

lighting depth

scrim

lobby/lounge

classroom

lecture hall

electrical depth

transformer analysis

architecture breadth

open office + facade

mechanical breadth

energy modeling + ductwork layout

mae supplemental study

daylighting + parametric modeling



UNIVERSITY OF PENNSYLVANIA

neural and behavioral sciences building



UNIVERSITY OF PENNSYLVANIA

neural and behavioral sciences building

reinhardt swart

topic **outline**

building overview

topic **outline**

building overview

lighting scrim
lobby/lounge
lecture hall

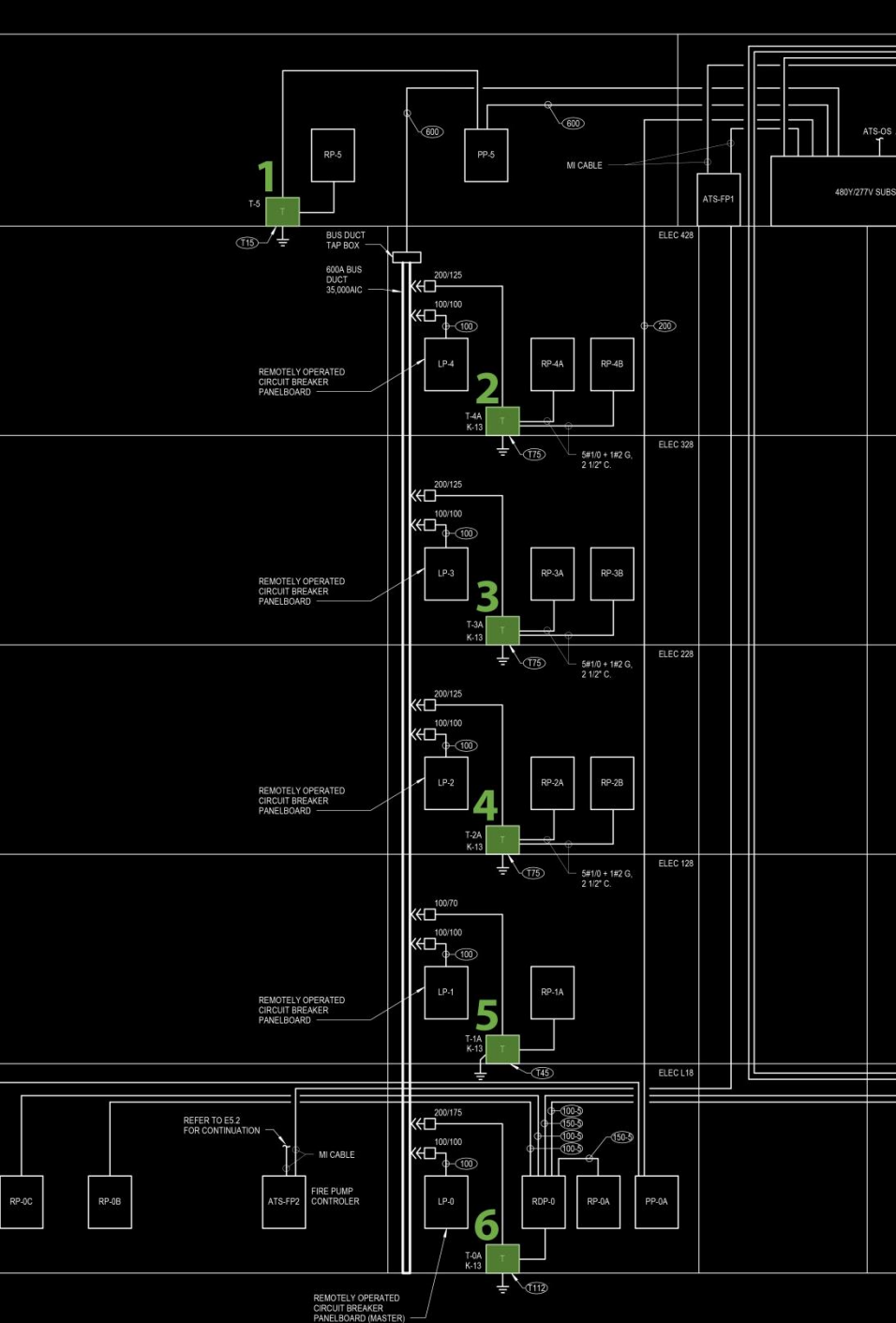


topic outline

building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis



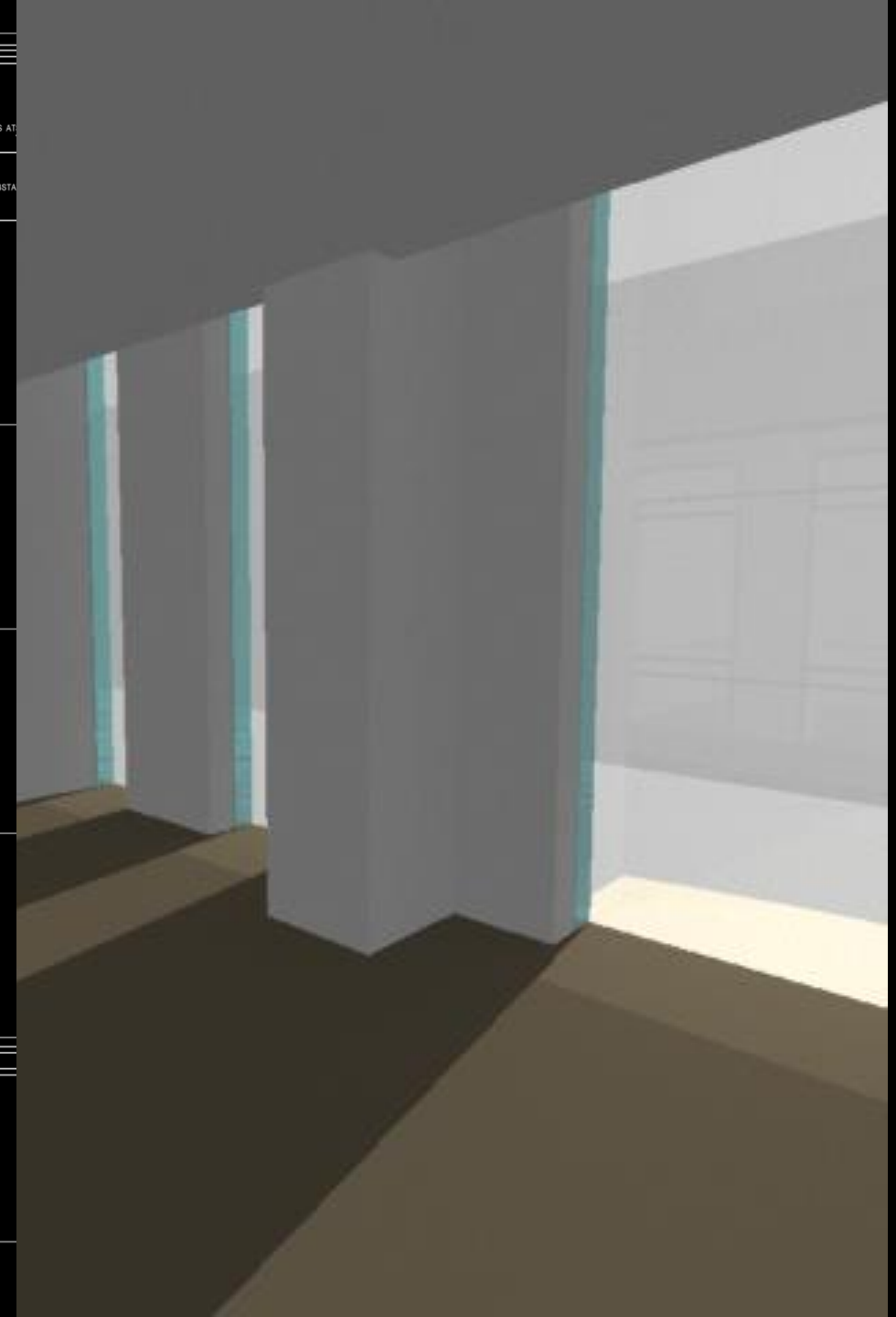
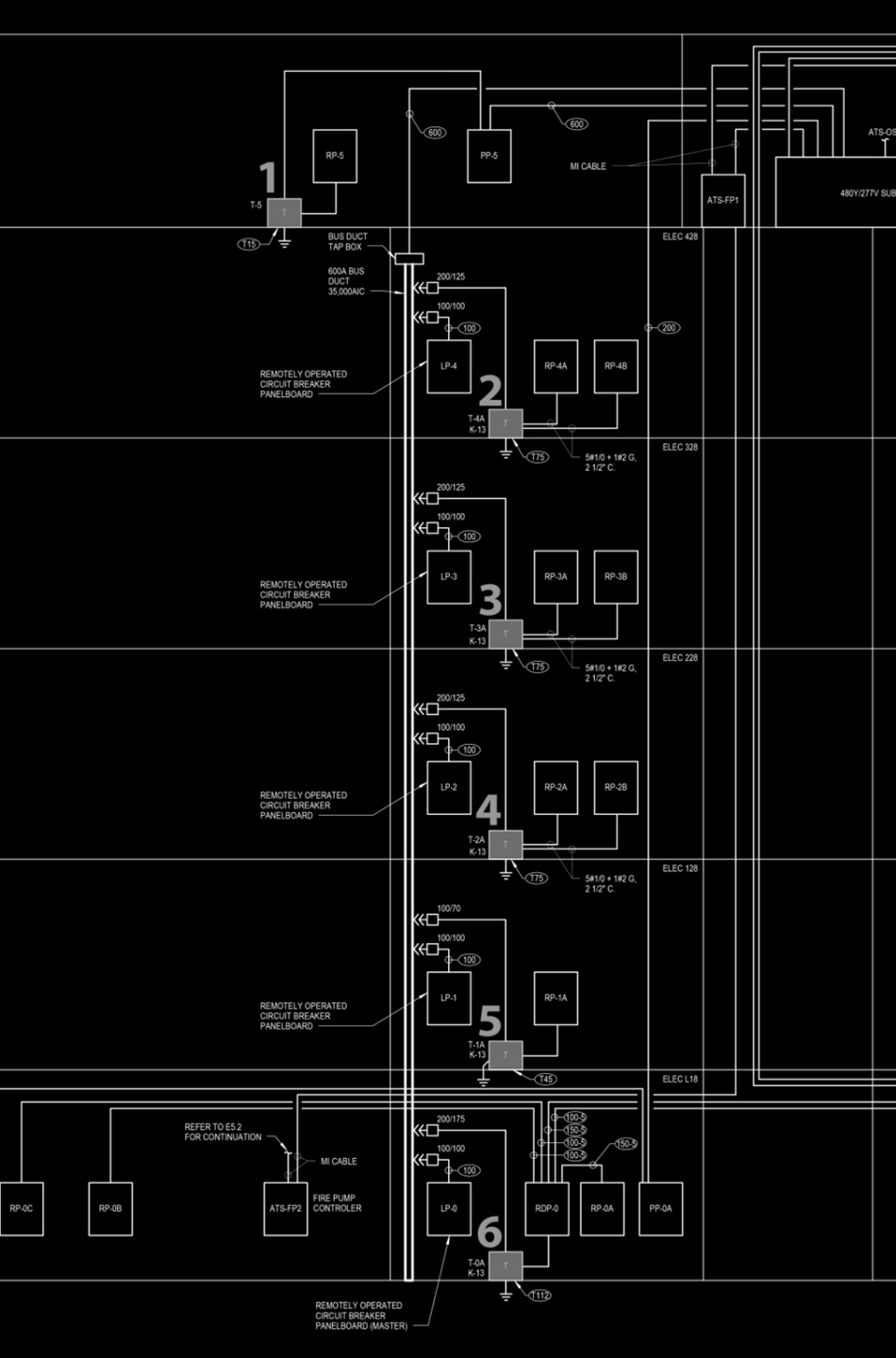
topic outline

building overview

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lobby/lounge
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electrical transformer analysis

architecture open office + facade



topic outline

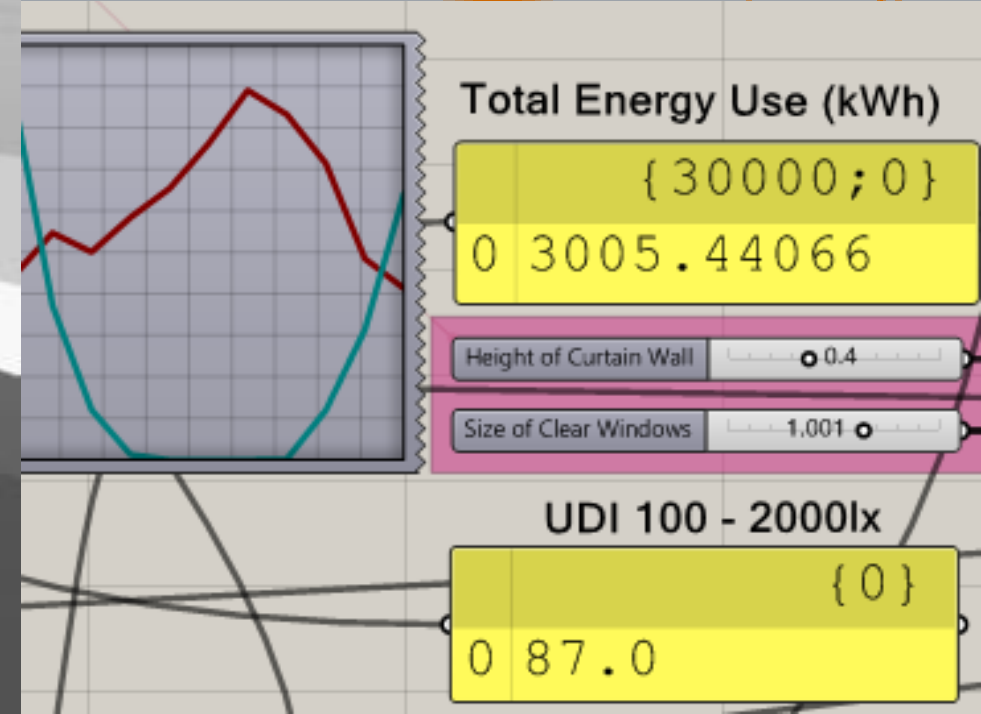
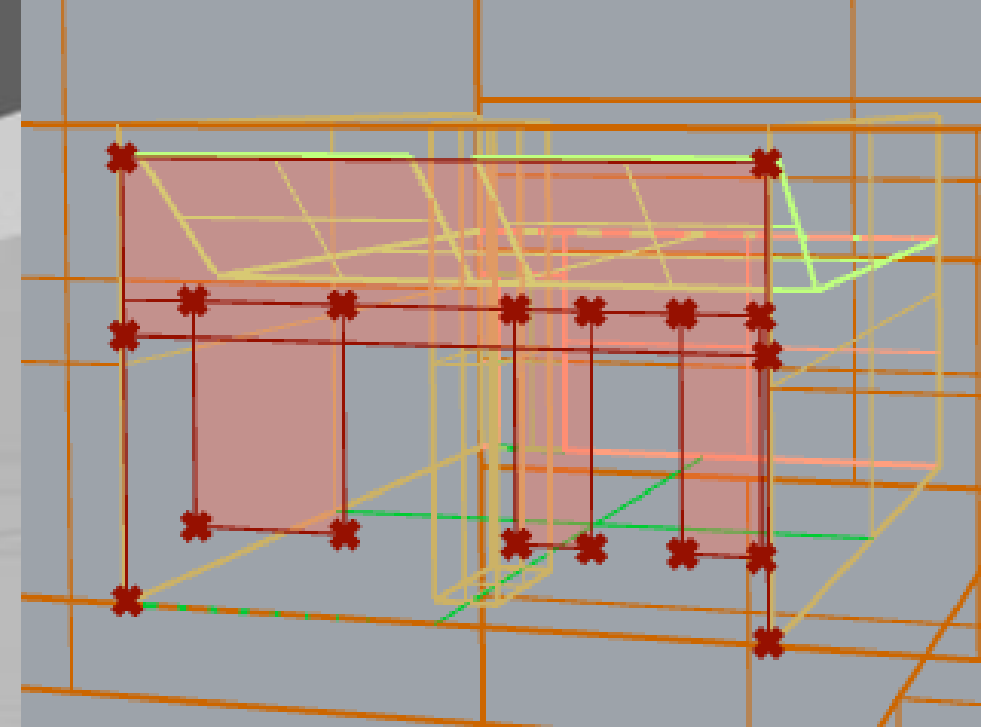
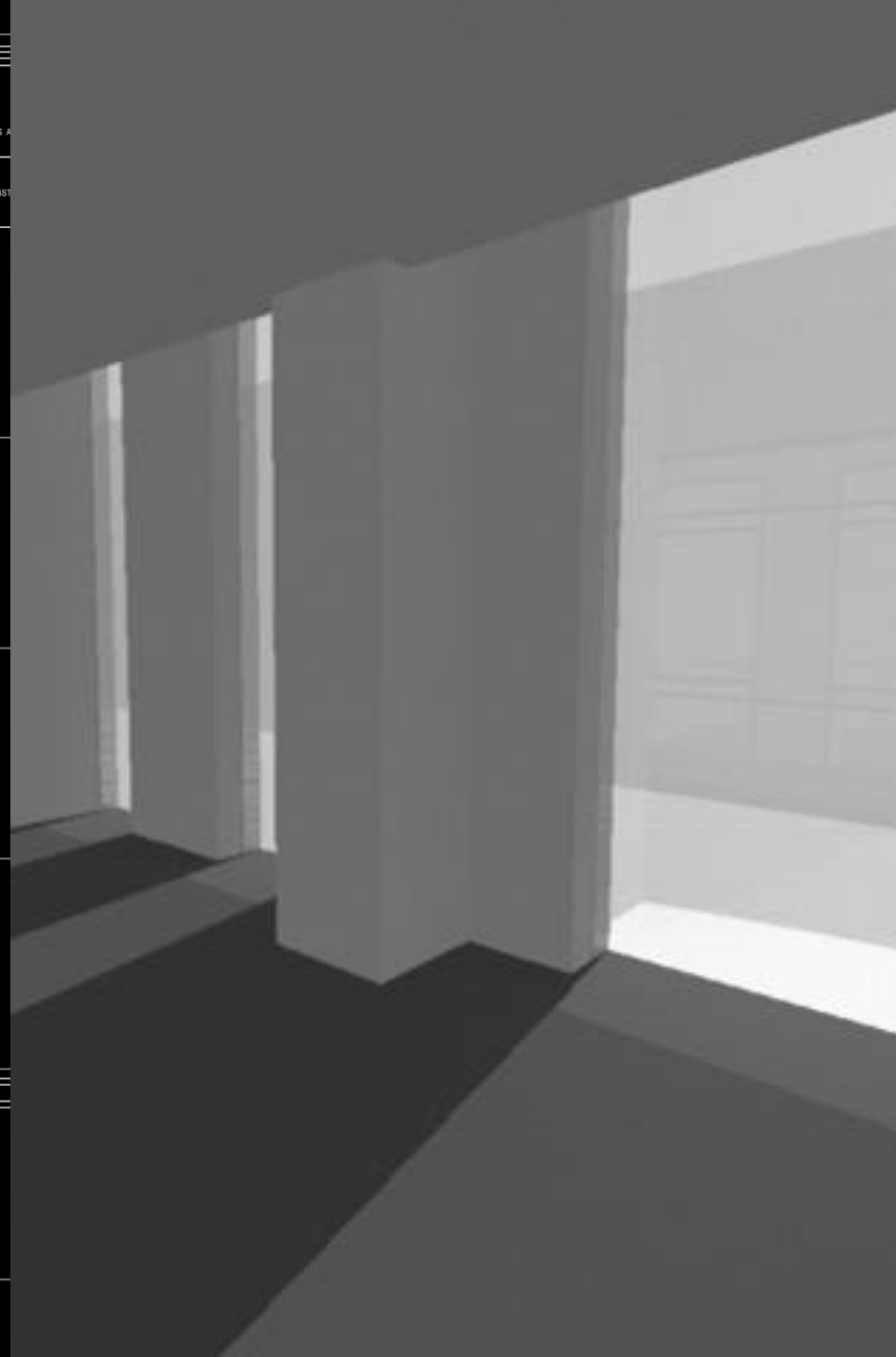
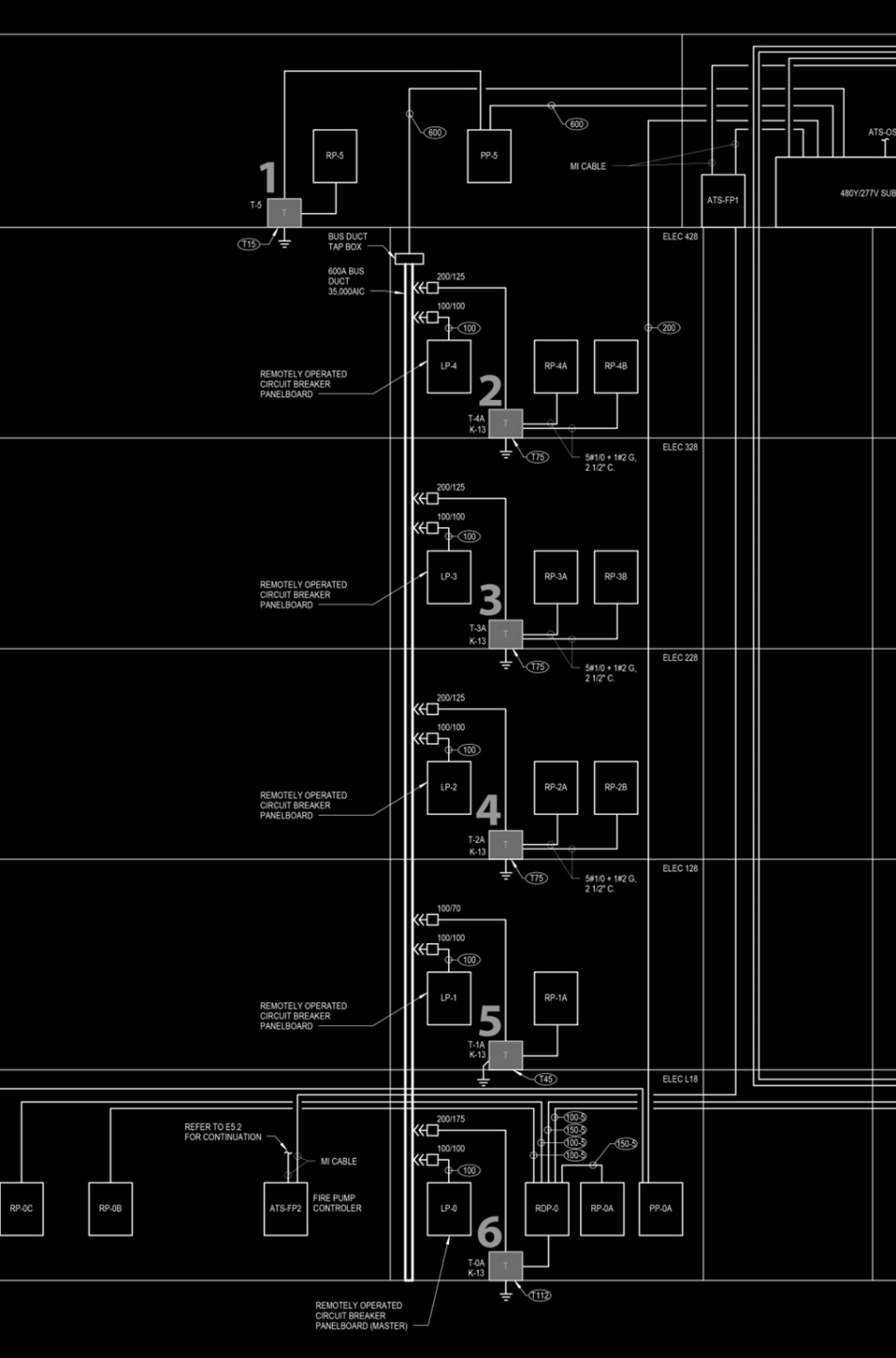
building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment



Total Energy Use (kWh)

{30000; 0}
0 30005.44066

Height of Curtain Wall 0.4

Size of Clear Windows 1,001

UDI 100 - 2000lx

{0}
0 87.0

building statistics

building overview

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location philadelphia, pa
size 77,100 gsf
occupancy business, assembly, storage
cost \$49,300,000
delivery guaranteed maximum price

architect smithgroupjjr
const. manager p. anges

building location

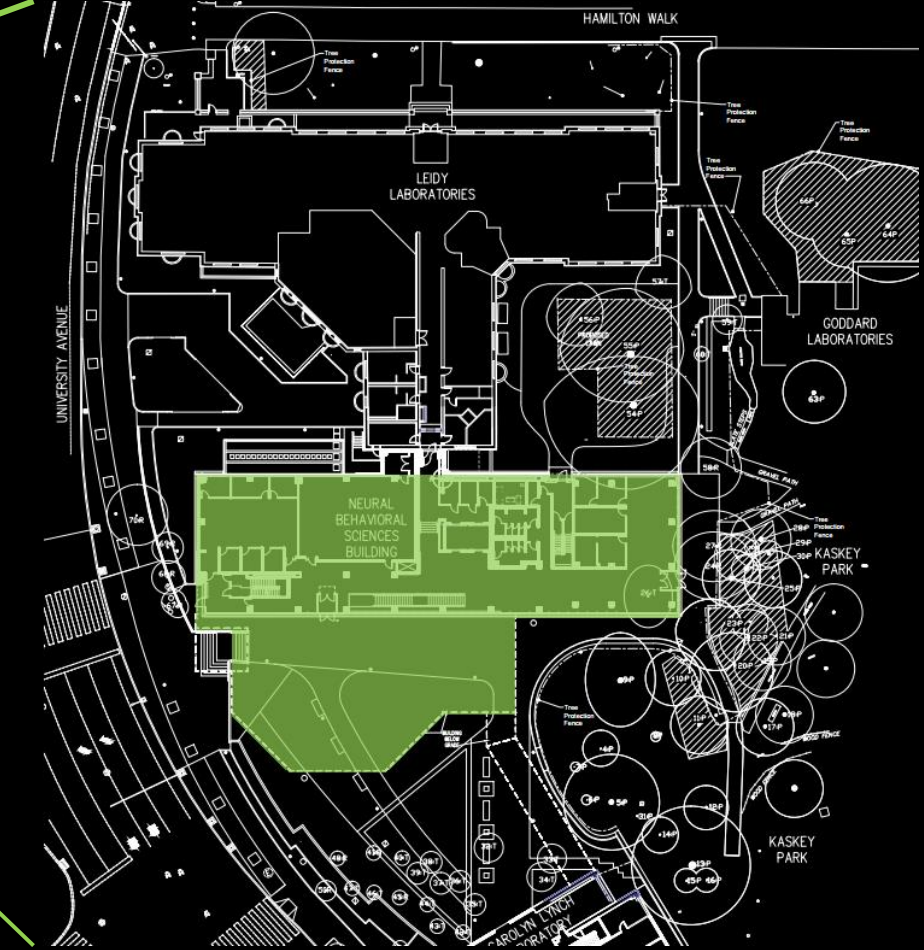
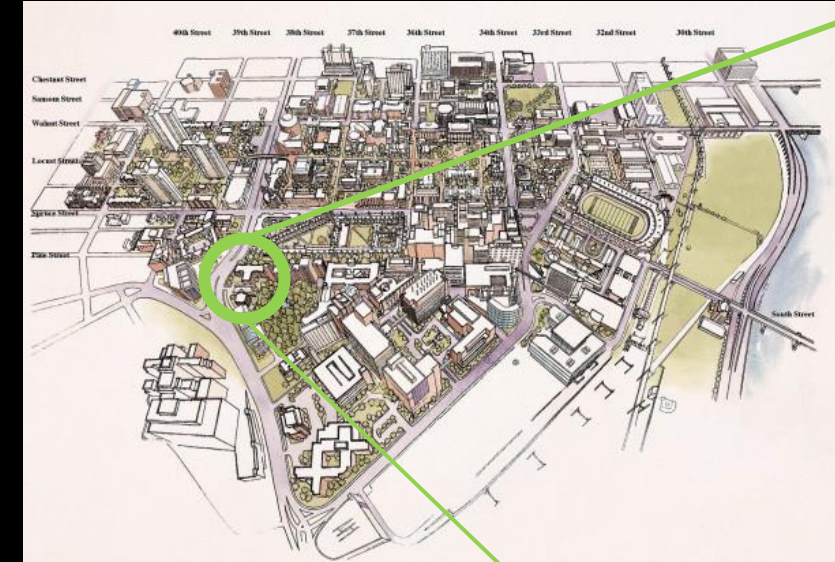
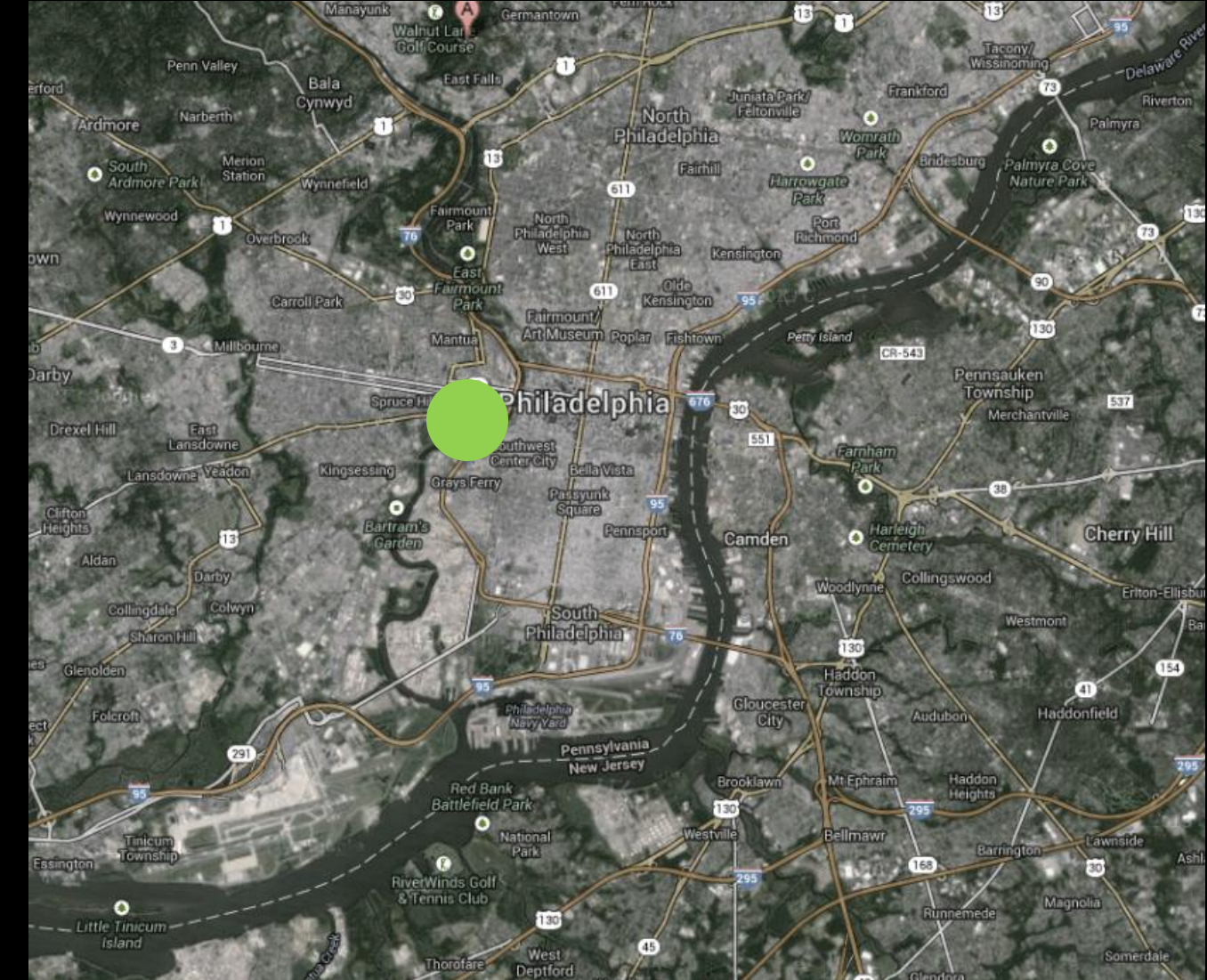
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open office + facade

impact
daylighting offices
energy use + equipment



lighting concept

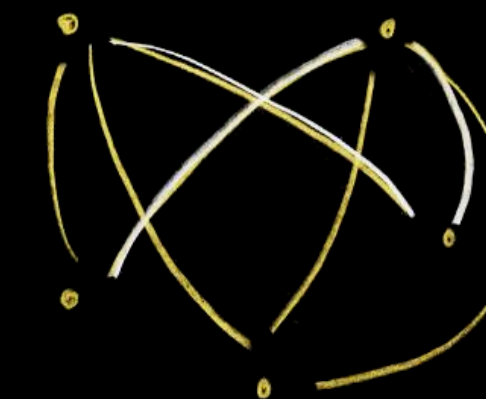
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"...the main objective is to have a place where Penn undergraduates who are life science majors have a place where they can relate to...if you bring people together, there's a higher likelihood of interactions happening among them.."

- **Richard Shultz**, Associate Dean for the Natural Sciences

lighting concept

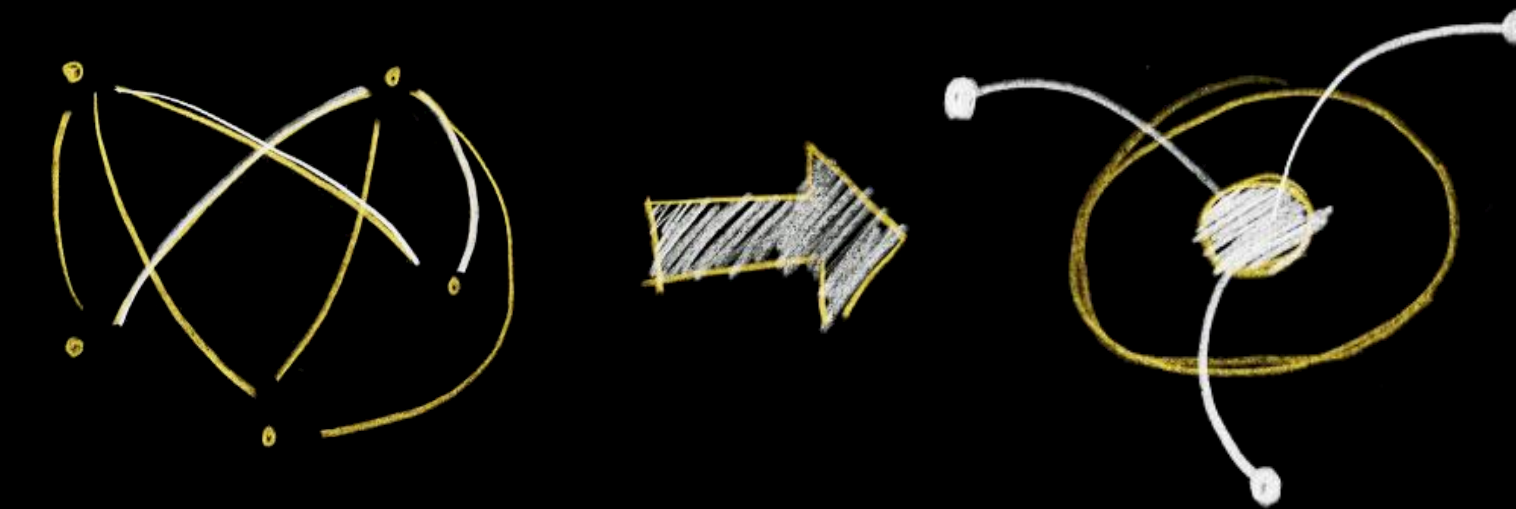
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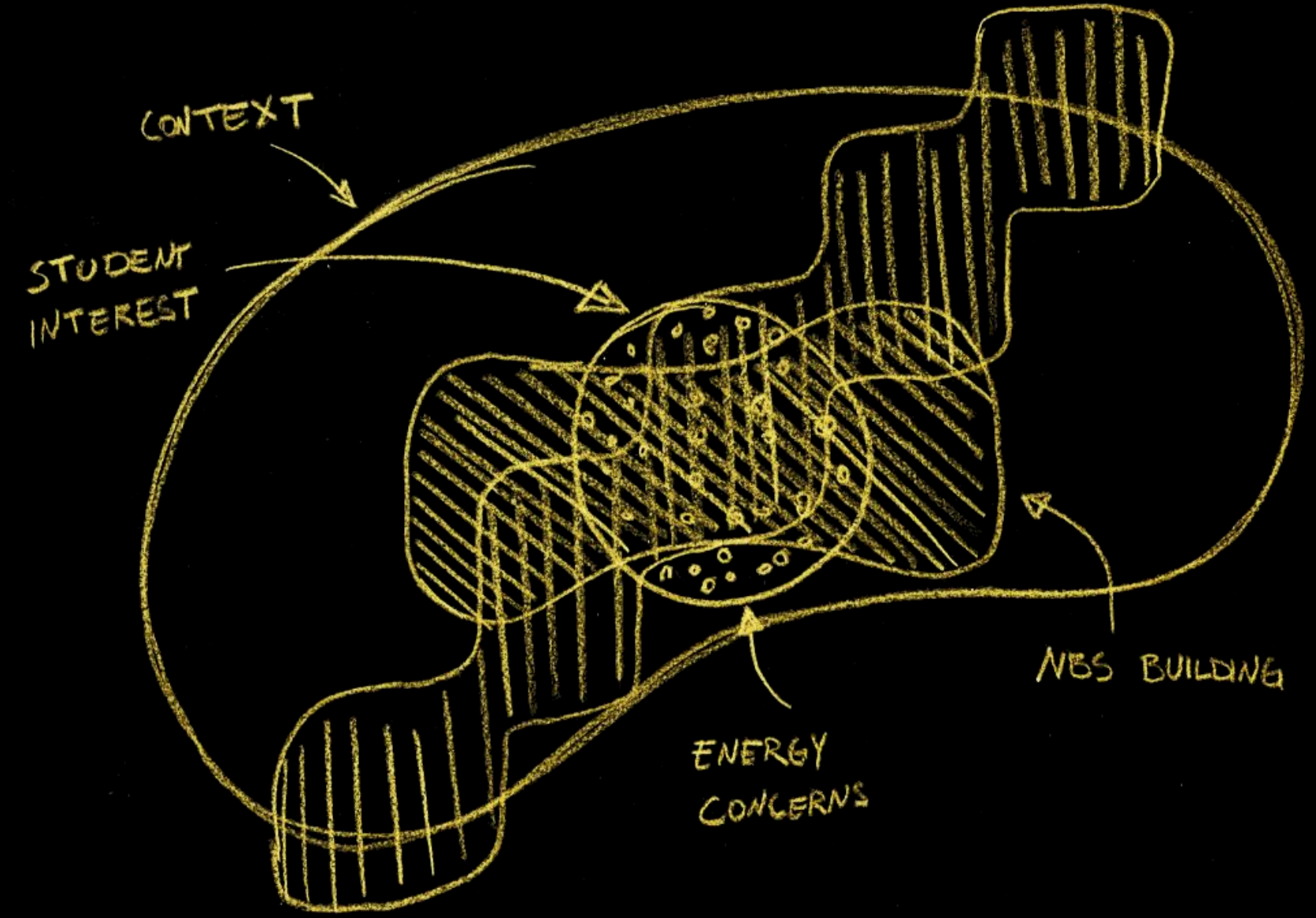


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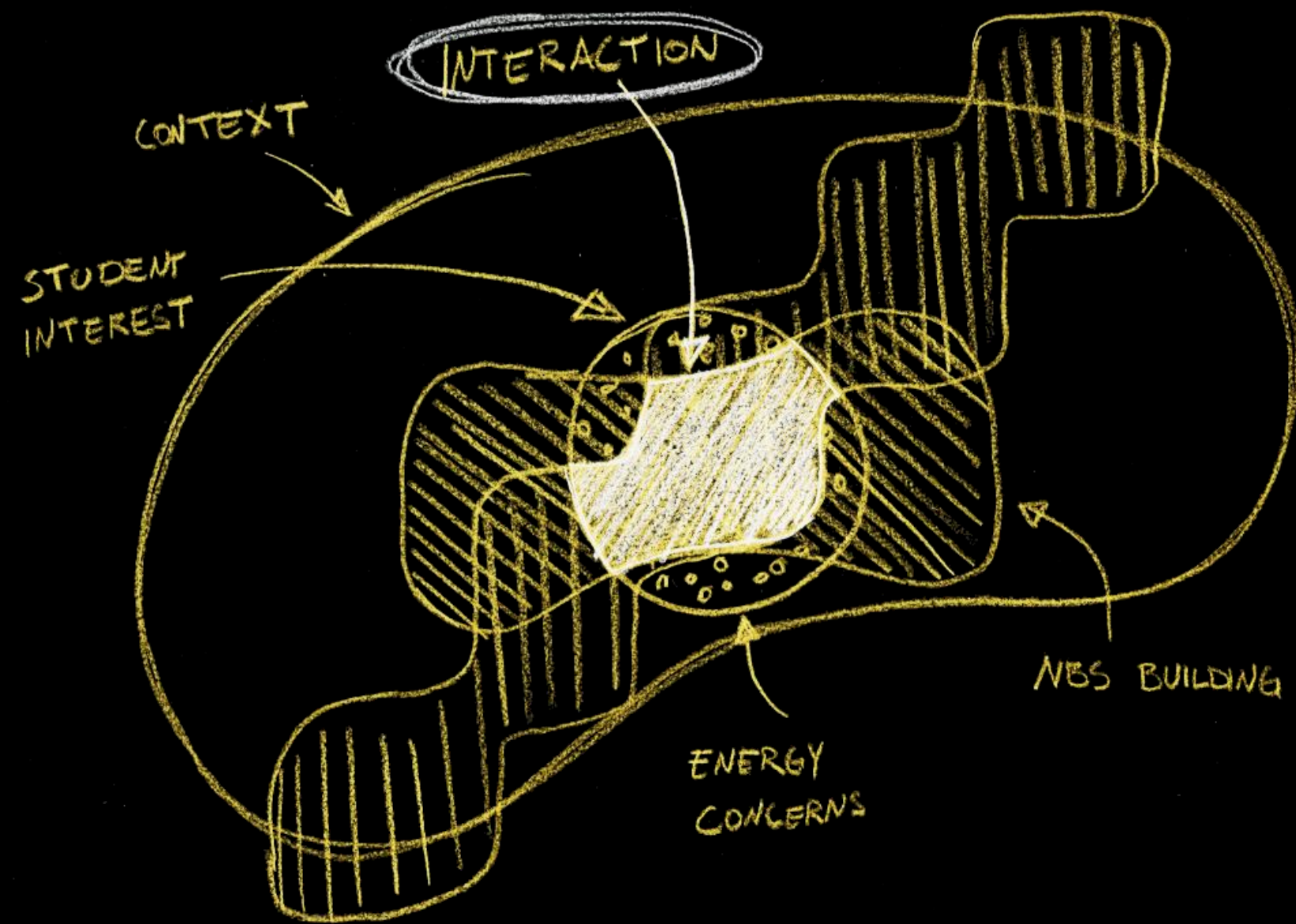
lighting concept

- building overview
- lighting** scrim
lobby/lounge
lecture hall
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lighting concept

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connection + interaction...



...through biomimicry

lighting scrim

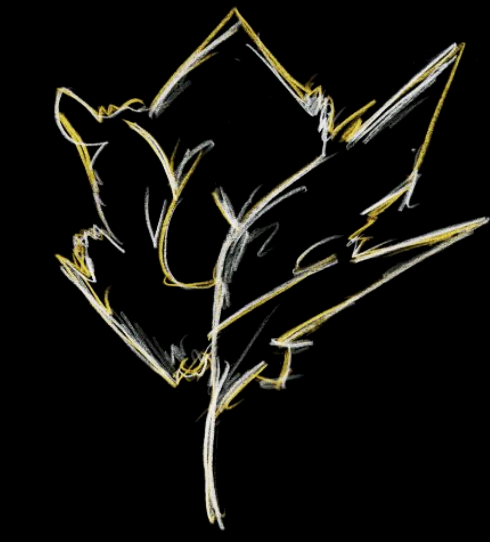
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a festive expression of the absence of daylight

lighting scrim

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lighting scrim

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lighting scrim

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lighting scrim

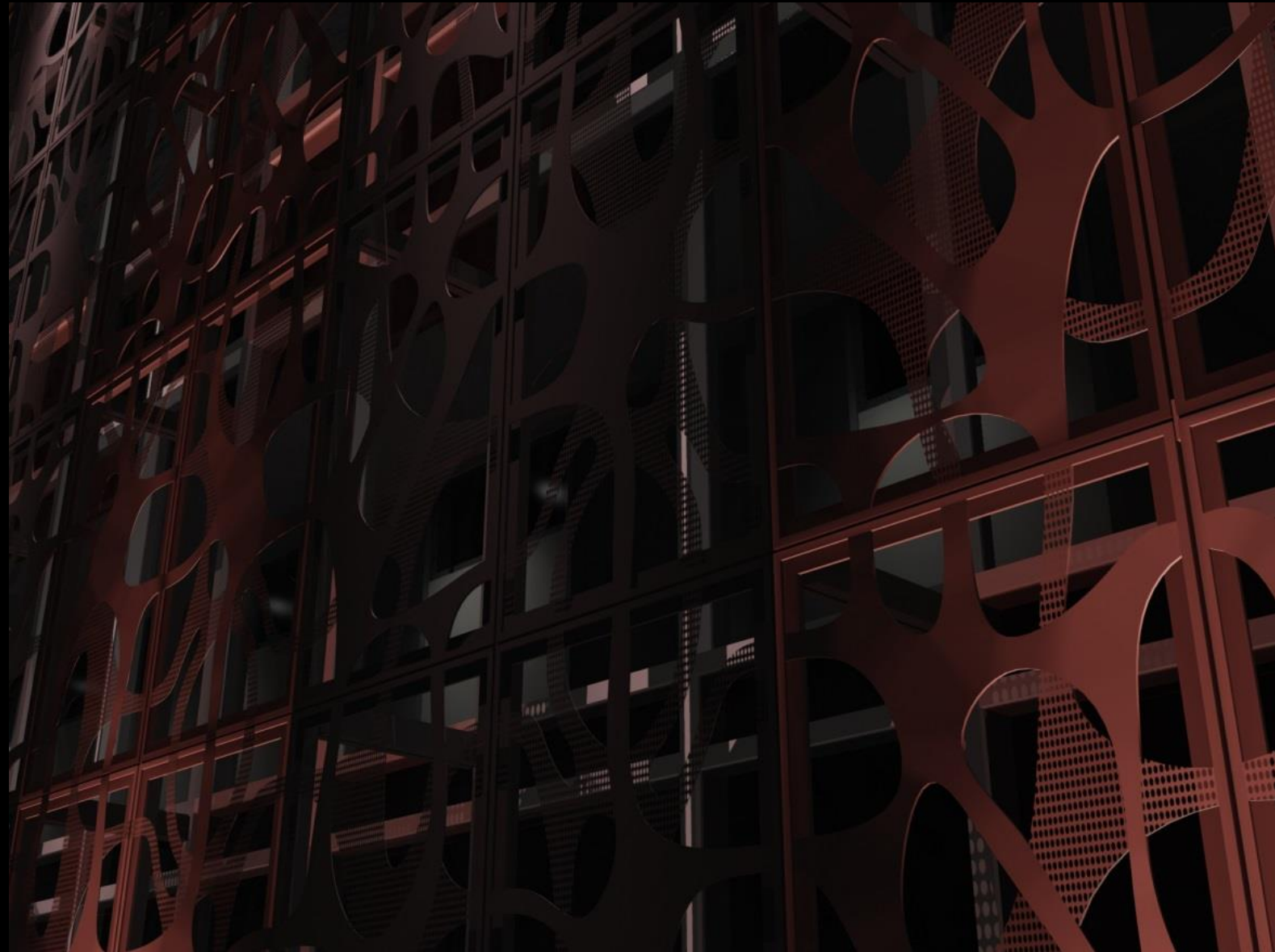
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lighting scrim



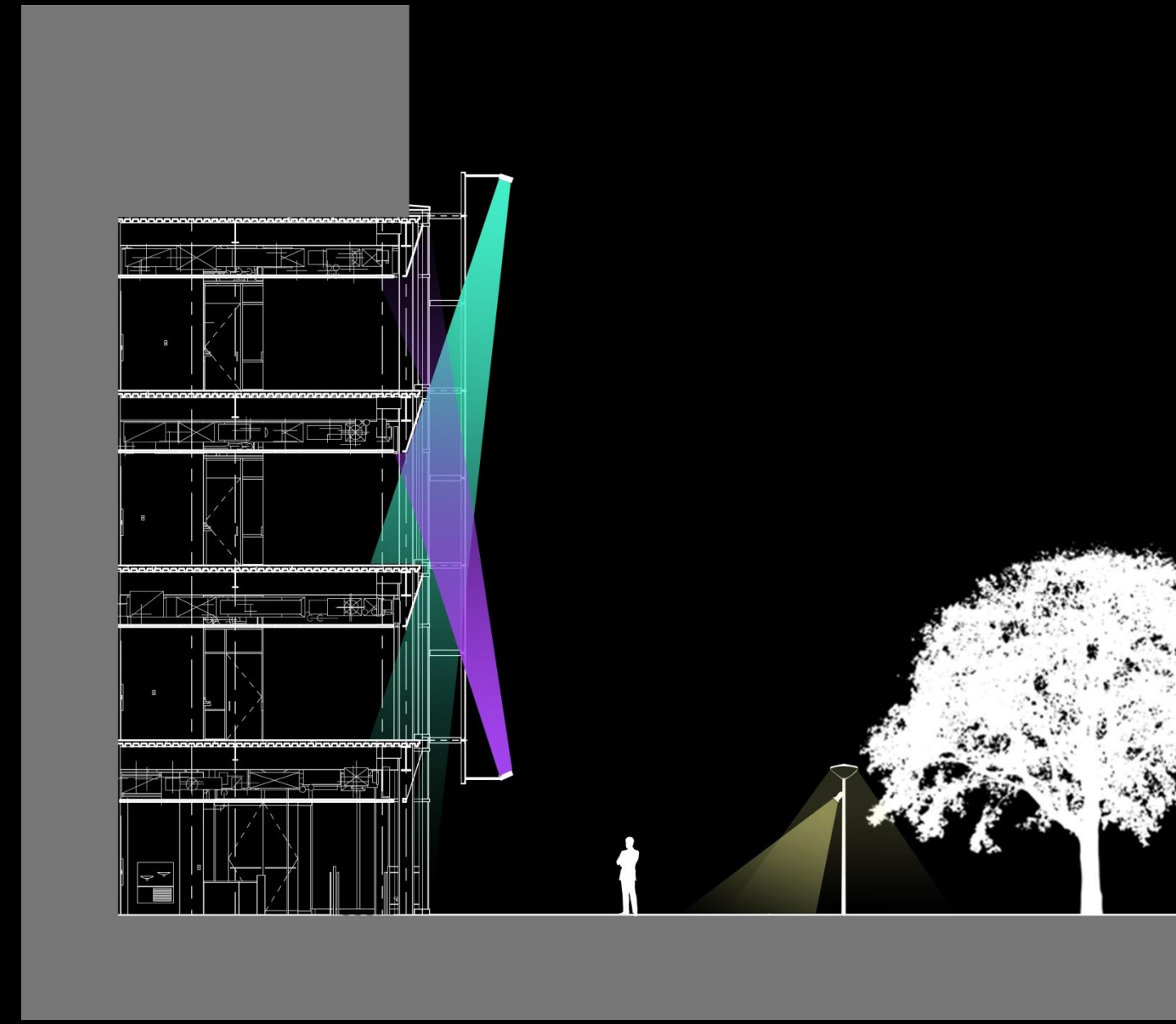
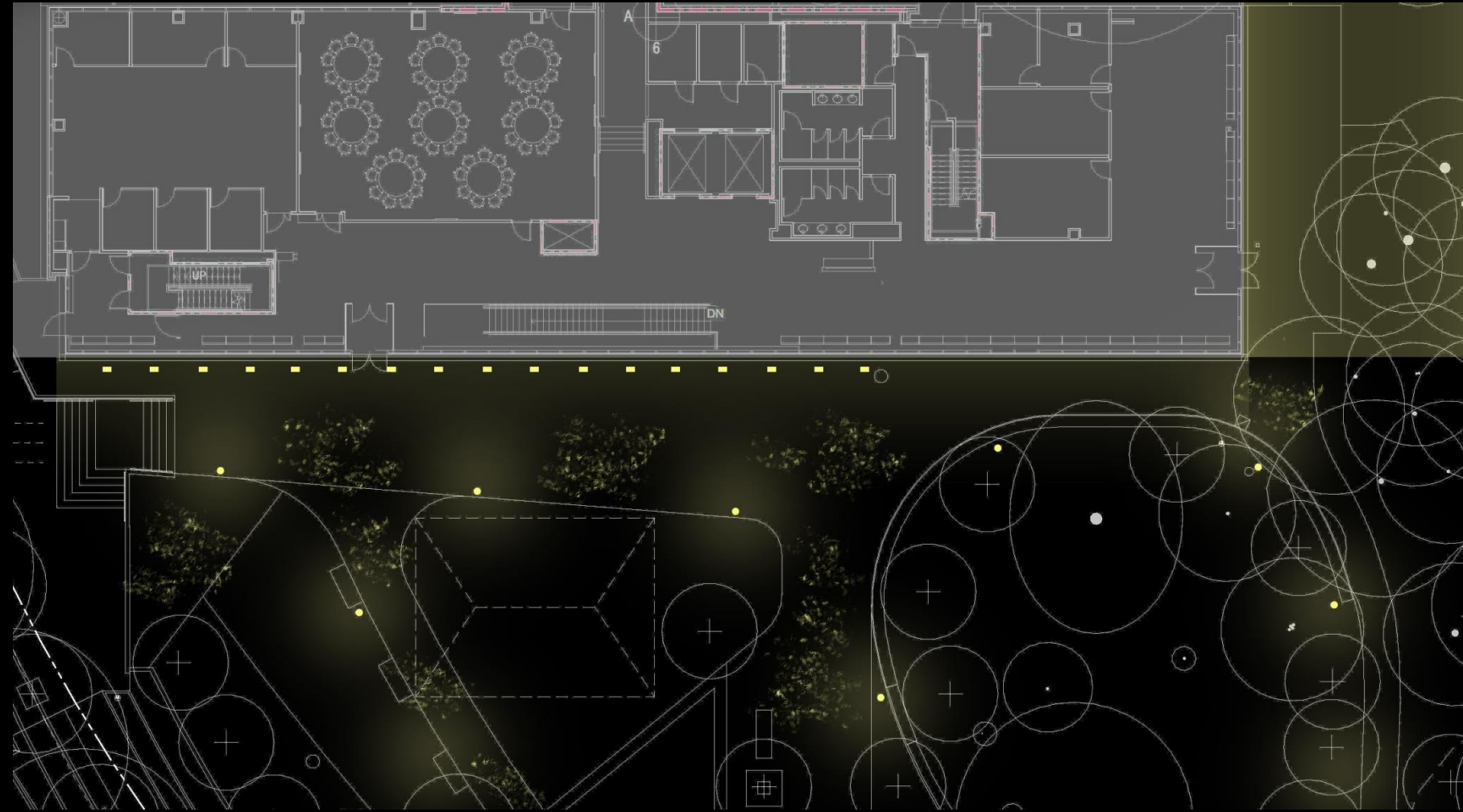
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lighting scrim

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lighting lobby/lounge

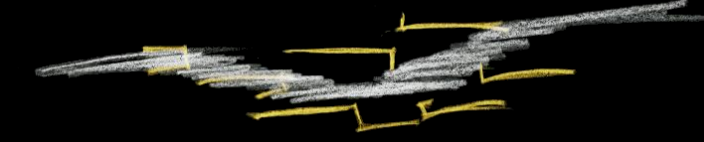
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organic form and movement parallels transitional pull

lighting lobby/lounge

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lighting lobby/lounge

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lighting lobby/lounge

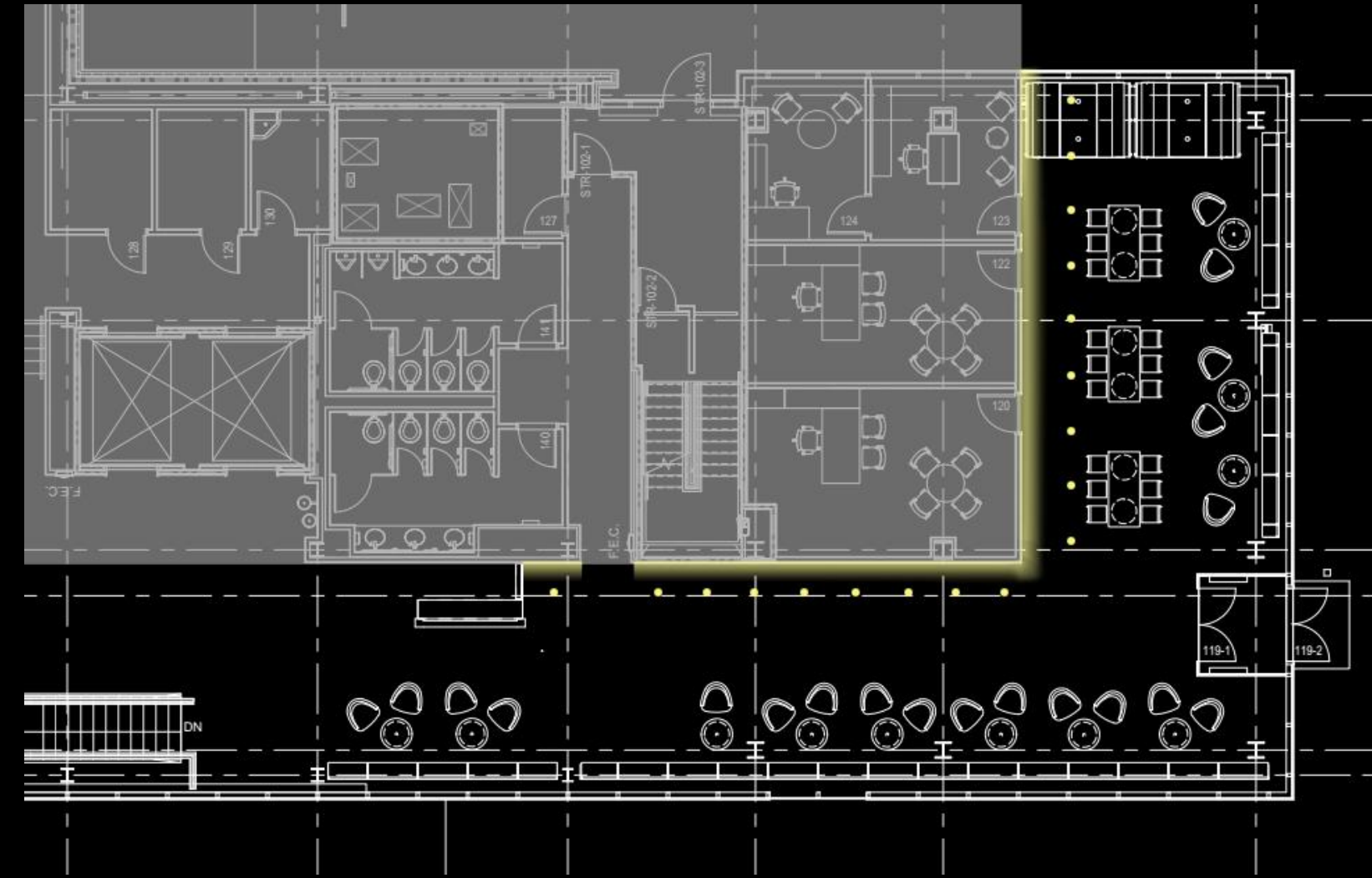
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lighting lobby/lounge

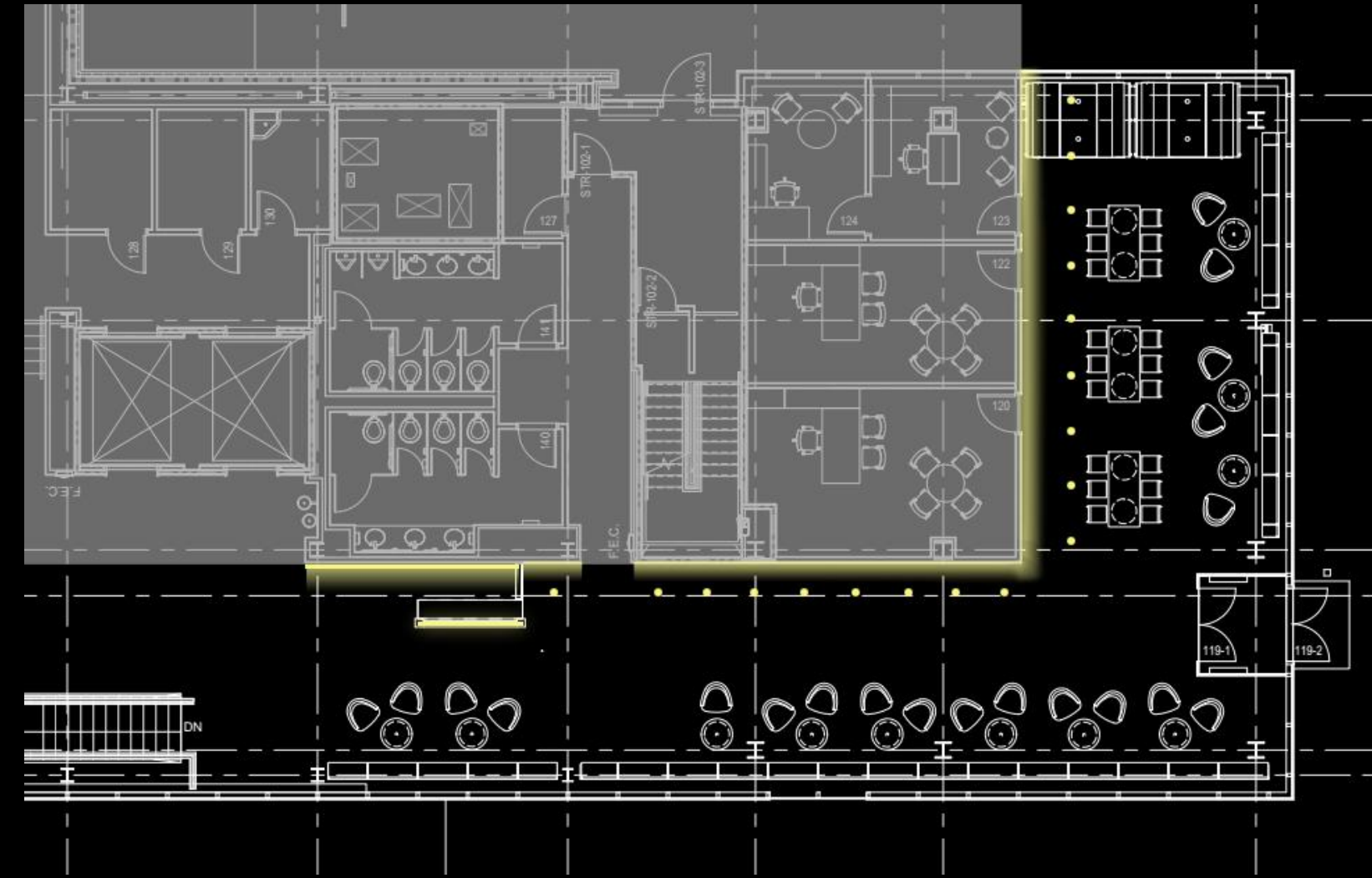
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lighting lobby/lounge



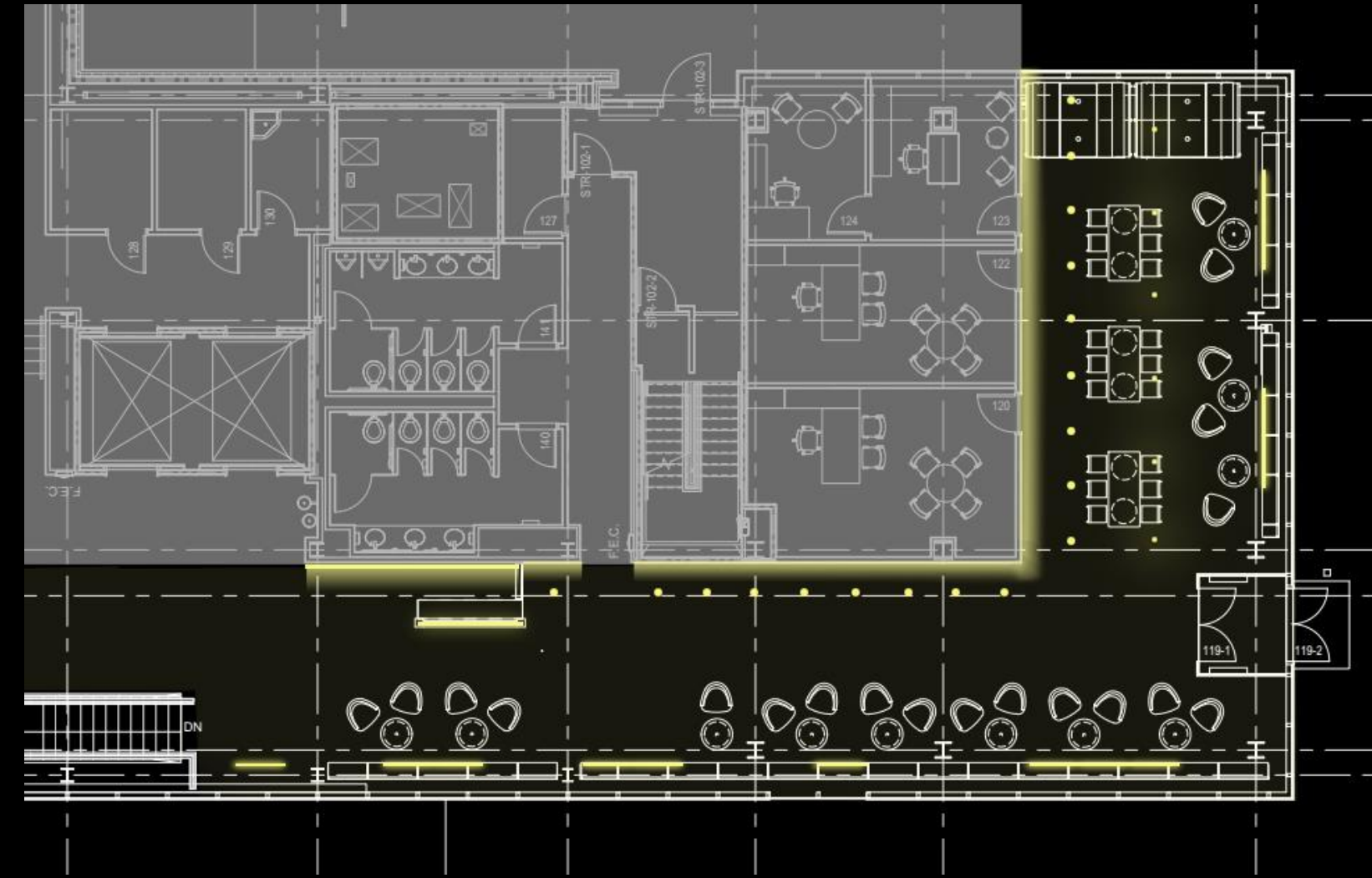
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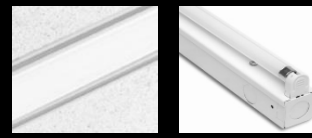
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lighting lobby/lounge



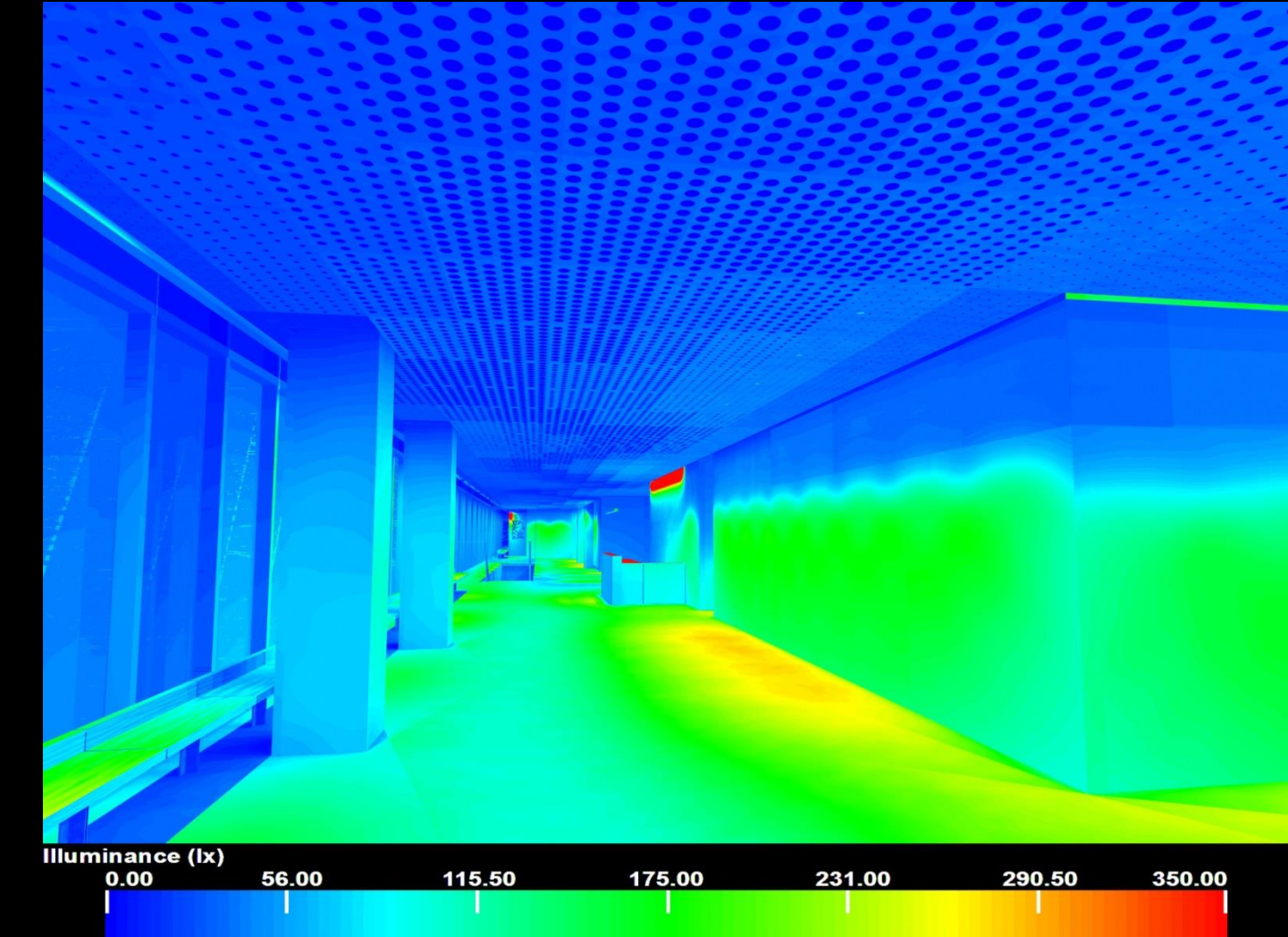
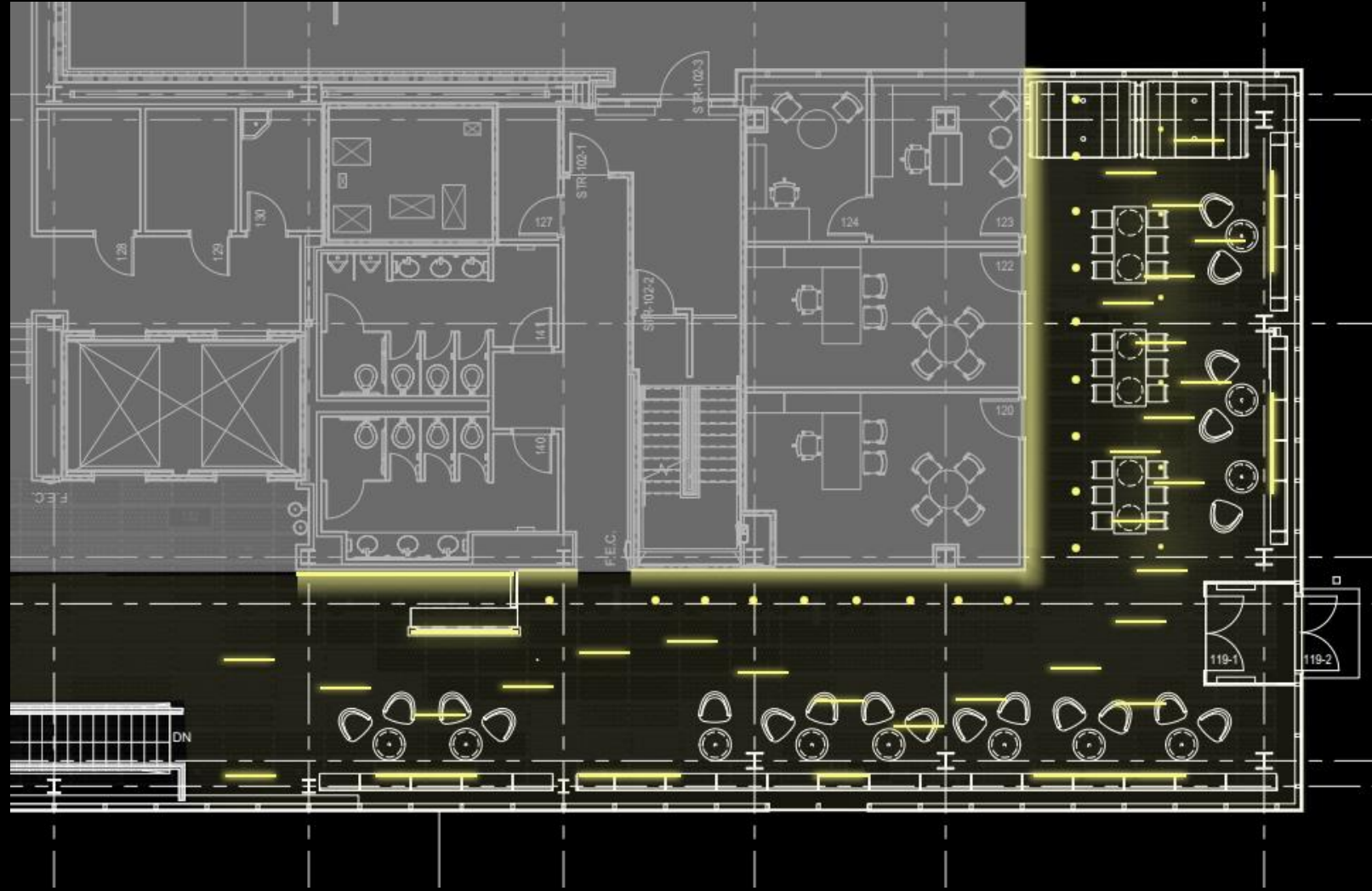
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lighting lobby/lounge

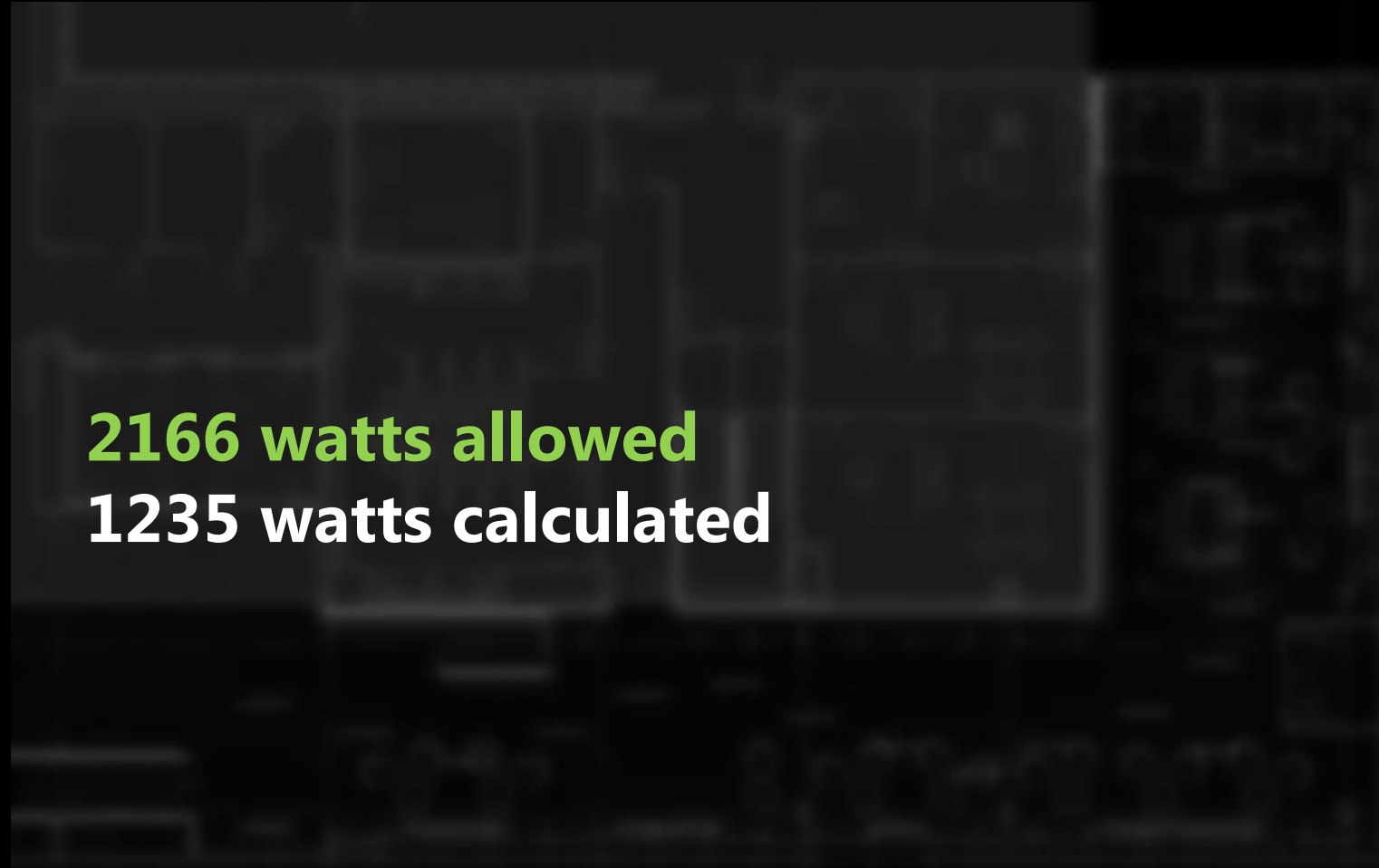
building overview

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2166 watts allowed
1235 watts calculated



43% improvement

lighting lecture hall

building overview

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impact daylighting offices
energy use + equipment



lateral roots branch out from central root growing cells

lighting lecture hall

building overview

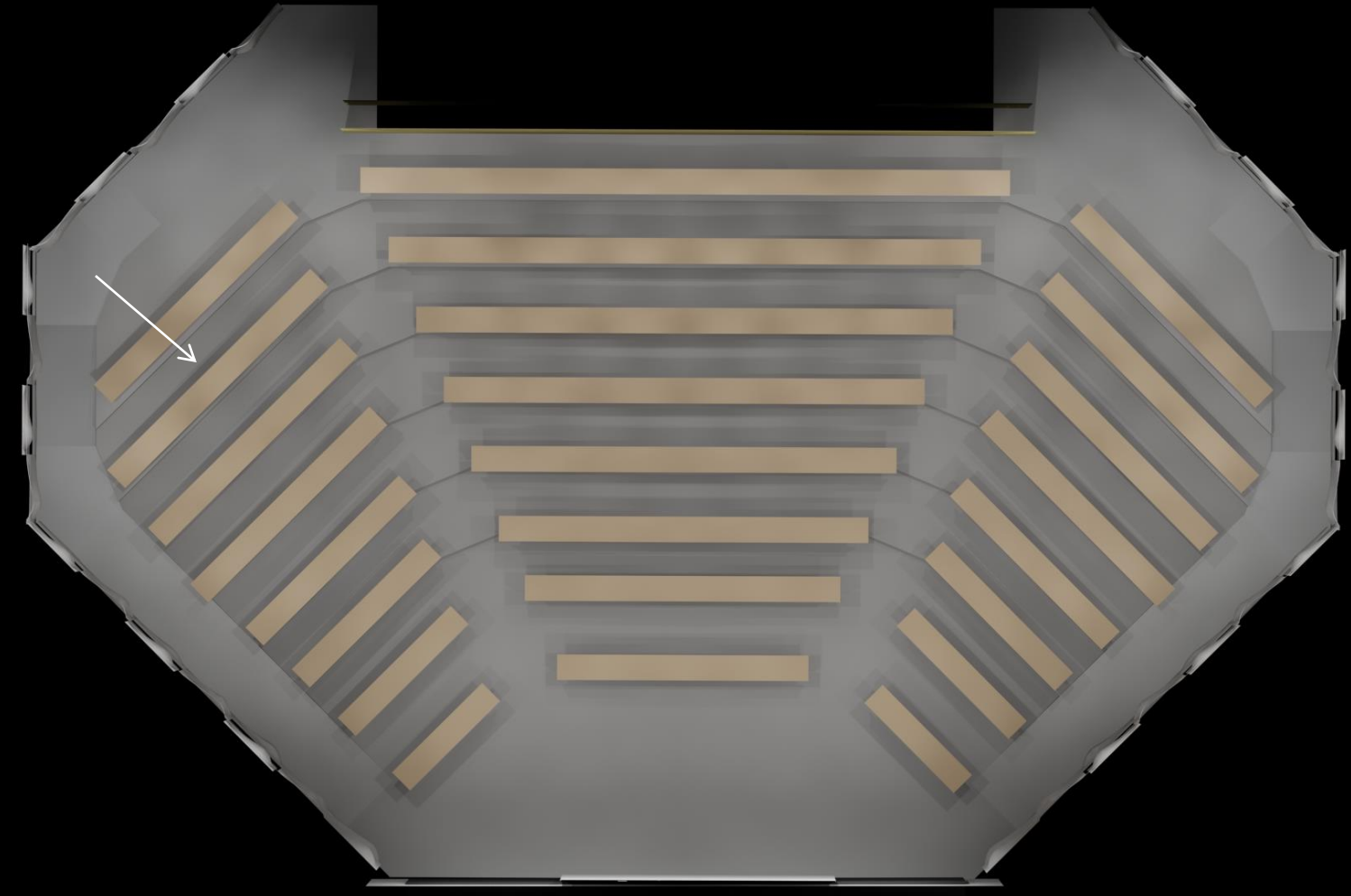
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

exam mode



lighting lecture hall

building overview

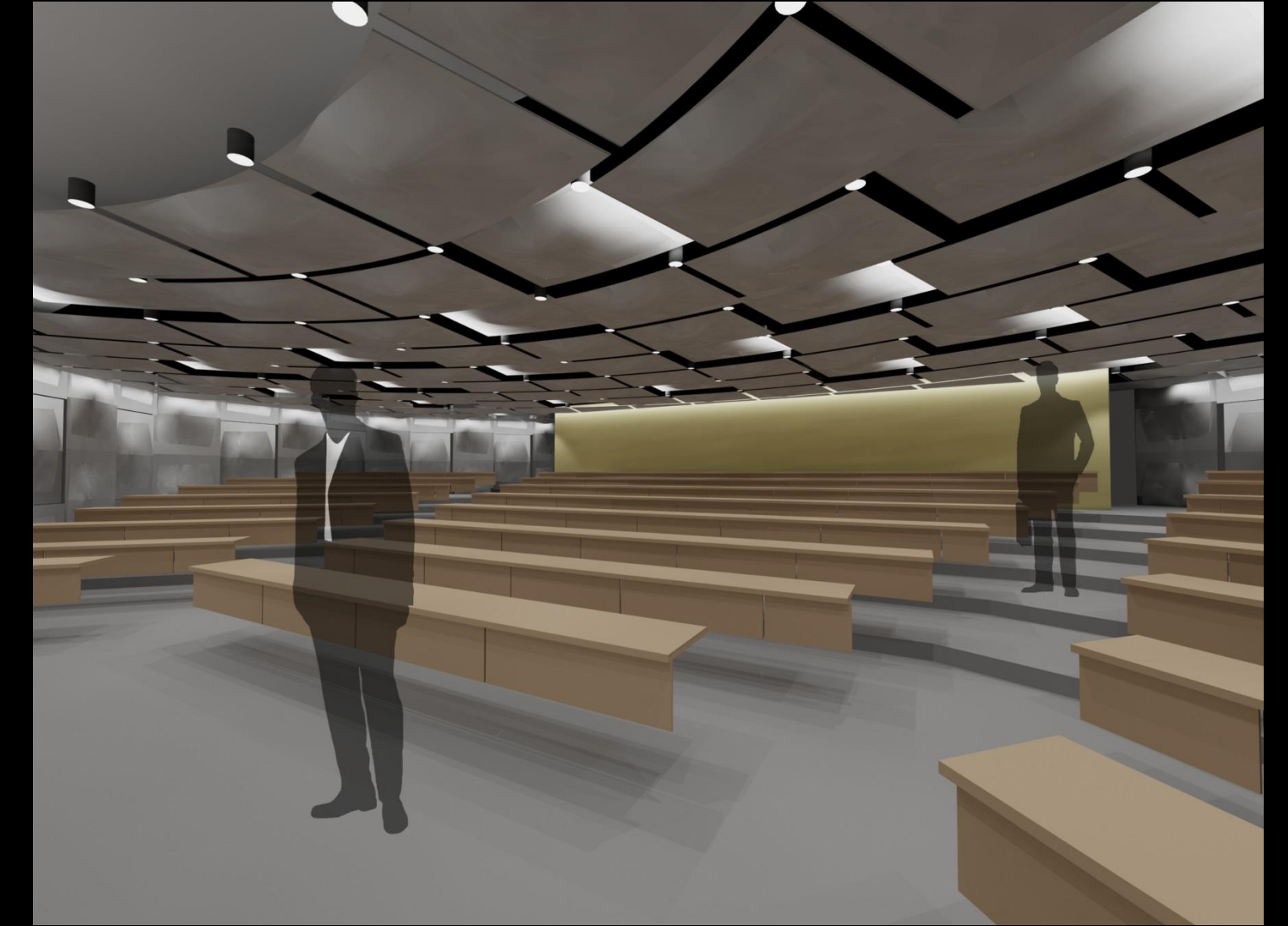
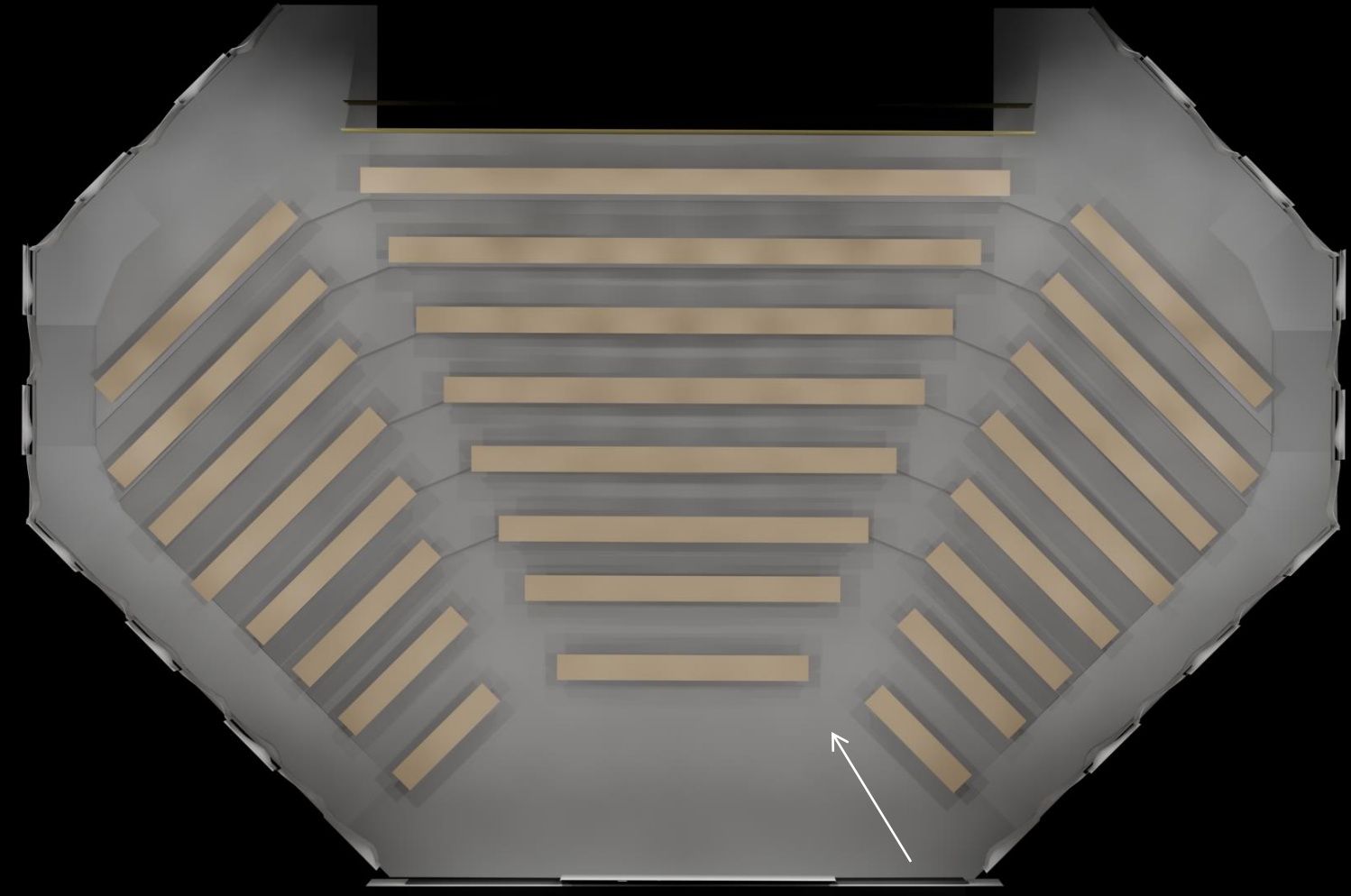
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electrical transformer analysis

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impact daylighting offices
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exam mode



lighting lecture hall

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energy use + equipment

a/v mode



lighting lecture hall

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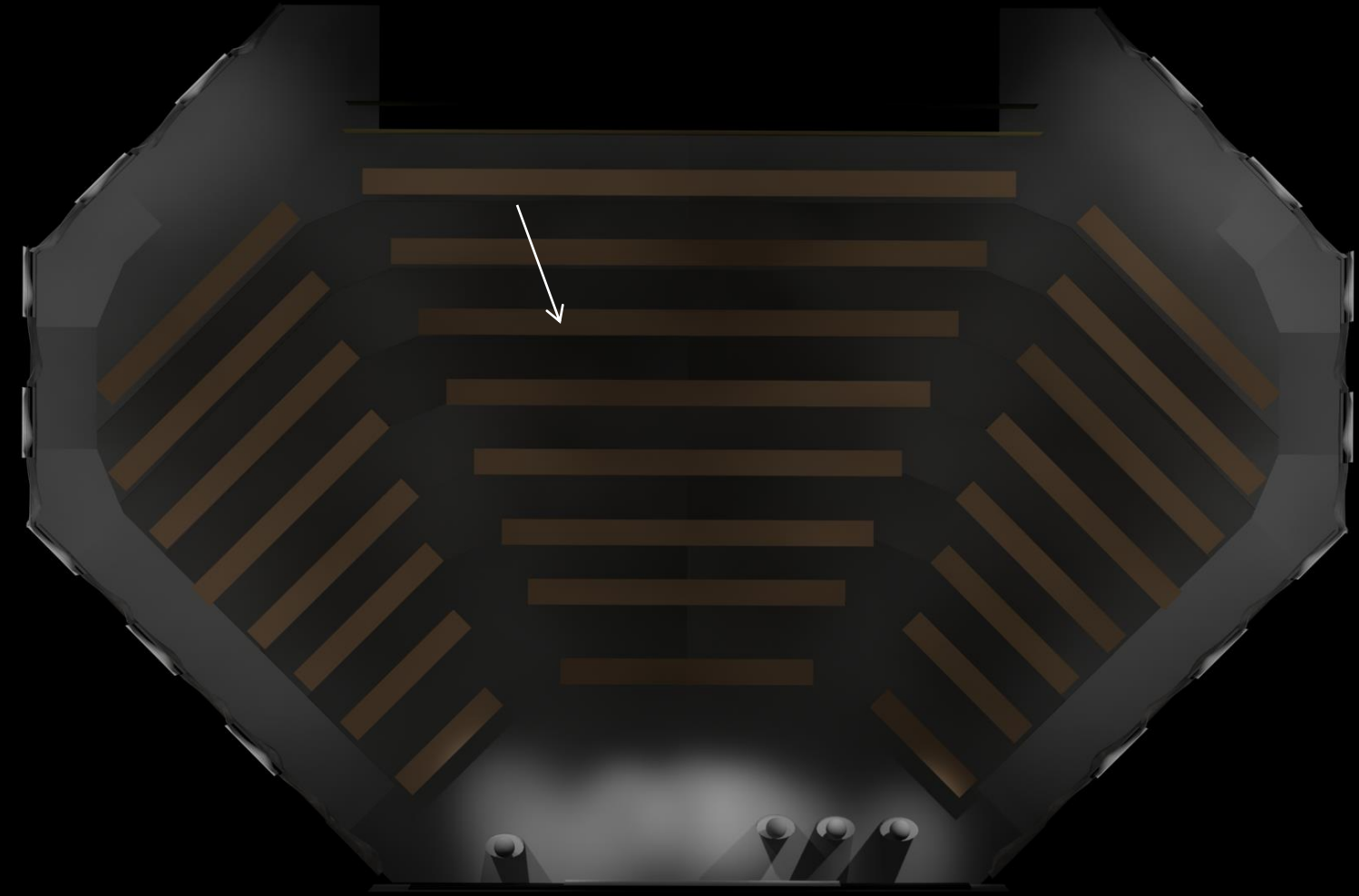
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presenter mode



lighting lecture hall

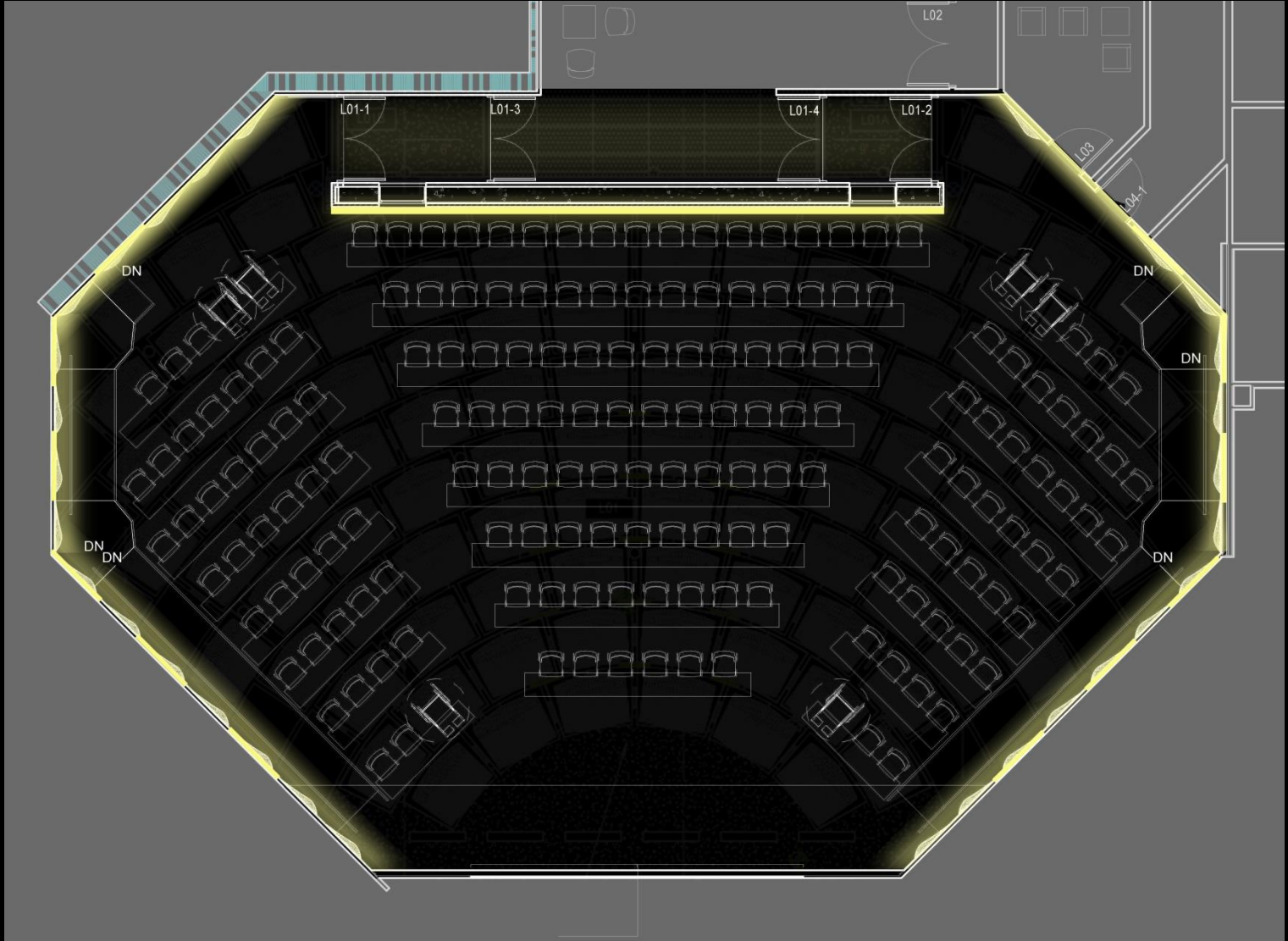
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lighting lecture hall

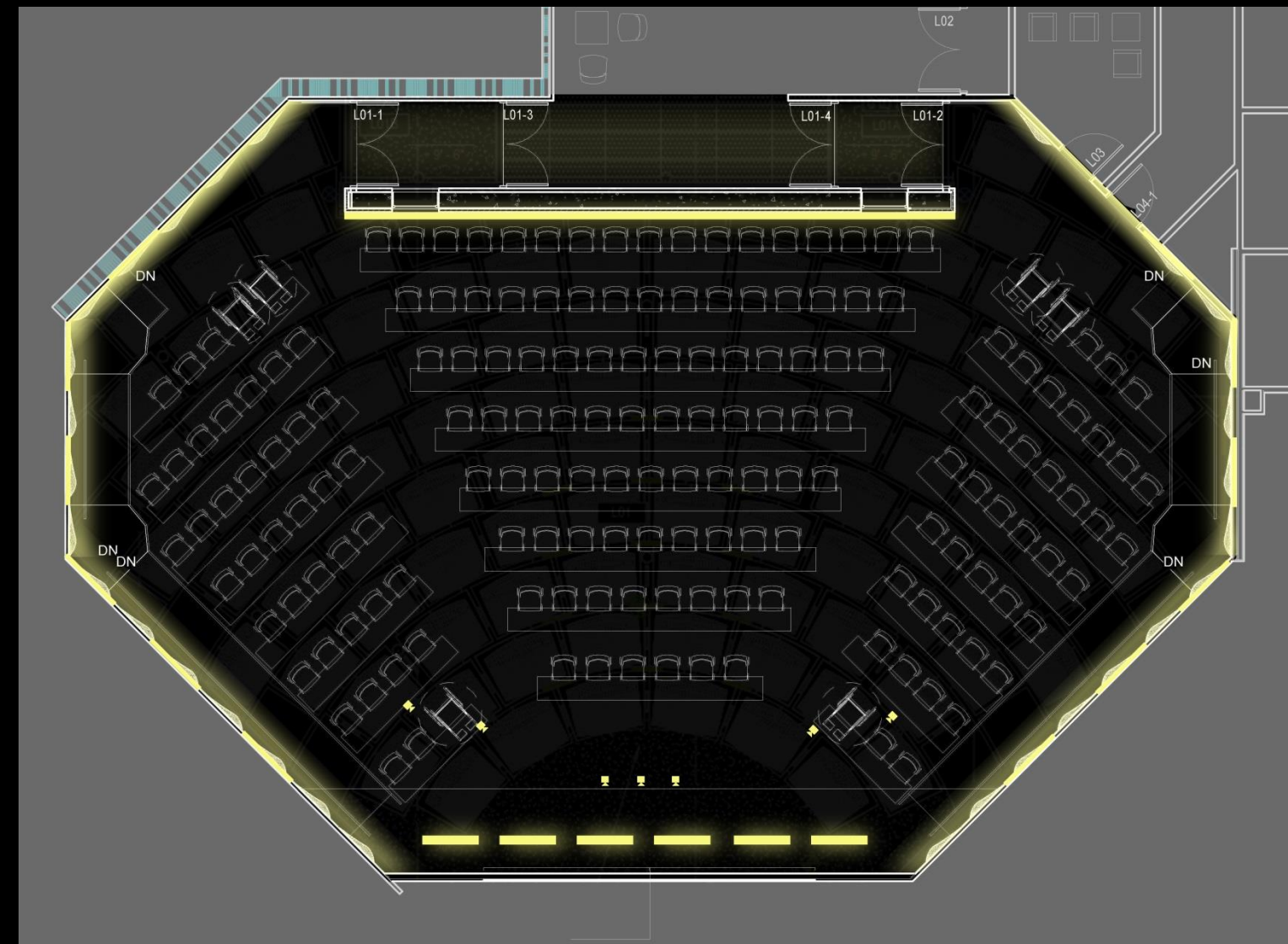
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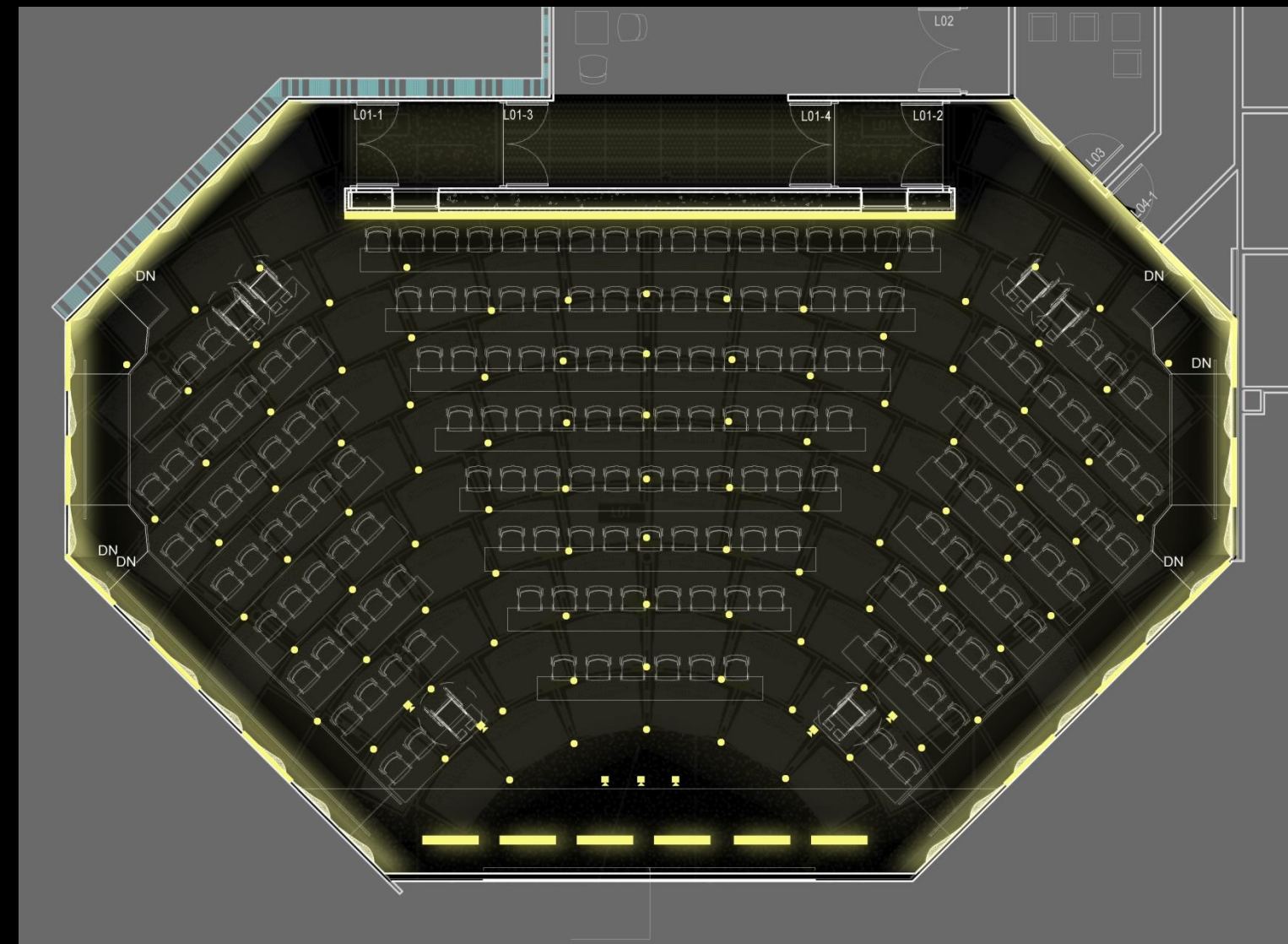
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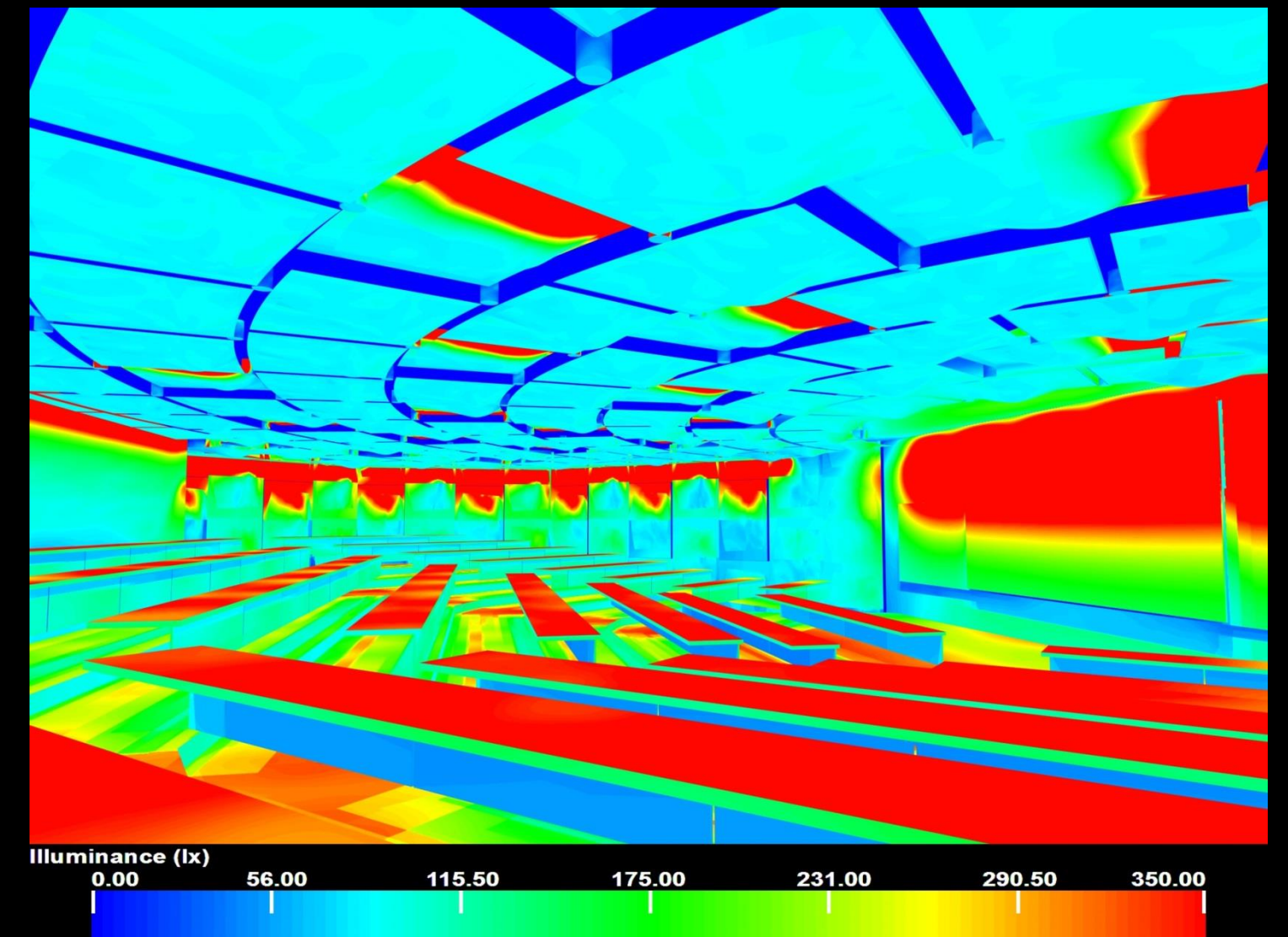
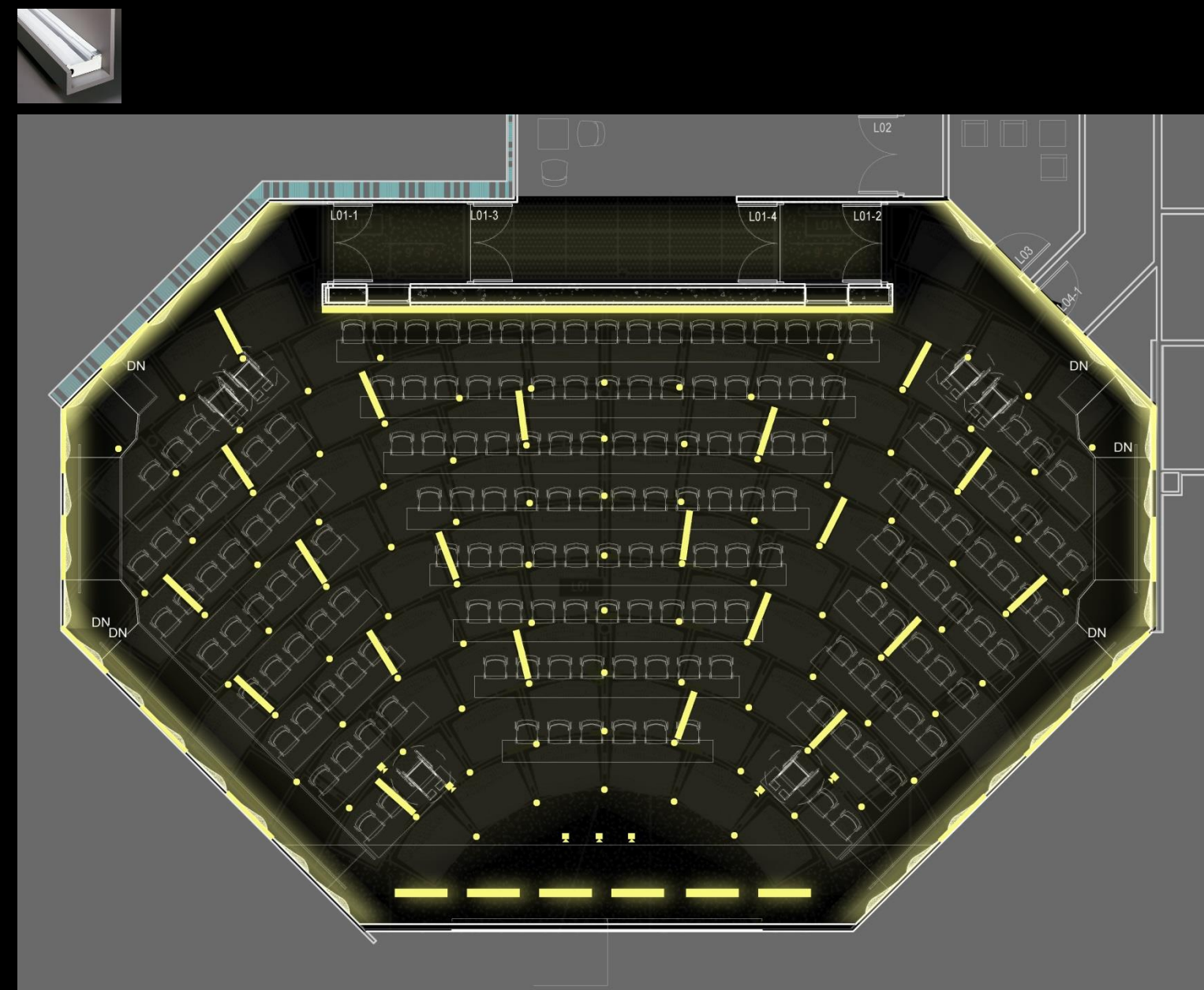
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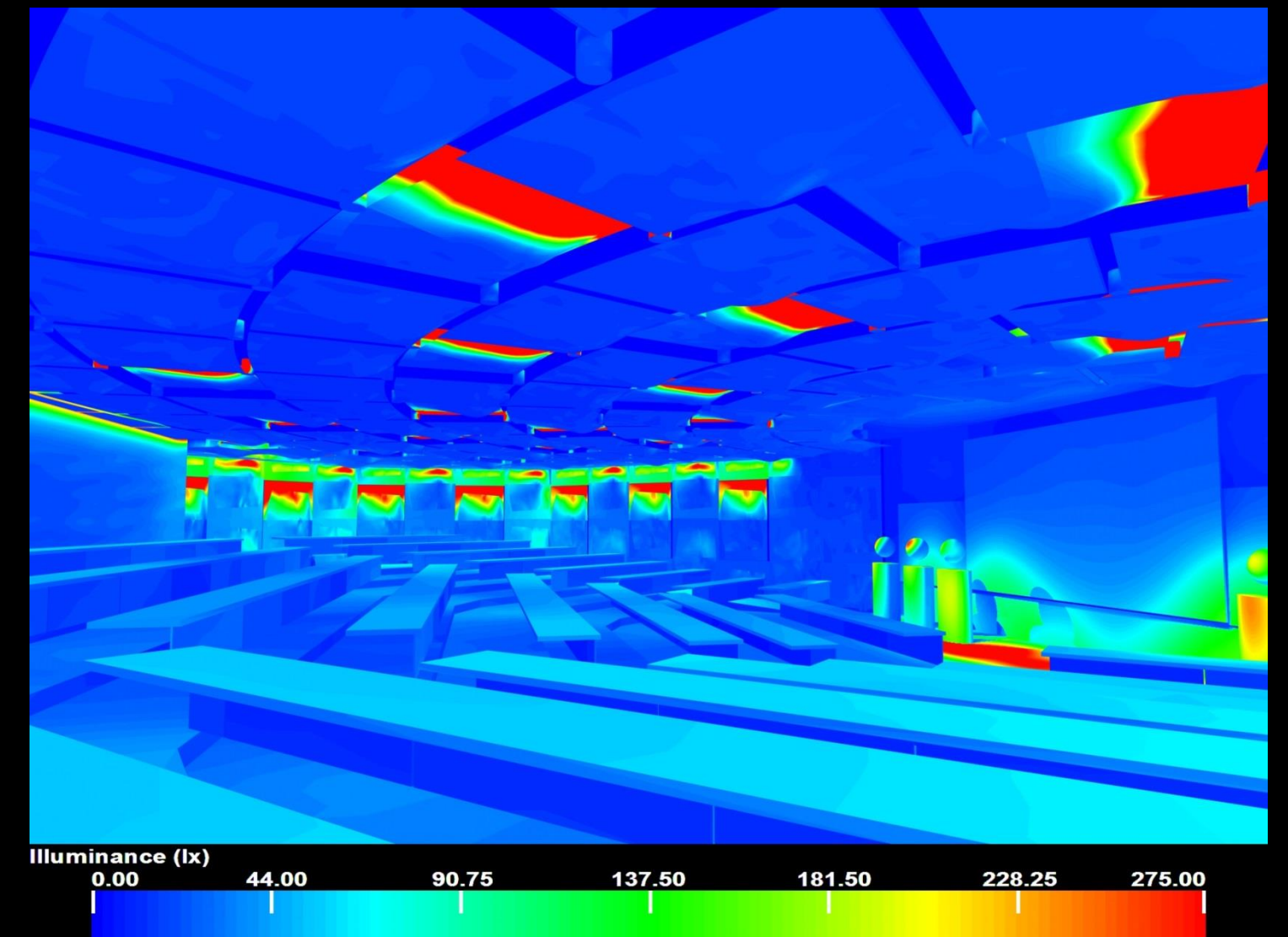
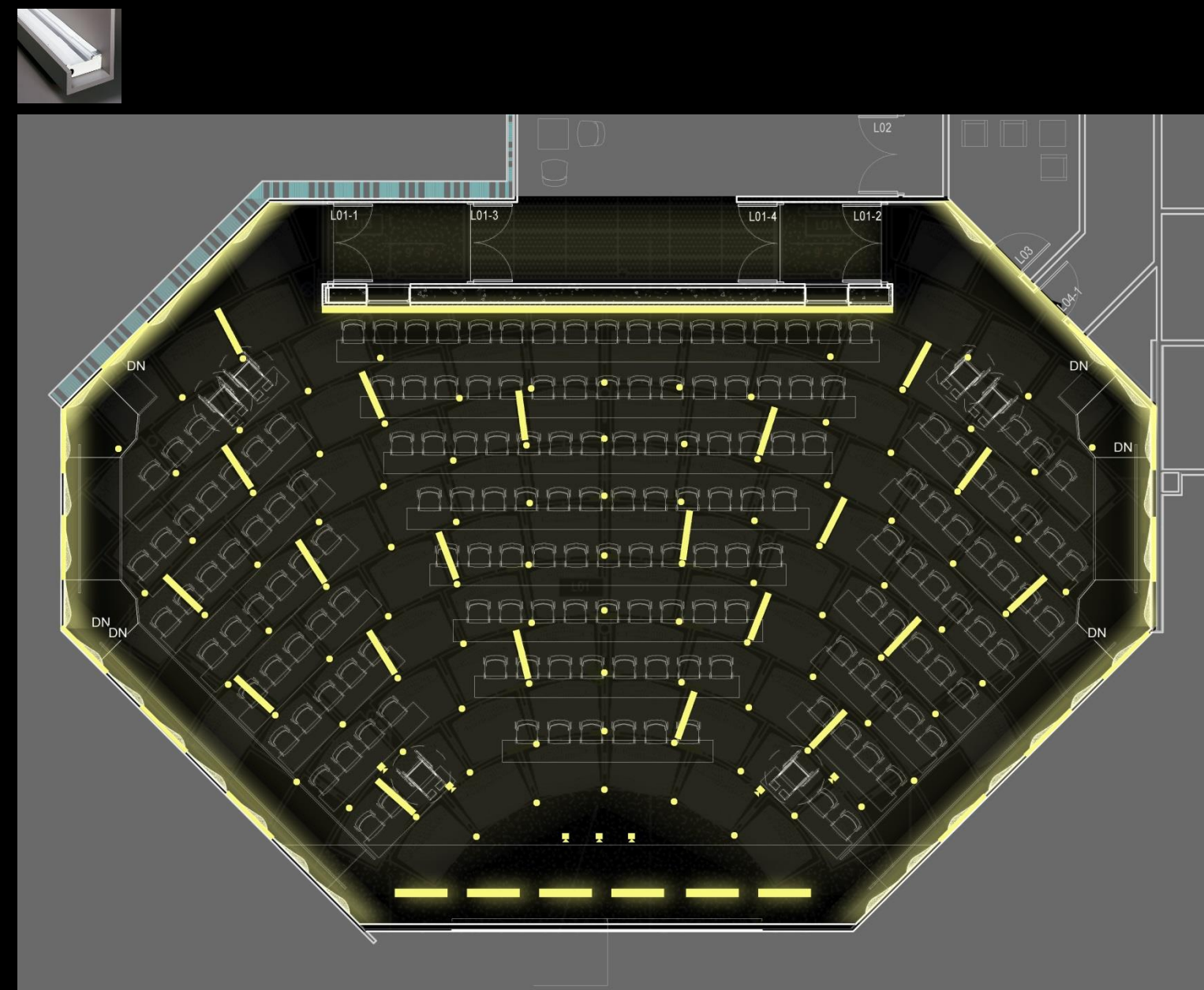
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lighting lecture hall

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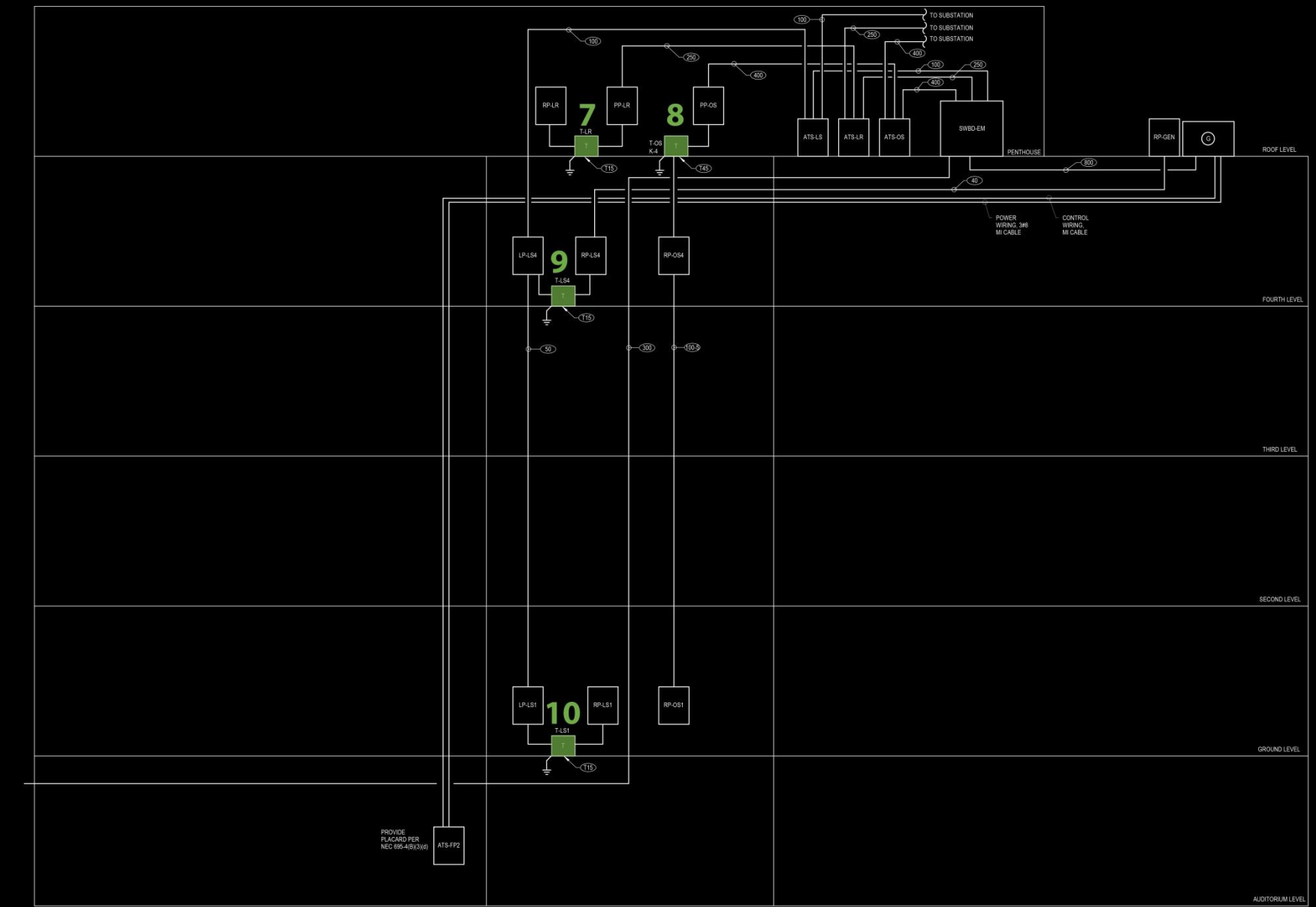
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electrical distribution transformers

- building overview
- lighting scrim
lobby/lounge
lecture hall
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- impact daylighting offices
energy use + equipment



electrical **distribution transformers**

| building | overview | kVA | Initial Cost (\$) | | Total Losses (kWh) | | Annual Energy Savings (\$) | Simple Payback |
|--------------|---|-------|-------------------|-----------|--------------------|---------|----------------------------|-----------------|
| | | | TP-1 | Premium | TP-1 | Premium | | |
| lighting | scrim lobby/lounge lecture hall | 15 | \$ 4,206 | \$ 5,680 | 1000 | 693 | \$ 38.93 | 37.9 yrs |
| | | 45 | \$ 6,506 | \$ 8,412 | 3190 | 2350 | \$ 106.43 | 17.6 yrs |
| electrical | transformer analysis | 75 | \$ 8,830 | \$ 11,920 | 2370 | 1570 | \$ 101.36 | 30.5 yrs |
| | | 112.5 | \$ 13,175 | \$ 16,474 | 4400 | 3290 | \$ 140.64 | 23.5 yrs |
| architecture | open office + facade | | | | | | | |
| impact | daylighting offices energy use + equipment | | | | | | | |

electrical unit substation transformer

building overview

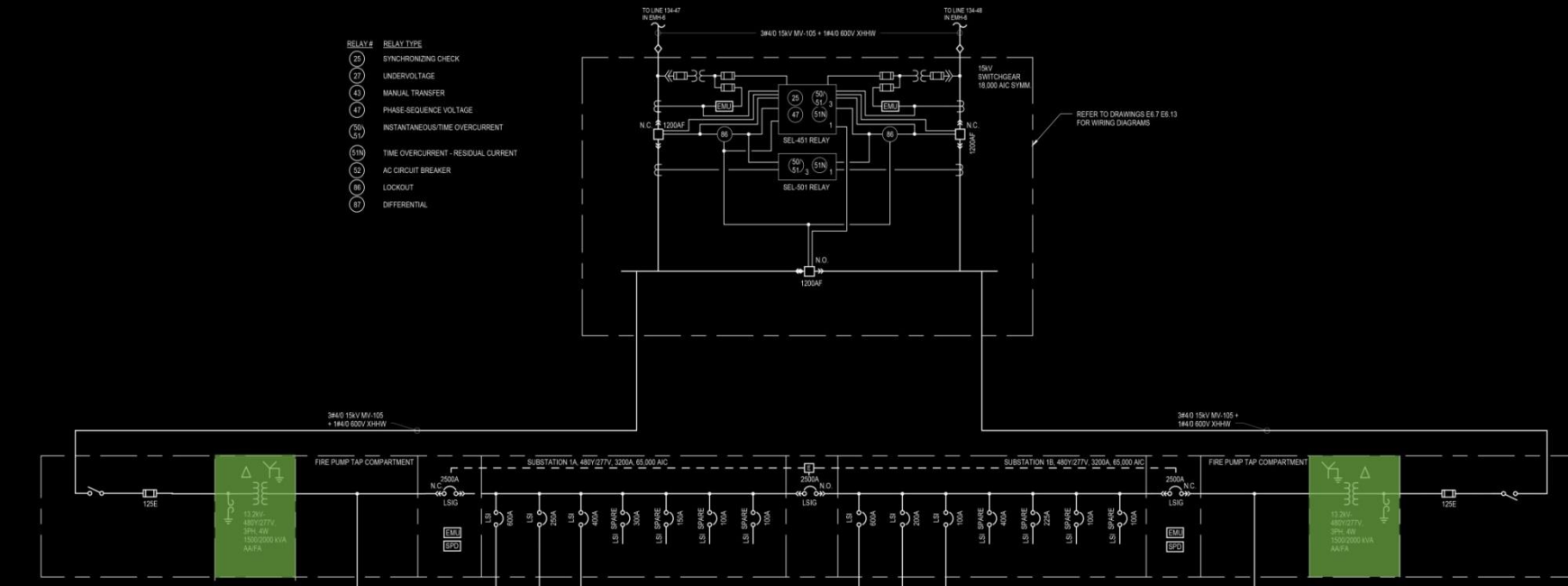
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

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impact daylighting offices
energy use + equipment

| Metric | Cast-Coil | Vegetable-Based |
|----------------|-----------|-----------------|
| Initial Cost | \$ 51,512 | \$ 34,341 |
| Total Losses | 5138 kWh | 2647 kWh |
| Operating Cost | \$ 5,702 | \$ 2,938 |



electrical unit substation transformer

building overview

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| Metric | Cast-Coil | Vegetable-Based |
|--------|-----------|-----------------|
|--------|-----------|-----------------|

| | | |
|--------------|-----------|-----------|
| Initial Cost | \$ 51,512 | \$ 34,341 |
|--------------|-----------|-----------|

\$ 17,171 initial cost savings

| | | |
|--------------|----------|----------|
| Total Losses | 5138 kWh | 2647 kWh |
|--------------|----------|----------|

\$ 2,765 operating cost savings

| | | |
|----------------|----------|----------|
| Operating Cost | \$ 5,702 | \$ 2,938 |
|----------------|----------|----------|

20% of gas + combustion products
'less flammable' rating
longer life expectancy

architecture open office + kalwall lumira

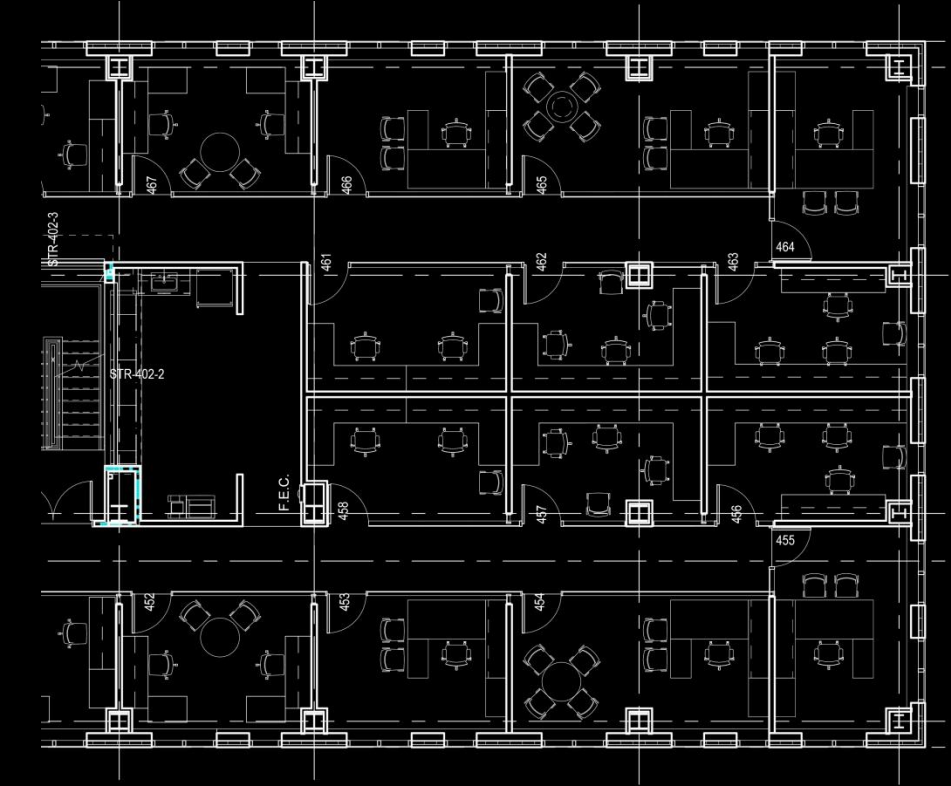
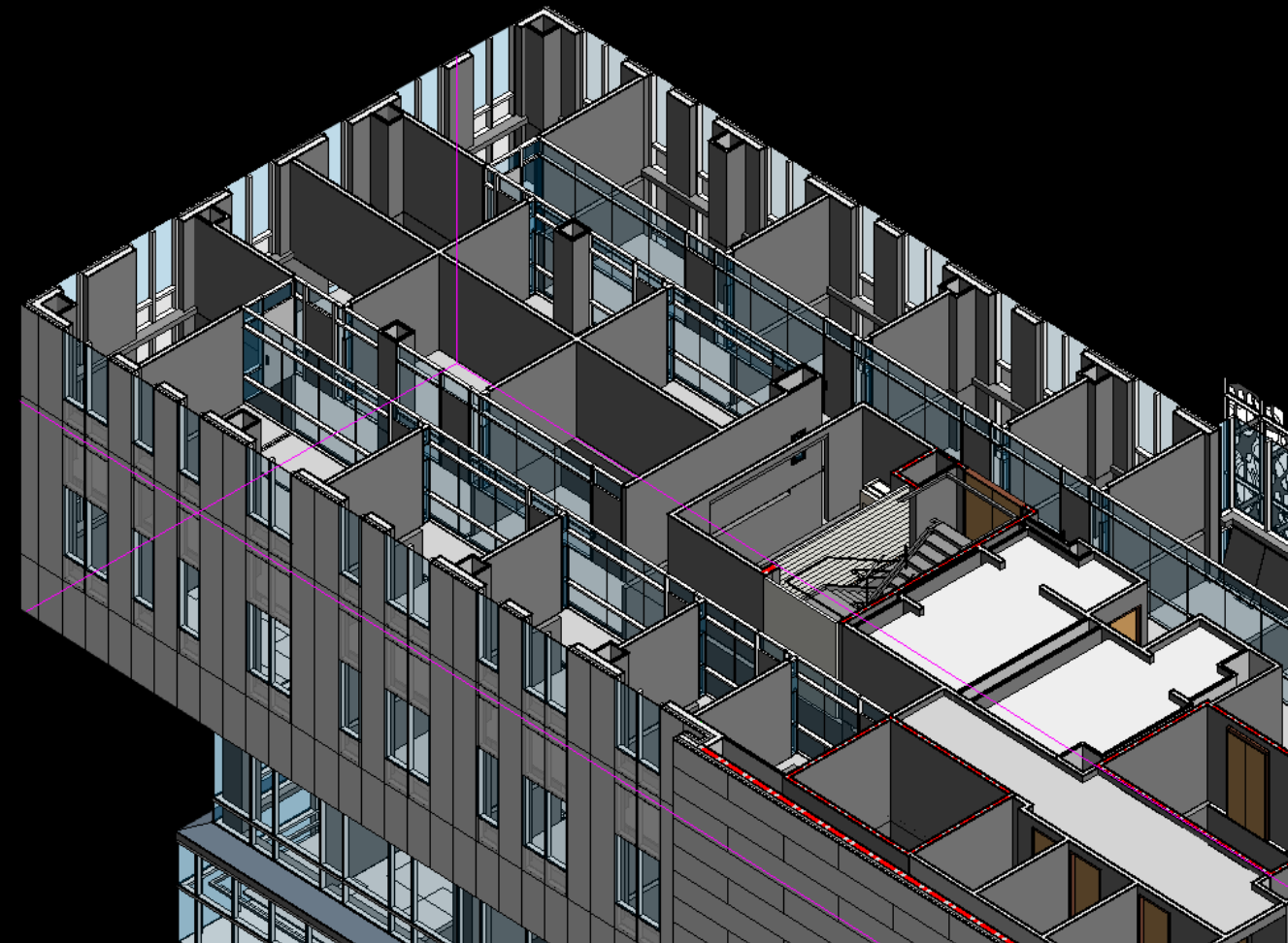
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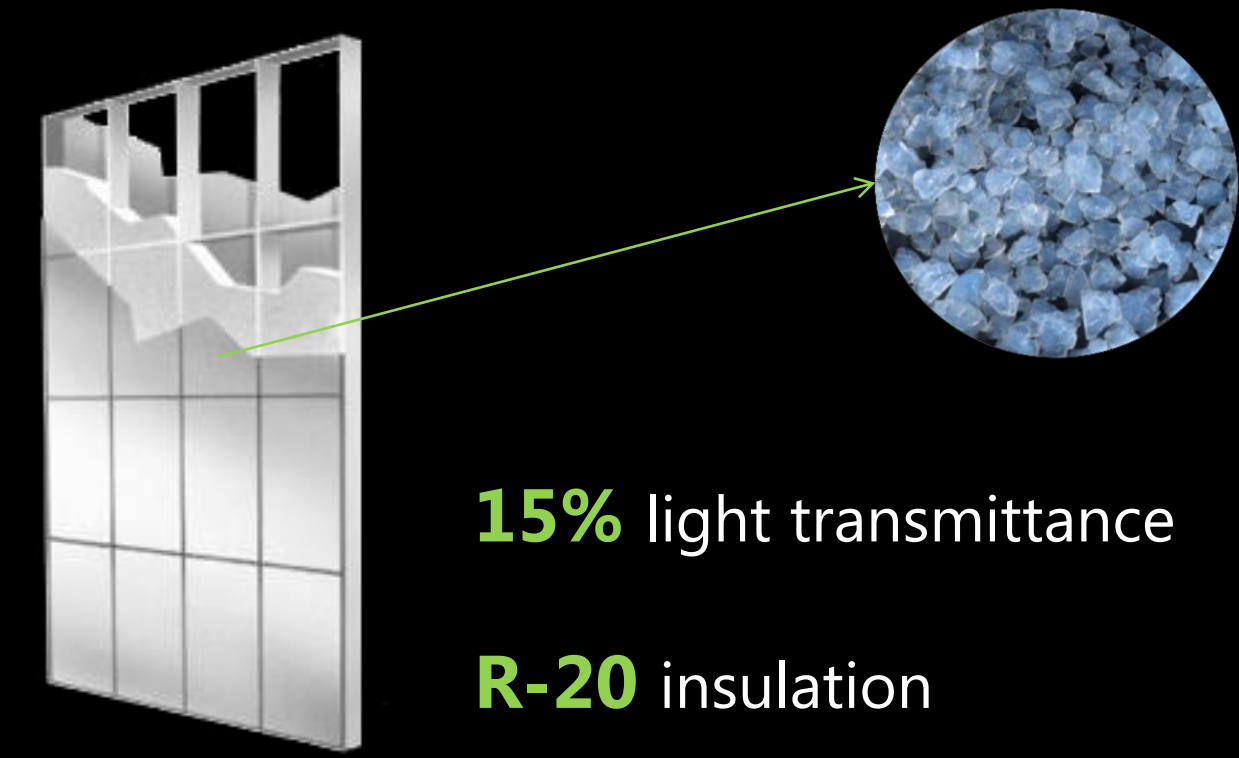
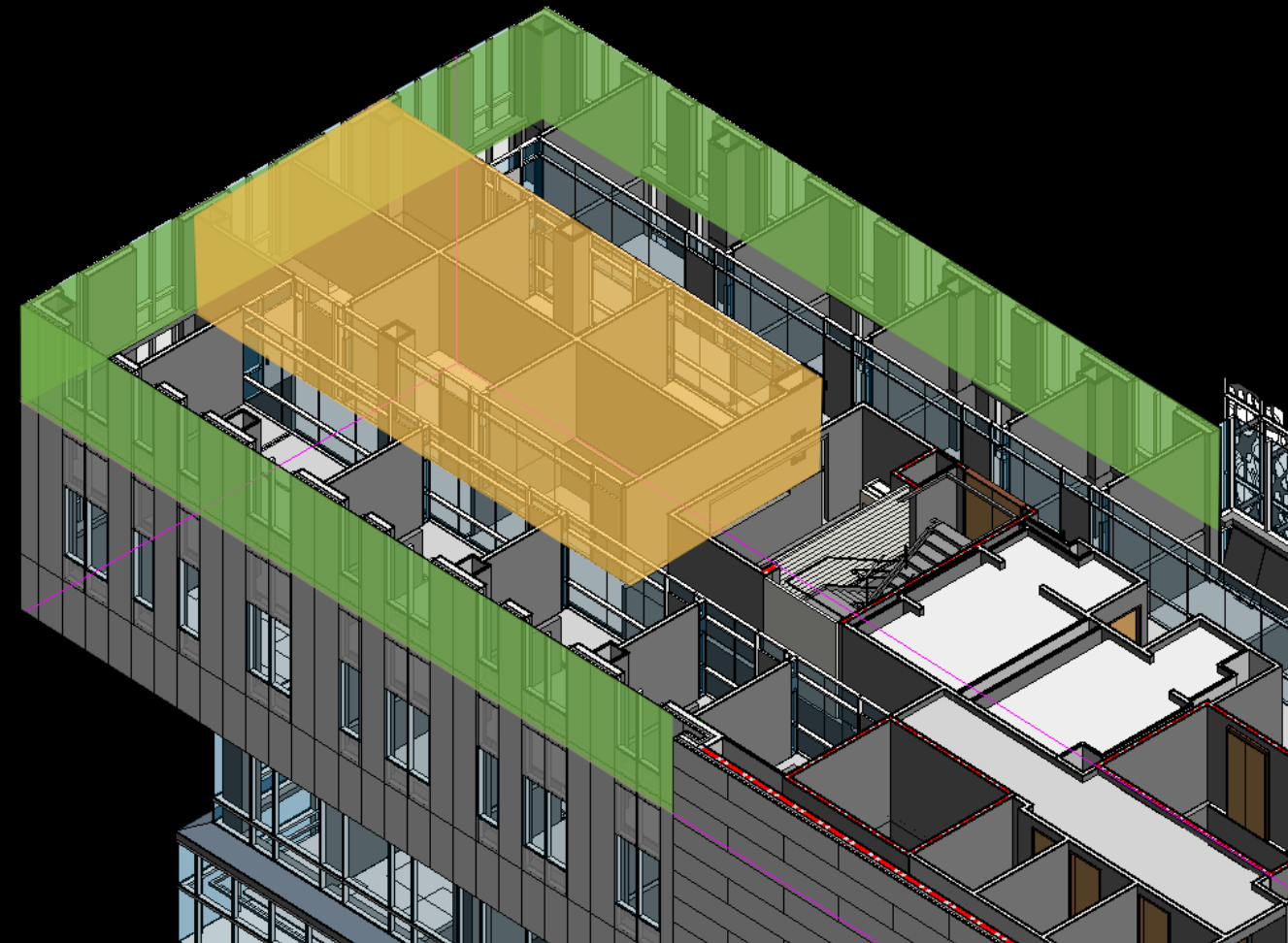
architecture open office + facade

impact daylighting offices
energy use + equipment



architecture open office + kalwall lumira

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15% light transmittance
R-20 insulation

architecture **open office**

building overview

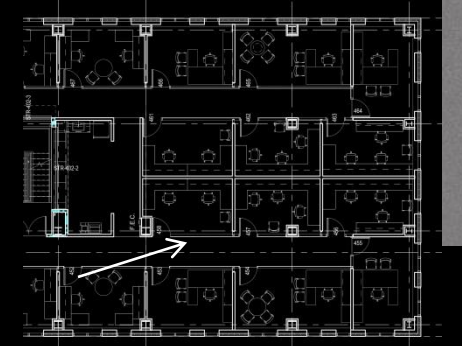
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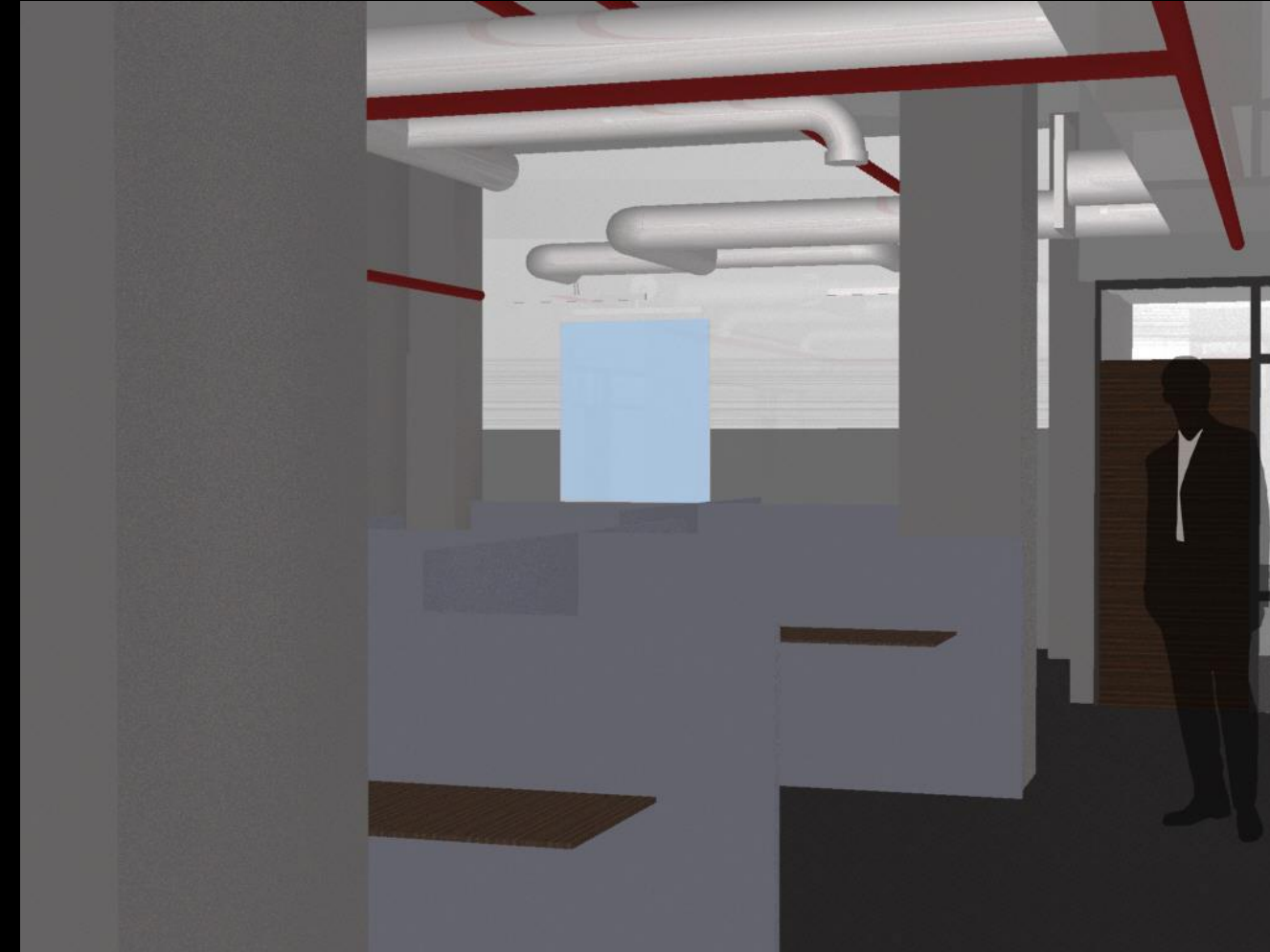
architecture open office + facade

impact daylighting offices
energy use + equipment

original



proposed



architecture **open office**

building overview

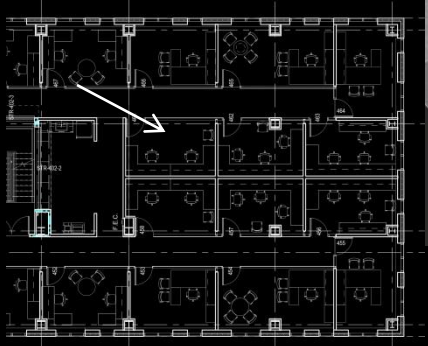
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original



proposed



impact existing conditions

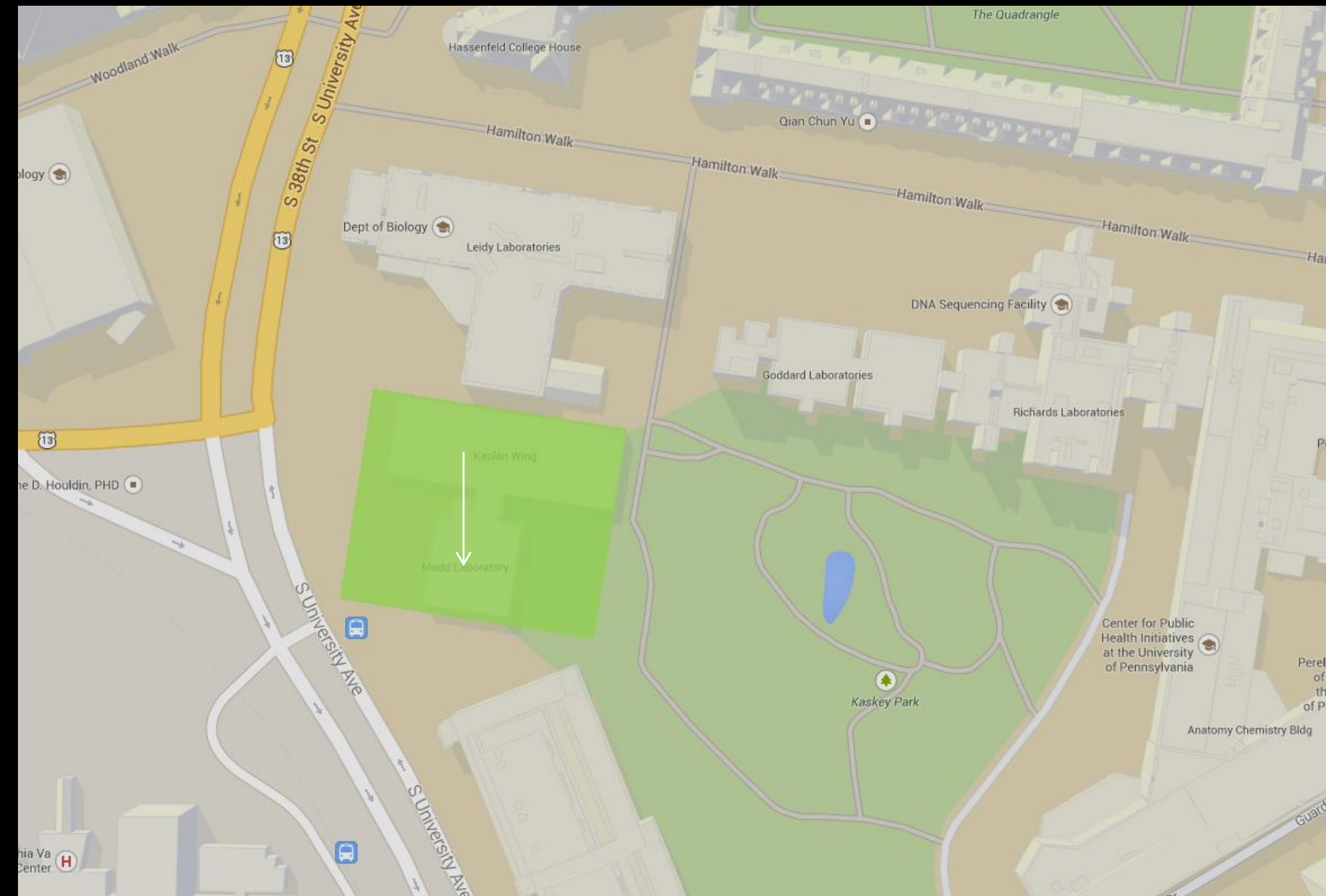
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impact existing conditions

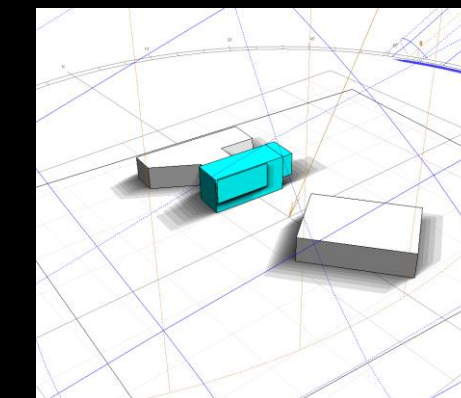
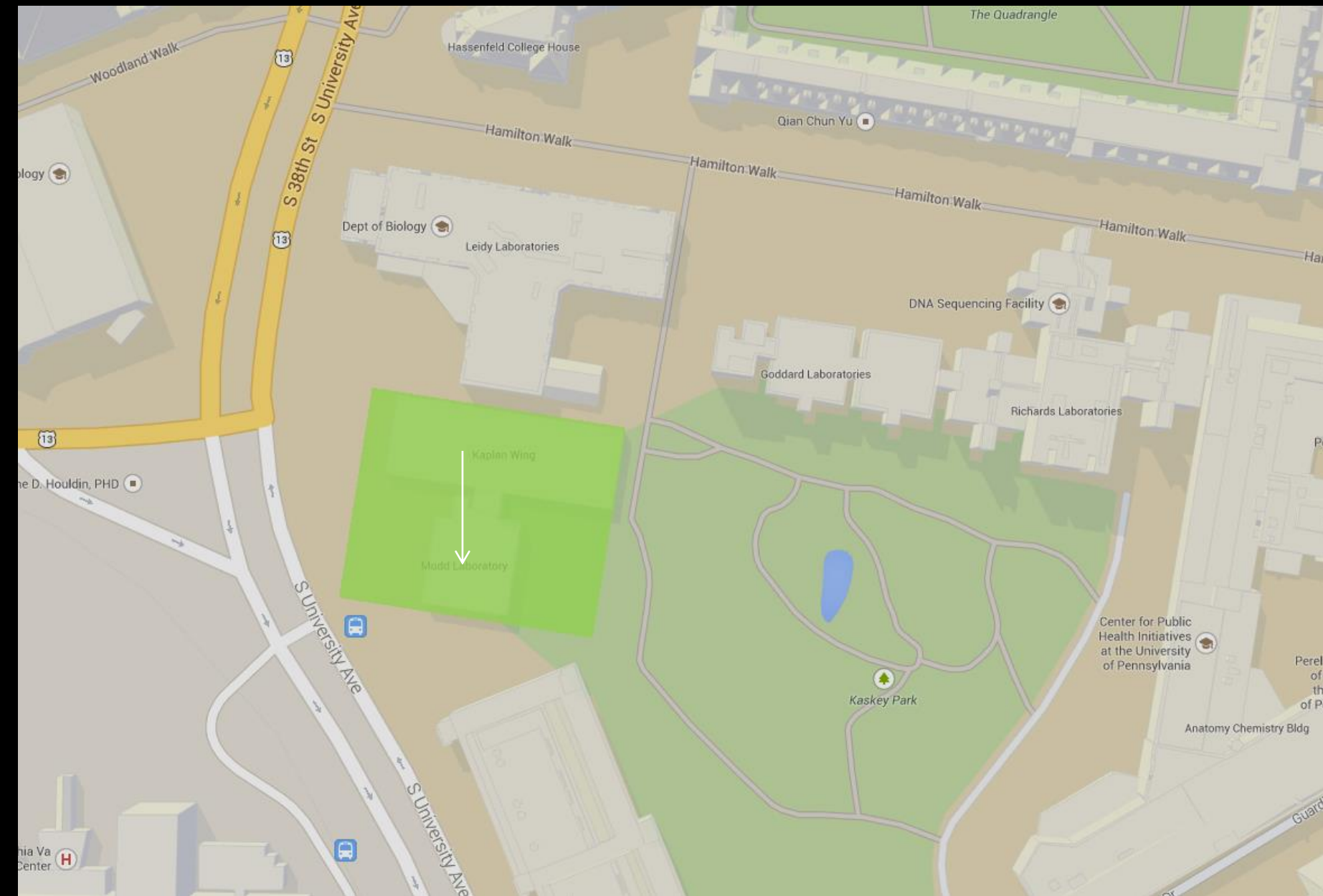
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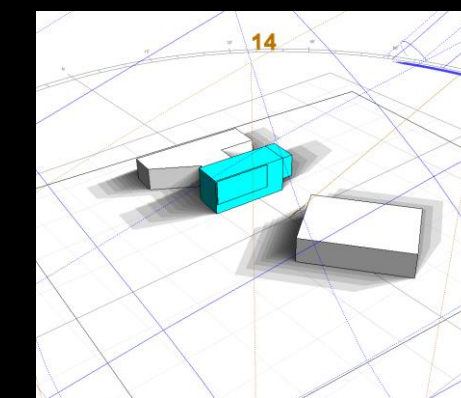
electrical transformer analysis

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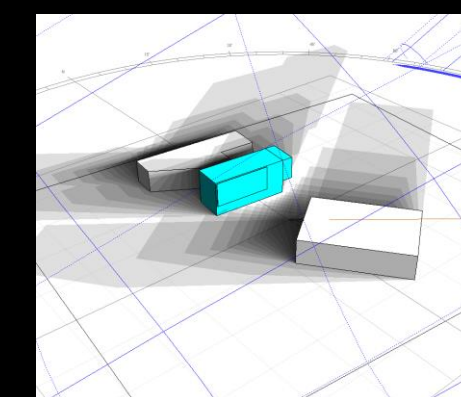
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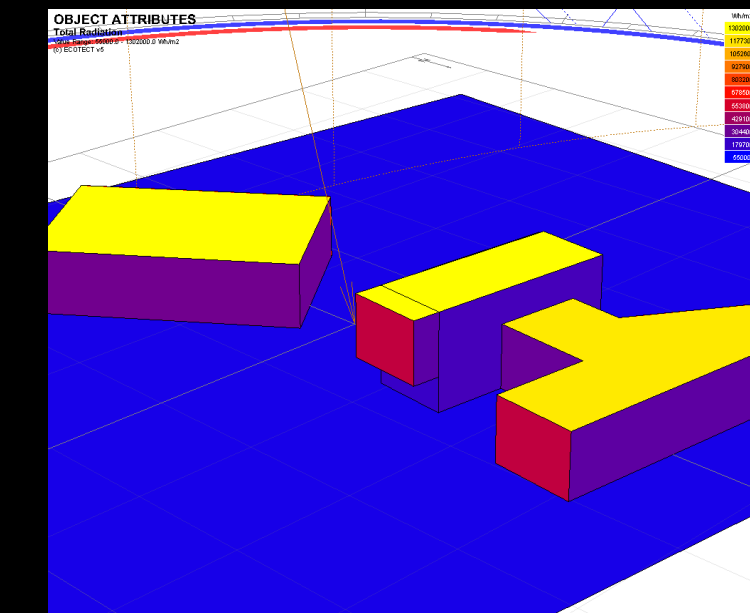
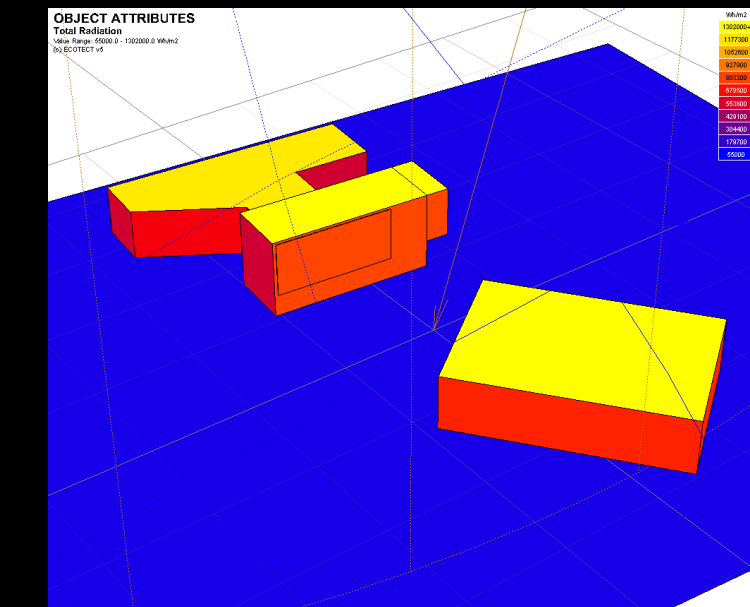
june 21



sept 21



dec 21



impact parametric design

building overview

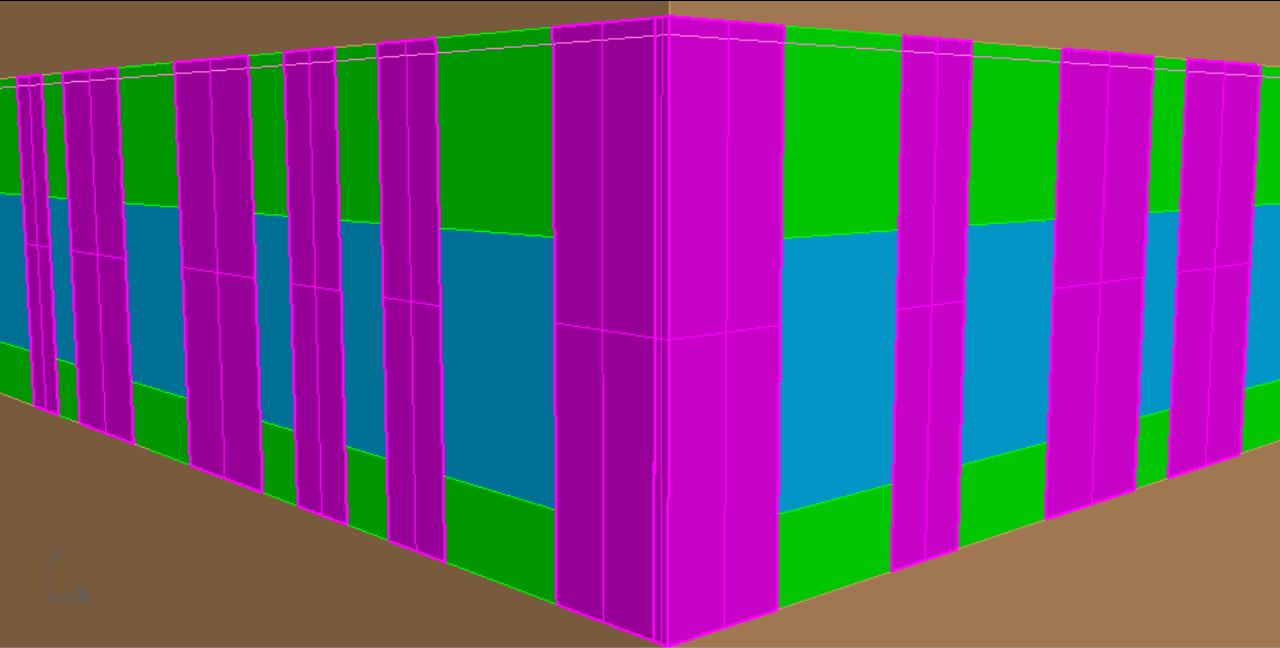
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electrical
transformer analysis

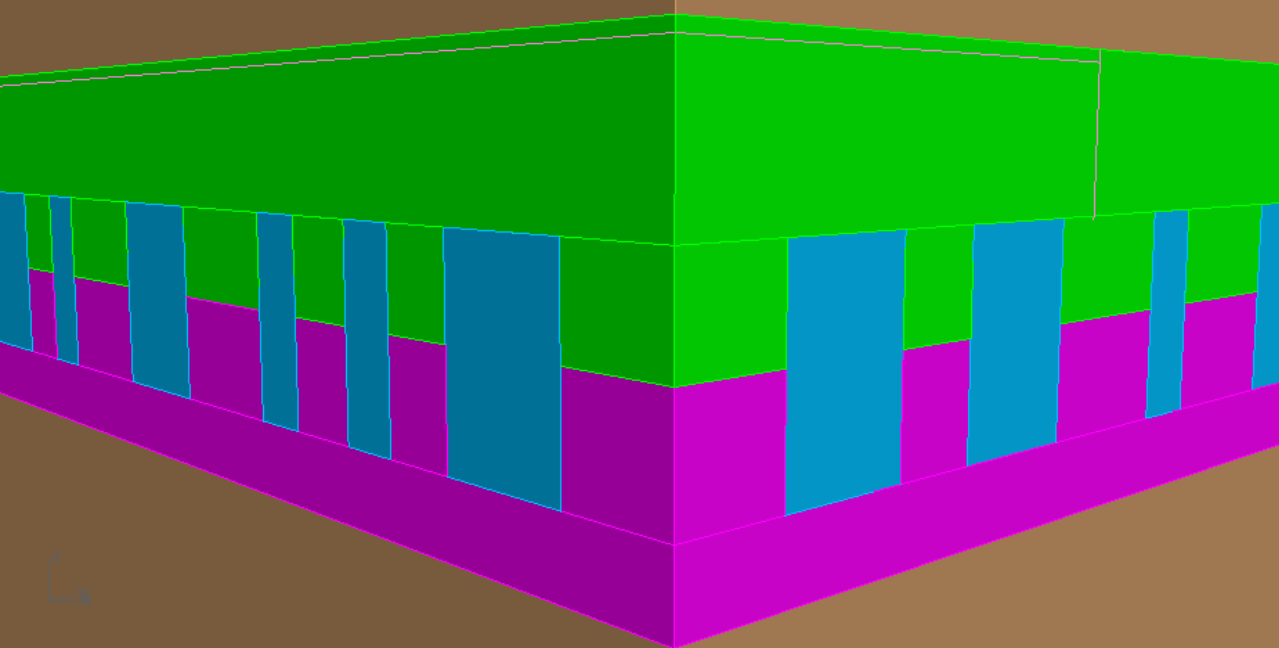
architecture
open office + facade

impact
daylighting offices
energy use + equipment

original



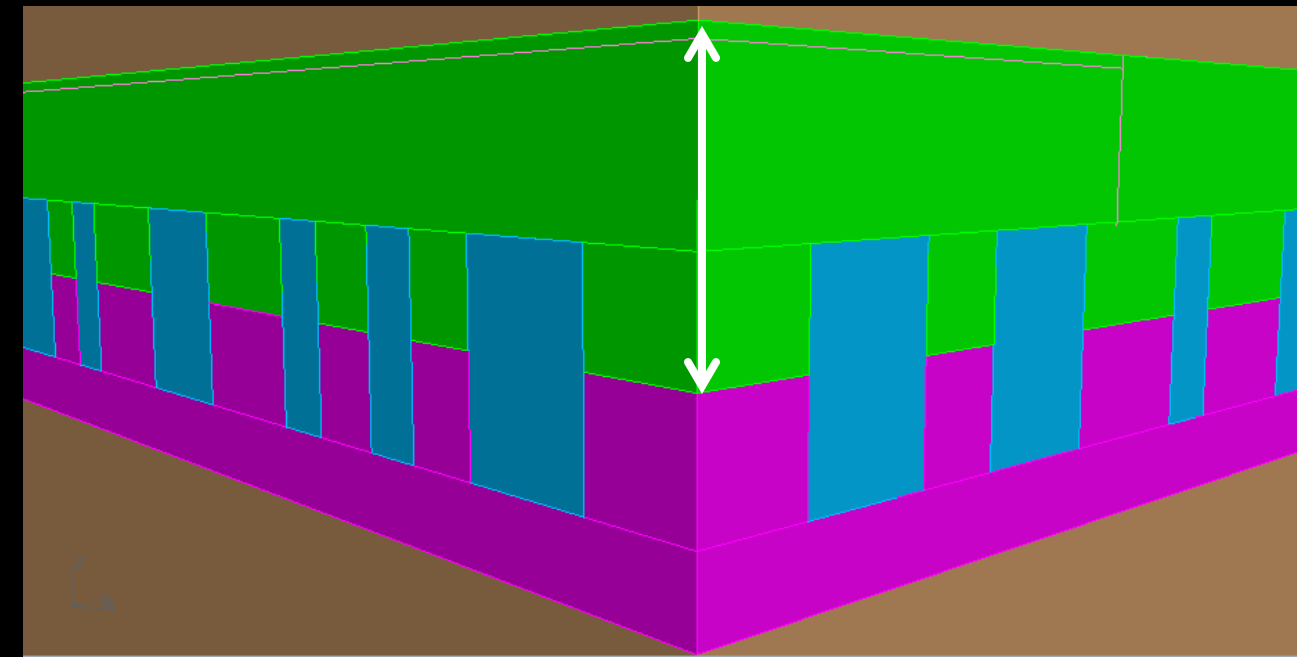
proposed



impact parametric design

| | |
|---------------|--|
| building | overview |
| lighting | scrim lobby/lounge lecture hall |
| electrical | transformer analysis |
| architecture | open office + facade |
| impact | daylighting offices energy use + equipment |

parameter



impact parametric design

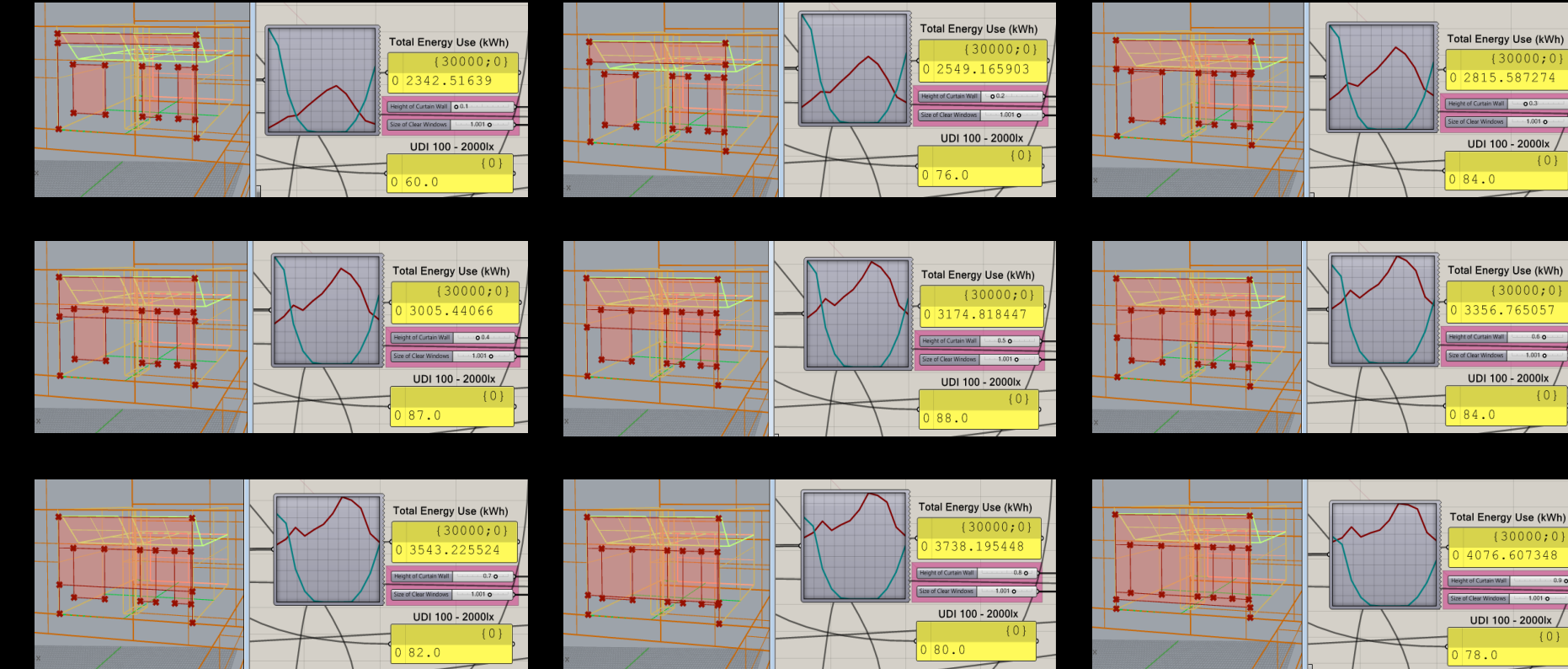
building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

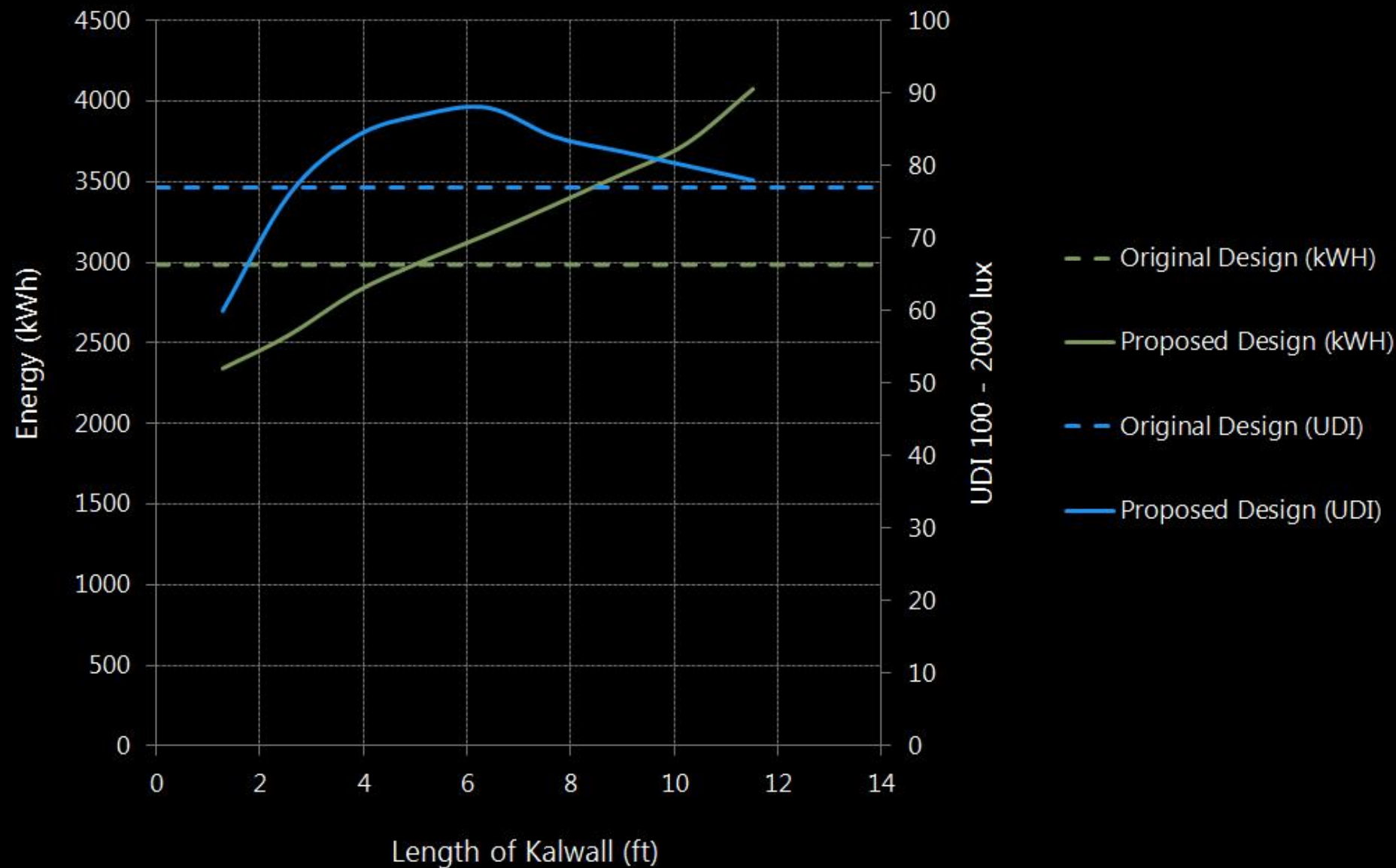
impact daylighting offices
energy use + equipment



impact parametric design

| | |
|--------------|---|
| building | overview |
| lighting | scrim lobby/lounge lecture hall |
| electrical | transformer analysis |
| architecture | open office + facade |
| impact | daylighting offices energy use + equipment |

Kalwall Optimization: Balancing Non-Relatable Variables



impact parametric design

building overview

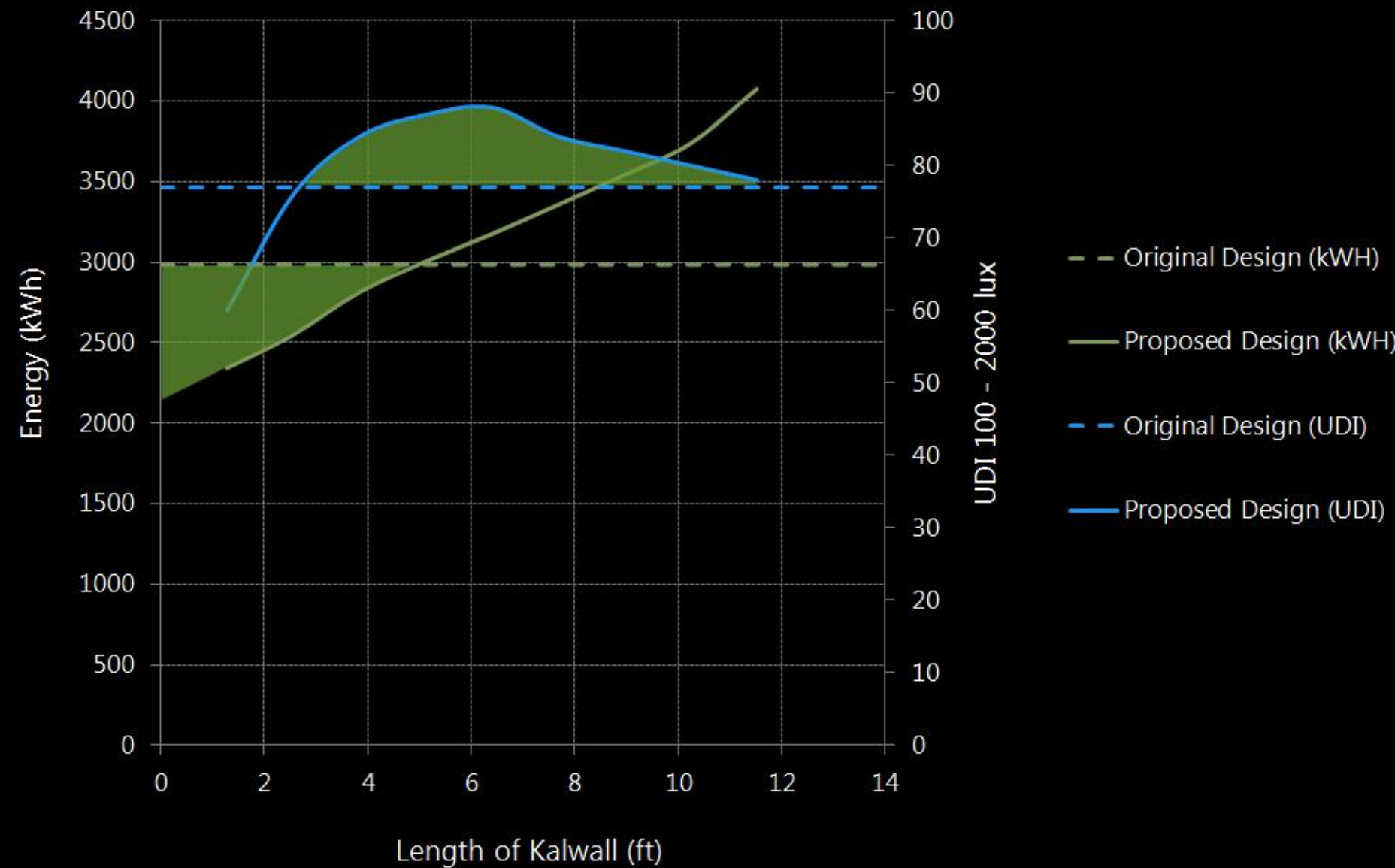
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

Kalwall Optimization: Balancing Non-Relatable Variables



impact parametric design

building overview

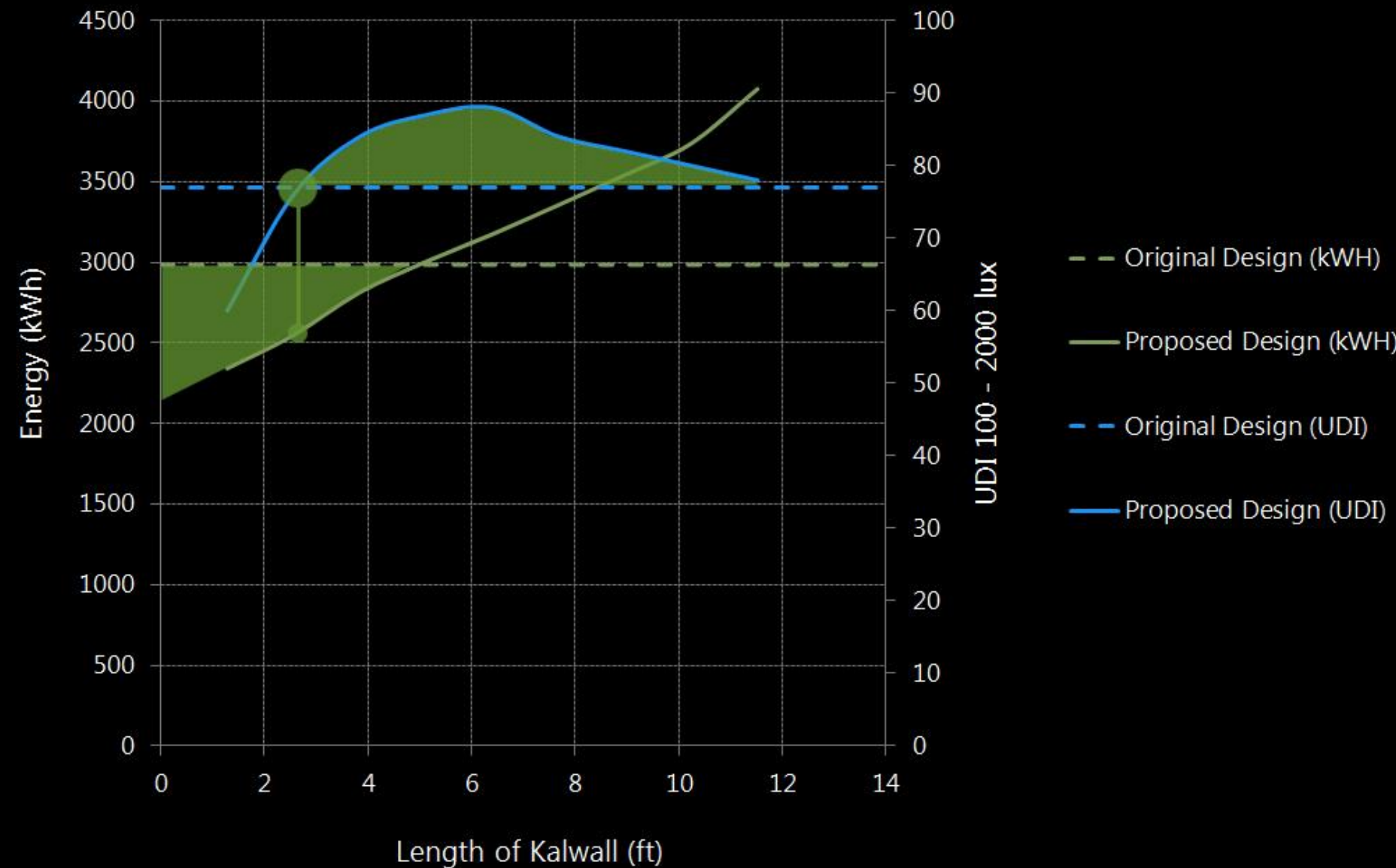
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

Kalwall Optimization: Balancing Non-Relatable Variables



impact parametric design

building overview

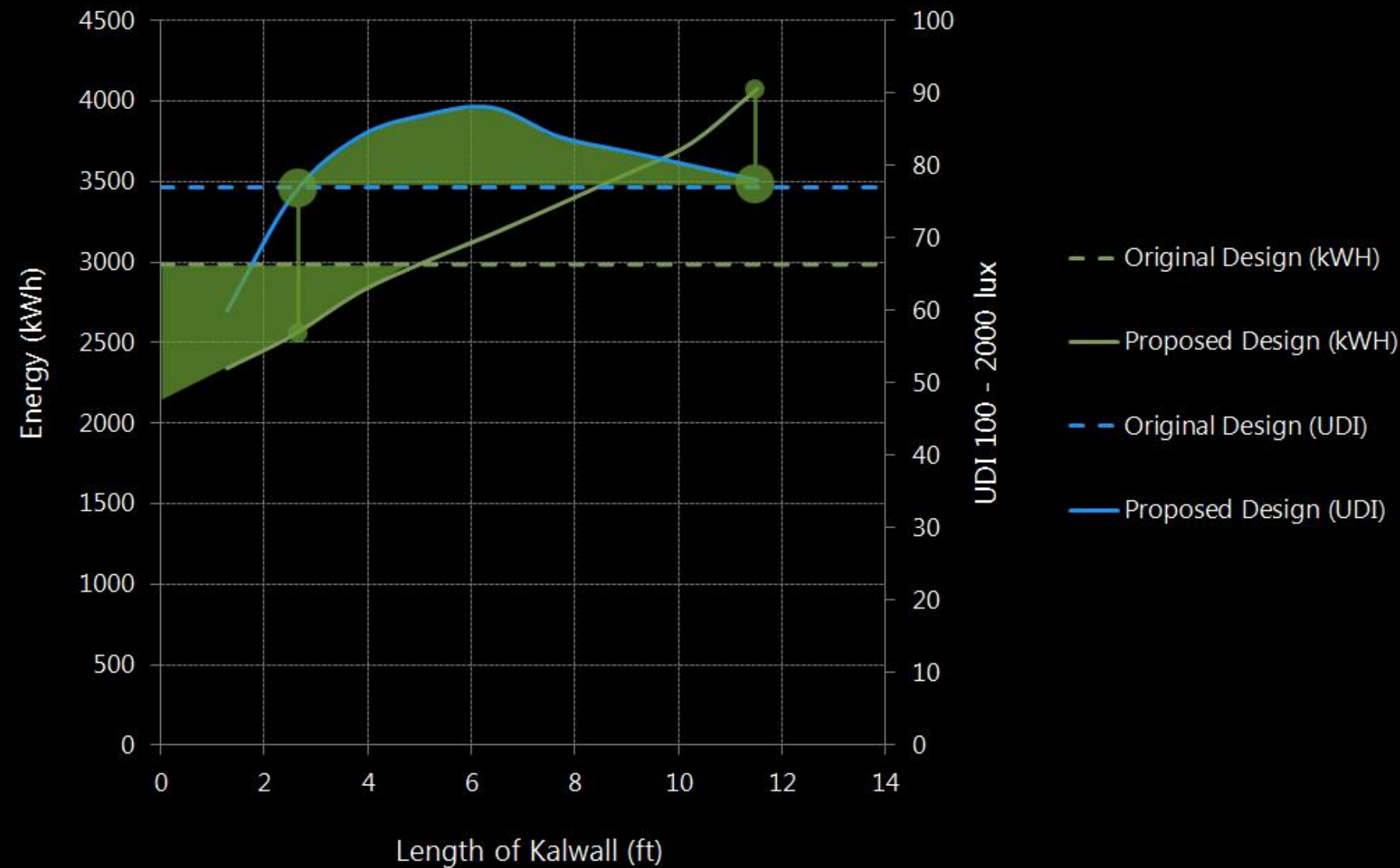
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

Kalwall Optimization: Balancing Non-Relatable Variables



impact parametric design

building overview

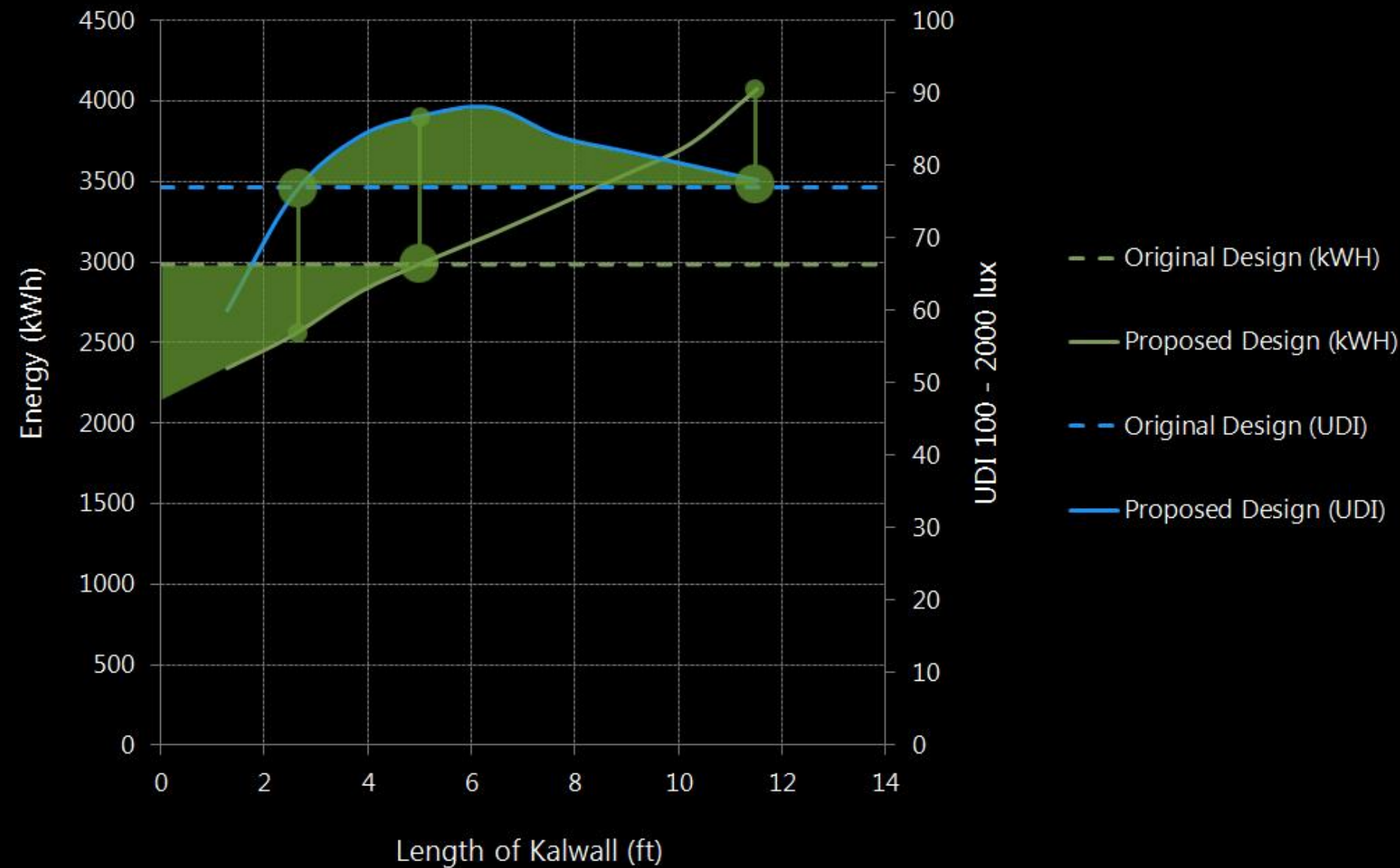
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

Kalwall Optimization: Balancing Non-Relatable Variables



impact parametric design

building overview

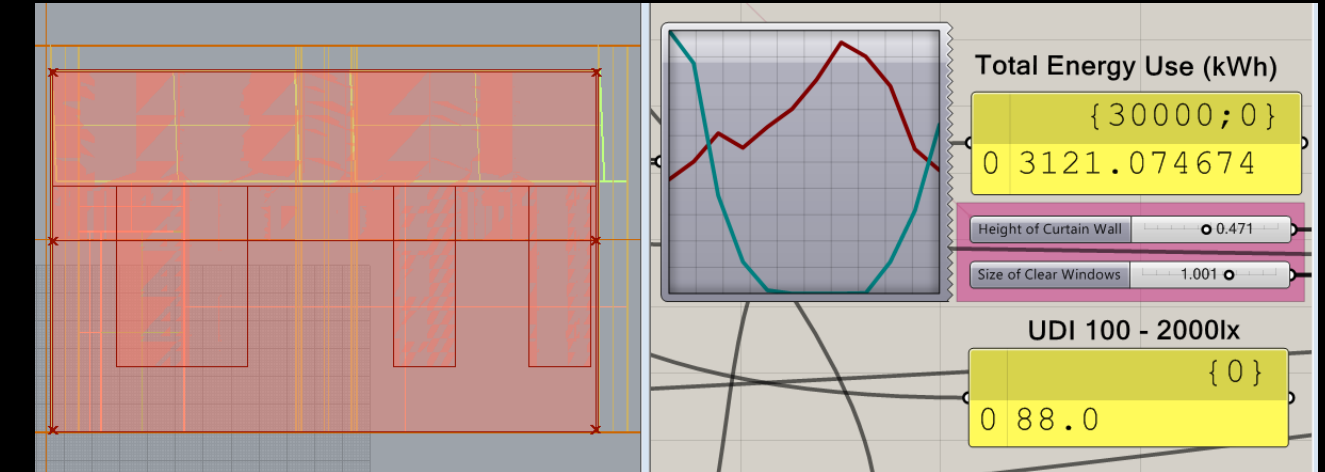
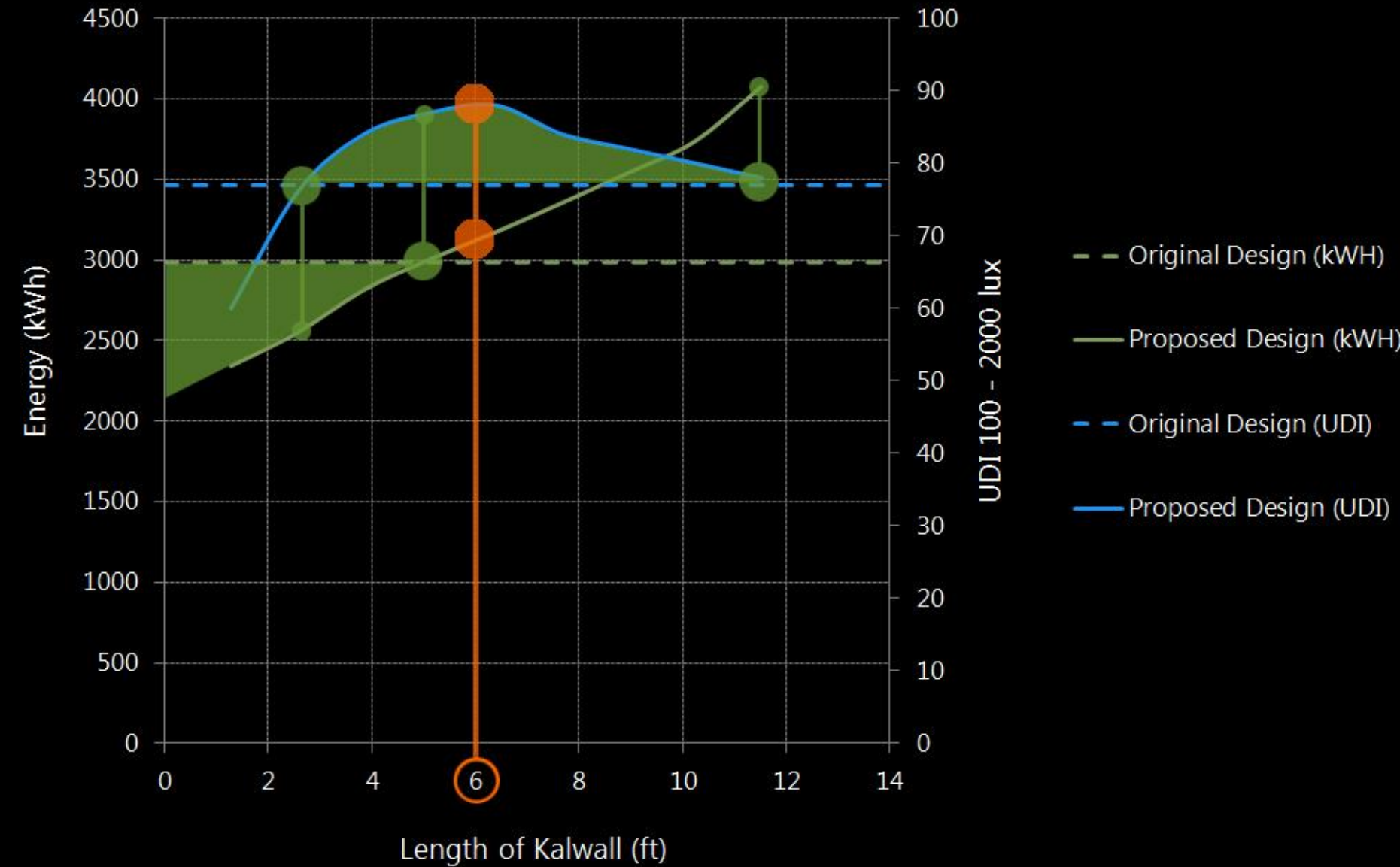
lighting
scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

Kalwall Optimization: Balancing Non-Relatable Variables



impact radiance renderings

building overview

lighting
scrim
lobby/lounge
lecture hall

electrical transformer analysis

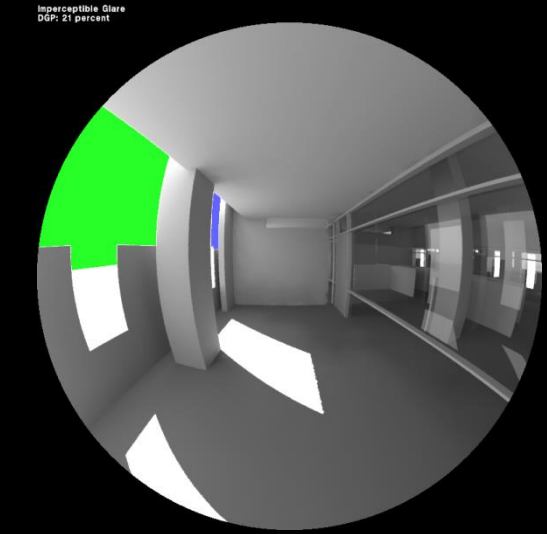
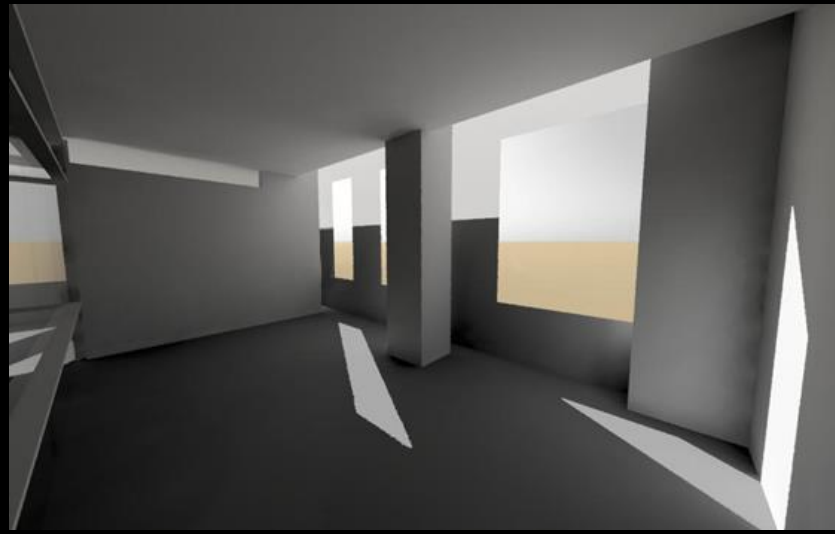
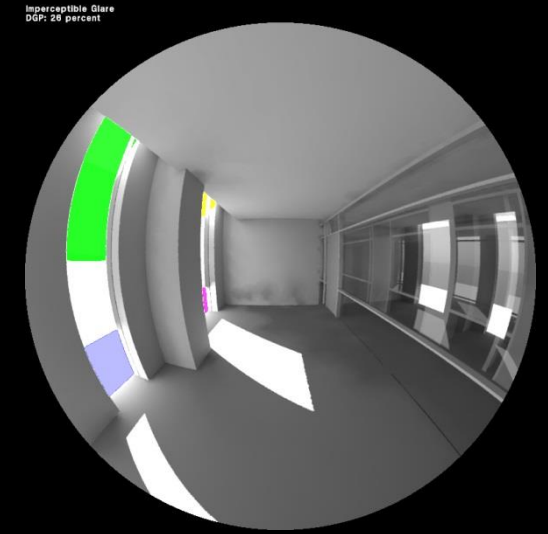
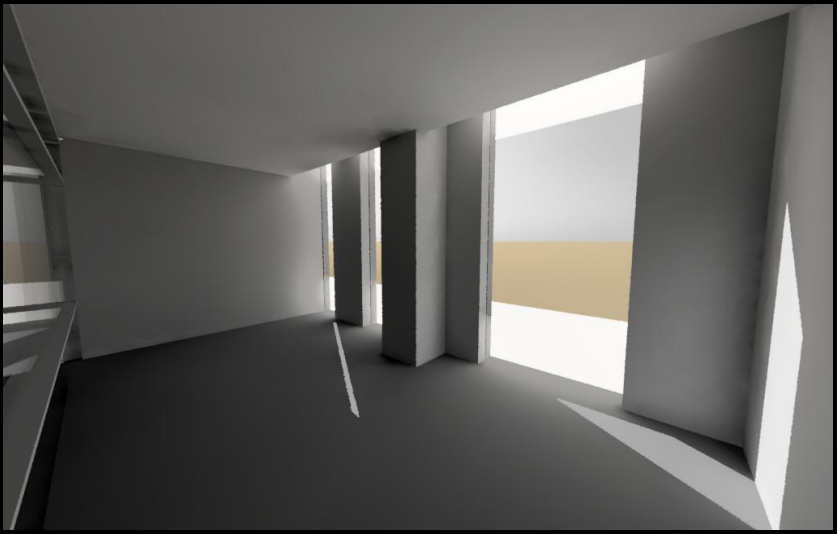
architecture open office + facade

impact **daylighting offices**
energy use + equipment

original



proposed



impact annual metrics

building overview

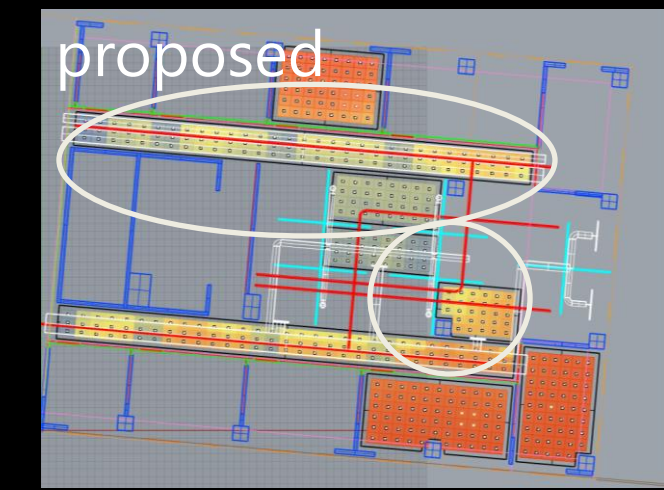
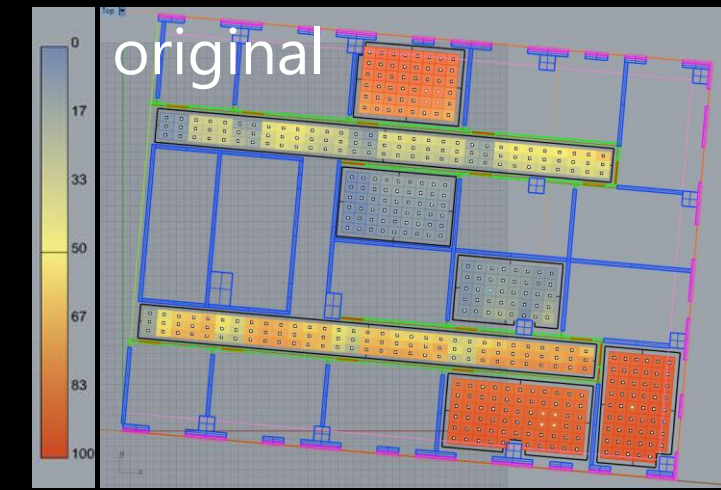
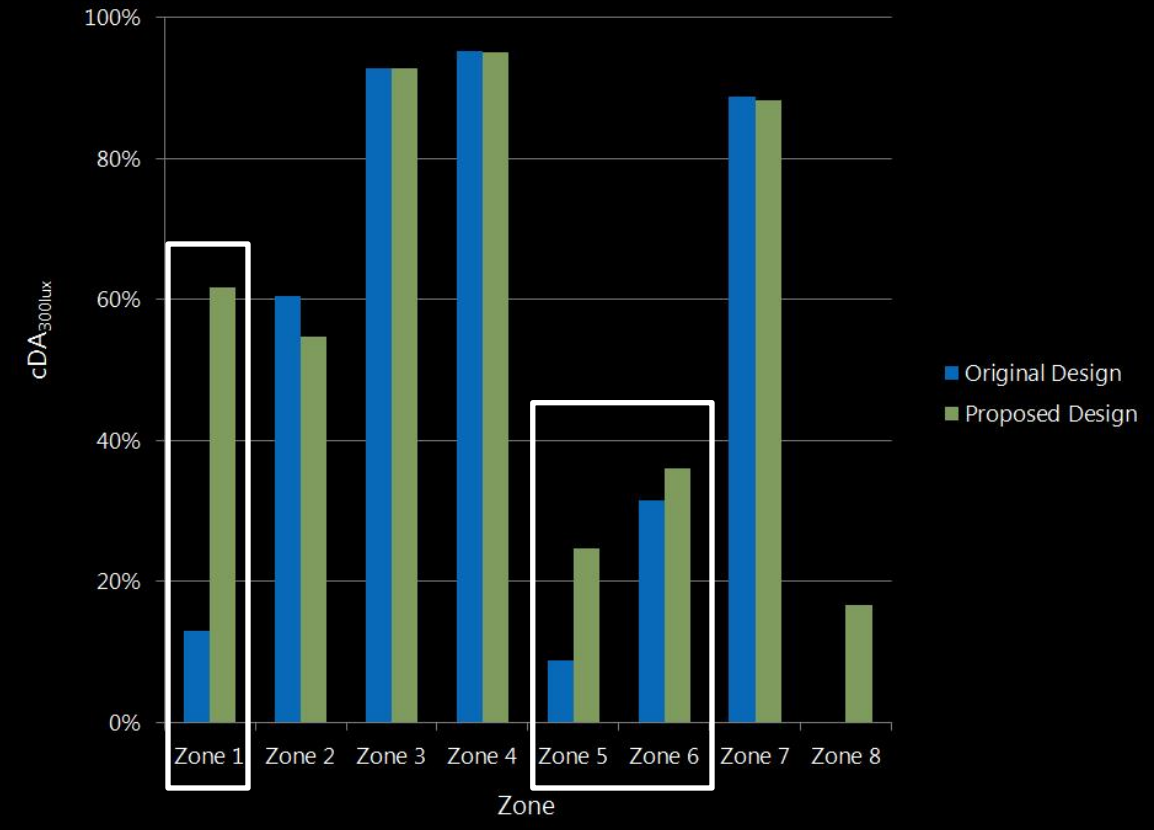
lighting
scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

Continuous Daylight Autonomy 300 lux: Original vs. Proposed Design



impact annual metrics

building overview

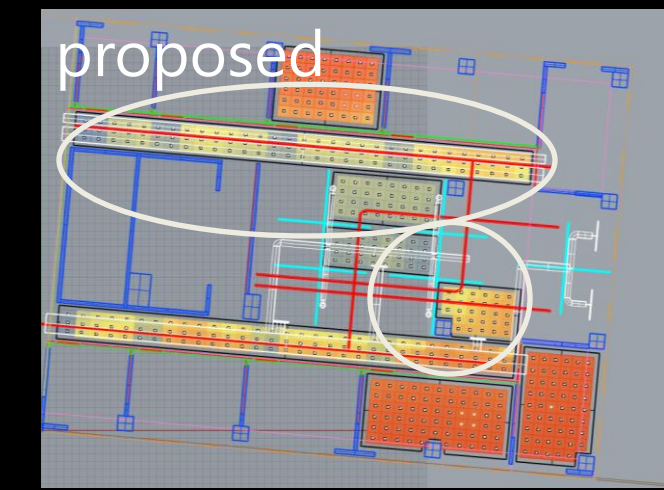
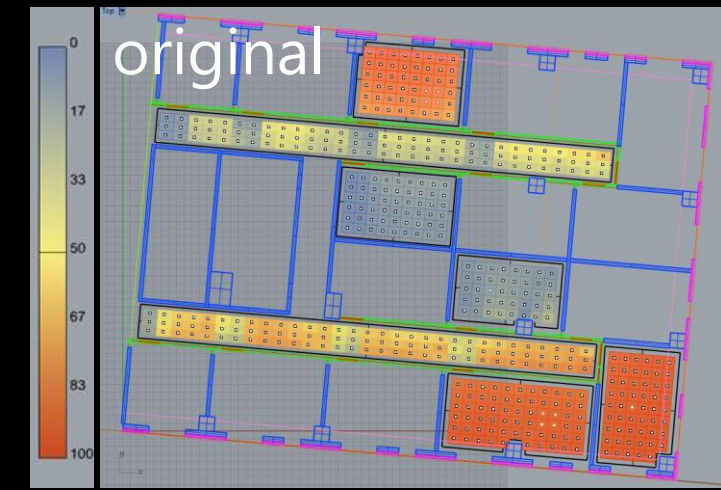
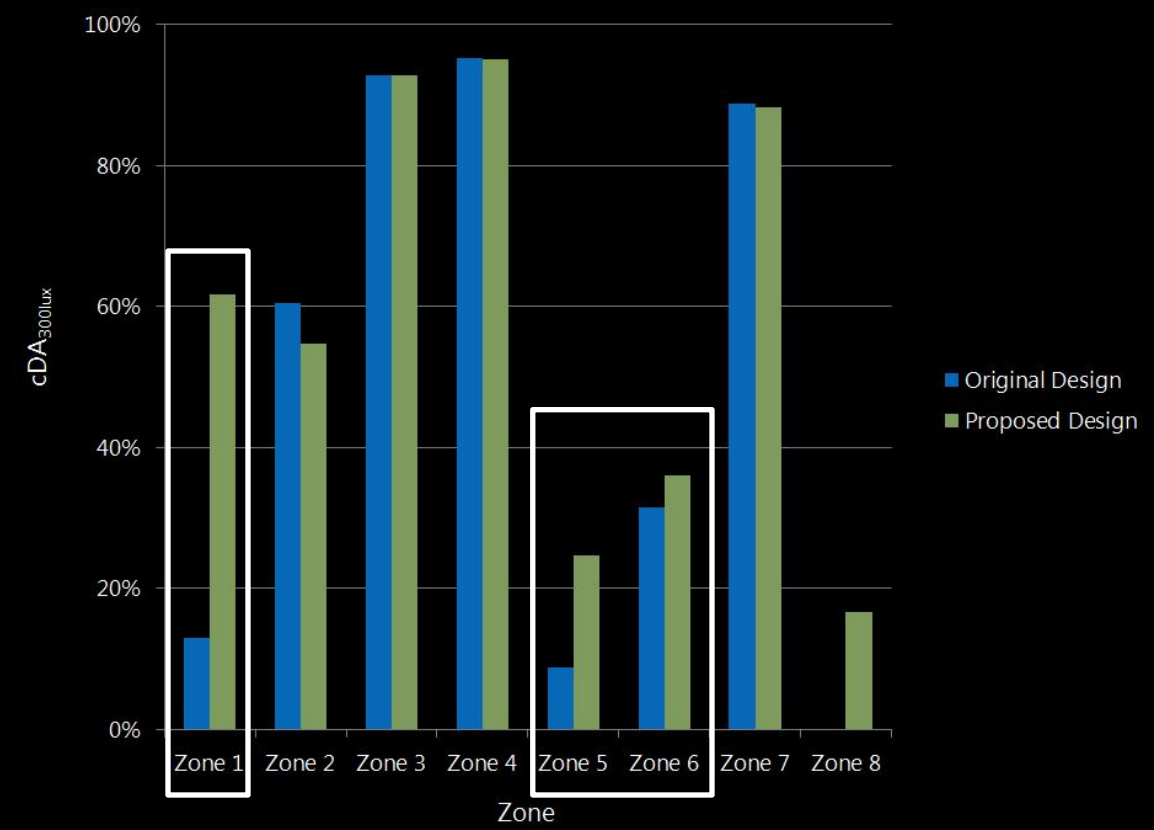
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

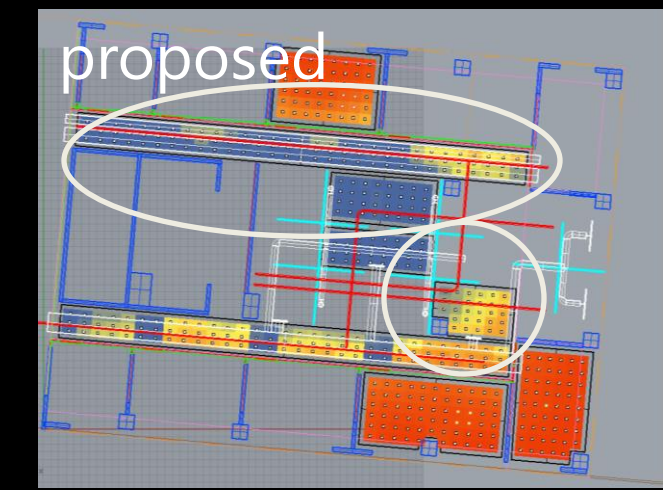
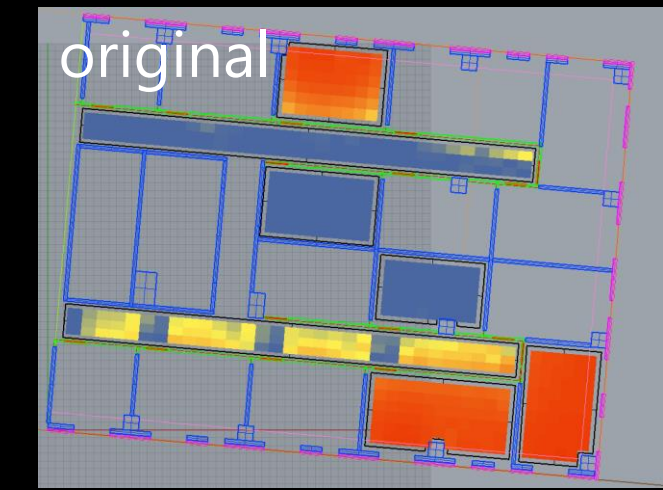
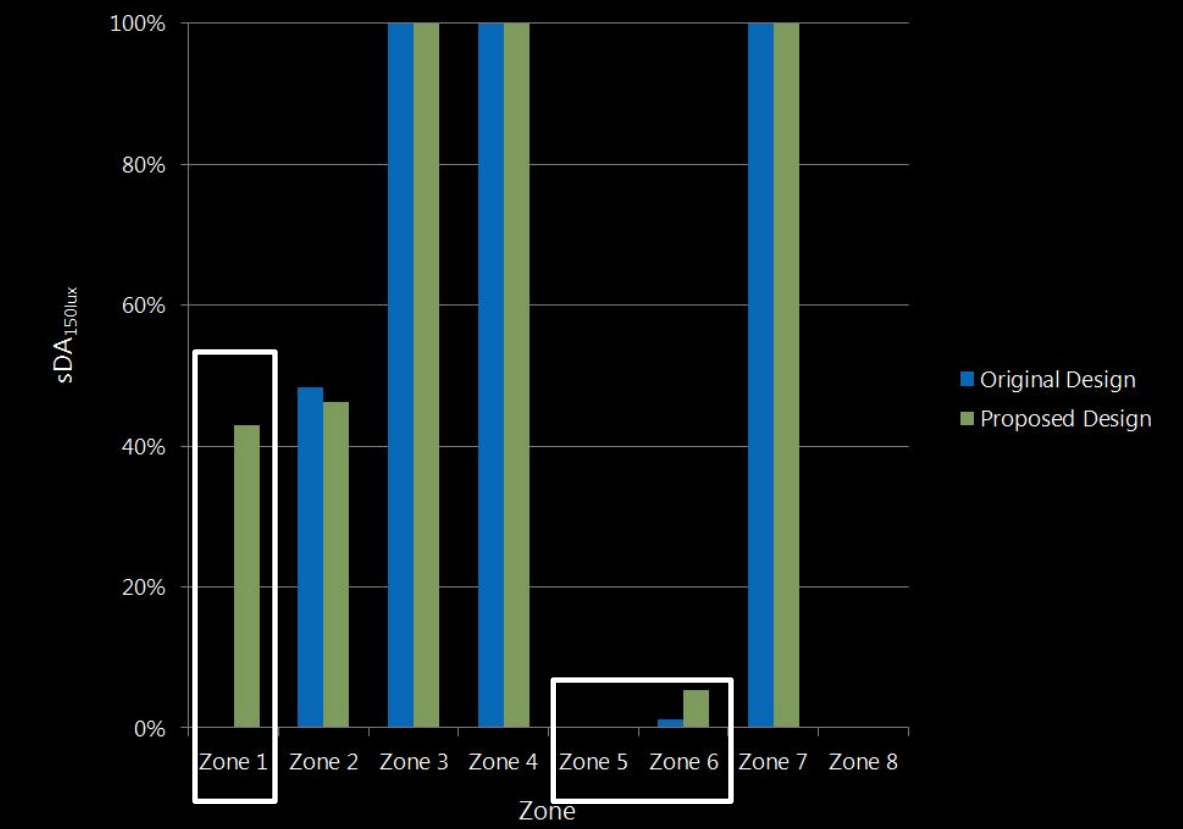
architecture open office + facade

impact daylighting offices
energy use + equipment

Continuous Daylight Autonomy 300 lux: Original vs. Proposed Design



Spatial Daylight Autonomy 150 lux: Original vs. Proposed Design



impact annual metrics

building overview

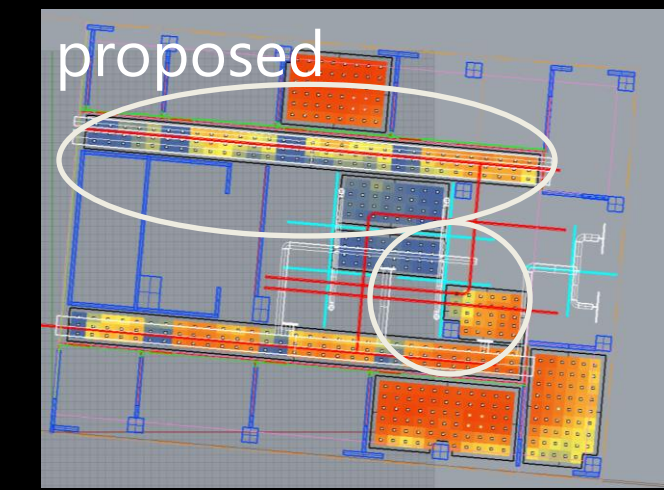
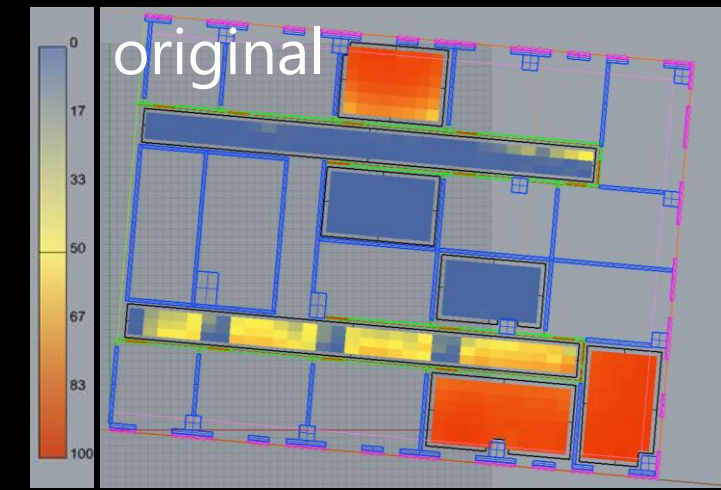
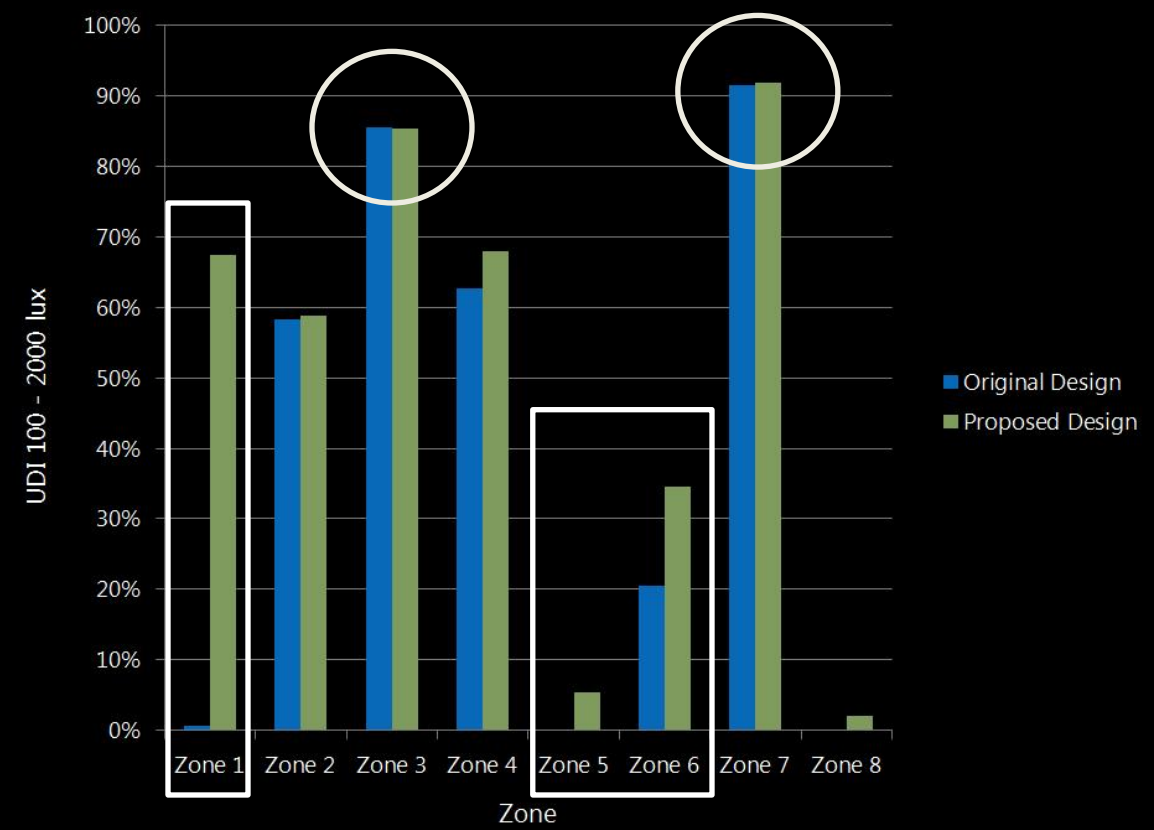
lighting
scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

Useful Daylight Illuminance 100 - 2000 lux: Original vs. Proposed Design



impact lighting energy

building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

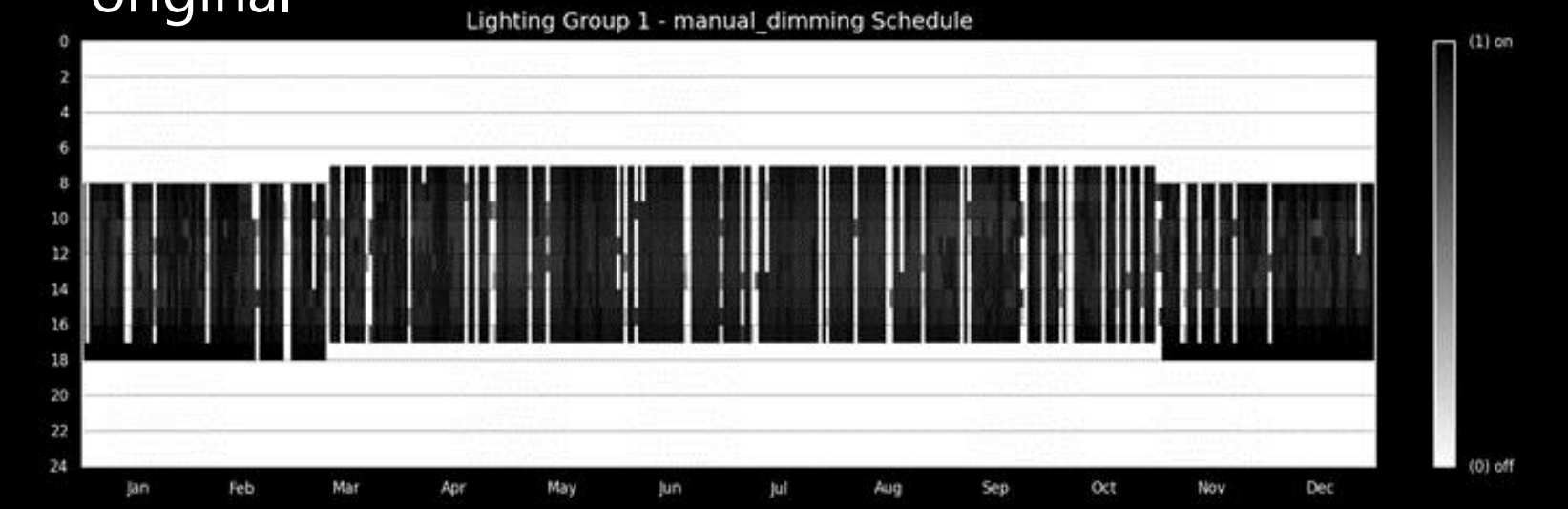
architecture open office + facade

impact daylighting offices
energy use + equipment

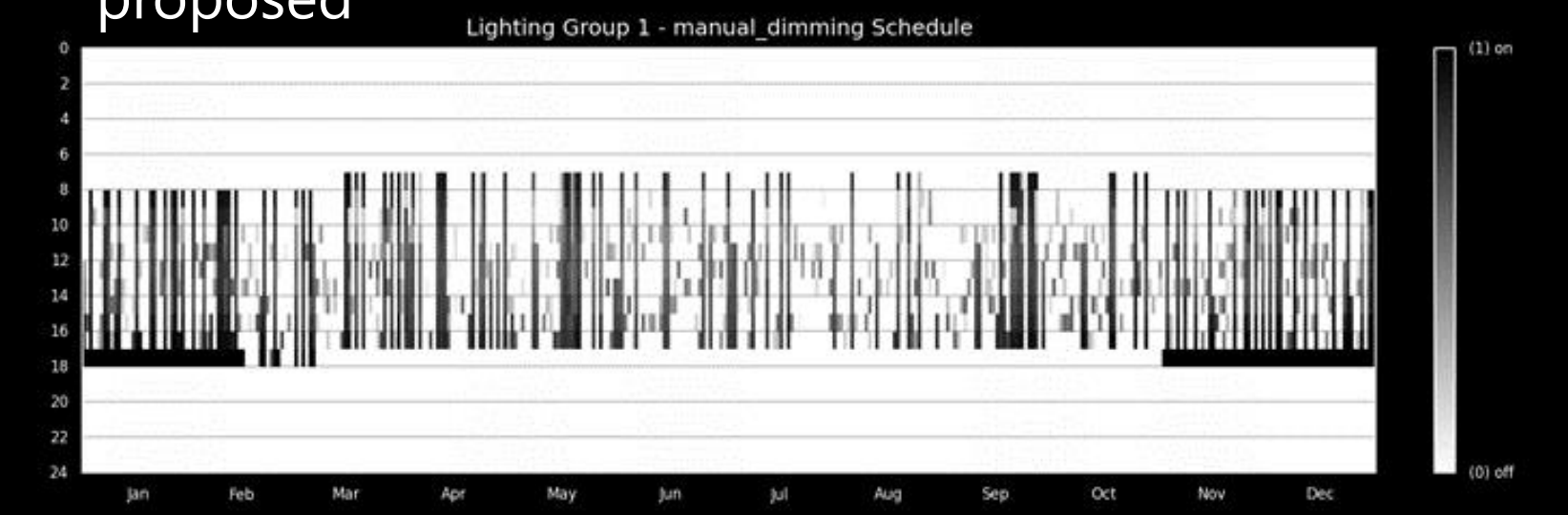
save 868 kWh annually

graduate student lighting

original



proposed



impact annual energy use

building overview

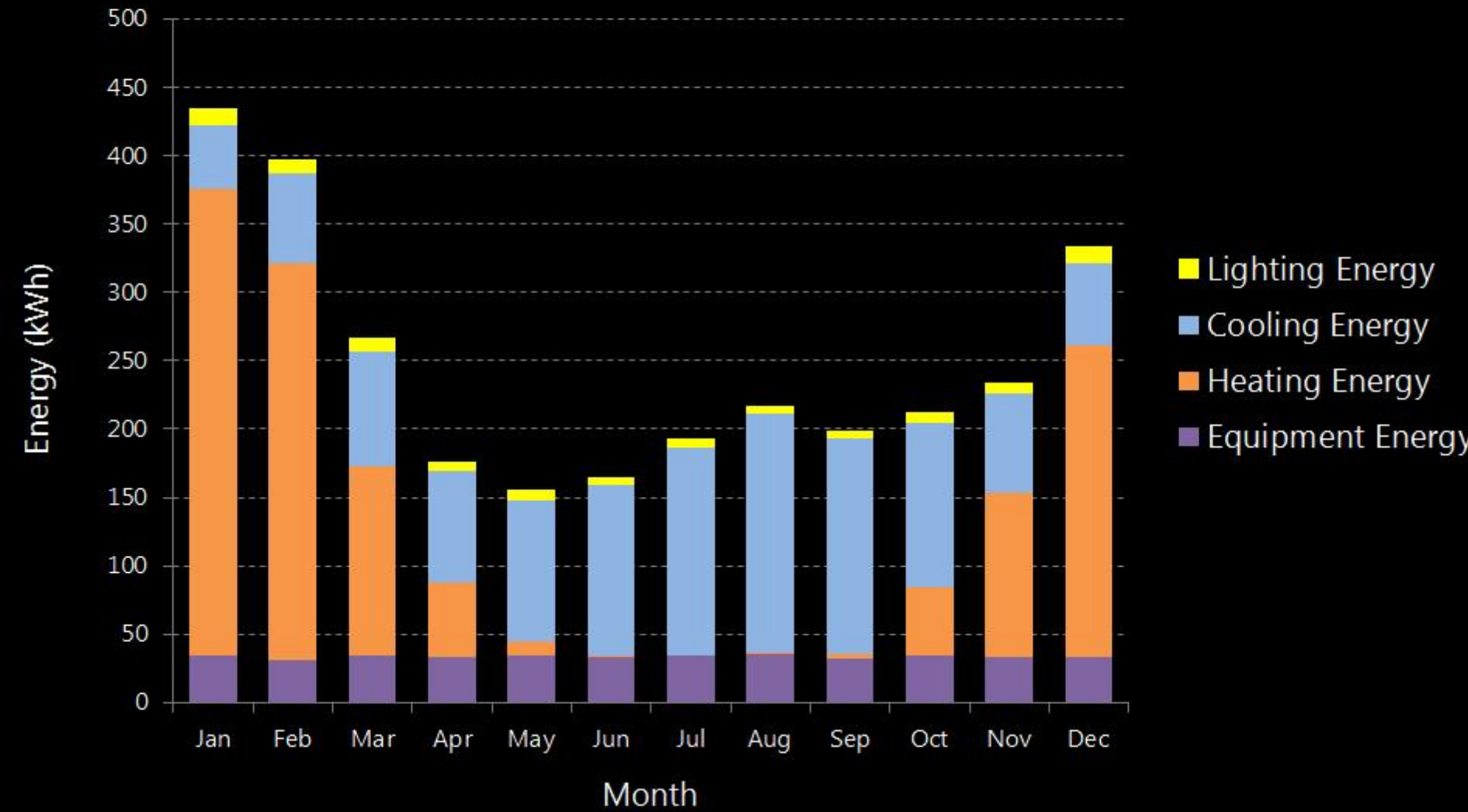
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

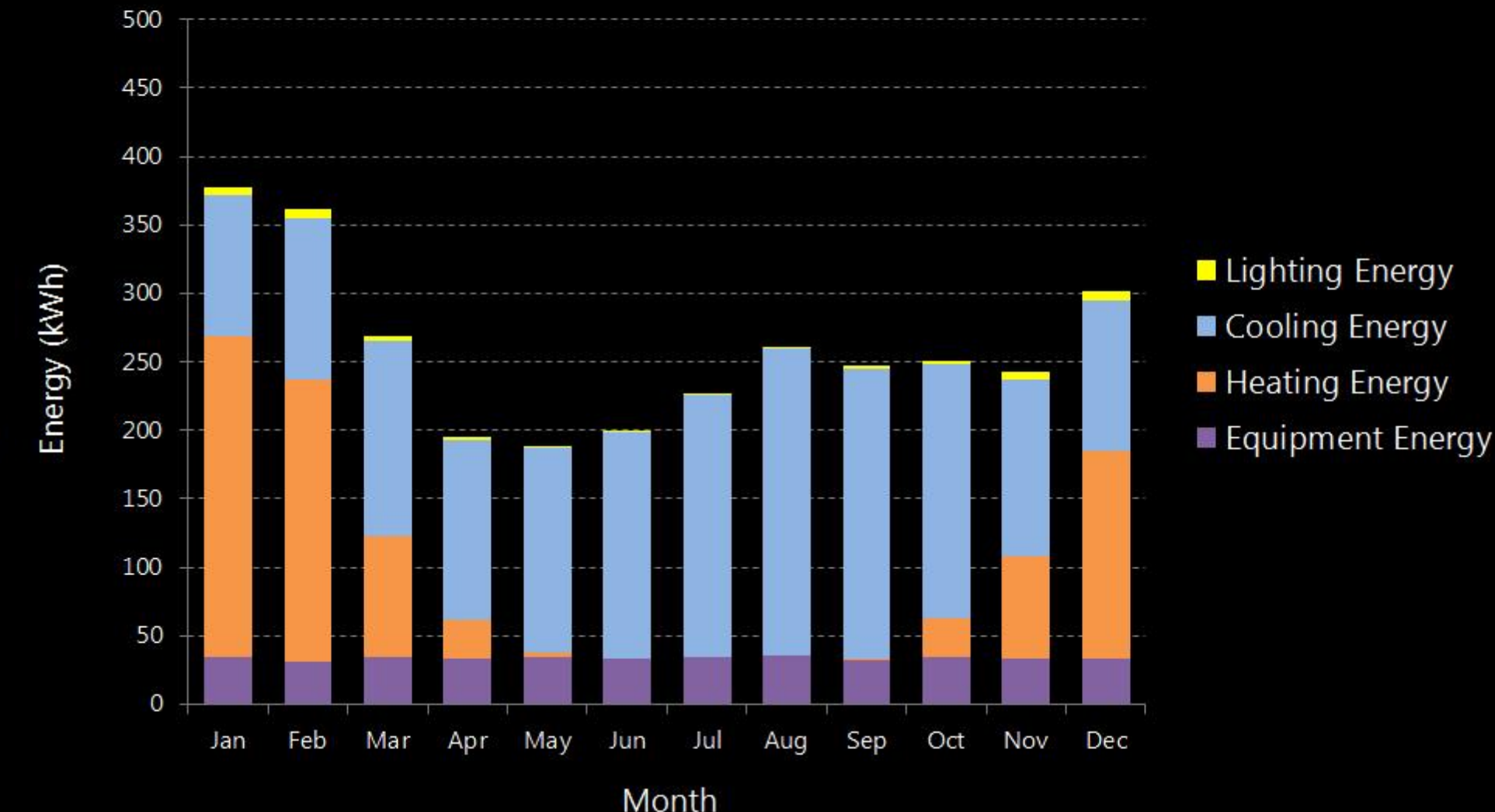
architecture open office + facade

impact daylighting offices
energy use + equipment

Energy Demand: Original Design Energy+ Simulation



Energy Demand: Kalwall Design Energy+ Simulation



impact annual energy use

building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment



increase 5.6%

south office annual energy use



decrease 15%

north office annual energy use

impact revised mechanical layout

building overview

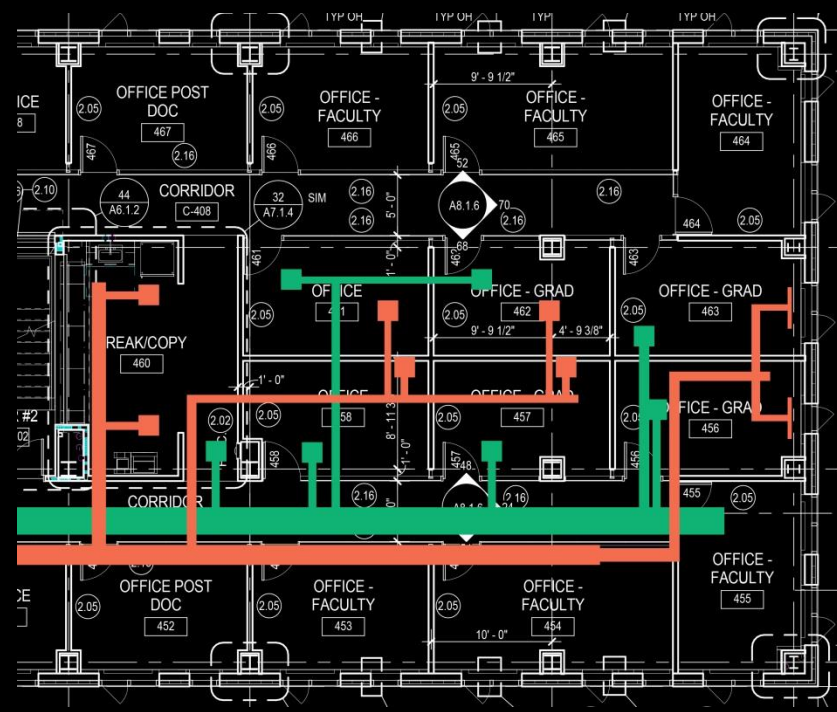
lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

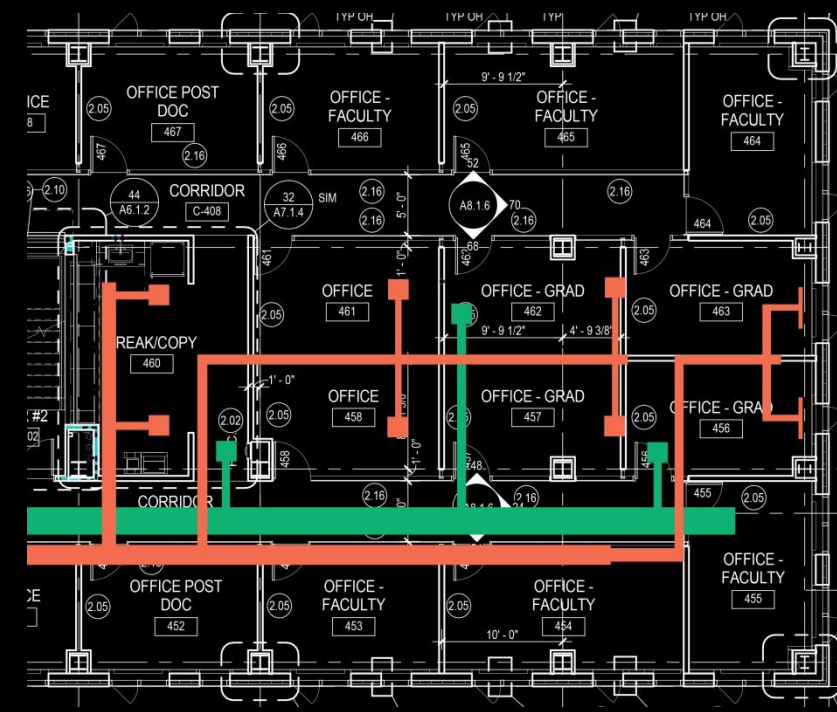
architecture open office + facade

impact daylighting offices
energy use + equipment

original



proposed



\$ 4,234 original design

\$ 3,179 proposed design

impact energy + construction savings

building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

save \$ 1,130

revised mechanical layout

1875 kWh

total annual energy savings

impact cost analysis

building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

\$ 10,975

exterior + interior alterations

1875 kWh

total annual energy savings

impact cost analysis

building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment

46 years

simple payback

1875 kWh

total annual energy savings

conclusion

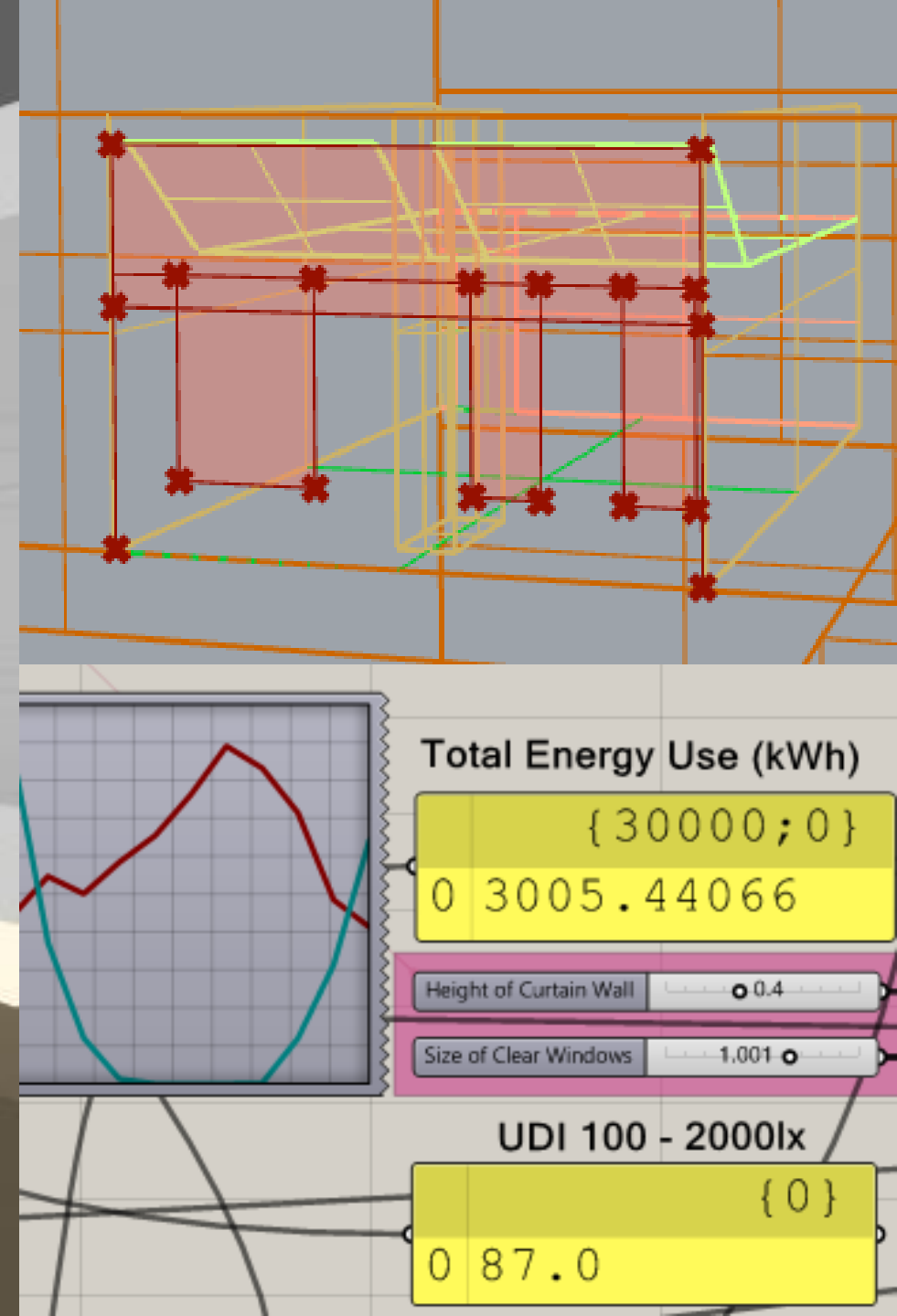
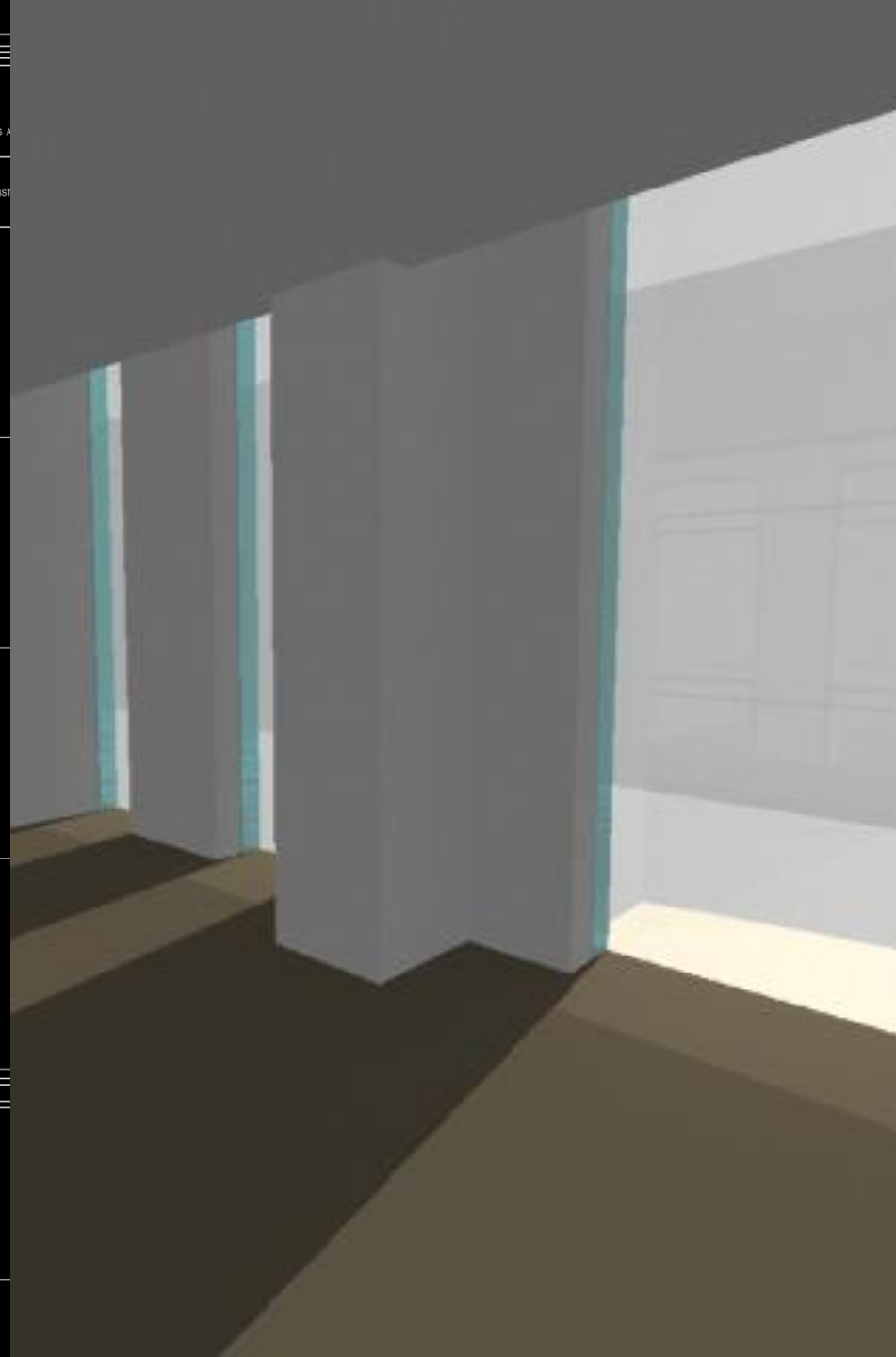
building overview

lighting scrim
lobby/lounge
lecture hall

electrical transformer analysis

architecture open office + facade

impact daylighting offices
energy use + equipment



thank you

Dr. Richard Mistrick
Dr. Kevin Houser
Professor Kevin Parfitt
Professor Charles Cox
Professor Shawn Good
Professor Leslie Beahm
Professor Freihaut
Corey Wilkinson
AE Department

SGJR
Leland Curtis
Luke Renwick
Matt Alleman
Andrew Varilone
Sven Shockey

Lighting students
Penn State

Mom + Dad

lighting scrim

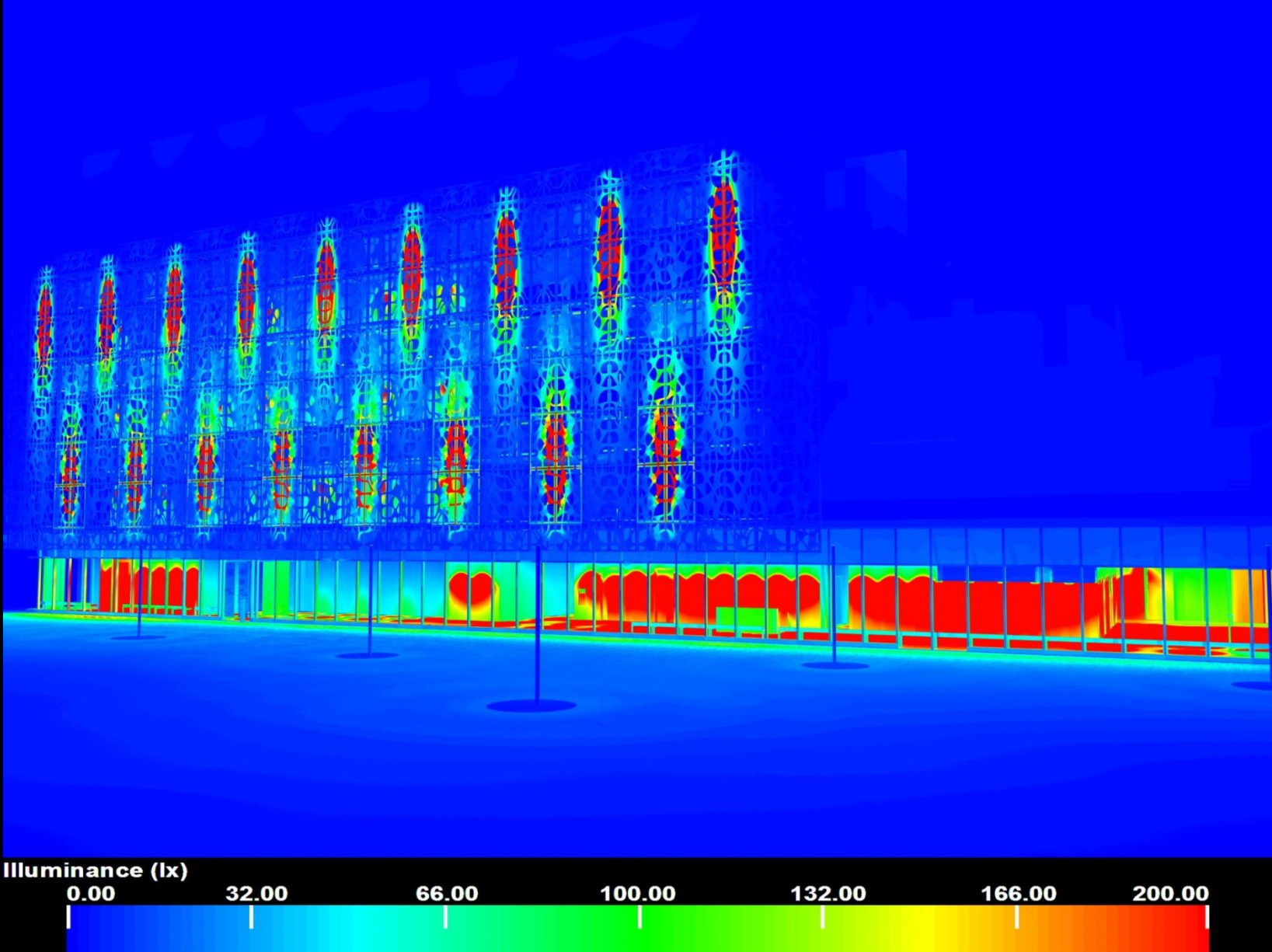
Energy Consumption (ASHRAE/IESNA 90.1 – 2010) – Facade

| Category | Allowable | Calculated |
|----------------------|-----------|------------|
| Area (SF) | - | 17150 |
| Input Wattage | 2573 | 2465 |
| Power Density (W/SF) | 0.15 | 0.14 |

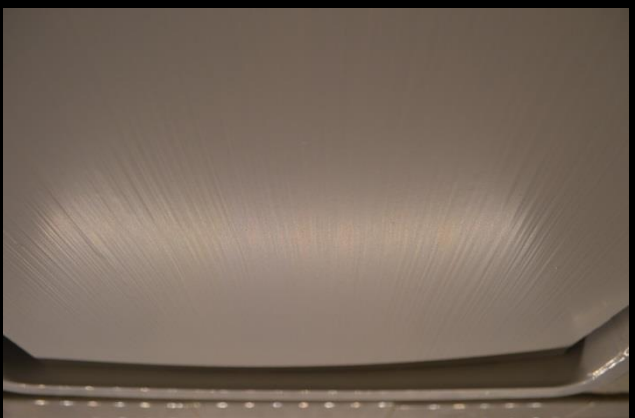
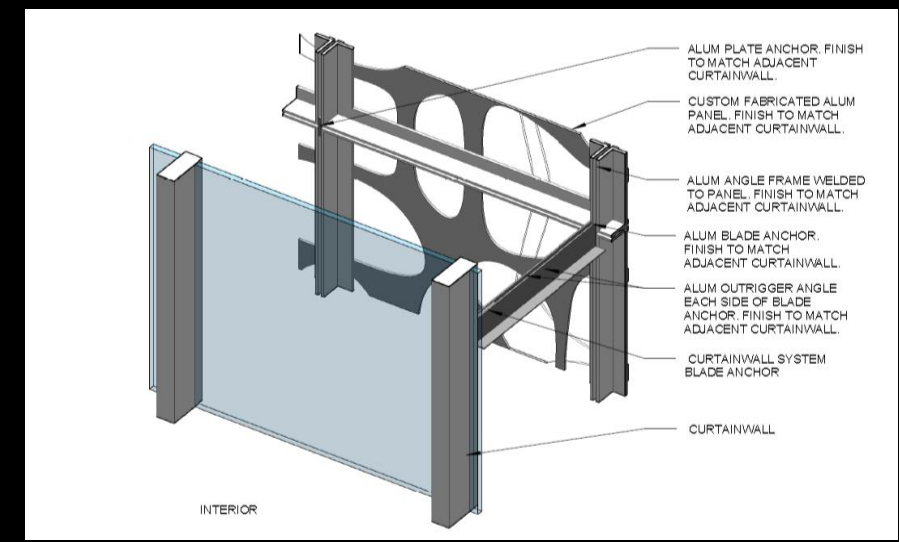
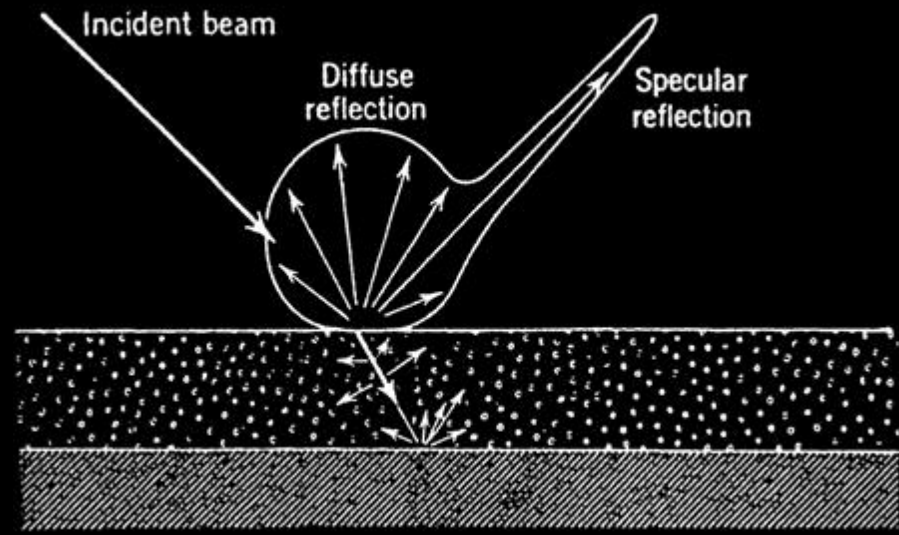
17150 SF @ 0.15 LPD (façade)
39000 SF @ 0.16 LPD (grounds)

light levels

E_v (min): 0 lux (50 avg)
 E_v (max): 200 lux
 E_h (avg): 4 lux (4 avg)



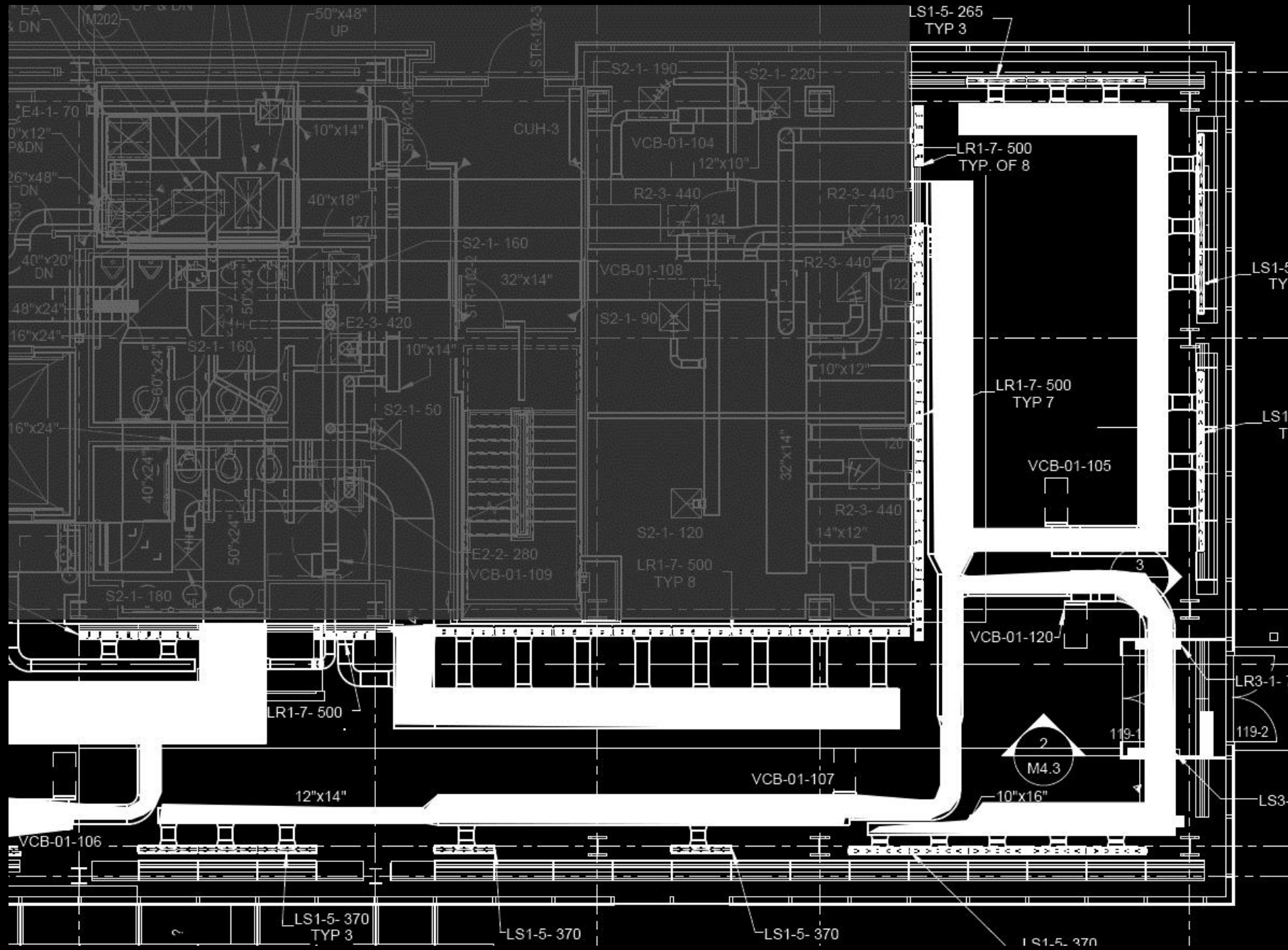
lighting scrim



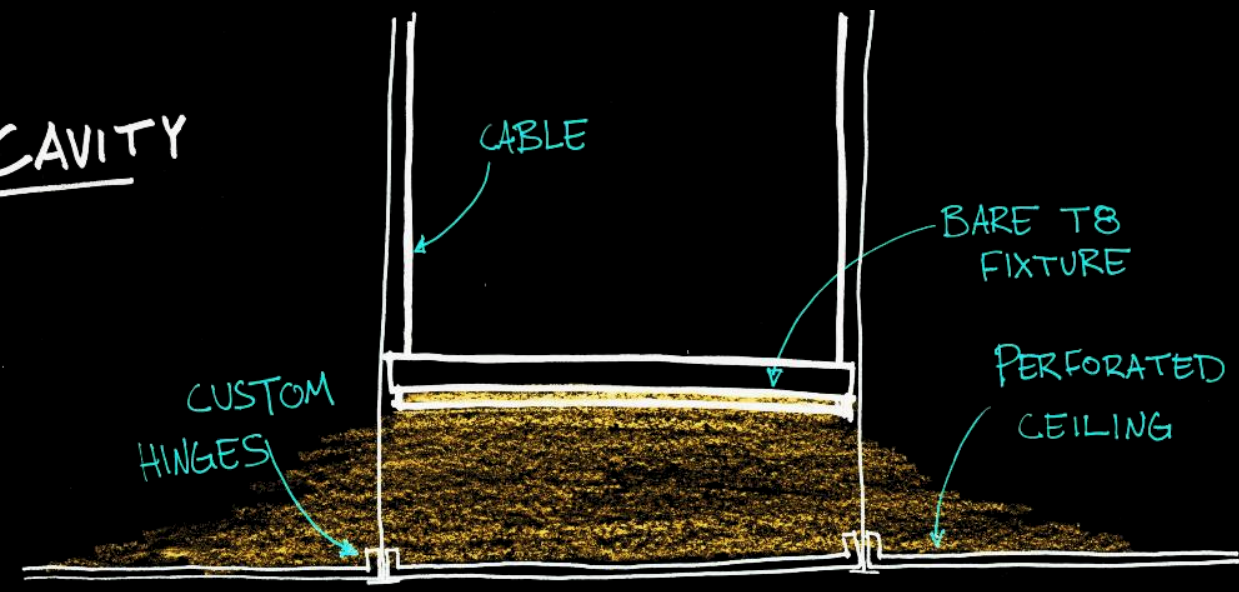
Helsingborg Waterfront
Sweden
Allan Ruberg, IALD



lighting lobby/lounge

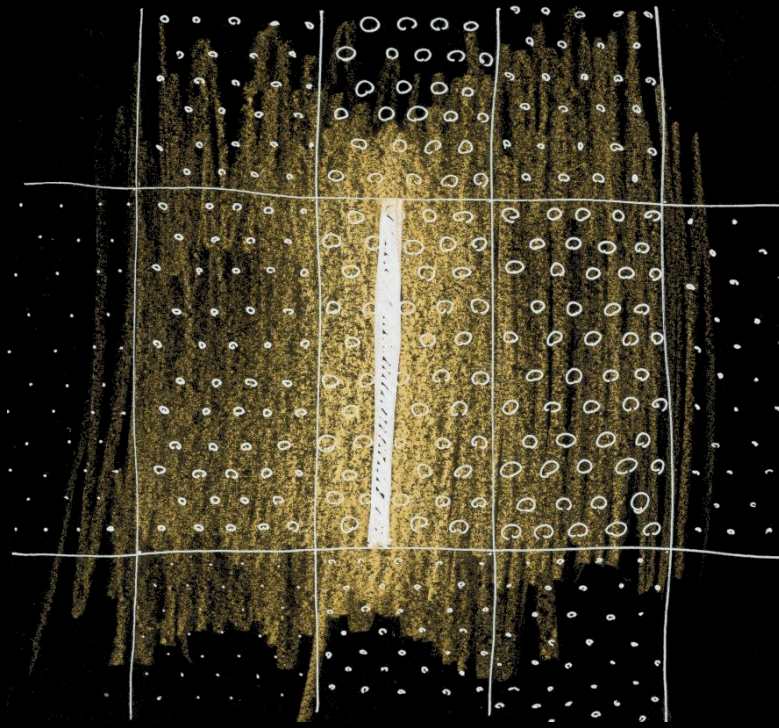


CAVITY



SECTION

LOBBY



lighting lobby/lounge

2407 SF @ 0.90 LPD

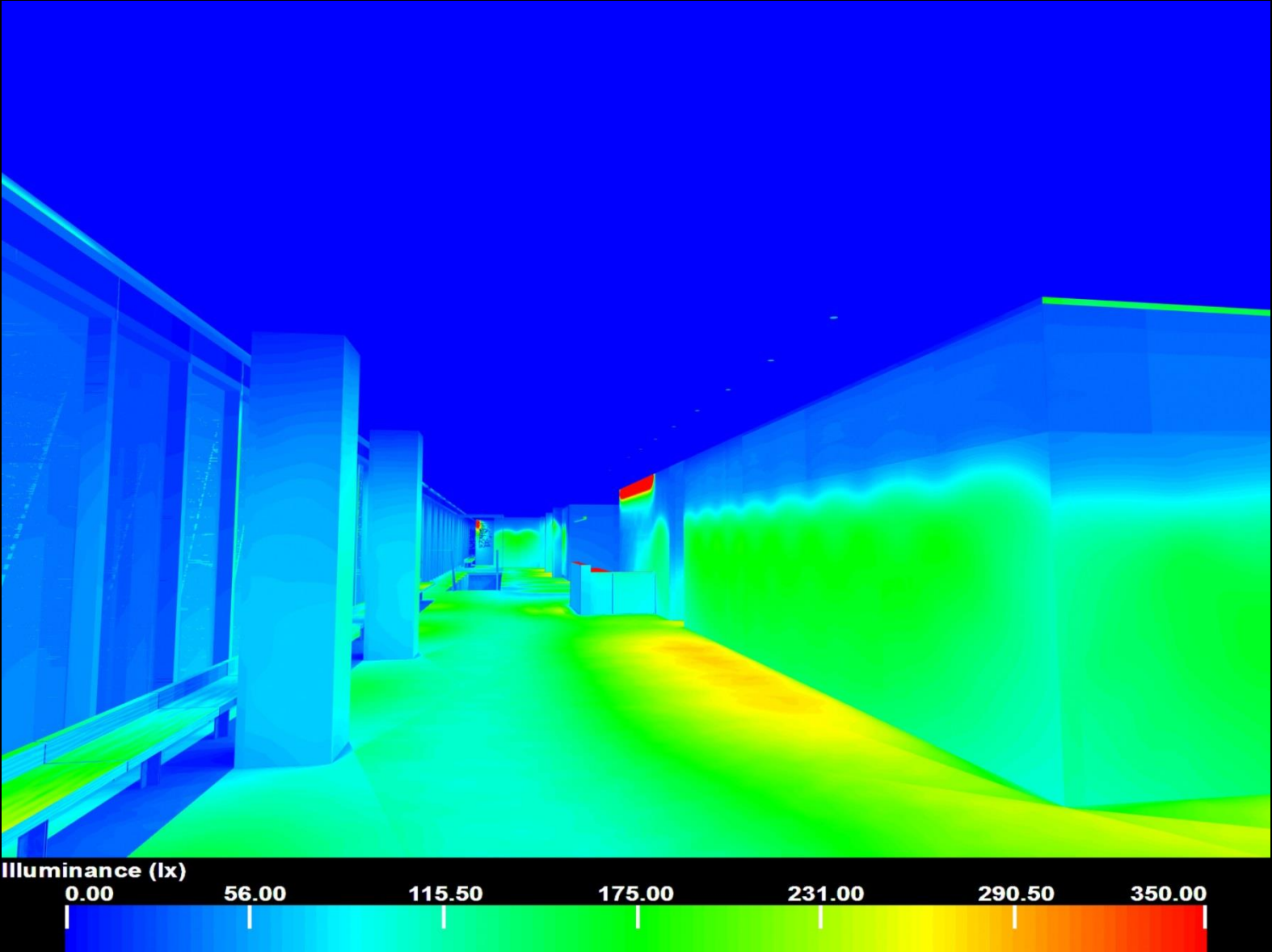
light levels

E_h (avg, floor): 105 lux (40)

E_h (avg, seats): 150 lux (150)

E_h (avg, desk): 430 lux (400)

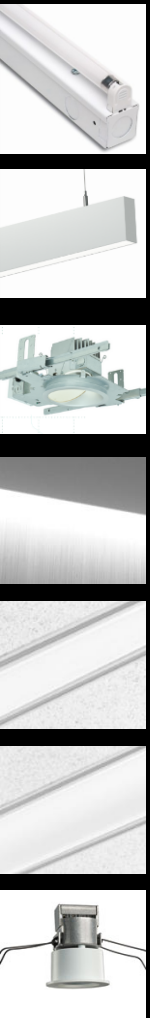
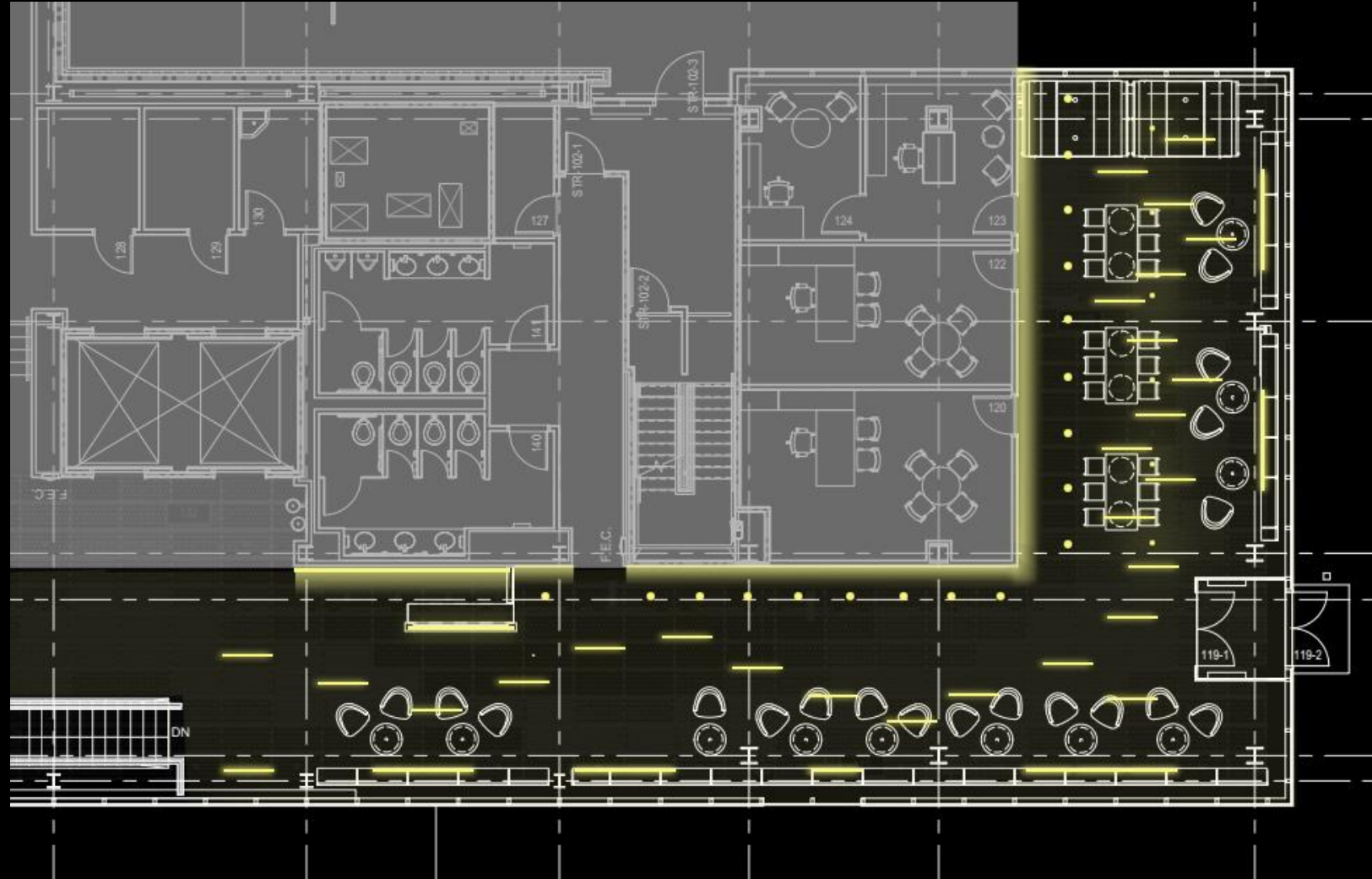
E_v (avg, wall): 148 lux (150)



lighting lobby/lounge

Energy Consumption (ASHRAE/IESNA 90.1 – 2010) – Lobby

| Category | Allowable | Calculated |
|----------------------|-----------|------------|
| Area (SF) | - | 2407 |
| Input Wattage | 2166 | 1235 |
| Power Density (W/SF) | 0.90 | 0.51 |

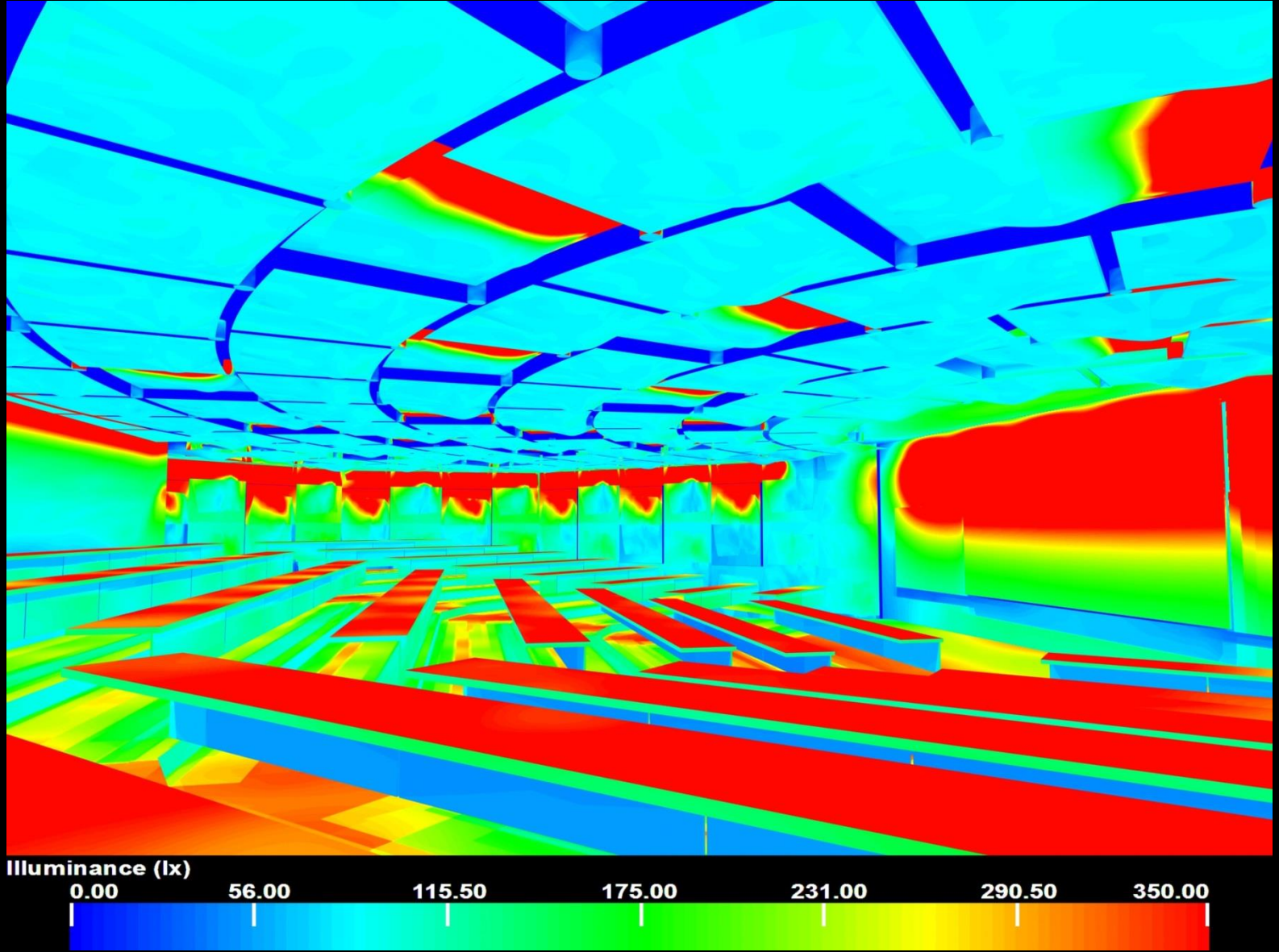


lighting lecture hall

light levels

E_h (avg, desk): 330 lux (200)

E_v (avg, board): 260 lux (400)



lighting lecture hall

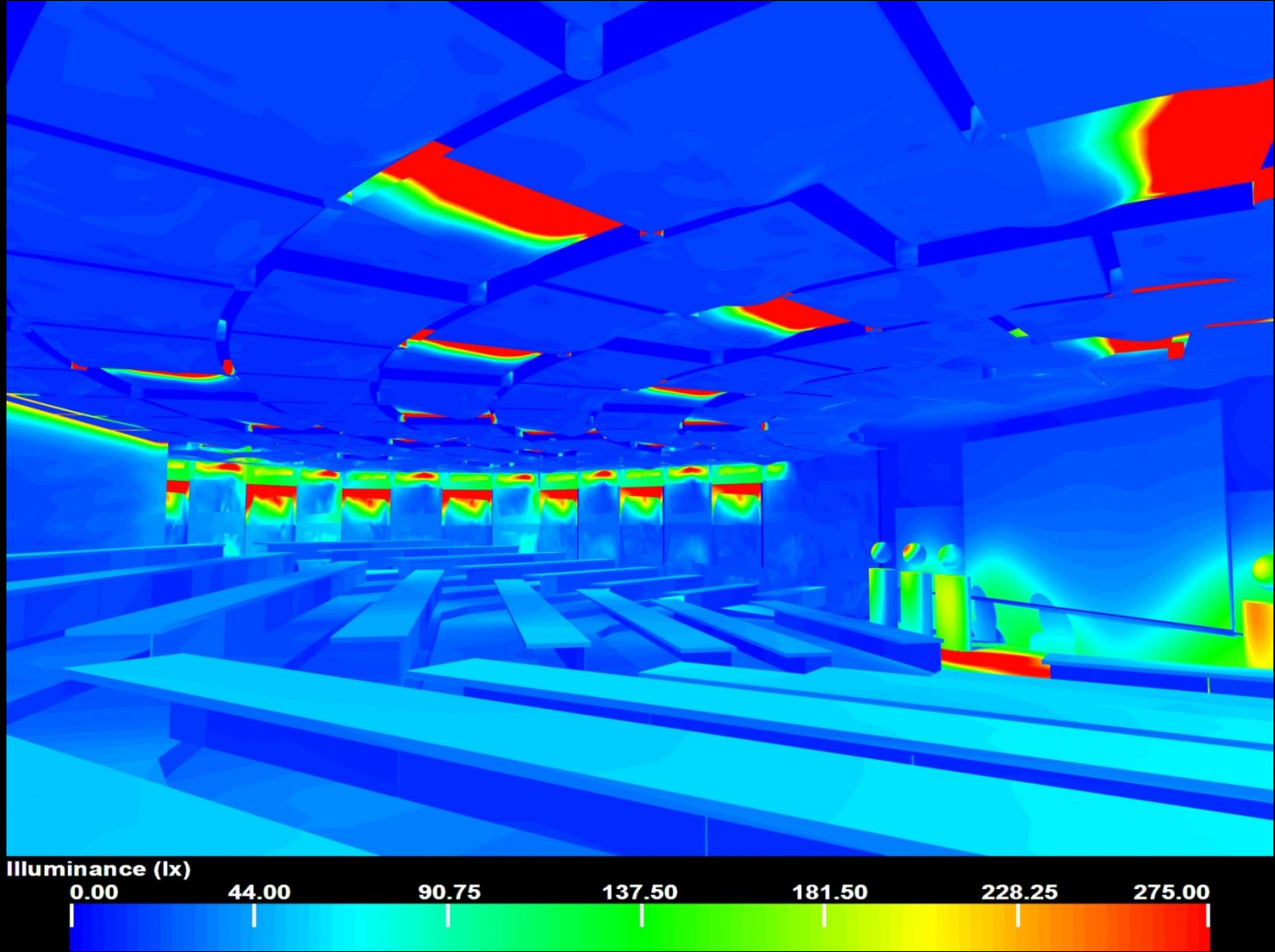
3200 SF @ 1.24 LPD

light levels

E_h (avg, desk): 55 lux (50)

E_v (avg, board): 12 lux (10)

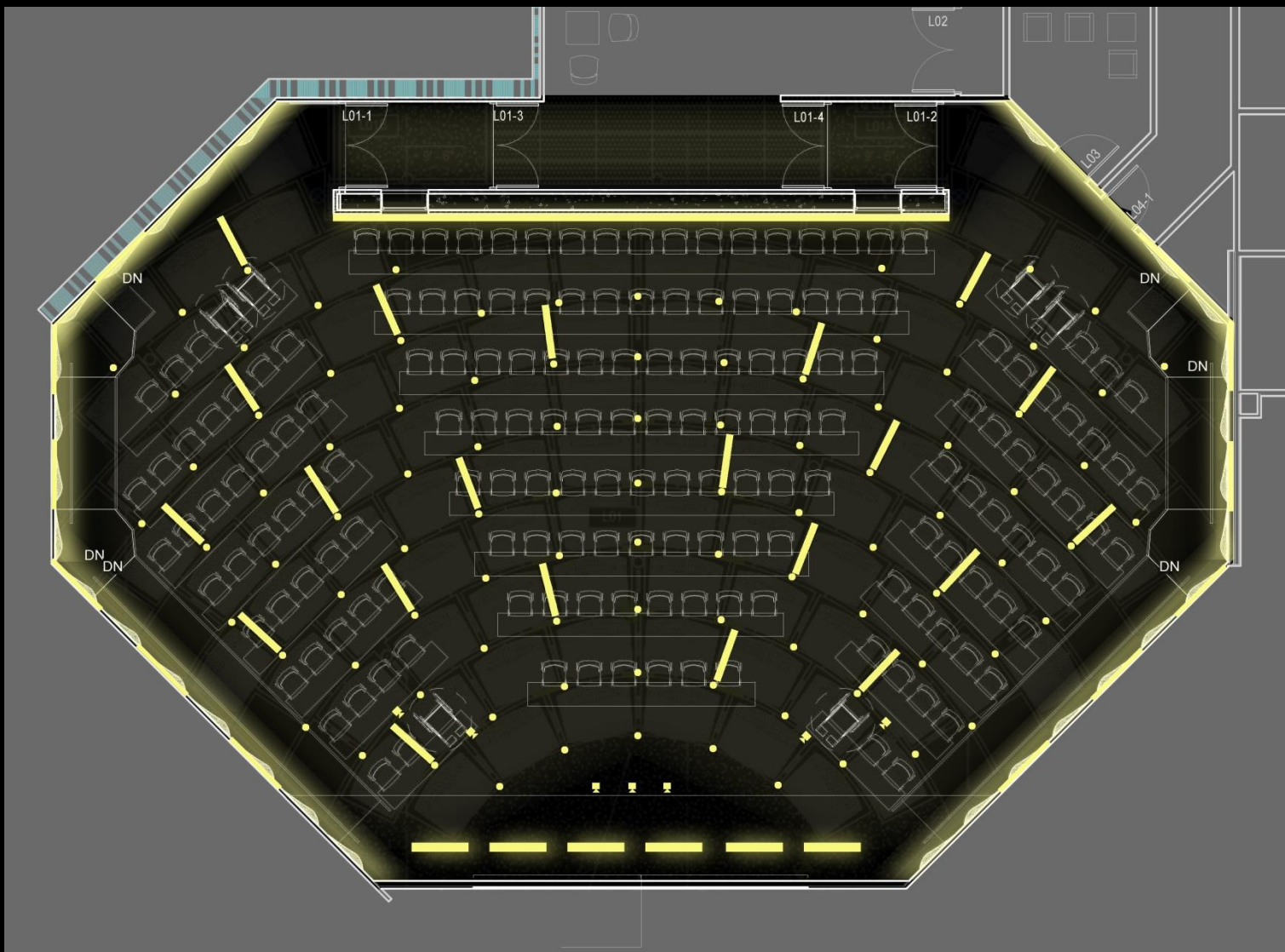
E_v (avg, faces): 215 lux (200)



lighting lecture hall

Energy Consumption (ASHRAE/IESNA 90.1 – 2010) – Lecture Hall

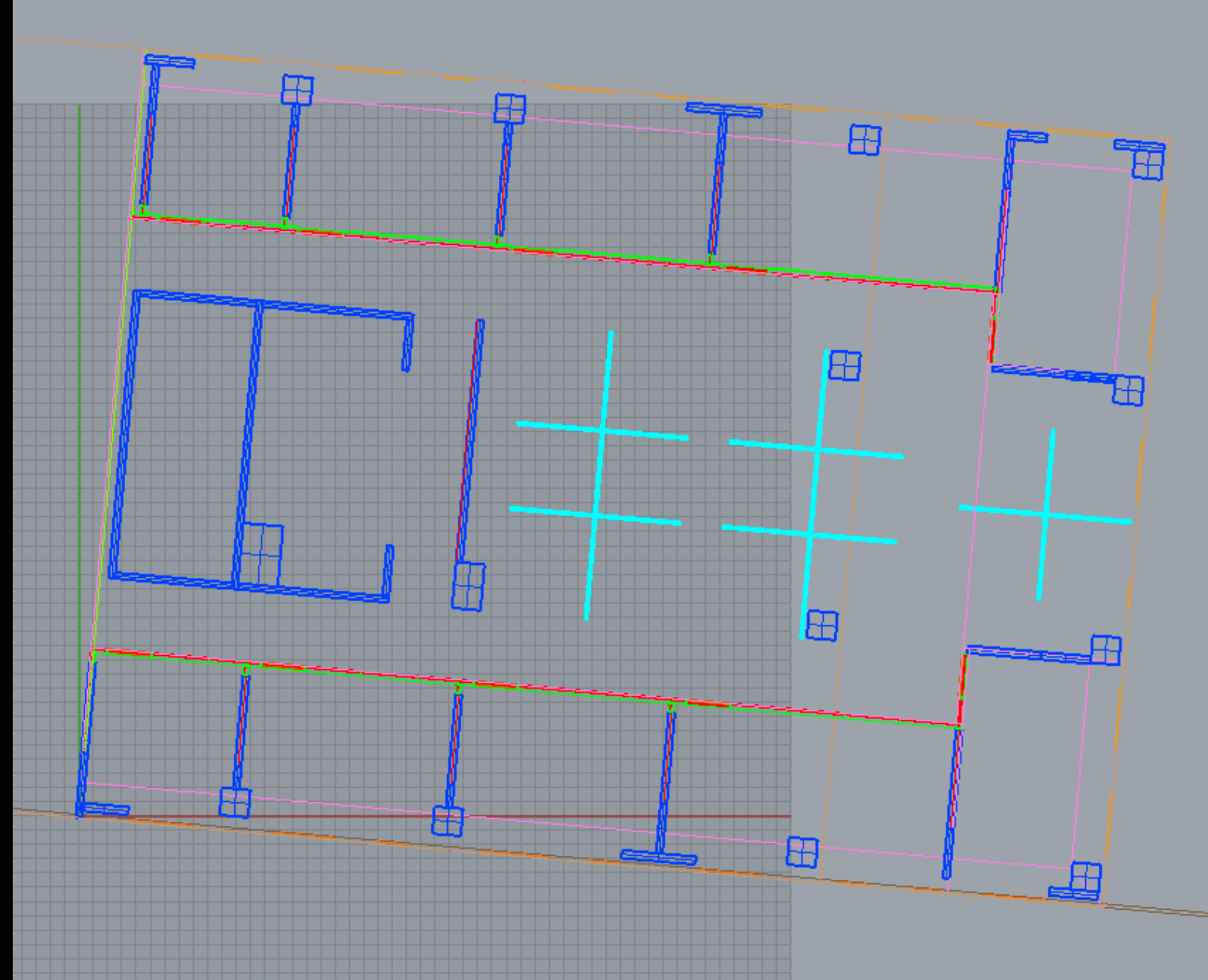
| Category | Allowable | Calculated |
|----------------------|-----------|------------|
| Area (SF) | - | 3200 |
| Input Wattage | 3968 | 3311 |
| Power Density (W/SF) | 1.24 | 1.04 |



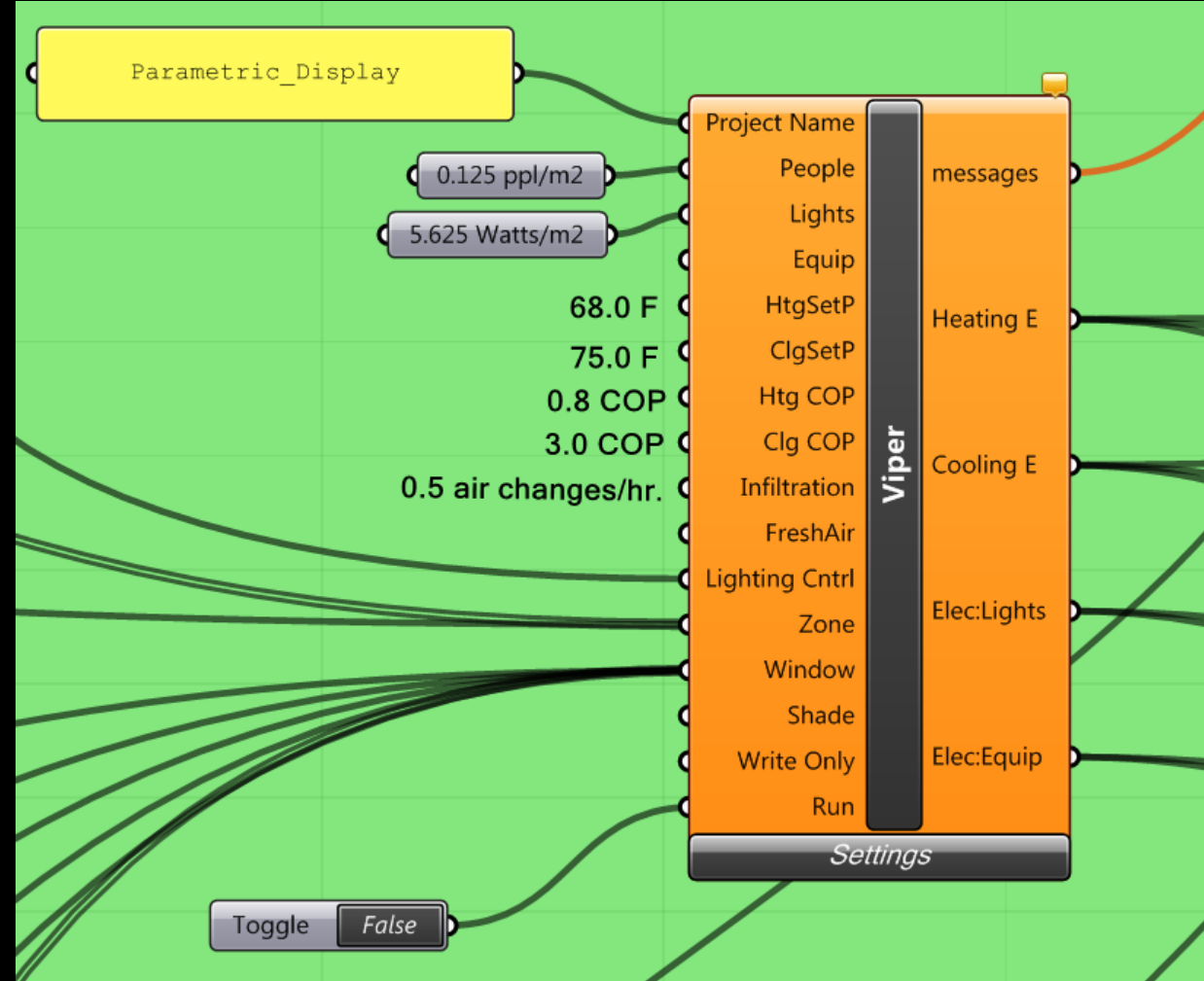
electrical ust analysis

| Process | | Cast-Coil | Vegetable-Based |
|--|--|--------------|-----------------|
| A | Initial Costs | \$ 51,511.71 | \$ 34,341.14 |
| B | Total Load Losses (W) | 20000 | 12400 |
| C | No-Load Losses (W) | 4000 | 1900 |
| D | I²R Losses @ Full Load | 16000 | 10500 |
| E | For LF1: I²R Losses | 0.2667 | 1137.78 |
| F | For LF1: Total Losses | 5137.78 | 2646.67 |
| G | Rate 1: \$/kWh | \$ 0.1267 | -- |
| H | LF1 hrs/yr @ R1 | 8760 | \$ 5,702.38 |
| I | Total Operating Cost | \$ 5,702.38 | \$ 2,937.51 |
| Operating Cost Difference (Savings) | | | \$ 2,764.86 |
| Initial Cost Difference | | | \$ 17,170.57 |
| Payback (years) | | | 0.00 |

open office



mechanical resizing



| Peak Energy Use for Original Design | | |
|-------------------------------------|--------------------------|--------------------------|
| Type of Energy Use | Extreme Summer Day (kWh) | Extreme Winter Day (kWh) |
| Heating | 0.00 | 9.00 |
| Cooling | 7.85 | 2.72 |

| Peak Energy Use for Proposed Design | | |
|-------------------------------------|--------------------------|--------------------------|
| Type of Energy Use | Extreme Summer Day (kWh) | Extreme Winter Day (kWh) |
| Heating | 0.00 | 5.22 |
| Cooling | 9.60 | 6.40 |

$$\frac{9.00 \text{ kWh}}{660 \text{ cfm}} = \frac{9.60 \text{ kWh}}{X \text{ cfm}}$$

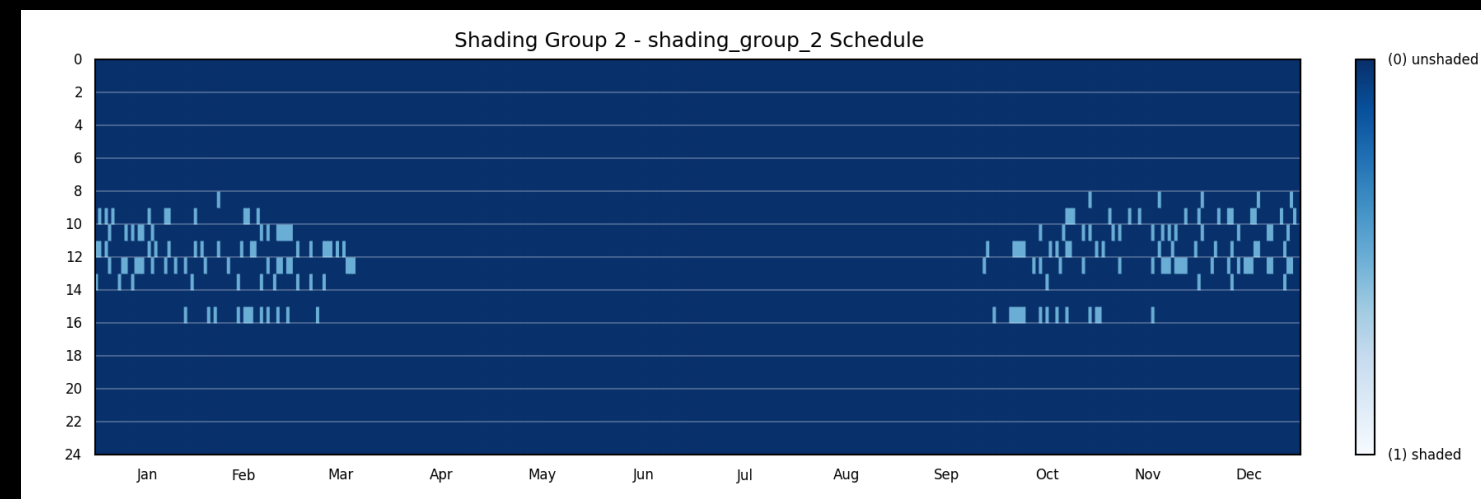
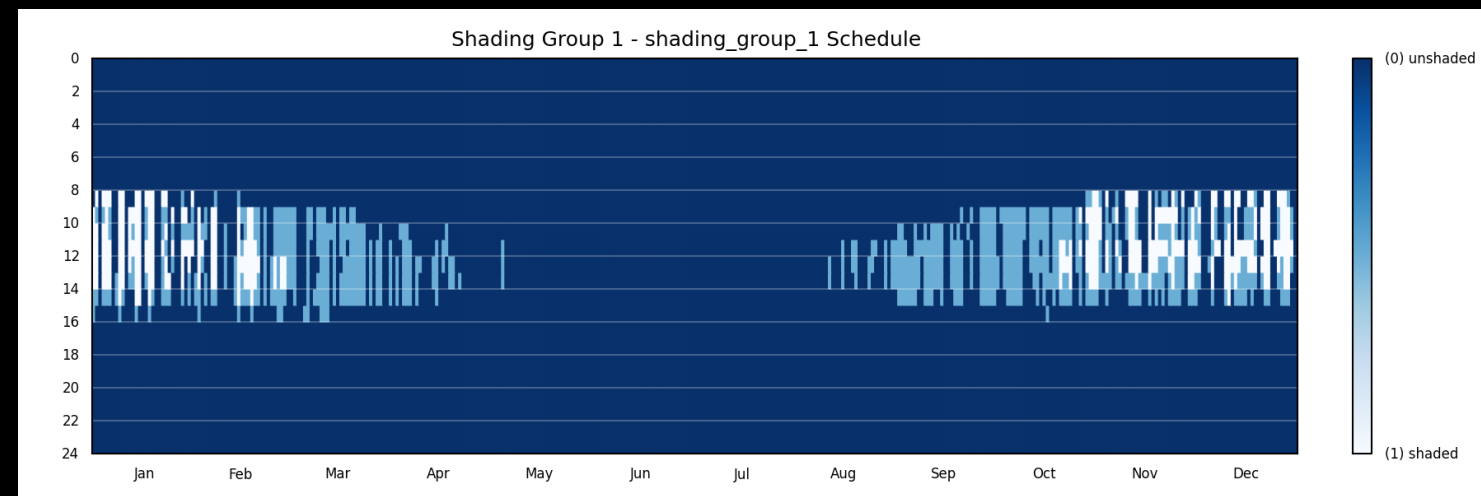
X(proposed design) = 704 cfm total

aerogel

Aerogel is a synthetic porous ultralight material derived from a gel, in which the liquid component of the gel has been replaced with a gas

Kalwall has been classified with lifetime of 25 years regarding durability (ETA-07/0244). Kalwall meets requirements as defined by the American code US Standard UL-972: Kalwall is sufficient in handling soft and hard body impacts including vandalism and large missile impact tests. Kalwall would generally meet the NFPA definition of “Limited Combustibility” in relation with fire resistance. Kalwall + Lumira Aerogel achieves a 34 dB R_w Weighted Noise Reduction rating and weighs no more than 4.5 pounds per square foot (psf).

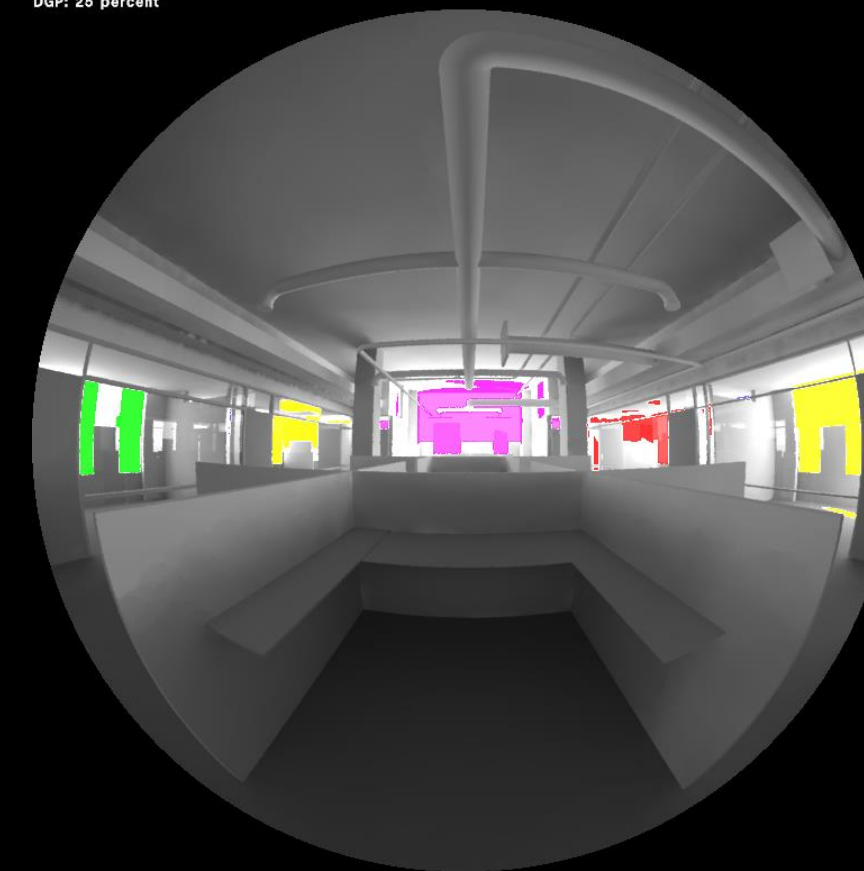
Panels are prefabricated to the exact size and configuration for each project. Hereby, flexibility in design as informed by parametric modeling is possible. Finally, it is expected that vertical Kalwall facing North or East with average exposure is to be maintained every 15 to 20 years: wash with soapy water and clear water rinse.



open 74% of time

open 94% of time

Imperceptible Glare
DGP: 25 percent



energy use

| Annual Energy Savings with Kalwall + Lumira Proposed Design | | |
|---|----------------------------|------------------------|
| Room | Energy Savings (+)/Loss(-) | Annual Cost Difference |
| South Room 451 | - 86.96 kWh | -\$ 11.02 |
| South Room 452 | - 113.42 kWh | -\$ 14.37 |
| South Room 453 | - 120.98 kWh | - \$ 15.33 |
| South Room 454* | - 166.35 kWh | - \$ 21.08 |
| South Room 455 | - 124.76 kWh | - \$15.81 |
| North Room 464 | 329.78 kWh | \$ 41.78 |
| North Room 465* | 439.71 kWh | \$ 55.71 |
| North Room 466 | 319.79 kWh | \$ 40.52 |
| North Room 467 | 299.80 kWh | \$ 37.98 |
| North Room 468 | 229.85 kWh | \$ 29.12 |
| Annual Energy Savings | | \$ 127.52 |

| ELECTRICAL ENERGY | | | | | | |
|-------------------|----------|---------|-----------|----------|---------------------|------------------|
| Room | Original | Cost | Total | Proposed | Cost | Total |
| 458 | 400.1 | \$ 0.13 | \$ 50.69 | 166.8 | \$ 0.13 | \$ 21.13 |
| 457 | 393.6 | \$ 0.13 | \$ 49.87 | 281.6 | \$ 0.13 | \$ 35.68 |
| 456 | 198.2 | \$ 0.13 | \$ 25.11 | 67.9 | \$ 0.13 | \$ 8.60 |
| 461 | 430.8 | \$ 0.13 | \$ 54.58 | 308.0 | \$ 0.13 | \$ 39.02 |
| 462 | 433.1 | \$ 0.13 | \$ 54.87 | 186.7 | \$ 0.13 | \$ 23.65 |
| 463 | 71.7 | \$ 0.13 | \$ 9.08 | 48.2 | \$ 0.13 | \$ 6.11 |
| | | | \$ 244.21 | | | \$ 134.20 |
| | | | | | Annual Saved | \$ 110.01 |

save 868 kWh annually

graduate student lighting

cost analysis

| Original Design | Supply Air | Unit | Duct Size | LF | Shape | Diffuser Size | CFM | RS Means Unit | Cost (Material + Labor) |
|------------------------|------------|----------------|-------------|-------------|-------------|---------------|-----------|---------------|-------------------------|
| | | S2-1-120 | 6" x 8" | 5 | Rectangular | 24" x 24" | 120 | 11.5 lbs. | \$ 67.39 |
| | | S2-1-120 | 6" x 8" | 1 | Rectangular | 24" x 24" | 120 | 2.3 lbs. | \$ 13.48 |
| | | S2-1-120 | 6" x 8" | 6 | Rectangular | 24" x 24" | 120 | 13.8 lbs. | \$ 80.87 |
| | | S2-1-120 | 6" x 8" | 1 | Rectangular | 24" x 24" | 120 | 2.3 lbs. | \$ 13.48 |
| | | LS-1-4-310 | 12" x 10" | 9 | Rectangular | 1" x 48" | 310 | 33.3 lbs. | \$ 195.14 |
| | LS-1-3-205 | 12" x 10" | 5 | Rectangular | 1" x 48" | 205 | 18.5 lbs. | \$ 108.41 | |
| | | | | | | 995 | | | |
| | Return Air | Unit | Duct Size | LF | Shape | Grille Size | CFM | RS Means Unit | Cost (Material + Labor) |
| | | R2-1-120 | 6" x 8" | 5 | Rectangular | 24" x 24" | 120 | 11.5 lbs. | \$ 67.39 |
| | | R2-1-120 | 6" x 8" | 7 | Rectangular | 24" x 24" | 120 | 16.1 lbs | \$ 94.35 |
| | | R2-1-120 | 6" x 8" | 2 | Rectangular | 24" x 24" | 120 | 4.6 lbs. | \$ 26.96 |
| | | R2-1-120 | 6" x 8" | 2 | Rectangular | 24" x 24" | 120 | 4.6 lbs. | \$ 26.96 |
| | | R2-3-310 | 12" DIA | 13.5 | Round | 24" x 24" | 310 | 2 LF. | \$ 20.36 |
| | R2-2-205 | 6" x 8" | 5.75 | Rectangular | 24" x 24" | 205 | 13.2 lbs. | \$ 77.35 | |
| | | | | | | 995 | | | |
| | Branches | Unit | Duct Size | LF | Shape | N/A | CFM | RS Means Unit | Cost (Material + Labor) |
| | | Main Return | 30" x 10" | 44.5 | Rectangular | -- | -- | 382.7 lbs. | \$ 2,150.77 |
| | | Supply Branch1 | 10" DIA | 19.5 | Round | -- | -- | 19.5 LF. | \$ 154.83 |
| Supply Branch2 | | 12" x 10" | 25 | Rectangular | -- | -- | 92.5 lbs. | \$ 542.05 | |
| Linear Diffuser Branch | | 12" x 10" | 16.5 | Rectangular | -- | -- | 61.1 lbs. | \$ 358.05 | |
| Return Air Branch | 6" x 8" | 17.75 | Rectangular | -- | -- | 40.8 lbs. | \$ 239.09 | | |

TOTAL COST \$ 4,236.93

cost analysis

| Renovated Open Office | Supply Air | Unit | Duct Size | LF | Shape | Diffuser Size | CFM | RS Means Unit | Cost (Material + Labor) |
|------------------------|------------|-------------|-----------|-------|-------------|---------------|-----------|---------------|-------------------------|
| | | S2-1-120 | 7" DIA | 7 | Round | 8" DIA | 120 | 7 LF. | \$ 37.80 |
| | | S2-1-120 | 7" DIA | 7 | Round | 8" DIA | 120 | 7 LF. | \$ 37.80 |
| | | S2-1-120 | 7" DIA | 7 | Round | 8" DIA | 120 | 7 LF. | \$ 37.80 |
| | | S2-1-120 | 7" DIA | 7 | Round | 8" DIA | 120 | 7 LF. | \$ 37.80 |
| | | LS-1-4-310 | 10" DIA | 10.25 | Round | 1" x 48" | 310 | 10.25 LF. | \$ 81.39 |
| | LS-1-3-205 | 8" DIA | 10.25 | Round | 1" x 48" | 205 | 10.25 LF. | \$ 65.19 | |
| | | | | | | | | 995 | |
| | Return Air | Unit | Duct Size | LF | Shape | Grille Size | CFM | RS Means Unit | Cost (Material + Labor) |
| | | R2-1-330 | 12" DIA | 2 | Round | 24" x 24" | 332 | 2 LF. | \$ 20.36 |
| | | R2-1-330 | 12" DIA | 2 | Round | 24" x 24" | 332 | 9 LF. | \$ 91.62 |
| | | R2-1-330 | 12" DIA | 2 | Round | 24" x 24" | 332 | 2 LF. | \$ 20.36 |
| | | Removed | -- | -- | -- | -- | -- | -- | -- |
| | | Removed | -- | -- | -- | -- | -- | -- | -- |
| | Removed | -- | -- | -- | -- | -- | -- | -- | |
| | | | | | | | | 996 | |
| | Branches | Unit | Duct Size | LF | Shape | N/A | CFM | RS Means Unit | Cost (Material + Labor) |
| | | Main Return | 30" x 10" | 44.5 | Rectangular | -- | -- | 382.7 lbs. | \$ 2,150.77 |
| Supply Branch | | 10" DIA | 24 | Round | -- | -- | 24 LF. | \$ 190.56 | |
| Supply Branch | | 10" DIA | 25 | Round | -- | -- | 25 LF. | \$ 198.50 | |
| Linear Diffuser Branch | | 12" DIA | 20.5 | Round | -- | -- | 20.5 LF. | \$ 208.69 | |
| Removed | -- | -- | -- | -- | -- | -- | -- | | |

| | |
|----------------------|--------------------|
| TOTAL COST | \$ 3,178.64 |
| TOTAL SAVINGS | \$ 1,058.29 |

cost analysis

| INTERIOR REDESIGN | | | | |
|--|-------|---------------|-------------|-------------|
| Material | Unit | Bare Material | Bare Labor | Bare Total |
| 5/8" FR drywall, no base layer, 2-1/2" @ 16" O.C., 5/8" regular drywall | SF | \$ 1.15 | \$ 3.44 | \$ 4.59 |
| Interior glazed opening, aluminum tube finish, 1/4" float, 12'x4' opening size | Opng. | \$ 1,725.00 | \$ 1,175.00 | \$ 2,900.00 |
| Wood Door/Wood Frame, hollow core/flush, 3'0"x7'0" | Ea. | \$ 340.00 | \$ 250.00 | \$ 590.00 |
| Acoustic Ceiling, 5/8" fiberglass board, 24"x24", tee, suspended | SF | \$ 2.35 | \$ 1.86 | \$ 4.21 |
| Office workstations (16) | Ea. | \$ 2,500.00 | \$ 200.00 | \$ 2,700.00 |
| Misc. Office Equipment (Tables) | Ea. | -- | -- | \$ 500.00 |
| Savings due to renovated mechanical layout | -- | -- | -- | \$ 1,129.55 |

| REMOVAL (SAVINGS) | | | |
|----------------------|------------|-----------------------|---------------------|
| Item | Quantity | Cost/Item | \$ Saved |
| Interior Walls | 688.5 SF | \$ 4.59/SF | \$ 3,160.22 |
| Acoustic Ceiling | 1337.81 SF | \$ 4.21/SF | \$ 5,632.18 |
| Mechanical Duct Work | -- | -- | \$ 4,236.93 |
| Glass Walls | 402.34 SF | \$ 2900/48 SF opening | \$ 24,308.04 |
| Doors | 6 | \$ 590/ea | \$ 3,540.00 |
| Tables | 10 | \$ 500/ea | \$ 5,000.00 |
| Total Savings | | | \$ 45,877.37 |

| ADDITIONS (COSTS) | | | |
|---------------------------|----------|------------|---------------------|
| Item | Quantity | Cost/Item | \$ Spent |
| Office Workstations | 16 | \$ 2700/ea | \$ 43,200.00 |
| Mechanical Duct Work | -- | -- | \$ 3,178.64 |
| Total Expenditures | | | \$ 46,378.64 |
| Difference | | | \$ 501.27 |

| EXTERIOR WALL REDESIGN | | | |
|------------------------|---------------------|----------|---------------------|
| Original | | Proposed | |
| Quantity | Cost | Quantity | Cost |
| 1468 | \$ 29,873.80 | 770 | \$ 15,669.50 |
| 627 | \$ 20,408.85 | 627 | \$ 20,408.85 |
| 665 | \$ 31,321.50 | 0 | \$ - |
| 0 | \$ - | 700 | \$ 56,000.00 |
| | \$ 81,604.15 | | \$ 92,078.35 |

references

All architectural renderings courtesy of SmithGroupJJR

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