

The word "APOLLO" is written in a white, serif font. Above the letters is a thick yellow arc that starts above the 'A', goes over the 'P', 'O', 'L', 'L', and ends above the 'O'.

# APOLLO

Rebecca Bires | Scott Brown | Scott Eckert | Jordan Huey | Helen Leenhouts | Andrew Levy | Jeffrey Loeb | Patrick Vogel

INTRODUCTION

- 350 Mission Site**
- Immediate Occupancy Goals
- Near Net-Zero Goals
- Building Overview



# AT A GLANCE

30 Story Mixed – Use High Rise

4 Story Lobby

Restaurant

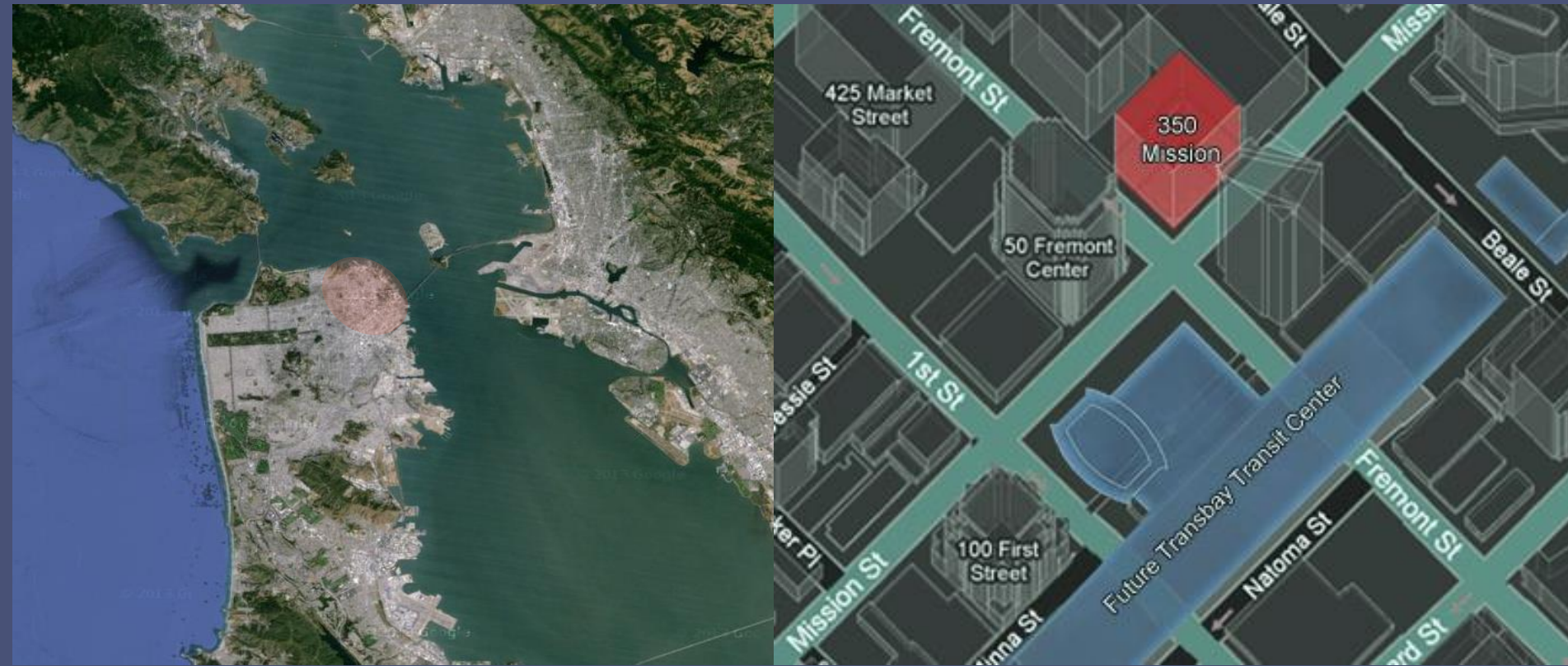
Retail

25 Office Floors

4 Story Underground Parking Garage

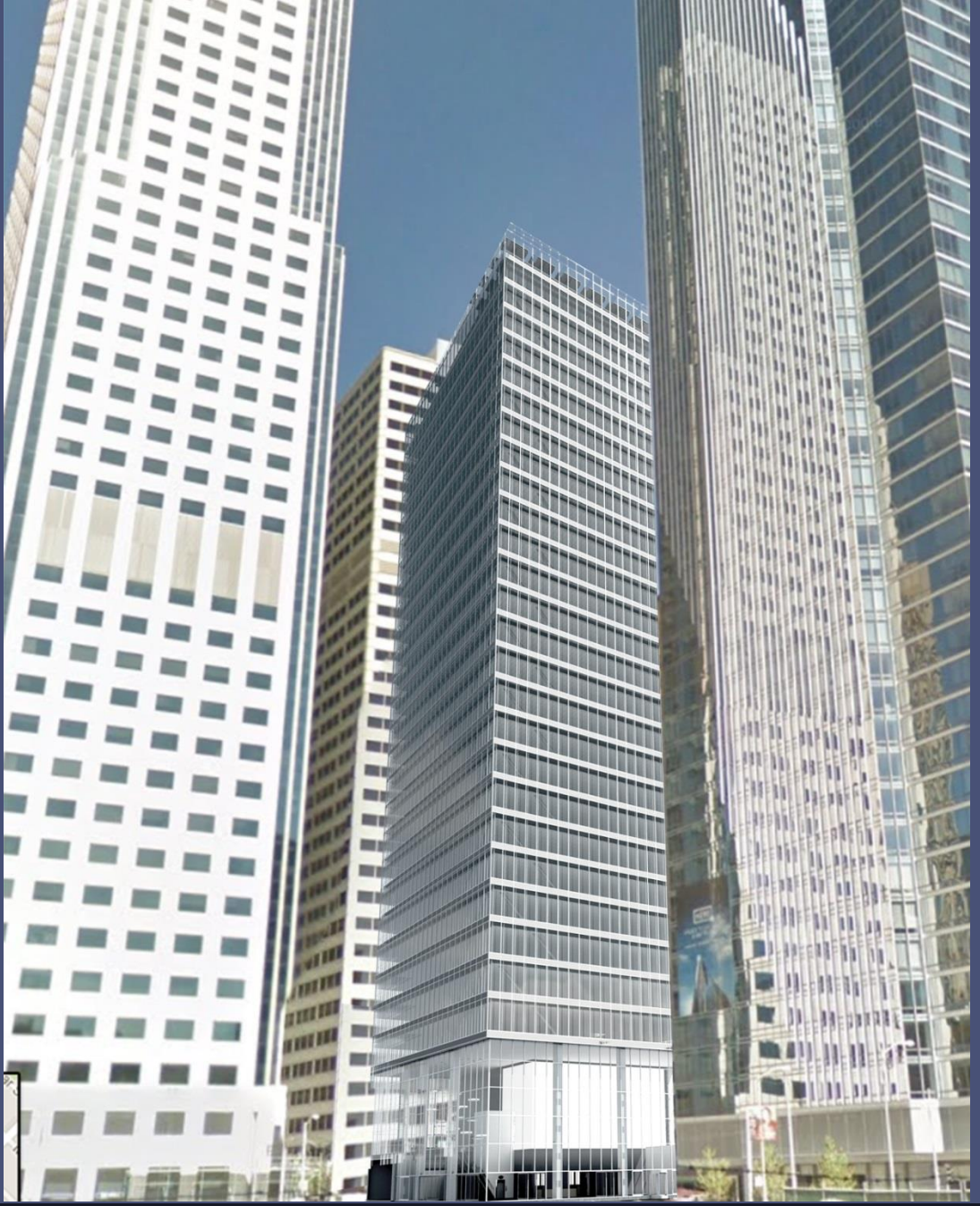
San Francisco, CA

Business District



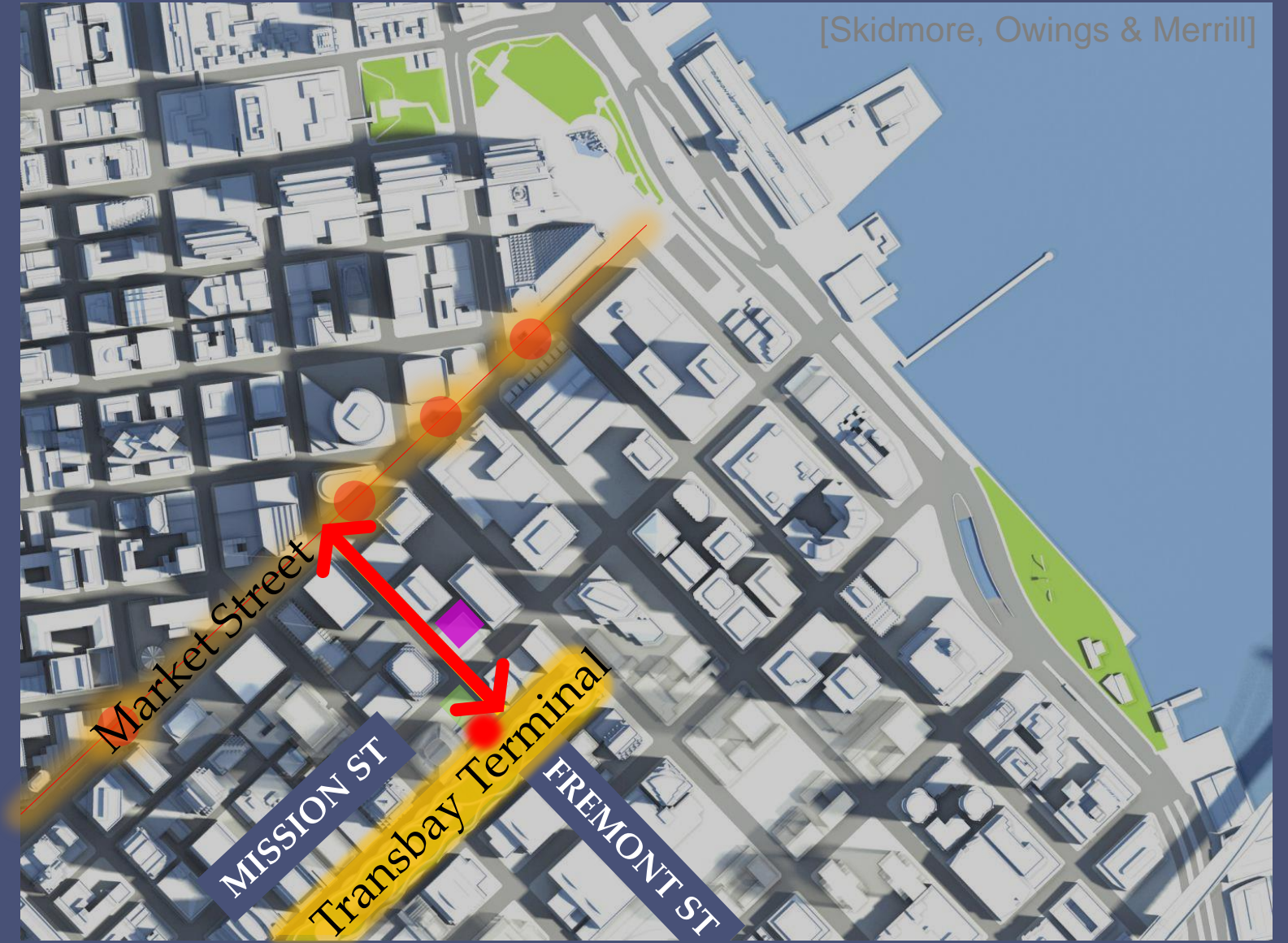
# INTRODUCTION

- 350 Mission Site**
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- Building Overview



# AT A GLANCE

- 30 Story Mixed – Use High Rise
- 4 Story Lobby
- Restaurant
- Retail
- 25 Office Floors
- 4 Story Underground Parking Garage
- San Francisco, CA



## INTRODUCTION

350 Mission Site

### **Immediate Occupancy Goals**

Near Net-Zero Goals

Building Overview

Minimize Drift  
*Strategy: Seismic Design Strategies*

Minimize Structural Repairs  
*Strategy: Material Selection*

Mechanical Design  
*Strategy: Seismic Design Strategies*

Fire Protection  
*Strategy: Gas Protection System*

## INTRODUCTION

350 Mission Site

Immediate Occupancy Goals

**Near Net-Zero Goals**

Building Overview

Net Off-Site Energy Use (ZEB)

*Strategy: Buy renewable Energy*

**Goal: 35%**

Net-Zero Source Energy Use (ZNE)

*Strategy: Combined Heat-and-Power System*

**Goal: 20%**

Net-Zero Energy Emissions (ZEE)

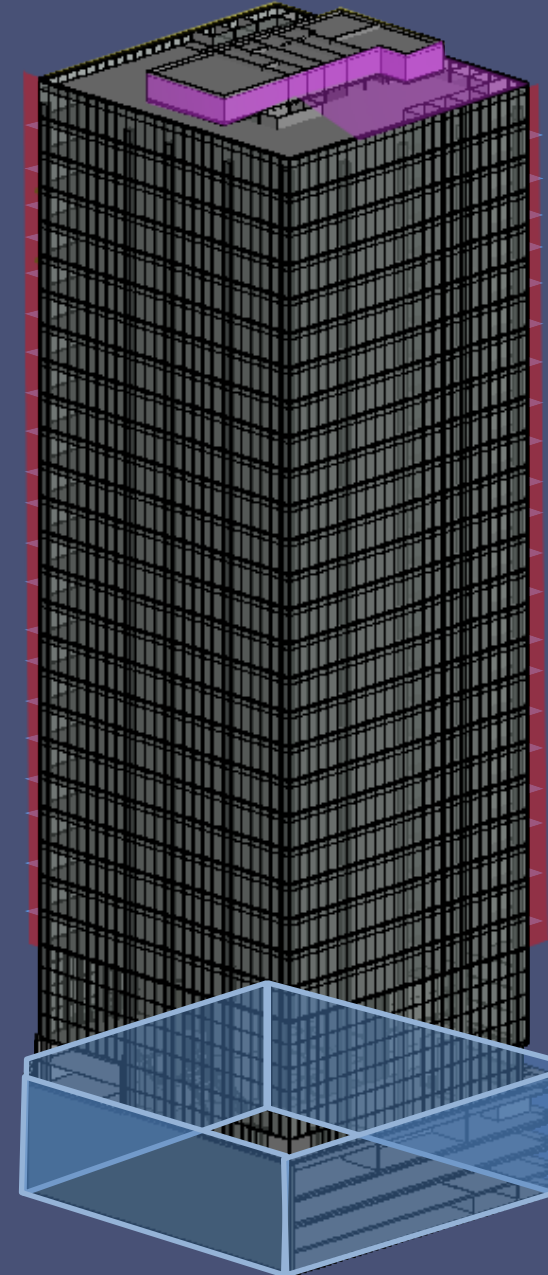
*Strategy: Algae Bioreactors*

**Goal: 50%**

# INTRODUCTION

- 350 Mission Site
- Immediate Occupancy Goals
- Near Net-Zero Goals

## Building Overview



Price Estimate: \$148.1 million

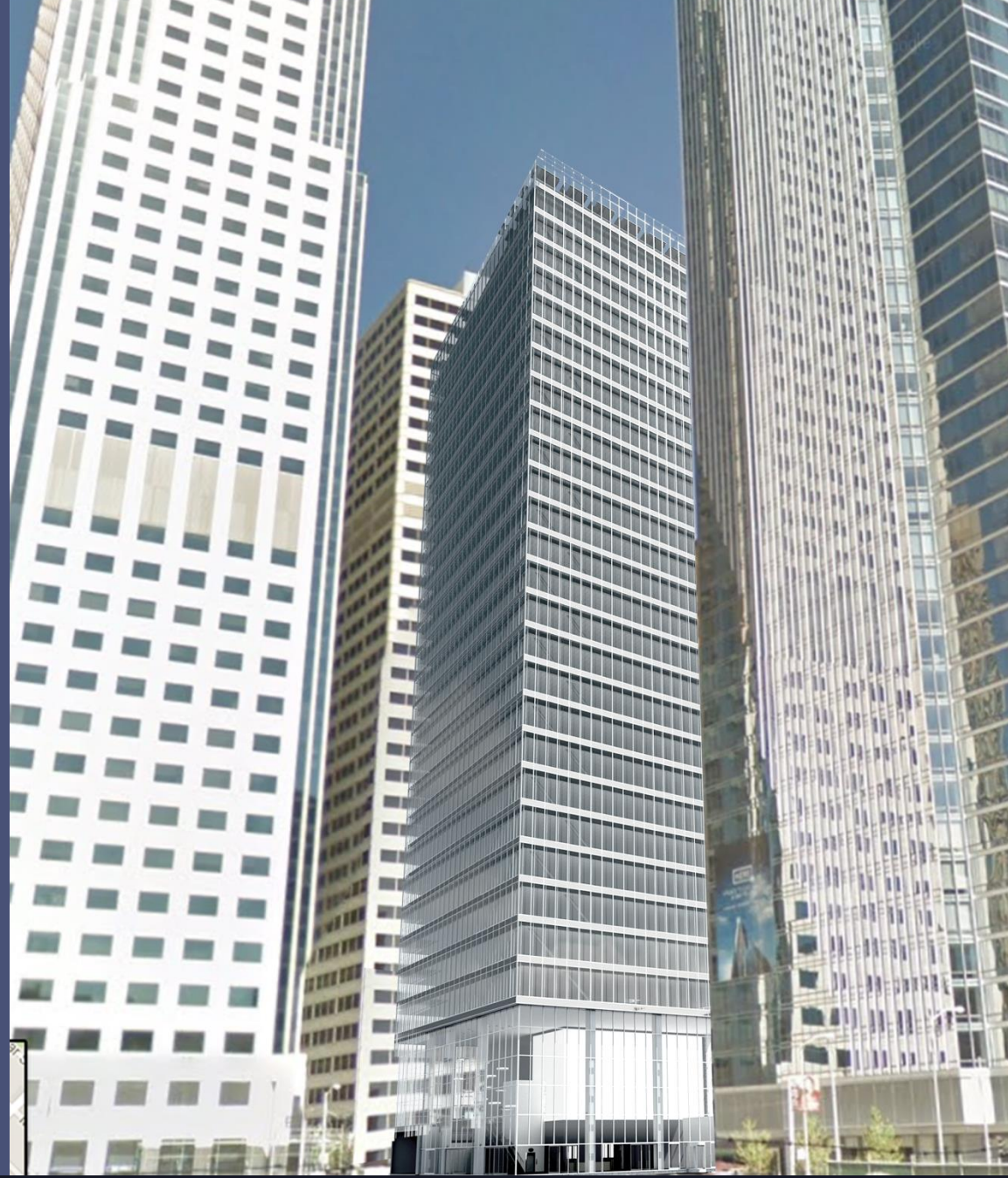
Schedule: 29 Months

LEED Certification: Platinum

### Systems

- Structural Steel System
- Raised Access Floor System
- Double Façade
- Photovoltaic Grid
- Combined Heat and Power

4 Story Parking Garage



# Lobby

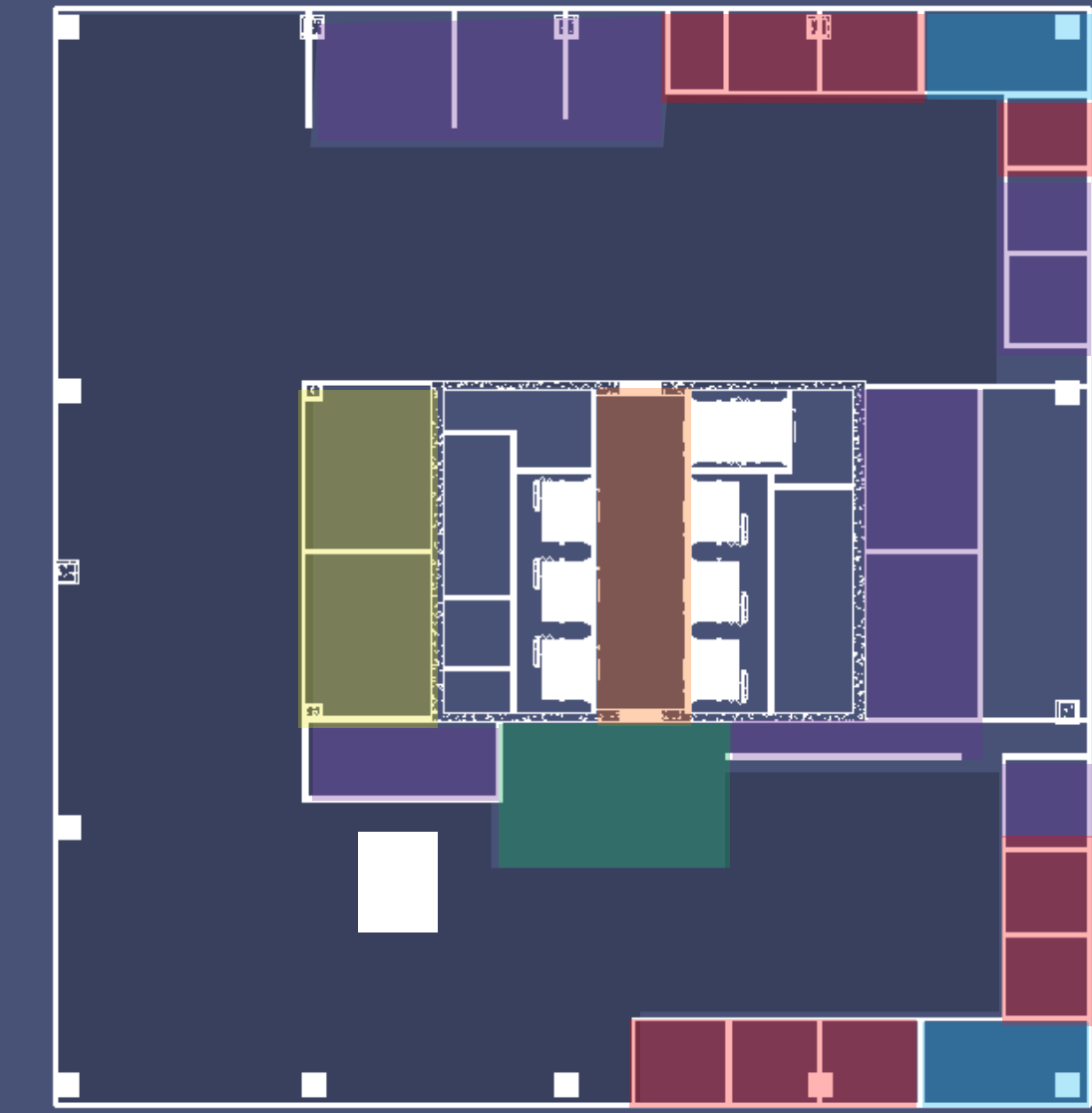
# Typical Office

## INTRODUCTION

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- Street Level
  - Lower Lobby
  - Retail
  - Back of House
  - Elevator Lobby
- Staircase
- Second Level
  - Upper Lobby
  - Restaurant
  - Elevator Lobby



- Elevator Lobby
- Reception
- Executive Offices
- Partner Offices
- Open Offices
- Conference Rooms
- Ancillary Spaces
- Floor Cutout



# INTRODUCTION

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CONSTRUCTION



MECHANICAL



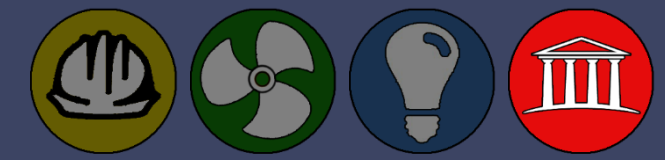
LIGHTING/ELECTRICAL



STRUCTURAL



# OCCUPANCY CATEGORY IV



## IMMEDIATE OCCUPANCY

### Occupancy Category

- Gravity System
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection

### Immediate Occupancy:

The Immediate Occupancy performance level is used for essential facilities which require being in operation after the design earthquake event and without loss of life

### Strategy:

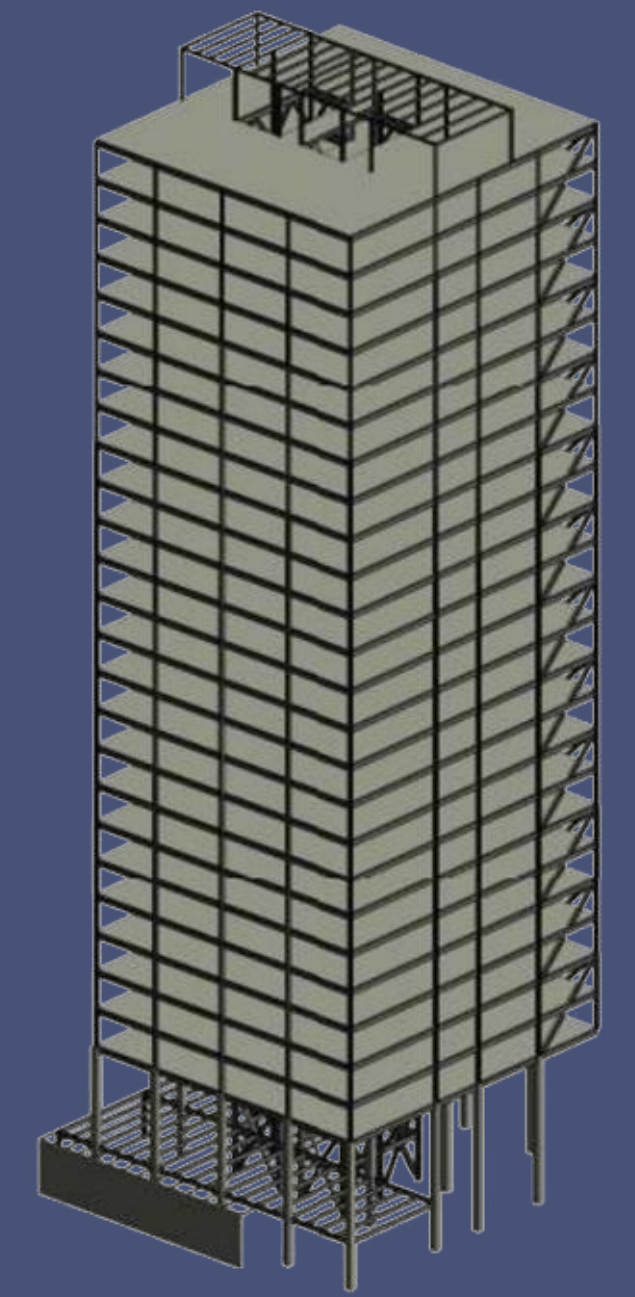
- The code dictates the seismic loading on the building through the use of occupancy category
- We designed for heavier loads in order to truly reach goal of immediate occupancy
- Same occupancy category as **hospitals, fire stations, police stations,** etc.

**TABLE 1-1 OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES FOR FLOOD, WIND, SNOW, EARTHQUAKE, AND ICE LOADS**

Nature of Occupancy	Occupancy Category
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: <ul style="list-style-type: none"> <li>• Agricultural facilities</li> <li>• Certain temporary facilities</li> <li>• Minor storage facilities</li> </ul>	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: <ul style="list-style-type: none"> <li>• Buildings and other structures where more than 300 people congregate in one area</li> <li>• Buildings and other structures with daycare facilities with a capacity greater than 150</li> <li>• Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250</li> <li>• Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities</li> <li>• Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities</li> <li>• Jails and detention facilities</li> </ul>	III
Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: <ul style="list-style-type: none"> <li>• Power generating stations*</li> <li>• Water treatment facilities</li> <li>• Sewage treatment facilities</li> <li>• Telecommunication centers</li> </ul>	

<p><b>Buildings and other structures designated as essential facilities, including, but not limited to:</b></p> <ul style="list-style-type: none"> <li>• Hospitals and other health care facilities having surgery or emergency treatment facilities</li> <li>• Fire, rescue, ambulance, and police stations and emergency vehicle garages</li> <li>• Designated earthquake, hurricane, or other emergency shelters</li> <li>• Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response</li> <li>• Power generating stations and other public utility facilities required in an emergency</li> <li>• Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency</li> <li>• Aviation control towers, air traffic control centers, and emergency aircraft hangars</li> <li>• Water storage facilities and pump structures required to maintain water pressure for fire suppression</li> <li>• Buildings and other structures having critical national defense functions</li> </ul> <p>Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction.</p> <p>Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.</p>	<b>IV</b>
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# DESIGN SUMMARY



## Steel Super-Structure

- Design Considerations:
  - Long span conditions for steel beams
  - Limit excessive beam depths
  - Limit Floor to Floor height increase
- Loads:
  - Live Load: 100 psf
  - Dead load: self weight + 10 psf
  - Partition Load: 20 psf
  - Raised Floor: 10 psf

## Strategy:

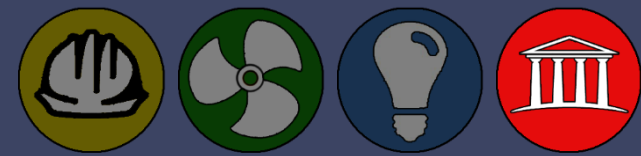
- RAM SS was used to design all gravity elements
- Initial RAM model was built for a typical floor with non-composite beams and unreducible loads to determine a worst case beam depth
- Team check-in to discuss beam depths
- RAM model rebuilt to a typical floor with composite beams and reducible loads

## Structural Elements:

- Beams range from W14 shapes to W36 shapes
- All columns in upper floors are W14 shapes
- Built up columns were designed where W14 had inadequate capacity
- 2VLI20 deck from the Vulcraft Manufacturer's catalog was used with a 4 ½ inch topping thickness of normal weight concrete (2 hour fire rating)

## IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System**
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection



# IMMEDIATE OCCUPANCY

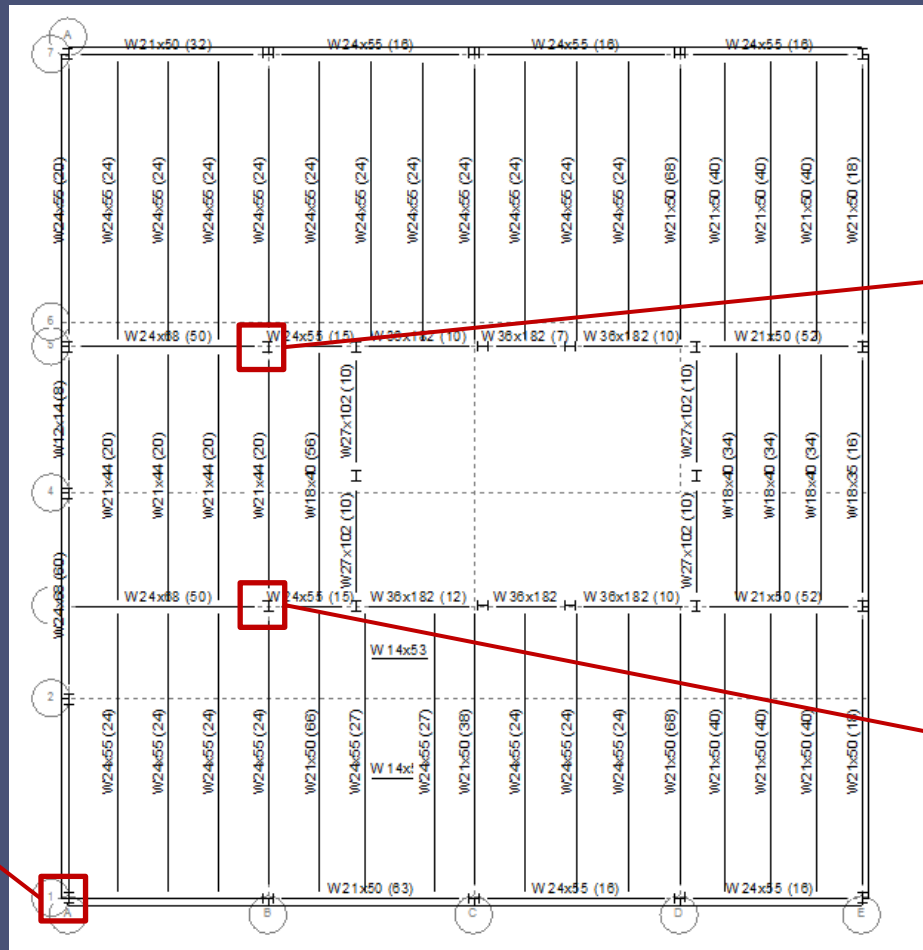
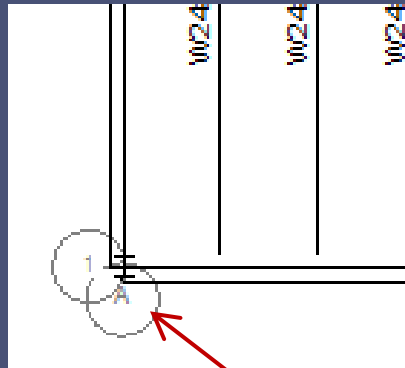
- Occupancy Category
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## Problems:

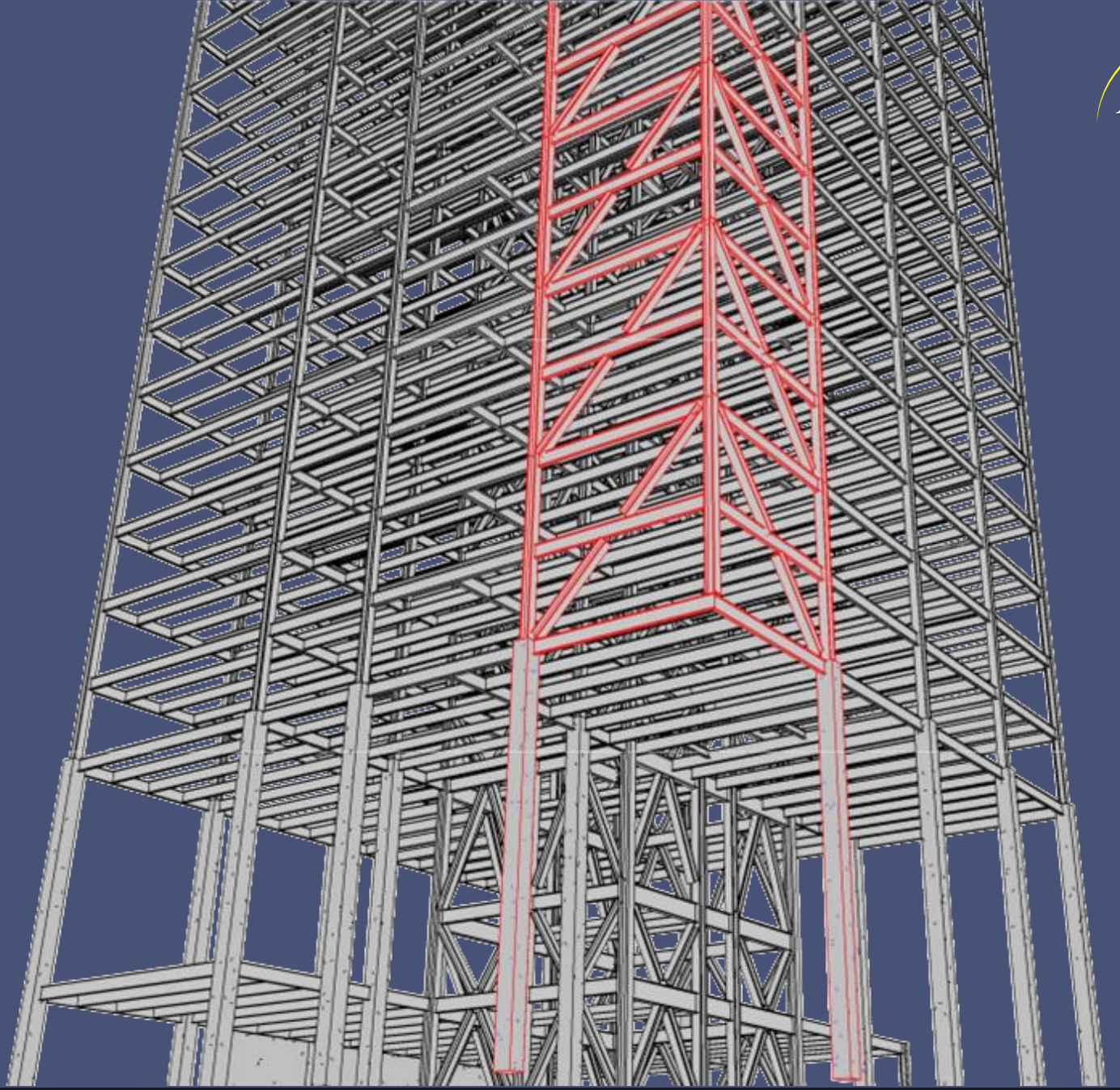
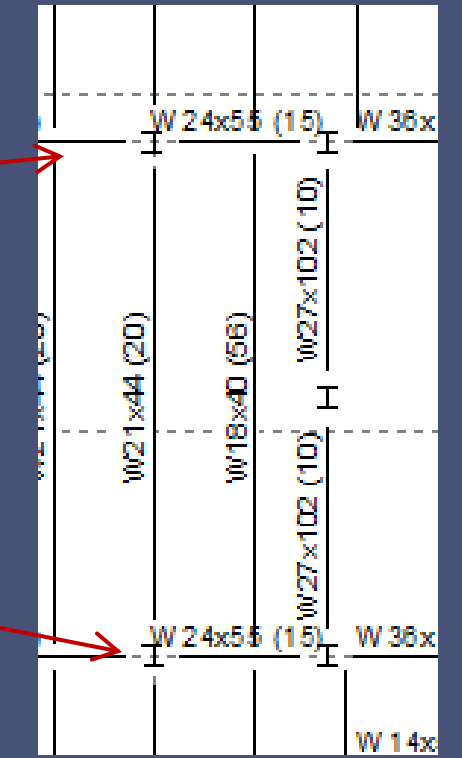
- Beam depths still excessive
- Cantilever
- Large unbraced column length at lobby level

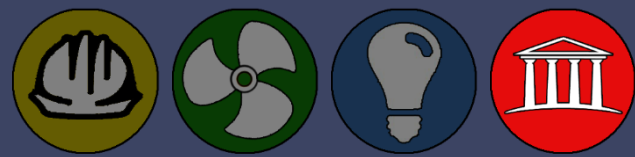
## Solution:

- Interior columns added, new spaces created
- Corner column introduced above lobby level, cantilever now only exists at lobby level
- Transfer braces added to cantilevered corner to transfer load away from corner



Typical Floor Beam Layout





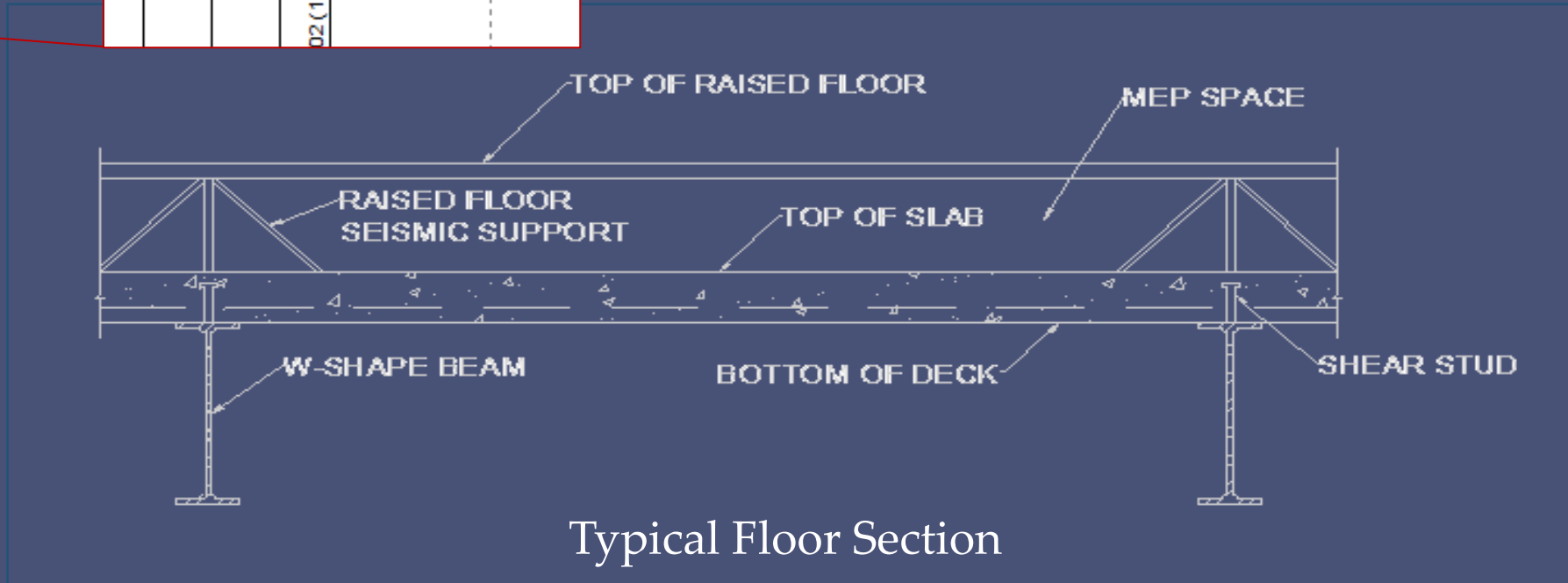
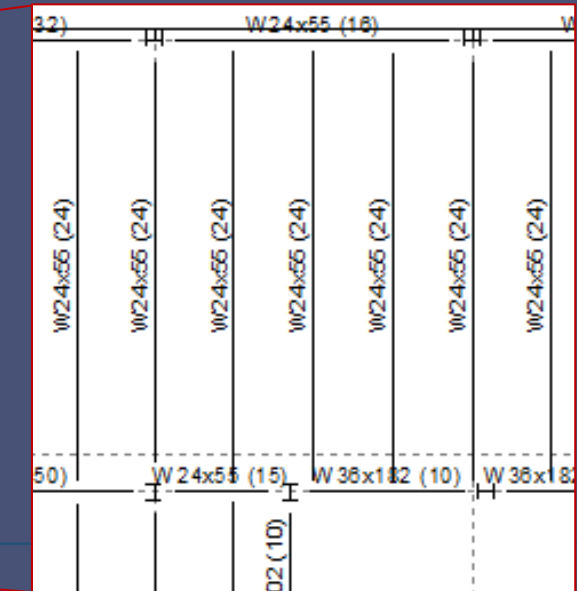
# IMMEDIATE OCCUPANCY

## Structural Elements:

- Occupancy Category
- Gravity System**
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection
- Beams range from W14 shapes to W36 shapes
- All columns in upper floors are W14 shapes
- Columns spliced every two levels
- Built up columns were designed where W14 had inadequate capacity
- Special transfer braces designed in order to showcase iconic lobby cantilever



Typical Floor Beam Layout

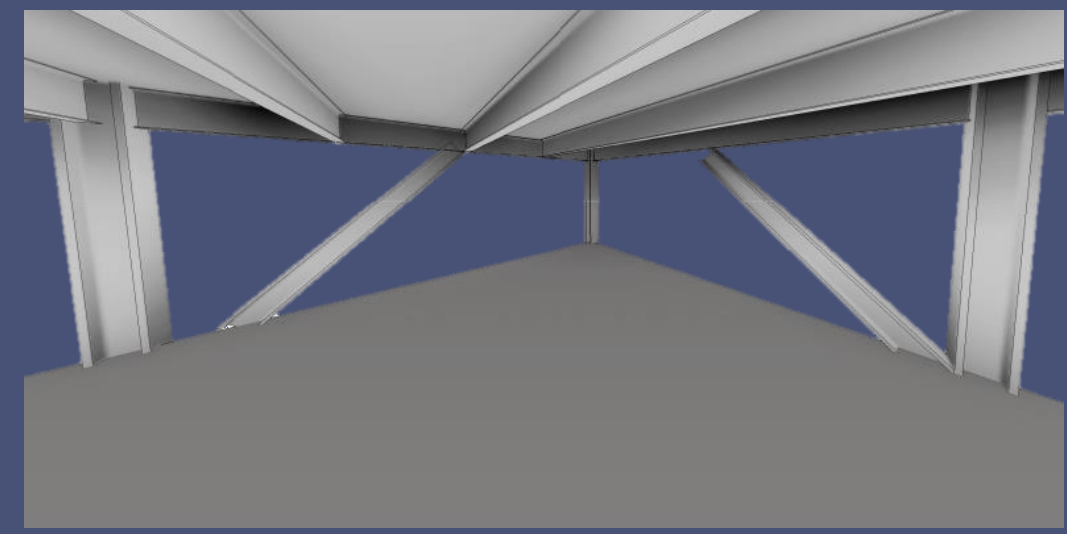


Typical Floor Section

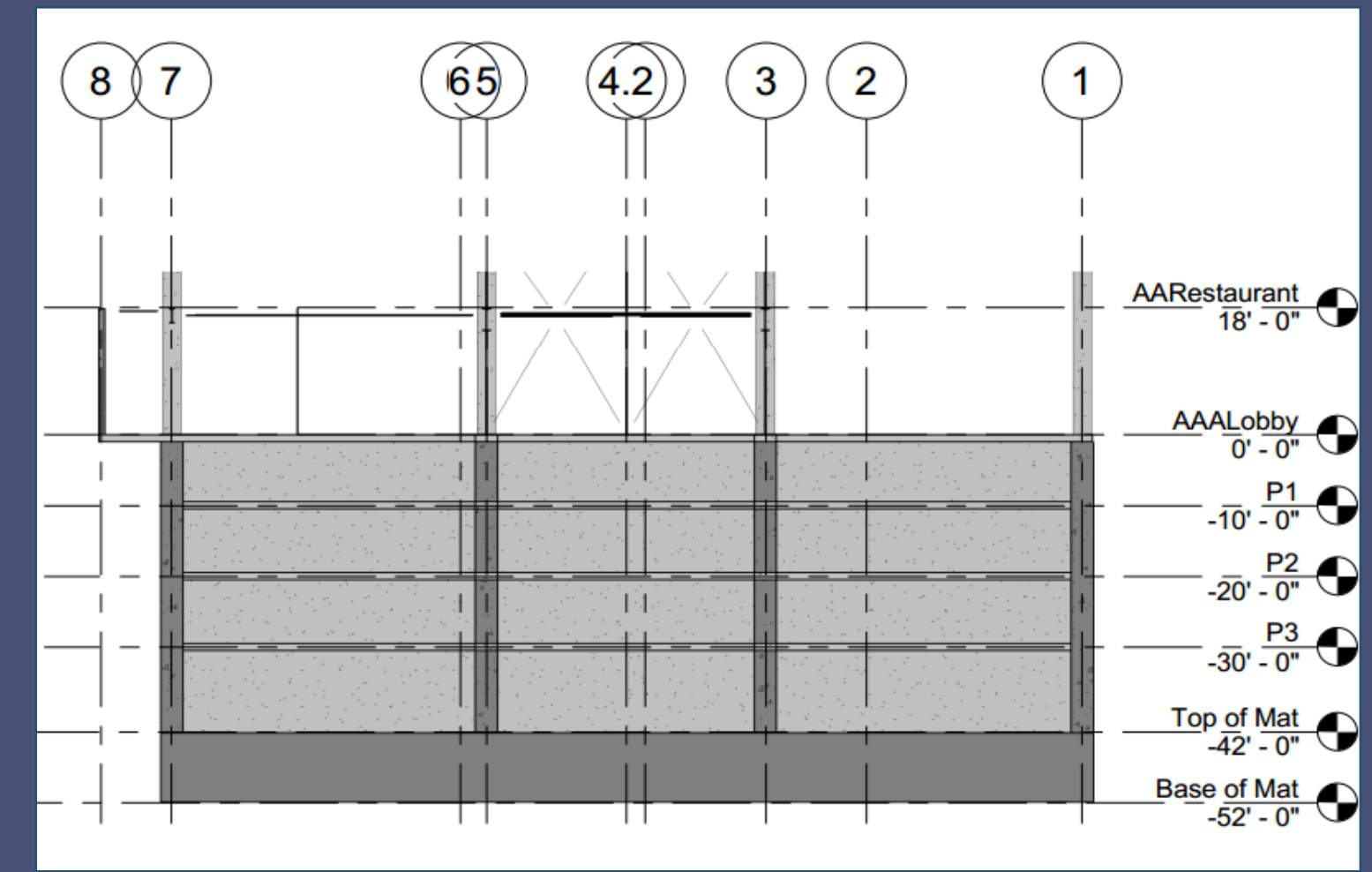


# IMMEDIATE OCCUPANCY

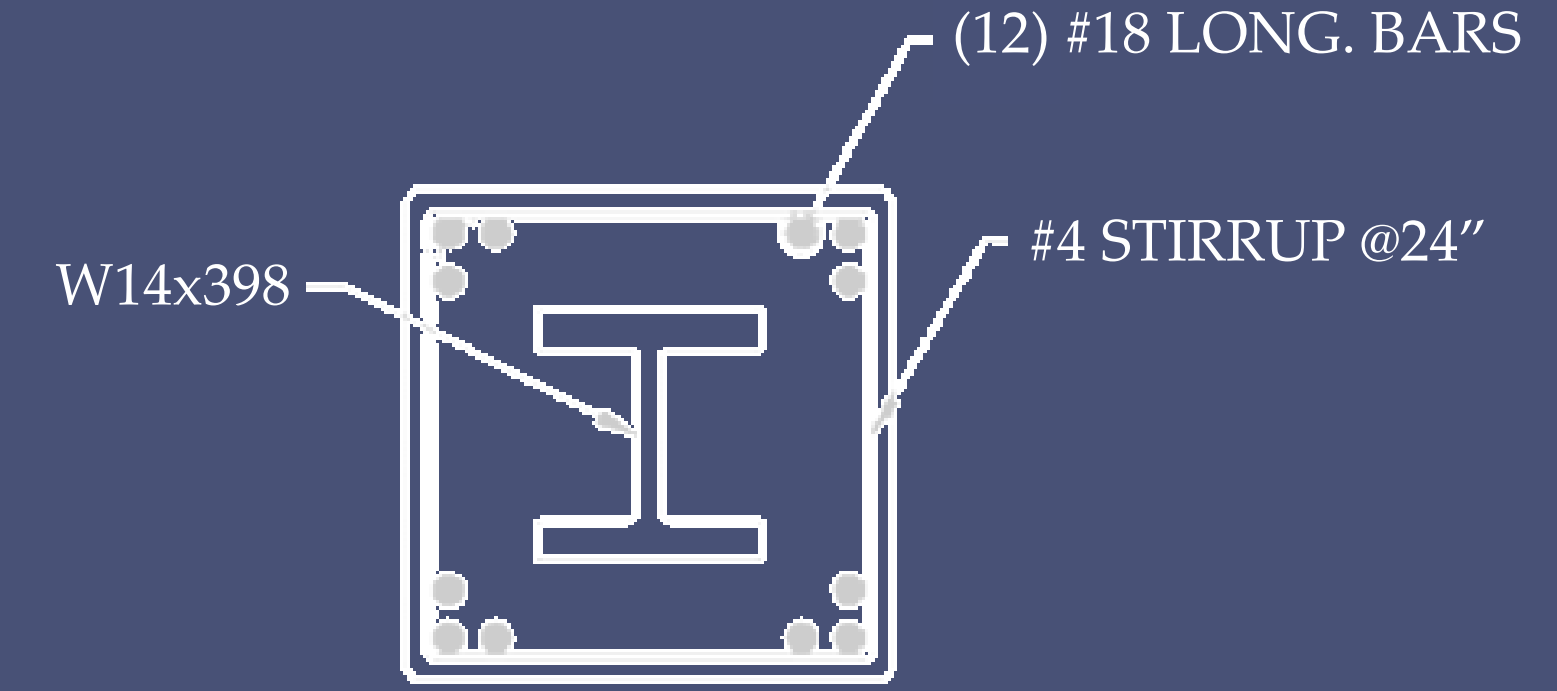
- Occupancy Category
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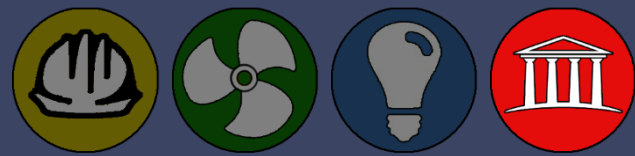
Interior View of Transfer Braces



Foundation and Parking Structure Section



Column Encased in Concrete Section



# IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System
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- Raised Access
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- Fire Protection
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**TABLE 12.12-1 ALLOWABLE STORY DRIFT,  $\Delta_d^{a,b}$**

Structure	Occupancy Category		
	I or II	III	IV
Structures, other than masonry shear wall structures, 4 stories or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts.	$0.025h_{xx}^c$	$0.020h_{xx}$	$0.015h_{xx}$
Masonry cantilever shear wall structures <sup>d</sup>	$0.010h_{xx}$	$0.010h_{xx}$	$0.010h_{xx}$
Other masonry shear wall structures	$0.007h_{xx}$	$0.007h_{xx}$	$0.007h_{xx}$
All other structures	$0.020h_{xx}$	$0.015h_{xx}$	$0.010h_{xx}$

<sup>a</sup> $h_{xx}$  is the story height below Level  $x$ .  
<sup>b</sup>For seismic force-resisting systems comprised solely of moment frames in Seismic Design Categories D, E, and F, the allowable story drift shall comply with the requirements of Section 12.12.1.1.  
<sup>c</sup>There shall be no drift limit for single-story structures with interior walls, partitions, ceilings, and exterior wall systems that have been designed to accommodate the story drifts. The structure separation requirement of Section 12.12.3 is not waived.  
<sup>d</sup>Structures in which the basic structural system consists of masonry shear walls designed as vertical elements cantilevered from their base or foundation support which are so constructed that moment transfer between shear walls (coupling) is negligible.

**2.3 COMBINING FACTORED LOADS USING STRENGTH DESIGN**

**2.3.1 Applicability.** The load combinations and load factors given in Section 2.3.2 shall be used only in those cases in which they are specifically authorized by the applicable material design standard.

**2.3.2 Basic Combinations.** Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations:

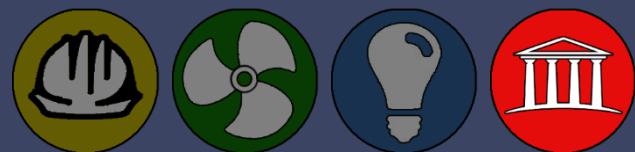
1.  $1.4(D + F)$
2.  $1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } S \text{ or } R)$
3.  $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.8W)$
4.  $1.2D + 1.6W + L + 0.5(L_r \text{ or } S \text{ or } R)$
5.  $1.2D + 1.0E + L + 0.2S$
6.  $0.9D + 1.6W + 1.6H$
7.  $0.9D + 1.0E + 1.6H$

Level	F <sub>x</sub> (kips)	M (kip-ft)
Roof	258.12	114603.37
30	194.45	83419.72
29	182.84	75695.71
28	171.53	68441.00
27	160.53	61643.12
26	153.02	56465.09
25	142.42	50417.00
24	132.14	44796.41
23	122.19	39590.04
22	115.81	35785.56
21	106.26	31239.88
20	97.05	27078.25
19	88.21	23286.27
18	80.14	19955.64
17	71.98	16842.28
16	64.18	14055.75
15	56.77	11580.62
14	51.01	9640.52
13	44.21	7692.35
12	37.82	6014.15
11	31.87	4588.70
10	26.59	3429.76
9	21.47	2447.39
8	16.82	1665.09
7	12.66	1063.25
6	9.45	652.03
5	6.18	333.92
Restaurant	0.58	10.52
Lobby	0.00	0
	<b>2456.3</b>	<b>812433.396</b>



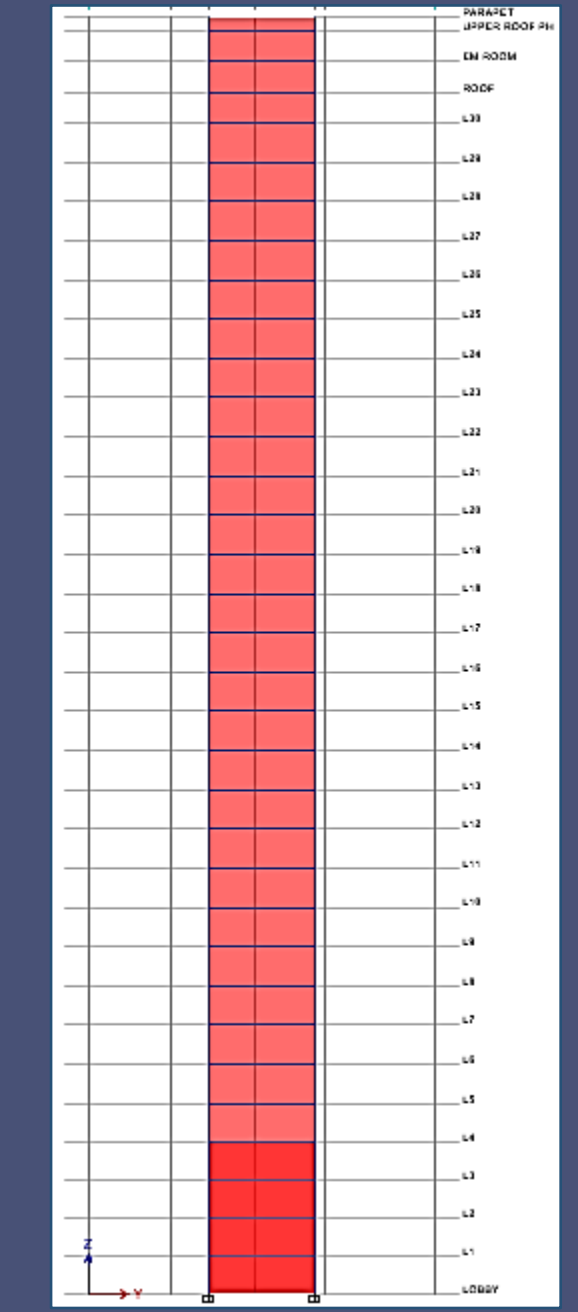
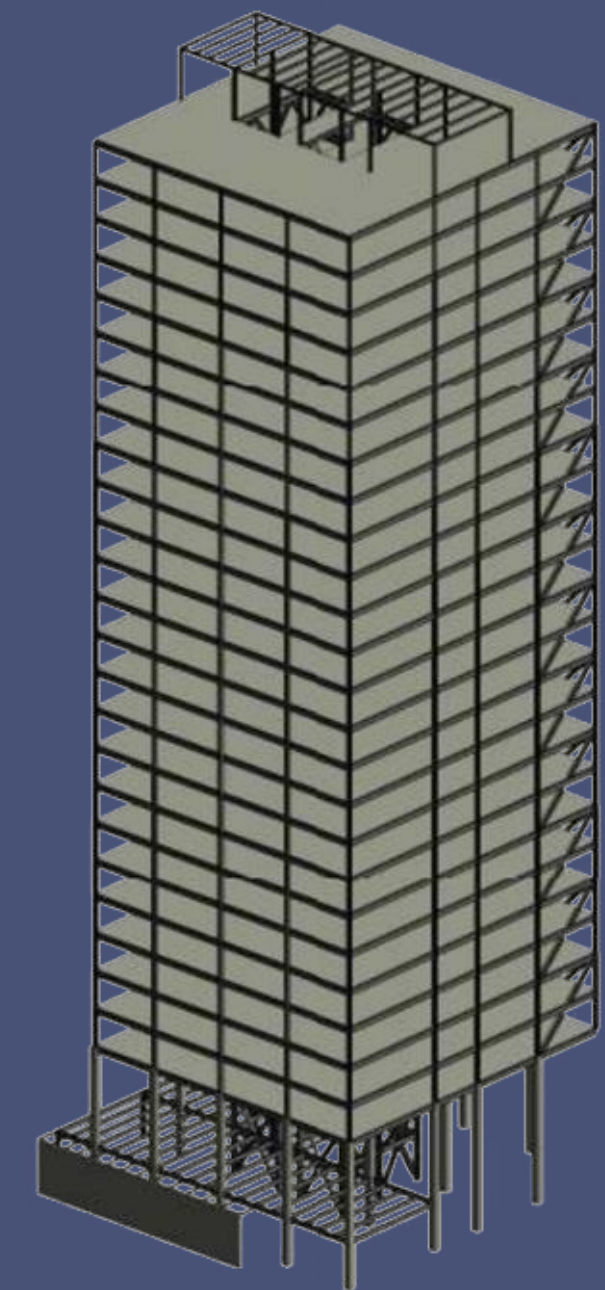
## Goals

- Immediate Occupancy
- Drift Limit ~ 41.5"
- Economic Design
- Strong Yet Ductile



## IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System
- Lateral System**
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection



### Concrete Complications:

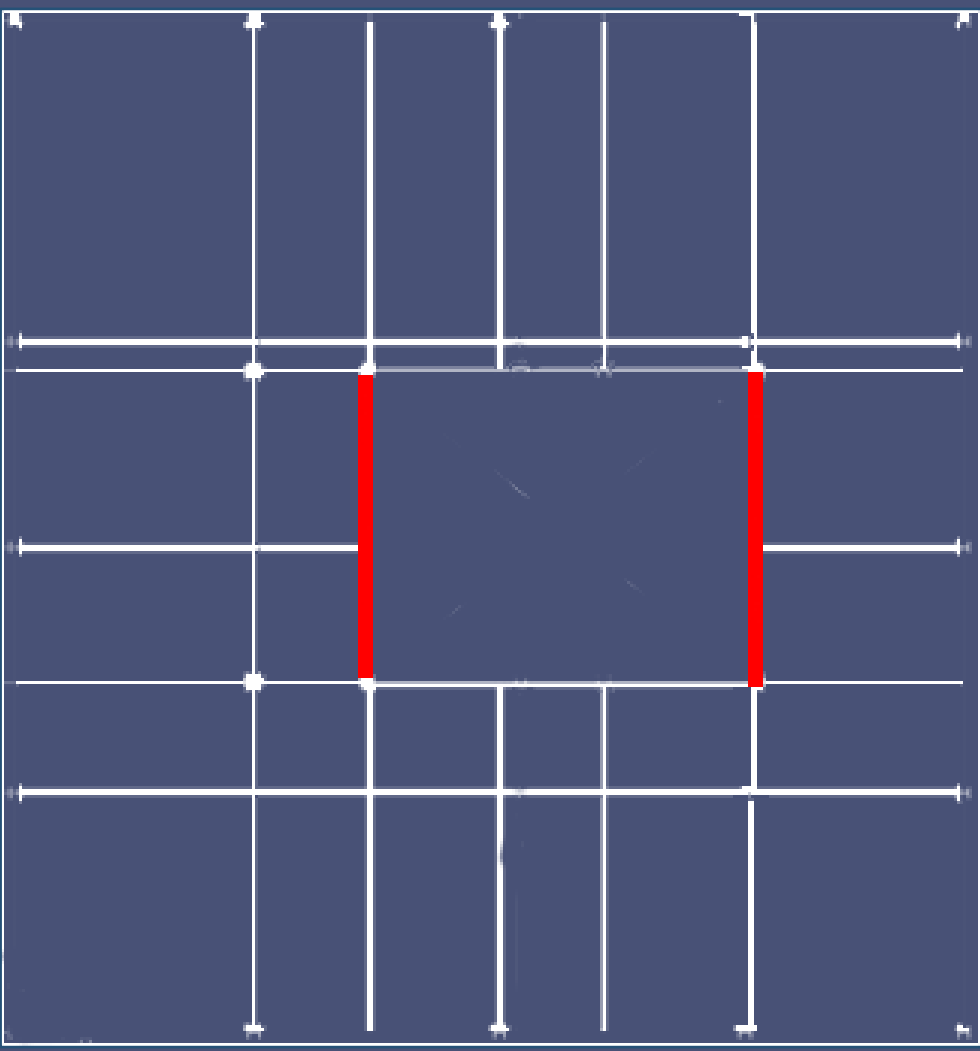
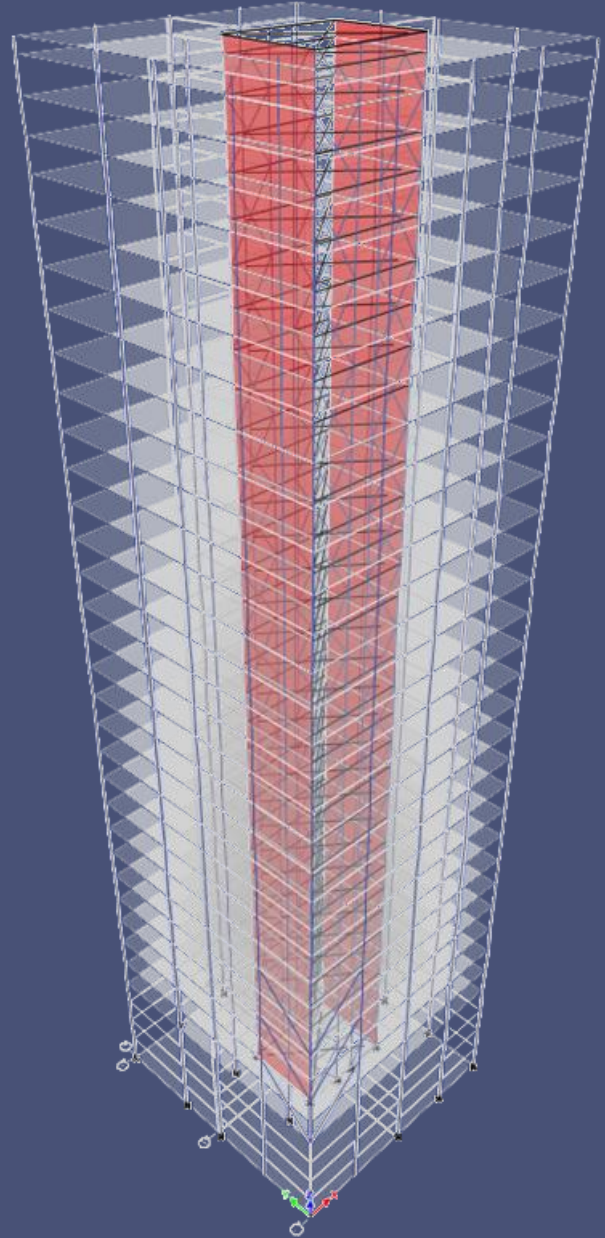
- Repair concerns
  - Immediate Occupancy
- System Clash
- Drift Limit Requirements





# IMMEDIATE OCCUPANCY

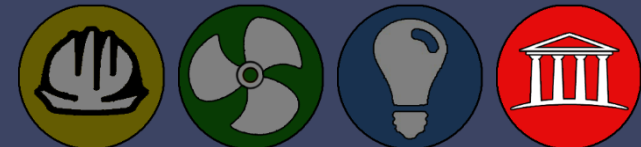
- Occupancy Category
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## SPSW Complications

- Stiffness too great
- Clashes with mechanical/electrical equipment
- Economics
- Reparability





## IMMEDIATE OCCUPANCY

Occupancy Category

Gravity System

**Lateral System**

Raised Access

Light Fixture Selection

Fire Protection

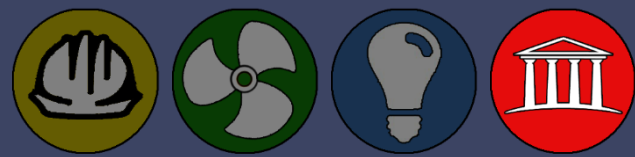
Electrical Distribution

Double Façade Connection

D. DUAL SYSTEMS WITH SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES	12.2.5.1								
1. Steel eccentrically braced frames	14.1	8	2½	4	NL	NL	NL	NL	NL
2. Special steel concentrically braced frames	14.1	7	2½	5½	NL	NL	NL	NL	NL
3. Special reinforced concrete shear walls	14.2	7	2½	5½	NL	NL	NL	NL	NL
4. Ordinary reinforced concrete shear walls	14.2	6	2½	5	NL	NL	NP	NP	NP
5. Composite steel and concrete eccentrically braced frames	14.3	8	2½	4	NL	NL	NL	NL	NL
6. Composite steel and concrete concentrically braced frames	14.3	6	2½	5	NL	NL	NL	NL	NL
7. Composite steel plate shear walls	14.3	7½	2½	6	NL	NL	NL	NL	NL
8. Special composite reinforced concrete shear walls with steel elements	14.3	7	2½	6	NL	NL	NL	NL	NL
9. Ordinary composite reinforced concrete shear walls with steel elements	14.3	6	2½	5	NL	NL	NP	NP	NP
10. Special reinforced masonry shear walls	14.4	5½	3	5	NL	NL	NL	NL	NL
11. Intermediate reinforced masonry shear walls	14.4	4	3	3½	NL	NL	NP	NP	NP
12. Buckling-restrained braced frame	14.1	8	2½	5	NL	NL	NL	NL	NL
13. Special steel plate shear walls	14.1	8	2½	6½	NL	NL	NL	NL	NL

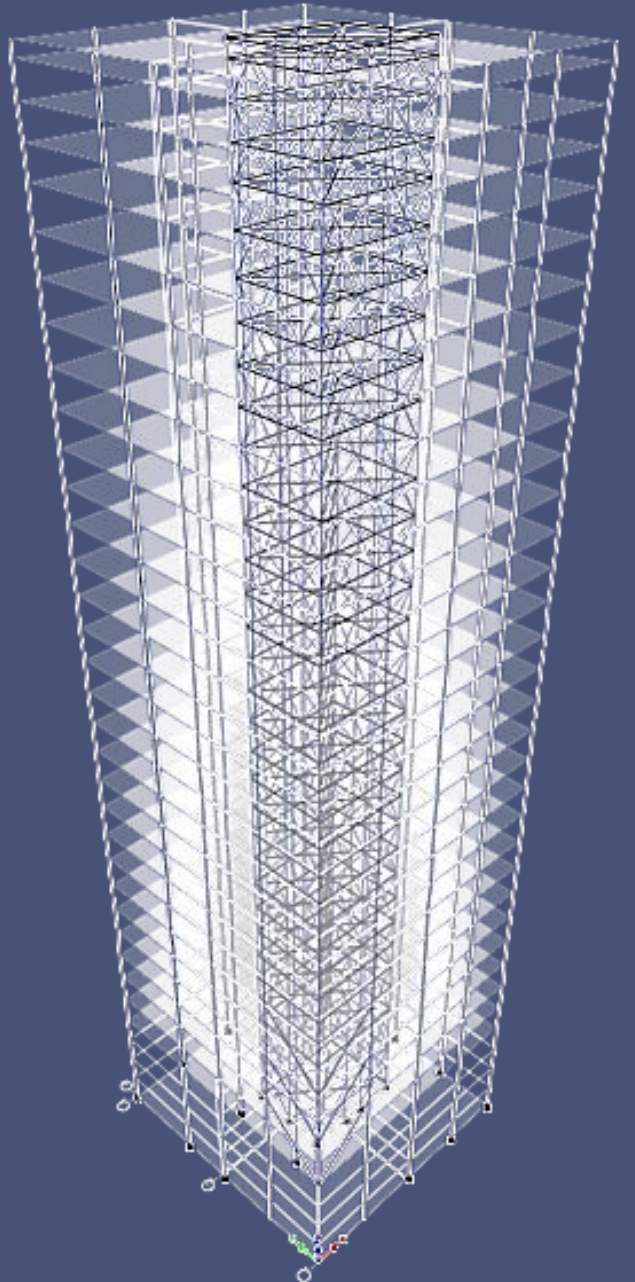
## Design Solutions

- W-shape construction for ductility
- Braced frame core to eliminate clashes
- Braced/moment frames allow for easy repair
- Immediate occupancy
- Economy
- Drift control

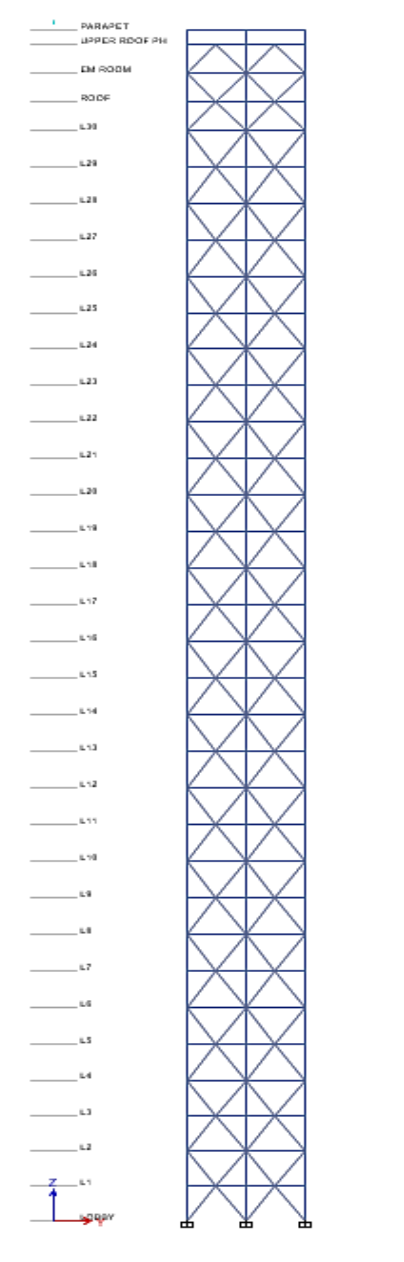


# IMMEDIATE OCCUPANCY

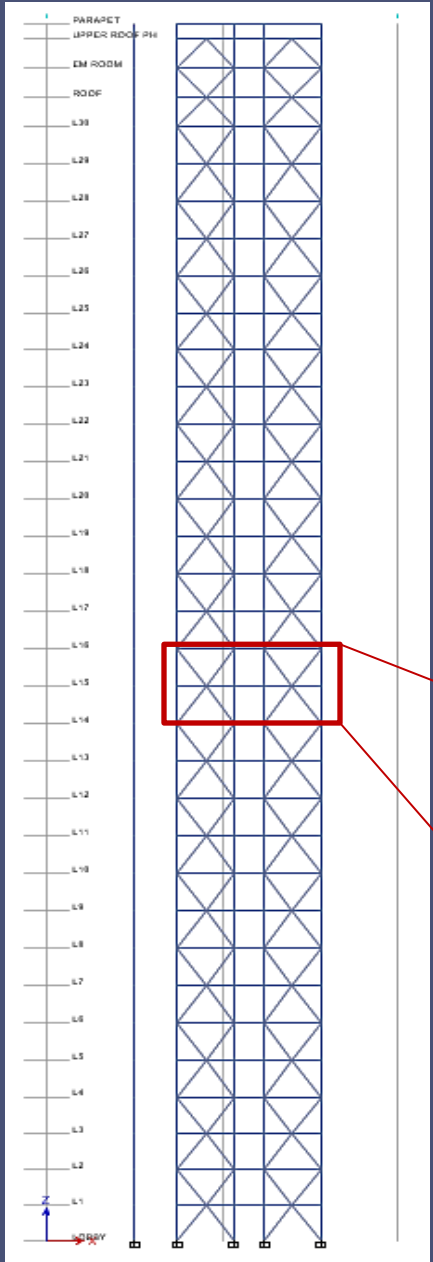
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Immediate Occupancy



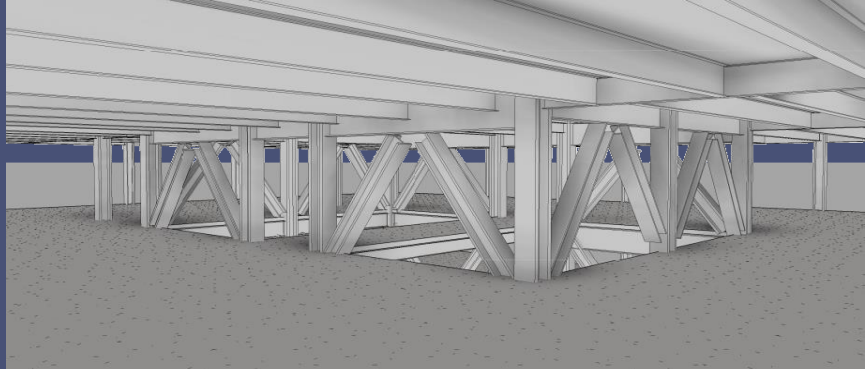
East and West



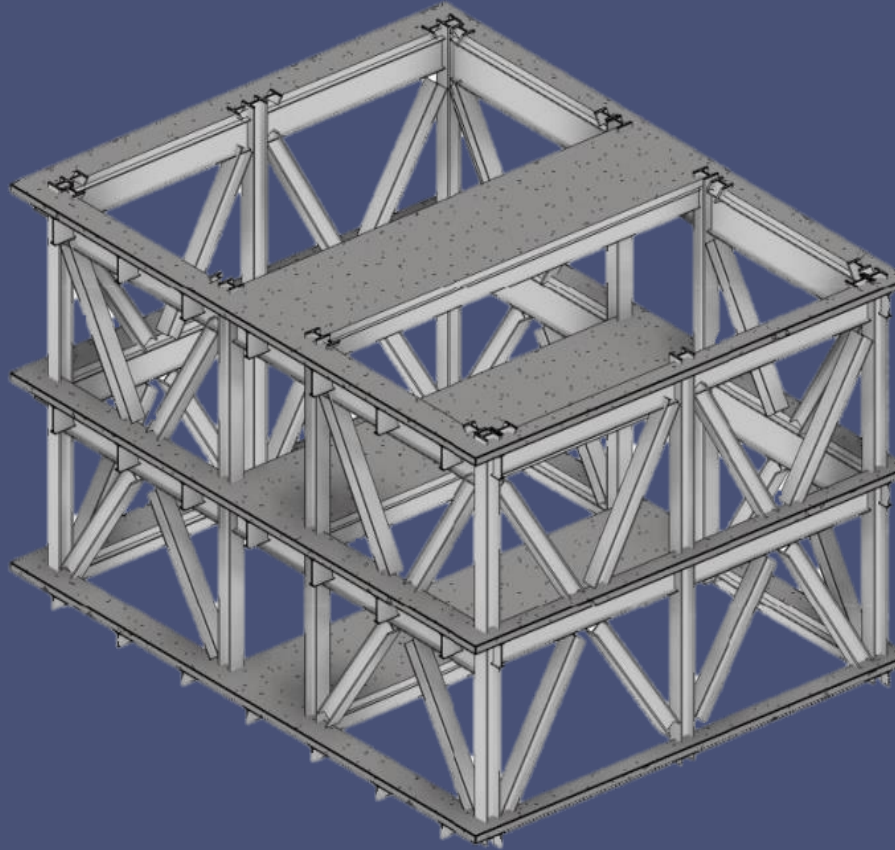
North and South

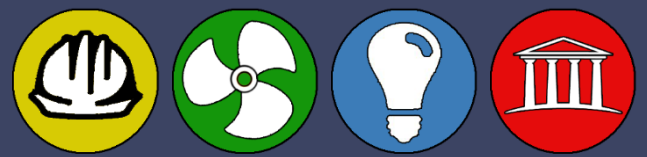
## Results:

- Iterative beam design – 36” beams 14” braces
- Drift achieved – 39.0”
- Revised ELF procedure



W14X193	W36X182	W36X182	W36X182	W14X193
W12X106	W12X106	W14X193	W12X106	W14X193
W12X96	W36X182	W36X182	W36X182	W14X193
W12X106	W12X106	W14X193	W12X106	W14X193





## IMMEDIATE OCCUPANCY

Occupancy Category

Gravity System

Lateral System

**Raised Access**

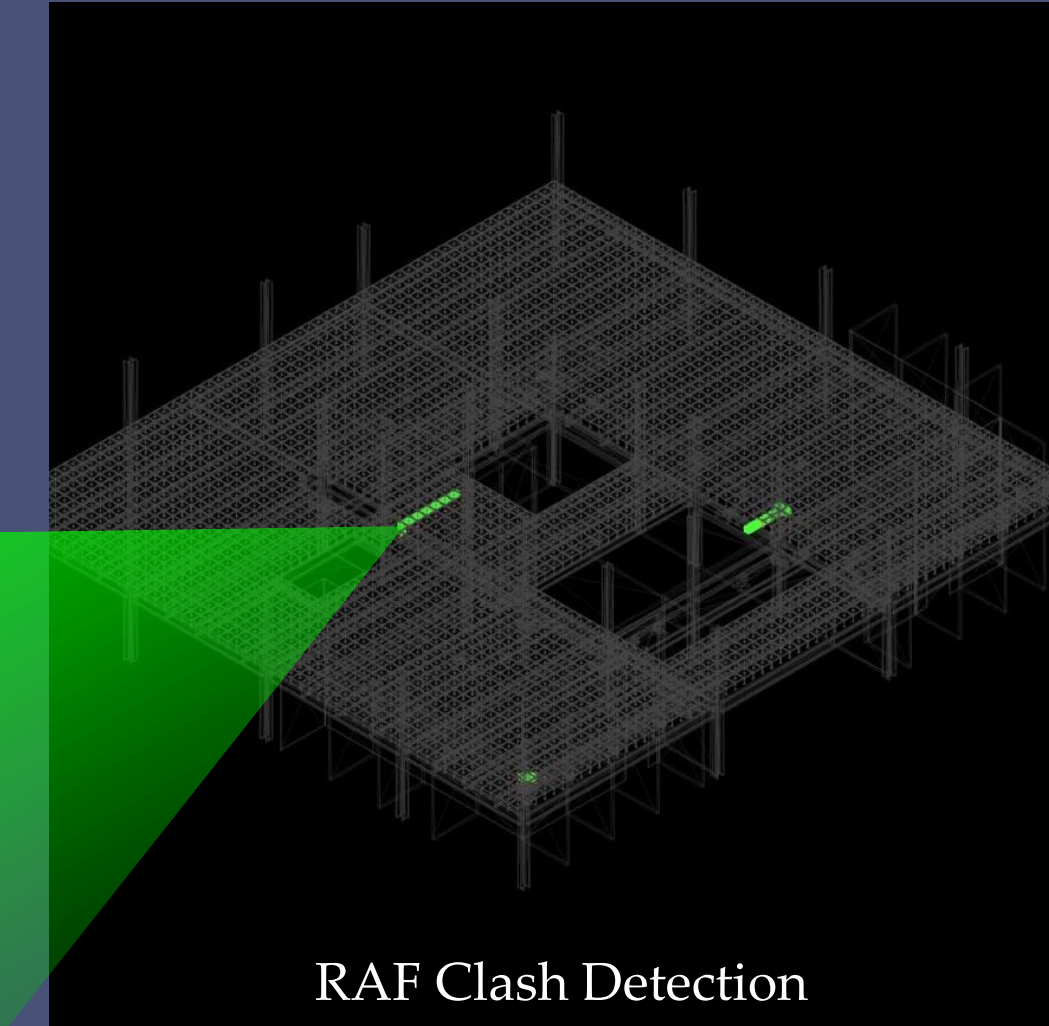
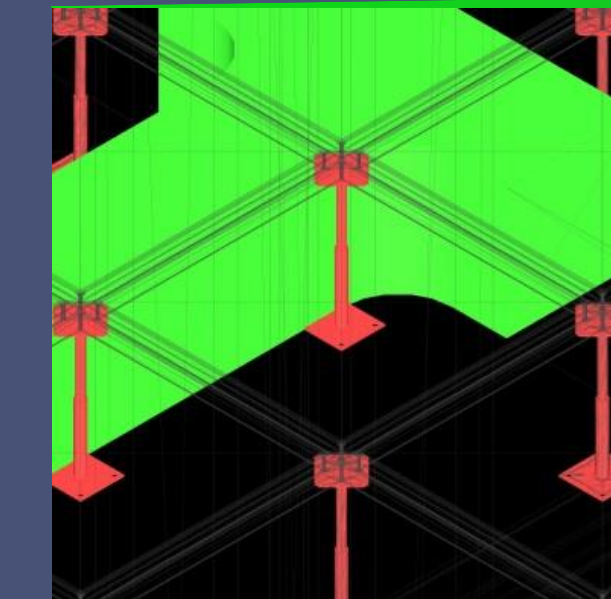
Light Fixture Selection

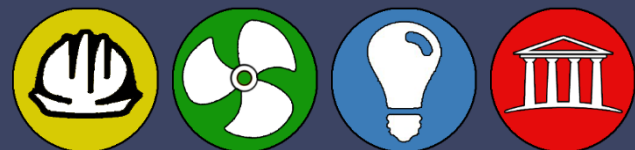
Fire Protection

Electrical Distribution

Double Façade Connection

- 1 Raised Access Floor (RAF)
- 2 Data Cable Tray
- 3 Supply Air Duct
- 4 Seismic Bracing
- 5 Supply Diffuser

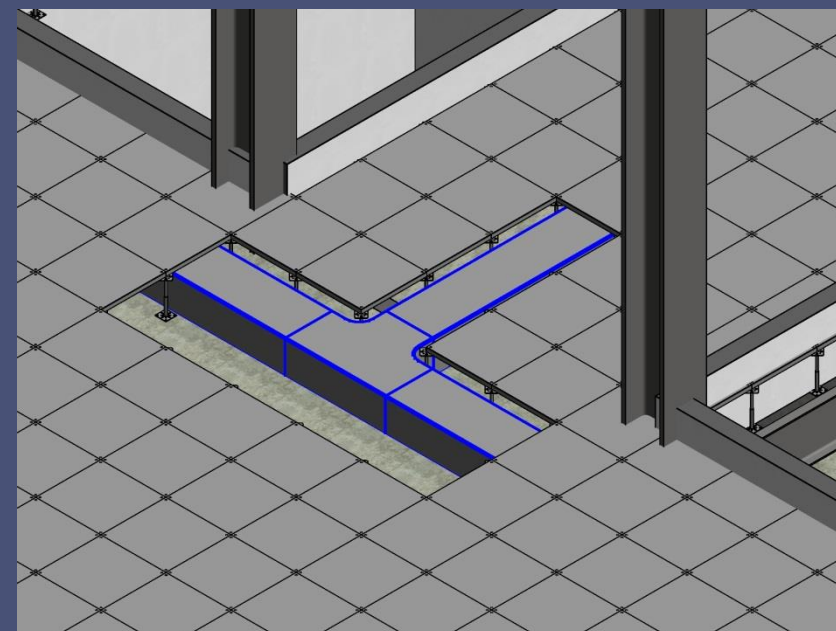




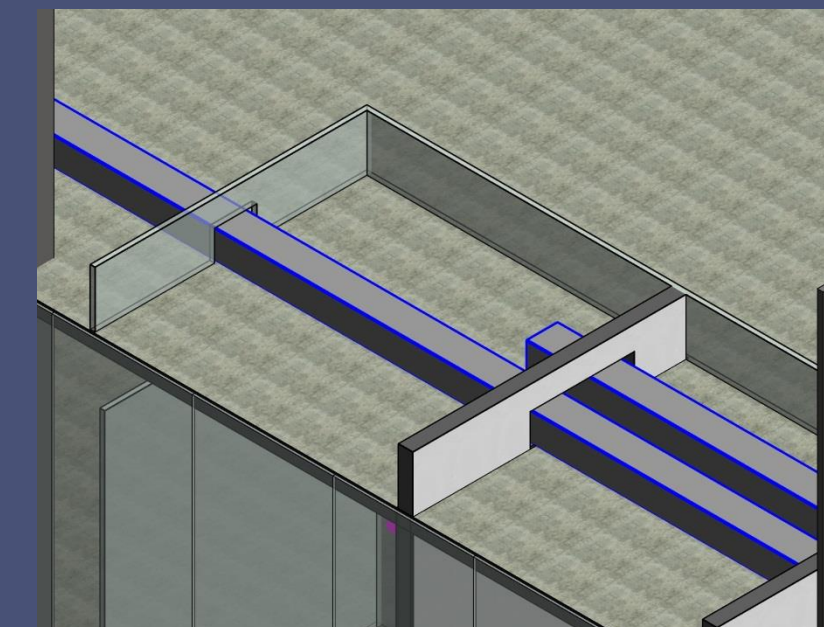
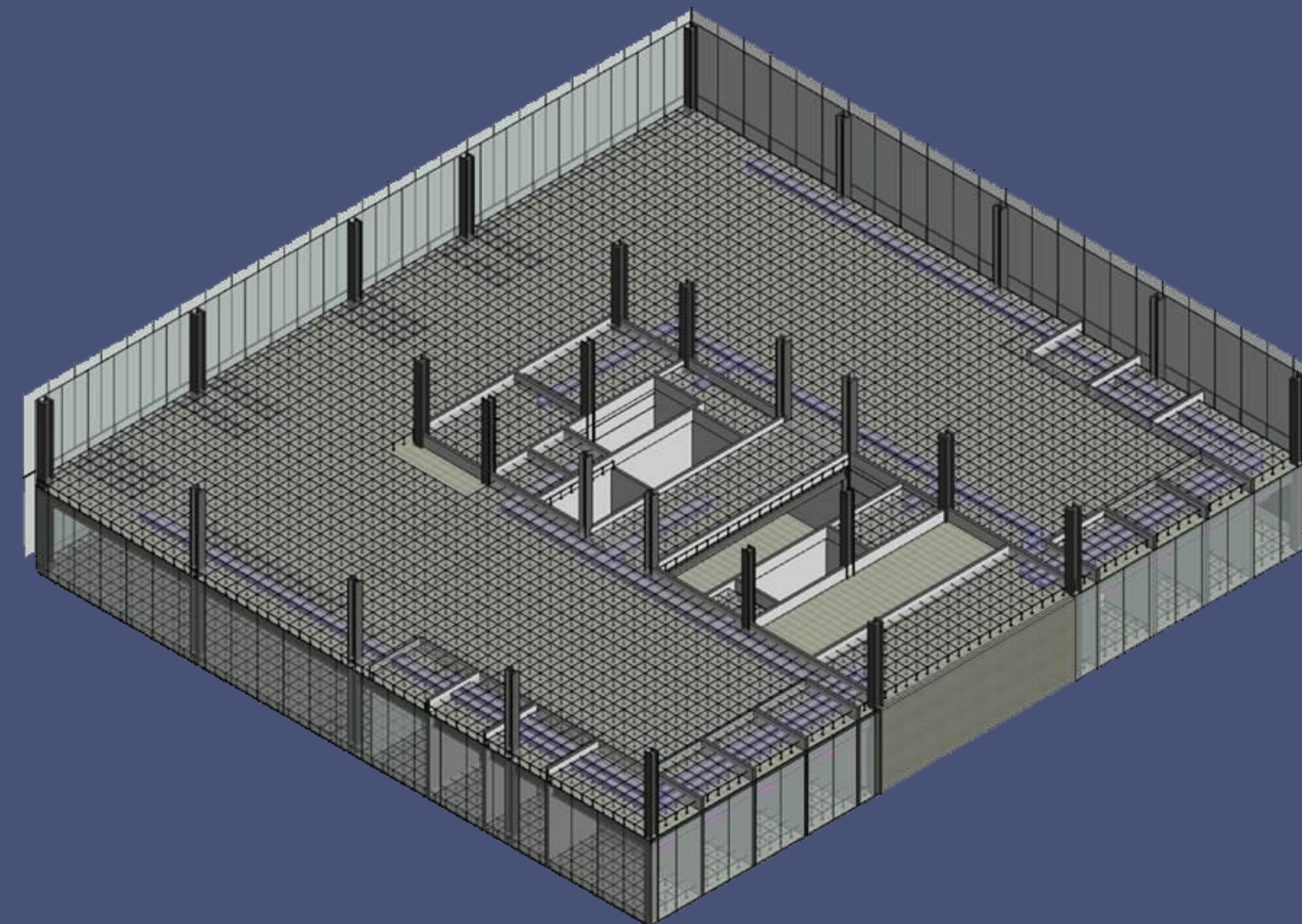
## IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System
- Lateral System
- Raised Access**
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection

# SUPPLY DUCT COORDINATION

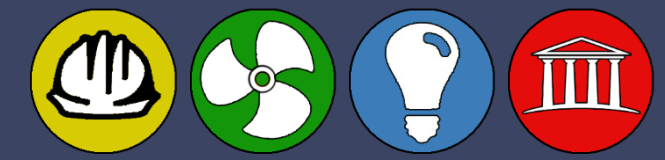


**Raised Access Floor**



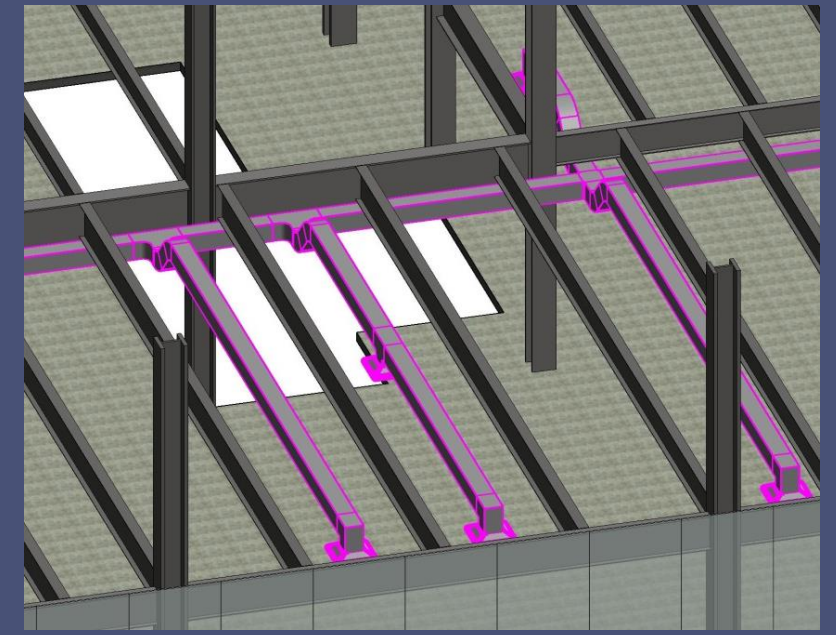
**Wall Cutouts**

# RETURN DUCT COORDINATION

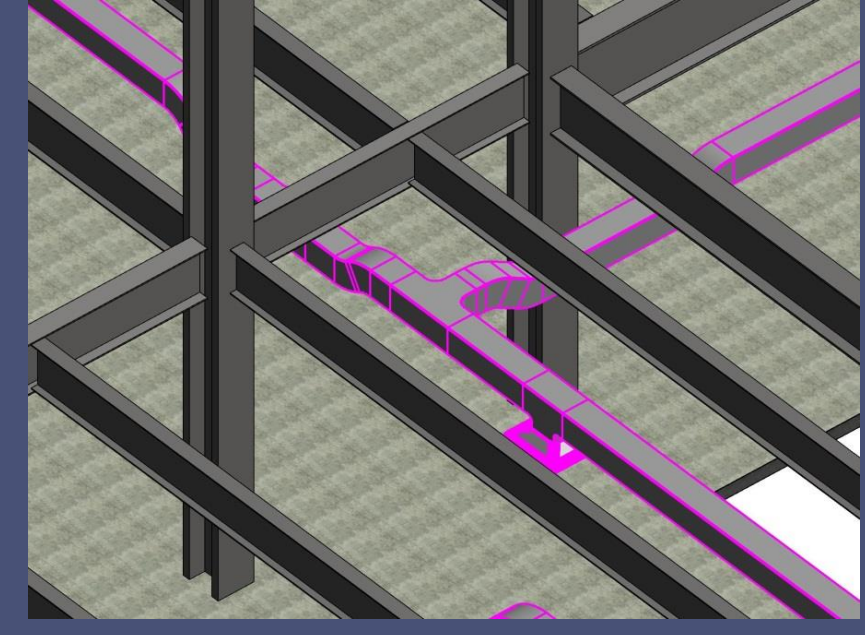
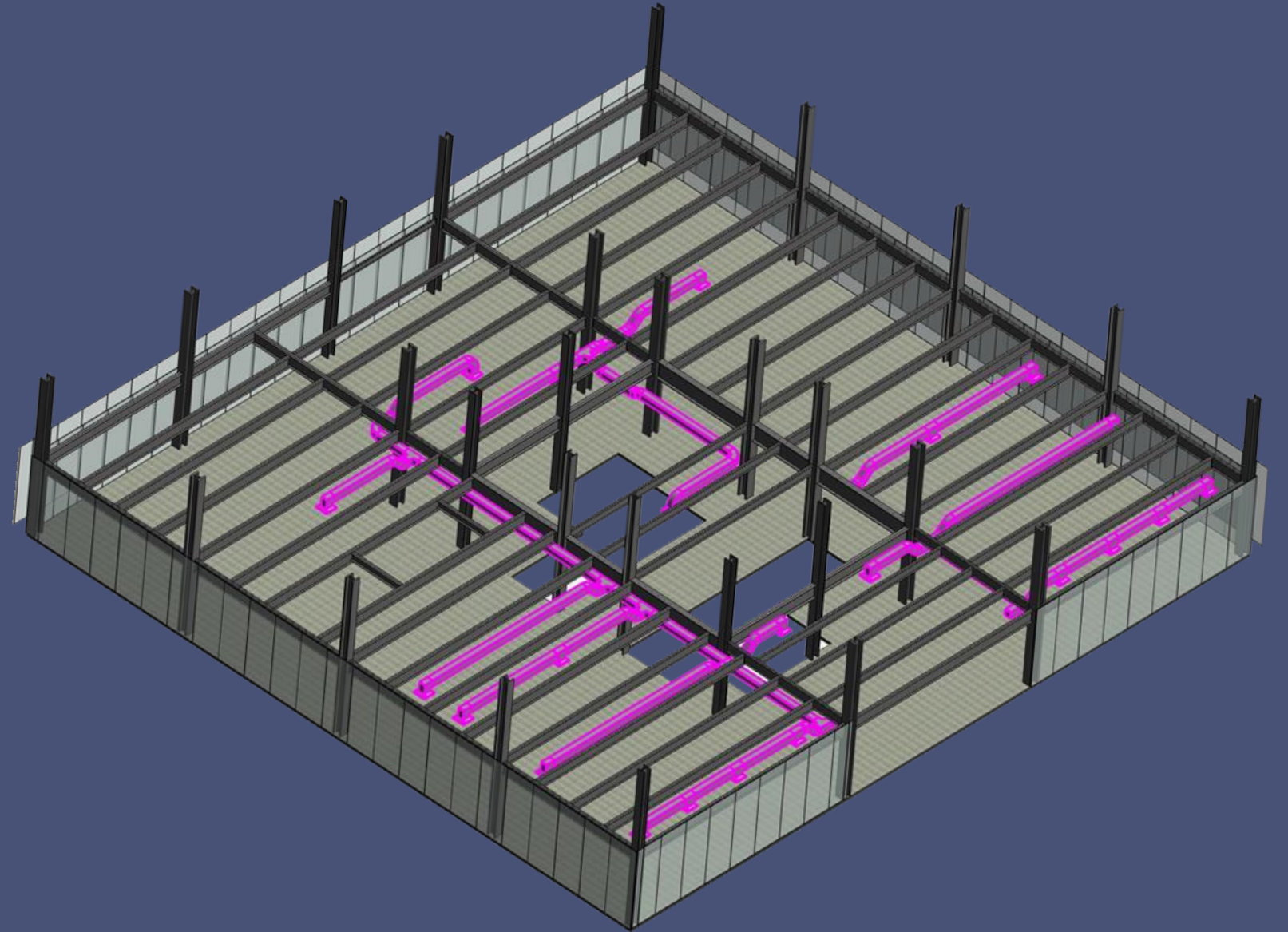


## IMMEDIATE OCCUPANCY

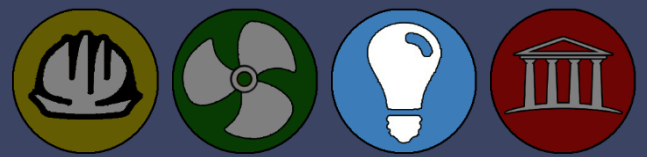
- Occupancy Category
- Gravity System
- Lateral System
- Raised Access**
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection



Gravity System

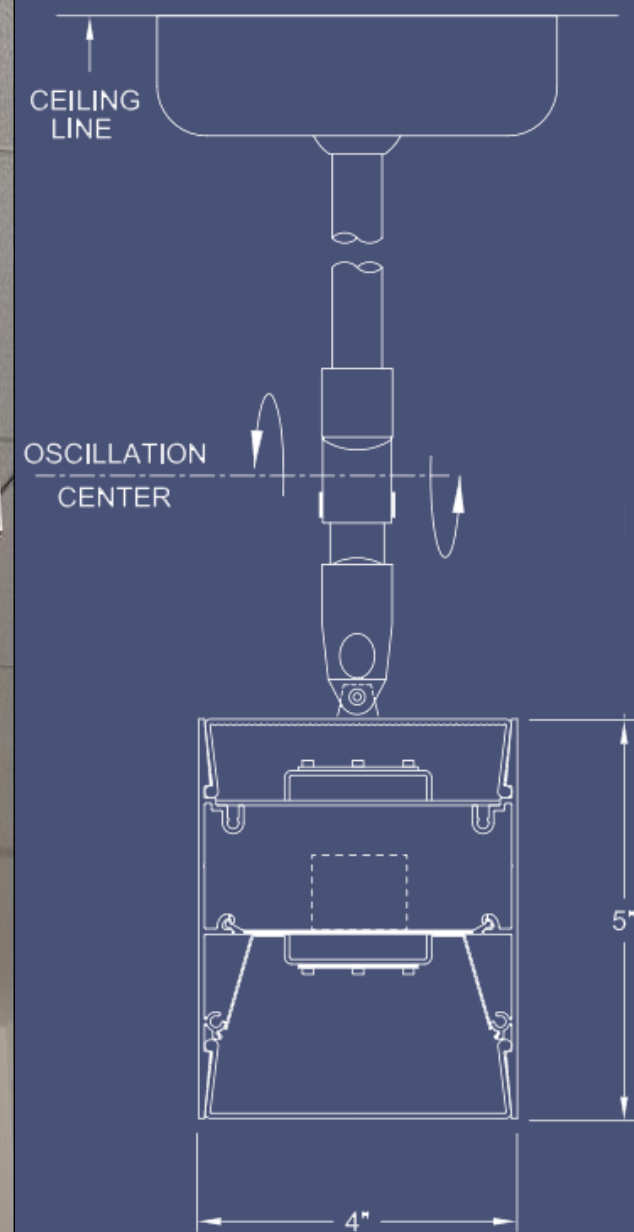


Core



# IMMEDIATE OCCUPANCY

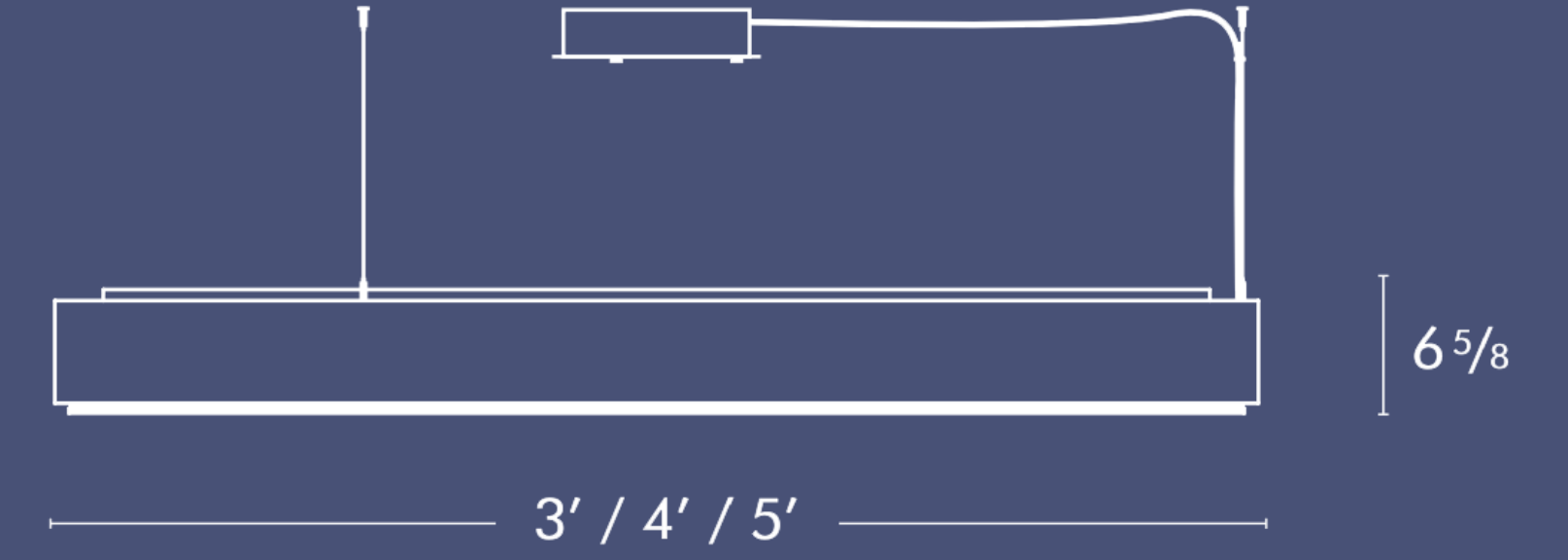
- Occupancy Category
- Gravity System
- Lateral System
- Raised Access
- Light Fixture Selection**
- Fire Protection
- Electrical Distribution
- Double Façade Connection

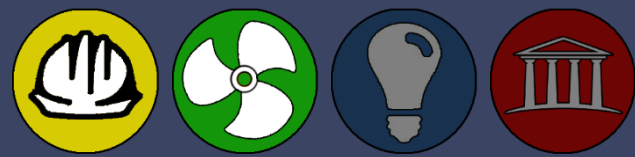


Fixture Type A, Gammalux  
CA Specific Earthquake resistant fittings for stem mounted applications

Fixture Type E and Types M-1 and M-2  
Aircraft cable suspension to allow for motion in case of seismic events

Recessed Light Fixtures Throughout



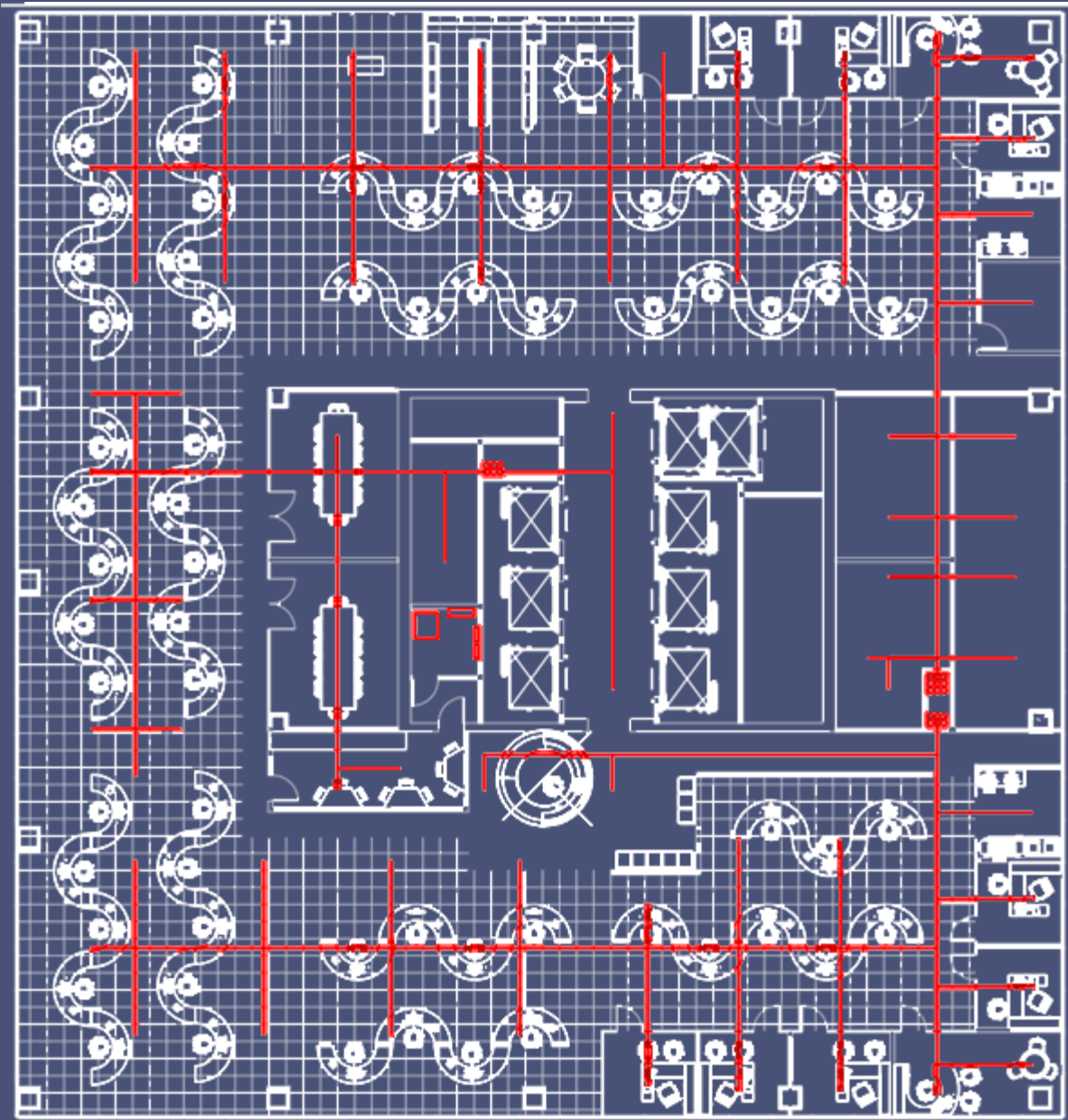


# IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection**
- Electrical Distribution
- Double Façade Connection



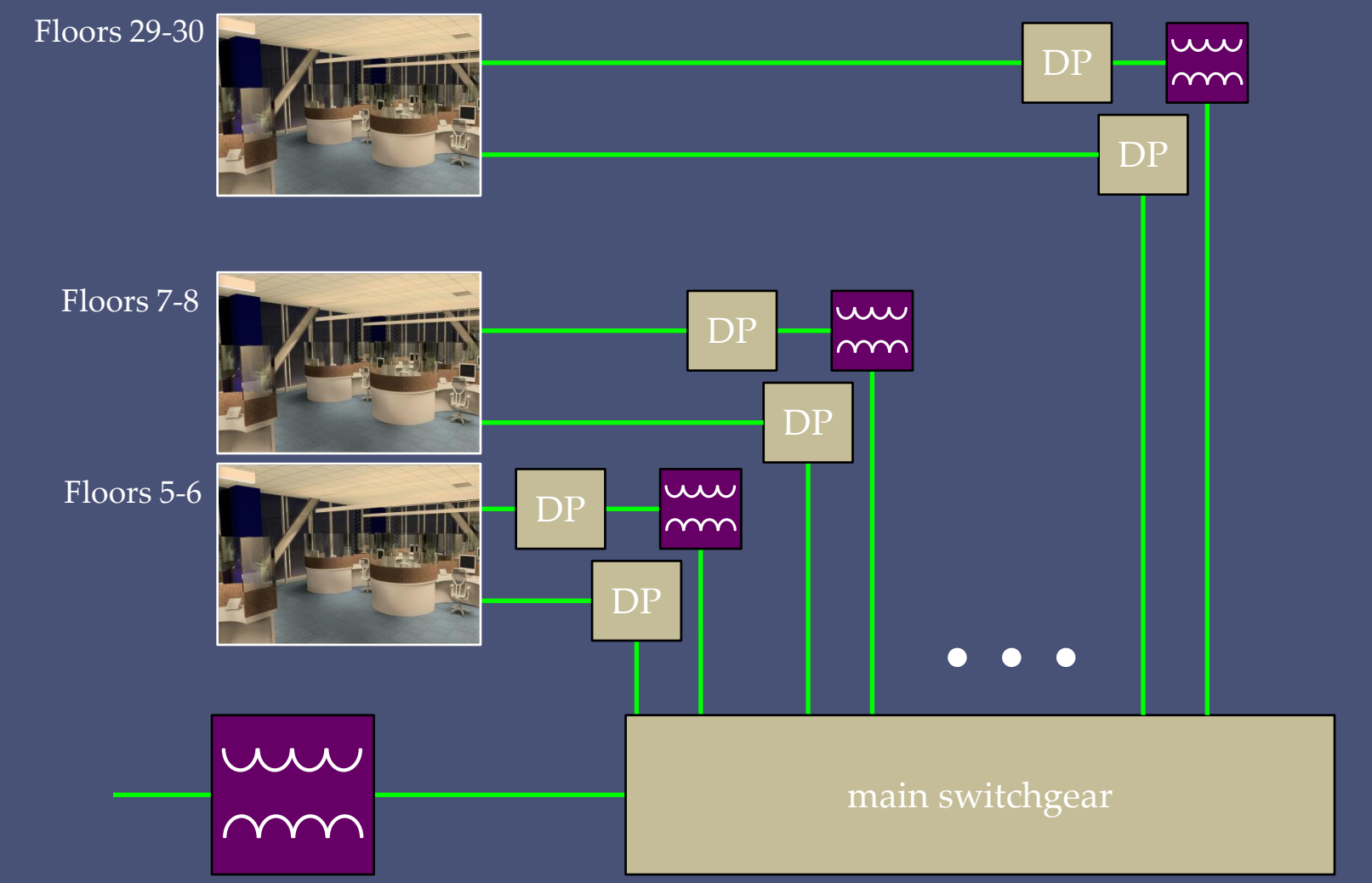
<b>Cost Difference</b>	
Traditional:	\$3.4 million
Gas:	\$7.5 million
<b>Down Time</b>	
Traditional:	Weeks
Gas:	None
<b>Damage Costs</b>	
Traditional:	~\$5.5 million
Gas:	\$0
<b>Total Cost:</b>	
Traditional:	<b>\$8.9 + loss of time(millions more potentially)</b>
Gas:	<b>\$7.5 million</b>





# IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution**
- Double Façade Connection

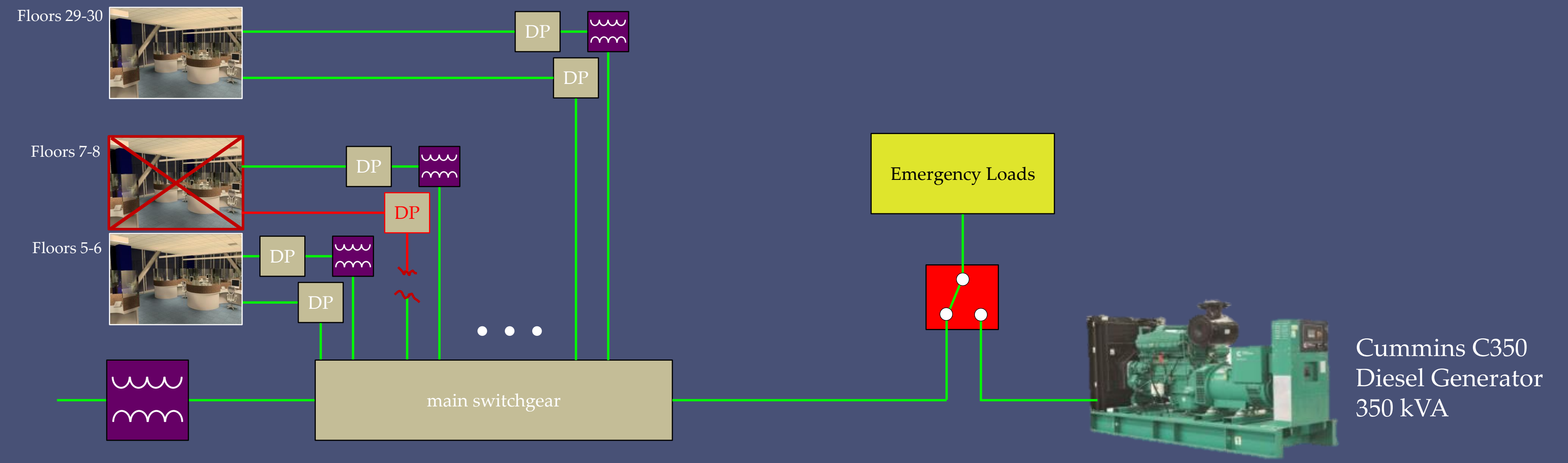


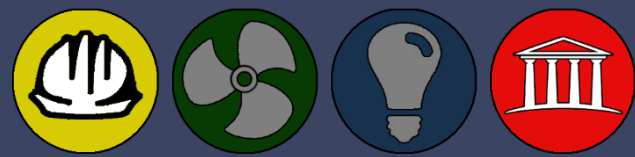




# IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution**
- Double Façade Connection



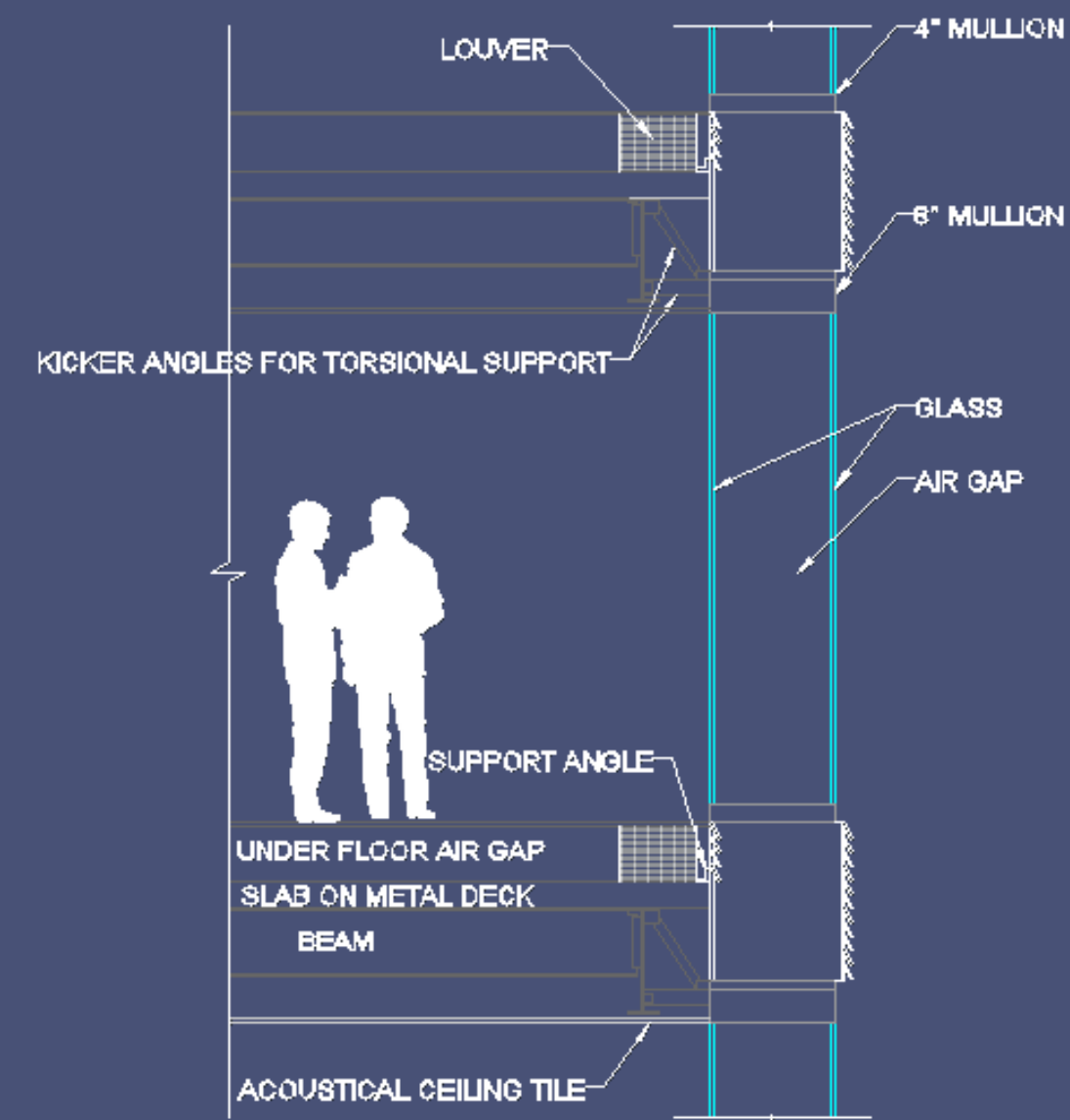


# IMMEDIATE OCCUPANCY

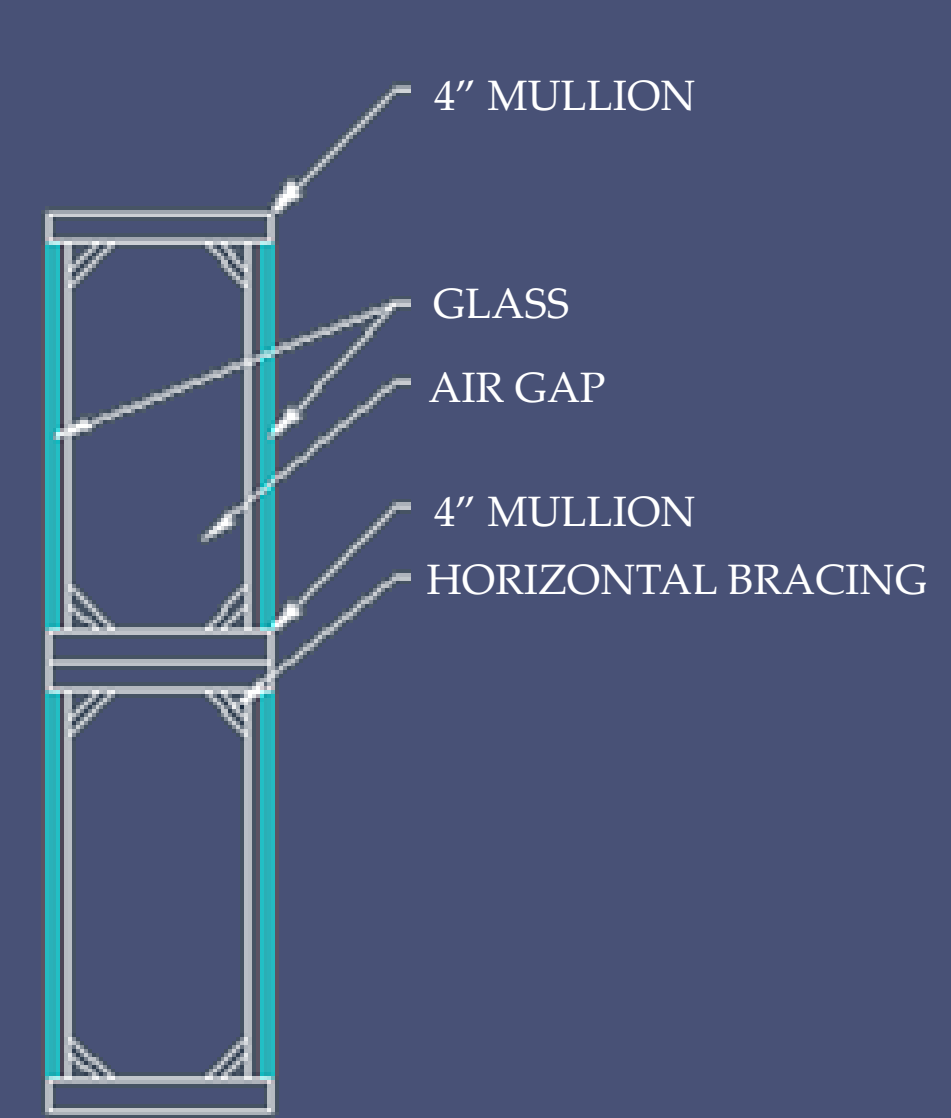
- Occupancy Category
- Gravity System
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection**

## Design:

- Heavy loads due to extra layer of glass, added steel grating, and structural framing
- Specially braced for seismic stability

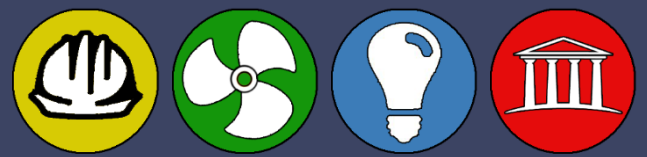


Section Detail  
(Person Shown 6'3")



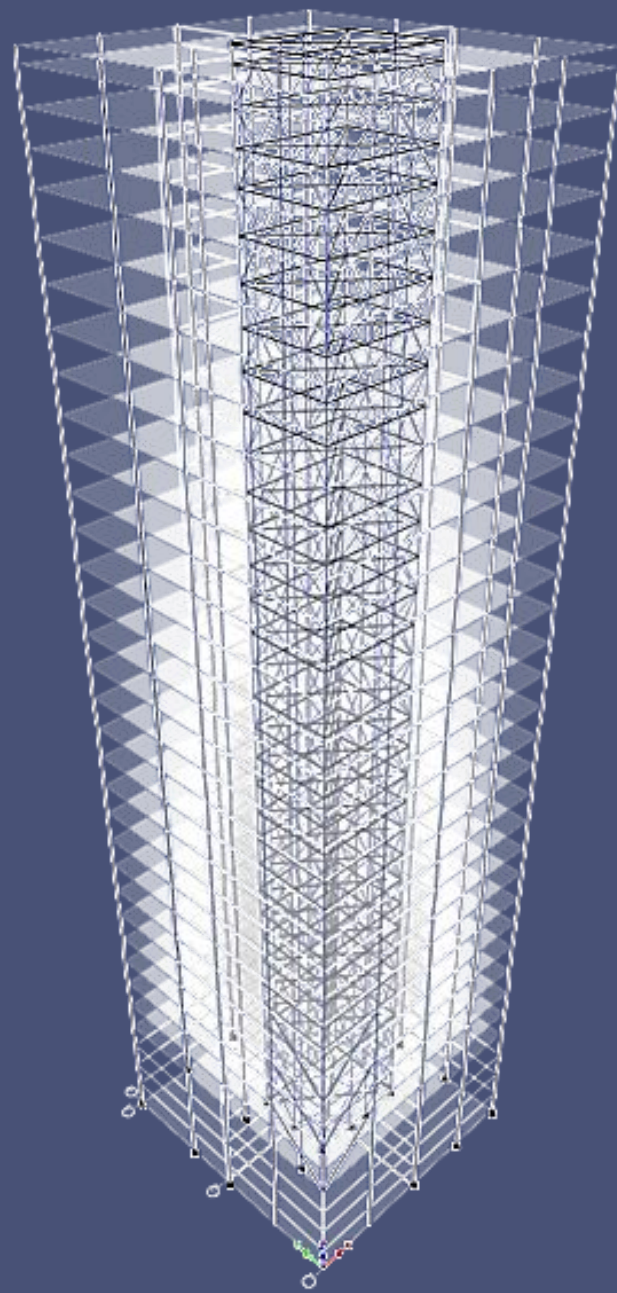
Elevation Section Detail





## IMMEDIATE OCCUPANCY

- Occupancy Category
- Gravity System
- Lateral System
- Raised Access
- Light Fixture Selection
- Fire Protection
- Electrical Distribution
- Double Façade Connection**



By utilizing these strategies and building systems, our team was able to minimize the personal and financial danger of a potential seismic event.





# NEAR NET-ZERO ENERGY

## Energy Reduction

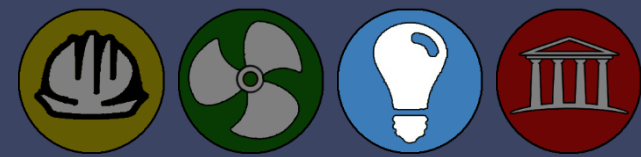
- Lighting Savings
- Double Façade
- Air Distribution

## Energy Production

- Photovoltaic
- CHP / Algae

## Additional

## Summary / Results



NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

Double Façade

Air Distribution

Energy Production

Photovoltaic

CHP / Algae

Additional

Summary / Results



Transition



Immediate Occupancy

# LIGHTING DESIGN CONCEPT

“Use geometry to define areas of transition and create places of congregation, while producing an aesthetically pleasing lighting design”

Near Net-Zero Energy



Congregation

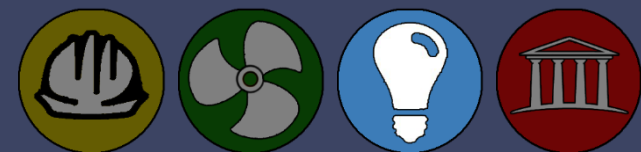


Construction

Achievements



Introduction



NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

Double Façade

Air Distribution

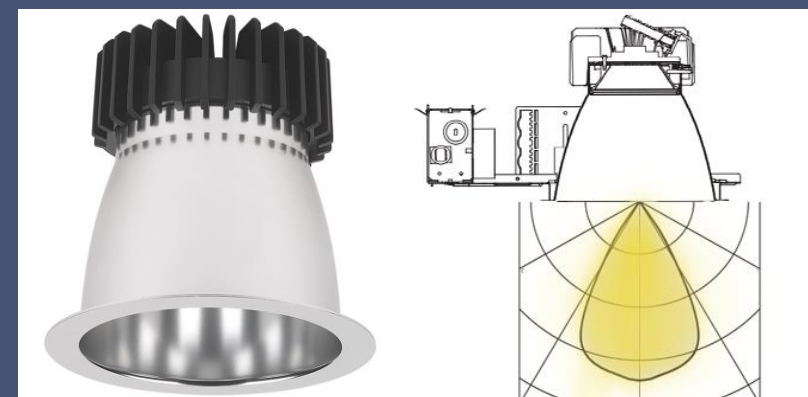
Energy Production

Photovoltaic

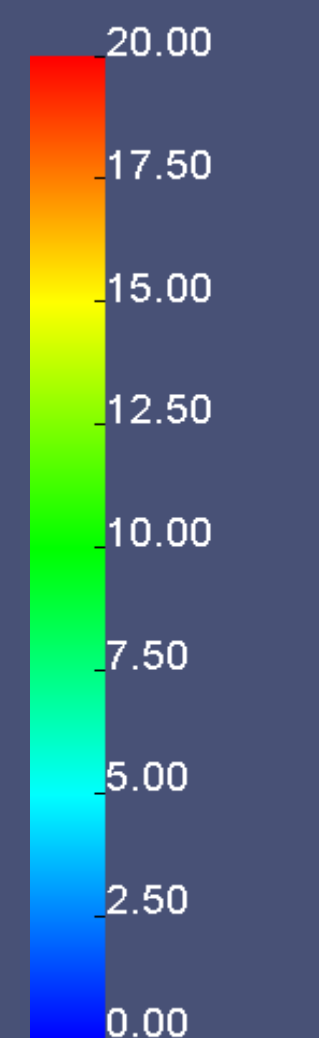
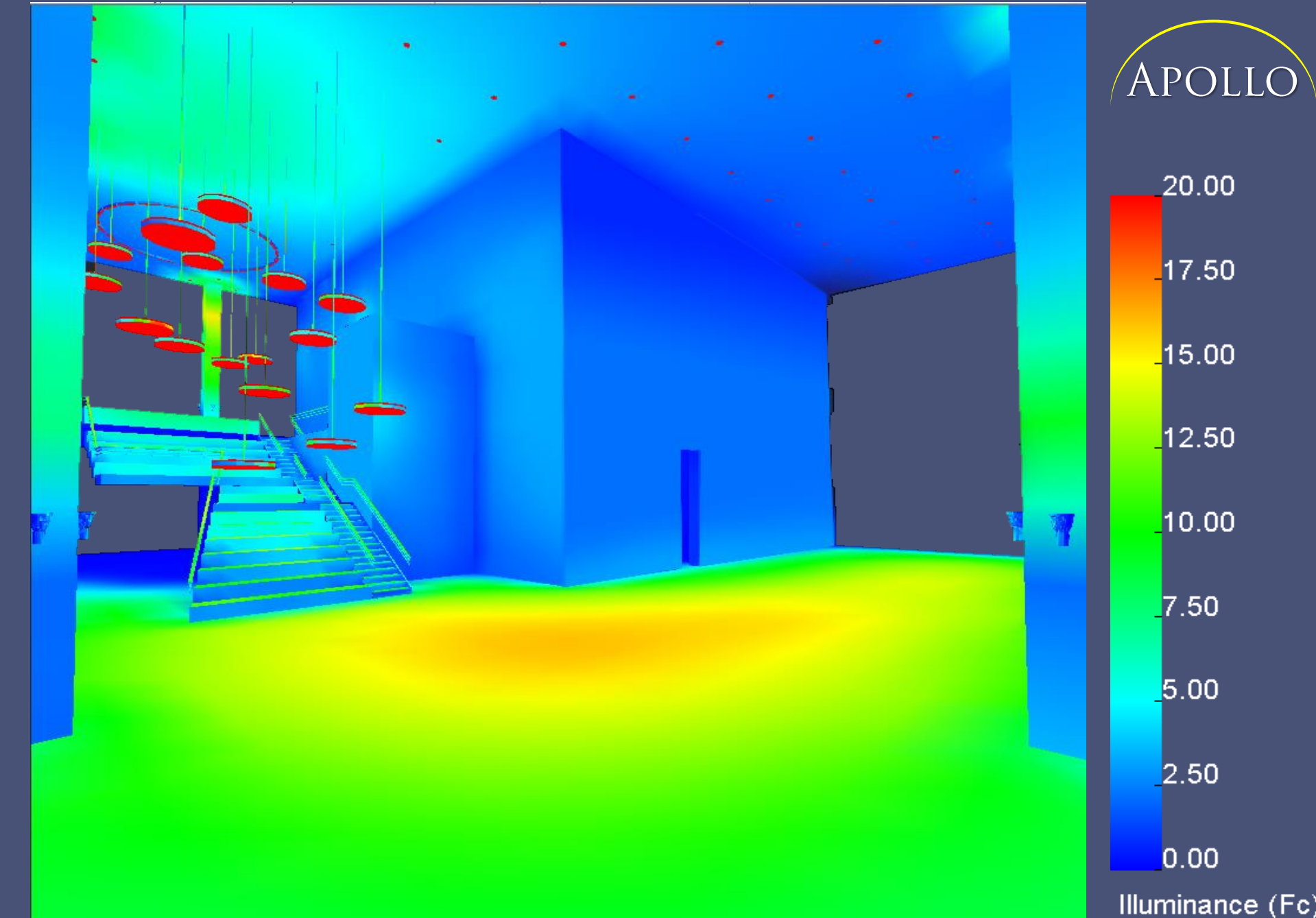
CHP / Algae

Additional

Summary / Results



# LOBBY LIGHTING DESIGN



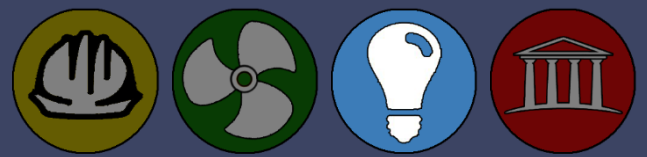
Introduction

Immediate Occupancy

**Near Net-Zero Energy**

Construction

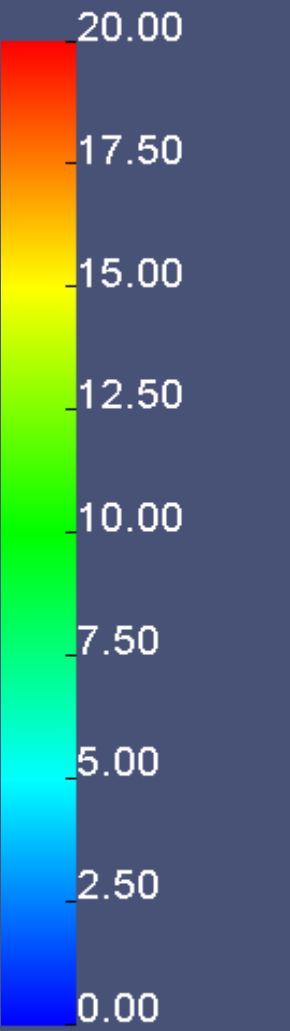
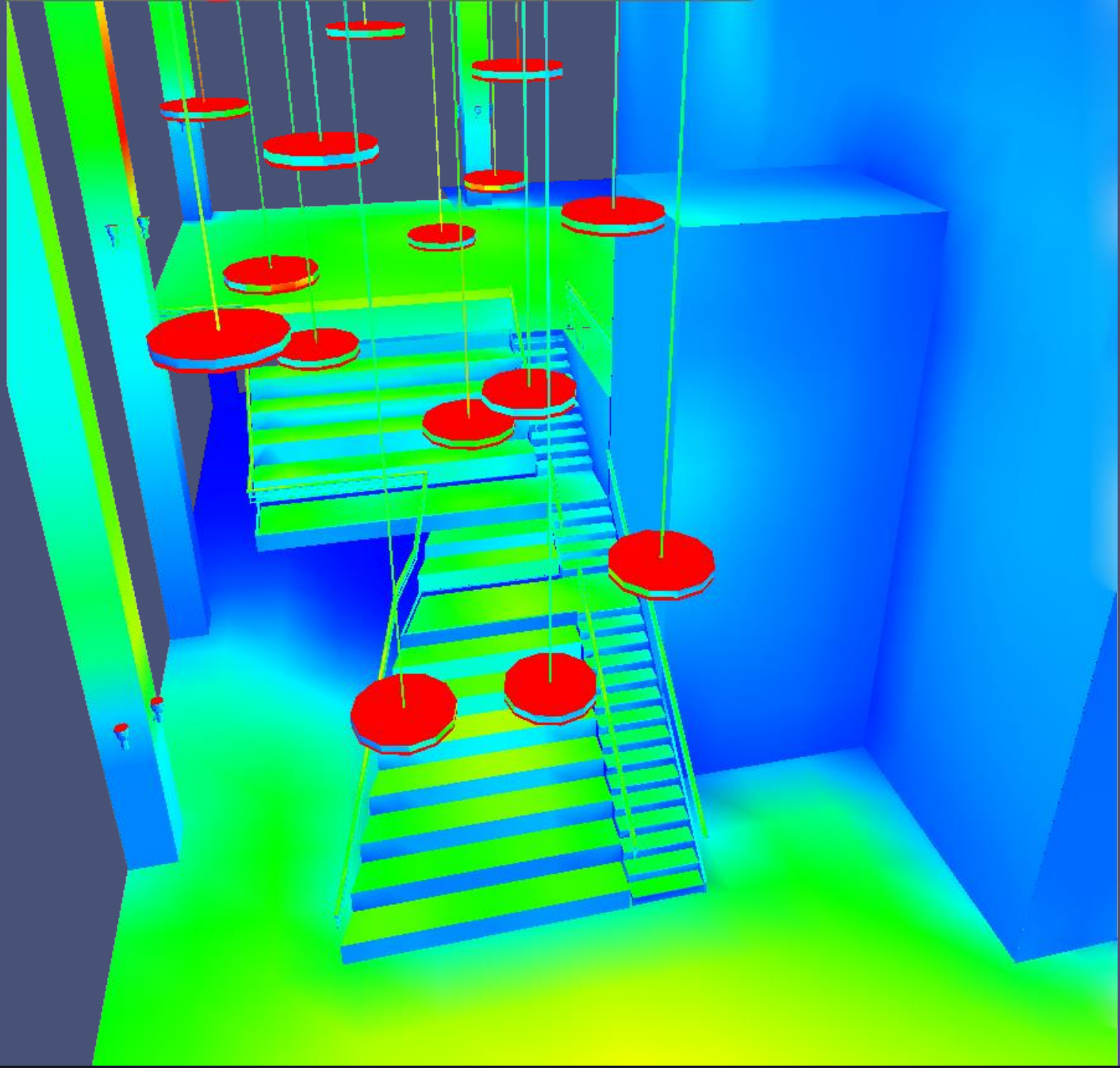
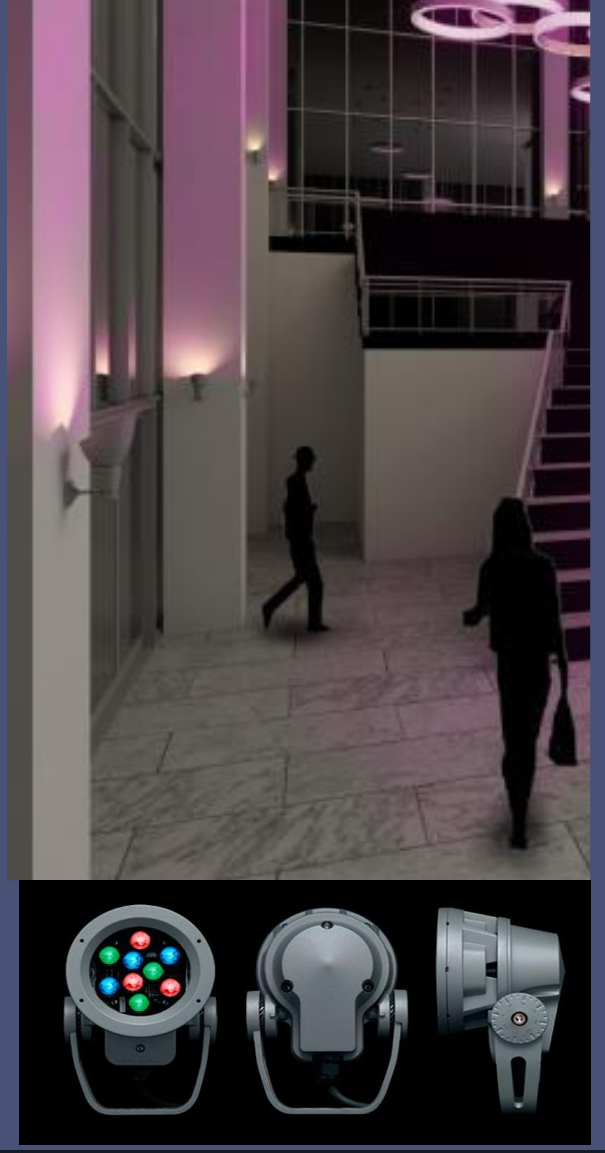
Achievements



# NEAR NET-ZERO ENERGY

- Energy Reduction**
- Lighting Savings
- Double Façade
- Air Distribution
- Energy Production
- Photovoltaic
- CHP / Algae
- Additional
- Summary / Results

# LOBBY LIGHTING DESIGN



Illuminance (Fc)

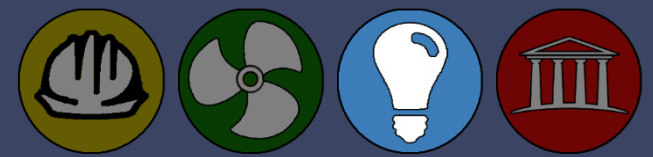
Introduction

Immediate Occupancy

Near Net-Zero Energy

Construction

Achievements



# NEAR NET-ZERO ENERGY

## Energy Reduction

Lighting Savings

Double Façade

Air Distribution

Energy Production

Photovoltaic

CHP / Algae

Additional

Summary / Results

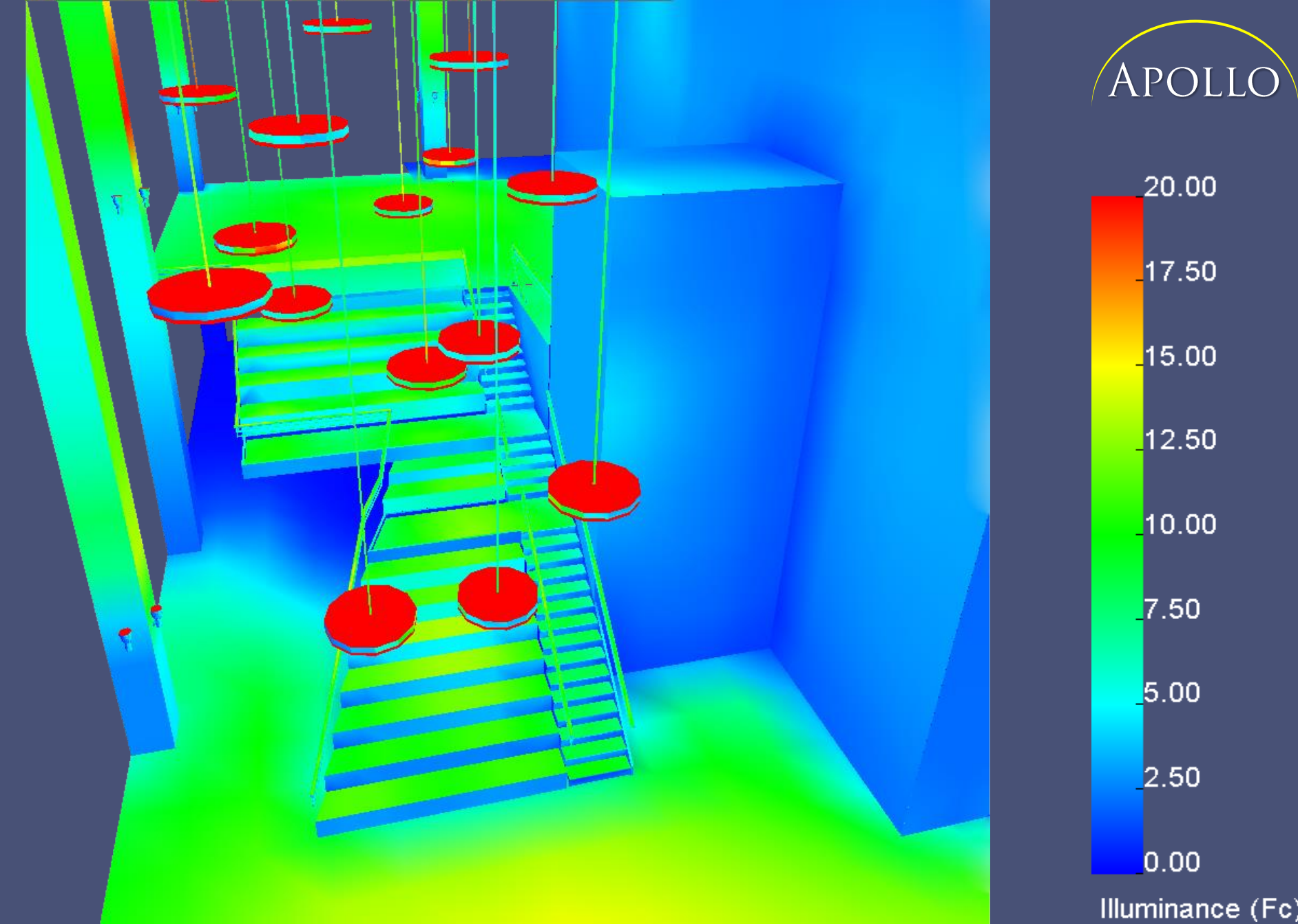


Immediate Occupancy

# LOBBY LIGHTING DESIGN



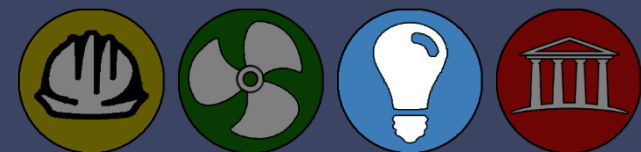
Near Net-Zero Energy



Construction

Achievements





NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

Double Façade

Air Distribution

Energy Production

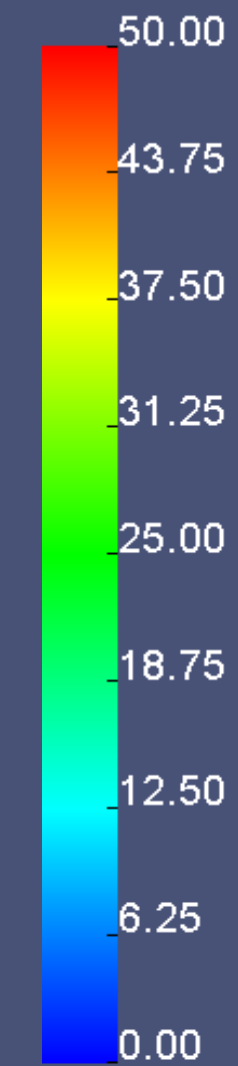
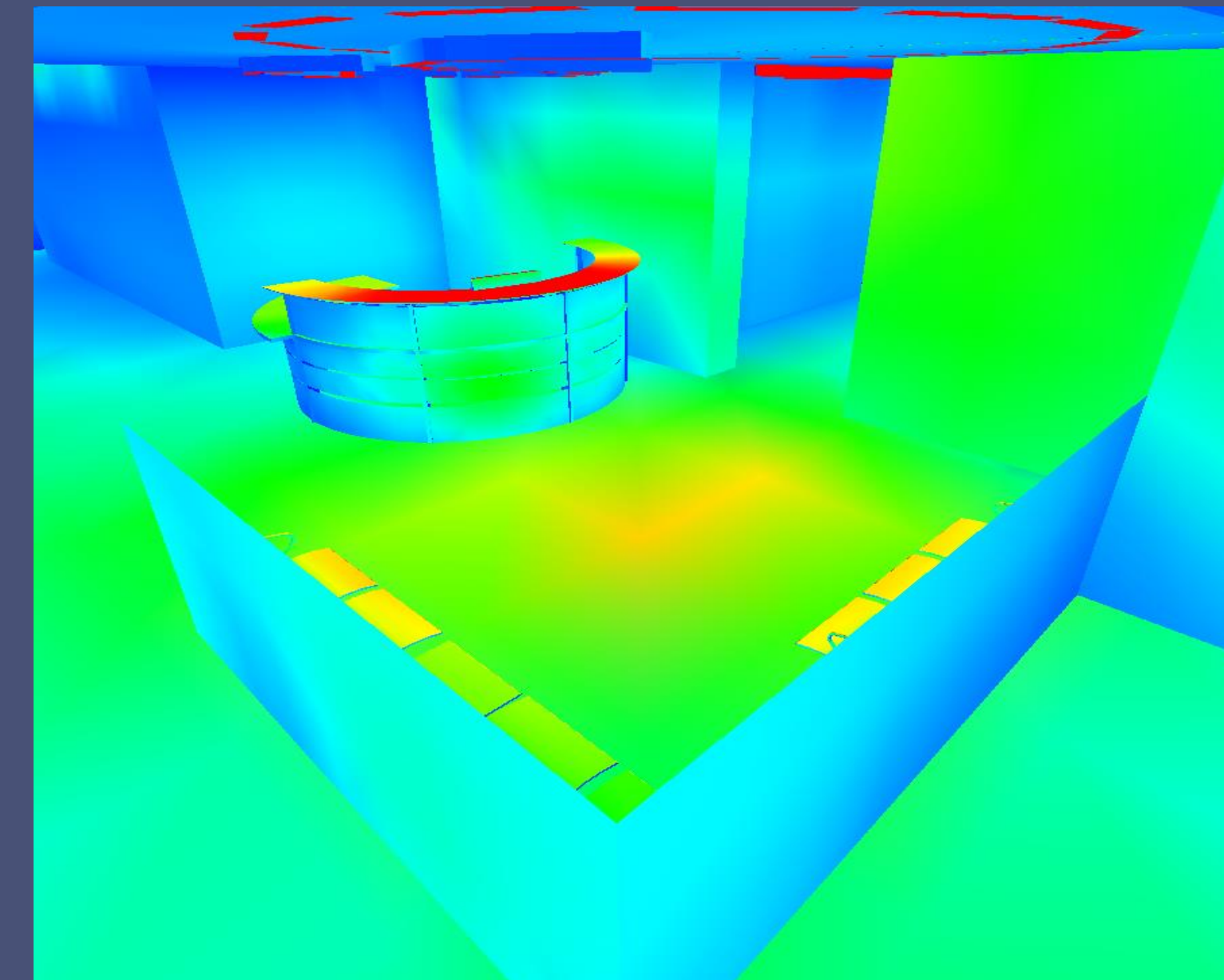
Photovoltaic

CHP / Algae

Additional

Summary / Results

# OFFICE LIGHTING DESIGN



Illuminance (Fc)

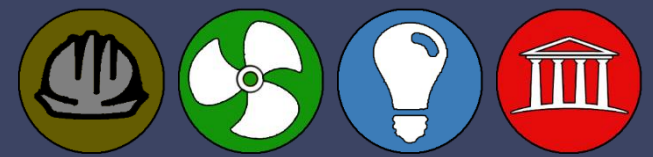
Introduction

Immediate Occupancy

**Near Net-Zero Energy**

Construction

Achievements



NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

Double Façade

Air Distribution

Energy Production

Photovoltaic

CHP / Algae

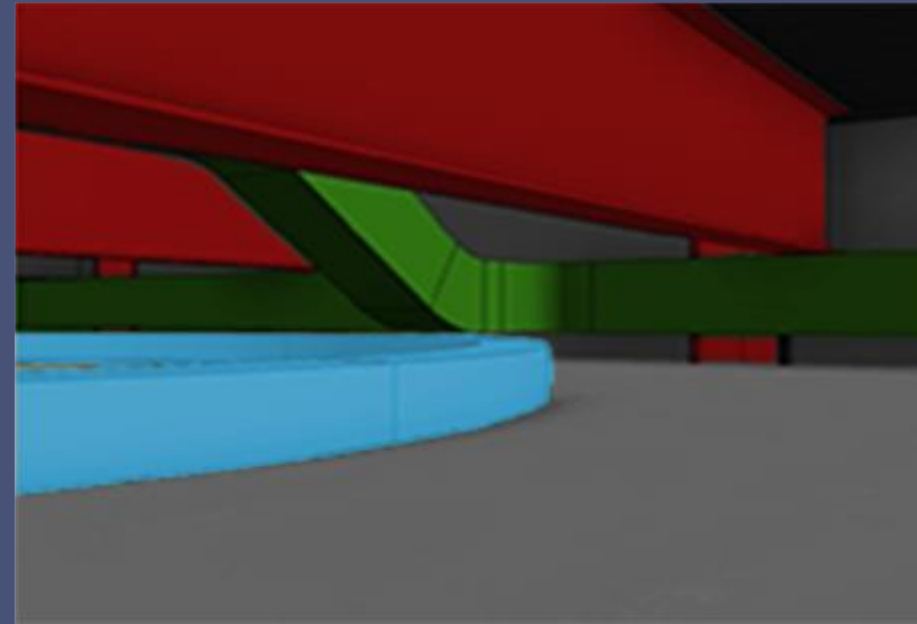
Additional

Summary / Results

# OFFICE LIGHTING DESIGN



Immediate Occupancy

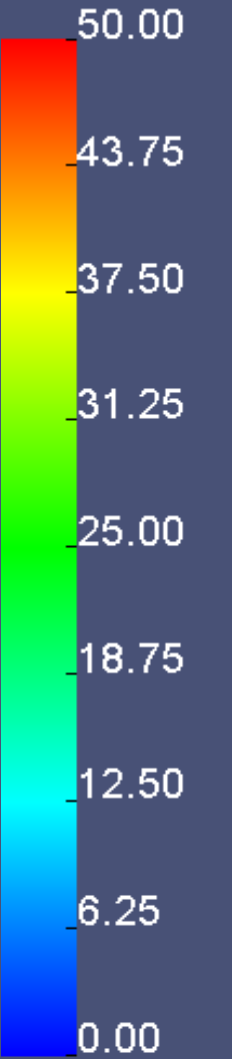
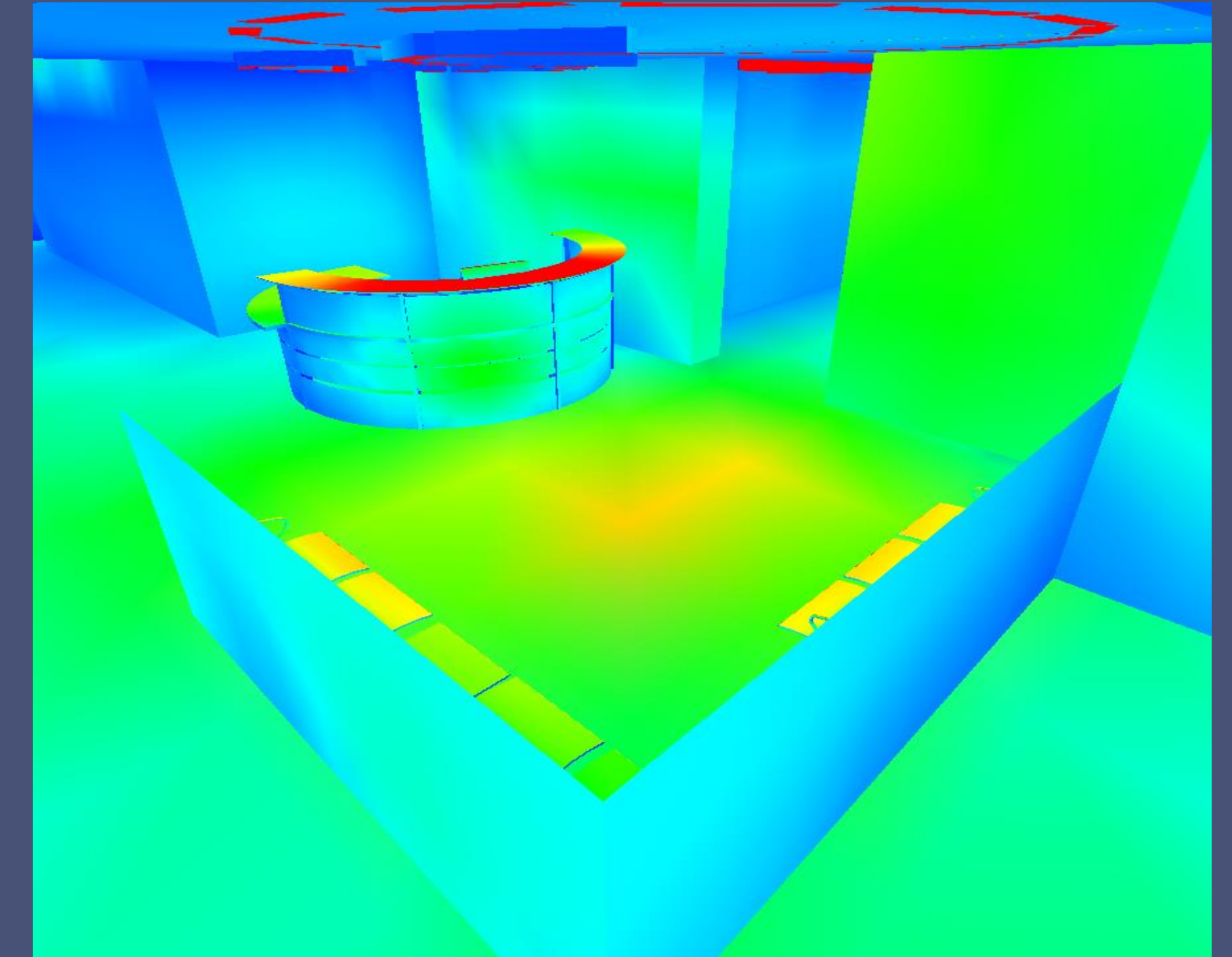


■ Recessed Light Fixtures

■ Mechanical Duct

■ Structural Steel Members

Near Net-Zero Energy

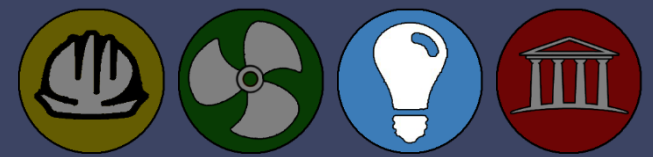


Illuminance (Fc)

Construction

Achievements

Introduction



NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

Double Façade

Air Distribution

Energy Production

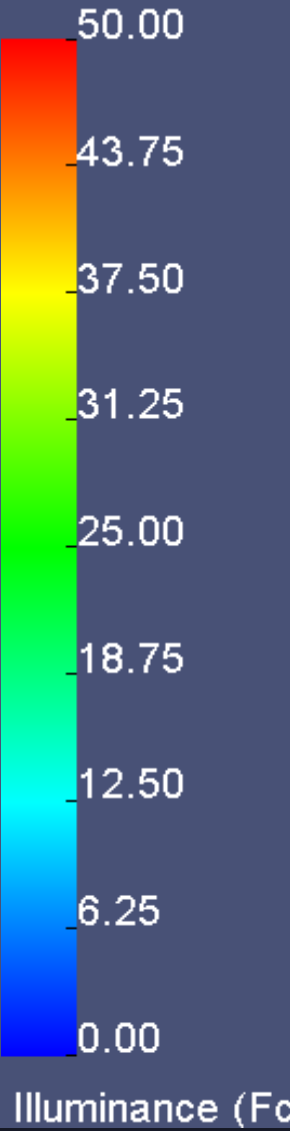
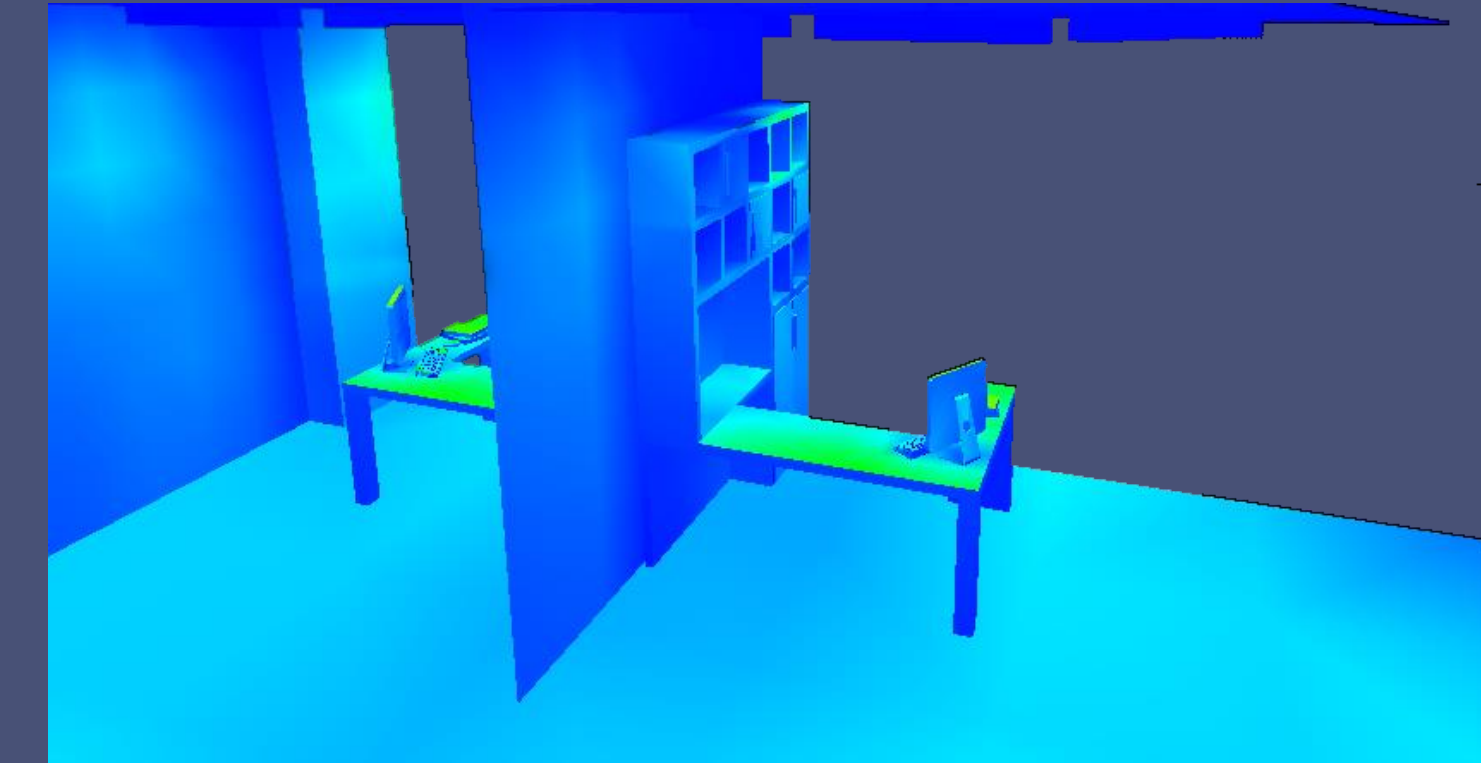
Photovoltaic

CHP / Algae

Additional

Summary / Results

# OFFICE LIGHTING DESIGN



Illuminance (Fc)

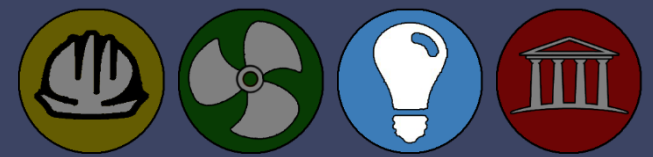
Introduction

Immediate Occupancy

**Near Net-Zero Energy**

Construction

Achievements



# NEAR NET-ZERO ENERGY

## Energy Reduction

Lighting Savings

Double Façade

Air Distribution

Energy Production

Photovoltaic

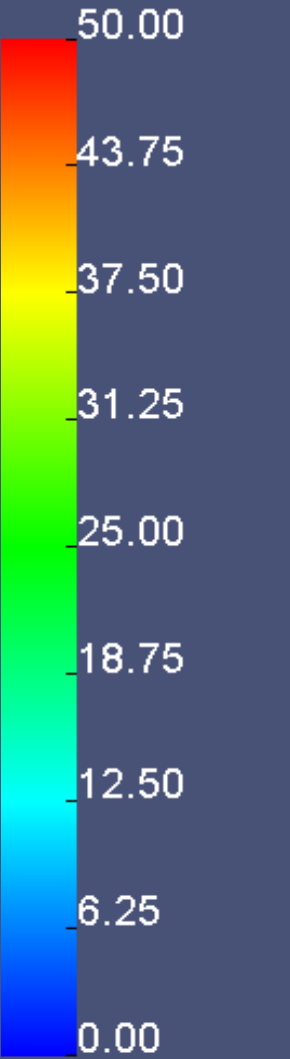
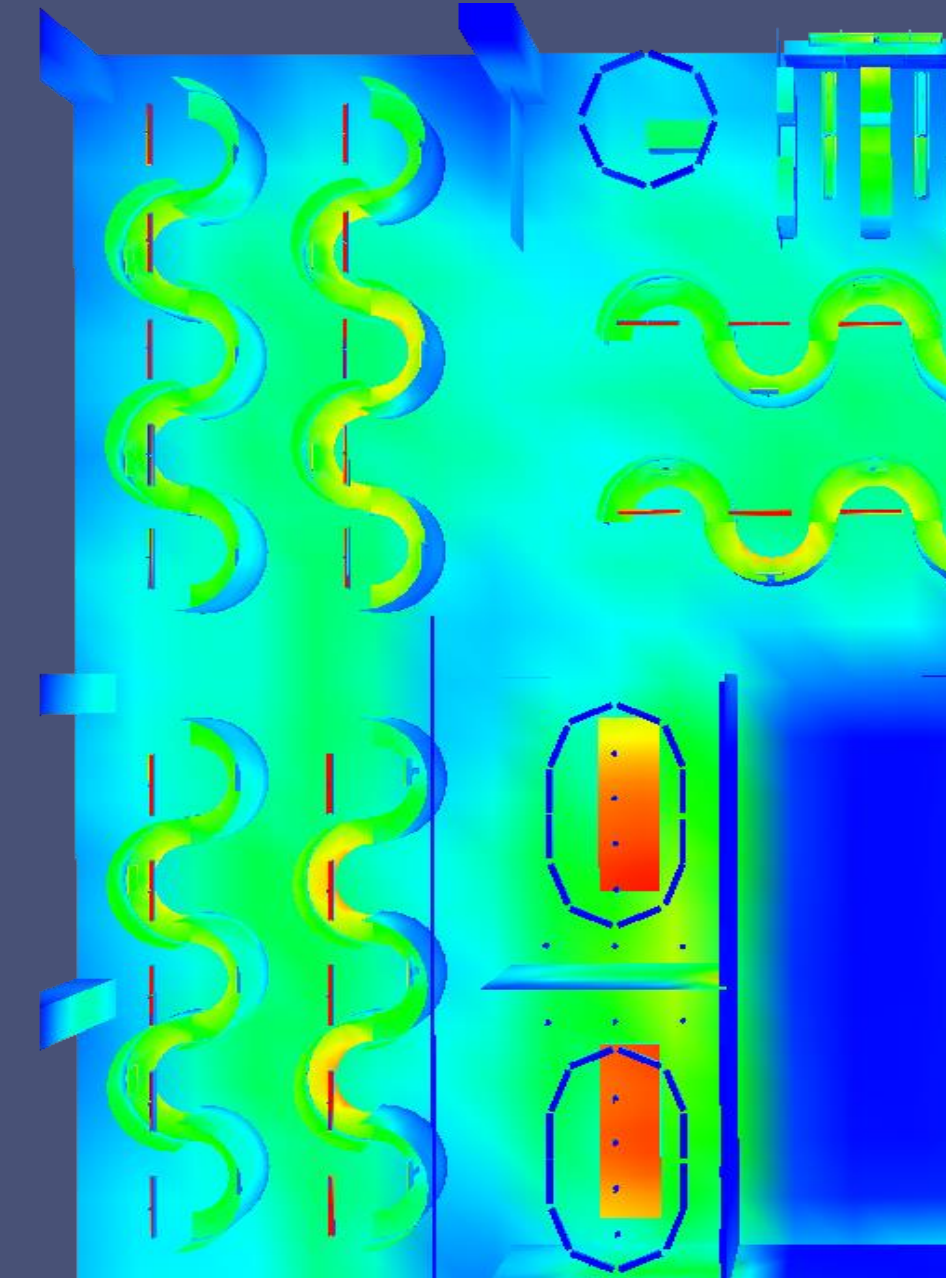
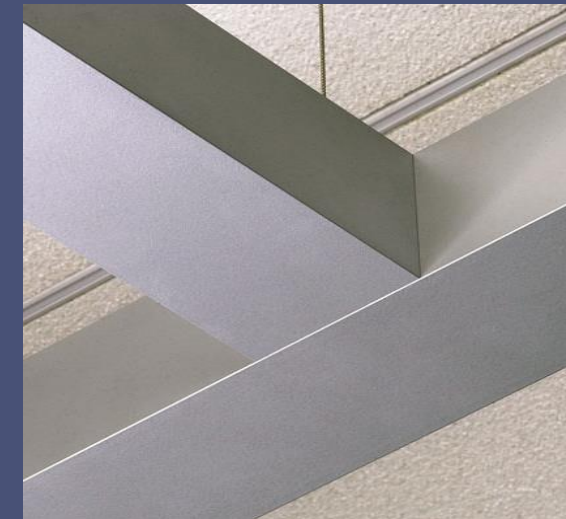
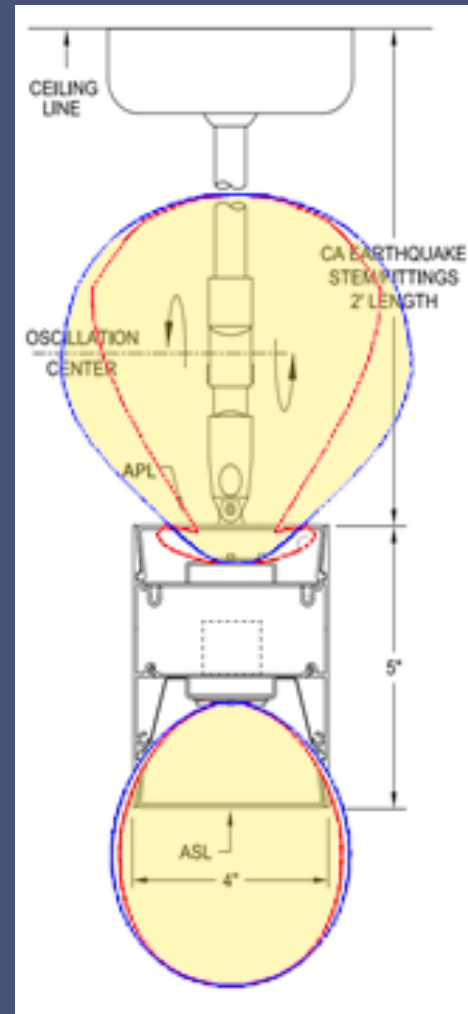
CHP / Algae

Additional

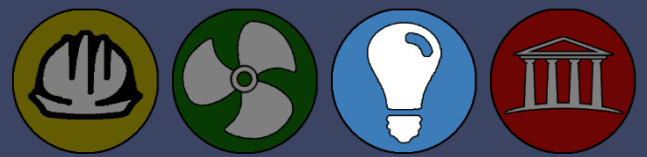
Summary / Results



# OFFICE LIGHTING DESIGN



Illuminance (Fc)



# NEAR NET-ZERO ENERGY

## Energy Reduction

### Lighting Savings

Double Façade

Air Distribution

## Energy Production

Photovoltaic

CHP / Algae

## Additional

Summary / Results



Immediate Occupancy

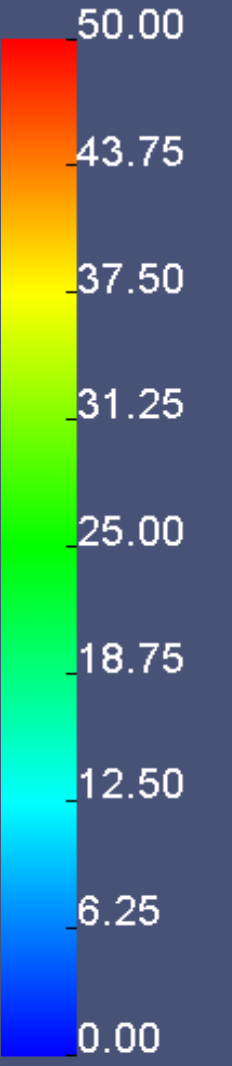
# OFFICE LIGHTING DESIGN



522 Conference

- Low
- Medium
- High
- Audio/Visual Presentation

Near Net-Zero Energy

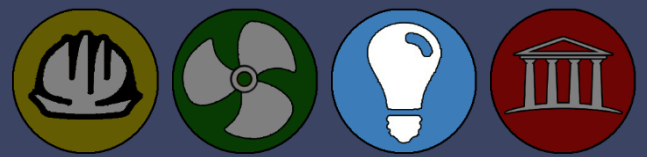


Illuminance (Fc)

Construction

Achievements

Introduction



# NEAR NET-ZERO ENERGY

## Energy Reduction

Lighting Savings

Double Façade

Air Distribution

## Energy Production

Photovoltaic

CHP / Algae

## Additional

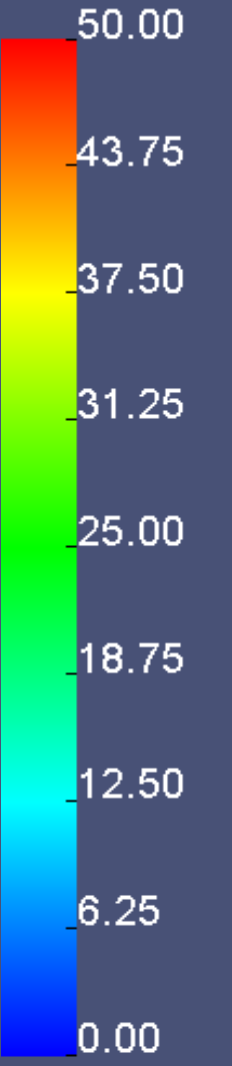
Summary / Results



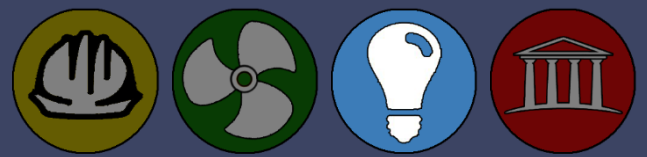
# OFFICE LIGHTING DESIGN



- Low
- **Medium**
- High
- Audio/Visual Presentation



Illuminance (Fc)



# NEAR NET-ZERO ENERGY

## Energy Reduction

Lighting Savings

Double Façade

Air Distribution

Energy Production

Photovoltaic

CHP / Algae

Additional

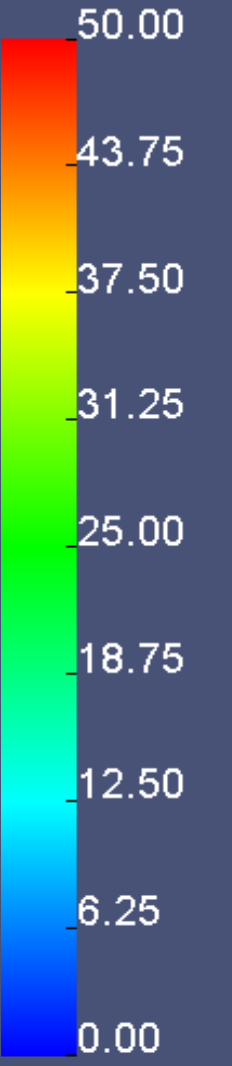
Summary / Results



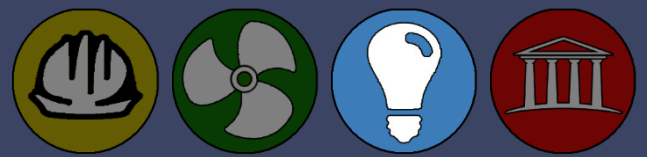
# OFFICE LIGHTING DESIGN



- Low
- Medium
- **High**
- Audio/Visual Presentation



Illuminance (Fc)



# NEAR NET-ZERO ENERGY

## Energy Reduction

### Lighting Savings

Double Façade

Air Distribution

## Energy Production

Photovoltaic

CHP / Algae

## Additional

Summary / Results

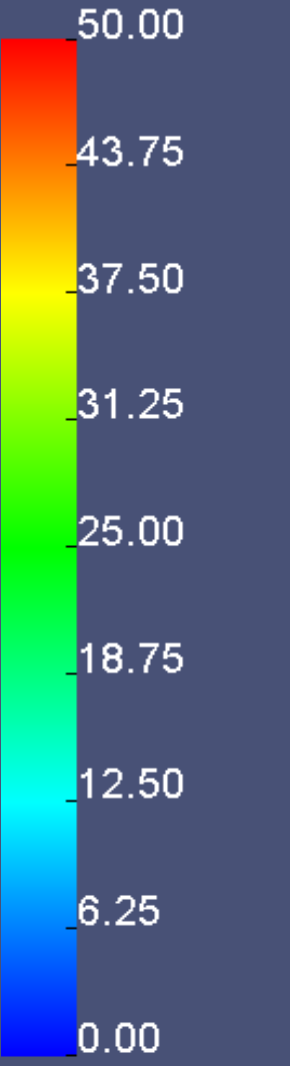


# OFFICE LIGHTING DESIGN

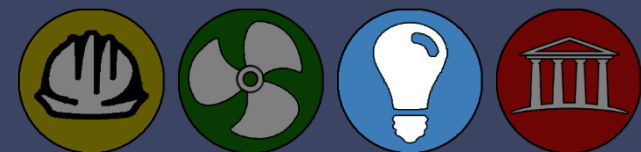


522 Conference

- Low
- Medium
- High
- **Audio/Visual Presentation**







NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

Double Façade

Air Distribution

Energy Production

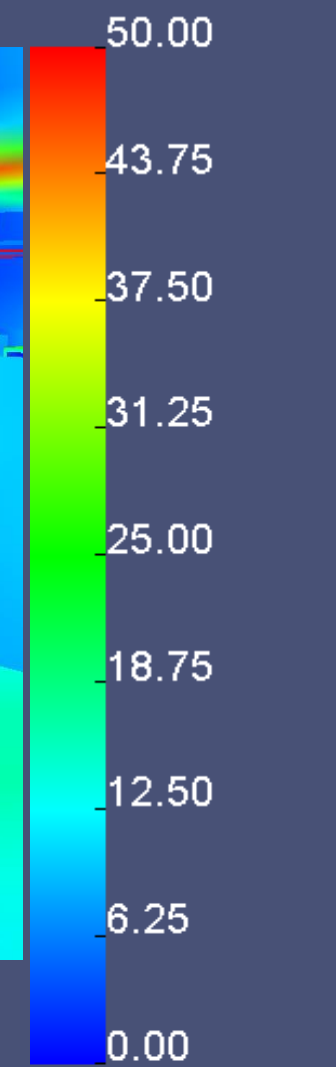
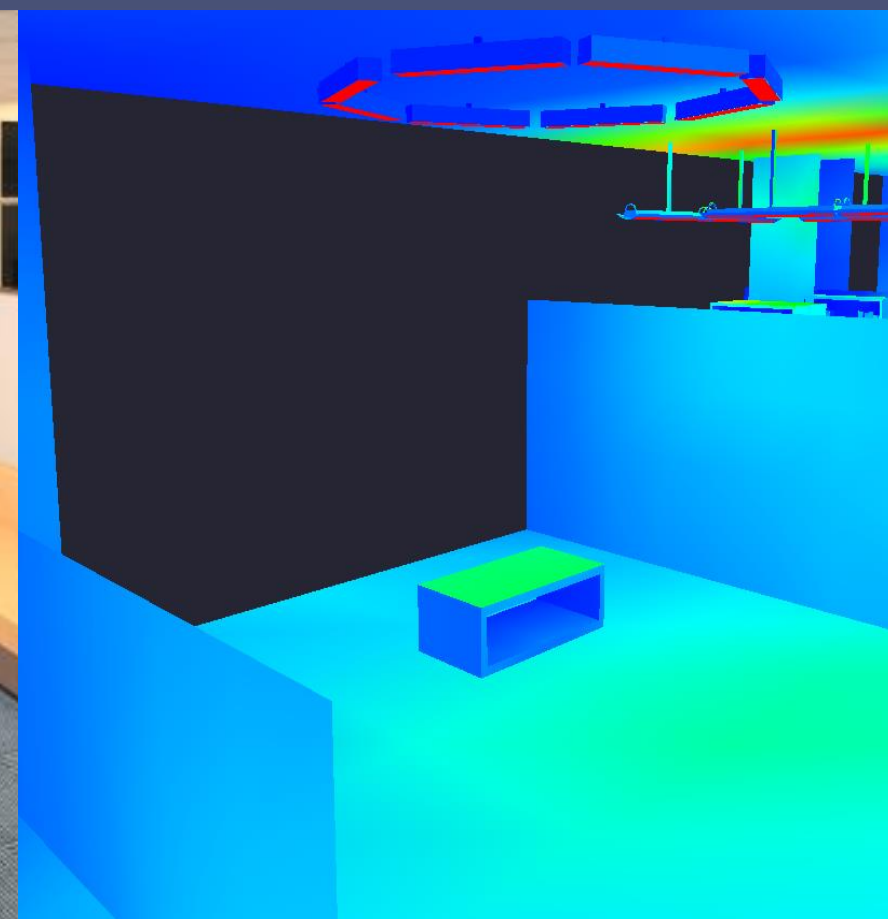
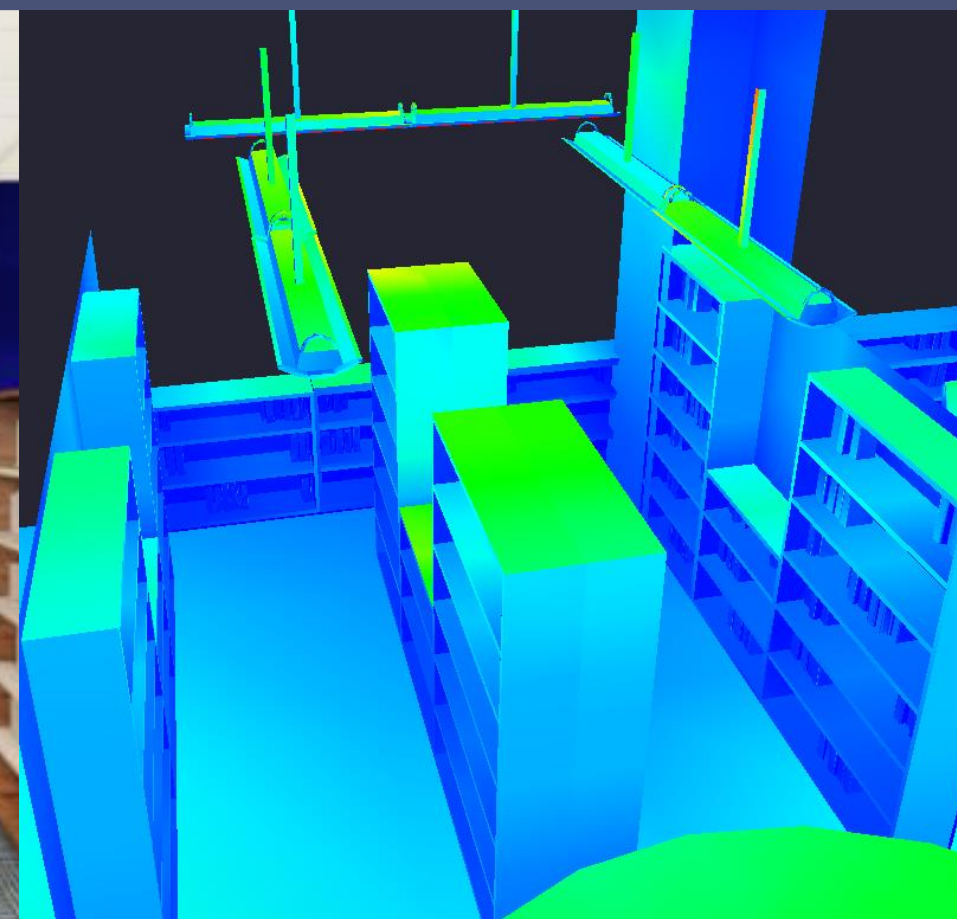
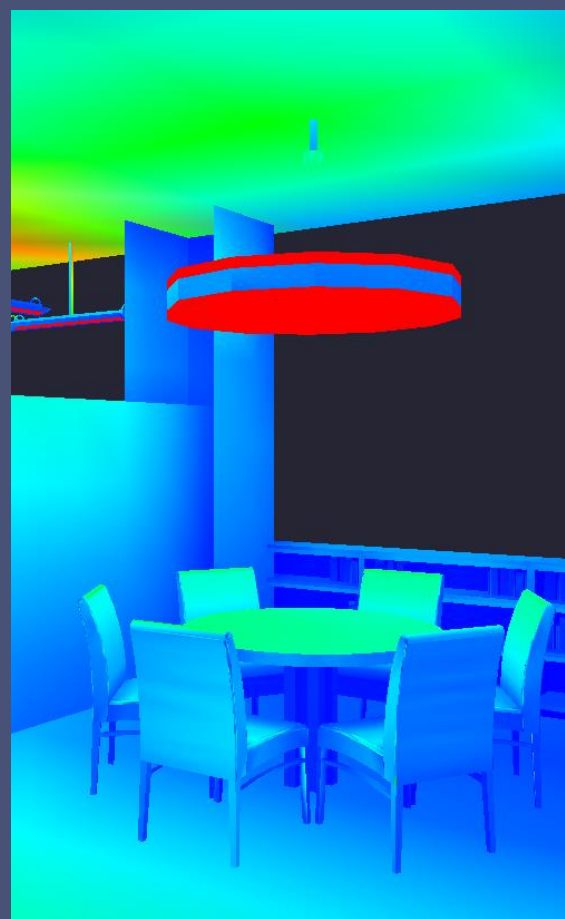
Photovoltaic

CHP / Algae

Additional

Summary / Results

# OFFICE LIGHTING DESIGN



Illuminance (Fc)

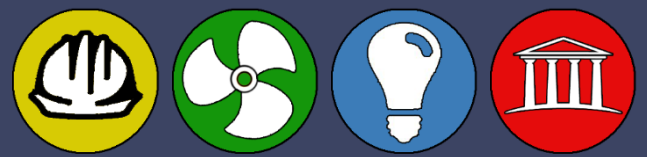
Introduction

Immediate Occupancy

**Near Net-Zero Energy**

Construction

Achievements

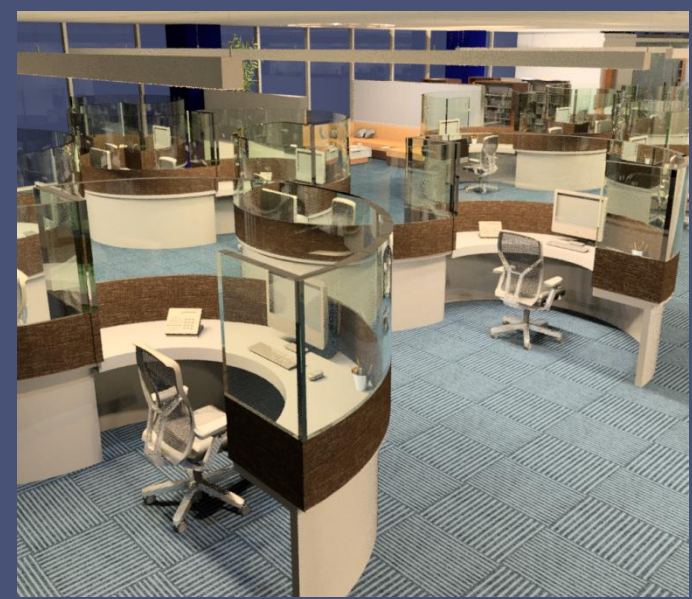


# NEAR NET-ZERO ENERGY

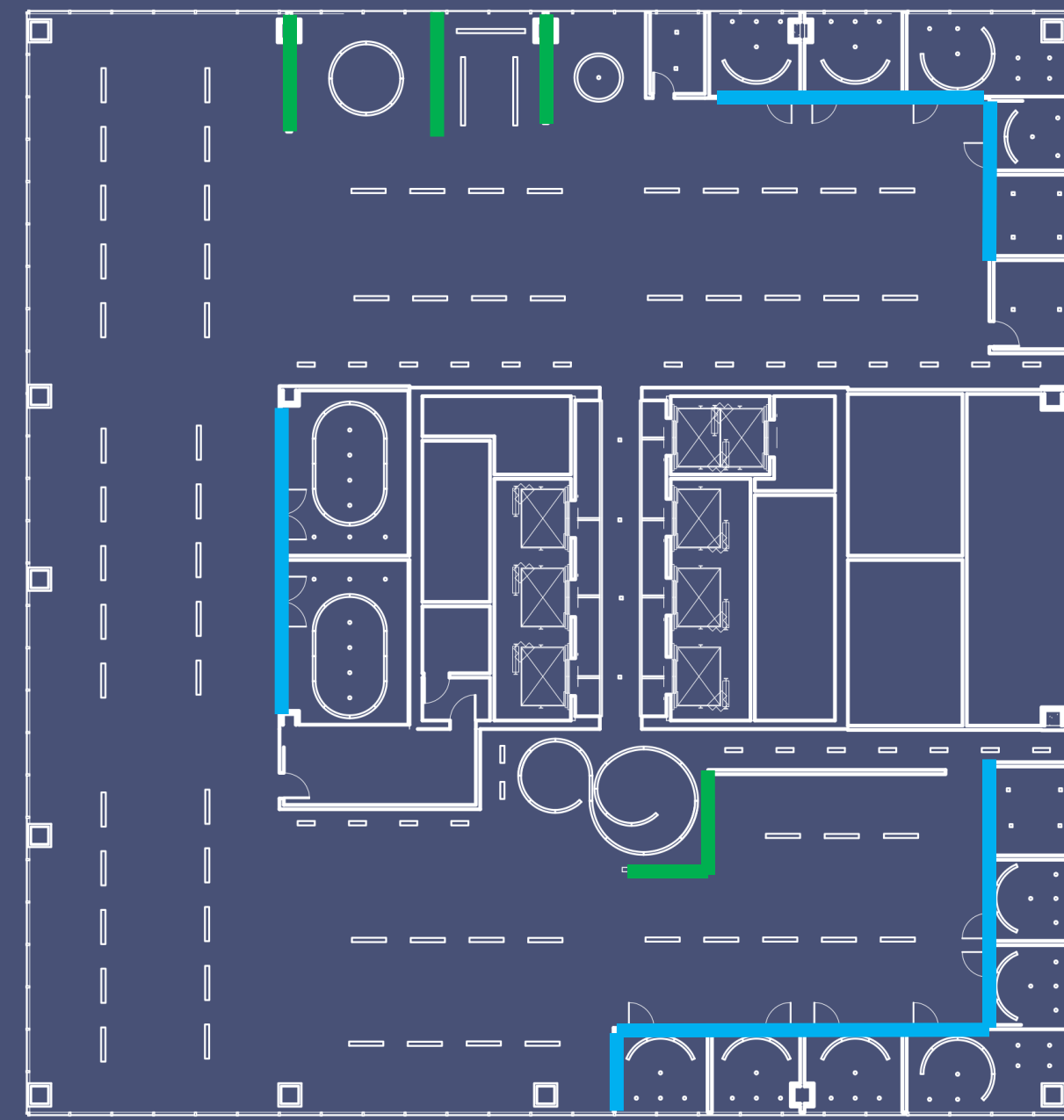
- Energy Reduction**
- Lighting Savings
- Double Façade
- Air Distribution
- Energy Production
- Photovoltaic
- CHP / Algae
- Additional
- Summary / Results

Clear Glass Walls

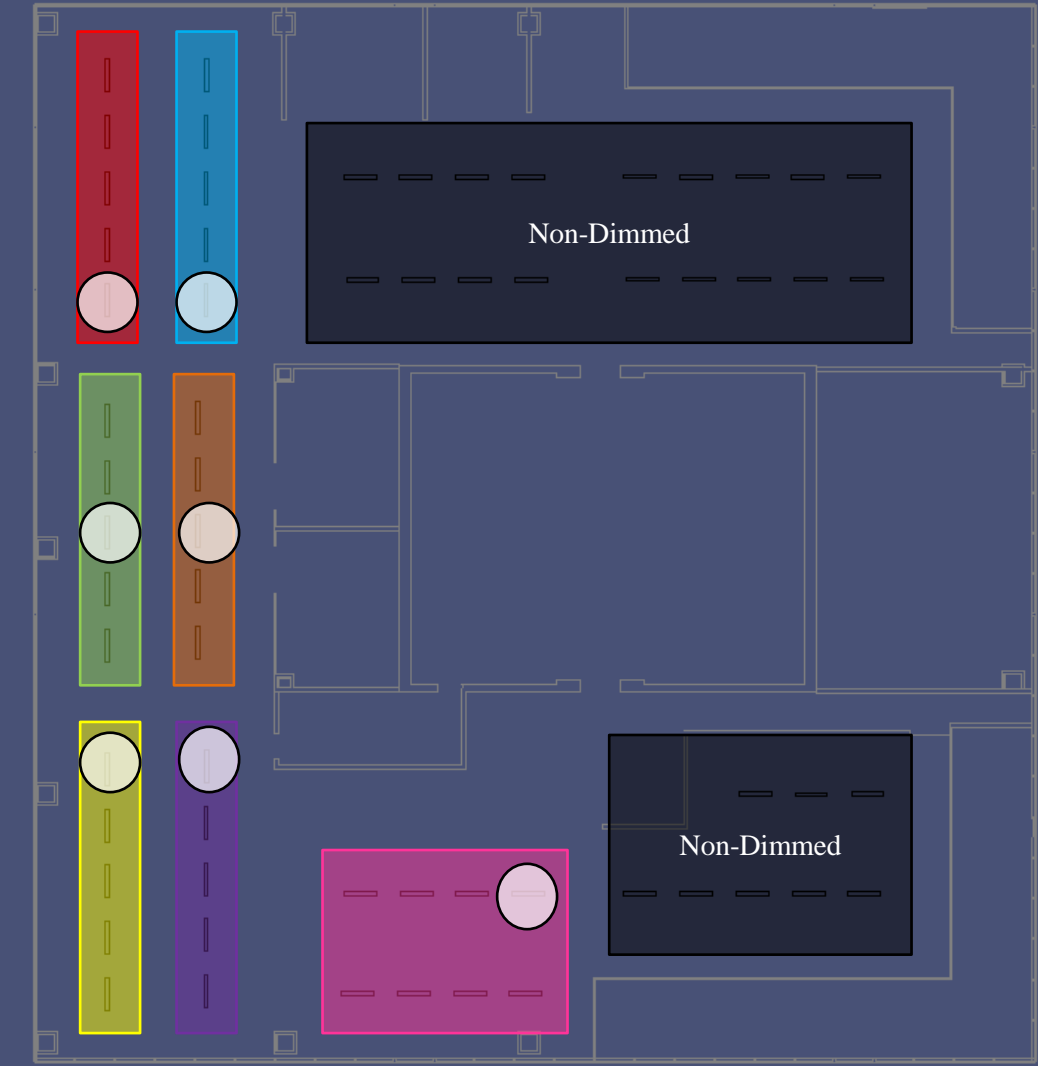
Half Height Walls



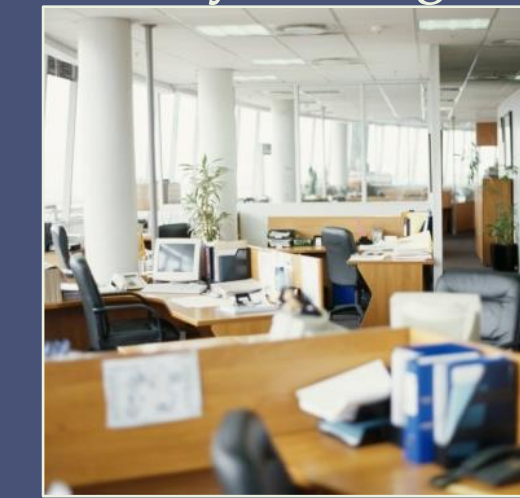
Glass Desk Partitions



## Daylight Harvesting

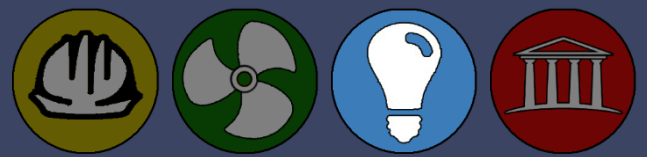


## Vacancy Sensing



## Light Level Tuning





# NEAR NET-ZERO ENERGY

## Energy Reduction

### Lighting Savings

Double Façade

Air Distribution

### Energy Production

Photovoltaic

CHP / Algae

Additional

Summary / Results

LPD Reduction

*36% reduction*

**191,360 kWhr**

Daylight Harvesting

*average dimming level of 24%*

**98,300 kWhr**

Light Level Tuning

**24,700 kWhr**

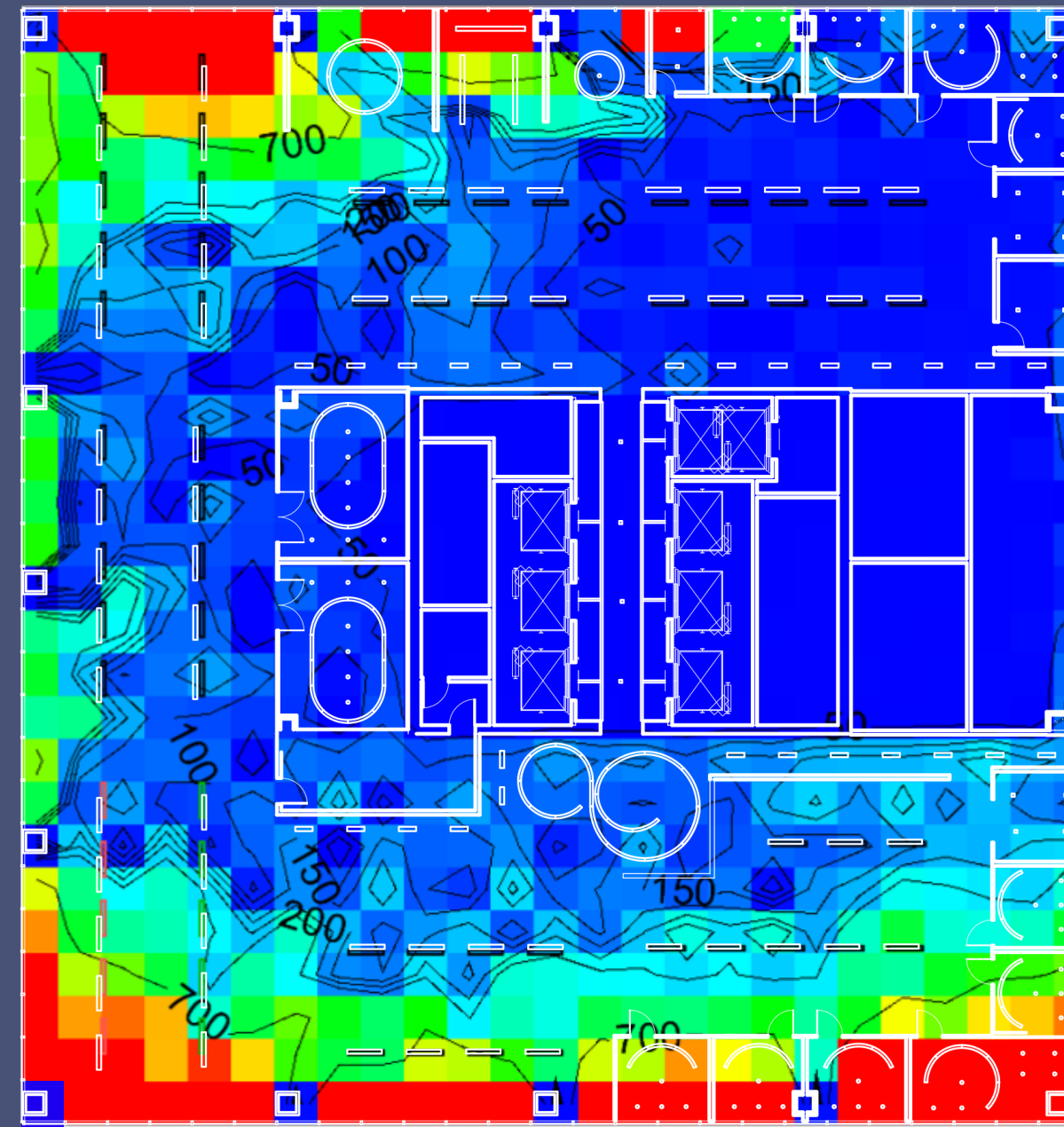
Vacancy Sensing

*turning off lights in unoccupied spaces*

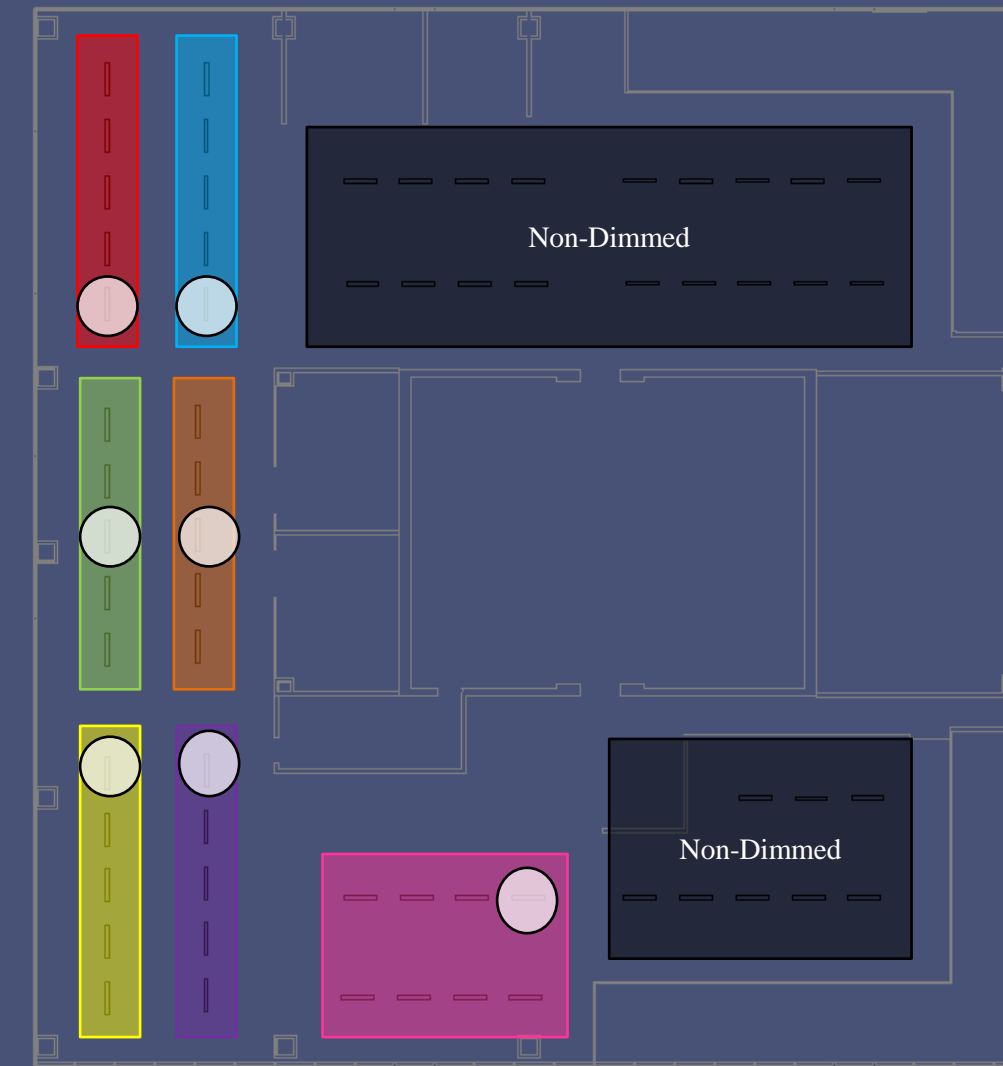
**29,000 kWhr**

**Total Reduction**

**383,814 kWhr**



## Daylight Harvesting

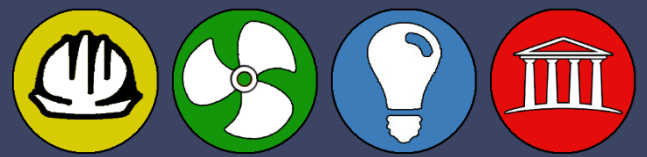


## Vacancy Sensing



## Light Level Tuning





NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

**Double Façade**

Air Distribution

Energy Production

Photovoltaic

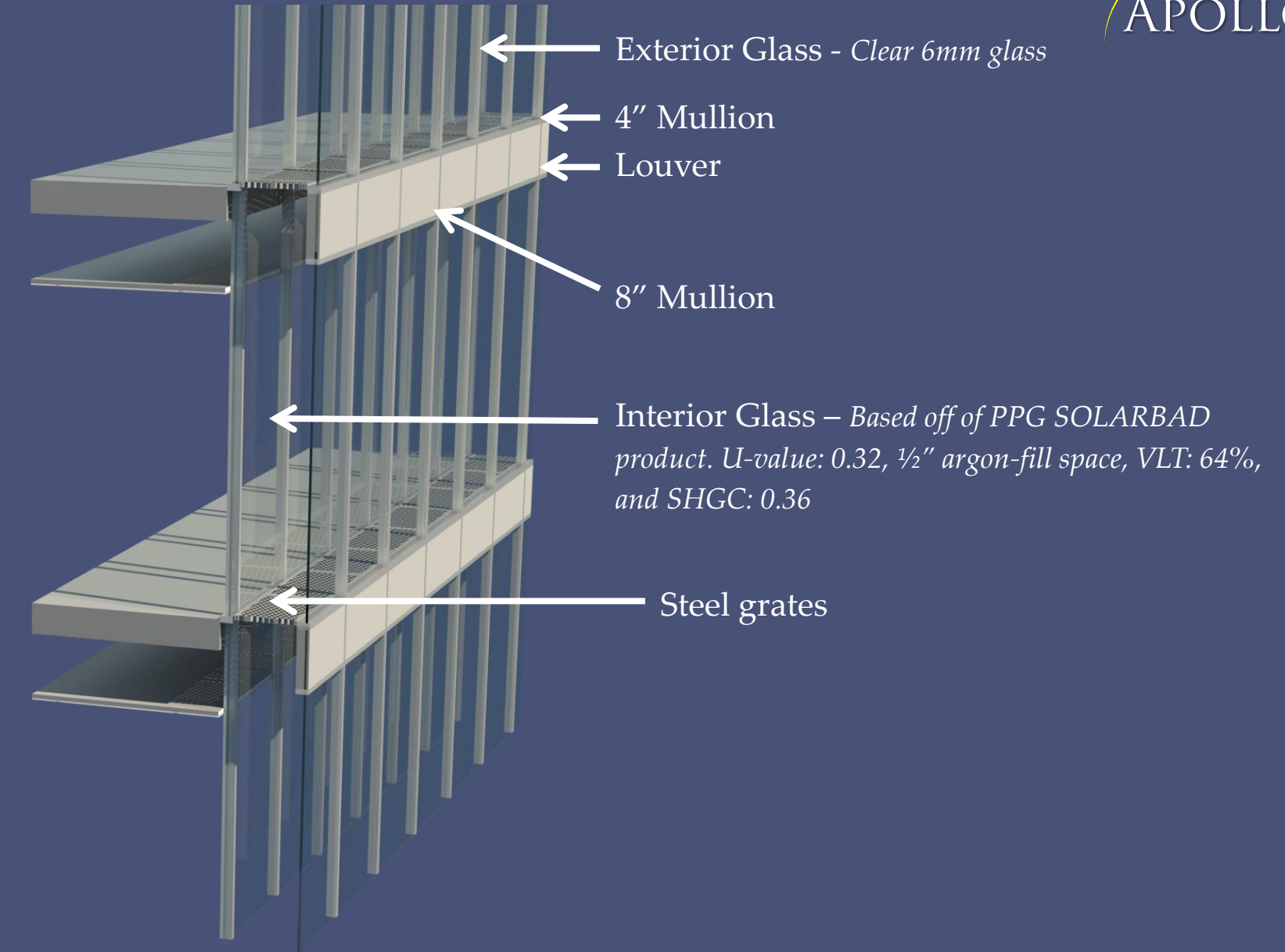
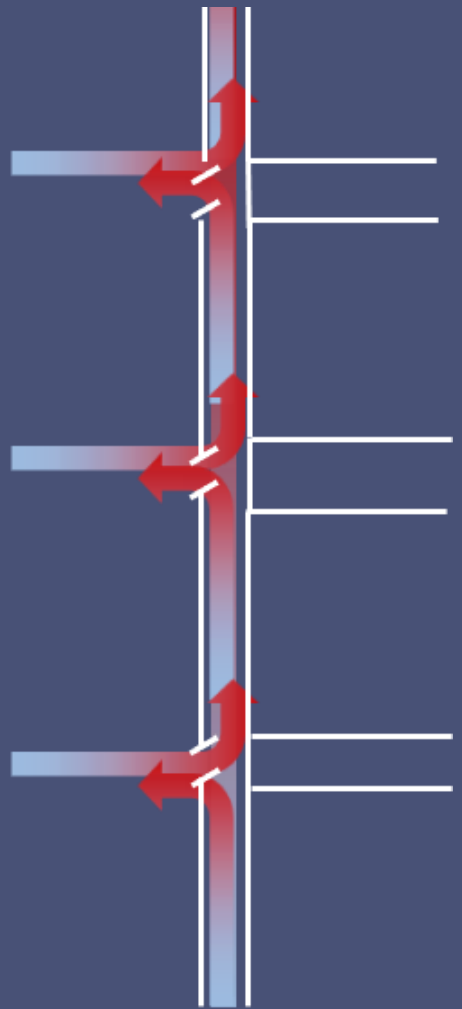
CHP / Algae

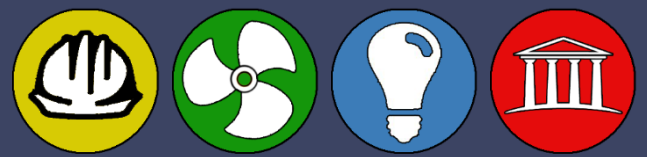
Additional

Summary / Results

Window Layer	Action
Outer	Open
Plenum	Opens when plenum >85°F
Inner	Closed

Summer Conditions (>74°F)





NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

**Double Façade**

Air Distribution

Energy Production

Photovoltaic

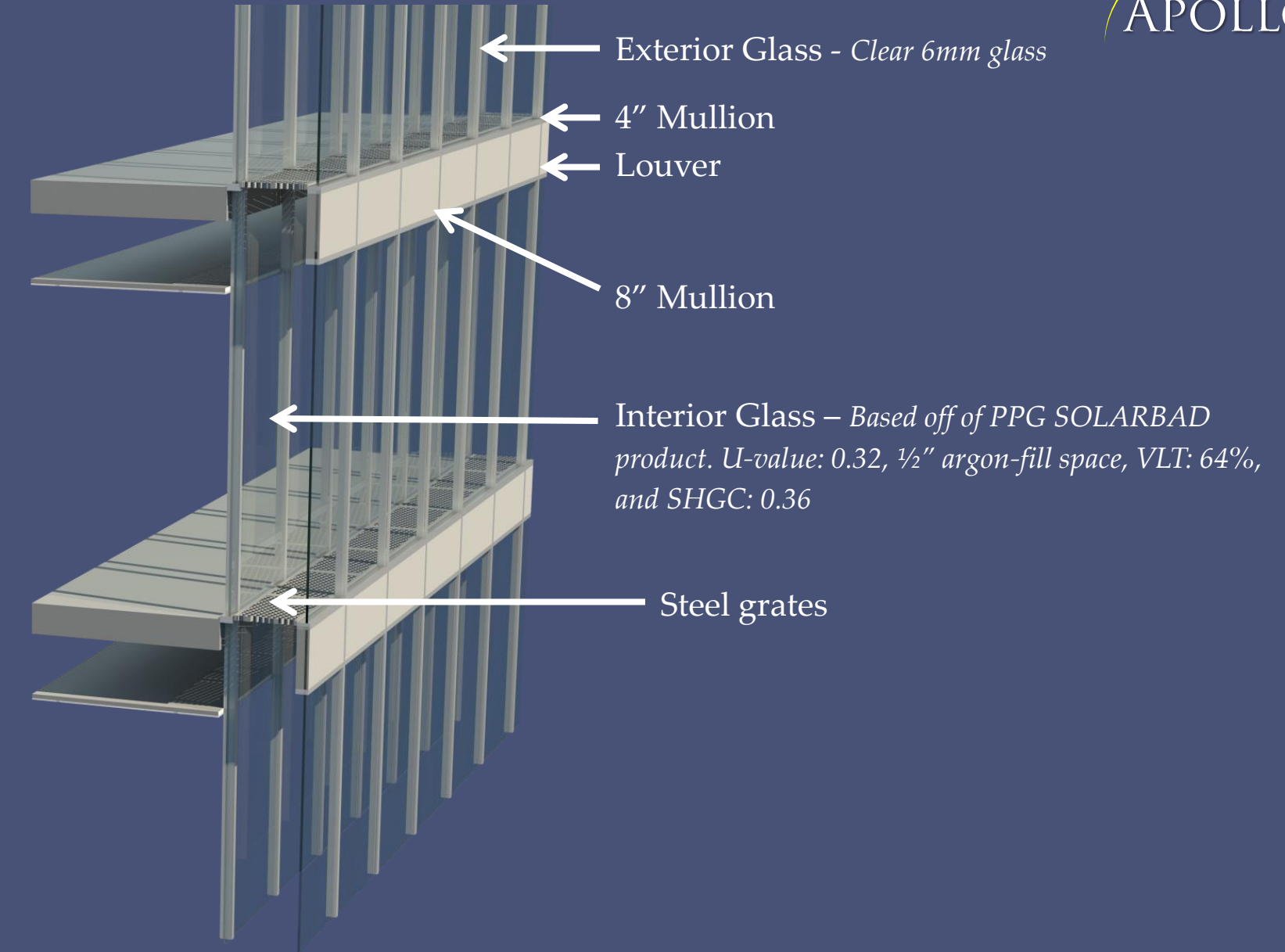
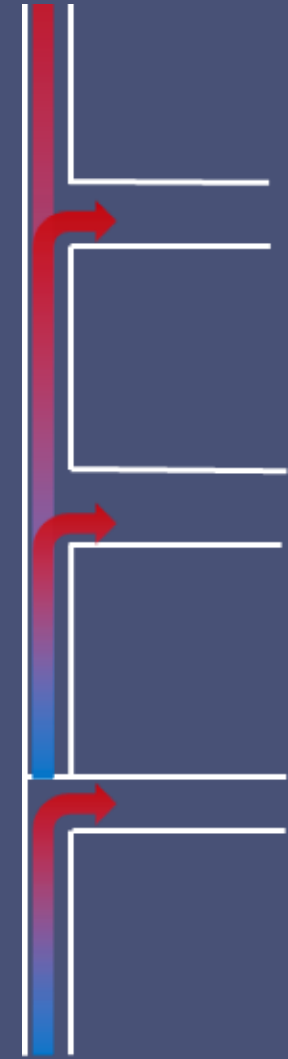
CHP / Algae

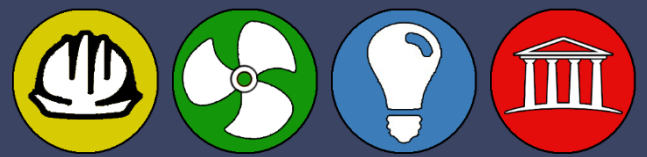
Additional

Summary / Results

Winter Conditions (0-45°F)

Window Layer	Action
Outer	Closed
Plenum	Opens when plenum >85°F
Inner	Opens When plenum >70°F





NEAR NET-ZERO ENERGY

**Energy Reduction**

Lighting Savings

**Double Façade**

Air Distribution

Energy Production

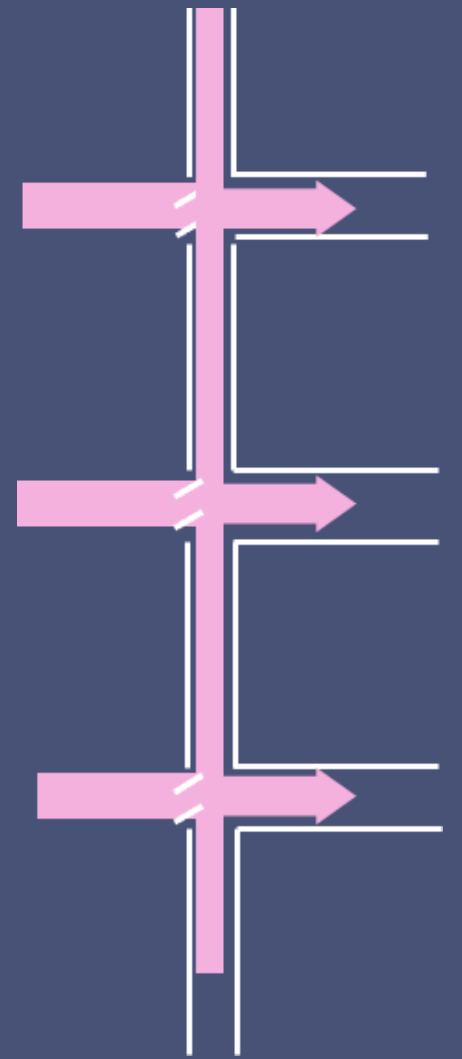
Photovoltaic

CHP / Algae

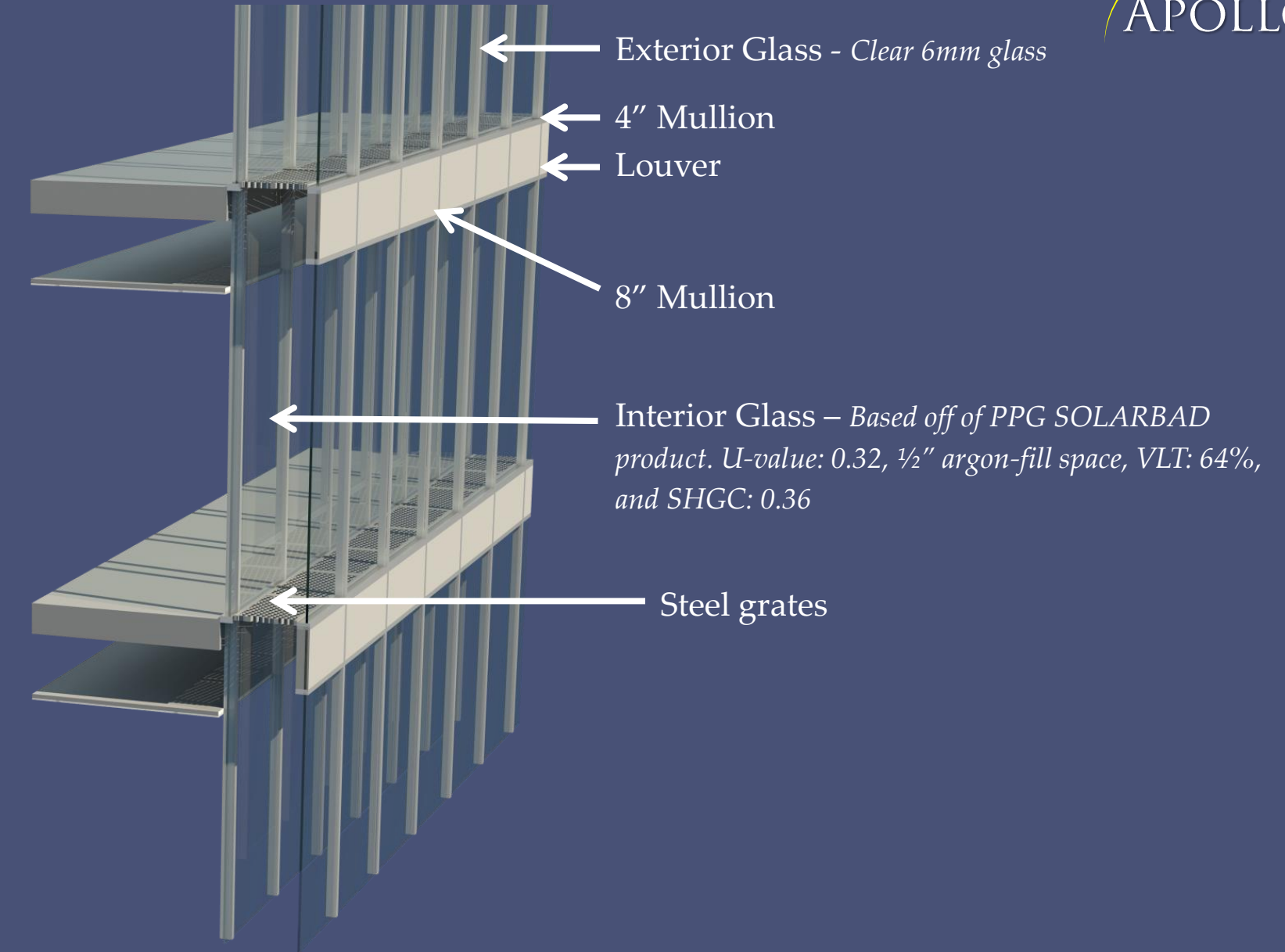
Additional

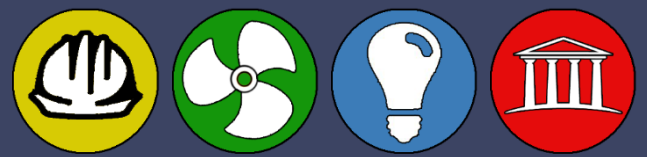
Summary / Results

# Natural Ventilation Conditions (55-74°F)



Window Layer	Action
Outer	Open
Plenum	Opens when plenum >85°F
Inner	Open





# NEAR NET-ZERO ENERGY

## Energy Reduction

Lighting Savings

## Double Façade

Air Distribution

Energy Production

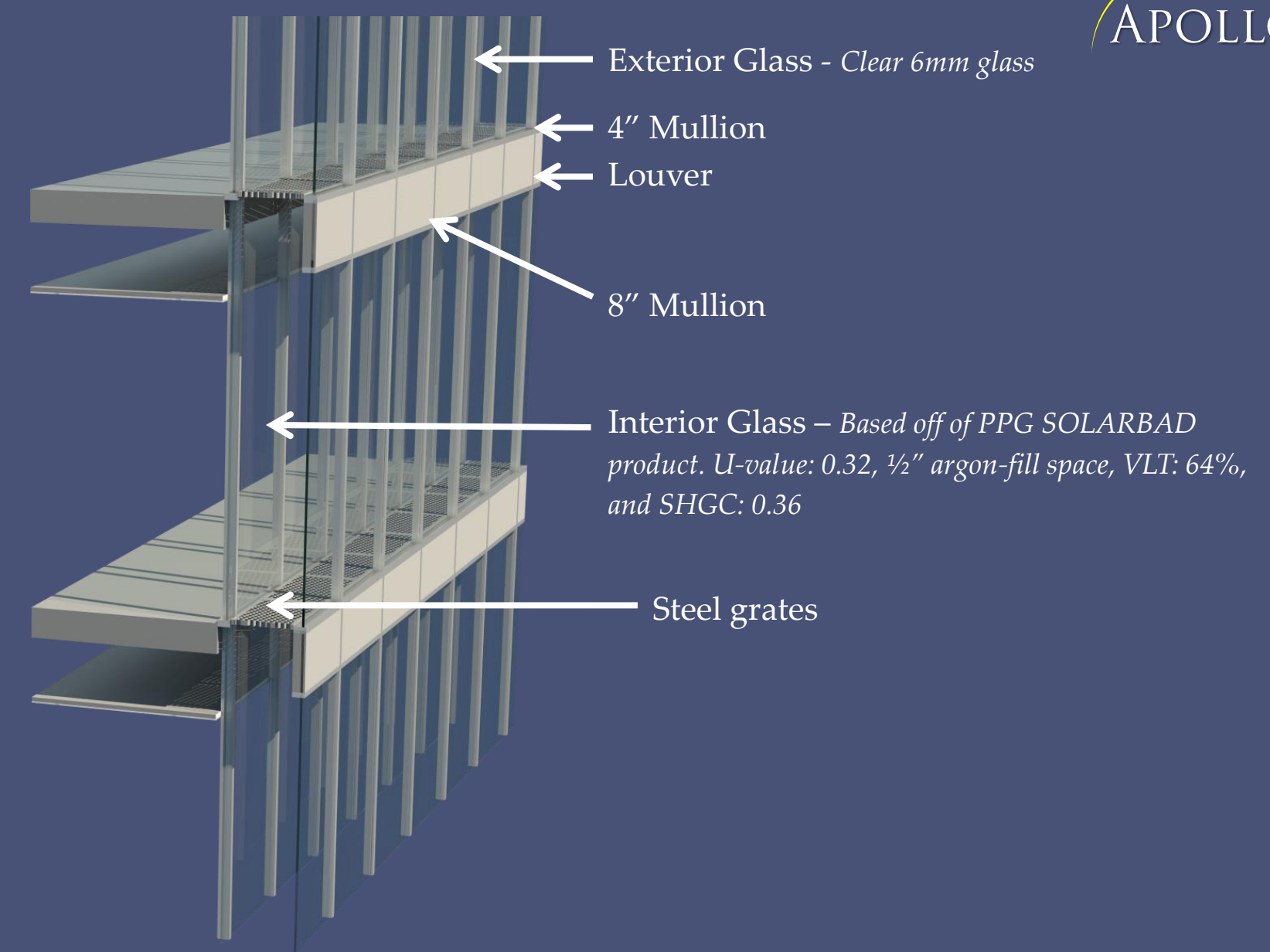
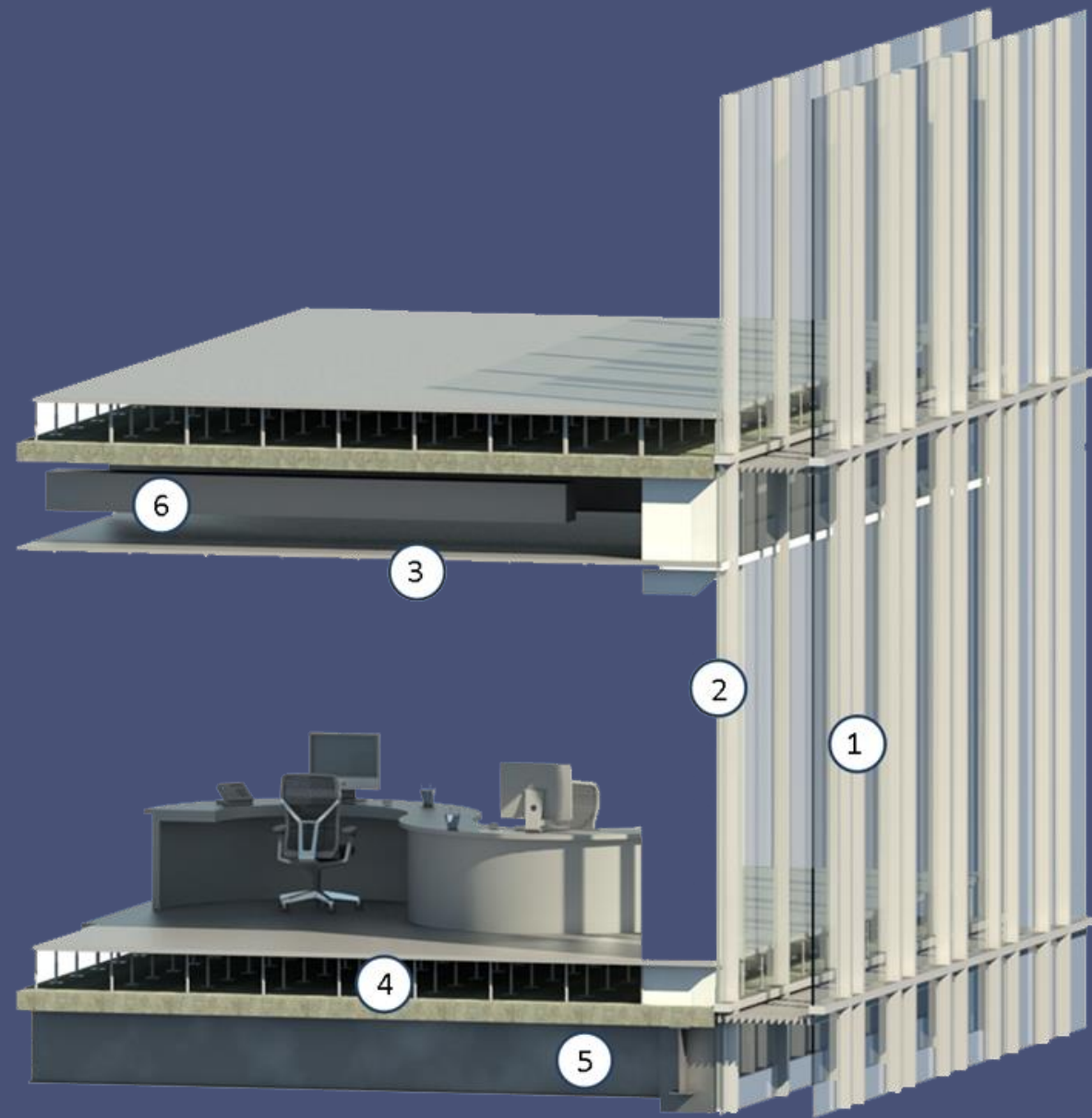
Photovoltaic

CHP / Algae

Additional

Summary / Results

- 1 Double Façade System (DFS)
- 2 Daylight Control Retractable Shading
- 3 Daylight Sensor
- 4 Underfloor Duct and Data Cable
- 5 Structural Steel Members
- 6 Return Duct





# NEAR NET-ZERO ENERGY

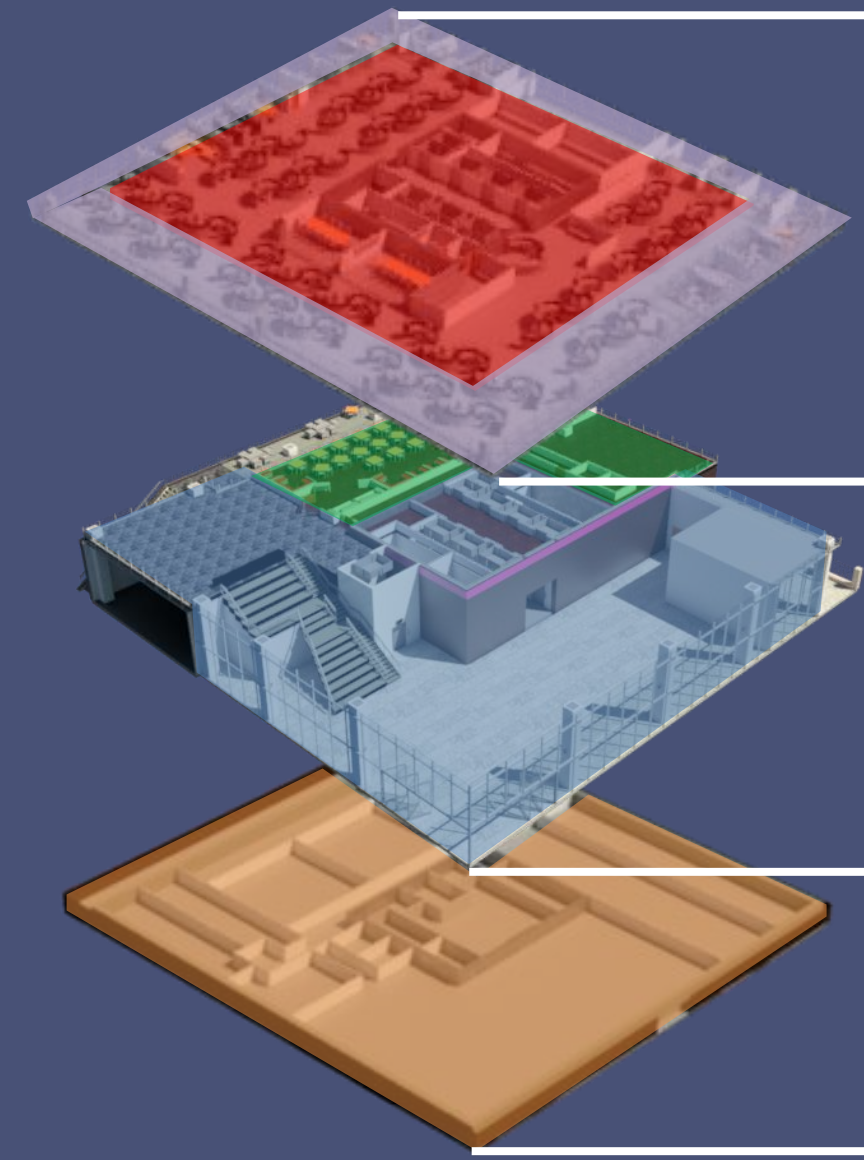
## Energy Reduction

- Lighting Savings
- Double Façade

## Air Distribution

- Energy Production
  - Photovoltaic
  - CHP / Algae





- Additional
  - Summary / Results



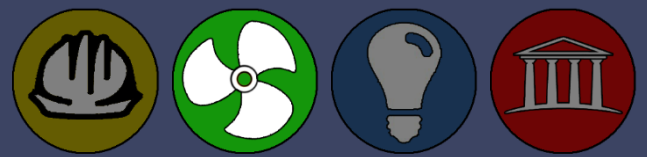
Office Floors 5-30

Lobby/Retail

Garage

-  Zone 1: Lobby and Retail
-  Zone 2: Podium
-  Zone 3: Restaurant
-  Zone 4 & 5: Office Floors





# NEAR NET-ZERO ENERGY

## Energy Reduction

- Lighting Savings
- Double Façade

## Air Distribution

- Energy Production
- Photovoltaic
- CHP / Algae

- Additional
- Summary / Results

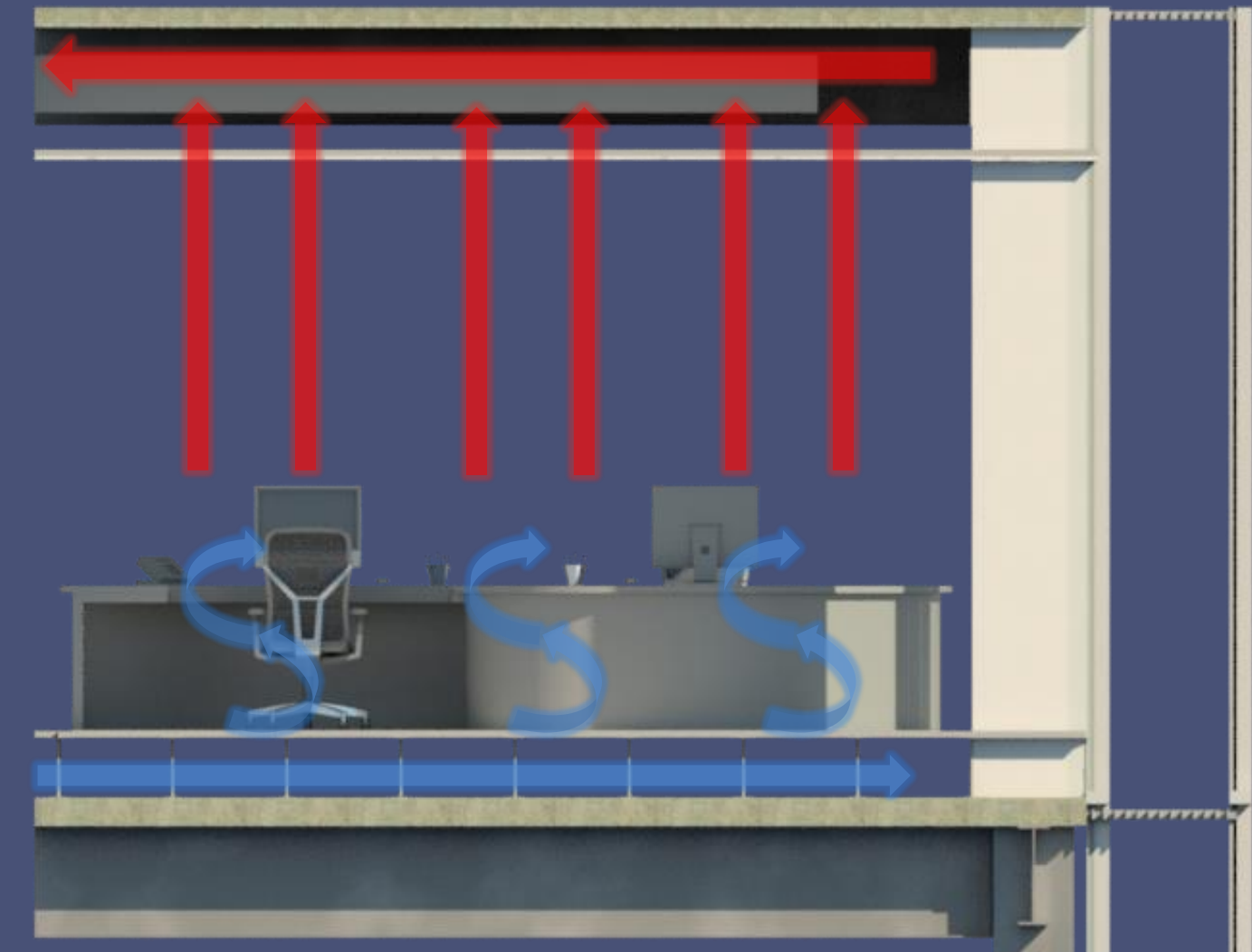
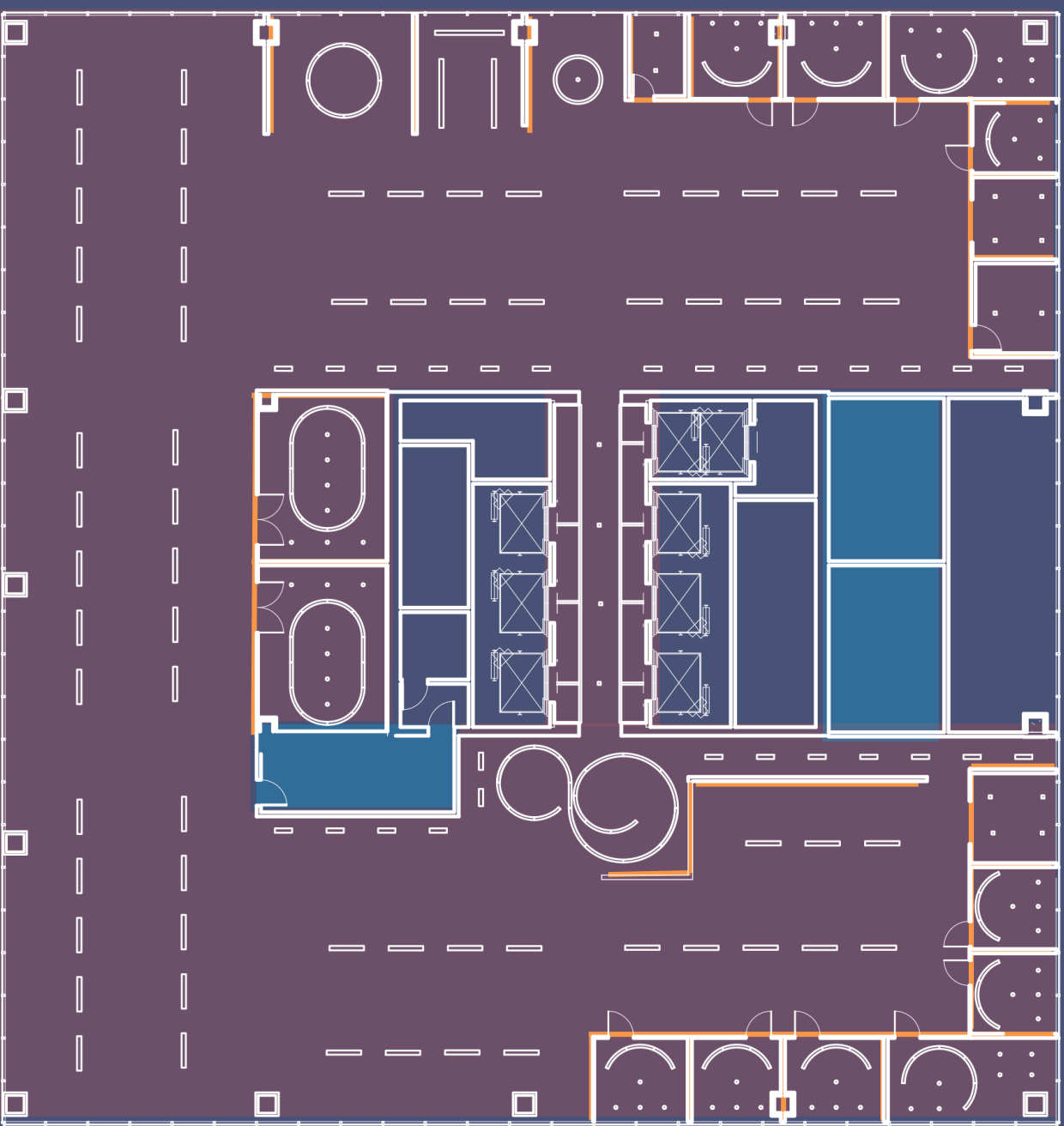


Mechanical Room

Raised Floor System

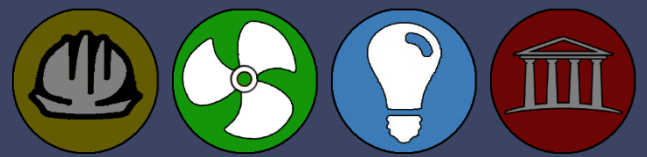
Walls that penetrate the raised floor

Pods



Displacement Ventilation





# NEAR NET-ZERO ENERGY

## Energy Reduction

Lighting Savings

Double Façade

## Air Distribution

Energy Production

Photovoltaic

CHP / Algae

Additional

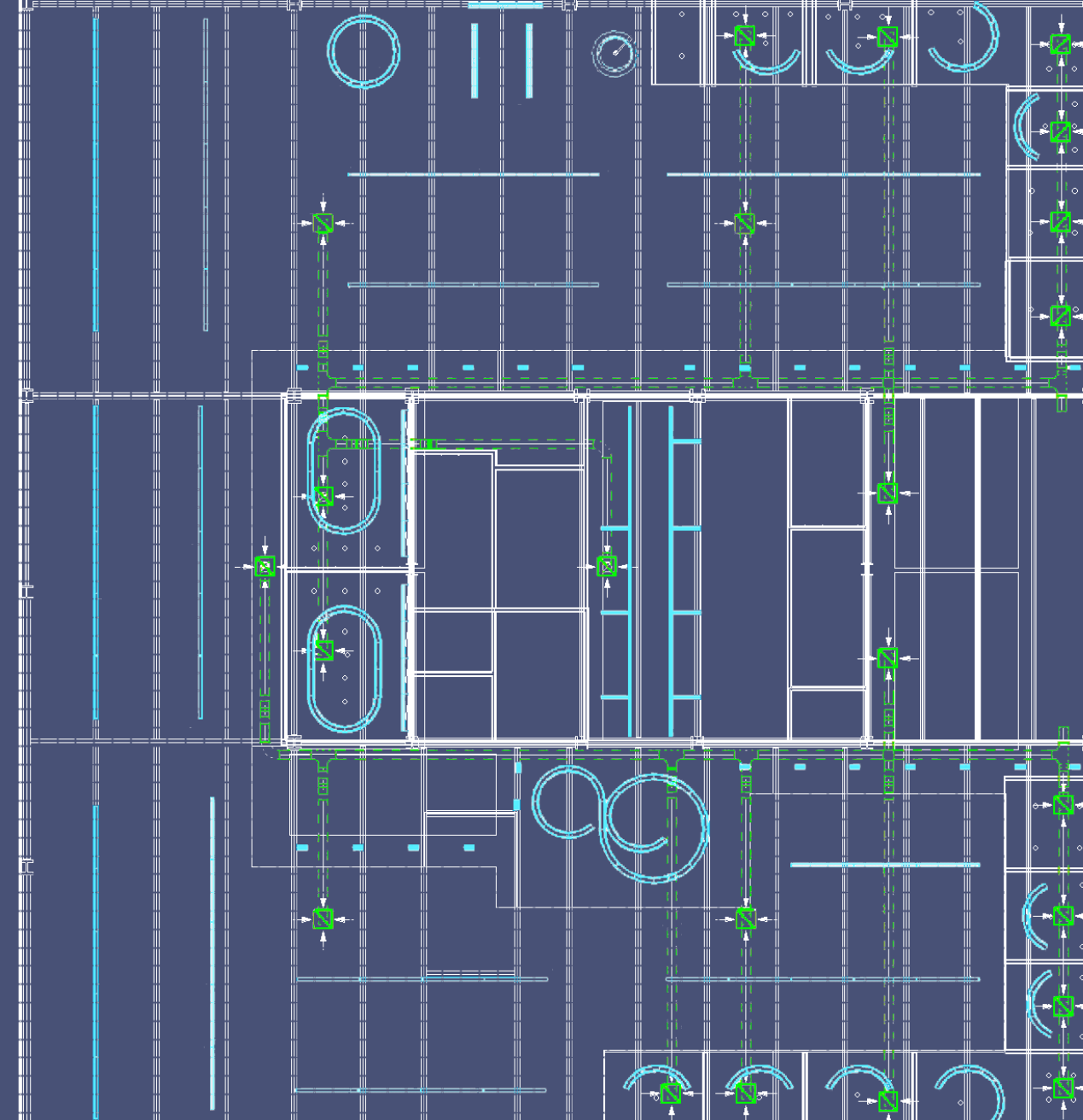
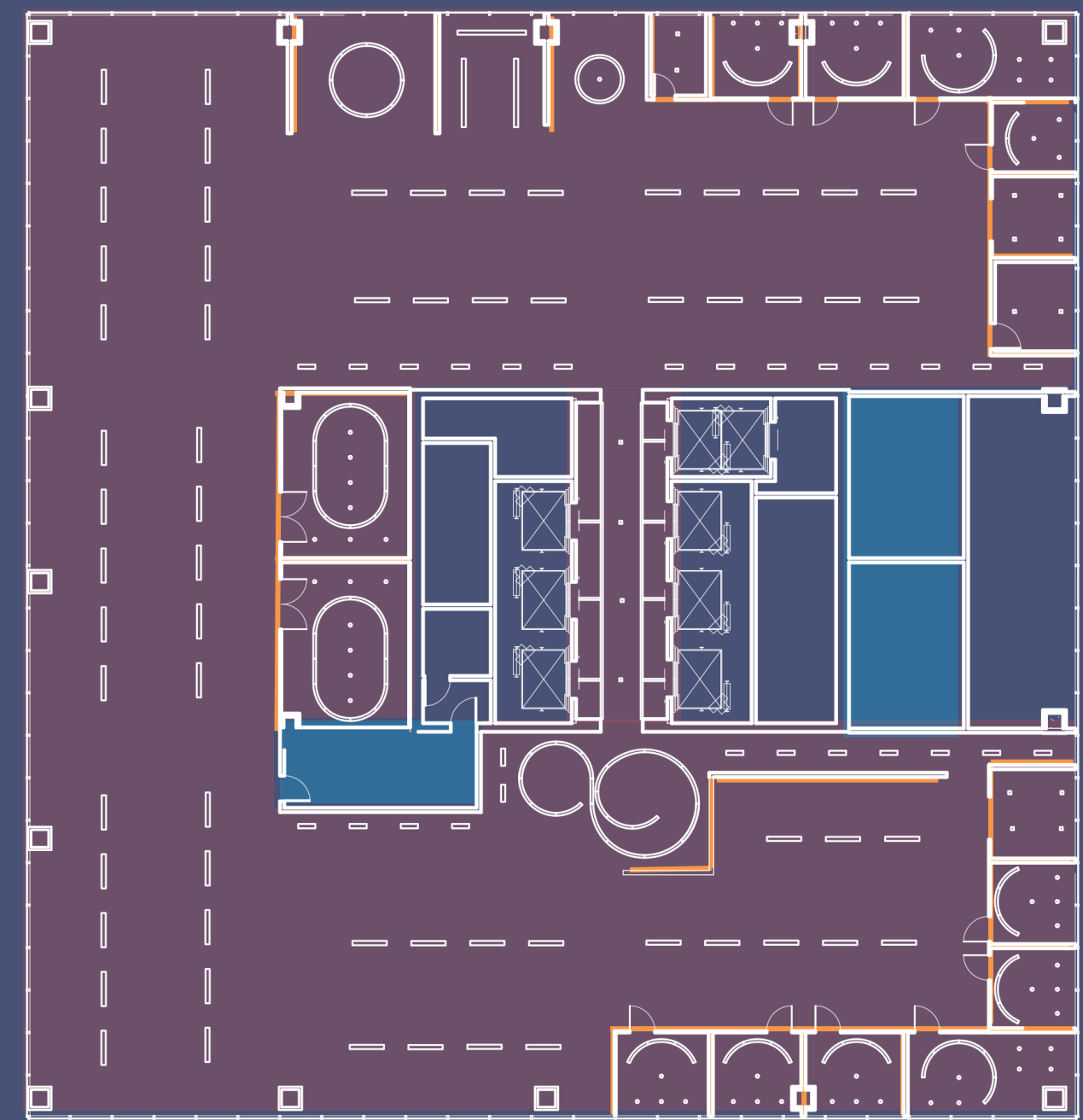
Summary / Results



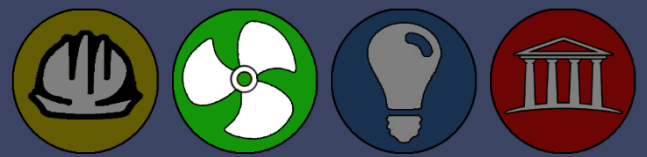
Raised Floor System

Walls that penetrate the raised floor

Pods



- Lighting
- Diffusers



# NEAR NET-ZERO ENERGY

## Energy Reduction

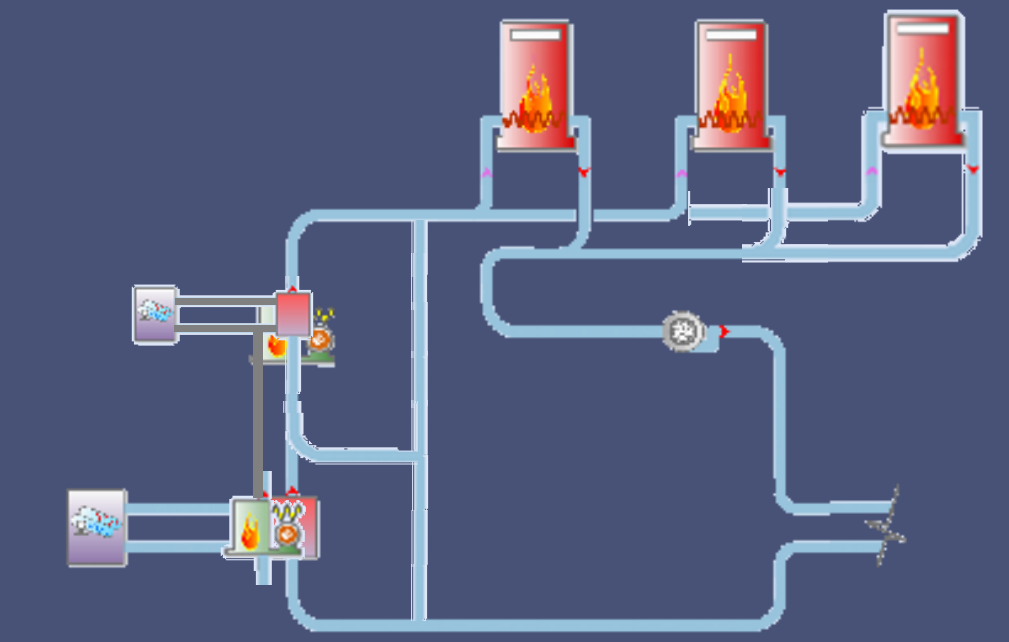
- Lighting Savings
- Double Façade

## Air Distribution

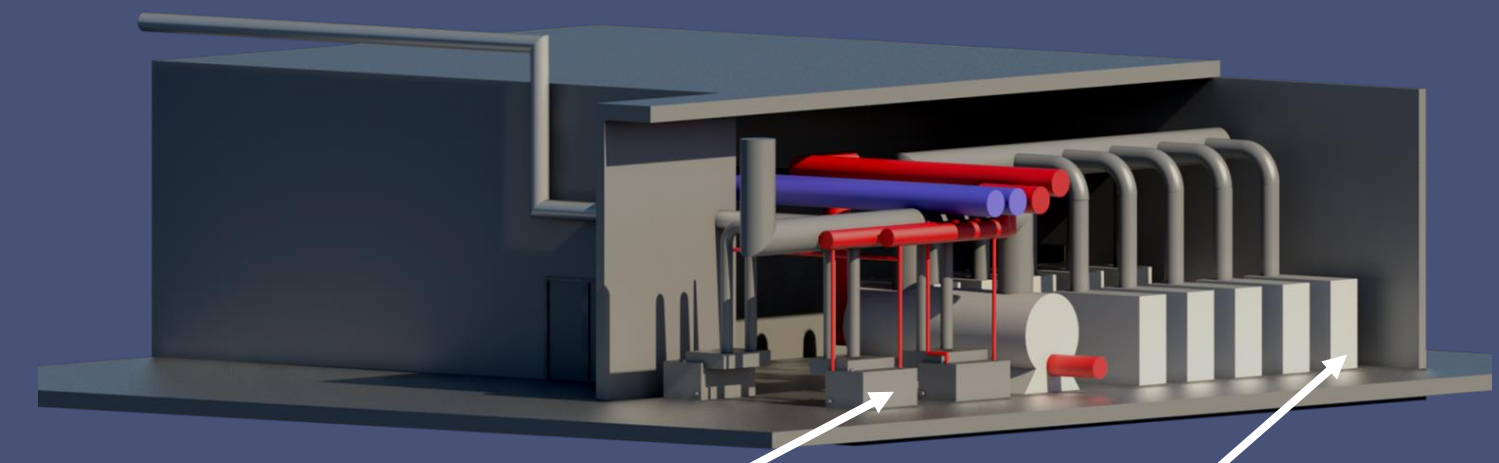
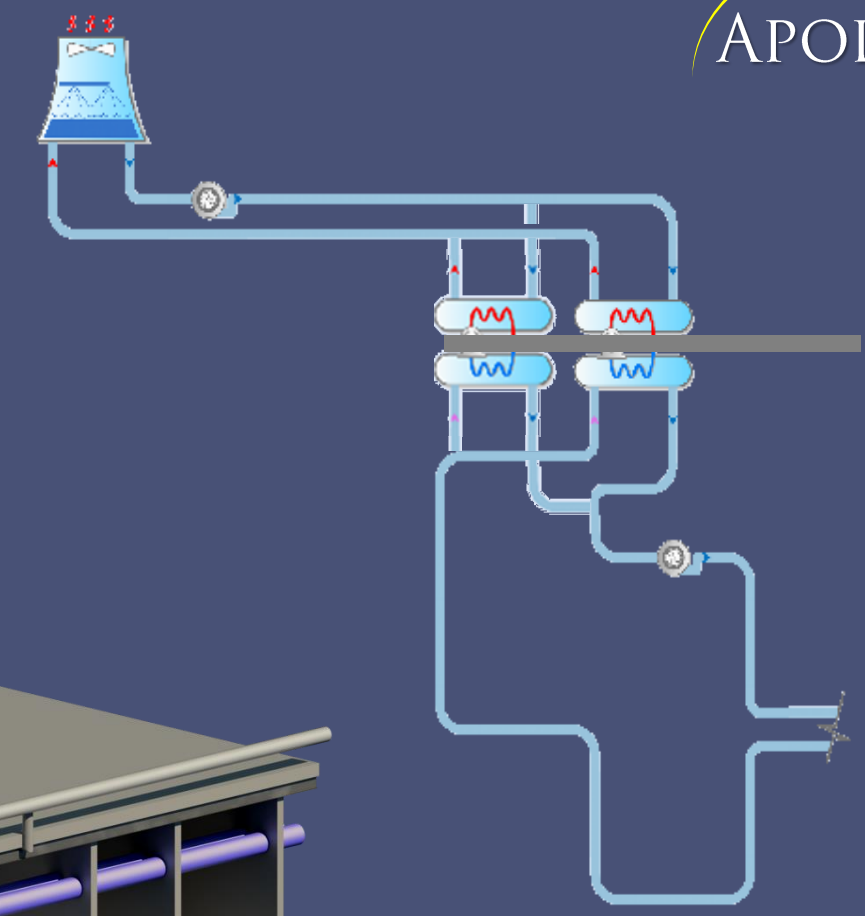
- Energy Production
- Photovoltaic
- CHP / Algae

- Additional
- Summary / Results

### Hot Water Loop



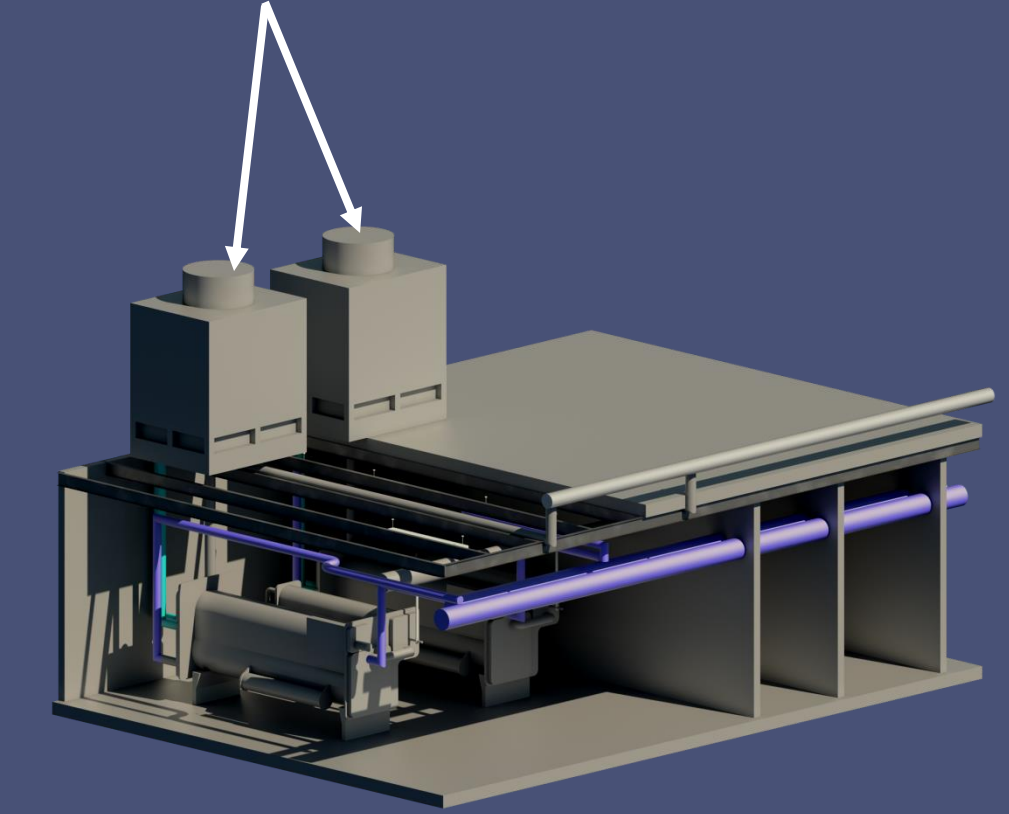
### Chilled Water Loop



750 MBH Natural Gas Boilers

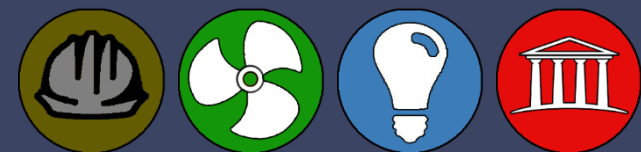
65 kW Capstone Microturbines

### 700 Ton Cooling Tower



450 Ton Absorption Chillers





# NEAR NET-ZERO ENERGY

- Energy Reduction
- Lighting Savings
- Double Façade
- Air Distribution
- Energy Production**
- Photovoltaic
- CHP / Algae
- Additional
- Summary / Results

## Size:

241 Photovoltaic panels mounted at 10 degrees from horizontal

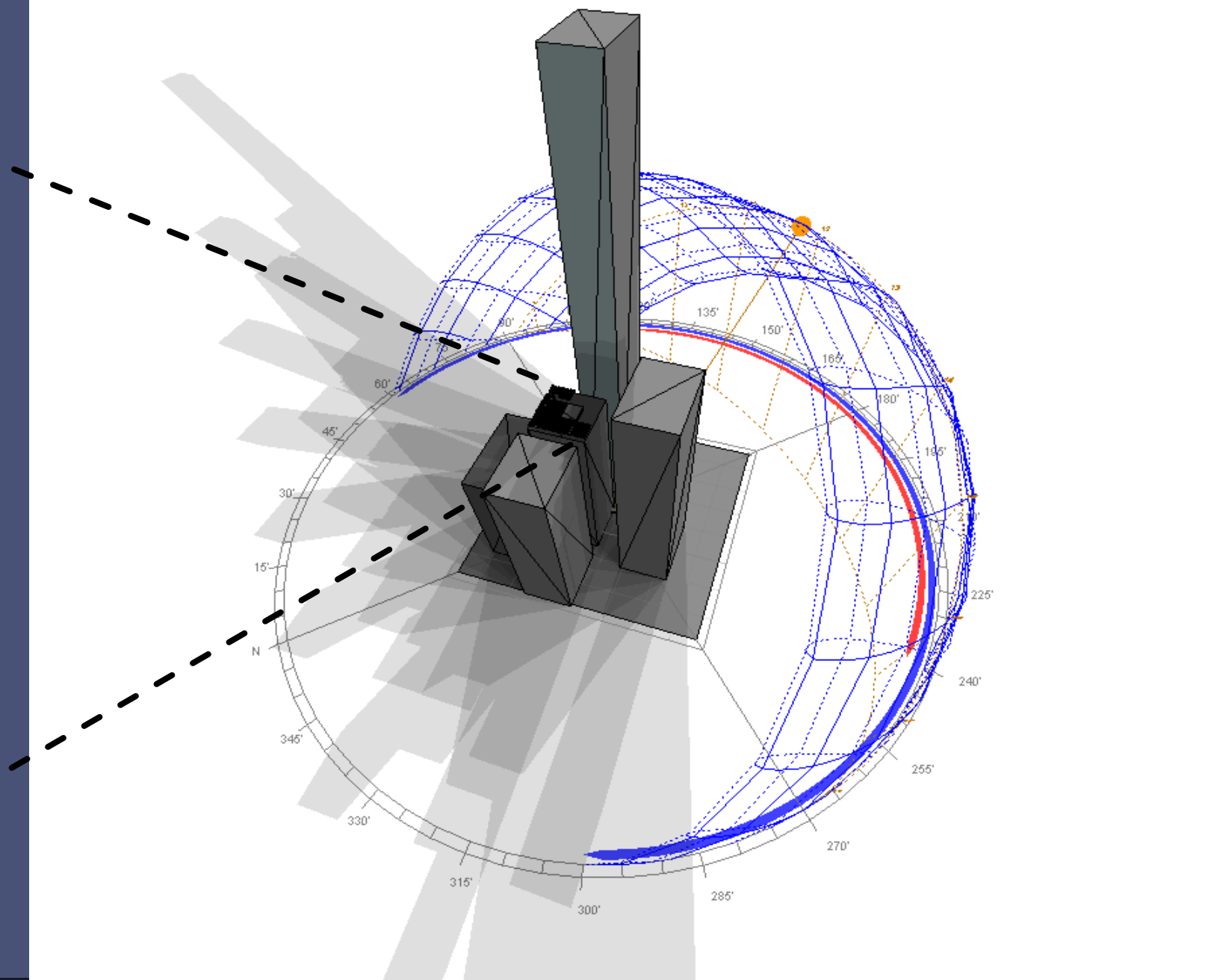
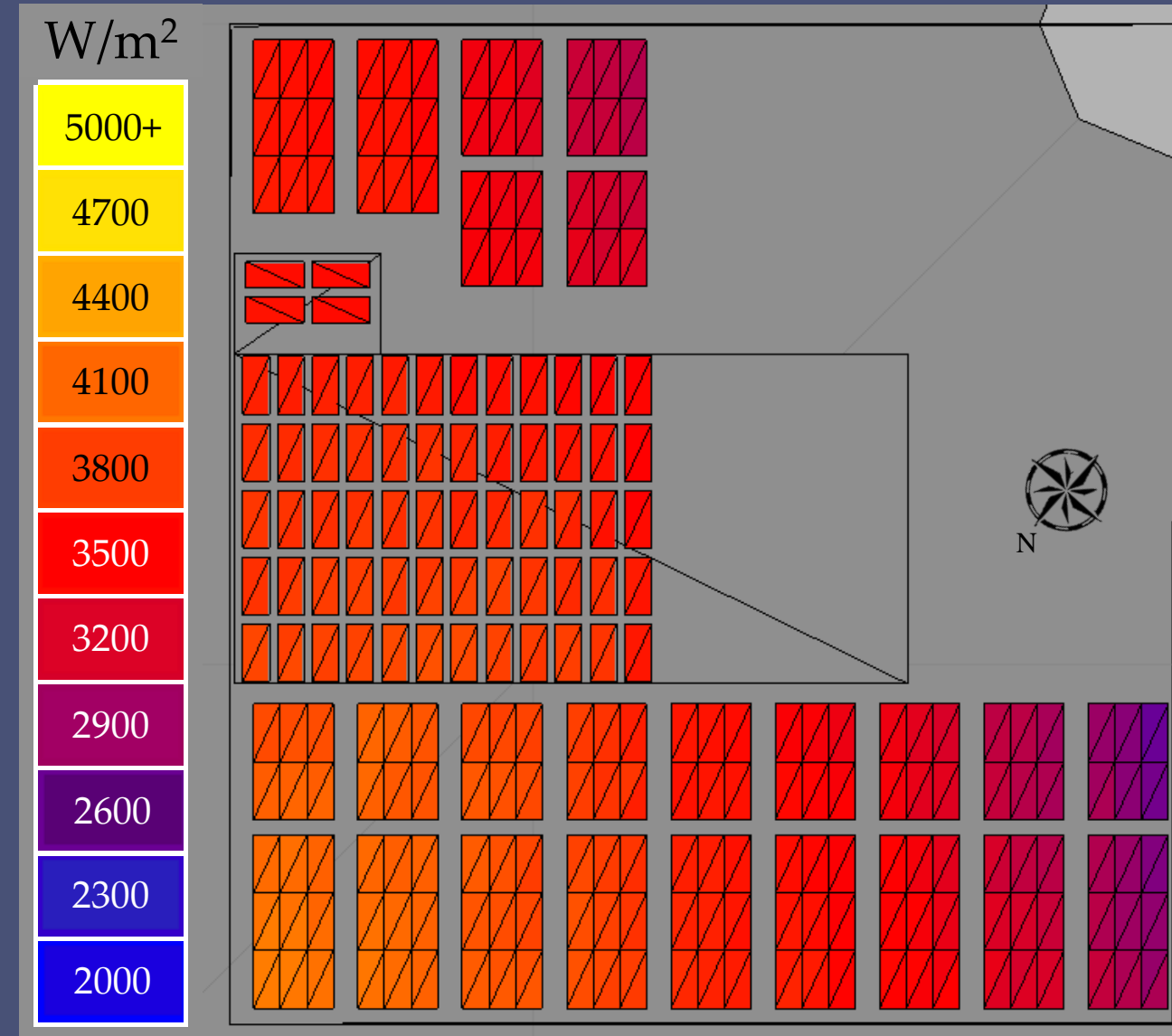
## Distribution:

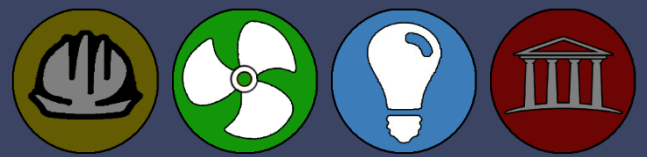
Transformed and fed into a distribution panel in rooftop electrical room

## Output:

149,808 kWhr per year

Over 4.5% of total energy use





# NEAR NET-ZERO ENERGY

- Energy Reduction
- Lighting Savings
- Double Façade
- Air Distribution

## Energy Production

- Photovoltaic
- CHP / Algae
- Additional
- Summary / Results



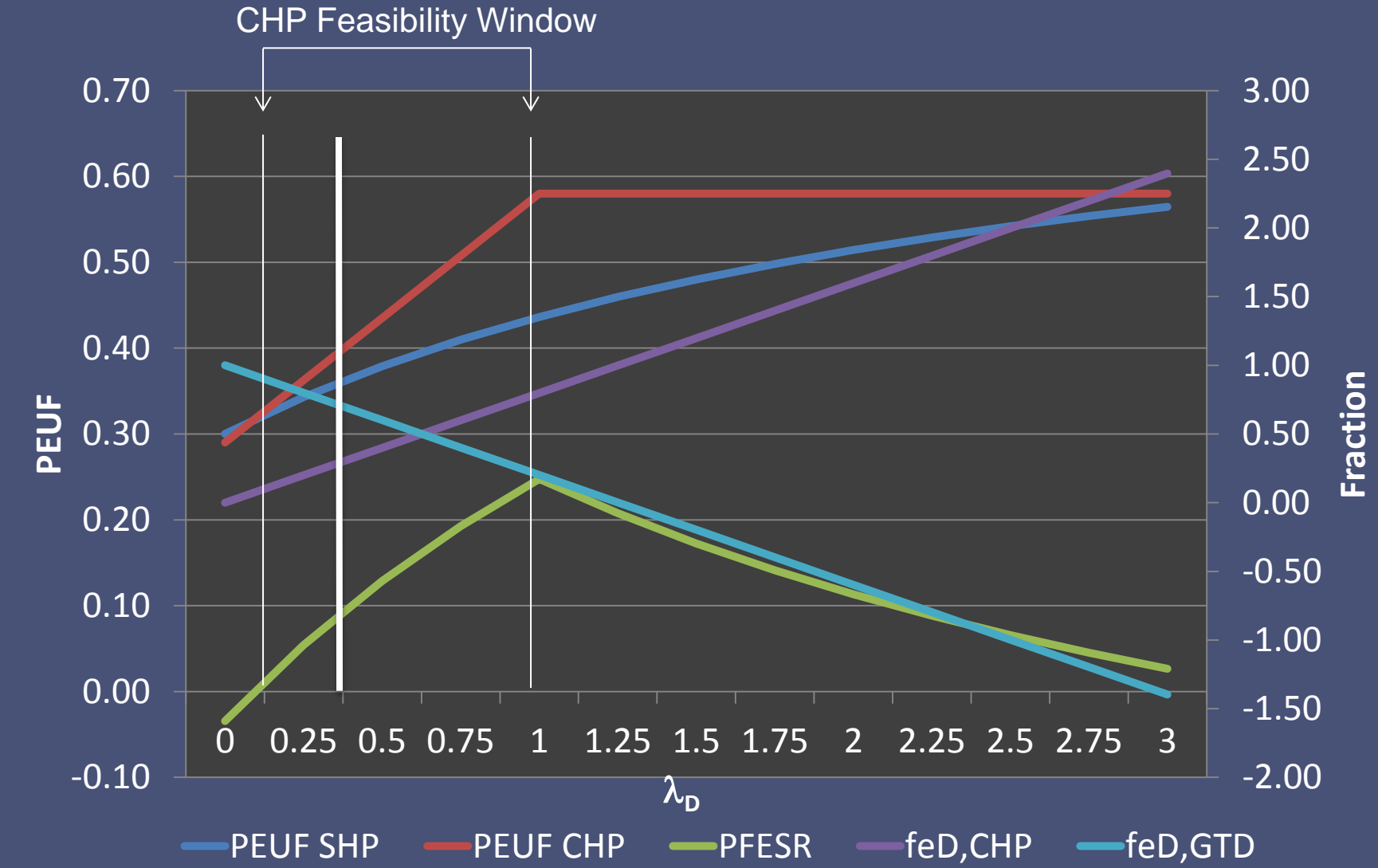
## Feasibility

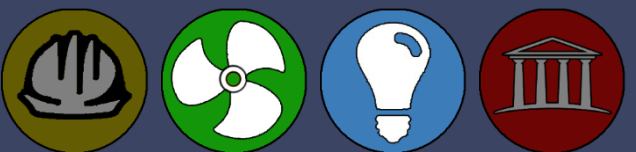
- High Electric Rates: **\$0.18/kWh**
- Desirable Spark Spread: **\$0.10/kWh**
- Future Energy Cost Concerns: **Yes**
- Reducing Environmental Impact: **Yes**

## Simple Payback Period (SPP)

- Initial System Cost **\$815,000**
- California CHP/Cogeneration Incentives Rebates **\$312,000**
- Capital Cost Post Rebate **\$503,000**
- Annual Operational Savings **\$101,400**

$$SPP = \frac{\text{Capital Cost}}{\text{Annual Savings}} = \frac{503,000}{101,400} = 5 \text{ years}$$





# NEAR NET-ZERO ENERGY

- Energy Reduction
- Lighting Savings
- Double Façade
- Air Distribution

## Energy Production

- Photovoltaic
- CHP / Algae
- Additional
- Summary / Results

### Electrical Output:

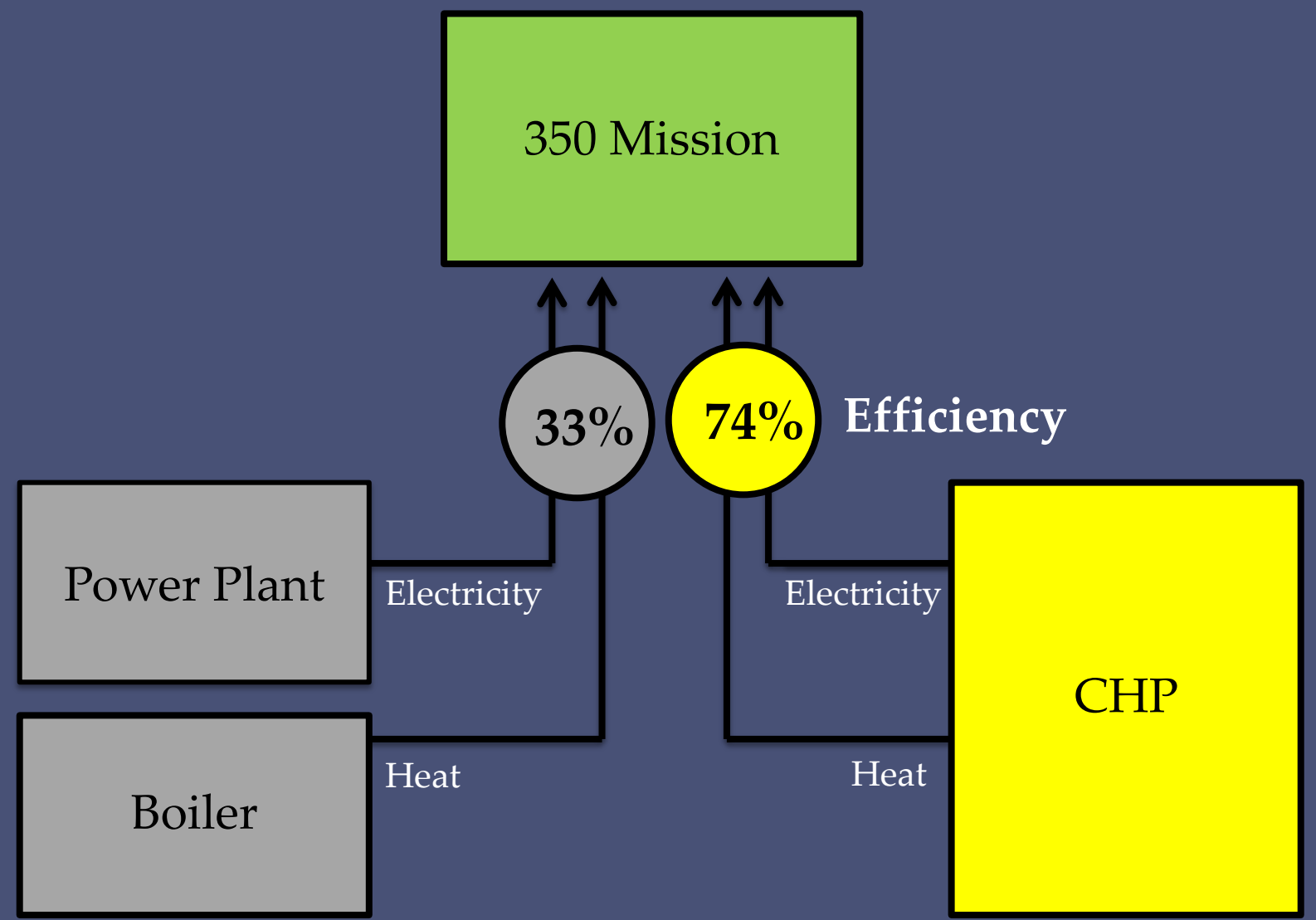
**Generation Capacity:** 650 kW  
**Generated Power:** 1,014,000 kWh/yr  
**Electrical Capacity Met:** 30%

### Thermal Output:

**Heat Recovery:** 1,850 MBtu/hr  
**Heat Recovery Efficiency:** 45%  
**Heat Capacity Met:** 88%

### CHP Fuel Savings and Carbon Emission Reduction:

**Fuel Savings:** 625 MCF (5%)  
**Carbon Reduction:** 355,663 lbs. CO<sub>2</sub> (20%)



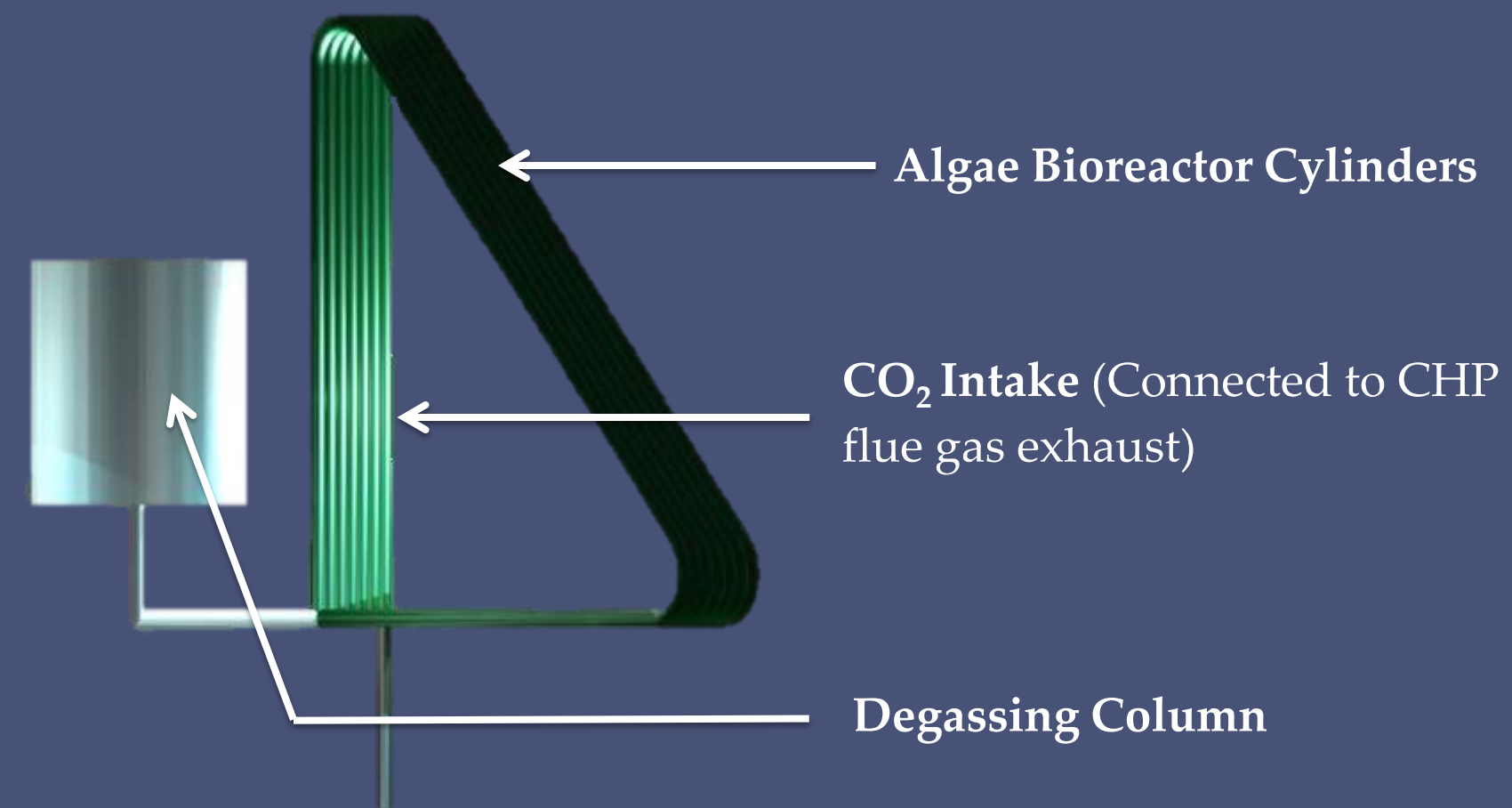


# NEAR NET-ZERO ENERGY

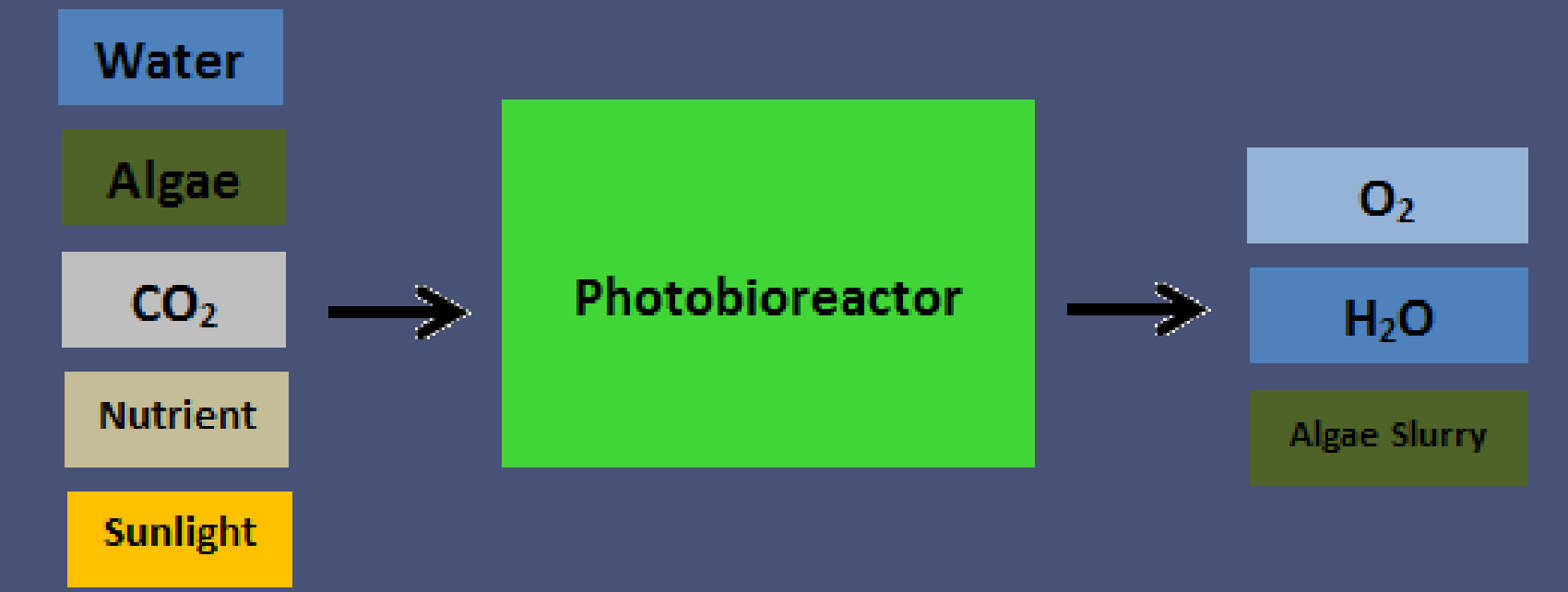
- Energy Reduction
  - Lighting Savings
  - Double Façade
  - Air Distribution
- Energy Production**
  - Photovoltaic
  - CHP / Algae
- Additional
- Summary / Results

## Carbon Reduction:

**Yearly Emissions:** 1,369,638 lbs CO<sub>2</sub>  
**Algae Sequestration:** 837,503 lbs CO<sub>2</sub>  
**Percent Reduction:** 60%



## Photosynthesis Chemical Reaction:



# WATER REDUCTION

## NEAR NET-ZERO ENERGY

### Energy Reduction

Lighting Savings

Double Façade

Air Distribution

### Energy Production

Photovoltaic

CHP / Algae

### Additional

Summary / Results

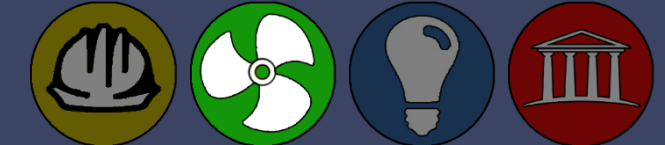
Water Use (Baseline)			
	# of Units	Gallons Per Flush	Total Use (Gal/Year)
Toilet - Men	53	1.6	60,420
Toilet - Women	105	1.6	359,100
Urinal	52	1.0	74,100
Total Non-Potable			<b>493,620</b>
		Gallons Per Minute	
Faucet	108	0.5	115,425
TOTAL			<b>609,045</b>

Water Use (Proposed)			
	# of Units	Gallons Per Flush	Total Use (Gal/Year)
Toilet - Men	53	1.0	37,763
Toilet - Women	105	1.0	224,438
Urinal	52	1.0	74,100
Total Non-Potable			<b>336,300</b>
		Gallons Per Minute	
Faucet	108	0.5	115,425
TOTAL			<b>451,725</b>

**26% Reduction**



# RAINWATER COLLECTION



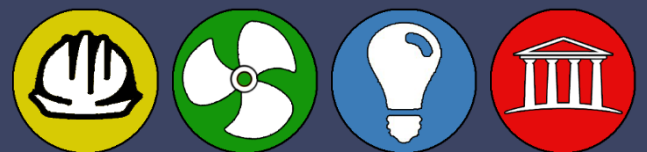
## NEAR NET-ZERO ENERGY

- Energy Reduction
  - Lighting Savings
  - Double Façade
  - Air Distribution
- Energy Production**
  - Photovoltaic
  - CHP / Algae
- Additional**
  - Summary / Results

Non-Potable Water Demand				
	Use (Gal/unit)	Units	Gal/month	Total Yearly Gal
Toilets	2,850	158	21,850	262,200
Urinals	1,425	52	6,175	74,100
<b>Total</b>			28,025	<b>336,300</b>
	July (min)	Feb (max)		Annual
Rainfall (in)	0.00	4.61		
Collection Capacity (Gal)	0.00	36,759		<b>189,774</b>

**56% of Demand Supplied**

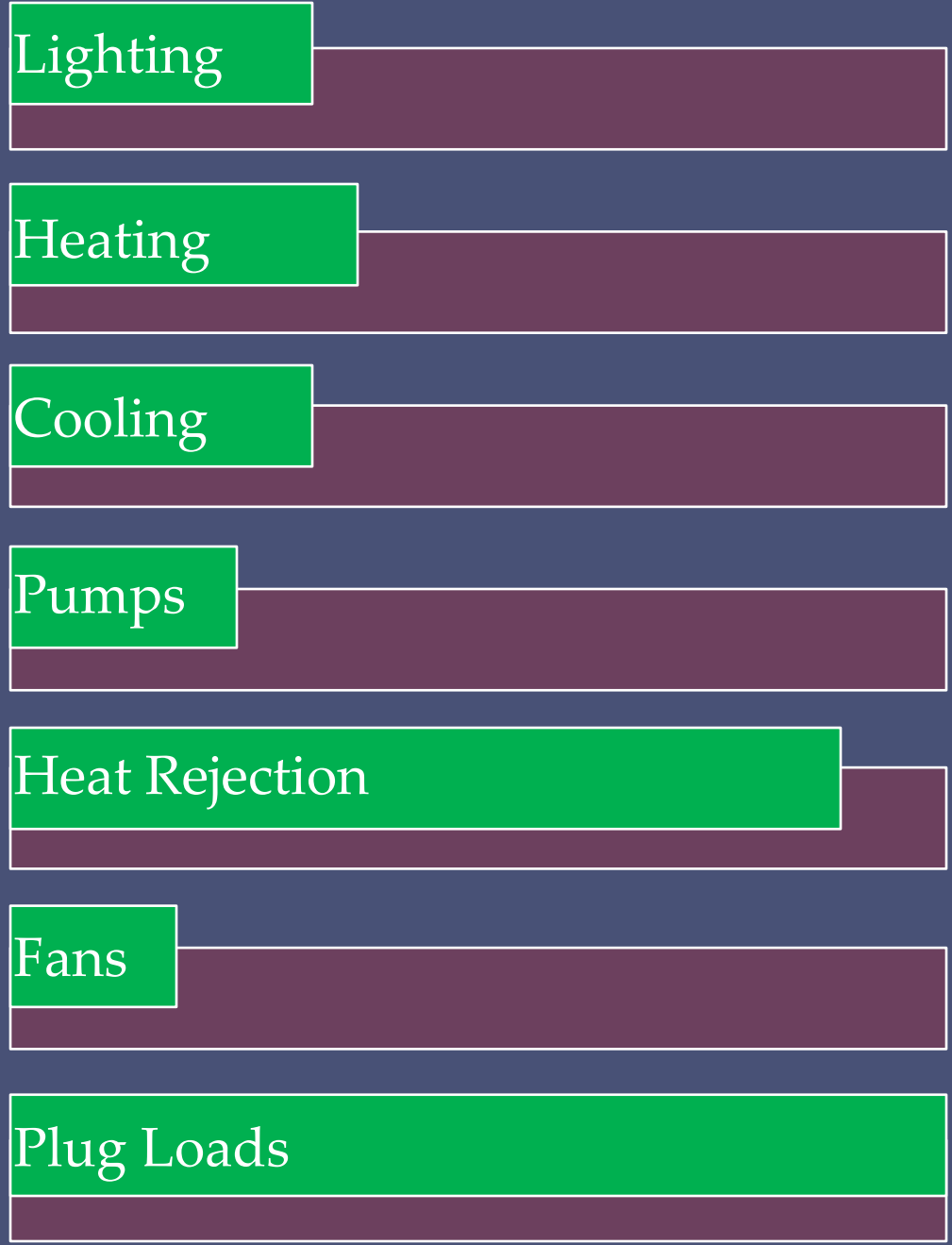
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Urinal	52	1.0	74,100
<b>Total Non-Potable</b>			<b>336,300</b>
		Gallons Per Minute	
Faucet	108	0.5	115,425
<b>TOTAL</b>			<b>451,725</b>



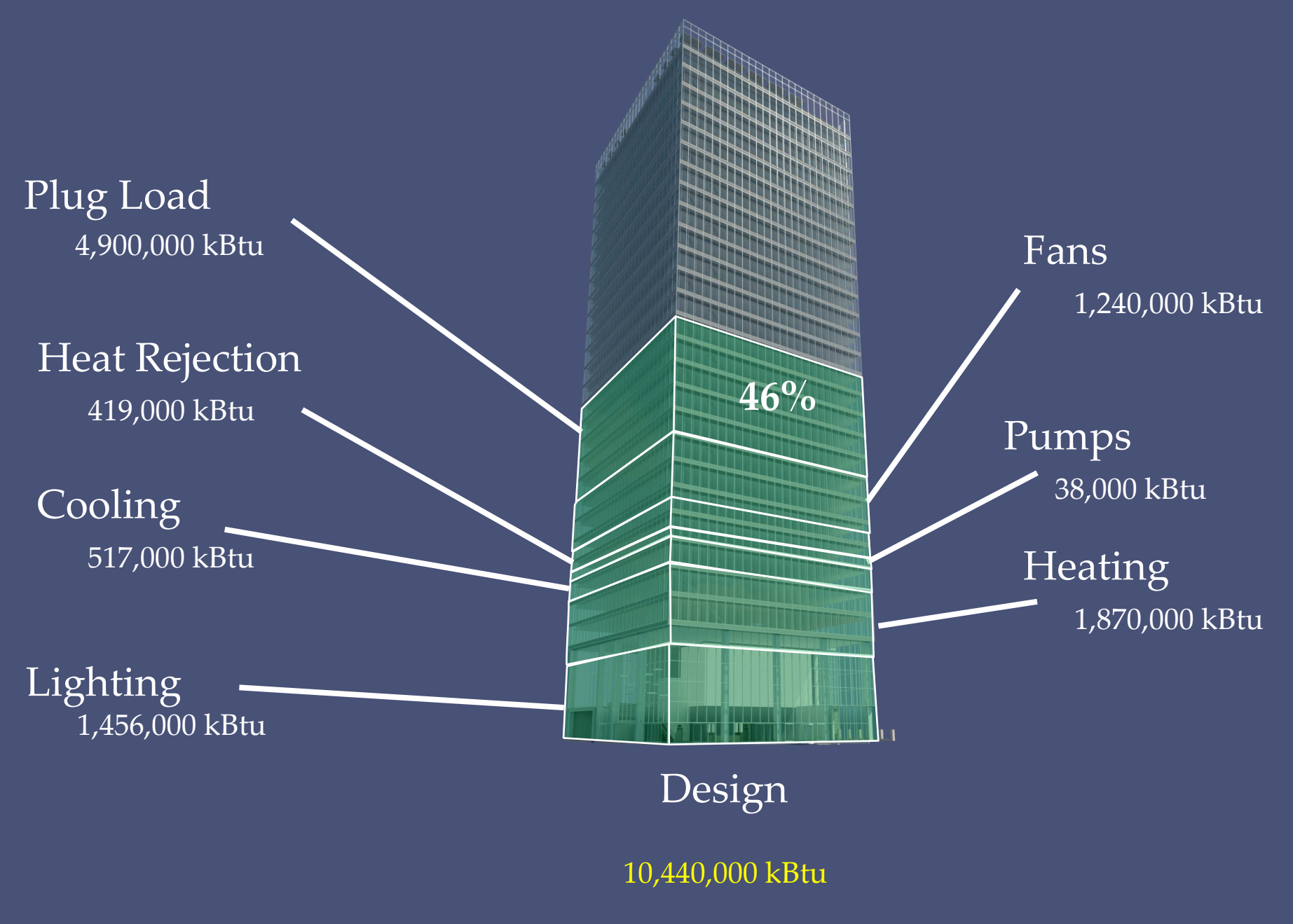
NEAR NET-ZERO ENERGY

- Energy Reduction
- Lighting Savings
- Double Façade
- Air Distribution
- Energy Production
- Photovoltaic
- CHP / Algae
- Additional

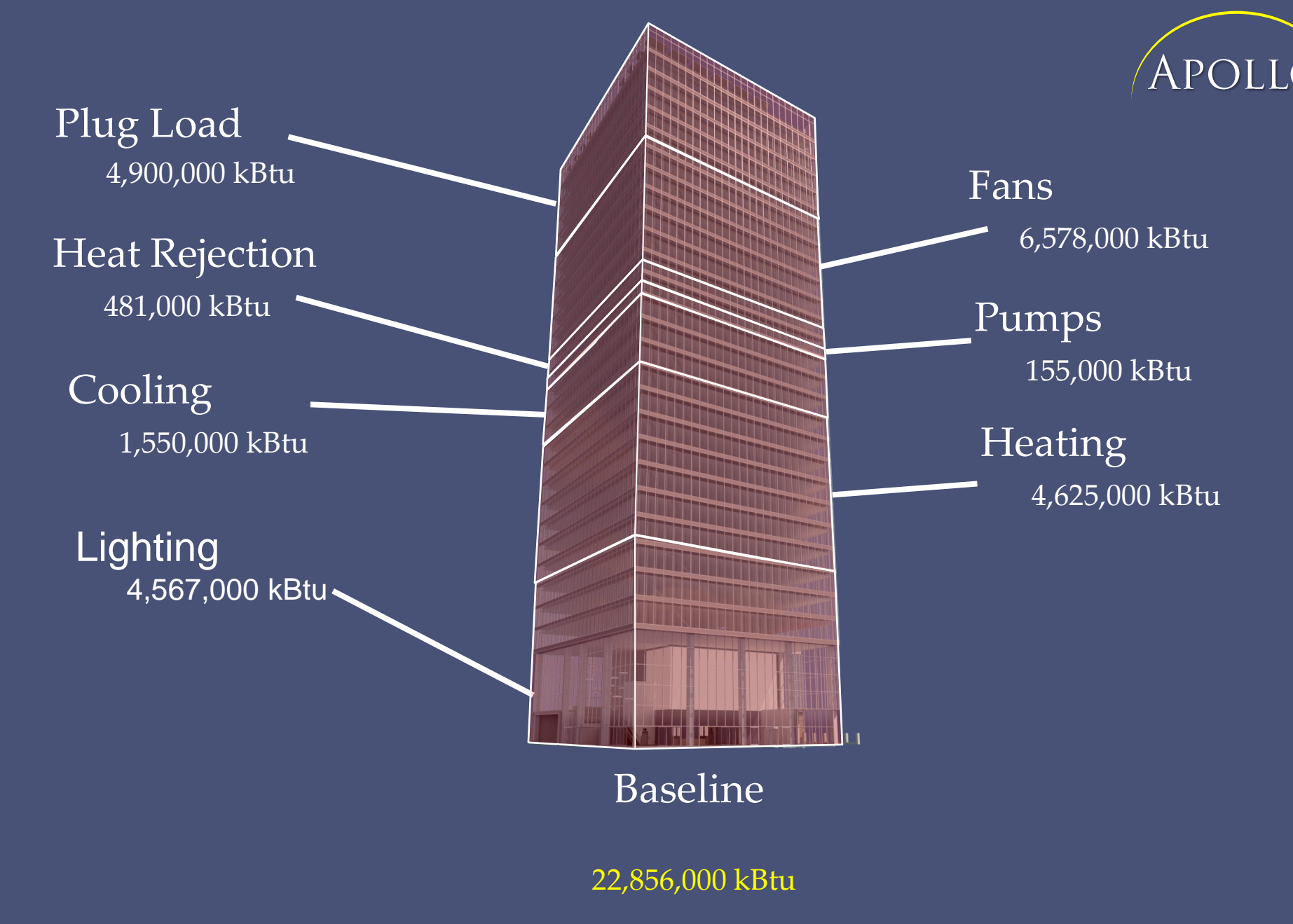
Summary / Results



Immediate Occupancy



Near Net-Zero Energy

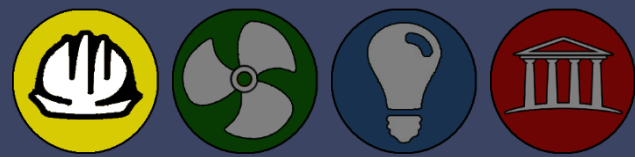


Construction

Achievements



Introduction



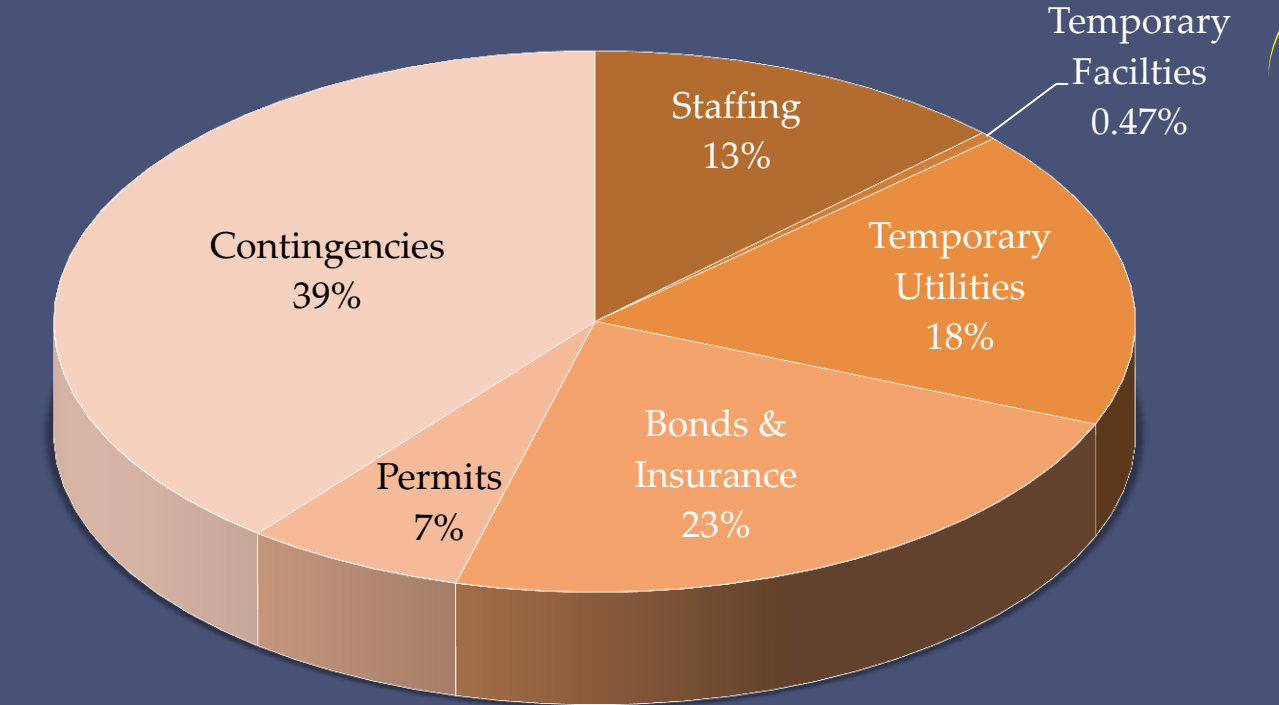
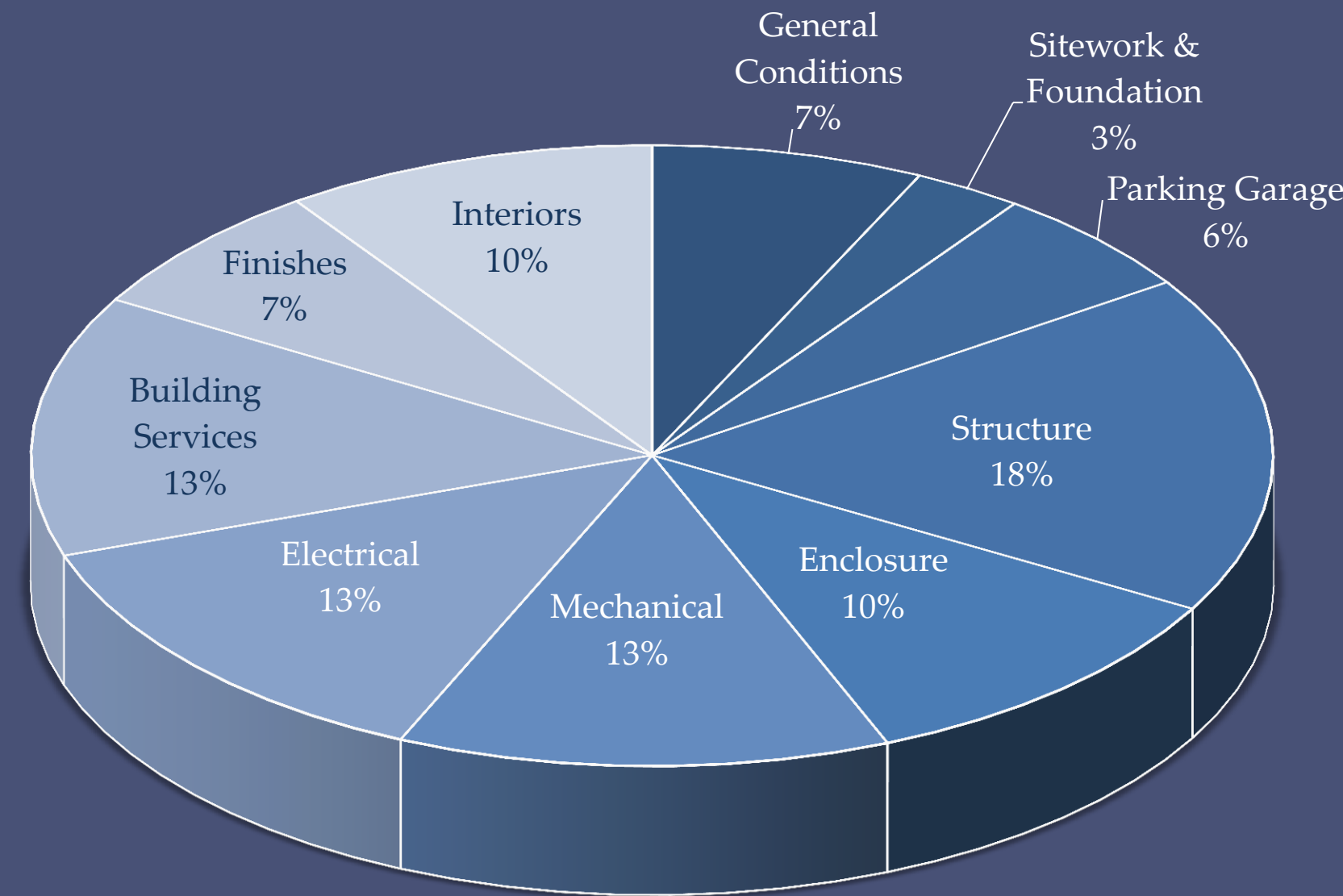
## CONSTRUCTION

### Cost Analysis

- Site Conditions
- Demolition
- Excavation
- Steel Sequencing
- Prefabrication
- Enclosure

General Conditions	\$ 10,500,566
Sitework & Foundation	\$ 4,204,416
Parking Garage	\$ 8,363,950
Structure	\$ 26,139,244
Enclosure	\$ 15,686,885
Mechanical	\$ 18,969,095
Electrical	\$ 19,443,945
Building Services	\$ 20,152,892
Finishes	\$ 10,249,287
Interiors	\$ 14,384,990

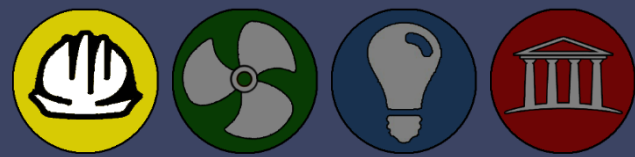
**Total** **\$ 148,095,270**



Staffing	\$ 1,336,560
Temporary Facilities	\$ 49,428
Temporary Utilities	\$ 1,890,856
Bonds & Insurance	\$ 2,407,908
Permits	\$ 687,974
Contingences	\$ 8,255,682

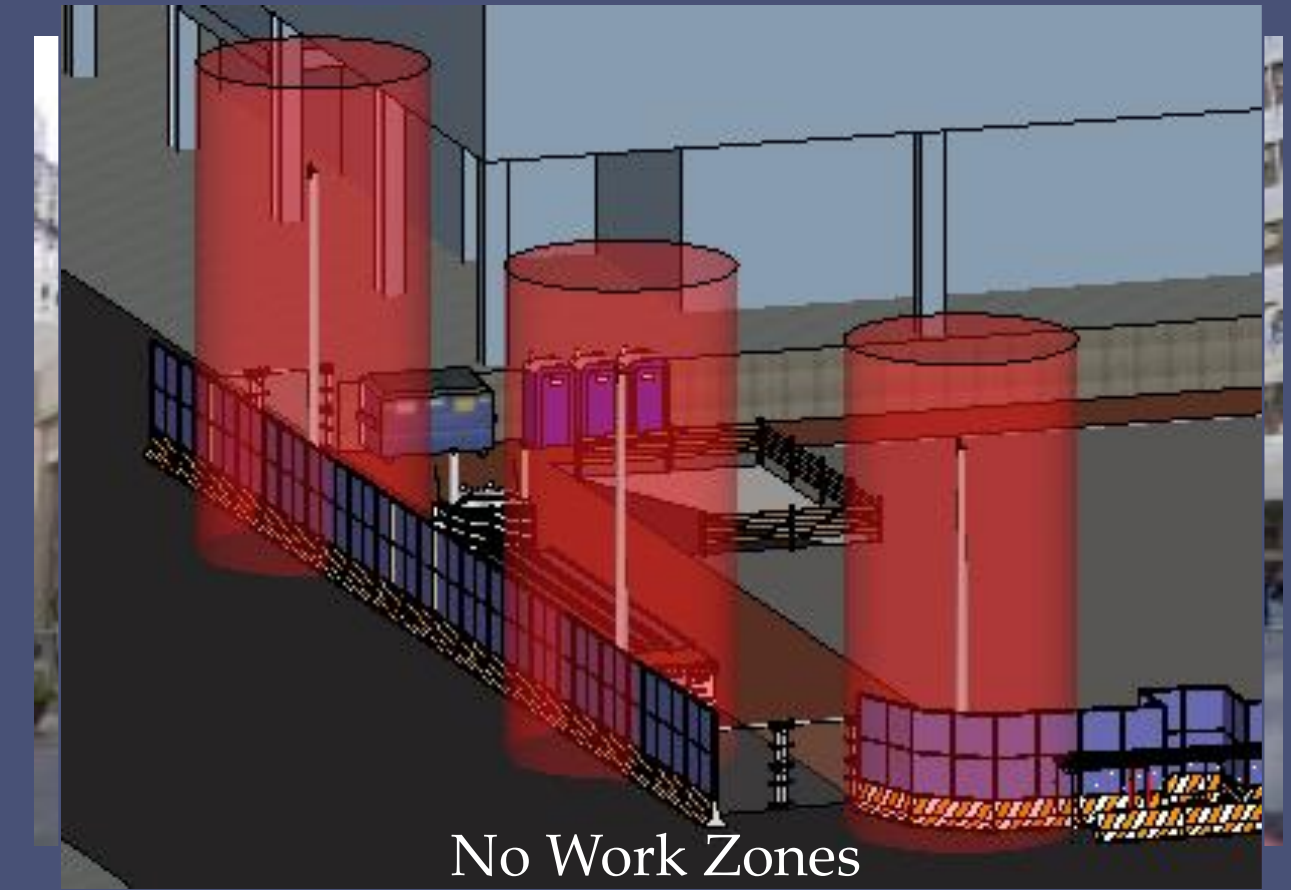
**Total** **\$ 10,500,566**

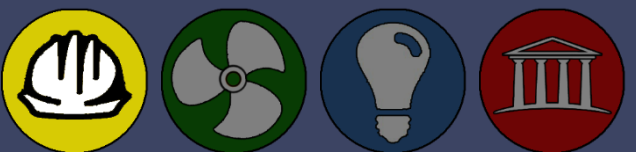




# CONSTRUCTION

- Cost Analysis
- Site Conditions**
- Demolition
- Excavation
- Steel Sequencing
- Prefabrication
- Enclosure



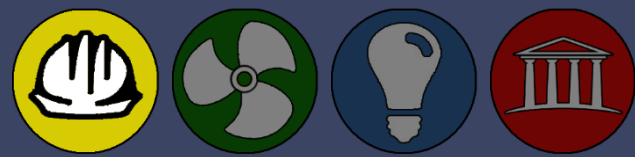


# CONSTRUCTION

- Cost Analysis
- Site Conditions
- Demolition
- Excavation
- Steel Sequencing
- Prefabrication
- Enclosure

## 29 MONTH SCHEDULE





# CONSTRUCTION

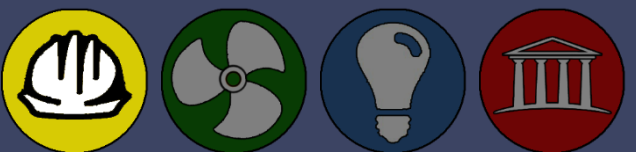
- Cost Analysis
- Site Conditions
- Demolition**
- Excavation
- Steel Sequencing
- Prefabrication
- Enclosure

## Abatement:

- Testing done by California Department of Health Services
- Roughly 50 Days



4/21/14



# CONSTRUCTION

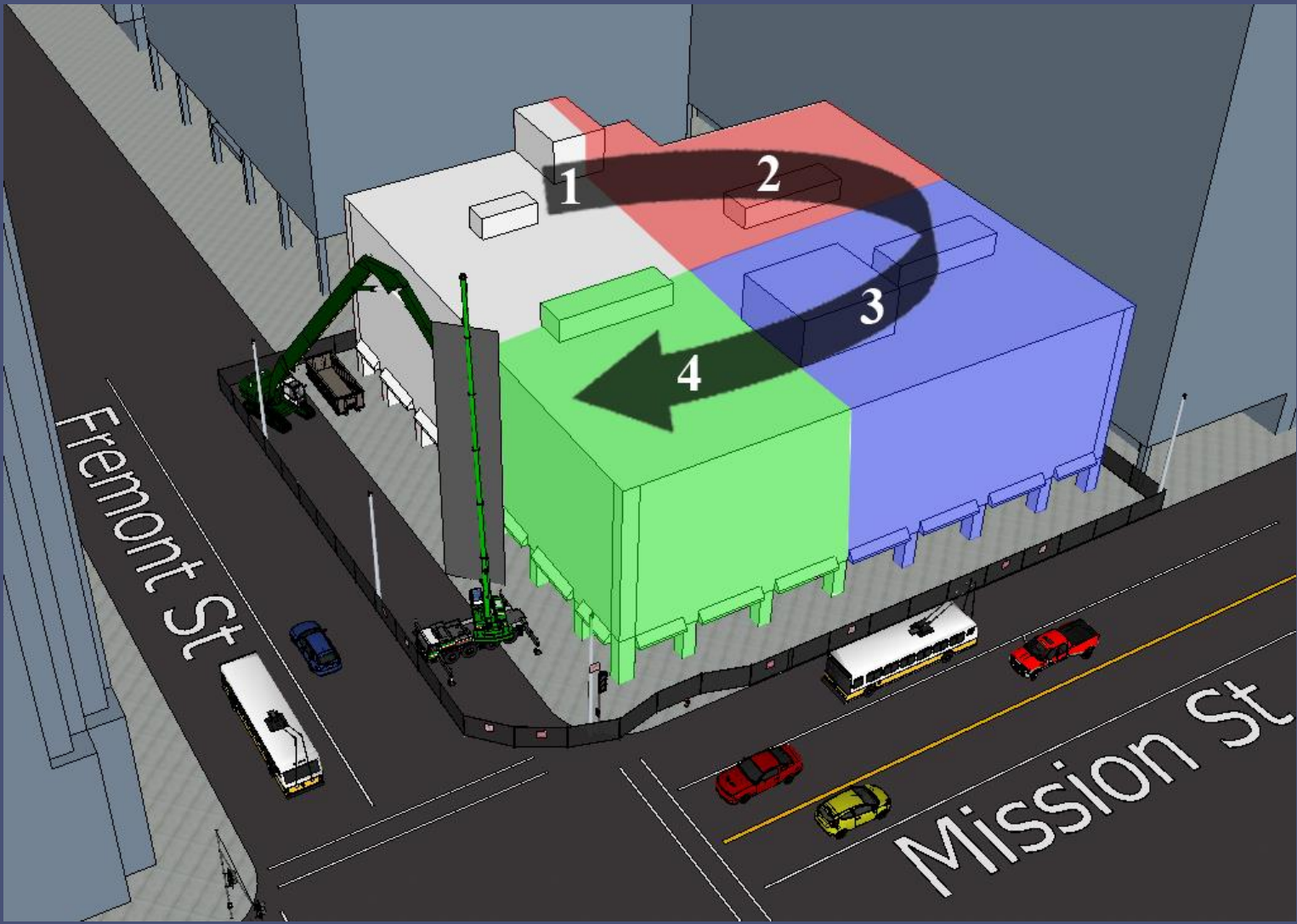
- Cost Analysis
- Site Conditions
- Demolition**
- Excavation
- Steel Sequencing
- Prefabrication
- Enclosure

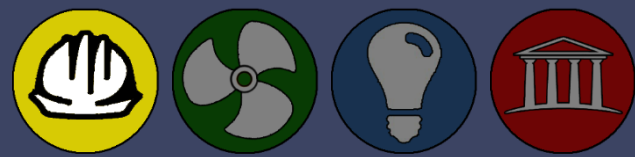
## Abatement:

- Testing done by California Department of Health Services
- Roughly 50 Days

## Demolition:

- Demolition Mat
- Sort & Recycle Off Site
- Concrete Reuse





# CONSTRUCTION

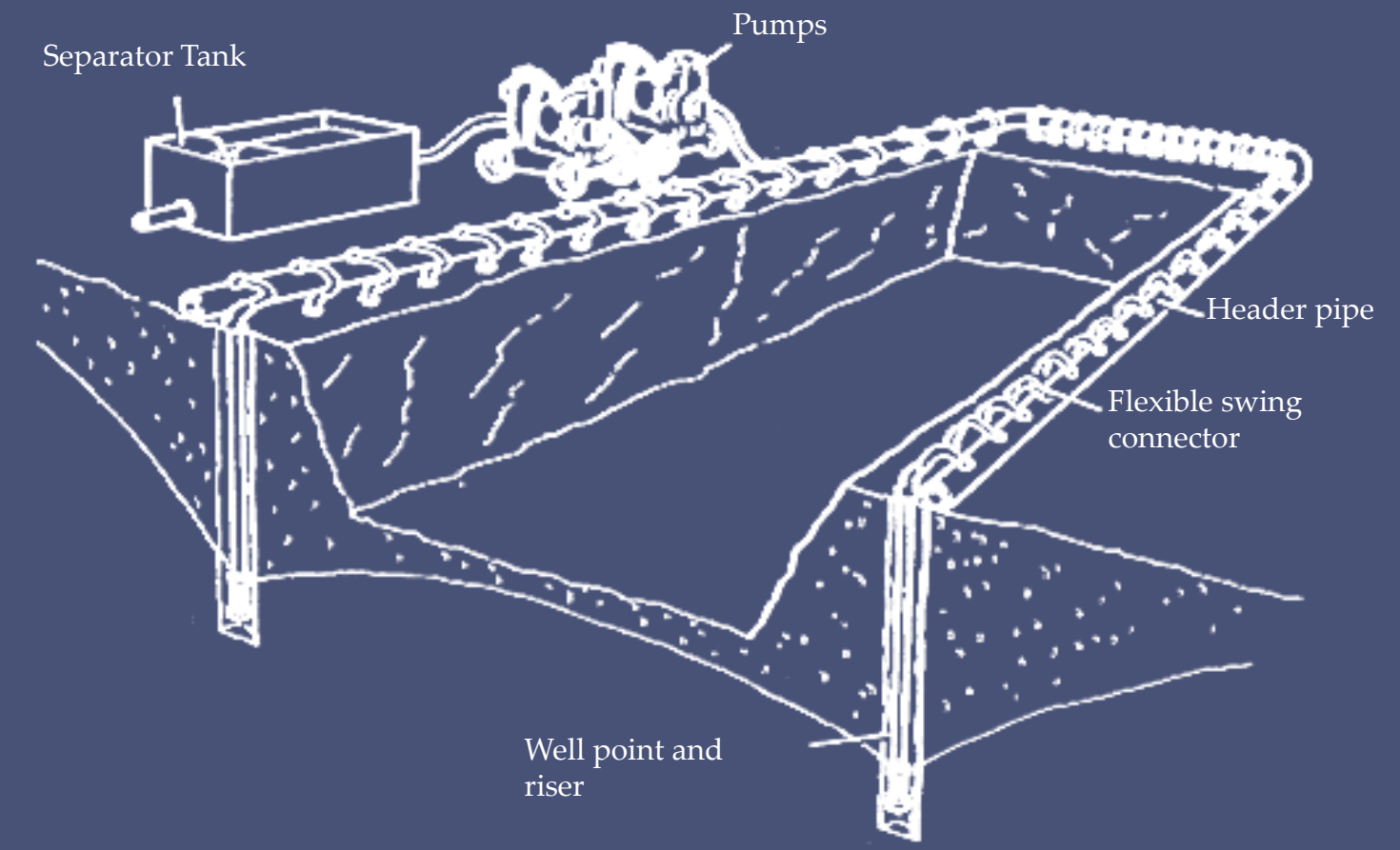
- Cost Analysis
- Site Conditions
- Demolition
- Excavation**
- Steel Sequencing
- Prefabrication
- Enclosure

## Dewatering:

- Deep Well Dewatering System
- Design Groundwater elevation = -3 ft
- Total Excavation Depth = -55 ft

## Slurry Wall

### Typical Wellpoint System



6/16/14





# CONSTRUCTION

- Cost Analysis
- Site Conditions
- Demolition
- Excavation**
- Steel Sequencing
- Prefabrication
- Enclosure

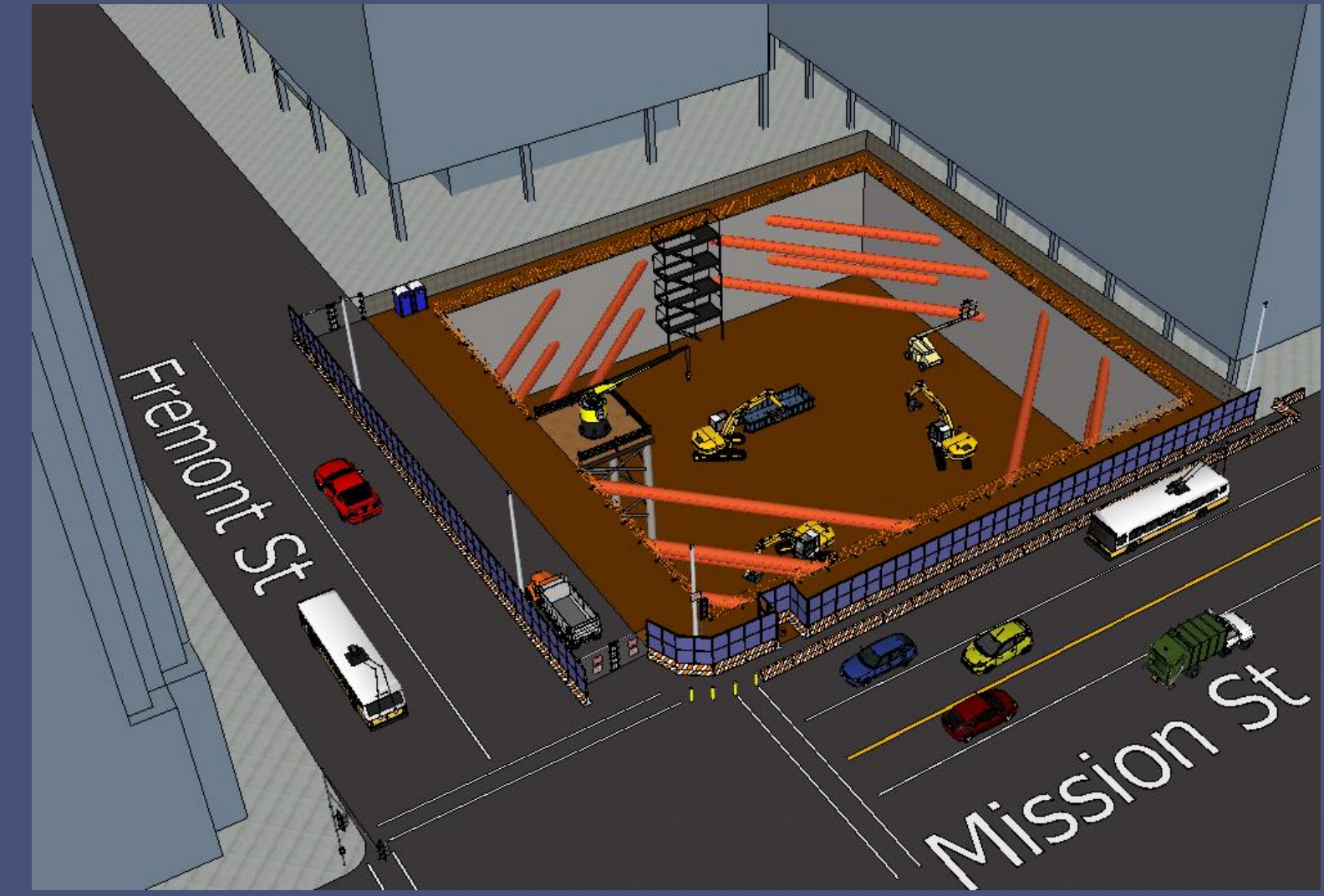
## Dewatering:

- Deep Well Dewatering System
- Design Groundwater elevation = -3 ft
- Total Dewatering Depth = -55 ft

## Slurry Wall

## Excavation:

- Temporary Internal Bracing
- Delivery Area
- Transportation Routes



6/16/14



# CONSTRUCTION

- Cost Analysis
- Site Conditions
- Demolition
- Excavation**
- Steel Sequencing
- Prefabrication
- Enclosure

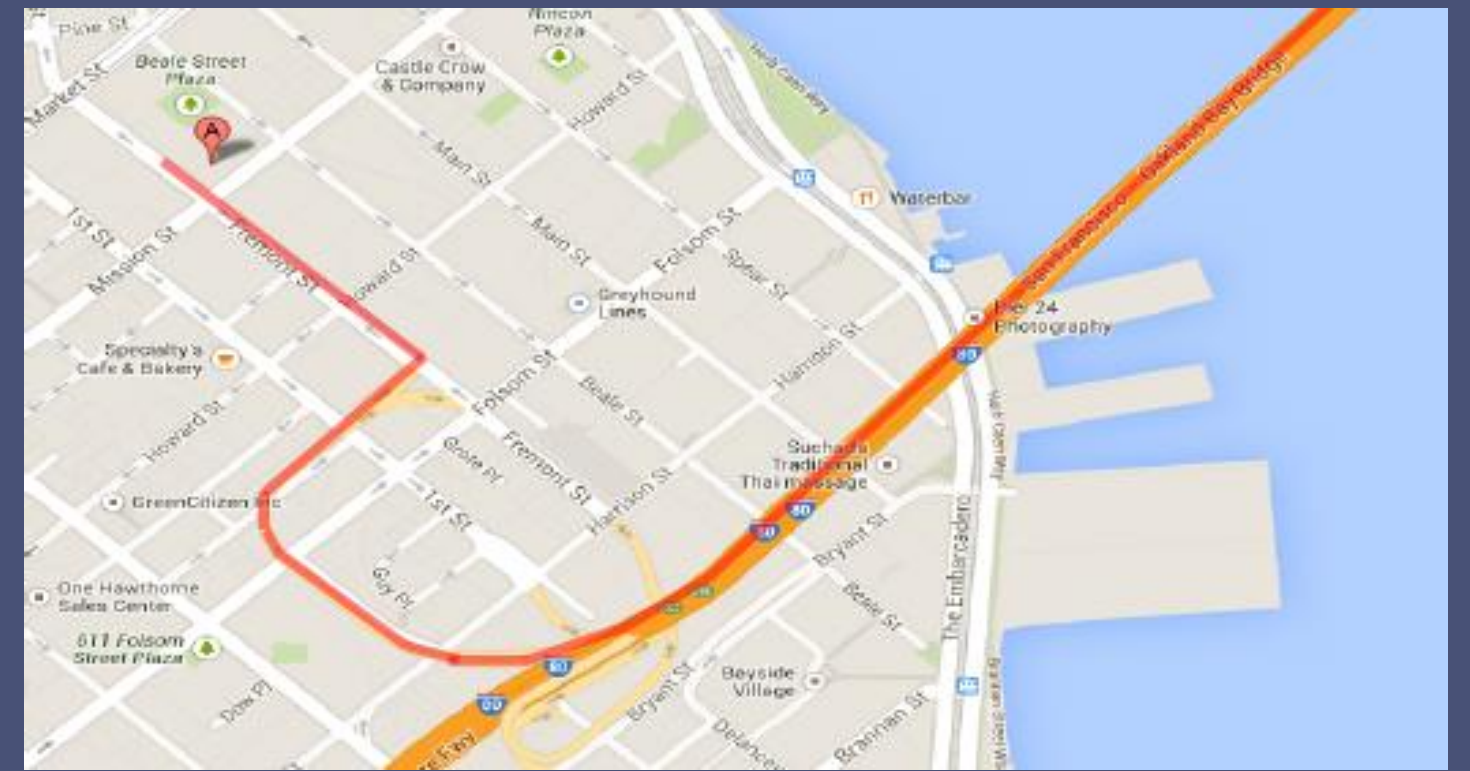
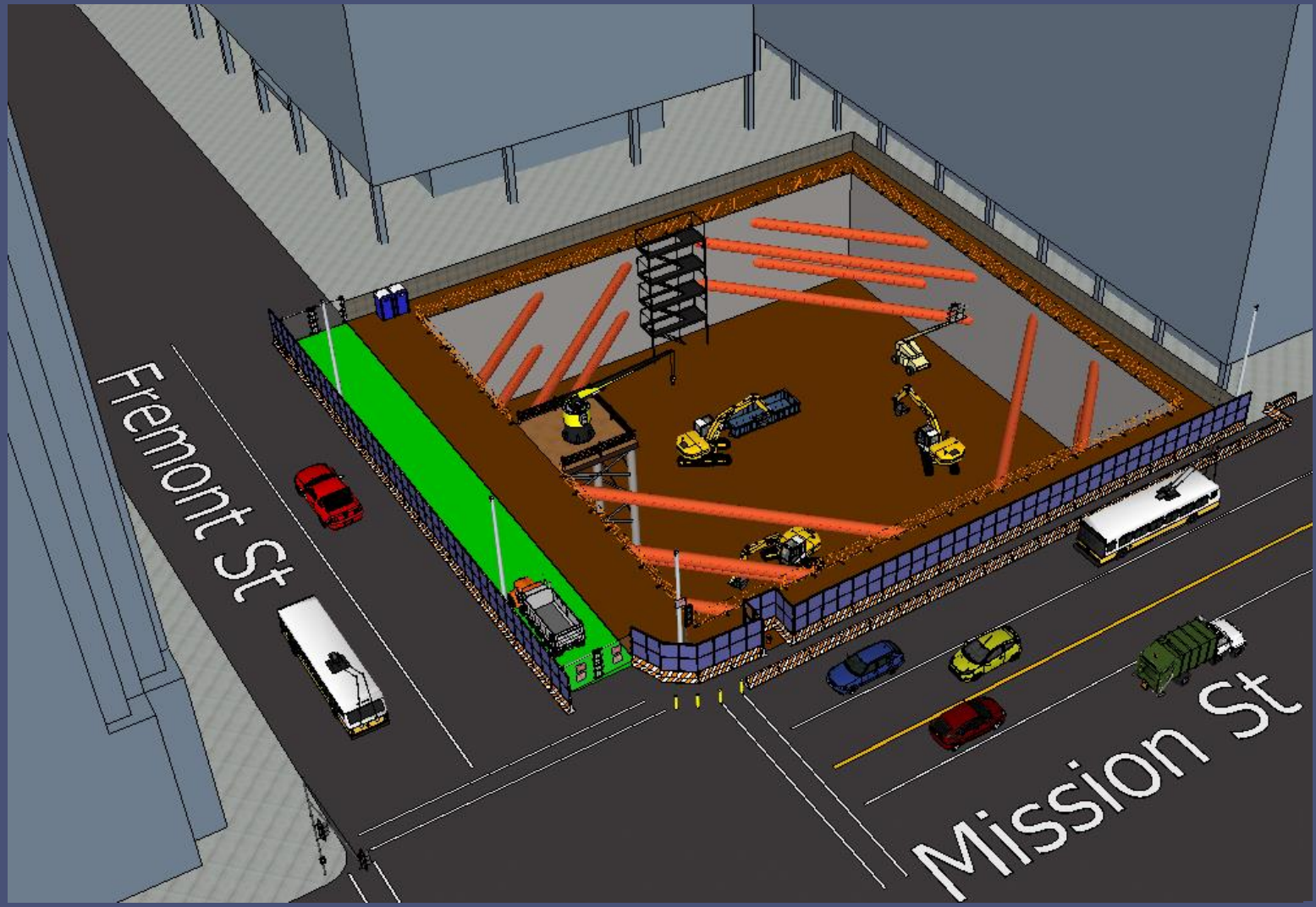
## Dewatering:

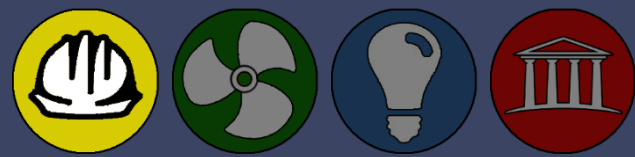
- Deep Well Dewatering System
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- Total Excavation Depth = -55 ft

## Slurry Wall

## Excavation:

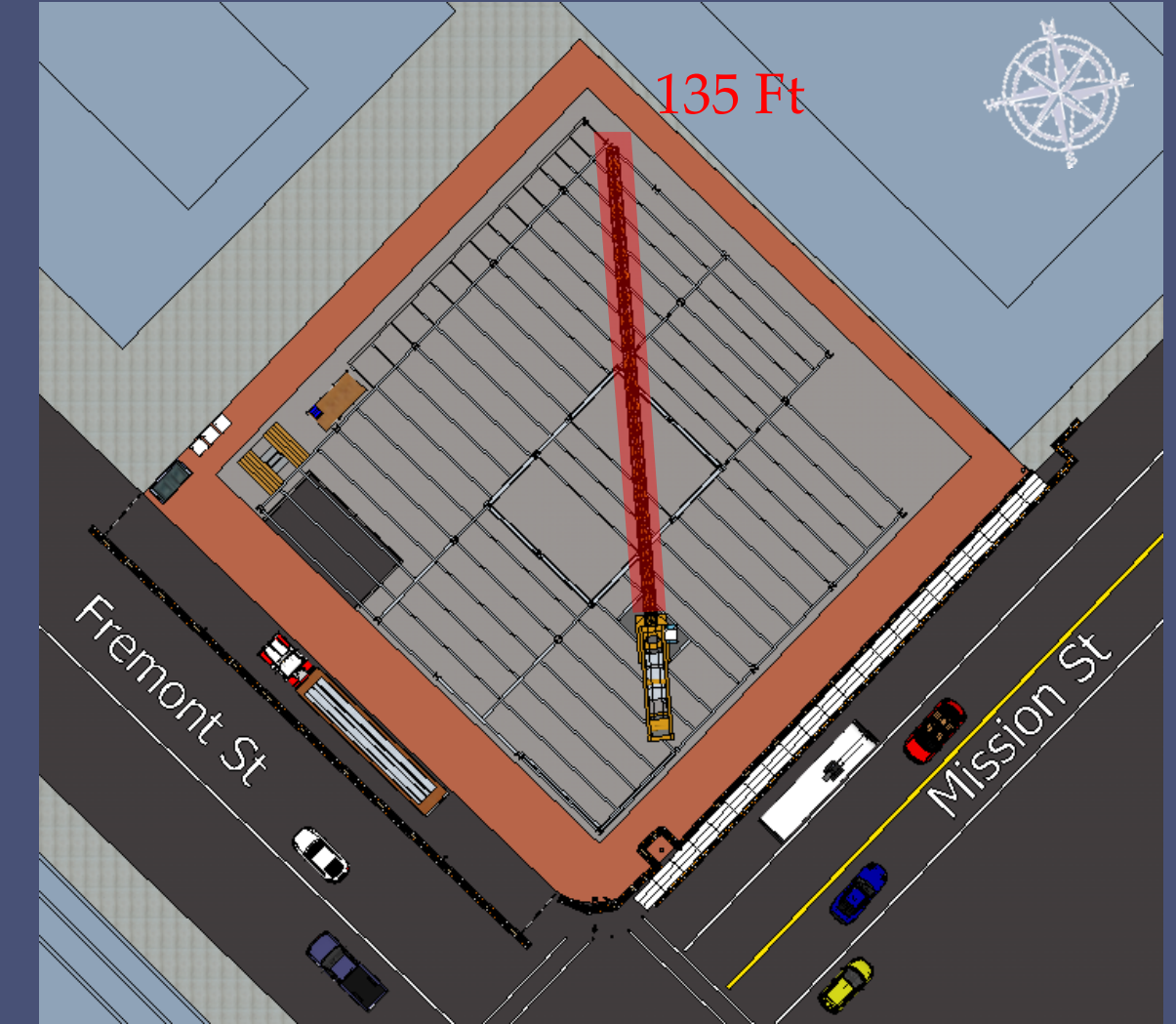
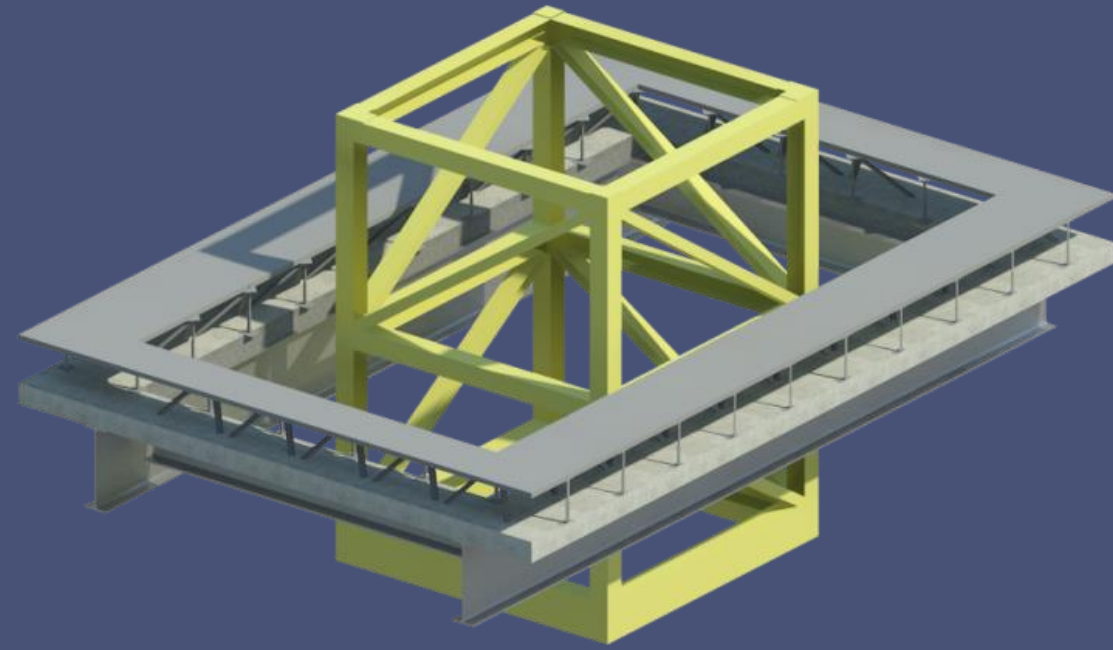
- Temporary Internal Bracing
- Delivery Area
- Transportation Routes





# CONSTRUCTION

- Cost Analysis
- Site Conditions
- Demolition
- Excavation
- Steel Sequencing**
- Prefabrication
- Enclosure



9/30/15

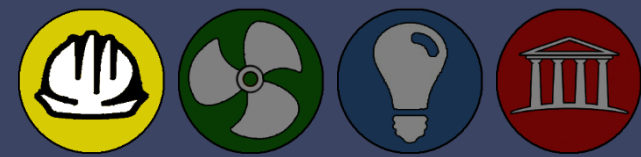
Introduction

Immediate Occupancy

Near Net-Zero Energy

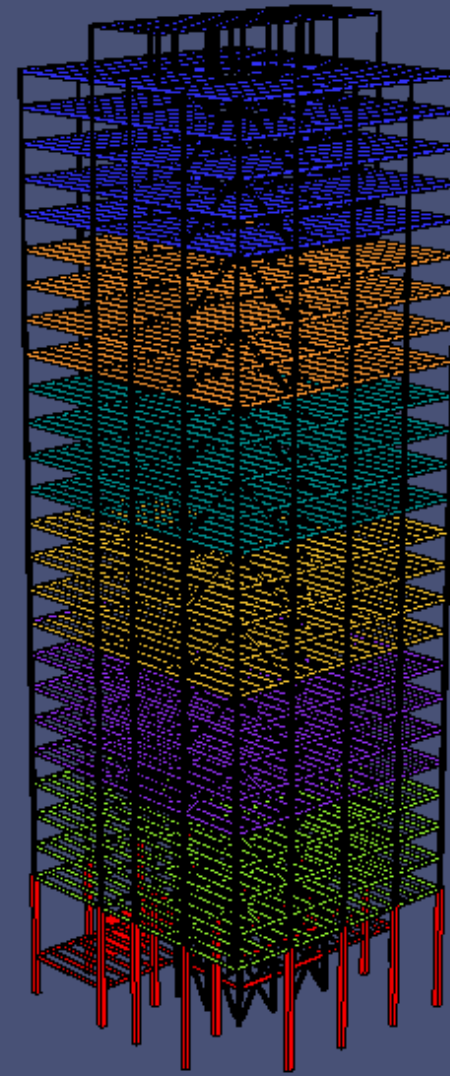
**Construction**

Achievements

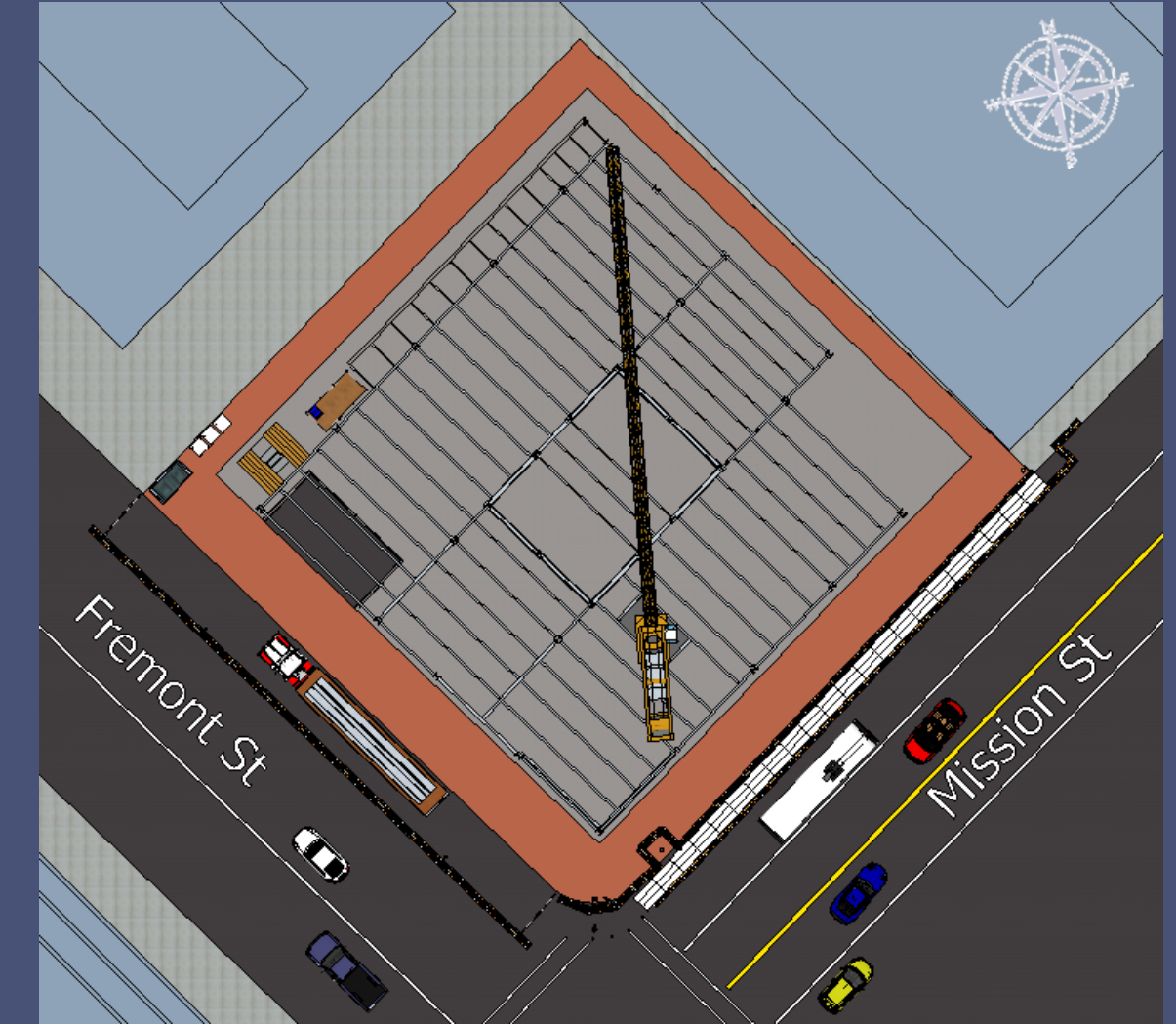


# CONSTRUCTION

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- Levels 25 - 30
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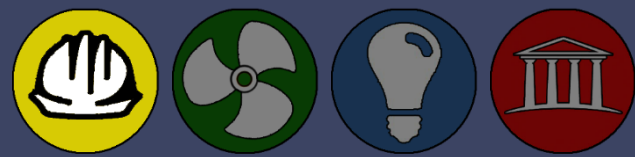
## Construction

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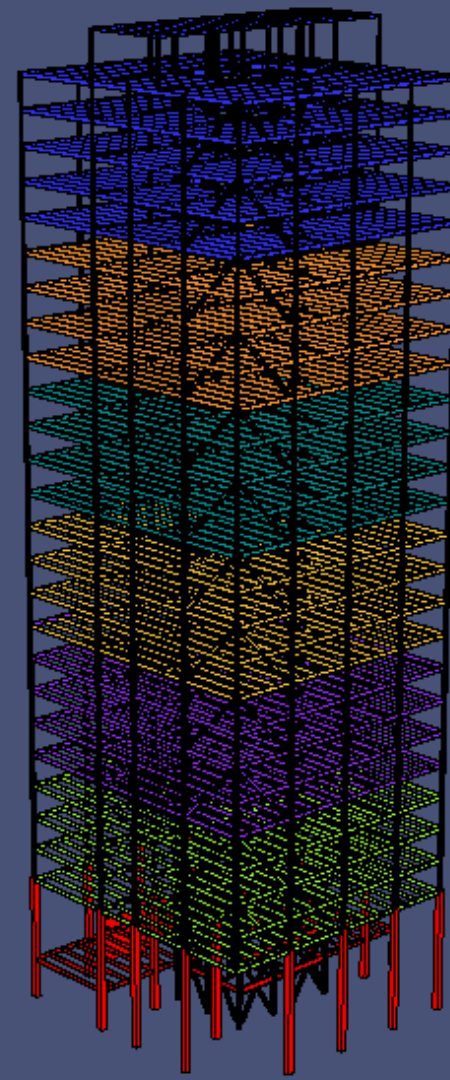
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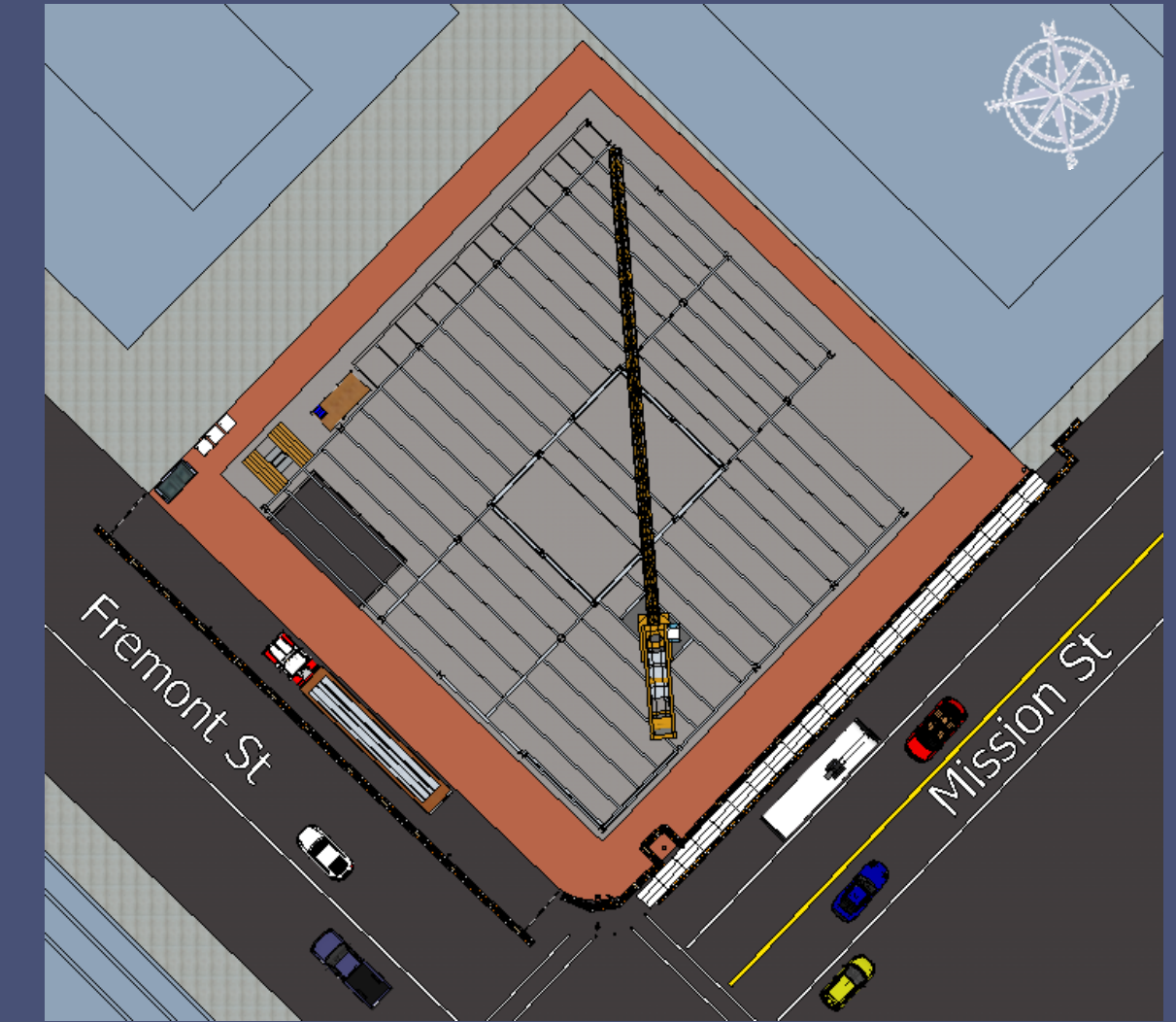
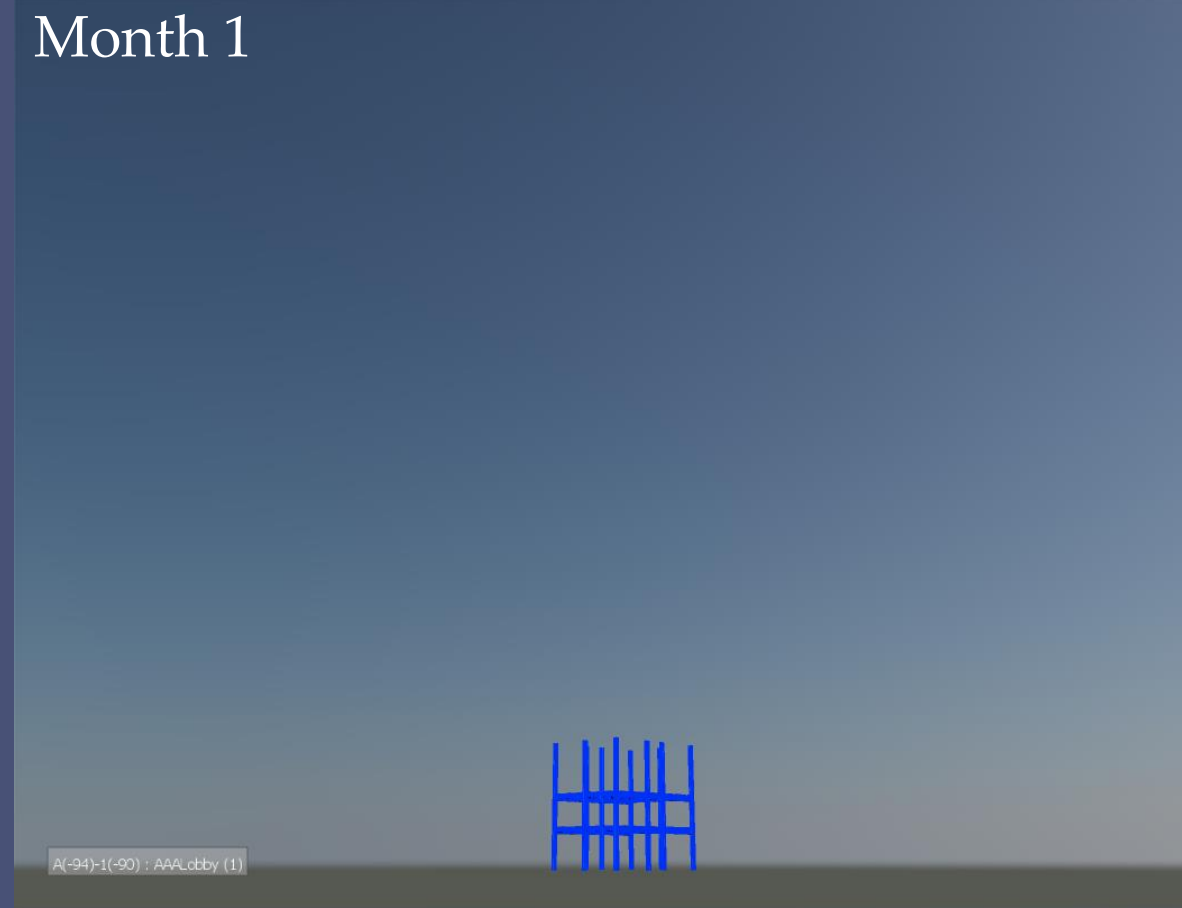


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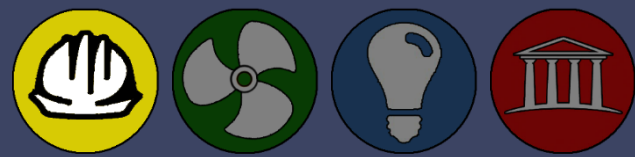
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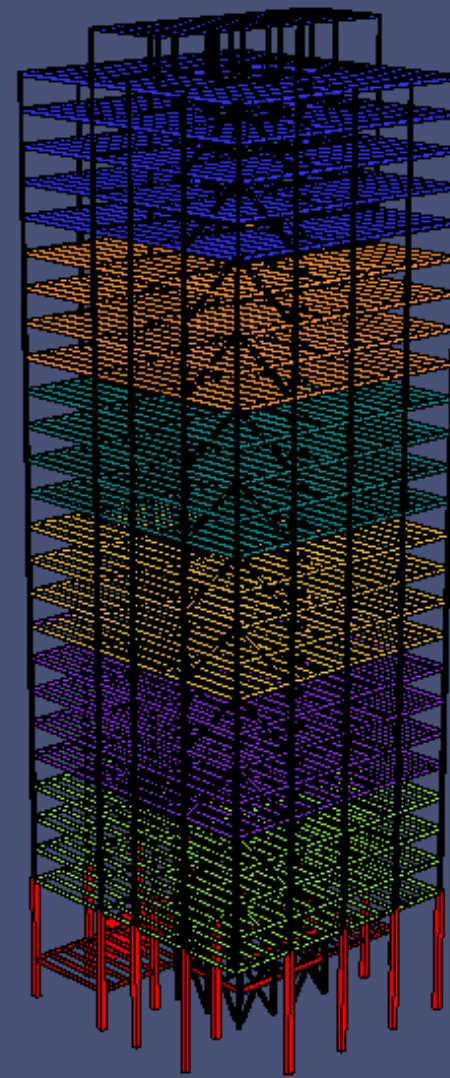
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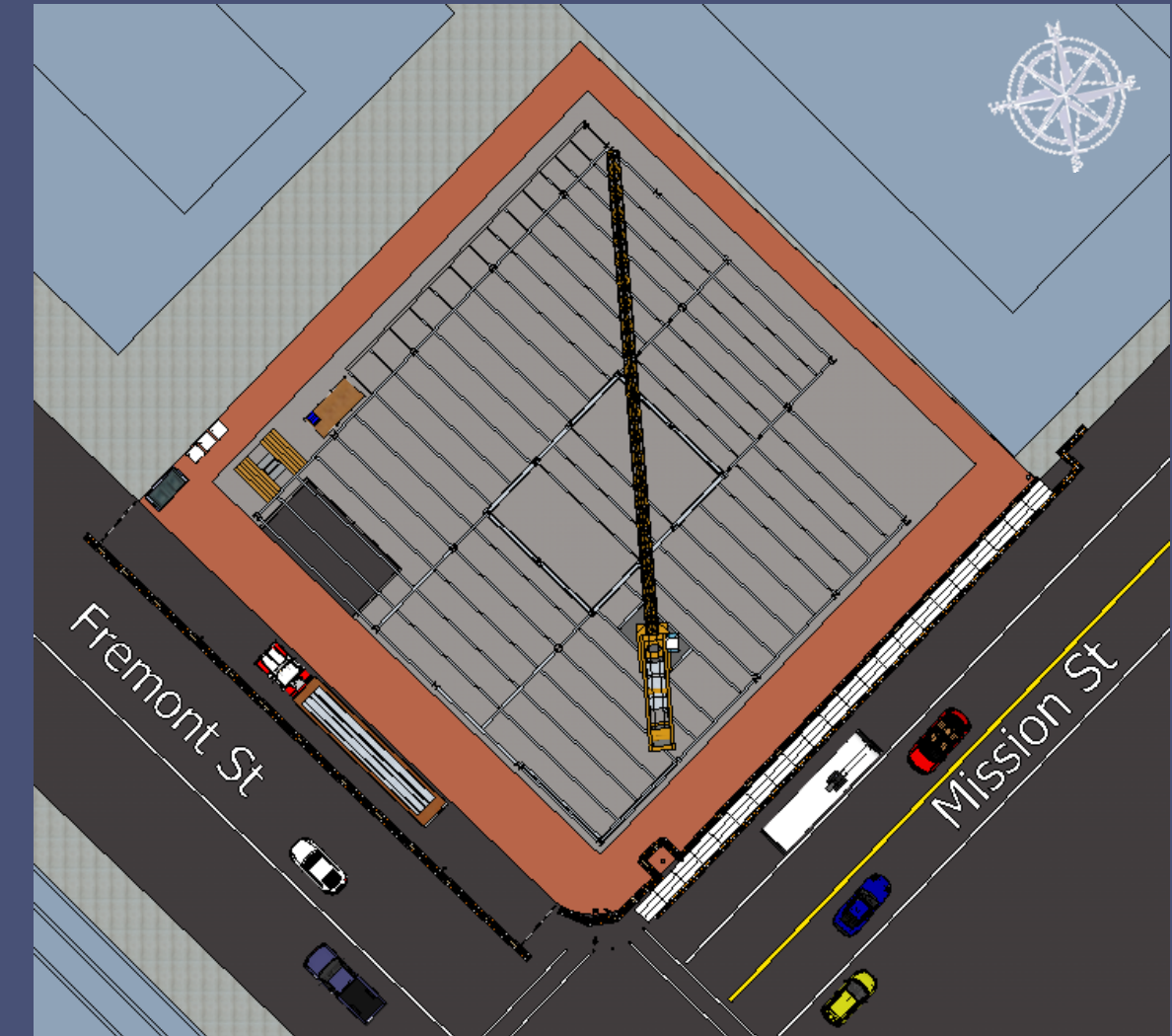
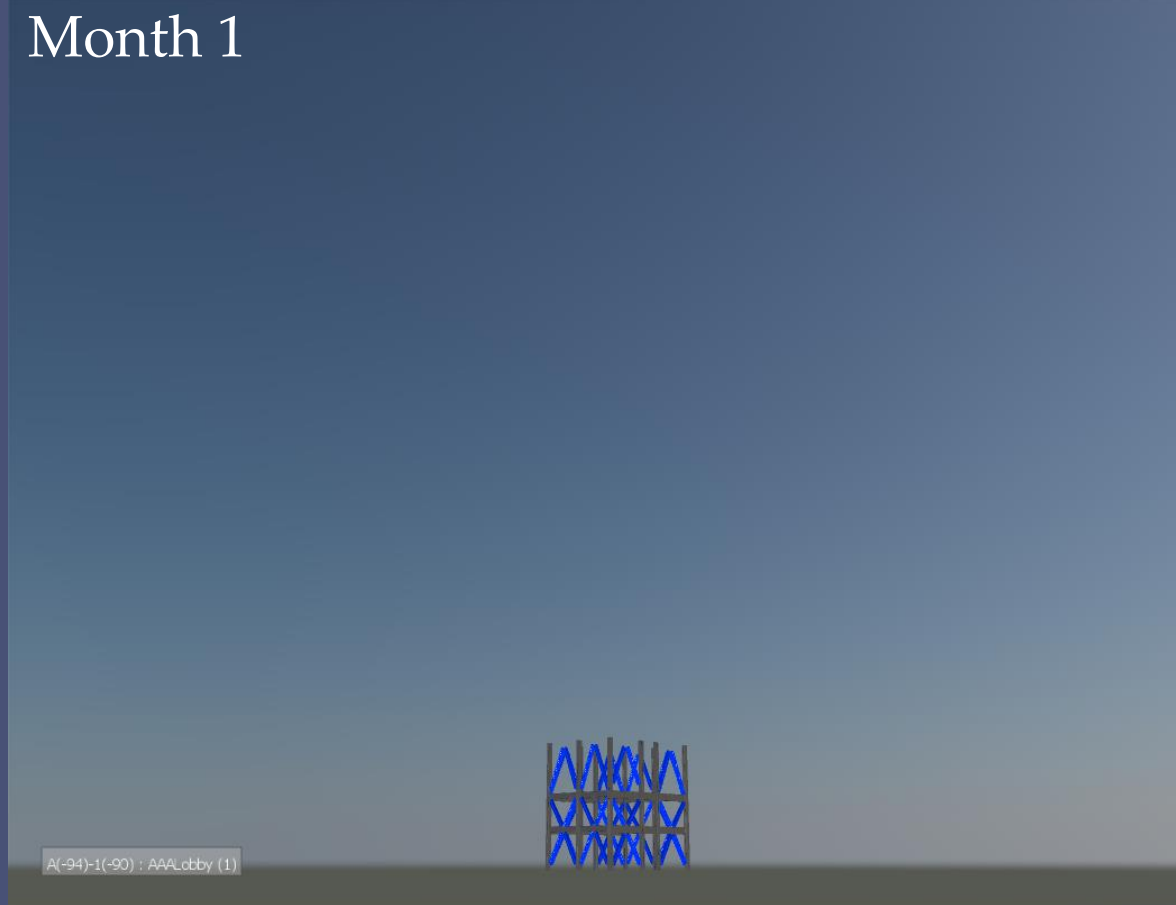


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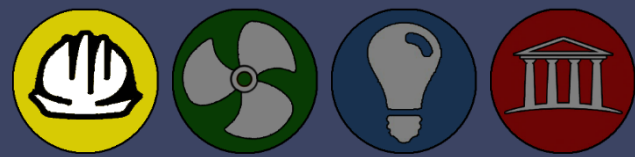
Introduction

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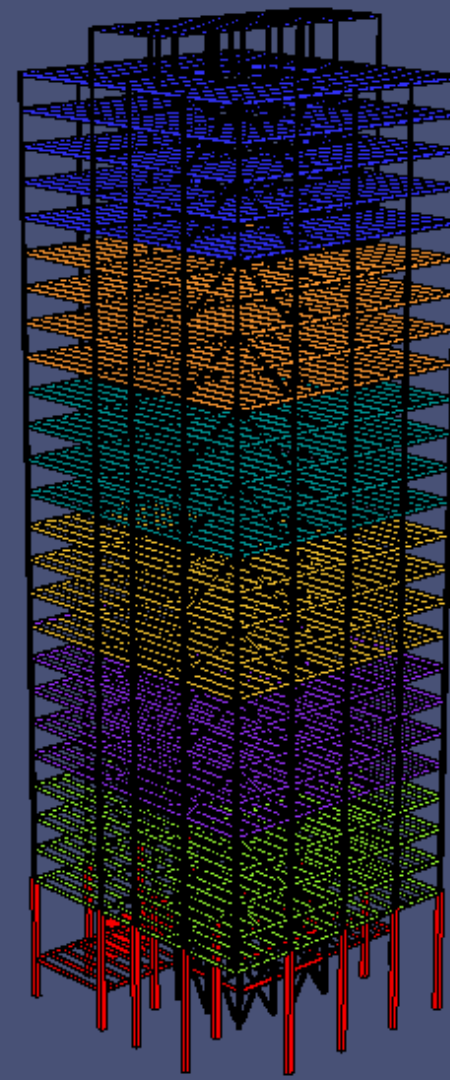
**Construction**

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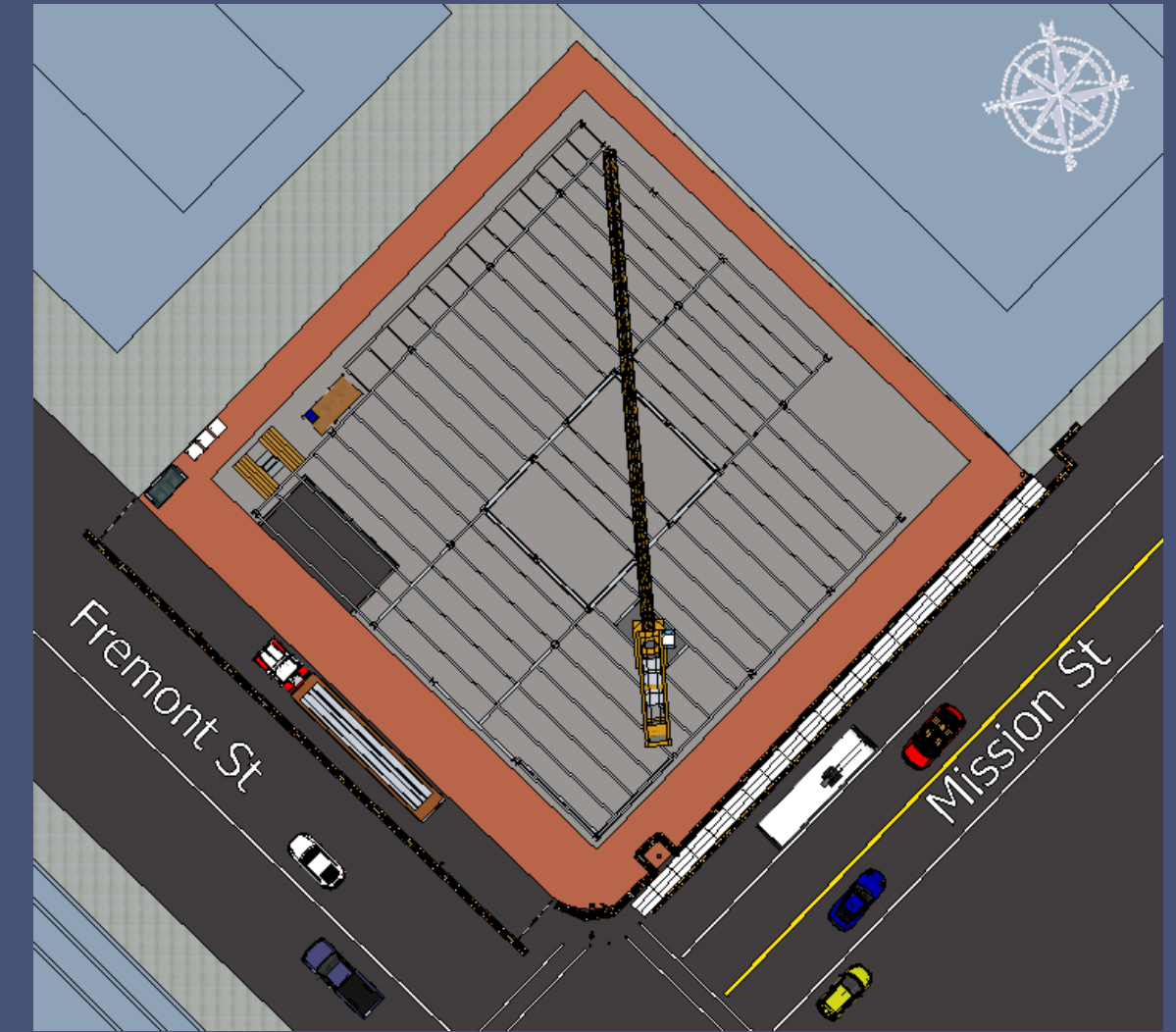
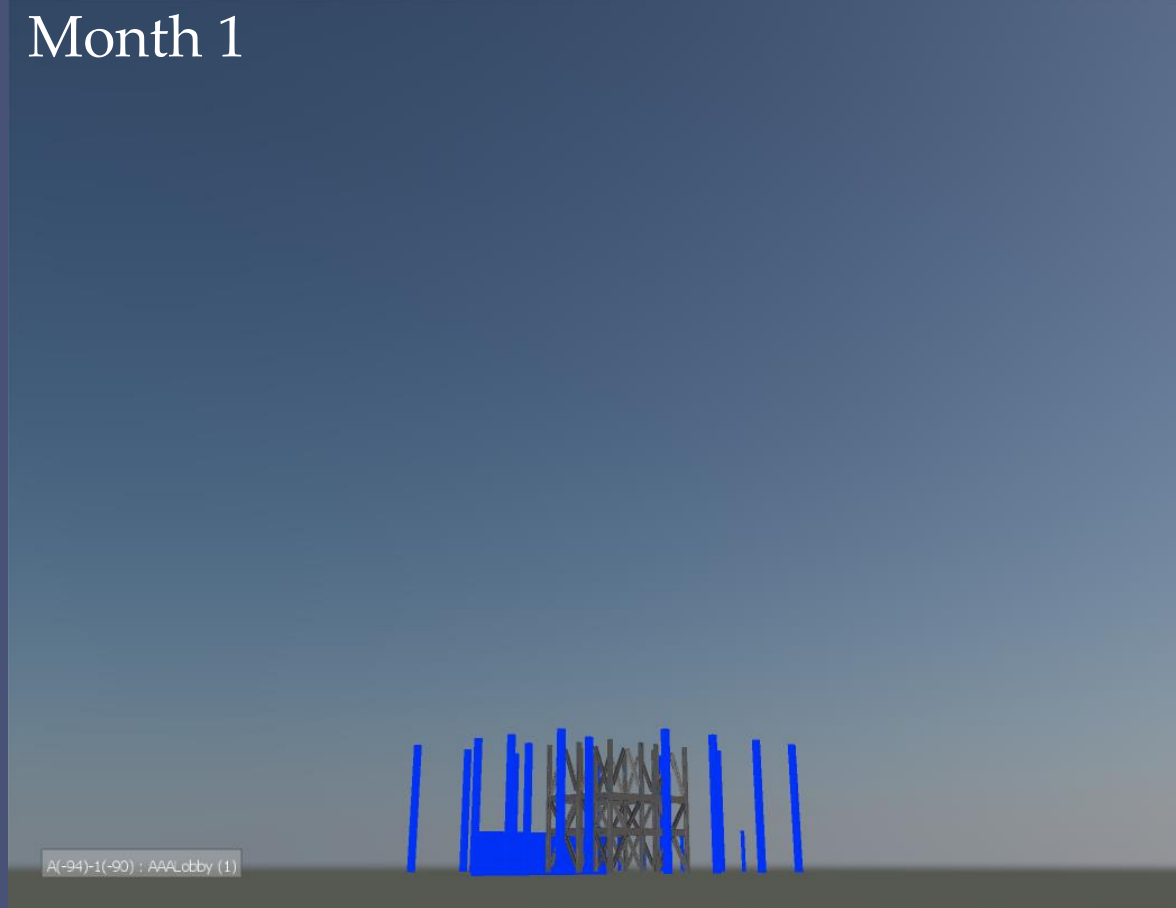


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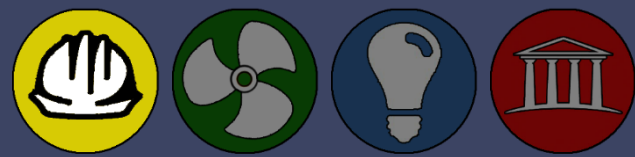
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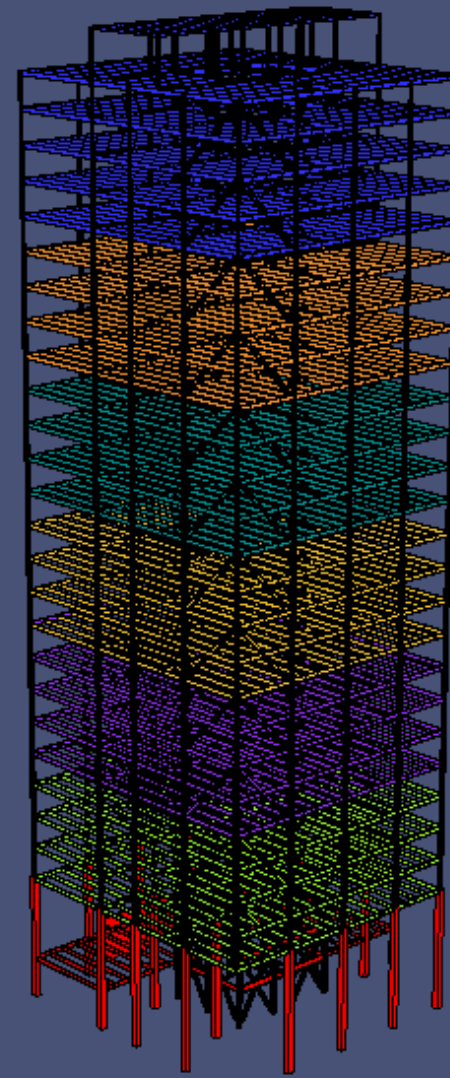
**Construction**

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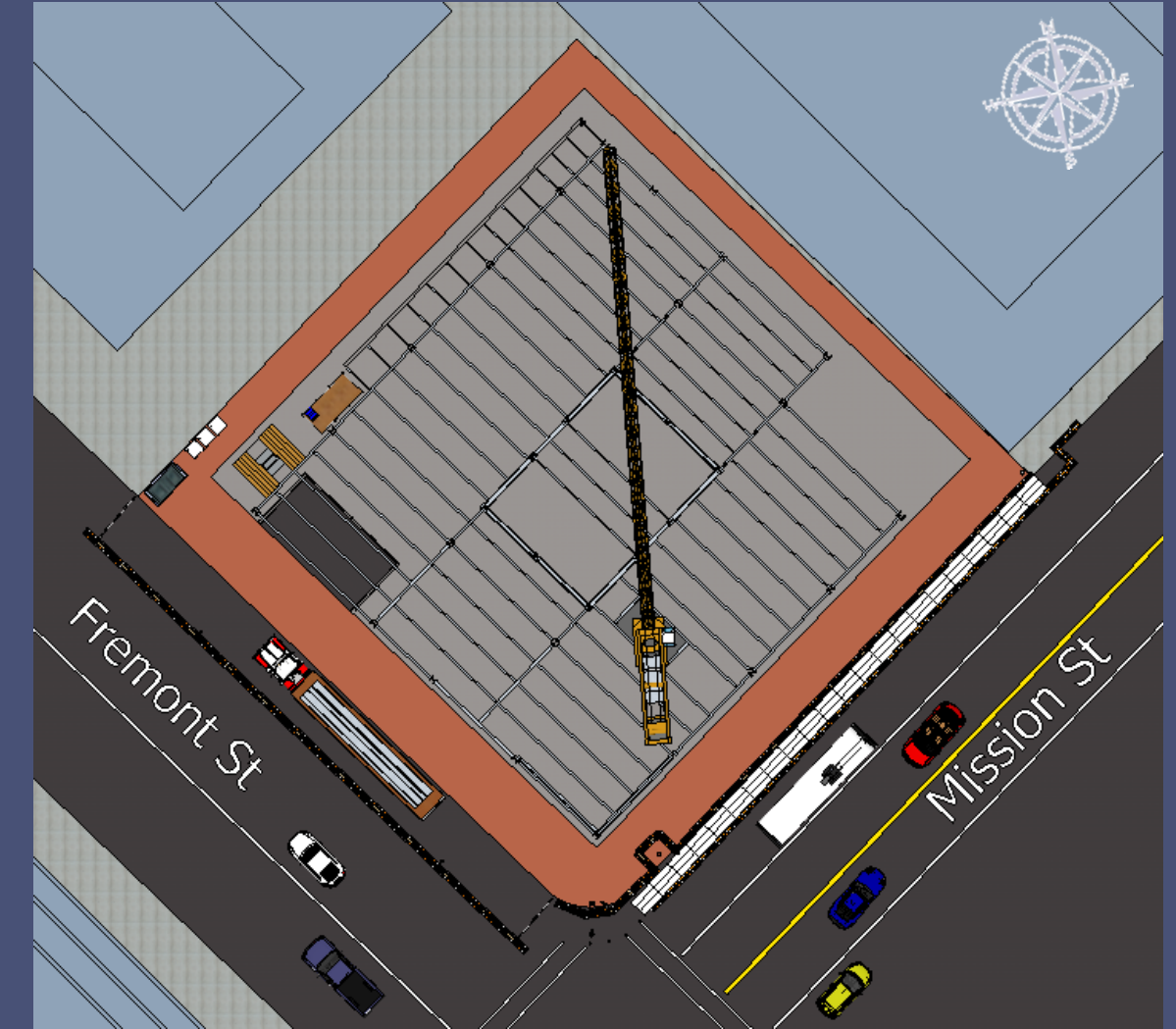
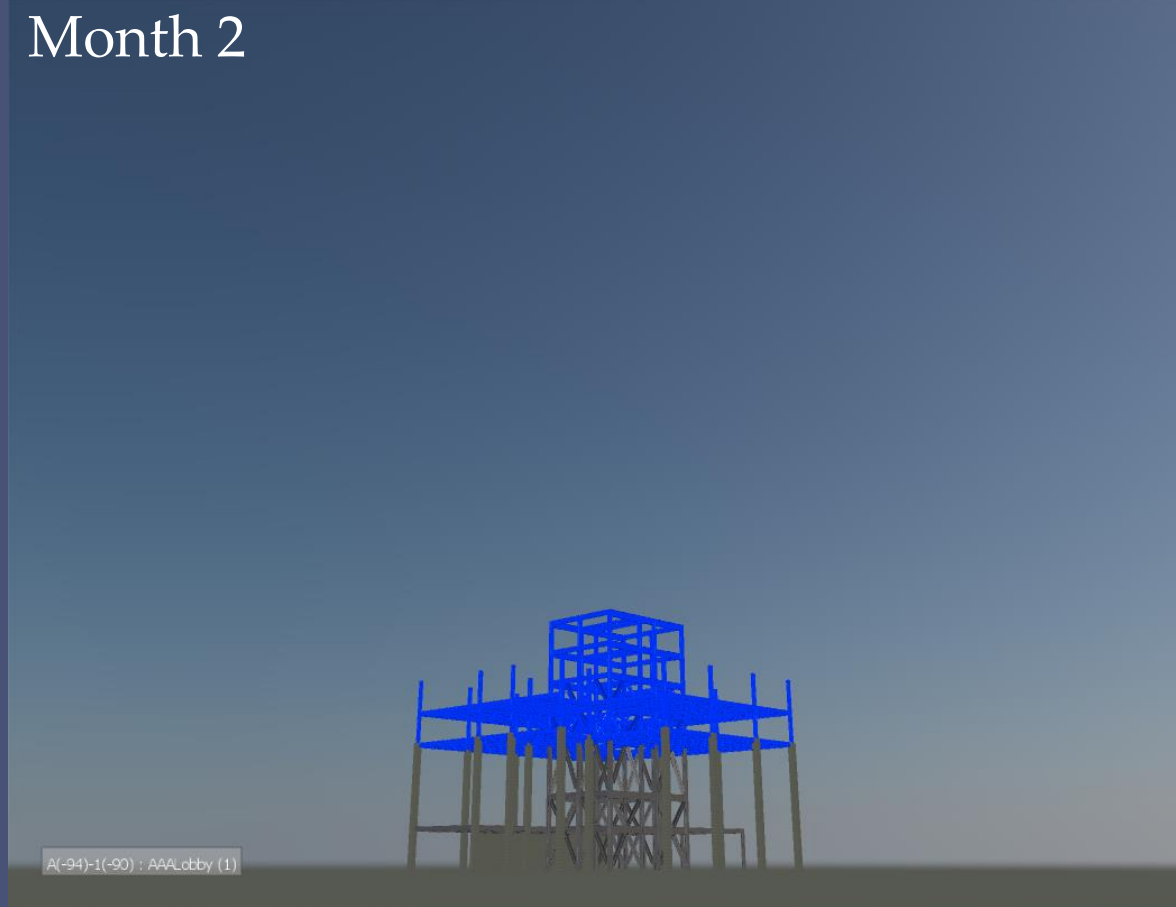


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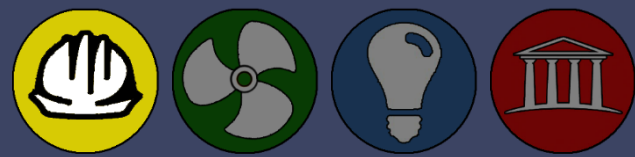
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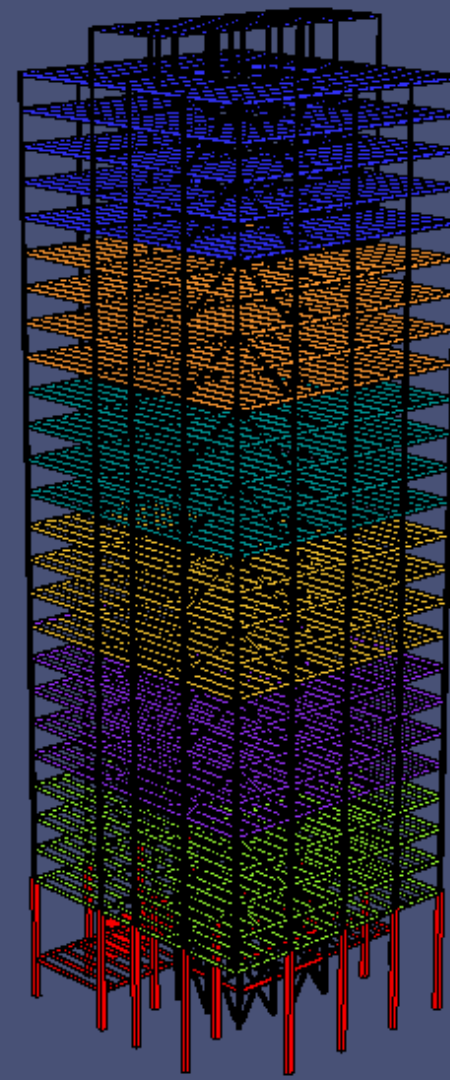
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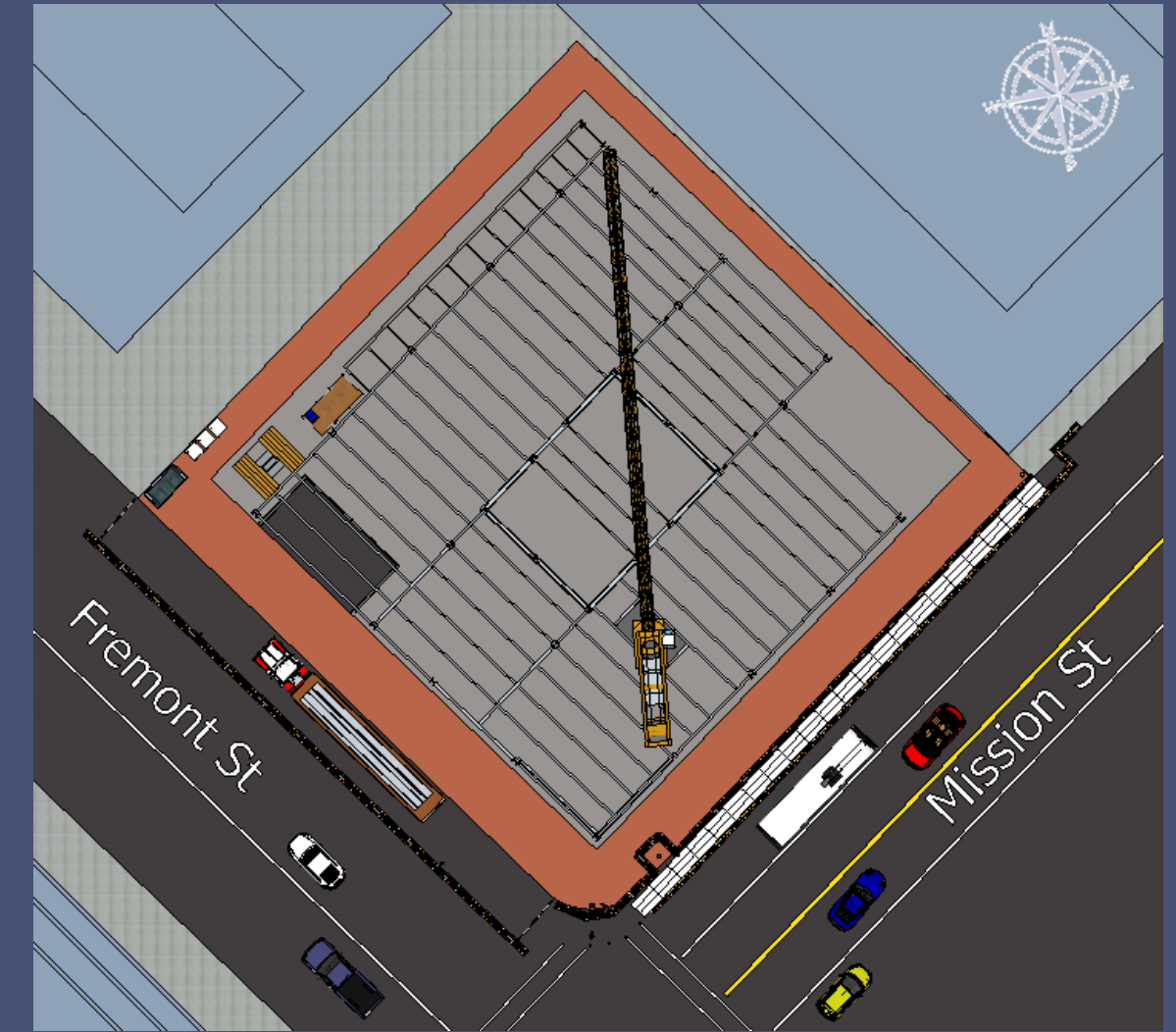
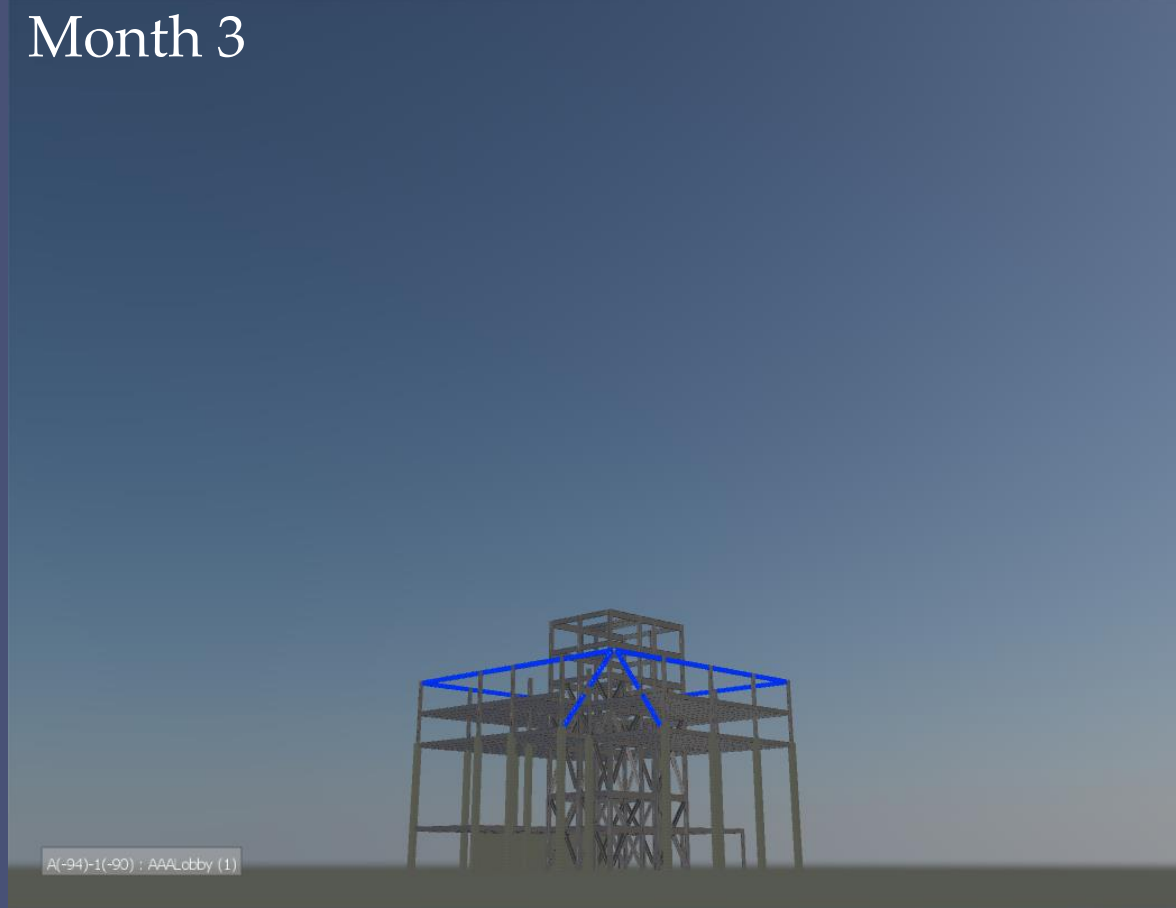


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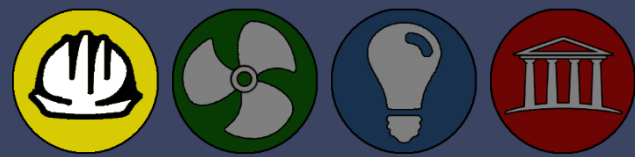
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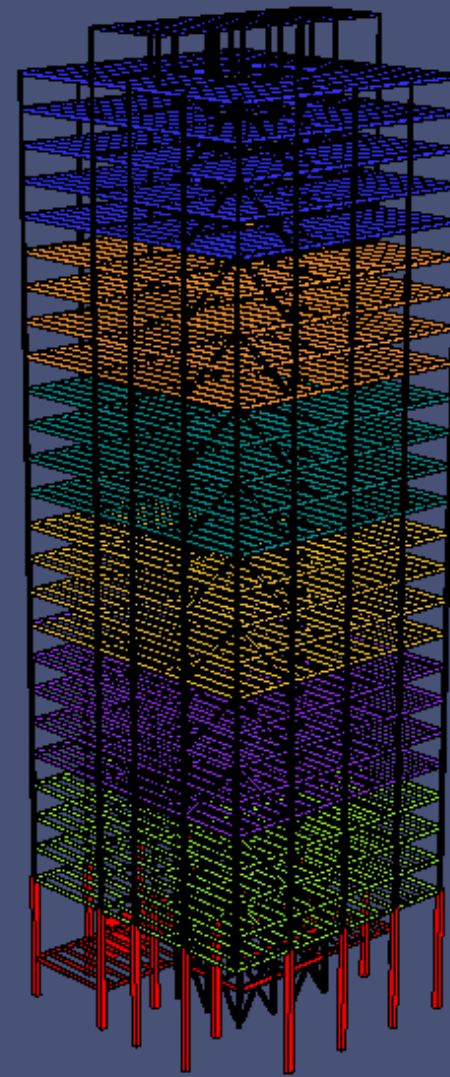


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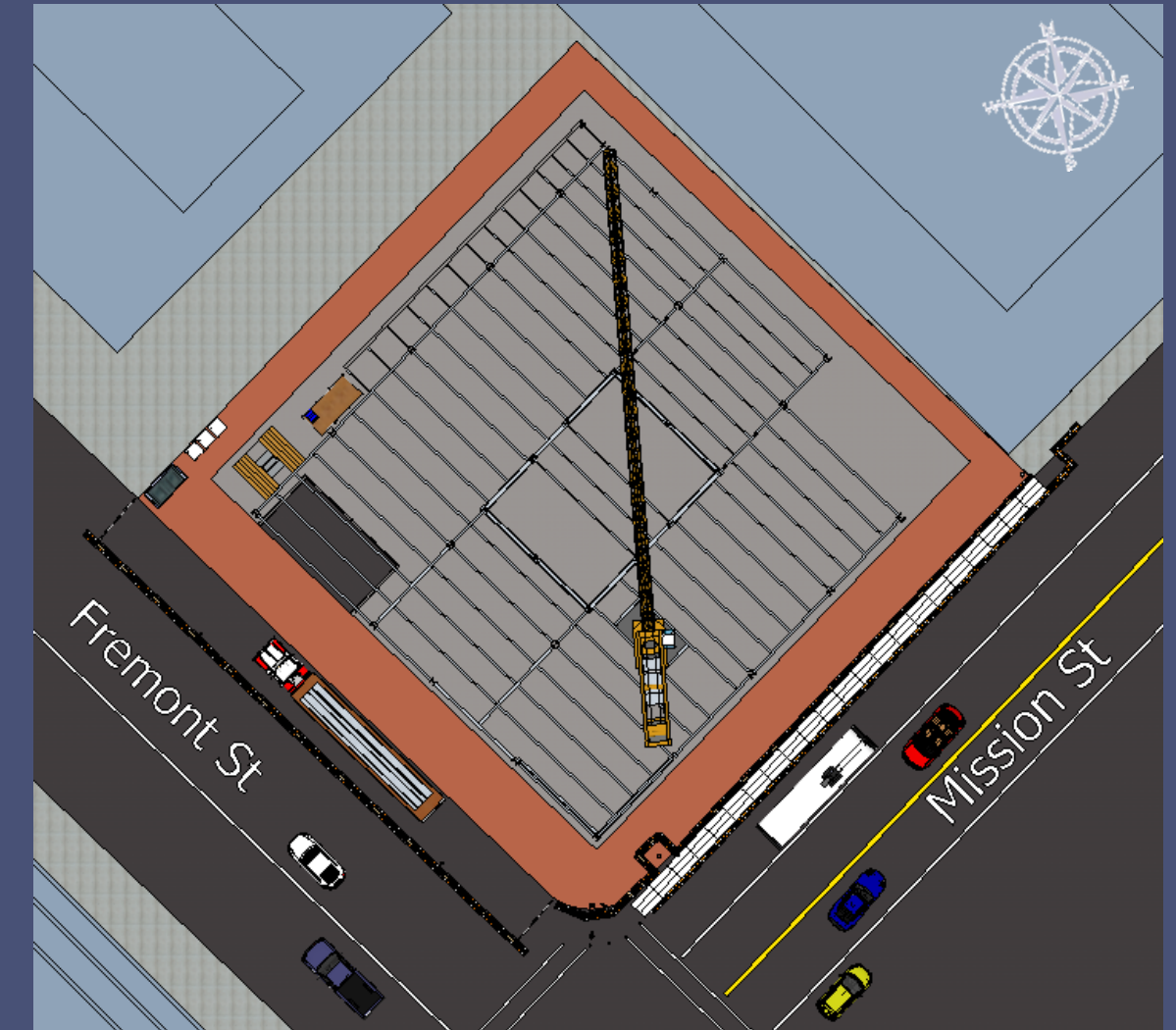
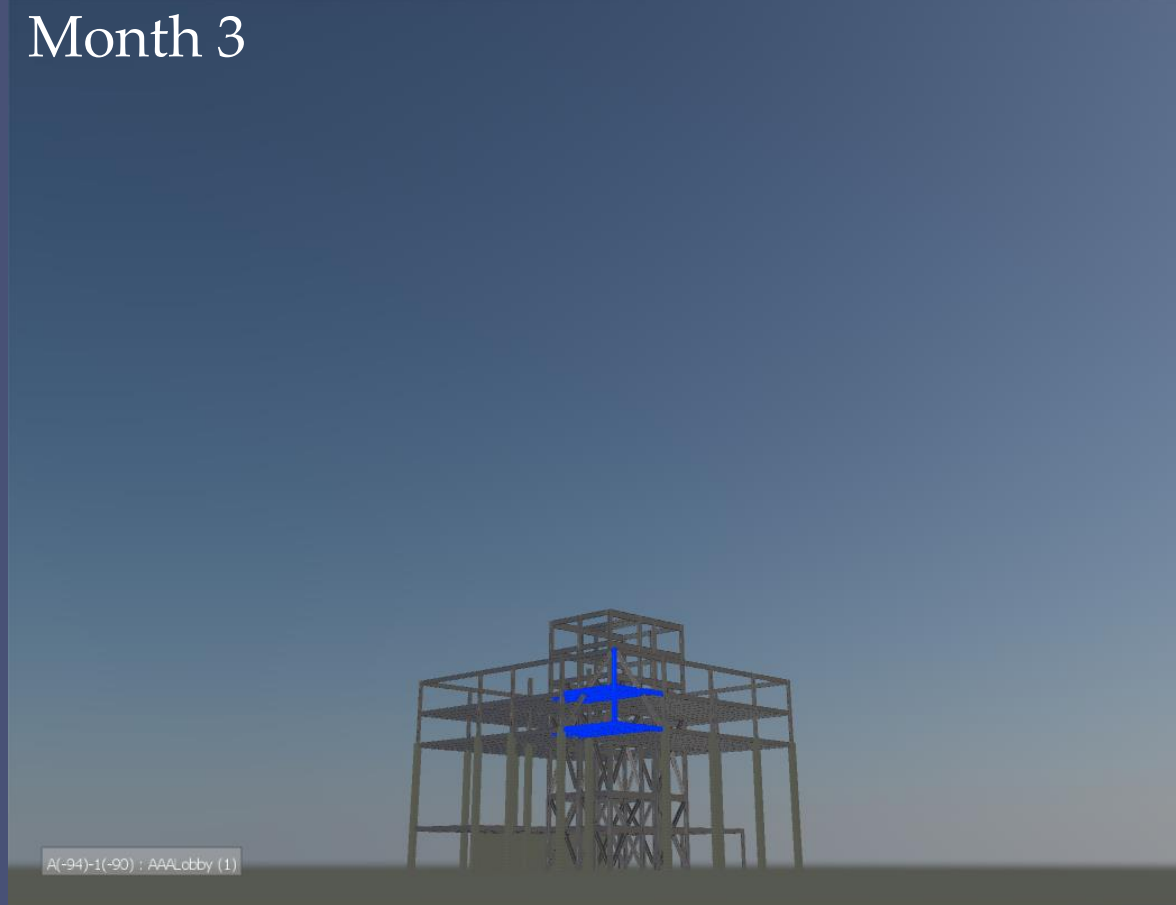


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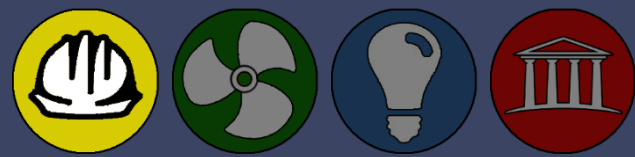
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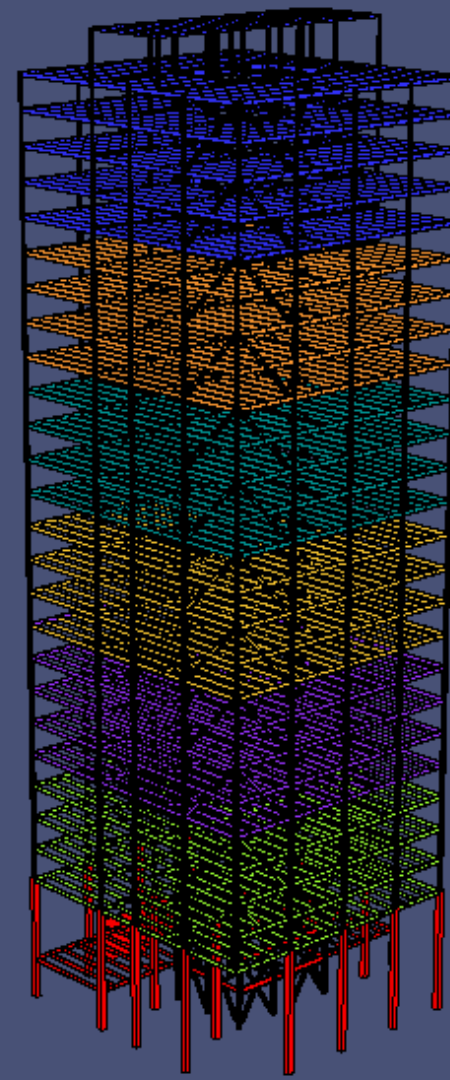
Near Net-Zero Energy

Achievements

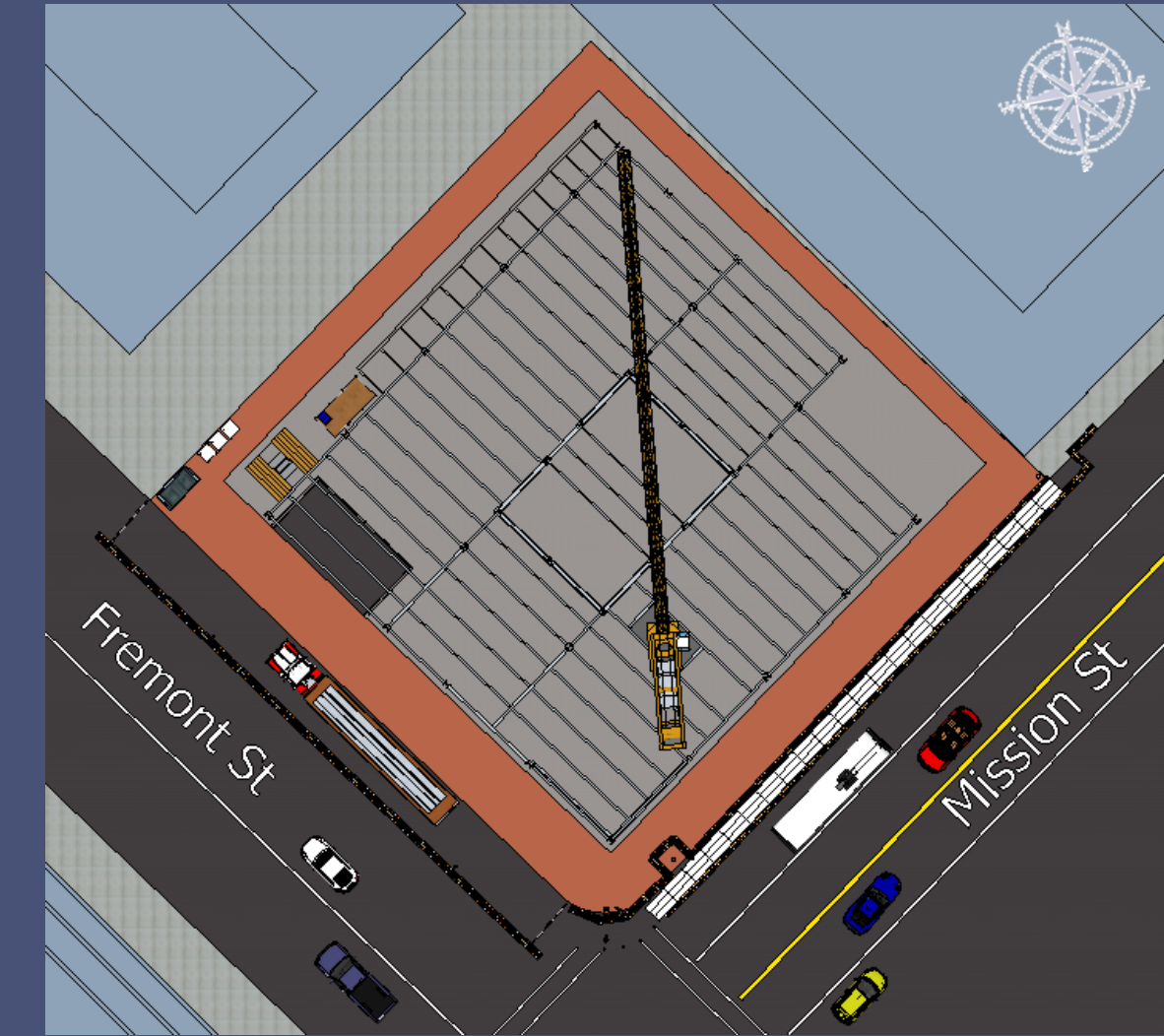
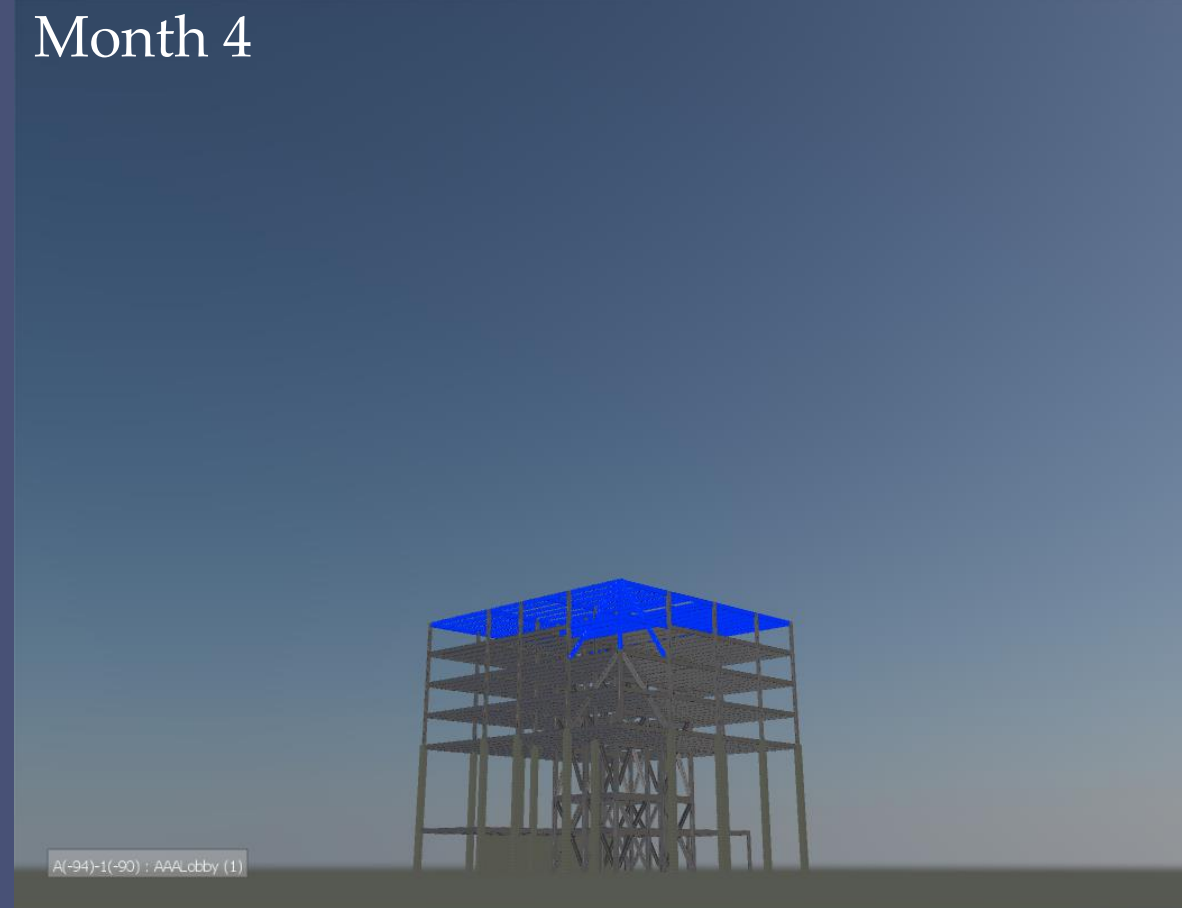


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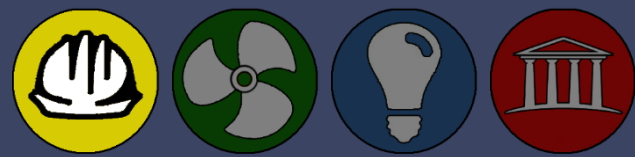
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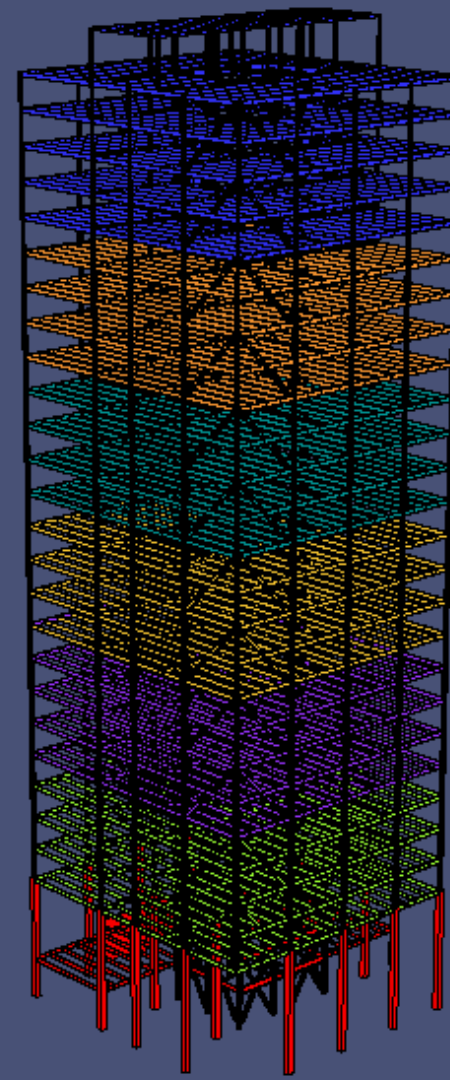


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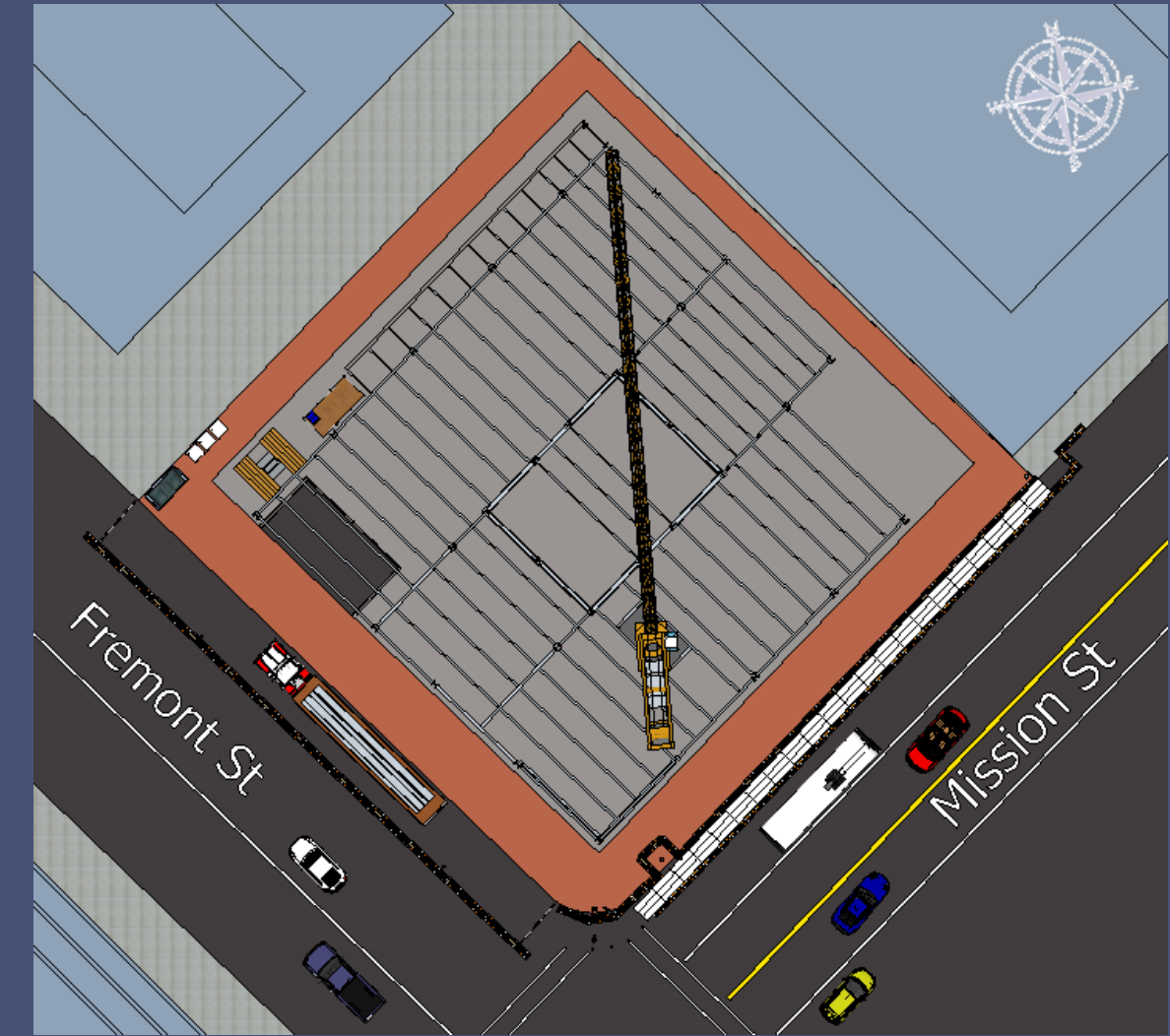
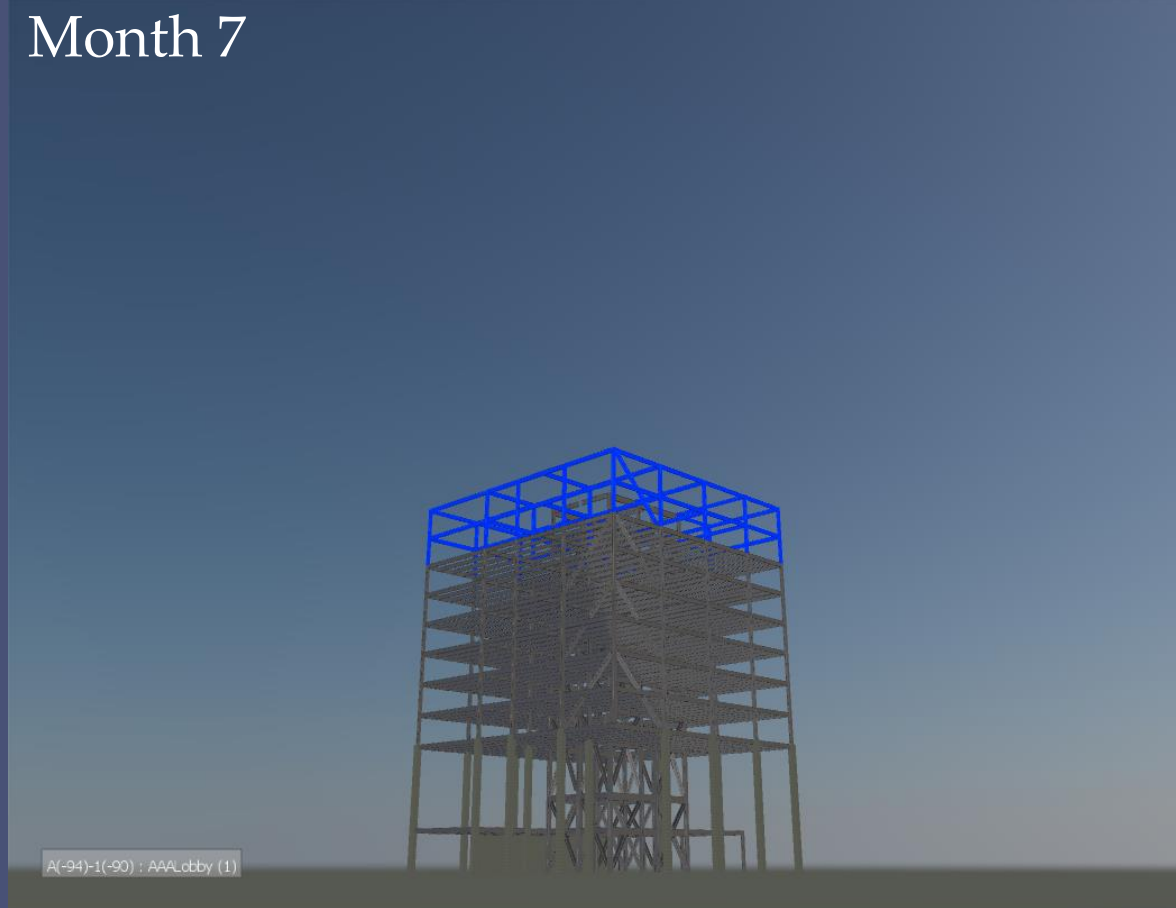


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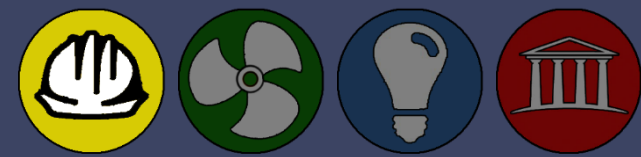
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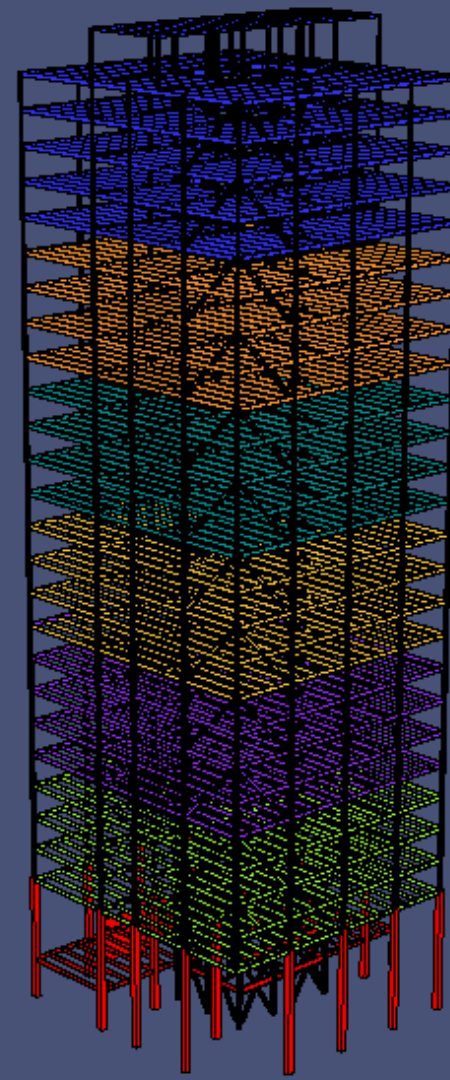


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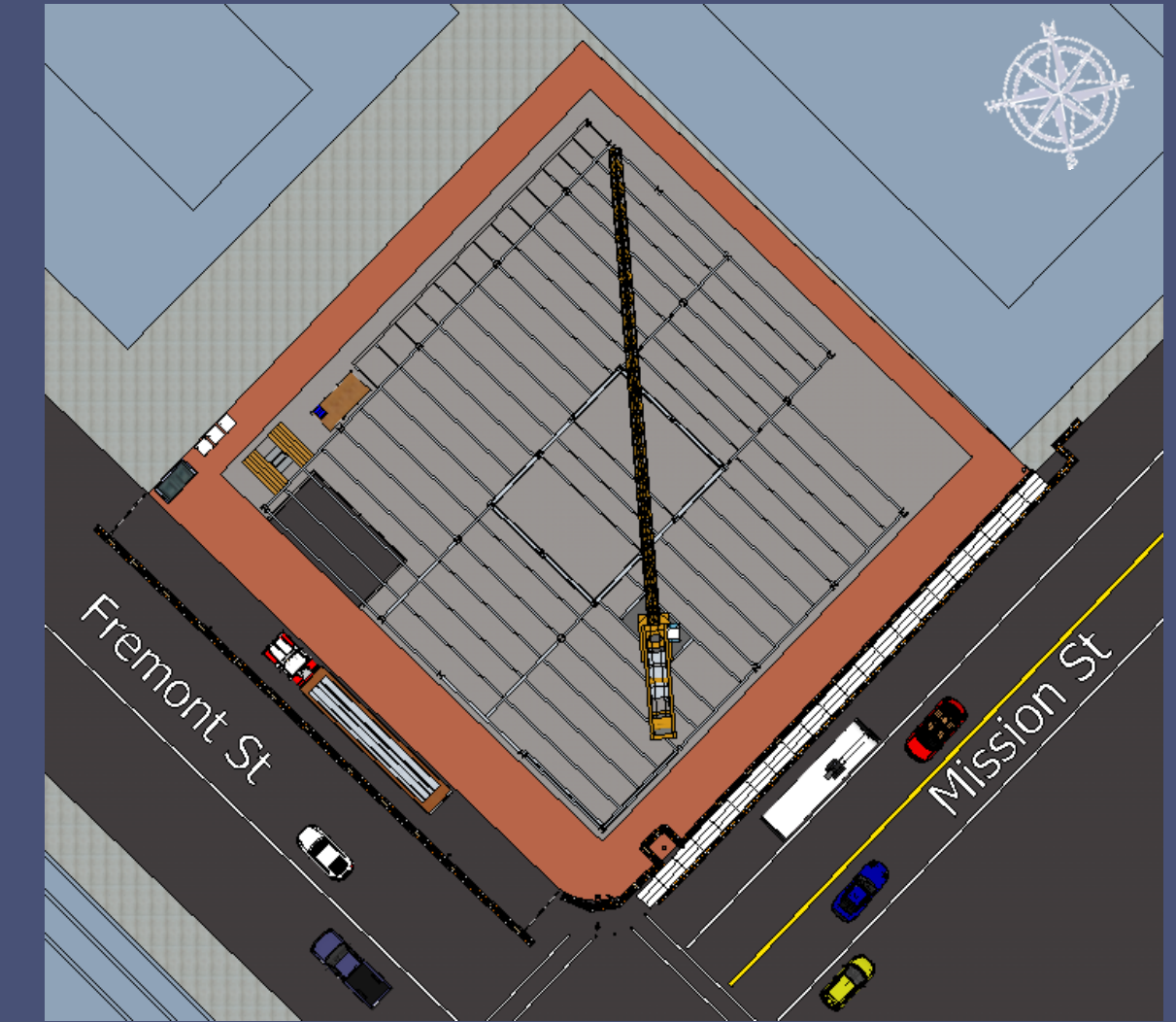
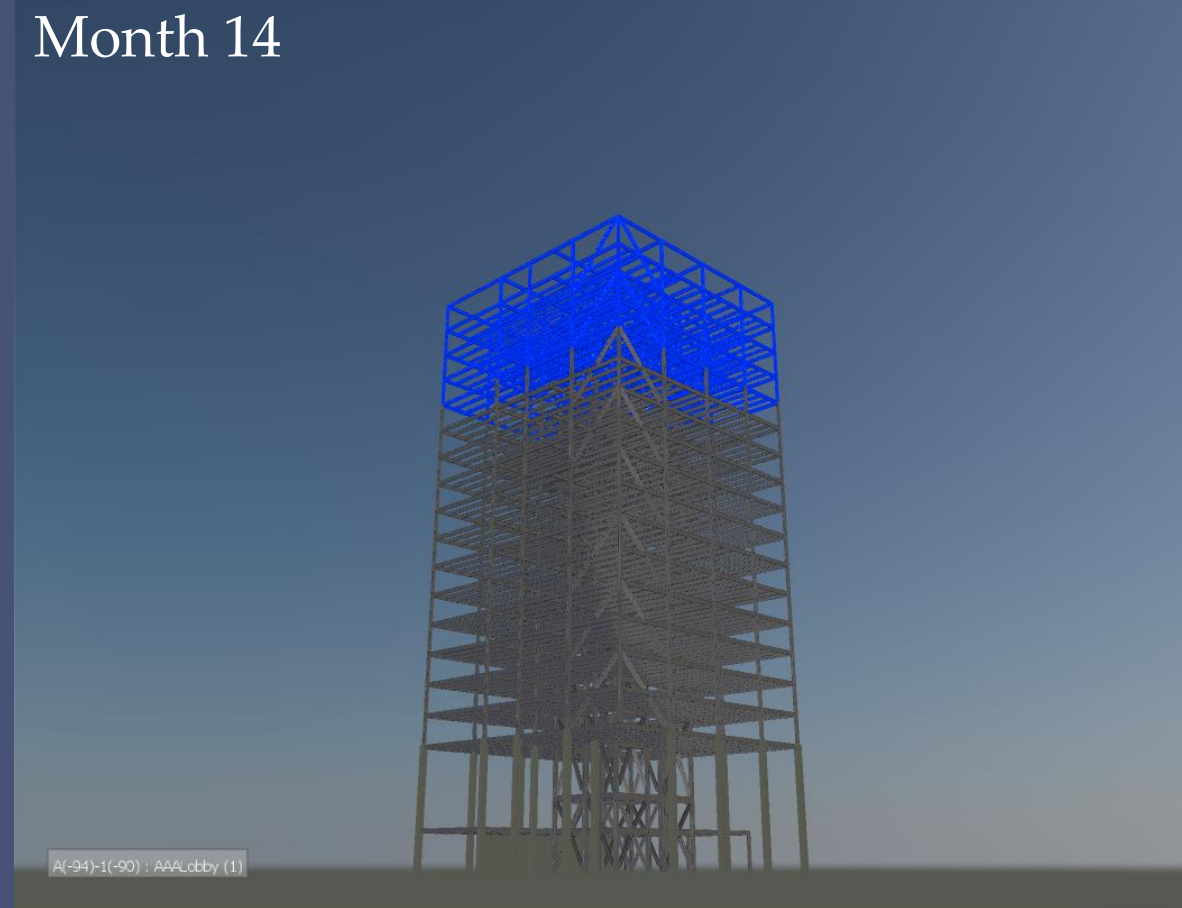


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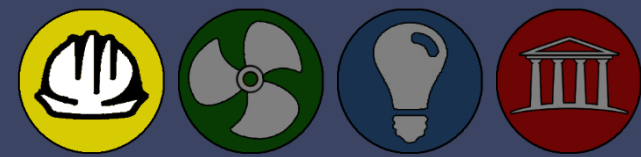
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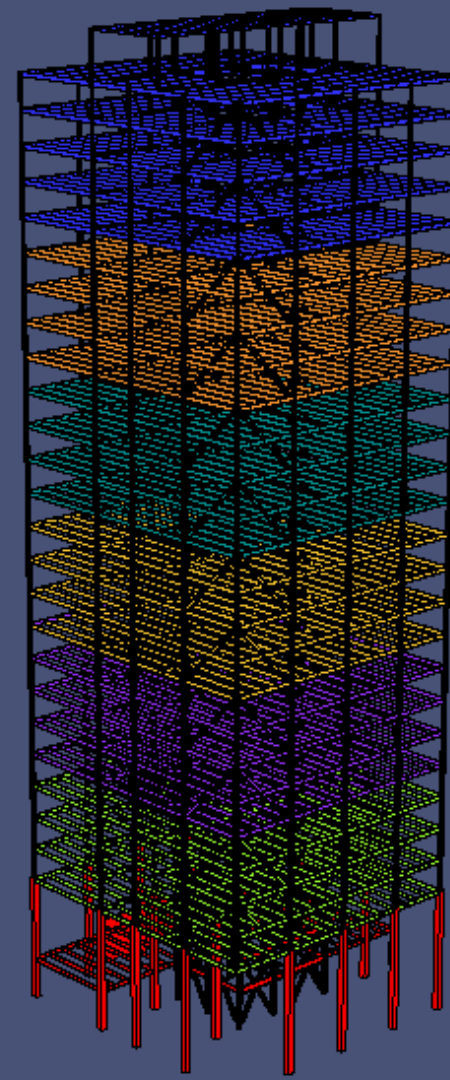
**Construction**

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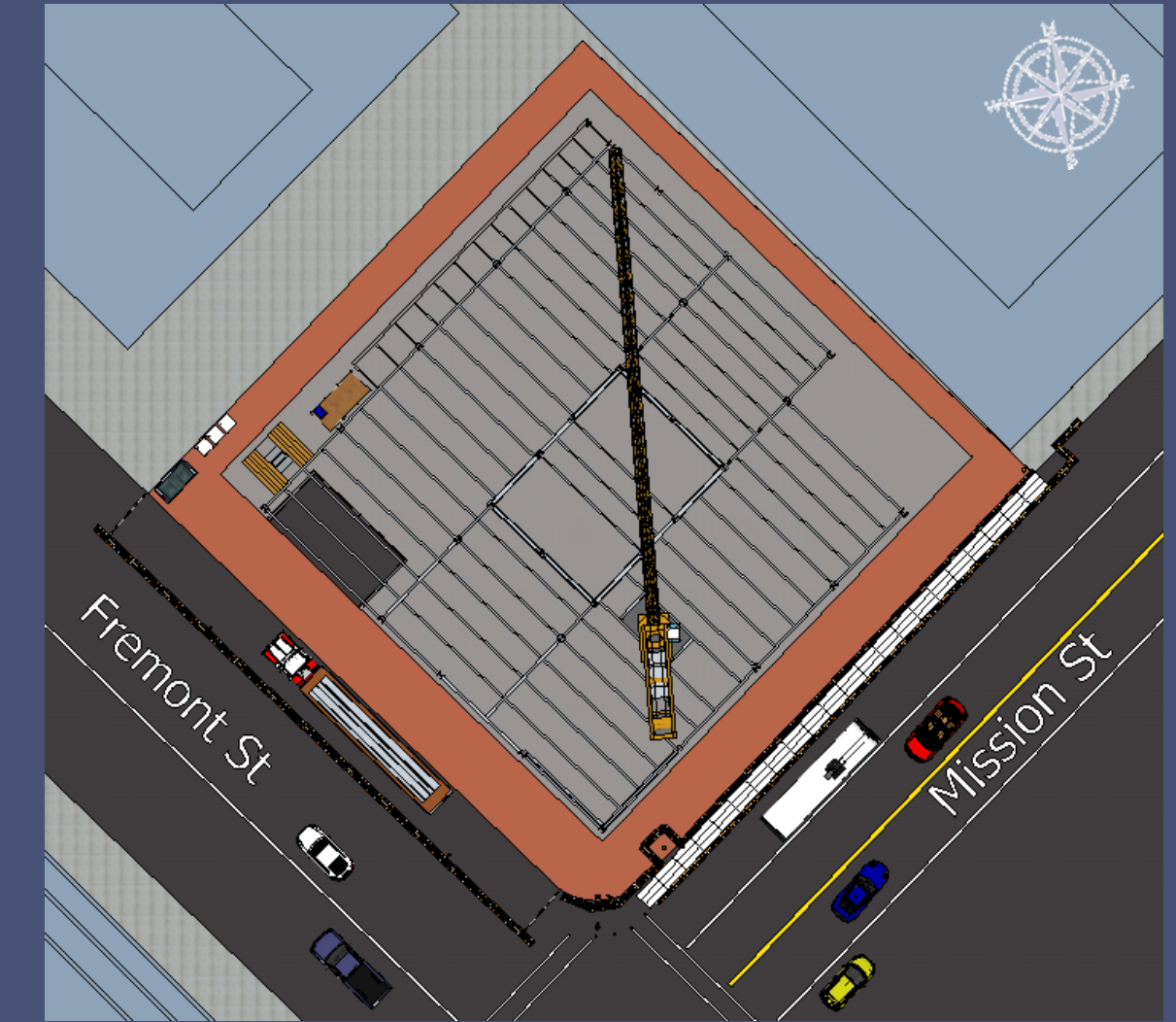
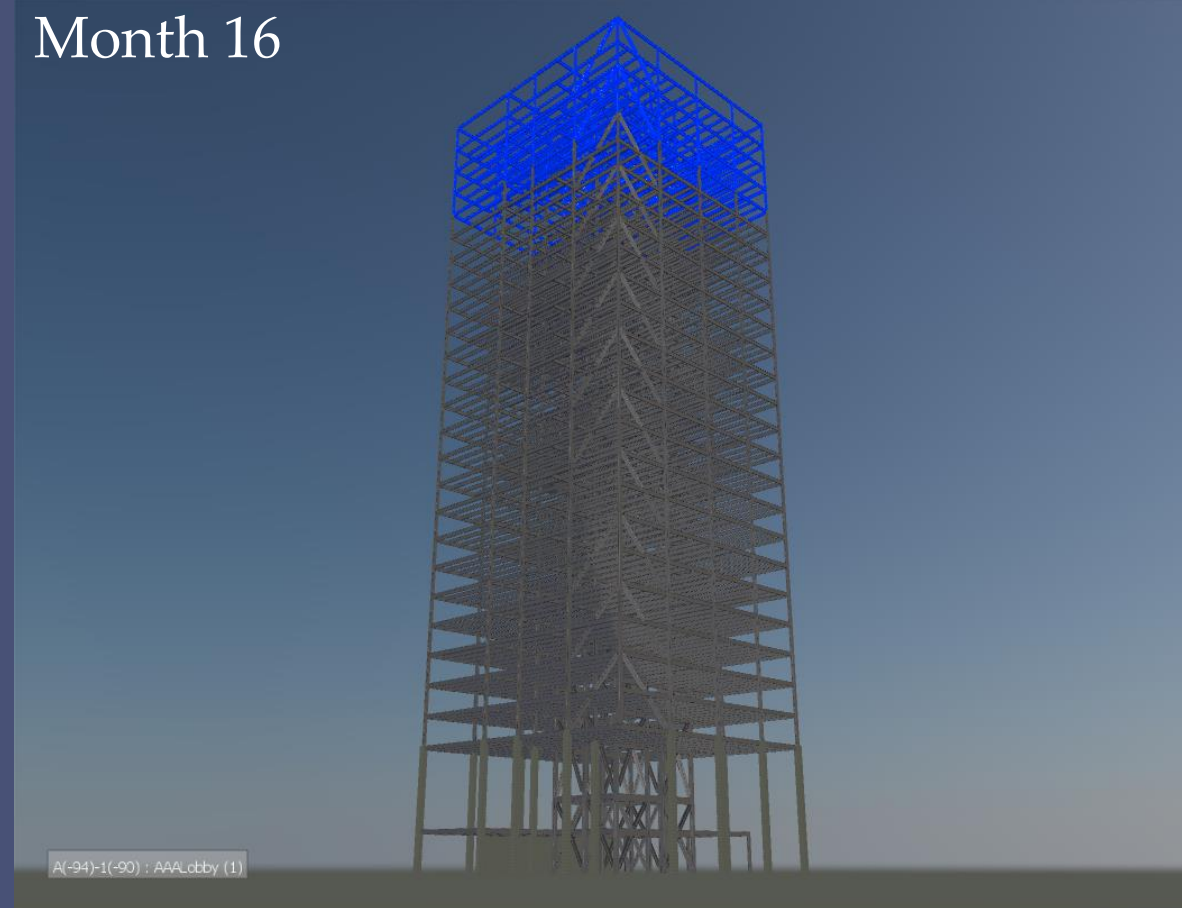


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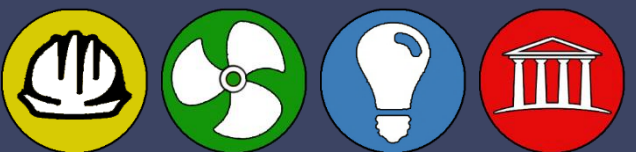
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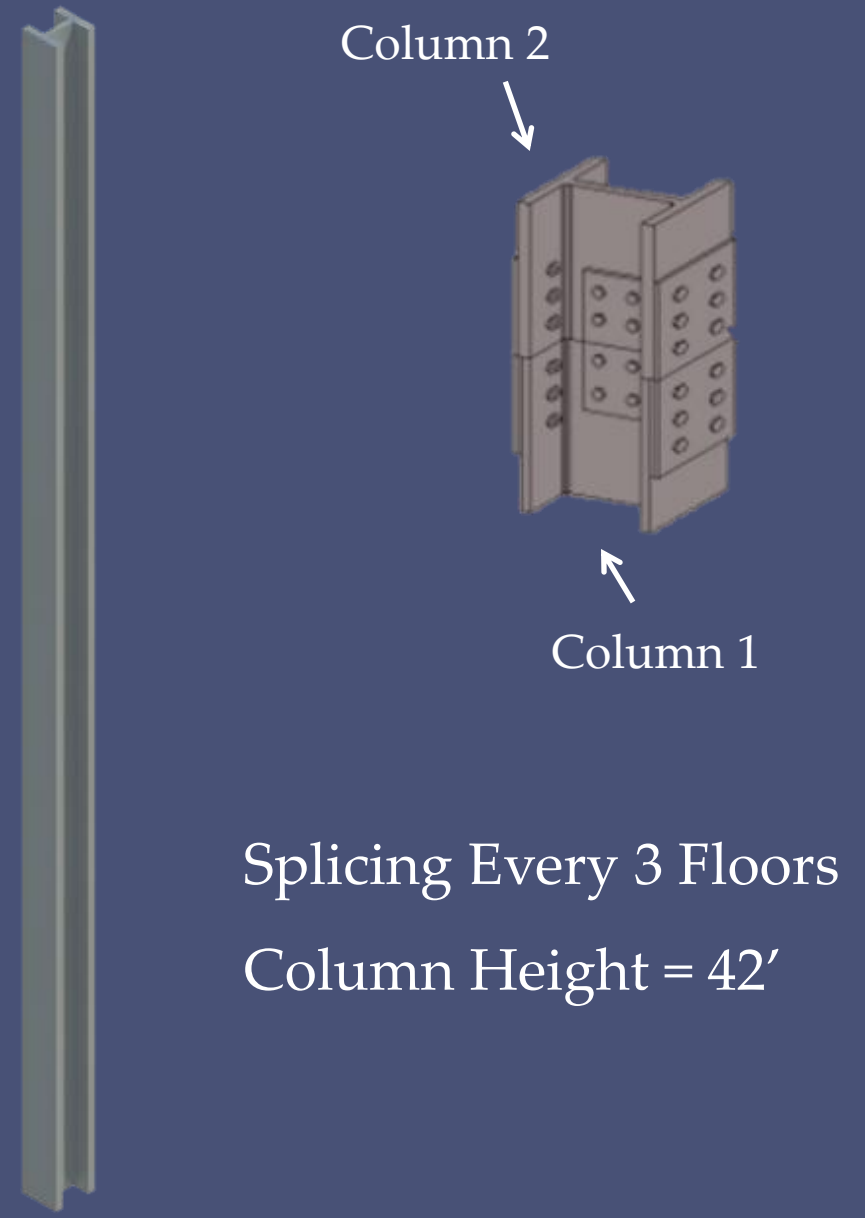
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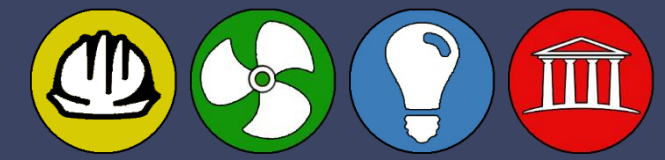


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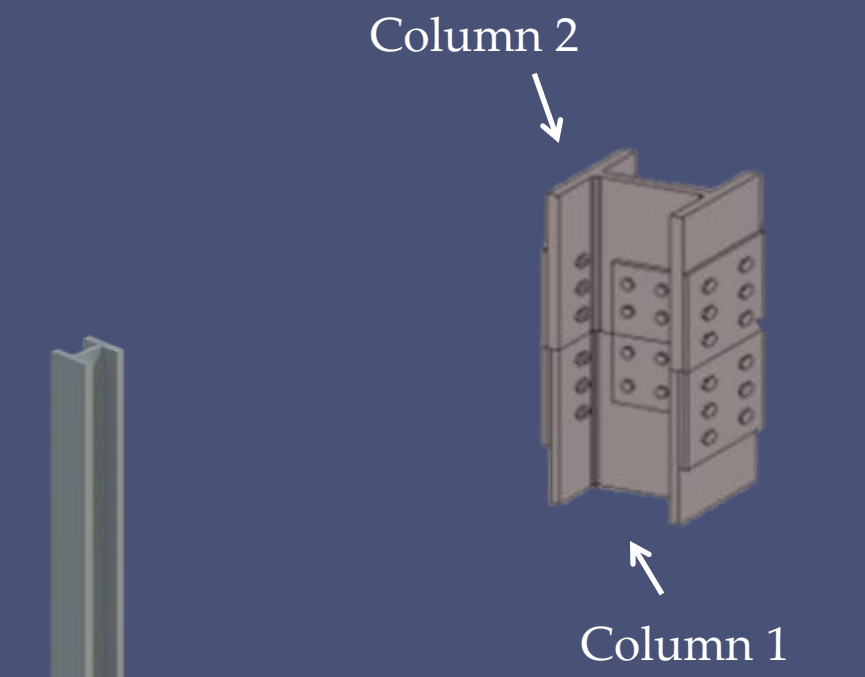


Splicing Every 3 Floors  
Column Height = 42'

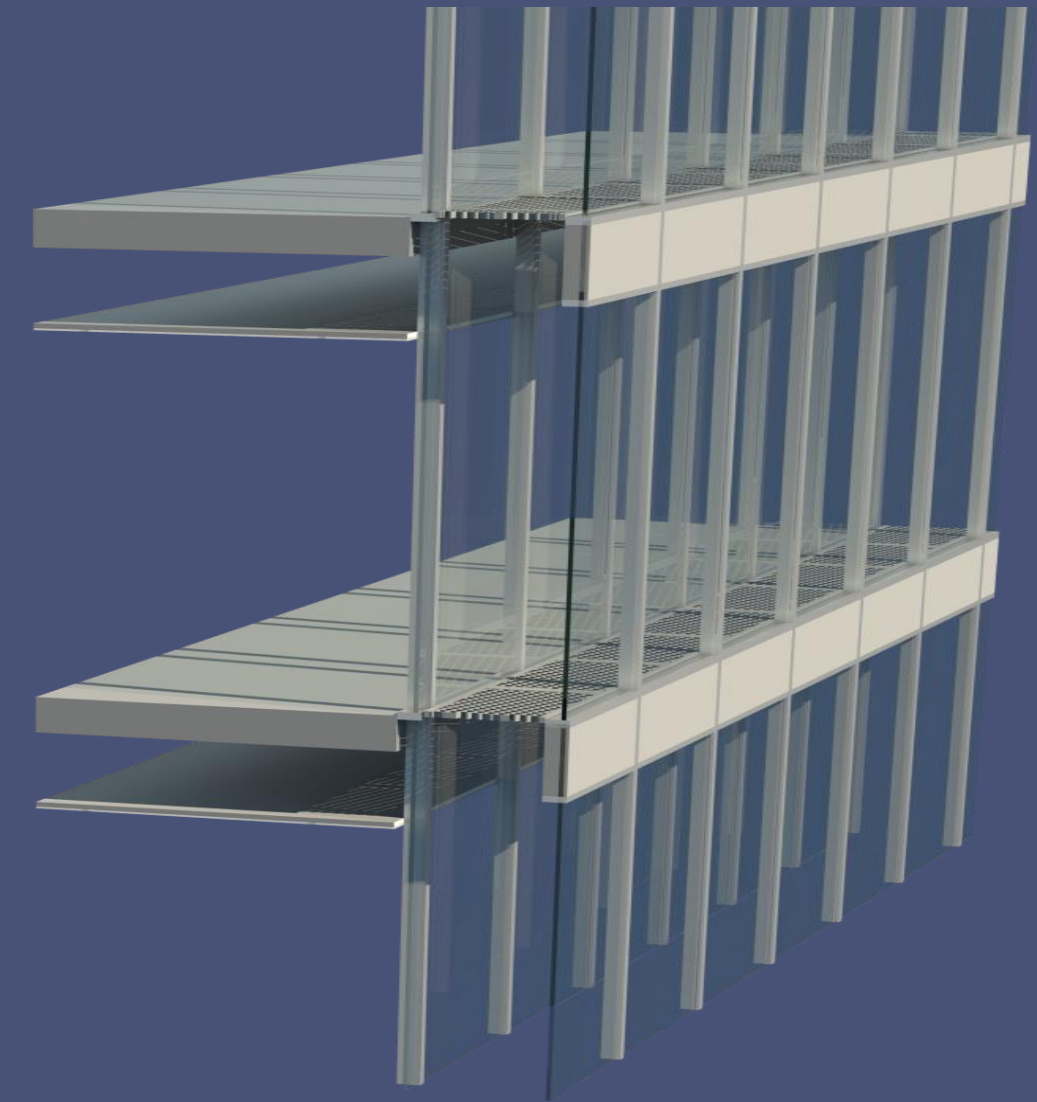
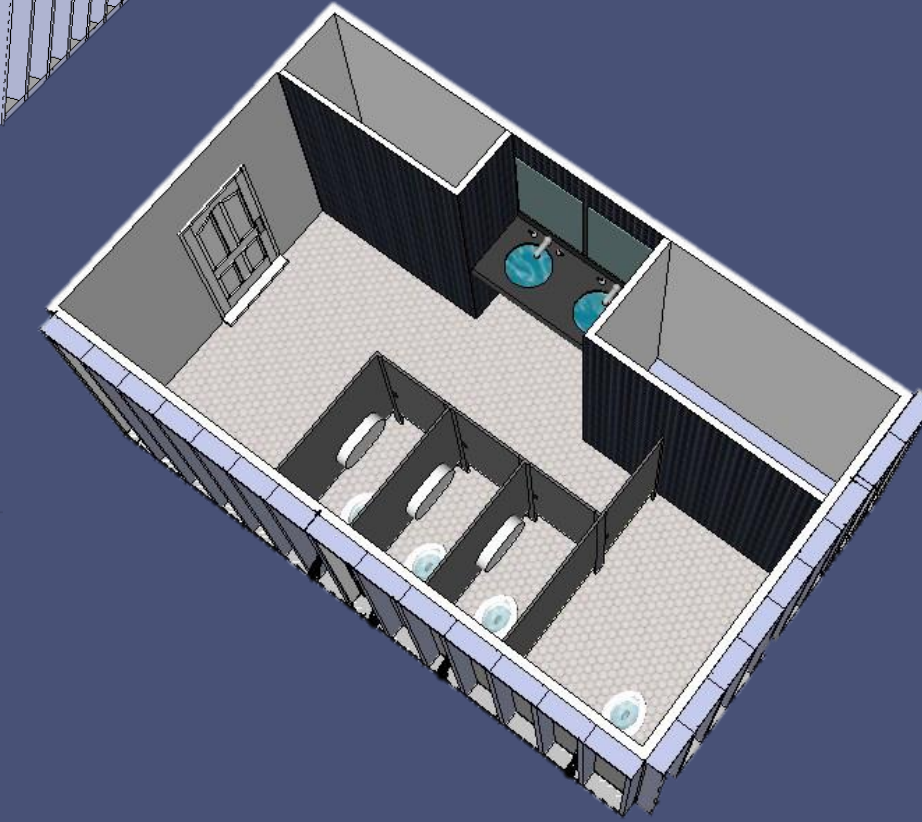
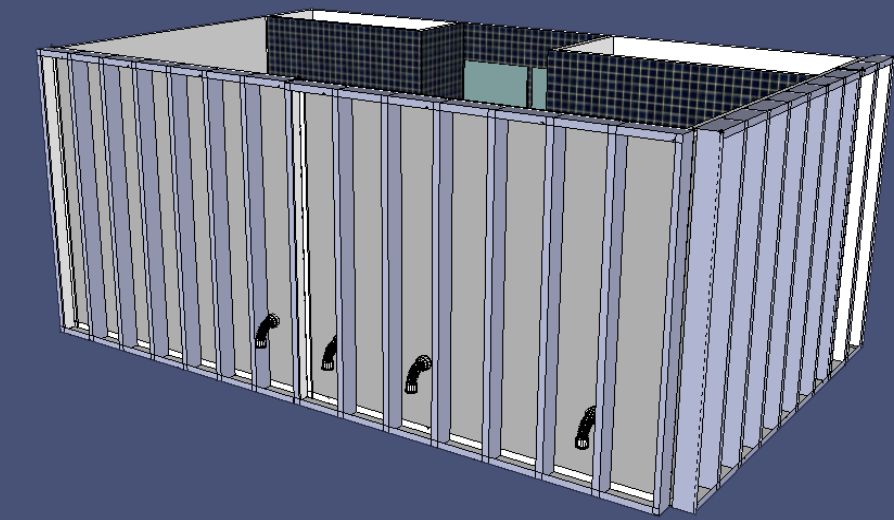


# CONSTRUCTION

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Splicing Every 2 Floors  
Column Height = 28'



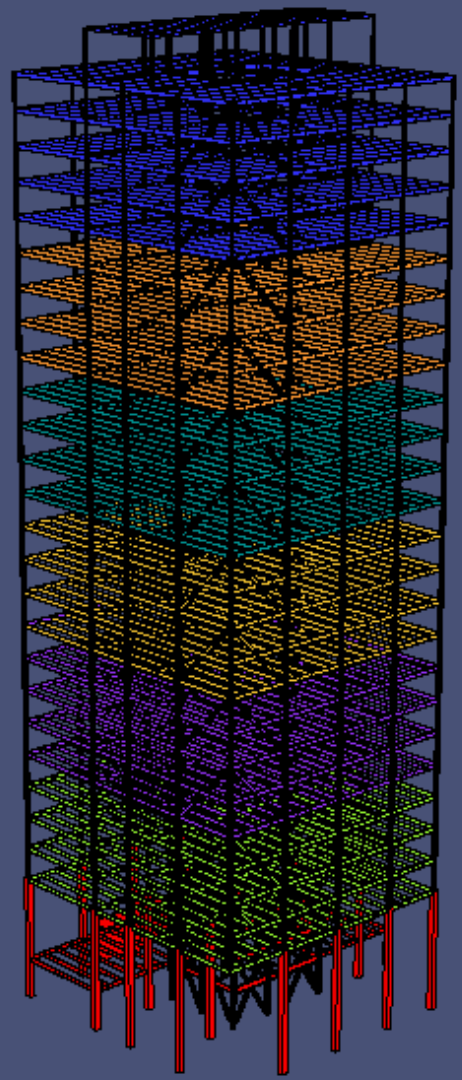




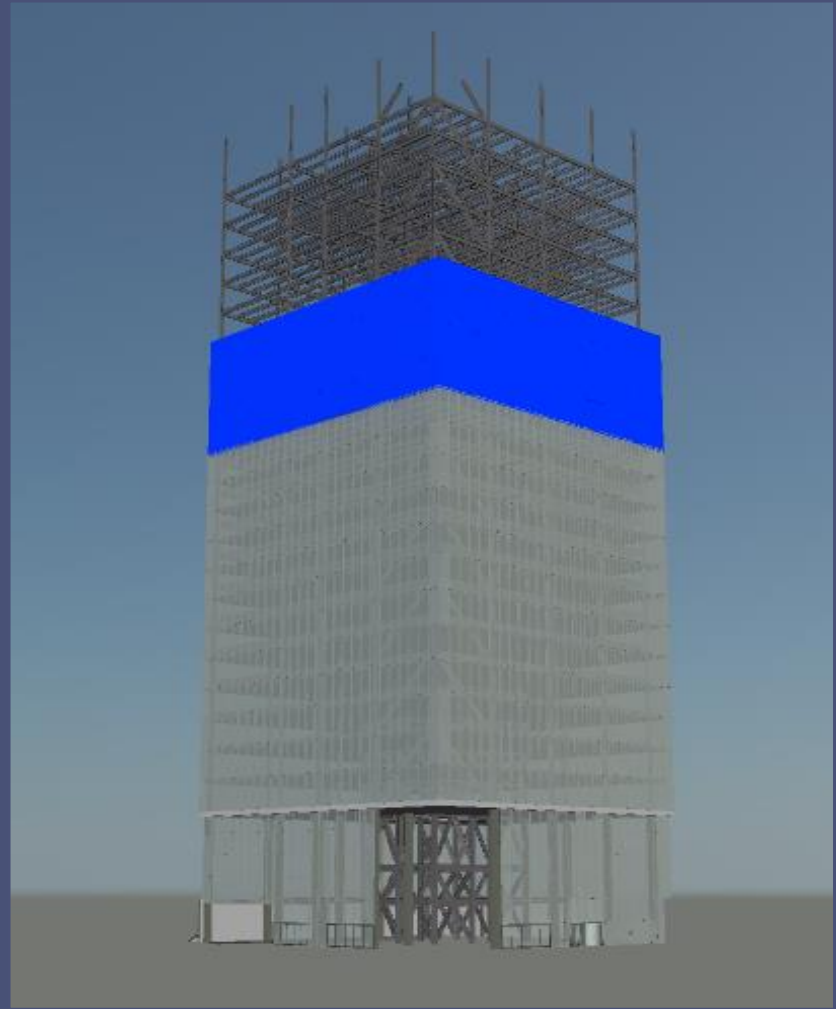
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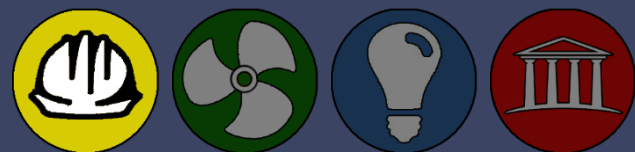
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Achievements



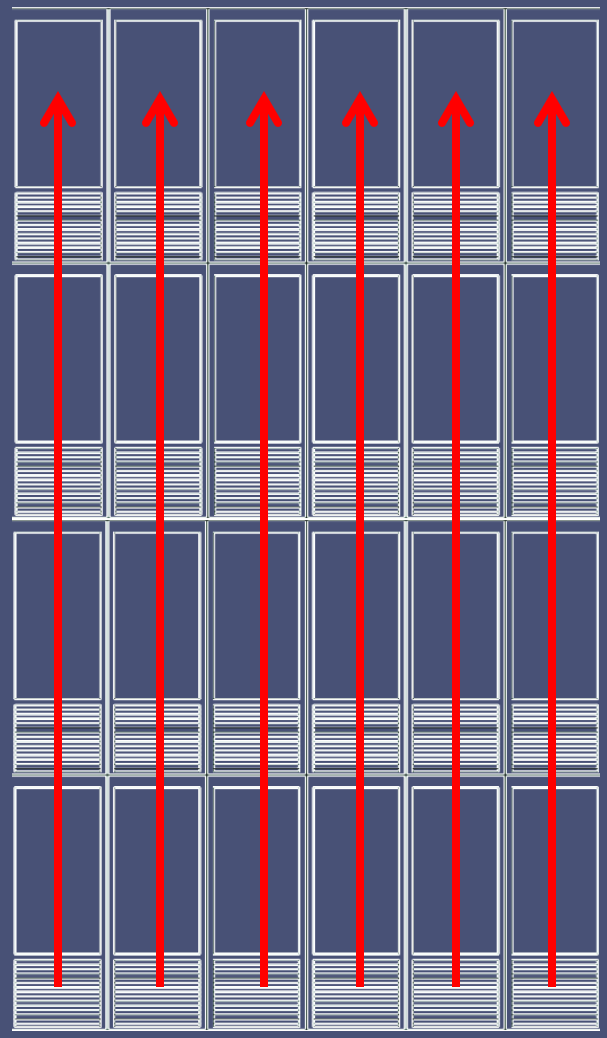
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Twin Hook Monorail Hoist



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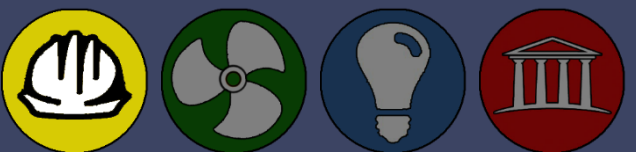
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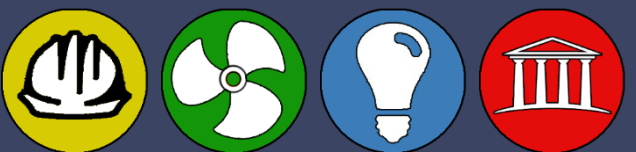


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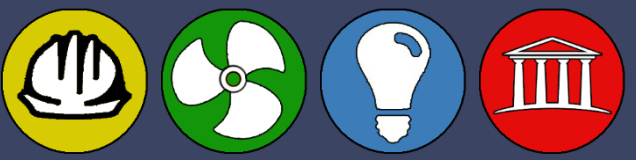


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ACHIEVEMENTS  
**LEED**  
SUMMARY





ACHIEVEMENTS  
LEED  
SUMMARY

	Goal	Design
Building Energy Use Reduction:	30%	54%
Net-Zero Energy Emissions:	50%	68%
Net-Zero Source Energy Use:	20%	30%
Net Off-Site Energy Use:	35%	19%*
Drift Limit:	41.5 in	39 in
Schedule Time	29 Months	
Cost	\$148 million	

\*P.G. & E. Restrictions



Introduction



Near Net-Zero Energy

## Acknowledgments:

Ms. Leslie Beahm  
Mr. Liam Buckley  
Dr. Charles Cox, PhD, PE, RA  
Mr. Robert Holland  
Mr. Moses Ling, PE, RA  
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Dr. John Messner, PhD  
Dr. Richard Mistrick, PhD, PE  
Mr. Kevin Parfit, PE  
Mr. Victor Sanvido, Southland Industries  
Dr. Ryan Solnosky, Ph.D

Skidmore, Owings, & Merrill LLP  
Friends, Family, and Penn State AE Faculty

Construction

Achievements