SOLAR HARBOR

NURTURING NATURE IN INDUSTRIAL DESIGN

SOLAR HARBOR - THESIS 2024
ARCH 772 Design Thesis
Software Used: Adobe Creative Cloud,
Revit, Rhino, Lumion, AutoCad, Cove.tool

Jacob Wielenberg

PROBLEM

PART 1

Figure 1 (Baker and Canessa, 2009)

The current state of warehouse design is outdated, failing to keep pace with the evolving demands of modern commerce, supply chain management, and, most importantly, employee work environment standards. Every day, millions of people go to work in a factory or a warehouse. In these environments, laborers are forced to work in sub-standard conditions, with no greens spaces, no standard for natural lighting exposure, and little to no amenities to maintain their health. More than 50% of these warehouses were constructed in the 1980's or earlier, making them extremely outdated, and, in some cases, outright dangerous.

PROBLEM STATMENT

BACKGROUND

PART 2

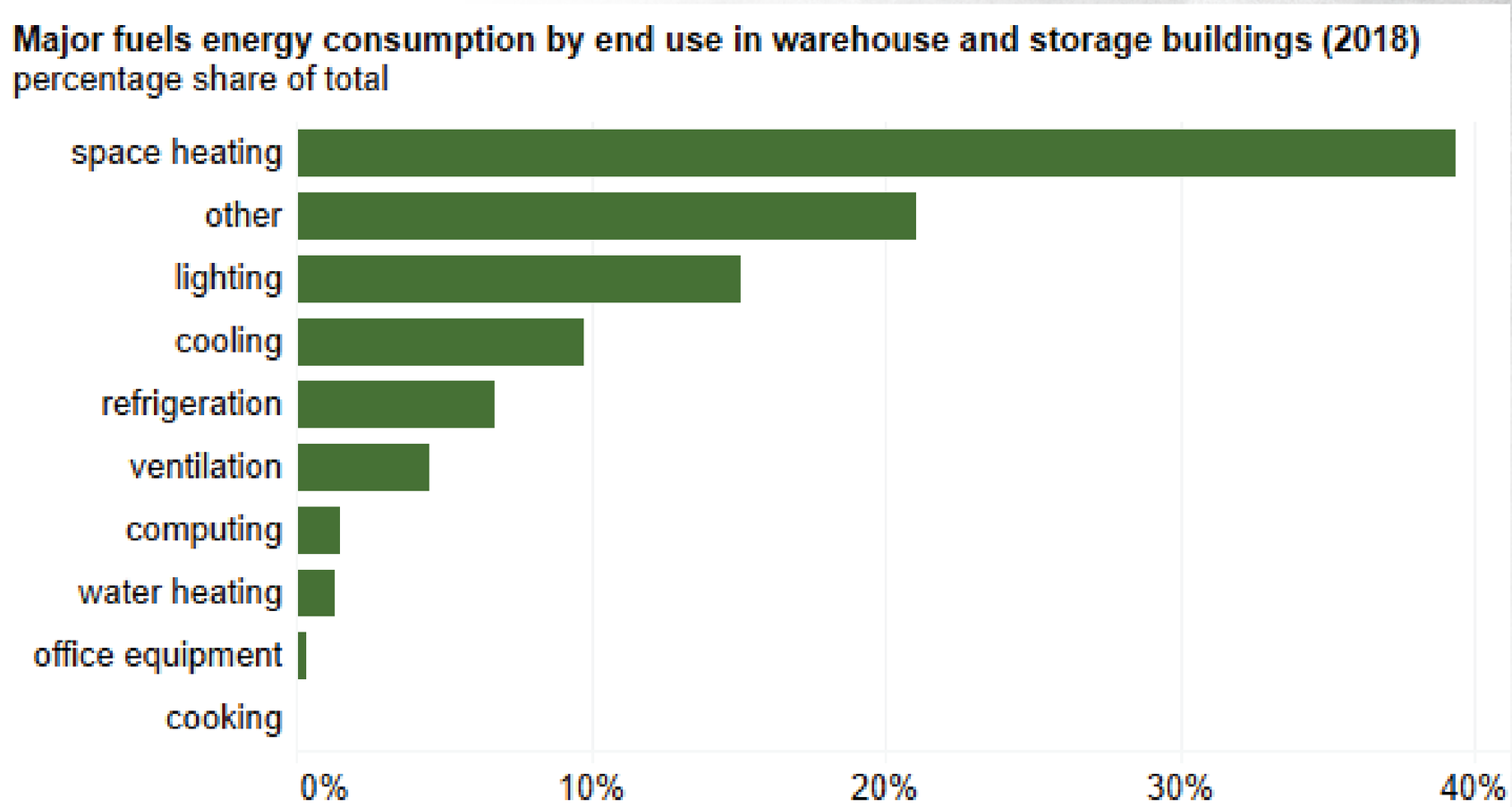


Figure 2 (U.S. Energy Information Administration, 2018)

Energy Consumption

- Warehouses Consume High Amounts of Energy
- Difficulties Implementing Sustainable Practices
- Carbon Footprint is Massive
- Need for Multiple Climate-Controlled Zones

ENERGY CONSUMPTION

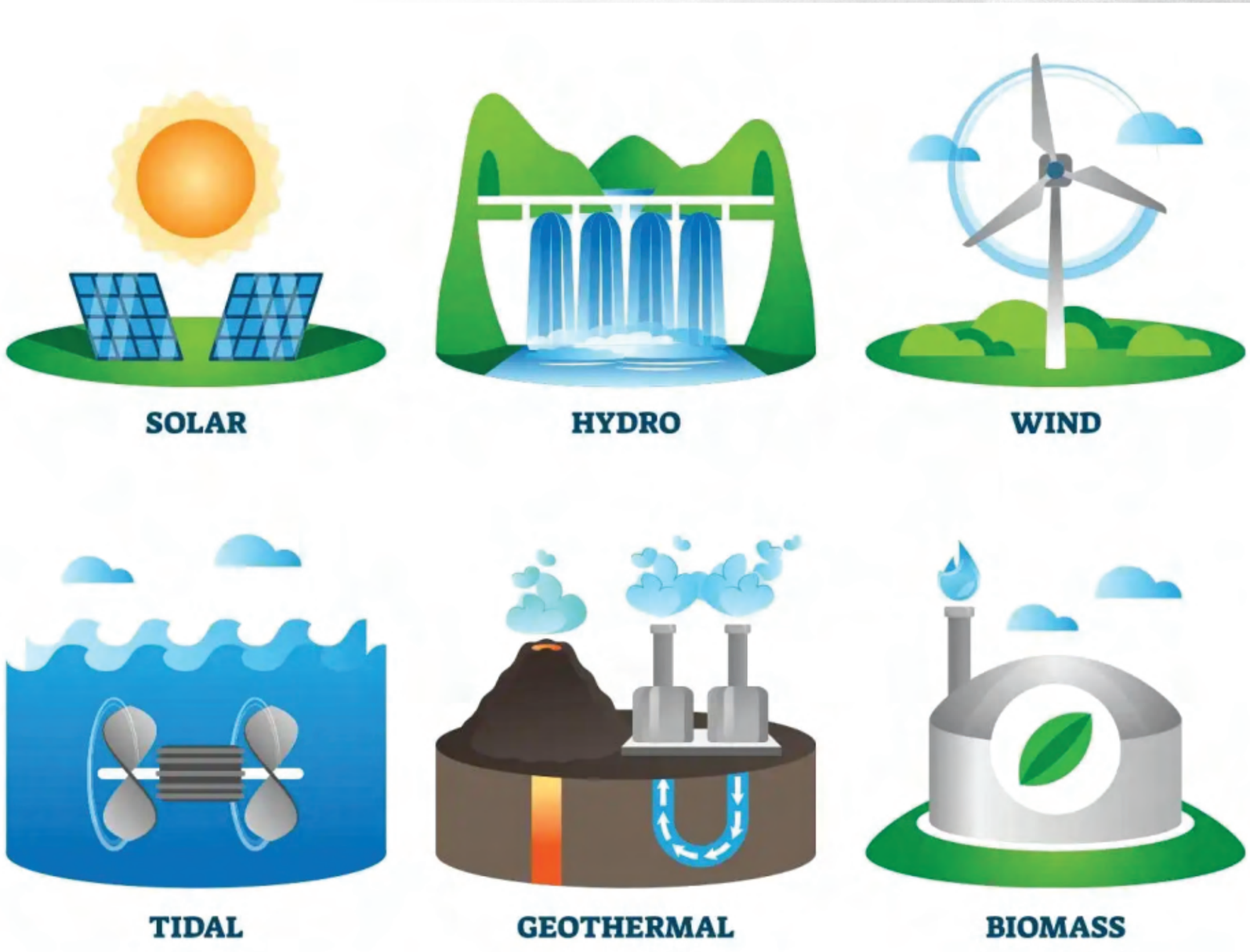


Figure 3 (Melgar, 2018)

Sustaibable Energy Options

- High Output
  - Hydro
  - Tidal
  - Wind
  - Biomass
- Low Output
  - Geothermal
  - Solar

(Hodge, 2017)

SUSTAINABILITY

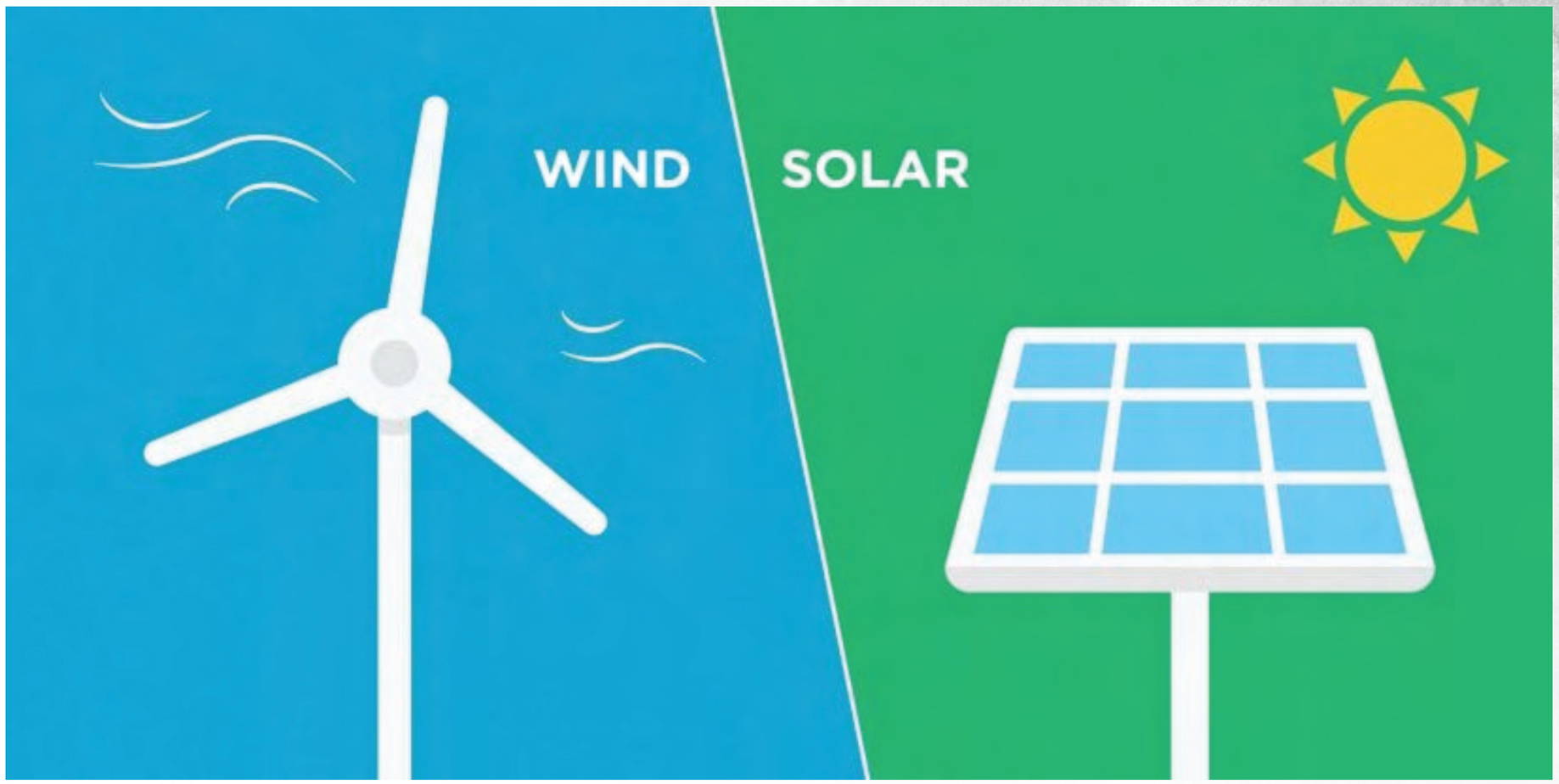


Figure (Melgar, 2018)

Practicality
- Solar Energy
- Wind Energy
- Geothermal Energy

SUSTAINABILITY

Figure 5 (DOT School of Design, 2023)

Green Design Practices

- Implementing Vegetation
- Mitigating Transition from Nature to Industry
- Providing Useable Green Spaces
- Maintaining Mindfulness of Surrounding Environment

(Kafka, 2023)

Benefits

- Fostering Relationships within Surrounding Communities
- Boosting Mood
- Improving Health
- Lowering Carbon Footprint

(Semeraro et al., 2021)

GREEN DESIGN

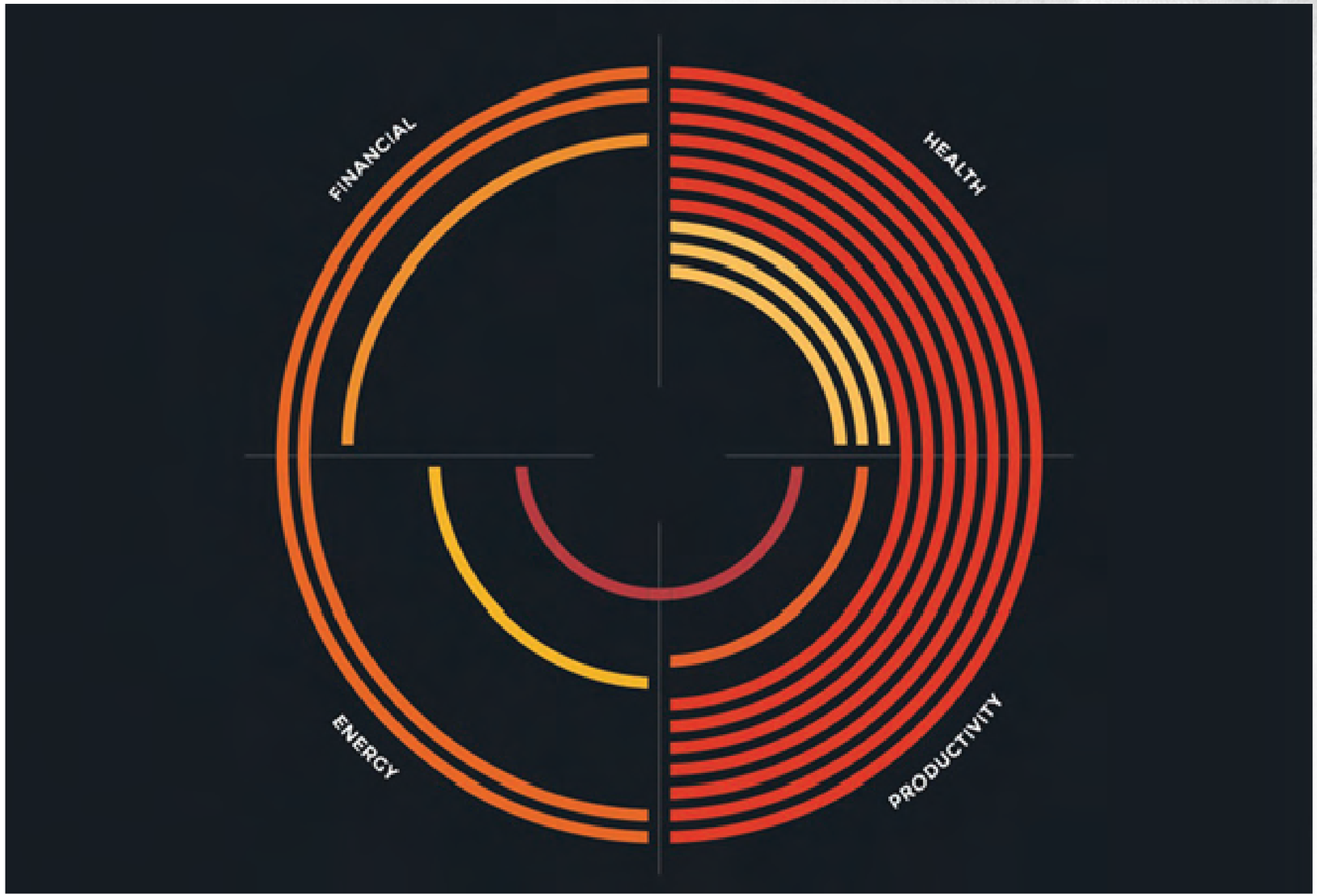


Figure 6 (Bendheim, 2015)

Natural Lighting
Benefits

- Physical Health
  - Increased Vitamin D
  - Improved Immune System
  - Skin Health
  - Visual Sustainability
- Mental Health
  - Increased Serotonin
  - Circadian Rhythm
  - Boosted Mood
- Productivity
  - Increased Energy
  - Increased Satisfaction at Work
  - Increased Alertness

(Wang et al., 2023)

NATURAL LIGHTING

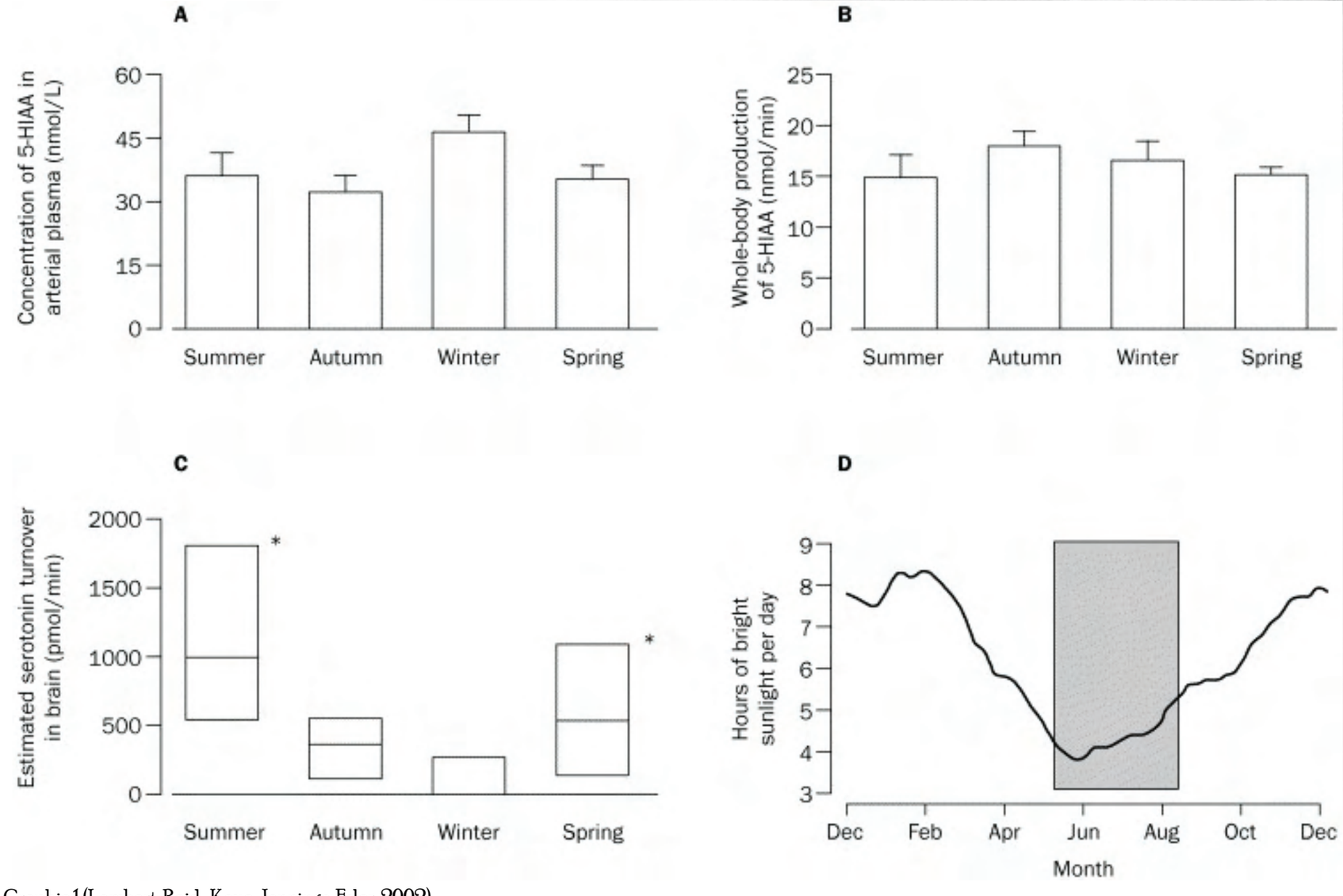
Figure 7 (Haran, 2009)

Natural Lighting Challenges

- Sustainability
  - Increased Heat Gain / Loss
- Costs
  - Glazing Cost Increase
  - More Square Footage Requirements
  - Heating and Cooling Costs
  - Customized Roof Design
- Practicality
  - Custom Structure Design
  - Spread-Out Strorage Facilities
  - Glare / Diffusion Issues

(Haran, 2009)

NATURAL LIGHTING



Graphic 1 (Lambert, Reid, Kaye, Jennings, Esler, 2002)

Study Conducted by Neurotransmitter Laboratory

- Studied 101 Healthy Men
- Investigated the Relationship between Season and Serotonin Levels

(Lambert, Reid, Kaye, Jennings, Esler, 2002)

NATURAL LIGHTING STUDY

Figure 8 (Del Bello, 2021)

Importance of Quality Aesthetics

- Boosts Mood
- Piques Interest
- Helps with Wayfinding
- Increases Productivity
- Aids with Funding

(Herriott, 2021)

AESTHETICS

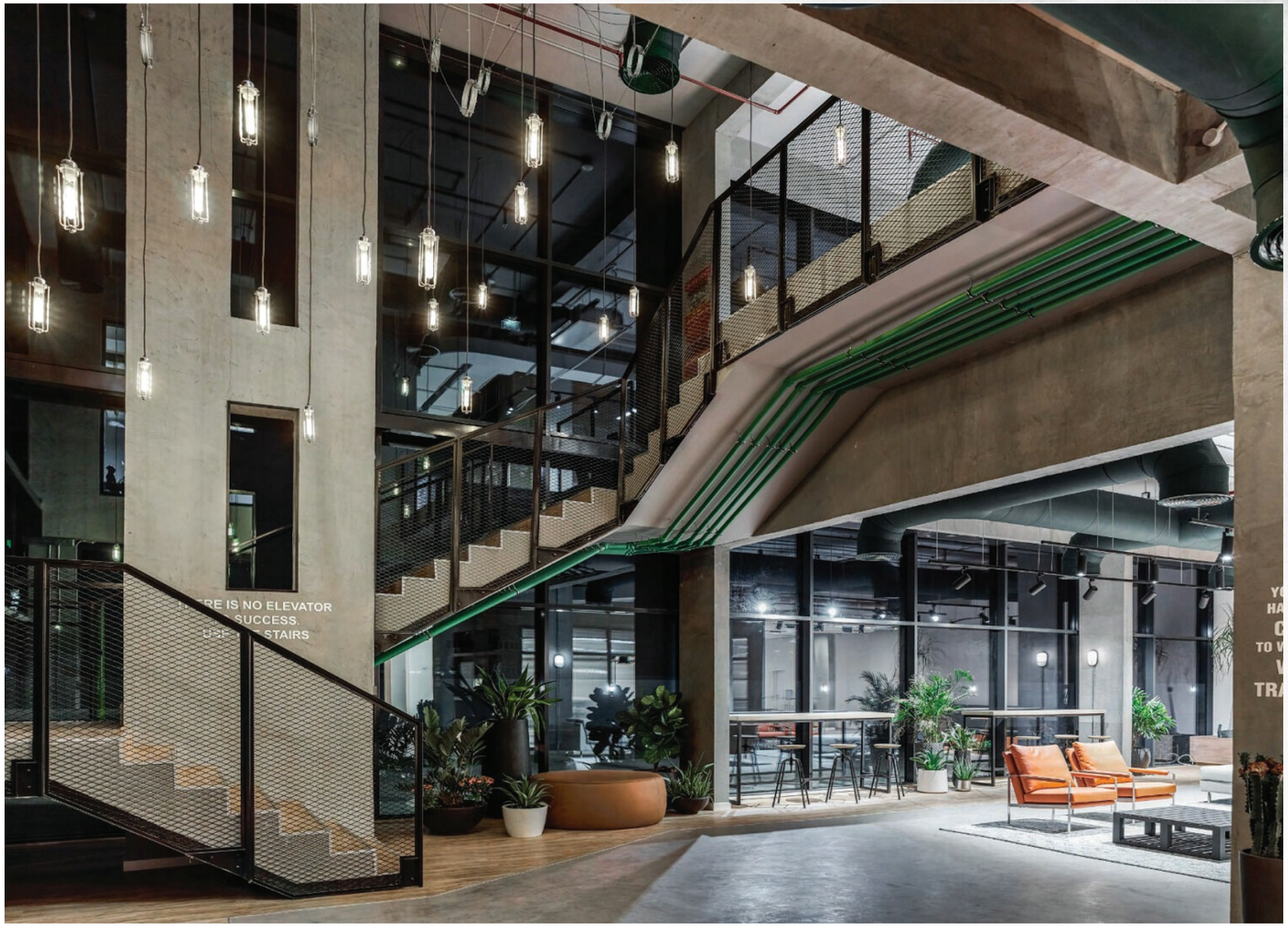


Figure 9 (Mdd.eu, 2021)

Good Practice in Warehouses

- Materiality
  - Less Concrete and Steel
  - Lighter Woods
  - Local Materials
  - Natural Materials
- Colors
  - Warm Color Palette
  - Low Saturation
  - Minimal
- Biophilic Design
  - Shapes
  - Forms
  - Patterns
  - Structural Elements

(Cook and Sproul, 2011)

AESTHETICS

Figure 10 (PLP Architects, 2015)

THE EDGE

- Typology:
  - Office Building
- 15 Stories, 430,000 sq. ft.
- Designed by PLP Architects
- Location
  - Amsterdam, The Netherlands
- Learning Opportunities
  - One of the best examples of natural lighting implementation in the world
  - Articulation of glazing in reponse to sun paths
  - Study of spacial relations and employee work patterns

(PLP Architects, 2015)

CASE STUDY

Figure 11 (Herzog and DeMeuron, 2008)

038 Ricola Storage Building

- Typology:
  - Storage Facility
- Year Completed:
  - 1987
- Designed by Herzog and De Meuron
- Location:
  - Laufen, Switzerland
- Learning Opportunities
  - Blending functionality with unique aesthetics
  - Articulation of walls to serve multiple purposes

(Herzog and DeMeuron, 2008)

THESIS

PART 3

PRIMARY

- Increase levels of Natural Lighting within the industrial environment. With the numerous benefits that this would provide to workers and the industry as a whole, natural lighting must be put at the forefront of industrial design.

SECONDARY

- Implement sustainable practices within the industrial environment. There are many case studies found around the world that prove both the capabilities of industry to do more and the advantages provided regarding sustainable practices.

TERTIARY

- Producing Quality Aesthetics within the industrial environment. Aesthetic plays a larger role in our daily lives than we realize, and paying attention to simple design choices can make the world of difference in mood, productivity, efficiency, etc.

DESIGN GOALS

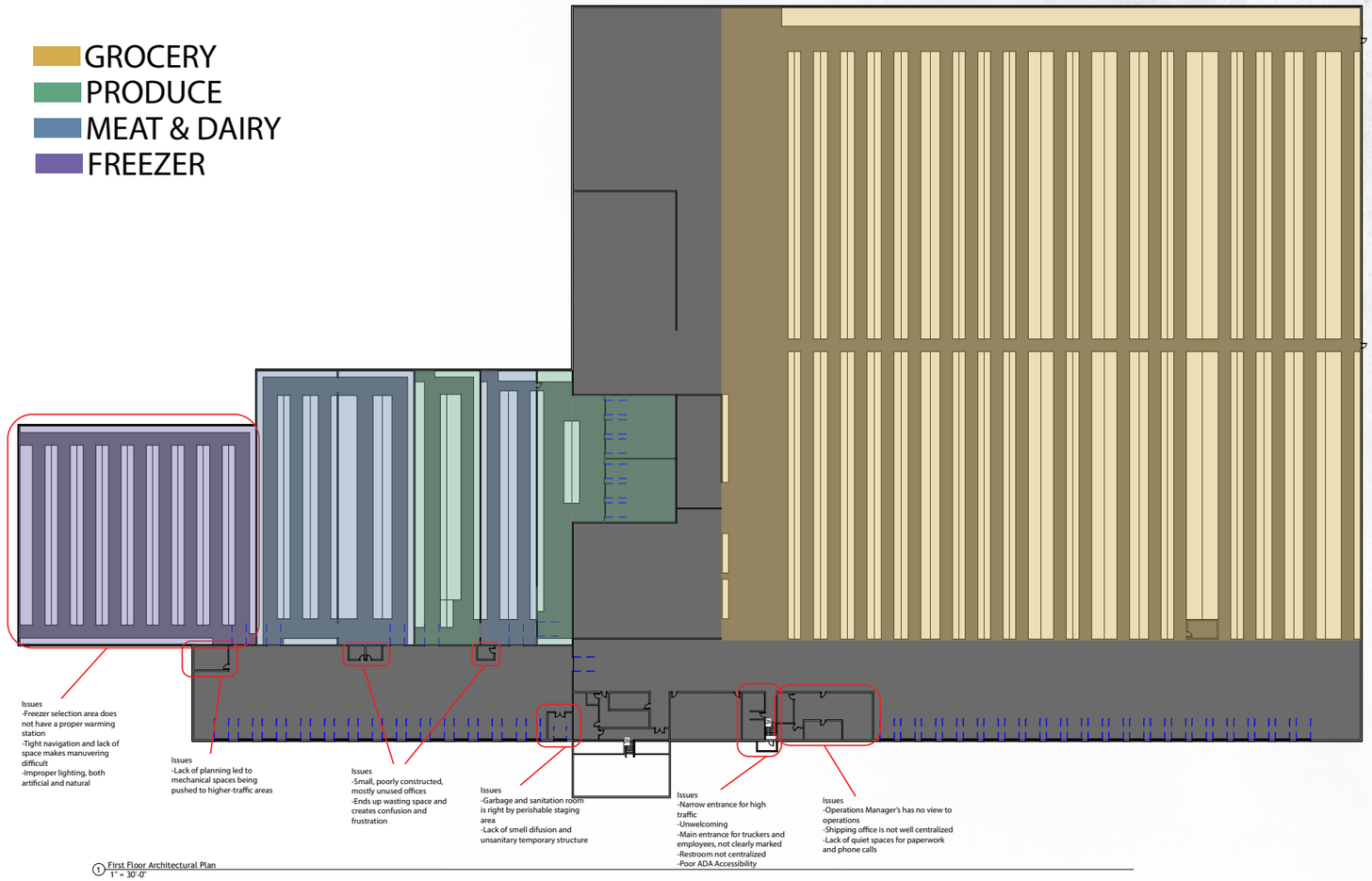
Figure 12 (Google Earth, 2024)

Address:
3501 12th Ave N, Fargo, ND

Current Building
- UNFI Fargo DC

Site Conditions:
- Little Elevation Change
- No Accessible Green Space
- Lack of Tree Cover
- Waterfowl Attraction
- Wasted Space
- Railroad to the North
- Northeast Intersection of 12th Ave N and I-29

SITE



Redlining Document

- Existing Building Floor Plan
- Highlighted Areas of Improvement or Opportunity

Main Objectives:

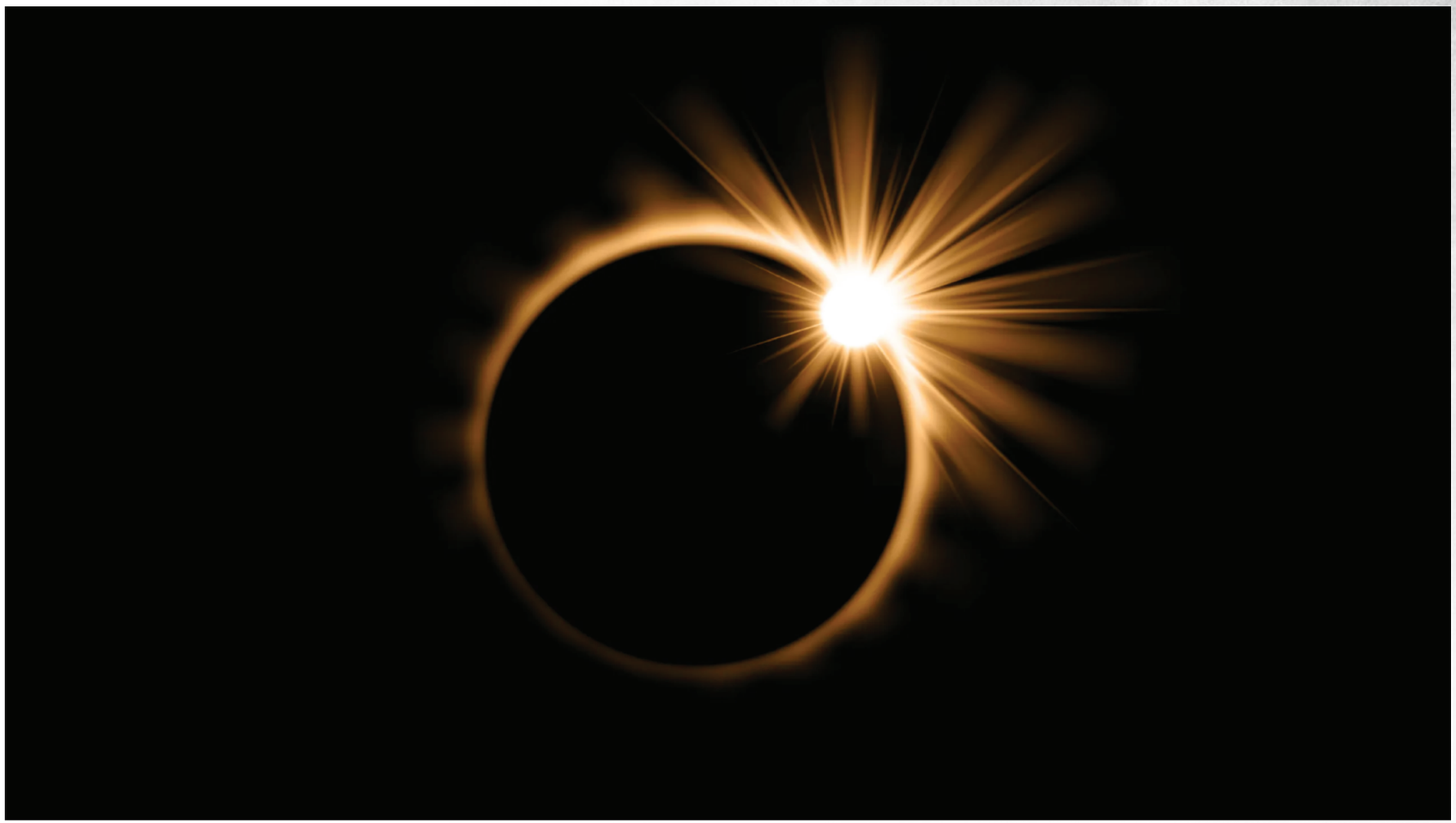
- Improve Daylighting
- Eliminate Areas of Intersecting Traffic
- Provide Accessible Greenspace
- Separate Break Areas from Work Areas
- Provide Health and Wellness Amenities
- Provide Separation between Refridgerated / Non-Refridgerated

EXISTING CONDITIONS

DESIGN

PART 4

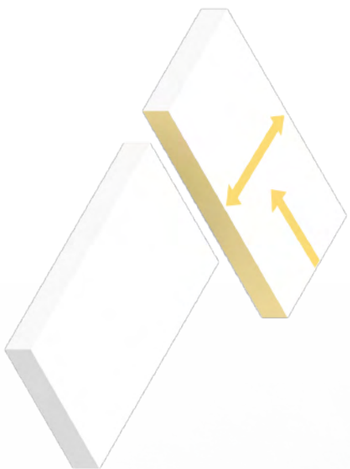
SOLAR HARBOR



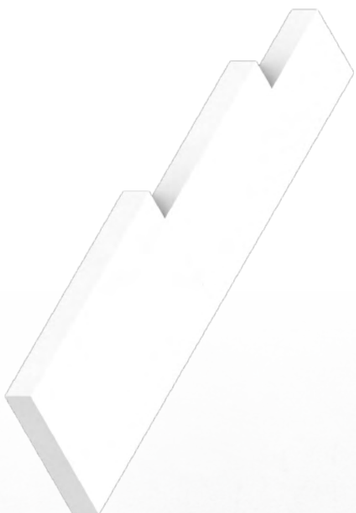
Inspiration
- Solar Eclipse
  - Time of Change
  - Lighting Style

INSPIRATION

CONDENSING

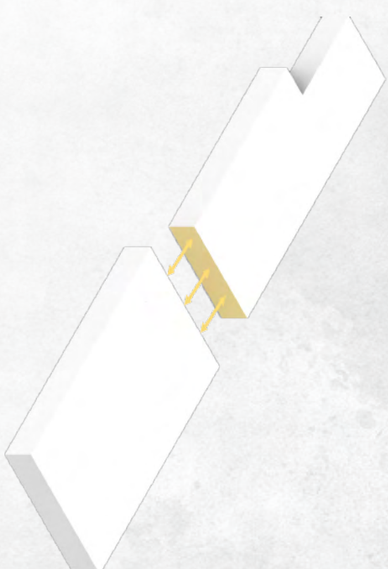


ORIGINAL

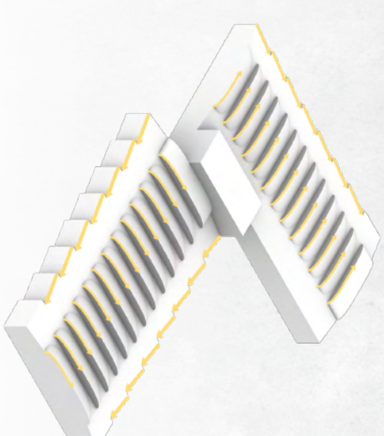


EXTRUDING

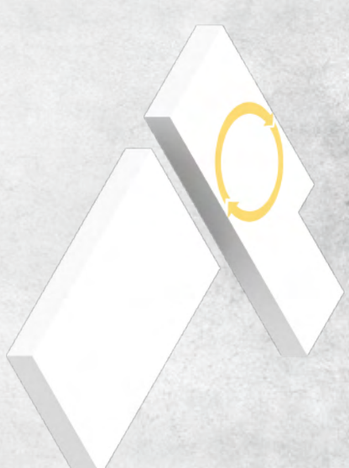
DIVIDING

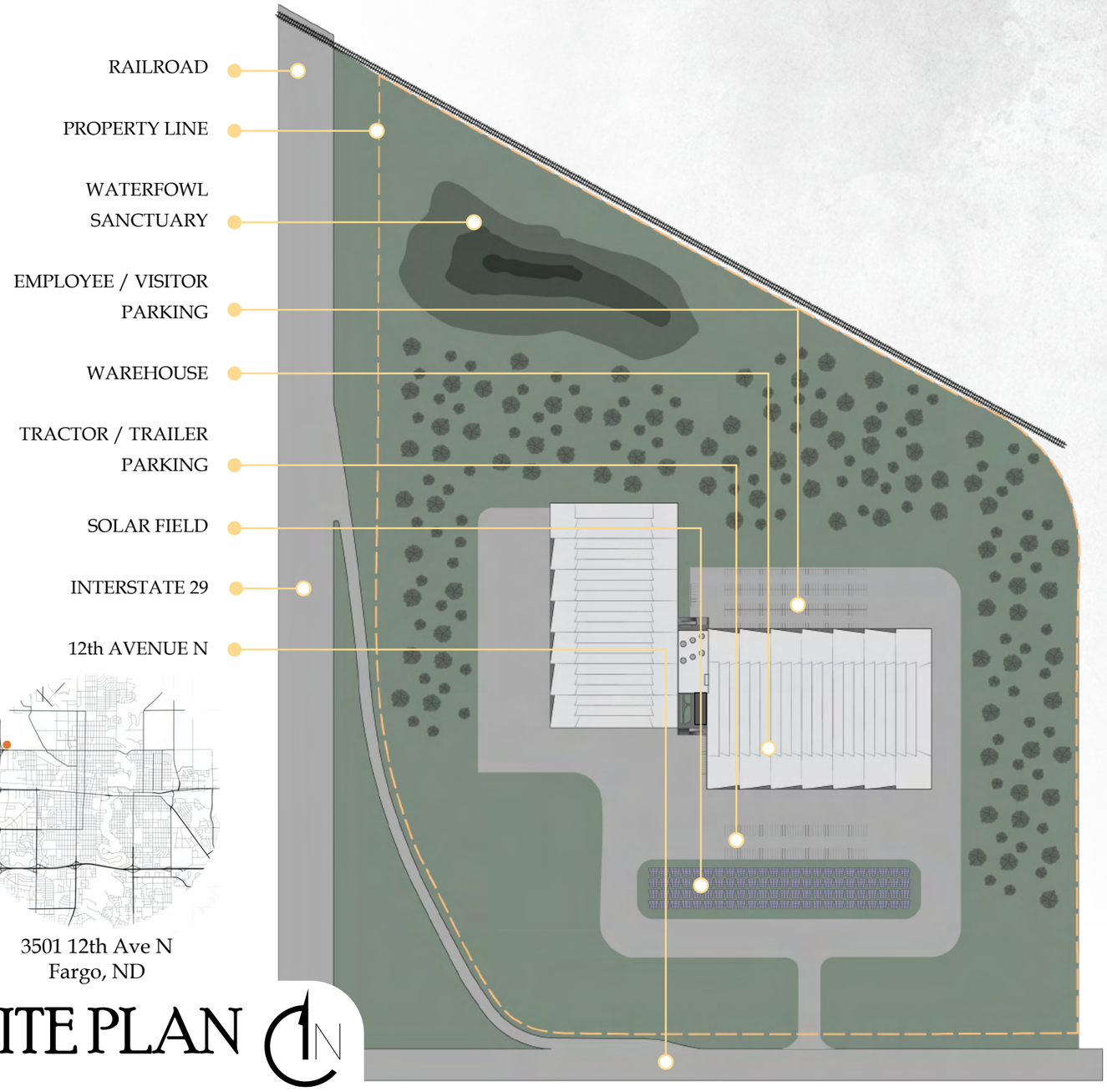


ESTABLISHING



ROTATING





3501 12th Ave N
Fargo, ND

SITE PLAN

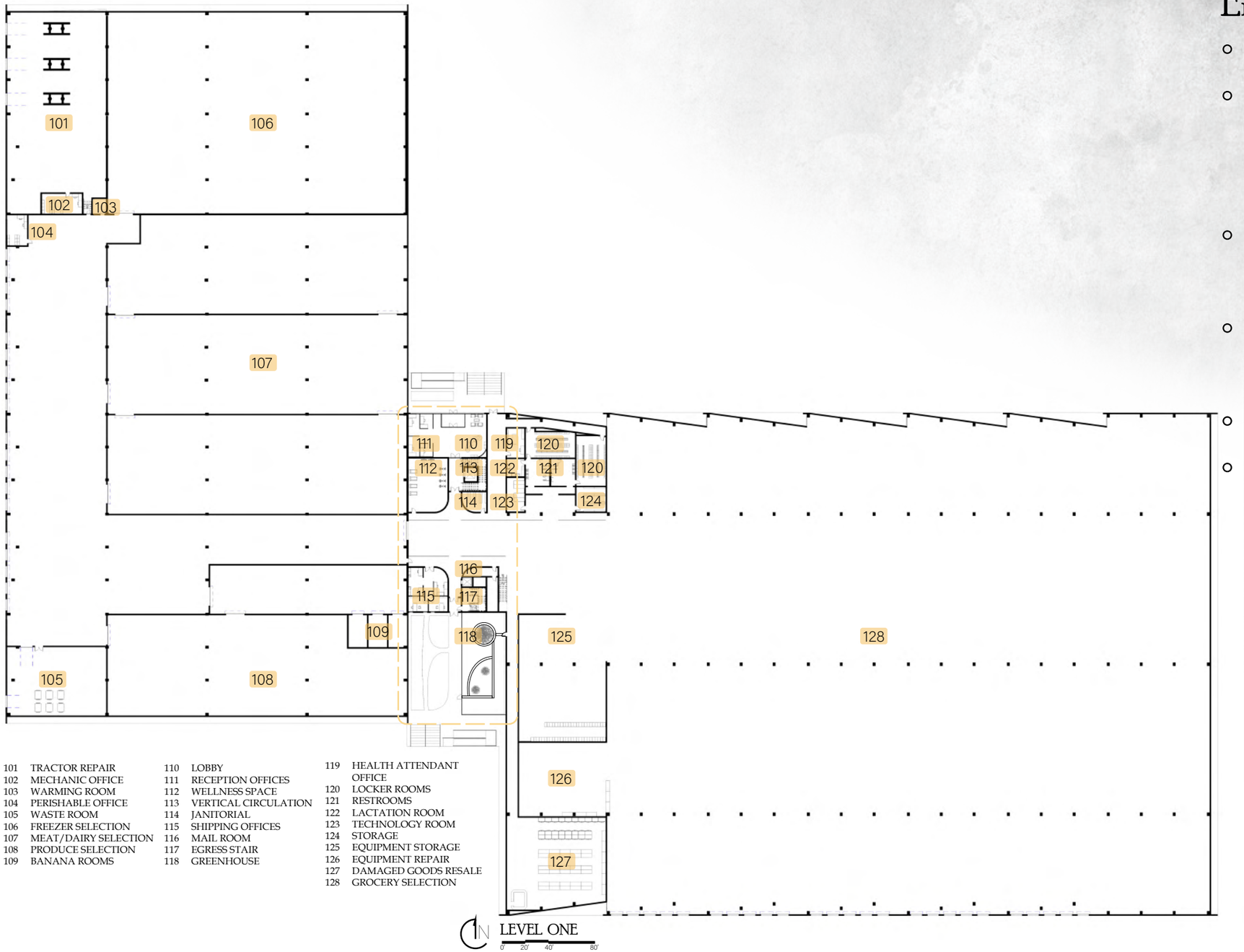
Employee Focus

- Separating Parking
- Creating Greenspace
- Directing Flow of Traffic
- Building Orientation

Environmental Focus

- Solar Field
- Tree Planting
- Protecting Waterfowl Habitat
- Minimizing Concrete Square Footage

IMPROVING SITE CONDITIONS

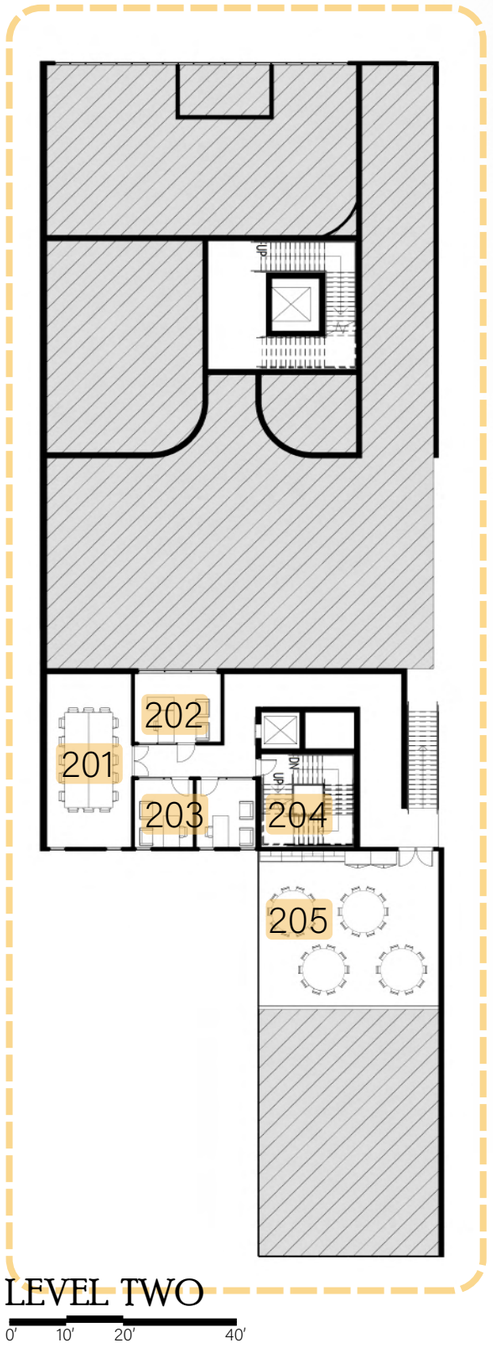


101 TRACTOR REPAIR
102 MECHANIC OFFICE
103 WARMING ROOM
104 PERISHABLE OFFICE
105 WASTE ROOM
106 FREEZER SELECTION
107 MEAT/DAIRY SELECTION
108 PRODUCE SELECTION
109 BANANA ROOMS
110 LOBBY
111 RECEPTION OFFICES
112 WELLNESS SPACE
113 VERTICAL CIRCULATION
114 JANITORIAL
115 SHIPPING OFFICES
116 MAIL ROOM
117 EGRESS STAIR
118 GREENHOUSE
119 HEALTH ATTENDANT OFFICE
120 LOCKER ROOMS
121 RESTROOMS
122 LACTATION ROOM
123 TECHNOLOGY ROOM
124 STORAGE
125 EQUIPMENT STORAGE
126 EQUIPMENT REPAIR
127 DAMAGED GOODS RESALE
128 GROCERY SELECTION

Employee Focus

- Separating Entrances
- Eliminating Intersection between Pedestrian and Vehicle Traffic
- Separating Break Spaces and Work Spaces
- Articulating Walls to Maximize Daylight
- Adding Warming Rooms
- Creating Spaces for Improving and Maintaining Health at Work

EMPLOYEE-DRIVEN PLANNING

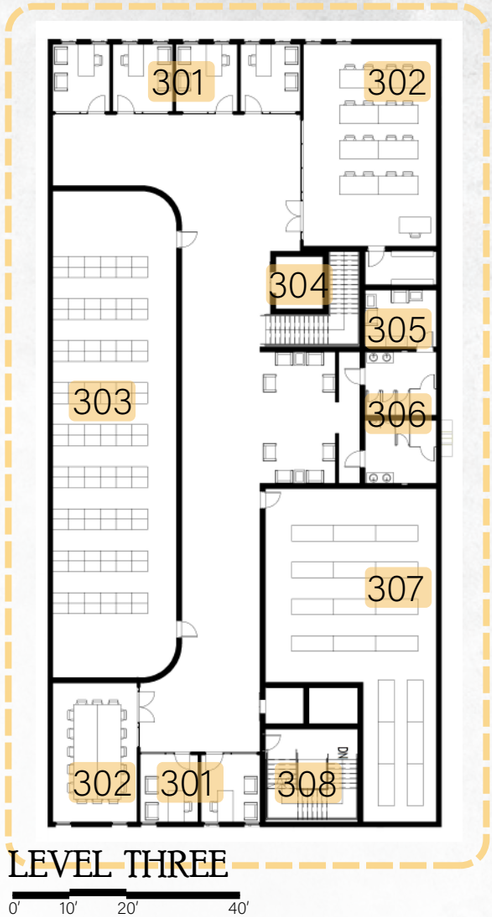


201 CONFERENCE ROOM
202 MANAGER'S OFFICE
203 OFFICES
204 EGRESS STAIR
205 BREAK ROOM

301 OFFICES
302 CONFERENCE ROOM
303 SERVER ROOM
304 VERTICAL CIRCULATION
305 LACTATION ROOM
306 RESTROOMS
307 ARCHIVES
308 EGRESS STAIR

NOT DISPLAYED
401 MECHANICAL SPACE

NOT DISPLAYED
501 MECHANICAL SPACE



LEVEL THREE
0' 10' 20' 40'

LEVEL TWO
0' 10' 20' 40'

Employee Focus

- Creating Year-Round Greenspace
- Separating Break Spaces from Work Spaces
- Elevating Offices away from Selection Floor
- Utlizing Translucent Paneling to Maximize Lighting in Office Spaces

EMPLOYEE-DRIVEN PLANNING

Circulation

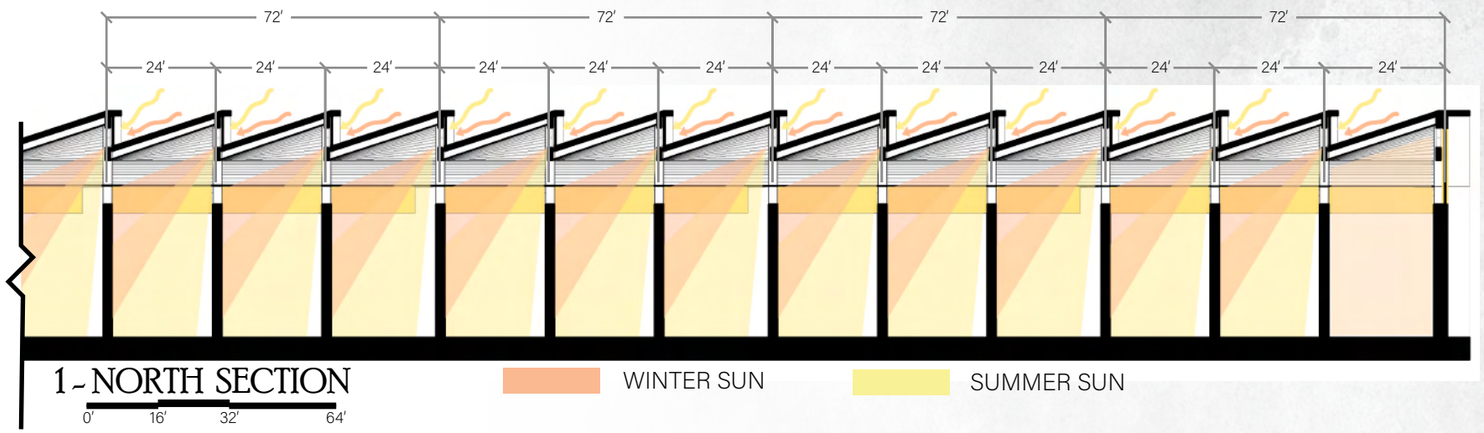
- Eliminate Intersections between Vehicle and Pedestrian Traffic
- Separate Entrances allow for Smoother Traffic Flow Internally

EMPLOYEE-DRIVEN PLANNING

SOLUTIONS

PART 5

LIGHTING INVESTIGATION

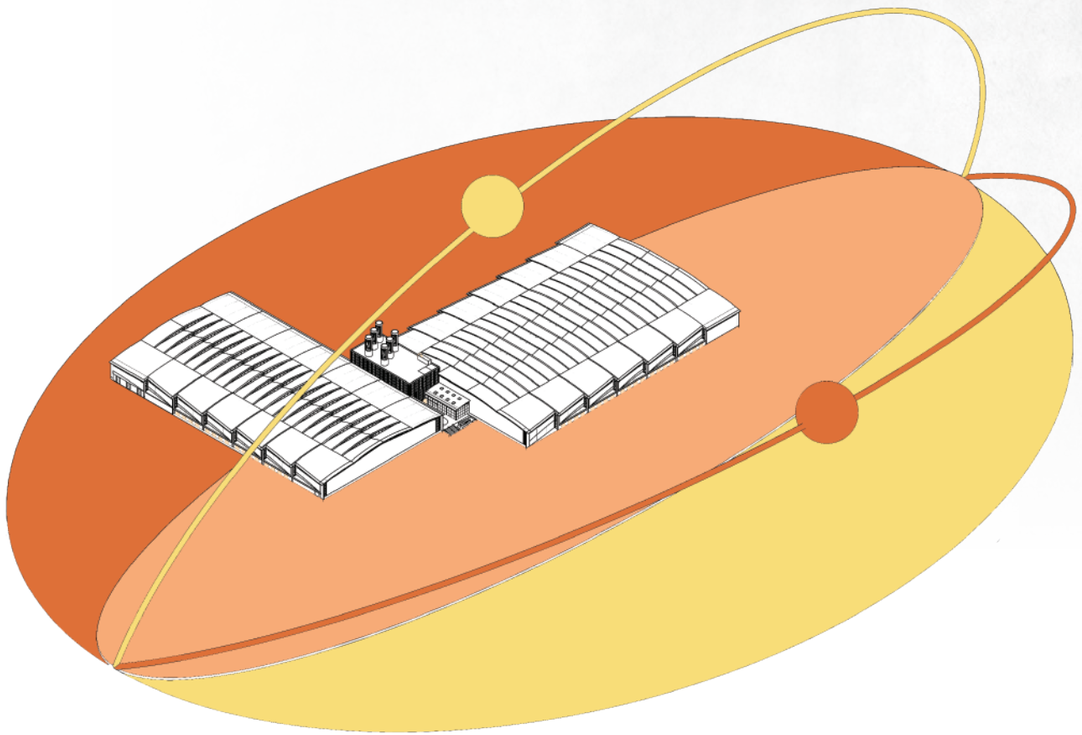


Lighting Section

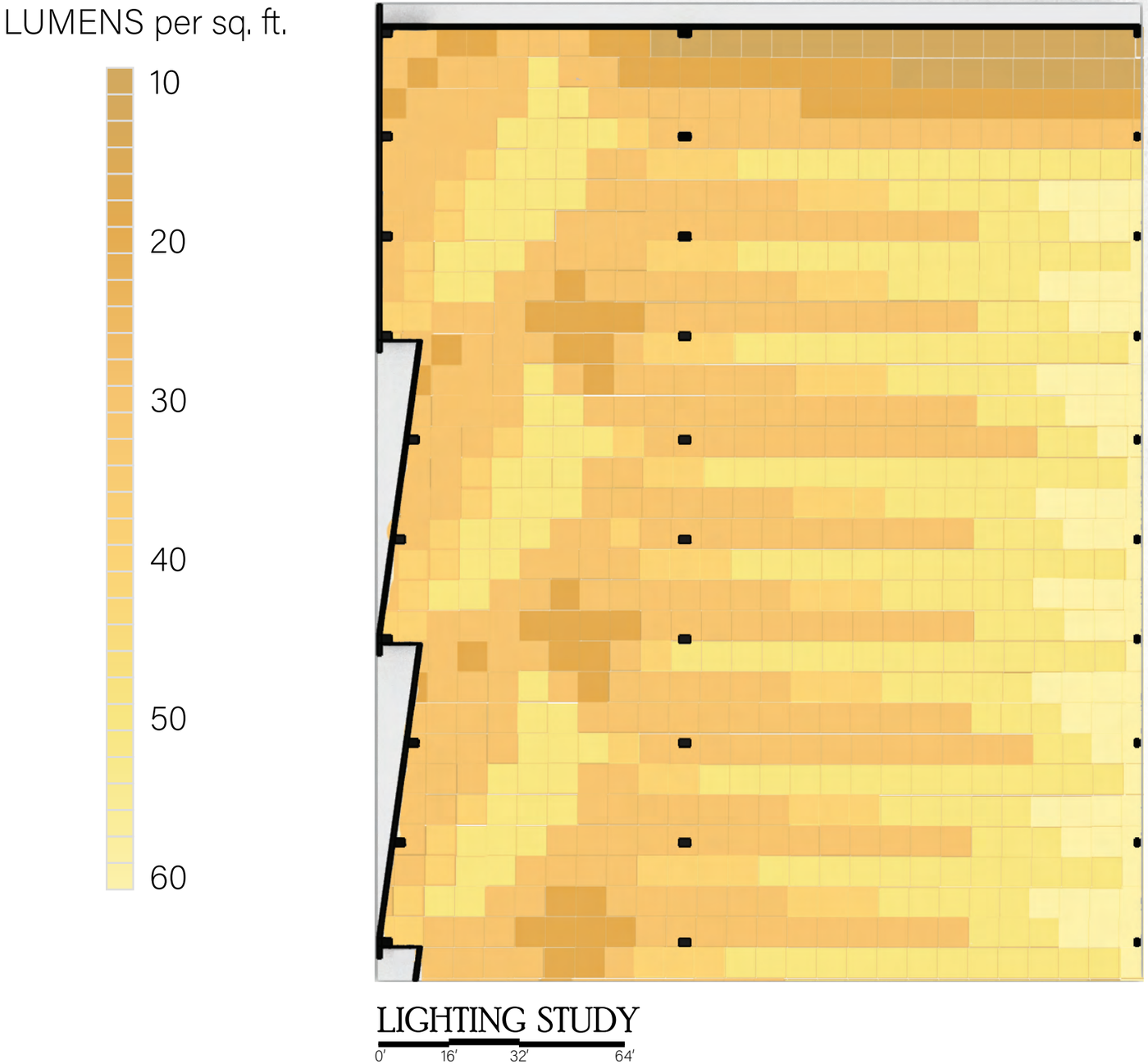
- Angle of Roof Captures Light Year-Round

Sun Path Diagram

- Displays Light Saturation during Summer and Winter Months



SUNPATH INVESTIGATION



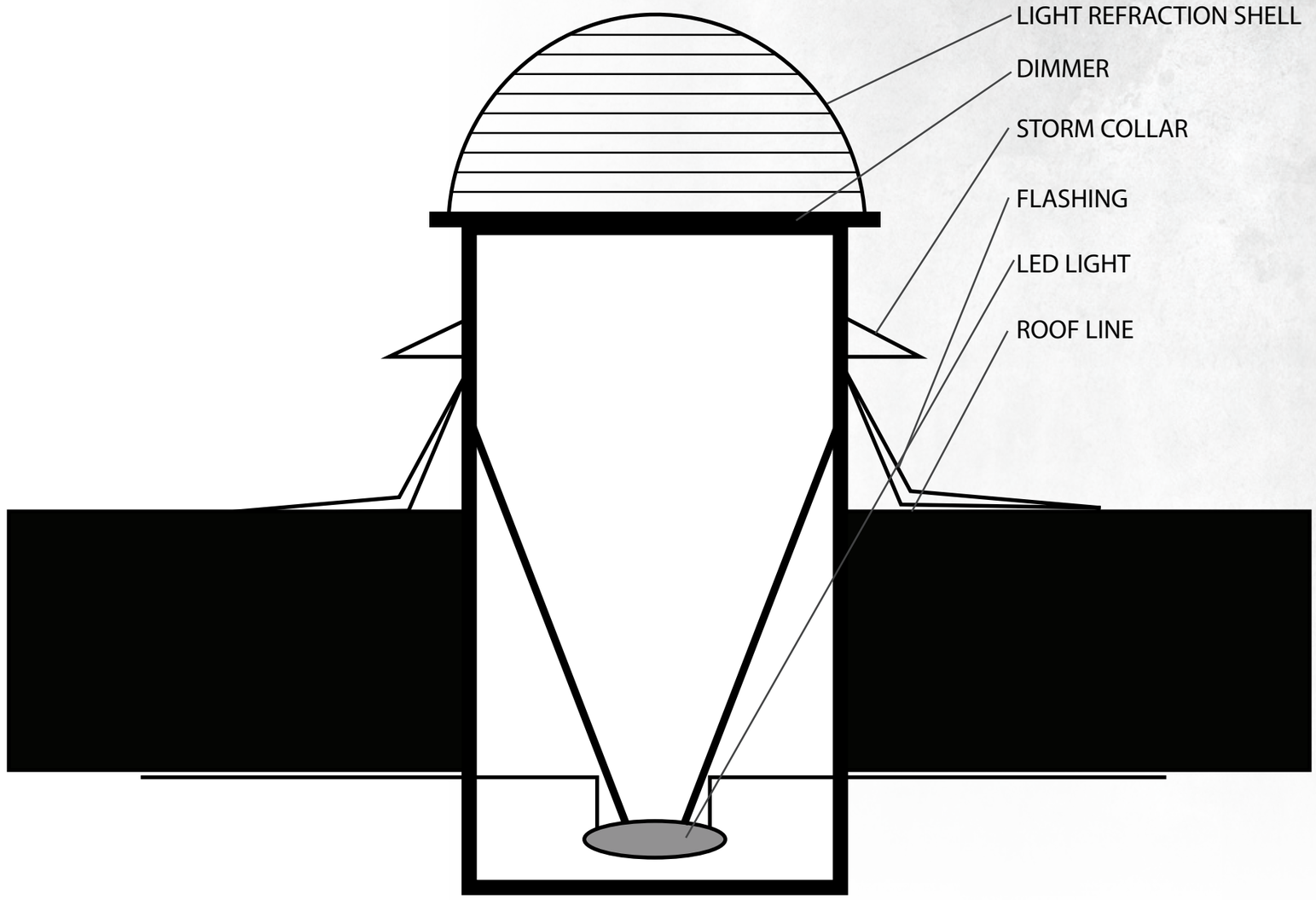
Setting the Standard

- Warehouse Requirements
  - Large Cases
    - 10-20 lumens / sq. ft.
  - Small Cases
    - 20-40 lumens / sq. ft.
- Average Bedroom
  - 10-20 lumens / sq. ft.
- Average Kitchen
  - 60-80 lumens / sq. ft.
- Average Bathroom
  - 60-80 lumens / sq. ft.
- Average Office Space
  - 50-100 lumens / sq. ft.

Study through Cove.tool

- Aprox. 40,000 sq. ft. Section
  - East / West Oriented Glazing
  - Winter Sun Path Study
  - Lumens / sq. ft. Levels from Natural Lighting

LIGHTING INVESTIGATION

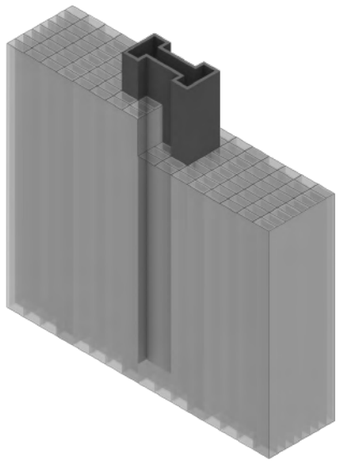


Artificial Lighting Option

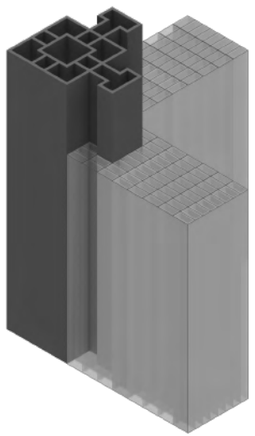
- Tubular Skylights
- Utilizes Sunlight to Illuminate Spaces
- Integrated LED

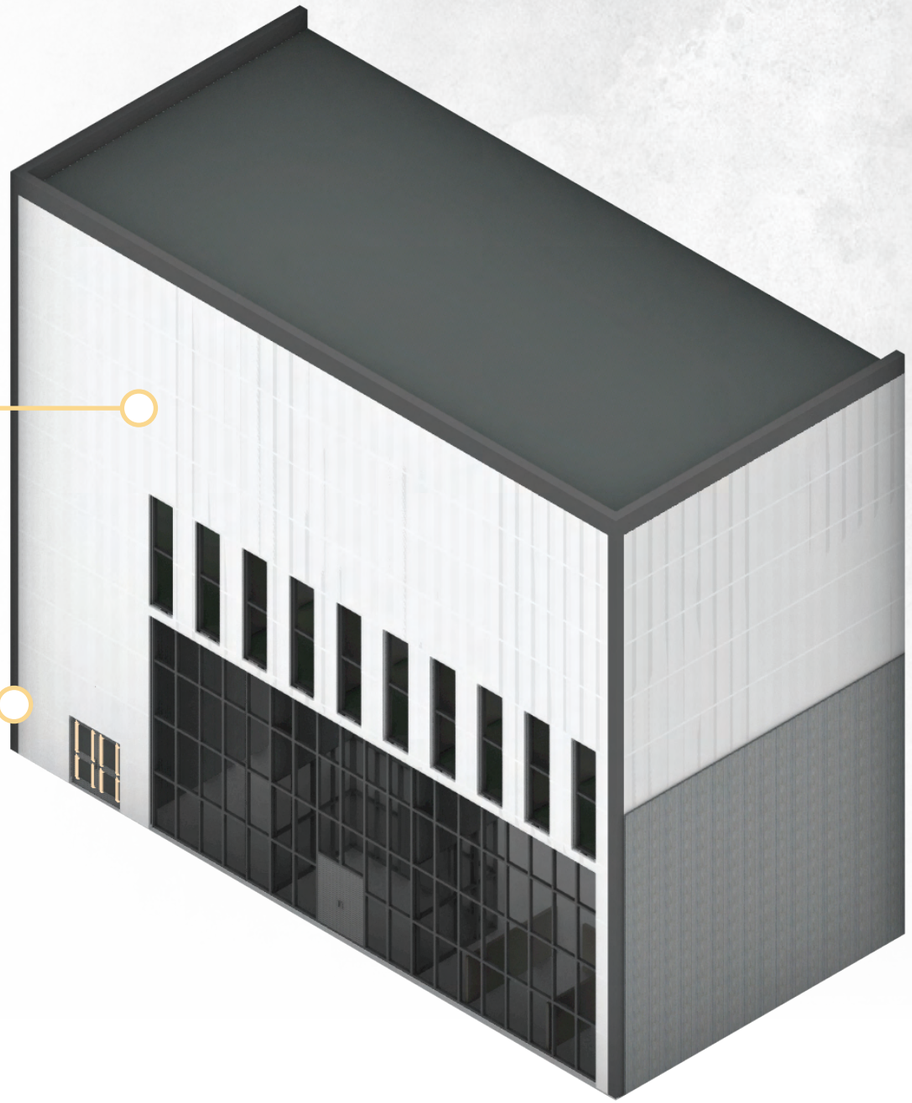
ARTIFICIAL LIGHTING

PANEL CONNECTION



CORNER CONNECTION

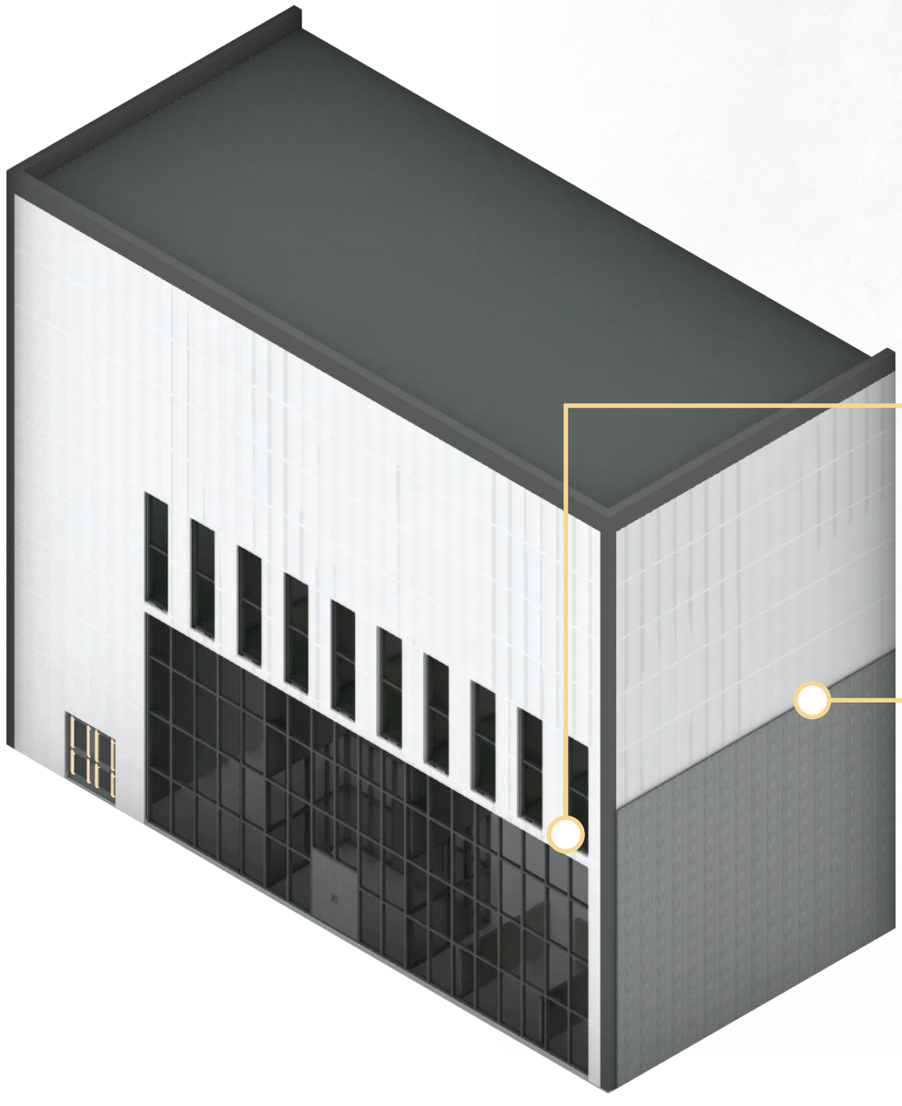


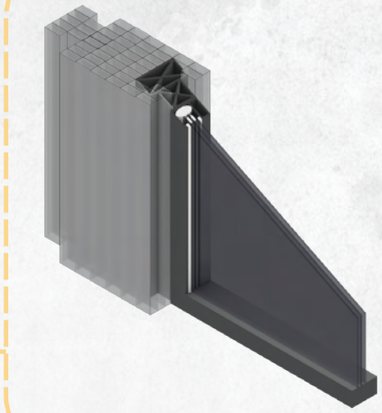


Paneling vs. Glazing

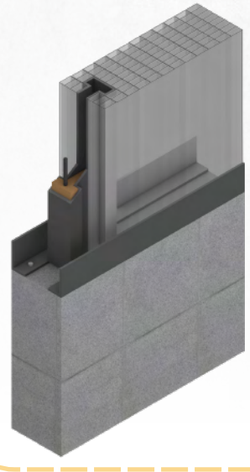
- Traditional Glazing
  - Expensive
  - Inefficient Insulative Properties
  - Low-Durability
  - High Maintenance
  - Direct Sunlighting
- Paneling
  - Relatively Inexpensive
  - Insulative Properties comparative to Concrete
  - Highly Durable Aerogel
  - Low Maintenance
  - Diffused Sunlight

INSULATED TRANSLUCENT PANELING





WINDOW CONNECTION



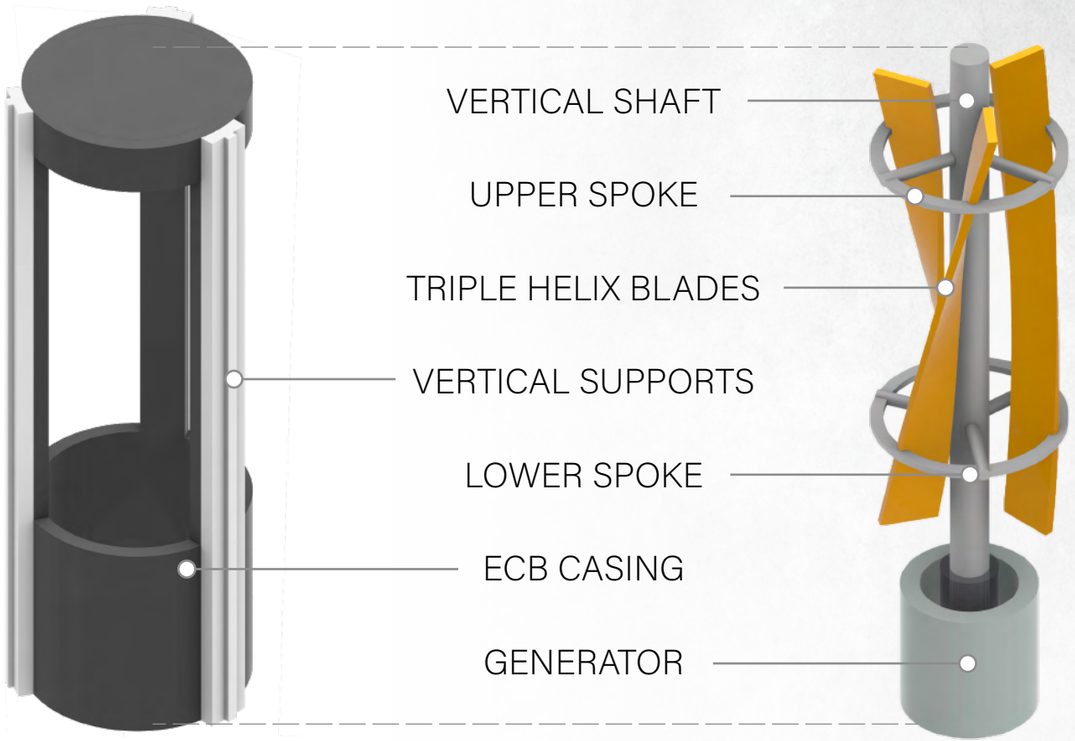
WALL CONNECTION

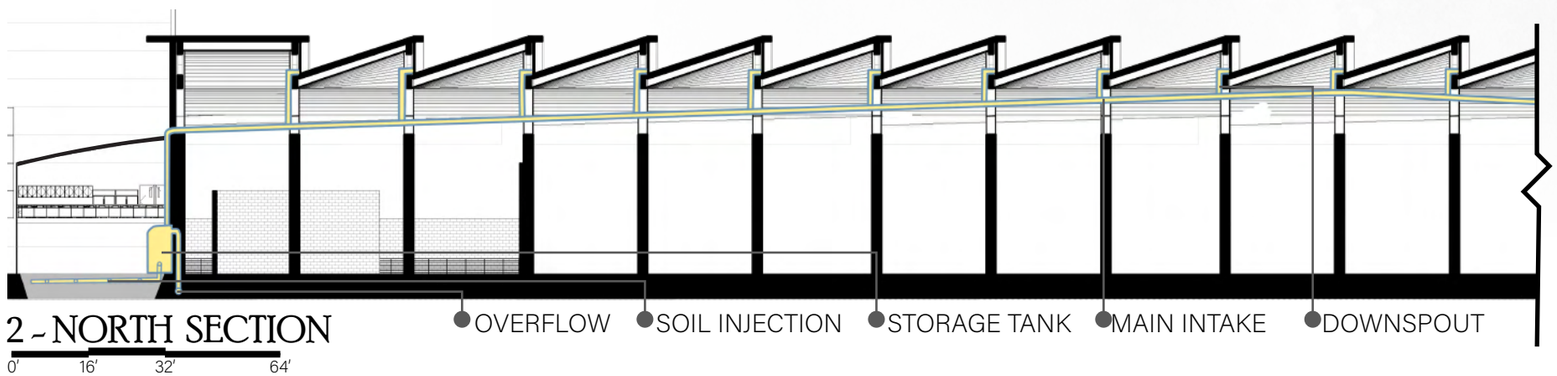
Paneling Usage
- Office Spaces
- Selection Spaces
- Clearstory Addition

Modularity in Construction
- Paneling is easily replaced
- Consists of 6’ x 10” x 8’ Panels
- Lack of Fasteners and Screws provides Ease of Construction
- Custom Window Mullions and Wall Connections create a self-sealing joints

INSULATED TRANSLUCENT PANELING

GREEN DESIGN

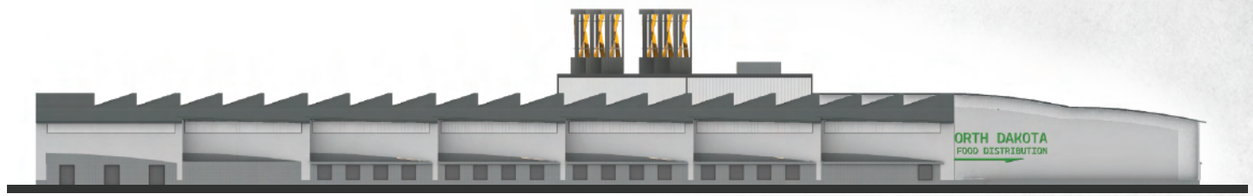




GREEN ENERGY PRODUCTION

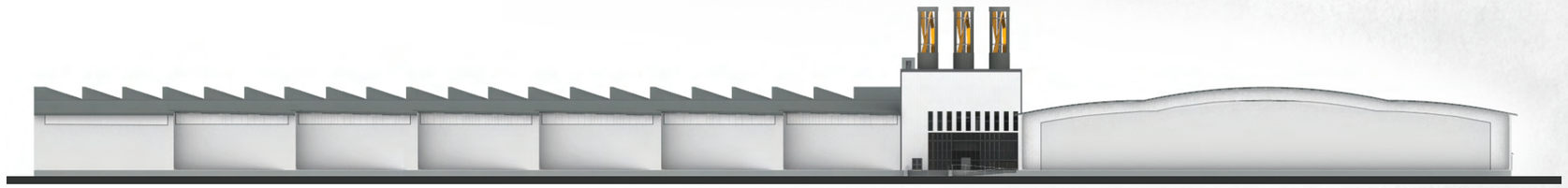
Energy Needs
- Around 10 kWh / sq. ft. / year
- Around 4,000,000 kWh / year

Green Energy
- Solar Field
  - Sprawls Near Site Entrance
  - Average Sun Hours
    - 7 hours / day
  - Efficiency of Panels
    - Power Output Rating
      - 250 to 400 W
    - Around 1.5 kWh / day / panel
    - Around 2,000 Panels
  - Covers 1,000,000 kWh / year
- Vertical Wind Harvesters
  - Located on Roof of Offices
  - Average Wind Speed
    - 12 mph
  - Efficiency of Harvesters
    - Around 500 kWh / day
    - 6 Harvesters
  - Covers 1,000,000 kWh / year



WEST ELEVATION

0' 40' 80' 160'



NORTH ELEVATION

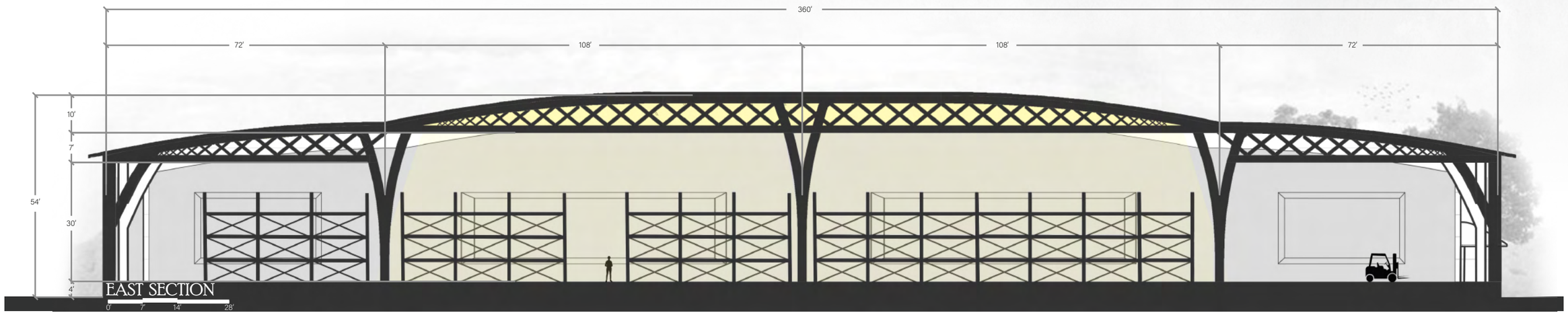
0' 40' 80' 160'

Roof Articulation

- 30 Degree Angle
- Captures Light throughout the Year

Debris Accumulation

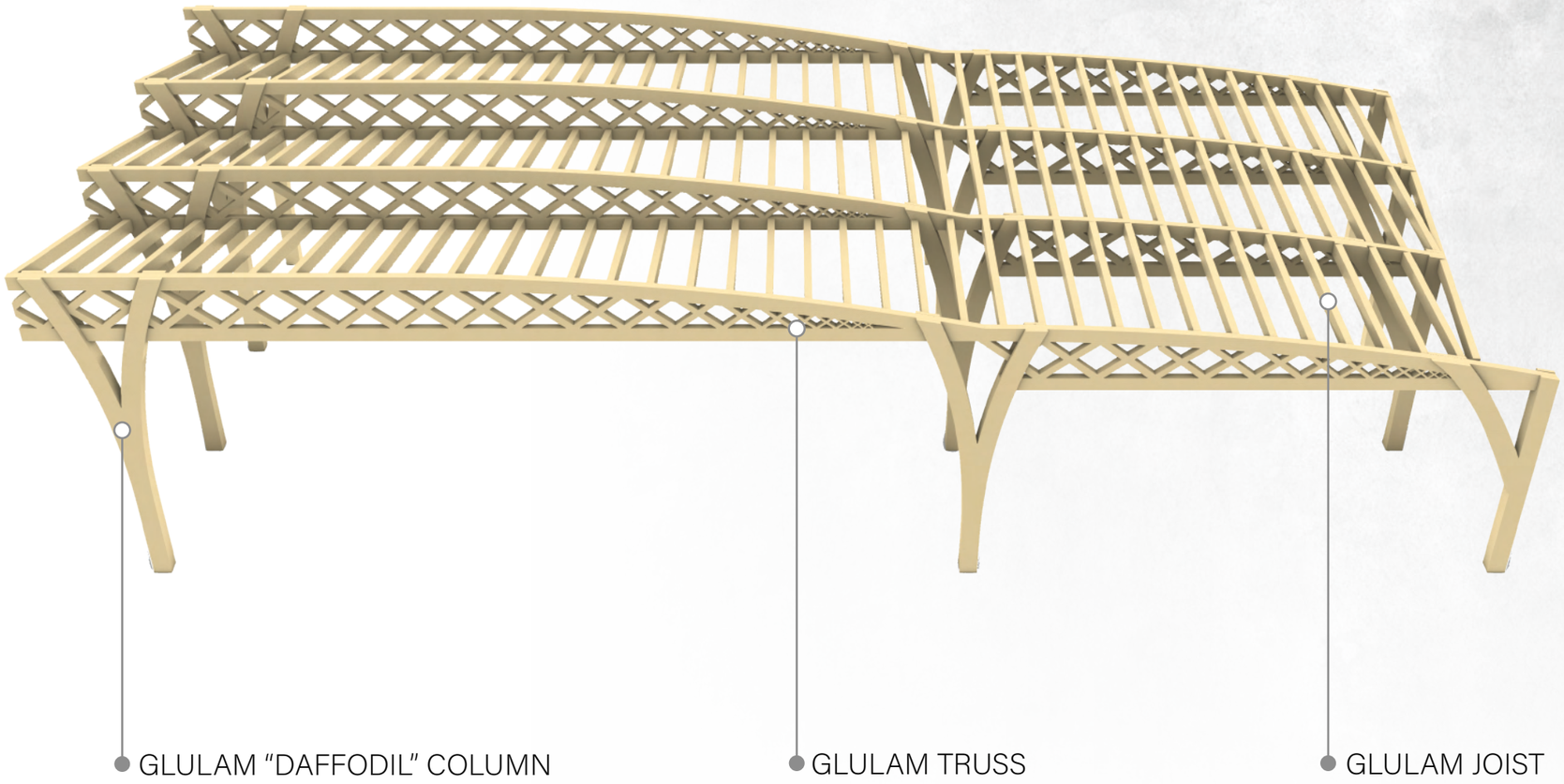
- Snow and Rain Build-up
- Heated Strips Melt Snow and allow Drainage
- Leaf Accumulation poses a Problem



EAST SECTION

0' 7' 14' 28'

STRUCTURAL ASPECTS



GLULAM "DAFFODIL" COLUMN

GLULAM TRUSS

GLULAM JOIST

Structural Elements

- Glulam Columns
- Glulam Trusses
- Glulam Joists

Custom Shapes Developed for Roof Structure

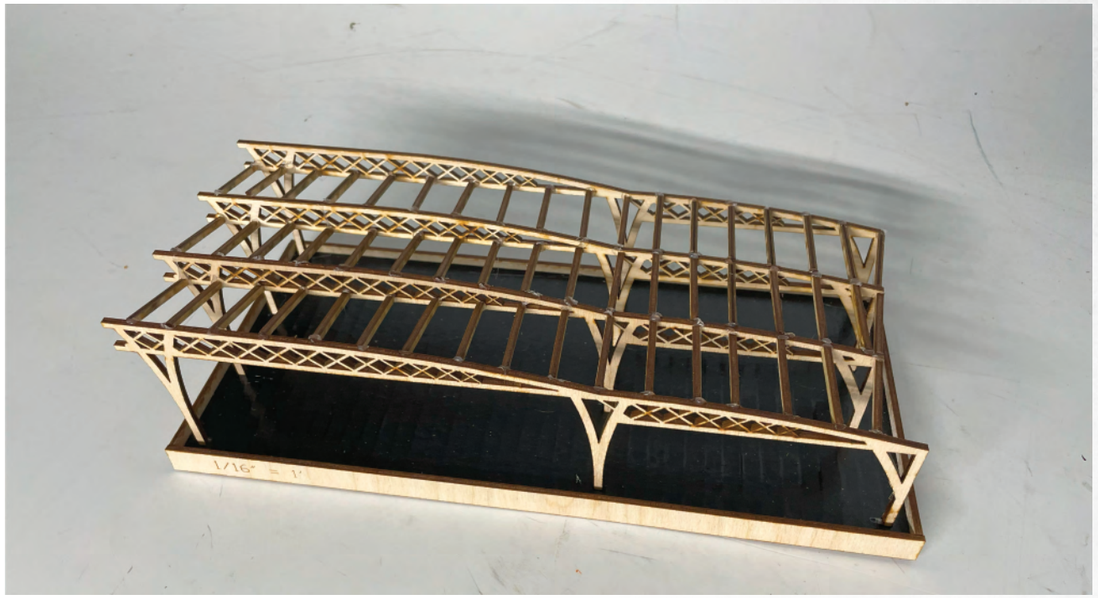
- Utilizes Curves and Angles found in Nature
- Maximizes Material Usage
- Minimizes Material Waste

LIGHTING / STRUCTURE STUDY

Large Model of Structural Truss and Column

- Constructed Using Laser Cutter
  - Materials
    - 1/8" Plywood
    - 1/4" Cardboard
- Scale:
  - 1/4" = 1'

STRUCTURAL STUDY - PHYSICAL



Large Model of Structural Truss and Column

- Scale:
  - 1/16" = 1'
- Constructed Using Laser Cutter
  - Materials
    - 1/8" Plywood
    - 1/4" Cardboard

STRUCTURAL STUDY - PHYSICAL

Project Costs					
Land Acquisition	Land Area (sf)		1,300,000	1	Area varies per lot
	Land Cost ($/sf)	$	300.00	2	Assessed Value' / SF
Demolition Costs	Building/Lot Floor Area (sf)		40,000	3	Varies per lot
	Demolition Cost ($/sf)	$	10.00	4	Generally $15 or $10 for open lot (includes cut, hauling, landfill)
Building Construction	Proposed Gross Floor Area (sf)		430,000	5	Max allowable Zoning - Later use 'Actual'
	Building Cost ($/sf)	$	500.00	6	May range: $300-500/sf+ (Low to High)
Fees, Permits, & Misc (rate)	Fee Rate (%)		20%	7	Generally 20%
Construction Financing	Construction Interest Rate (per anum)		7%	8	Generally 7%
	Construction Length (yrs)		3	9	May vary by constr/type (prefab, precast?)
Total Land Acquisition		$	390,000,000.00	10	Line 1 x 2
Total Demolition Costs		$	400,000.00	11	Line 3 x 4
Total Building Construction		$	215,000,000.00	12	Line 5 x 6
Total Fees, Permits, & Misc		$	43,000,000.00	13	Line 7 x 12
Total Construction Financing		$	50,310,000.00	14	Lines (12+13) x line8 x line9
Total Project Cost		$	698,710,000.00	15	Total of Lines 10-14

Balance Sheet					
	Gross Floor Area (gsf)		430,000	22	Line 5
	Leaseable Area (Efficiency)		70%	23	Rentable Area vs Non (stairs,shafts,etc)
	Net Leasable Floor Area		301,000	24	Line 22 x 23
	Income Rate ($/SF/YEAR) - SEE NOTES	$	350.00	25	Composite of ALL Uses (Show calcs)
	Occupancy Rate		80%	26	Generally 80%+ is good
	Tax Rate		15%	27	Generally 15%
	Operating/Maint Cost (per GSF/Mon)	$	0.80	28	Generally $.80/gsf/month
Assets/Income per month	Income / Month	$	7,023,333.33	29	Line 24 x Line25/12 x Line26
Liabilities/Expenses per month	Debt Service (from above)	$	3,868,342.57	30	Line 20
	Operating Costs (total)	$	28,666.67	31	Line 22 x 28
	Total Liabilities	$	3,897,009.24	32	Total of Lines 30+31
	TOTAL Monthly Cash Flow	$	3,126,324.09	33	Assets minus Liabilities
	Monthly Depreciation ('Paper Loss')	$	(951,574.07)	34	Lines (12+13+14) div by 27/12mos
	Gross Profit	$	2,174,750.02	35	Lines 33+34
	Taxes on Gross Profits	$	326,212.50	36	Tax Rate (Ln27) x Gross Prof.(Ln35)
NET PROFIT per month	Net Profit (per month)	$	1,848,537.52	37	(x) is loss, should be positive
	NET Profit (per YEAR)	$	22,182,450.21	38	Ln37 x 12mos
	ROI % per year		3.17%	39	Ln38/ Ln21

Return on Investment

- Simplified Calculations
- Numbers are Average of ND
- Increased Construction Costs
- ROI % per Year
  - 3.17%

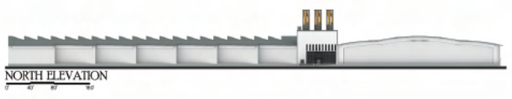
RETURN ON INVESTMENT

SOLAR HARBOR

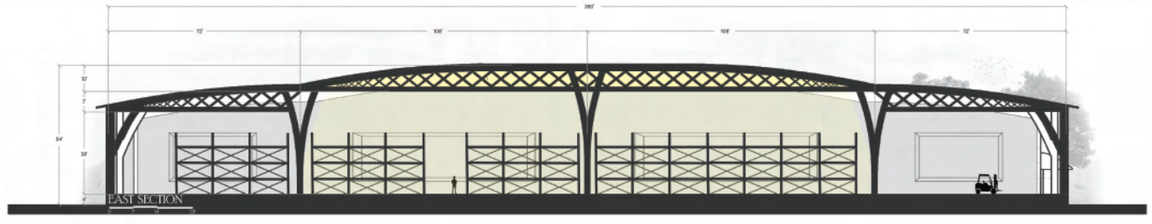
NURTURING NATURE IN INDUSTRIAL DESIGN

SITE PLAN

Solar Harbor is a 420,000 square foot warehouse where tradition meets transformation. Nestled amidst the plains of North Dakota, this facility redefines the industrial landscape by prioritizing the well-being of its workforce and the health of the planet. Shifting the focus of the industry from efficiency and cost reduction to health is the undeniable way of the future, and this design places itself at the forefront of this revolution.



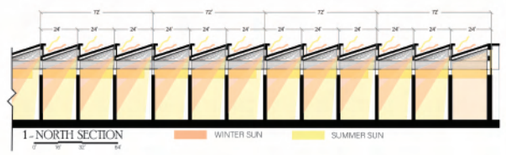
NORTH ELEVATION

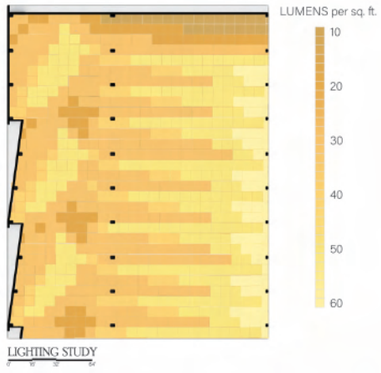


EAST SECTION

BOARD ONE

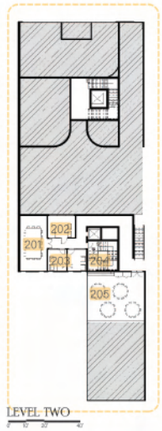
Unlike conventional warehouses, natural light floods every corner, creating an uplifting ambiance that boosts productivity and enhances mood. By harnessing sunlight, this workplace not only illuminates workspaces but also brightens the lives of employees, fostering a more energized environment, increasing mental health, and facilitating workflow.





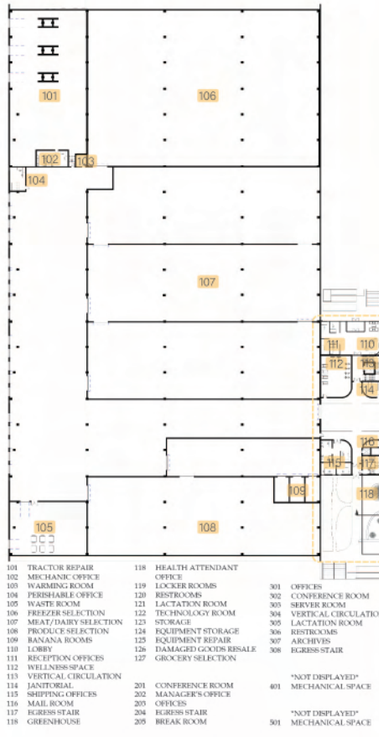
LIGHTING STUDY

The commitment to well-being extends beyond lighting. On site health assessors, spacious break areas, and wellness amenities promote physical comfort and mental rejuvenation, ensuring that employees and users thrive each day.



LEVEL TWO

LEVEL THREE



LEVEL ONE

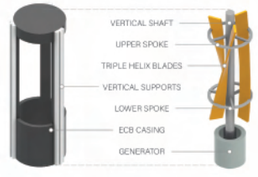
STRUCTURE

The industrial landscape is ruled by steel and concrete, the standard for construction in the industry used since the Industrial Revolution. These materials make construction cheap and efficient, but hold little regard for the users and occupants of the building.

Alternatively, Solar Harbor utilizes a glulam truss system. The gentle curves of the roof line and the custom column design evoke a certain familiarity, providing users with an image of the tree from which the wood was harvested. This system simultaneously provides an efficient use of the material, following curves and angles in which trees naturally grow.

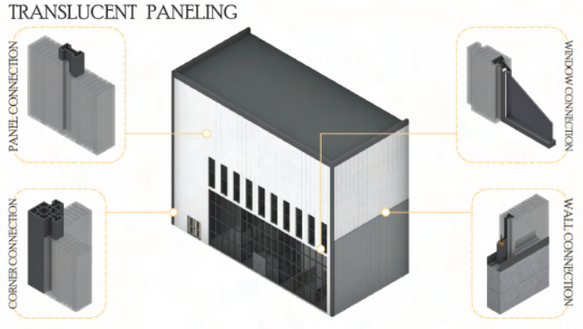
FLOOR PLANS

VERTICAL WIND HARVESTERS



Sustainability is at the core of the design philosophy. Solar panels adorn the grounds, rainwater is collected, and wind is utilized for energy needs. The structure employs curves and forms found in nature to minimize its the material usage and consumption.This warehouse is not just reimagining spaces; it's setting a standard for shaping a brighter, greener future for generations to come.

TRANSLUCENT PANELING



BOARD TWO

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THANK YOU

QUESTIONS/COMMENTS