You and Me, Carbon Free! - Reducing Carbon Emissions in Commercial Buildings through Glazing and Louver Design Code.

Team Texas Sun Wranglers

The University of Texas at Austin

Mission Statement

This report seeks to address increasing energy demands from buildings due to extreme weather driven by climate change. As our communities continue to urbanize, we need to develop systemic solutions to transition into more sustainable city landscapes.

Members

Thomas Almendra

Thomas is a Senior double majoring in Architectural Engineering and music performance, with an emphasis on structures. Ultimately his goal is to create lasting buildings that positively impact their community and environment. As an Austin Native, he is familiar with the issues facing Austin and its energy grid, which helped contribute to this project.

Ben Claflin

Ben is a junior majoring in Architectural Engineering with a minor in History and a certificate in security studies. He has previously interned with general contractors, developing projects for renewable energy companies and semiconductor manufacturers. Additionally, he has an extensive background in international affairs and has worked with or for the U.S. Department of State for the past two years.

Sofia Leal Cavazos

Sofia is a junior majoring in Architectural Engineering with an interest in decarbonizing construction and mass-timber structural performance. She is currently an undergraduate research assistant at UT Austin's structural engineering laboratory and has worked on shear-bolt testing of composite beams and mechanical properties of cold joints in large-scale concrete beams. Additionally, she is an international student from Mexico, and integrates the passive cooling methods of her hometown city landscape into her design projects in school.

All three of us have been brought together for this project through the recommendation of one of our professors, Zoltan Nagy. We have all taken the architectural engineering design studio course, which has introduced us to many concepts in the industry and gave us the tools to analysis the systems our buildings are being built upon. We are all heavily invested in the future of building design and plan to promote environmentally conscious design moving forward.

Diversity Statement

Diversity is essential in the building science field. Buildings and structures that have stood the test of time are the basis of our understanding of past civilizations. The structures we build today will last longer than those built in the stone age and should represent our current society for generations in the future.

Despite our majors being architectural engineering, our interest and involvements lie outside building science and inform our individual academic pursuits. Sofia is co-president of the Negative Emissions Project at UT Austin, which is a student organization focused on education and outreach surrounding carbon reduction initiatives in a political and scientific scope. Thomas is heavily involved in music at UT Austin and toured the continental United States with a professional marching band in 2022. After living in Germany during high school, Ben has dedicated a significant portion of his undergraduate career to studying international affairs and national security.

Our diverse backgrounds elevate our ability to design a solution that will impact large swaths of the population and helped foster a collaborative environment. The Texas Sun Wranglers' innovative solution incentivizes commercial buildings across Austin to invest in technology that reduces building loads and carbon emissions. This project is a clear indication that diversity is beneficial to society and that differing perspectives often lead to the most impactful solutions. America should continue to advocate for and enable underrepresented students to leverage the benefits of comprehensive and representational thinking.

Background

Texas' hot climate dramatically increases the energy demands when operation buildings. Now, the independent Texan power grid is struggling to manage these excessive loads and frequently calls upon residents to reduce consumption to avoid blackouts (St. John, 2023). The impacts of global warming will radically increase building loads as weather events and weather become more extreme. To address this impending issue, it is critical that buildings are designed in an efficient, sustainable manner.

While the responsibility to achieve these climate-conscious goals lies in the hands of building owners and designers, homeowners and occupants are the ones suffering. Minimizing buildings' operating demands is crucial to reducing energy consumption and carbon altogether, benefiting taxpayers, Texas' infrastructure, and personal comfort at the same time. Wealthy, large businesses have an opportunity to lead the charge and ensure a sustainable, green future by reducing carbon output and elevating commercial building's design standards.

Ultimately, local government and policy makers shoulder the responsibility of encouraging and implementing a sustainable change across Texas. In Austin, current codes and recommendations for green building practices do not satisfy the needs of the future.

Problem Statement

Two neglected aspects of building design are building glazing and shading louvers. Building glazing controls how much of a building's façade is made of glass, and louvers are shades added to the outside of a building that prevent solar radiation gain. These two features can easily and efficiently decrease a building's operating loads and increase performance.

We looked through the resources currently available for designers in Austin, the International Energy Conservation Code (IECC) for commercial buildings, Austin green building program, and LEED building certification program. We have found that they are outdated and lack requirements for passive systems such as louvers. Our goal is to create a policy for passive building design that professionals can easily follow and quickly implement throughout Austin's building industry.

Solution

Our solution is modeled after cap-and-trade systems and seeks to amend current Austin commercial building code. The proposed changes would establish a baseline building performance through passive heat gain prevention strategies. For buildings, this will look like a maximum glazing percentage and minimum shading requirement.

Buildings that perform better than the baseline value will be eligible for a reduced energy rate prorated on performance. To account for this reduction in energy price, buildings that underperform from the baseline will have to pay a premium for the additional energy and would

be similarly prorated. This allows for an equitable distribution of energy costs that rewards and incentivizes highly efficient building envelopes and penalizes a lack of climate conscious design. We avoid the characterization of this code change as a cap-and-trade system to avoid the negative connotation any restriction tends to have in Texan private entities. Additionally, we emphasize the ability of designers and owners to build more efficiently in a way that remains financially beneficial as well as socially responsible.

To establish a baseline performance and showcase the benefits of passive solar design, we modeled a sample commercial building: 20 stories tall and 60 ft by 80 ft. Using the analytical capabilities of *Ladybug* and *RHINO*, we ran a six-month analysis from January to July, every 30 minutes, and derived an average direct sun quantity for the interior of six different building combinations spanning 30%, 50%, and 70% glazing with and without louvers for each.

Importantly, the louvers implemented in this model do not hinder visibility or internal lighting conditions. The south-facing shading strategy employs five horizontal elements with an extension of 4ft and provides shade during the hottest months when the sun is higher in the sky. This allows for much welcome sun during the cold months when the solar incident angle is reduced. Additionally, the east and west shading strategy employs 4ft wide vertical louvers on a 30-degree rotation towards the north.

As can be seen in Figure 1, direct sun hours for the period studied range from 53.3 hours to 315.6 hours, an approximately 600% increase from a shaded low glazing percentage to an unshaded high glazing percentage.

For our baseline, we averaged the performance of optimized glazing and no shading at 118.7 hours and the performance of least optimized glazing with full shading at 154.3. By averaging the two values, we settled on 135 direct sun hours which should be evaluated proportionally to the interior area of the commercial buildings that must meet the new requirement. This metric allows for some flexibility during the design process for new buildings: either increasing the level of shading elements, reducing the glazing percentage, or some combination of both.

Further, the model highlights the possible impact of our solution. When comparing shaded buildings with equivalently glazed non-shaded buildings, the unshaded building experiences more than double the direct sun than its shaded counterpart. For glazing, the shift from 30% to 50% glazing, shaded or unshaded, is drastic as well, with more than double the direct sun hours in both cases.

An additional analysis that factored into our recommended use of louvers is the direct sun hours on the building façade as this increases the temperature differential and subsequently the cooling load. As can be seen in Figure 2, the greatest impact can be seen in the south façade as it ranges from 1600 hours for the unshaded sample in our analysis and close to 200 sun hours for the equivalent shaded sample.

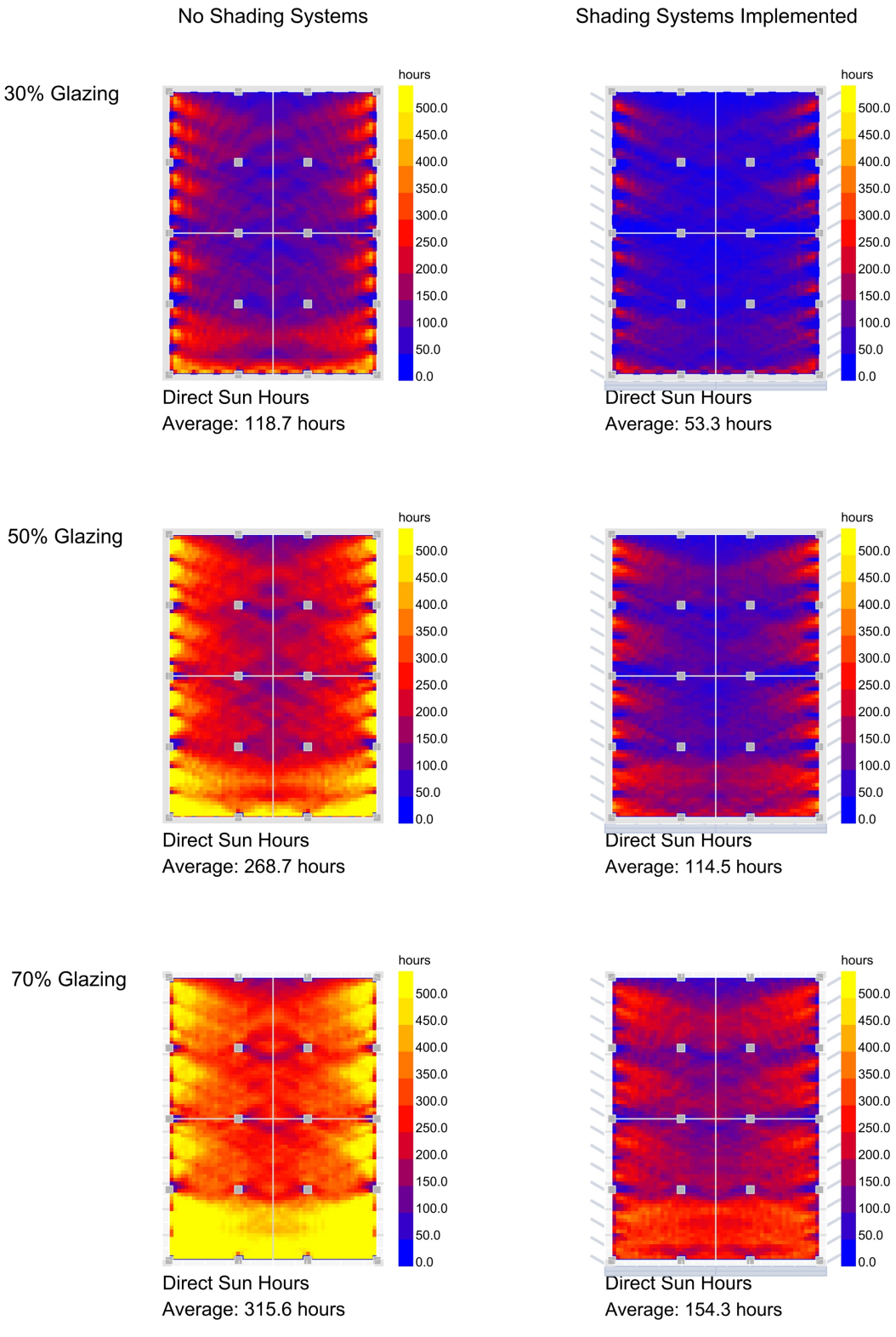

Figure 1 - Direct Sun Study Results for Six Building Iterations

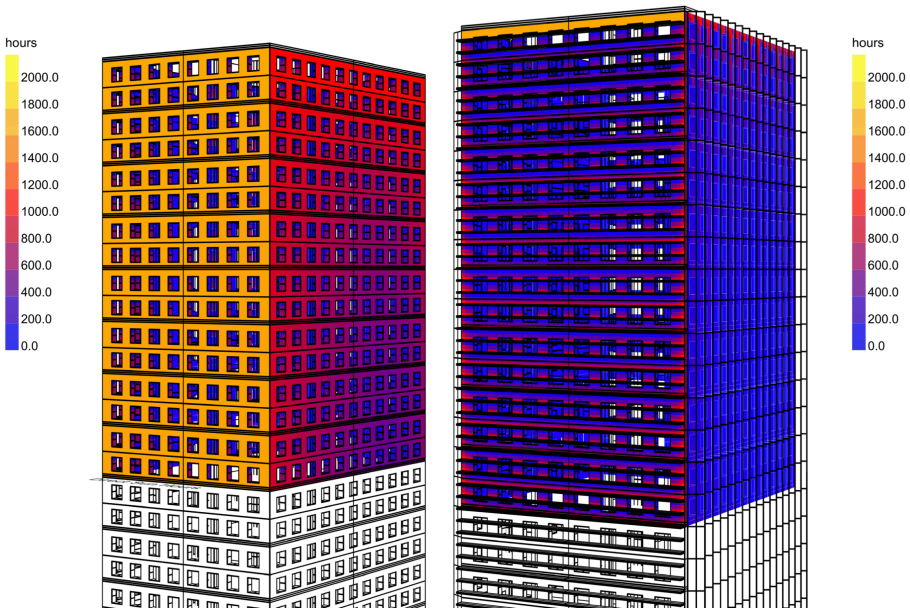

Figure 2 - Direct Sun Study Result for Building Facade

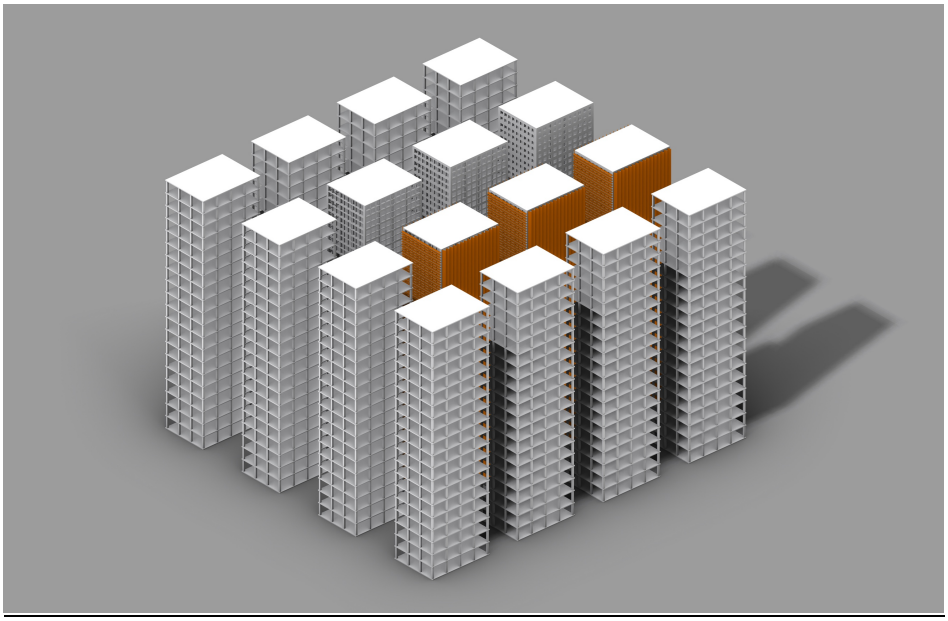

Figure 3 - RHINO Massings Used in Analysis with Shading Elements Shown in Orange

Feasibility

Our solution will primarily impact designers, and current/existing building owners. Ultimately, this effort to reduce hours of direct sun will save money on a building's operational costs.

Furthermore, it could also make the building cheaper to construct, as less solar heat gain will mean less resources can go towards cooling. The burden will be on the designers to change the way they design these types of buildings and certain aesthetics may be limited now that there is a limit on sun hours.

Technology-to-Market Plan

Analyzing Current Practices

Ultimately, we envision our policy being passed through local government, resulting in more and more buildings upholding higher levels of solar efficient design, which will contribute to its carbon output immensely. Our new policy for design includes shading to reduce solar heat gain. Because this is not something currently in our codes, we will be reaching higher levels of sustainability than our current practices.

Currently, the code used for commercial buildings in Austin is the International Energy Conservation Code (IECC). The IECC establishes standards for building envelope performance, insulation levels, HVAC systems, lighting, and other energy-related components to help reduce energy consumption in commercial buildings. It does not provide a limit on energy needs. In addition to this code, Austin has voluntary programs that prioritize giving benefits to buildings that are sustainable and financially support buildings that try to save energy and use alternative energy. Austin has their own green building program that has guidelines for designers to follow.

Our policy is fundamentally different than the systems currently set in place. First, the IECC does not mention external shading and its impact. Secondly, our policy establishes a direct negative financial consequence for buildings that don't meet our proposed code, which is not something done currently in Austin and that can improve implementation of sustainable features.

Key Stake Holders

Our solution utilizes existing infrastructure and established technology; facades that minimize solar heat gain and sun hours through shading and reduced glazing. Local governing agencies and lawmakers will advocate for our policy to reduce the strain on the Texan power grid, increase government revenue and elevate air quality.

Adoption Barrier

Integrating our policy into the design of pre-existing buildings presents a major adoption barrier. We plan to circumvent this issue by setting a minimum time to adoption, wherein existing buildings will have to pay the premium energy costs if they are not below the new baseline within 15-20 years. We recognize that phasing out of equipment and methods as performance standards are instituted will remain point of contention. To address the expected disagreement to increased energy costs, our proposed code changes would include trainings and resources emphasizing that businesses that meet a substantial threshold of profit will be expected to implement the designs while small businesses will not be expected to.

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