result of a rise in the heating and cooling demands due to the increased surface area of glazing and heat loss / gain through conduction. Analysis 1 (Figure 6.1.1.1.) required only 40,797 kBtu/yr. for space heating where Analysis 2 (Figure 6.1.1.2.) requires 420,826 kBtu/yr. Similarly, Analysis 1 required 6,590,854 kBtu/yr. for space cooling where Analysis 2 used 8,119,123 kBtu/yr. Analysis 7 required only 3,664 kBtu/yr. for space heating where Analysis 8 requires 8,632 kBtu/yr. Similarly, Analysis 7 (Figure 6.1.1.3.) required 6,183,256 kBtu/yr. for space cooling where Analysis 8 used 6,491,970 kBtu/yr. Analysis 8 is 20% lower than Analysis 2. In fact, Analysis 8 (Figure 6.1.1.4.) cooling loads are more than 20 percentage points lower than Analysis 2. Note the increase in energy use intensity and heating / cooling loads is not as dramatic from Analysis 7 to 8 as it is in Analysis 1 to 2. This demonstrates higher insulation qualities of the high performance double pane glass which reduces the negative effects of increasing percentage of glass on the energy use intensity. The graph in 6.1.1.5 demonstrates that percentage of glazing has a greater effect on energy use intensity in single pane glazing than on high performance double pane glazing. Energy use intensity is increased as percentage of glazing is increased. Percentage of glazing has a greater impact on single pane glazing than it does on high performance double pane glazing with regard to energy use intensity.

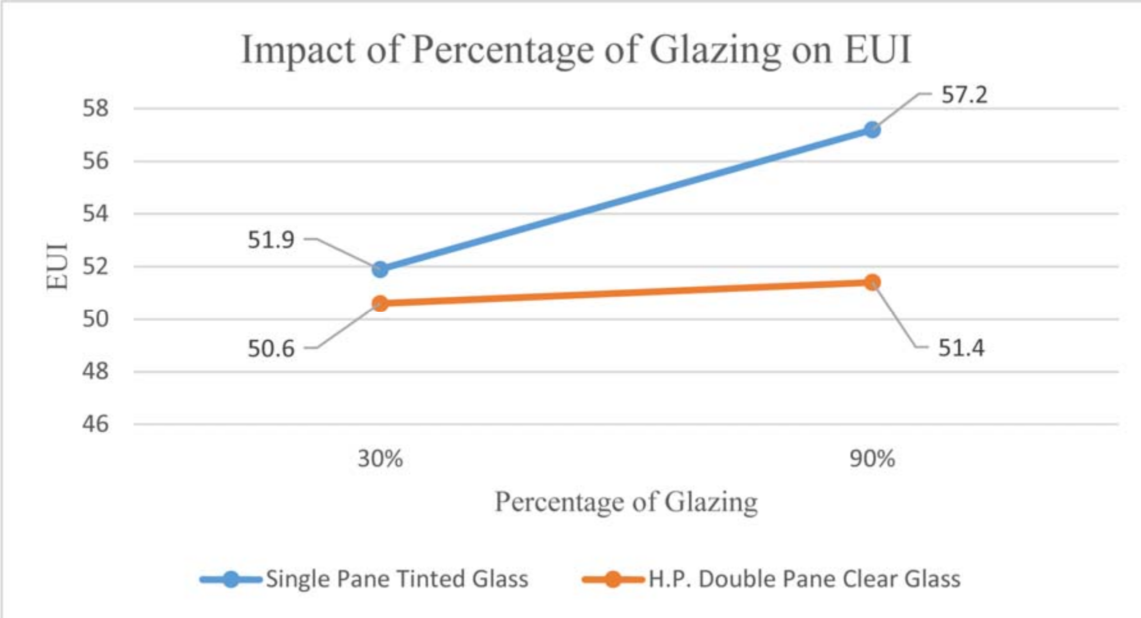


Figure 6.1.1.5: Impact of Percentage of Glazing on Energy Use Intensity Graph

6.1.2. Impact of Glazing Type on EUI

What is the impact of the type of glazing in a facade system on energy use intensity?

The impact of type of glazing on energy use intensity was studied by comparing Analysis 1 to 7 and Analysis 2 to 8, from Groups A and C.

<u>Analysis Key:</u>

Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).
Analysis 7 - 30% High performance double pane glazing.

Analysis 2 – 90% Single pane tinted glazing.
Analysis 8 - 90% High performance double pane glazing.

The two types of glazing studied during this section were Single Pane Tinted Glass and Double Pane Clear High Performance, LowE, High Tvis, Low SHGC Glass. It should be noted that Triple Pane Clear - LowE Glass and Quad Pane Clear - LowE Glass were also tested. However, they did not demonstrate distinguishable impacts on EUI when compared to Double Pane Clear High Performance, LowE, High Tvis, Low SHGC Glass, and therefore were not included in this research. In Analyses 1-12, all shaded and non-shaded scenarios showed improved energy use intensity when the construction setting was changed from Single Pane Tinted to Double Pane Clear High Performance, LowE, High Tvis, Low SHGC (refer to Table 6.3 Analysis, Groups and EUI Matrix). In Analysis 1 and 7, the 30% glass was changed from single pane to double pane glass and demonstrated a 2.5 percentage point improvement in EUI. In Analysis 2 and 8, the 90% glass was changed from single pane to double pane and demonstrated a 10% improvement in EUI.

Table 6.1.2.1 displays the Impact of type of glazing on energy use intensity.

Impact of Type of Glazing on EUI

EUI **kBtu / sf /yr**	**Existing Building** **30% Glass**	**Updated Building Curtain Wall at South and North Facade 90% Glass**
Single Pane Tinted		
Single Pane Tinted Glass	51.9	57.2
H.P. Clear Double Pane		
Double Pane Clear H.P. Glass	50.6, 2.5% Improvement	51.4, 10% Improvement

Abbreviation Legend
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC

Table 6.1.2.1: Impact of Type of Glazing on EUI

Analysis 1 Synthesized EUI Report

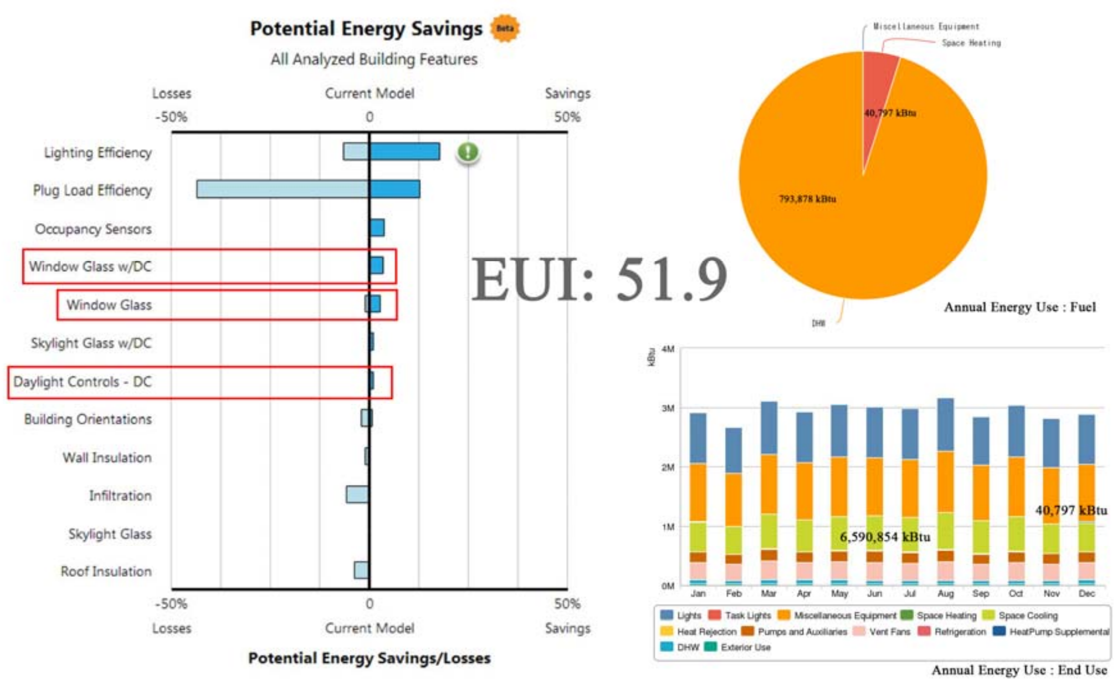


Figure 6.1.2.1: Analysis 1 Synthesized EUI Report

Analysis 7 Synthesized EUI Report

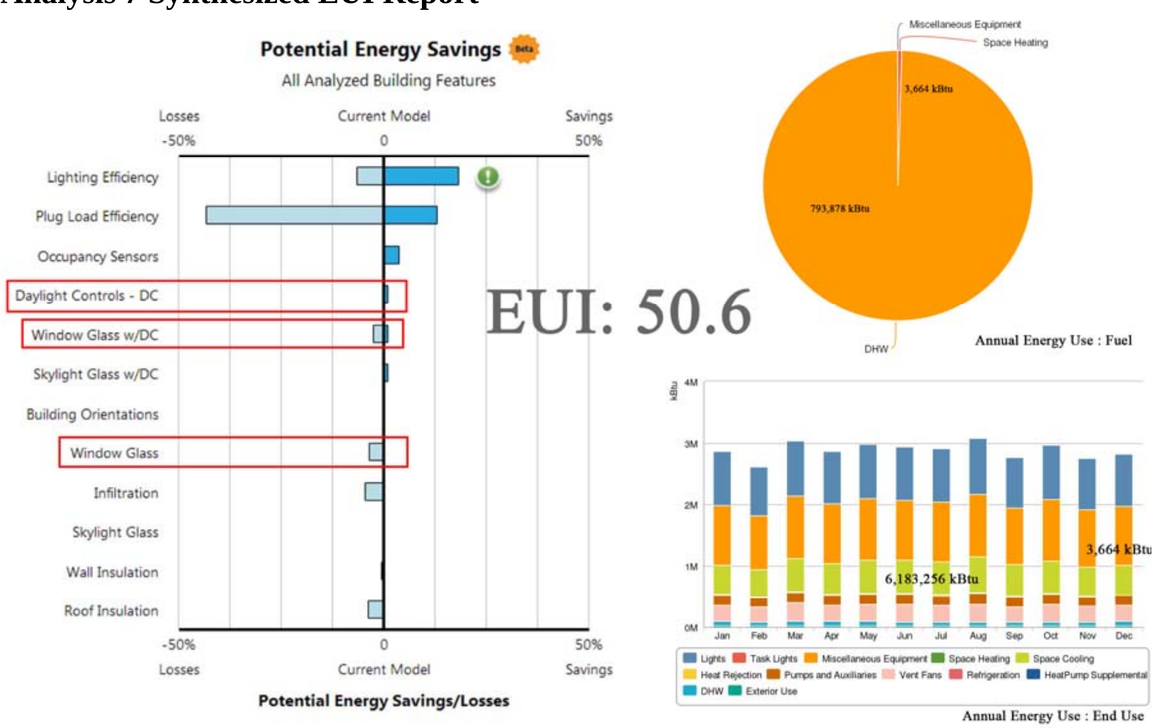


Figure 6.1.2.2: Analysis 7 Synthesized EUI Report

Analysis 2 Synthesized EUI Report

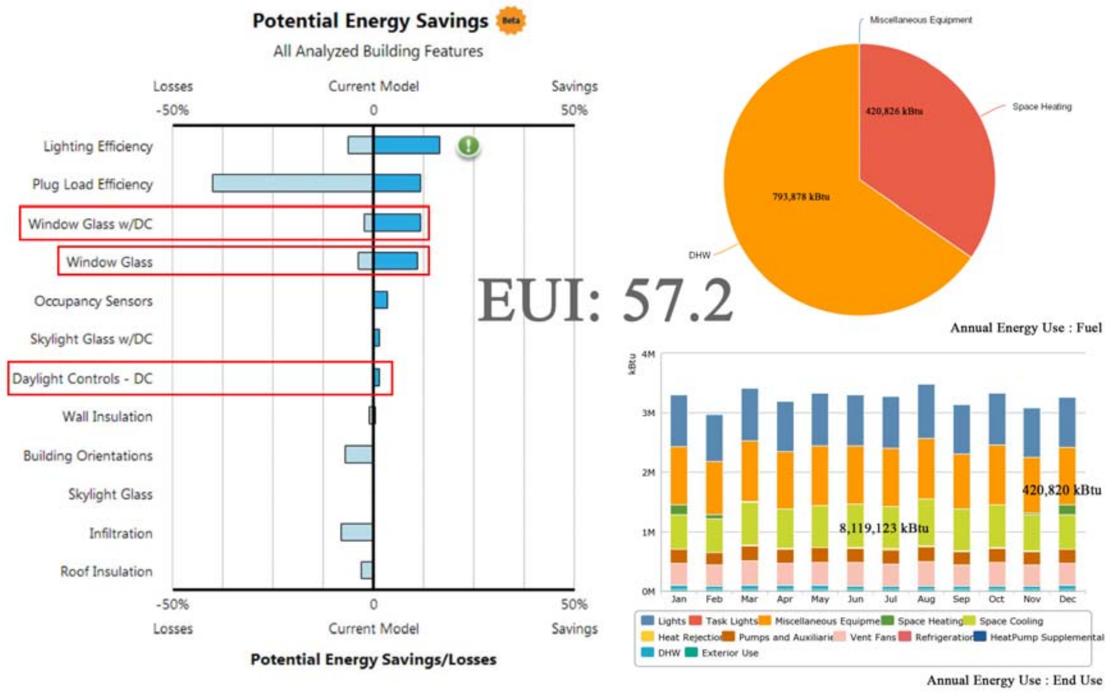


Figure 6.1.2.3: Analysis 2 Synthesized EUI Report

Analysis 8 Synthesized EUI Report

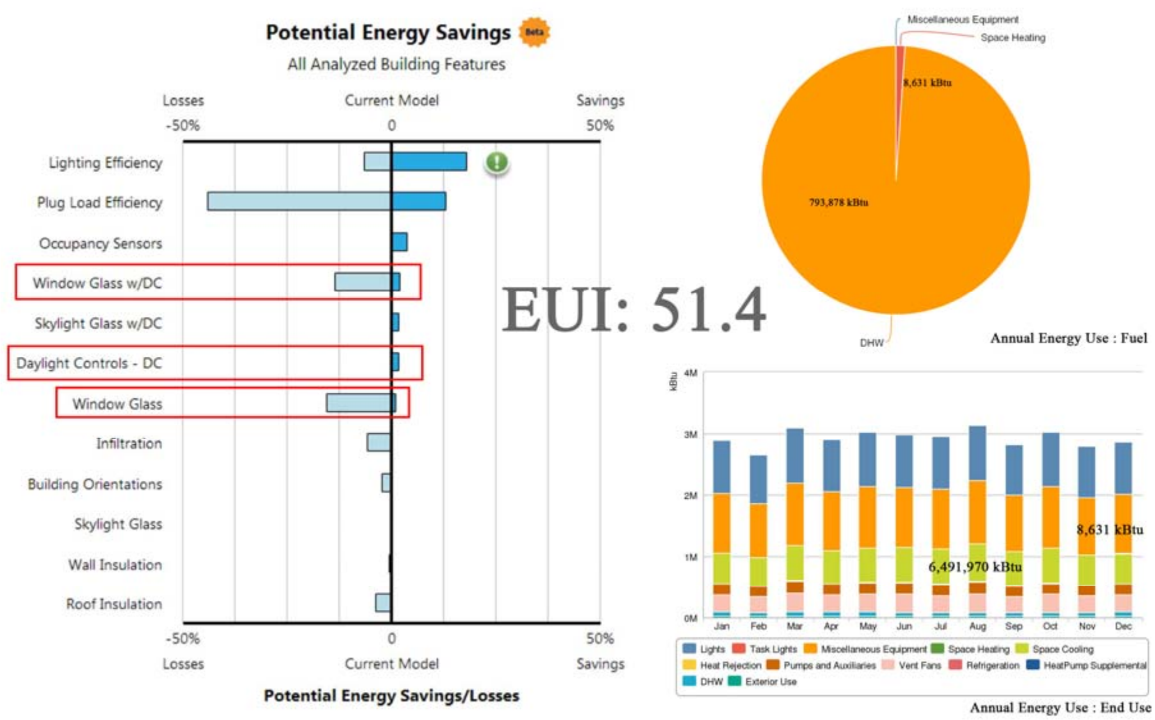


Figure 6.1.2.4: Analysis 8 Synthesized EUI Report

In all analyses, changing Single Pane Tinted Glass to Double Pane Clear High Performance, LowE, High Tvis, Low SHGC Glass resulted in improved energy use intensity. Figures 6.1.2.1, 6.1.2.2, 6.1.2.3, 6.1.2.4 demonstrate that Double Pane Clear High Performance, LowE, High Tvis, Low SHGC glass's effectiveness at reducing heat gain and loss through conduction. This is apparent when looking at the space heating and cooling loads that are substantially lower in comparing Analysis 1 and 7 and Analysis 2 and 8. Analysis 1 required 40,797 kBtu/yr. for space heating where Analysis 7 required only 3,664 kBtu/yr, demonstrating a 91percentage point improvement. Analysis 1 required only 6,590,854 kBtu/yr. for space cooling where Analysis 7 required only 6,183,256 kBtu/yr, demonstrating a 6 percentage point improvement. Analysis 2 required 420,820 kBtu/yr. for space heating where Analysis 8 required only 8,631 kBtu/yr, demonstrating a 98% improvement. Analysis 2 required only 8,119,123 kBtu/yr. for space cooling where Analysis 8 required only 6,491,970 kBtu/yr, demonstrating a 20 percentage point improvement.

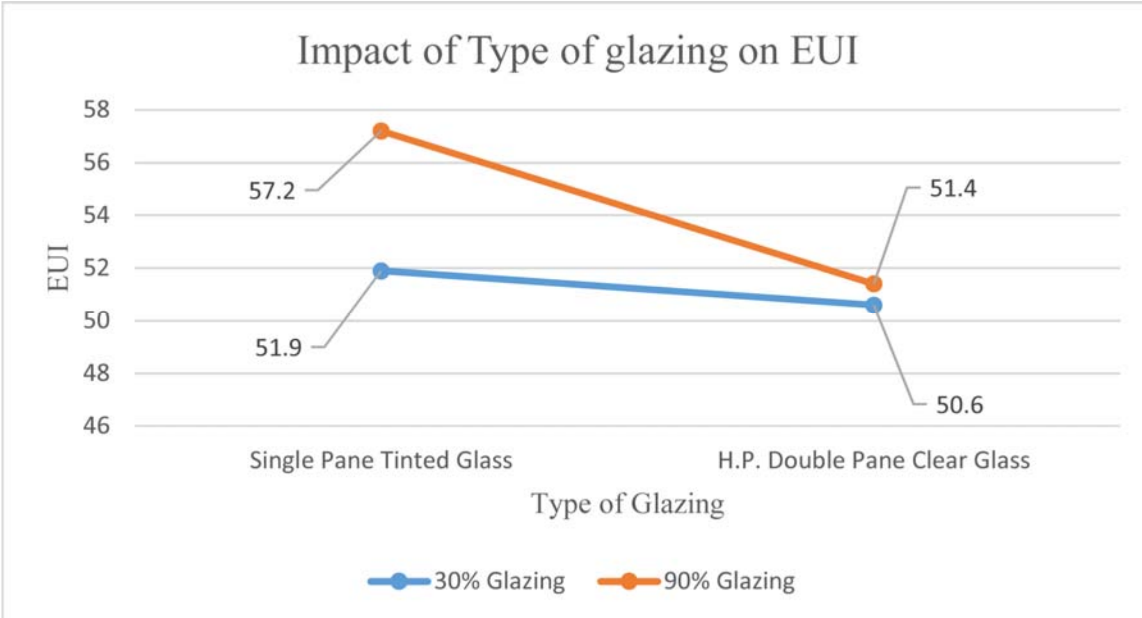


Figure 6.1.2.5: Impact of Type of Glazing on EUI Graph

Changing from single pane tinted glass to high performance double pane glass decreases energy use intensity. The greater the percentage of glass, the greater the effects of changing from single pane tinted glass to high performance double pane glass will have on energy use intensity. Type of glazing has an impact on energy use intensity due to the increased insulation qualities found in high performance double pane glazing which dramatically decreases heating and cooling loads.

6.1.3. Glazing Percentage and Type in Terms of EUI

What is the relationship between glazing percentage and glazing type in terms of energy use intensity?

The impact of glazing percentage and type of glazing as they relate to energy use intensity were studied by comparing and contrasting the data gathered in Sections 6.1.2 and 6.1.3. High performance double pane glazing allows for a significant increase (30% to 90%) in glazing percentage with minimal increase in energy use intensity (1.5

percentage points, Figure 6.1.1.5.). Upgrading single pane glazing to high performance double pane glazing significantly decreases energy use intensity. In a 30% glazing study energy use intensity was decreased by 2.5 percentage points and in the 90% glazing study energy use intensity was decreased by 10 percentage points (refer to Figure 6.1.2.5.).

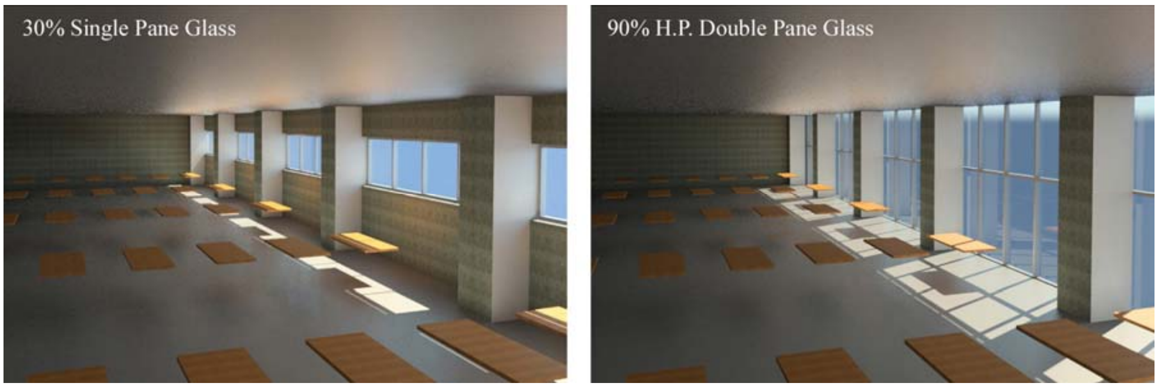


Figure 6.1.3.1: 30% Glazing vs. 90% Glazing Diagram

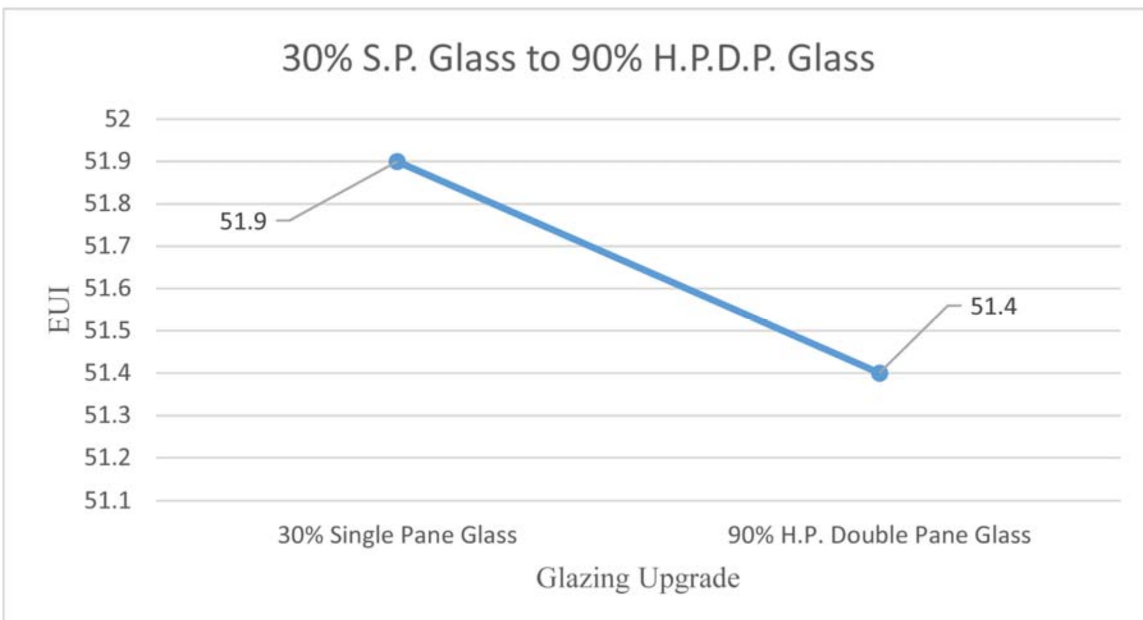


Figure 6.1.3.2: 30% S.P. Glass to 90% H.P.D.P. Glass Graph

Furthermore, 30% single pane glazing compared to 90% high performance double pane glazing will result in a .01 percentage point decrease in EUI. In other words, an older office building with 30% single pane glazing could increase its view and access to natural daylight by 200% (30% to 90%) and slightly decrease its energy demand (Figure

6.1.3.1.). Additionally, the increased glazing percentage would result in an increase of natural daylighting, which would reduce the electrical lighting demand and further decrease the building energy use intensity.

6.2. Impact of Solar Shade Device on EUI

This section discusses the following research sub-question:

4. What is the impact of a passive solar designed, horizontal and slanted vertical louvers shade system on energy use intensity?
5. What is the impact of a parametrically modeled passive solar designed egg-crate and slanted vertical louvers shade system on energy use intensity?
6. How do passive solar horizontal and slanted vertical louvers compare to a parametrically modeled passive solar egg-crate and slanted vertical louvers in terms of energy use intensity?

Section 6.2.1 addresses sub-question 4, on the impact of horizontal and vertical louvers shade device, as defined in Section 5.1, on energy use intensity. Section 6.2.2 discusses sub-question 5, regarding the impact of a parametrically modeled egg-crate and slanted vertical louver shade device, as defined in Section 5.2 on energy use intensity. Then the two shade devices are compared and contrasted in terms of the effectiveness to lower energy use intensity in Section 6.2.3.

6.2.1. Impact of Horizontal and Slanted Vertical Shade Device on EUI

What is the impact of a passive solar designed horizontal and vertical louver shade system on energy use intensity?

The impact of passive solar designed horizontal and slanted vertical louvers shade system on energy use intensity was studied by comparing Analysis 1 to 3, Analysis 2 to 4, Analysis 7 to 9 and Analysis 8 to 10, from Groups A and C.

Analysis Key:

Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).
Analysis 3 – 30% Single pane tinted glazing with horizontal and slanted vertical shading devices.

Analysis 2 – 90% Single pane tinted glazing.
Analysis 4 – 90% Single pane tinted glazing with horizontal and slanted vertical shading devices.

Analysis 7 - 30% High performance double pane glazing.
Analysis 9 - 30% High performance double pane glazing with horizontal and slanted vertical shading devices.

Analysis 8 - 90% High performance double pane glazing.
Analysis 10 - 90% High performance double pane glazing with horizontal and slanted vertical shading devices.

Analyses 3, 4, 9 and 10 all showed improved energy use intensity when the energy setting for shade device was set to "yes" when the horizontal and vertical louvers shade device were added (Table 6.2.1.1.). Analysis 3 demonstrated a 2.1% improvement in EUI from its baseline value in Analysis 1. Analysis 4 demonstrated a 7.5% improvement in EUI from its baseline value in Analysis 2. Analysis 9 demonstrated a .3% improvement in EUI from its baseline value in Analysis 7. Finally, Analysis 10 showed a 1.7 % improvement in EUI of its baseline value in Analysis 8.

Impact of Horizontal and Vertical Louvers Shade Devices on EUI

EUI **kBtu / sf /yr**	**Existing Building 30% Glass**	**Updated Building Curtain Wall at South and North Facade 90% Glass**
Single Pane Tinted		
Single Pane Tinted Glass	A1 - 51.9, Baseline	A2 - 57.2, Baseline
Horizontal Shade Device & S.P. Glass	A3 - 50.8, 2.1% Improvement	A4 - 52.9, 7.5 % Improvement
H.P. Clear Double Pane		
Double Pane Clear H.P. Glass	A7 - 50.4, Baseline	A8 - 50.5, Baseline
Horizontal Shade Device & H.P. Clear Glass	A9 - 50.3, .3% Improvement	A10 - 50.1, 1.7% Improvement

Abbreviation Ledged
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC

Table 6.2.1.1: Impact of Horizontal and Vertical Louvers Shade Devices on EUI

Analysis 1 Synthesized EUI Report

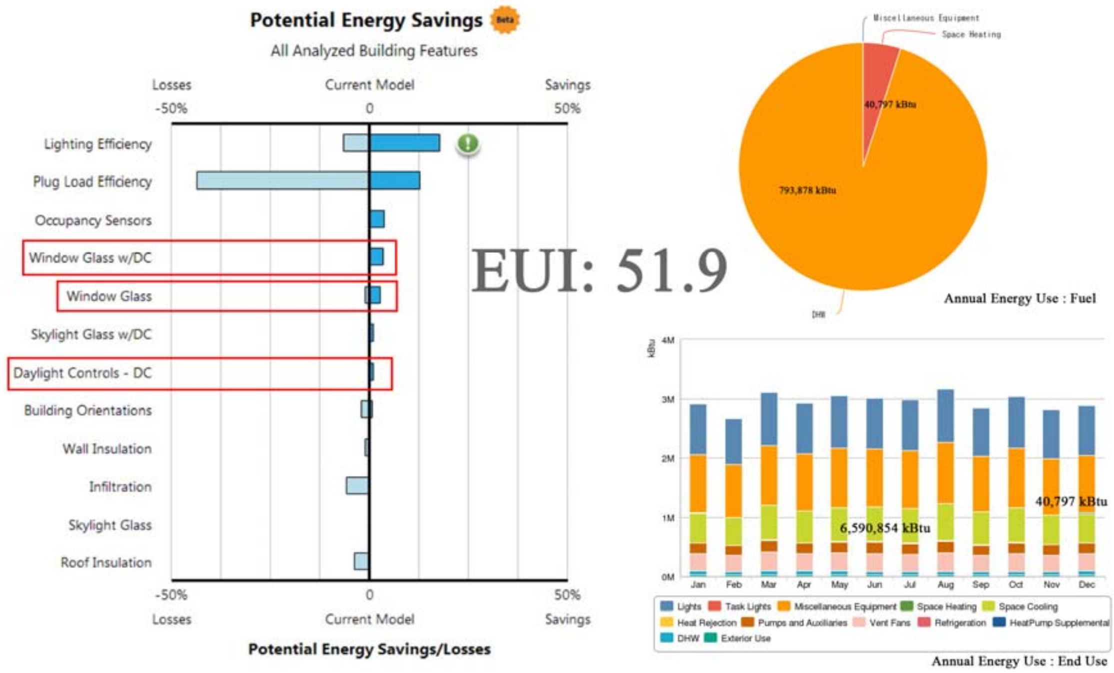


Figure 6.2.1.1: Analysis 1 Synthesized EUI Report

Analysis 3 Synthesized EUI Report

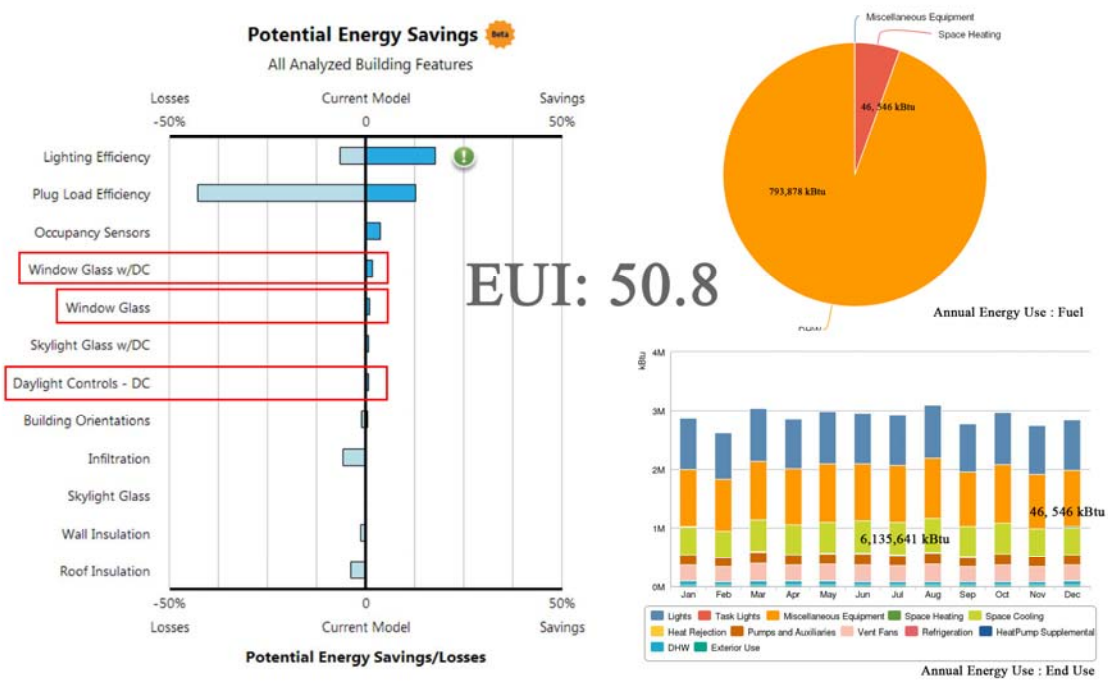


Figure 6.2.1.2: Analysis 3 Synthesized EUI Report

Analysis 2 Synthesized EUI Report

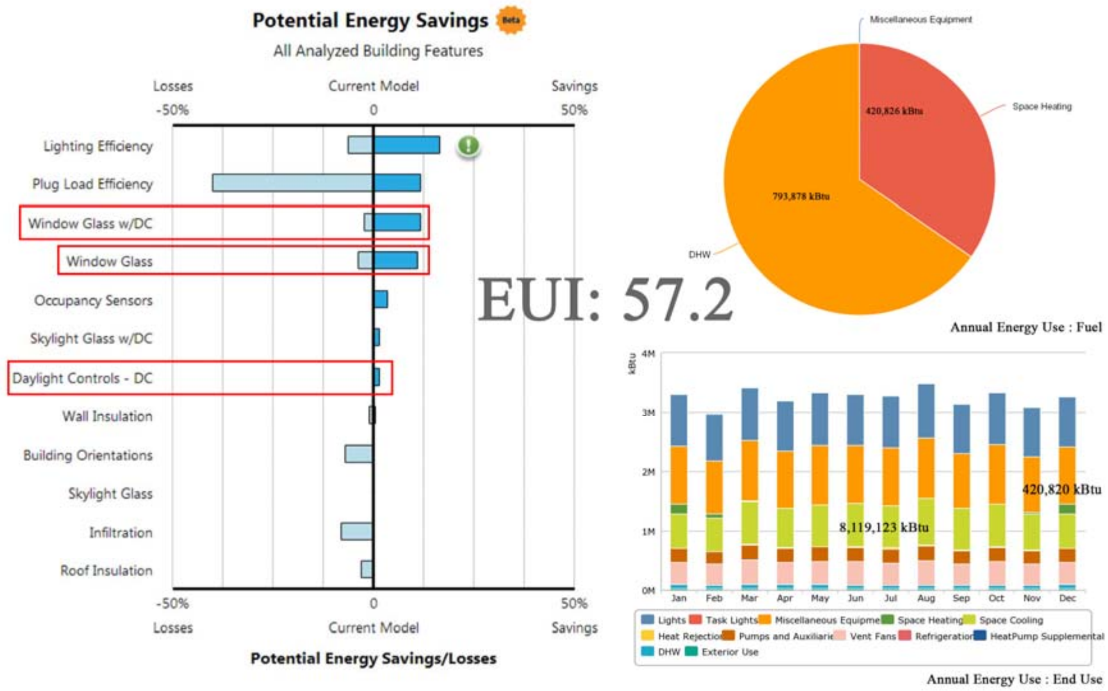


Figure 6.2.1.3: Analysis 2 Synthesized EUI Report

Analysis 4 Synthesized EUI Report

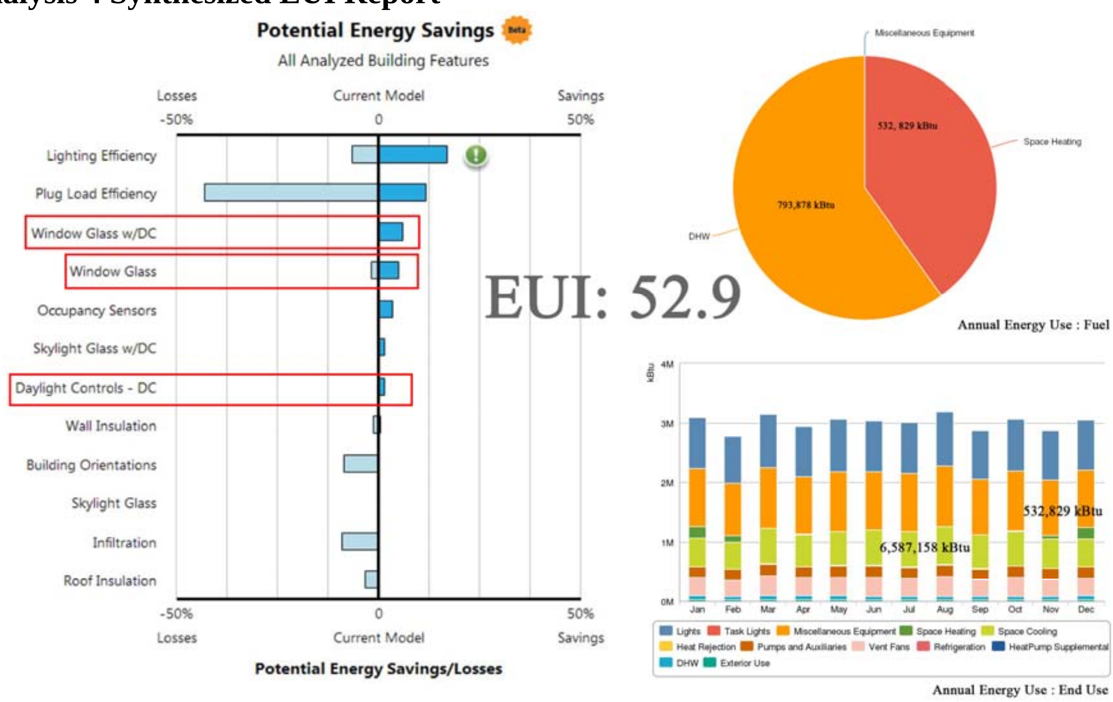


Figure 6.2.1.4: Analysis 4 Synthesized EUI Report

Analysis 7 Synthesized EUI Report

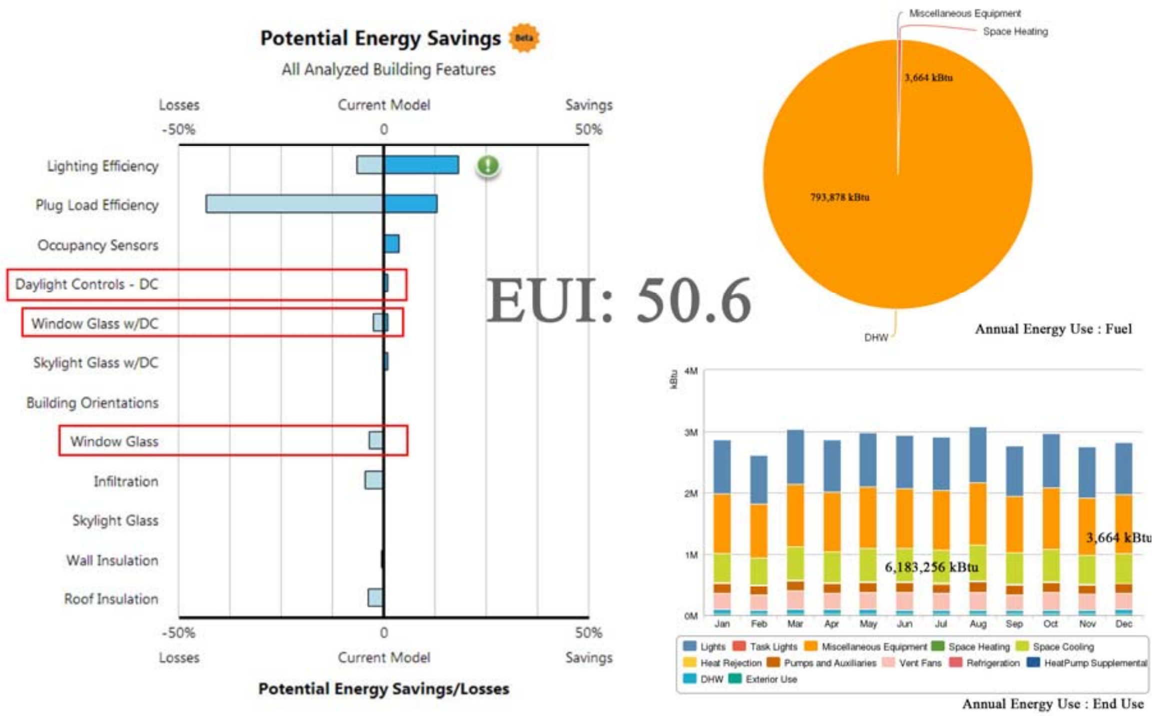


Figure 6.2.1.5: Analysis 7 Synthesized EUI Report

Analysis 9 Synthesized EUI Report

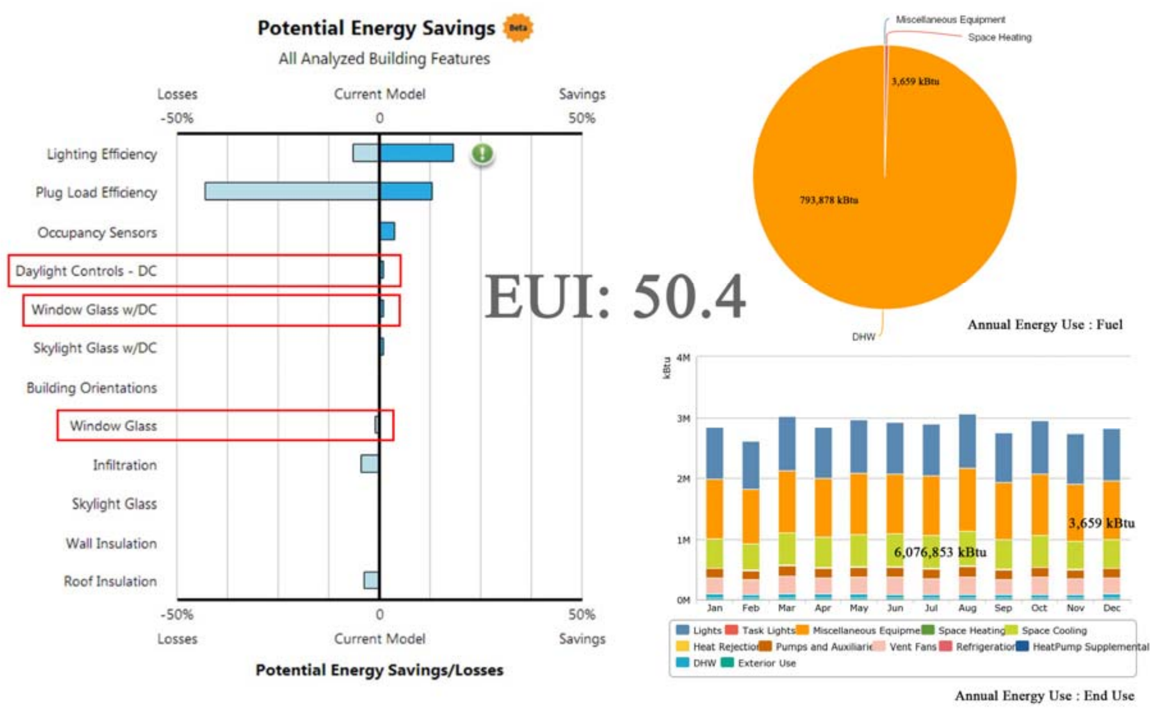


Figure 6.2.1.6: Analysis 9 Synthesized EUI Report

Analysis 8 Synthesized EUI Report

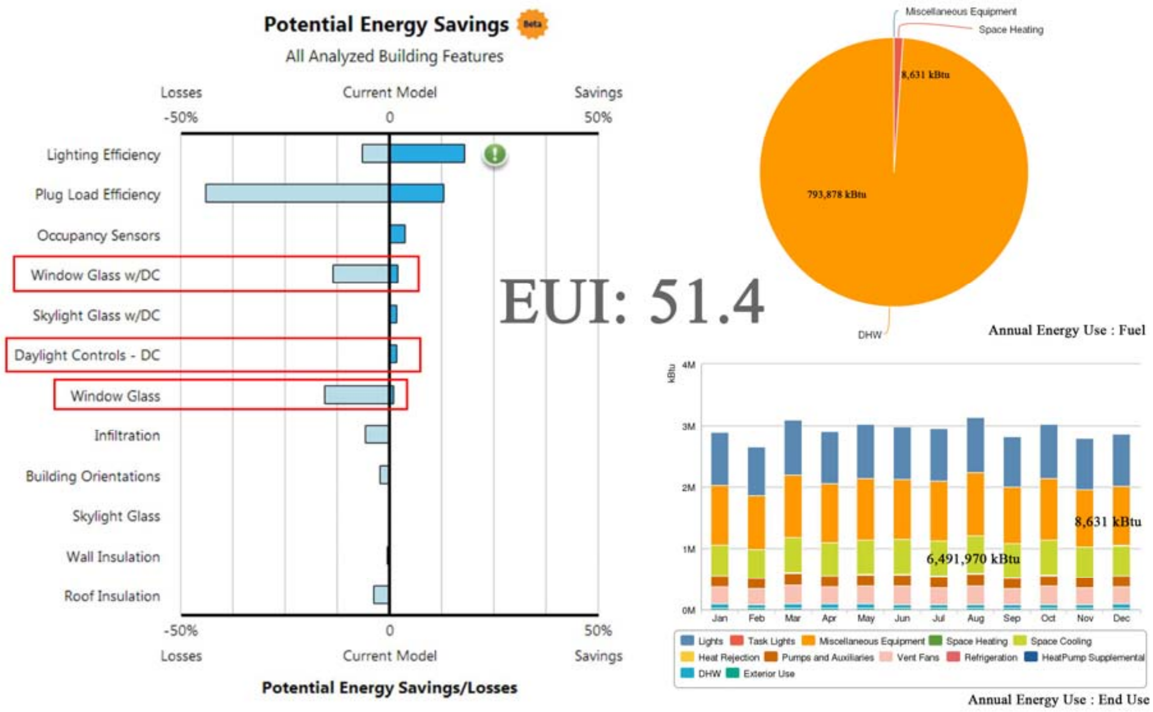


Figure 6.2.1.7: Analysis 8 Synthesized EUI Report

Analysis 10 Synthesized EUI Report

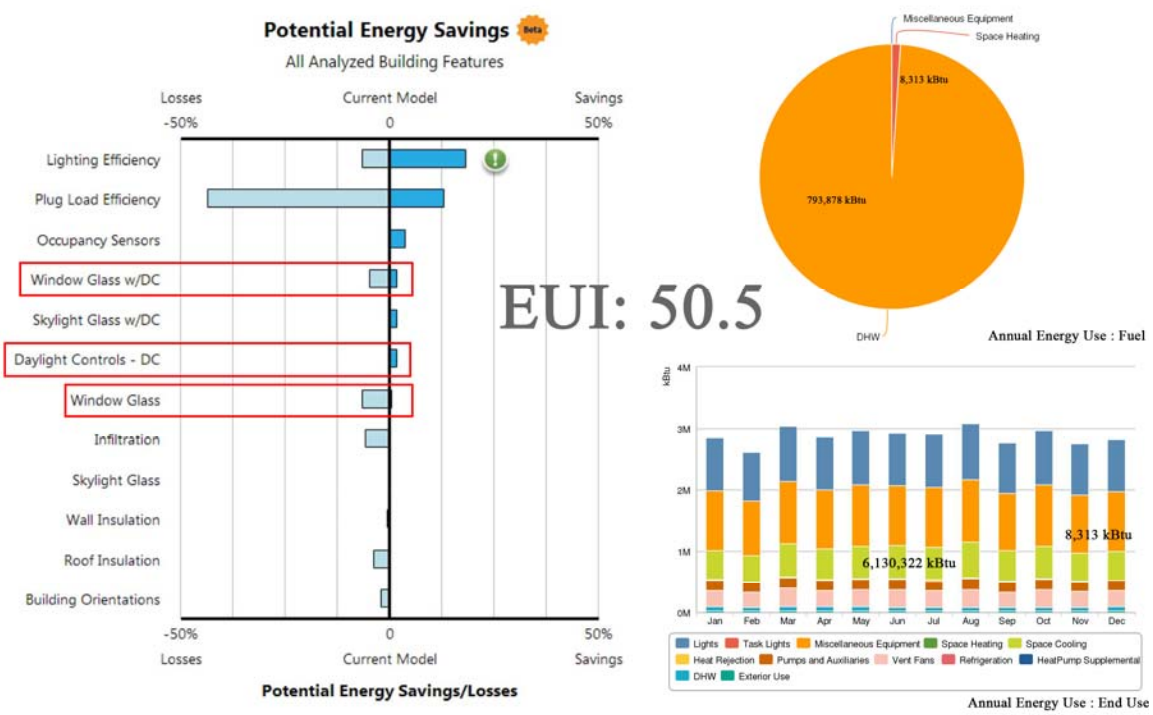


Figure 6.2.1.8: Analysis 10 Synthesized EUI Report

Analyses 3, 4, 9 and 10 all showed improved energy use intensity when the energy setting for shade device was set to “yes” and the horizontal and vertical shade devices were added. The data in the section demonstrate the horizontal and vertical shade devices effectiveness at lowering cooling loads by reducing heat gain through passive shading. However, these same figures also show a slight increase in heating loads. The horizontal shade devices were designed to block out the majority of the average summer sun and allow the majority of the average winter sun to enter into the space and provide passive heating. As a result, the building facade’s passive shading capabilities are substantially increased and its passive solar heating abilities are slightly decreased. That is because the horizontal shade device is providing some undesirable shade during a portion of the day during the winter months. A facade without shading devices results in a facade that is exposed to constant undesirable solar heat gain in the summer and maximum heat gain during the winter months. A facade system that blocks the majority of the summer sun while allowing for maximum heat gain during the winter can only be achieved through a dynamic shading system. As the primary focus of this research is passive (static) shading strategies, dynamic strategies were not explored (refer to Section 5). In a hot-mediterranean environment blocking out heat gain during the summer is more effective than maximizing heat gain during the winter at lowering energy use intensity. That is because, in a hot-mediterranean environment, more energy is required to cool a building during the summer than energy required to heat a building during the winter.

The research in this section demonstrated that applying a horizontal and slanted vertical louvers shade system results in a dramatic increase in passive cooling, a slight decrease in passive heating and an overall decrease in energy use intensity. This is apparent when looking at the space cooling loads that are notably lower and heating loads that are slightly higher when comparing Analysis 1 and 3, Analysis 2 and 4, Analysis 7 and 9 and Analysis 8 and 10 in Figures 6.2.1.1, 6.2.1.2, 6.2.1.3, 6.2.1.4, 6.2.1.5., 6.2.1.6, 6.2.1.7, and 6.2.1.8.

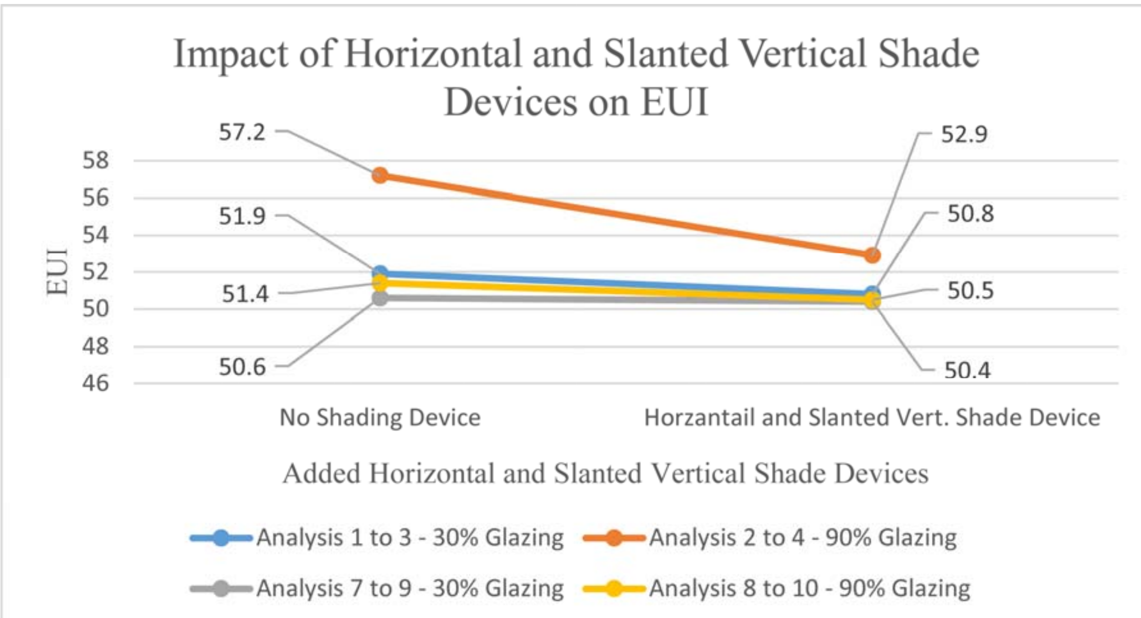


Figure 6.2.1.9: Impact of Horizontal and Slanted Vertical Shading Devices on EUI Graph

This research also showed that a horizontal and slanted vertical louvers shade system have a greater effect on energy use as the percentage of glass is increased (Figure 6.2.1.9.).

6.2.2. Impact of Egg-Crate Shade Device on EUI

What is the impact of a parametrically modeled passive solar designed egg-crate and slanted vertical louvers shade system on energy use intensity?

The impact of parametrically modeled passive solar designed egg-crate and slanted vertical louvers shade system on energy use intensity was studied by comparing Analysis 1 to 5, Analysis 2 to 6, Analysis 7 to 11 and Analysis 8 to 12, from Groups A and C.

<u>Analysis Key:</u>

Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).
Analysis 5 – 30% Single pane tinted glazing with egg crate style and slanted vertical shading devices.

Analysis 2 – 90% Single pane tinted glazing.
Analysis 6 – 90% Single pane tinted glazing with egg crate style and slanted vertical shading devices.

Analysis 7 - 30% H.P. double pane glazing.
Analysis 11 - 30% H.P. double pane glazing with egg crate style and slanted vertical shading devices.

Analysis 8 - 90% H.P. double pane glazing.
Analysis 12 - 90% H.P. double pane glazing with egg crate style and slanted vertical shading devices.

Analysis 5, 6, 11 and 12 all showed improved energy use intensity when parametrically modeled passive solar designed egg-crate and slanted vertical louvers shade system were applied to the energy model. Analysis 5 demonstrated a 2.8 percentage point improvement in EUI from its baseline value in Analysis. Analysis 6 demonstrated a 9.9 percentage point improvement in EUI from its baseline value in Analysis 2. Analysis 11 demonstrated a .5 percentage point improvement in EUI from its baseline value in Analysis 7. Analysis 12 demonstrated a 2.5 percentage point improvement in EUI of its baseline value in Analysis 8.

Impact of Egg-Crate Shading Device on EUI

EUI **kBtu / sf /yr**	**Existing Building 30% Glass**	**Updated Building Curtain Wall at South and North Facade 90% Glass**
Single Pane Tinted		
Single Pane Tinted Glass	A1 - 51.9, Baseline	A2 - 57.2, Baseline
Parametric Solar Shade Design & S.P. Glass	A5 - 50.4, 2.8% Improvement	A6 - 51.5, 9.9% Improvement
H.P. Clear Double Pane		
Double Pane Clear H.P. Glass	A7 - 50.6, Baseline	A8 - 51.4, Baseline
Parametric Solar Shade Design & H.P. Clear Glass	A11 - 50.3, .5% Improvement	A12 - 50.1, 2.5% Improvement

Abbreviation Ledged
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC

Table 6.2.2.1: Impact of Egg-Crate Shading Device on EUI

Analysis 1 Synthesized EUI Report

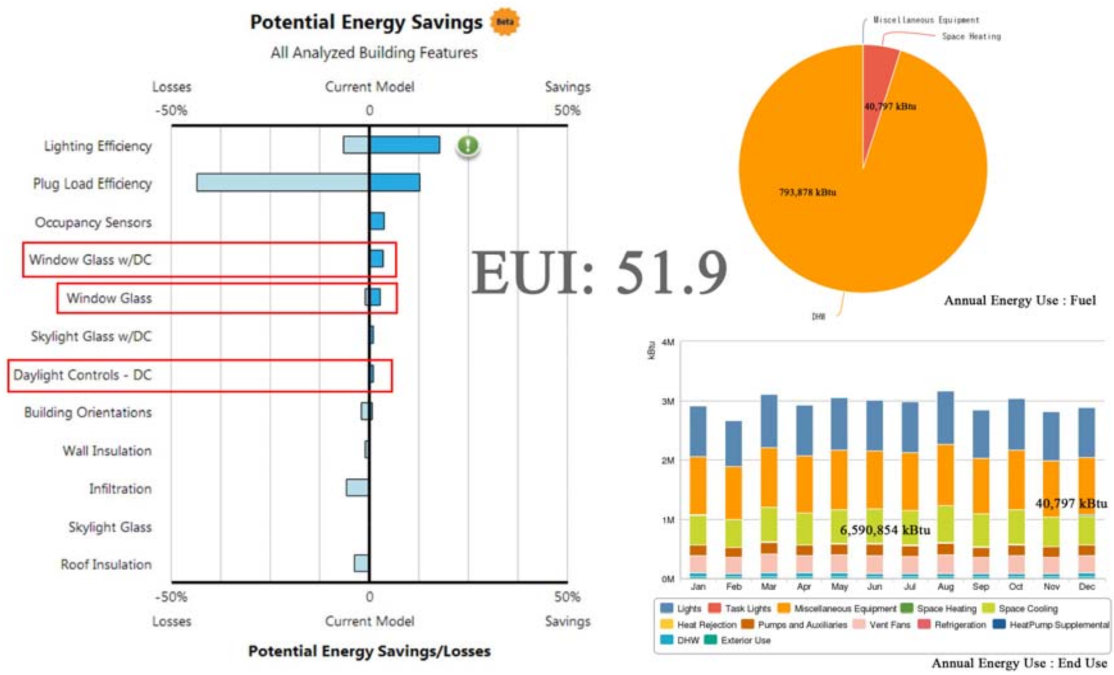


Figure 6.2.2.1: Analysis 1 Synthesized EUI Report

Analysis 5 Synthesized EUI Report

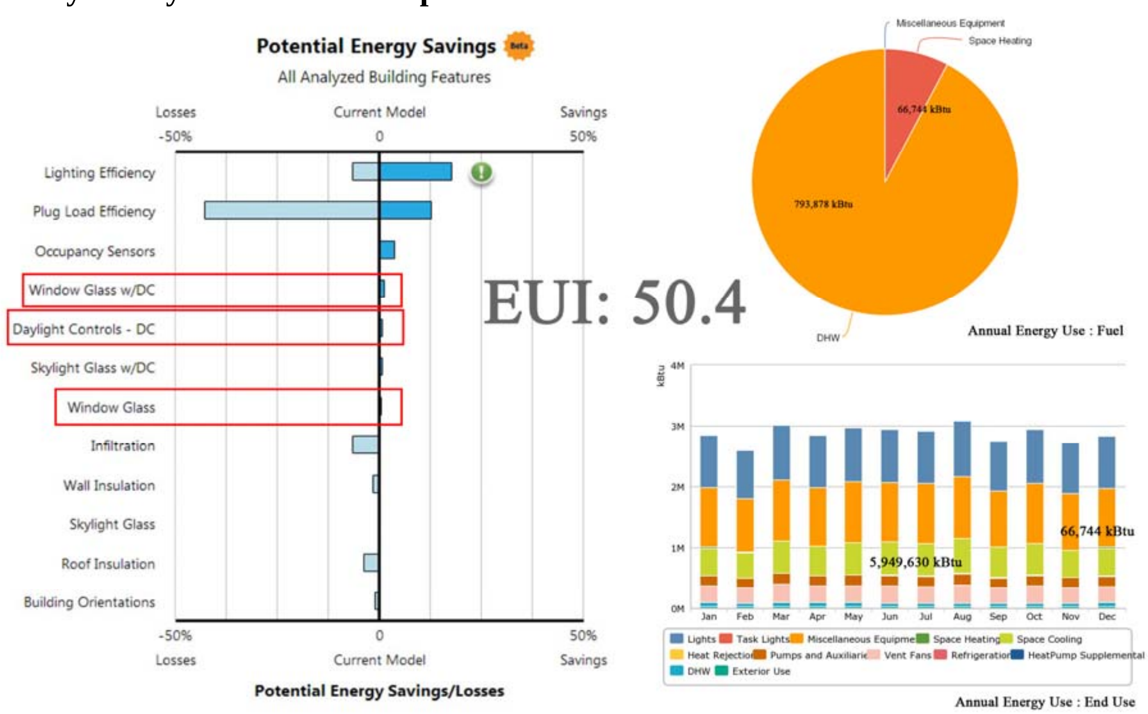


Figure 6.2.2.2: Analysis 5 Synthesized EUI Report

Analysis 2 Synthesized EUI Report

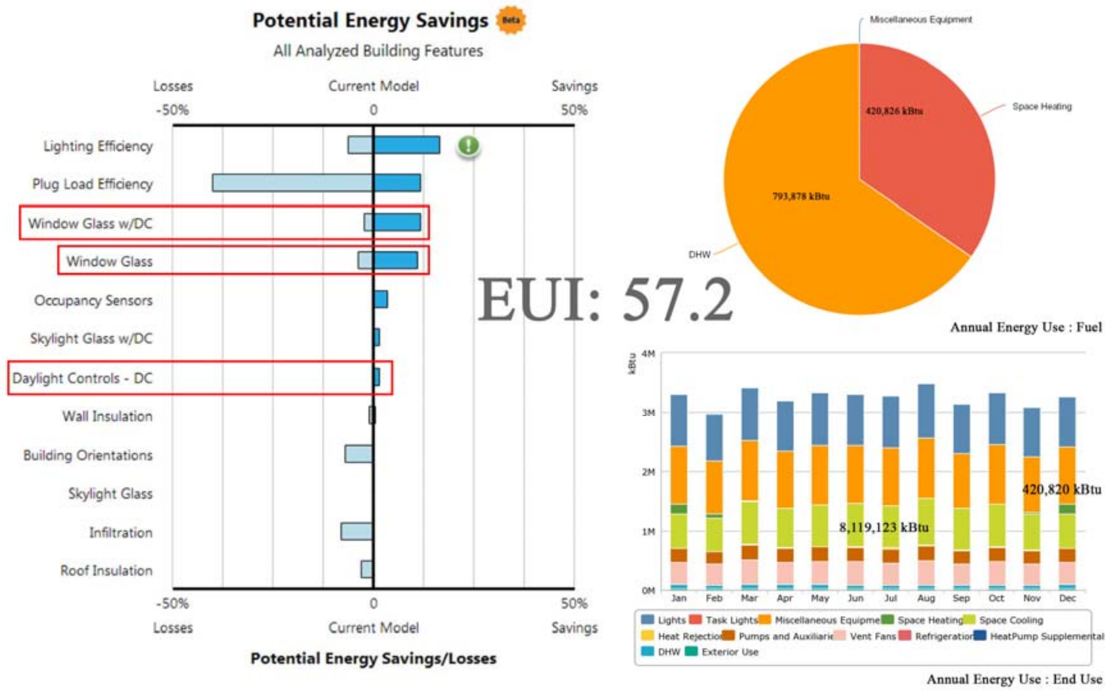


Figure 6.2.2.3: Analysis 2 Synthesized EUI Report

Analysis 6 Synthesized EUI Report

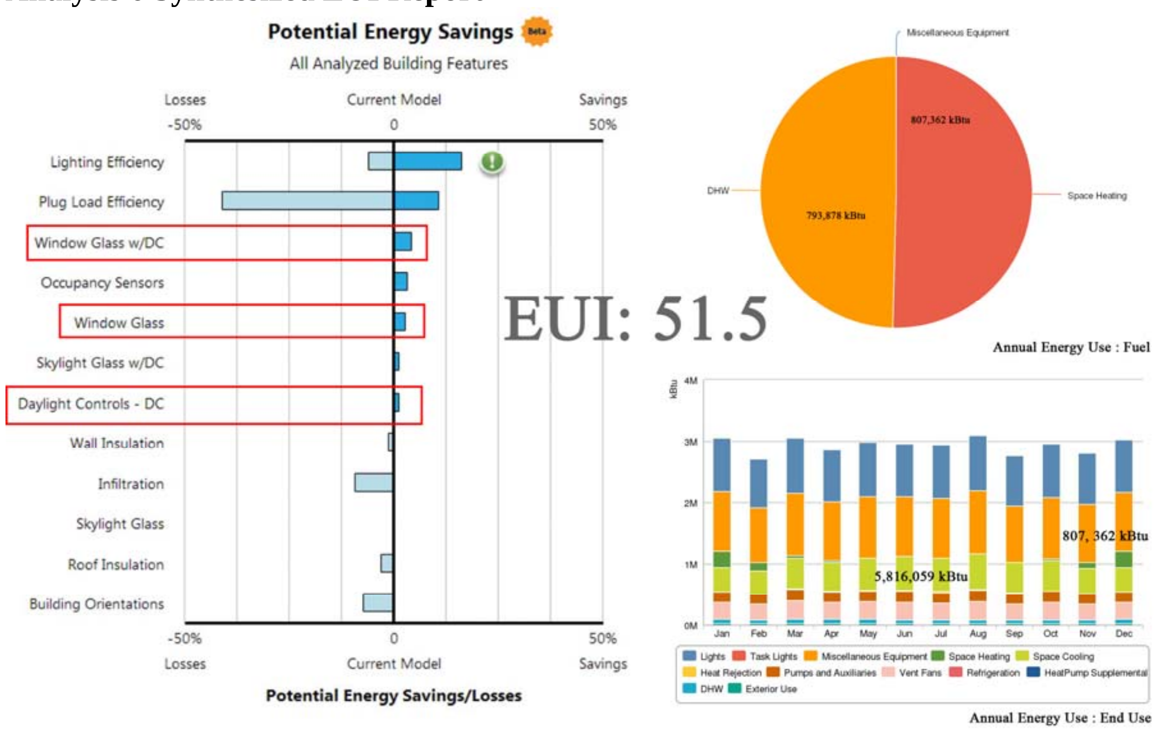


Figure 6.2.2.4: Analysis 6 Synthesized EUI Report

Analysis 7 Synthesized EUI Report

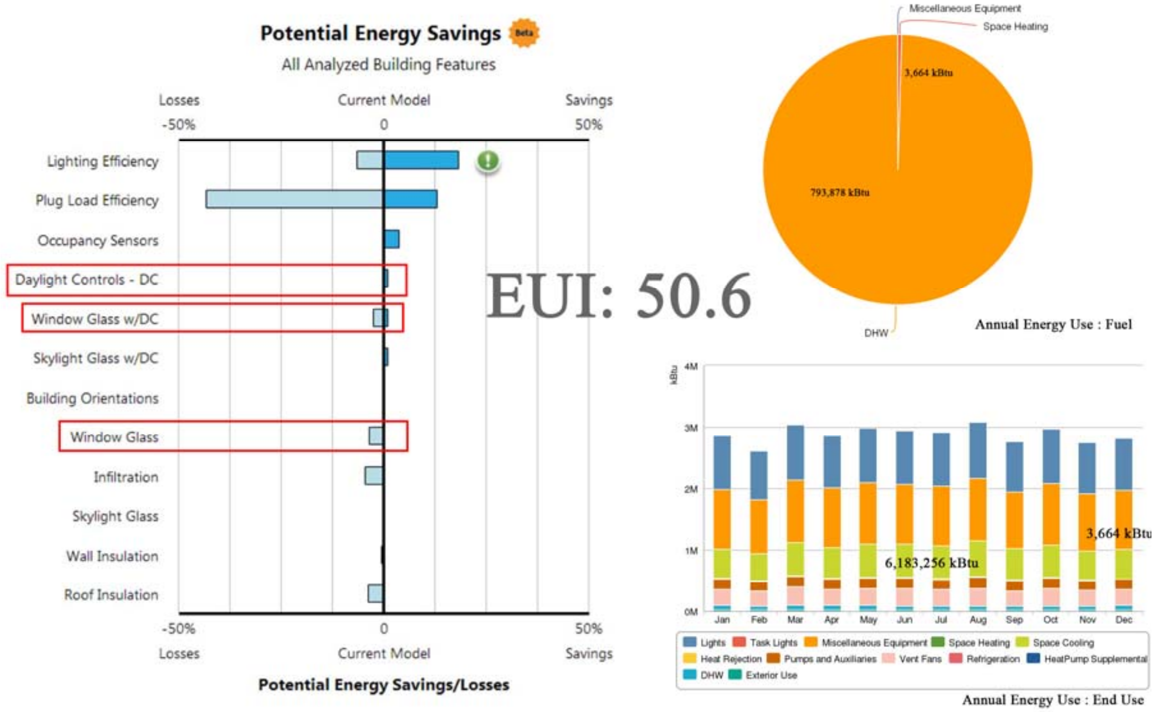


Figure 6.2.2.5: Analysis 7 Synthesized EUI Report

Analysis 11 Synthesized EUI Report

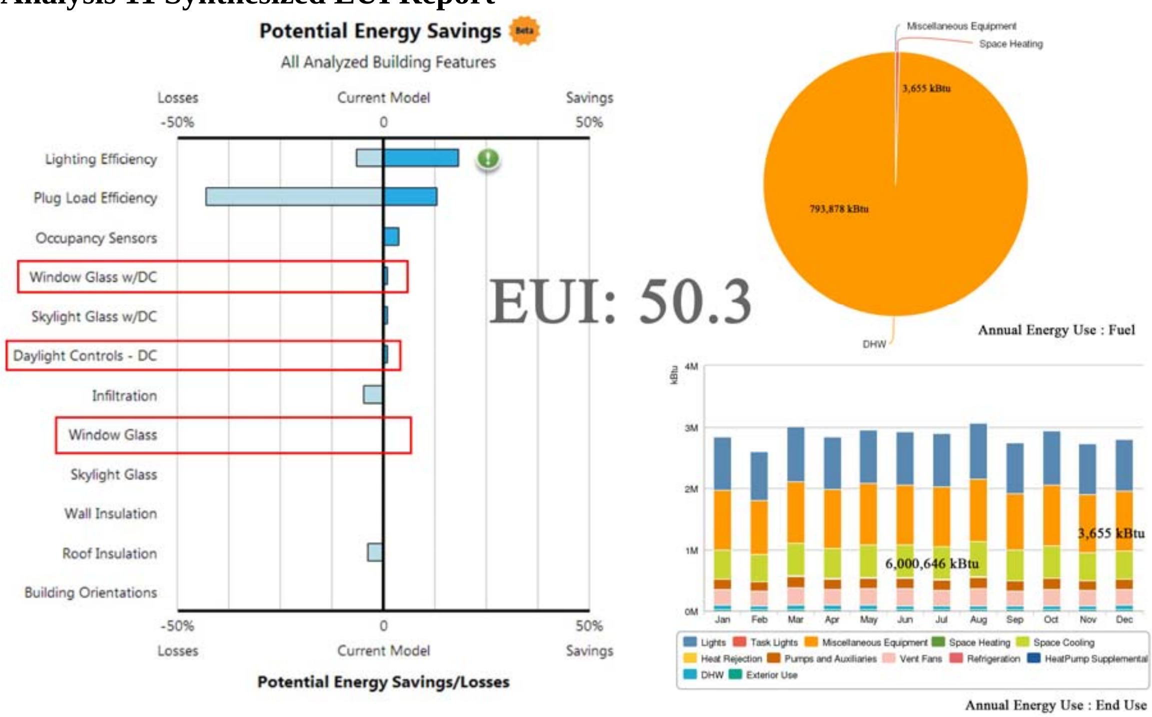


Figure 6.2.2.6: Analysis 11 Synthesized EUI Report

Analysis 8 Synthesized EUI Report

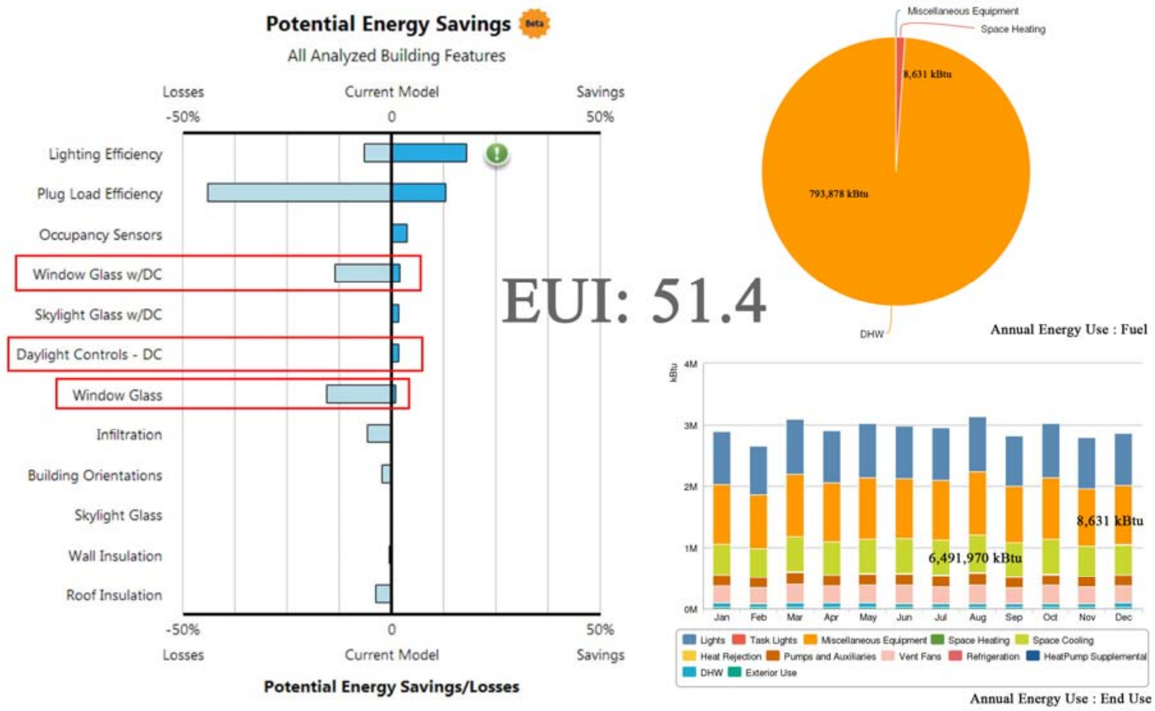


Figure 6.2.2.7: Analysis 8 Synthesized EUI Report

Analysis 12 Synthesized EUI Report

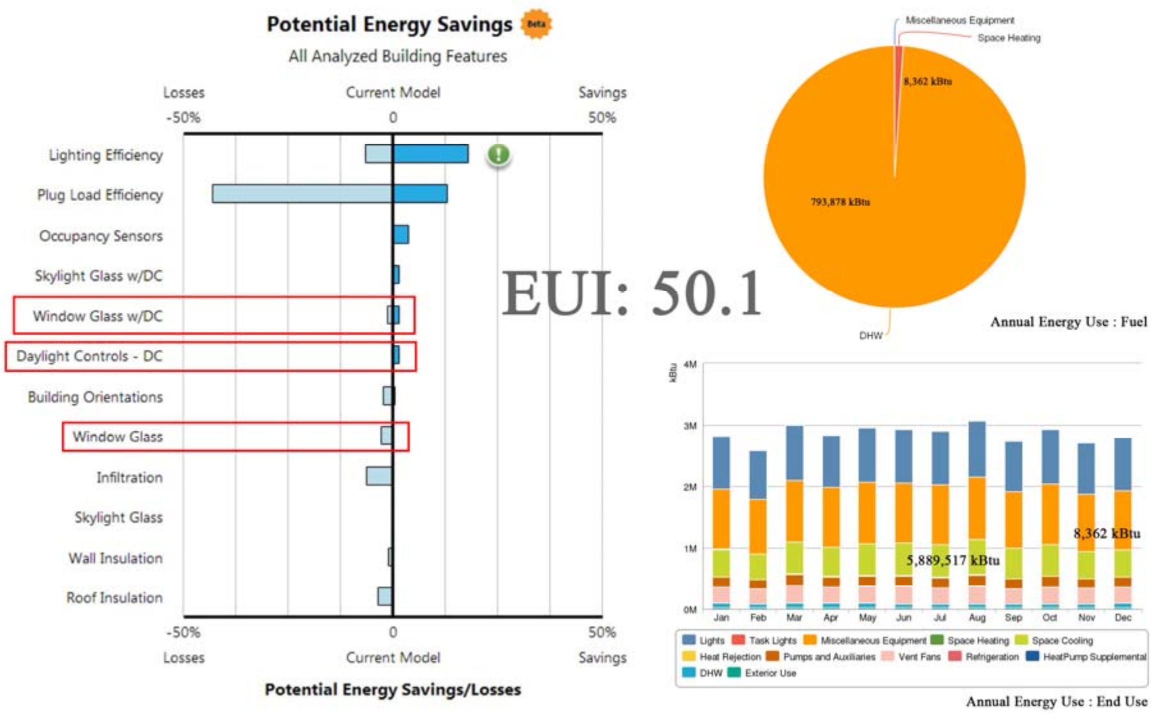


Figure 6.2.2.8: Analysis 12 Synthesized EUI Report

Analyses 5, 6, 11, and 12 all showed improved energy use intensity when the energy setting for shade device was set to “yes” and the egg-crate and slanted vertical shade devices were added. Similar to Section 6.2.1., the data in this section demonstrated that the egg-crate and slanted vertical shade devices are effective at lowering cooling loads by reducing heat gain though passive shading while slightly increasing heating loads (refer to Figures 6.2.2.1. – 6.2.2.8.).

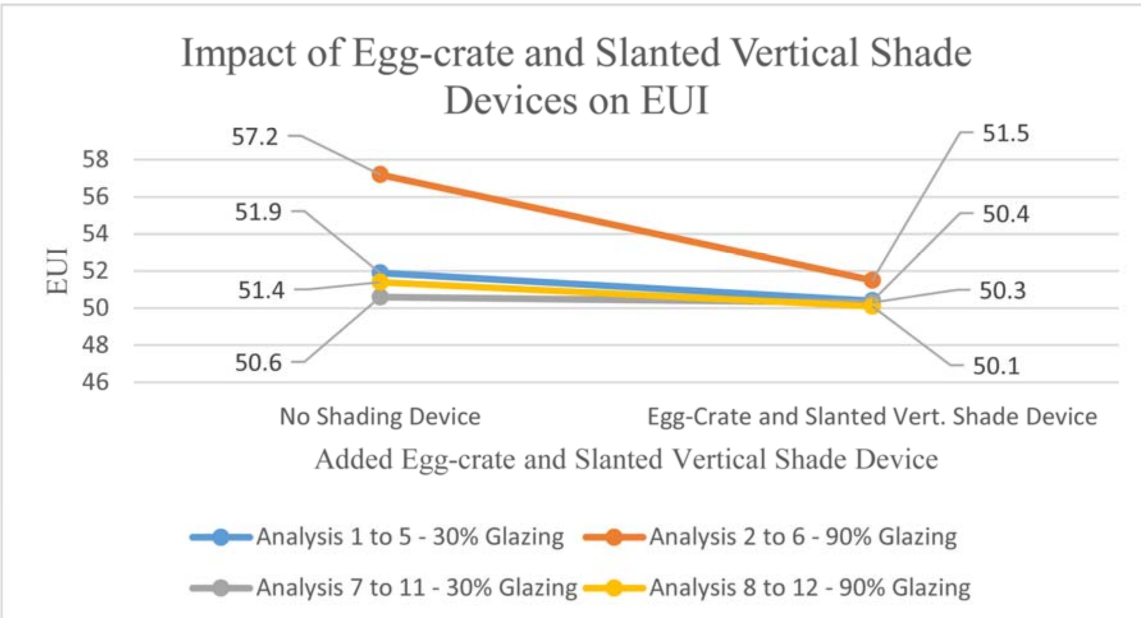


Figure 6.2.2.9: Impact of Egg-Crate and Slanted Vertical Louvers Shading Devices on EUI Graph

This research also demonstrated that an egg-crate and slanted vertical louvers shade system has a greater effect on energy use intensity as the percentage of glass is increased (Figure 6.2.2.9.).

6.2.3. Comparative Analysis of Horizontal Shade Device and Egg-Crate Shade Device

How do passive solar horizontal and slanted vertical louvers compare to a parametrically modeled passive solar egg-crate and slanted vertical louvers, in terms of energy use intensity?

The horizontal shade device was compared to the egg-crate shade device by comparing the energy use intensity of Analysis 3 with 5, Analysis 4 with 6, and Analysis 9 with 11 and Analysis 10 with 12, from Groups A and C. These Analyses were compared in terms of how they improved from their baseline analyses (1, 2, 7, and 8).

Shade Device Comparative Analysis

EUI **Btu / sf /yrk**	**Existing Building 30% Glass**	**Updated Building Curtain Wall at South and North Facade 90% Glass**
Single Pane Tinted		
Single Pane Tinted Glass	A1 -Baseline 51.9	A2 - Baseline 57.2
Horizontal Shade Device & S.P. Glass	A3 - 50.8 Improvement 2.1%	A4 - 52.9 Improvement 7.5%
Egg-Crate Shade Device & S.P. Glass	A5 - 50.4 Improvement 2.8%	A6 - 51.5 Improvement 9.9%
H.P. Clear Double Pane		
Double Pane Clear H.P. Glass	A7 - Baseline 50.6	A8 - Baseline 51.4
Horizontal Shade Device & H.P. Clear Glass	A9 - 50.4 Improvement .3%	A10 - 50.5 Improvement 1.7%
Egg-Crate Shade Device & H.P. Clear Glass	A11 - 50.3 Improvement .5%	A12 - 50.1 Improvement 2.5%

<u>Abbreviation Ledged</u>
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC
D.C. = Daylighting Controls
L.S. = Light Shelf

Table 6.2.3.1: Shade Device Comparative Analysis

In all scenarios the egg-crate device proved more effective at lowering the energy use intensity than the horizontal shade device, regardless of the percentage of glazing (30% or 90%) and the type of glazing (Single pane or H.P. Double pane). Furthermore, the shading device's effectiveness at lowering the energy use intensity increased as the percentage of glazing was increased (Table 6.2.3.1.). Table 6.2.3.2 shows that the egg-crate shade device was more effective at lowering cooling loads than the horizontal shade device. That is because the egg-crate device has both vertical and horizontal shade integrated into its design resulting in increased passive cooling capabilities. Increased passive cooling drives down energy use intensity in a hot-mediterranean environment.

Shade Device Decrease in Cooling Load Comparative Analysis

EUI **Btu / sf /yrk**	**Existing Building 30% Glass**	**Updated Building Curtain Wall at South and North Facade 90% Glass**
Single Pane Tinted		
Single Pane Tinted Glass	A1 - Baseline 6,590,854 kBtu	A2 - Baseline 8,119,123 kBtu
Horizontal Shade Device & S.P. Glass	A3 - 6,135,461 kBtu Imp 7%	A4 - 6,587,158 kBtu Imp 19%
Egg-Crate Shade Device & S.P. Glass	A5 - 5,949,630 kBtu Imp 10%	A6 - 5,816,059 kBtu Imp 28%
H.P. Clear Double Pane		
Double Pane Clear H.P. Glass	A7 - Baseline 6,183,256 kBtu	A8 - Baseline 6,491,970 kBtu
Horizontal Shade Device & H.P. Clear Glass	A9 - 6,076,853 kBtu Imp 2%	A10 - 6,130,322 kBtu Imp 6%
Egg-Crate Shade Device & H.P. Clear Glass	A11- 6,000,646 kBtu Imp 3%	A12 - 5,889,517 Imp 9%

Abbreviation Ledged
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC
D.C. = Daylighting Controls
L.S. = Light Shelf

Table 6.2.3.2: Shade Device Decrease in Cooling Load Comparative Analysis

6.3. Impact of Daylighting Controls on EUI

This section discusses research sub-question 7.

7. What is the impact of using day lighting controls on energy use intensity?

Daylight controls in this research refer to an automated control system that adjusts the amount of artificial light in a room based on the amount of natural daylight and number of occupants. In other words, when natural daylight is provided, less artificial light is required. Furthermore, when no occupants are in the room, no artificial light will be provided. As a result, less artificial light and electrical energy is used. This helps to reduce energy use intensity.

This section evaluates the effect of daylight controls on EUI. Group A, B, C, and D were all analyzed in this section. Group B was compared to its baseline values in Group A and Group D was compared to its baseline values in Group C. The research in this section demonstrated that in all scenarios in Analyses 1a – 12a, when daylight controls were set to "on," the energy use intensity was decreased.

<u>Group Key:</u>

Group B – Daylighting Controls "On"
Group A – No Daylighting Controls

Group D – Daylighting Controls "On"
Group C – No Daylighting Controls

Impact of Daylight Controls on EUI

EUI kBtu / sf /yr	Existing Building 30% Glass Group A	Updated Building Curtain Wall at South and North Facade 90% Glass	Existing Building 30% Glass & D.C. Group B	Updated Building Curtain Wall at South and North Facade 90% Glass & D.C.
Single Pane Tinted				
Single Pane Tinted Glass	Baseline 51.9	Baseline 57.2	51.5 Imp .8%	56.4 Imp 1.4%
Horizontal Shade Device & S.P. Glass	Baseline 50.8	Baseline 52.9	50.4 Imp .8%	52.2 Imp 1.3%
Egg-Crate Shade Device & S.P. Glass	Group C Baseline 50.4	Baseline 51.5	Group D 50.1 Imp .6%	50.9 Imp 2.0%
H.P. Clear Double Pane				
Double Pane Clear H.P. Glass	Baseline 50.6	Baseline 51.4	50.2 Imp .8%	50.6 Imp 1.6%

Abbreviation Ledged
S.P. = Single Pane Tinted Glass
H.P. = Double Pane Clear High Performance, LowE, High Tvis, Low SHGC
D.C. = Daylighting Controls
L.S. = Light Shelf
Imp = Improvment

Table 6.3.1: Impact of Daylight Controls on EUI

This research demonstrated that daylighting controls are effective at lowering energy use intensity in all scenarios tested in this section. Table 6.3.1 illustrates that daylighting controls are more effective when the percentage of glazing is increased and glass is properly shaded. This research also showed that daylight controls can improve energy use intensity by .8-1.6 percentage points. Refer to Appendix A for the energy use intensity reports for this section.

6.4. Illuminance Levels

This section discusses the following research sub-questions:

8. What is the impact of the percentage of glazing in a facade system on illuminance levels (lux)?

9. What is the impact of shading devices on illuminance levels (lux)?

10. What is the impact of light shelves on illuminance levels (lux)?

Section 6.4.1 discusses sub-question 8, on the impact of the percentage of glazing in a facade system on illuminance levels (lux). Section 6.4.2 addresses sub-question 9, which addresses the impact of shading devices on illuminance levels (lux). Finally, Section 6.4.3 discusses sub-question 10, concerning the impact of light shelves on illuminance levels (lux). During the course of this research, twenty eight scenarios were studied in order to address the main research question and sub questions. However, this section only addresses the eight scenarios that are applicable to the study of illuminance levels. Each color in Table 6.4.1 demonstrates the various studies in this research that are similar in nature in terms of illuminance. This is because when single pane tinted glazing (Analysis 1 – Figures 6.4.1. and 6.4.3.) was compared to high performance double pane clear glazing (Analysis 7 – Figures 6.4.2. and 6.4.4.), the difference in illuminance levels was not distinguishable in the illuminance renderings. The illuminance renderings below demonstrate the indistinguishable data in Analysis 1 and 7 (Figures 6.4.1, 6.4.2, 6.4.3, and 6.4.4.).

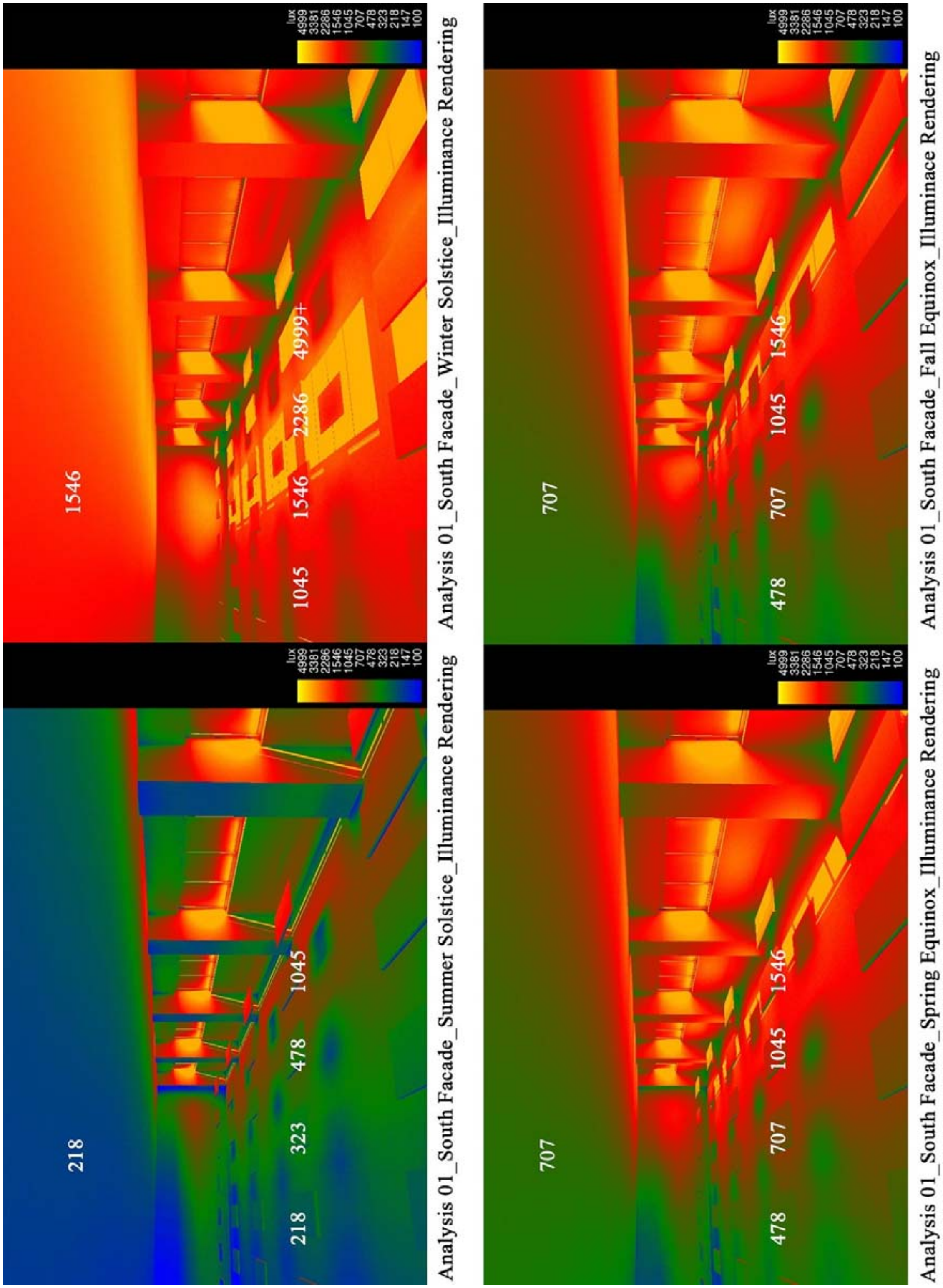


Figure 6.4.1: Analysis 1 Illuminance Renderings

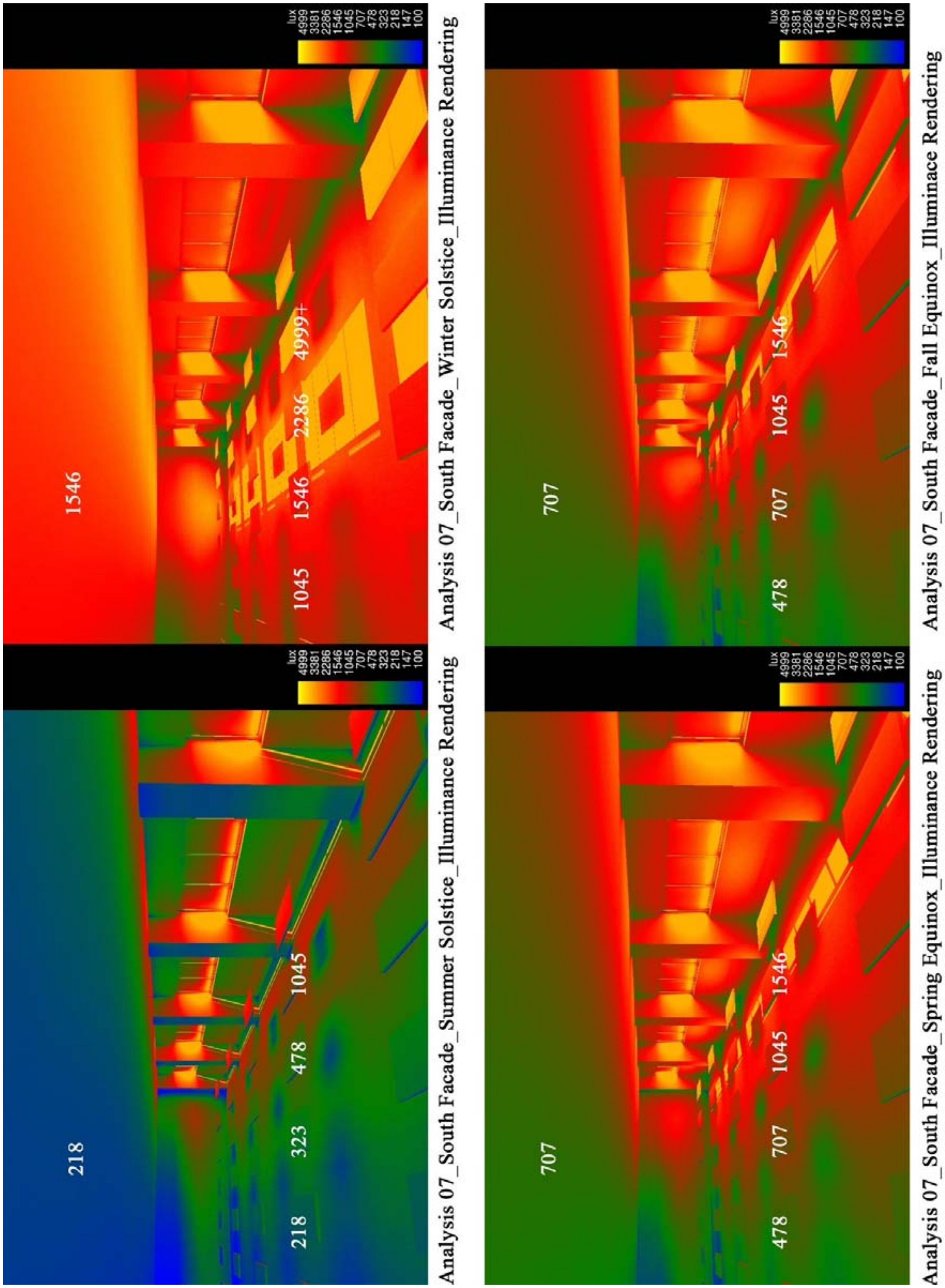


Figure 6.4.2: Analysis 7 Illuminance Renderings

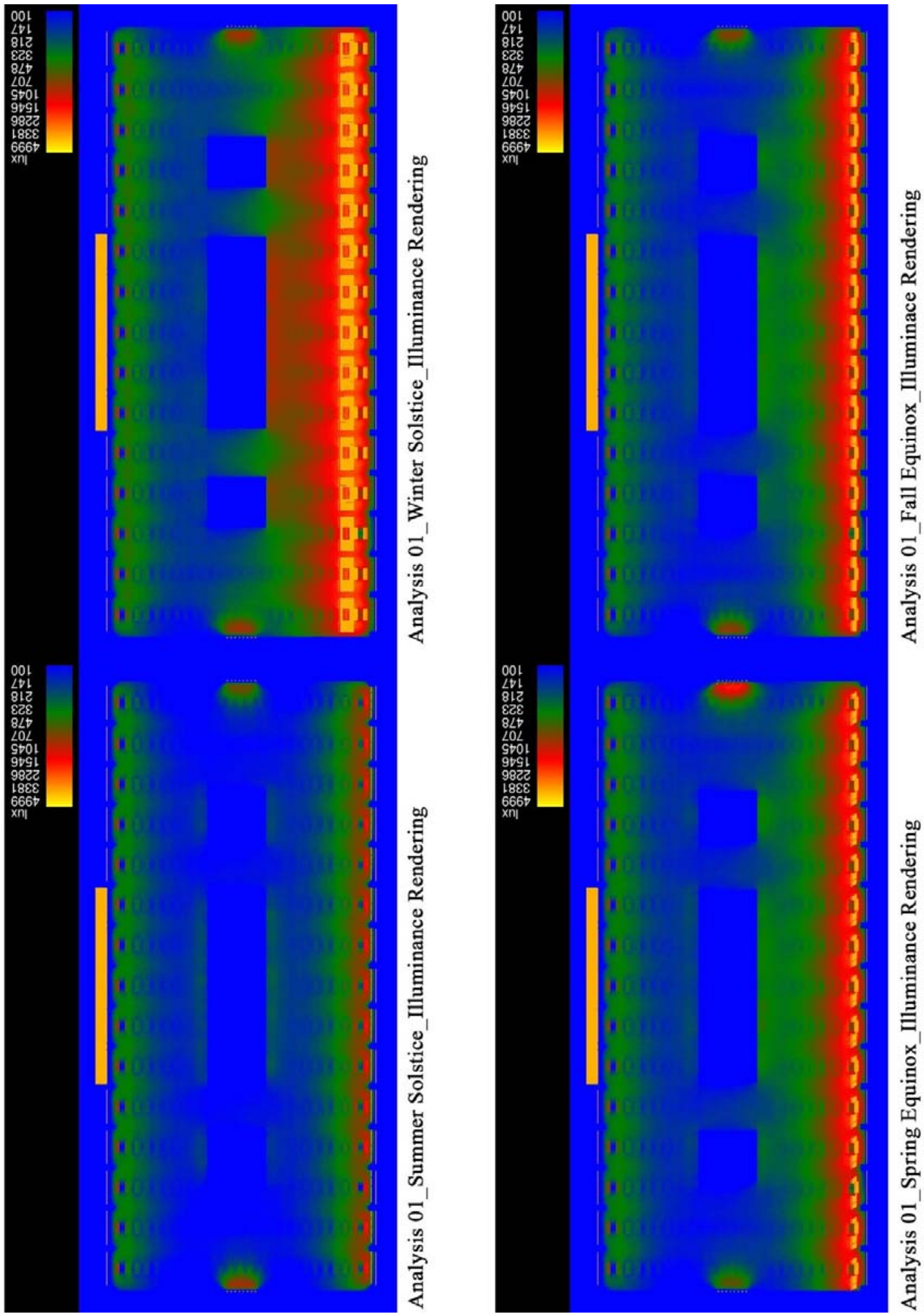


Figure 6.4.3: Analysis 1 Illuminance Plan Renderings

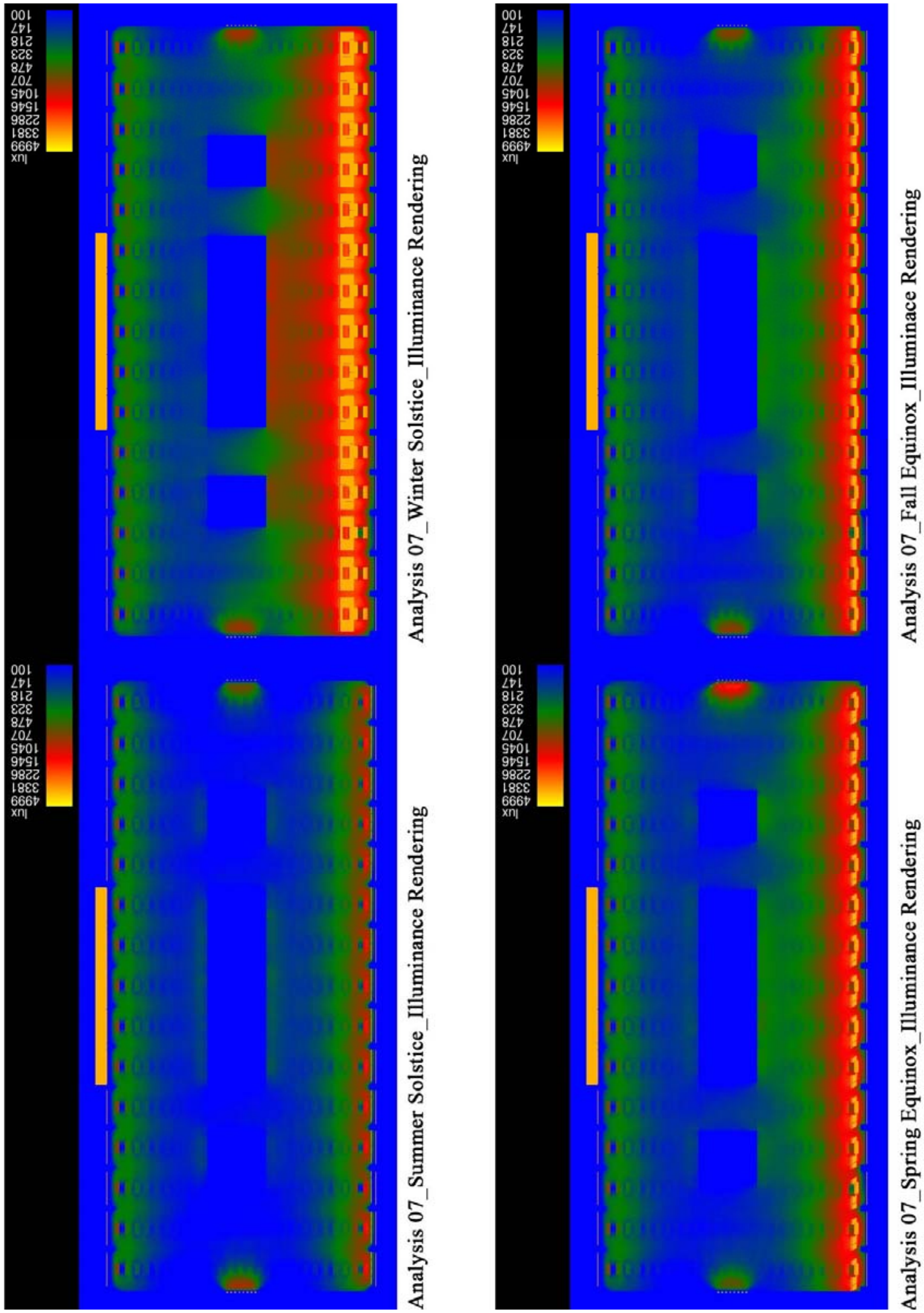


Figure 6.4.4: Analysis 7 Illuminance Plan Renderings

Illuminance Analysis Matrix

Energy Use Intensity Matrix Analysis Label	Existing Building 30% Glass Group A	Updated Building Curtain Wall at South and North Façade 90% Glass	Existing Building 30% Glass & D.C. Group B	Updated Building Curtain Wall at South and North Facade 90% Glass & D.C.
Single Pane Tinted				
Single Pane Tinted Glass	1	2	1a	2a
Horizontal Shade Device & S.P. Glass	3	4	3a	4a
Egg-crate Shade Device & S.P. Glass	5	6	5a	6a
H.P. Clear Double Pane	Group C		Group D	
Double Pane Clear H.P. Glass	7	8	7a	8a
Horizontal Shade Device & H.P. Clear Glass	9	10	9a	10a
Egg-crate Shade Device & H.P. Clear Glass	11	12	11a	12a
Light Shelf		Group E		Group F
Horizontal Shade Device, H.P. Clear Glass & L.S.	NA	13	NA	13a
Egg-crate Shade Device H.P. Clear Glass & L.S.	NA	14	NA	14a

Table 6.4.1: Illuminance Analysis Matrix

All illuminance renderings in this section are set to render a lux range from 100–5000 lux. Lux values are assigned to the various illuminance renderings using Adobe Photoshop RGB values. For ranges from 100-5000 lux; blue typically falls below 750 lux, green falls nearest to 750 lux, and yellow and orange were generally above 750 lux. Table 6.4.1 represents the analysis and group, numeric and alphanumeric labeling system for the illuminance studies in the sections that follow.

6.4.1. Impact of Percentage of Glazing on Illuminance Levels

What is the impact of the percentage of glazing in a facade system on illuminance levels (lux)?

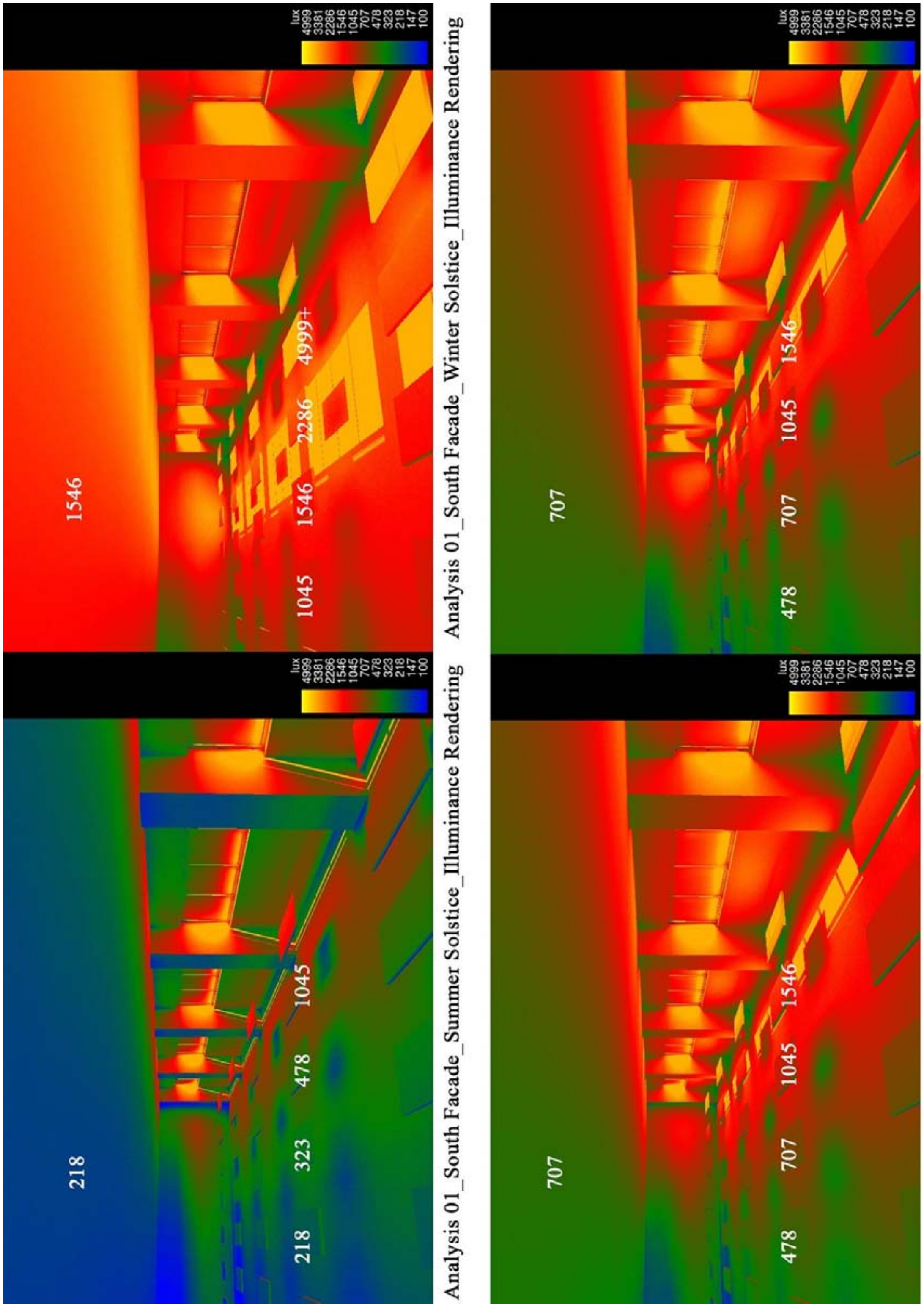
The impact of percentage of glazing on illuminance levels was studied by comparing Analysis 1 to 2 from Groups A.

<u>Analysis Key:</u>

Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).
Analysis 2 – 90% Single pane tinted glazing.

This section analyzes the impact of percentage of glazing on illuminance levels in Lux. Analysis 1 represent the baseline analysis for 30% glazing and Analysis 2 represents the baseline analysis for 90% glazing. Comparing Analysis 1 with Analysis 2 clearly establishes that increasing the glazing percentage from 30% to 90% has a negative impact on maintaining acceptable illuminance levels (Figures 6.4.1.1, 6.4.1.2, 6.4.1.3 and 6.4.1.4.). In Analysis 1, summer solstice, spring equinox and fall equinox were determined to be between 200–1500 lux where the majority of the illuminance levels fall near the 500-1000 lux range. The winter solstice for Analysis 1 reveals levels of 1045-4999+ lux. By contrast, in Analysis 2, a visual analysis clearly demonstrates illuminance levels well above the acceptable visual comfort range (1000-4999+ lux). In Analysis 1 Illuminance Plan Rendering (Figure 6.4.1.2.), about 21% of the floor area is green, near the optimal 750 lux range. Analysis 2 Illuminance Plan Rendering (Figure 6.4.1.4.) demonstrates a substantial amount of yellow to orange in the 1500-4999+ lux range. Figures 6.4.1.2 and 6.4.1.4 demonstrate that the average yearly floor area with an acceptable lux level (500 – 800 lux) was 21% in Analysis 1 and 22% in Analysis 2. Technically, Analysis 2 showed a 1 percentage point improvement over Analysis 1;

however, the overall average illuminance levels in Analysis 2 were very high and in the unacceptable illuminance range. This would result in an extremely bright and visually uncomfortable space.



Analysis 01_South Facade_Summer Solstice_Illuminance Rendering

Analysis 01_South Facade_Winter Solstice_Illuminance Rendering

Analysis 01_South Facade_Spring Equinox_Illuminance Rendering

Analysis 01_South Facade_Fall Equinox_Illuminace Rendering

Figure 6.4.1.1: Analysis 1 Illuminance Renderings

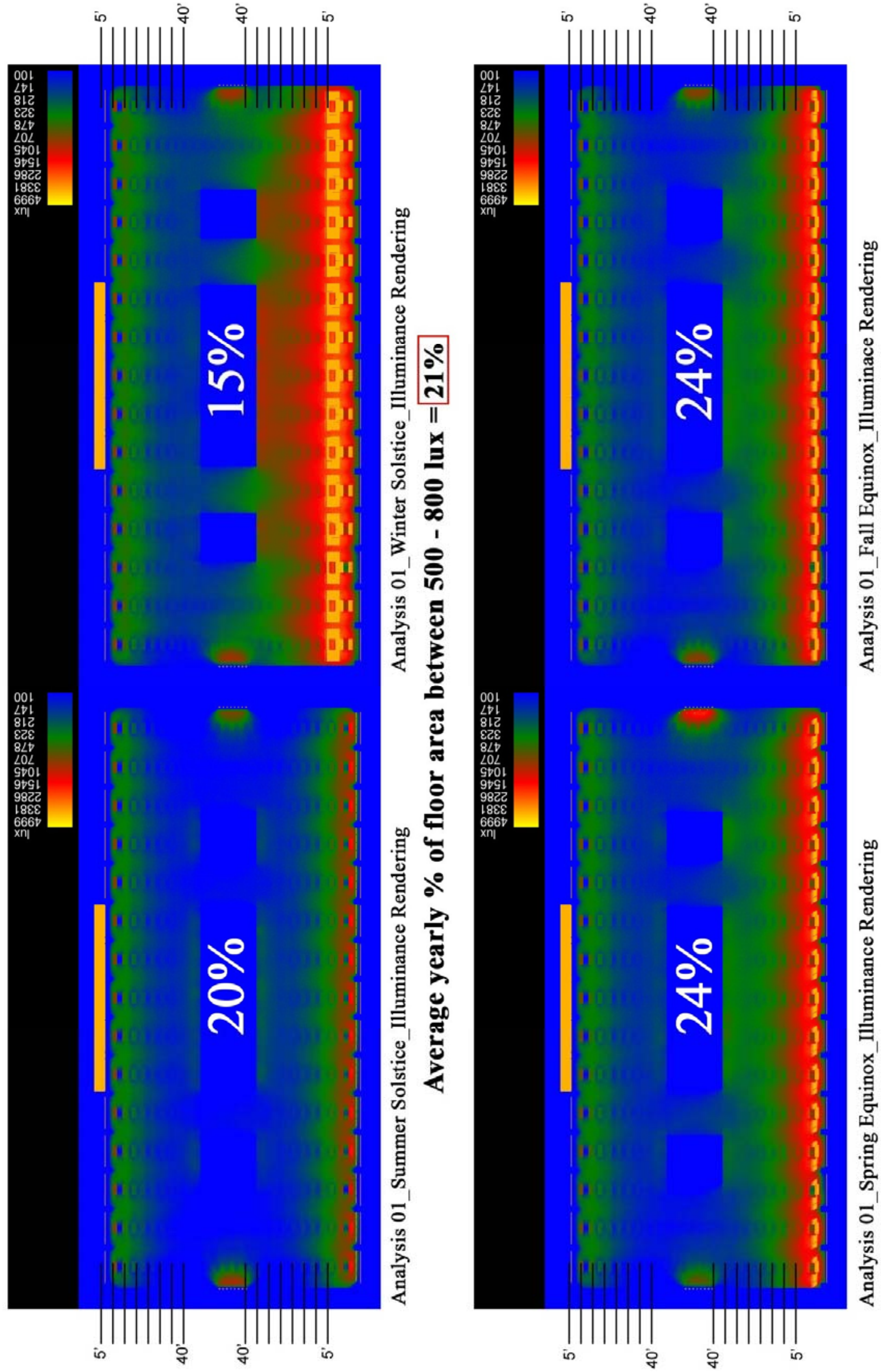


Figure 6.4.1.2: Analysis 1 Illuminance Plan Renderings

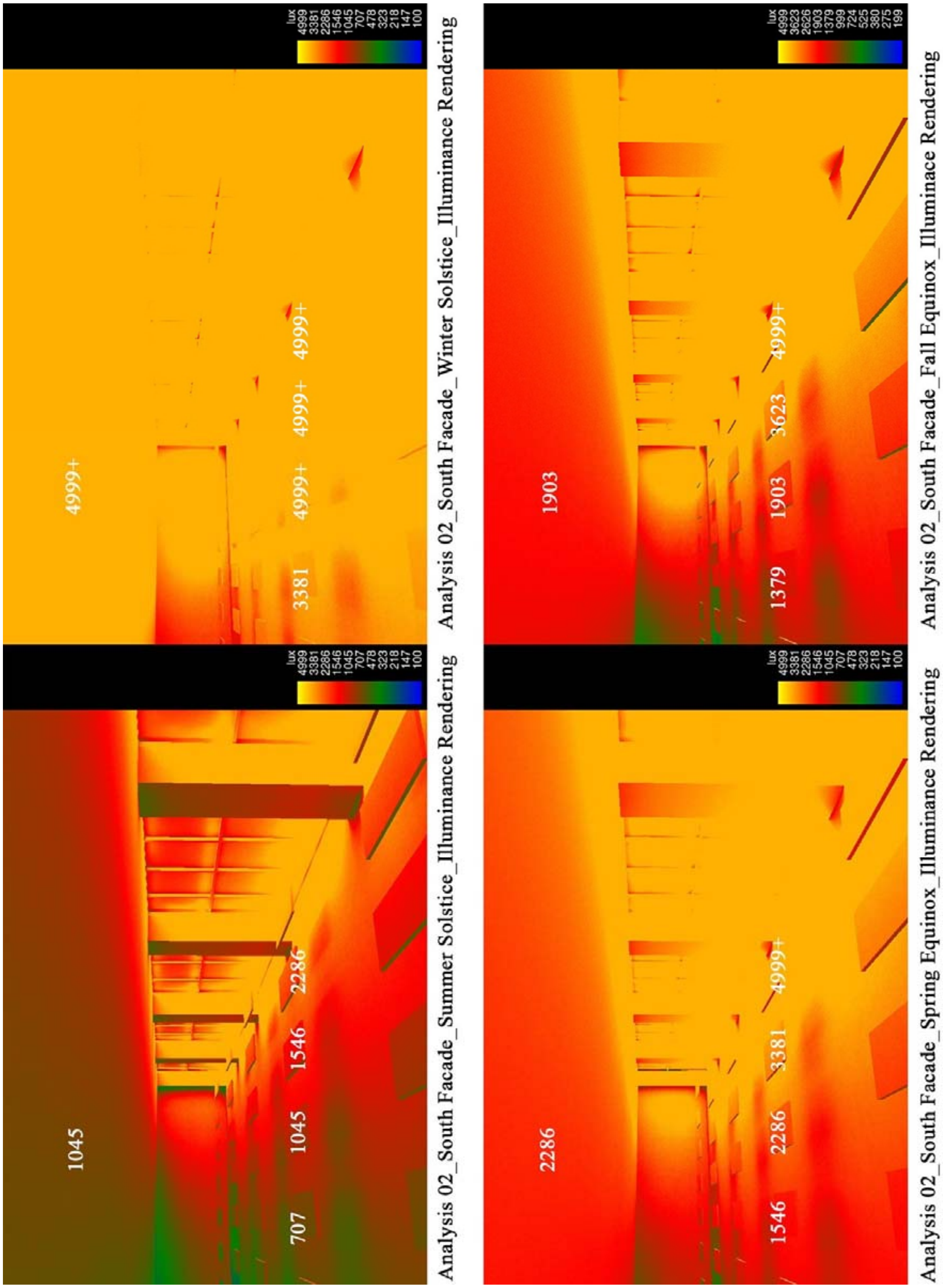


Figure 6.4.1.3: Analysis 2 Illuminance Renderings

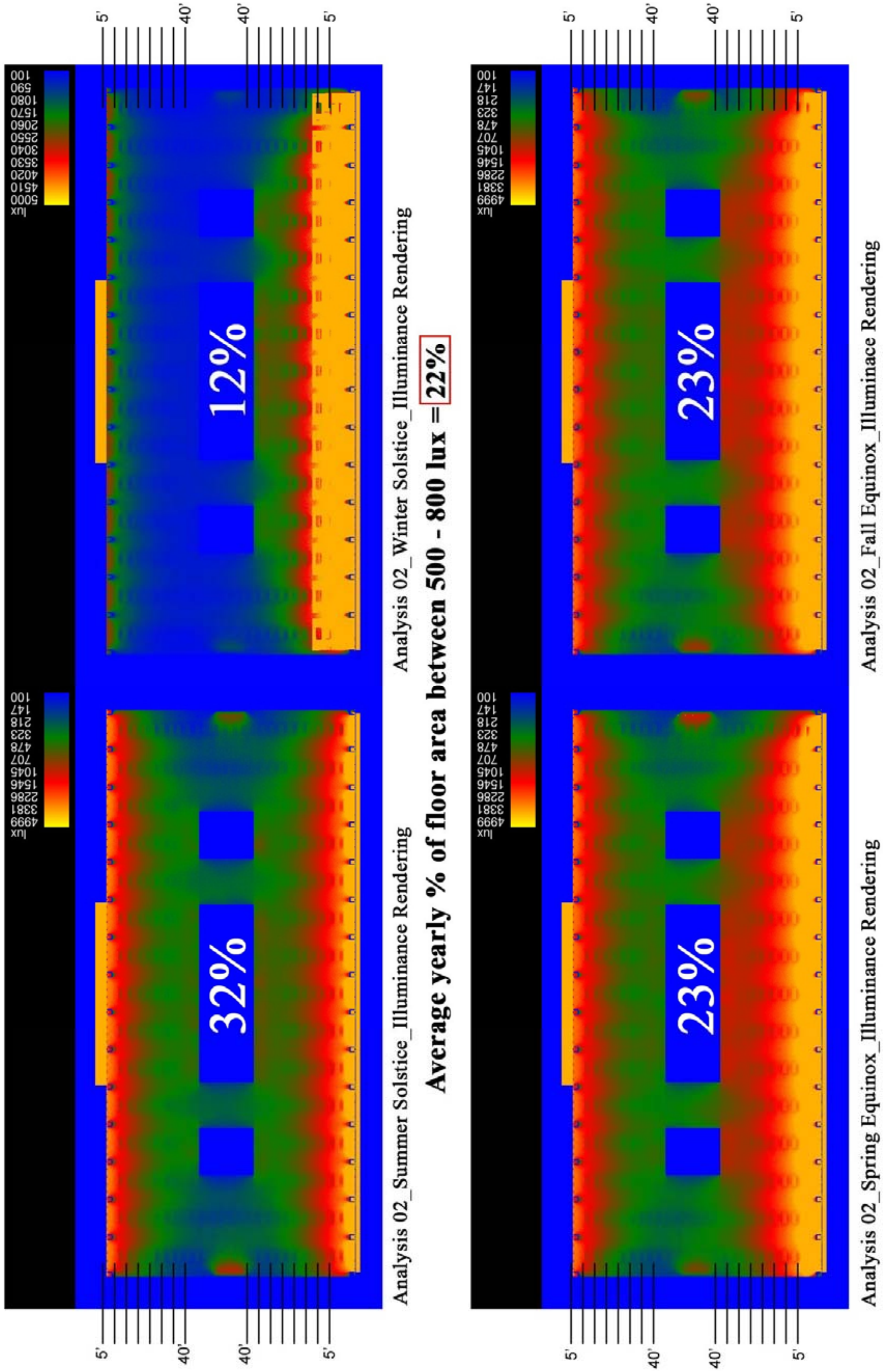


Figure 6.4.1.4: Analysis 2 Illuminance Plan Renderings

6.4.2. Impact of Shade Device of Glazing on Illuminance Levels

What is the impact of shading devices on illuminance levels (lux)?

The impact of shading devices on illuminance levels was studied by comparing Analysis 3 to 1, Analysis 4 to 2, Analysis 5 to 1 and Analysis 6 to 2.

<u>Analysis Key:</u>

Analysis 3 – 30% Single pane tinted glazing with horizontal and slanted vertical shading devices.
Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).

Analysis 4 – 90% Single pane tinted glazing with horizontal and slanted vertical shading devices.
Analysis 2 – 90% Single pane tinted glazing.

Analysis 5 – 30% Single pane tinted glazing with egg crate style and slanted vertical shading devices.
Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).

Analysis 6 – 90% Single pane tinted glazing with egg crate style and slanted vertical shading devices.
Analysis 2 – 90% Single pane tinted glazing.

This section looks at the impact of shade devices on illuminance levels. Analysis 3 (Figures 6.4.2.1 and 6.4.2.2.) represents a 30% glazing design with a horizontal shade device. When compared to the baseline analysis for 30% glazing (Analysis 1), Analysis 3 demonstrates that the passive solar shade device blocks out the sun during the summer solstice, spring equinox and fall equinox, bringing the illuminance levels to 150-500 lux, which is well below the acceptable level of 750 lux. During the winter solstice, the effects of the passive solar shade device drops the typically overly bright space (Analysis 2) down to 500-1500 lux. This research clearly demonstrates that the horizontal shade device is effective at lowering acceptable illuminance levels. When compared to its baseline in Analysis 1, Analysis 3 demonstrated an 11percentage point decrease in average yearly floor area with an acceptable lux level (500 – 800 lux).

Analysis 4 (Figures 6.4.2.3 and 6.4.2.4.) represents 90% glazing with a horizontal shade device. When compared to the baseline analysis for 90% glazing (Analysis 2), the effects of the passive solar shade device in Analysis 4 are positive. Analysis 2 demonstrated illuminance levels far above the acceptable visual comfort range. By contrast, in Analysis 4 illuminance levels have been greatly decreased. When compared to its baseline in Analysis 2, Analysis 3 demonstrated a 4 percentage point increase in average yearly floor area with an acceptable lux level (500 – 800 lux). Unfortunately, the illuminance levels produced in Analysis 4 (800-4999 + lux) are still well above the accepted (800-4999+ lux), well above 750 lux for the majority of the year.

Analysis 5 (Figures 6.4.2.5 and 6.4.2.6.) represents 30% glazing with the egg-crate shading device. When compared to Analysis 1 (baseline analysis for 30% glazing) the egg-crate shading device has little to no impact on illuminance levels during the summer and winter solstice. However, during the spring and fall equinox, the illuminance levels are evened out and reveal a more gradual distribution of illuminance. When compared to its baseline in Analysis 1, Analysis 5 demonstrated a 3 percentage point decrease in average yearly floor area with an acceptable lux level (500 – 800 lux).

Analysis 6 (Figures 6.4.2.7 and 6.4.2.8.) represents 90% glazing with shading device. When compared to the baseline analysis for 90% glazing (Analysis 2), the effects of the egg-crate shading device are positive. Analysis 2 illuminance levels are far above the acceptable visual comfort range. By contrast, in Analysis 6 illuminance levels have been greatly decreased. When compared to its baseline in Analysis 2, Analysis 6 demonstrated a 17 percentage point increase in average yearly floor area with an acceptable lux level (500 – 800 lux). Unfortunately, the illuminance levels produced nearest to the window (first 5 feet) in Analysis 6 are still well above the accepted level of 750 lux for the majority of the year.

In conclusion, this section demonstrated that shading devices do effect illuminance. In the 30% baseline analysis, the summer solstice, spring equinox and fall equinox all demonstrated illuminance levels that fell near the acceptable visual comfort range. However, when shade devices were applied, the illuminance levels dropped to well below 750 lux during the summer solstice, spring equinox and fall equinox. During the winter solstice the 30% baseline analysis demonstrated illuminance levels above the acceptable visual comfort range. Shade devices were effective at lowering illuminance levels to a more acceptable range. However, they were not lowered sufficiently enough to produce accepted illuminance levels near 750 lux.

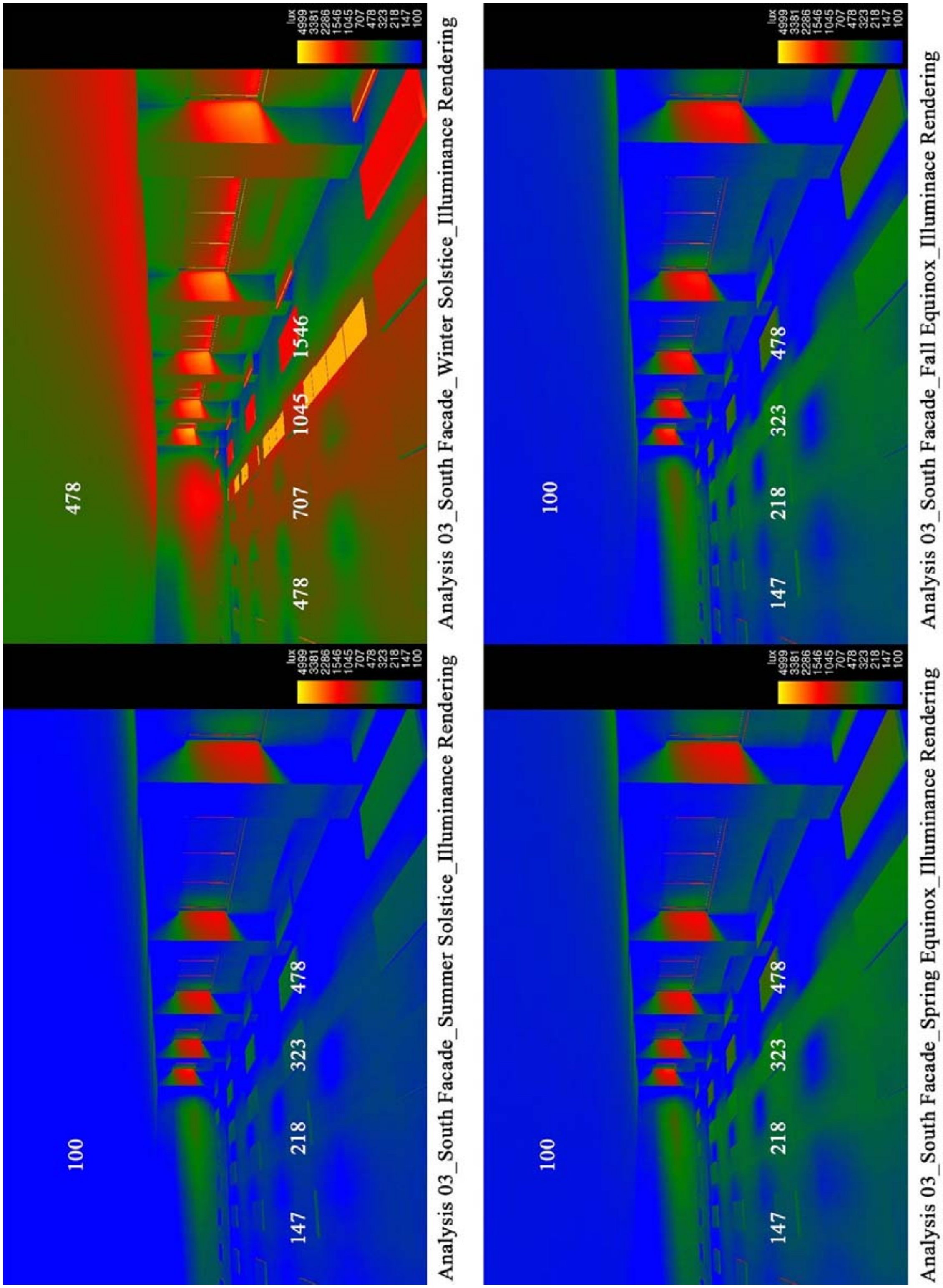


Figure 6.4.2.1: Analysis 3 Illuminance Renderings

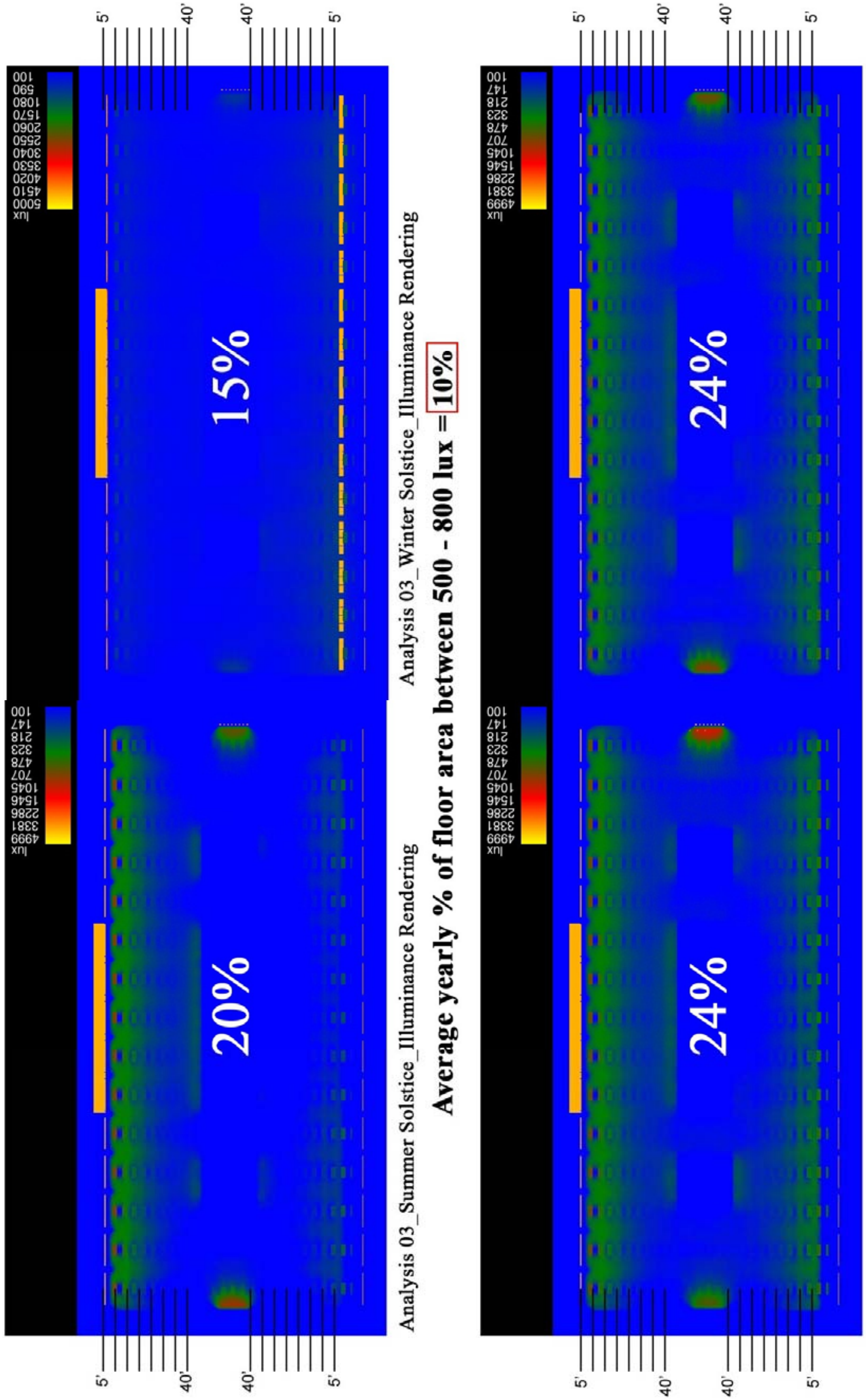


Figure 6.4.2.2: Analysis 3 Illuminance Plan Renderings

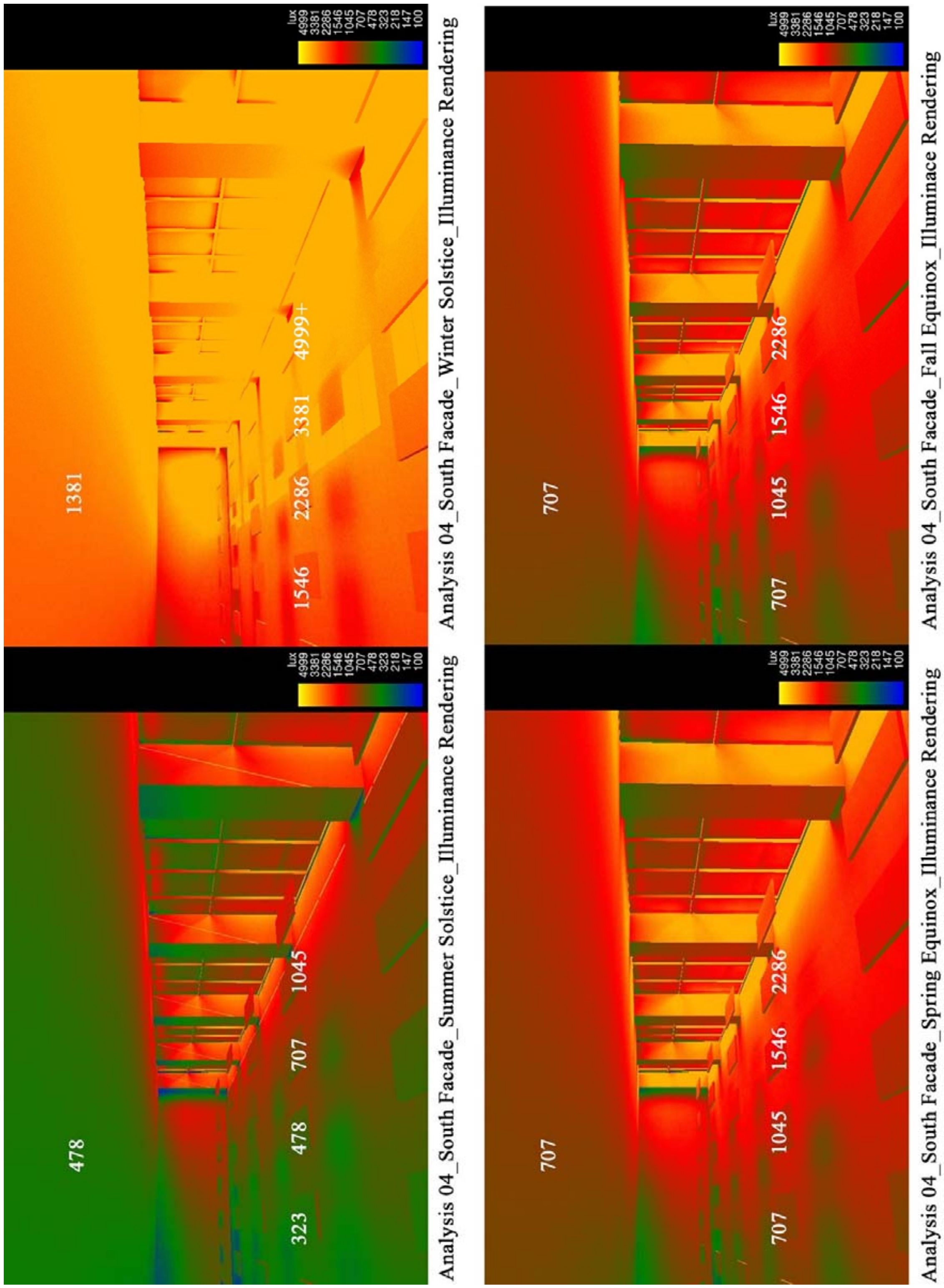


Figure 6.4.2.3: Analysis 4 Illuminance Renderings

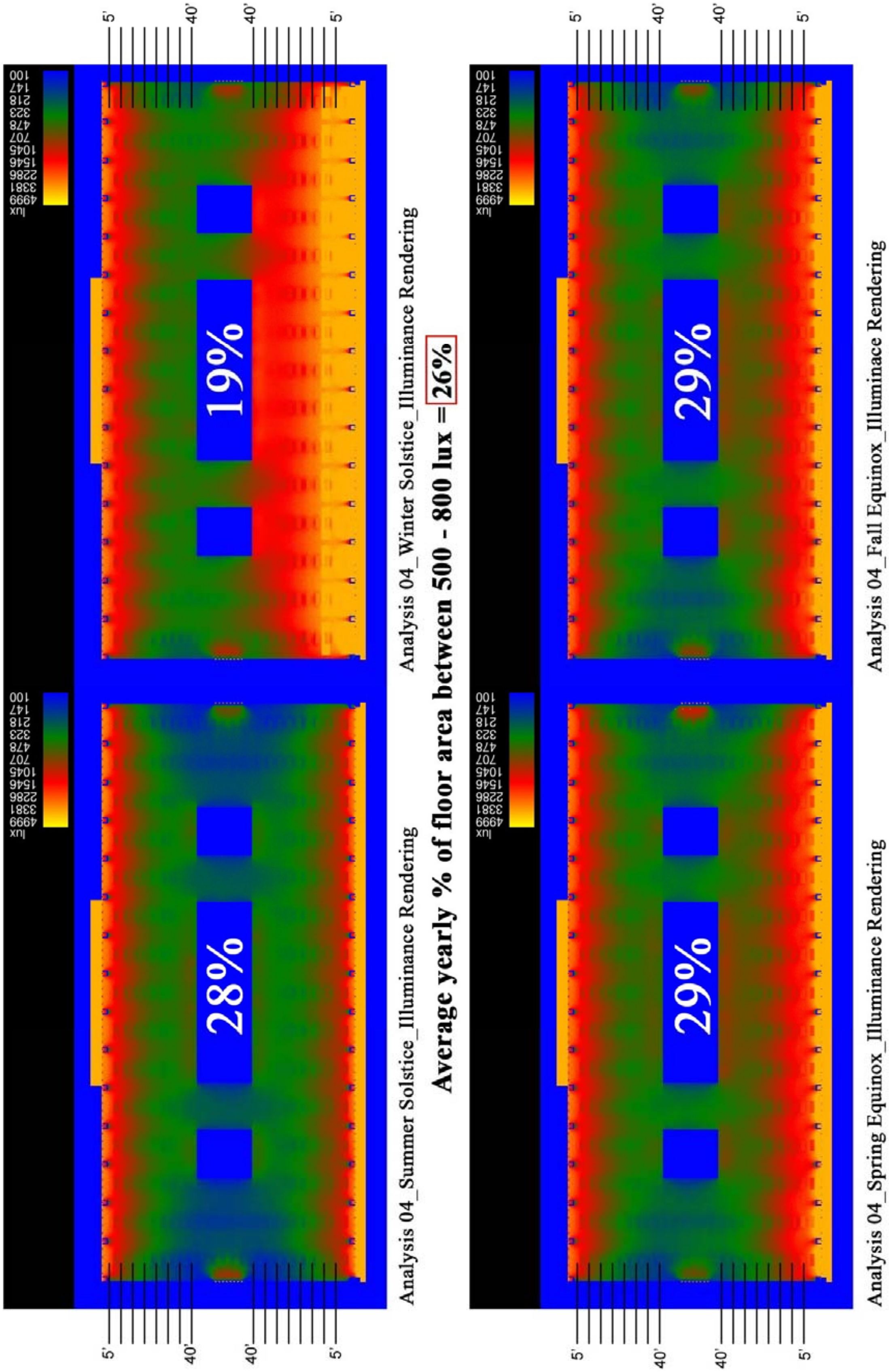


Figure 6.4.2.4: Analysis 4 Illuminance Plan Renderings

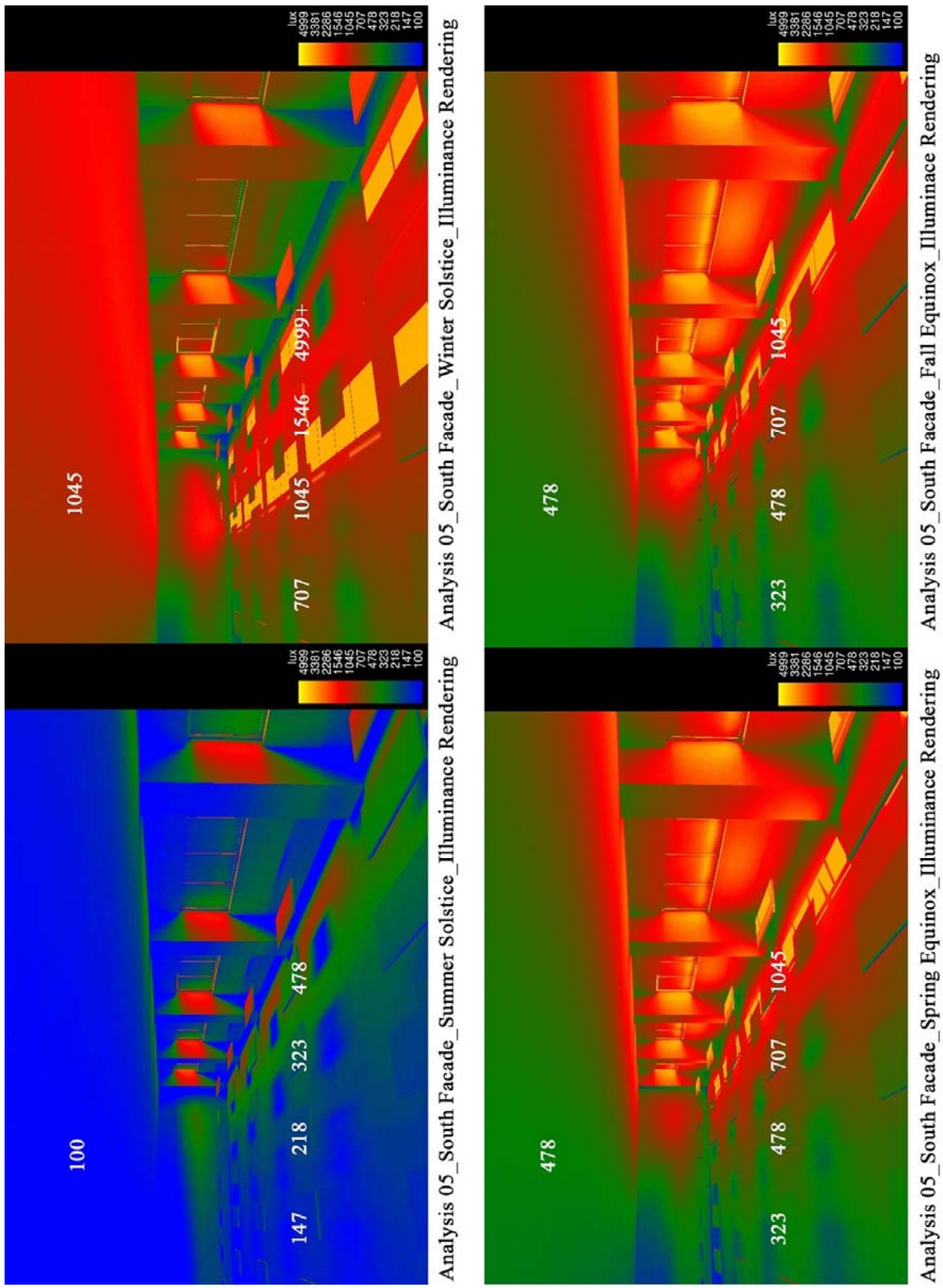


Figure 6.4.2.5: Analysis 5 Illuminance Renderings

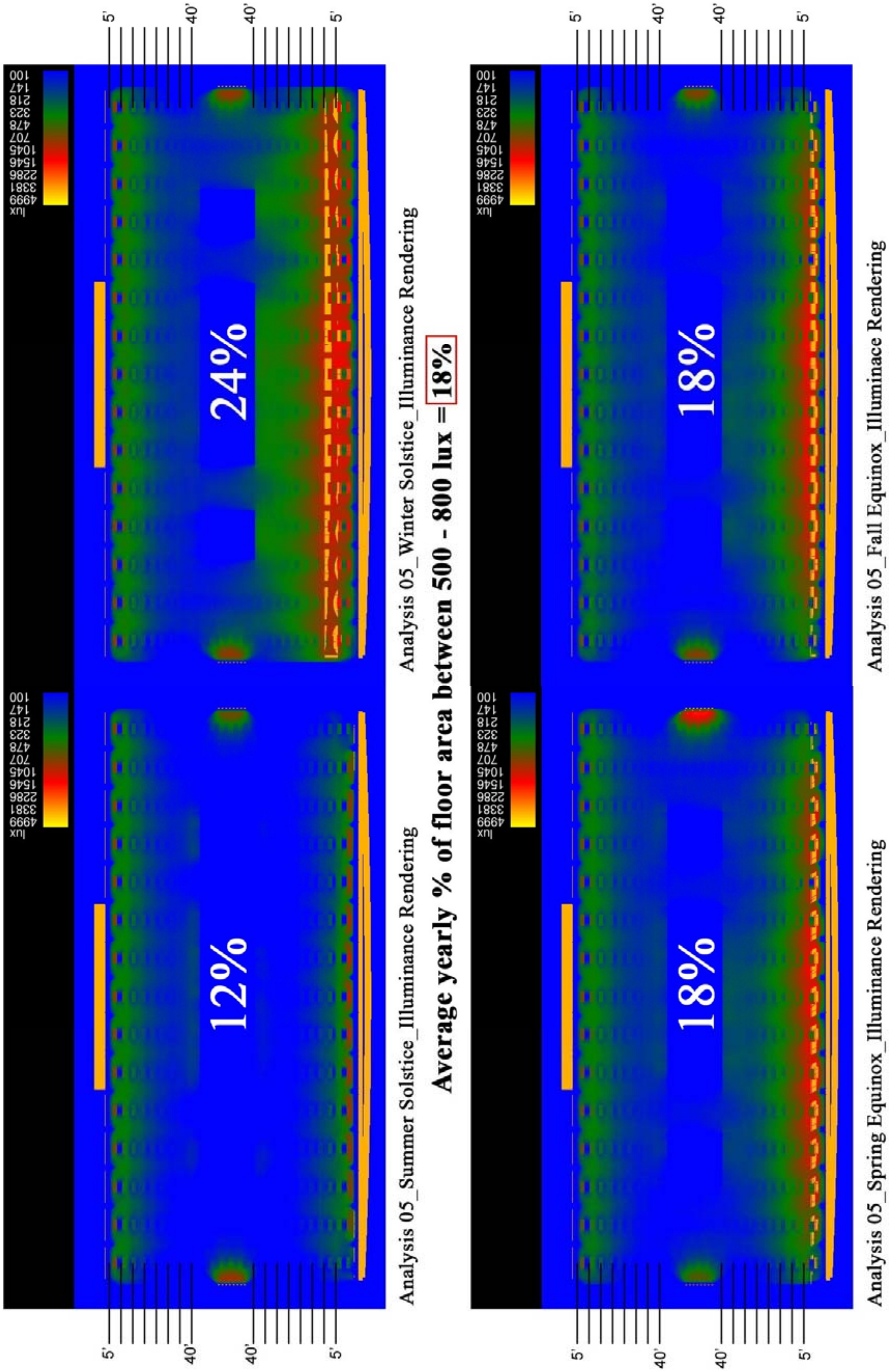


Figure 6.4.2.6: Analysis 5 Illuminance Plan Renderings

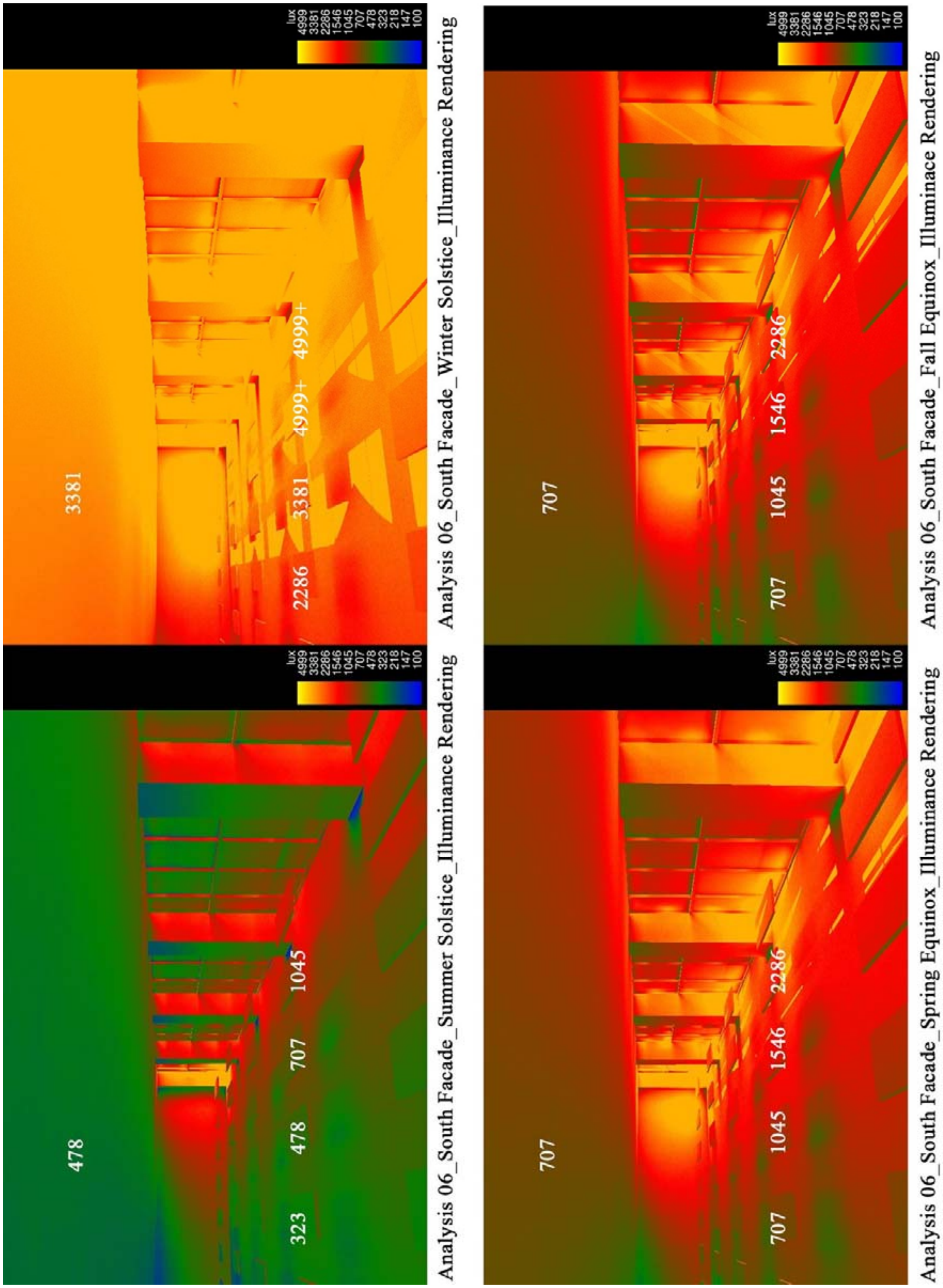


Figure 6.4.2.7: Analysis 6 Illuminance Renderings

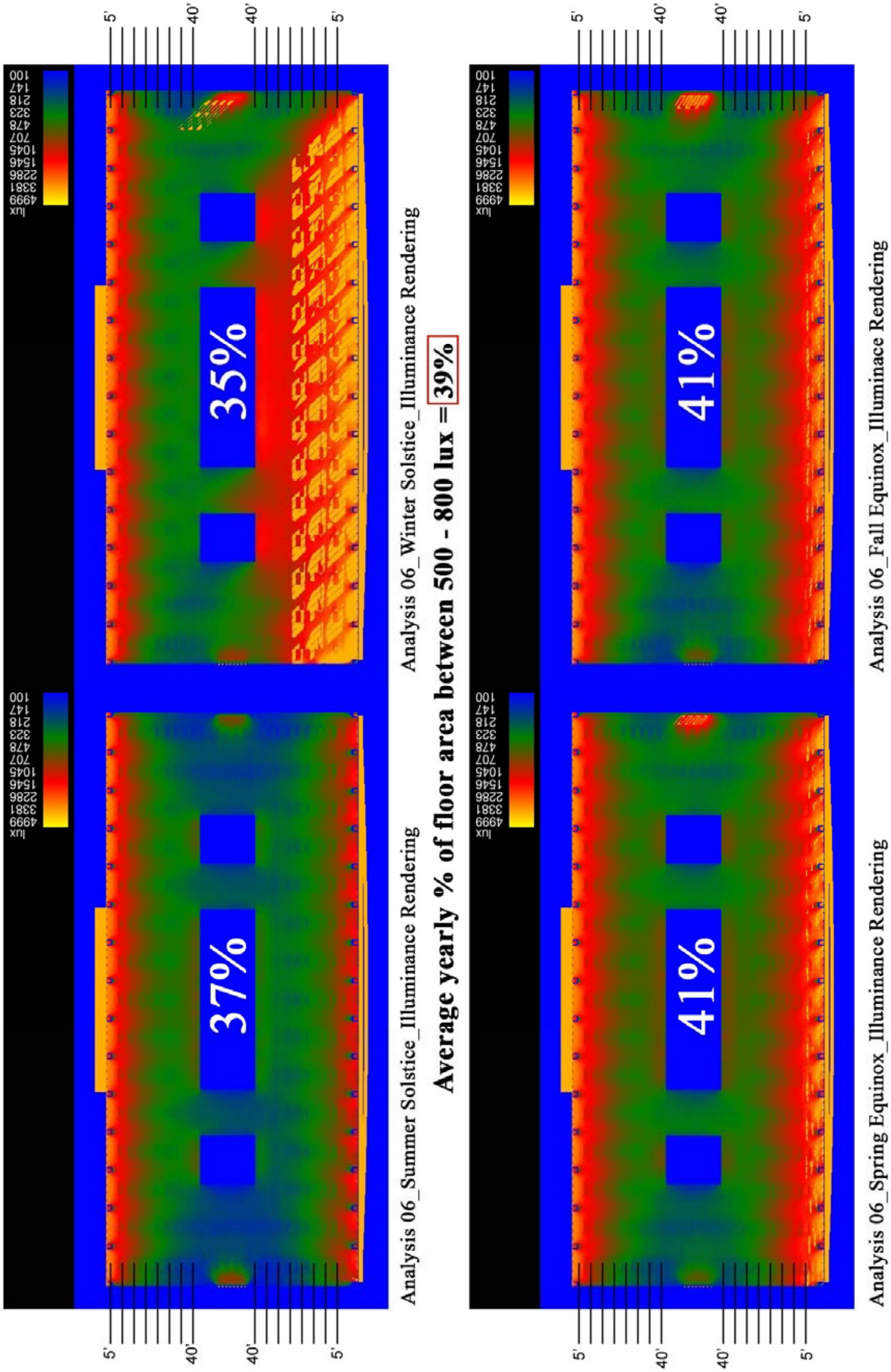


Figure 6.4.2.8: Analysis 6 Illuminance Plan Renderings

6.4.3. Impact of Light Shelf on Illuminance Levels

What is the impact of light shelves on illuminance levels (lux)?

The impact of light shelves on illuminance levels was studied by comparing Analysis 13 to 2 and Analysis 14 to 2 from Groups E and F.

Analysis Key:

Analysis 13 - 90% H.P. double pane glazing with horizontal and slanted vertical shading devices and light selves.
Analysis 2 – 90% Single pane tinted glazing

Analysis 14 - 90% H.P. double pane glazing with egg crate style and slanted vertical shading devices and light selves.
Analysis 2 – 90% Single pane tinted glazing

This section analyzed the impact of light shelves on illuminance levels. Analysis 13 (Figures 6.4.3.1. and 6.4.3.2.) represents 90% glazing with a horizontal shade device and light shelves. When compared to the baseline analysis for 90% glazing (Analysis 2), Analysis 13 demonstrates improved illuminance levels. Illuminance levels during the summer solstice, spring equinox and fall equinox in Analysis 2 ranged from 707 to 4999+ lux. However, Analysis 13 during the same time periods revealed 323 – 1045 lux, demonstrating a more accepted visual comfort range constantly nearer to optimal 750 lux. The baseline analysis for 90% glazing (Analysis 2), winter solstice demonstrated illuminance levels that ranged from 1045-4999+ lux .However, Analysis 13 reveals a much lower illuminance range of 1045-3381 lux. The Illuminance Plan Rendering (Figure 6.4.3.2.) for Analysis 13 shows nearly 40% of the total floor in green for the majority of the year. When compared to its baseline in Analysis 2, Analysis 13 demonstrated a 17percentage point increase in average yearly floor area with an acceptable lux level (500 – 800 lux).

Analysis 14 (Figures 6.4.3.3 and 6.4.3.4) represents 90% glazing with an egg-crate shade device and light selves. When compared to the baseline analysis for 90% glazing (Analysis 2), Analysis 14 demonstrates impressively consistent illuminance levels throughout the year. Where Analysis 2 was constantly above 4999 + in illuminance levels, Analysis 14 demonstrates illuminance levels of 218-1045 lux. The baseline analysis for 90% glazing (Analysis 2), winter solstice demonstrated illuminance levels that ranged from 1045-4999+ lux. However, Analysis 14 reveals a much lower illuminance range of 707-1546 lux, a nearly acceptable visual comfort range during the most difficult part of the year. The Illuminance Plan Rendering (Figure 6.4.3.4.) for Analysis 14 shows nearly 50% of the total floor in green for the majority of the year. When compared to its baseline in Analysis 2, Analysis 14 demonstrated a 31% increase in average yearly floor area with an acceptable lux level (500 – 800 lux). The illuminance studies for Analysis 14 demonstrate the most evenly distributed acceptable illuminance levels throughout the year.

The egg-crate shade device (Analysis 14) with a light shelf is most effective at achieving acceptable illuminance level over the majority of the floor area throughout the entire year.

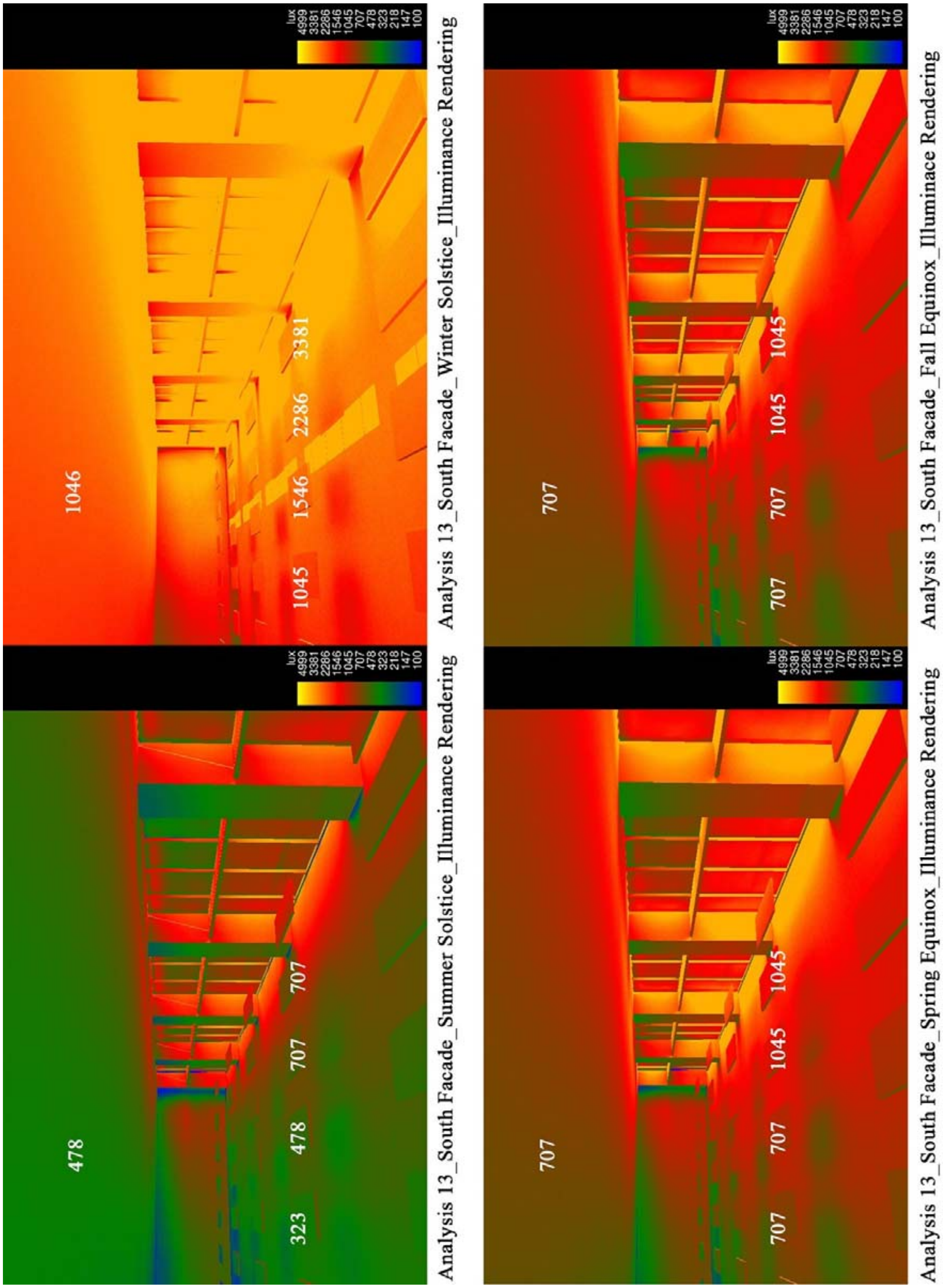


Figure 6.4.3.1: Analysis 13 Illuminance Renderings

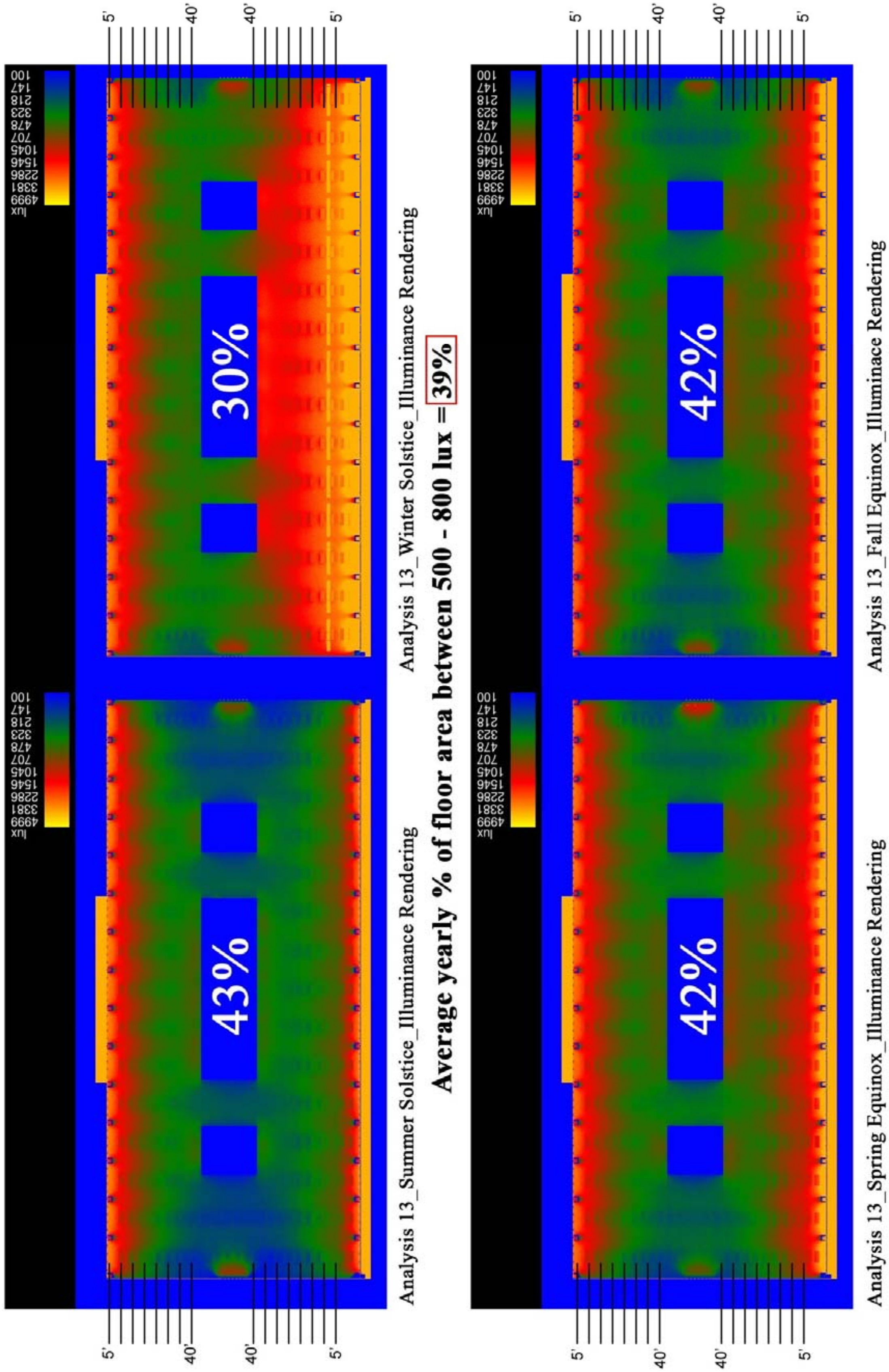


Figure 6.4.3.2: Analysis 13 Illuminance Plan Renderings

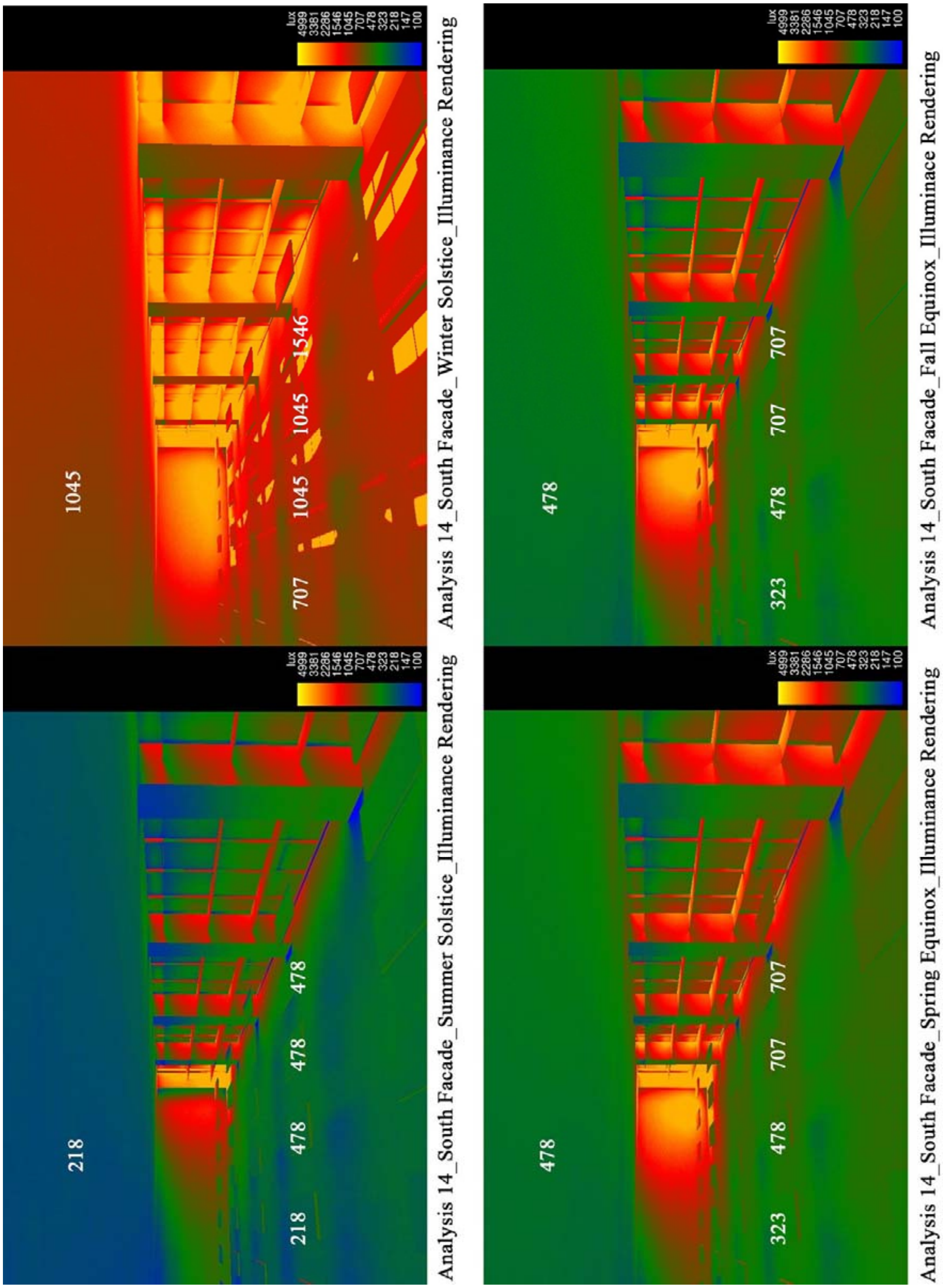


Figure 6.4.3.3: Analysis 14 Illuminance Renderings

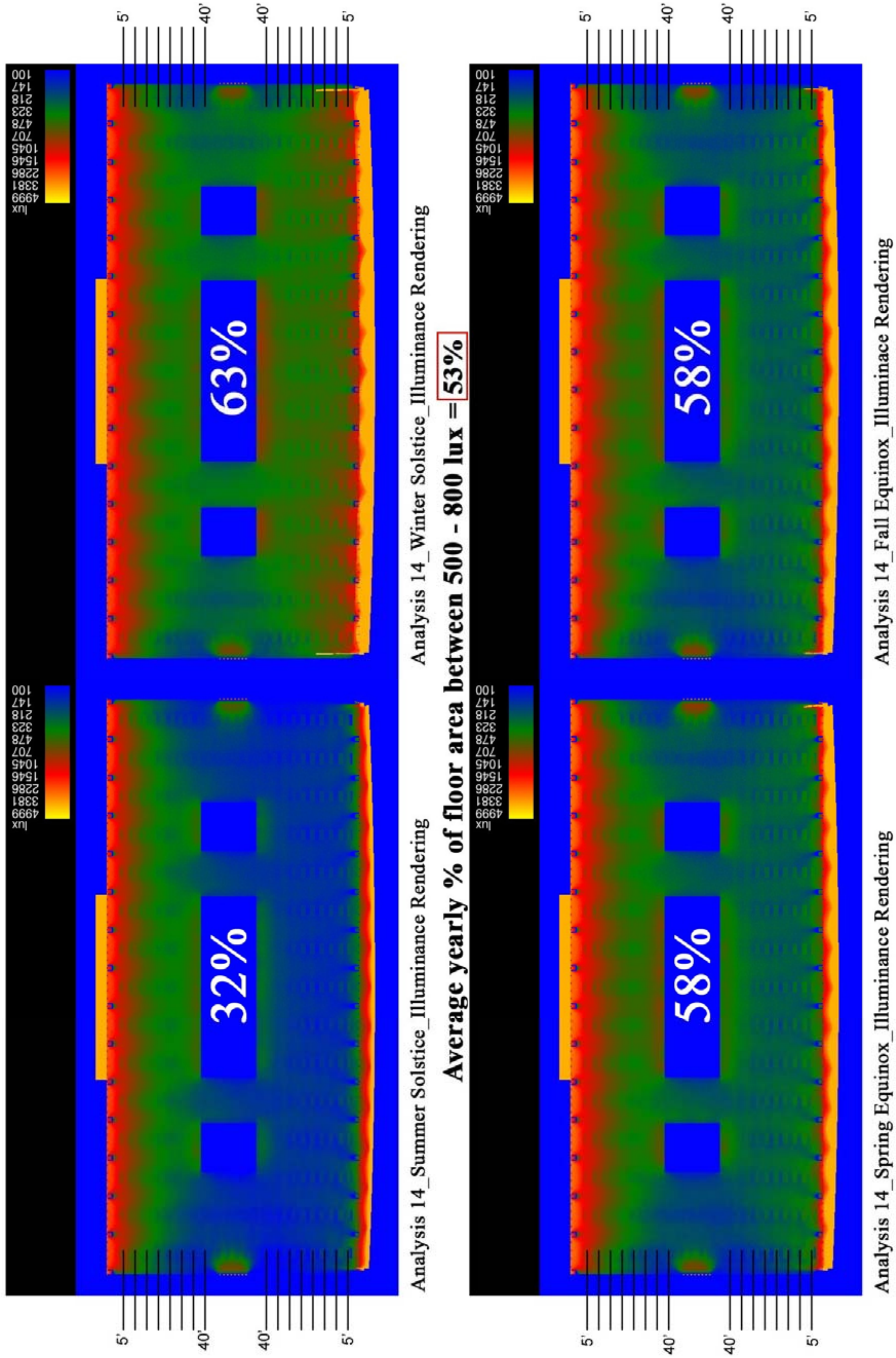


Figure 6.4.3.4: Analysis 14 Illuminance Plan Renderings

6.5. Views

This section discusses research sub-question 11.

11. How is an occupant's view impacted by a facade system's percentage of glazing, shading devices, and light shelves?

Section 6.5.1 discusses the impact of percentage of glazing on view. Section 6.5.2 presents the impact of shading devices on view and Section 6.5.3 discusses the impact of light shelves on view.

This section looks at the impact of percentage of glazing, shade device and light shelves on views. Daylight Renderings were taken in Autodesk Revit 2015 in the same orientation as the Illuminance Renderings to determine the effect of the facade on the view to the exterior of the building. Although these analyses are not represented by a metric, a visual analysis of these images clearly reveals the impact of the facade on view.

6.5.1. Impact of Percentage of Glazing on View

How is an occupant's view impacted by a facade system's percentage of glazing?

The impact of percentage of glazing on the occupant's views were studied by comparing Analysis 1 to Analysis 2, from Groups A and C.

Analysis Key:

Analysis 1 – 30% Single pane tinted glazing with no modifications (baseline analysis).
Analysis 2 – 90% Single pane tinted glazing.

Percentage of glazing is the most distinguishable impact on view for obvious reasons. The 30% (6.5.1.1) glazing offers far less view than the 90% (6.5.1.2) glazing example.

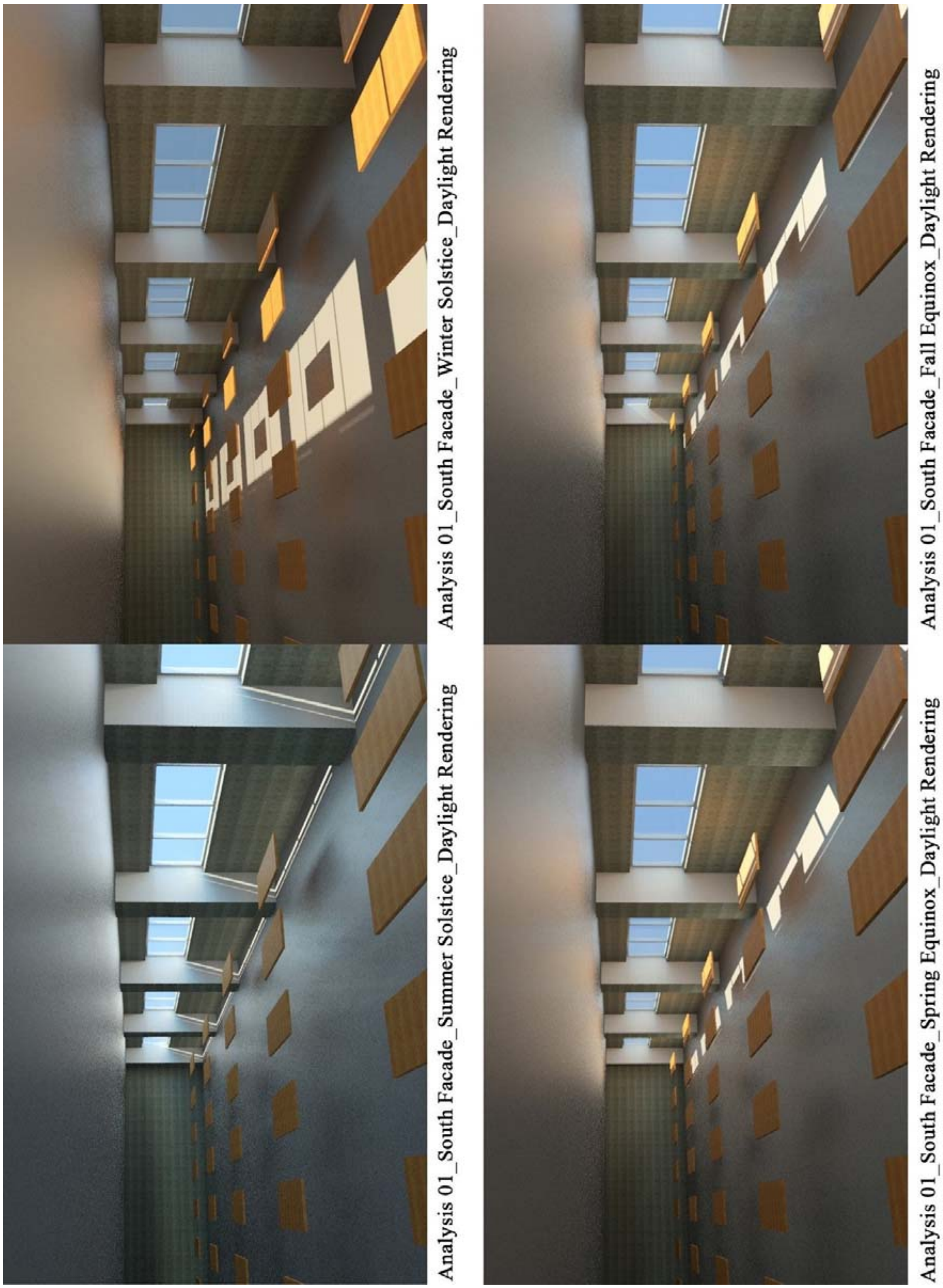
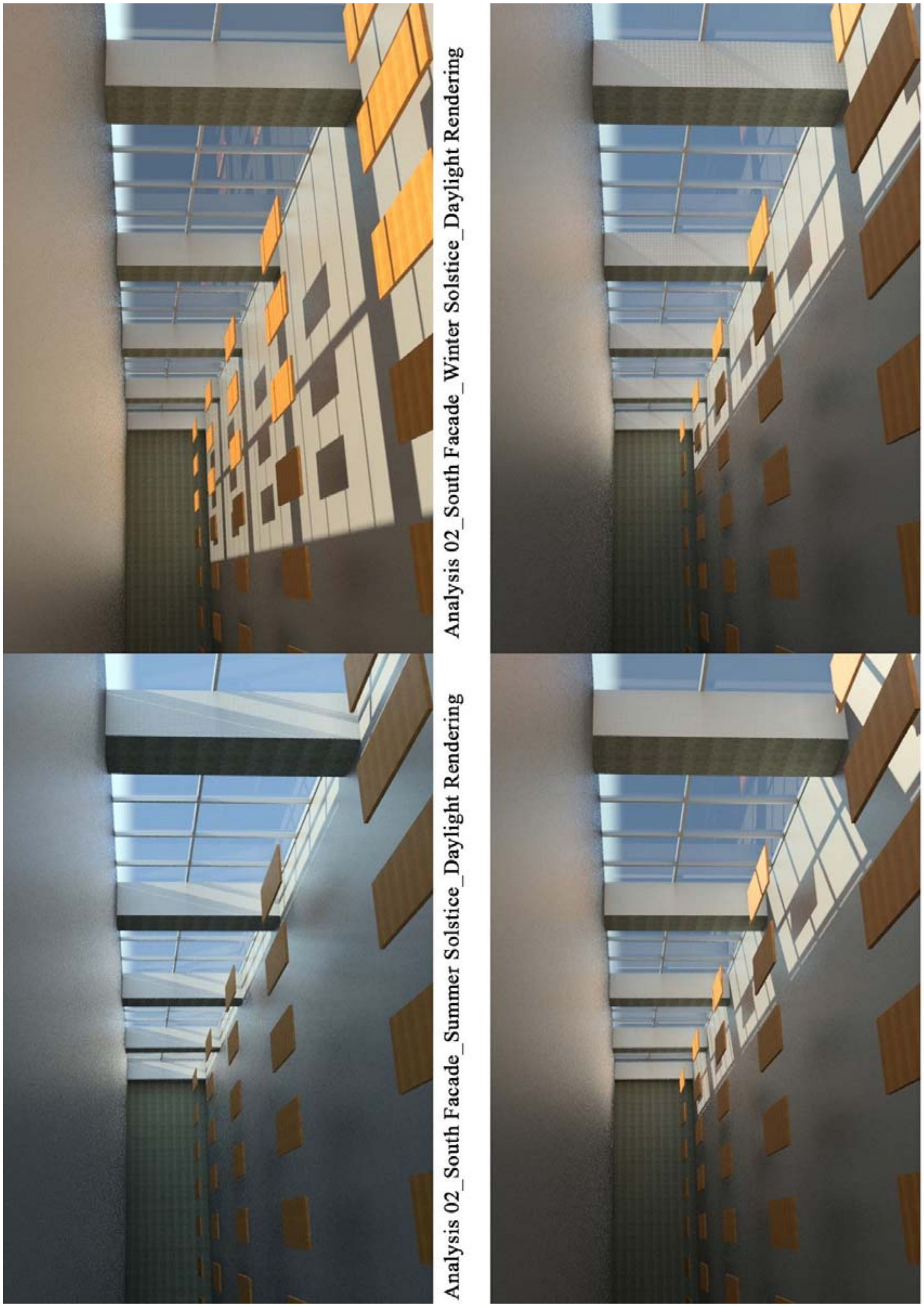


Figure 6.5.1.1: Analysis 1 Daylight Renderings



Analysis 02_South Facade_Winter Solstice_Daylight Rendering

Analysis 02_South Facade_Summer Solstice_Daylight Rendering

Analysis 02_South Facade_Fall Equinox_Daylight Rendering

Analysis 02_South Facade_Spring Equinox_Daylight Rendering

Figure 6.5.1.2: Analysis 2 Daylight Renderings

6.5.2. Impact of Shade Device of Glazing on View

How is an occupant’s view impacted by a facade system’s shading device?

The impact of percentage of glazing on the occupant’s views was studied by comparing Analysis 3 to Analysis 5 and Analysis 4 to Analysis 6 from Groups A and C.

Analysis Key:

Analysis 3 – 30% Single pane tinted glazing with horizontal and slanted vertical shading devices.
Analysis 5 – 30% Single pane tinted glazing with egg crate style and slanted vertical shading devices.

Analysis 4 – 90% Single pane tinted glazing with horizontal and slanted vertical shading devices.
Analysis 6 – 90% Single pane tinted glazing with egg crate style and slanted vertical shading devices.

A visual examination of Analysis 3 (Figure 6.5.2.1.) and Analysis 5 (Figure 6.5.2.2.) demonstrated that the horizontal shade device is more effective than the egg-crate shade device at preserving the occupant’s view. The horizontal shade device has less of an impact on the occupants view because it does not have the vertical portion of the shade device that the egg-crate style shade device has.

By contrast, Analysis 4 (Figure 6.5.2.3.) and Analysis 6 (Figure 6.5.2.4.) are visually similar in terms of percentage of view. The horizontal nature of the egg-crate device in the 90% glazing studies resulted in less of a visual impact due to the vertical fins in its design. As a result, the horizontal and egg-crate device appear to have a similar visual impact on the occupant’s view.

When comparing the visual impacts of the horizontal shade device to the egg-crate shade device, the research in this section demonstrated that, as the percentage of glazing increases, the impact of shading devises on the occupant’s view decreases.

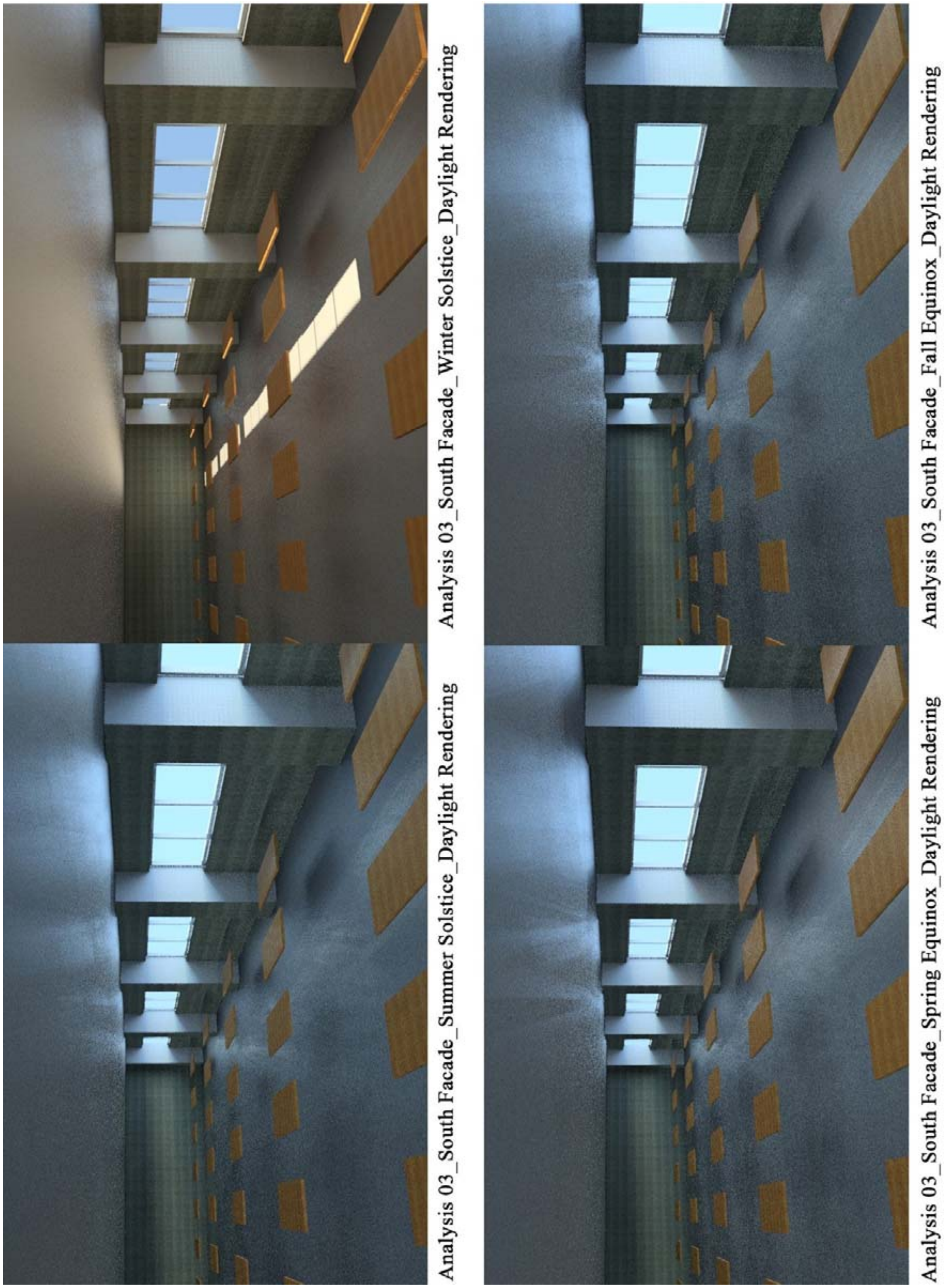


Figure 6.5.2.1: Analysis 3 Daylight Renderings

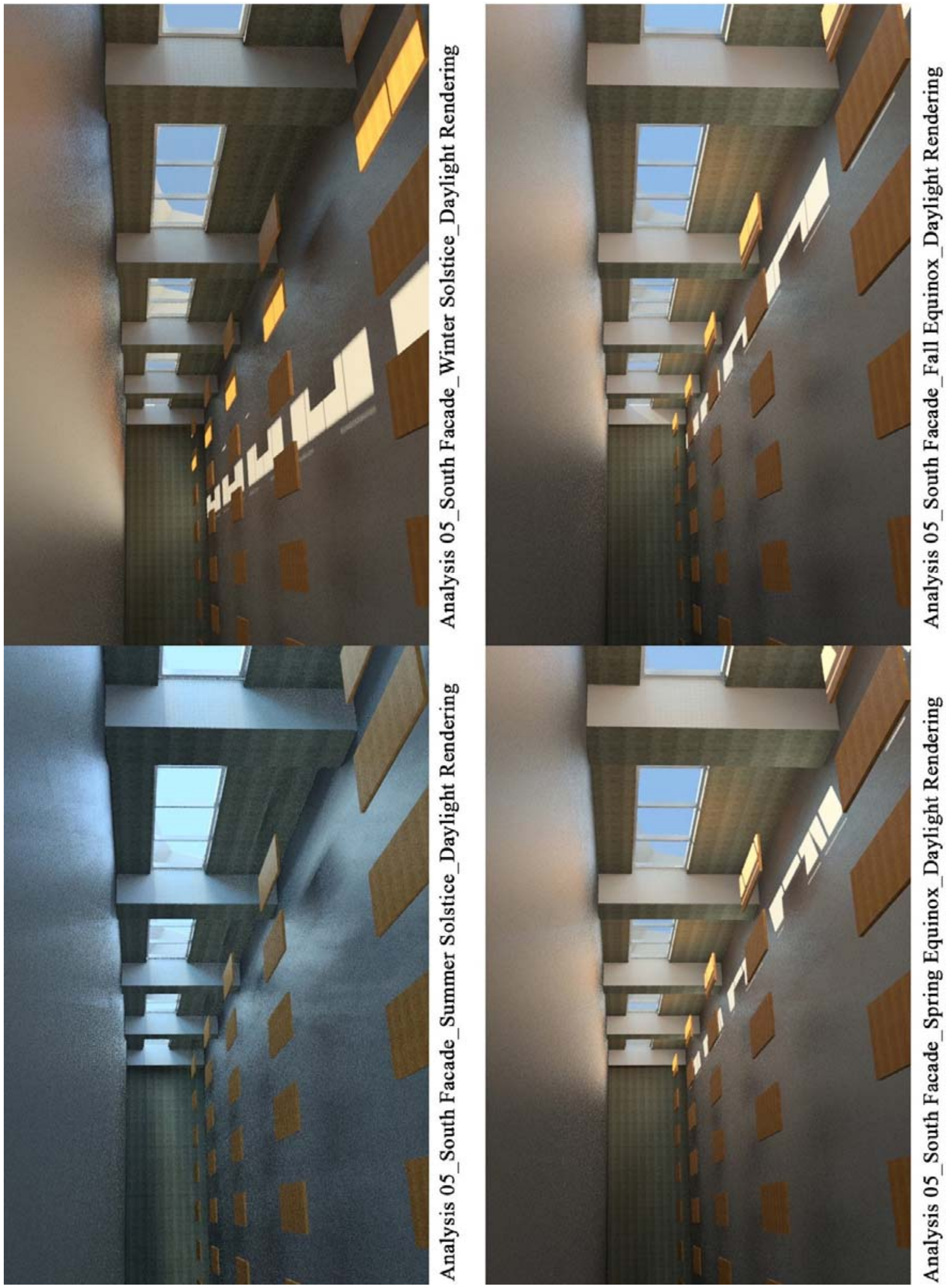


Figure 6.5.2.2: Analysis 5 Daylight Renderings

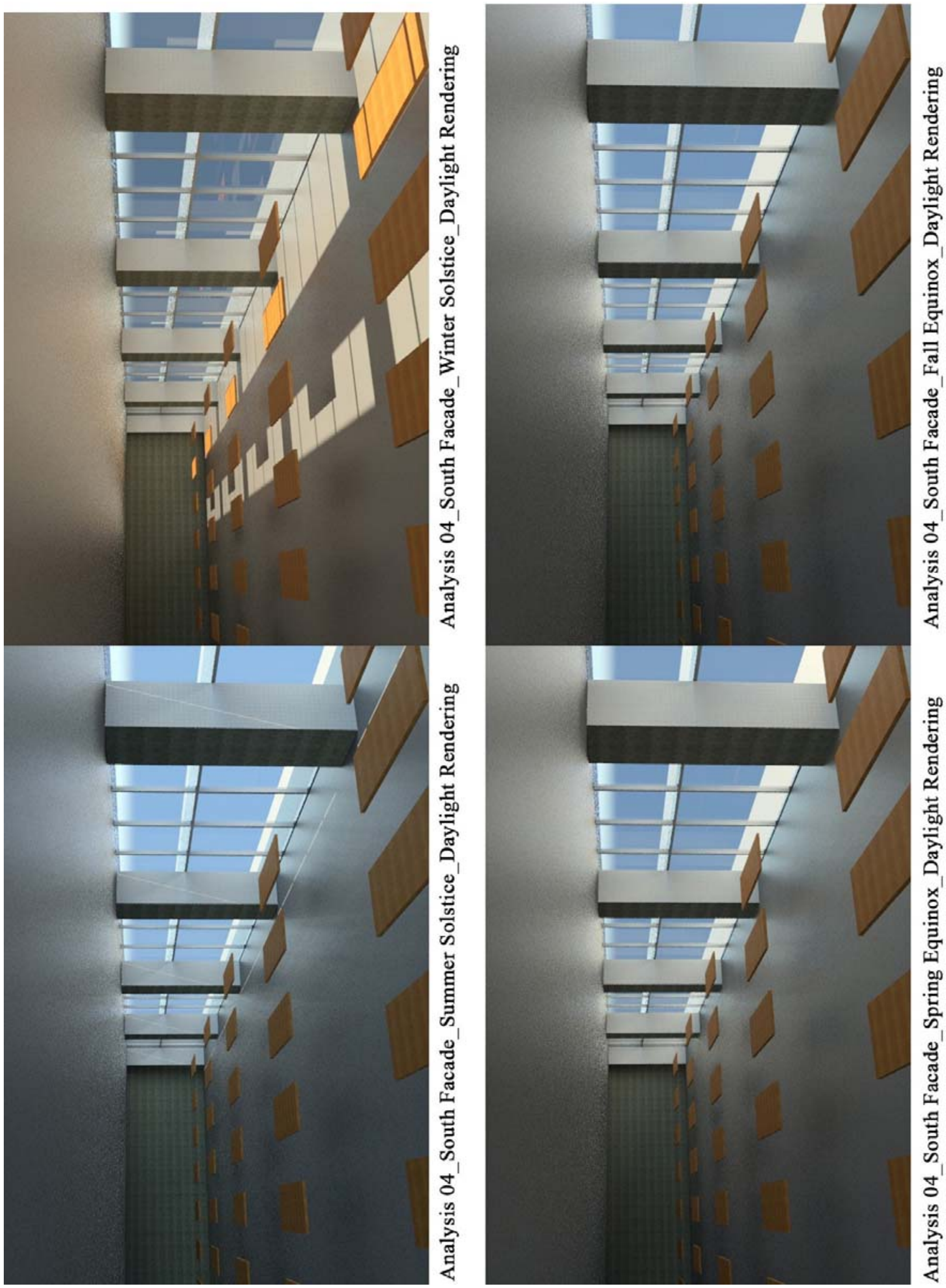


Figure 6.5.2.3: Analysis 4 Daylight Renderings

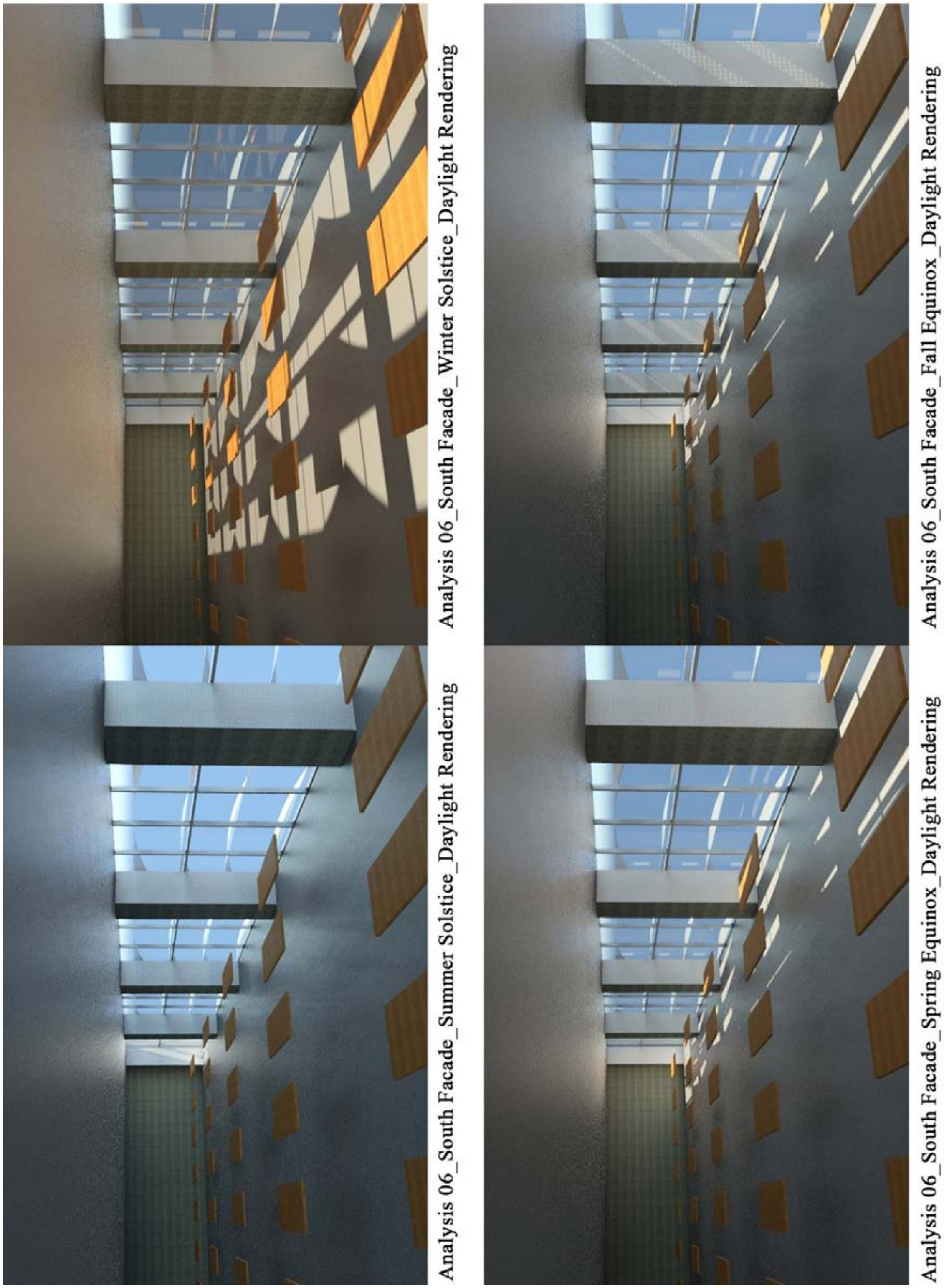


Figure 6.5.2.4: Analysis 6 Daylight Renderings

6.5.3. Impact of Light Shelf on View

How is an occupant's view impacted by a facade system's light shelves?

The impact of percentage of glazing on the occupant's views was studied by comparing Analysis 4 (Figure 6.5.2.1.) to Analysis 13 and Analysis 6 (Figure 6.5.2.4.) to Analysis 14 from Groups A and C.

Analysis Key:

Analysis 4 – 90% Single pane tinted glazing with horizontal and slanted vertical shading devices.
Analysis 13 - 90% H.P. double pane glazing with horizontal and slanted vertical shading devices and light selves.

Analysis 6 – 90% Single pane tinted glazing with egg crate style and slanted vertical shading devices.
Analysis 14 - 90% H.P. double pane glazing with egg crate style and slanted vertical shading devices and

The research in this section shows that the visual impact on the occupant's view due to light shelves is minimal. A visual examination of Analysis 13 and 14 demonstrate a similar view to their baseline in Analysis 4 and 6. That is because the light shelves sit to the inside of the facade system and therefore do not obstruct a substantial portion of the occupants view.

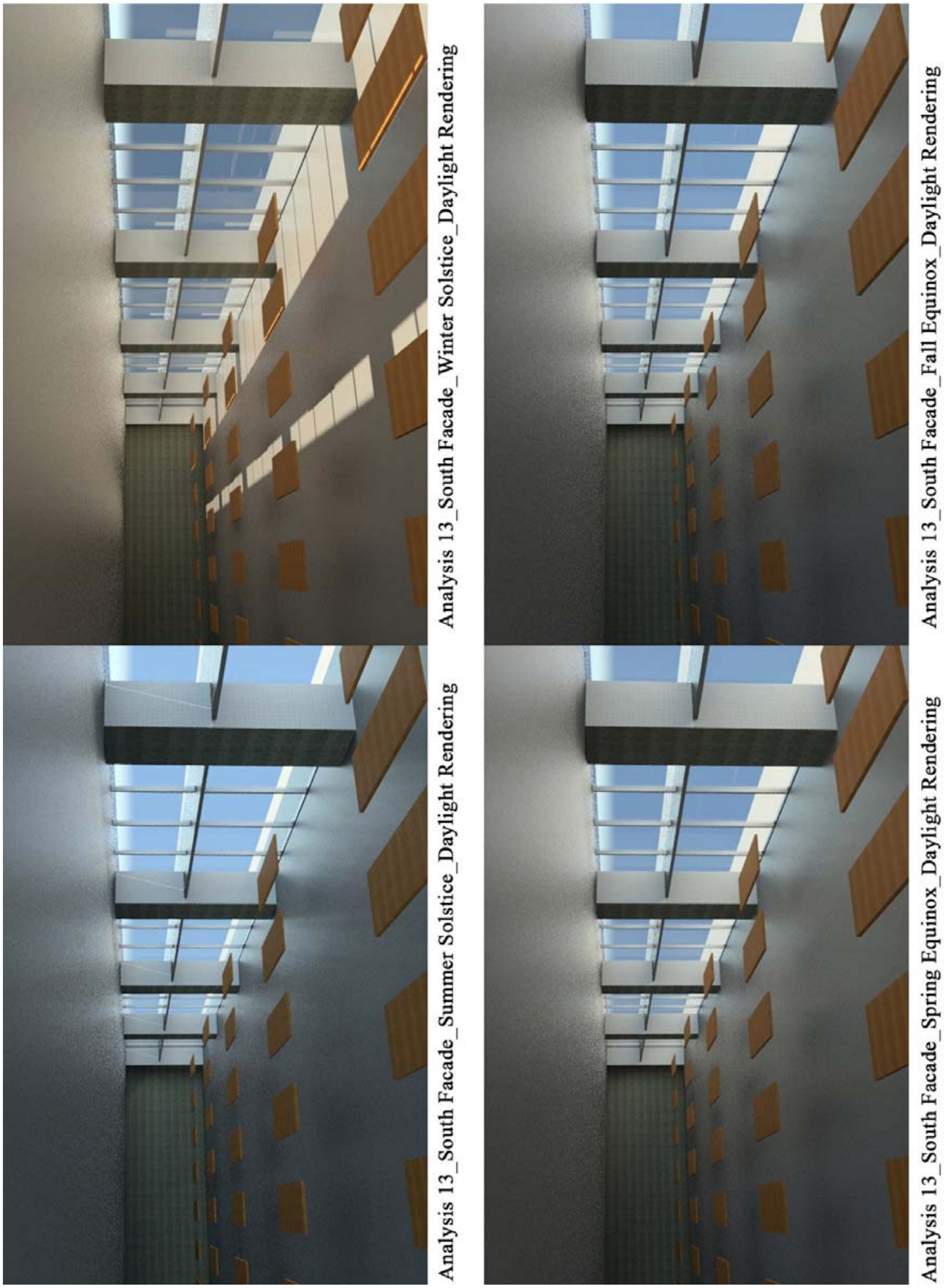


Figure 6.5.3.1: Analysis 13 Daylight Renderings

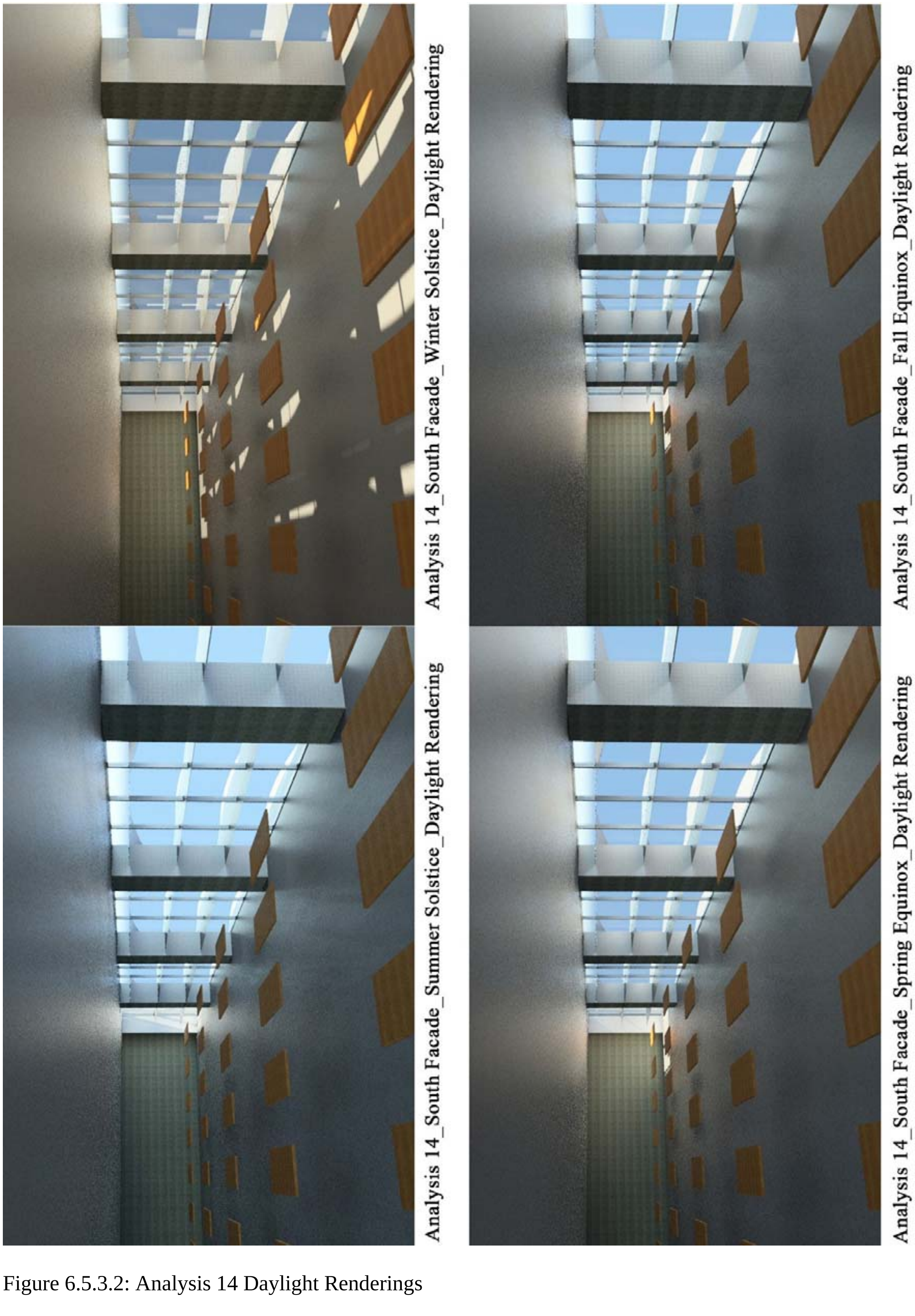


Figure 6.5.3.2: Analysis 14 Daylight Renderings

6.6. Comparative Analysis of Group H

This section discusses research sub-question 12.

1. What combination of glazing percentage, glazing type, shade device type, and light shelf creates the lowest energy use intensity while maintaining appropriate visual comfort and maximum view?

This section compares Group H (Figure 6.6.1.), Analysis 1 with Analysis 14a to determine how much a parametric performance-driven passive solar designed facade system minimizes the energy use intensity (EUI) of a building while maintaining appropriate illuminance levels (lux). The energy use intensity for Analysis 1 is 51.9 kBtu/sf/yr.

Group H Analysis Matrix

Energy Use Intensity Matrix Analysis Label	Existing Building 30% Glass Group H	Updated Building Curtain Wall at South and North Façade 90% Glass	Existing Building 30% Glass & D.C.	Updated Building Curtain Wall at South and North Facade 90% Glass & D.C.
Single Pane Tinted				
Single Pane Tinted Glass	1	2	1a	2a
Horizontal Shade Device & S.P. Glass	3	4	3a	4a
Egg-crate Shade Device & S.P. Glass	5	6	5a	6a
H.P. Clear Double Pane				
Double Pane Clear H.P. Glass	7	8	7a	8a
Horizontal Shade Device & H.P. Clear Glass	9	10	9a	10a
Egg-crate Shade Device & H.P. Clear Glass	11	12	11a	12a
Light Shelf				
Horizontal Shade Device, H.P. Clear Glass & L.S.	NA	13	NA	13a Group H
Egg-crate Shade Device H.P. Clear Glass & L.S.	NA	14	NA	14a

Table 6.6.1: Group H Analysis Matrix

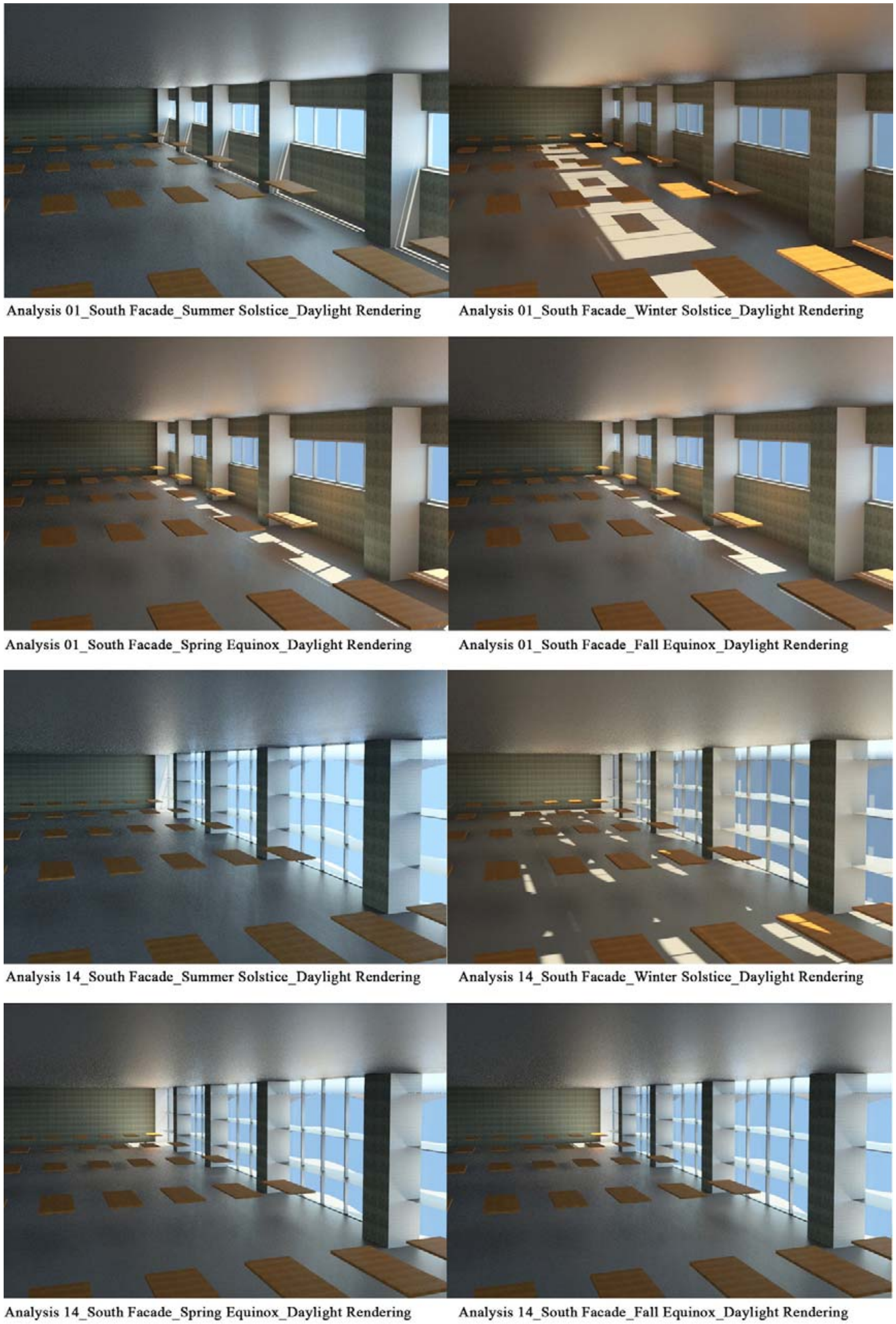


Figure 6.6.1: Analysis 1 and Analysis 14 Daylight Renderings

The energy use intensity for Analysis 14a is 49.4 kBtu/sf/yr. Representing nearly 5 (4.8) percentage point decrease in energy use intensity. During the summer solstice, spring equinox and fall equinox the illuminance levels range from 218-1546 lux. During the same time period. Analysis 14 illuminance levels range from 218-707, resulting in illuminance levels that are more consistently near the optimal 750 lux level. During the winter solstice, the illuminance levels for Analysis 1 range from 1045-4999+ lux. During the same time period Analysis 14 demonstrates an illuminance range of 707-1546 lux, a much more reasonable visual comfort range. When compared Analysis 1, Analysis 14 demonstrated a 30 percentage point increase in average yearly floor area with an acceptable lux level (500 – 800 lux). Furthermore, Figure 6.6.1 clearly demonstrates that Analysis 14a provides a more constantly naturally lit space with an increase of about 50 percentage points more of view.

7. CONCLUSIONS

7.1. Research Conclusions

This section discusses the conclusion related to the main research question;

How much can a parametric performance-driven passive solar designed facade system (glazing, shading devices, and light shelves) lower the energy use intensity (EUI) of an existing building while maintaining appropriate illuminance levels (lux)?

The results from Section 6 clearly demonstrated that the proposed parametric performance-driven passive solar design process is effective at lowering energy use intensity (EUI) while maintaining an acceptable illuminance levels (lux) for an existing office building in a hot-mediterranean environment. This design process demonstrated to be effective at lowering the energy use intensity of the existing office building from 51.9 kBtu to 49.8 kBtu. The process was also effective at improving illuminance levels. The new facade design naturally lit up to 63% of the interior space to an acceptable lux level of 500 – 800. When compared to its baseline in Analysis 1, Analysis 14 demonstrated a 32 percentage point increase in average yearly floor area with an acceptable lux level. The resulting design also offered a 45 percentage point increase of the occupant's view and connection to the exterior, making for a more comfortable space (Figure 7.1.1.).

Figure 7.1.1: Analysis 1 and Analysis 14 Winter Solstice Daylight Renderings

During this design process, the building's EUI was lowered by nearly 5 percentage points. This however, was not sufficient to meet the 2030 Challenge. In order to meet the 2030 Challenge, the building's EUI would have needed to drop from 51.9 kBtu to 40.5 kBtu, nearly 22 percentage points less than the original EUI.

Redesigning the facades of outdated buildings is a key factor to meeting the 2030 Challenge. However, a facade retrofit alone will not lower EUI enough to meet the high standards set by Architecture 2030. The reason that this design process did not meet the 2030 Challenge, is because it was specific to the facade of the building. In order to meet the 2030 Challenge a more holistic design process must be employed. As this research was focused on the building facade, many opportuninites to further lower the building's EUI were not leveraged. The baseline EUI report in Figure 4.3.2.1.2 revealed that there were many potential energy saving opportunities that fell outside of the scope of this research (Figure 7.1.2.). Some of these energy saving opportunities were: lighting efficiency, plug load efficiency, occupancy sensors, skylights, and roof insulation. This same report also revealed renewable energy saving potentials that were not considered during this process. Figure 7.1.2 reveals that high efficiency roof mounted photo voltaic panels would produce 1,749,215 kWh/yr. This would have further lowered the cooling load, further reducing the building's EUI. Another potential energy saving opportunity that was not included in research that could greatly impact EUI is natural ventilation. Photovoltaic panels combined with other energy saving potentials may have brought the EUI down enough to meet the 2030 challenge.

Renewable Energy Potential

Renewable Energy Potential

Roof Mounted PV System (Low efficiency):	583,072 kWh / yr
Roof Mounted PV System (Medium efficiency):	1,166,144 kWh / yr
Roof Mounted PV System (High efficiency):	1,749,215 kWh / yr
Single 15' Wind Turbine Potential:	0 kWh / yr

*PV efficiencies are assumed to be 5%, 10% and 15% for low, medium and high efficiency systems

Figure 7.1.2: Renewable Energy Potential (Autodesk Green Building Studio)

Conclusion Summary

In summary, this research found that the proposed parametric performance-driven passive solar designed facade system was effective at lowering the energy use intensity (EUI) of the selected office building while maintaining appropriate illuminance levels (lux). Analysis 14a proved to achieve the best balance between minimizing EUI and maintaining appropriate illuminance levels. Analysis 14a lowered the energy use intensity of the selected office building from 51.9 kBtu to 49.8 kBtu and increased the yearly average floor area with an acceptable illuminance level by 32 percentage points.

7.2. Major Findings

This section revisits previous sections and restates the major findings from each analysis section.

Impact of Glazing Percentage on EUI (Section 6.1.1.)

The results from Section 6.1.1 demonstrated that the percentage of glazing can have a substantial impact on EUI. When percentage of glazing goes up, EUI will also rise. The increase in energy use intensity is a result of a rise in the heating and cooling demands due to the increased surface area of glazing. However, other sections of this research have shown that shade systems and high performance double pane glazing can offset some of the negative effects of increasing percentage of glazing.

Impact of Glazing Type on EUI (Section 6.1.2.)

Section 6.1.2 demonstrated that type of glazing can dramatically effect EUI. In Section 6.1.2, changing single pane tinted glass to high performance double pane glass decreased energy use intensity up to 10 percentage points. The greater the percentage of glass, the greater the effects of changing from single pane tinted glass to high performance double pane glass will have on energy use intensity.

Glazing Percentage and Type in Terms of EUI (Section 6.1.3.)

Section 6.1.3 studied both percentage of glazing and type of glazing in terms of EUI. The research in this section demonstrated that percentage of glazing can be increased sustainably with minimal impacts on energy use intensity when high performance double pane glazing is employed. In Analysis 8, glazing percentage was increased from 30% to 90%, and single pane glazing was changed to high performance double pane glazing, with minimal increase in energy use intensity (1.5 percentage points).

Impact of Horizontal and Slanted Vertical Shade Device on EUI (Section 6.2.1.)

Section 6.2.1 showed that when a horizontal and slanted vertical louvers shade system is applied to an existing building in a hot-mediterranean environment, EUI is greatly reduced. This section demonstrated that a horizontal shade device can decrease

EUI .3 – 7.5 percentage points. The reduction in EUI is due to a dramatic increase in passive cooling. In Analysis 10, a horizontal shade device was applied to a facade system with 90% high performance double pane glazing and the cooling loads were reduced by 6 percentage points, resulting in a 1.7 percentage point drop in energy use intensity. This research also showed that a horizontal shade device will slightly increase a building's heating loads. In Analysis 10, the heating loads were increased from 8,313 kBtu to 8,631 kBtu (nearly 4%). However, cooling loads greatly outweigh heating loads in a hot-mediterranean environment. This research also demonstrated that an egg-crate and slanted vertical louvers shade system has a greater effect on energy use intensity as the percentage of glass is increased.

Impact of Egg-Crate Shade Device on EUI (Section 6.2.2.)

Section 6.2.2 showed that when an egg-crate and slanted vertical louvers shade system is applied to an existing building in a hot-mediterranean environment, EUI is greatly reduced. This section demonstrated that an egg-crate shade device can decrease EUI .5 – 9.9 percentage points. The reduction in EUI is due to a dramatic increase in passive cooling. In Analysis 12, an egg-crate shade device was applied to a facade system with 90% high performance double pane glazing and the cooling loads were reduced by 9 percentage points, resulting in a 2.5% drop in energy use intensity. This research also showed that an egg-crate shade device will slightly increase a building is heating loads. In Analysis 8, the heating loads were increased from 8,362 kBtu to 8,631 kBtu (3 percentage points). However, cooling loads greatly outweigh heating loads in a hot-mediterranean environment. This research also demonstrated that an egg-crate and slanted vertical louvers shade system has a greater effect on energy use intensity as the percentage of glass is increased.

Comparative Analysis of Horizontal Shade Device and Egg-Crate Shade Device (Section 6.2.3.)

Section 6.2.3 demonstrated that, in all scenarios in Group A and C, the egg-crate shade device was more effective at lowering the energy use intensity in a hot mediterranean climate than the horizontal shade device. Regardless of percentage of glazing (30% or 90%) and type of glazing (Single pane or H.P. Double pane). The horizontal shade device decreased EUI .3 – 7.5 percentage points, while the egg-crate shade device can decrease EUI .5 – 9.9 percentage points.

Impact of Daylighting Controls on EUI (Section 6.3.)

The research in Section 6.3 showed that daylight controls are effective in all scenarios tested in this research at lowering energy use intensity. Table 6.3.1 illustrates that daylighting controls are more effective at lowering EUI as percentage of glazing is increased and glass is properly shaded. This research demonstrated daylight controls can improve energy use intensity .8-1.6 percentage points.

Impact of Percentage of Glazing on Illuminance Levels (Section 6.4.1.)

Section 6.4.1 demonstrated that percentage of glazing has a noticeable impact on illuminance levels. A visual analysis of the illuminance rendering for Analysis 1 and Analysis 2 clearly show how increasing glazing percentage from 30% to 90% has a negative impact on illuminance levels Analysis 1 renderings display a substantial amount of green (near the optimal 750) while the Analysis 2 renderings show a lot of yellow and orange (1500 – 4999+). Analysis 2 would create an extremely visually uncomfortable space (Figure 7.1.3.)

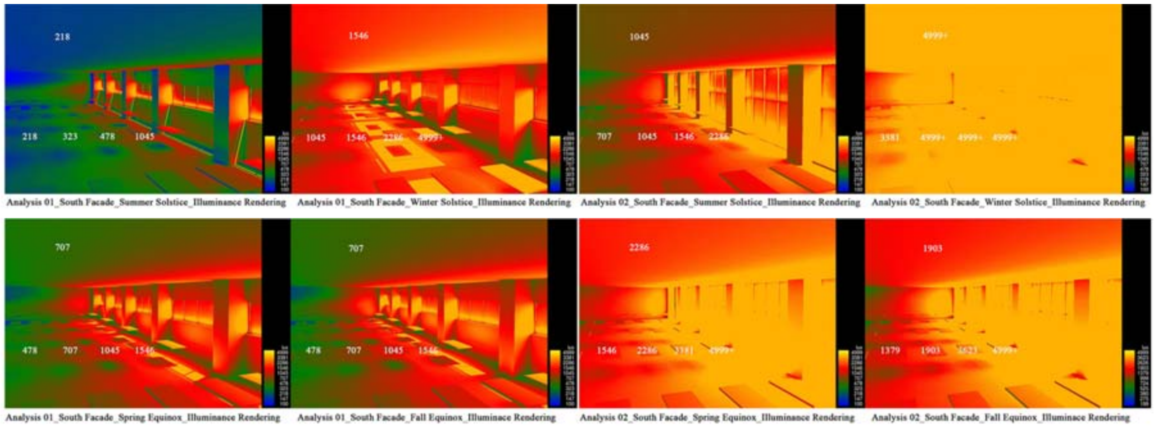


Figure 7.1.3: Visual Comparison of Analysis 1 and Analysis 2 Illuminance Renderings

Impact of Shade Device of Glazing on Illuminance Levels (Section 6.4.2.)

The research in this section demonstrated that a shade device has an effect on illuminance levels. For a facade system with 30% glazing, shade devices bring illuminance levels from near acceptable to below acceptable illuminance levels. For a facade system with 90% glazing, shade devices can bring unacceptable illuminance levels down to near acceptable illuminance levels. Both the horizontal and egg-crate shade device proved to be effective in achieving acceptable illuminance levels over the majority of the floor area throughout the entire year in a facade with 90% glazing.

Impact of Light Shelf on Illuminance Levels (Section 6.4.3.)

The research in this section demonstrated that light shelves are in fact effective at increasing illuminance levels. When compared to its baseline in Analysis 2, Analysis 13 demonstrated a 17 percentage point increase in average yearly floor area with an acceptable lux level (500 – 800 lux). When compared to its baseline in Analysis 2, Analysis 14 demonstrated a 31% increase in average yearly floor area with an acceptable lux level (500 – 800 lux).

Impact of Percentage of Glazing on View (Section 6.5.1.)

Section 6.5.1 reinforced a general understating that an increased percentage of glazing also increases the occupant's view. A visual analysis and comparison of Analysis 1 to Analysis 2, clearly reinforces that the 30% glazing offers less view than the 90% glazing example.

Impact of Shade Device of Glazing on View (Section 6.5.2.)

Section 6.5.2 shows that both horizontal and egg-crate shading devices decrease the occupant's view.

Impact of Light Shelf on View (Section 6.5.3.)

This section shows that light shelves also have a negative impact on the occupants view. However, when used in combination with a shade device, the impact on view is less substantial. A visual examination of daylight rendering for Analyses 13 and 14 demonstrates a similar view to their baseline in Analyses 4 and 6. This is because the light shelves sit to the inside of the facade system and therefore do not obstruct a substantial portion of the occupant's view.

7.3. Recommendations for Future Research

The following are a few recommendations that might increase the effectiveness of research of a similar nature.

Fewer Variables

A number of variable were studied during this research: glazing percentage, glazing type, shading devices, light shelves and daylight controls. As a result, this research rendered a broad range of data. If each variable was studied individually, a more detailed study of each variable could be realized.

Small to Medium Size Office Building

The selected building for the proof of concept portion of this research was a large high rise office building. As a result, much time was spent modeling the building and its components. The size of the building also increased the performance analysis processing time. The size of the building also resulted in more subtle EUI results. A similar study of a small to medium size office building may deliver quicker and more dramatic results with regard to EUI.

Building Documentation

Research related to EUI requires a significant amount of information about the building that is being studied. During the course of this research, much time was spent finding documentation of the selected building. In order to realize the research found in this project, construction documentation, building use schedule, HVAC equipment, lighting, and insulation values had to be found and documented.

Select a building that has post occupancy data available. Post occupancy data would allow the researcher to compare data gathered with actual data and covert research findings into nearly actual values.

Energy Consultant

Mechanical engineers and energy consultants are very familiar with the topics explored in this research and can answer technical questions early in the design process. Energy professionals can also help interpret data gathered.

8. FURTHER RESEARCH

8.1. Potential Areas of Research

- More research could be done on the impact of glazing percentage on EUI. One could study 30%, 35% 40%, 45%, 50%, 55%, 60%, etc. glazing in a facade system. Is there an optimal glazing percentage related to EUI?
- More research could be done on the impact of glazing type on EUI. One could study a greater range of glazing types in a facade system to determine if there is a point of diminishing returns with regard to EUI.
- A greater variety of more complex shading devices could be explored in order to realize a specific performance target.
- This research only studied the effects of having or not having light shelves. The depth was based on a typical light shelf depth. Further research could be done on the impact of light shelves on illuminance levels. Various depths could be studied to find the optimal depth in relation to distance to achieve optimal illuminance levels.
- Cost analysis studies could be done to determine if the amount of energy saved over a course of time would outweigh the cost of the facade retrofit.

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APPENDICES

A. Autodesk Green Building Studio, Alternate Runs Reports

My Projects > **Analysis 01 Existing Building Base Line**

Run List | Run Charts | Project Defaults | Project Details | Project Members | Utility Information | Weather Station

Actions ▾ Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost[1] Electric	Total Annual Cost[1] Fuel	Total Annual Cost[1] Energy	Total Annual Energy[1] Electric (kWh)	Total Annual Energy[1] Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
30 Percent S.P. Tinted Glass	5/26/2014 10:05 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,196,587	$6,702	$1,203,289	10,149,170	8,347	9,176.1		
Alternate Run(s) of 30 Percent S.P. Tinted Glass														
Analysis 1 Existing Building_Lighting_1.3_W/sqft	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	55.3	$0.12	$0.80	$1,277,243	$6,606	$1,283,848	10,833,270	8,227	9,913.0		
Analysis 1 Existing Building_Lighting_0.48_W/sqft	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	42.8	$0.12	$0.80	$975,299	$8,100	$983,400	8,272,260	10,089	7,162.5		
Analysis 1 Existing Building_PlugLoad_2.60_W/sqft	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	74.5	$0.12	$0.80	$1,731,423	$6,374	$1,737,797	14,685,520	7,939	14,064.9		
Analysis 1 Existing Building_PlugLoad_0.78_W/sqft	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	45.4	$0.12	$0.80	$1,041,102	$7,272	$1,048,374	8,830,383	9,057	7,758.3		
Analysis 1 Existing Building_Orientation_(-) 135	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,203,076	$7,187	$1,210,263	10,204,210	8,951	9,238.9		
Analysis 1 Existing Building_Orientation_(-)90	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.7	$0.12	$0.80	$1,216,252	$6,919	$1,223,170	10,315,960	8,617	9,357.5		
Analysis 1 Existing Building_Orientation_(-)45	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,211,537	$6,757	$1,218,294	10,275,970	8,415	9,313.2		
Analysis 1 Existing Building_Orientation_(+) 180	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.6	$0.12	$0.80	$1,187,685	$7,331	$1,195,016	10,073,660	9,131	9,099.2		
Analysis 1 Existing Building_Orientation_(+) 135	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,209,728	$7,088	$1,216,816	10,260,630	8,827	9,299.1		
Analysis 1 Existing Building_Orientation_(+)90	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	53.0	$0.12	$0.80	$1,222,380	$6,860	$1,229,240	10,367,940	8,544	9,413.1		
Analysis 1 Existing Building_Orientation_(+)45	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.7	$0.12	$0.80	$1,215,262	$6,652	$1,221,915	10,307,570	8,285	9,346.5		
Analysis 1 Existing Building_OccSens_ON	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,152,073	$6,800	$1,158,873	9,771,613	8,469	8,769.7		
Analysis 1 Existing Building_OccSens_No_Change	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,196,529	$6,702	$1,203,231	10,148,680	8,347	9,175.6		
Analysis 1 Existing Building_BaseRun_w/DC_No_Change	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,196,529	$6,702	$1,203,231	10,148,680	8,347	9,175.6		
Analysis 1 Existing Building_R-60_continuous_Ins_Roof	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,197,272	$6,701	$1,203,973	10,154,980	8,346	9,182.4		
Analysis 1 Existing Building_Uninsulated_framed_Wall	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	53.9	$0.12	$0.80	$1,215,167	$13,596	$1,228,763	10,306,760	16,933	9,395.8		
Analysis 1 Existing Building_Quad_Kryp_Clear_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,187,356	$6,735	$1,194,090	10,070,870	8,388	9,091.9		
Analysis 1 Existing Building_Dbl_LowE_HP_Window_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,187,356	$6,735	$1,194,090	10,070,870	8,388	9,091.9		
Analysis 1 Existing Building_Triple_LowE_film_Window_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,187,356	$6,735	$1,194,090	10,070,870	8,388	9,091.9		
Analysis 1 Existing Building_Single_Low_Iron_Window_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,187,356	$6,735	$1,194,090	10,070,870	8,388	9,091.9		
Analysis 1 Existing Building_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,173,607	$6,374	$1,179,981	9,954,256	7,939	8,963.6		
Analysis 1 Existing Building_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,461	$6,404	$1,163,864	9,817,308	7,976	8,816.1		
Analysis 1 Existing Building_Triple_LowE_film_Skylight_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,538	$6,411	$1,166,949	9,843,411	7,985	8,844.3		
Analysis 1 Existing Building_Single_Low_Iron_Skylight_w/DC	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.0	$0.12	$0.80	$1,199,608	$6,548	$1,206,156	10,174,790	8,155	9,202.6		
Analysis 1 Existing Building_BaseRun_w/DC_ON	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,187,356	$6,735	$1,194,090	10,070,870	8,388	9,091.9		
Analysis 1 Existing Building_Quad_Kryp_Clear_Window	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,196,529	$6,702	$1,203,231	10,148,680	8,347	9,175.6		
Analysis 1 Existing Building_Dbl_LowE_HP_Window	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,196,529	$6,702	$1,203,231	10,148,680	8,347	9,175.6		
Analysis 1 Existing Building_Triple_LowE_film_Window	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,196,529	$6,702	$1,203,231	10,148,680	8,347	9,175.6		
Analysis 1 Existing Building_Single_Low_Iron_Window	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.9	$0.12	$0.80	$1,196,529	$6,702	$1,203,231	10,148,680	8,347	9,175.6		
Analysis 1 Existing Building_Quad_Kryp_Clear_Skylight	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,183,664	$6,374	$1,190,038	10,039,560	7,939	9,055.5		
Analysis 1 Existing Building_Dbl_LowE_HP_Skylight	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,913.6		
Analysis 1 Existing Building_Triple_LowE_film_Skylight	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,793	$6,404	$1,172,197	9,887,980	7,975	8,892.3		
Analysis 1 Existing Building_Single_Low_Iron_Skylight	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.4	$0.12	$0.80	$1,210,911	$6,515	$1,217,426	10,270,660	8,114	9,305.7		
Analysis 1 Existing Building_R-44_framed_Wall	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.8	$0.12	$0.80	$1,196,343	$6,477	$1,202,820	10,147,100	8,067	9,172.2		
Analysis 1 Existing Building_Uninsulated_framed_Roof	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,185,631	$12,839	$1,198,469	10,056,240	15,990	9,120.2		
Analysis 1 Existing Building_Infiltration_3.5_ACH	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	55.0	$0.12	$0.80	$1,206,485	$21,341	$1,227,826	10,233,120	26,579	9,372.4		
Analysis 1 Existing Building_Infiltration_0.17_ACH	5/26/2014 10:06 AM	tpshorey@rrmdesign.com	683,670	51.8	$0.12	$0.80	$1,195,543	$6,736	$1,202,279	10,140,310	8,390	9,166.8		

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Version 2015.1.33.1393 (DOE-2.2-48r)

My Projects > **Analysis 02**

Run List | Run Charts | Project Defaults | Project Details | Project Members | Utility Information | Weather Station

Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Fuel	Energy	Total Annual Energy [1] Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings (Beta)
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
90 Percent S.P. Tinded Glass	5/26/2014 10:14 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,621	$9,753	$1,319,375	11,107,900	12,147	10,060.4		
Alternate Run(s) of 90 Percent S.P. Tinded Glass														
Analysis 3 Existing Building_Lighting_1.3_W/sqft	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	60.8	$0.12	$0.80	$1,398,023	$9,067	$1,407,090	11,857,700	11,292	10,863.9		
Analysis 3 Existing Building_Lighting_0.48_W/sqft	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	47.9	$0.12	$0.80	$1,072,247	$13,569	$1,085,816	9,094,548	16,900	7,917.1		
Analysis 3 Existing Building_PlugLoad_2.60_W/sqft	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	80.2	$0.12	$0.80	$1,865,726	$6,777	$1,872,503	15,824,650	8,440	15,124.6		
Analysis 3 Existing Building_PlugLoad_0.78_W/sqft	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,136,297	$13,200	$1,149,497	9,637,801	16,440	8,500.2		
Analysis 3 Existing Building_Orientation_(-) 135	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	60.2	$0.12	$0.80	$1,379,547	$9,864	$1,389,411	11,700,990	12,285	10,700.7		
Analysis 3 Existing Building_Orientation_(-) 90	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	61.1	$0.12	$0.80	$1,404,241	$9,030	$1,413,271	11,910,440	11,246	10,920.5		
Analysis 3 Existing Building_Orientation_(-) 45	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	59.2	$0.12	$0.80	$1,359,218	$9,209	$1,368,428	11,528,570	11,470	10,510.0		
Analysis 3 Existing Building_Orientation_ (+)180	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.1	$0.12	$0.80	$1,299,569	$11,647	$1,311,216	11,022,640	14,506	9,982.1		
Analysis 3 Existing Building_Orientation_ (+)135	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	59.2	$0.12	$0.80	$1,357,883	$9,541	$1,367,424	11,517,240	11,883	10,500.2		
Analysis 3 Existing Building_Orientation_ (+)90	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	61.3	$0.12	$0.80	$1,409,986	$9,140	$1,419,127	11,959,170	11,384	10,973.8		
Analysis 3 Existing Building_Orientation_ (+)45	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	60.6	$0.12	$0.80	$1,390,537	$9,277	$1,399,814	11,794,210	11,553	10,796.9		
Analysis 3 Existing Building_OccSens_ON	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	55.3	$0.12	$0.80	$1,262,015	$10,473	$1,272,488	10,704,110	13,044	9,630.2		
Analysis 3 Existing Building_OccSens_No_Change	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,528	$9,760	$1,319,288	11,107,110	12,155	10,059.6		
Analysis 3 Existing Building_BaseRun_w/DC_No_Change	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,528	$9,760	$1,319,288	11,107,110	12,155	10,059.6		
Analysis 3 Existing Building_R-60_continuous_Ins_Roof	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,959	$9,701	$1,319,660	11,110,760	12,082	10,063.1		
Analysis 3 Existing Building_Uninsulated_framed_Wall	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	59.1	$0.12	$0.80	$1,326,479	$16,027	$1,342,506	11,250,880	19,961	10,259.9		
Analysis 3 Existing Building_Quad_Kryp_Clear_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	56.4	$0.12	$0.80	$1,289,128	$10,241	$1,299,369	10,934,080	12,755	9,876.5		
Analysis 3 Existing Building_Dbl_LowE_HP_Window_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	56.4	$0.12	$0.80	$1,289,128	$10,241	$1,299,369	10,934,080	12,755	9,876.5		
Analysis 3 Existing Building_Triple_LowE_film_Window_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	56.4	$0.12	$0.80	$1,289,128	$10,241	$1,299,369	10,934,080	12,755	9,876.5		
Analysis 3 Existing Building_Single_Low_Iron_Window_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	56.4	$0.12	$0.80	$1,289,128	$10,241	$1,299,369	10,934,080	12,755	9,876.5		
Analysis 3 Existing Building_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,211,987	$6,374	$1,218,361	10,279,790	7,939	9,143.1		
Analysis 3 Existing Building_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,769	$6,444	$1,175,213	9,913,220	8,026	8,748.3		
Analysis 3 Existing Building_Triple_LowE_film_Skylight_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,945	$6,443	$1,172,388	9,889,272	8,025	8,722.5		
Analysis 3 Existing Building_Single_Low_Iron_Skylight_w/DC	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	58.5	$0.12	$0.80	$1,342,320	$9,322	$1,351,642	11,385,240	11,610	10,356.3		
Analysis 3 Existing Building_BaseRun_w/DC_ON	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	56.4	$0.12	$0.80	$1,289,128	$10,241	$1,299,369	10,934,080	12,755	9,876.5		
Analysis 3 Existing Building_Quad_Kryp_Clear_Window	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,528	$9,760	$1,319,288	11,107,110	12,155	10,059.6		
Analysis 3 Existing Building_Dbl_LowE_HP_Window	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,528	$9,760	$1,319,288	11,107,110	12,155	10,059.6		
Analysis 3 Existing Building_Triple_LowE_film_Window	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,528	$9,760	$1,319,288	11,107,110	12,155	10,059.6		
Analysis 3 Existing Building_Single_Low_Iron_Window	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,528	$9,760	$1,319,288	11,107,110	12,155	10,059.6		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Fuel	Energy	Total Annual Energy [1] Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Analysis 3 Existing Building_Quad_Kryp_Clear_Skylight	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	53.3	$0.12	$0.80	$1,232,290	$6,374	$1,238,664	10,451,990	7,939	9,328.7		
Analysis 3 Existing Building_Dbl_LowE_HP_Skylight	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	8,919.8		
Analysis 3 Existing Building_Triple_LowE_film_Skylight	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	51.0	$0.12	$0.80	$1,177,739	$6,443	$1,184,182	9,989,307	8,024	8,830.4		
Analysis 3 Existing Building_Single_Low_Iron_Skylight	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	59.5	$0.12	$0.80	$1,366,691	$8,944	$1,375,635	11,591,950	11,140	10,576.4		
Analysis 3 Existing Building_R-44_framed_Wall	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.0	$0.12	$0.80	$1,306,795	$9,260	$1,316,055	11,083,930	11,533	10,031.0		
Analysis 3 Existing Building_Uninsulated_framed_Roof	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.9	$0.12	$0.80	$1,304,547	$14,709	$1,319,256	11,064,860	18,319	10,049.8		
Analysis 3 Existing Building_Infiltration_3.5_ACH	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	61.9	$0.12	$0.80	$1,346,018	$26,992	$1,373,011	11,416,610	33,617	10,517.8		
Analysis 3 Existing Building_Infiltration_0.17_ACH	5/26/2014 10:15 AM	tpshorey@rrmdesign.com	683,670	57.2	$0.12	$0.80	$1,309,672	$9,907	$1,319,579	11,108,330	12,338	10,061.9		

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Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Passive Solar Shade Devices 3.5 30 Percent S.P. Glass	5/26/2014 10:23 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,170,473	$6,748	$1,177,221	9,927,678	8,404	8,977.2		
Alternate Run(s) of Passive Solar Shade Devices 3.5 30 Percent S.P. Glass														
Passive Solar Shade Devices 30 P S.P. Glass_Lighting_1.3_W/sqft	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	54.1	$0.12	$0.80	$1,249,693	$6,625	$1,256,318	10,599,600	8,251	9,700.8		
Passive Solar Shade Devices 30 P S.P. Glass_Lighting_0.48_W/sqft	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	41.8	$0.12	$0.80	$951,743	$8,247	$959,991	8,072,464	10,271	6,987.7		
Passive Solar Shade Devices 30 P S.P. Glass_PlugLoad_2.60_W/sqft	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	72.5	$0.12	$0.80	$1,686,093	$6,374	$1,692,467	14,301,040	7,939	13,690.0		
Passive Solar Shade Devices 30 P S.P. Glass_PlugLoad_0.78_W/sqft	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	44.4	$0.12	$0.80	$1,017,692	$7,316	$1,025,008	8,631,823	9,112	7,584.1		
Passive Solar Shade Devices 30 P S.P. Glass_Orientation_(-)135	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,171,177	$7,299	$1,178,476	9,933,649	9,091	8,987.7		
Passive Solar Shade Devices 30 P S.P. Glass_Orientation_(-)90	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	51.1	$0.12	$0.80	$1,177,630	$7,070	$1,184,700	9,988,377	8,806	9,045.0		
Passive Solar Shade Devices 30 P S.P. Glass_Orientation_(-)45	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,173,232	$6,919	$1,180,151	9,951,075	8,617	9,003.7		
Passive Solar Shade Devices 30 P S.P. Glass_Orientation_(+)180	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,162,375	$7,386	$1,169,761	9,858,990	9,199	8,907.8		
Passive Solar Shade Devices 30 P S.P. Glass_Orientation_(+)135	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,171,050	$7,164	$1,178,214	9,932,570	8,922	8,985.5		
Passive Solar Shade Devices 30 P S.P. Glass_Orientation_(+)90	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,182,352	$6,988	$1,189,340	10,028,430	8,704	9,087.6		
Passive Solar Shade Devices 30 P S.P. Glass_Orientation_(+)45	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	51.2	$0.12	$0.80	$1,180,796	$6,874	$1,187,670	10,015,230	8,562	9,072.5		
Passive Solar Shade Devices 30 P S.P. Glass_OccSens_ON	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	49.0	$0.12	$0.80	$1,126,738	$6,999	$1,133,737	9,556,727	8,717	8,579.1		
Passive Solar Shade Devices 30 P S.P. Glass_OccSens_No_Change	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,170,416	$6,748	$1,177,164	9,927,192	8,405	8,976.7		
Passive Solar Shade Devices 30 P S.P. Glass_BaseRun_w/DC_No_Change	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,170,416	$6,748	$1,177,164	9,927,192	8,405	8,976.7		
Passive Solar Shade Devices 30 P S.P. Glass_R-60_continuous_Ins_Roof	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,171,160	$6,747	$1,177,907	9,933,500	8,403	8,983.5		
Passive Solar Shade Devices 30 P S.P. Glass_Uninsulated_framed_Wall	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	52.8	$0.12	$0.80	$1,187,723	$13,644	$1,201,368	10,073,990	16,993	9,184.8		
Passive Solar Shade Devices 30 P S.P. Glass_Quad_Kryp_Clear_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,492	$6,869	$1,168,361	9,851,503	8,555	8,896.0		
Passive Solar Shade Devices 30 P S.P. Glass_Dbl_LowE_HP_Window_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,492	$6,869	$1,168,361	9,851,503	8,555	8,896.0		
Passive Solar Shade Devices 30 P S.P. Glass_Triple_LowE_film_Window_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,492	$6,869	$1,168,361	9,851,503	8,555	8,896.0		
Passive Solar Shade Devices 30 P S.P. Glass_Single_Low_Iron_Window_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,492	$6,869	$1,168,361	9,851,503	8,555	8,896.0		
Passive Solar Shade Devices 30 P S.P. Glass_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,161,680	$6,403	$1,168,084	9,853,100	7,975	8,894.3		
Passive Solar Shade Devices 30 P S.P. Glass_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,175	$6,411	$1,159,586	9,780,957	7,985	8,816.6		
Passive Solar Shade Devices 30 P S.P. Glass_Triple_LowE_film_Skylight_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,214	$6,411	$1,163,625	9,815,215	7,985	8,853.5		
Passive Solar Shade Devices 30 P S.P. Glass_Single_Low_Iron_Skylight_w/DC	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,164,959	$6,749	$1,171,708	9,880,908	8,406	8,926.8		
Passive Solar Shade Devices 30 P S.P. Glass_BaseRun_w/DC_ON	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,492	$6,869	$1,168,361	9,851,503	8,555	8,896.0		
Passive Solar Shade Devices 30 P S.P. Glass_Quad_Kryp_Clear_Window	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,170,416	$6,748	$1,177,164	9,927,192	8,405	8,976.7		
Passive Solar Shade Devices 30 P S.P. Glass_Dbl_LowE_HP_Window	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,170,416	$6,748	$1,177,164	9,927,192	8,405	8,976.7		
Passive Solar Shade Devices 30 P S.P. Glass_Triple_LowE_film_Window	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,170,416	$6,748	$1,177,164	9,927,192	8,405	8,976.7		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Fuel	Energy	Total Annual Energy [1] Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Passive Solar Shade Devices 30 P S.P. Glass_Single_Low_Iron_Window	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,170,416	$6,748	$1,177,164	9,927,192	8,405	8,976.7		
Passive Solar Shade Devices 30 P S.P. Glass_Quad_Kryp_Clear_Skylight	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,171,361	$6,374	$1,177,735	9,935,208	7,939	8,982.7		
Passive Solar Shade Devices 30 P S.P. Glass_Dbl_LowE_HP_Skylight	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,912.9		
Passive Solar Shade Devices 30 P S.P. Glass_Triple_LowE_film_Skylight	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,467	$6,411	$1,168,878	9,859,770	7,985	8,901.6		
Passive Solar Shade Devices 30 P S.P. Glass_Single_Low_Iron_Skylight	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	51.0	$0.12	$0.80	$1,175,923	$6,628	$1,182,551	9,973,901	8,255	9,026.2		
Passive Solar Shade Devices 30 P S.P. Glass_R-44_framed_Wall	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,171,887	$6,473	$1,178,361	9,939,672	8,062	8,988.2		
Passive Solar Shade Devices 30 P S.P. Glass_Uninsulated_framed_Roof	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,158,536	$13,210	$1,171,746	9,826,430	16,452	8,914.7		
Passive Solar Shade Devices 30 P S.P. Glass_Infiltration_3.5_ACH	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	53.8	$0.12	$0.80	$1,175,751	$22,121	$1,197,872	9,972,441	27,550	9,136.5		
Passive Solar Shade Devices 30 P S.P. Glass_Infiltration_0.17_ACH	5/26/2014 10:24 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,169,354	$6,752	$1,176,106	9,918,182	8,410	8,967.0		

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Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Passive Solar Shade Devices (2) 4.75 90 Percent S.P. Glass	5/26/2014 3:00 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,978	$10,652	$1,214,631	10,211,860	13,267	9,261.0		
Alternate Run(s) of Passive Solar Shade Devices (2) 4.75 90 Percent S.P. Glass														
Passive Solar Shade Devices (2) 4.75 90 P SP_Lighting_1.3_W/sqft	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	56.4	$0.12	$0.80	$1,291,157	$9,725	$1,300,882	10,951,290	12,112	10,051.6		
Passive Solar Shade Devices (2) 4.75 90 P SP_Lighting_0.48_W/sqft	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	44.0	$0.12	$0.80	$977,968	$14,296	$992,264	8,294,892	17,805	7,220.4		
Passive Solar Shade Devices (2) 4.75 90 P SP_PlugLoad_2.60_W/sqft	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	75.7	$0.12	$0.80	$1,758,658	$6,990	$1,765,648	14,916,520	8,706	14,307.2		
Passive Solar Shade Devices (2) 4.75 90 P SP_PlugLoad_0.78_W/sqft	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	46.8	$0.12	$0.80	$1,043,599	$14,434	$1,058,033	8,851,557	17,977	7,821.6		
Passive Solar Shade Devices (2) 4.75 90 P SP_Orientation_(-)135	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	56.1	$0.12	$0.80	$1,278,694	$10,842	$1,289,536	10,845,580	13,503	9,945.7		
Passive Solar Shade Devices (2) 4.75 90 P SP_Orientation_(-)90	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	57.3	$0.12	$0.80	$1,311,468	$9,551	$1,321,018	11,123,560	11,895	10,236.1		
Passive Solar Shade Devices (2) 4.75 90 P SP_Orientation_(-)45	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	55.3	$0.12	$0.80	$1,264,357	$9,772	$1,274,129	10,723,980	12,171	9,806.8		
Passive Solar Shade Devices (2) 4.75 90 P SP_Orientation_(+)180	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.8	$0.12	$0.80	$1,196,611	$11,845	$1,208,456	10,149,370	14,753	9,202.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Orientation_(+)135	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	55.3	$0.12	$0.80	$1,262,685	$10,223	$1,272,908	10,709,800	12,732	9,794.8		
Passive Solar Shade Devices (2) 4.75 90 P SP_Orientation_(+)90	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	57.5	$0.12	$0.80	$1,316,993	$9,606	$1,326,598	11,170,420	11,963	10,287.0		
Passive Solar Shade Devices (2) 4.75 90 P SP_Orientation_(+)45	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	56.5	$0.12	$0.80	$1,289,877	$10,191	$1,300,068	10,940,430	12,693	10,043.2		
Passive Solar Shade Devices (2) 4.75 90 P SP_OccSens_ON	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	51.1	$0.12	$0.80	$1,157,695	$11,404	$1,169,099	9,819,297	14,203	8,843.2		
Passive Solar Shade Devices (2) 4.75 90 P SP_OccSens_No_Change	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,889	$10,661	$1,214,549	10,211,100	13,277	9,260.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_BaseRun_w/DC_No_Change	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,889	$10,661	$1,214,549	10,211,100	13,277	9,260.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_R-60_continuous_Ins_Roof	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,204,433	$10,574	$1,215,008	10,215,720	13,170	9,264.6		
Passive Solar Shade Devices (2) 4.75 90 P SP_Uninsulated_framed_Wall	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	54.6	$0.12	$0.80	$1,221,723	$16,011	$1,237,734	10,362,370	19,940	9,462.0		
Passive Solar Shade Devices (2) 4.75 90 P SP_Quad_Kryp_Clear_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,184,164	$11,129	$1,195,293	10,043,800	13,861	9,083.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Dbl_LowE_HP_Window_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,184,164	$11,129	$1,195,293	10,043,800	13,861	9,083.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Triple_LowE_film_Window_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,184,164	$11,129	$1,195,293	10,043,800	13,861	9,083.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Single_Low_Iron_Window_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,184,164	$11,129	$1,195,293	10,043,800	13,861	9,083.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,170,906	$6,404	$1,177,310	9,931,349	7,976	8,927.9		
Passive Solar Shade Devices (2) 4.75 90 P SP_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,715.7		
Passive Solar Shade Devices (2) 4.75 90 P SP_Triple_LowE_film_Skylight_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	49.9	$0.12	$0.80	$1,151,259	$6,442	$1,157,700	9,764,704	8,023	8,748.5		
Passive Solar Shade Devices (2) 4.75 90 P SP_Single_Low_Iron_Skylight_w/DC	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	53.0	$0.12	$0.80	$1,208,526	$10,248	$1,218,774	10,250,430	12,764	9,299.7		
Passive Solar Shade Devices (2) 4.75 90 P SP_BaseRun_w/DC_ON	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,184,164	$11,129	$1,195,293	10,043,800	13,861	9,083.3		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1]			Total Annual Energy [1]			Compare	Potential Energy Savings
							Electric	Fuel	Energy	Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)		
Passive Solar Shade Devices (2) 4.75 90 P SP_Quad_Kryp_Clear_Window	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,889	$10,661	$1,214,549	10,211,100	13,277	9,260.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Dbl_LowE_HP_Window	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,889	$10,661	$1,214,549	10,211,100	13,277	9,260.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Triple_LowE_film_Window	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,889	$10,661	$1,214,549	10,211,100	13,277	9,260.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Single_Low_Iron_Window	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,889	$10,661	$1,214,549	10,211,100	13,277	9,260.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Quad_Kryp_Clear_Skylight	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,189,770	$6,374	$1,196,144	10,091,350	7,939	9,100.2		
Passive Solar Shade Devices (2) 4.75 90 P SP_Dbl_LowE_HP_Skylight	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,884.3		
Passive Solar Shade Devices (2) 4.75 90 P SP_Triple_LowE_film_Skylight	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,674	$6,441	$1,169,115	9,861,529	8,022	8,852.9		
Passive Solar Shade Devices (2) 4.75 90 P SP_Single_Low_Iron_Skylight	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	54.0	$0.12	$0.80	$1,232,840	$9,690	$1,242,530	10,456,660	12,069	9,518.0		
Passive Solar Shade Devices (2) 4.75 90 P SP_R-44_framed_Wall	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.7	$0.12	$0.80	$1,202,127	$10,155	$1,212,282	10,196,160	12,647	9,240.5		
Passive Solar Shade Devices (2) 4.75 90 P SP_Uninsulated_framed_Roof	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	53.6	$0.12	$0.80	$1,201,670	$15,023	$1,216,693	10,192,280	18,710	9,271.5		
Passive Solar Shade Devices (2) 4.75 90 P SP_Infiltration_3.5_ACH	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	57.7	$0.12	$0.80	$1,243,783	$27,955	$1,271,738	10,549,470	34,817	9,750.0		
Passive Solar Shade Devices (2) 4.75 90 P SP_Infiltration_0.17_ACH	5/26/2014 3:01 PM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,203,814	$10,837	$1,214,652	10,210,470	13,497	9,260.9		

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Actions ▾ Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Parametric Solar Shade Device 3.5 30 Percent S.P Glass	5/26/2014 3:21 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,507	$6,910	$1,168,417	9,851,628	8,606	8,910.0		
Alternate Run(s) of Parametric Solar Shade Device 3.5 30 Percent S.P Glass														
Parametric Solar Shade Device 3.5 90 Percent S.P._Lighting_1.3_W/sqft	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	53.8	$0.12	$0.80	$1,240,841	$6,800	$1,247,641	10,524,520	8,469	9,634.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Lighting_0.48_W/sqft	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	41.5	$0.12	$0.80	$943,327	$8,619	$951,946	8,001,079	10,734	6,927.0		
Parametric Solar Shade Device 3.5 90 Percent S.P._PlugLoad_2.60_W/sqft	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	72.1	$0.12	$0.80	$1,675,647	$6,374	$1,682,021	14,212,440	7,939	13,608.1		
Parametric Solar Shade Device 3.5 90 Percent S.P._PlugLoad_0.78_W/sqft	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	44.1	$0.12	$0.80	$1,009,079	$7,557	$1,016,635	8,558,766	9,412	7,520.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Orientation_(-)135	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,168,474	$7,334	$1,175,808	9,910,719	9,134	8,976.8		
Parametric Solar Shade Device 3.5 90 Percent S.P._Orientation_(-)90	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,172,865	$7,114	$1,179,979	9,947,967	8,860	9,015.4		
Parametric Solar Shade Device 3.5 90 Percent S.P._Orientation_(-)45	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,166,594	$7,045	$1,173,639	9,894,777	8,774	8,957.5		
Parametric Solar Shade Device 3.5 90 Percent S.P._Orientation_(+)180	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,160,613	$7,384	$1,167,997	9,844,048	9,196	8,905.3		
Parametric Solar Shade Device 3.5 90 Percent S.P._Orientation_(+)135	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,164,495	$7,178	$1,171,674	9,876,975	8,940	8,939.3		
Parametric Solar Shade Device 3.5 90 Percent S.P._Orientation_(+)90	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,167,957	$7,101	$1,175,058	9,906,337	8,844	8,970.4		
Parametric Solar Shade Device 3.5 90 Percent S.P._Orientation_(+)45	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,167,664	$6,944	$1,174,608	9,903,851	8,649	8,966.6		
Parametric Solar Shade Device 3.5 90 Percent S.P._OccSens_ON	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	48.6	$0.12	$0.80	$1,117,759	$7,075	$1,124,834	9,480,568	8,811	8,511.1		
Parametric Solar Shade Device 3.5 90 Percent S.P._OccSens_No_Change	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,461	$6,968	$1,168,429	9,851,237	8,679	8,910.0		
Parametric Solar Shade Device 3.5 90 Percent S.P._BaseRun_w/DC_No_Change	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,461	$6,968	$1,168,429	9,851,237	8,679	8,910.0		
Parametric Solar Shade Device 3.5 90 Percent S.P._R-60_continuous_Ins_Roof	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,178	$6,880	$1,169,057	9,857,316	8,568	8,915.9		
Parametric Solar Shade Device 3.5 90 Percent S.P._Uninsulated_framed_Wall	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	52.4	$0.12	$0.80	$1,178,296	$14,006	$1,192,303	9,994,031	17,444	9,114.8		
Parametric Solar Shade Device 3.5 90 Percent S.P._Quad_Kryp_Clear_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,152,516	$7,038	$1,159,554	9,775,371	8,765	8,828.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Dbl_LowE_HP_Window_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,152,516	$7,038	$1,159,554	9,775,371	8,765	8,828.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Triple_LowE_film_Window_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,152,516	$7,038	$1,159,554	9,775,371	8,765	8,828.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Single_Low_Iron_Window_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,152,516	$7,038	$1,159,554	9,775,371	8,765	8,828.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,155,741	$6,403	$1,162,144	9,802,721	7,975	8,853.6		
Parametric Solar Shade Device 3.5 90 Percent S.P._Dbl_LowE_HP_Skylight_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,149,916	$6,411	$1,156,328	9,753,320	7,985	8,800.4		
Parametric Solar Shade Device 3.5 90 Percent S.P._Triple_LowE_film_Skylight_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,154,502	$6,411	$1,160,914	9,792,217	7,985	8,842.3		
Parametric Solar Shade Device 3.5 90 Percent S.P._Single_Low_Iron_Skylight_w/DC	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,153,950	$6,846	$1,160,796	9,787,535	8,526	8,840.4		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Potential Energy Savings
Parametric Solar Shade Device 3.5 90 Percent S.P._BaseRun_w/DC_ON	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,152,516	$7,038	$1,159,554	9,775,371	8,765	8,828.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Quad_Kryp_Clear_Window	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,461	$6,968	$1,168,429	9,851,237	8,679	8,910.0		
Parametric Solar Shade Device 3.5 90 Percent S.P._Dbl_LowE_HP_Window	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,461	$6,968	$1,168,429	9,851,237	8,679	8,910.0		
Parametric Solar Shade Device 3.5 90 Percent S.P._Triple_LowE_film_Window	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,461	$6,968	$1,168,429	9,851,237	8,679	8,910.0		
Parametric Solar Shade Device 3.5 90 Percent S.P._Single_Low_Iron_Window	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,461	$6,968	$1,168,429	9,851,237	8,679	8,910.0		
Parametric Solar Shade Device 3.5 90 Percent S.P._Quad_Kryp_Clear_Skylight	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,420	$6,403	$1,171,823	9,884,816	7,975	8,942.1		
Parametric Solar Shade Device 3.5 90 Percent S.P._Dbl_LowE_HP_Skylight	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,896.7		
Parametric Solar Shade Device 3.5 90 Percent S.P._Triple_LowE_film_Skylight	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,159,753	$6,411	$1,166,164	9,836,750	7,985	8,890.4		
Parametric Solar Shade Device 3.5 90 Percent S.P._Single_Low_Iron_Skylight	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,164,885	$6,754	$1,171,639	9,880,277	8,412	8,939.8		
Parametric Solar Shade Device 3.5 90 Percent S.P._R-44_framed_Wall	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,423	$6,532	$1,169,955	9,867,883	8,135	8,924.8		
Parametric Solar Shade Device 3.5 90 Percent S.P._Uninsulated_framed_Roof	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,148,260	$14,586	$1,162,846	9,739,271	18,167	8,844.3		
Parametric Solar Shade Device 3.5 90 Percent S.P._Infiltration_3.5_ACH	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	53.8	$0.12	$0.80	$1,169,232	$23,413	$1,192,645	9,917,151	29,160	9,099.9		
Parametric Solar Shade Device 3.5 90 Percent S.P._Infiltration_0.17_ACH	5/26/2014 3:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,160,457	$6,887	$1,167,344	9,842,723	8,577	8,900.2		

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My Projects > **Analysis 06**

Run List | Run Charts | Project Defaults | Project Details | Project Members | Utility Information | Weather Station

Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Parametric Solar Shade Device 2.25 90 Percent S.P. Glass	5/26/2014 3:33 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,309	$12,857	$1,174,166	9,849,949	16,012	8,951.5		
Alternate Run(s) of Parametric Solar Shade Device 2.25 90 Percent S.P. Glass														
Parametric Solar Shade Device 3.5 90 Percent S.P G_Lighting_1.3_W/sqft	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	54.6	$0.12	$0.80	$1,240,537	$11,535	$1,252,071	10,521,940	14,366	9,666.5		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Lighting_0.48_W/sqft	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	43.1	$0.12	$0.80	$940,828	$18,240	$959,068	7,979,884	22,716	6,974.0		
Parametric Solar Shade Device 3.5 90 Percent S.P G_PlugLoad_2.60_W/sqft	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	72.7	$0.12	$0.80	$1,685,880	$7,554	$1,693,434	14,299,240	9,408	13,710.5		
Parametric Solar Shade Device 3.5 90 Percent S.P G_PlugLoad_0.78_W/sqft	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	46.0	$0.12	$0.80	$1,007,413	$18,437	$1,025,850	8,544,642	22,962	7,584.3		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Orientation_(-)135	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	55.0	$0.12	$0.80	$1,248,737	$12,025	$1,260,761	10,591,490	14,976	9,745.0		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Orientation_(-)90	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	55.4	$0.12	$0.80	$1,257,142	$11,751	$1,268,893	10,662,780	14,635	9,819.9		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Orientation_(-)45	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	53.3	$0.12	$0.80	$1,207,528	$12,075	$1,219,604	10,241,970	15,039	9,368.5		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Orientation_(+)180	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,188,551	$11,997	$1,200,548	10,081,010	14,942	9,194.4		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Orientation_(+)135	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	53.1	$0.12	$0.80	$1,203,145	$11,835	$1,214,979	10,204,790	14,739	9,326.7		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Orientation_(+)90	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	53.1	$0.12	$0.80	$1,203,793	$11,836	$1,215,629	10,210,290	14,741	9,332.6		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Orientation_(+)45	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	52.4	$0.12	$0.80	$1,182,668	$12,584	$1,195,252	10,031,110	15,673	9,144.8		
Parametric Solar Shade Device 3.5 90 Percent S.P G_OccSens_ON	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,117,210	$14,026	$1,131,236	9,475,912	17,469	8,556.6		
Parametric Solar Shade Device 3.5 90 Percent S.P G_OccSens_No_Change	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,235	$12,938	$1,174,172	9,849,319	16,113	8,951.4		
Parametric Solar Shade Device 3.5 90 Percent S.P G_BaseRun_w/DC_No_Change	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,235	$12,938	$1,174,172	9,849,319	16,113	8,951.4		
Parametric Solar Shade Device 3.5 90 Percent S.P G_R-60_continuous_Ins_Roof	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,946	$12,804	$1,174,751	9,855,354	15,947	8,956.9		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Uninsulated_framed_Wall	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	53.1	$0.12	$0.80	$1,179,206	$17,456	$1,196,662	10,001,750	21,740	9,148.3		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Quad_Kryp_Clear_w/DC	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,142,846	$13,721	$1,156,567	9,693,349	17,089	8,788.8		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Dbl_LowE_HP_Window_w/DC	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,142,846	$13,721	$1,156,567	9,693,349	17,089	8,788.8		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Triple_LowE_film_Window_w/DC	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,142,846	$13,721	$1,156,567	9,693,349	17,089	8,788.8		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Single_Low_Iron_Window_w/DC	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,142,846	$13,721	$1,156,567	9,693,349	17,089	8,788.8		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,148,833	$6,403	$1,155,236	9,744,128	7,975	8,790.7		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,139,201	$6,471	$1,145,672	9,662,437	8,059	8,703.1		
	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	49.6	$0.12	$0.80	$1,144,920	$6,442	$1,151,362	9,710,944	8,023	8,755.2		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1]			Total Annual Energy [1]			Compare	Potential Energy Savings
							Electric	Fuel	Energy	Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Triple_LowE_film_Skylight_w/DC														
Parametric Solar Shade Device 3.5 90 Percent S.P G_Single_Low_Iron_Skylight_w/DC	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,146,083	$13,185	$1,159,268	9,720,805	16,421	8,814.6		
Parametric Solar Shade Device 3.5 90 Percent S.P G_BaseRun_w/DC_ON	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,142,846	$13,721	$1,156,567	9,693,349	17,089	8,788.8		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Quad_Kryp_Clear_Window	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,235	$12,938	$1,174,172	9,849,319	16,113	8,951.4		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Dbl_LowE_HP_Window	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,235	$12,938	$1,174,172	9,849,319	16,113	8,951.4		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Triple_LowE_film_Window	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,235	$12,938	$1,174,172	9,849,319	16,113	8,951.4		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Single_Low_Iron_Window	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,161,235	$12,938	$1,174,172	9,849,319	16,113	8,951.4		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Quad_Kryp_Clear_Skylight	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,167,130	$6,403	$1,173,533	9,899,320	7,975	8,958.1		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Dbl_LowE_HP_Skylight	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,355	$6,441	$1,163,796	9,816,414	8,022	8,869.0		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Triple_LowE_film_Skylight	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,274	$6,441	$1,162,715	9,807,245	8,022	8,859.1		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Single_Low_Iron_Skylight	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.7	$0.12	$0.80	$1,168,093	$12,465	$1,180,557	9,907,486	15,524	9,010.7		
Parametric Solar Shade Device 3.5 90 Percent S.P G_R-44_framed_Wall	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,161,301	$12,523	$1,173,824	9,849,884	15,597	8,949.0		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Uninsulated_framed_Roof	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,156,321	$17,788	$1,174,110	9,807,646	22,155	8,941.5		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Infiltration_3.5_ACH	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	56.4	$0.12	$0.80	$1,191,219	$32,629	$1,223,848	10,103,640	40,638	9,367.8		
Parametric Solar Shade Device 3.5 90 Percent S.P G_Infiltration_0.17_ACH	5/26/2014 3:34 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,160,719	$13,228	$1,173,946	9,844,942	16,474	8,948.7		

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Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Fuel	Energy	Total Annual Energy [1] Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
30 Percent H.P. Glass	5/26/2014 10:08 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,165	$6,404	$1,174,568	9,908,097	7,975	8,957.1		
Alternate Run(s) of 30 Percent H.P. Glass														
Analysis 2 Existing Building_Lighting_1.3_W/sqft	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	54.0	$0.12	$0.80	$1,248,091	$6,404	$1,254,494	10,586,010	7,975	9,688.1		
Analysis 2 Existing Building_Lighting_0.48_W/sqft	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	41.5	$0.12	$0.80	$949,589	$6,927	$956,516	8,054,190	8,627	6,962.0		
Analysis 2 Existing Building_PlugLoad_2.60_W/sqft	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	72.6	$0.12	$0.80	$1,688,120	$6,374	$1,694,495	14,318,240	7,939	13,712.0		
Analysis 2 Existing Building_PlugLoad_0.78_W/sqft	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	44.1	$0.12	$0.80	$1,014,453	$6,411	$1,020,864	8,604,349	7,985	7,551.5		
Analysis 2 Existing Building_Orientation_(-) 135	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,170,101	$6,411	$1,176,512	9,924,518	7,985	8,974.9		
Analysis 2 Existing Building_Orientation_(-) 90	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,170,879	$6,404	$1,177,283	9,931,116	7,976	8,982.0		
Analysis 2 Existing Building_Orientation_(-) 45	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,469	$6,404	$1,174,873	9,910,682	7,976	8,959.9		
Analysis 2 Existing Building_Orientation_ (+)180	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,529	$6,411	$1,171,940	9,885,741	7,985	8,933.1		
Analysis 2 Existing Building_Orientation_ (+)135	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,167,662	$6,411	$1,174,074	9,903,838	7,985	8,952.6		
Analysis 2 Existing Building_Orientation_ (+)90	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,170,281	$6,411	$1,176,692	9,926,044	7,985	8,976.5		
Analysis 2 Existing Building_Orientation_ (+)45	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,171,931	$6,404	$1,178,335	9,940,041	7,976	8,991.6		
Analysis 2 Existing Building_OccSens_ON	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	48.8	$0.12	$0.80	$1,124,183	$6,411	$1,130,595	9,535,058	7,985	8,555.0		
Analysis 2 Existing Building_OccSens_No_Change	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,956.8		
Analysis 2 Existing Building_BaseRun_w/DC_No_Change	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,956.8		
Analysis 2 Existing Building_R-60_continuous_Ins_Roof	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,936	$6,404	$1,175,339	9,914,638	7,975	8,964.2		
Analysis 2 Existing Building_Uninsulated_framed_Wall	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,184,498	$13,229	$1,197,727	10,046,630	16,476	9,155.8		
Analysis 2 Existing Building_Quad_Kryp_Clear_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,461	$6,404	$1,163,864	9,817,308	7,976	8,859.2		
Analysis 2 Existing Building_Dbl_LowE_HP_Window_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,461	$6,404	$1,163,864	9,817,308	7,976	8,859.2		
Analysis 2 Existing Building_Triple_LowE_film_Window_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,461	$6,404	$1,163,864	9,817,308	7,976	8,859.2		
Analysis 2 Existing Building_Single_Low_Iron_Window_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,461	$6,404	$1,163,864	9,817,308	7,976	8,859.2		
Analysis 2 Existing Building_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.8	$0.12	$0.80	$1,173,607	$6,374	$1,179,981	9,954,256	7,939	9,006.7		
Analysis 2 Existing Building_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,461	$6,404	$1,163,864	9,817,308	7,976	8,859.2		
Analysis 2 Existing Building_Triple_LowE_film_Skylight_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,538	$6,411	$1,166,949	9,843,411	7,985	8,887.4		
Analysis 2 Existing Building_Single_Low_Iron_Skylight_w/DC	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	52.0	$0.12	$0.80	$1,199,608	$6,548	$1,206,156	10,174,790	8,155	9,245.7		
Analysis 2 Existing Building_BaseRun_w/DC_ON	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,461	$6,404	$1,163,864	9,817,308	7,976	8,859.2		
Analysis 2 Existing Building_Quad_Kryp_Clear_Window	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,956.8		
Analysis 2 Existing Building_Dbl_LowE_HP_Window	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,956.8		
Analysis 2 Existing Building_Triple_LowE_film_Window	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,956.8		
Analysis 2 Existing Building_Single_Low_Iron_Window	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,956.8		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Fuel	Energy	Total Annual Energy [1] Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
Analysis 2 Existing Building_Quad_Kryp_Clear_Skylight	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,183,664	$6,374	$1,190,038	10,039,560	7,939	9,098.7		
Analysis 2 Existing Building_Dbl_LowE_HP_Skylight	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,124	$6,404	$1,174,527	9,907,749	7,975	8,956.8		
Analysis 2 Existing Building_Triple_LowE_film_Skylight	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,793	$6,404	$1,172,197	9,887,980	7,975	8,935.4		
Analysis 2 Existing Building_Single_Low_Iron_Skylight	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	52.4	$0.12	$0.80	$1,210,911	$6,515	$1,217,426	10,270,660	8,114	9,348.9		
Analysis 2 Existing Building_R-44_framed_Wall	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,170,411	$6,403	$1,176,814	9,927,149	7,975	8,977.7		
Analysis 2 Existing Building_Uninsulated_framed_Roof	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	51.0	$0.12	$0.80	$1,158,253	$10,575	$1,168,828	9,824,027	13,171	8,896.6		
Analysis 2 Existing Building_Infiltration_3.5_ACH	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	52.9	$0.12	$0.80	$1,168,480	$19,117	$1,187,598	9,910,774	23,810	9,051.9		
Analysis 2 Existing Building_Infiltration_0.17_ACH	5/26/2014 10:09 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,166,865	$6,404	$1,173,269	9,897,074	7,975	8,945.2		

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Version 2015.1.33.1393 (DOE-2.2-48r)

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Run List | Run Charts | Project Defaults | Project Details | Project Members | Utility Information | Weather Station

Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
90 Percent H.P. Glass	5/26/2014 10:18 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,575	$6,444	$1,194,018	10,072,730	8,025	9,105.5		
Alternate Run(s) of 90 Percent H.P. Glass														
90 P H.P. Glass_Lighting_1.3_W/sqft	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	54.9	$0.12	$0.80	$1,268,472	$6,405	$1,274,877	10,758,880	7,977	9,845.0		
90 P H.P. Glass_Lighting_0.48_W/sqft	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	42.2	$0.12	$0.80	$966,861	$7,127	$973,988	8,200,688	8,876	7,091.9		
90 P H.P. Glass_PlugLoad_2.60_W/sqft	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	74.1	$0.12	$0.80	$1,723,519	$6,374	$1,729,893	14,618,480	7,939	14,006.3		
90 P H.P. Glass_PlugLoad_0.78_W/sqft	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	44.9	$0.12	$0.80	$1,031,589	$6,612	$1,038,200	8,749,692	8,235	7,680.2		
90 P H.P. Glass_Orientation_(-)135	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,205,052	$6,447	$1,211,499	10,220,970	8,029	9,265.3		
90 P H.P. Glass_Orientation_(-)90	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	52.7	$0.12	$0.80	$1,217,203	$6,449	$1,223,652	10,324,030	8,032	9,376.5		
90 P H.P. Glass_Orientation_(-)45	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	52.3	$0.12	$0.80	$1,208,126	$6,448	$1,214,574	10,247,040	8,030	9,293.5		
90 P H.P. Glass_Orientation_(+)180	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,186,770	$6,444	$1,193,214	10,065,900	8,026	9,098.1		
90 P H.P. Glass_Orientation_(+)135	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	52.3	$0.12	$0.80	$1,207,159	$6,448	$1,213,607	10,238,840	8,030	9,284.6		
90 P H.P. Glass_Orientation_(+)90	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	52.7	$0.12	$0.80	$1,217,942	$6,449	$1,224,392	10,330,300	8,032	9,383.2		
90 P H.P. Glass_Orientation_(+)45	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	52.3	$0.12	$0.80	$1,208,230	$6,447	$1,214,677	10,247,920	8,030	9,294.4		
90 P H.P. Glass_OccSens_ON	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	49.6	$0.12	$0.80	$1,143,025	$6,445	$1,149,470	9,694,870	8,027	8,698.1		
90 P H.P. Glass_OccSens_No_Change	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	9,105.0		
90 P H.P. Glass_BaseRun_w/DC_No_Change	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	9,105.0		
90 P H.P. Glass_R-60_continuous_Ins_Roof	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,188,294	$6,444	$1,194,738	10,078,830	8,025	9,112.1		
90 P H.P. Glass_Uninsulated_framed_Wall	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	53.5	$0.12	$0.80	$1,206,277	$13,369	$1,219,647	10,231,360	16,651	9,326.6		
90 P H.P. Glass_Quad_Kryp_Clear_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,769	$6,444	$1,175,213	9,913,220	8,026	8,933.5		
90 P H.P. Glass_Dbl_LowE_HP_Window_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,769	$6,444	$1,175,213	9,913,220	8,026	8,933.5		
90 P H.P. Glass_Triple_LowE_film_Window_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,769	$6,444	$1,175,213	9,913,220	8,026	8,933.5		
90 P H.P. Glass_Single_Low_Iron_Window_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,769	$6,444	$1,175,213	9,913,220	8,026	8,933.5		
90 P H.P. Glass_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,211,987	$6,374	$1,218,361	10,279,790	7,939	9,328.2		
90 P H.P. Glass_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,769	$6,444	$1,175,213	9,913,220	8,026	8,933.5		
90 P H.P. Glass_Triple_LowE_film_Skylight_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,945	$6,443	$1,172,388	9,889,272	8,025	8,907.7		
90 P H.P. Glass_Single_Low_Iron_Skylight_w/DC	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	58.5	$0.12	$0.80	$1,342,320	$9,322	$1,351,642	11,385,240	11,610	10,541.5		
90 P H.P. Glass_BaseRun_w/DC_ON	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,168,769	$6,444	$1,175,213	9,913,220	8,026	8,933.5		
90 P H.P. Glass_Quad_Kryp_Clear_Window	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	9,105.0		
90 P H.P. Glass_Dbl_LowE_HP_Window	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	9,105.0		
90 P H.P. Glass_Triple_LowE_film_Window	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	9,105.0		
		tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	9,105.0		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
90 P H.P. Glass_Single_Low_Iron_Window	5/26/2014 10:19 AM													
90 P H.P. Glass_Quad_Kryp_Clear_Skylight	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	53.3	$0.12	$0.80	$1,232,290	$6,374	$1,238,664	10,451,990	7,939	9,513.9		
90 P H.P. Glass_Dbl_LowE_HP_Skylight	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,187,522	$6,444	$1,193,965	10,072,280	8,025	9,105.0		
90 P H.P. Glass_Triple_LowE_film_Skylight	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.0	$0.12	$0.80	$1,177,739	$6,443	$1,184,182	9,989,307	8,024	9,015.5		
90 P H.P. Glass_Single_Low_Iron_Skylight	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	59.5	$0.12	$0.80	$1,366,691	$8,944	$1,375,635	11,591,950	11,140	10,761.6		
90 P H.P. Glass_R-44_framed_Wall	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,188,100	$6,405	$1,194,504	10,077,180	7,977	9,110.0		
90 P H.P. Glass_Uninsulated_framed_Roof	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.8	$0.12	$0.80	$1,181,252	$9,798	$1,191,049	10,019,100	12,202	9,071.9		
90 P H.P. Glass_Infiltration_3.5_ACH	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	54.5	$0.12	$0.80	$1,201,978	$19,746	$1,221,724	10,194,890	24,593	9,333.3		
90 P H.P. Glass_Infiltration_0.17_ACH	5/26/2014 10:19 AM	tpshorey@rrmdesign.com	683,670	51.4	$0.12	$0.80	$1,186,543	$6,444	$1,192,987	10,063,980	8,025	9,096.1		

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Actions ▾

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates														Weather Data: GBS_04R20_049116
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Passive Solar Shade Devices 3.5 30 Percent H.P. Glass	5/26/2014 11:16 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,756	$6,404	$1,170,160	9,870,703	7,975	8,923.5		
Alternate Run(s) of Passive Solar Shade Devices 3.5 30 Percent H.P. Glass														
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Lighting_1.3_W/sqft	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	53.8	$0.12	$0.80	$1,243,533	$6,404	$1,249,936	10,547,350	7,975	9,653.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Lighting_0.48_W/sqft	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	41.3	$0.12	$0.80	$945,679	$6,985	$952,664	8,021,028	8,699	6,933.3		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_PlugLoad_2.60_W/sqft	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	72.2	$0.12	$0.80	$1,678,380	$6,374	$1,684,754	14,235,620	7,939	13,629.7		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_PlugLoad_0.78_W/sqft	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	43.9	$0.12	$0.80	$1,010,192	$6,412	$1,016,604	8,568,213	7,985	7,519.2		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Orientation_(-)135	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,340	$6,411	$1,168,751	9,858,696	7,985	8,910.6		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Orientation_(-)90	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,893	$6,404	$1,170,297	9,871,868	7,975	8,924.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Orientation_(-)45	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,164,245	$6,411	$1,170,656	9,874,848	7,985	8,928.0		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Orientation_(+)180	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,161,805	$6,411	$1,168,216	9,854,153	7,985	8,905.7		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Orientation_(+)135	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,345	$6,411	$1,169,756	9,867,216	7,985	8,919.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Orientation_(+)90	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,164,736	$6,411	$1,171,147	9,879,015	7,985	8,932.5		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Orientation_(+)45	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,052	$6,404	$1,171,455	9,881,693	7,976	8,935.4		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_OccSens_ON	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	48.6	$0.12	$0.80	$1,119,981	$6,411	$1,126,393	9,499,416	7,985	8,523.2		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_OccSens_No_Change	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,923.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_BaseRun_w/DC_No_Change	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,923.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_R-60_continuous_Ins_Roof	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,164,518	$6,404	$1,170,922	9,877,171	7,975	8,930.5		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Uninsulated_framed_Wall	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	52.3	$0.12	$0.80	$1,179,449	$13,250	$1,192,700	10,003,810	16,503	9,116.5		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Quad_Kryp_Clear_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,175	$6,411	$1,159,586	9,780,957	7,985	8,826.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Dbl_LowE_HP_Window_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,175	$6,411	$1,159,586	9,780,957	7,985	8,826.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Triple_LowE_film_Window_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,175	$6,411	$1,159,586	9,780,957	7,985	8,826.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Single_Low_Iron_Window_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,175	$6,411	$1,159,586	9,780,957	7,985	8,826.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,161,680	$6,403	$1,168,084	9,853,100	7,975	8,904.5		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,175	$6,411	$1,159,586	9,780,957	7,985	8,826.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Triple_LowE_film_Skylight_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,214	$6,411	$1,163,625	9,815,215	7,985	8,863.7		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Single_Low_Iron_Skylight_w/DC	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,164,959	$6,749	$1,171,708	9,880,908	8,406	8,937.0		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_BaseRun_w/DC_ON	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,175	$6,411	$1,159,586	9,780,957	7,985	8,826.8		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Quad_Kryp_Clear_Window	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,923.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Dbl_LowE_HP_Window	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,923.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Triple_LowE_film_Window	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,923.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Single_Low_Iron_Window	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,923.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Quad_Kryp_Clear_Skylight	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,171,361	$6,374	$1,177,735	9,935,208	7,939	8,992.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Dbl_LowE_HP_Skylight	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,715	$6,404	$1,170,119	9,870,360	7,975	8,923.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Triple_LowE_film_Skylight	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,467	$6,411	$1,168,878	9,859,770	7,985	8,911.8		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Single_Low_Iron_Skylight	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	51.0	$0.12	$0.80	$1,175,923	$6,628	$1,182,551	9,973,901	8,255	9,036.4		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_R-44_framed_Wall	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,381	$6,403	$1,172,784	9,892,966	7,975	8,947.5		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Uninsulated_framed_Roof	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,150,193	$10,721	$1,160,914	9,755,666	13,352	8,830.7		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Infiltration_3.5_ACH	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	52.7	$0.12	$0.80	$1,161,846	$19,424	$1,181,270	9,854,503	24,192	9,000.1		
Passive Solar Shade Devices 3.5 30 P H.P. Galss_Infiltration_0.17_ACH	5/26/2014 11:17 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,539	$6,404	$1,168,943	9,860,386	7,975	8,912.4		

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Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Passive Solar Shade Devices (2) 4.75 90 Percent H.P. Glass	5/26/2014 11:49 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,164	$6,441	$1,172,605	9,891,132	8,022	8,942.1		
Alternate Run(s) of Passive Solar Shade Devices (2) 4.75 90 Percent H.P. Glass														
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Lighting_1.3_W/sqft	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	54.0	$0.12	$0.80	$1,246,999	$6,411	$1,253,410	10,576,750	7,985	9,681.2		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Lighting_0.48_W/sqft	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	41.4	$0.12	$0.80	$947,897	$7,214	$955,111	8,039,839	8,985	6,951.6		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_PlugLoad_2.60_W/sqft	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	72.6	$0.12	$0.80	$1,686,846	$6,374	$1,693,220	14,307,430	7,939	13,703.4		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_PlugLoad_0.78_W/sqft	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	44.1	$0.12	$0.80	$1,012,365	$6,634	$1,018,998	8,586,638	8,262	7,537.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Orientation_(-)135	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	51.1	$0.12	$0.80	$1,180,338	$6,444	$1,186,782	10,011,350	8,026	9,071.8		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Orientation_(-)90	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	51.6	$0.12	$0.80	$1,192,155	$6,446	$1,198,601	10,111,580	8,028	9,179.9		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Orientation_(-)45	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,183,066	$6,444	$1,189,511	10,034,490	8,026	9,096.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Orientation_(+)180	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,166,539	$6,442	$1,172,980	9,894,306	8,023	8,945.6		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Orientation_(+)135	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	51.2	$0.12	$0.80	$1,182,115	$6,444	$1,188,559	10,026,420	8,026	9,088.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Orientation_(+)90	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	51.7	$0.12	$0.80	$1,192,945	$6,446	$1,199,391	10,118,280	8,028	9,187.1		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Orientation_(+)45	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	51.2	$0.12	$0.80	$1,181,819	$6,444	$1,188,263	10,023,910	8,026	9,085.3		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_OccSens_ON	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	48.7	$0.12	$0.80	$1,122,107	$6,442	$1,128,549	9,517,446	8,024	8,539.2		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_OccSens_No_Change	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_BaseRun_w/DC_No_Change	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_R-60_continuous_Ins_Roof	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,166,887	$6,441	$1,173,328	9,897,259	8,022	8,948.8		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Uninsulated_framed_Wall	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,183,747	$13,368	$1,197,115	10,040,260	16,649	9,153.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Quad_Kryp_Clear_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Dbl_LowE_HP_Window_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Triple_LowE_film_Window_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Single_Low_Iron_Window_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,170,906	$6,404	$1,177,310	9,931,349	7,976	8,985.2		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Triple_LowE_film_Skylight_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	49.9	$0.12	$0.80	$1,151,259	$6,442	$1,157,700	9,764,704	8,023	8,805.8		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Single_Low_Iron_Skylight_w/DC	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	53.0	$0.12	$0.80	$1,208,526	$10,248	$1,218,774	10,250,430	12,764	9,357.1		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_BaseRun_w/DC_ON	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1]			Total Annual Energy [1]			Compare	Potential Energy Savings
							Electric	Fuel	Energy	Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Quad_Kryp_Clear_Window	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Dbl_LowE_HP_Window	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Triple_LowE_film_Window	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Single_Low_Iron_Window	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Quad_Kryp_Clear_Skylight	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,189,770	$6,374	$1,196,144	10,091,350	7,939	9,157.5		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Dbl_LowE_HP_Skylight	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Triple_LowE_film_Skylight	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,674	$6,441	$1,169,115	9,861,529	8,022	8,910.2		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Single_Low_Iron_Skylight	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	54.0	$0.12	$0.80	$1,232,840	$9,690	$1,242,530	10,456,660	12,069	9,575.4		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_R-44_framed_Wall	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,166,999	$6,404	$1,173,403	9,898,214	7,975	8,949.5		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Uninsulated_framed_Roof	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,160,075	$9,937	$1,170,012	9,839,484	12,376	8,911.7		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Infiltration_3.5_ACH	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	53.5	$0.12	$0.80	$1,175,541	$20,283	$1,195,823	9,970,658	25,261	9,127.9		
Passive Solar Shade Devices 4.75 90 P H.P. Glass_Infiltration_0.17_ACH	5/26/2014 11:50 AM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,220	$6,441	$1,171,661	9,883,124	8,022	8,933.5		

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Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates										Weather Data: GBS_04R20_049116				
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Parametric Solar Shade Device 3.5 30 Percent H.P. Glass	5/26/2014 2:20 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,492	$6,404	$1,166,896	9,843,023	7,975	8,898.6		
Alternate Run(s) of Parametric Solar Shade Device 3.5 30 Percent H.P. Glass														
Parametric Device 3.5 90 P H.P. GL_Lighting_1.3_W/sqft	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	53.7	$0.12	$0.80	$1,240,204	$6,403	$1,246,608	10,519,120	7,975	9,627.6		
Parametric Device 3.5 90 P H.P. GL_Lighting_0.48_W/sqft	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	41.2	$0.12	$0.80	$942,553	$7,059	$949,611	7,994,510	8,791	6,910.2		
Parametric Device 3.5 90 P H.P. GL_PlugLoad_2.60_W/sqft	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	72.0	$0.12	$0.80	$1,674,172	$6,374	$1,680,546	14,199,930	7,939	13,596.1		
Parametric Device 3.5 90 P H.P. GL_PlugLoad_0.78_W/sqft	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	43.8	$0.12	$0.80	$1,006,831	$6,412	$1,013,243	8,539,702	7,985	7,493.4		
Parametric Device 3.5 90 P H.P. GL_Orientation_(-)135	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,161,428	$6,411	$1,167,839	9,850,957	7,985	8,907.2		
Parametric Device 3.5 90 P H.P. GL_Orientation_(-)90	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,936	$6,404	$1,168,340	9,855,268	7,975	8,911.8		
Parametric Device 3.5 90 P H.P. GL_Orientation_(-)45	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,161,617	$6,411	$1,168,028	9,852,562	7,985	8,908.9		
Parametric Device 3.5 90 P H.P. GL_Orientation_(+)180	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,161,294	$6,411	$1,167,705	9,849,824	7,985	8,906.0		
Parametric Device 3.5 90 P H.P. GL_Orientation_(+)135	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,896	$6,411	$1,168,307	9,854,924	7,985	8,911.5		
Parametric Device 3.5 90 P H.P. GL_Orientation_(+)90	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,453	$6,411	$1,168,864	9,859,649	7,985	8,916.6		
Parametric Device 3.5 90 P H.P. GL_Orientation_(+)45	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,161,962	$6,411	$1,168,373	9,855,488	7,985	8,912.1		
Parametric Device 3.5 90 P H.P. GL_OccSens_ON	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	48.4	$0.12	$0.80	$1,116,740	$6,412	$1,123,152	9,471,927	7,985	8,498.5		
Parametric Device 3.5 90 P H.P. GL_OccSens_No_Change	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,898.2		
Parametric Device 3.5 90 P H.P. GL_BaseRun_w/DC_No_Change	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,898.2		
Parametric Device 3.5 90 P H.P. GL_R-60_continuous_Ins_Roof	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,161,248	$6,404	$1,167,652	9,849,431	7,975	8,905.5		
Parametric Device 3.5 90 P H.P. GL_Uninsulated_framed_Wall	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	52.2	$0.12	$0.80	$1,175,986	$13,309	$1,189,295	9,974,436	16,575	9,090.2		
Parametric Device 3.5 90 P H.P. GL_Quad_Kryp_Clear_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,149,916	$6,411	$1,156,328	9,753,320	7,985	8,801.9		
Parametric Device 3.5 90 P H.P. GL_Dbl_LowE_HP_Window_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,149,916	$6,411	$1,156,328	9,753,320	7,985	8,801.9		
Parametric Device 3.5 90 P H.P. GL_Triple_LowE_film_Window_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,149,916	$6,411	$1,156,328	9,753,320	7,985	8,801.9		
Parametric Device 3.5 90 P H.P. GL_Single_Low_Iron_Window_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,149,916	$6,411	$1,156,328	9,753,320	7,985	8,801.9		
Parametric Device 3.5 90 P H.P. GL_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,155,741	$6,403	$1,162,144	9,802,721	7,975	8,855.2		
Parametric Device 3.5 90 P H.P. GL_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,149,916	$6,411	$1,156,328	9,753,320	7,985	8,801.9		
Parametric Device 3.5 90 P H.P. GL_Triple_LowE_film_Skylight_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,154,502	$6,411	$1,160,914	9,792,217	7,985	8,843.9		
Parametric Device 3.5 90 P H.P. GL_Single_Low_Iron_Skylight_w/DC	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,153,950	$6,846	$1,160,796	9,787,535	8,526	8,842.0		
Parametric Device 3.5 90 P H.P. GL_BaseRun_w/DC_ON	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,149,916	$6,411	$1,156,328	9,753,320	7,985	8,801.9		
Parametric Device 3.5 90 P H.P. GL_Quad_Kryp_Clear_Window	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,898.2		
Parametric Device 3.5 90 P H.P. GL_Dbl_LowE_HP_Window	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,898.2		
		tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,898.2		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Fuel	Energy	Total Annual Energy [1] Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
Parametric Device 3.5 90 P H.P. GL_Triple_LowE_film_Window	5/26/2014 2:21 PM													
Parametric Device 3.5 90 P H.P. GL_Single_Low_Iron_Window	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,898.2		
Parametric Device 3.5 90 P H.P. GL_Quad_Kryp_Clear_Skylight	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,420	$6,403	$1,171,823	9,884,816	7,975	8,943.7		
Parametric Device 3.5 90 P H.P. GL_Dbl_LowE_HP_Skylight	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,452	$6,404	$1,166,855	9,842,679	7,975	8,898.2		
Parametric Device 3.5 90 P H.P. GL_Triple_LowE_film_Skylight	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,159,753	$6,411	$1,166,164	9,836,750	7,985	8,891.9		
Parametric Device 3.5 90 P H.P. GL_Single_Low_Iron_Skylight	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,164,885	$6,754	$1,171,639	9,880,277	8,412	8,941.3		
Parametric Device 3.5 90 P H.P. GL_R-44_framed_Wall	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,574	$6,403	$1,169,978	9,869,163	7,975	8,926.8		
Parametric Device 3.5 90 P H.P. GL_Uninsulated_framed_Roof	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,144,849	$11,263	$1,156,112	9,710,340	14,027	8,790.6		
Parametric Device 3.5 90 P H.P. GL_Infiltration_3.5_ACH	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	52.7	$0.12	$0.80	$1,159,598	$19,855	$1,179,453	9,835,436	24,728	8,987.6		
Parametric Device 3.5 90 P H.P. GL_Infiltration_0.17_ACH	5/26/2014 2:21 PM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,159,294	$6,404	$1,165,697	9,832,855	7,975	8,887.6		

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Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings (Beta)
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Parametric Solar Shade Device 2.25 90 Percent H.P. Glass	5/26/2014 1:32 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,224	$6,441	$1,162,666	9,806,823	8,022	8,866.3		
Alternate Run(s) of Parametric Solar Shade Device 2.25 90 Percent H.P. Glass														
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Lighting_1.3_W/sqft	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	53.5	$0.12	$0.80	$1,235,565	$6,412	$1,241,976	10,479,770	7,985	9,591.7		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Lighting_0.48_W/sqft	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	41.1	$0.12	$0.80	$939,067	$7,583	$946,650	7,964,947	9,444	6,888.6		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_PlugLoad_2.60_W/sqft	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	71.8	$0.12	$0.80	$1,668,687	$6,374	$1,675,061	14,153,410	7,939	13,552.4		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_PlugLoad_0.78_W/sqft	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	43.7	$0.12	$0.80	$1,003,101	$6,804	$1,009,905	8,508,068	8,474	7,468.6		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Orientation_(-)135	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,184,754	$6,445	$1,191,198	10,048,800	8,027	9,127.3		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Orientation_(-)90	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,183,520	$6,445	$1,189,965	10,038,340	8,027	9,116.0		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Orientation_(-)45	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,169,180	$6,481	$1,175,661	9,916,706	8,072	8,985.1		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Orientation_(+)180	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,746	$6,478	$1,160,224	9,785,801	8,068	8,843.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Orientation_(+)135	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	51.0	$0.12	$0.80	$1,177,487	$6,444	$1,183,931	9,987,165	8,025	9,060.8		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Orientation_(+)90	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,152,966	$6,478	$1,159,444	9,779,185	8,068	8,836.8		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Orientation_(+)45	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,980	$6,479	$1,167,459	9,847,159	8,069	8,910.1		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_OccSens_ON	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	48.3	$0.12	$0.80	$1,112,680	$6,480	$1,119,160	9,437,493	8,070	8,468.4		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_OccSens_No_Change	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_BaseRun_w/DC_No_Change	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_R-60_continuous_Ins_Roof	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,894	$6,441	$1,163,335	9,812,498	8,022	8,872.4		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Uninsulated_framed_Wall	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	52.0	$0.12	$0.80	$1,170,499	$13,420	$1,183,919	9,927,893	16,714	9,047.3		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Quad_Kryp_Clear_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Dbl_LowE_HP_Window_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Triple_LowE_film_Window_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Single_Low_Iron_Window_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.7	$0.12	$0.80	$1,146,208	$6,403	$1,152,611	9,721,864	7,975	8,774.4		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Dbl_LowE_HP_Skylight_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Triple_LowE_film_Skylight_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.6	$0.12	$0.80	$1,144,524	$6,471	$1,150,994	9,707,579	8,059	8,759.5		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Single_Low_Iron_Skylight_w/DC	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,141,182	$14,090	$1,155,272	9,679,234	17,549	8,784.0		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_BaseRun_w/DC_ON	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Potential Energy Savings
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Quad_Kryp_Clear_Window	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Dbl_LowE_HP_Window	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Triple_LowE_film_Window	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Single_Low_Iron_Window	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Quad_Kryp_Clear_Skylight	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,848	$6,403	$1,170,251	9,871,484	7,975	8,935.8		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Dbl_LowE_HP_Skylight	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Triple_LowE_film_Skylight	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,155,352	$6,441	$1,161,793	9,799,422	8,022	8,858.3		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Single_Low_Iron_Skylight	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	51.6	$0.12	$0.80	$1,162,533	$13,139	$1,175,672	9,860,329	16,364	8,972.4		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_R-44_framed_Wall	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,406	$6,411	$1,163,817	9,816,842	7,985	8,876.9		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Uninsulated_framed_Roof	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,149,007	$11,106	$1,160,113	9,745,610	13,832	8,834.0		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Infiltration_3.5_ACH	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	53.4	$0.12	$0.80	$1,164,166	$22,387	$1,186,553	9,874,180	27,882	9,054.1		
Parametr Solar Shade Device 2.25 90 P H.P. Glass_Infiltration_0.17_ACH	5/26/2014 1:33 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,155,239	$6,470	$1,161,710	9,798,466	8,059	8,857.5		

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Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Beta Potential Energy Savings
Project Default Utility Rates										Weather Data: GBS_04R20_049116				
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Passive Solar Shade D. (2) 4.75 90 Percent H.P. Glass L.S	5/26/2014 1:21 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,164	$6,441	$1,172,605	9,891,132	8,022	8,942.1		
Alternate Run(s) of Passive Solar Shade D. (2) 4.75 90 Percent H.P. Glass L.S														
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Lighting_1.3_W/sqft	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	54.0	$0.12	$0.80	$1,246,999	$6,411	$1,253,410	10,576,750	7,985	9,681.2		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Lighting_0.48_W/sqft	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	41.4	$0.12	$0.80	$947,897	$7,214	$955,111	8,039,839	8,985	6,951.6		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._PlugLoad_2.60_W/sqft	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	72.6	$0.12	$0.80	$1,686,846	$6,374	$1,693,220	14,307,430	7,939	13,703.4		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._PlugLoad_0.78_W/sqft	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	44.1	$0.12	$0.80	$1,012,365	$6,634	$1,018,998	8,586,638	8,262	7,537.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Orientation_(-)135	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	51.1	$0.12	$0.80	$1,180,338	$6,444	$1,186,782	10,011,350	8,026	9,071.8		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Orientation_(-)90	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	51.6	$0.12	$0.80	$1,192,155	$6,446	$1,198,601	10,111,580	8,028	9,179.9		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Orientation_(-)45	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,183,066	$6,444	$1,189,511	10,034,490	8,026	9,096.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Orientation_(+)180	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,166,539	$6,442	$1,172,980	9,894,306	8,023	8,945.6		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Orientation_(+)135	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	51.2	$0.12	$0.80	$1,182,115	$6,444	$1,188,559	10,026,420	8,026	9,088.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Orientation_(+)90	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	51.7	$0.12	$0.80	$1,192,945	$6,446	$1,199,391	10,118,280	8,028	9,187.1		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Orientation_(+)45	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	51.2	$0.12	$0.80	$1,181,819	$6,444	$1,188,263	10,023,910	8,026	9,085.3		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._OccSens_ON	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	48.7	$0.12	$0.80	$1,122,107	$6,442	$1,128,549	9,517,446	8,024	8,539.2		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._OccSens_No_Change	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._BaseRun_w/DC_No_Change	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._R-60_continuous_Ins_Roof	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,166,887	$6,441	$1,173,328	9,897,259	8,022	8,948.8		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Uninsulated_framed_Wall	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	52.5	$0.12	$0.80	$1,183,747	$13,368	$1,197,115	10,040,260	16,649	9,153.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Quad_Kryp_Clear_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Dbl_LowE_HP_Window_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Triple_LowE_film_Window_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Single_Low_Iron_Window_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,170,906	$6,404	$1,177,310	9,931,349	7,976	8,985.2		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Dbl_LowE_HP_Skylight_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Triple_LowE_film_Skylight_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	49.9	$0.12	$0.80	$1,151,259	$6,442	$1,157,700	9,764,704	8,023	8,805.8		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Single_Low_Iron_Skylight_w/DC	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	53.0	$0.12	$0.80	$1,208,526	$10,248	$1,218,774	10,250,430	12,764	9,357.1		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Fuel	Energy	Total Annual Energy [1] Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._BaseRun_w/DC_ON	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	49.8	$0.12	$0.80	$1,147,673	$6,442	$1,154,115	9,734,295	8,023	8,773.0		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Quad_Kryp_Clear_Window	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Dbl_LowE_HP_Window	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Triple_LowE_film_Window	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Single_Low_Iron_Window	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Quad_Kryp_Clear_Skylight	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	51.5	$0.12	$0.80	$1,189,770	$6,374	$1,196,144	10,091,350	7,939	9,157.5		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Dbl_LowE_HP_Skylight	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,166,112	$6,441	$1,172,553	9,890,688	8,022	8,941.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Triple_LowE_film_Skylight	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,162,674	$6,441	$1,169,115	9,861,529	8,022	8,910.2		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Single_Low_Iron_Skylight	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	54.0	$0.12	$0.80	$1,232,840	$9,690	$1,242,530	10,456,660	12,069	9,575.4		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._R-44_framed_Wall	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.6	$0.12	$0.80	$1,166,999	$6,404	$1,173,403	9,898,214	7,975	8,949.5		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Uninsulated_framed_Roof	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,160,075	$9,937	$1,170,012	9,839,484	12,376	8,911.7		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Infiltration_3.5_ACH	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	53.5	$0.12	$0.80	$1,175,541	$20,283	$1,195,823	9,970,658	25,261	9,127.9		
Passive Solar Shade D. (2) 4.75 90 P H.P. GL L.S._Infiltration_0.17_ACH	5/26/2014 1:22 PM	tpshorey@rrmdesign.com	683,670	50.5	$0.12	$0.80	$1,165,220	$6,441	$1,171,661	9,883,124	8,022	8,933.5		

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Run List | Run Charts | Project Defaults | Project Details | Project Members | Utility Information | Weather Station

Actions

Display Options

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Potential Energy Savings (Beta)
Project Default Utility Rates												Weather Data: GBS_04R20_049116		
Project Default Utility Rates	--	--	--	--	$0.12	$0.80	--	--	--	--	--	--		
Base Run														
Parametric Solar Shade Device 2.25 90 Percent H.P. Glass L.S	5/26/2014 1:37 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,224	$6,441	$1,162,666	9,806,823	8,022	8,866.3		
Alternate Run(s) of Parametric Solar Shade Device 2.25 90 Percent H.P. Glass L.S														
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Lighting_1.3_W/sqft	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	53.5	$0.12	$0.80	$1,235,565	$6,412	$1,241,976	10,479,770	7,985	9,591.7		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Lighting_0.48_W/sqft	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	41.1	$0.12	$0.80	$939,067	$7,583	$946,650	7,964,947	9,444	6,888.6		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._PlugLoad_2.60_W/sqft	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	71.8	$0.12	$0.80	$1,668,687	$6,374	$1,675,061	14,153,410	7,939	13,552.4		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._PlugLoad_0.78_W/sqft	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	43.7	$0.12	$0.80	$1,003,101	$6,804	$1,009,905	8,508,068	8,474	7,468.6		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Orientation_(-)135	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,184,754	$6,445	$1,191,198	10,048,800	8,027	9,127.3		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Orientation_(-)90	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	51.3	$0.12	$0.80	$1,183,520	$6,445	$1,189,965	10,038,340	8,027	9,116.0		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Orientation_(-)45	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,169,180	$6,481	$1,175,661	9,916,706	8,072	8,985.1		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Orientation_(+)180	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,153,746	$6,478	$1,160,224	9,785,801	8,068	8,843.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Orientation_(+)135	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	51.0	$0.12	$0.80	$1,177,487	$6,444	$1,183,931	9,987,165	8,025	9,060.8		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Orientation_(+)90	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.0	$0.12	$0.80	$1,152,966	$6,478	$1,159,444	9,779,185	8,068	8,836.8		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Orientation_(+)45	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.3	$0.12	$0.80	$1,160,980	$6,479	$1,167,459	9,847,159	8,069	8,910.1		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._OccSens_ON	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	48.3	$0.12	$0.80	$1,112,680	$6,480	$1,119,160	9,437,493	8,070	8,468.4		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._OccSens_No_Change	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._BaseRun_w/DC_No_Change	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._R-60_continuous_Ins_Roof	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,894	$6,441	$1,163,335	9,812,498	8,022	8,872.4		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Uninsulated_framed_Wall	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	52.0	$0.12	$0.80	$1,170,499	$13,420	$1,183,919	9,927,893	16,714	9,047.3		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Quad_Kryp_Clear_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Dbl_LowE_HP_Window_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Triple_LowE_film_Window_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Single_Low_Iron_Window_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Quad_Kryp_Clear_Skylight_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.7	$0.12	$0.80	$1,146,208	$6,403	$1,152,611	9,721,864	7,975	8,774.4		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Dbl_LowE_HP_Skylight_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Triple_LowE_film_Skylight_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.6	$0.12	$0.80	$1,144,524	$6,471	$1,150,994	9,707,579	8,059	8,759.5		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Single_Low_Iron_Skylight_w/DC	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.9	$0.12	$0.80	$1,141,182	$14,090	$1,155,272	9,679,234	17,549	8,784.0		

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Total Annual Energy [1] Carbon Emissions (tons)	Compare	Potential Energy Savings
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._BaseRun_w/DC_ON	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	49.4	$0.12	$0.80	$1,138,689	$6,478	$1,145,168	9,658,094	8,069	8,706.2		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Quad_Kryp_Clear_Window	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Dbl_LowE_HP_Window	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Triple_LowE_film_Window	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Single_Low_Iron_Window	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Quad_Kryp_Clear_Skylight	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.4	$0.12	$0.80	$1,163,848	$6,403	$1,170,251	9,871,484	7,975	8,935.8		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Dbl_LowE_HP_Skylight	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,156,173	$6,441	$1,162,614	9,806,387	8,022	8,865.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Triple_LowE_film_Skylight	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,155,352	$6,441	$1,161,793	9,799,422	8,022	8,858.3		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Single_Low_Iron_Skylight	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	51.6	$0.12	$0.80	$1,162,533	$13,139	$1,175,672	9,860,329	16,364	8,972.4		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._R-44_framed_Wall	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.2	$0.12	$0.80	$1,157,406	$6,411	$1,163,817	9,816,842	7,985	8,876.9		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Uninsulated_framed_Roof	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.7	$0.12	$0.80	$1,149,007	$11,106	$1,160,113	9,745,610	13,832	8,834.0		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Infiltration_3.5_ACH	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	53.4	$0.12	$0.80	$1,164,166	$22,387	$1,186,553	9,874,180	27,882	9,054.1		
Parametr Solar Shade Device 2.25 90 P H.P. GL L.S._Infiltration_0.17_ACH	5/26/2014 1:38 PM	tpshorey@rrmdesign.com	683,670	50.1	$0.12	$0.80	$1,155,239	$6,470	$1,161,710	9,798,466	8,059	8,857.5		

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