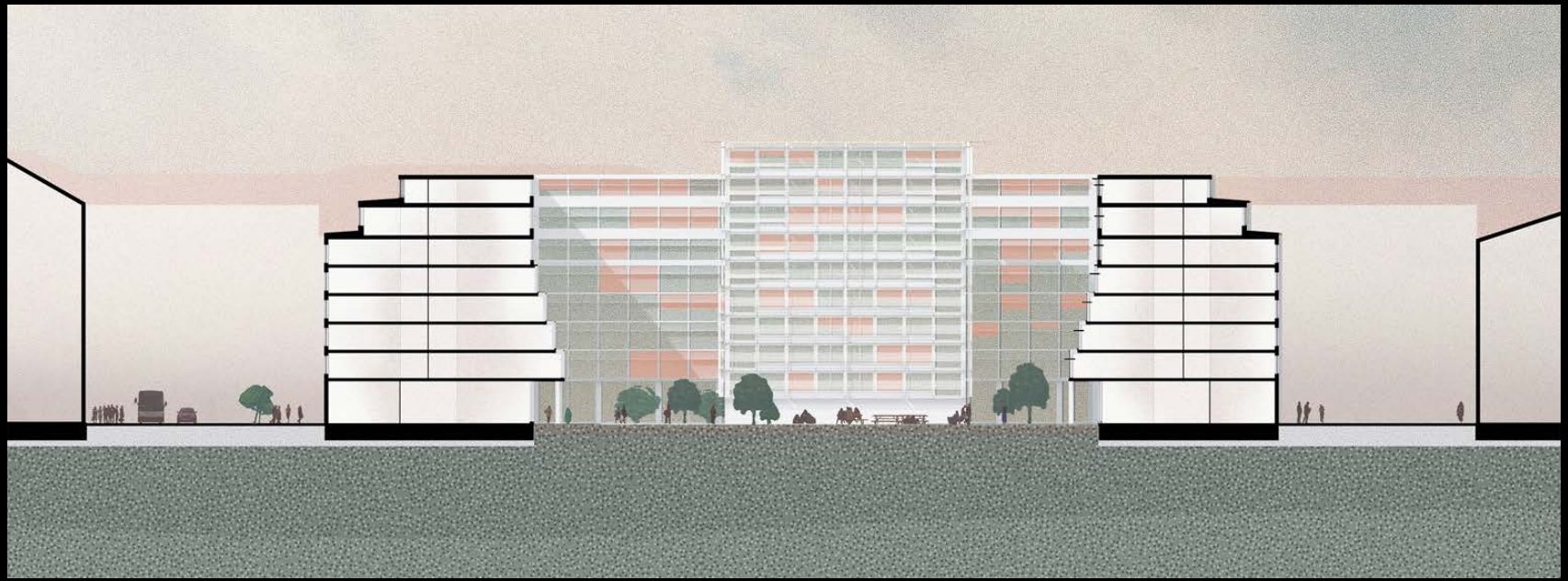
Toward a More Sustainable Munich

Zach Berzolla, Niall Buckley, Claire Holley, and Tristan Searight

4.433 Final Presentation



Design Philosophy

Guiding Principles

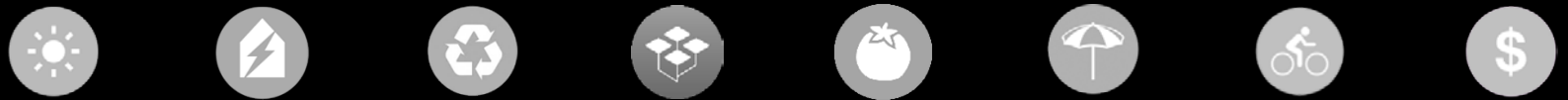
- ❑ Efficient energy consumption, sustainable energy supply
- ❑ Vibrant, attractive, inclusive community to live, work, and play
- ❑ Design for climate resilient comfort

Munich Context

- ❑ Respect historical context and surrounding scale

Mixed Use

- ❑ First-floor retail
- ❑ Six stories of residential



Munich Maxvorstadt Context

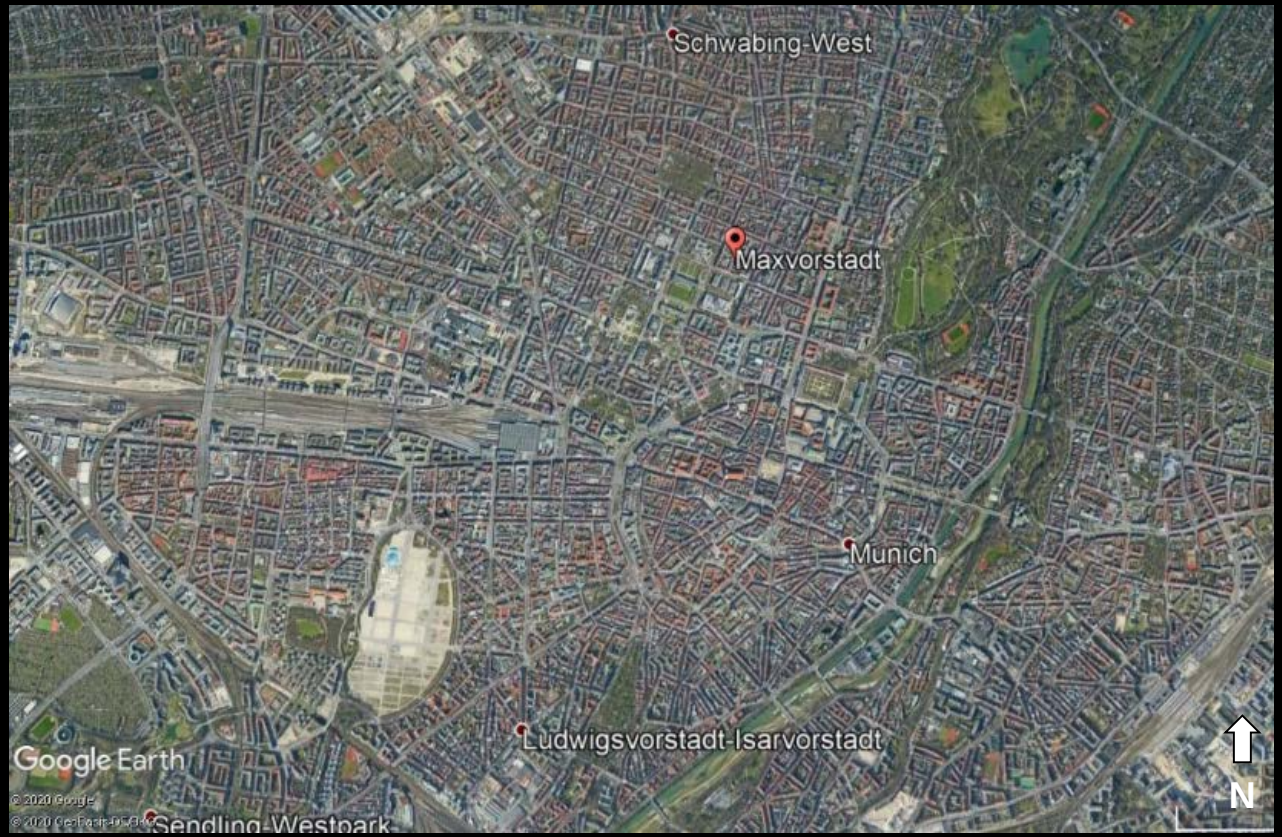
- Arts and University District
- Typical population
  - Students
  - Working professionals
- Generally wealthy neighborhood
- Traditional energy supply
  - Gas
  - Electricity

https://upload.wikimedia.org/wikipedia/commons/b/bc/MU_Maxvorstadt_RichardWagnerStra%C3%9FeA.jpg

https://en.wikipedia.org/wiki/History_of_BMW#/media/File:4_cilindros_y_museo_BMW,_M%C3%BAnich,_Alemania_2012-04-28,_DD_02.JPG

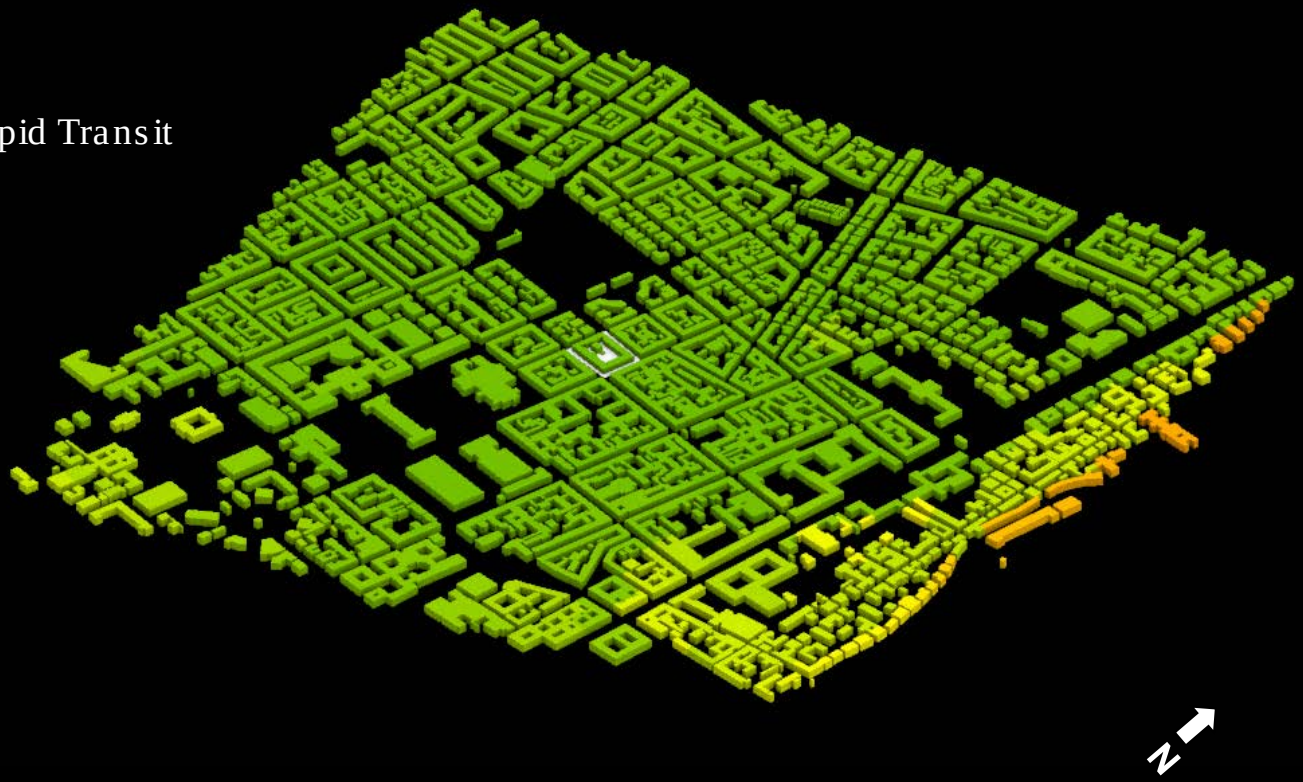
Munich Maxvorstadt Context

- ❑ Building age: 1950s-1960s
- ❑ Population: 1.5 Million
- ❑ Characteristic European city
- ❑ Desire to increase density



Walkable Neighborhood

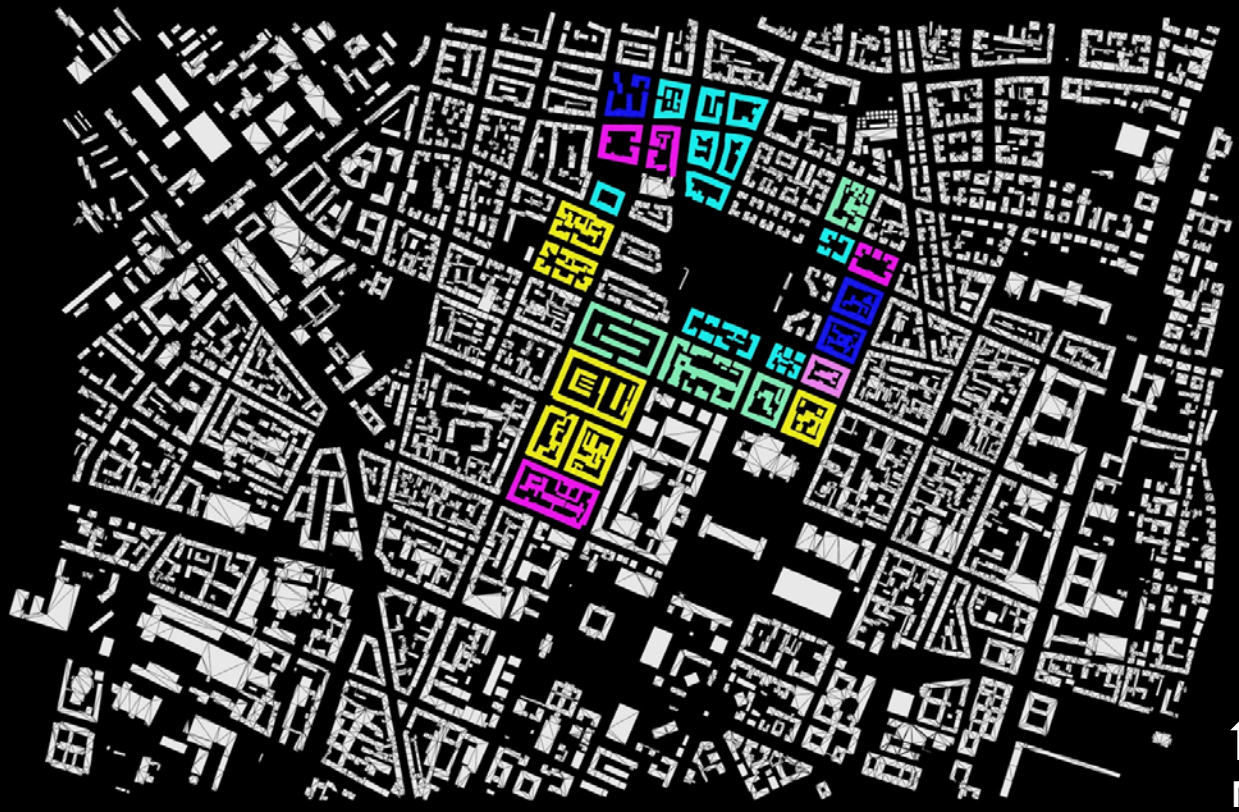
- Walk Score: 78
- U-Bahn Underground Rapid Transit
- Surface Trams & Buses



Protoblock Replicability

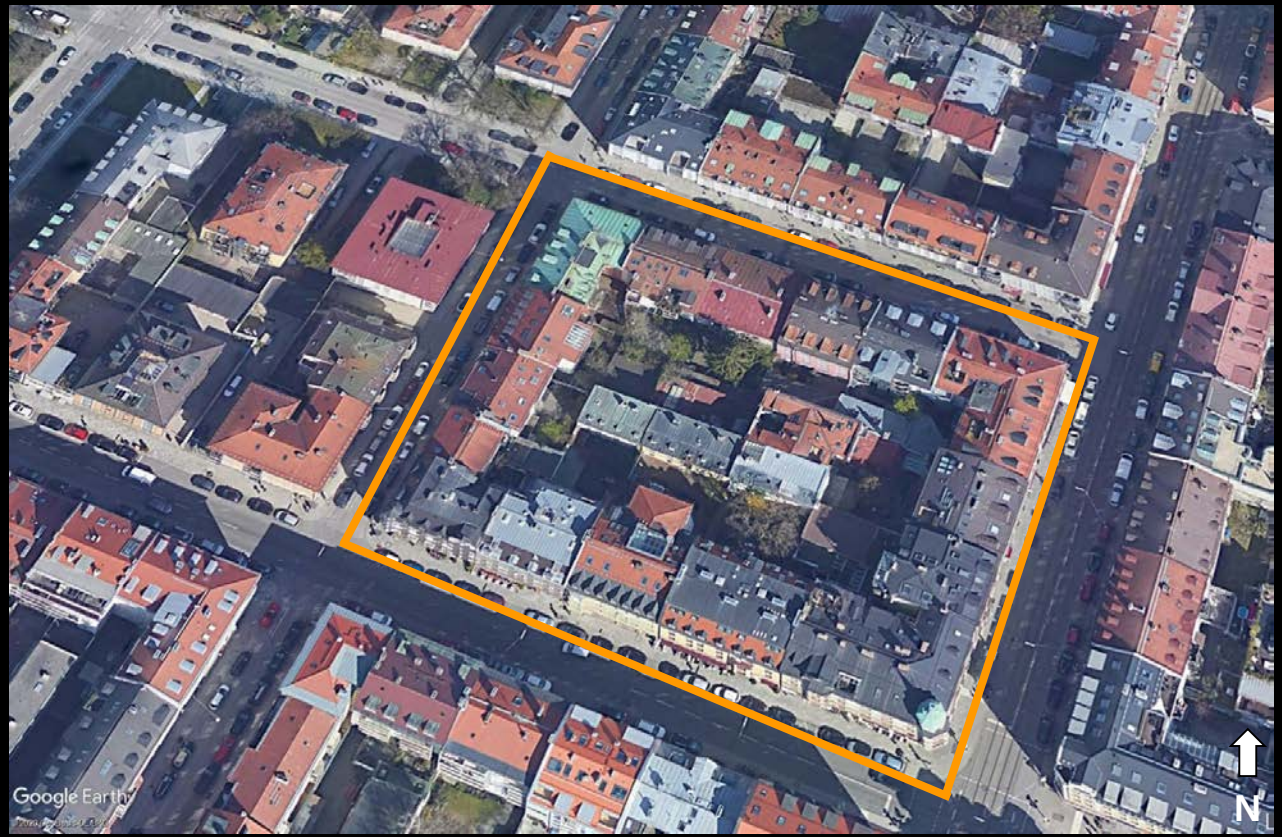
Block Sizes

- 10,000 m²
  - 11
- 15,000 m²
  - Protoblock Design
  - 6
- 18,000 m²
  - 3
- 20,000 m²
  - 6
- 22,000 m²
  - 7



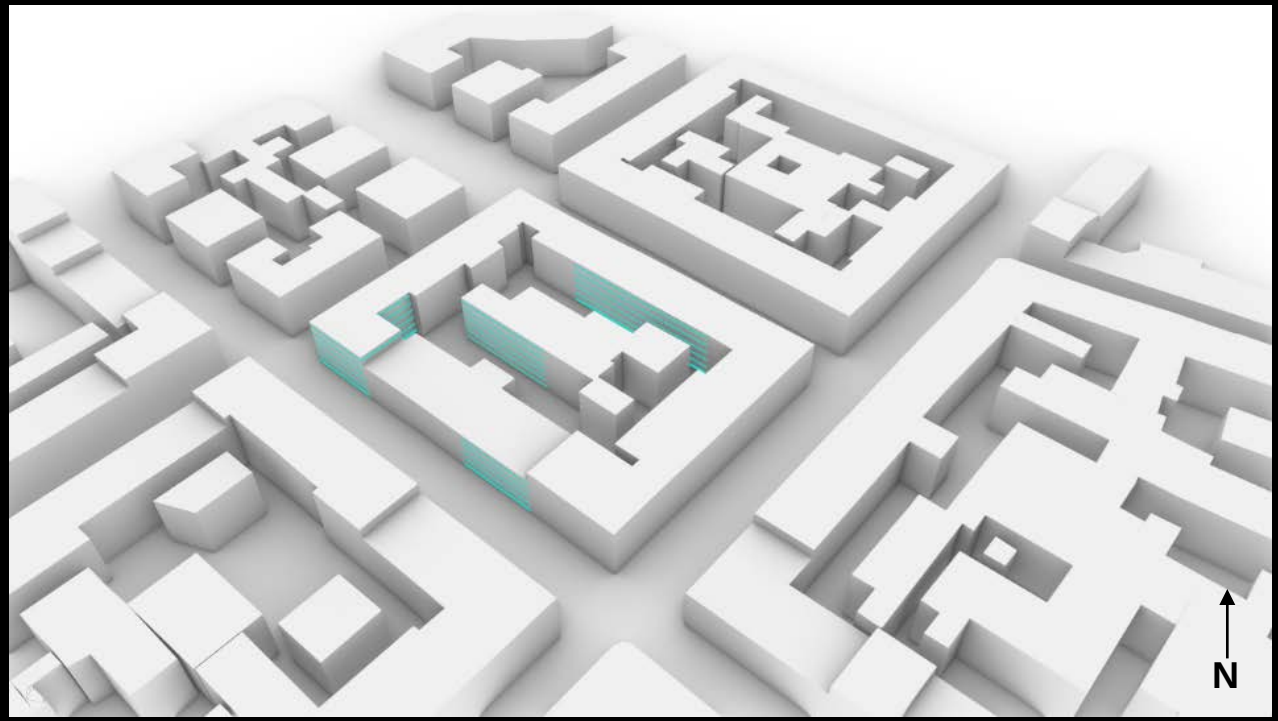
Existing 15,000 m^2 Protoblock

- Mixed Use
  - Retail first floor
  - Residential floors two through six
- 1,474 Occupants

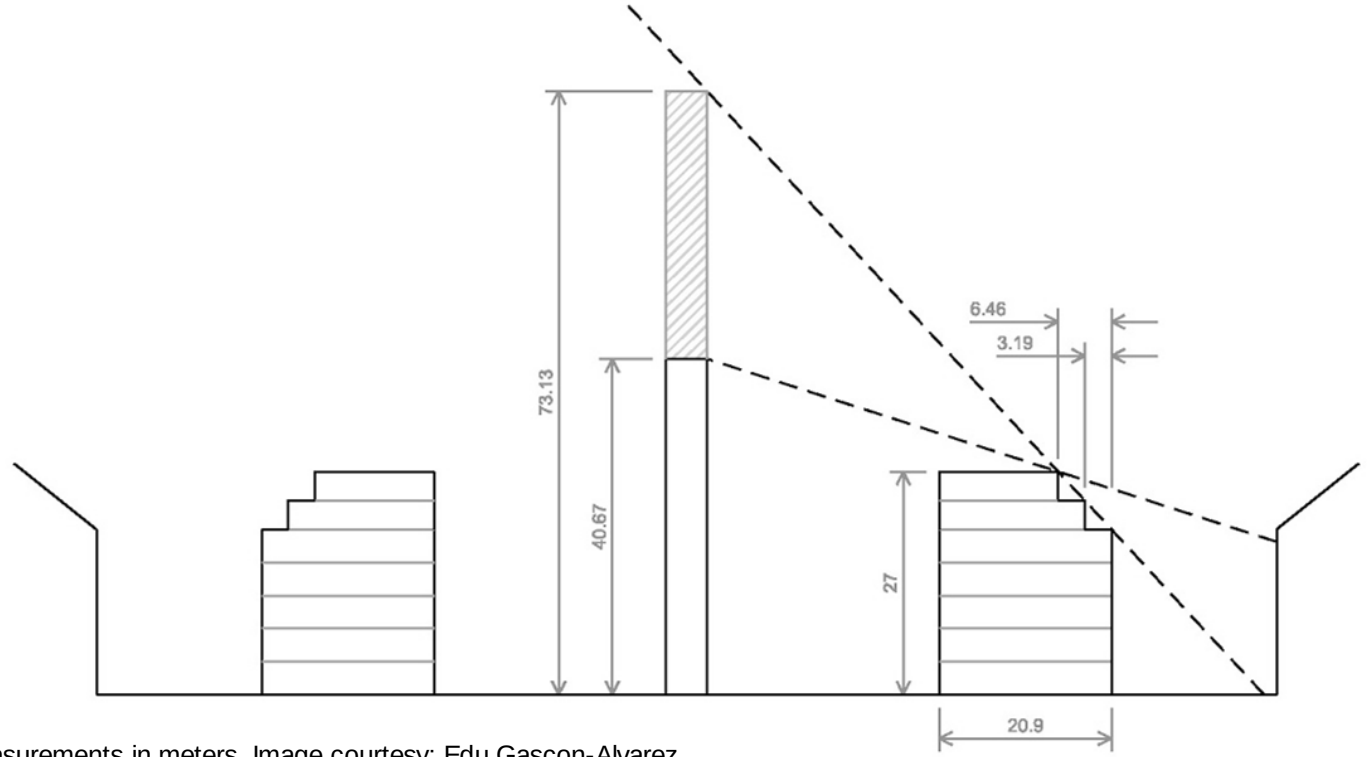


Existing Protoblock: 105m x 140m

- Enclosure U-Values (W/m^2K)
  - Wall: 1.21
  - Roof: 0.51
  - Slab: 1.08
  - Windows: 3
- HVAC System
  - Gas Boiler
    $\eta = 0.84$
- Window-to-Wall Ratio
  - Residential = 20%
  - Retail = 40%



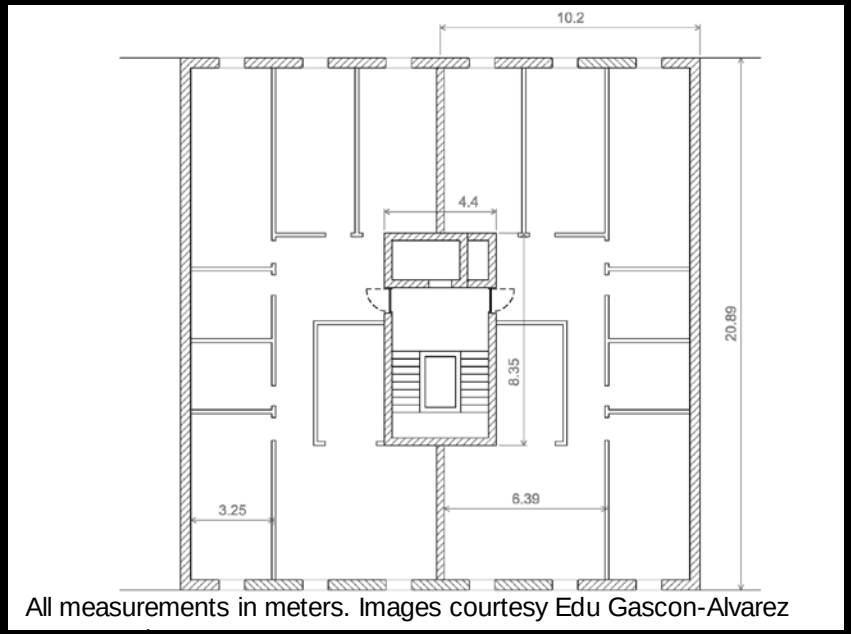
Munich Development Rules: Street View Preservation



All measurements in meters. Image courtesy: Edu Gascon-Alvarez

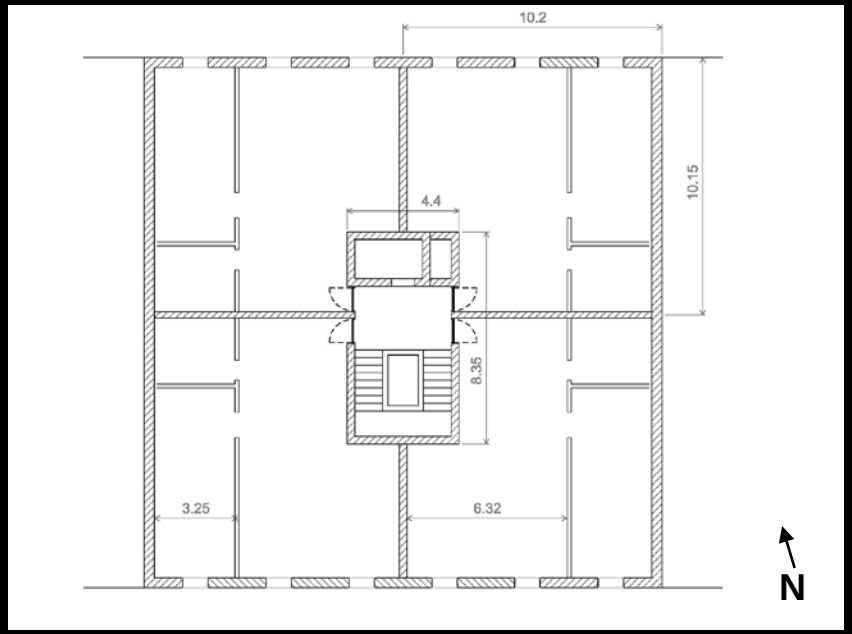
Typical Floor Plan for Existing Buildings

2 Apartments/floor 180 m^2/apartment



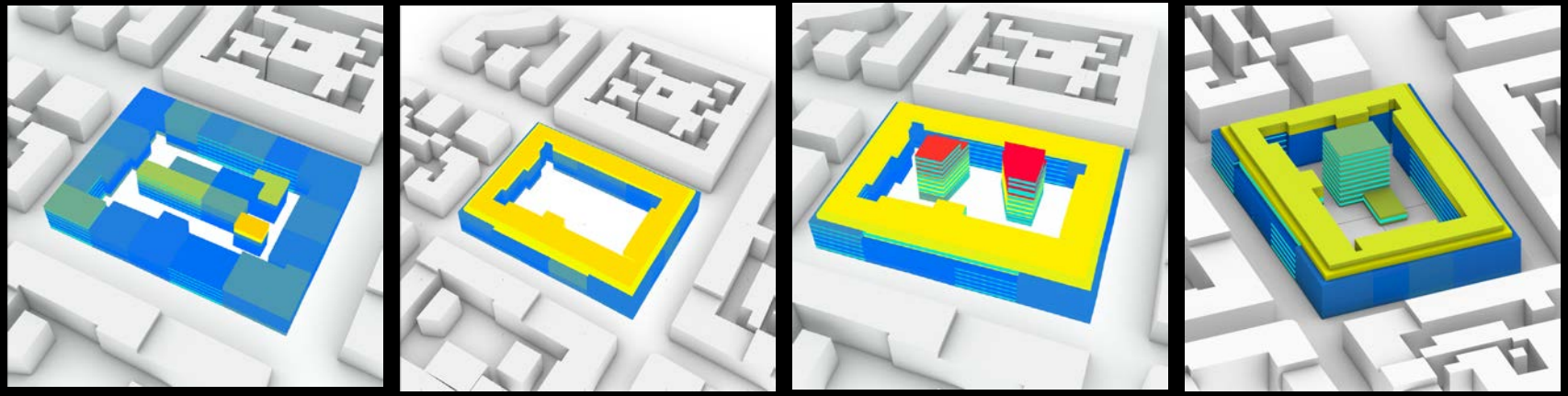
All measurements in meters. Images courtesy Edu Gascon-Alvarez

4 Apartments/floor 90 m^2/apartment

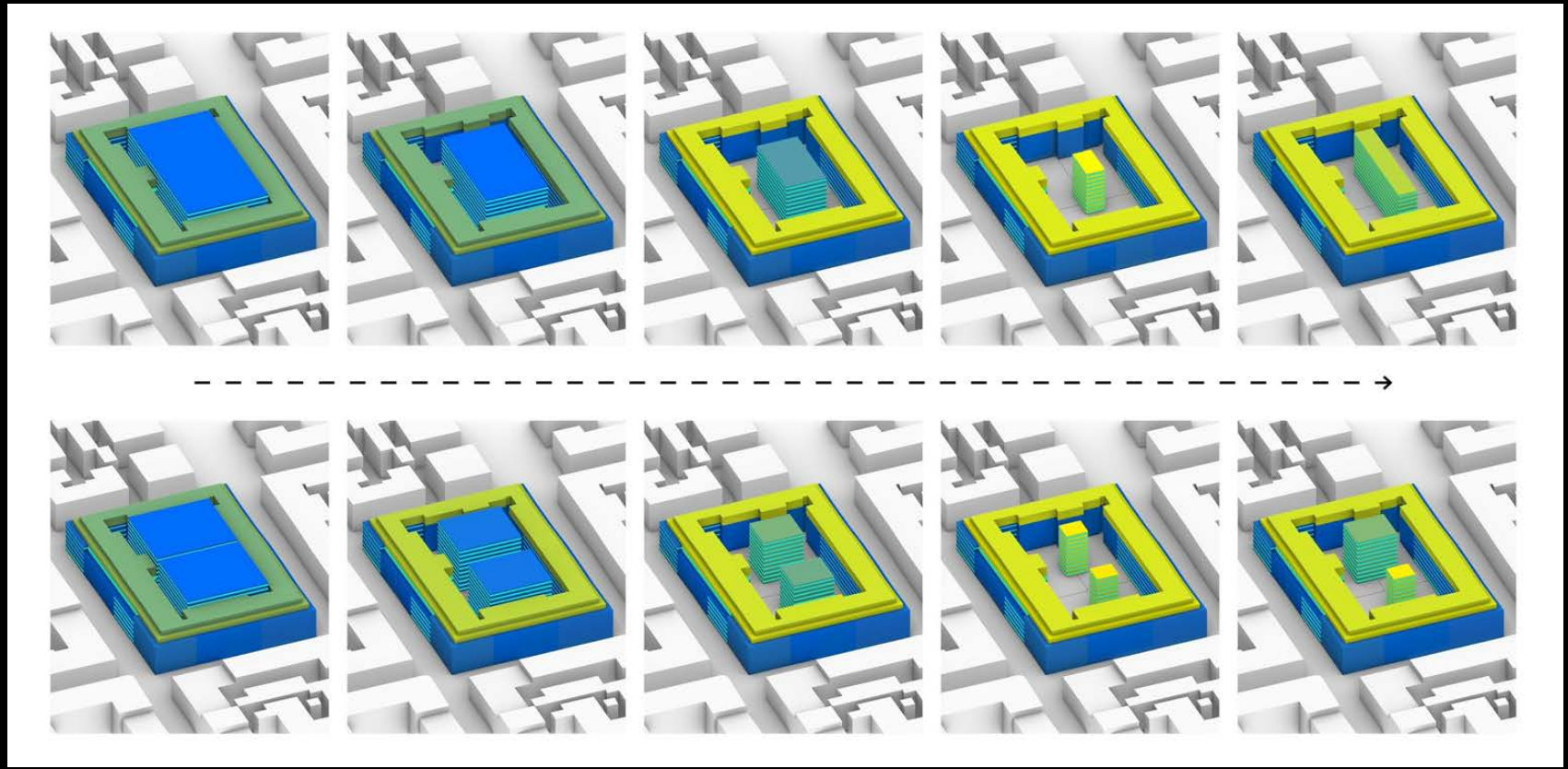


Massing Evolution

- ❑ Improve access to daylight
- ❑ Maintain access to greenspace
- ❑ Increase occupant density
- ❑ Preserve historic character

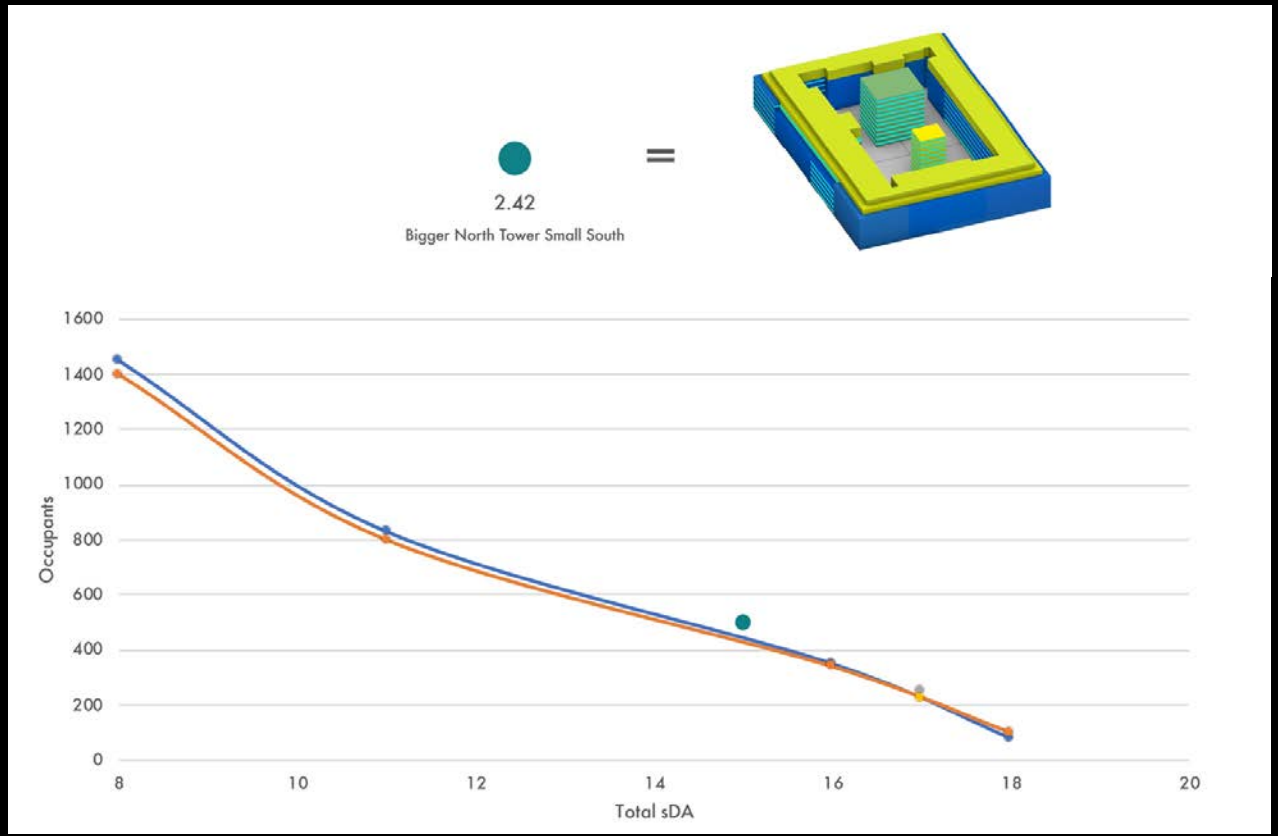


Massing Evolution for Daylight



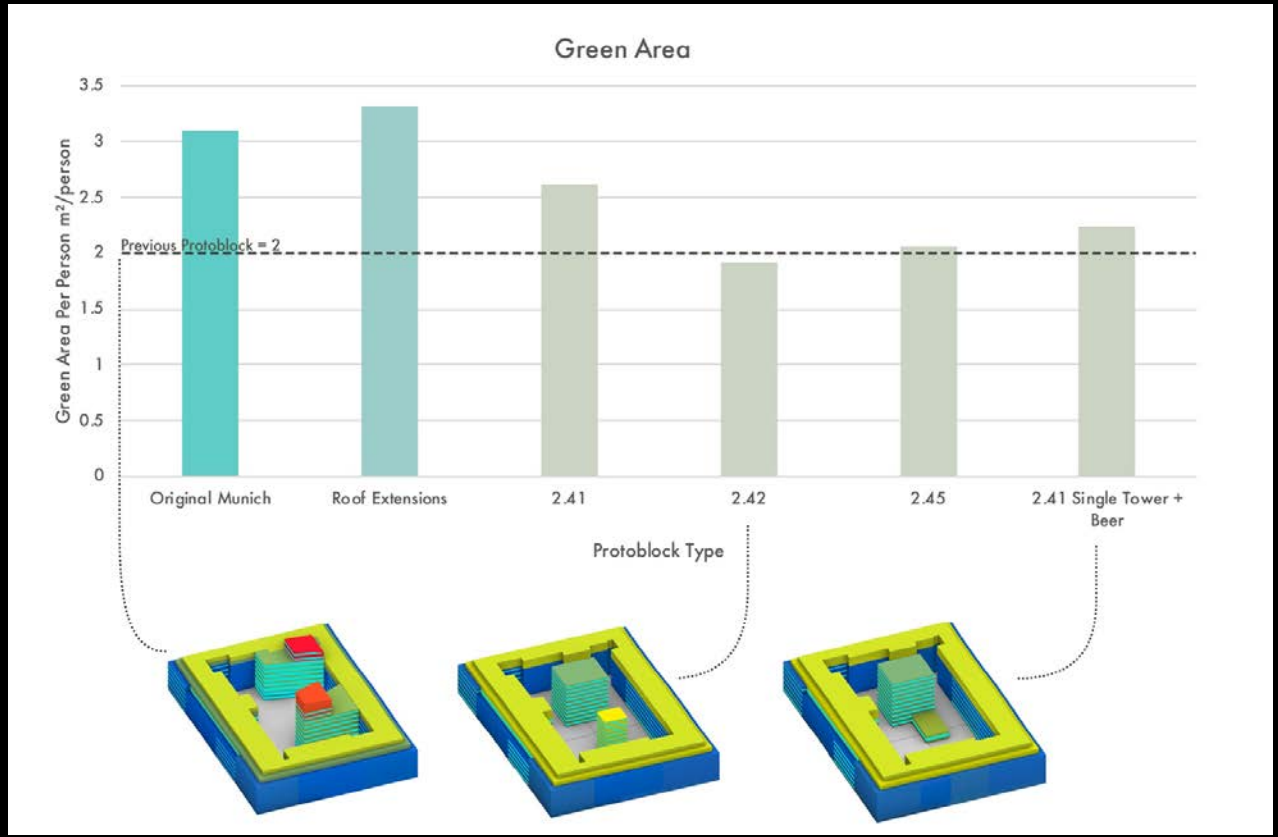
First Set of Protoblock Iterations

- Tradeoff between daylight and density



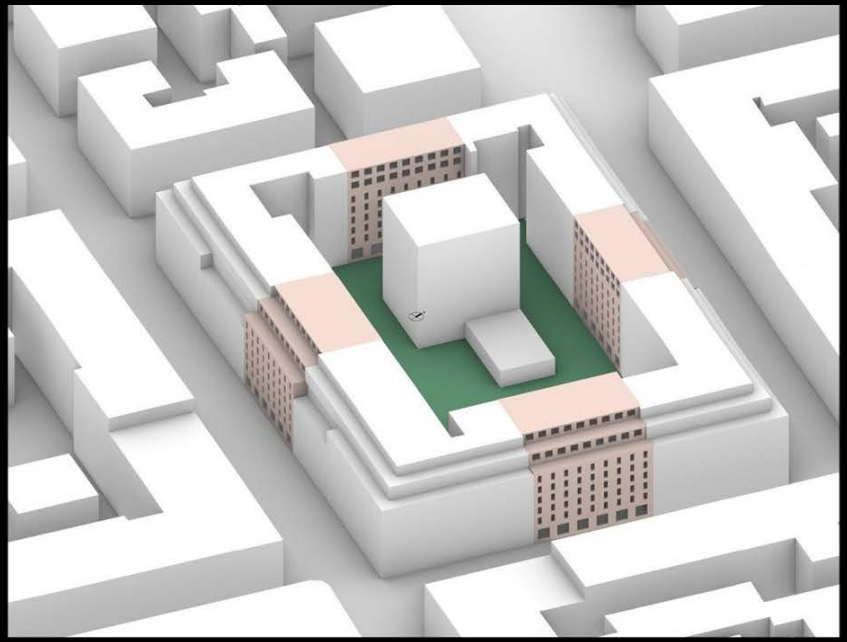
Massing Evolution for Greenspace

- Tradeoff between density and green space for occupants



Courtyard Perimeter Buildings Daylight Studies

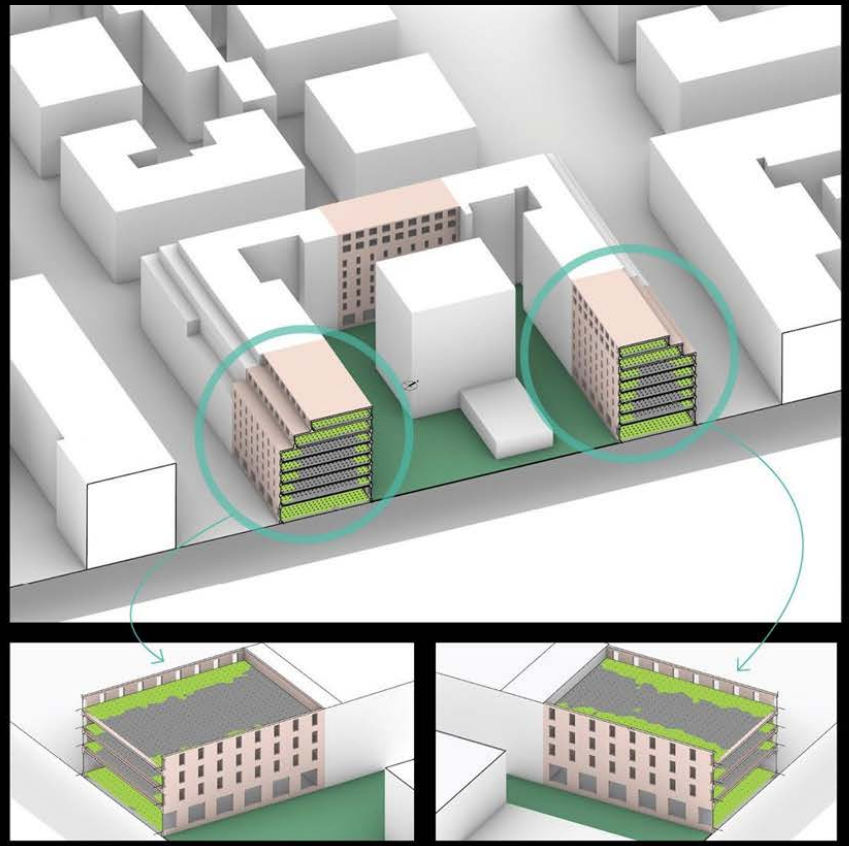
- ❑ Existing buildings
- ❑ Top two story addition



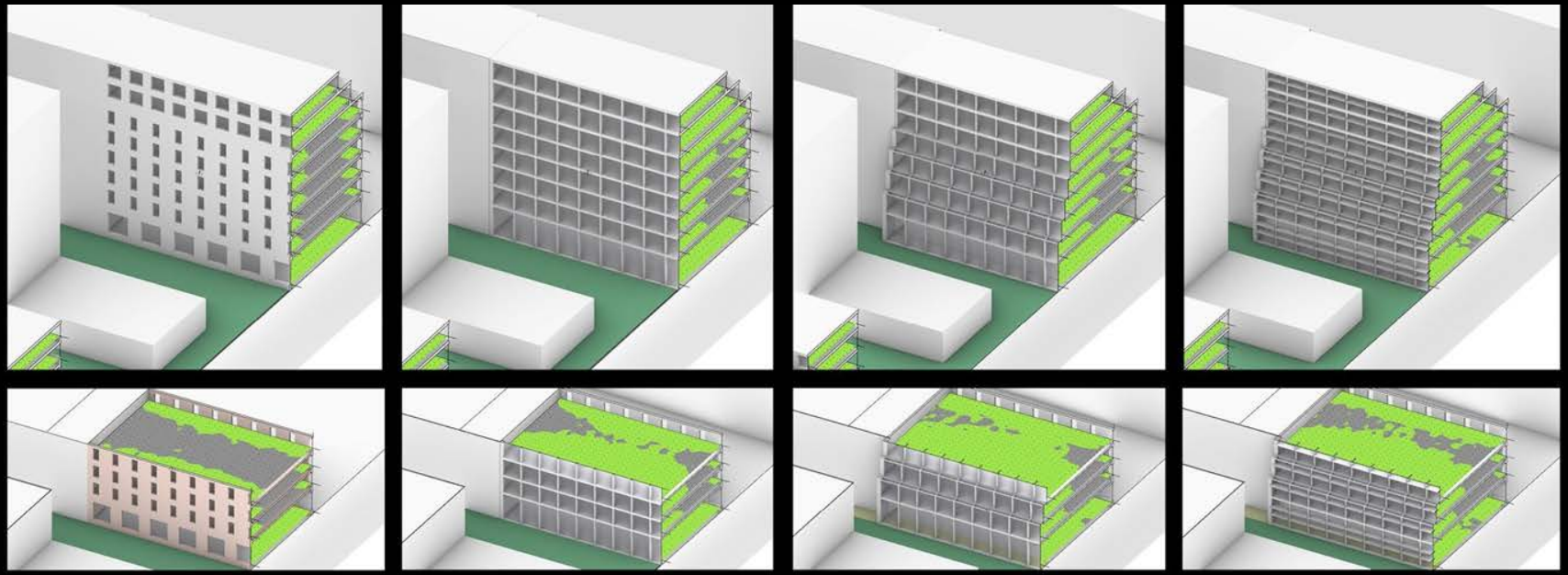
sDA	**50.1**
Mean Lux	**1075**

Simulation Approach

- Four models

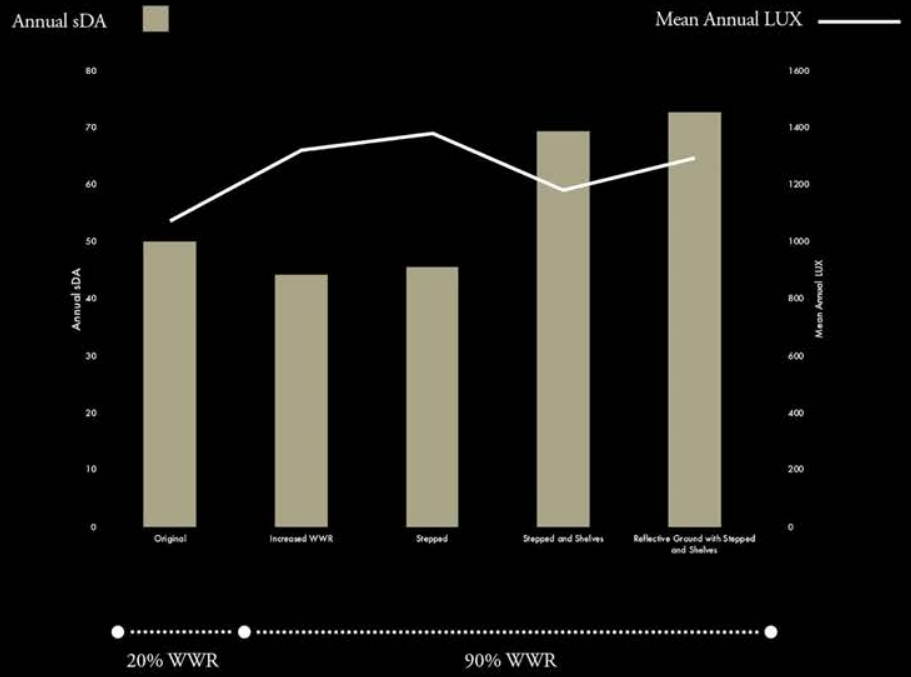


Perimeter Buildings Initial Daylighting Results



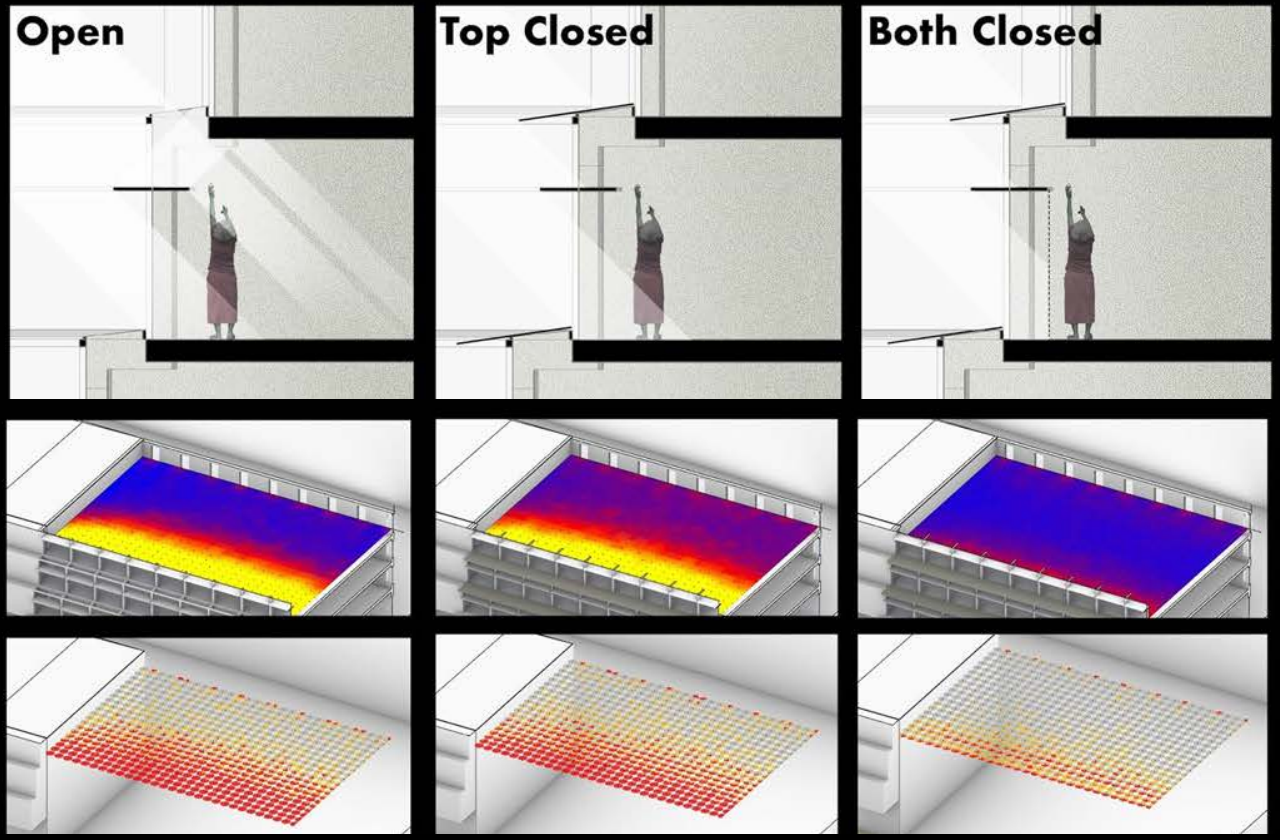
sDA	49.6	sDA	44	sDA	46	sDA	69
Mean Lux	1065	Mean Lux	1319	Mean Lux	1382	Mean Lux	1182

Perimeter Buildings Initial Daylighting Results



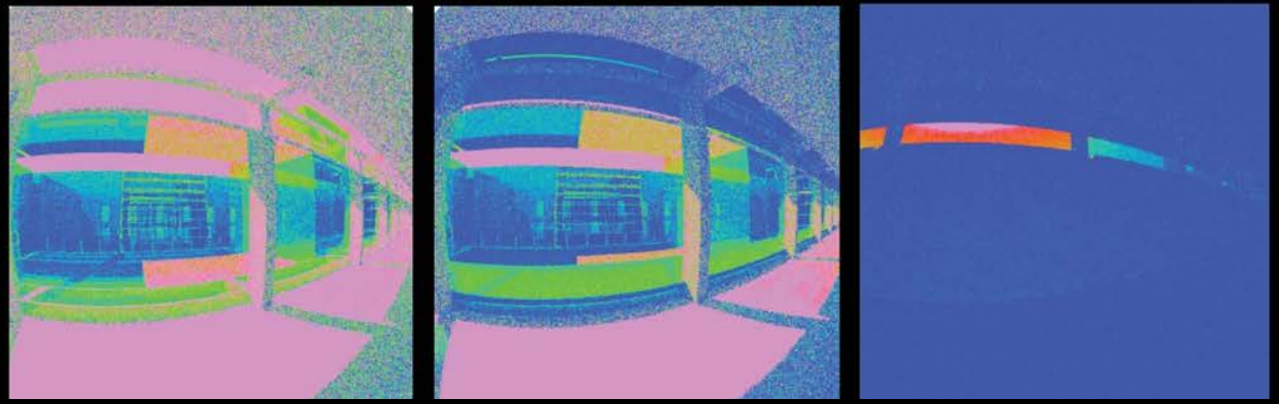
Visual Comfort Analysis

Blind State
Section of 4th Floor

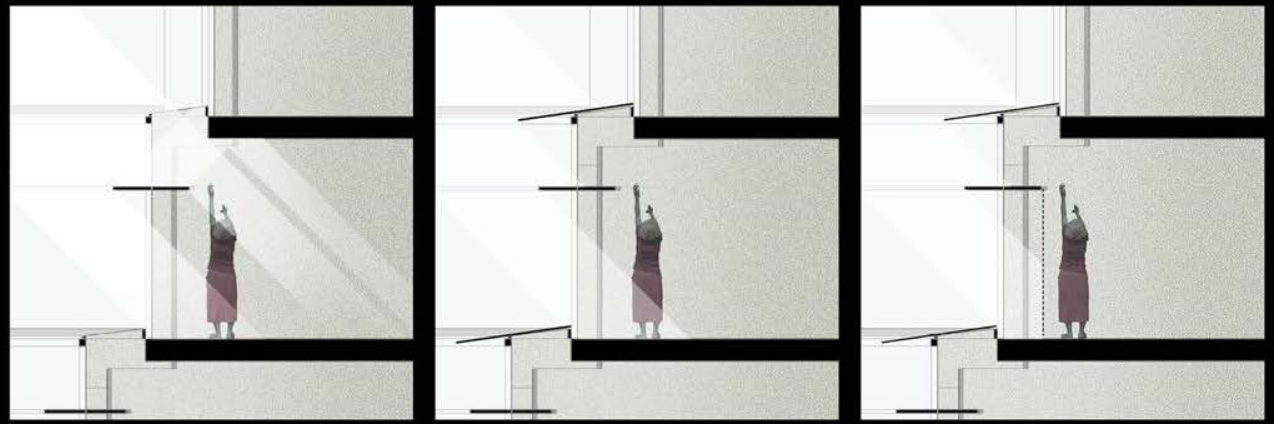


Visual Comfort Analysis

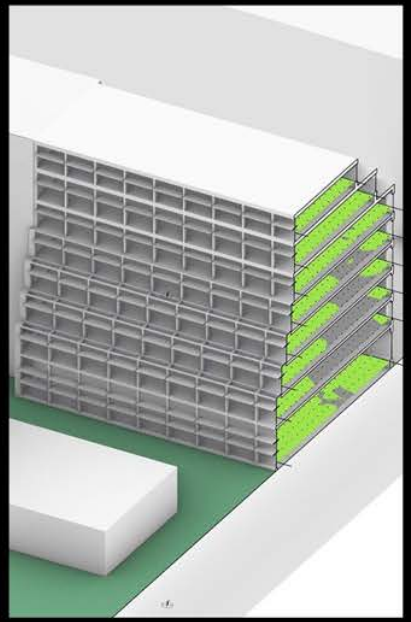
False Colour Glare
Interior view on 4th Floor



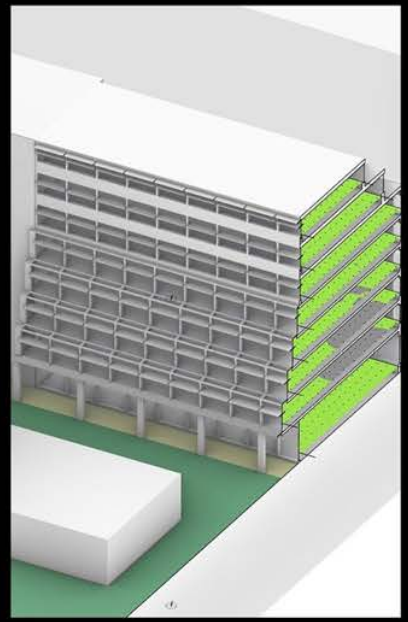
Blind State
Section of 4th Floor

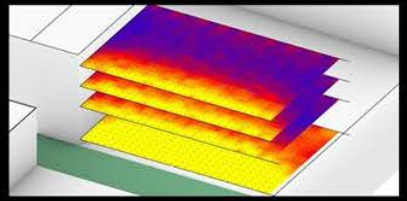


Final Perimeter Daylighting Results

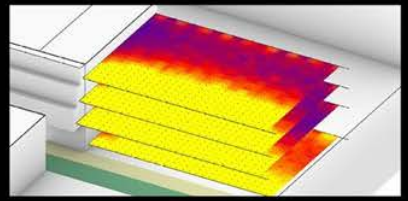


1. *Push back ground floor*
2. *Reduce WWR on top floors*
3. *Add Static Shading to top Floor*





Illuminance
Spring Equinox
12pm



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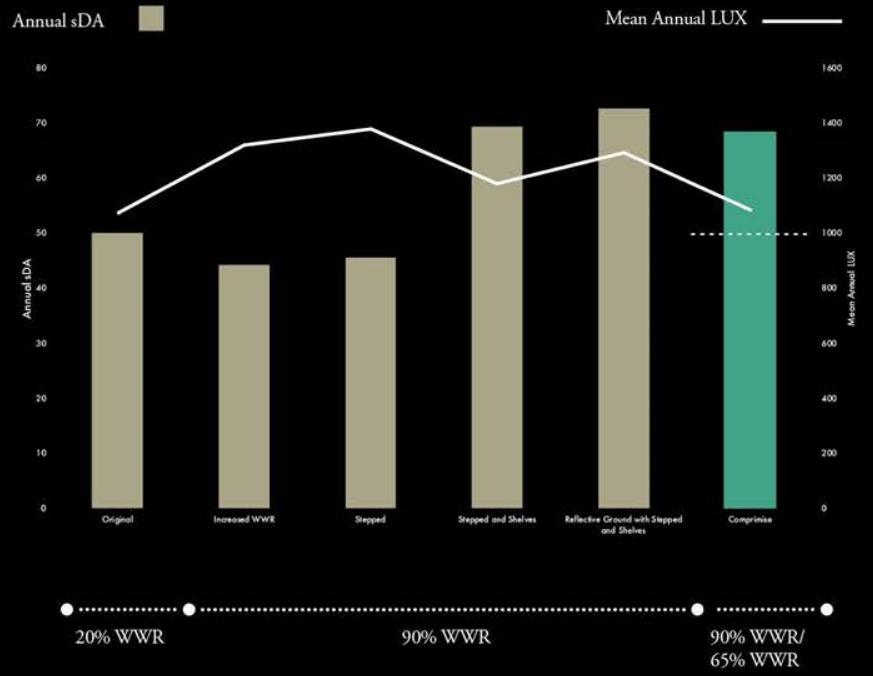
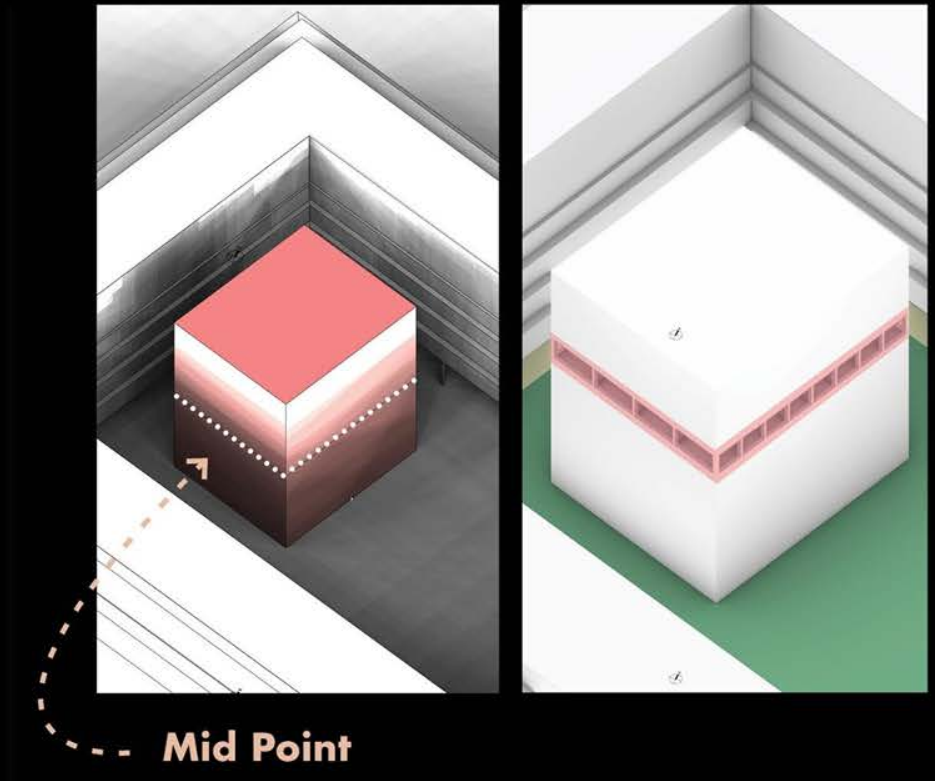
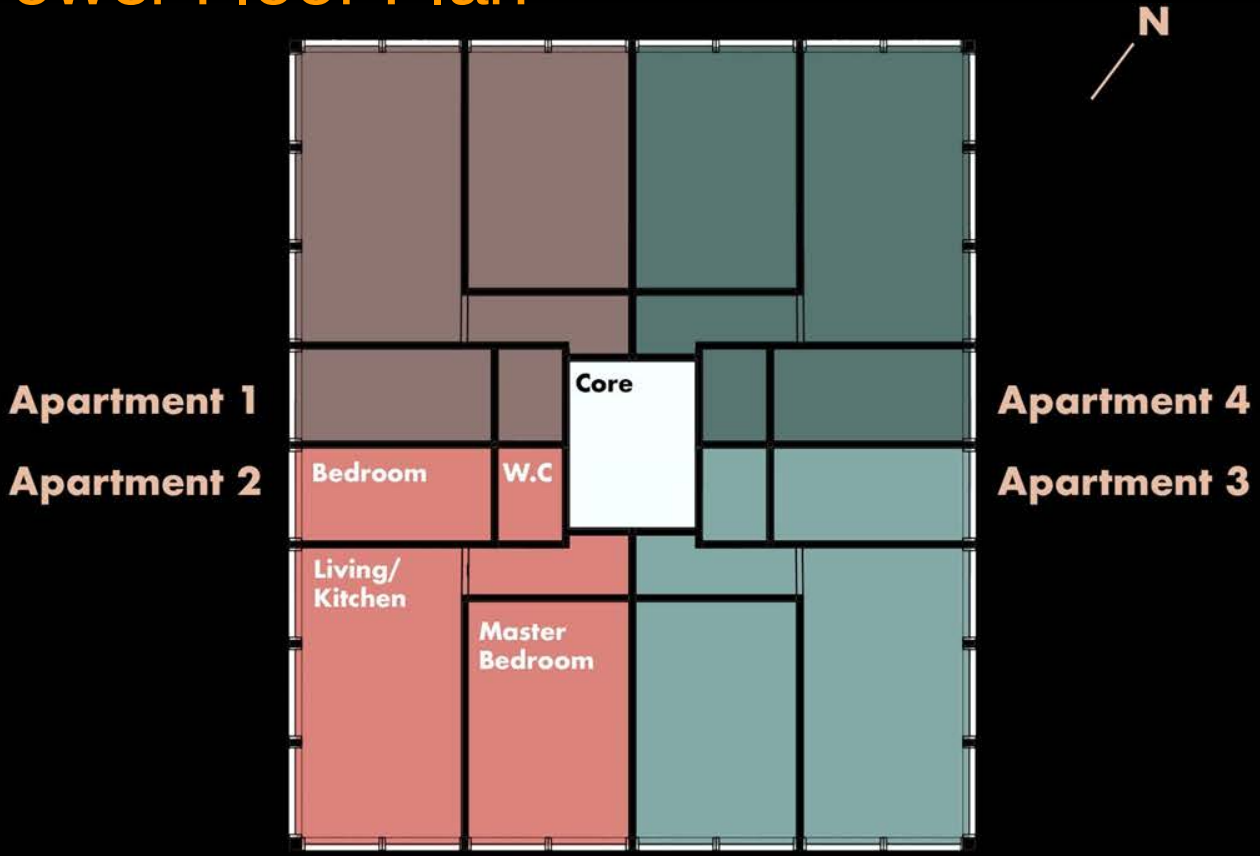


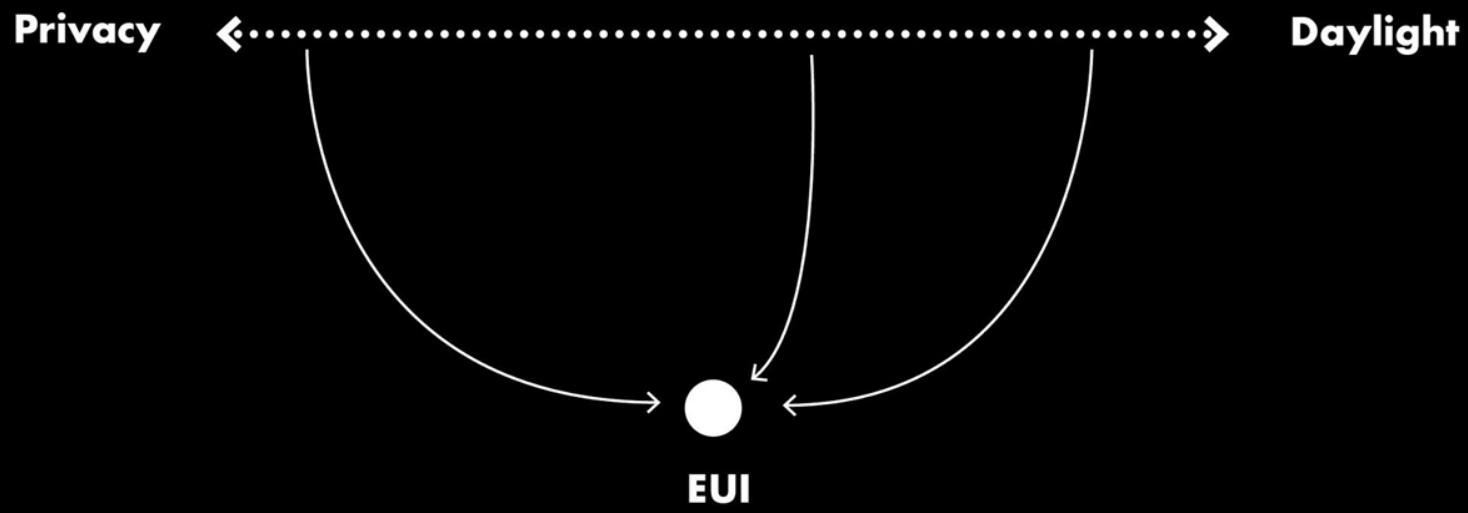
Central Building Daylighting Study



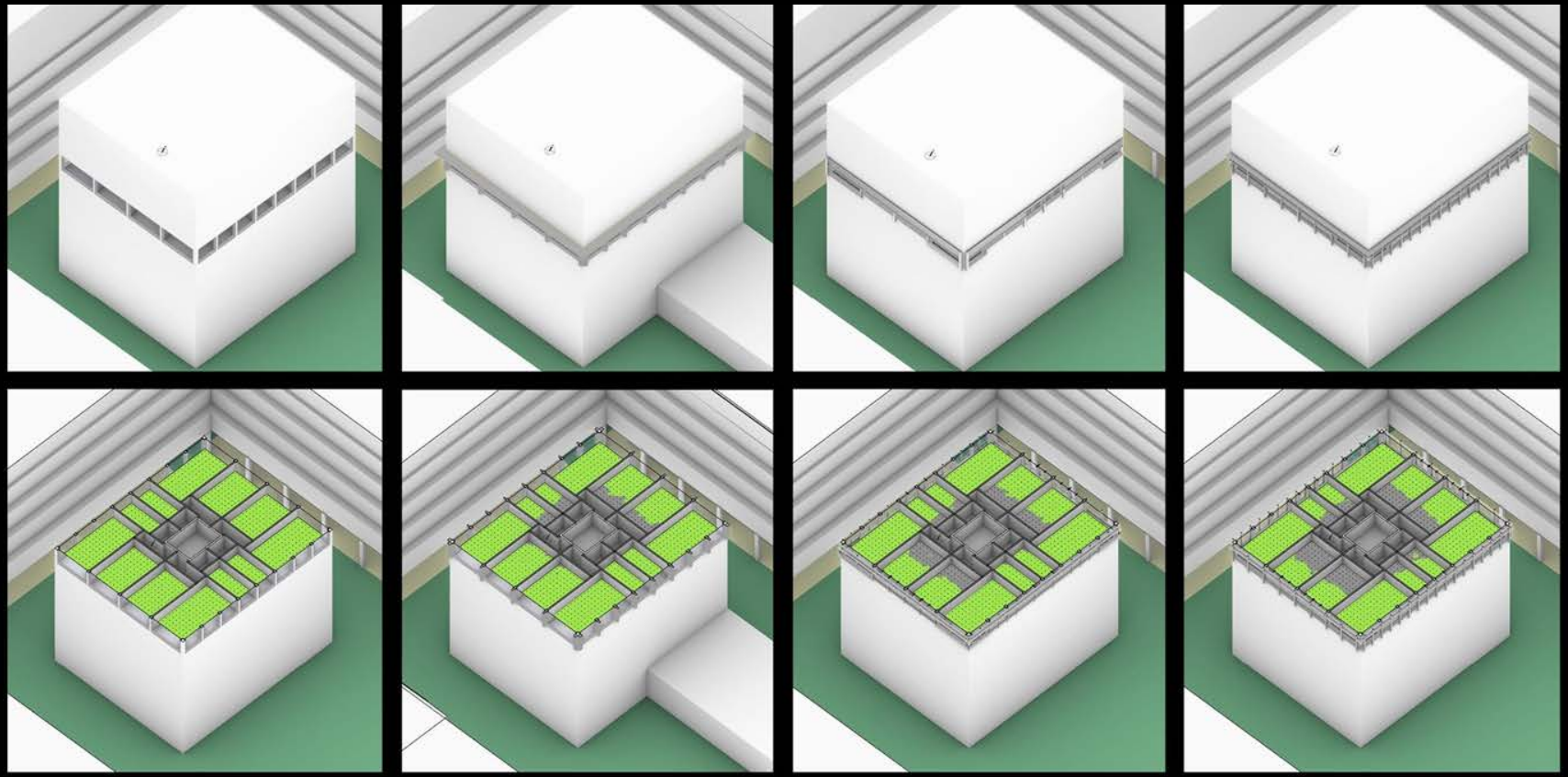
Central Tower Floor Plan



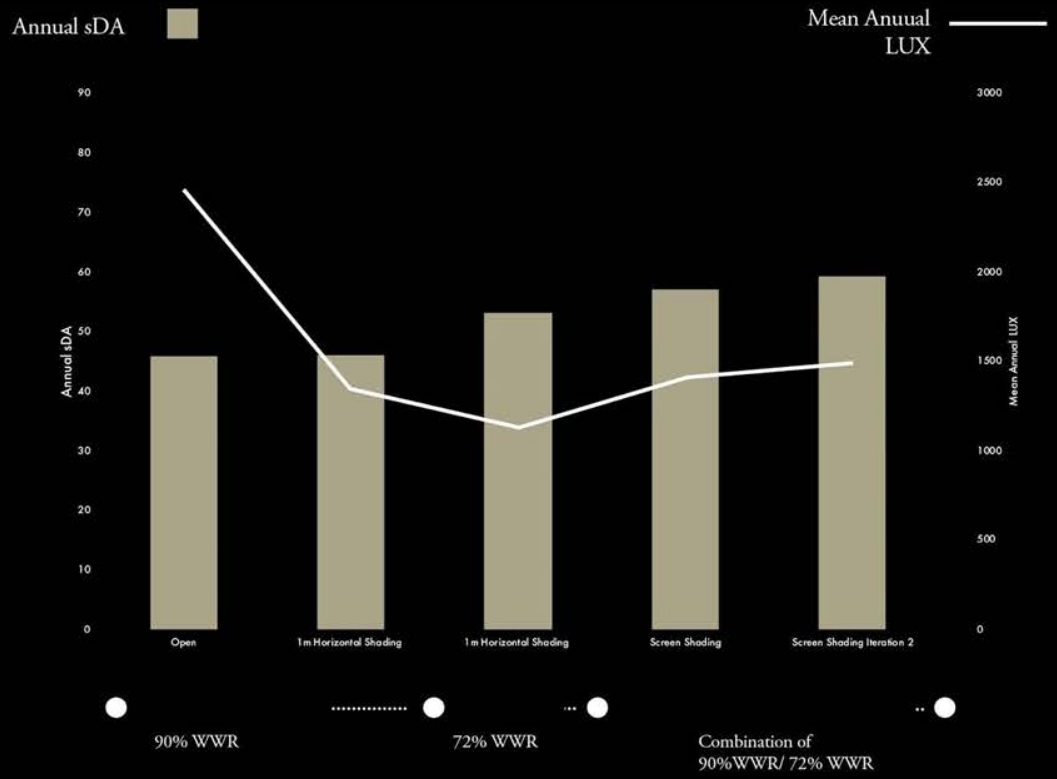
The Challenge



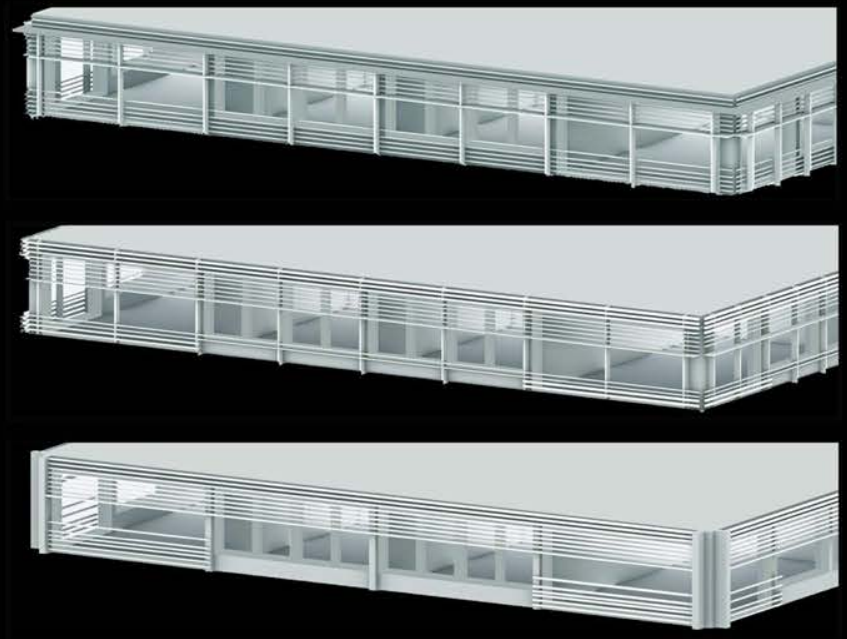
Central Building Daylighting Study



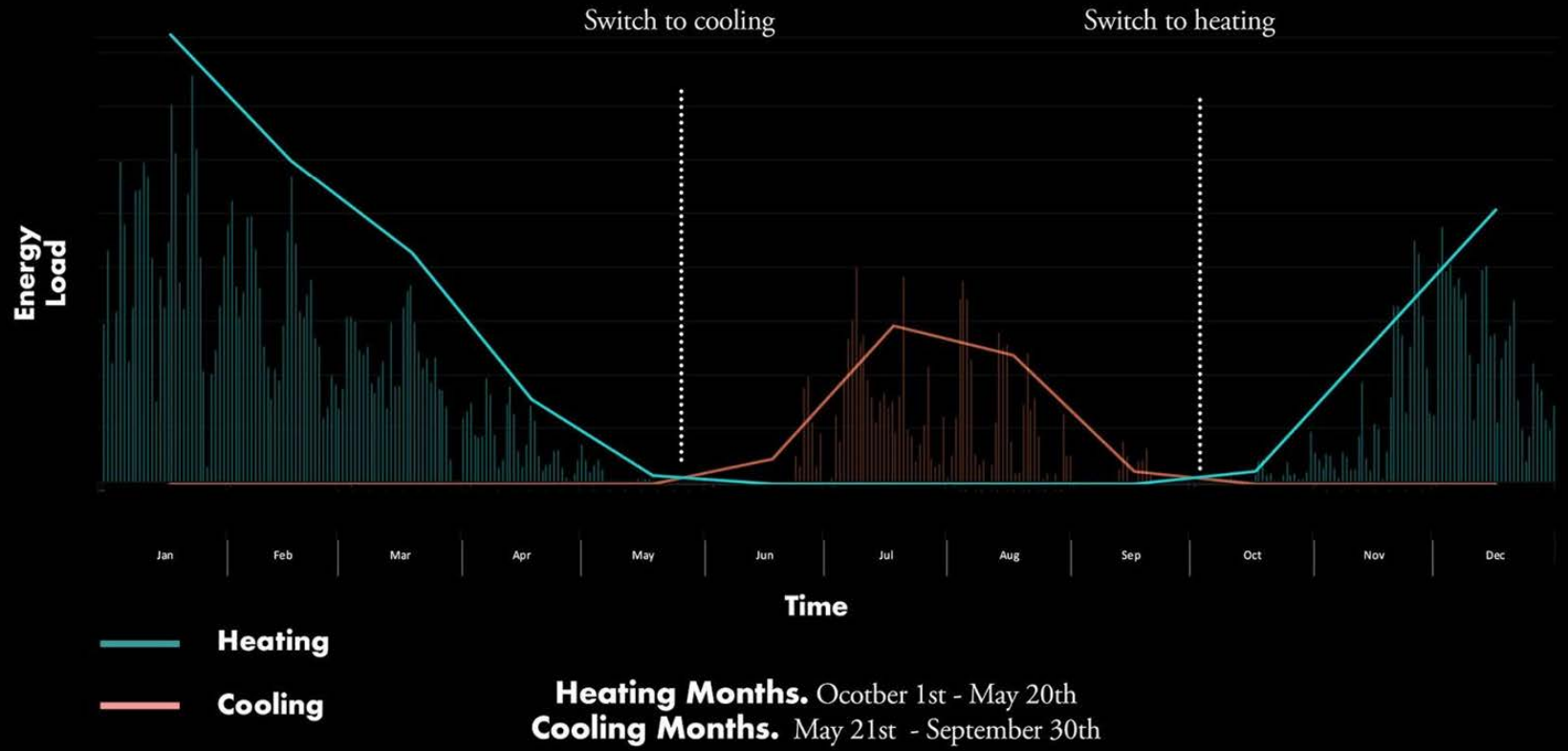
Central Building Initial Daylighting Results



Shading Adjustments



Shading for Solar Heat Gain Control

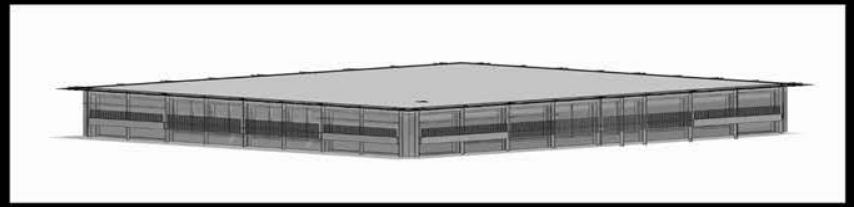


Shading for Solar Heat Gain Control

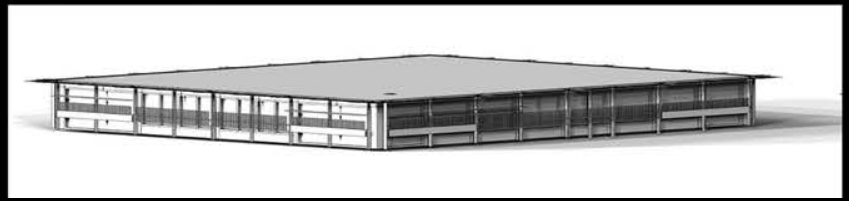
Needs Sunlight ⟷ **Needs Shade**

Heating Months
Cumulative Sunlight

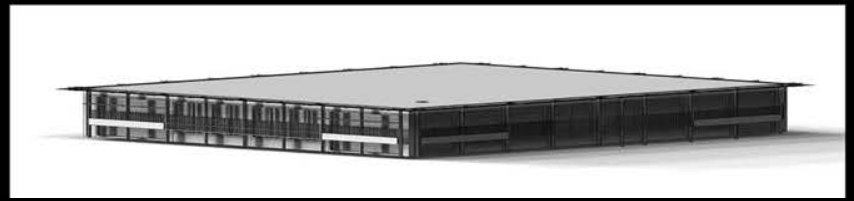
Cooling Months
Cumulative Sunlight



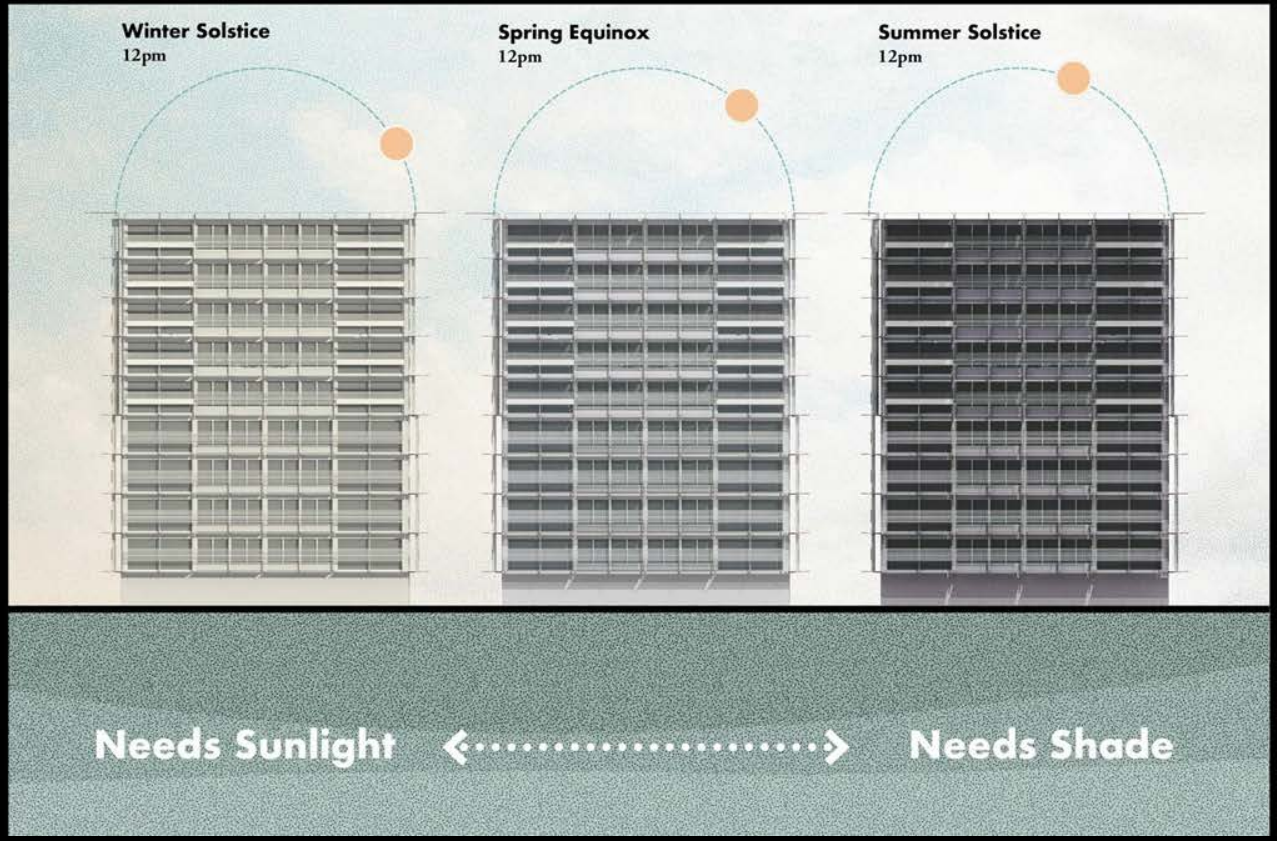
Winter Solstice
12pm Sunlight



Summer Solstice
12pm Sunlight



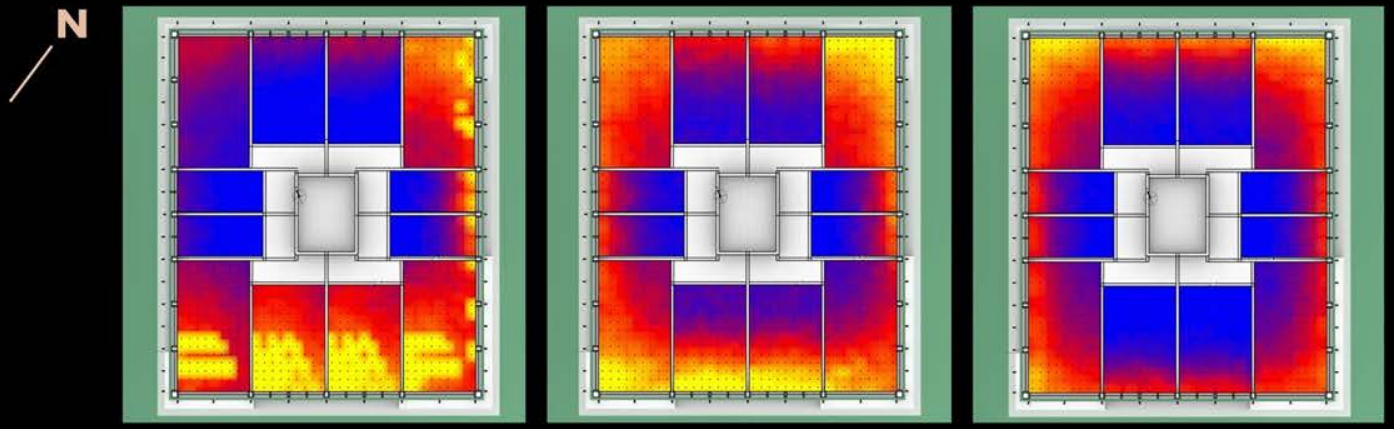
Shading for Solar Heat Gain Control



Central Building Middle Floor Daylighting Analysis

Needs Sunlight ⟷ Needs Shade

Illuminance on 5th Floor

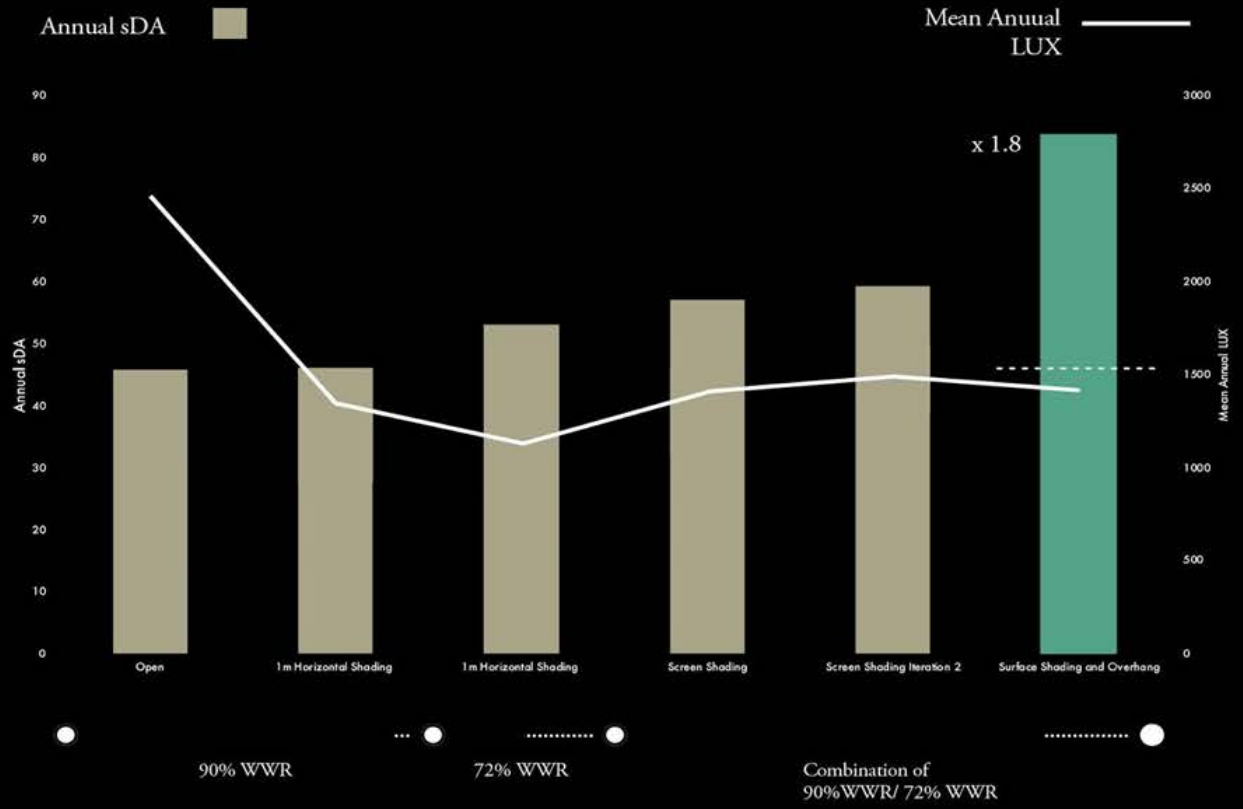


Winter Solstice
12pm

Spring Equinox
12pm

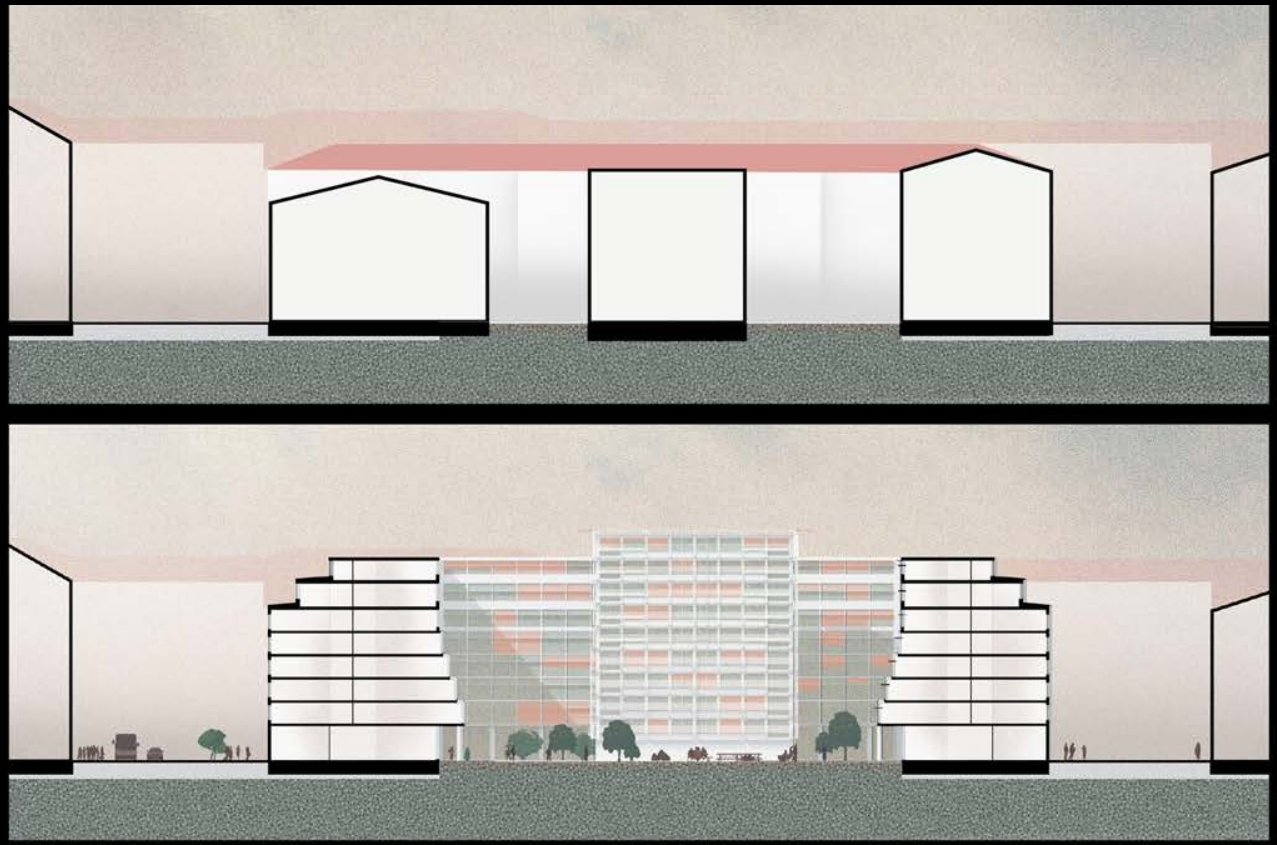
Summer Solstice
12pm

Central Building Middle Floor Daylighting Analysis



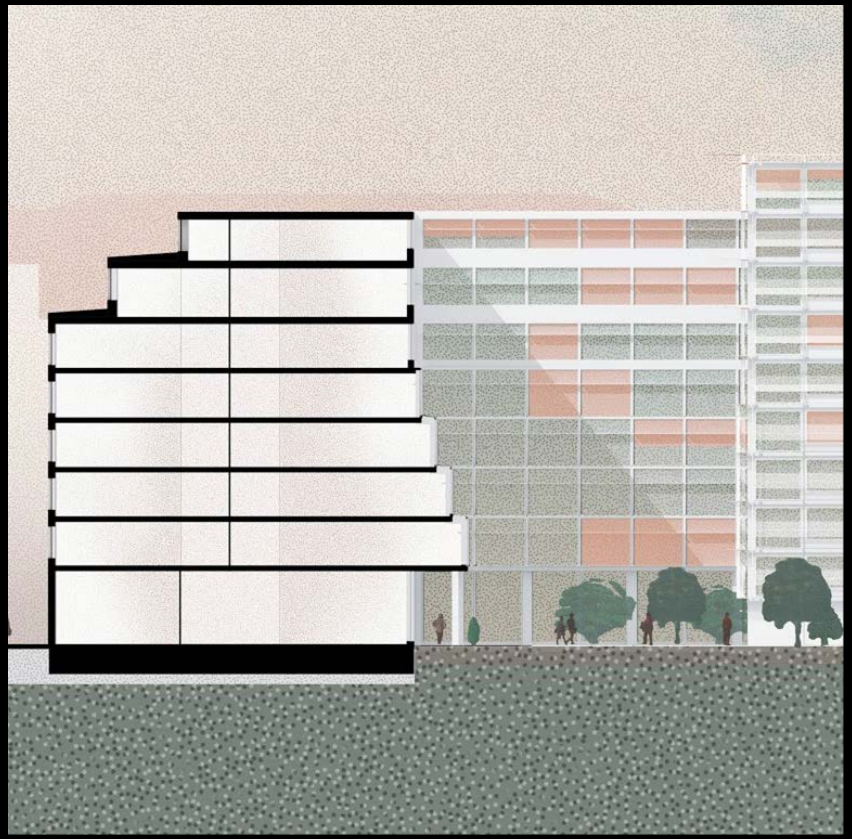
Privacy ‹·····› Daylight

New Central Building Design

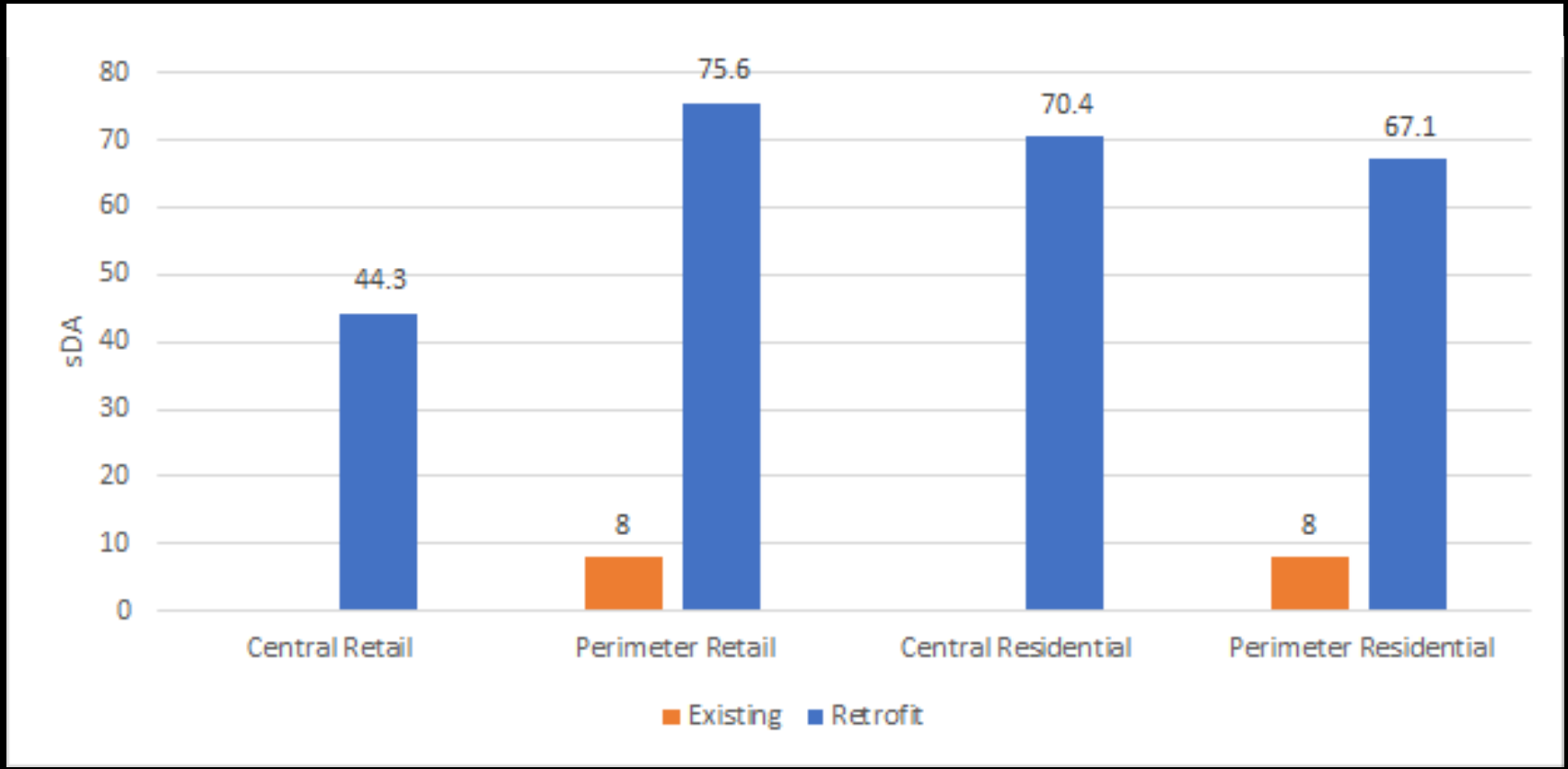


Summary of Proposed Retrofit

- Enclosure U-Values (W/m^2K)
  - Wall = 0.13
  - Roof = 0.09
  - Slab = 0.23
  - Windows = 0.8
- HVAC Systems
  - Heat Pump COP = 3.8
- Window-to-Wall Ratio
  - Perimeter residential street-side = 20%
  - Perimeter residential courtyard-side = 90%
  - Central residential = 65%
  - Retail = 40%
- 1,778 Occupants

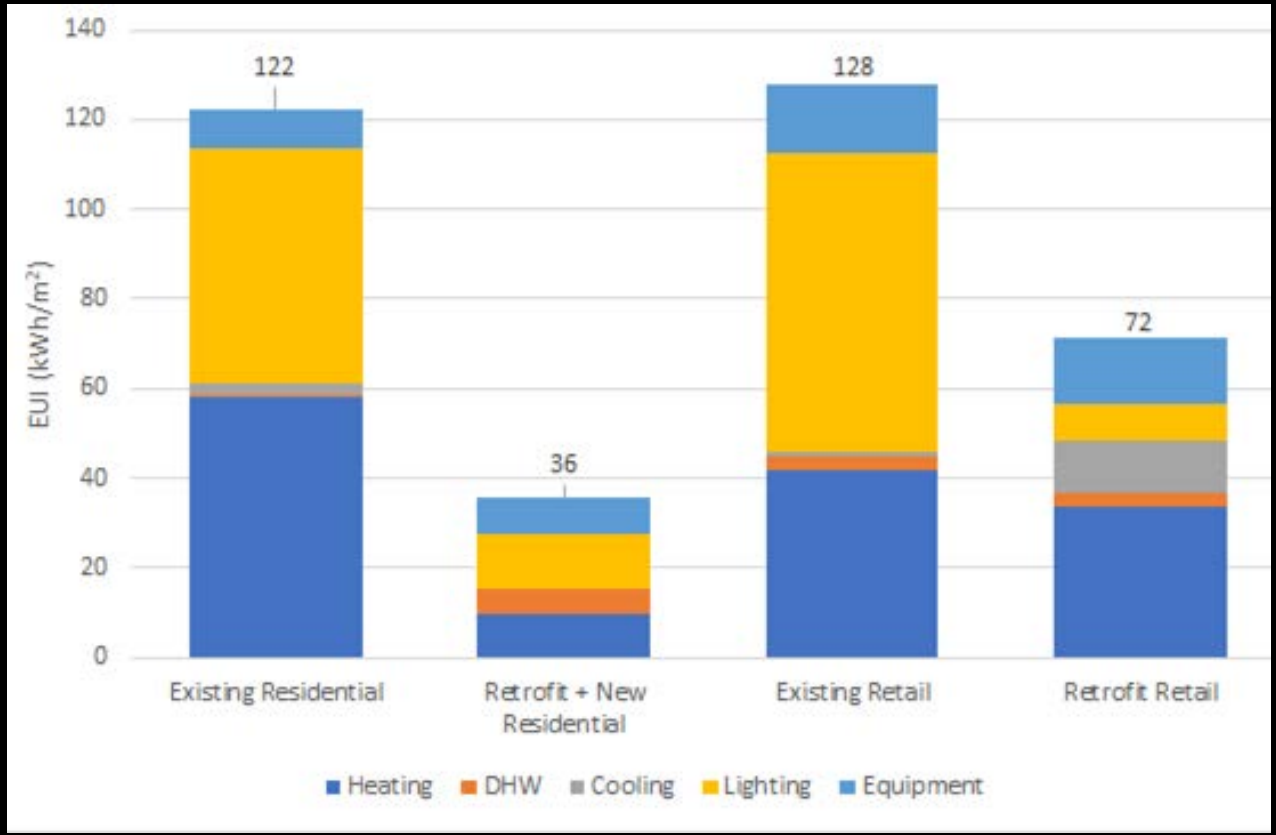


Daylight Availability



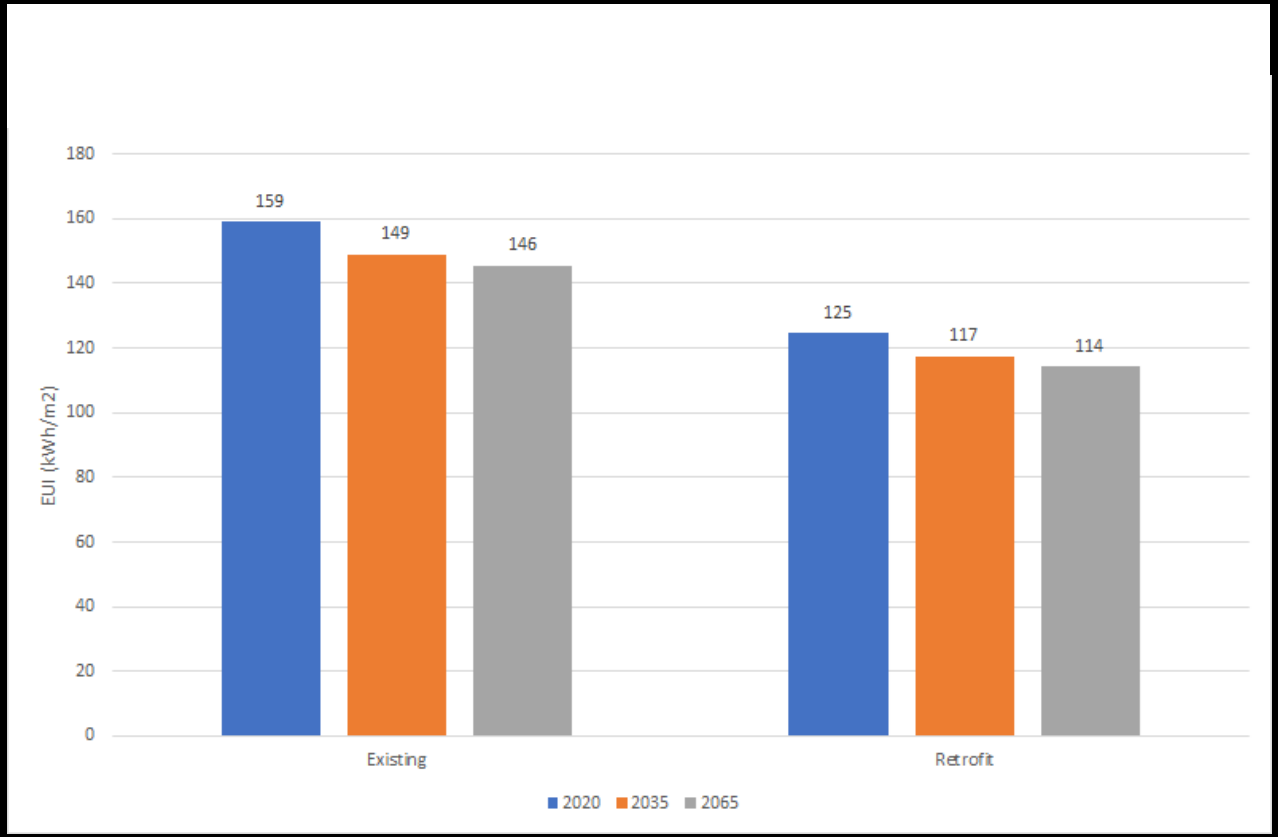
Operational Energy

- Residential EUI
  - 71% decrease
- Retail EUI
  - 44% decrease
- Overall EUI
  - 40 kWh/m^2
  - 68% decrease



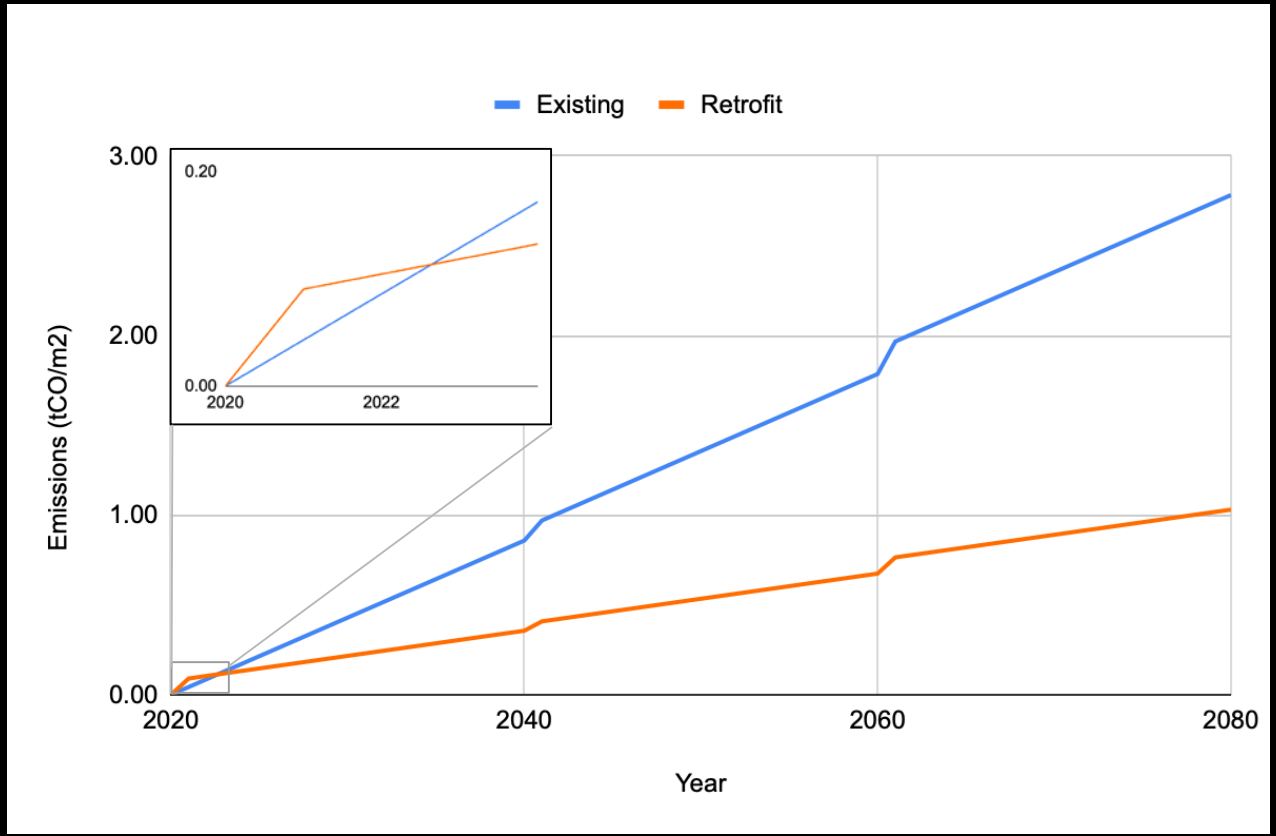
Climate Change Effects on EUI

- Warmer winters
  - Less heating energy
- Warmer summers
  - Need to add air conditioning
- EUI decreases 9% from 2020 to 2065

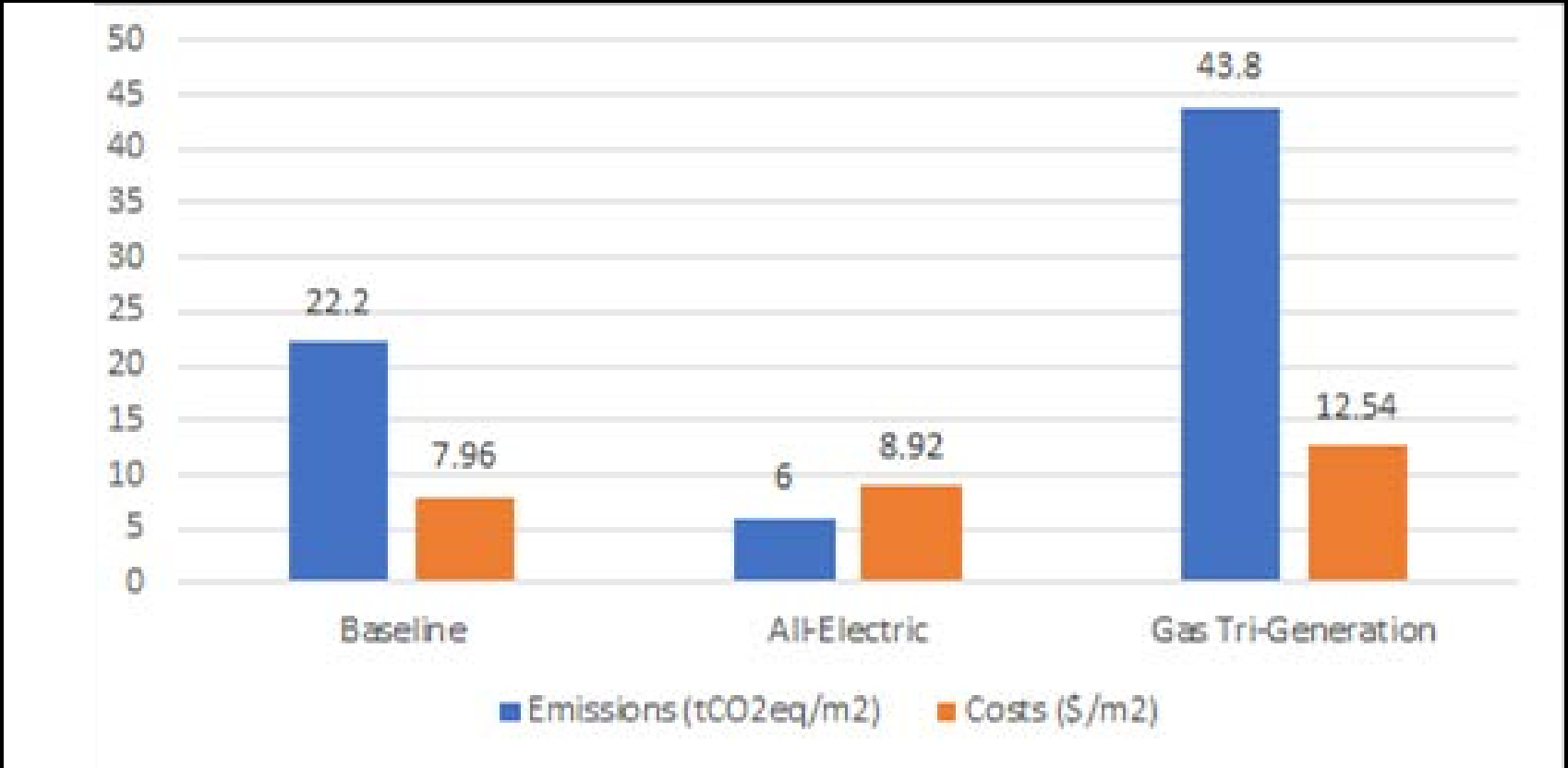


Carbon Emissions Over Time

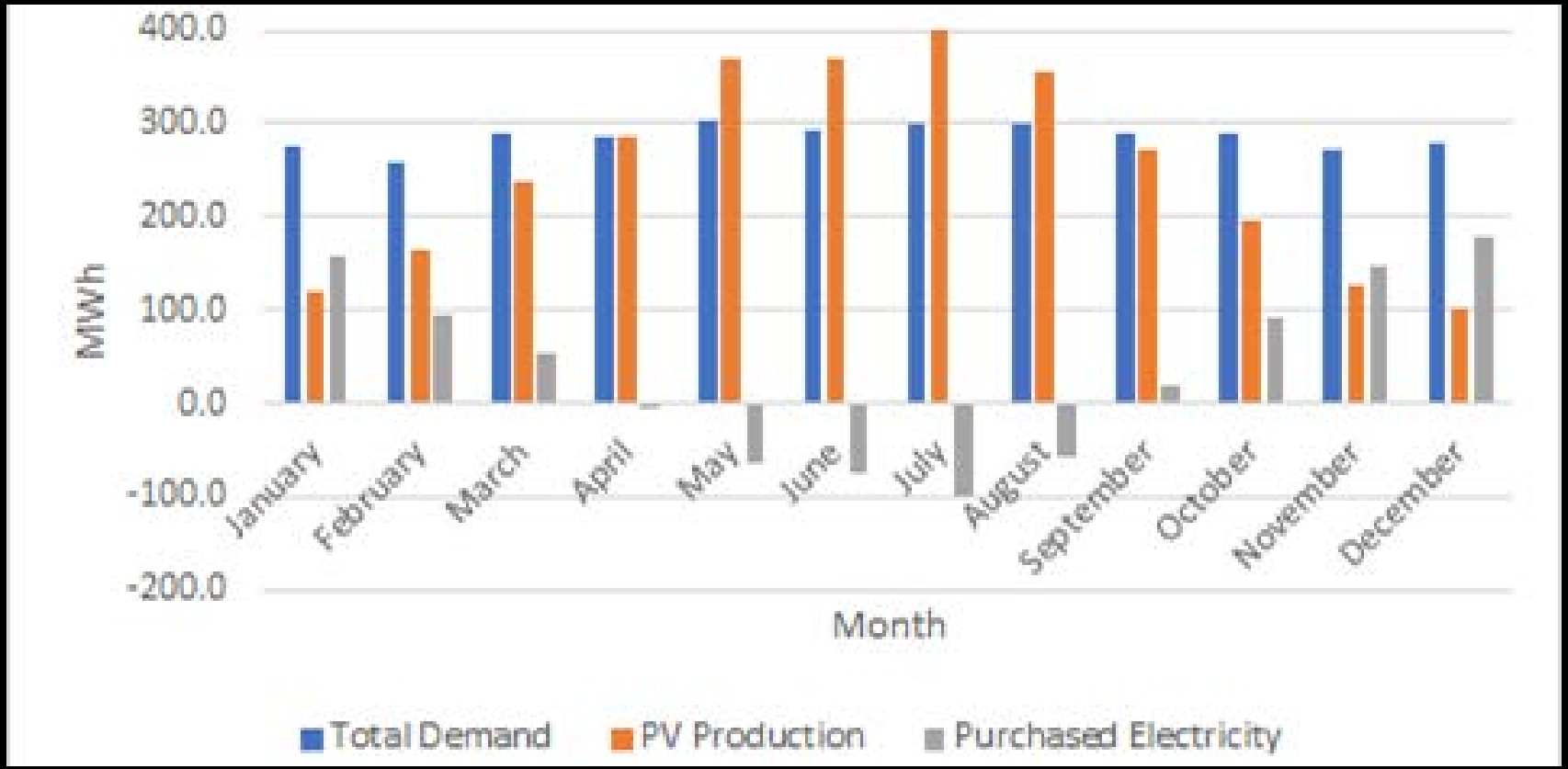
- Retrofit has higher initial embodied energy
- High EUI of existing buildings causes it to quickly overtake emissions from retrofit
- 63% decrease in total CO_2 emissions by 2080



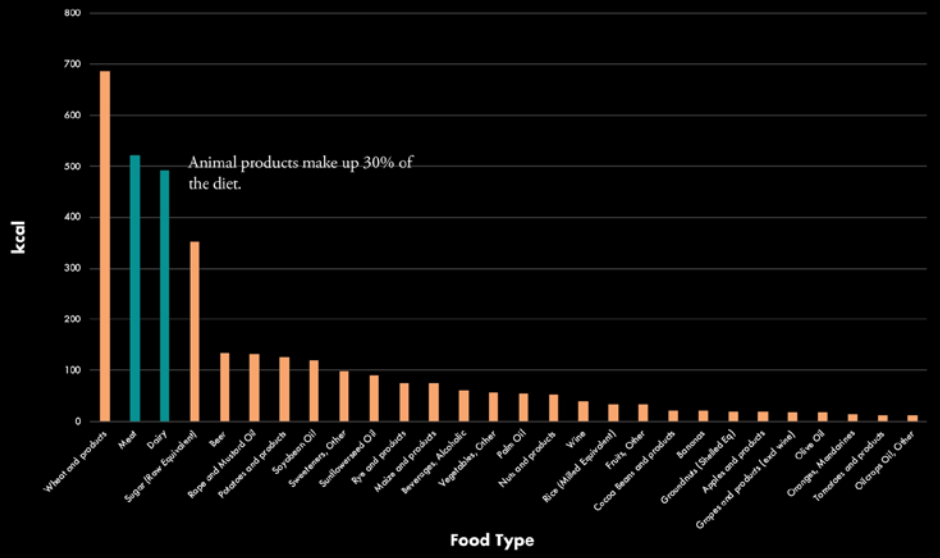
Potential Energy Systems

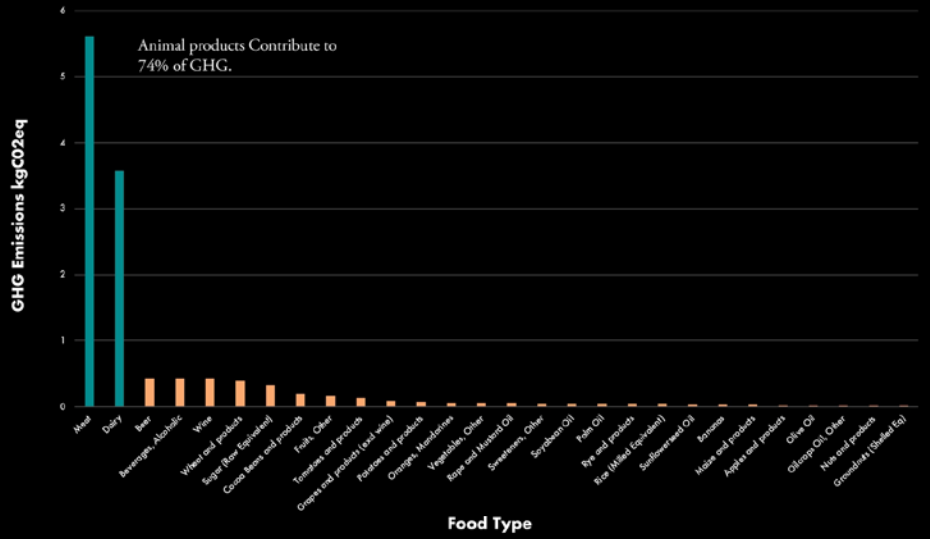


All-Electric Scenario

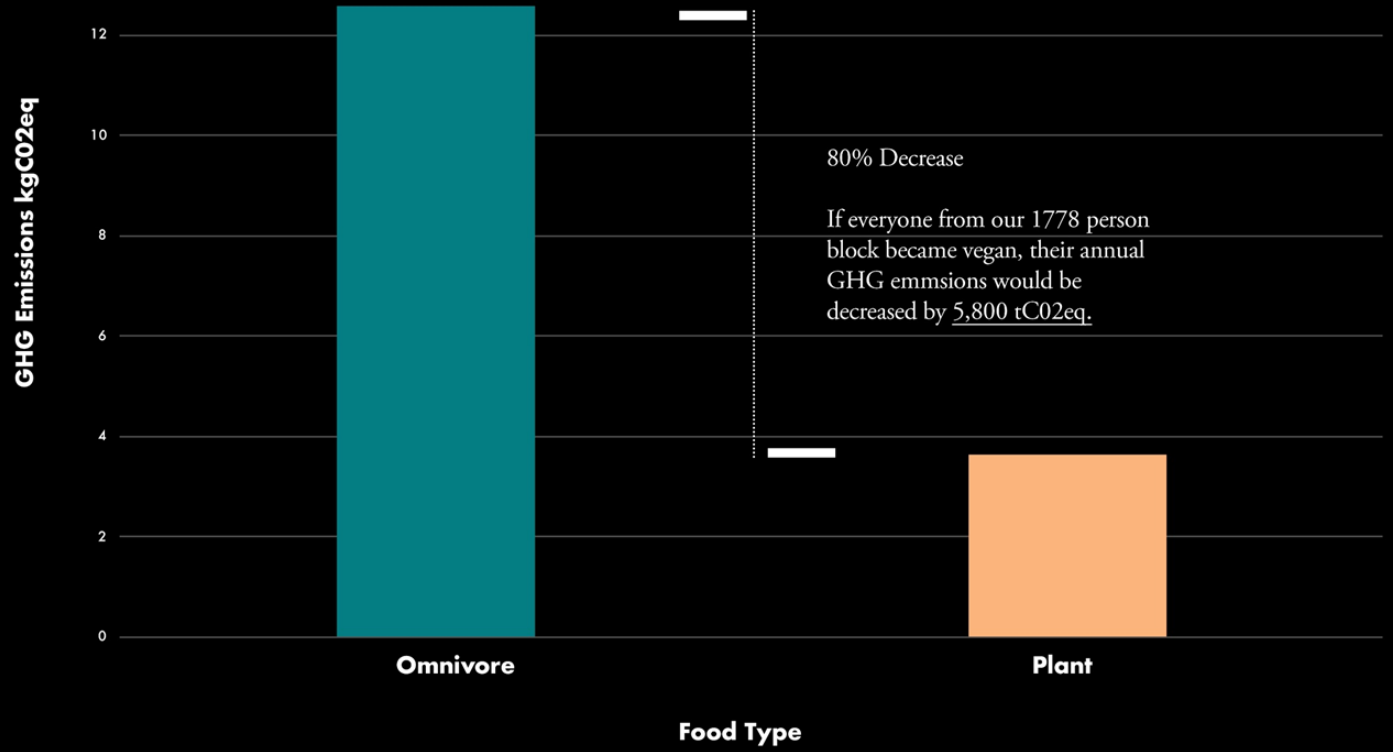


Diet Composition: Average Daily German Diet

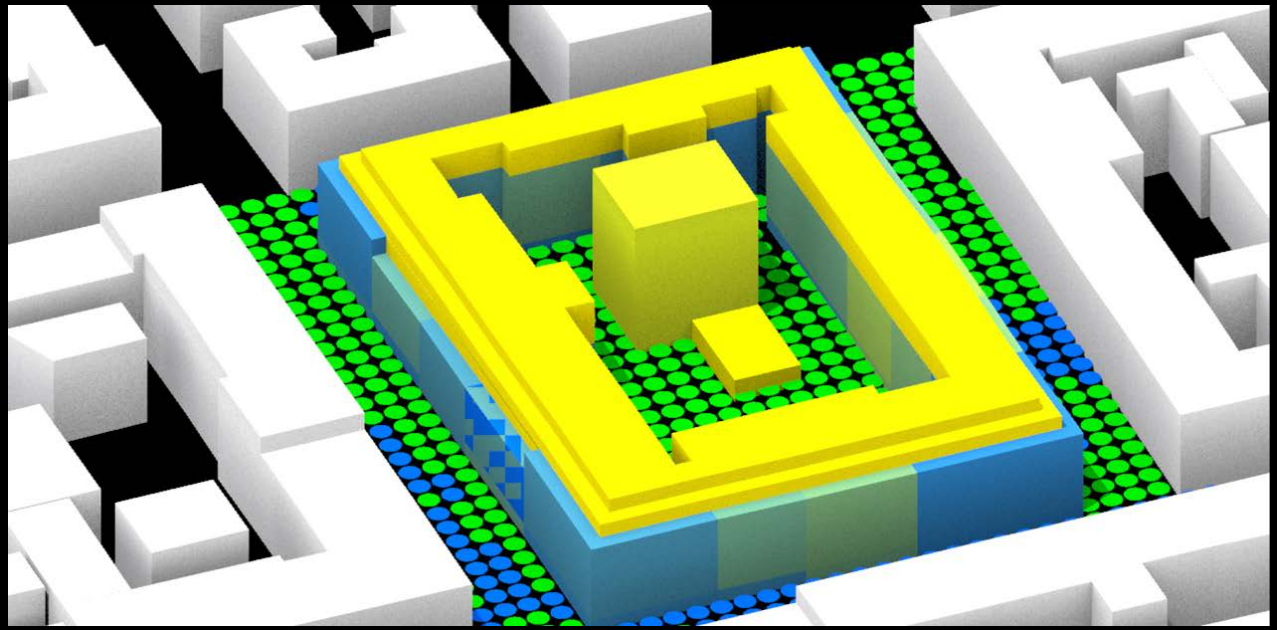




Greenhouse Gas Comparison of Diets



Urban Mobility: Outdoor Thermal Comfort



UTCI (°C) range	Stress Category
above +46	extreme heat stress
+38 to +46	very strong heat stress
+32 to +38	strong heat stress
+26 to +32	moderate heat stress
+9 to +26	no thermal stress
+9 to 0	slight cold stress
0 to -13	moderate cold stress
-13 to -27	strong cold stress
-27 to -40	very strong cold stress
below -40	extreme cold stress

- Original protoblock outdoor thermal comfort = 28%
- Final design outdoor thermal comfort = 43%

Urban Mobility

- 1,616 Amenities
  - Open Street Map
  - 800 meter radius of site
- Limited parking
  - On-site transit options eliminate additional needs
- Highly walkable neighborhood

Financial Performance

- Average rent in Munich
  - €24.6/m²/month
- Rent increases because sDA > 50%
  - €26.1/m²/month
  - 6% premium
- Rent from improving sDA in existing apartments
  - +€73,900
- Rent from added residential space
  - +€305,500/month
- Total residential rental income
  - €1.6 Million/month
  - +€380,000/month
  - +30%

Conclusions

- 8,900 m^2 of retail (+ 500 m^2)
- 61,700 m^2 of residential (+11,700 m^2)
- 1,778 Occupants (+23%)
- Retain historical facade

68
+750%

40 kWh/m^2
-68%

-80% GHG emissions

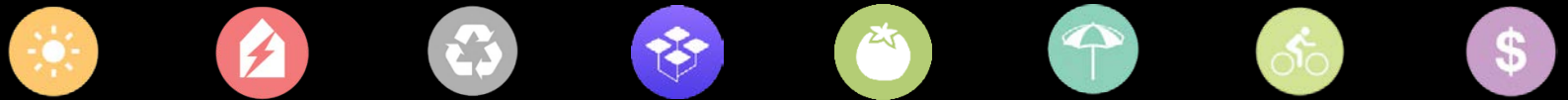
43
+15%

-63% by 2080

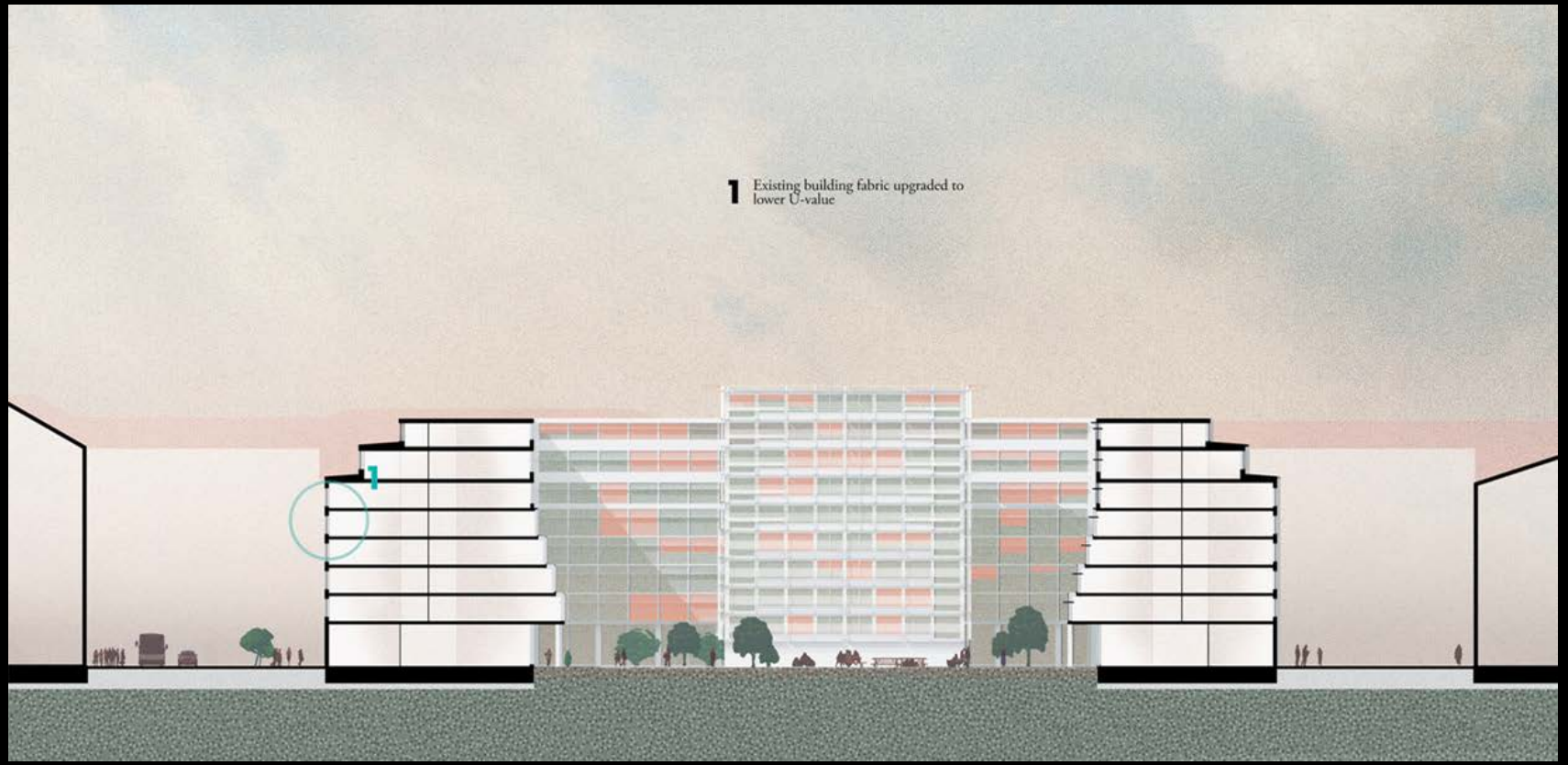
87% on-site energy production

78

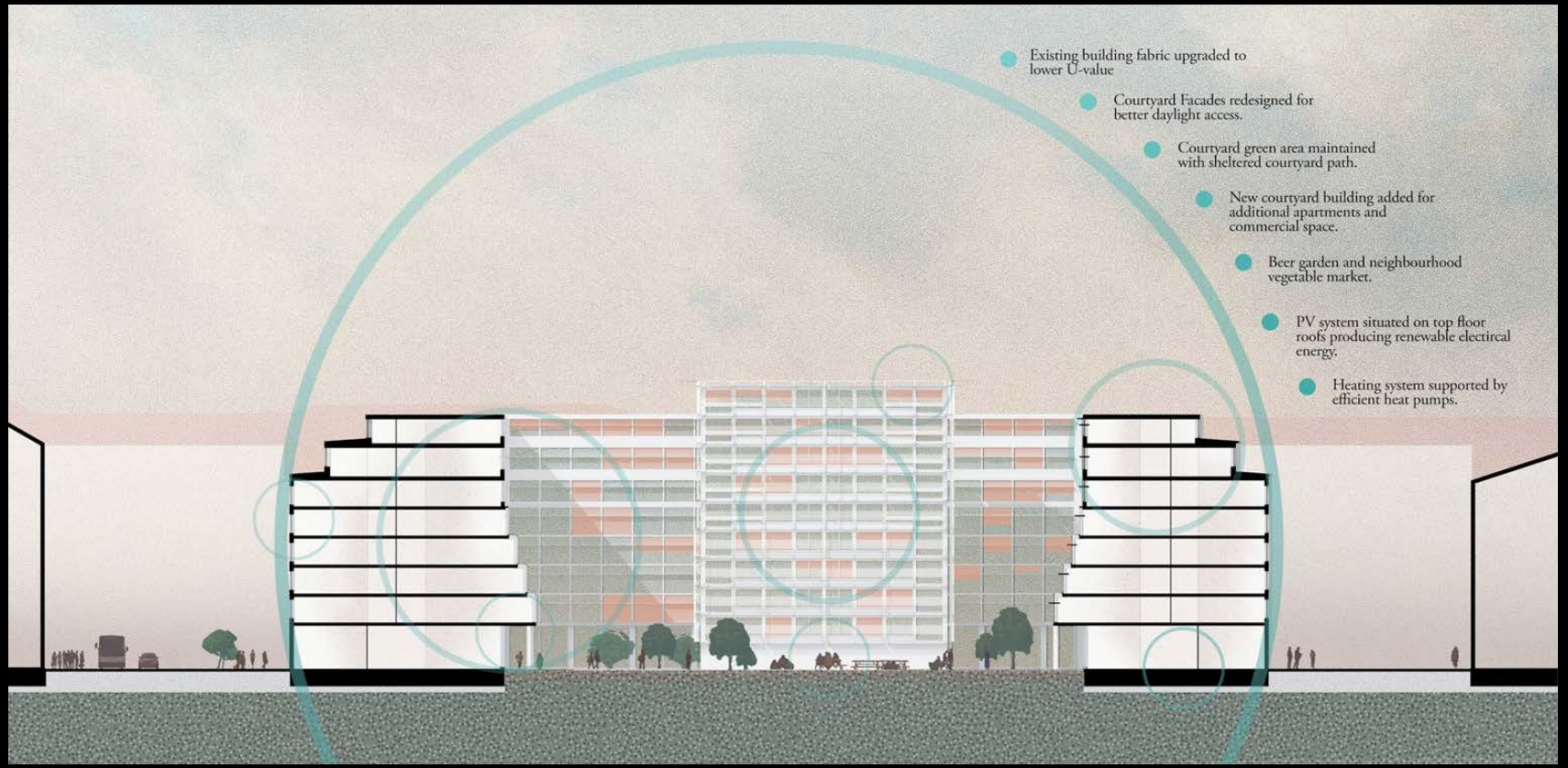
€380,000/month
+30%



Conclusions



Questions?


Existing building fabric upgraded to lower U-value
Courtyard Facades redesigned for better daylight access.
Courtyard green area maintained with sheltered courtyard path.
New courtyard building added for additional apartments and commercial space.
Beer garden and neighbourhood vegetable market.
PV system situated on top floor roofs producing renewable electircal energy.
Heating system supported by efficient heat pumps.