Spring 2024

Reimagining Comfort: Designing for Climate Resilience

Dissinger

Reimagining Comfort: Designing for Climate Resilience

Figure 0. Cover Art

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Project Intentions

I have chosen the topic of designing for climate change with the intention of acquiring knowledge about a pressing global issue that I believe warrants the attention and understanding of the design industry. As an emerging member of the professional interior design community, I sense a responsibility to familiarize myself with the current environmental issues and explore how design can play a role. While I recognize that design alone cannot rectify all the damage inflicted upon our atmosphere, I firmly believe it can assist society in adapting to the new environmental challenges we face.

This project is driven by my desire to deepen my understanding of the climate crisis and to examine various passive design strategies. I intend to analyze energy consumption in the built environment and explore solutions to curtail it. The scope of this endeavor encompasses addressing global warming and its profound repercussions on our planet while prioritizing the physical, emotional, and social well-being of its inhabitants in the built environment.

Abstract

In a world undergoing constant transformation, driven by factors like extensive CO2 emissions since the Industrial Revolution, the impacts of greenhouse gases are irreversible, necessitating innovative solutions to confront global warming. Adapting to a progressively warmer planet presents unforeseen challenges, from shifting ecosystems to heightened vulnerability to natural disasters, and rising global temperatures.

The solution lies in the creation of a harmonious structure that fuses nature and technology, fostering self-sufficiency and compassion for the climate crisis. This structure aspires to be a paragon of eco-consciousness, adorned with entirely recyclable materials and integrated green systems, promoting sustainability. In a departure from traditional construction practices, this design aims to coexist with nature, providing a nurturing habitat for vegetation.

By employing passive design strategies, the structure seeks to maximize energy conservation, fulfilling not only our physical but also our psychological and social needs. Leveraging thermal massing, it strives to seamlessly merge with its natural surroundings. As global warming looms, there arises a pressing need for structures that offer stable temperatures for comfort, a cohesive design for mental well-being, and the capability to significantly reduce energy consumption. This concept represents a proactive response to the evolving demands of our changing world.

Thesis Statement

The constructed environment can play a pivotal role in reducing human energy consumption by employing passive design strategies and optimizing a structures ability to adapt to it's environment.

Project Objective

Redefining comfort amidst a climate crisis involves prioritizing sustainability, selecting green building materials, and focusing on optimizing occupant well-being. The architecture will incorporate features enabling it to store and release thermal energy, thereby adapting to the escalating temperatures of its surroundings.

Research Objectives

- How global warming impacts our ecosystem and what the worse case scenarios are
- How the increase in temperature effects the human body
- Daylight needs for humans to sustain a healthy lifestyle
- Explore the different levels of energy consumption
- Understand thermal massing and what the best practice is for levels of massing
- Research passive design techniques

Research Techniques

- Internet and literary research and analysis
- Expert interviews
- Precedent studies

Defining Climate Change and Global Warming

What is Climate Change?

While the weather can change in just a few hours, climate changes over longer time frames. Climate change is the significant variation of average weather conditions becoming, for example, warmer, wetter, or drier over several decades or longer. It is the longer-term trend that differentiates climate change from natural weather variability.

What is Global Warming?

Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released by people burning fossil fuels. Earth's climate changed due to natural causes unrelated to human activity. These natural causes are still in play today, but their influence is too small or they occur too slowly to explain the rapid warming seen in recent decades.

What are Fossil Fuels?

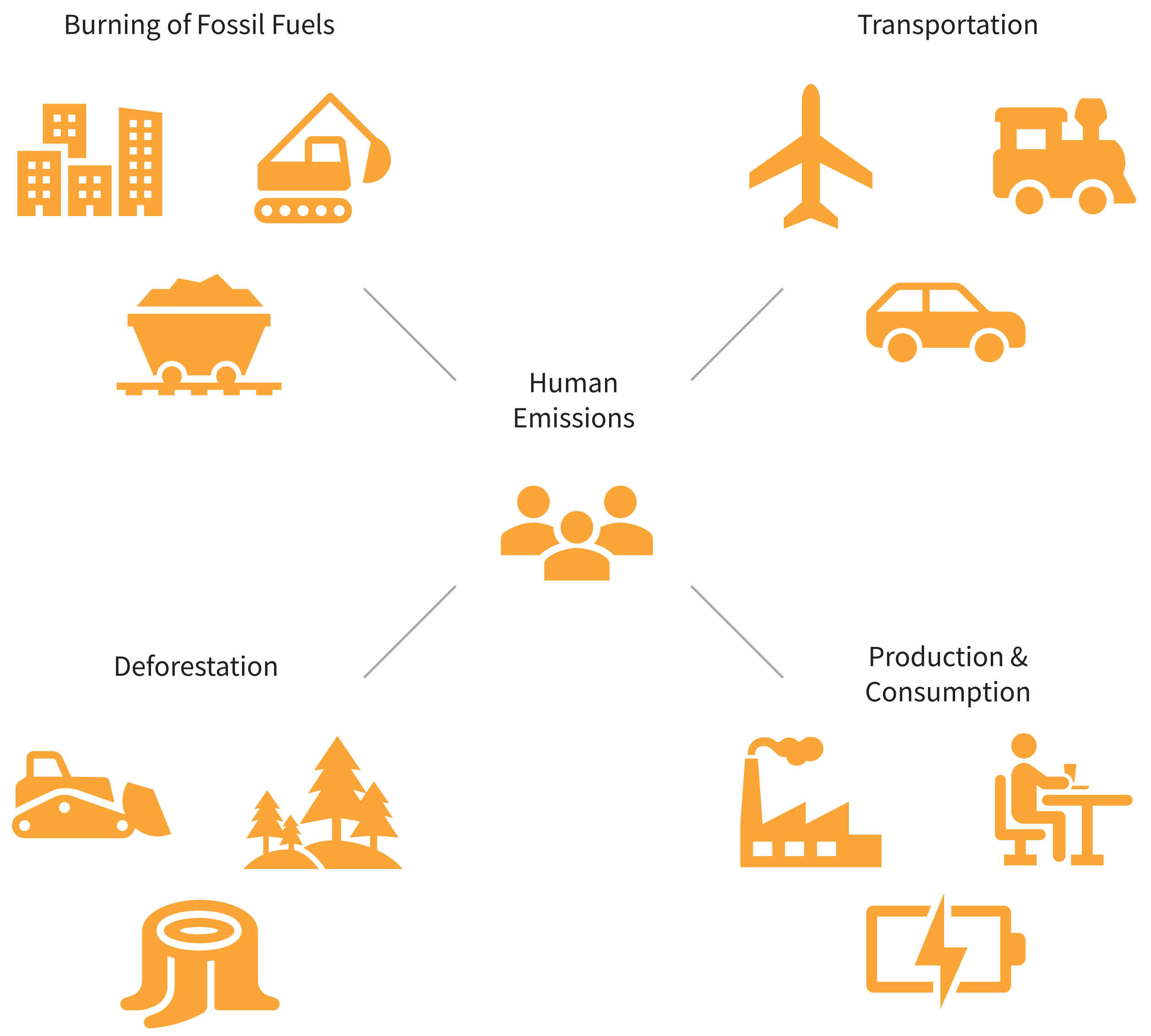
Coal, crude oil, and natural gas are all considered fossil fuels because they were formed from the fossilized, buried remains of plants and animals that lived millions of years ago. Because of their origins, fossil fuels have a high carbon content.

Figure 1. Picture of the Release of Carbon into the Atmosphere

1. Denchak, Melissa. "Fossil Fuels: The Dirty Facts." Be a Force for the Future, June 1, 2022. https://www.nrdc.org/stories/fossil-fuels-dirty-facts#sec-whatis.

Human Contribution to Global Warming:

The existing condition of our environment can be attributed to numerous factors, but one crucial aspect worth highlighting is the element within our control. Human involvement in exacerbating global warming manifests in various ways. Among these, our most significant contributions stem from the combustion of fossil fuels, our transportation systems, deforestation, and the production and consumption of goods.



Climate Change and the Increase in Global Warming

Figure 2. The Industrial Revolution

Figure 3. Persian Gulf Oil Rig

How Did We Get Here?

1750 — The Industrial Revolution created the first boom in energy consumption.

1896 — Svante Arhennius constructs the first climate model on the influence of atmospheric carbon dioxide.

1920's — Era of large-scale petroleum development begins with the opening of the Texas and Persian Gulf oil fields.

1960 — Curve developed by Charles David Keeling begins to track atmospheric CO2 concentrations.

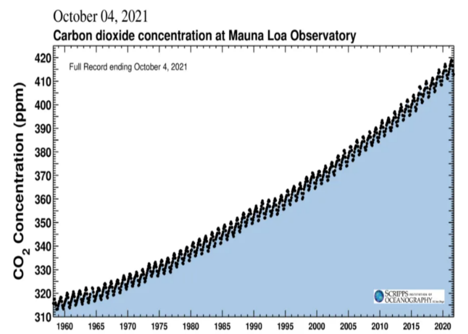


Figure 4. The Keeling Curve

1973 — The embargo caused an oil crisis, or "shock", with many short- and long-term effects on global politics and the global economy.

1990 — The first IPCC report notes pattern of past warming while signaling that future warming is likely.

1997 — The Kyoto Protocol is created with the intent to limit greenhouse gas emissions from industrialized countries. The US does not sign on.

2005 — Kyoto Protocal goes into effect. All major industrialized countries sign on except for the US.

2007 — The fourth IPCC report notes that effects of global warming are occurring.

2015 — The Paris Agreement was adopted by 196 countries at the UN Climate Change Conference in 2021 on December 15th, 2015, and put into effect November 4th, 2016.

Figure 5. The Paris Agreement

2021 — The sixth IPCC report notes that human activity has brought widespread and rapid changes to the atmosphere, hydrosphere, and biosphere.

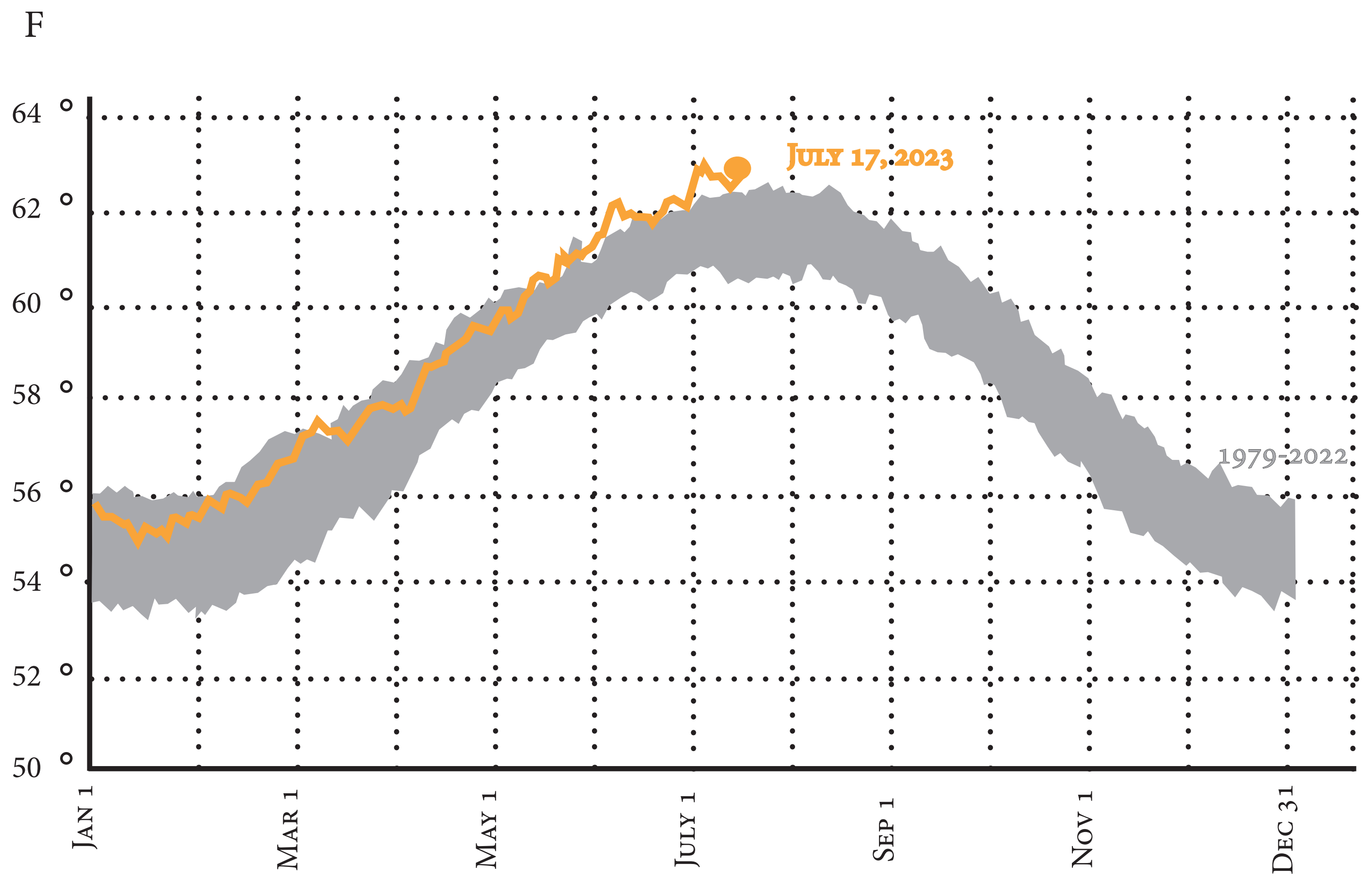
2023 — The hottest summer ever recorded swept across the world.

2. Riley, Patrick. "Timeline of Climate Change." Encyclopædia Britannica, 2021. https://www.britannica.com/story/timeline-of-climate-change.
3. "The Paris Agreement: What Is the Paris Agreement?" Unfccc.int. Accessed October 27, 2023. https://unfccc.int/process-and-meetings/the-paris-agreement.

Temperatures are on the rise!

Amidst the consequences of global warming on our climate, the noteworthy escalation in temperatures has garnered worldwide attention. In the past year alone, there has been a substantial surge in temperatures, exerting a pronounced influence on our atmospheric conditions. This surge is primarily attributable to the combustion of fossil fuels, resulting in unprecedented temperature fluctuations and the release of harmful gases into our atmosphere.

Global Surface Air Temperatures on the Rise



This new record comes as exceptional heat swept across much of the world, exacerbating deadly wildfires in Canada and Hawaii, and searing heat waves in South America, Japan, Europe, and the U.S., while likely contributing to severe rainfall in Italy, Greece, and Central Europe.

Figure 6. Global Surface Air Temperatures on the Rise

What happens when temperatures rise? A rise in toxic gases!

Formaldehyde is a common colorless, strong-smelling chemical that is a gas at room temperature. It is released mainly through industrial emissions and fuel combustion from traffic. Formaldehyde is also extensively produced industrially worldwide for use in the manufacture of resins, as a disinfectant and fixative, or as a preservative in consumer products. In the environment, it is released through biomass combustion or decomposition.

Carbon Dioxide is a colorless, odorless gas found in our atmosphere. Its chemical formula is CO_2, which means it is one carbon atom bonded to two oxygen atoms. It is a waste product in our bodies and is also produced by burning fossil fuels.

Methane is a colorless, odorless gas that occurs abundantly in nature and as a product of certain human activities. Methane is the simplest member of the paraffin series of hydrocarbons and is among the most potent of the greenhouse gases.

Nitrous Oxide, also known as "laughing gas," is the most important greenhouse gas after methane and carbon dioxide and the biggest human-related threat to the ozone layer. Nitrous oxide enhances the greenhouse effect just as carbon dioxide does by capturing re-radiated infrared radiation from the Earth's surface and subsequently warming the troposphere (lower atmosphere).

Chlorofluorocarbons are nontoxic, nonflammable chemicals containing atoms of carbon, chlorine, and fluorine. They are used in the manufacture of aerosol sprays, blowing agents for foams and packing materials, as solvents, and as refrigerants.

4. Network, The Learning. "What's Going on in This Graph? | Global Record Temperatures." The New York Times, September 7, 2023. https://www.nytimes.com/2023/09/07/learning/whats-going-on-in-this-graph-sept-13-2023.html.

What are the environmental outcomes of climate change?

A rise in natural disasters!

Wildfires

Figure 7. Wildfires

How do they start?
An availability with aridity or fuel. Dry fuels such as grass, trees, leaves, wooden structures.

Where are they prominent?
Dry and hot climates

Droughts

Figure 8. Droughts

How do they start?
Lack of precipitation, humans over-use of water sources, a change in ocean temperatures

Where are they prominent?
Dry and hot climates, developing nations

Tsunamis

Figure 9. Tsunamis

How do they start?
Earthquakes, landslides, volcanic activity, certain types of weather, and meteorites can cause a tsunami.

Where are they prominent?
Alaska, Chile, Japan, Indonesia, Pakistan, and Russia.

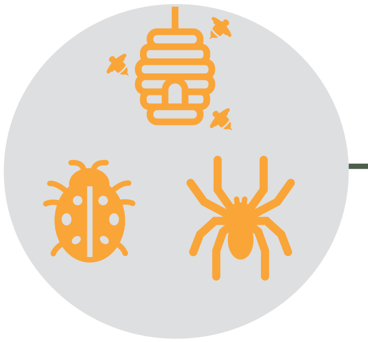
Landslides

Figure 10. Landslides

How do they start?
Rainfall, snowmelt, changes in water level, stream erosion, changes in ground water, earthquakes, volcanic activity, or by human activities

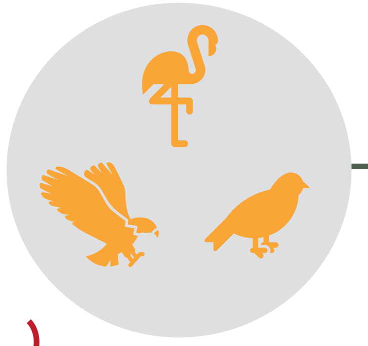
Where are they prominent?
Mountainous and coastal regions

A shift in ecosystem!



Bugs

Insect pests account for the loss of 40% of global crop production.

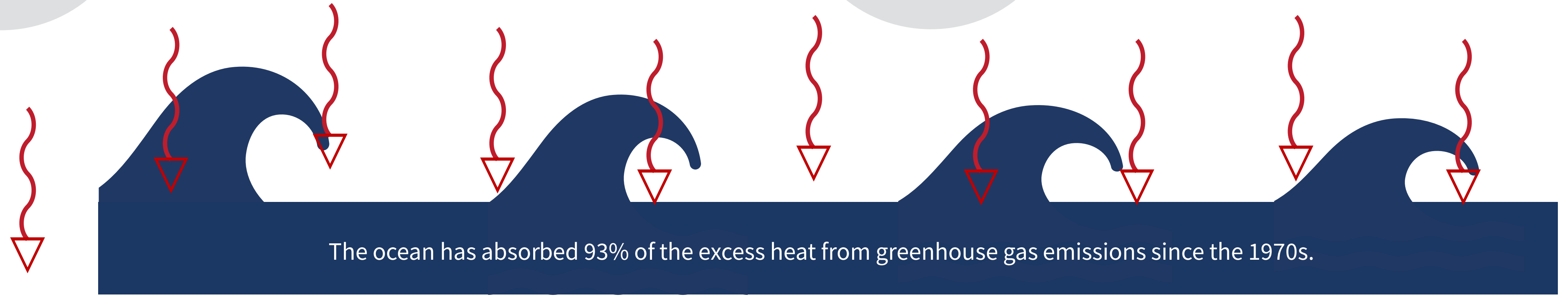


Birds

Bird populations face global conservation challenges, with 1 in 8 species facing a high risk of extinction in the near future

A rise in sea temperatures!

Solar radiation :



5. Denchak, Melissa. "Drought: Everything You Need to Know." Be a Force for the Future, September 13, 2018. https://www.nrdc.org/stories/drought-everything-you-need-know?gclid=CjwKCAjwkNOpBhBEEiwAb3MvvbQXKUCfDgHImhBgqRjFIJnsrBT6yex_ZMwmVd1N9b7jDyNi3umeCRoCuc4QAvD_BwE#what.
6. Wibbenmeyer, Matthew, and Anne McDarris. "Wildfires in the United States 101: Context and Consequences." Resources for the Future, July 30, 2021. https://www.rff.org/publications/explainers/wildfires-in-the-united-states-101-context-and-consequences/?gclid=CjwKCAjwkNOpBhBEEiwAb3MvvXkhmYS-IS-XYOVxiYBvjMRs0KO8AeSzszUXAmUTGePsqUfN-pXa-ExoCeuAQAvD_BwE.
7. "Landslide Basics." Landslide Basics | U.S. Geological Survey, 2023. https://www.usgs.gov/programs/landslide-hazards/landslide-basics.
8. Weaving, Hester. "Insects Will Struggle to Keep Pace with Global Temperature Rise – Which Could Be Bad News for Humans." The Conversation, December 2, 2022. https://theconversation.com/insects-will-struggle-to-keep-pace-with-global-temperature-rise-which-could-be-bad-news-for-humans-190791#:~:text=A%20weak%20ability%20to%20adjust%20to%20higher%20temperatures%20will%20mean,the%20delicate%20balance%20of%20ecosystems.

Location Studies: Natural Disasters

With each drought, the country experiences an estimated economic loss of...

$9.6 billion

In the US, a typical fire season used to last for four months. Now, fire seasons usually last up to...

8 months

The number of people that have experienced heat waves is...

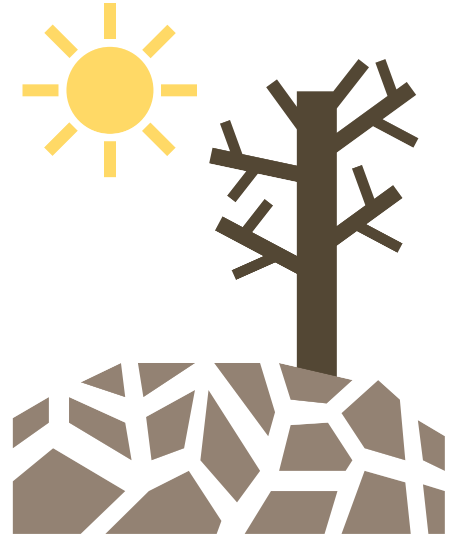
65.2 million

The emissions into the atmosphere in 2020 reached...

68 million

The percentage of polluted rivers and streams in the United States is...

50%

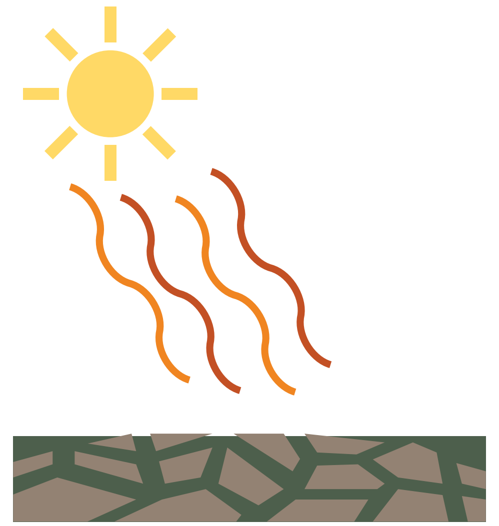


Top 5 cities that encounter drought most frequently

- California
- Colorado
- New Mexico
- Oklahoma
- Texas

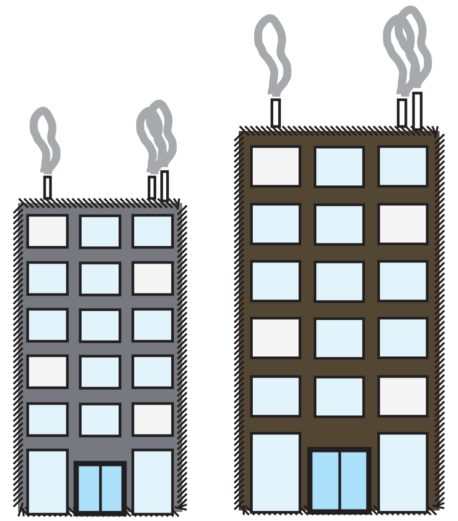
Top10 states with the highest number of acres burned by wild-fires

- California (2,233,666 acres)
- Oregon (828,777 acres)
- Montana (747,678 acres)
- Washington (674,222 acres)
- Arizona (524,428 acres)
- Idaho (439,600 acres)
- Alaska (253,357 acres)
- Texas (168,258 acres)
- Kansas (163,982 acres)
- New Mexico (123,792 acres)



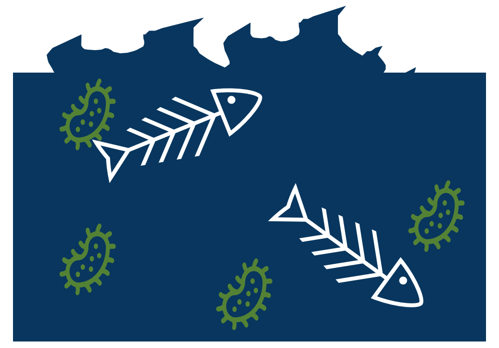
Top 5 cities with a record break-ing heat wave in the summer of 2022

- Paducah, Kentucky (97°F)
- Evansville, Indiana (98°F)
- Cape Girardeau, Missouri (100°F)
- Poplar Bluff, Missouri (100°F)
- Carbondale, Illinois (99°F)



Top 10 cities with the most air pollution in 2022

- Visalia, California
- Fresno, California
- Hanford, California
- San Jose, California
- Oakland, California
- San Francisco, California
- Los Angeles, California
- Grants Pass, Oregon
- Fairbanks, Alaska
- Phoenix-Mesa, Arizona



Top 10 states with the most pollut-ed rivers and streams in 2020

- Delaware (97%)
- New Jersey (95%)
- Hawaii (91%)
- California (87%)
- Louisiana (86%)
- Oregon (86%)
- Iowa (84%)
- South Carolina (81%)
- Kansas (79%)
- South Dakota (78%)

Figure 11. Location Studies: Natural Disasters

9. Lai, Charlie. "The Worst States for Climate Change in the US in 2023." Earth.Org, June 25, 2023. https://earth.org/worst-states-for-climate-change/.

Location Studies: United States Climate Change

California

Figure 12. California

Population: 38,915,693 people

Carbon Emissions: 8.3 Metric tons per person

Climate: Tropical, Dry

Influences in Place: Spanish, Asian, Mexican

Ideal Built Environment:
California's ideal built environment should also consider various factors due to its diverse climate zones, which range from Mediterranean along the coast to arid and semi-arid in the interior regions. Here are some considerations for creating an ideal built environment in California:

1. Passive Solar Design
2. Natural Ventilation
3. High Thermal Mass
4. Cool Roofing and Reflective Materials
5. Water Efficient Landscaping
6. Renewable Energy Integration

Oregon

Figure 13. Oregon

Population: 4,223,973 people

Carbon Emissions: 9.1 Metric tons per person

Climate: Tropical, Dry, Temperate

Influences in Place: Native American, Spanish

Ideal Built Environment:
Oregon's ideal built environment for its climate should prioritize sustainability, energy efficiency, and resilience to address the state's unique climatic conditions, which vary across different regions from the coast to the inland valleys and mountainous areas. Here are some key considerations for designing buildings and communities that are well-suited to Oregon's climate:

1. Passive Solar Design
2. Natural Ventilation and Indoor Air Quality
3. High Thermal Mass Construction
4. Weatherization and Insulation
5. Green Building Practices
6. Water Conservation and Stormwater Management

Arizona

Figure 14. Arizona

Population: 7,453,517 people

Carbon Emissions: 11.4 metric tons per person

Climate: Dry

Influences in Place: Native American, Mexican

Ideal Built Environment:
Arizona's ideal built environment for its climate should prioritize strategies that address extreme temperatures, low humidity, and intense sunlight while promoting sustainability, energy efficiency, and resilience. Here are key considerations for designing buildings and communities that are well-suited to Arizona's climate:

1. Passive Solar Design
2. High Thermal Mass Construction
3. Reflective Roofing and Surfaces
4. Shading and Outdoor Surfaces
5. Water-Efficient Landscaping
6. Energy Efficient Building Systems

Texas

Figure 15. Texas

Population: 30,500,280 people

Carbon Emissions: 22.4 metric tons per person

Climate: Tropical, Dry

Influences in Place: Native American, Mexican, Spanish

Ideal Built Environment:
Texas's ideal built environment should consider several factors to accommodate its climate effectively. Texas experiences a variety of climates across its vast area, including hot and humid conditions in the eastern region and hot and arid conditions in the western and southern parts. Here are some considerations for creating an ideal built environment in Texas:

1. Energy Efficiency
2. Orientation
3. Materials
4. Landscaping
5. Water Efficiency
6. Resilience to Extreme Weather

Figure 16. Bermed Structure Graphics

10. "State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA)." State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA), July 23, 2023. https://www.eia.gov/environment/emissions/state/.
11. "U.S. States Ranked by Population." US states - ranked by population 2023, 2023. https://worldpopulationreview.com/states.

Electricity Consumption by Occupancy

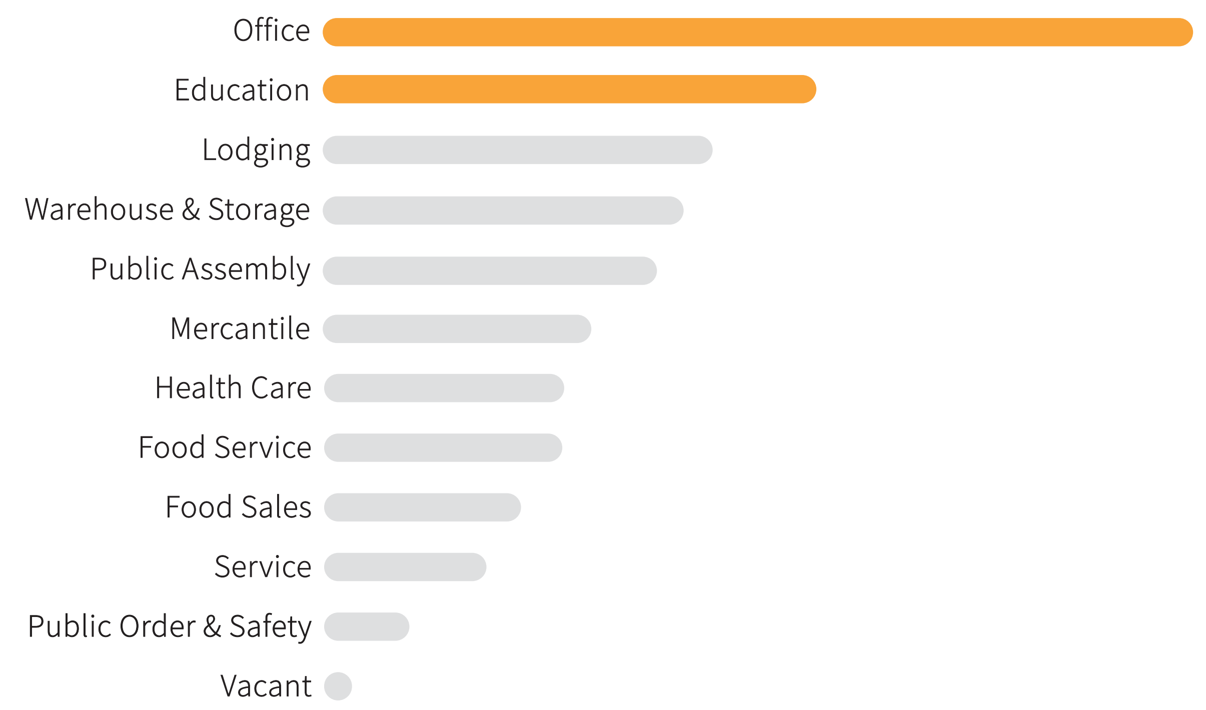


Figure 17. Electricity Consumption in Commercial Buildings

Natural Gas Usage by Occupancy

Figure 18. Natural Gas Consumption in Commercial Buildings

Summary of Commercial Energy Consumption

Buildings play a pivotal role in our transition towards a lower-carbon future, as they constitute the spaces where we reside, relax, and work. They also bear a significant responsibility, accounting for approximately 40% of global energy consumption and about one-third of global greenhouse gas emissions. Commercial buildings, in particular, stand out as prominent energy consumers in the United States, owing in part to their substantial size. The expansive square footage within these structures necessitates increased energy usage for heating, cooling, and artificial lighting. Among commercial buildings, offices and educational facilities stand out as some of the largest energy consumers.

In educational and office buildings, a common practice involves keeping lights illuminated even after regular operating hours. This is often done for safety reasons, ensuring that the building remains well-lit even when students, faculty, or employees have left for the day. Additionally, continuous lighting serves the purpose of facilitating safe access for maintenance personnel who need to enter and exit the buildings. Numerous state codes mandate a minimum level of illumination for common areas or pathways of egress, such as stairwells, hallways, and corridors.

Office Building After Hours

Figure 19. After Hours Electricity Usage-Office Building

Educational Building After Hours

Figure 20. After Hours Electricity Usage-Educational Building

12. "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Energy Information Administration (EIA)- Commercial Buildings Energy Consumption Survey (CBECS), December 2022. https://www.eia.gov/consumption/commercial/.

Major Fuel Consumption by End Use in US Commercial Buildings

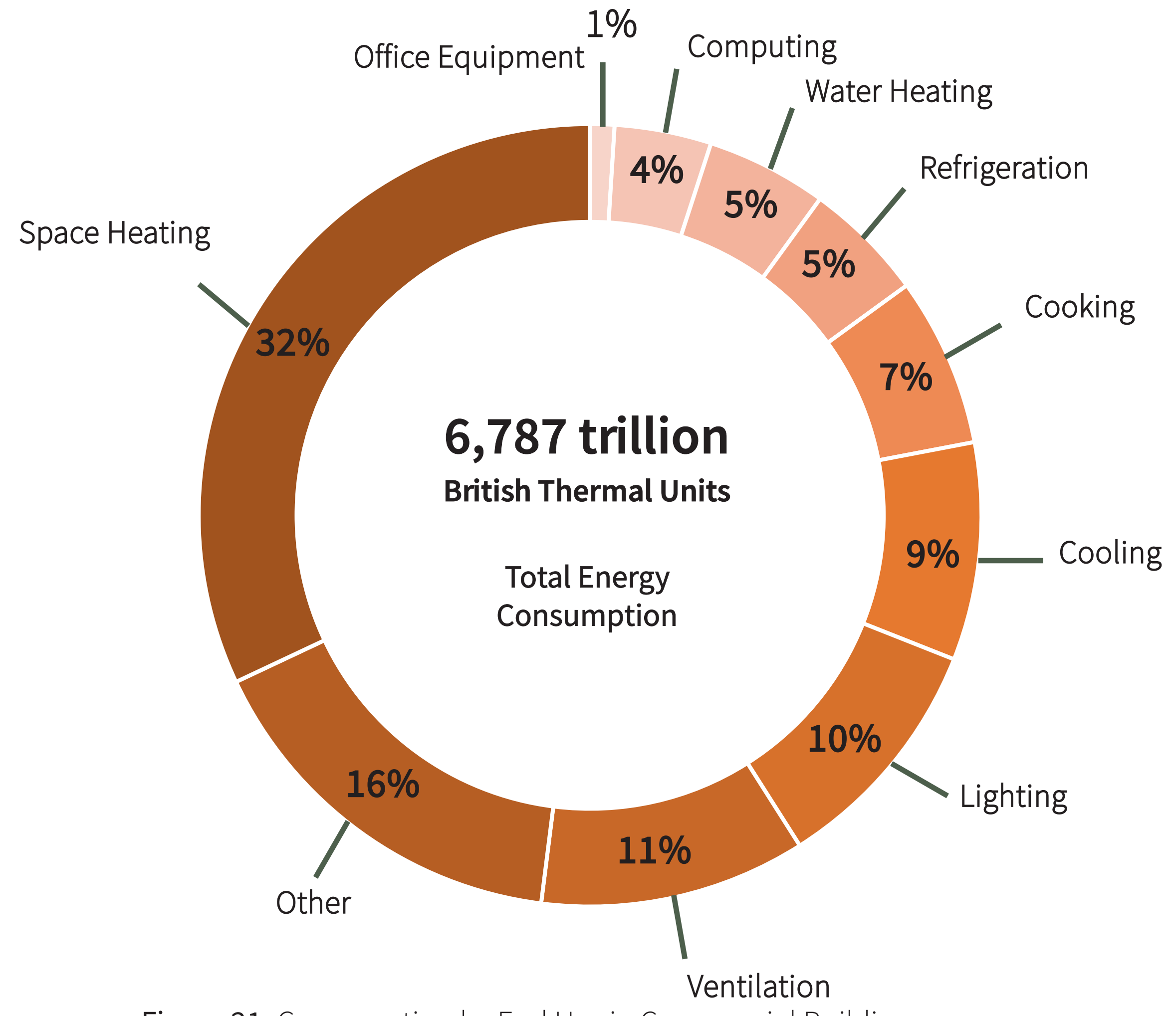


Figure 21. Consumption by End Use in Commercial Buildings

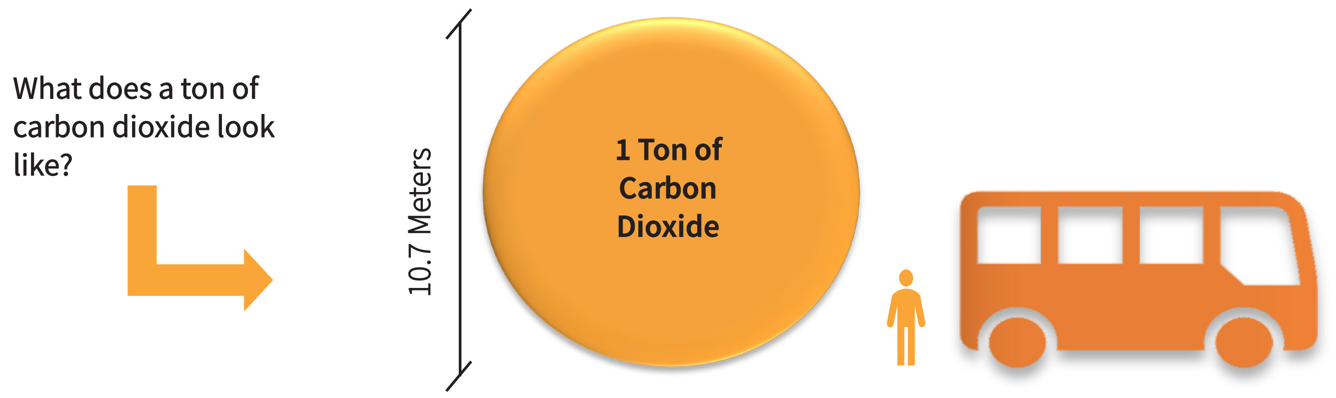


Figure 22. Measuring Carbon Dioxide

The largest fuel consumption activities in commercial buildings

Space Heating Mitigation:
Heating a space, particularly when it comes to large commercial areas, often incurs significant expenses. In the contemporary scenario, a substantial portion of buildings continues to rely on fossil fuels for their heating needs. However, exploring alternative and traditional methodologies in construction holds the potential to mitigate or even eliminate the necessity for extensive heating and cooling. The utilization of techniques such as thermal massing, where materials with high heat capacity are strategically placed within a structure, plays a pivotal role. Additionally, augmenting insulation volume can serve as a proactive measure to retain heat effectively, thereby minimizing the requirement for continuous heating. Moreover, the strategic placement of windows is another facet that can significantly impact the thermal dynamics of indoor spaces, allowing for efficient heat retention or dissipation as needed.

Ventilation Mitigation:
The value of natural ventilation within design often goes unappreciated despite its pivotal role in shaping our indoor environments. Considering that nearly 90% of our daily routine is confined within indoor spaces—be it our residences, educational institutions, or workplaces—the quality of indoor air becomes a critical determinant of our overall well-being. Failure to ensure proper air circulation can result in the accumulation of pollutants and toxins, which, over time, pose significant health risks to occupants. Design interventions wield immense potential in establishing an optimal air circulation pathway that purifies the air we breathe within enclosed spaces. By placing windows, vents, and other openings, designers can harness natural airflow patterns to effectively ventilate indoor spaces, mitigating the accumulation of harmful substances and promoting a healthier indoor atmosphere conducive to improved health and comfort for occupants.

Lighting Mitigation:
Electricity expenses pose a substantial financial burden for corporations, notably due to the continuous illumination of buildings like universities, offices, municipal structures, and industrial facilities, where lights remain switched on throughout the day and night. Implementing passive daylighting strategies emerges as a viable solution to reduce reliance on fossil fuel-powered lighting systems. While solar panels represent an initial step in this direction, the strategic placement of windows and the incorporation of architectural features like atriums or light wells can significantly enhance not only the access to natural light but also the overall thermal comfort within a space.

Cooling Mitigation:
Cooling expenses, akin to heating costs, often lead to substantial financial burdens, particularly noticeable in regions characterized by hot and arid climates, where individuals seek respite from the intense heat. Employing a combination of natural ventilation techniques, alongside the implementation of solar panels and meticulous site orientation strategies, offers a viable solution to regulate and manage solar radiation, thereby mitigating the impact of high cooling costs within these environments.

13. "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Energy Information Administration (EIA)- Commercial Buildings Energy Consumption Survey (CBECS), December 2022. https://www.eia.gov/consumption/commercial/.

How does global warming impact health?

The rising global temperatures pose significant threats to both human health and the environment. Rapid surges in heat exert adverse effects on the body's ability to regulate its internal temperature, potentially resulting in a range of health issues. Such extreme heat conditions can strain the body, causing heat-related illnesses and placing considerable pressure on essential resources, including medical care facilities and services.

Moreover, escalating temperatures not only affect human health but also impose detrimental consequences on the environment. Heatwaves contribute to various ecological imbalances, such as droughts, wildfires, and disruptions in ecosystems. These adverse environmental impacts further exacerbate the challenges faced by communities and wildlife, amplifying the urgency for comprehensive measures to mitigate the escalating global temperatures and their multifaceted repercussions.

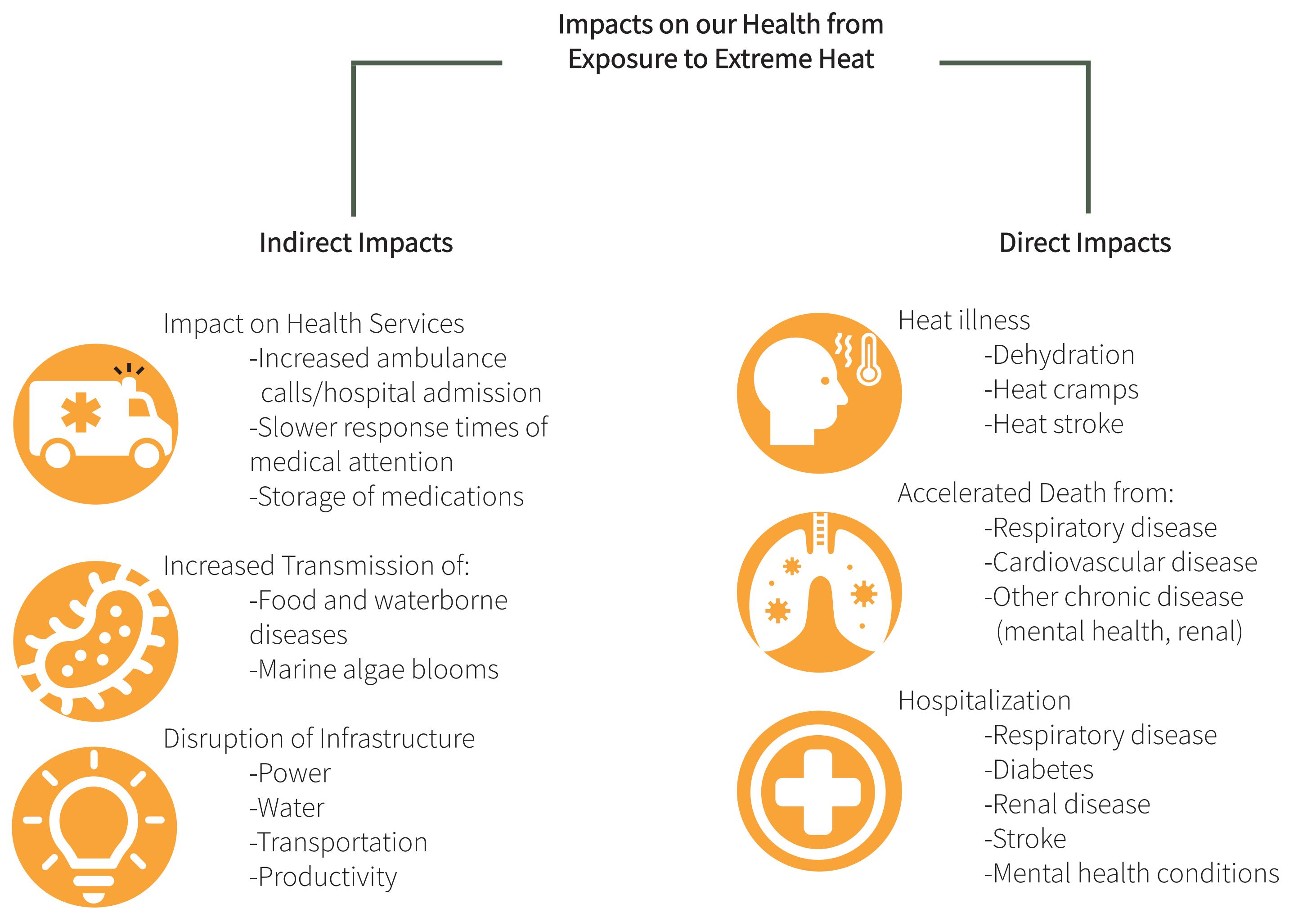


Figure 23. Indirect and Direct Impacts on Human Health

Who is most at risk due to global warming?

Figure 24. The Most at Risk

14. "Heat and Health." World Health Organization, June 1, 2018. https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health.

What is the human relationship with the sun?

Daylight is a fundamental requirement for maintaining our overall health and well-being. The sun has influenced human behavior, social structures, and daily routines throughout history. Our circadian rhythms, or internal biological clocks, are synchronized with the solar cycle, influencing our sleep-wake patterns, metabolism, and hormonal regulation. The rising and setting of the sun mark the passage of time, shaping human activities such as agriculture, trade, and rituals. In modern times, our relationship with the sun has evolved alongside technological advancements and scientific understanding. We harness solar energy through photovoltaic cells and solar panels to generate electricity, reducing our reliance on fossil fuels and mitigating climate change. Additionally, sunlight exposure is recognized for its role in promoting vitamin D synthesis and supporting mental health and well-being.

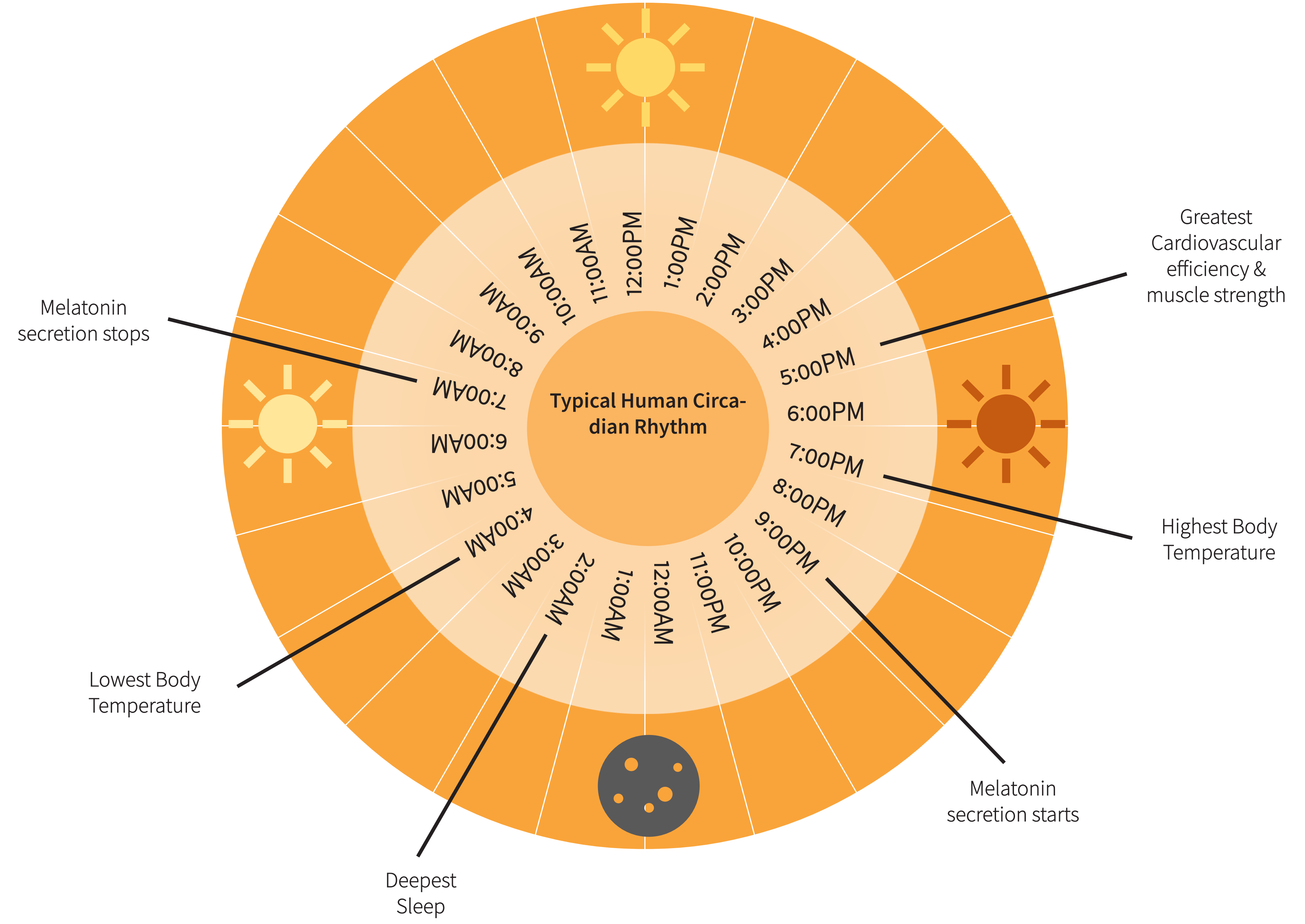


Figure 25. Human Circadian Rhythm

Daylight needs

Advantages

- Lowered rate of depressive symptoms
- Fewer Insomnia symptoms
- Less fatigue
- Heightened mood
- Increase vitamin D
- Strengthens bones
- Regulates the circadian rhythm

Disadvantages

- Increase risk of melanoma
- UV radiation can cause cataracts over time
- Ages the skin faster
- Sun burn

15. Mead, M Nathaniel. "Benefits of Sunlight: A Bright Spot for Human Health." Environmental health perspectives, April 2008. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2290997/.
16. Wenk, Gary. "Walking on Sunshine: The Light of Day Improves Mental Health." Psychology Today, February 26, 2022. https://www.psychologytoday.com/us/blog/your-brain-food/202202/walking-sunshine-the-light-day-improves-mental-health.

Passive Design Strategies: Insulation

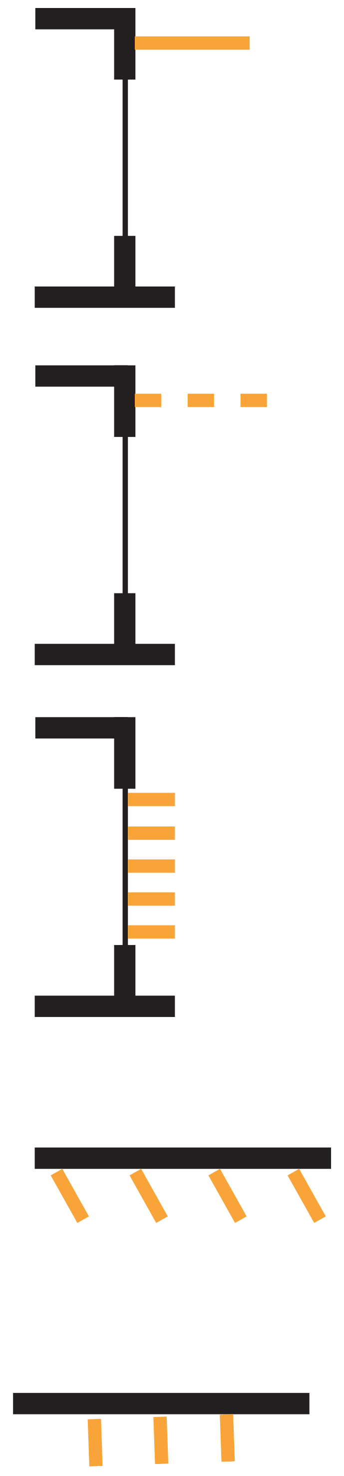
Type of Insulation	Material Options	Where Applicable	Installation Methods	Advantages	Disadvantages
Blanket	• Fiberglass • Mineral Wool • Plastic Fibers • Natural Fibers	• Unfinished Walls • Floors & Ceilings	Fitted between studs, joists, and beams	Suited for standard stud and joist spacing that is relatively free from obstructions. Relatively inexpensive.	• Rolls of blanket insulation need to be hand cut to fit into smaller spaces. • Blanket insulation can compress easily causing it to lose efficacy.
Concrete Block	Foam board to be placed on the outside or inside of wall.	• Unfinished walls • New construction • Major renovation • Walls(insulating concrete blocks)	Insulating concrete blocks are sometimes stacked without mortar (dry-stacked) and surface bonded.	Insulating outside of concrete block wall places mass inside conditioned space, which can moderate indoor temperatures.	• Higher costs from specialized labor • Releasing them too early could lead to structural issues • Indoor humidity problems
Foam Board	• Polystyrene • Polyisocyanurate • Polyurethane • Phenolic	• Unfinished walls, including foundation walls • Floors and ceilings • Unvented low-slope roofs	Interior applications: must be covered with 1/2-inch gypsum board or other building-code approved material for fire safety.	High insulating value for relatively little thickness.	• Cost • Foam boards are not as durable as other insulations • Poor thermal capability
Rigid Fibrous or Fibrous Insulation	• Fiberglass • Mineral wool	Ducts in unconditioned spaces or other places requiring insulation that can withstand high temperatures.	HVAC contractors fabricate the insulation into ducts either at their shops or at the job sites.	Can withstand high temperatures.	• Porosity and permeability, which can cause gases to build up • Difficulties while installing them • Less dense and effective against air leaks
Loose-fill/Blown in	• Cellulose • Fiberglass • Mineral (rock or slag) wool	• Enclosed existing wall or open new wall cavities • Unfinished attic floors • Other hard-to-reach places	Blown into place using special equipment and, although not recommended, sometimes poured in.	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.	• Messy and often requires the help of a professional to install. • It needs to be applied evenly • It is difficult to dry if it gets wet and may develop mold.
Sprayed Foam and foamed-in-place	• Cementitious • Phenolic • Polyisocyanurate • Polyurethane	• Enclosed existing wall • Open new wall cavities • Unfinished attic floors	Applied using small spray containers or in larger quantities as a pressure sprayed (foamed-in-place) product.	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions.	• Takes time to cure • Can release harmful chemicals such as formeldahyde

Figure 26. Insulation Chart

17. "Types of Insulation." Energy.gov. Accessed December 3, 2023. https://www.energy.gov/energysaver/types-insulation.

Passive Design Strategies: Shading and Indoor Air Quality

Shading Techniques



Horizontal Single Blade
Ideal Orientation: South
View Restriction: ● ● ● ●

Outrigger System
Ideal Orientation: South
View Restriction: ● ● ● ●

Horizontal Multiple Blade
Ideal Orientation: South
View Restriction: ● ● ○ ○

Slanted Vertical Fin
Ideal Orientation: East/West
View Restriction: ● ● ○ ○

Vertical Fin
Ideal Orientation: East/West
View Restriction: ● ○ ○ ○

Figure 27. External Shading Strategies

Poor Indoor Air Quality

90% of peoples time is spent indoors

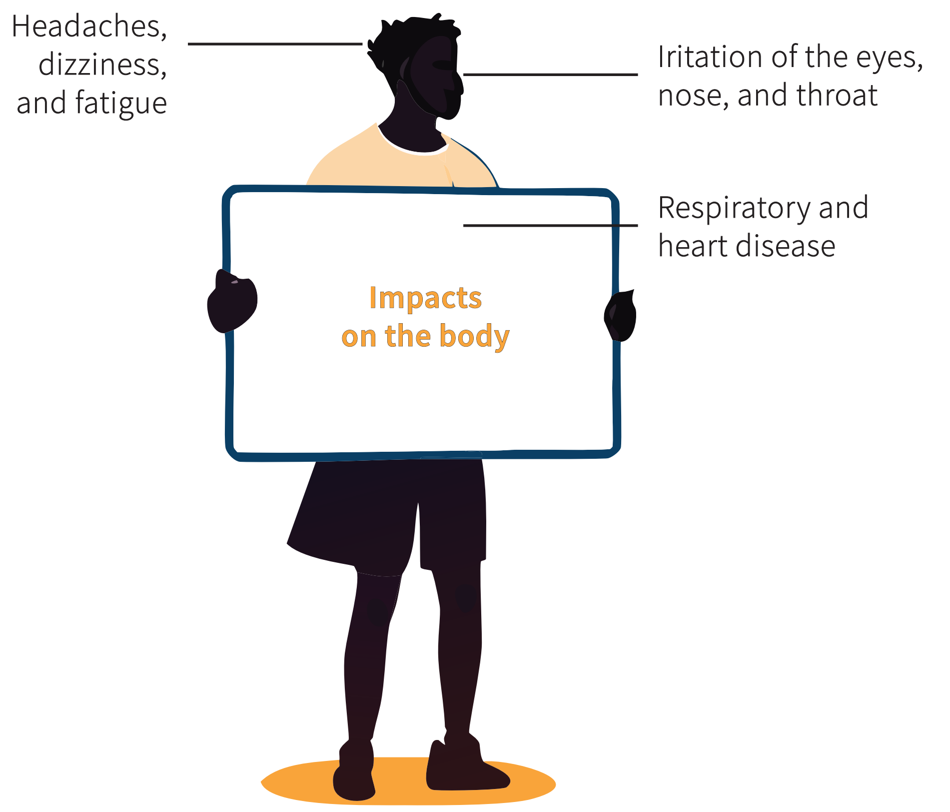
Causes:

Synthetic Building Materials
- Faux flooring
- Fiberglass
- Glass, or carbon fibers
- Nylon, acrylic, polyester
- Vinyl siding
- Composite decking

Furnishings
- Faux leather
- Faux wood
- Foam
- Polyvinyl chloride
- Rayon

Household Cleaners
- Bleach
- Air fresheners
- Fabric softeners
- Dryer Sheets
- Antibacterial products
- Corrosive drain cleaners

Impacts: **50%** of all respiratory diseases are caused by poor indoor air quality!



Poor Indoor Air Quality Risks

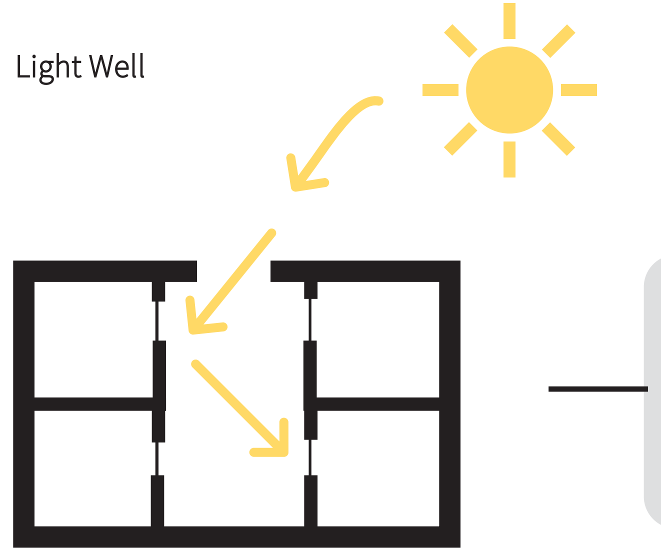
Poor indoor air quality can have significant impacts on health, affecting both short-term well-being and long-term health outcomes. Indoor air pollution can exacerbate respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), and allergies. Pollutants such as dust, mold, pet dander, and volatile organic compounds (VOCs) can trigger asthma attacks, cause breathing difficulties, and worsen symptoms for individuals with respiratory conditions. Exposure to indoor air pollutants such as particulate matter, carbon monoxide, and nitrogen dioxide can increase the risk of cardiovascular diseases, including heart attacks, strokes, and hypertension. Fine particles can penetrate deep into the lungs and enter the bloodstream, leading to inflammation and damage to blood vessels and organs.

Figure 28. Poor Indoor Air Quality Impacts

18. "Indoor Air Quality | US EPA - U.S. Environmental Protection Agency." EPA United States Environmental Protection Agency, 2020. https://www.epa.gov/report-environment/indoor-air-quality.

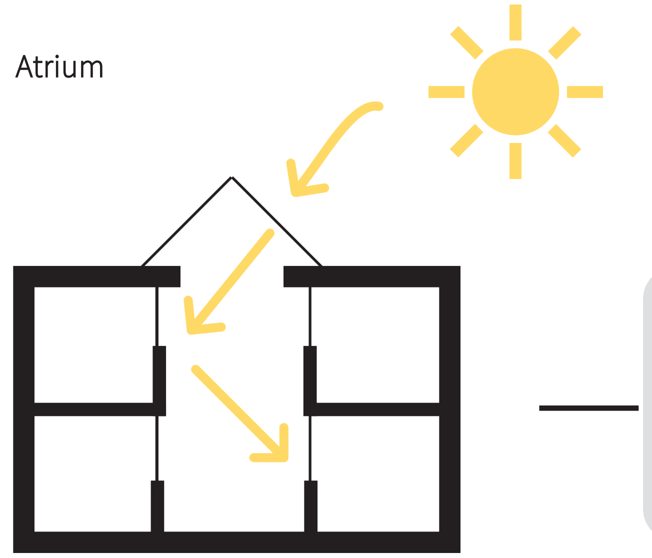
Passive Design Strategies: Daylighting

Light Well



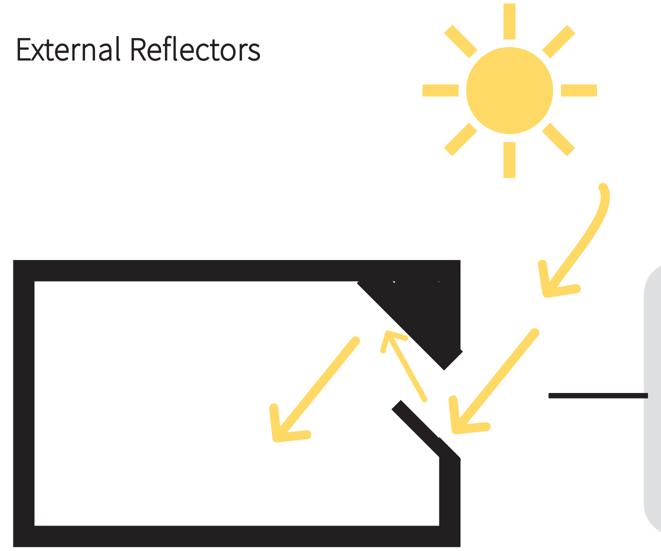
Light wells reduce the need for artificial lighting. They offer diffused daylighting into adjoining rooms in more abundance than direct sunlight. They also indirectly create a central space in a building which can be helpful for wayfinding.

Atrium



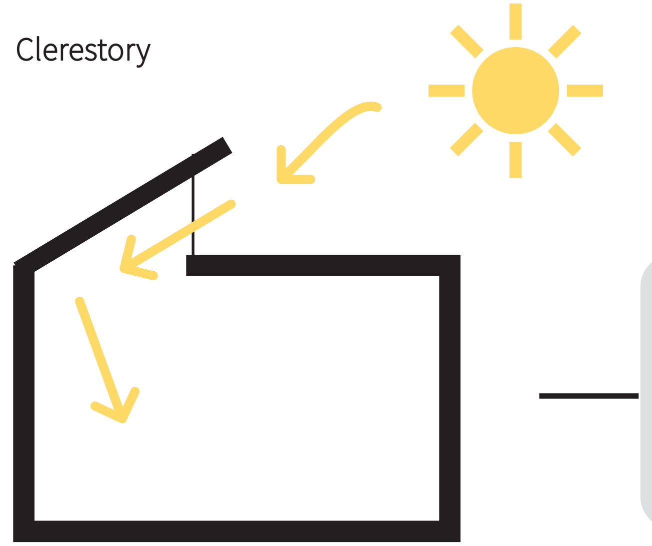
Atriums are a strategy that allow copious amounts of natural light to penetrate the space while giving shelter from the natural elements. Typical atrium configurations can be totally surrounded by building elements or partially enclosed. They maybe top lit, side lit or a combination of both.

External Reflectors



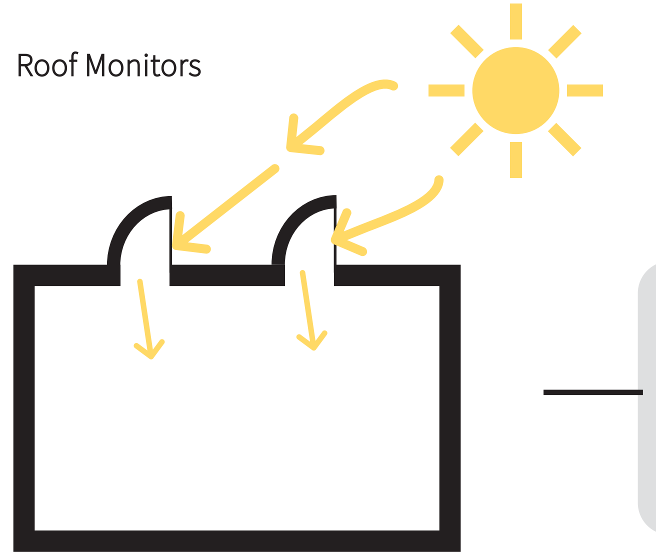
Reflective glass allows just the right amount of natural light into a building, while at the same time reduces glare and the need for interior shading devices. It also makes it possible to see out, while preventing people from seeing in, in order to preserve privacy during the day.

Clerestory



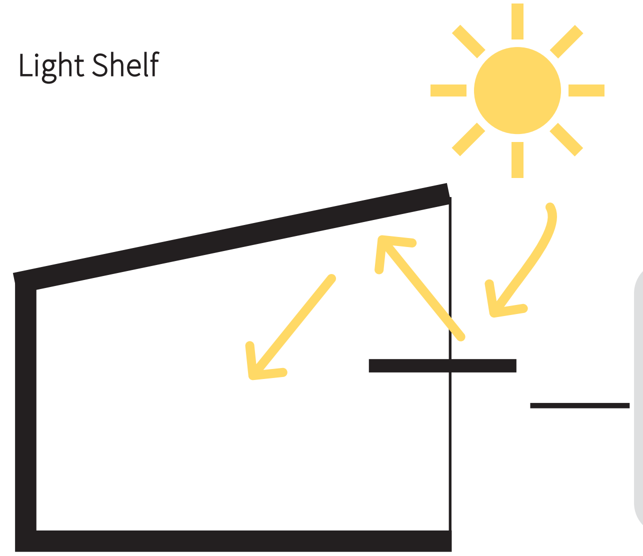
Clerestory windows are typically located on the upper end of tall walls. While bringing glare-free light into the space, they also keep the privacy of a space given their higher location. Clerestory windows are also known for being very aesthetically pleasing in a space.

Roof Monitors



Roof monitors are located on the top of buildings and help to disperse natural light more evenly than windows on the side of a building. They also reduce the need for artificial lighting and can assist with air circulation given their location.

Light Shelf



Light Shelves are located directly below skylights or clerestories. They bounce light back toward the ceiling and provide good indirect lighting to a large room. Light shelves can also block glare from overhead sun when skylight placement options are limited.

Figure 29. Passive Daylighting Strategies

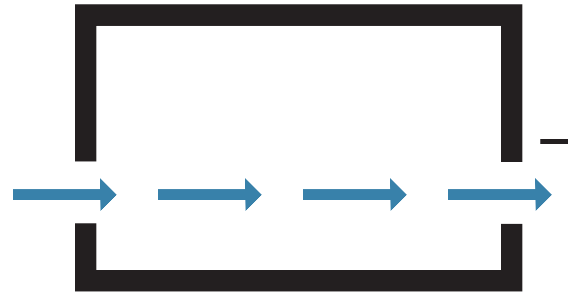
19. Gritch, Todd. "Atria Systems ." WBDG, October 5, 2016. https://wbdg.org/guides-specifications/building-envelope-design-guide/atria-systems.

Passive Design Strategies: Ventilation

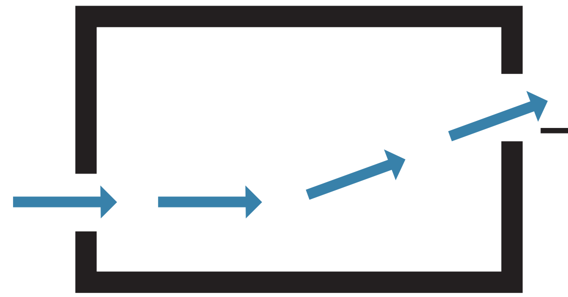
The Benefits of Natural Ventilation

- Better humidity control
- Lower operating and maintenance costs
- Better health and wellness
- Access to daylight
- Reduced unhealthy air pollutants, such as formaldehyde and radon

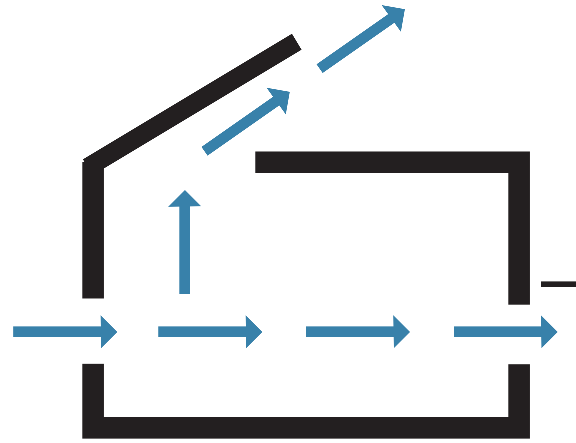
Good Ventilation



Having low openings allows the fresh air to travel throughout the entire space whereas high openings don't allow the fresh air to circulate throughout the entire space as efficiently.

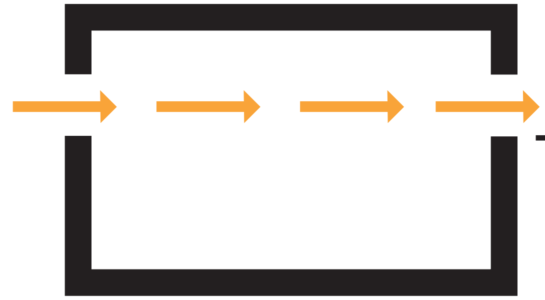


Variation of opening heights can allow for more efficient circulation, allowing the air to travel through the users space and exit at a different height.

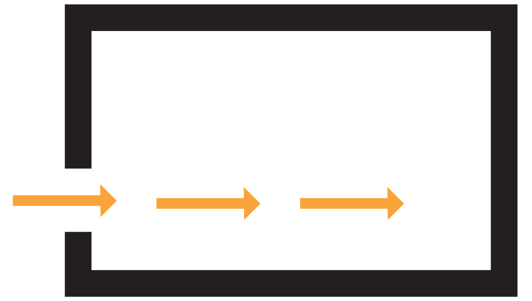


A clerestory window paired with low openings maximizes the efficiency of air circulation. It allows for air to travel equally throughout the volume of the space.

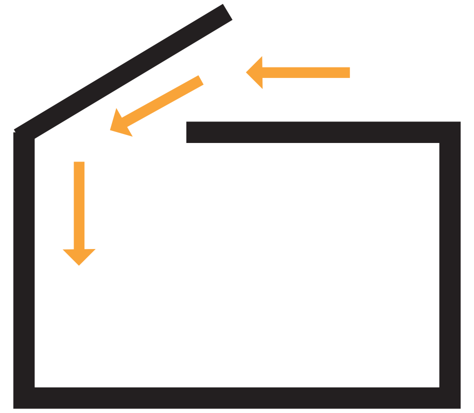
Bad Ventilation



Openings placed higher off the floor in spaces do not allow for proper circulation of air. As the air enters the space, it travels upwards and eliminates the opportunity for users to feel the fresh air.



Limited openings to the outdoors does not allow for the air to properly circulate and refresh the space.



Restricted access to openings prohibits the use of the opening. Openings that are too high for users to reach, often don't get used which ultimately renders them useless for ventilation unless they can be opened with the push of a button.

Figure 30. Passive Ventilation Strategies

20. "Indoor Air Quality | US EPA - U.S. Environmental Protection Agency." EPA United States Environmental Protection Agency, 2020. https://www.epa.gov/report-environment/indoor-air-quality.

About Thermal Massing

What is thermal mass?

Thermal mass constitutes the materials within a building that serve as a stabilizing force, curbing temperature fluctuations across the day and minimizing the structure's reliance on heating and cooling mechanisms. This inherent ability to regulate temperature variations contributes significantly to moderating the overall energy demands for heating and cooling within a building. The integration of thermal mass materials is pivotal, creating a more balanced and energy-efficient indoor environment.

When seamlessly integrated into passive solar heating and cooling systems, thermal mass materials become crucial in optimizing a building's energy utilization. By harnessing the natural cycles of heat absorption and release, these materials effectively mitigate the need for excessive artificial heating or cooling methods. Through their strategic placement and incorporation into architectural designs, thermal mass elements work symbiotically with passive solar technologies, facilitating a substantial reduction in a building's overall energy consumption while ensuring a more sustainable and comfortable indoor climate.

Internal Temperatures with High and Low Thermal Mass

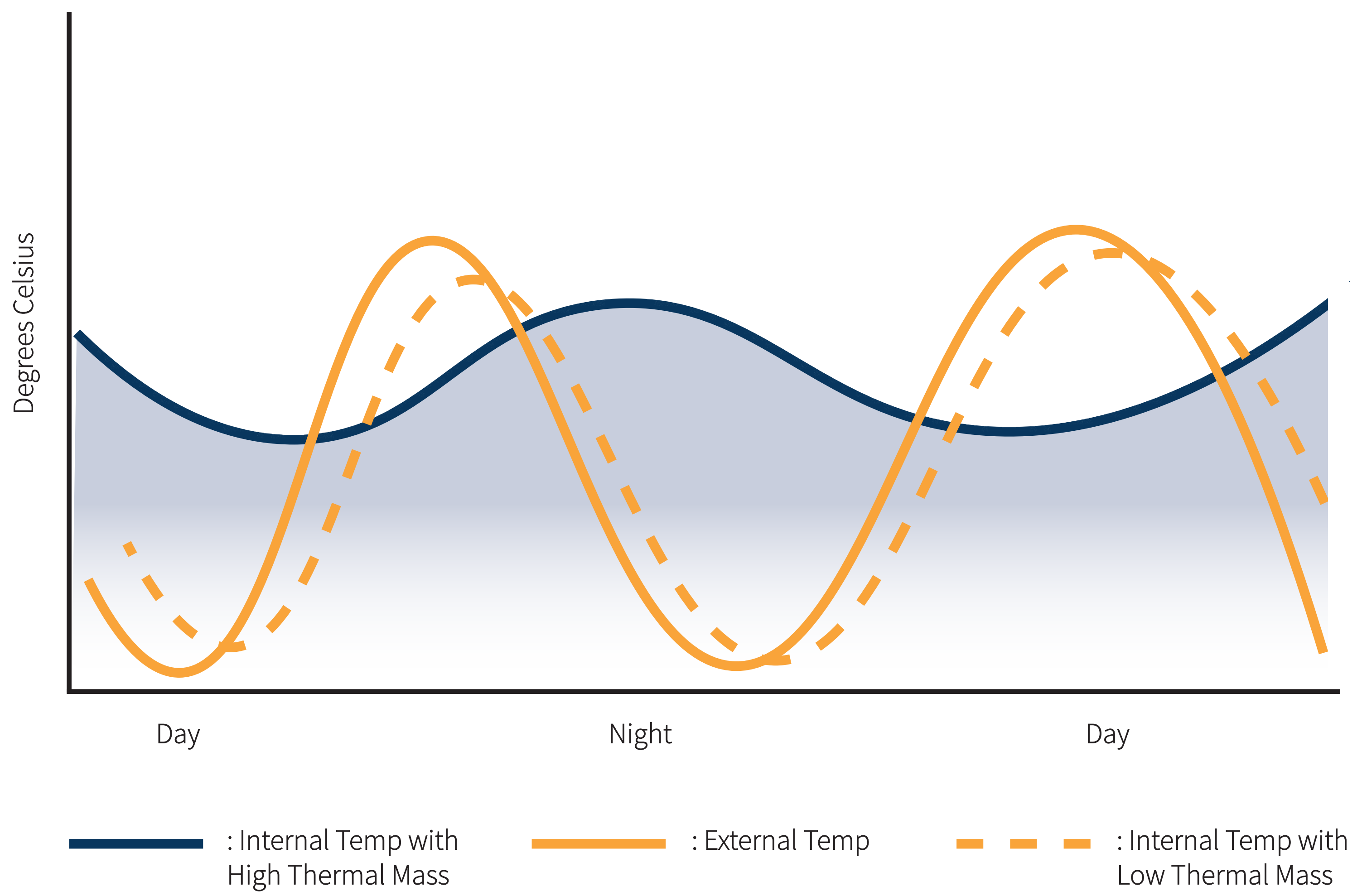


Figure 31. Temperature Fluctuations with High and Low Thermal Mass

21. Facebook.com/fairconditioning. "Thermal Mass." Fairconditioning. Accessed December 3, 2023. https://fairconditioning.org/knowledge/passive-design/thermal-mass/.
22. "Earth-Sheltered Buildings." NCMA, April 26, 2019. https://ncma.org/resource/earth-sheltered-buildings/.

Contributors to thermal mass: Materiality

The role of facades is pivotal in serving as a mediator between the external environmental elements and the desired indoor conditions essential for comfort. These facades act as a barrier, influencing factors such as temperature, humidity, water, wind, solar energy, light, and views. While mechanical systems are responsible for the actual regulation of heating and cooling within a building, their scale, expenses, and energy consumption are profoundly impacted by the design of the building mass and facade.

The choice of materials profoundly influences a building's ability to retain and moderate the impact of solar heat gain. By leveraging appropriate facade materials aligned with strategic site planning, a structure gains the capability to harness natural elements in a way that minimizes reliance on external energy sources. This synergy between materiality and orientation empowers buildings to achieve a degree of self-sufficiency in controlling their indoor thermal environments, thereby fostering sustainability and enhanced occupant comfort.

Materials that contribute to the thermal mass of a built environment :

Material	Volumetric Heat Capacity MJ/m K	Application
Water	4.18	Water feature, ponds, streams, fountains
Gypsum	1.746	Wall applications
Air	0.0012	Atrium, Trombe wall,
Concrete	2.086	Foundation, facade
Brick	2.018	Facade, feature walls
Limestone	2.193	Facade, feature walls
Granite	2.125	Feature walls, interior applications
Wood	0.231	Foundation, facade

Figure 32. Materials That Contribute to Thermal Mass

Thermal Massing: Earth

Overview

Earth-sheltering involves utilizing the earth as an integral part of a building's thermal regulation system. Such buildings can be integrated into the earth or an existing hillside, or they can be constructed above ground and then earth is piled around the exterior post-construction. While they can be entirely underground, more commonly they are partially sheltered by earth to allow natural light into the interiors. These structures are renowned for their energy efficiency, benefiting from the earth's insulating properties and reduced air infiltration through earth-covered surfaces. Furthermore, earth-sheltered buildings provide excellent storm protection, sound insulation, decreased maintenance expenses, and minimized impact on the surrounding environment.

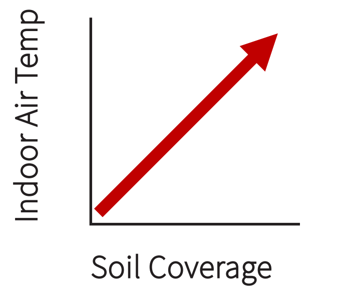


Figure 33. Indoor Air Temp vs. Soil Coverage

Levels of Thermal Massing

The extent of thermal massing plays a pivotal role in determining a structure's capacity to either retain or alleviate heat within its confines. By incorporating higher levels of thermal massing into a building's construction, the ability to store and distribute heat more efficiently is enhanced, thereby influencing the overall comfort levels experienced by occupants. Manipulating the thermal mass within a structure becomes instrumental in creating environments that can better withstand fluctuating temperatures, fostering a more stable and comfortable atmosphere.

Berming, as a design technique, offers an additional layer of insulation and protection to a structure against various natural elements that significantly impact our thermal comfort. Berming not only acts as a barrier to harsh weather conditions but also aids in regulating internal temperatures by minimizing heat loss or gain through the building envelope. Incorporating this method contributes to enhancing a structure's energy efficiency while creating more temperate indoor environments conducive to improved comfort and sustainability.

Temperature Exchange with Thermal Massing

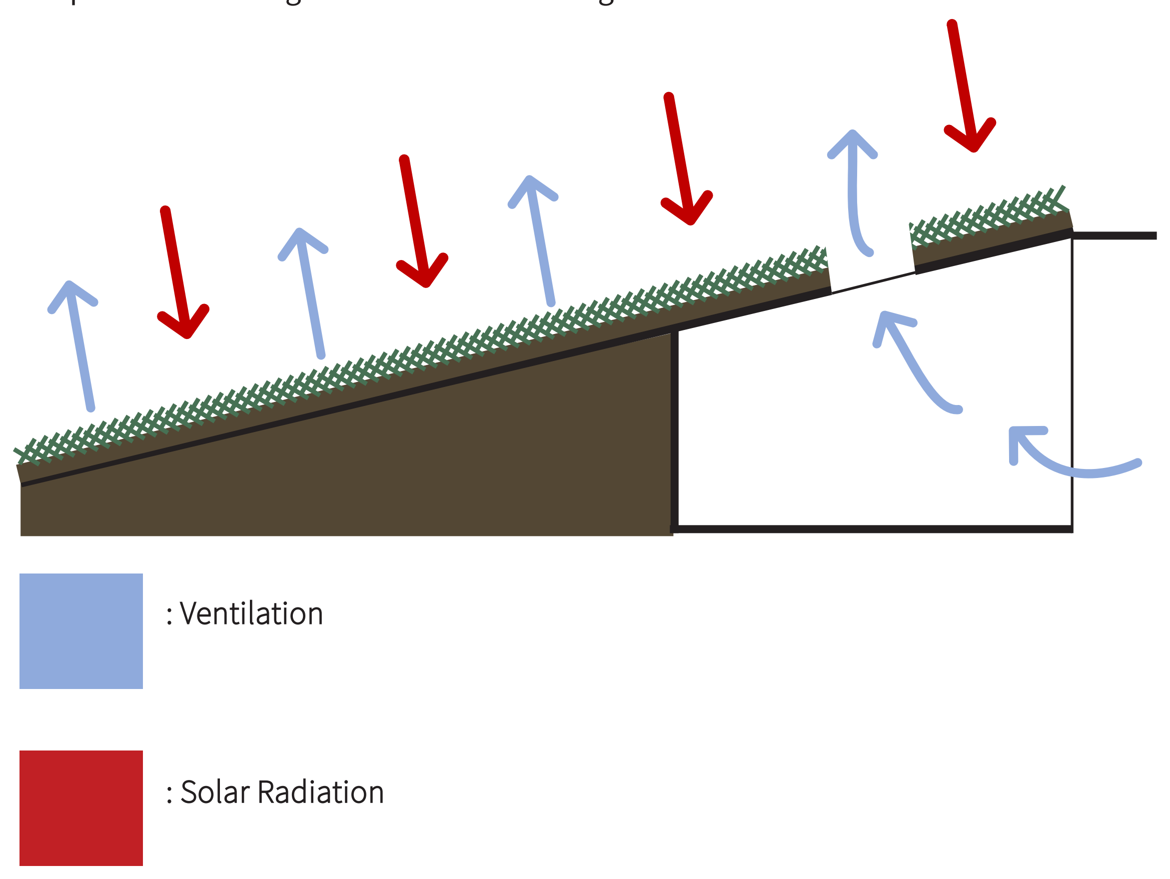


Figure 34. Temperature Exchange with Thermal Massing

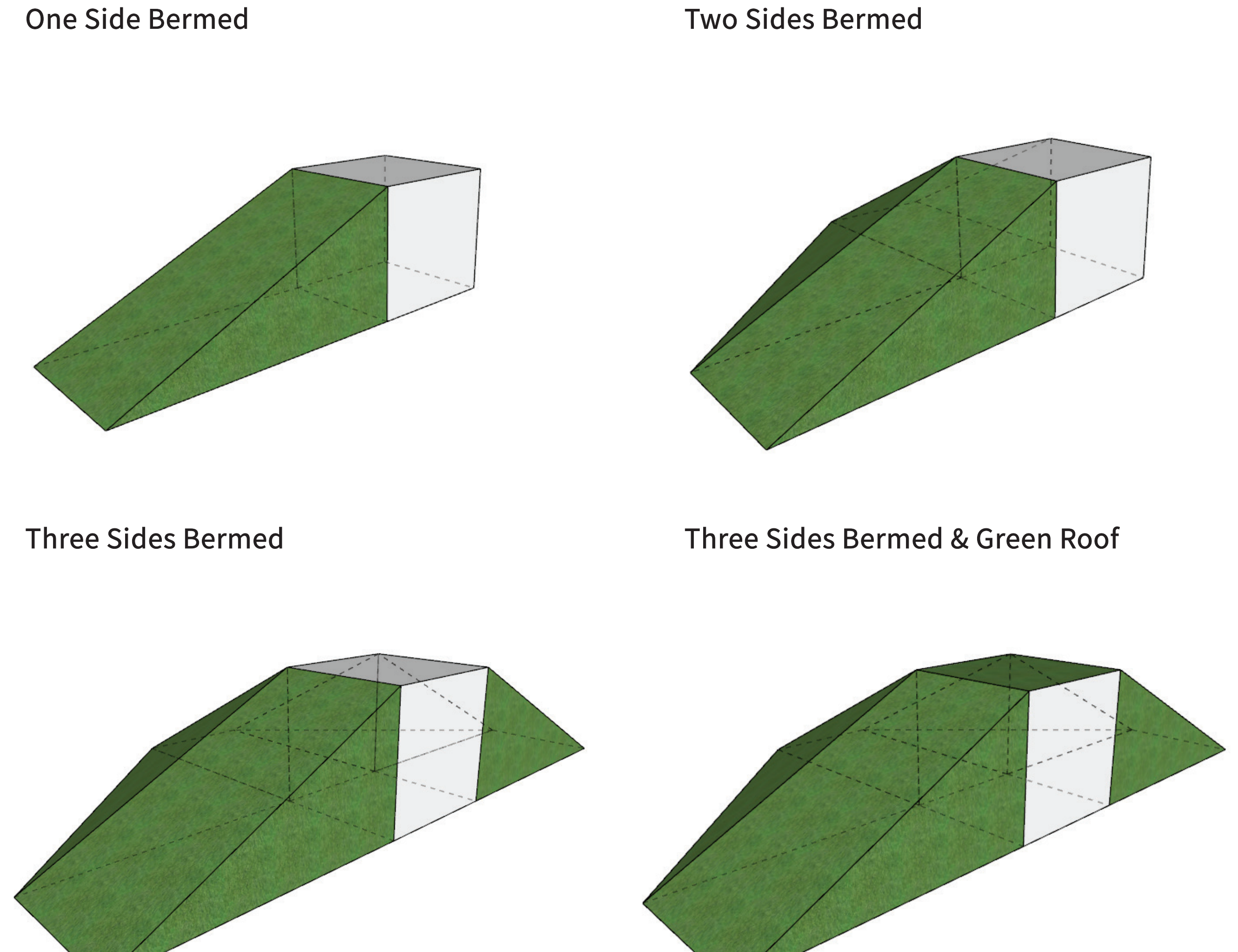


Figure 16. Bermed Structure Graphics

23. Boyer, Lester L, and Walter T Grondzik. Earth Shelter Technology. Texas, Texas: Texas A&M University Press, 1987.

The Advantages of Bermed Structures

Inspiration Picture

Figure 35. Initial Inspiration Picture

Pros and Cons of Bermed Construction & Design

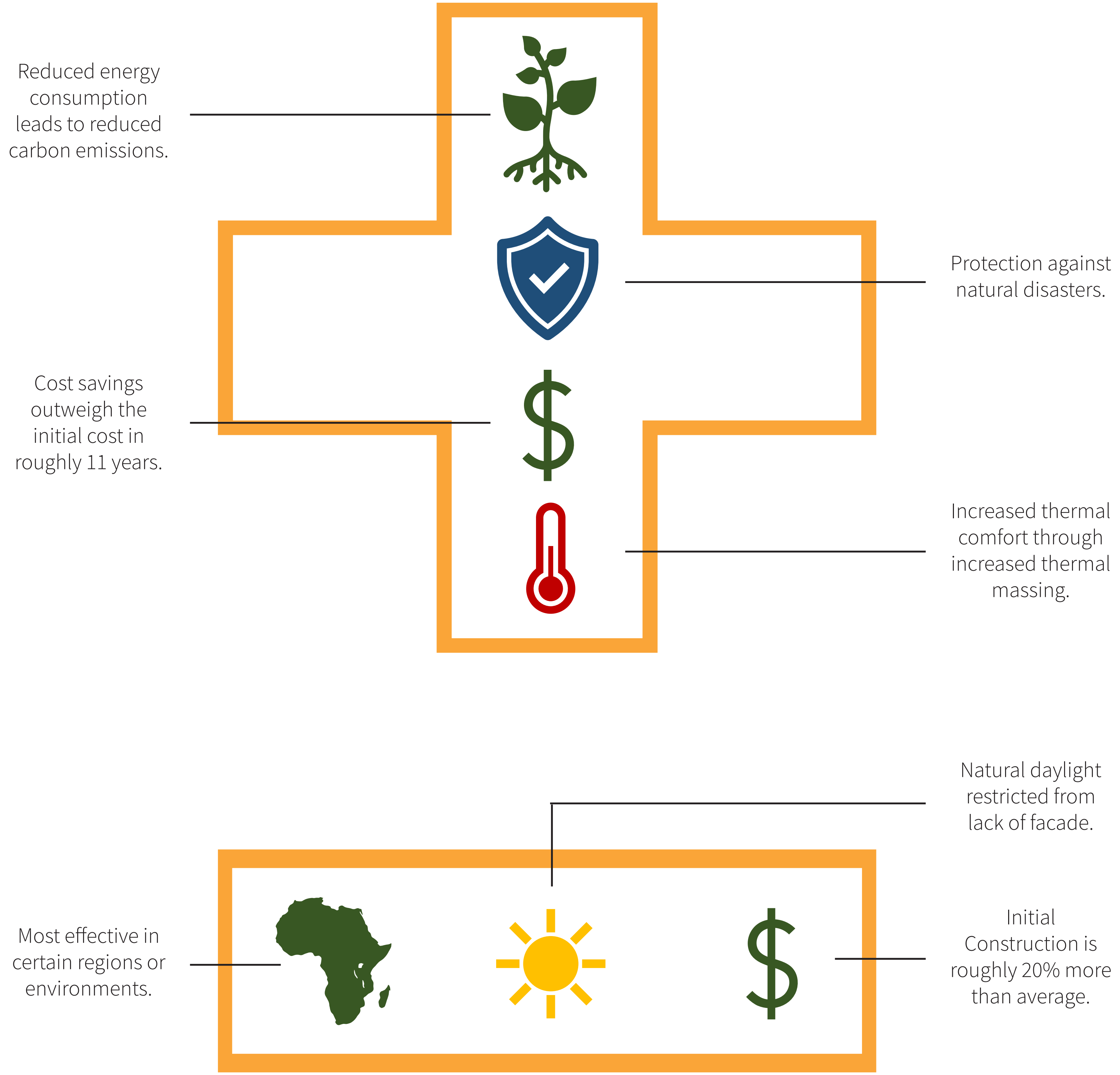


Figure 36. Positive vs Negative of Bermed Construction

Advantages of Bermed Construction

Bermed architecture, when appropriately designed, showcases remarkable energy-saving capabilities. While the initial construction expenses might be approximately 20% higher compared to standard above-grade buildings, the long-term benefits and cost savings significantly outweigh this initial investment. Studies suggest that within an estimated period of around 11 years, the accrued savings from reduced energy consumption and operational costs substantially offset the higher construction expenses. Additionally, beyond cost-efficiency, bermed structures offer inherent advantages such as enhanced protection against various natural disasters. The incorporation of earth embankments as an integral part of the structure acts as a protective shield, offering increased durability and resistance against adverse weather conditions. Moreover, these structures provide a stable and consistent level of thermal comfort, which is conducive to maintaining a pleasant indoor environment throughout the year. The thermal mass provided by the earth embankments contributes significantly to the stable indoor temperatures within bermed structures. This thermal regulation minimizes the need for excessive reliance on heating or cooling systems, thereby reducing energy consumption and fostering sustainability. The amalgamation of cost-effectiveness, environmental resilience, and enhanced thermal comfort positions bermed architecture as an innovative and promising solution in the realm of sustainable construction practices.

24. "Earth-Sheltered Buildings." NCMA, April 26, 2019. https://ncma.org/resource/earth-sheltered-buildings/.

Maximizing Daylight in Bermed Structures

Plan View Bermed Structures: Access to Daylight

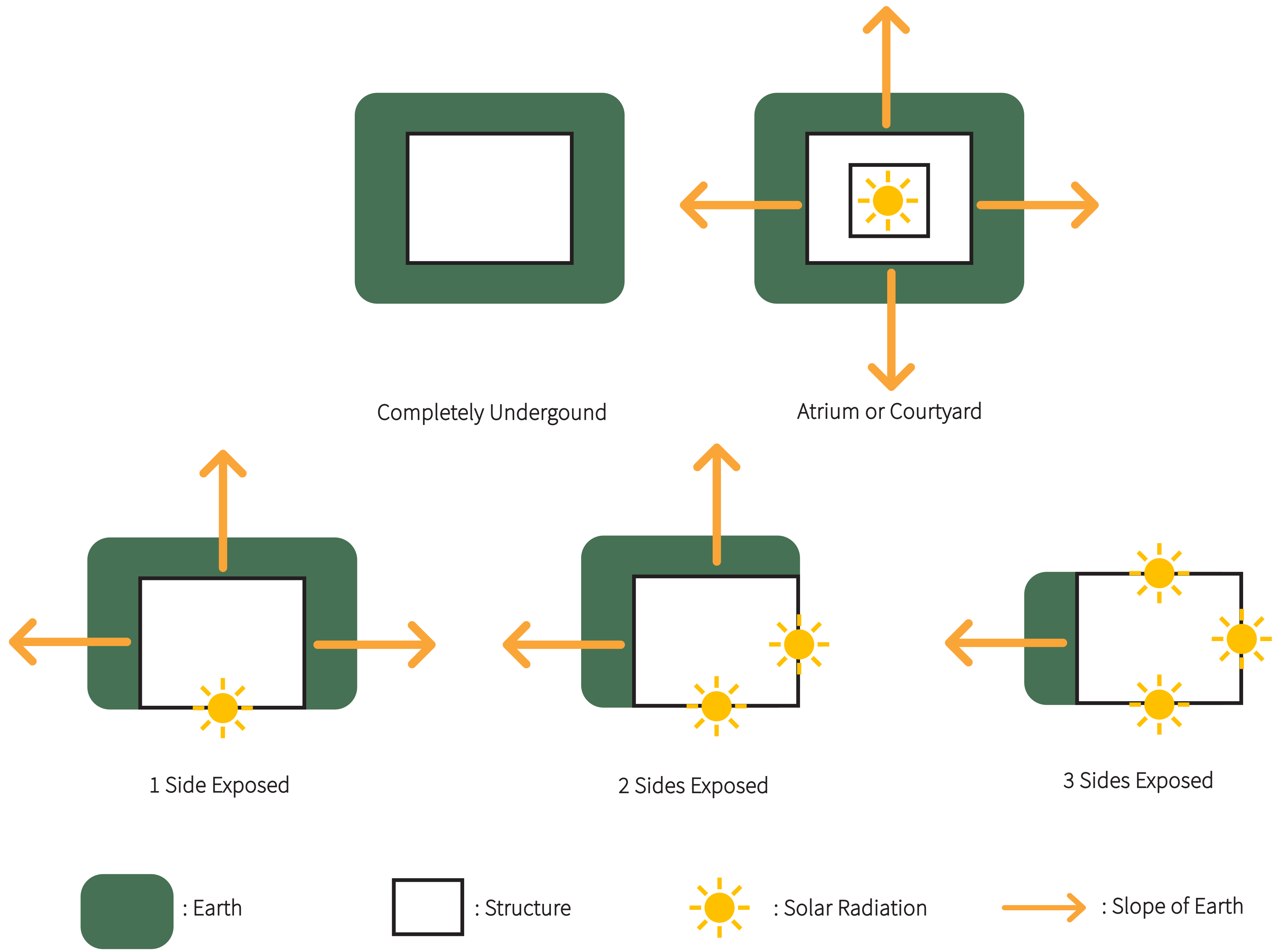


Figure 37. Bermed Structures: Access to Daylight

Accessing Daylight in Bermed Structures

Daylight accessibility within bermed structures can be constrained by the very nature of their construction. The degree to which a structure is enveloped by earth directly impacts the availability of natural light. Despite potential limitations, the number of sides covered by earth doesn't entirely preclude the utilization of daylighting and ventilation techniques. It presents an opportunity to strategically implement these techniques with careful consideration and innovative approaches. The structure's fewer open sides might pose challenges for natural airflow, but this limitation underscores the necessity of adopting passive strategies and systems to ensure adequate ventilation for a healthier indoor environment.

In bermed structures where open sides for proper air circulation might be limited, the integration of passive ventilation mechanisms becomes crucial. Implementing intelligent design solutions, such as strategically positioned vents or duct systems, can facilitate the movement of fresh air through the space. By harnessing passive ventilation methods, these structures can effectively circulate and filter the air indoors, ensuring a continuous supply of clean, fresh air despite the limited openings available for natural airflow.

Furthermore, optimizing the use of natural daylight in bermed constructions requires innovative design considerations. Designers might explore techniques like light wells, reflective surfaces, atriums, or strategically placed openings to channel sunlight into interior spaces. By creatively leveraging these methods, it becomes possible to maximize natural light penetration within the structure, even with a reduced number of exposed sides, thereby enhancing the overall quality of the indoor environment.

25. Boyer, Lester L, and Walter T Grondzik. Earth Shelter Technology. Texas, Texas: Texas A&M University Press, 1987.

Precedent Study 1: Ramat Hanadiv Visiting Center

Bird's Eye View

Figure 38. Ramat Hanadiv Bird's Eye View

Thermal Massing

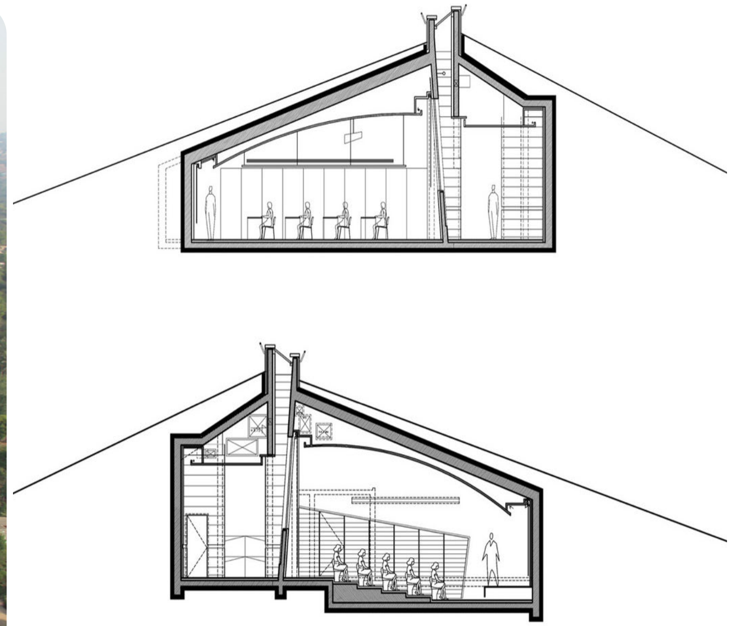


Figure 39. Ramat Hanadiv Section Cuts

Shading Strategy

Figure 40. Ramat Hanadiv Shading Strategy

Light Well

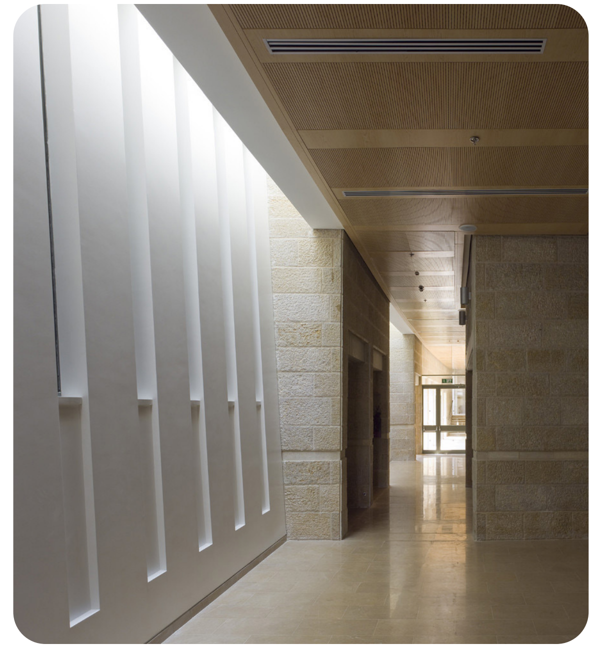


Figure 41. Ramat Hanadiv Light Well

Project: Ramat Hanadiv Visiting Center

Architects: Ada Karmi-Melamede Architects / Guy Teomi, Yuval Amitzi

Year Built: 2008

Location: Zichron Yaakov, Israel

Overview of Project: The architectural concept evolved from the need to create a foyer in front of the gardens which will function as a meeting place for the diverse groups of visitors. The architectural composition extends approximately 150 meters in a curvilinear fashion. It contains an auditorium, classrooms, small courtyards, an exhibition space and a small cafeteria at the extremity. These functions are housed within a berm formed by two inclined landscaped surfaces that lean against each other with light penetrating in between.

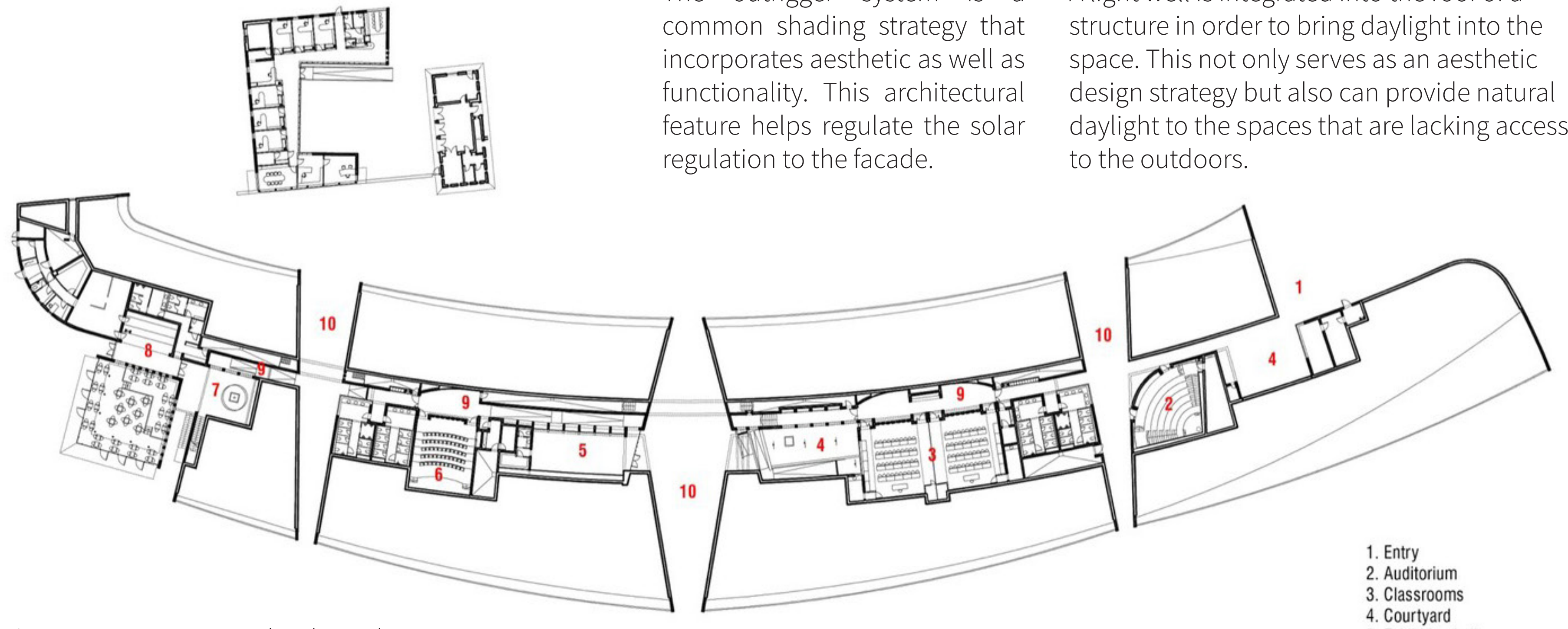
Strategy Analysis

The outrigger system is a common shading strategy that incorporates aesthetic as well as functionality. This architectural feature helps regulate the solar radiation to the facade.

Strategy Analysis

A light well is integrated into the roof of a structure in order to bring daylight into the space. This not only serves as an aesthetic design strategy but also can provide natural daylight to the spaces that are lacking access to the outdoors.

Floor Plan



1. Entry
2. Auditorium
3. Classrooms
4. Courtyard
5. Exhibition hall
6. Lecture room
7. Courtyard
8. Cafeteria
9. Internal walkway
10. North-South pedestrian passages

Figure 42. Ramat Hanadiv Floor Plan

26. "Ramat Hanadiv Visiting Center / Ada Karmi-Melamede Architects" 08 Dec 2011. ArchDaily. Accessed 6 Nov 2023. <https://www.archdaily.com/189050/ramat-hanadiv-visiting-center-ada-karmi-melamede-architects> ISSN 0719-8884

Precedent Study 2: Puey Ungpahakorn Centenary Hall

Bird's Eye View

Figure 43. Puey Ungpahakorn Bird's Eye View

Shading

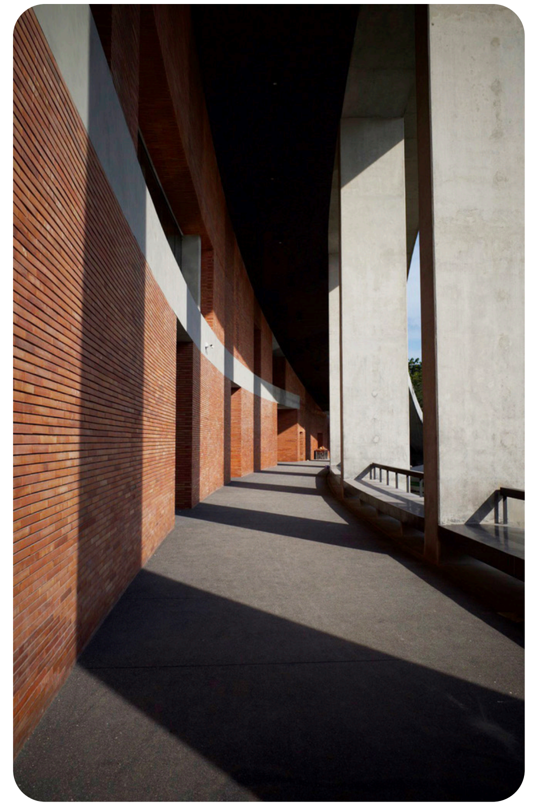


Figure 44. Puey Ungpahakorn Shading

Water Cooling

Figure 45. Puey Ungpahakorn Water Cooling

Atrium

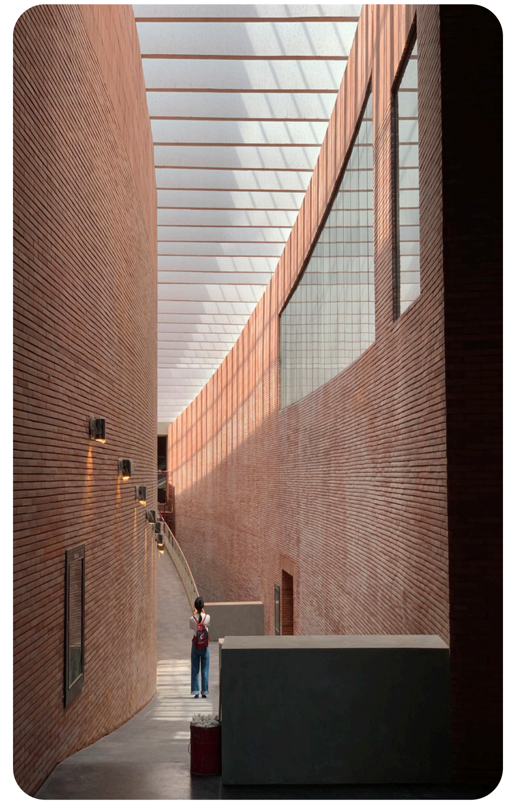


Figure 46. Puey Ungpahakorn Atrium

Project: Puey Ungpahakorn Centenary Hall

Architects: Arsomslip Community and Environmental Architect

Year Built: 2019

Location: Tambon Khlong Nung, Thailand

Overview of Project: The design is inspired by his name, "Puey" meaning earth mound that nourishes, cultures, and strengthens a tree from its base, reflecting how he devoted his whole life to the importance of environmental ecology within his homeland. The design combines harmoniously the relationship between architecture and landscape architecture (Land Process) to engage the community with functionality and leisure space by designing a green vegetation roof covering the whole building. The plants growing on the green roof are all edible to educate the university students about agricultural practices, and sufficient economies and to build up environmental awareness which corresponds with Thammasat University's intention to manage their own food source.

Elevations

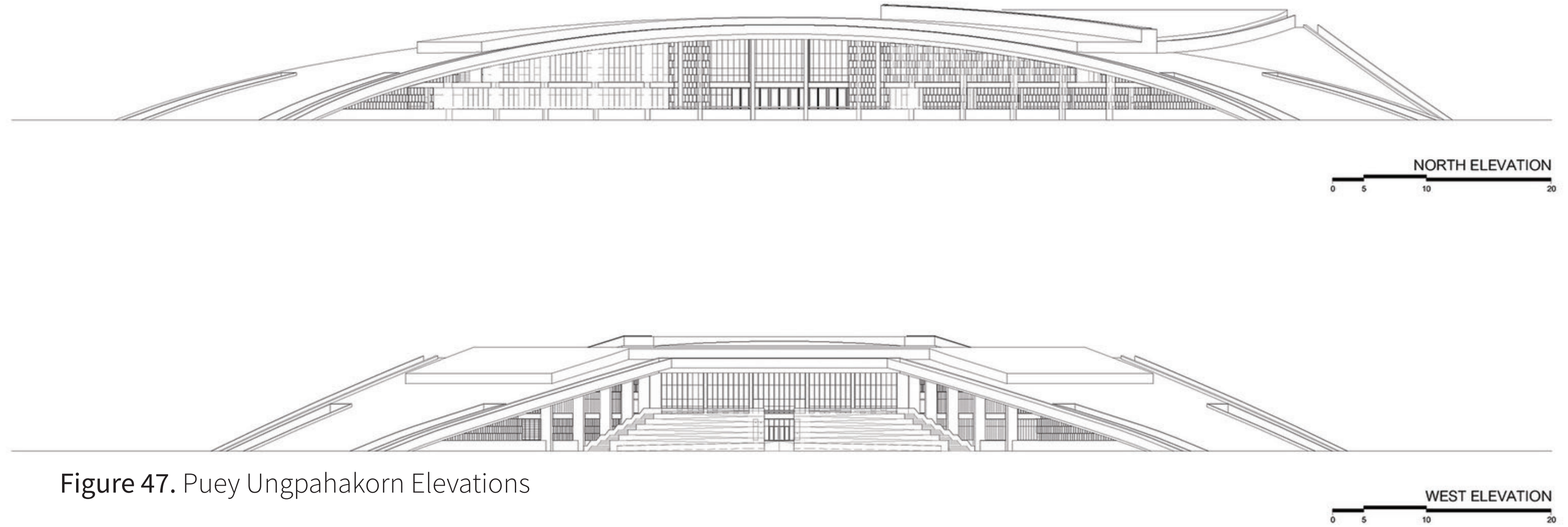


Figure 47. Puey Ungpahakorn Elevations

27. "Puey Ungpahakorn Centenary Hall / Arsomslip Community and Environmental Architect" 16 Aug 2023. ArchDaily. Accessed 6 Nov 2023. <https://www.archdaily.com/1005449/puey-ungpahakorn-centenary-hall-arsomslip-community-and-environmental-architect> ISSN 0719-8884

FACADE STUDY 1: DANPALON

Facade Applied to a Daycare Facility

Figure 48. Danpalon-Daycare Example

Opportunity for Color

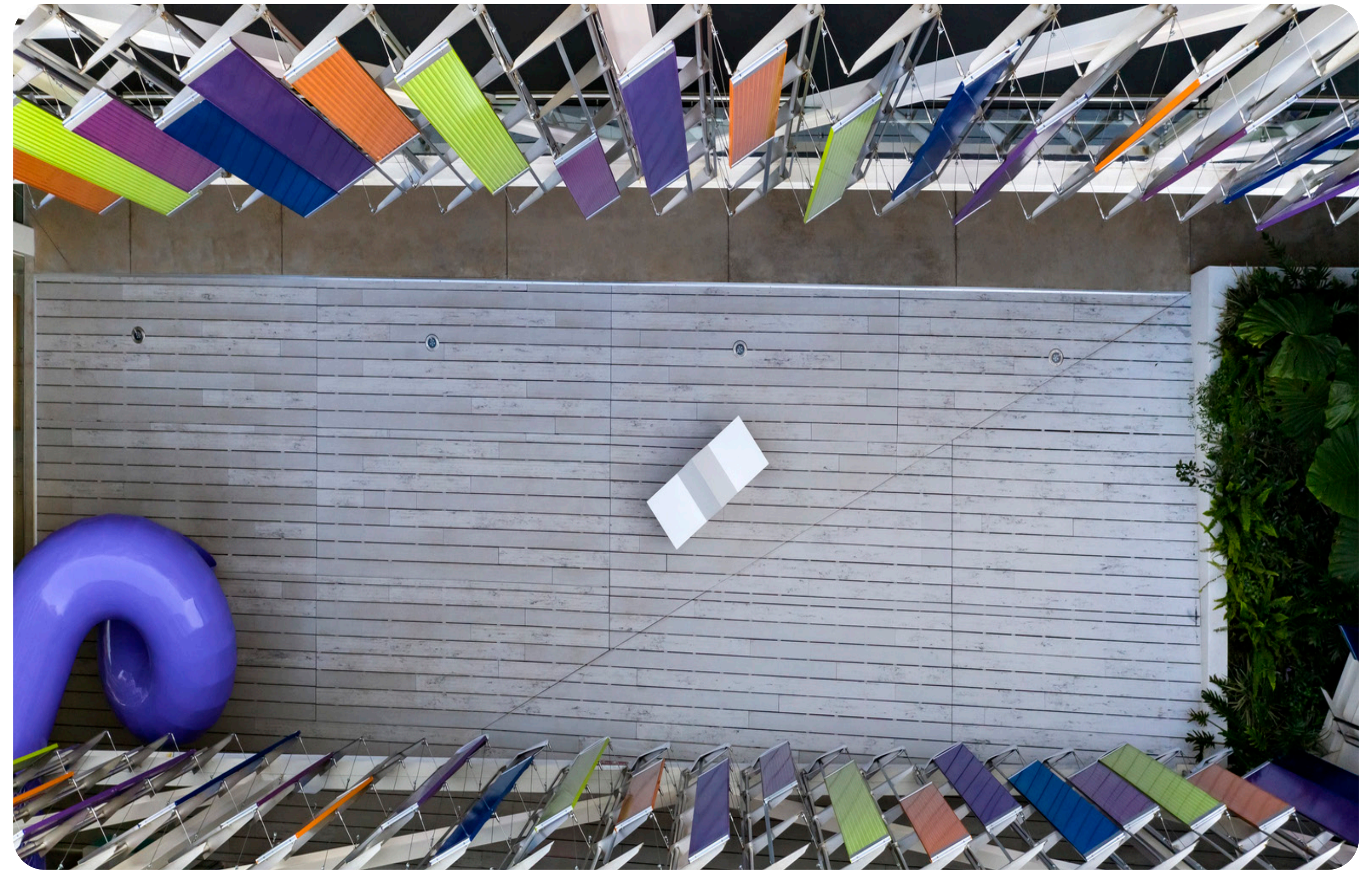


Figure 49. Danpalon-Use of Color

Facade Applied to an Office Building

Figure 50. Danpalon-Office Example

About this product:

Danpalon 3DLITE is a new technologically advanced and innovative system, developed by Danpal that allows architects to design creatively while contributing to energy savings and better use of natural light. Its advanced multicellular system selectively controls the sunlight that penetrates during the day, at the same time offering thermal insulation and a unique appearance.

Use: Solar control system for exterior use on roofs and facades. For interior use in dividing walls, soffits or screens.

Applications: Buildings, offices, commercial centers, hotels, museums, etc.

Characteristics: Light conditioner, efficient, aesthetic, innovative, contributes to energy saving.

Colors: White, green, clear, ivory, orange, violet, dark brown, blue, silver, red

Facade Applied to a Gymnasium

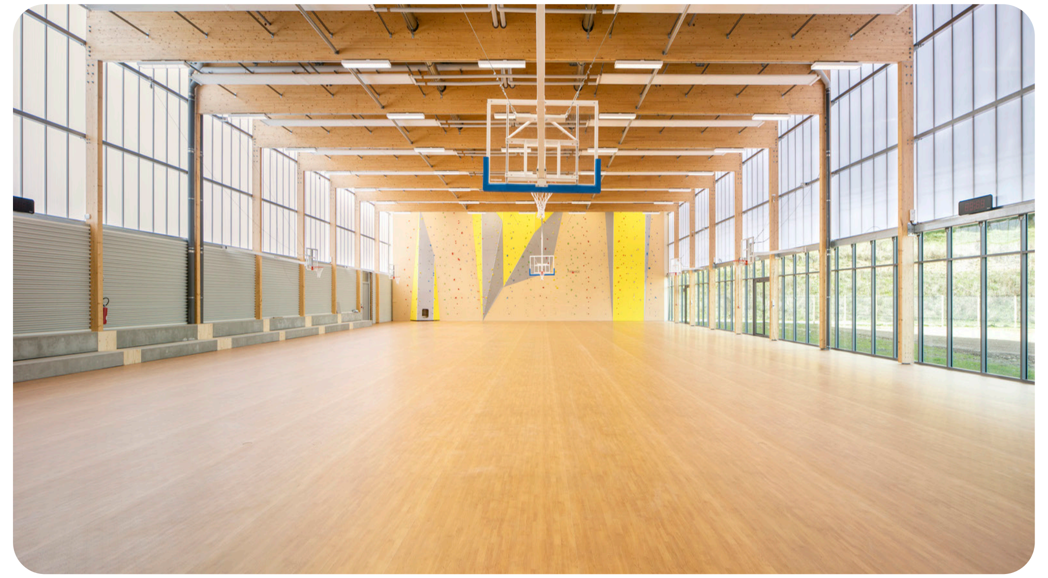


Figure 51. Danpalon-Gymnasium Example

28. ArchDaily. “Danpalon 3dlite - Solar Control from Danpal.” ArchDaily, September 21, 2023. https://www.archdaily.com/catalog/us/products/13408/control-solar-3dlite-danpal?ad_source=search&ad_medium=search_result_all.

FACADE STUDY 2: KALWALL

Kalwall Facade System

Figure 52. Kalwall Facade System Example

Kalwall External View

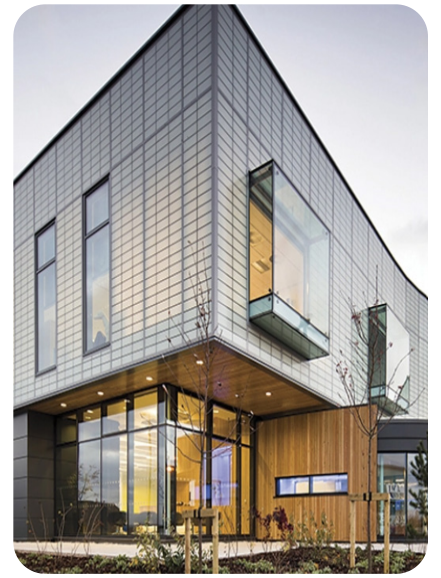


Figure 53. Kalwall External View Example

Kalwall Design Example

Figure 54. Kalwall Design Example

Kalwall Conference Room

Figure 55. Kalwall Conference Room

About this product:

KalWall is a translucent, structural sandwich panel which uses prismatic glass fibers embedded in the panels face sheets. The glass prisms refract sunlight to provide a balanced, diffuse wash of glare-free light. Kalwall provides full-spectrum, natural visible light, without distorting color rendition. During the manufacturing process, panels are fitted with translucent insulation to reduce solar heat gains.

Kalwall Facade Systems can be custom engineered to meet a variety of specialty applications including:

- Hurricane rated walls and windows
- High impact options
- Class A fire ratings
- Blast resistant systems meet DOD UFC 4-010-01 Anti-Terrorism Force Protection (ATFP)
- Factory Mutual certified systems: Class I Exterior Wall FM 4881 & FM 4411
- Factory Mutual explosion venting/pressure relief system: FM 4440
- Bespoke designs

Use: Facades

Applications: Industrial, commercial, sports, educational, cultural, industrial, transportation

Characteristics: Structural, glare-free, balanced daylighting, thermal performance, low maintenance, durable

Certifications: NFRC Certified, UL Listed, OSHA Fall thru compliant, ICC-ES, CE, BS, contributes to LEED, BREEAM, GreenSpec listed

Kalwall Industrial Use Example

Figure 56. Kalwall Industrial Use Example

29. ArchDaily. “Facades - Specialty Applications from Kalwall®.” ArchDaily, February 1, 2019. https://www.archdaily.com/catalog/us/products/15017/facades-specialty-applications-kalwall?ad_source=search&ad_medium=search_result_all.

Technology Study 1:

The CarbonCure Steps:

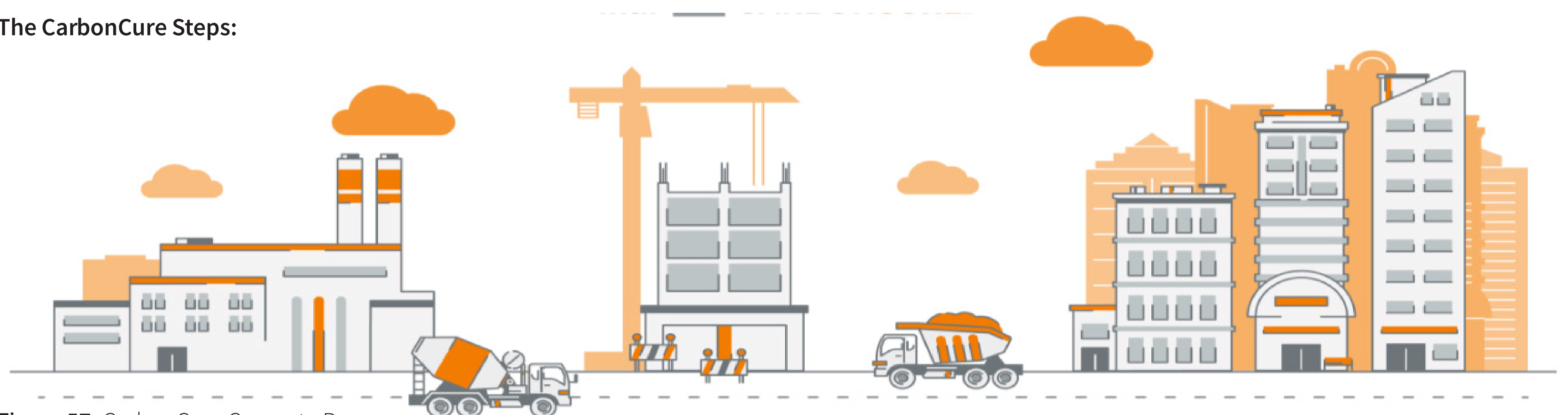


Figure 57. CarbonCure Concrete Process

1. Waste CO2 emissions are collected from local industrial emitters by gas companies and then purified.

2. The purified CO2 is stored onsite at the concrete plant and connected to the CarbonCure technology.

3. CarbonCure injects CO2 into the concrete during mixing, resulting in the same concrete, with less carbon.

4. Private and public projects are built with CarbonCure concrete, reducing embodied carbon in new buildings.

CarbonCure Valve Box

Figure 58. CarbonCure Concrete Valve Box

CarbonCure System

Figure 59. CarbonCure System

About this technology:

CarbonCure manufactures carbon dioxide removal technologies for concrete producers of all sizes. The technology injects a precise dosage of captured carbon dioxide into concrete during mixing, where it mineralizes. This improves the concrete's compressive strength, enabling mix optimization and significant carbon footprint reductions as well as cost savings.

Use: CarbonCure injects CO_2 into fresh concrete via the Valve Box. Batching is controlled by the Control Box, which is synced with the software in the control room — so it is as easy and simple as adding an admixture.

Applications: Commercial Buildings, Residential Buildings, Sidewalks, Pillars

Technolpgy Options: CarbonCure Ready Mix, CarbonCure Precast, CarbonCure Reclaimed Water, CarbonCure Masonry

30. "Carboncure's Sustainable Concrete Solution." CarbonCure Technologies Inc., November 29, 2023. https://www.carboncure.com/.

Technology Study 2:

Holcim Poured Concrete

Figure 60. Holcim Poured Concrete

Holcim Concrete Sections

Figure 61. Holcim Concrete Sections

Holcim Cast-in-place Concrete

Figure 62. Holcim Cast-in-place Concrete

About this technology:

Airium from Holcim is a fully recyclable mineral foam for insulation. This insulating system increases a building's energy efficiency and can even be applied in green retrofitting applications to expand a building's lifespan. Airium is mineral-based, thus, it is a fully recyclable foam that does not release any volatile organic compounds, enhancing indoor air quality.

Applied as a semi-liquid foam, Airium can reach any shape or corner where it hardens to create a long-lasting, fire-resistant insulating solution that is also unfavorable to insects and rodents and has a low CO2 footprint. Airium is made of a cement-based slurry, aqueous foam, and enclosed and distributed air bubbles. It can be used in different climatic conditions.

Use: Construction materials

Applications: Roofs, walls, floors, block-filling

Characteristics: Easy to use, mold-resistant, long lifespan

Certification: A1 according to EU standards

Advantages

- Sustainability

Up to 80% of current buildings and infrastructure are expected to still be in use by 2050. With this in mind, Holcim insulation products play an increasing role in the repair, renovation, and green retrofitting of spaces. Holcim's advanced insulation solutions help make buildings more sustainable in use.

- Energy-efficiency

Choosing advanced insulation technologies will enhance the efficiency of the entire building envelope, limit the environmental footprint and reduce heating and cooling costs. Holcim offers insulation for greater comfort, energy savings, and air quality

Holcim Insulation

Figure 63. Holcim Insulation

31. ArchDaily. "Smart Insulation from Holcim." ArchDaily, March 8, 2023. https://www.archdaily.com/catalog/us/products/32510/smart-insulation-holcim?ad_source=neufert&ad_medium=gallery&ad_name=close-gallery.

January 11, 2024 - April 17, 2024

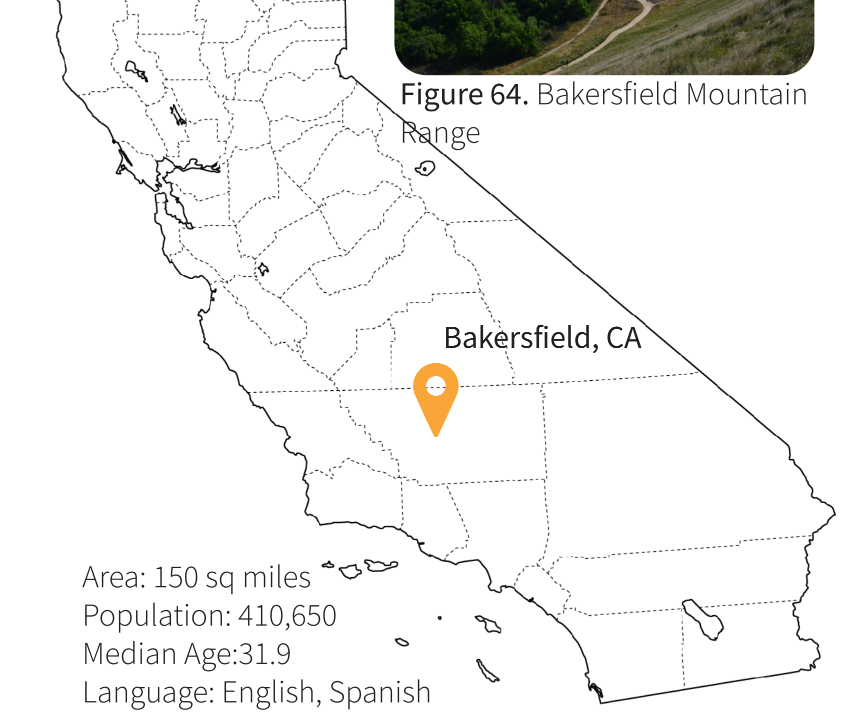
Pre-Design, Design Methodology, Design Response

Pre-Design

Design Methodology

Design Response

Zooming In on California



Area: 150 sq miles
Population: 410,650
Median Age:31.9
Language: English, Spanish

Figure 64. Bakersfield Mountain Range

Why Bakersfield, CA?

California stands out as one of the states profoundly affected by climate change and global warming. Notably, it boasts some of the most rigorous green energy initiatives in the nation. However, certain microclimates within California are anticipated to experience an average temperature increase of up to 4 degrees. While 4 degrees may seem insignificant, given California's propensity for 100-degree days, even a slight elevation in temperature could pose significant health risks.

Moreover, Bakersfield, CA, situated in a valley—a characteristic common to many Californian regions owing to its mountainous terrain—faces heightened temperatures due to limited access to open air circulation. This geographical feature underscores the urgency for Bakersfield to prioritize a shift in design responsibilities towards energy efficiency. Additionally, the city must focus on designing for resilience and adaptation to accommodate the challenges posed by a warmer climate.

Figure 65. Welcome to Bakersfield

Figure 66. Bakersfield City Center

Figure 67. Bakersfield Mountain View

Microclimates

In Southern California, there are five to seven different microclimates. A microclimate is a small area within the surrounding larger area with a different climate. These microclimates are most distinct in summer and are mostly defined by temperature and humidity. On a typical summer day, it could be 65 degrees and cloudy at the beach and 90 degrees and sunny just 10 miles away. This temperature difference is driven by topography. The mountain chain separates the two microclimates. On one side you have cold, moist air adjacent to the ocean. On the other side, you have hot, dry air. This is the case between Los Angeles County beaches and the San Fernando Valley. 10 miles separate these two microclimates. In general, the farther inland you live, the warmer it gets.

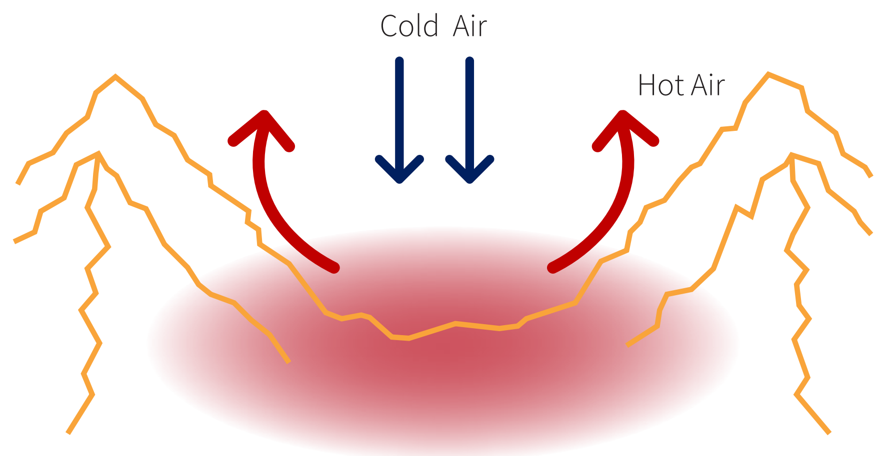


Figure 68. Valley Air Circulation

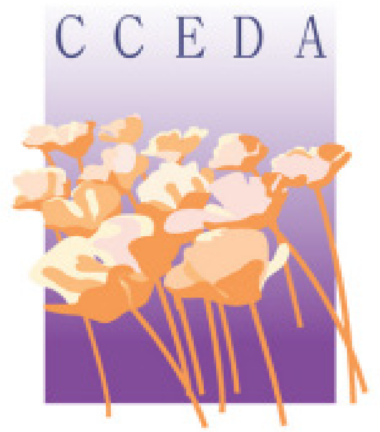


Figure 69. CCEDA Logo

California's Climate Initiative

Southern California governments have made progress to reduce greenhouse gas emissions and make plans to adapt to climate change. Several plans highlighted are: County of Los Angeles OurCounty Sustainability plan (2019), City of Los Angeles Green New Deal plan (2020), Metro Climate Action and Adaptation Plan (2019), City of Long Beach CAAP (2020), SCAG Resilience Plans, Santa Ana Climate Action Plan (2015), City of Santa Clarita CAP (2012), and the County of Ventura Climate Action Plan (2019). Additionally, municipalities are updating their General Plans to include strategies that address climate mitigation and adaptation. Although Los Angeles will be impacted in many ways by a changing climate, the region already has specific plans in place to address those impacts with innovative solutions that will create more livable cities for everyone. There are two pieces of legislation and one executive order that drive climate action in California.

- Senate Bill 32 (2016) requires California Air Resources Board (CARB) to reduce green house gas emissions to 40% below 1990 levels by 2030.
- Senate Bill 100 (2018) commits California to achieving 100% renewable energy by 2045.
- Executive Order B-55-18 commits California to achieving carbon neutrality in every sector by 2045

Bakersfield Climate Analysis

Bakersfield, CA Temperature Range

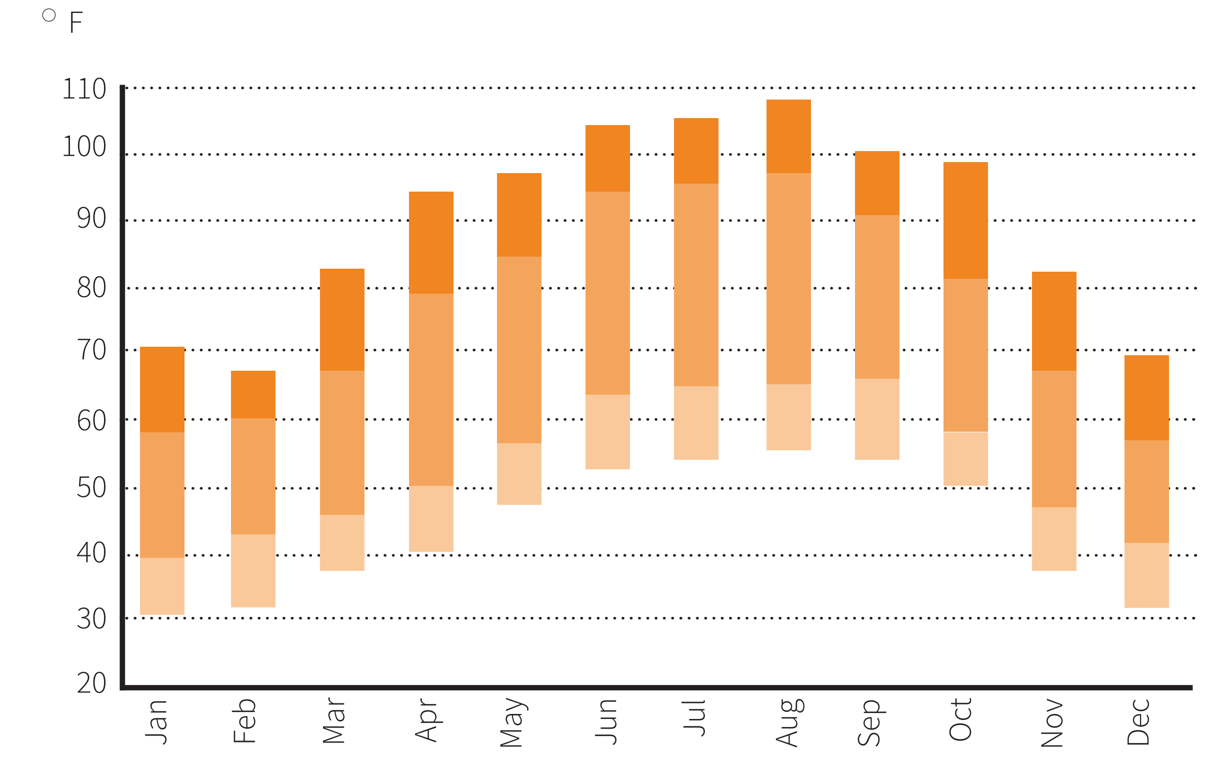


Figure 70. Bakersfield Temp Graph

Temperature Analysis

According to climate consultant, Bakersfield experiences extreme temperatures that necessitate resilient design strategies prioritizing occupant comfort. Implementing a range of strategies becomes essential to mitigate high temperatures while simultaneously improving energy efficiency and enhancing human comfort levels. The key insight is the extreme temperatures in the month of August.

Bakersfield, CA Sky Coverage

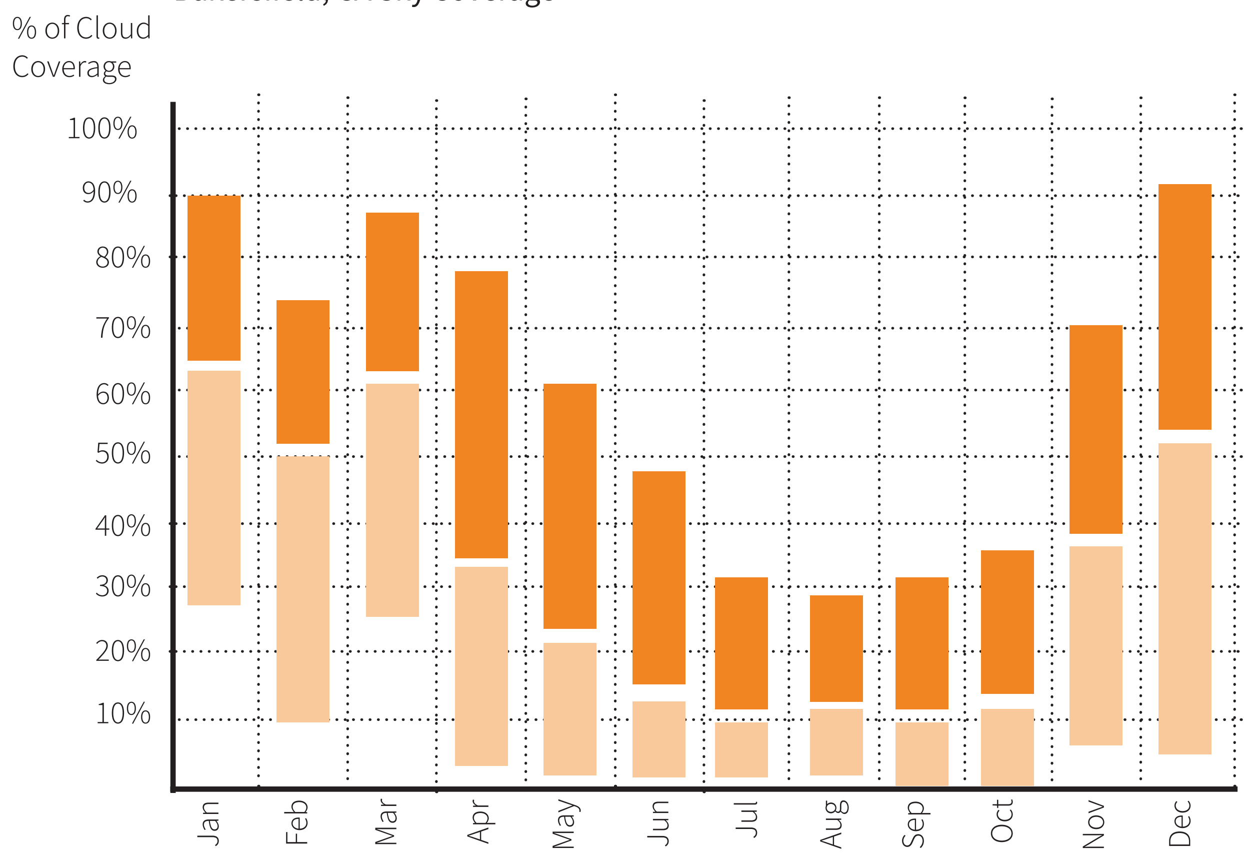


Figure 71. Bakersfield Cloud Graph

Sky Coverage Analysis

The key insight from the Bakersfield Sky Coverage graph is that the least amount of cloud coverage coincides with the hottest months of the year, posing significant risks to local residents. For instance, in August, when temperatures soar to 109 degrees Fahrenheit, the average cloud coverage is only 29%. This situation is likely to result in increased electricity bills and potentially higher rates of hospital admissions due to greater risk of heat related illnesses.

Bakersfield, CA Topography

Figure 72. Bakersfield Topography

Bakersfield, CA Topography Analysis

Bakersfield, California, is situated in the southern part of the San Joaquin Valley, which is part of the larger Central Valley of California. The topography of Bakersfield and its surrounding areas is characterized by a mixture of flat plains, rolling hills, and low mountains. Bakersfield lies primarily on the valley floor of the San Joaquin Valley. This area is generally flat and characterized by fertile agricultural land, making it an important hub for farming and agriculture in California. The city is surrounded by low hills and mountains, including the Tehachapi Mountains to the northwest and the Sierra Nevada Range to the east. These mountain ranges provide a scenic backdrop to the city and contribute to its overall topography. The Kern River flows through Bakersfield, providing water for irrigation and recreational opportunities. The river cuts through the valley floor, creating a natural feature within the city's landscape. Bakersfield is also known for its oil fields, which dot the landscape surrounding the city. The extraction of oil and natural gas has shaped the topography of the area, with oil derricks and pumpjacks visible throughout the region. Overall, the topography of Bakersfield, CA, is characterized by a mix of flat valley floor, rolling hills, and nearby mountain ranges. This diverse landscape contributes to the city's economy, recreational opportunities, and overall aesthetic appeal.

Bakersfield's Comfort Analysis

Comfort Analysis Chart

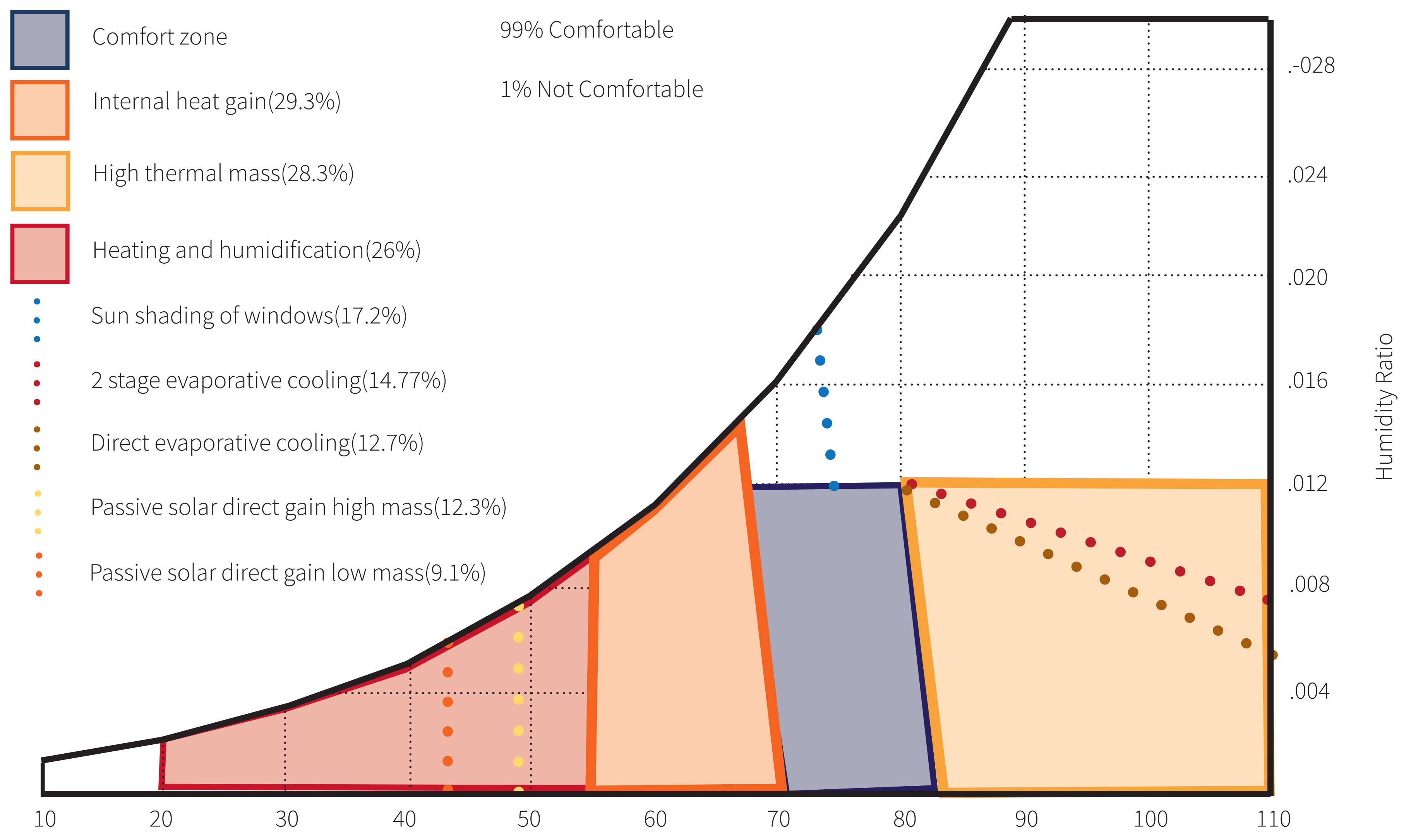


Figure 73. Comfort Analysis

Internal heat gain(29.3%)

Definition:

Internal heat gain refers to the heat produced within a building or a space as a result of various internal sources such as human occupants, electrical appliances, lighting, and machinery. These sources generate heat energy that contributes to the overall thermal load within the building. Understanding and managing internal heat gain is crucial for designing efficient heating, ventilation, and air conditioning (HVAC) systems, as well as for optimizing thermal comfort and energy efficiency within buildings.

Strategies:

Insulation: Properly insulate walls, roofs, and floors to minimize heat transfer between the interior and exterior of the building. Insulation helps maintain stable indoor temperatures and reduces the need for heating and cooling.

Efficient Lighting: Replace inefficient incandescent bulbs with energy-efficient LED or CFL (compact fluorescent lamp) lighting fixtures. LEDs produce less heat than traditional lighting sources, reducing internal heat gain.

Appliance Efficiency: Choose energy-efficient appliances and equipment with low heat output for use within the building. Opt for appliances with ENERGY STAR ratings and consider replacing older, less efficient models.

Occupancy Sensors: Install occupancy sensors and timers for lighting and HVAC systems to ensure that energy is only used when needed. This helps reduce unnecessary heat gain from lighting and HVAC operation in unoccupied areas.

High thermal mass(28.3%)

Definition:

High thermal mass refers to the ability of a material or structure to absorb, store, and release heat energy over time. Materials with high thermal mass have the capacity to absorb heat during periods of high temperature and release it slowly when the surrounding conditions cool down. This property helps to moderate temperature fluctuations within a space and can contribute to improved thermal comfort and energy efficiency in buildings.

Strategies:

Insulation and Thermal Mass Balance:

- Pair thermal mass elements with appropriate insulation to minimize heat loss or gain through the building envelope.
- Place insulation on the exterior of thermal mass elements in hot climates to prevent heat from penetrating the building during the cooling season.

Material Selection:

- Choose dense materials with high thermal mass properties such as concrete, brick, stone, rammed earth, or adobe for walls, floors, and ceilings.

Heating and humidification(26%)

Definition:

Heating systems can use various energy sources, including electricity, natural gas, oil, and renewable energy sources like solar or geothermal energy. Humidification is the process of adding moisture to the air to increase relative humidity levels. Maintaining appropriate humidity levels indoors is important for comfort, health, and the preservation of materials. Low humidity levels can lead to dry skin, respiratory discomfort, and static electricity buildup, while high humidity levels can promote mold growth and discomfort.

Strategies:

Natural Ventilation:

- Take advantage of natural ventilation strategies, such as cross-ventilation and stack ventilation, to promote airflow and moisture removal.

Moisture Control:

- Use vapor barriers and moisture-resistant materials in areas prone to moisture accumulation, such as basements and crawl spaces.

Insulation and Air Sealing:

- Improve insulation and air sealing to prevent condensation on cold surfaces, which can contribute to indoor humidity levels.

Bakersfield's Comfort Analysis

Sun shading of windows(17.2%)

Definition:

Sun shading for windows refers to the installation of devices or structures designed to reduce the amount of direct sunlight and solar heat entering a building through windows. The primary purpose of sun shading is to improve occupant comfort, minimize glare, and reduce the need for mechanical cooling systems, thereby enhancing energy efficiency.

Strategies:

Exterior Shading:

- Exterior shading devices are installed outside the building envelope to intercept sunlight before it reaches the windows. Common types of exterior shading include:
  - -Awnings
  - -Louvers
  - -Exterior Blinds

Interior Shading:

- Interior shading devices are installed inside the building near windows to control sunlight and glare. These include:
  - -Blinds
  - -Shades
  - -Curtains

Solar Control Films:

- Transparent or translucent films applied to window glass to reduce solar heat gain and glare while allowing natural light to enter.

2 stage evaporative cooling(14.77%)

Definition:

Two-stage evaporative cooling is a cooling technology that uses the principles of evaporative cooling to lower the temperature of air in a building or space. Unlike traditional single-stage evaporative coolers, which rely solely on the evaporation of water to cool the air, two-stage evaporative cooling systems incorporate an additional cooling stage to further enhance the cooling process and improve energy efficiency.

Strategies:

Commercial and Industrial Cooling Systems:

- These systems are often integrated into HVAC (Heating, Ventilation, and Air Conditioning) systems to provide cooling in large spaces such as warehouses, factories, data centers, and shopping malls.

Cooling Towers:

- In some applications, two-stage evaporative cooling technology is utilized in cooling towers to remove heat from industrial processes or power generation facilities.
- These cooling towers use evaporative cooling principles to dissipate heat from water or other fluids, resulting in lower operating temperatures and increased efficiency.

Direct evaporative cooling(12.7%)

Definition:

Direct evaporative cooling is a method of air cooling that utilizes the natural process of water evaporation to reduce the temperature of air. This cooling technique is often used in evaporative coolers, also known as swamp coolers, and is especially effective in arid or dry climates. The process involves bringing outdoor air into contact with water, causing the water to evaporate and extract heat from the air, resulting in a cooler and more comfortable indoor environment.

Strategies:

Water Distribution System:

- A water distribution system is used to saturate the pads with water. This can involve pumps or gravity-fed systems that continuously supply water to the pads, ensuring they remain wet during operation.

Maintenance and Water Management:

- Regular maintenance is essential to ensure the effective operation of direct evaporative cooling systems. This includes cleaning and inspecting the wetted pads, checking for leaks or blockages in the water distribution system, and replacing any worn-out components as needed.

Integration with Building Design:

- Direct evaporative cooling systems can be integrated into the overall design of buildings to optimize their performance.

Passive solar direct gain high mass(12.3%)

Definition:

Passive solar direct gain high mass refers to a design strategy for passive solar heating in buildings, which relies on the principles of solar energy absorption, storage, and distribution to naturally heat indoor spaces. This design approach incorporates high thermal mass materials into the building structure to capture and store solar heat during the day and release it gradually at night, helping to stabilize indoor temperatures and reduce the need for mechanical heating systems.

Strategies:

Direct Solar Gain:

- The design of the building includes large south-facing windows or glazed areas that allow sunlight to enter the interior space directly. This incoming solar radiation heats the interior surfaces, floors, walls, and other thermal mass elements within the building.

Heat Storage and Release:

- During the day, the high thermal mass materials absorb and store solar heat gained through the windows. The absorbed heat is stored within the mass of the building elements, gradually raising their temperature.

High Thermal Mass Materials:

- The building incorporates materials with high thermal mass properties, such as concrete, brick, stone, or adobe, into its structure.

Passive solar direct gain low mass(9.1%)

Definition:

Passive solar direct gain low mass is a design strategy for passive solar heating in buildings that relies on the principles of solar energy absorption and distribution to naturally heat indoor spaces. In contrast to passive solar direct gain high mass, which utilizes materials with high thermal mass to store and release heat, passive solar direct gain low mass focuses on using lightweight building materials that heat up and cool down quickly in response to solar radiation.

Strategies:

Lightweight Building Materials:

- Unlike high mass construction, which uses dense materials like concrete or brick, low mass construction employs lightweight materials such as wood, gypsum board, or insulation panels. These materials have low thermal inertia, meaning they heat up and cool down relatively quickly in response to changes in solar radiation.

Natural Heat Distribution:

- As the indoor surfaces absorb solar heat, warm air rises and circulates through the space via convection currents. This natural convection helps distribute the heat evenly throughout the building, providing thermal comfort to occupants.

Direct Solar Gain:

- The building design incorporates south-facing windows or glazed areas to allow sunlight to enter the interior space directly.

Site Analysis

Front View of Site

Figure 74. Existing South Facade

Location: 1600 Norris Rd Bakersfield, CA 93308

Lot Size: 1.5 Acres

Square Footage: 16,000 sq'

Figure 75. Existing Building

Site approximization

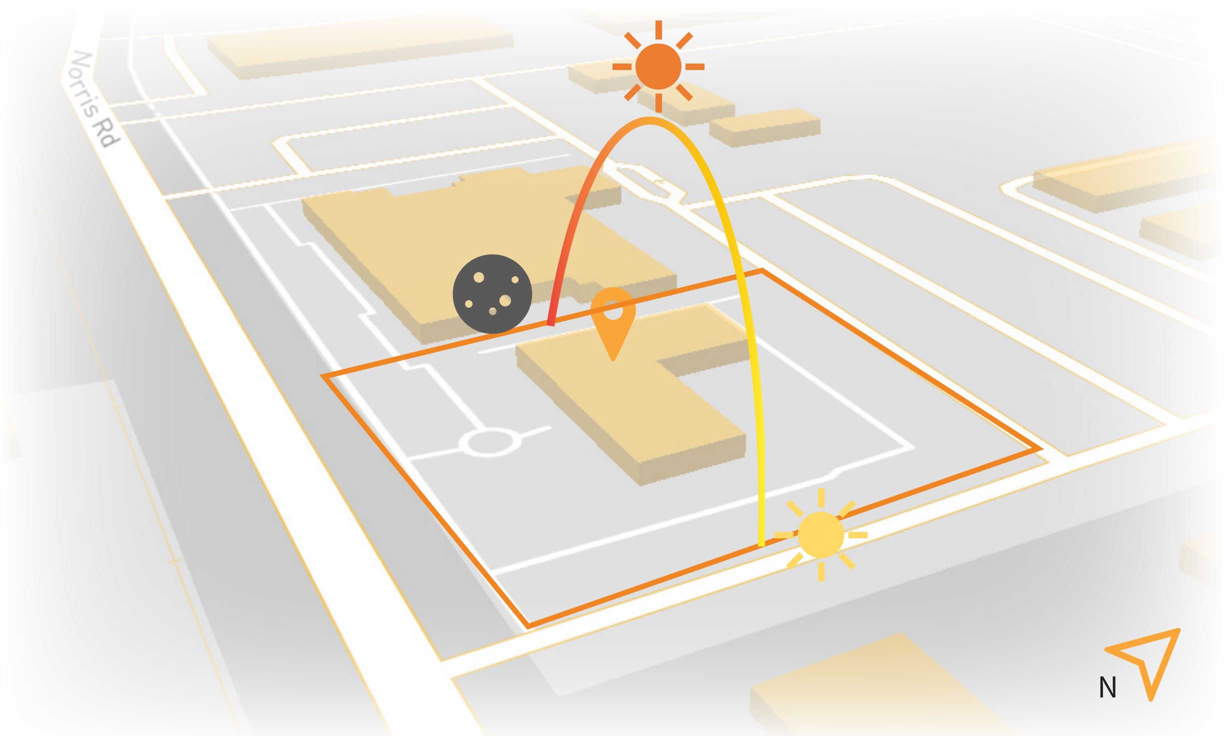


Figure 76. Sun Path over Site

1600 Norris Rd is a 3 story building with roughly 5,333 sq' on each level. The site was previously used as an office building, it is comprised of roughly 30 offices, a conference room, training rooms, and a kitchen. This site was chosen due to it's location in Bakersfield. The climate in Bakersfield, CA is very hot and dry and therefore it's structures need to be designed to weather the heat.

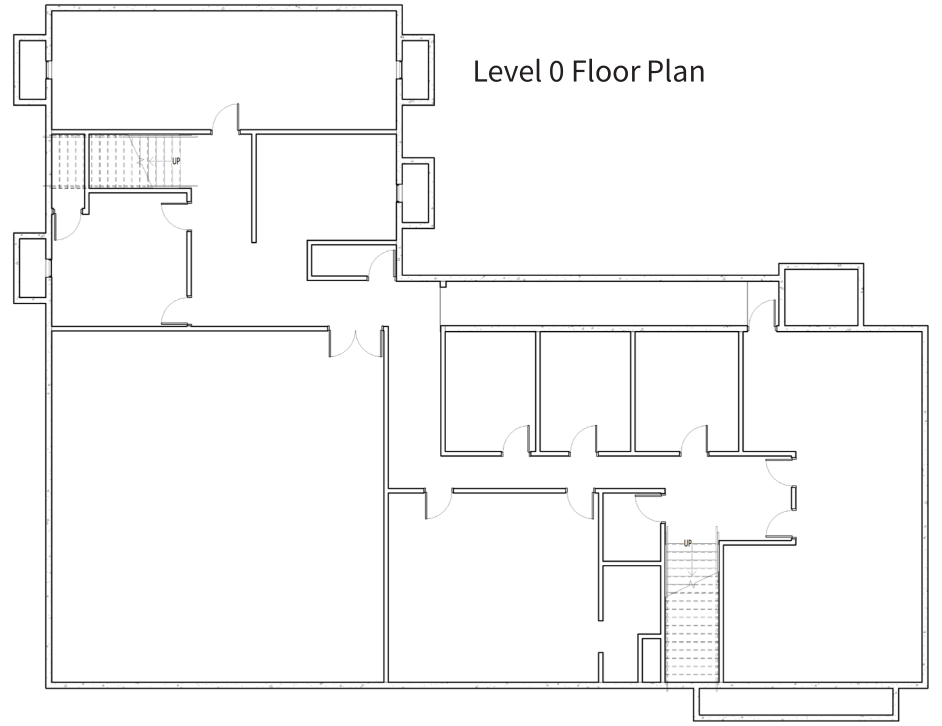


Figure 77. Level 0 Existing Floor Plan

Figure 78. Level 1 Existing Floor Plan

Figure 79. Level 2 Existing Floor Plan

Programming: Adjacencies

Adjacency Matrix

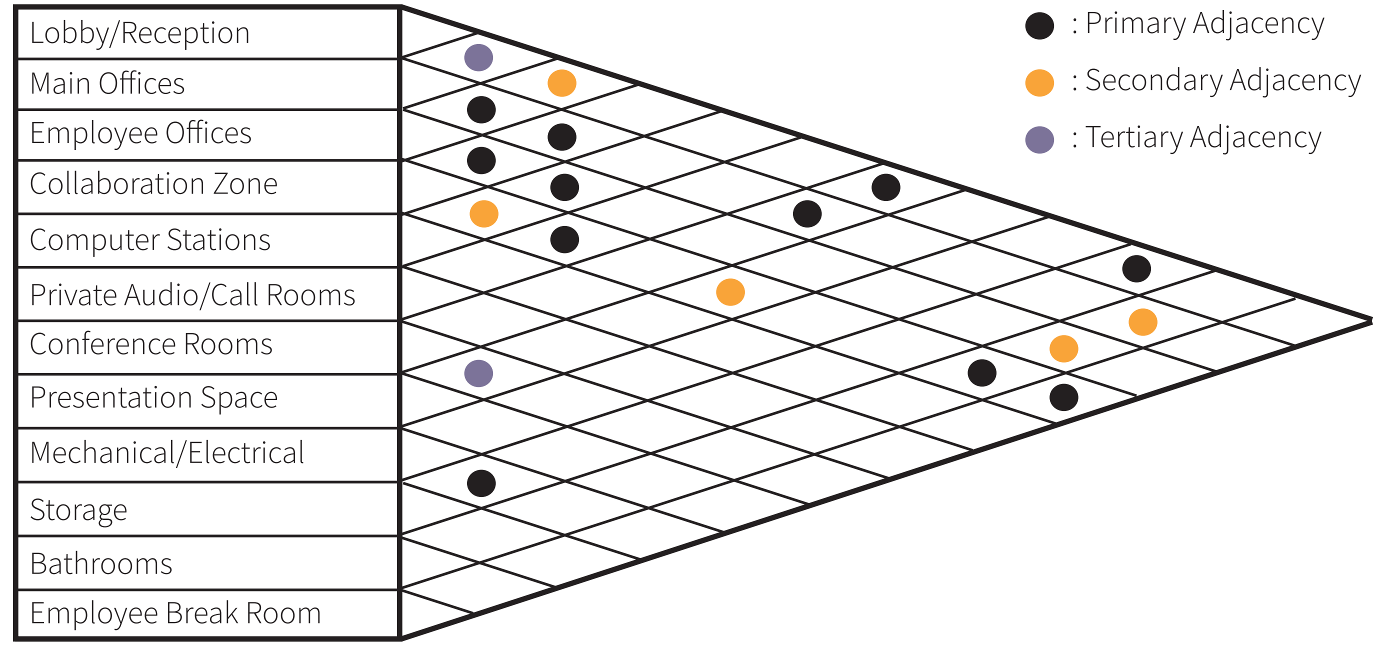


Figure 80. Adjacency Matrix

Bubble Diagrams

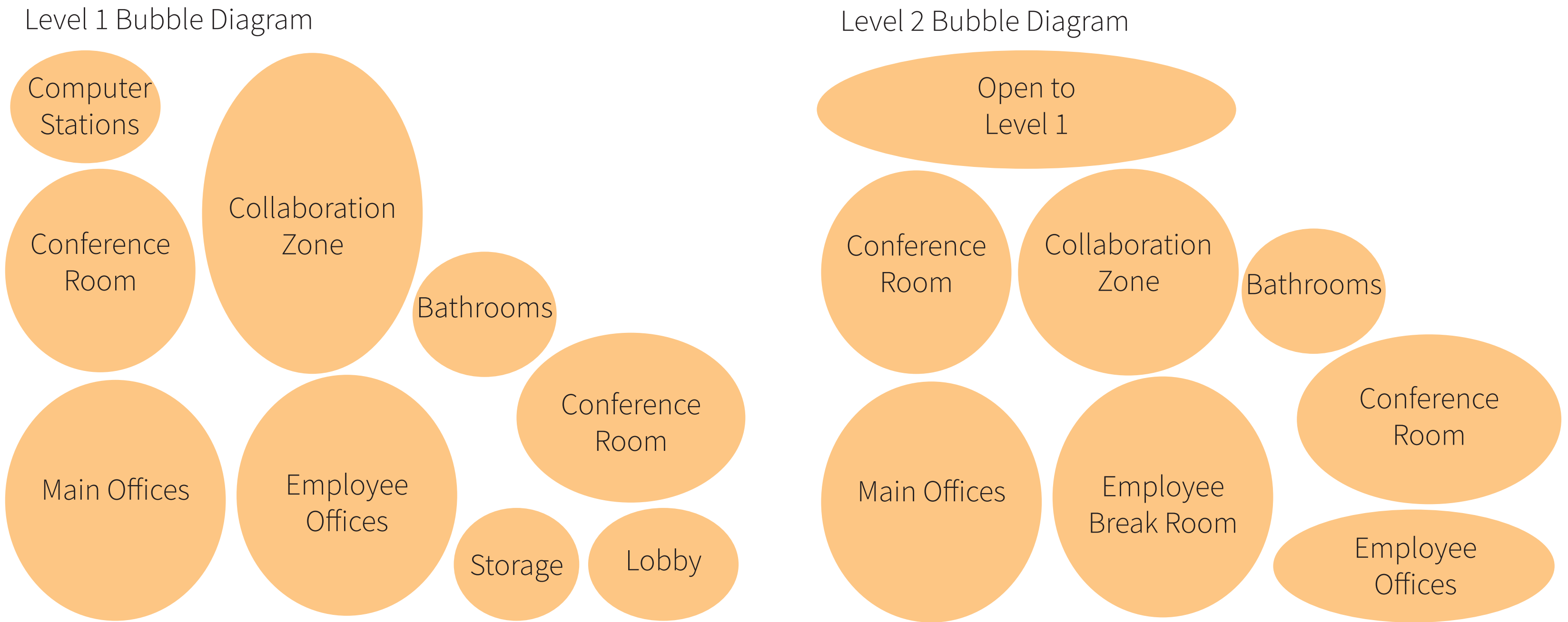


Figure 81. Bubble Diagram Level 1

Figure 82. Bubble Diagram Level 2

Blocking Diagrams

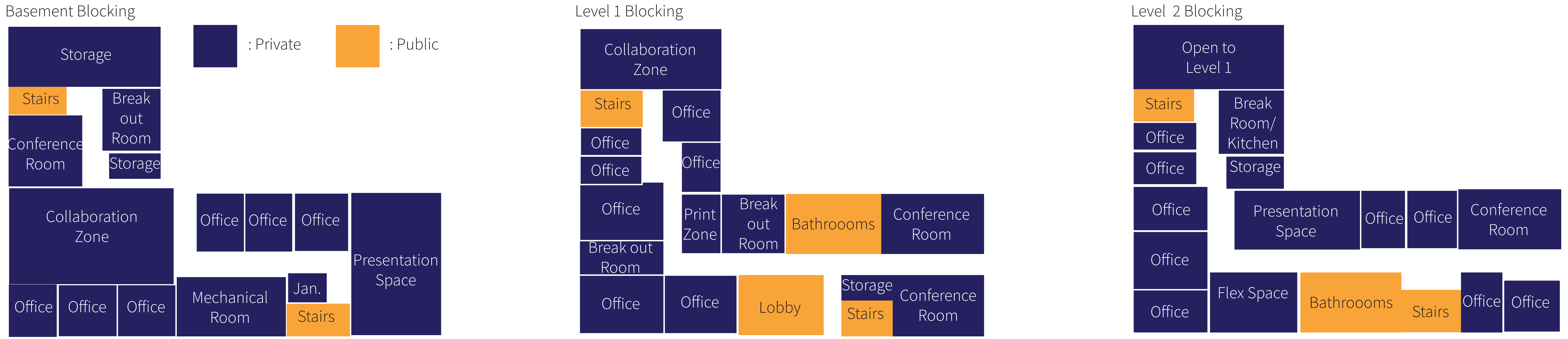


Figure 83. Blocking Level 0

Figure 84. Blocking Level 1

Figure 85. Blocking Level 2

Energy Priorities Chart

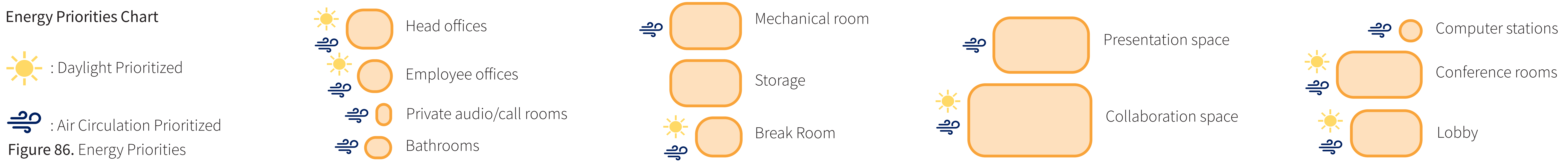


Figure 86. Energy Priorities

Programming

Spaces	QTY	Level	Ceiling Height	Furniture	Equipment	Plumbing	Lighting	Acoustics	Flooring	Passive Strategies
Lobby	1	1	12'	Reception desk, chairs,	Computer system, hardware		Natural daylight, LED	Refelt Acoustic Partitions	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows
Presidents Office	1	1	12'	The Steelcase Series™ 1 Task, UrbanWoodGoods L Shaped Desk	Computer system, hardware		Natural daylight, LED	Refelt Acoustic Panels	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows
Vice Presidents Office	1	1	12'	The Steelcase Series™ 1 Task, UrbanWoodGoods L Shaped Desk	Computer system, hardware		Natural daylight, LED	Refelt Acoustic Panels	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows
Managers Office	1	1	12'	The Steelcase Series™ 1 Task, UrbanWoodGoods L Shaped Desk	Computer system, hardware		Natural daylight, LED	Refelt Acoustic Panels	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows
HR Office	1	0	12'	The Steelcase Series™ 1 Task, UrbanWoodGoods L Shaped Desk	Computer system, hardware		Natural daylight, LED	Refelt Acoustic Panels	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows
Employee Offices	10	0, 1, 2,	12'	The Steelcase Series™ 1 Task, UrbanWoodGoods L Shaped Desk	Computer system, hardware		Natural daylight, LED	Refelt Acoustic Panels	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows
Floating Work Station	34	0, 1	24'	The Steelcase Series™ 1 Task, UrbanWoodGoods Standing Desk	Computer system, hardware		Natural daylight, LED	Refelt Acoustic Partitions	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass solar chimney, SmartGlass light well(Level 0, 1, 2)
Meeting Room	2	0, 1, 2	10', 12'	The Steelcase Series™ 1 Task, UrbanWoodGoods Standard Conference Table	Projector		Natural daylight, LED	Refelt Acoustic Panels	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows
Conference Room	6	0, 1, 2,	12'	The Steelcase Series™ 1 Task, UrbanWoodGoods Standard Conference Table, UrbanWoodGoods Credenza	Projector		Natural daylight, LED, Kohler Chandelier	Refelt Acoustic Panels	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass light well(Level 0)
Presentation Space	1	0	10'	Van De Sant Inagua Modular Sofa, UrbanWoodGoods Standard Conference Table, UrbanWoodGoods Credenza	Projector, Miniature Fridge	Sink	LED	Refelt Acoustic Partitions	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue)	SmartGlass Windows(Level 1, 2)
Collaboration Zone	1	0, 1, 2	24'	Van De Sant Inagua Modular Sofa, Steelcase stools, UrbanWoodGoods Standing Desks, Refelt Acoustic Partitions	Miniature Fridge	Sink	Natural daylight, LED, Kohler Sconces,	Refelt Acoustic Partitions	Mohawk Group's Chromatic Cadence Carpet Tile(Color: Kind of Blue), Mohawk Group's Uplifting Others Carpet Tile(Color: Flow State)	SmartGlass solar chimney, SmartGlass light well(Level 0, 1, 2)
Private Audio/Call Rooms	2	2	12'	Chair, side table			Natural daylight, LED	Refelt Acoustic Panels	Mohawk Group's Uplifting Others Carpet Tile(Color: Flow State)	SmartGlass Windows
Womens Bathrooms	2	1, 2	12'		Hand Dryer, Trash Can	Toilets, Sinks,	Natural daylight, LED		Armstrong porcelain tile planks	SmartGlass Windows
Mens Bathrooms	2	1, 2	12'		Hand Dryer, Trash Can	Toilets, Urinals, Sinks,	Natural daylight, LED		Armstrong porcelain tile planks	SmartGlass Windows
Respite Room	2	1, 2	12'	Chair, side table			Natural daylight, LED		Mohawk Group's Uplifting Others Carpet Tile(Color: Flow State)	SmartGlass Windows
Mechanical/Electrical	1	1	10'	Rolling carts, shelving	Electrical Hub		LED		Polished Concrete	
Storage	5	1, 2, 3	10', 12'	Shelving			LED		Polished Concrete	

Figure 87. Project Program

Code Considerations

Occupancy Classification: B-2

All codes taken from the California Building Code 2022

Fire Codes	Chapter 49- Fire resistant vegitation NFPA 257- Standard on fire test for window and glass block assemblies
Ventilation Codes	1202.1- Buildings should be provided with natural ventilation in accordance with section 1202.5, or mechanical ventilation in accordance with California's Mechanical code ASHRAE STANDARD 62.1- is the American Society of Heating, Refrigerating and Air-Conditioning Engineers document titled "Ventilation for Acceptable Indoor Air Quality," 2019 (ANSI/ASHRAE Standard 62.1-2019, including Addenda y, ao, P, B).
Egress	Occupant Load: 150 Gross (1 occupant per 50 sq') Common Path of Egress Travel Distance with sprinkler system: 100' Minimum number of exits: 4
Plumbing Codes	Water Closets: 1 per 25 for the first 50, and 1 per 50 for the remainder exceeding 50 Lavatories: 1 per 40 for the first 80, and 1 per 80 for the remainder exceeding 80 Drinking Fountains: 1 per 100 1 service sink required
Environmental	Section 1203: Temperature Control Section 1212: Pullutant Control

Design Methodology Process

Process Timeline

Fall 2023
Research

- Literary research and analysis
- Expert interviews
- Precedent studies

January 9, 2024 - January 26, 2024
Programming

- Project Context
- Location Analysis
- Comfort Analysis

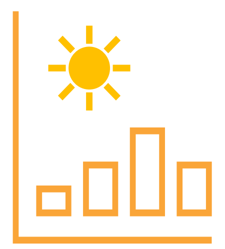
January 26, 2024 - February 16, 2024
Design Methodology

- Outline Process
- Evaluate Representational Methods
- Represent Prototypes

February 16, 2024- March 29, 2024
Design Response

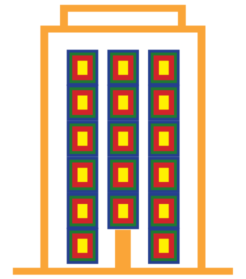
- Apply Design Strategies
- Formulate Design Response

Evaluation Methods



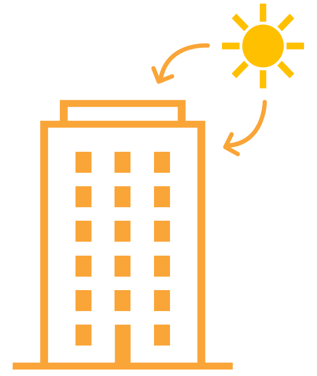
Daylight Analysis

Revit's daylighting analysis tools show the relative level of daylight or solar access at given times of the year. The cube is set to the location of the project, Bakersfield CA, and has been analyzed in the winter and summer solstice in order to evaluate where shading techniques will be most beneficial.



Illuminance Level

The illuminance level feature enables architects, designers, and lighting engineers to analyze and evaluate the amount of light reaching surfaces within a building or project area. This feature allows users to assess the quality and adequacy of lighting conditions in interior spaces, outdoor environments, or specific areas of interest.



Solar Access

The Solar Access feature helps architects and designers analyze how sunlight interacts with a building or site throughout the day and across different seasons. This feature allows users to assess the potential solar exposure of specific areas within a building or site and evaluate how shading elements, neighboring structures, or natural features may affect solar access. The cube is showing the sun path during the winter and summer solstice.

Figure 88. Evaluation Methods

Illuminance Level

Solar Access

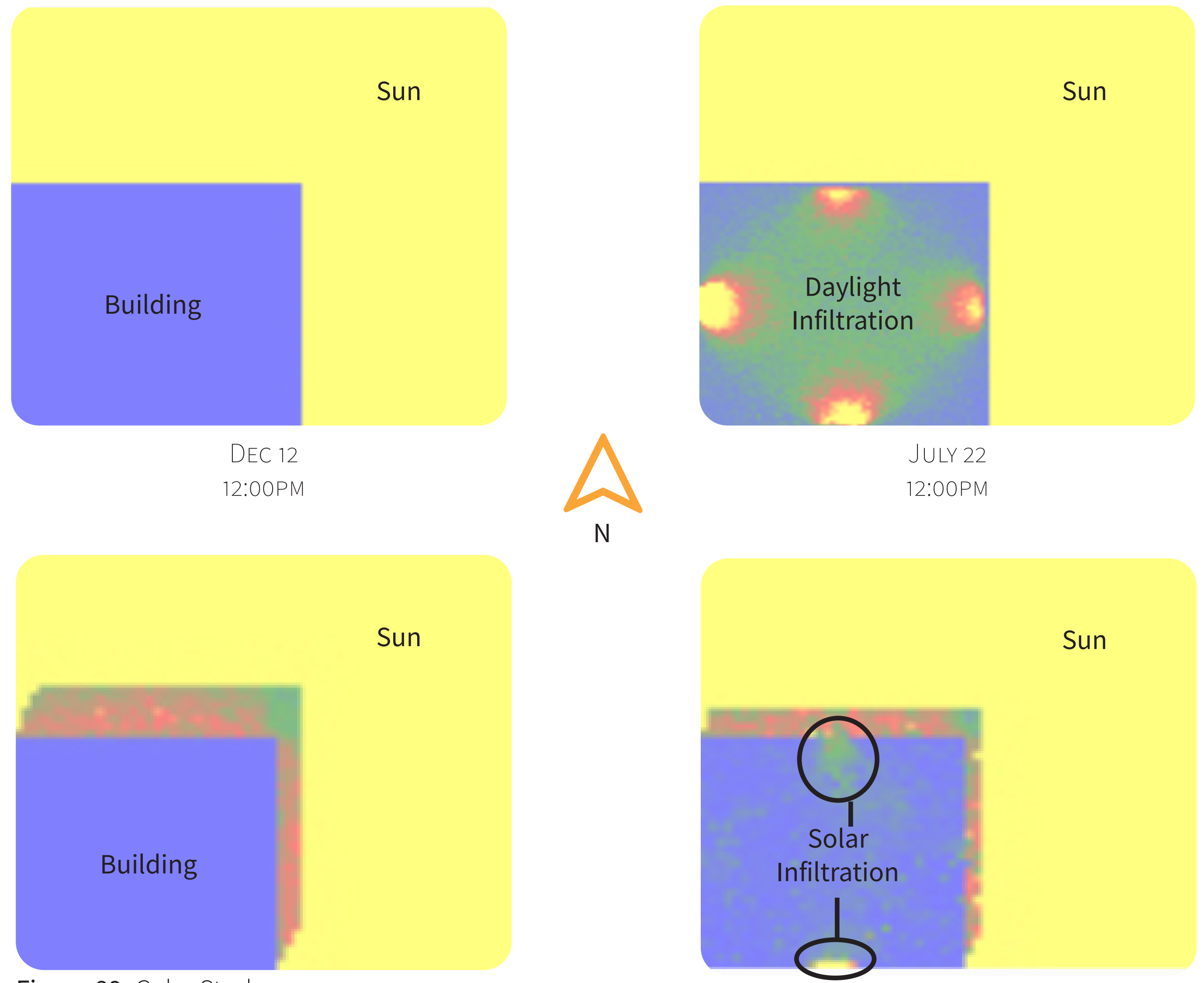
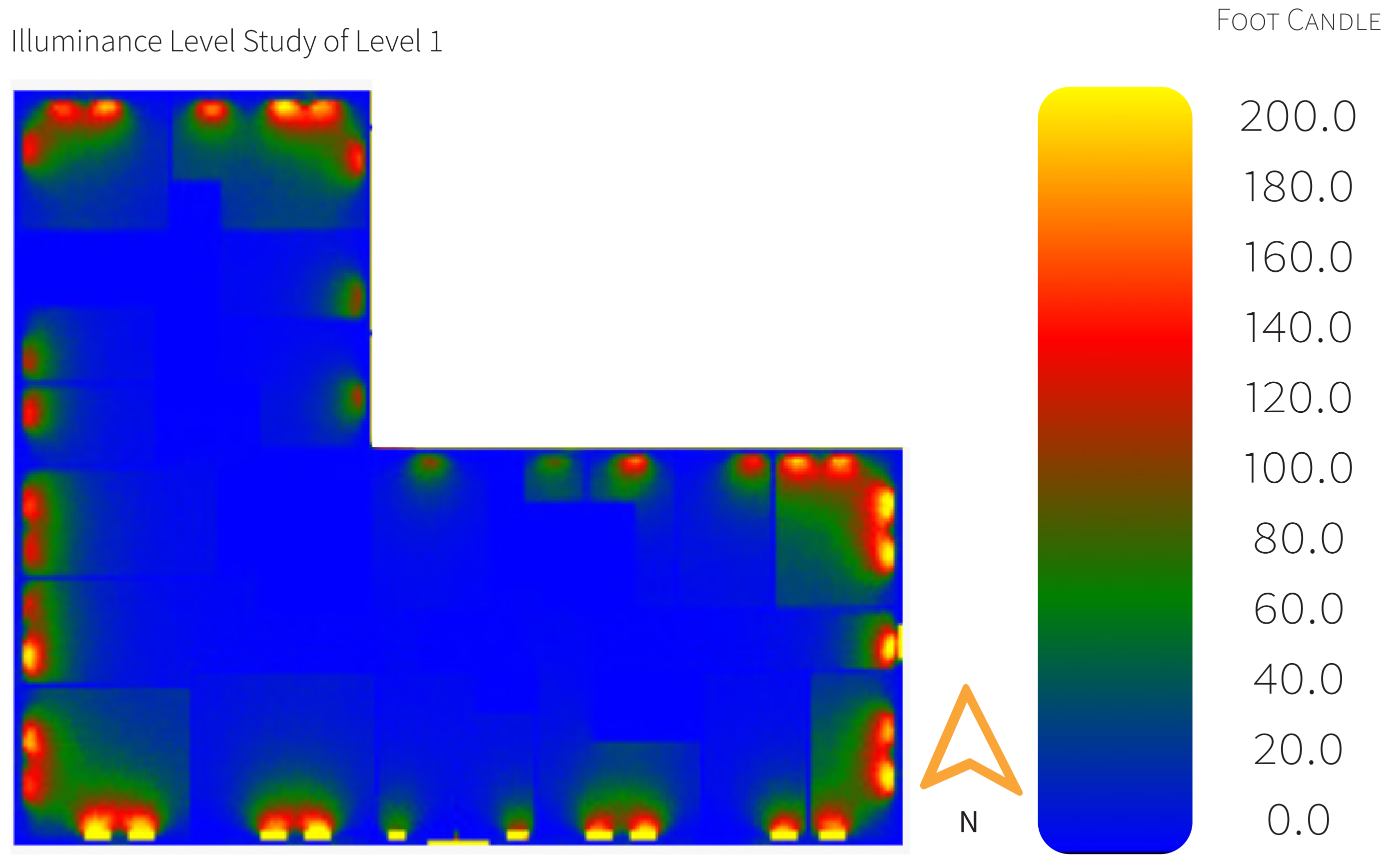


Figure 89. Cube Study

Design Methodology Prototyping

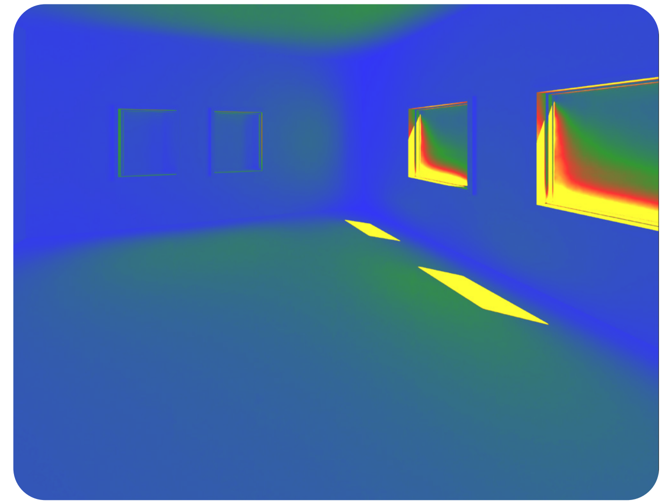
Illuminance Study of Existing Conditions

Illuminance Level Study of Level 1

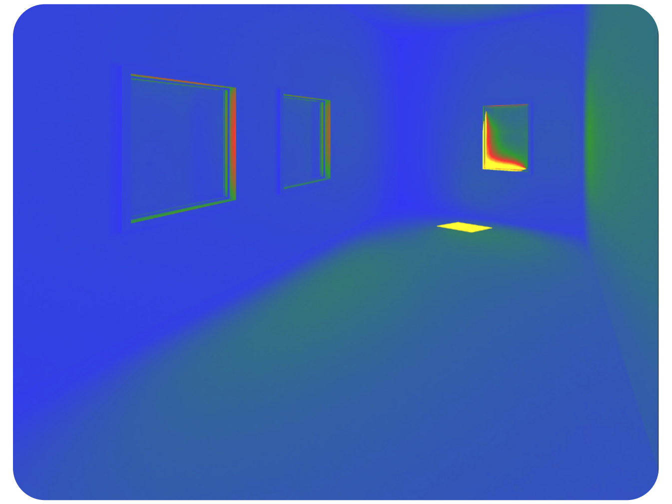


All images captured on July 22 at 2 PM aim to assess the illuminance level specifically during the summer solstice. Due to the existing building's dimensions and window placements, minimal thermal energy infiltrates the interior spaces. Nevertheless, certain regions exhibit hot spots, signaling the potential for improvement through diverse shading techniques. Although the images taken at 2 PM on July 22 shed light on the illuminance levels during the summer solstice, the building's current design limits significant thermal energy absorption within its interior due to window size and placement.

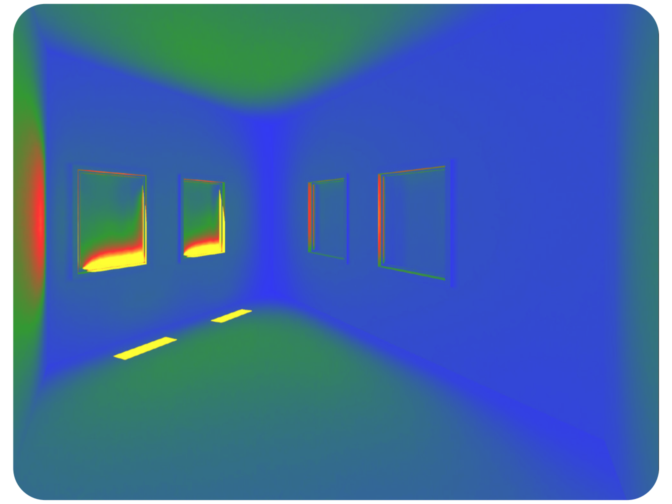
Level 1 South Office



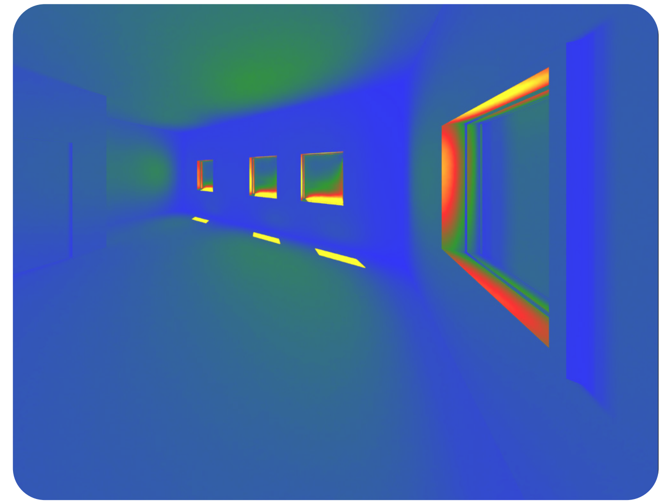
Level 2 South Conference Room



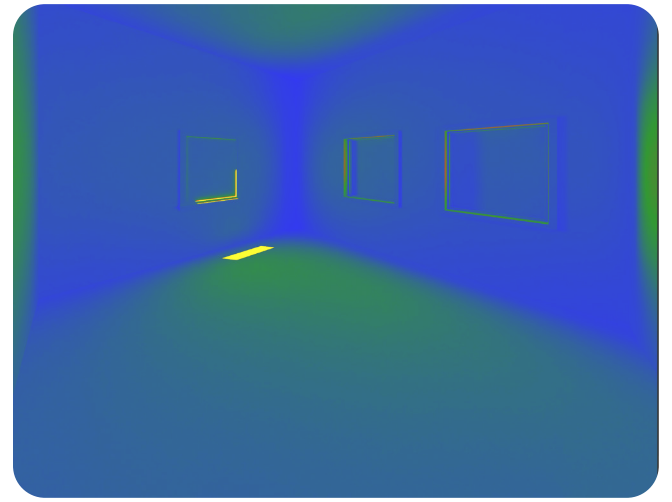
Level1 North East Meeting Room



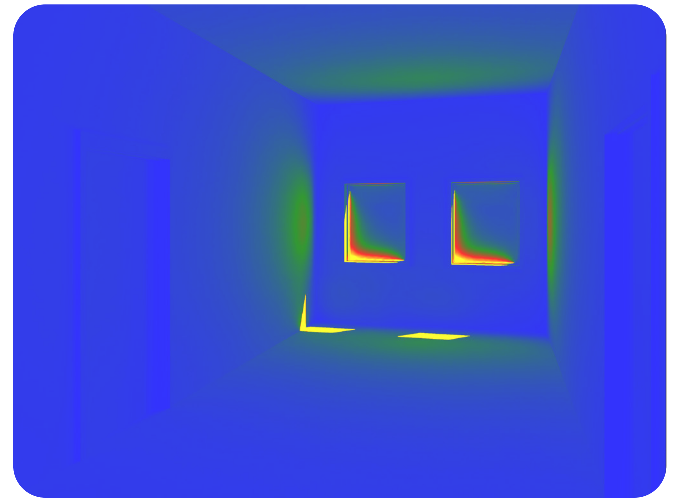
Level 1 North East Conference Room



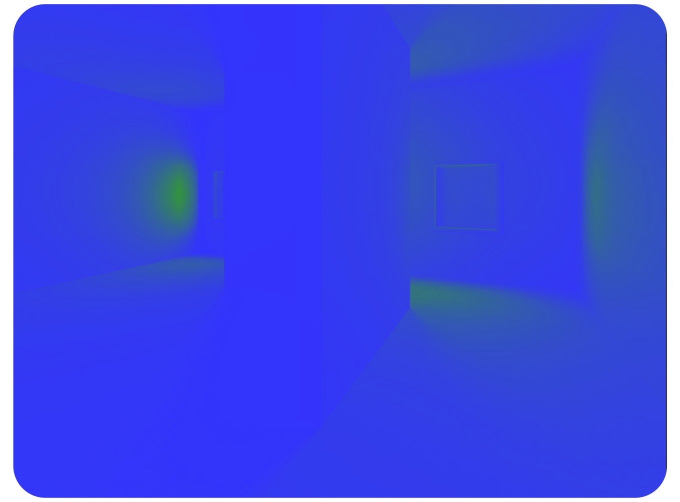
Level 2 Back Office



Level 1 South West Corridor



Level 2 South Collaboration Zone



Level 1 South Conference Room

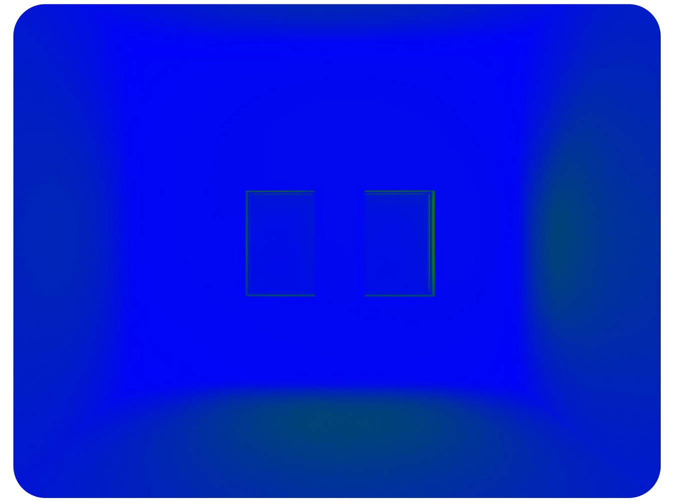


Figure 90. Illuminance Analysis

Design Methodology Prototyping

Daylight Autonomy Evaluation on Existing Conditions

In Revit, the Daylight Autonomy feature is a tool used to assess the amount of natural daylight within a building space over the course of a typical year. It calculates the percentage of time throughout the year when the natural daylight in a specific area of a building meets or exceeds a predetermined illuminance threshold. This threshold is often set based on recommended lighting levels for various activities within the space.

The Daylight Autonomy feature helps architects and designers optimize building designs for energy efficiency and occupant comfort by maximizing the use of natural daylight while minimizing the need for artificial lighting. By analyzing daylight autonomy, designers can make informed decisions about the placement and sizing of windows, the use of shading devices, and other design strategies to enhance natural lighting and reduce reliance on electric lighting systems.

: The daylight infiltration over a typical year

Level 1 Daylight Autonomy

Level 2 Daylight Autonomy

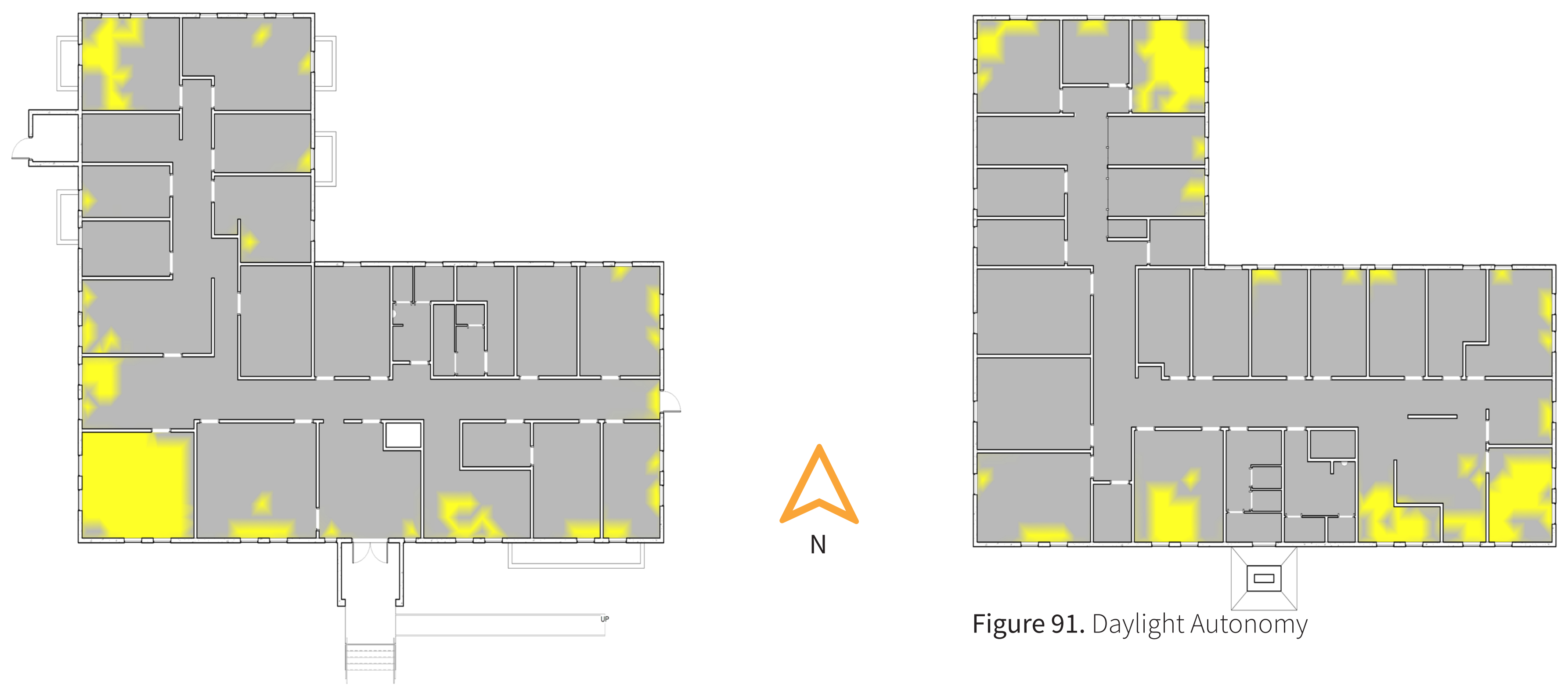
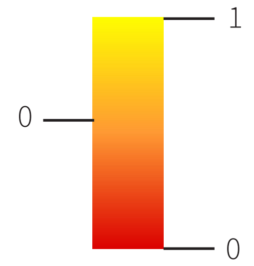


Figure 91. Daylight Autonomy

Solar Analysis on Existing Conditions

According to the Solar Access tool in Revit, every side of the building experiences sun exposure. Notably, the roof absorbs a significant amount of solar radiation, potentially affecting the comfort level of Level 2. Despite the existing tree shading on the south side, the building's front receives moderate sunlight; however, implementing shading techniques and improving insulation could enhance its comfort and energy efficiency.

Solar Access
kWh/m^2



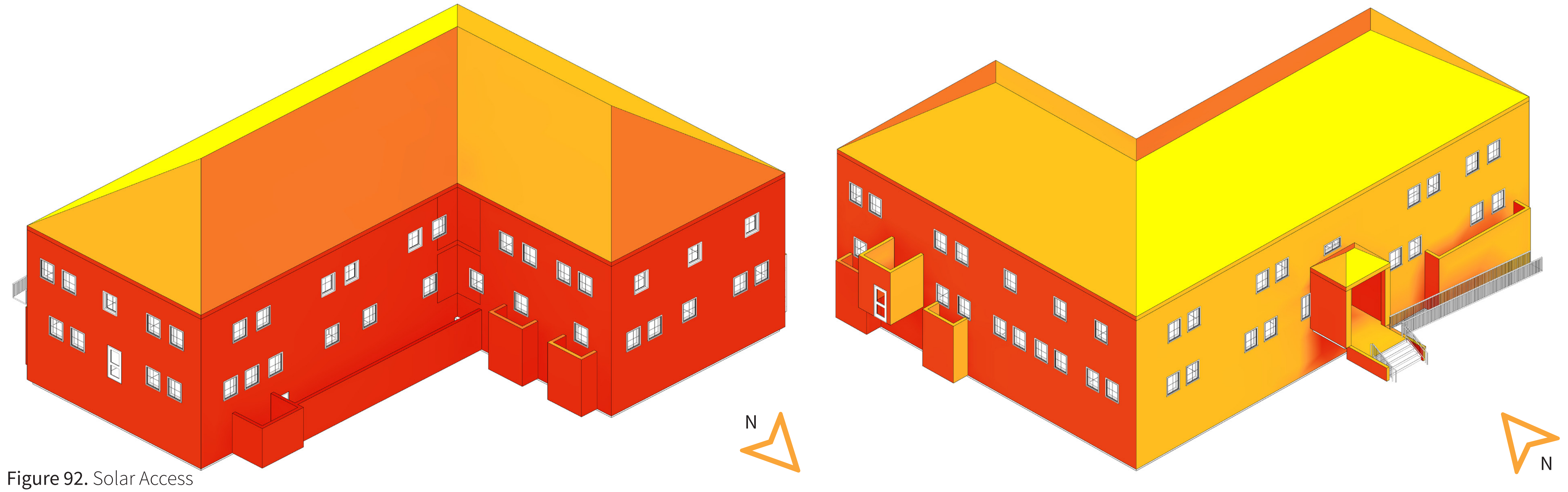


Figure 92. Solar Access

Energy Efficiency Encyclopedia

From The 2022 Building Energy Efficiency Standards from the California Energy Commission

ENERGY DESIGN RATING, ENERGY EFFICIENCY is an Energy Design Rating based on the TDV energy consumption of a building that results from the building's energy efficiency characteristics, calculated using Commission-approved compliance software as specified by the Alternative Calculation Methods Approval Manual.

ENERGY DESIGN RATING, SOLAR ELECTRIC GENERATION AND DEMAND FLEXIBILITY is the reduction in TDV energy consumption of a building expressed in terms of an Energy Design Rating reduction that results from the combination of the building's solar electric generation system and demand flexibility measures.

INTEGRATED HVAC SYSTEM is an HVAC system designed to handle both sensible and latent heat removal. Integrated HVAC systems may include, but are not limited to: HVAC systems with a sensible heat ratio of 0.65 or less and the capability of providing cooling, dedicated outdoor air systems, single package air conditioners with at least one refrigerant circuit providing hot gas reheat, and dehumidifiers modified to allow external heat rejection.

ANNUAL FUEL UTILIZATION EFFICIENCY (AFUE) is a measure of the percentage of heat from the combustion of gas or oil which is transferred to the space being heated during a year, as determined using the applicable test method in the Appliance Efficiency Regulations or Section 110.2.

CENTRAL FAN VENTILATION COOLING SYSTEM (CFVCS) is a ducting arrangement including outside air ducts, motorized dampers, and an automatic control system that allows a residential space conditioning system central fan and ducts to distribute outside air throughout a residential dwelling unit, intending to reduce or eliminate the need for mechanical cooling

CARBON DIOXIDE ENRICHMENT is injection of additional carbon dioxide into controlled environment horticulture spaces for the purpose of stimulating plant growth.

CLOSED-CIRCUIT COOLING TOWER is a cooling tower that utilizes indirect contact between a heated fluid, typically water or glycol, and the cooling atmosphere to transfer the source heat load through sensible heat, latent heat, and mass transfer indirectly to the air, essentially combining a heat exchanger and cooling tower into an integrated and relatively compact device.

DEMAND FLEXIBILITY MEASURE is a measure that reduces TDV energy consumption using communication and control technology to shift electricity use across hours of the day to decrease energy use onpeak or increase energy use offpeak, including but not limited to battery storage, or HVAC or water heating load shifting.

DESIGN HEAT GAIN RATE is the total calculated heat gain through the building envelope under design conditions.

DESIGN HEAT LOSS RATE is the total calculated heat loss through the building envelope under design conditions.

DYNAMIC GLAZING SYSTEMS are glazing systems that have the ability to reversibly change their performance properties, including U-factor, Solar Heat Gain Coefficient (SHGC), and/or Visible Transmittance (VT) between welldefined end points. These may include, but are not limited to chromogenic glazing systems and integrated shading systems (defined below). Dynamic Glazing systems do not include internally mounted or externally mounted shading devices that attach to the window framing/glazing that may or may not be removable.

AIR, SUPPLY is air entering a space from an air-conditioning, heating, or ventilating system for the purpose of comfort conditioning. Supply air is generally filtered, fan-forced, and heated, cooled, humidified or dehumidified as necessary to maintain specified temperature and humidity conditions.

AIR, TRANSFER is air transferred, whether actively by fans or passively by pressure differentials, from one room to another within a building through openings in the room envelope.

AIR BARRIER is a combination of interconnected materials and assemblies joined and sealed together to provide a continuous barrier to air leakage through the building envelope that separates conditioned from unconditioned space, or that separates adjoining conditioned spaces of different occupancies or uses.

AIR CONDITIONER is an appliance that supplies cooled and dehumidified air to a space for the purpose of cooling objects within the space.

AIR-COOLED AIR CONDITIONER is an air conditioner using an air-cooled condenser.

AIR CURTAIN UNIT means equipment providing a directionally-controlled stream of air moving across the entire height and width of an opening that reduces the infiltration or transfer of air from one side of the opening.

AIR FILTER, AIR FILTER EQUIPMENT, or AIR FILTER DEVICE is air-cleaning equipment used for removing particulate matter from the air.

AIR FILTER MEDIA is the part of the air filter equipment which is the actual particulate removing agent.

AIR-HANDLING UNIT or AIR HANDLER is a blower or fan that distributes supply air to a room, space, or area.

AIR-SOURCE HEAT PUMP is an appliance that consists of one or more factory-made assemblies, that includes an indoor conditioning coil, a compressor, and a refrigerant-to-air heat exchanger, and that provides heating and cooling functions.

AIR-TO-AIR HEAT EXCHANGER is a device which will reduce the heat losses or gains that occur when a building is mechanically ventilated, by transferring heat between the conditioned air being exhausted and outside air being supplied.

INTEGRATED SEASONAL COEFFICIENT OF PERFORMANCE (ISCOP) is a seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the two COP values for the heating season of a DX-DOAS unit water or air source heat pump, expressed in W/W.

INTEGRATED SEASONAL MOISTURE REMOVAL EFFICIENCY (ISMRE) is a seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the four dehumidification moisture removal efficiency (MRE) ratings required for DX-DOAS units, expressed in lb. of moisture/kWh.

MERV is the minimum efficiency reporting value as determined by ASHRAE Standard 52.2 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

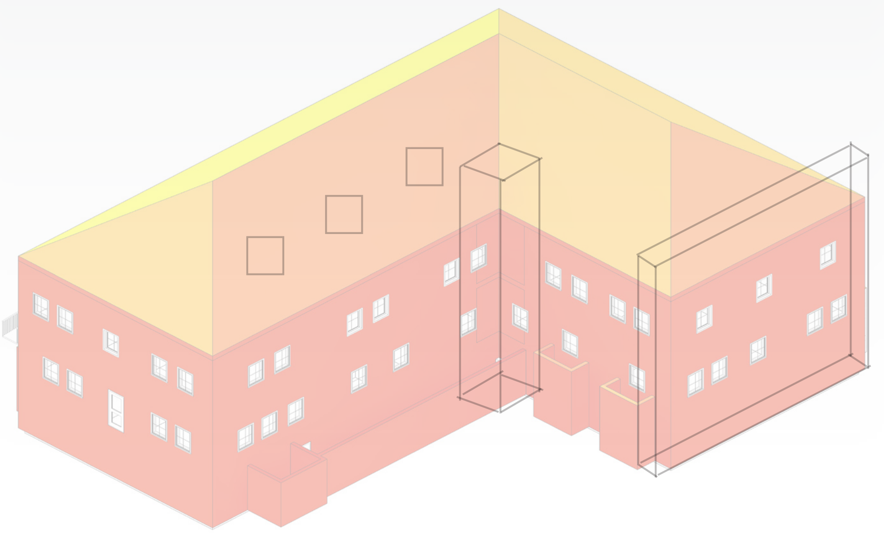
Design Response Plan

Demo Plans

- Open up spaces for collaboration
- Remove walls that are blocking sunlight from entering into the space
- Remove half of the second floor on the north side of the building to enhance air circulation

Revitalization Plans

- Create collaboration zone
- Create corridors that take advantage of natural daylight
- Create a double height space that enhances circulation and light dispersion



Renderings of Sustainable Choices

- Rendering of sustainable choices
- Sections of sustainable choices
- New floor plan

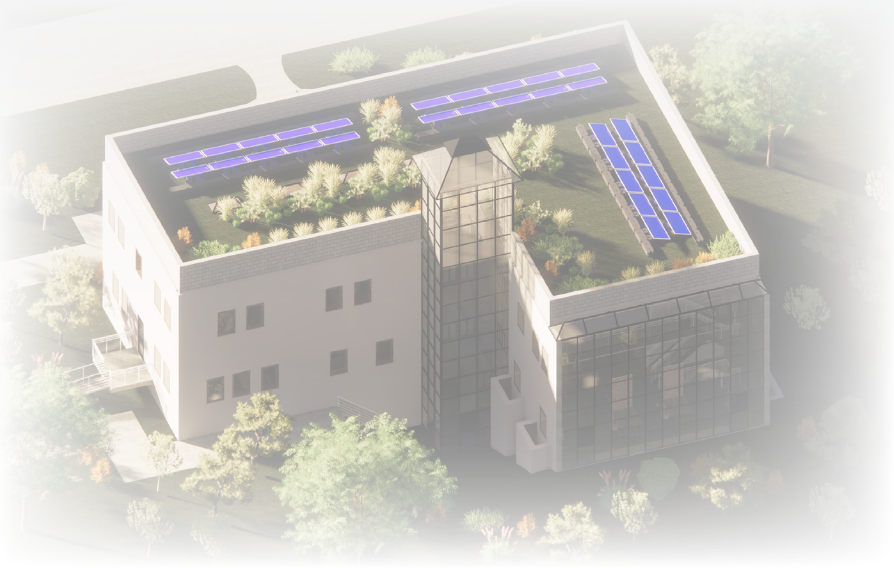
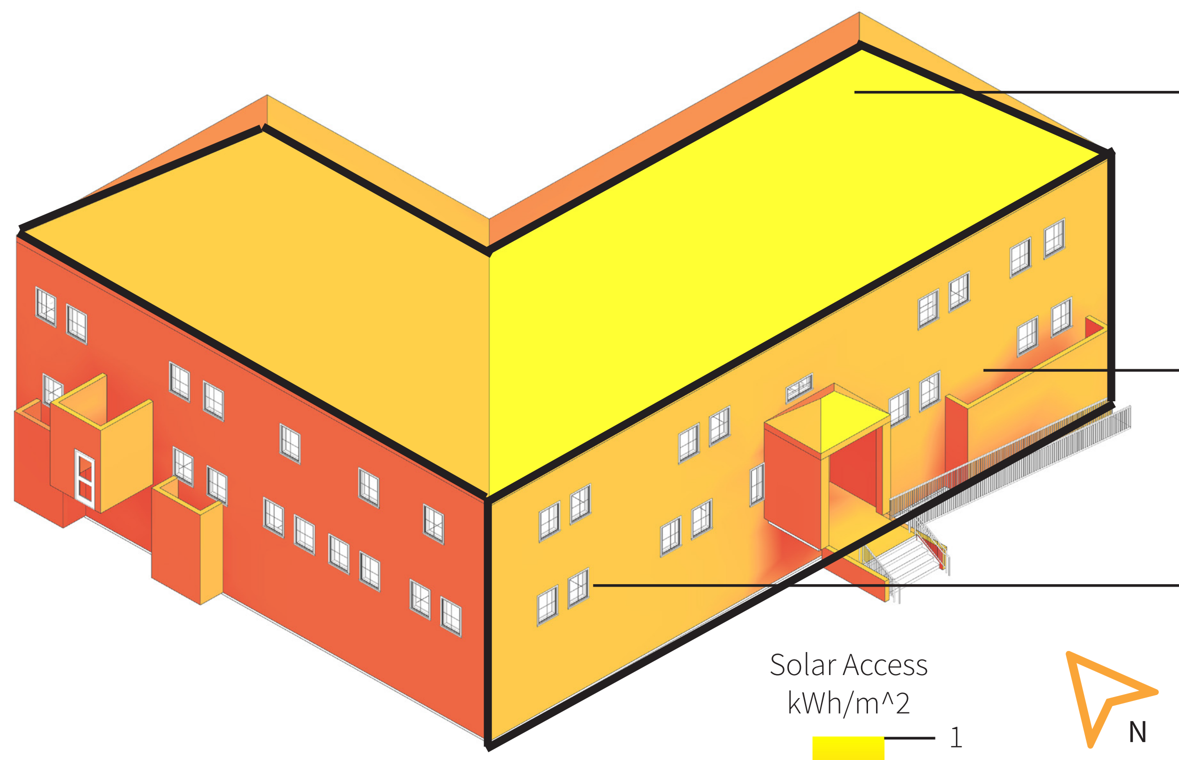
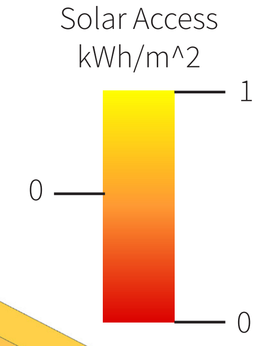


Figure 93. Design Response Plan

Revitalization for Energy Consumption

South West Side of the Building: Changes





North East Side of the Building: Changes

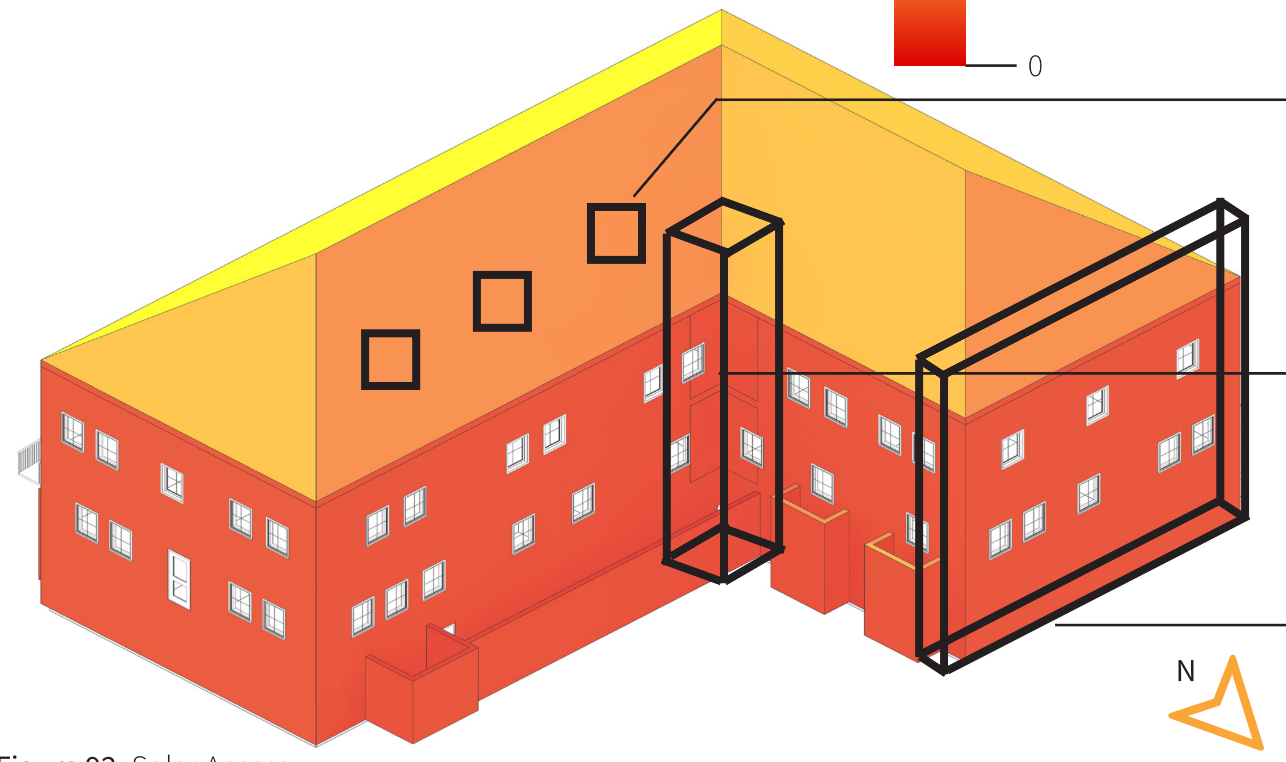


Figure 92. Solar Access

The south and west side of the roof will be utilized for the placement of solar panels. Considering this is the face of the structure that has the greatest solar access, it will be the best area to place the solar panels on. Solar panels help with generating electricity by converting sunlight into usable energy. This renewable energy source can be used to power various aspects of a building, including lighting, heating, cooling systems, appliances, and electronics. Additionally, solar panels contribute to reducing dependence on fossil fuels, decreasing carbon emissions, and promoting sustainability and environmental conservation.

Figure 94. Solar Panel Stack

Hempcrete is a bio-composite made of the inner woody core of the hemp plant mixed with a lime-based binder. The hemp core or "Shiv" has a high silica content which allows it to bind well with lime. This property is unique to hemp among all natural fibers. The result is a lightweight cementitious insulating material weighing about a seventh or an eighth of the weight of concrete.

Figure 95. Hempcrete Plastering

All windows in the building will have a glass replacement done. The replacement will be SmartGlass from Sage Glass Company. SmartGlass allows users to control their comfort with the touch of a button. The glass has the flexibility of changing from clear to opaque in order to limit the amount of illuminance in the room and better control the physical comfort.

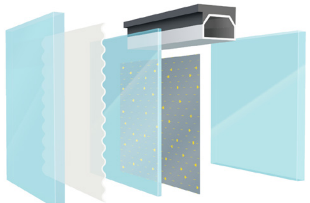


Figure 96. SmartGlass Layers

Skylights will be placed on the roof in order to bring more natural light and the option for ventilation. The skylights will have SmartGlass panels in order to easily control the amount of sunlight pouring in.

Solar Chimney made of SmartGlass will be nestled into the northern corner of the building to allow copious amounts of natural daylight and fresh air to flood throughout the space. It will also create a central point in the office for coworkers to gather and enjoy.

A light well will be introduced to the northern side of the building. The light well will soar through all three floors in order to bring more natural daylight to the basement. Currently there is little to no daylight entering the basement.

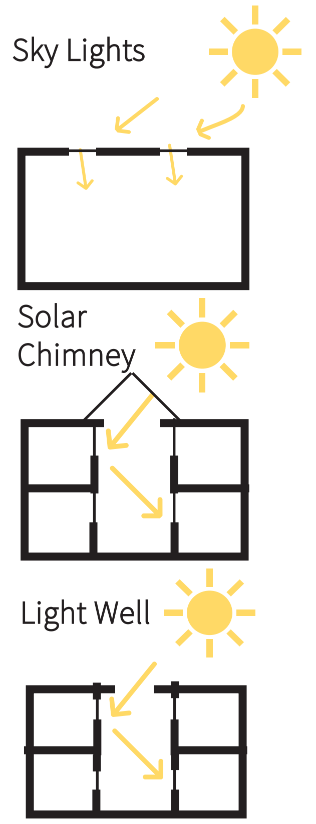


Figure 29. Passive Daylighting Strategies

Demo Plans

Level o Demo Plan

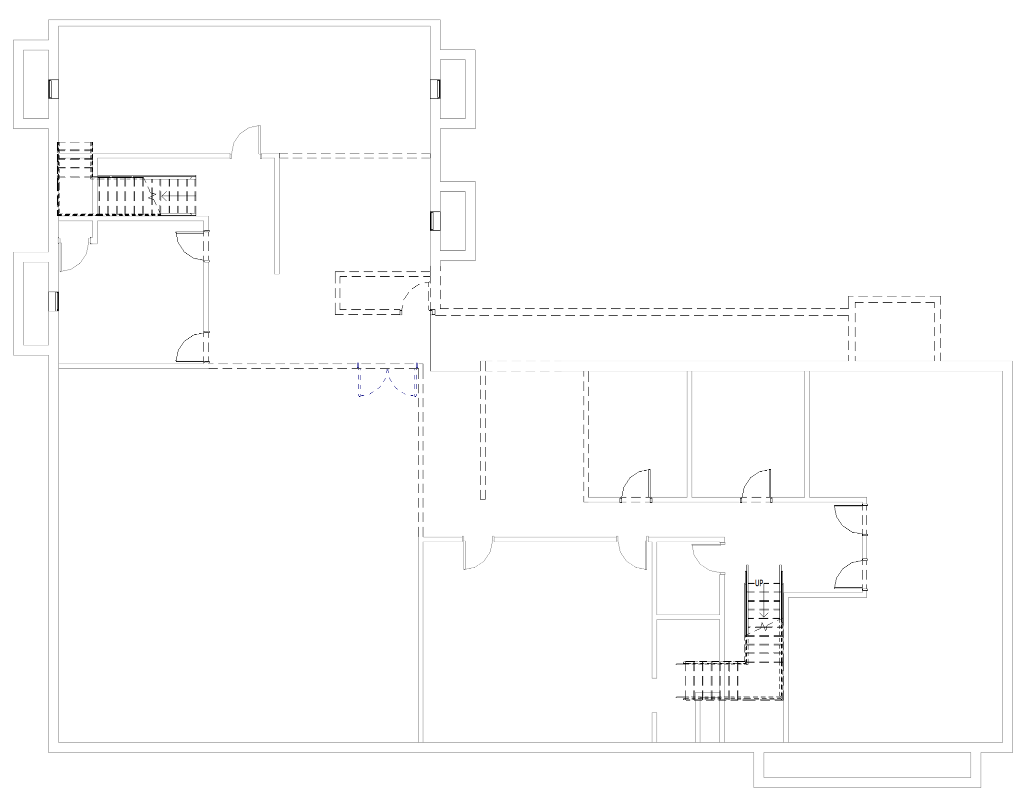


Figure 97. Demo Plan Level 0

Level 1 Demo Plan

Figure 98. Demo Plan Level 1

Level 2 Demo Plan

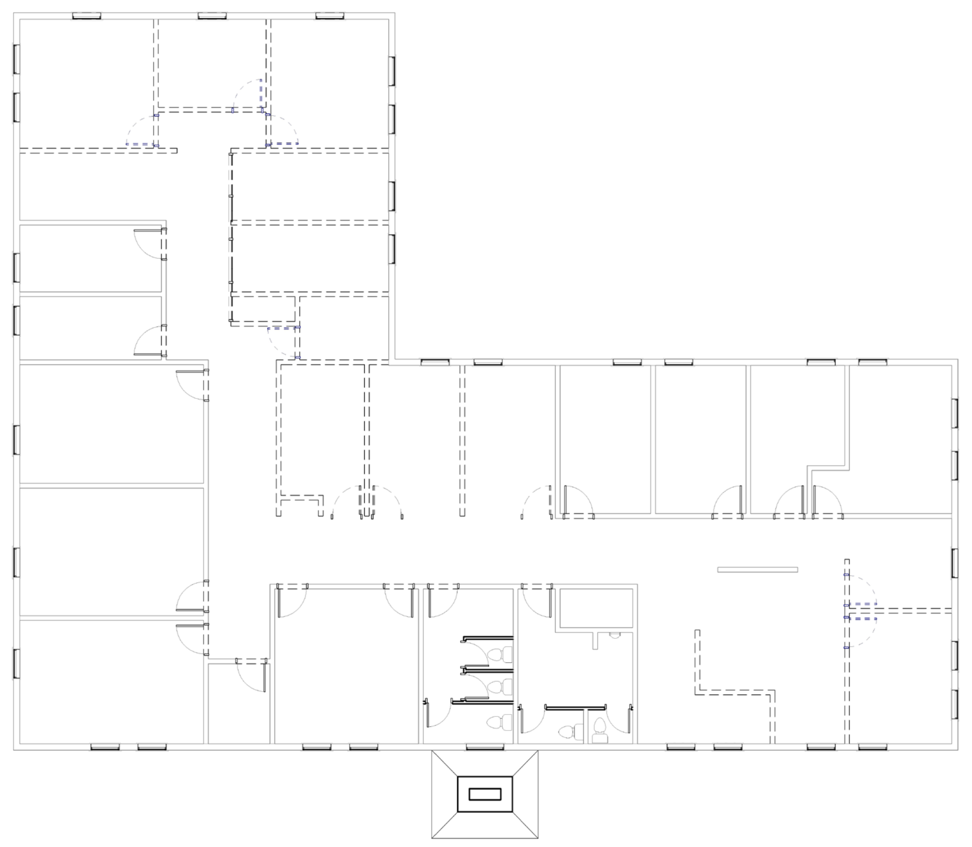


Figure 99. Demo Plan Level 2

Demolition Decision Process

Throughout the demolition phase, meticulous attention was given to sustainability principles, ensuring that all materials demo'd were either repurposed or recycled, thereby minimizing environmental impact. The comprehensive demolition efforts primarily targeted Levels 1 and 2, strategically preserving the integrity of the original walls wherever feasible. An integral aspect of the renovation involved reimagining the spatial layout to enhance both functionality and environmental quality. By strategically opening up the space, a concerted effort was made to optimize air circulation and harness the abundant natural daylight, thereby fostering a healthier and more vibrant indoor environment. Recognizing the evolving needs of contemporary society, particular emphasis was placed on the creation of collaborative areas. In response to the growing demand for flexible workspaces that foster creativity and teamwork, these collaborative zones were thoughtfully integrated into the design, serving as dynamic hubs for interaction and idea exchange. This deliberate prioritization underscores a commitment to facilitating synergy and innovation within the renovated space, aligning with the ethos of modern workplace dynamics.

Additions

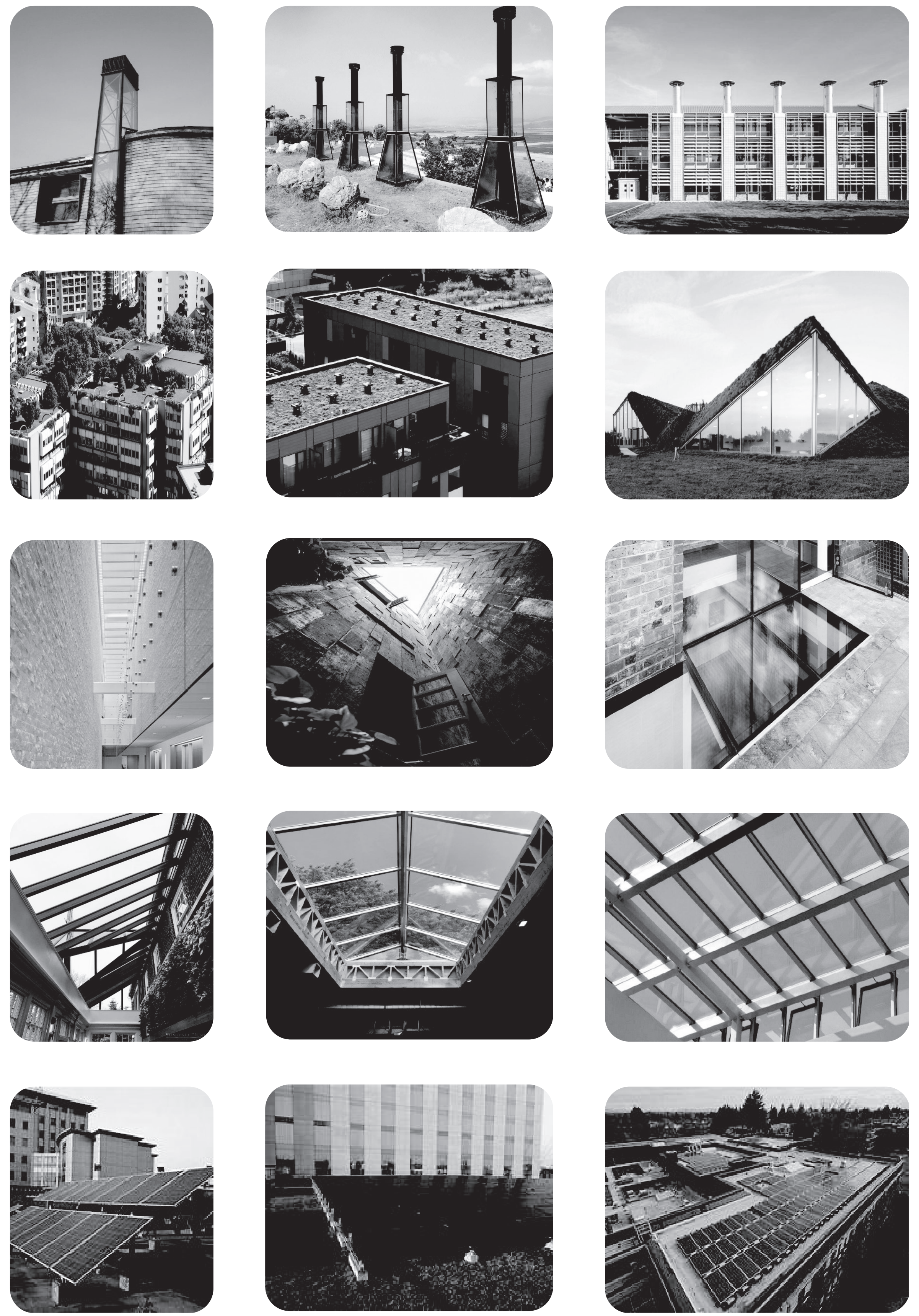


Figure 100. Collection of Inspiration Images

Solar Chimney

Solar Chimney made of SmartGlass will be nestled into the northern corner of the building to allow copious amounts of natural daylight and fresh air to flood throughout the space. A solar chimney, also known as a thermal chimney or solar updraft tower, is a passive ventilation system that uses solar energy to create airflow for cooling or ventilation purposes. It typically consists of a tall vertical shaft or chimney, often integrated into a building's design or constructed separately, with a transparent or translucent covering at the top to capture solar radiation.

Green Roof

A green roof, also known as a living roof or eco-roof, is a roofing system that incorporates vegetation, soil, and a waterproofing membrane on top of a building structure. Green roofs offer several environmental and practical benefits. Green roofs absorb rainwater, reducing stormwater runoff and the strain on drainage systems. The plants on the roof also help to filter pollutants from the water. Furthermore, the vegetation and soil layers on a green roof act as insulation, reducing heat absorption by the building during hot weather and minimizing heat loss during cold weather, which can lower energy costs for heating and cooling.

Light Well

A light well, also known as a courtyard or atrium, is an open space within a building that is designed to allow natural light to penetrate deeper into interior spaces. Light wells bring natural light into the center of a building, reducing the need for artificial lighting during daylight hours. This can help lower energy consumption and improve the overall quality of lighting within the building. Furthermore, light wells provide a connection to the outdoors, allowing occupants to experience natural elements such as sunlight, sky views, and vegetation within the building's interior. This connection can enhance the overall well-being and satisfaction of building users.

Sky Lights

Skylights, or roof windows, are windows installed in the roof of a building to allow natural light to enter interior spaces, they offer several benefits. Skylights provide abundant natural light, reducing the need for artificial lighting during daylight hours. This can help lower energy consumption and electricity costs. Some skylights are designed to be operable, allowing for natural ventilation and fresh air intake. This can improve indoor air quality and comfort, especially in areas where mechanical ventilation may be insufficient.

Solar Panels

Solar panels, also known as photovoltaic (PV) panels, convert sunlight directly into electricity through a process called the photovoltaic effect. Solar panels are designed to absorb sunlight efficiently. They consist of multiple layers, including a top layer of tempered glass to protect the cells, an anti-reflective coating to increase light absorption, and the photovoltaic cells themselves. When sunlight strikes the photovoltaic cells, it creates an electric field across the layers of the cell due to the internal structure of the material. This electric field causes the flow of electrons, generating a direct current (DC) within the cell. The direct current produced by the solar cells is then sent to an inverter, which converts it into alternating current (AC) electricity. AC electricity is the standard form of electricity used in homes and businesses.

Insulating the Facade

Façades account for 20% of a building's embodied carbon footprint. Therefore, adapting them in a way that minimizes emissions can be very helpful in reducing a project's overall environmental impact

R - Value :

Insulation levels are specified by R-Value. R-Value is a measure of insulation's ability to resist heat traveling through it. The higher the R-Value the better the thermal performance of the insulation.

U - Value :

U-value is the measure of the overall rate of heat transfer through a particular section of construction. U-value is sometimes known as thermal transmittance.

R-value is measured for specific material while U-value is usually measured for a whole structure

In essence, the U-value can be calculated by finding the reciprocal of the sum of the thermal resistances of each material making up the building element in question.

The accuracy of measurements is dependent on a number of factors:

- Magnitude of temperature difference (larger = more accurate)
- Weather conditions (cloudy is better than sunny)
- Good adhesion of thermopiles to test area
- Duration of monitoring (longer duration enables a more accurate average)
- More test points enable greater accuracy, to mitigate against anomalies

R-Value Equation Chart

Material	Thickness	Resistance = Thickness / Conductivity (R-Value)
Hempcrete	1 "	3.0 Per Inch
Stucco	1 1/8 "	0.20 Per Inch
Wood Stud	4 "	.90 Per Inch
Fiberglass Insulation	2 "	3.0 Per Inch
Gypsum Board	1/4 "	.90 Per Inch
U - Value =		1 / 8 = 0.125

Figure 101. R-Value Equation Chart

Recommended R-Values

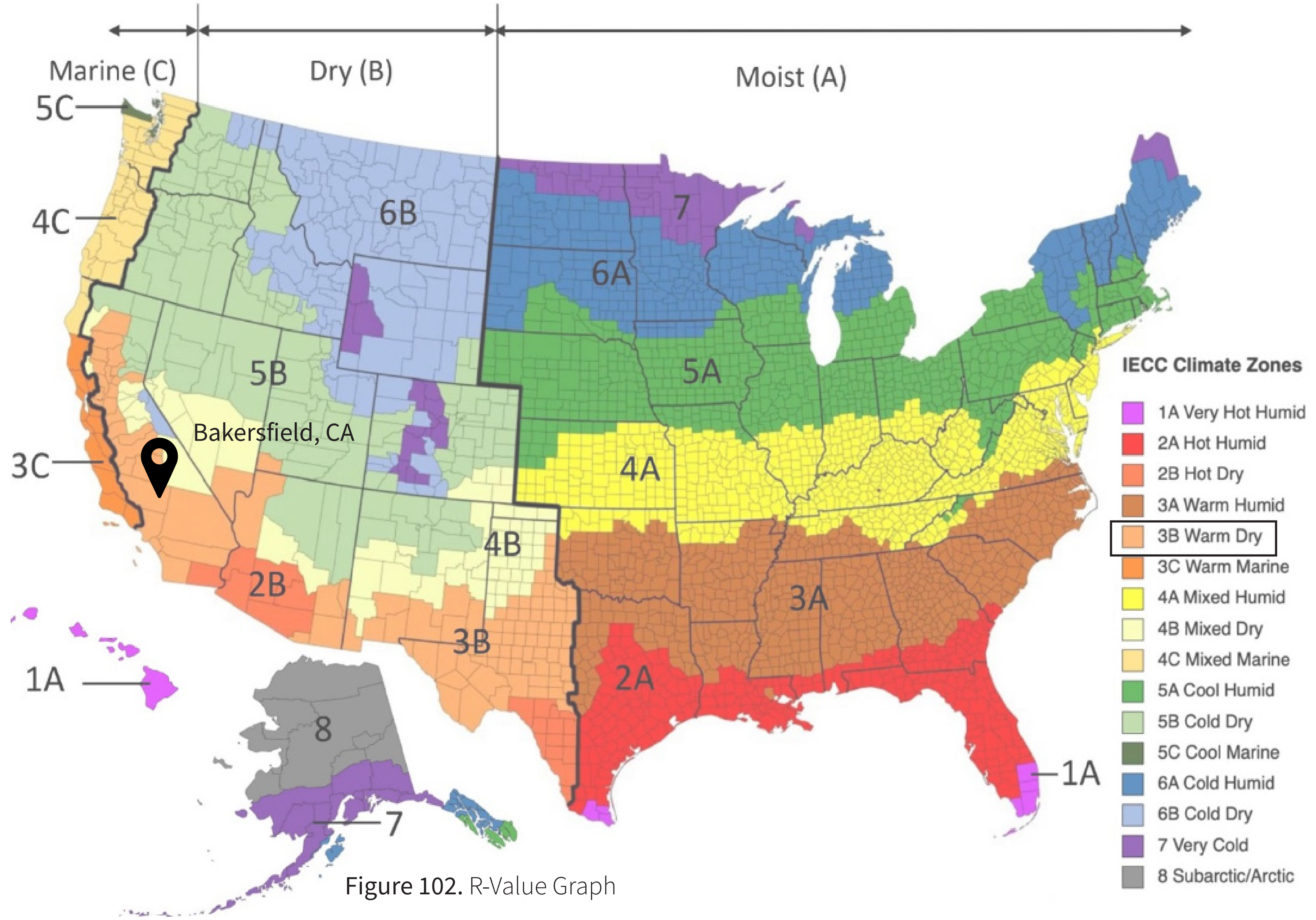


Figure 102. R-Value Graph

Recommended insulation levels for retrofitting existing wood-framed buildings

Zone	If attic is insulated	If 3-4" of insulation is existing	Floor
1	R30	R25	R13
2	R49	R38	R13
3	R49	R38	R19
4A and 4B	R60	R49	R19
4A , 5, 6,	R60	R49	R30
7, 8	R60	R49	R38

This guidance is based on the 2021 International Energy Conservation Code (IECC) Residential Provisions Chapter 4 Table R402.1.3.

Figure 103. Insulation Levels Chart

Hempcrete

What is Hempcrete?

Hempcrete is a bio-composite made of the inner woody core of the hemp plant mixed with a lime-based binder. The hemp core or "Shiv" has a high silica content which allows it to bind well with lime. This property is unique to hemp among all natural fibers. The result is a lightweight cementitious insulating material weighing about a seventh or an eighth of the weight of concrete. Hempcrete was discovered in a bridge abutment in France built in the 6th century. Since its rediscovery it has seen growing use in Europe. Hemp is not psychoactive. Given it has survived 14 centuries, people expect hempcrete buildings will have a long life. The material is finished on the exterior with a hard render coating about 20mm thick to protect it with a final colored topcoat finish added. The end result appears like any stucco finished building. The interior can be left natural or finished with lime plaster for a traditional look.

Water or vapor permeability helps to facilitate healthier buildings or spaces, which improves the quality of life while improving indoor air and humidity levels. Thus, the porosity of hempcrete material helps in fulfilling this phenomenon, thus reducing the active technologies for cooling and heating indoor spaces.

The binder consists of either hydrated lime or natural hydraulic lime. Hydrated lime (or air lime) has no impurities and is made by kiln-firing limestone. The firing process removes the carbon molecules from the limestone and converts it into a dry powder. When you want to use lime as a binder or mortar, you introduce carbon dioxide again, essentially converting the lime back into limestone as it absorbs surrounding CO2.

The Benefits of Hempcrete

- It is a carbon-negative material: the carbon hemp absorbs as a plant makes up for the carbon emitted during the processing phase of hempcrete.
- It is fire resistant and creates safe buildings.
- Hempcrete needs no added chemicals, hence it creates healthy indoors.
- It is an effective thermal insulator and performs well with temperature fluctuations.
- Hempcrete absorbs moisture during times of high relative humidity and releases it when the relative humidity drops.
- It is resistant to pests and other termites.
- In the processing phase, hempcrete requires less water than traditional cement.
- It takes decades to fully cure, so its strength and feature improve over time.

Figure 104. Hempcrete

Sustainable Furniture Planning

Steelcase

The Steelcase Series™ 1 the first task chair with a CarbonNeutral® product certification, completely offsetting emissions.

- Thoughtfully designed with integrated LiveBack® flexor system that conforms to your spine to provide flexibility and support
- Comes standard with an additional adjustable lumbar for extra support
- Steelcase Series 1 is tested above industry standards to ensure reliability now and in the future.

23% Recycled

96% Recyclable

Upholstery

Material: knit mesh
Color: Era-Persimmon
Pattern: herringbone

Upholstery

Material: knit mesh
Color: Connect: Blueprint
Pattern: woven

Figure 105. Steelcase Series 1 Chair

Van De Sant

Van de Sant sustainable design furniture is made from recycled plastic gathered from land and oceans. They change plastic waste into circular design. Every furniture piece can be reprocessed into raw materials and re-manufactured into new design furniture.

BIONIC ReBlend Partnership

The fabric partners are ReBlend® and BIONIC®. ReBlend® makes circular fabrics from post consumer textiles and PET, using only 1% water. The critical ingredient of BIONIC® is recovered plastic.

- Freedom of configuration allows for flexibility in the space
- The base frame consists of collected ocean plastic, supported by the modern metallic feet.
- An enormous color catalogue consisting of high-quality fabric creates a luxurious feel on top of the post-consumer textile foam that allows a soft yet supportive seat.

100% Recycled

100% Recyclable

Hawaii Armchair

Color: Denim

Inagua U-Shape Seating

Inagua U-Shape Sofa

Color: Rose Water

Figure 106. Van De Sant Modular Sofa

Urban Wood Goods

Urban Wood Goods has established decade-long relationships with contractors who specialize in deconstruction, giving us priority access to rare and unique woods from buildings of historic interest as they are being carefully disassembled.

Old-growth trees harvested at the turn of the 19th century grew more slowly in denser forests, challenged for sunlight and water. These conditions are evidenced in the grain with age rings closer together, making it harder, stronger and of higher quality than most newly harvested timber.

- Eco-friendly, water-based stains with low-to-zero volatile organic compounds (VOCs), and the dual-care topcoat we specify is a clear, formaldehyde-free, commercial-grade UV finish.
- Supporting each reclaimed wood top is a sculptural, hand-welded base of recycled, industrial steel made in the USA.

100% Recycled

100% Recyclable

Urban Wood Bookcase

Rustic Reclaimed Wood Coffee Table

Brooklyn Standing Desk

Latitude L Desk

Urban Wood Standard Conference Table

Figure 107. Urban Wood Goods

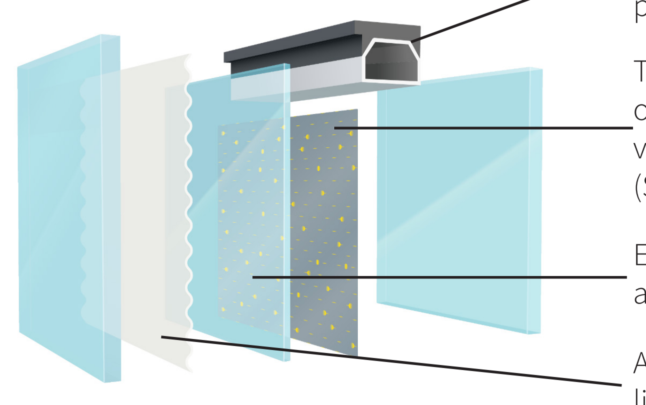
Sustainable Materials Planning

SageGlass

By tinting as needed throughout the day, SageGlass® smart glass technology creates energy-efficient spaces that people love—unobstructed by curtains or blinds. Buildings with smart glass products offer daylight and views with less glare and reduced energy use.

- Full automation
- BMS Integration
- Control at the fingertips
- Reduce HVAC needs

What's in the Glass?



Stainless steel warm edge spacer and industry-standard PIB and Silicone sealants, adding Air, Argon or Krypton based on performance needs.

The electrochromic coating is comprised of multiple layers of metallic elements that can dynamically modulate the visual light transmittance (VLT) and solar heat gain coefficient (SHGC) of the glass by application of a small electrical charge.

Electrochromic layers are sputter coated onto 2.2 mm annealed glass.

An interlayer laminates the outerboard lite to the EC coated lite.

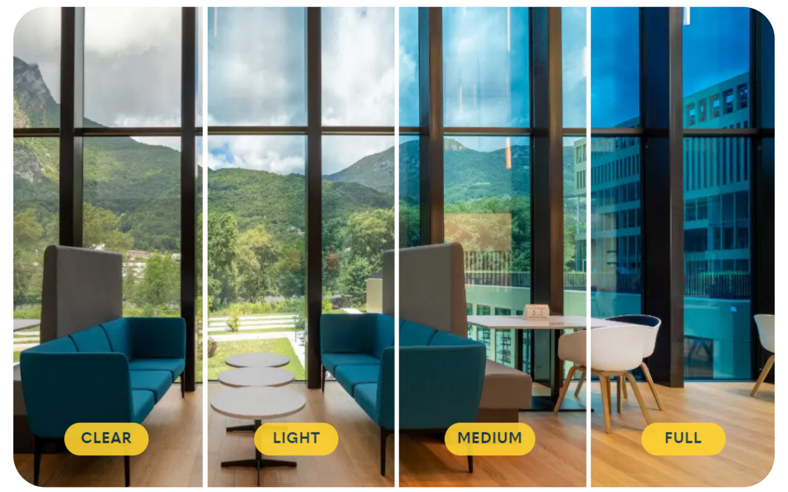


Figure 108. SageGlass SmartGlass

Mohawk Group

Mohawk Group's ReCover Recycling Program is an award-winning carpet recycling program that, since 2006, has diverted over 160 million pounds of carpet from landfills. As of 2022, all Mohawk Group floor covering products and other resilient surfaces are going Beyond Carbon Neutral. This means an additional carbon offset beyond neutral, for a 5% net-positive impact on the environment.

- Elimination of PVC and full material transparency
- LPC Petal Certified
- Zero water used in dyeing process
- Fully Recyclable

Color: Kind of Blue

Chromatic Cadence Carpet TIle

Product Type: Carpet Tile
Pile Weight: 26.00 oz/yd2 (882 g/m2)
Backing Material: EcoFlex AIR
Fiber Type: ColorStrand SD Nylon (CL4)
Tile Size: 24" X 24"
Surface Texture: Textured Patterned Cut & Loop
Dye Method: Precision Dyed Injection
Total Thickness: 0.359" (9.12 mm)
Flammability: ASTM E 648 Class 1 (Glue Down)
Smoke Density: ASTM E 662 Less than 450
Static Propensity: AATCC-134 Under 3.5 KV
Soil Release Technology: EcoSentry Plus Stain Protection

Figure 109. Mohawk Carpet Tile

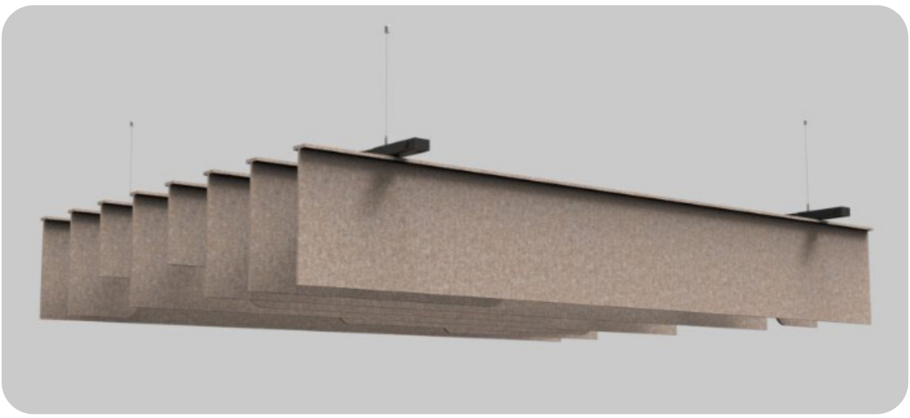
REFELT

PET Felt panels are made from recycled plastic bottles. Due to the porous structure, the material also has great acoustic properties. Pleasant to the eyes, ears and environment.

Every design is optimized to avoid cutting loss. Nothing is glued to facilitate recycling. During production, residual material is unavoidable, and we recycle it into filling for acoustic products. We also use larger pieces of residual material as packaging.

Baffle Light Linear 1200

Acoustic Baffles PET Felt Ambigu



Streets PET Felt Hanging Dividers

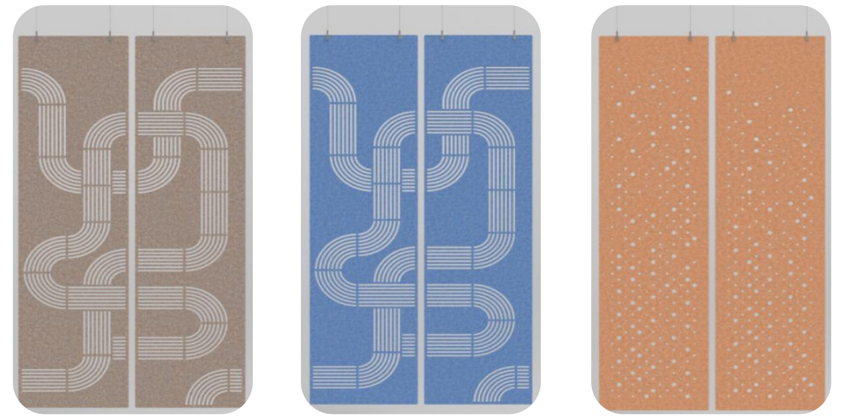


Figure 110. Refelt Acoustics

Floor Plans

Level 0 Floor Plan

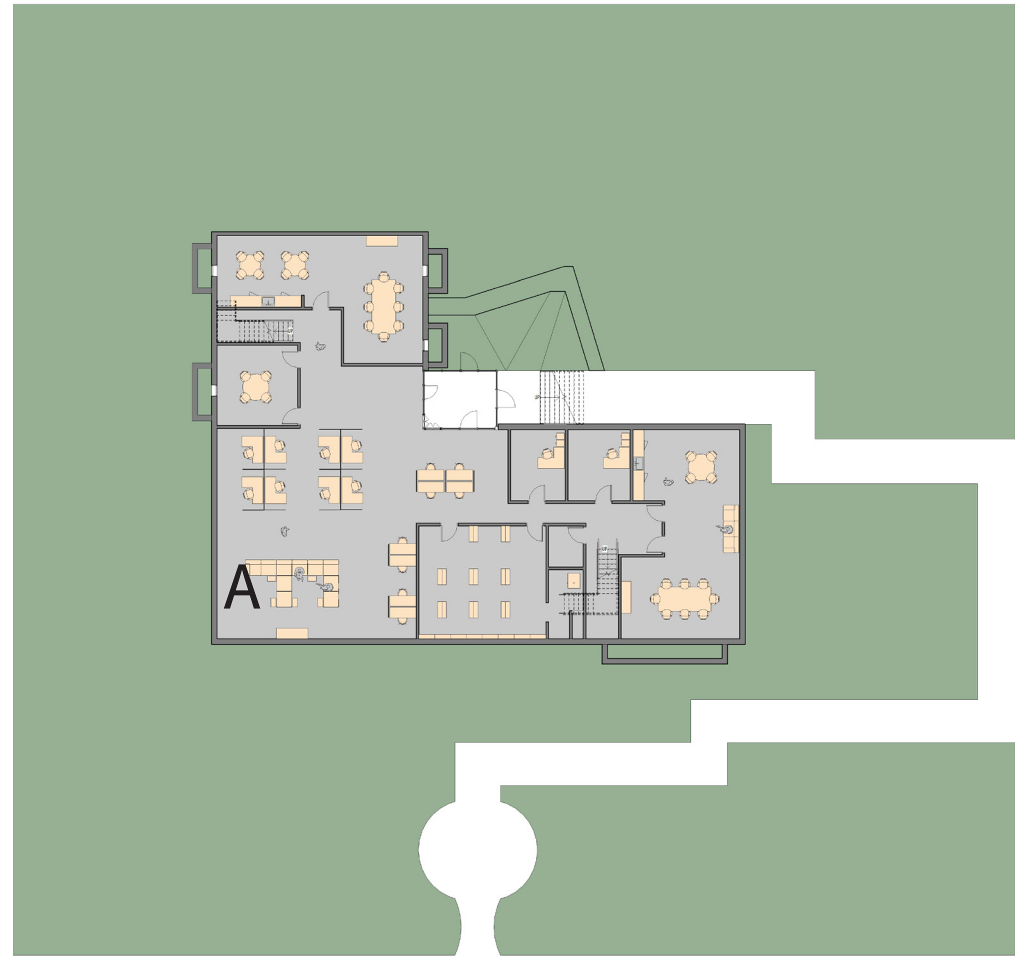


Figure 111. Level 0 Floor Plan

Level 1 Floor Plan

Figure 112. Level 1 Floor Plan

Level 2 Floor Plan

Figure 113. Level 2 Floor Plan

Furniture Selection and Use

Van De Sant

Van de Sant sustainable design furniture is made from recycled plastic gathered from land and oceans. They change plastic waste into circular design. Every furniture piece can be reprocessed into raw materials and re-manufactured into new design furniture.

Figure 106. Van De Sant Modular Sofa

Urban Wood Goods

Urban Wood Goods has established decade-long relationships with contractors who specialize in deconstruction, giving priority access to rare and unique woods from buildings of historic interest as they are being carefully disassembled.

Figure 107. Urban Wood Goods

Steelcase

The Steelcase Series™ 1 the first task chair with a CarbonNeutral® product certification, completely offsetting emissions. Steelcase Series 1 is tested above industry standards to ensure reliability now and in the future.

Figure 105. Steelcase Series 1 Chair

Roof Plan

Renovation for Energy Consumption

1 **Solar Chimney**

Located in the northern corner of the building, a SmartGlass solar chimney serves as an innovative feature to optimize both natural light and ventilation. Utilizing solar energy, this structure facilitates airflow, enhancing cooling and ventilation throughout the building. Its tall shaft is capped with solid material, strategically designed to capture sunlight and maximize its efficiency.

2 **Green Roof**

A green roof incorporates vegetation, soil, and waterproofing into a building's structure. By absorbing rainwater, it reduces runoff and alleviates strain on drainage systems, while simultaneously filtering pollutants. Furthermore, it serves as insulation, decreasing heat absorption during warmer weather and reducing heat loss in colder climates, resulting in energy conservation.

3 **Light Well**

Similar to a courtyard or atrium, a light well functions to introduce natural light into the depths of a building, diminishing the need for artificial illumination. Moreover, it fosters a link to the external environment, enriching occupants' quality of life through the infusion of sunlight and the presence of greenery within the building.

4 **Sky Lights**

Skylights, also known as roof windows, usher abundant natural light into indoor areas, diminishing the need for artificial lighting and thereby decreasing energy expenditures. Certain skylights are designed to open, offering natural ventilation that improves indoor air quality and enhances comfort levels.

5 **Solar Panels**

Solar panels, often referred to as PV panels, efficiently transform sunlight into electricity using the photovoltaic effect. Comprising layers such as tempered glass, anti-reflective coating, and photovoltaic cells, they facilitate this conversion process seamlessly.

6 **Hempcrete**

Hempcrete is a bio-composite material crafted from the inner woody core of the hemp plant, combined with a binder predominantly composed of lime. This combination yields a lightweight, cementitious insulation substance, weighing approximately one-seventh to one-eighth of the mass of traditional concrete.

Roof Plan View

Figure 114. Roof Plan

Isometric View

Figure 115. Isometric Rendering

This detailed isometric rendering prominently showcases two innovative design features: the solar chimney and light well. These strategic additions represent the culmination of thoughtful redesign efforts aimed at enhancing the functionality and sustainability of the original structure. The incorporation of a solar chimney and light well marks a significant departure from the building's previous configuration, underscoring a commitment to harnessing natural elements to improve the overall quality of the indoor environment. These features serve a dual purpose, addressing both the physiological needs of occupants and promoting environmental sustainability. At its core, the solar chimney serves as a dynamic mechanism for passive solar heating and cooling. By harnessing the power of sunlight, it facilitates the circulation of air throughout the space, effectively regulating temperature and reducing reliance on mechanical HVAC systems. This not only enhances energy efficiency but also fosters a more comfortable and inviting indoor atmosphere for occupants. Complementing the solar chimney, the light well acts as a conduit for natural daylight, channeling sunlight deep into the interior of the building. This strategic integration of daylighting elements not only reduces the need for artificial lighting but also creates a visually stimulating environment that promotes productivity and well-being among users. Beyond their functional benefits, these design features are emblematic of a larger ethos centered on occupant health and wellness. By maximizing access to natural daylight and fresh ventilation, the solar chimney and light well prioritize the holistic well-being of occupants, supporting both physical and psychological health.

Figure 116. Solar Chimney Close Up

Figure 117. Light Well Close Up

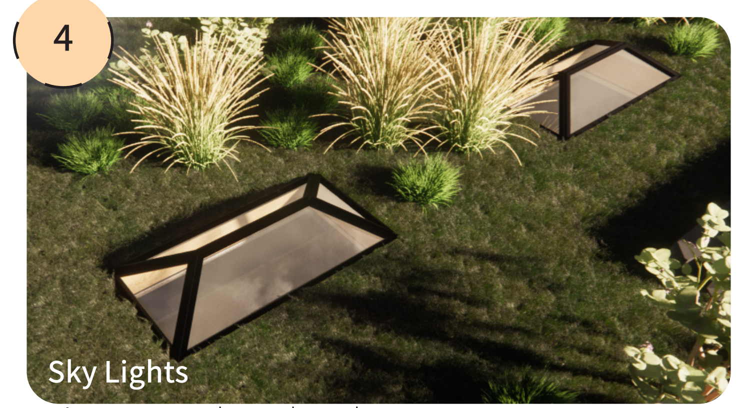


Figure 118. Sky Lights Close Up

Section Views

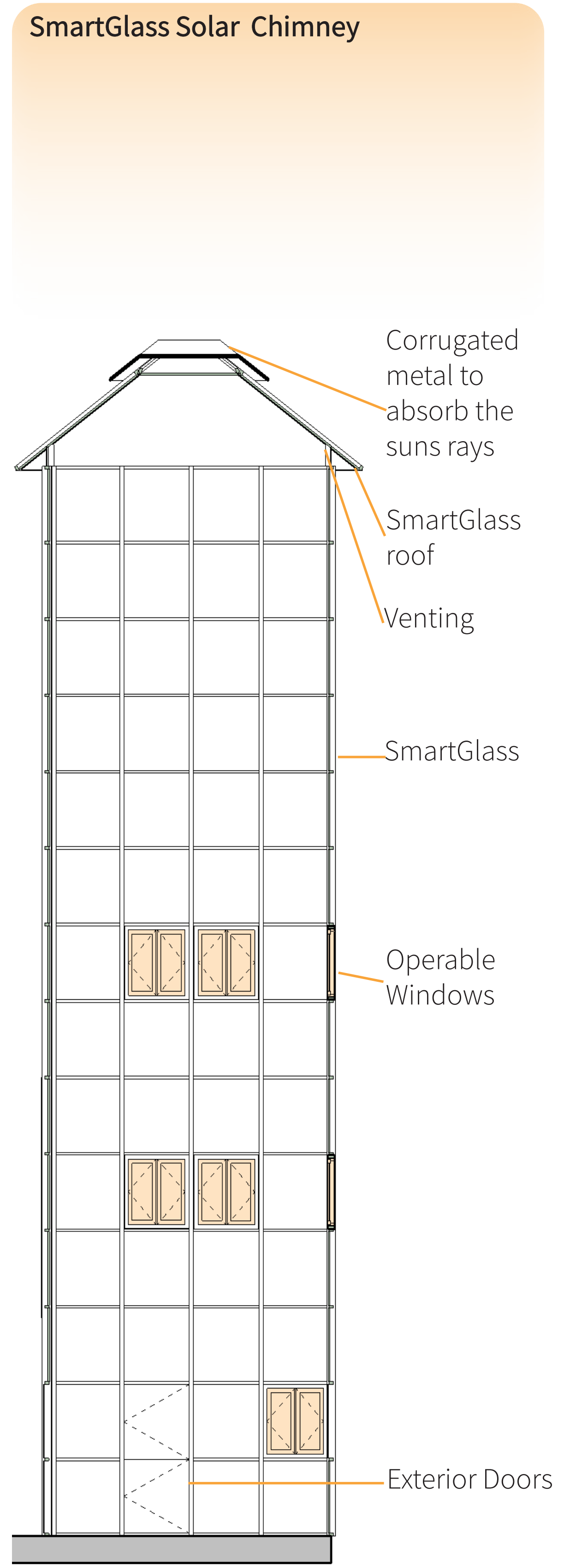


Figure 119. Solar Chimney Section

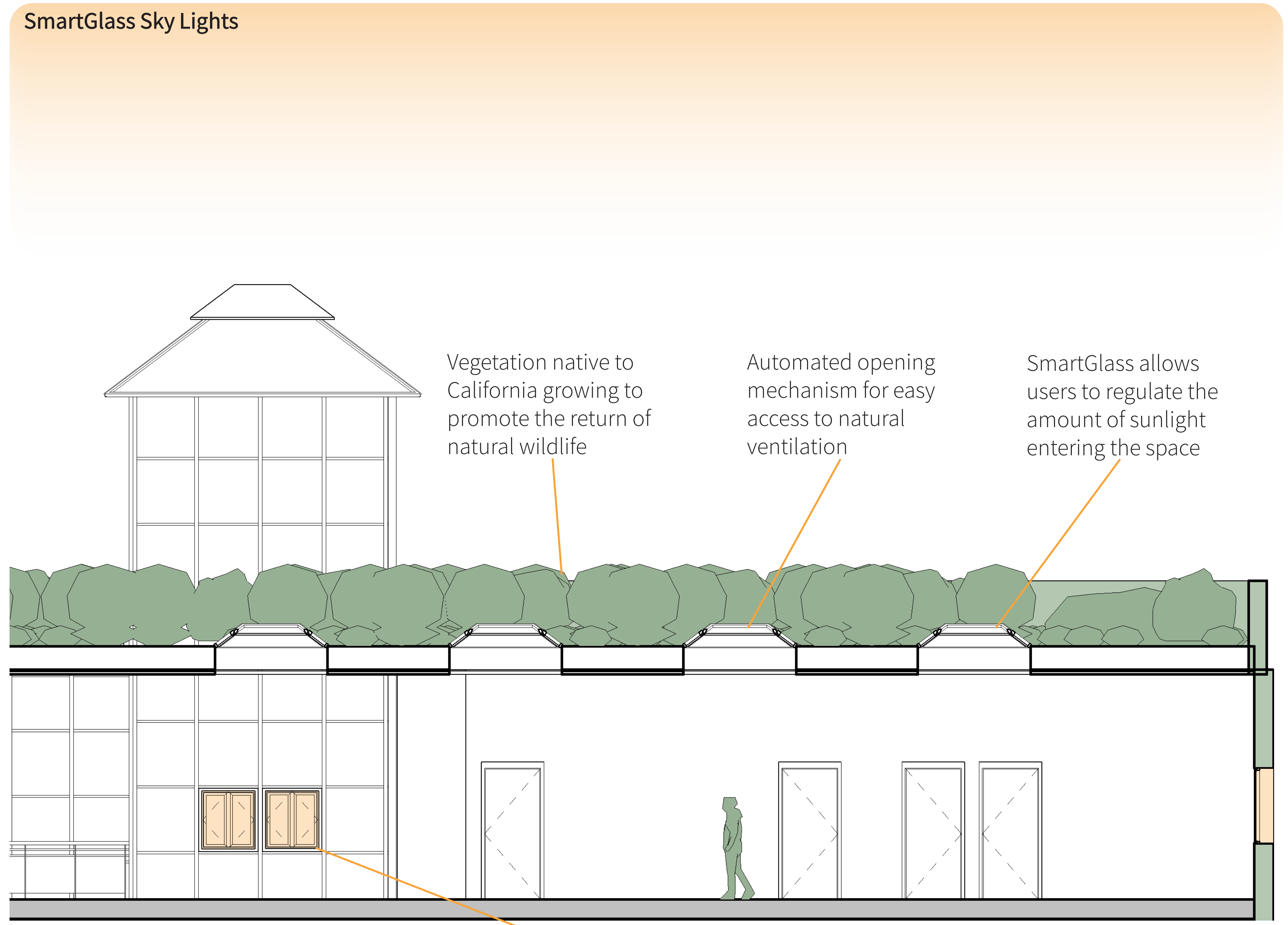


Figure 120. Sky Lights Section

The Solar Chimney boasts SmartGlass windows situated across levels 0, 1, and 2, strategically positioned to optimize functionality and user comfort. These innovative windows are designed to be operable, featuring hand-crank mechanisms for effortless opening and closing. Their presence offers occupants the flexibility to engage in optional passive ventilation, enhancing airflow and promoting a more dynamic indoor environment throughout all levels of the building. By incorporating SmartGlass windows into the design of the Solar Chimney, the project prioritizes both functionality and user experience. These operable windows not only facilitate ease of use but also empower occupants to customize their environment according to their preferences. Whether seeking to invite in a refreshing breeze or regulate indoor temperatures, the availability of passive ventilation options underscores a commitment to enhancing occupant comfort and well-being within the built environment.

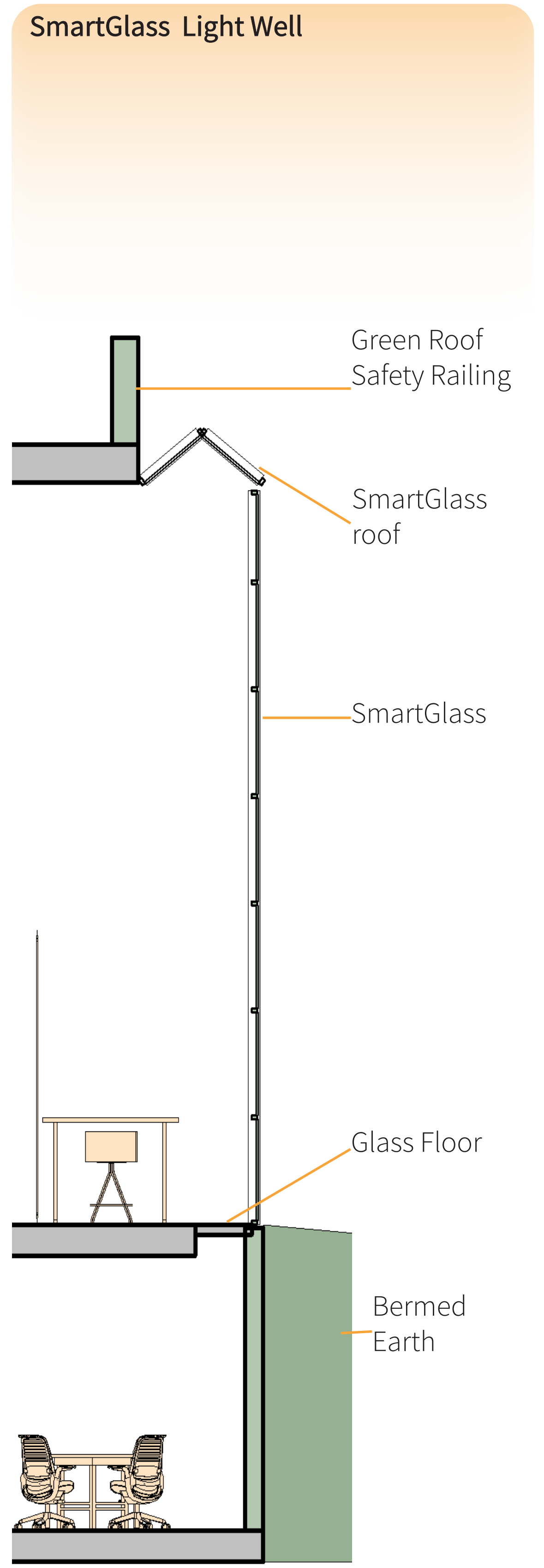


Figure 121. Light Well Section

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Figure 112. Dissinger, Celia. Level 1 Floor Plan. 2024.
Figure 113. Dissinger, Celia. Level 2 Floor Plan. 2024.
Figure 114. Dissinger, Celia. Roof Plan. 2024.
Figure 115. Dissinger, Celia. Isometric Rendering. 2024.
Figure 116. Dissinger, Celia. Solar Chimney Close Up. 2024.
Figure 117. Dissinger, Celia. Light Well Close Up. 2024.
Figure 118. Dissinger, Celia. Sky Lights. 2024.
Figure 119. Dissinger, Celia. Solar Chimney Section. 2024.
Figure 120. Dissinger, Celia. Sky Lights Section. 2024.
Figure 121. Dissinger, Celia. Light Well Section. 2024.

Literature Review

Climate Change Sources:

Network, The Learning. “What’s Going on in This Graph? | Global Record Temperatures.” The New York Times, September 7, 2023. https://www.nytimes.com/2023/09/07/learning/whats-going-on-in-this-graph-sept-13-2023.html.

Abstract: The above time series graph (see Stat Nugget below) accompanied the New York Times article “Here’s Where Global Heat Records Stand So Far in July,” published on July 19, 2023. It displays the average daily global surface air temperatures for 1979 to 2023. Specifically, these values are the area-weighted average of near-surface (two-meter height) air temperature over all land and ocean worldwide. The data for 2022 and 2023 are highlighted.

Summary: This is a recent and reliable source. The graph is easy to read and will be a great attention grabber and a relatable graphic seeing as the heat of this past summer was noticeable. The article does a good job of explaining the graph and was an interesting read.

“Landslide Basics.” Landslide Basics | U.S. Geological Survey, 2023. https://www.usgs.gov/programs/landslide-hazards/landslide-basics.

Abstract: Landslides occur in all 50 states and territories, and they affect lives, property, infrastructure, and the environment. Landslides are the downslope movement of earth materials (rock, debris, and soil) at rates that range from inches per year to tens of miles per hour. Some landslides can move faster than a person can run. Landslides can happen with no notice or can take place over a period of days, weeks, or longer.

Summary: Great source that details what a landslide is and the regions it impacts. Quality source that seems reliable since it is a government source. Has some very interesting facts and statistics about landslides and how disastrous they can be.

Fox, Karen, Aries Keck, and Jacob Richmond. “NASA Announces Summer 2023 Hottest on Record – Climate Change: Vital Signs of the Planet.” NASA, September 14, 2023. https://climate.nasa.gov/news/3282/nasa-announces-summer-2023-hottest-on-record/.

Abstract: Summer 2023’s record-setting temperatures aren’t just a set of numbers – they result in dire real-world consequences. From sweltering temperatures in Arizona and across the country, to wildfires across Canada, and extreme flooding in Europe and Asia, extreme weather is threatening lives and livelihoods around the world,” said NASA Administrator Bill Nelson. “The impacts of climate change are a threat to our planet and future generations, threats that NASA and the Biden-Harris Administration are tackling head on.

Summary: This is a reliable source that has a good graphic showing the temperature rise this past summer. I will revisit this site for talking points on this graphic.

Riebeek, Holli. “Global Warming.” NASA, June 3, 2010. https://earthobservatory.nasa.gov/features/GlobalWarming#:~:text=is%20Global%20Warming%3F-,Global%20warming%20is%20the%20unusually%20rapid%20increase%20in%20Earth’s%20average,as%20people%20burn%20fossil%20fuels.

Abstract: Throughout its long history, Earth has warmed and cooled time and again. Climate has changed when the planet received more or less sunlight due to subtle shifts in its orbit, as the atmosphere or surface changed, or when the Sun’s energy varied. But in the past century, another force has started to influence Earth’s climate: humanity.

Summary: This source is reliable and gives a good basic overview of what global warming is and how it is caused. Simply defines global warming and is easy to understand.

Weaving, Hester. “Insects Will Struggle to Keep Pace with Global Temperature Rise – Which Could Be Bad News for Humans.” The Conversation, December 2, 2022. https://theconversation.com/insects-will-struggle-to-keep-pace-with-global-temperature-rise-which-could-be-bad-news-for-humans-190791#:~:text=A%20weak%20ability%20to%20adjust%20to%20higher%20temperatures%20will%20mean,the%20delicate%20balance%20of%20ecosystems.

Abstract: Animals can only endure temperatures within a given range. The upper and lower temperatures of this range are called its critical thermal limits. As these limits are exceeded, an animal must either adjust or migrate to a cooler climate. However, temperatures are rising across the world at a rapid pace. The record-breaking heatwaves experienced across Europe this summer are indicative of this. Heatwaves such as these can cause temperatures to regularly surpass critical thermal limits, endangering many species. In a new study, my colleagues and I assessed how well 102 species of insect can adjust their critical thermal limits to survive temperature extremes. We found that insects have a weak capacity to do so, making them particularly vulnerable to climate change. The impact of climate change on insects could have profound consequences for human life. Many insect species serve important ecological functions while the movement of others can disrupt the balance of ecosystems.

Summary: This source outlines the existing issues with our ecosystem given the change in temperatures across the United States. It talks about how our ecosystems are being impacted by temperature and explains how they are changing and the affect it can have on our food sources as well as the environment.

Lai, Charlie. “The Worst States for Climate Change in the US in 2023.” Earth.Org, June 25, 2023. https://earth.org/worst-states-for-climate-change/.

Abstract: Pollution, extreme weather, and natural hazards are just some examples of events caused by global warming. The US is currently experiencing some of its worst droughts and heatwaves. Water as well as air pollution are rising to unprecedented levels across the country. We explore the worst states for climate change in the US.

Summary: This source has tons of attention grabbing statistics that will be good to include in research and represent graphically. Information should be pulled from this source regarding the impacts that different states are experiencing due to global warming.

Riley, Patrick. “Timeline of Climate Change.” Encyclopædia Britannica, 2021. https://www.britannica.com/story/timeline-of-climate-change.

Abstract: Climate change happens across a range of time scales from hours to eons. However, since the dawn of the Industrial Revolution in 1750, human beings and their activities have emerged as significant factors in driving climate on Earth. Greenhouse gases (which are emitted during the combustion of fossil fuels for manufacturing, heating, land clearing, and transportation) continue to build up in Earth’s atmosphere. These gases enhance the atmosphere’s ability to hold in heat, which has resulted in accelerated melting at the poles and of mountain glaciers and has altered reliable temperature and rainfall patterns in other parts of the world.

Summary: Great overall timeline of the human impacts on global warming. Has a couple of international government agreements that were set into motion which led to further research. Has a good graphic about the keeling curve and led to further investigation about the keeling curve.

“The Paris Agreement: What Is the Paris Agreement?” Unfccc.int. Accessed October 27, 2023. https://unfccc.int/process-and-meetings/the-paris-agreement.

Abstract: The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. It entered into force on 4 November 2016. Its overarching goal is to hold “the increase in the global average temperature to well below 2°C above pre-industrial levels” and pursue efforts “to limit the temperature increase to 1.5°C above pre-industrial levels.”

Summary: Overview of The Paris Agreement. Has the countries that signed on and the background information on how the agreement came about. Also has information about the actual agreement and it’s requirements and objectives about the climate initiative.

Denchak, Melissa. “Fossil Fuels: The Dirty Facts.” Be a Force for the Future, June 1, 2022. https://www.nrdc.org/stories/fossil-fuels-dirty-facts#sec-whatis.

Abstract: For more than a century, burning fossil fuels has generated most of the energy required to propel our cars, power our businesses, and keep the lights on in our homes. Even today, oil, coal, and gas serve about 80 percent of our energy needs. And we’re paying the price. Using fossil fuels for energy has exacted an enormous toll on humanity and the environment—from air and water pollution to global warming. That’s beyond all the negative impacts from petroleum-based products such as plastics and chemicals. Here’s a look at what fossil fuels are, what they cost us (beyond the wallet), and why it’s time to move toward a clean energy future.

Summary: Great overview of fossil fuels. The source is reliable and goes into detail about each different fossil fuel. Will revisit this source to analyze further.

Wibbenmeyer, Matthew, and Anne McDarris. “Wildfires in the United States 101: Context and Consequences.” Resources for the Future, July 30, 2021. https://www.rff.org/publications/explainers/wildfires-in-the-united-states-101-context-and-consequences/?gclid=CjwKCAjwkNOpBhBEEiwAb3MvvXkhmYS-IS-XYOVxiYBvjMRs0KO8AeSzszUXAmUTGePsqUfNpXa-ExoCeuAQAvD_BwE.

Abstract: A wildfire is an uncontrolled fire that burns in wildland vegetation such as forests, shrublands, or grasslands. Due to climate change, a preponderance of fuels in western forests, and an increase in the population living in proximity to high wildfire hazard areas, wildfires have become increasingly destructive in recent years. This explainer discusses the context and consequences of wildfires in the United States, including relevant trends; primary causes; and the impacts on the economy, the environment, and human health. While we will consider trends, causes, and impacts of fire throughout the United States, a substantial portion of this explainer will focus on western wildfires, due to the magnitude of wildfire impacts in the American West.

Summary: A great source that is organized well. Has very interesting graphics that should be visited again and analyzed. Source is abundant with information from how they are started to the common locations and regions that wildfires take place in.

Denchak, Melissa. “Drought: Everything You Need to Know.” Be a Force for the Future, September 13, 2018. https://www.nrdc.org/stories/drought-everything-you-need-know?gclid=CjwKCAjwkNOpBhBEEiwAb3MvvbQXKUCfDgHImhBgqRjFIJnsrBT6yex_ZMwmVd1N9b7jDyNi3umeCRoCuc4QAvD_BwE#what.

Abstract: Natural disasters usually announce their arrival: Hurricanes uproot trees, tornadoes roar, and wildfires wipe out entire landscapes. These large, sudden events generate destruction on impact—and then they’re gone. Drought is different. It doesn’t make a big entrance—the start of a drought might even be mistaken for a bit of a dry spell—and its impact builds over time. But while often described as a “creeping disaster,” drought leaves a trail of destruction as dangerous and deadly as any other extreme weather event. In fact, drought has affected more people around the world in the past four decades than any other type of natural disaster.

Summary: Fantastic source about drought, how it starts and what it impacts. Has some really interesting facts that will be a good thing to mention in a presentation to gain that wow factor. Quality source, easy to read and has lots of information that I did not know I was looking for. Revisit.

“Climate Change and Fishing: Marine Stewardship Council.” US & Canada - English, 2019. https://www.msc.org/en-us/what-we-are-doing/oceans-at-risk/climate-change-and-fishing?gad=1&gclid=CjwKCAjwkNOpBhBEEiwAb3MvvaNseoh55xohTOQxtgONwZ-9vPKcSTZLQPsJtGVNsqe56l9XqCxFzxoCXZ4QAvD_BwE.

Abstract: The ocean plays a major role in climate dynamics: 83% of the global carbon cycle is circulated through the ocean. It has absorbed 93% of the excess heat from greenhouse gas emissions since the 1970s. The ocean is home to between 500,000 and 10 million marine species, contributing enormously to the biodiversity of our planet. Given its importance to the planet, it is vital we manage the ocean in a sustainable way. Changes to the ocean mean changes to fish stocks. To manage fishing sustainably requires adapting to whatever issues climate change brings.

Summary: This source includes attention grabbing statistics and explains the impact that carbon emissions and the rise in temperature is having on our ocean/ecosystems. An interesting read about how the ocean has absorbed so much of the rise in carbon and the heat.

Weaving, Hester. “Insects Will Struggle to Keep Pace with Global Temperature Rise – Which Could Be Bad News for Humans.” The Conversation, December 2, 2022. https://theconversation.com/insects-will-struggle-to-keep-pace-with-global-temperature-rise-which-could-be-bad-news-for-humans-190791#:~:text=A%20weak%20ability%20to%20adjust%20to%20higher%20temperatures%20will%20mean,the%20delicate%20balance%20of%20ecosystems.

Abstract: Animals can only endure temperatures within a given range. The upper and lower temperatures of this range are called its critical thermal limits. As these limits are exceeded, an animal must either adjust or migrate to a cooler climate. However, temperatures are rising across the world at a rapid pace. The record-breaking heatwaves experienced across Europe this summer are indicative of this. Heatwaves such as these can cause temperatures to regularly surpass critical thermal limits, endangering many species. In a new study, my colleagues and I assessed how well 102 species of insect can adjust their critical thermal limits to survive temperature extremes. We found that insects have a weak capacity to do so, making them particularly vulnerable to climate change. The impact of climate change on insects could have profound consequences for human life. Many insect species serve important ecological functions while the movement of others can disrupt the balance of ecosystems.

Summary: This source outlines the existing issues with our ecosystem given the change in temperatures across the United States. It talks about how our ecosystems are being impacted by temperature and explains how they are changing and the affect it can have on our food sources as well as the environment.

Lai, Charlie. “The Worst States for Climate Change in the US in 2023.” Earth.Org, June 25, 2023. https://earth.org/worst-states-for-climate-change/.

Abstract: Pollution, extreme weather, and natural hazards are just some examples of events caused by global warming. The US is currently experiencing some of its worst droughts and heatwaves. Water as well as air pollution are rising to unprecedented levels across the country. We explore the worst states for climate change in the US.

Summary: This source has tons of attention grabbing statistics that will be good to include in research and represent graphically. Information should be pulled from this source regarding the impacts that different states are experiencing due to global warming.

“State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA).” State Carbon Dioxide Emissions Data - U.S. Energy Information Administration (EIA), July 23, 2023. https://www.eia.gov/environment/emissions/state/.

Abstract: The term energy-related CO2 emissions, as used in these tables, refers to emissions released at the location where fossil fuels are consumed. Energy-related carbon dioxide (CO2) emissions vary significantly across states, on both an absolute basis and on a per capita basis. Total state CO2 emissions include CO2 emissions from direct fuel use across all sectors, including residential, commercial, industrial, and transportation, as well as primary fuels consumed for electricity generation.

Summary: This source has many excel files that hold the data of emissions by state in the United States. Table is easy to navigate and seems credible given that it is being regularly updated with the carbon emissions output.

Human Health Resources:

“Heat and Health.” World Health Organization, June 1, 2018. https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health.

Abstract: Global temperatures and the frequency and intensity of heatwaves will rise in the 21st century as a result of climate change. Extended periods of high day and nighttime temperatures create cumulative physiological stress on the human body which exacerbates the top causes of death globally, including respiratory and cardiovascular diseases, diabetes mellitus and renal disease. Heatwaves can acutely impact large populations for short periods of time, often trigger public health emergencies, and result in excess mortality, and cascading socioeconomic impacts (e.g. lost work capacity and labor productivity). They can also cause loss of health service delivery capacity, where power-shortages which often accompany heatwaves disrupt health facilities, transport, and water infrastructure. Awareness remains insufficient of the health risks posed by heatwaves and prolonged exposure to increased temperatures. Health professionals must adjust their planning and interventions to account for increasing temperatures and heatwaves. Practical, feasible, and often low-cost interventions at the individual, community, organizational, governmental and societal levels, can save lives

Summary: Great source with some statistics that would be good attention grabbers. This source is reliable as it is from the World Health Organization and is written well and easy to understand. There are many good graphics in this article that will help explain the impact of climate change.

Mead, M Nathaniel. “Benefits of Sunlight: A Bright Spot for Human Health.” Environmental health perspectives, April 2008. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2290997/.

Abstract: Each day, Apollo’s fiery chariot makes its way across the sky, bringing life-giving light to the planet. For the ancient Greeks and Romans, Apollo was the god of medicine and healing as well as of sun and light—but Apollo could bring sickness as well as cure. Today’s scientists have come to a similarly dichotomous recognition that exposure to the ultraviolet radiation (UVR) in sunlight has both beneficial and deleterious effects on human health. Most public health messages of the past century have focused on the hazards of too much sun exposure. UVA radiation (95–97% of the UVR that reaches Earth’s surface) penetrates deeply into the skin, where it can contribute to skin cancer indirectly via generation of DNA-damaging molecules such as hydroxyl and oxygen radicals. Sunburn is caused by too much UVB radiation; this form also leads to direct DNA damage and promotes various skin cancers. Both forms can damage collagen fibers, destroy vitamin A in skin, accelerate aging of the skin, and increase the risk of skin cancers. Excessive sun exposure can also cause cataracts and diseases aggravated by UVR-induced immunosuppression such as reactivation of some latent viruses.

Summary: This source should be revisited. It has tons of information on the different illnesses and impacts that sunlight can cause while also explaining the necessary amounts. The source seems reliable as it is the National Library of Medicine and provides the author and resources.

“Indoor Air Quality | US EPA - U.S. Environmental Protection Agency.” EPA United States Environmental Protection Agency, 2020. https://www.epa.gov/report-environment/indoor-air-quality.

Abstract: The air exchange rate with the outdoors is an important factor in determining indoor air pollutant concentrations. The air exchange rate is affected by the design, construction, and operating parameters of buildings and is ultimately a function of infiltration (air that flows into structures through openings, joints, and cracks in walls, floors, and ceilings and around windows and doors), natural ventilation (air that flows through opened windows and doors), and mechanical ventilation (air that is forced indoors or vented outdoors by ventilation devices, such as fans or air handling systems). Outdoor climate and weather conditions combined with occupant behavior can also affect indoor air quality. Weather conditions influence whether building occupants keep windows open or closed and whether they operate air conditioners, humidifiers, or heaters, all of which can affect indoor air quality. Certain climatic conditions can increase the potential for indoor moisture and mold growth if not controlled by adequate ventilation or air conditioning.

Summary: This source has enough information to analyze. Covers the extent of indoor air pollution and what the most common kinds of pollutants are. It also talks about the many benefits of natural ventilation and why it is imperative to our buildings.

Lee, Eun H, George I Christopoulos, Kian W Kwok, Adam C Roberts, and Chee-Kiong Soh. “A Psychosocial Approach to Understanding Underground Spaces.” Frontiers in psychology, March 28, 2017. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368185/.

Abstract: With a growing need for usable land in urban areas, subterranean development has been gaining attention. While construction of large underground complexes is not a new concept, our understanding of various socio-cultural aspects of staying underground is still at a premature stage. With projected emergence of underground built environments, future populations may spend much more of their working, transit, and recreational time in underground spaces. Therefore, it is essential to understand the challenges and advantages that such environments have to improve the future welfare of users of underground spaces. The current paper discusses various psycho-social aspects of underground spaces, the impact they can have on the culture shared among the occupants, and possible solutions to overcome some of these challenges.

Summary: This article talked about the psychosocial characteristics of the underground environment. There is some really interesting points about religion and how it relates to underground spaces as well as the social aspects. There is a section that goes in depth about the psychological effects that can happen when a window is not in a room or if there is a lack of sunlight. The cultural association with underground structures is mostly based on societies that have existed.

Passive Design Resources:

“Types of Insulation.” Energy.gov. Accessed December 3, 2023. https://www.energy.gov/energysaver/types-insulation.

Abstract: The maximum thermal performance or R-value of insulation is very dependent on proper installation. Homeowners can install some types of insulation -- notably blankets, boards, and materials that can be poured in place. (Liquid foam insulation materials can be poured, but they require professional installation). Other types require professional installation.

Summary: This is an excellent source that talks about all of the different kinds of insulation and the advantages and disadvantages of every type. It also includes a table that indicated the thermal capability of each kind of insulation.

Facebook.com/fairconditioning. “Thermal Mass.” Fairconditioning. Accessed December 3, 2023. https://fairconditioning.org/knowledge/passive-design/thermal-mass/.

Abstract: Thermal mass is the ability of a material to absorb and store heat energy. Mass and density of a building material affect the heat storing capacity in buildings. A lot of heat energy is required to change the temperature of high-density materials like concrete, bricks, and tiles. They are therefore said to have high thermal mass. Lightweight materials such as timber have low thermal mass. The efficacy depends on the placements of the thermal mass with respect to direct irradiation of the sun. Appropriate use of thermal mass can make a big difference to comfort and heating and cooling bills.

Summary: This source provides good research and statistics on thermal massing. It also has some great graphics that help explain how thermal mass impacts the thermal comfort of our buildings. It also has links to other graphics made that help graphically communicate how thermal mass helps control temperature.

“Earth-Sheltered Buildings.” NCMA, April 26, 2019. https://ncma.org/resource/earth-sheltered-buildings/.

Abstract: Earth-sheltering refers to using earth as part of a building’s thermal control system Earth-sheltered buildings can be either built into the earth or an existing hillside, or can be built above grade, and earth bermed around the exterior after construction. Earth-sheltered buildings can be built entirely underground, but are more often only partially earth-sheltered to allow adequate natural light into the interior. These buildings are most widely recognized for their energy efficiency, due to the insulating capacity of the earth and lower air infiltration through the earth-sheltered surfaces. In addition, earth-sheltered buildings also offer superior protection from storms, insulation from outside noise, lower maintenance costs, and less impact on the surrounding landscape.

Summary: This is a good general source on earth sheltered buildings. It talks about the reasoning for these structures and the benefits that come from having an earth sheltered structure. This source should be revisited.

Pancholi, Preksha. “What Are Bermed Earth Shelter Homes.” RTF | Rethinking The Future, August 19, 2023. https://www.re-thinkingthefuture.com/architectural-community/a9836-what-are-bermed-earth-shelter-homes/.

Abstract: A bermed earth-sheltered house can be the ideal choice if you’re seeking a home with energy-saving features that will offer a cosy, serene, weather-resistant residence. Earth-sheltered homes, especially subterranean homes, are increasingly a viable passive design option. Bermed earth-sheltered homes were once only seen in traditional civilizations or in upscale construction styles. Bermed earth-sheltered dwellings are becoming more popular because of their built-in insulation.

Summary: Article gives a general overview of what bermed architecture is and the differences between the types of bermed architecture. This article talked about construction materials, the design and functionality of a bermed house, and it’s economic drawbacks. It mainly focused on bermed architecture and how it pertains to residential design rather than commercial, but is a solid overview of bermed structures. I probably would not reference this again, it was purely an overview.

Khaksar, Amirreza, Amir Tabadkani, Seyed Shemirani, Aso Hajirasouli, Saeed Banihashemi, and Shady Attia. “Thermal Comfort Analysis of Earth-Sheltered Buildings: The Case of Meymand Village, Iran.” Frontiers of Architectural Research, May 13, 2022. https://www.sciencedirect.com/science/article/pii/S2095263522000474?ref=pdf_download&fr=RR-2&rr=80336e5f3c100271.

Abstract: Vernacular buildings are known for their localized passive settings to provide comfortable indoor environment without air conditioning systems. One alternative is the consistent ground temperature over the year that earth-sheltered envelopes take the benefit; however, ensuring annual indoor comfort might be challenging. Thus, this research monitors the indoor thermal indicators of 22 earth-sheltered buildings in Meymand, Iran with a warm-dry climate. Furthermore, the observations are used to validate the simulation results through two outdoor and indoor environmental parameters, air temperature and relative humidity during the hottest period of the year. Findings indicated that the main thermal comfort differences among case studies were mainly due to their architectural layouts where the associated variables including length, width, height, orientation, window-to-wall ratio, and shading depth were optimized through a linkage between Ladybug-tools and Genetic Algorithm (GA) concerning adaptive thermal comfort model definition and could enhance the annual thermal comfort by 31%.

Summary: PDF goes in depth about the differences between underground and earth-in architecture. It also includes a simulation that could be referenced later on to look at the benefits of thermal mass. This pdf includes a lot of scientific explanation that will be useful in making graphics to help explain the benefits.

Tricoire, Jean-Pascal. “Buildings Are the Foundation of Our Energy-Efficient Future.” World Economic Forum, February 22, 2021. https://www.weforum.org/agenda/2021/02/why-the-buildings-of-the-future-are-key-to-an-efficient-energy-ecosystem/.

Abstract: COVID-19 and climate-related events have taken a big toll on the world this year. But all shocks, while painful, are also opportunities – to review past policies, to think more holistically, to do things more efficiently, and to build buffers for future challenges.

Summary: This article is a good read about how our buildings can help to mitigate climate change through multifaceted design. Resource seems credible and is an easy read and should be revisited because it explains things well.

Gritch, Todd. “Atria Systems .” WBDG, October 5, 2016. https://wbdg.org/guides-specifications/building-envelope-design-guide/atria-systems.

Abstract: Atriums have many advantages as a building form over conventional modern building configurations. Atrium buildings appeal to people not only logically, but also emotionally by providing a connection to the outside inside. By bringing natural light into the interior, atriums offer larger, more efficient floor areas than conventional buildings. Atriums provide more desirable work environments by providing more space with a connection to natural daylight and the outside environment. Many believe that access to natural full spectrum lighting creates a more healthful and productive environment. There have been several studies that support this view. The view into an atrium can and in most cases is more entertaining and connective than an exterior view as illustrated below at The Plaza of the Americas in Dallas, Texas. An atrium is a pleasant all weather gathering place providing shelter from the more extreme climate conditions outside. The atrium replicates a desirable outdoor environment by providing the benevolent aspects of the outdoor environment; natural light, moderate temperatures while sheltering us from the harsher elements of extreme temperatures, rain, and winds.

Summary: This source includes great graphics of atriums and explains their benefits. It also goes into how atriums can help regulate temperature for the right kind of environment. This source should be revisited for graphic inspiration.

Literature Review

Precedent Studies:

“Puey Ungpahakorn Centenary Hall / Arsomslip Community and Environmental Architect” 16 Aug 2023. ArchDaily. Accessed 6 Nov 2023. <https://www.archdaily.com/1005449/puey-ungpahakorn-centenary-hall-arsomslip-community-and-environmental-architect> ISSN 0719-8884

Abstract: Thammasat is a long-established university in Thailand, formerly named “The University of Moral and Political Sciences”. This project was initiated in 2016 in the occasion of the 100thanniversary birthday of Prof. Dr. Puey Ungphakorn, the 10th chancellor of Thammasat university. He was named by UNESCO as one of the world’s most important people for his “impeccable ethics”. He dedicated his life for the importance of the environment, quality of life and the health of the people in his homeland. To truly reflect his spirit, this project is placed on the university’s main axis from Phahonyothin Road as a landmark and public park that serves as the lung of Thammasat’s community and the people of northern Bangkok.

Summary: This source is used as a precedent study of a bermed educational space. It is a good example of form and function and utilizes passive design strategies to take note of.

“Ramat Hanadiv Visiting Center / Ada Karmi-Melamede Architects” 08 Dec 2011. ArchDaily. Accessed 6 Nov 2023. <https://www.archdaily.com/189050/ramat-hanadiv-visiting-center-ada-karmi-melamede-architects> ISSN 0719-8884

Abstract: The architectural concept evolved from the need to create a foyer in front of the gardens which will function as a meeting place for the diverse groups of visitors. The architectural composition extends approximately 150 meters in a curvilinear fashion. It contains an auditorium, classrooms, small courtyards, an exhibition space and a small cafeteria at the extremity. These functions are housed within a berm formed by two inclined landscaped surfaces that lean against each other with light penetrating in between.

Summary: This source was used as a precedent study. This project is a good example of a bermed structure that uses passive daylighting techniques.

“Carboncure’s Sustainable Concrete Solution.” CarbonCure Technologies Inc., November 29, 2023. https://www.carboncure.com/.

Abstract: CarbonCure creates carbon removal technologies that introduce recycled CO_2 into fresh concrete to reduce its carbon footprint, without compromising performance. Once injected, the CO_2 undergoes a mineralization process and becomes permanently embedded in the concrete. This results in economic and climate benefits for concrete producers—truly a win-win

Summary: CarbonCure Concrete is a product that I learned about years ago in the program and have been waiting to apply to a specific project. This technology is perfect for my topic of study and their website includes everything that I need to know about the technology.

ArchDaily. “Danpalon 3dlite - Solar Control from Danpal.” ArchDaily, September 21, 2023. https://www.archdaily.com/catalog/us/products/13408/control-solar-3dlite-danpal?ad_source=search&ad_medium=search_result_all.

Abstract: Danpalon 3DLITE is a new technologically advanced and innovative system, developed by Danpal that allows architects to design creatively while contributing to energy savings and better use of natural light. Its advanced multicellular system selectively controls the sunlight that penetrates during the day, at the same time offering thermal insulation and a unique appearance.

Summary: This source is used for a precedent study of façade applications. Danpalon is a façade technology that helps to reduce solar radiation to a building. This product promotes sustainability and provides ample energy savings. Another aspect of this product that I like is the range of colors that the product comes in.

ArchDaily. “Facades - Specialty Applications from Kalwall®.” ArchDaily, February 1, 2019. https://www.archdaily.com/catalog/us/products/15017/facades-specialty-applications-kalwall?ad_source=search&ad_medium=search_result_all.

Abstract: Kalwall is a translucent, structural sandwich panel which uses prismatic glass fibers embedded in the panels face sheets. The glass prisms refract sunlight to provide a balanced, diffuse wash of glare-free light. Kalwall provides full-spectrum, natural visible light, without distorting color rendition. During the manufacturing process, panels are fitted with translucent insulation to reduce solar heat gains.

Summary: This source is used as a façade study for a product that can help mitigate solar radiation. Tha Kalwall is a popular product, it is similar to Danpalon’s façade product. Used as a comparison to the other façade study.

ArchDaily. “Smart Insulation from Holcim.” ArchDaily, March 8, 2023. https://www.archdaily.com/catalog/us/products/32510/smart-insulation-holcim?ad_source=neufert&ad_medium=gallery&ad_name=close-gallery.

Abstract: Holcim is a manufacturer of innovative and sustainable building solutions operating in markets around the globe. Its goals are to decarbonize buildings, address climate change, drive a circular economy, and improve living standards for everyone. As part of its building envelope portfolio, Holcim develops state-of-the-art insulation solutions that guarantee performance and efficiency for buildings. Its innovative solutions suit all types of building projects, from new builds to renovations.

Summary: This source is used as a technology study for sustainable materiality. Holcim has an insulation product that helps mitigate carbon emissions. It is used as a comparison to another technology study.

Appendix: Expert Interview

Interview with Dr. Cynthia Pietras

Title: Associate Professor of Psychology at WMU

Lecture Topics: Human Behavior and Climate Change

About: Dr. Pietras’s research and scholarship involve using principles of behavioral psychology to better understand the human response to climate change. She is also conducting experimental research on climate-change decision-making and variables that influence choice. She is currently working on a book about behavioral psychology and its application to climate change. Pietras is a part of a team of researchers that is designing a community intervention using mobile technology to reward sustainable behaviors.

Transcription:
Grace: “I’m focusing on the four tiers of sustainability as a key research topic for my capstone so I was just wondering like how is climate change affecting the four tiers of sustainability, like what are the issues resulting in like social, economic, and cultural, and also environmental?”

Dr Cynthia Pietras: “Oh boy, I mean it's huge. I don't know if you saw the recent news report that we're likely gonna surpass the 1.5 degree mark by what, 2029, right? And it's so it's surprising that it's not always the first news story that you see in the morning paper. But uh but here we are and this coming at us like a freight train so it's gonna impact everybody and everything that we do. It already is impacting us in so many different ways as you all know when you look at how it's it's impacted our food systems right? It's already starting to have impacts on the prices of food, how food is grown, who's gonna be the big producers. It's impacting of course community life, communities trying to do what they can to you know which reduce their own carbon emissions and also at the same time trying to make their communities more, well to adapt to the climate and weather disasters that are becoming more and more frequent from the heating, the heat, the smoke, the wildfires all of it. And that's how we reorganize communities and I know a lot of local governments are doing what they can what's in their power to make changes to their communities and to encourage change. The state level too I'm really excited about some of the things that are going on in Michigan and I hope we get some of some new laws passed that are going to help us in that energy transition because that's going to happen with the larger organizational sector and you know socially I think it's just there's been what some have called kind of like the spiral of silence about climate change, it's just people don't even talk about it enough and I think in the past there’s been because there's been just political divide in our country right about addressing climate change and so people are experience having negative or presume negative consequences for talking about climate change but it just has to be part of every conversation and every you know every meeting that we go to every social group that we belong to we need to be talking about this because the more we can talk about the more we can come up with solutions and prepare ourselves for what to come now I'm not I'm not an organizational psychologist so I I can't speak so much to all the organizational change but I know that more and more companies are going to be looking very carefully at their own you know carbon footprints and thinking about ways that they can change their practices and their you know they're like looking at their I'm not sure what word I’m looking for not inventory but you know where they get their goods from and looking at this is that whole supply chain green and is it low carbon what about the way that they're interacting with their employees are they encouraging their employees to engage in pro environmental behavior are they making it easy for them to minimize their own carbon footprints and I think that there's going to be just more and more of that going forward. Yeah it’s gonna have impacts all cross the economy right and I think part of it also is gonna be part of this transition to to electric electrifying you know all parts of our society and that's going to involve all different sectors from businesses governments and there's going to be cultural shifts gonna have to happen as we think about energy coming from how we moving around how we living our lives so that was that was a long kind of all over the place answer.”

Celia: “What do you think the largest impacts will be to our bodies? What are we going to have to adapt to with climate change especially if we go past that degree mark?”

Dr Cynthia Pietras: “I just we just read a book from the climate change working group called overheated and I think 1 facet of climate change hasn't been given enough attention is the actual heat in all of our communities and in our urban settings there's gonna be individuals from especially vulnerable to temperature increases if they don't have ways to cool off and especially vulnerable and if people have to work outside during the day or manual labor jobs they're gonna be really at risk if they have to work in these temperatures that are very likely to be unhealthy or they get heat stroke and so that's gonna be something that will have to be paying more and more attention to making sure vulnerable populations have access to you know cool spaces and if that means looking carefully within cities whose our most vulnerable people and of course across the globe because as you all know there's gonna be places where or groups of people who don't have resources they're gonna be most at risk from these temperature increases and I think that's where some of your work is gonna be coming in in the design area how do we make sure that we think about those temperature fluctuations going forward in the way we live you know that they're the urban environment how do we make it so that we can stay cool as temperatures rise so that I mean that's certainly a big one it's gonna be affecting our health and along with that is going to be air quality changes going forward we already know that air pollution is sort of a hidden threat it doesn't often make the news you know how many people actually suffer from poor air quality around the globe and this is also something that's going to be they have these wildfires and and really poor air you know what's going to be happening to that quality and how do we make sure that people stay healthy and especially if you again people will have to be outside because that's the nature of the work that they do how are they going to stay safe”
Celia: “So would you say the wildfires have kind of sped up the process almost?”

Dr Cynthia Pietras: “Sped up the process of?”

Celia: “Just of global warming.”

Dr Cynthia Pietras: “Absolutely I mean if you look at the carbon emissions that have been released from the wildfires especially those massive ones in Canada how much forest was lost I mean the amount of carbon that was released from these forests that were burned last summer is is really jaw-dropping as much as you know years worth of driving cars is you know carbon that was released and certainly that's gonna be common.”

Grace: “What are your thoughts on a circular economy and how those could honestly work together with the four tiers of sustainability because we're in a linear economy right now do you think it's killing our planet if we change the way that we think about it do you think it could greatly affect our climate?”

Dr. Cynthia Pietras: “Absolutely I mean I'm just reading a book right now called the day of the world stop shopping and a main point of the author's argument is that you know it's these consumption patterns and the way we over consume that's really kind of a hidden driver of energy demand and thus of carbon emissions and it’s one that we often don't think about we think about much electrification and we think about you know moving away from fossil fuels which of course we need but it's also interesting to think about what are we using all that energy for right and if it's our own consumption then maybe we need to look at you know what has created these consumption practices and how do we change them as a big challenge because you know our society is built on consumption in capitalist society you know it's that flow of money and goods that sort of powers that you know growth economy so how do you how do you shift that and certainly the circular economy is one way to make that happen you know keep things in the in the flow so that we're not constantly extracting new resources from the planet which end up wasted when we can be thinking about how we can you know reuse things put them back into the economy and a great example’s like composting and we were just talking about that in our group the other day how doesn't it make so much sense for all our food waste right we don't have a good composting system even in Kalamazoo right how do you compost your goods it's not systematized but if we could have a community wide compost program then all that compost that's produced within our city could be you know reused giving back to the farmers or maybe for individuals who want to grow their own food in their gardens or even just for regular everyday gardening you know why can't we put the put all that back into the soils that are just ending up in landfills where it turns into methane creates more carbon emissions so that's just one example so many ways that we can kind of the break that sort of extraction cycle”

Celia: “In your experience what do you think the general kind of attitude towards climate change is? You know I’m assuming you’ve maybe given talks before, what do people, what’s their initial kind of attitude towards it?”

Dr Cynthia Pietras: “Well it depends on the audience you know but if you look at the numbers at least in the United states over you know over half the people are either very alarmed or concerned about climate change or you know or you know have some concerns so it is the majority of people are aware of the problem and actually support efforts like moving away towards fossil fuels and moving towards renewable energy now there is as I mentioned a political divide in this country and you are much more likely to see support for action on climate change in people who identify as Democrat than people who identify as republican and there might be reasons for that in terms of you know industry support and supporting the fossil fuel industry but even among those even those who are republican there is support for certain kinds of policies that are being beneficial and for everyone they just make sense and there's also more support among some of the younger Republicans who see climate changes as a much more serious threat and would like to see certainly more action so I do think that people do recognize the problem overall people do want to make change and but I think also the challenges come in what kind of changes do we want to see and how is that gonna happen”

Celia: “Yeah I was curious about that because I almost feel like even a few years ago people were a little wary of it, they weren’t sure if they believed in it or not and I feel like um this past summer with it hitting the record high kind of put people into perspective of like okay this is happening”

Dr Cynthia Pietras: “Absolutely, but I do think that we we still need more climate education because you know a lot of people aren't really exposed to you know the information about really the impacts of climate change and how serious it is it's not you know universally required that it’s taught in schools and those who are out of school how they get information about climate change is through the news and media and their friends or social groups and that information may not always be accurate so I think that we need better ways to communicate on the science other than through scientific reports which a lot of people aren’t just going to read those so I think our media needs to be doing a much much better job of educating the public about the seriousness of the problem and what the serious change that has to happen in order to address it climate change is a verbal process unless you directly experience the catastrophe you know you don't you know that climate change we understand it through what we learn through what others tell us and that is so critical that that has to be given more attention we have to find ways to communicate that more effectively”

Grace: “What do you believe, um so earthships are kind of self sufficient, um built environments so it’s kind of a self sufficient structure, do you think that you see a lot of people going towards the route of self sufficiency and do you think that could help climte change?

Dr Cynthia Pietras: “Oh I’d like to think it could more like community sufficient than just like self-sufficient but I certainly think so because I think there's you know there's a lot of traditional knowledge of how to live in a variety of different climates in a sustainable way and people could be taking much more advantage of some of that traditional understanding of how to live when it when it's hot out or how to live when water gets scarce or how to live without having that big impact on the land around you and how to you know grow your own garden if you want to grow your own garden so I definitely think that those kinds of changes would um I think they could certainly have an impact and I think they could actually lead to people having happier lives if you're you know living in communities where it's maybe the values are different the priorities are a little bit different but we have to also understand that if you look at the cities our cities are growing and so we need to think about what how you know how could we make this work at scale and how can you create systems like this even in more urban settings and I think that's a challenge you guys are probably thinking about in design how do you make those urban spaces more self resilient and make it more local”

Celia: “Do you think there’s still a chance to reverse um the damages of climate change or do you think at this point it’s about adapting to the new climate? Do you think there is a way that eventually we'll get that temperature back down or air quality will improve?”

Dr Cynthia Pietras: “Well we have to right we don't know we don't have a choice I mean there's a certain amount of warming already built into the system based on our historical missions and just the time it's gonna take right for us to make the changes that we need to shift away from fossil fuels and carbon emissions as a source of energy so it's gonna take time this can't happen overnight the systems just aren't in place for us to grow the food that we need and to you know the healthcare we need the education that we need it's just we just don't have systems in place for that rapid of a transition it needs to happen and we need to be moving as fast as possible so there's some heating that's already built in but I I can't remember who said this but every degree every fraction of a degree helps and so even if we're exceeding that 1.5 degree target which it looks like we will every year keeping it below 2 you know every 10th of a degree that we keep it below is gonna save lives it's gonna save species it's gonna save our environment and so we you know we have to kind of keep that in mind so there's no possibility of giving up because there's so much at stake”

Grace: “What are you thoughts on biodiversity I guess like flora fauna vs human? Do you think that if we created a built environment for those types of creatures or those ecosystems do you think we could give back to the environment or do you think it’s too late?”

Dry Cynthia Pietras: “Oh it's not too late and I think there's I don't know this literature that well but I know that there's plenty of examples of you sort of returning spaces to nature and that those spaces can actually recover pretty quickly you know efforts are made to kind of rewild and so I certainly don't believe it's too late that we can do what we can to create more wild spaces for all living things on earth that we share this planet with and addressing climate change is certainly going to be a huge one because of course there's habitat destruction just based on human expansion and development but also climate change is collapsing so many ecosystems making it hard for species to survive and so but yeah but climate changes is just one of the main threats of course you all know the other threats to our biodiversity and you know what's been happening with our insects populations just shocking but so many other species you know you hear about all the time and people don't understand how intertwined all these systems are and then you start taking species out and guess what the whole thing kind of gets out of whack and then it’s gonna come back to harm humans so you can't just use the planet as a dumping ground or paving it over and not expect to have negative consequences I understand you know people now understand you know what we've done to the pollinator species and what kind of impacts you know using you know pesticide just kind of blatantly what that does to I don't know if that's the only reason it could be habitat loss too this harmed our pollinators but that you keep doing that it has consequences not only for them or things but for us as humans”

Celia: “What do you think the rise in temperature will do to our psyche do you think that'll actually change our behavior?”

Dr Cynthia Pietras: “Oh absolutely I mean well first of all we understand that you know people's concern about climate change can lead to serious you know climate anxiety and that's well understood you when you think about the impacts of climate change and it can create a lot of worry and there's you know people who try to find out what's the most effective way to help people who are suffering from serious you know climate anxiety which is totally an understandable response to the predicament that we're in but there's also going to be direct health impacts of course there's trauma this experience by being part of a climate disaster there's losses are gonna come about where people are you know their communities are devastated by climate disasters and of course climate migration that people have to move away from their homes and there's gonna have serious negative health and mental health impacts that people have to migrate and move away from those places and of course there are just direct impacts of heat you know if you're obviously people are much less productive in the heat and heat does increase aggressive behavior that's also well known finding so that's not good and you know not to mention the fact that if resources become scarce that also can create conflict so there's just a lot of you know negative mental health impacts and change”

Celia: “Thank you so much for answering some questions.”