



# B.R.O.N.Z.E.



Bronzeville Residence Optimized for Net Zero Energy



**Team B.R.O.N.Z.E.**

# B.R.O.N.Z.E.



**Julia del Pino Torres**

2nd year M.E. Arch. E.

**Team Leader**

Energy Analysis, Photovoltaic System Design, IAQ and Ventilation



**Ariel White**

1st year M.S. Arch. E.

Mechanical Design, Lighting Design



**Elmira Hosseinkhani**

3rd year M. Arch.

Architectural Design, Architectural Drawings



**Lindsey Rice**

5th year M.E., B.S. Arch. E.

Building Envelope Design, Architectural Details, Construction Schedule



**Ezgi Bay**

2nd year PhD. Arch.

Architectural Design, Architectural Drawings, Team Logo Design



**Alexander Mitchell**

4th year B.S. Arch. E.

Plumbing Design, Electrical Design, Mechanical Design

# B.R.O.N.Z.E.

## ► Special Thanks to:

### ► Faculty Advisors:



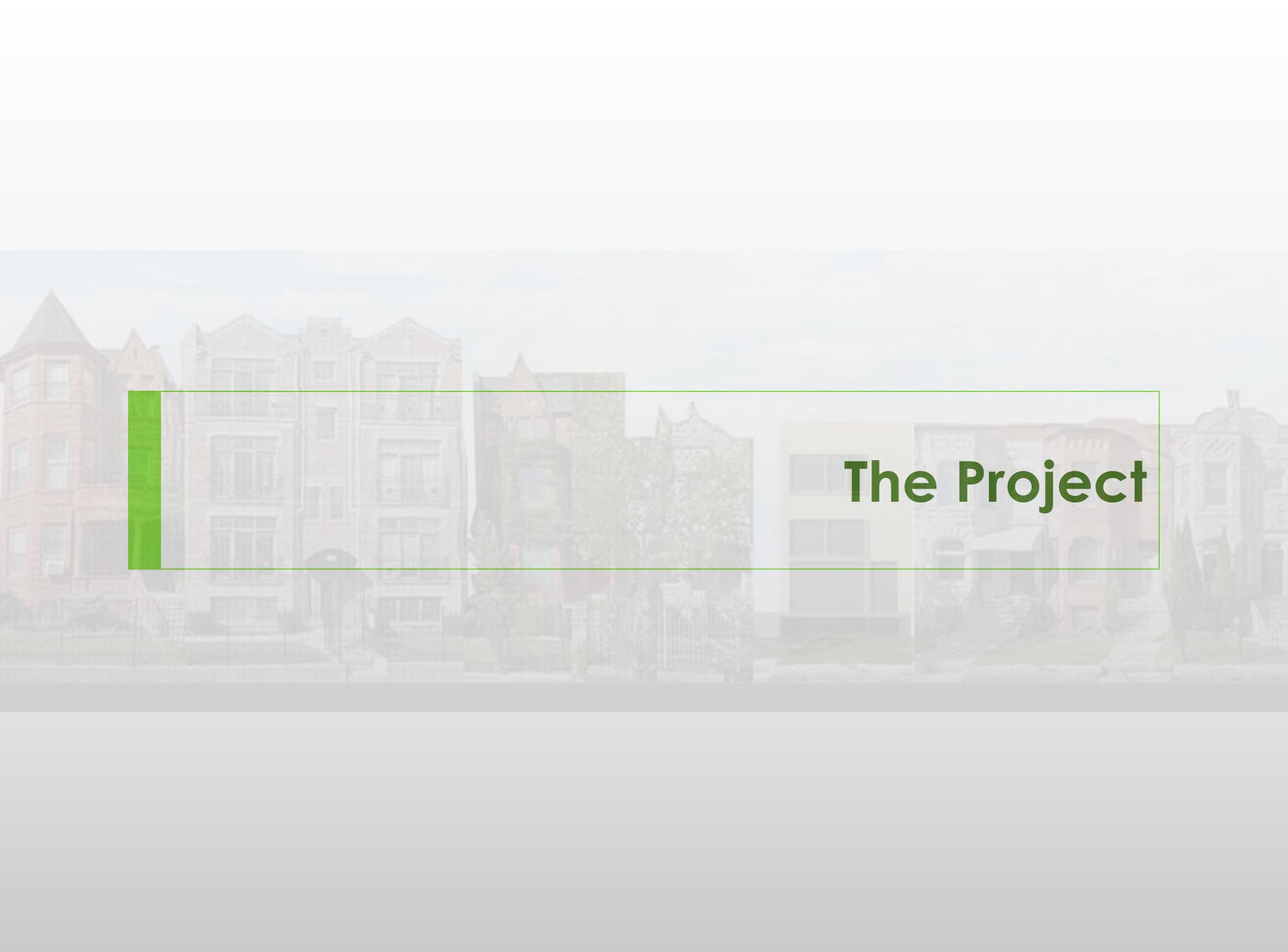
**Edoarda Corradi**  
**Dell Acqua, M.S.**  
Adjunct Professor



**Brent Stephens, Ph.D.**  
Associate Professor

### ► Industry Partners:





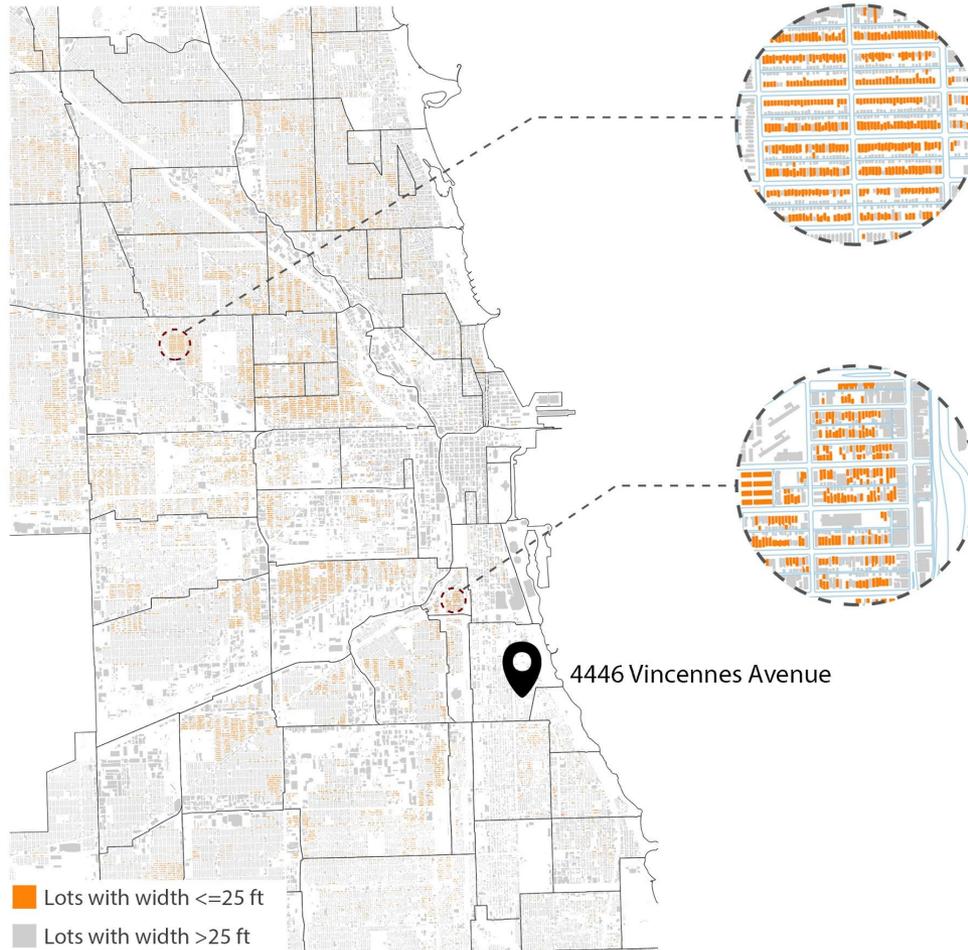
# The Project

# Bronzeville

- ▶ Bronzeville is a historical African American neighborhood
- ▶ Has roots coming from jazz and creole culture
- ▶ Average Family Income: \$60,000/yr
- ▶ Median Family Income: \$37,000/yr
- ▶ Median Home Sale Price: \$130,000

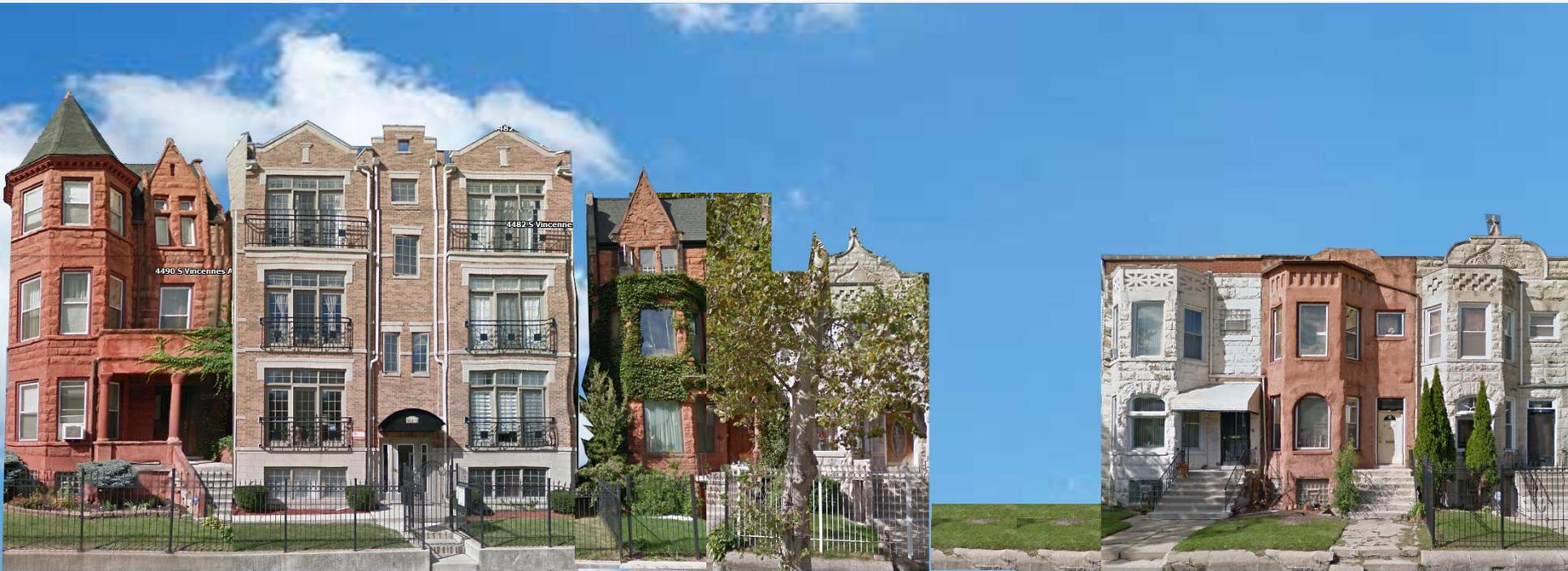
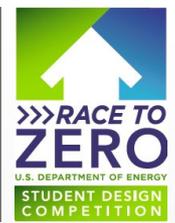


# Similar Lots in Chicago

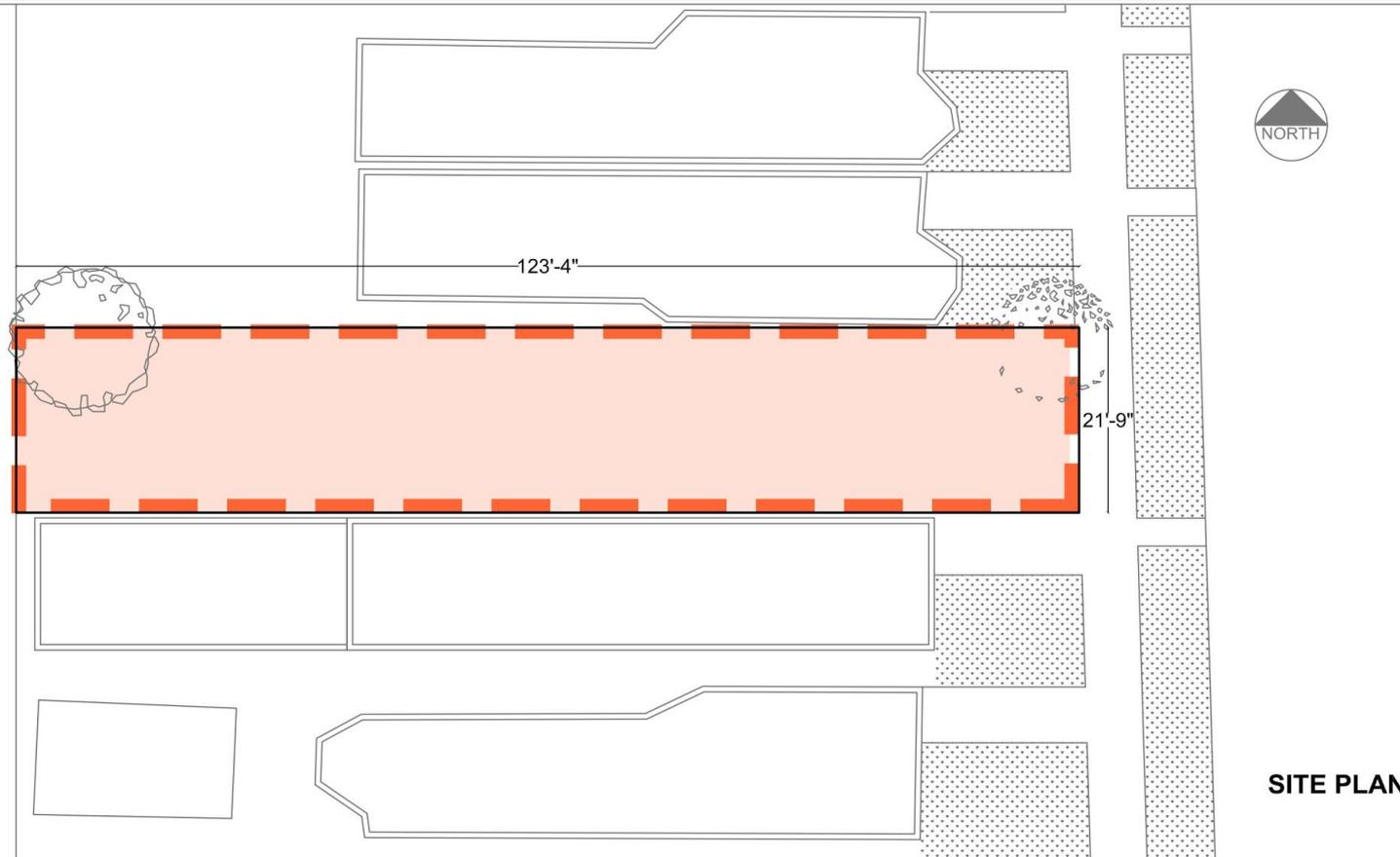


Typical lot size in Chicago are narrow and deep, approximately 70% of them have width of less than 25 ft.

# The Site



# The Site

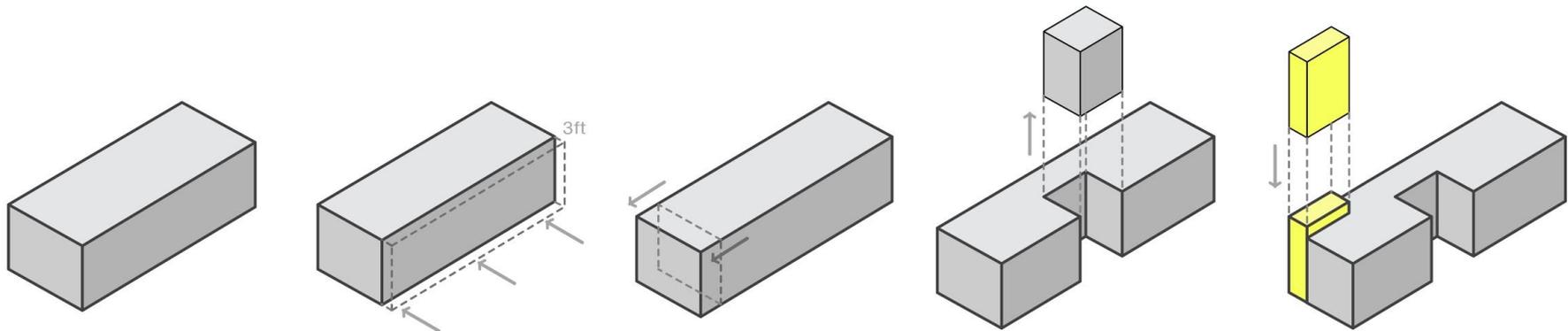


▶ 4446 S. Vincennes Ave Chicago, IL 60653



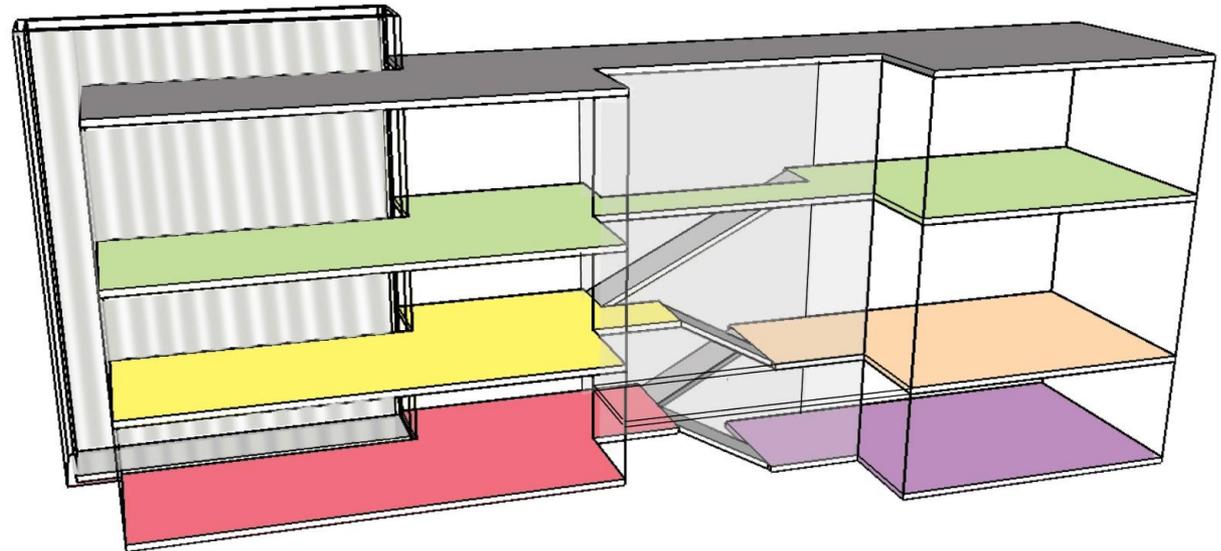
# Architectural Design

# Design Process



# Plan Configuration

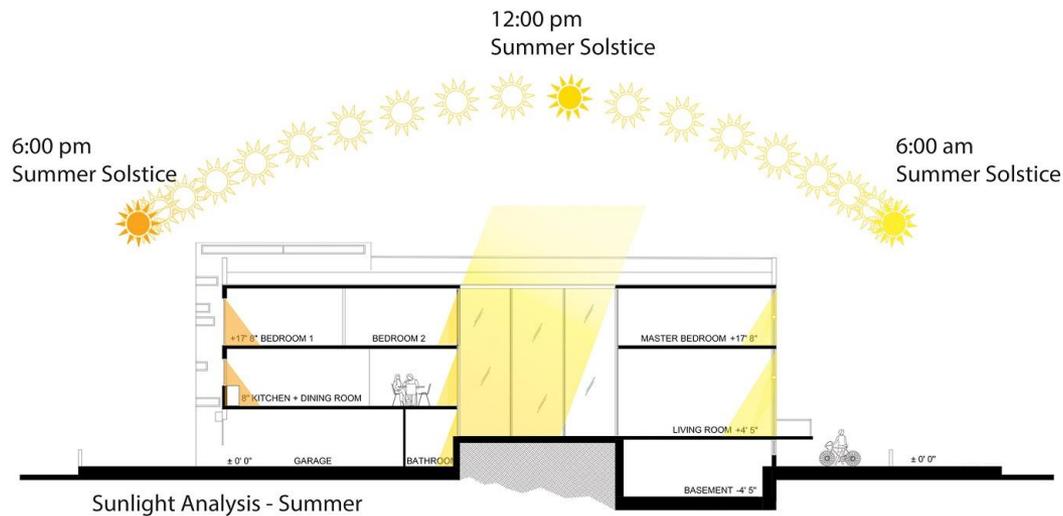
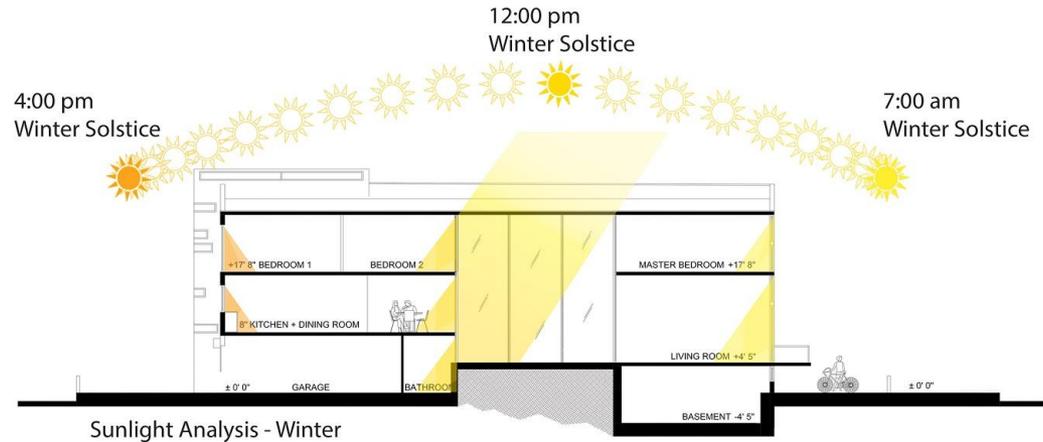
- ROOF
- LIGHTWELL
- BEDROOM LEVEL
- KITCHEN LEVEL
- LIVING ROOM LEVEL
- ENTERANCE LEVEL
- BASEMENT LEVEL
- CIRCULATION CORE



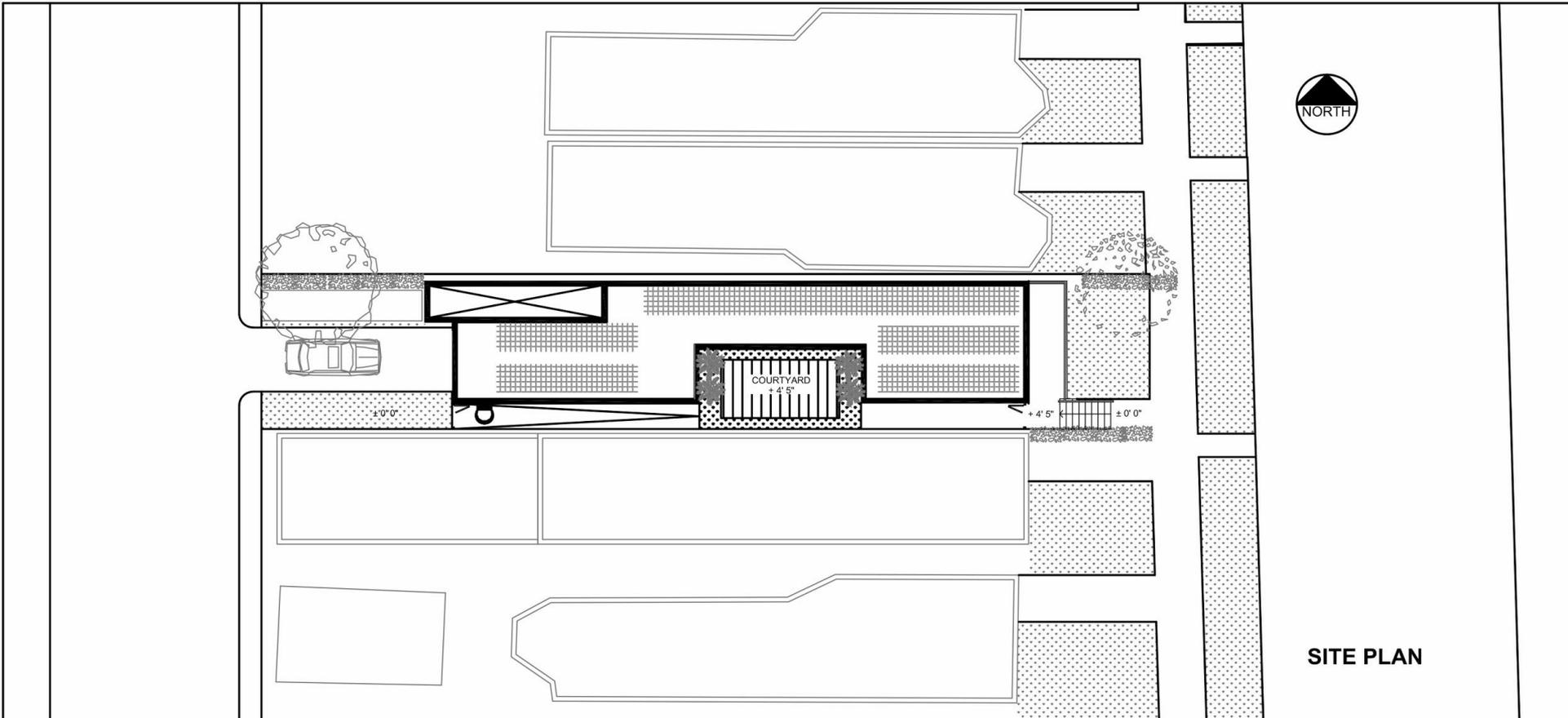
# Plans



# Sunlight Analysis

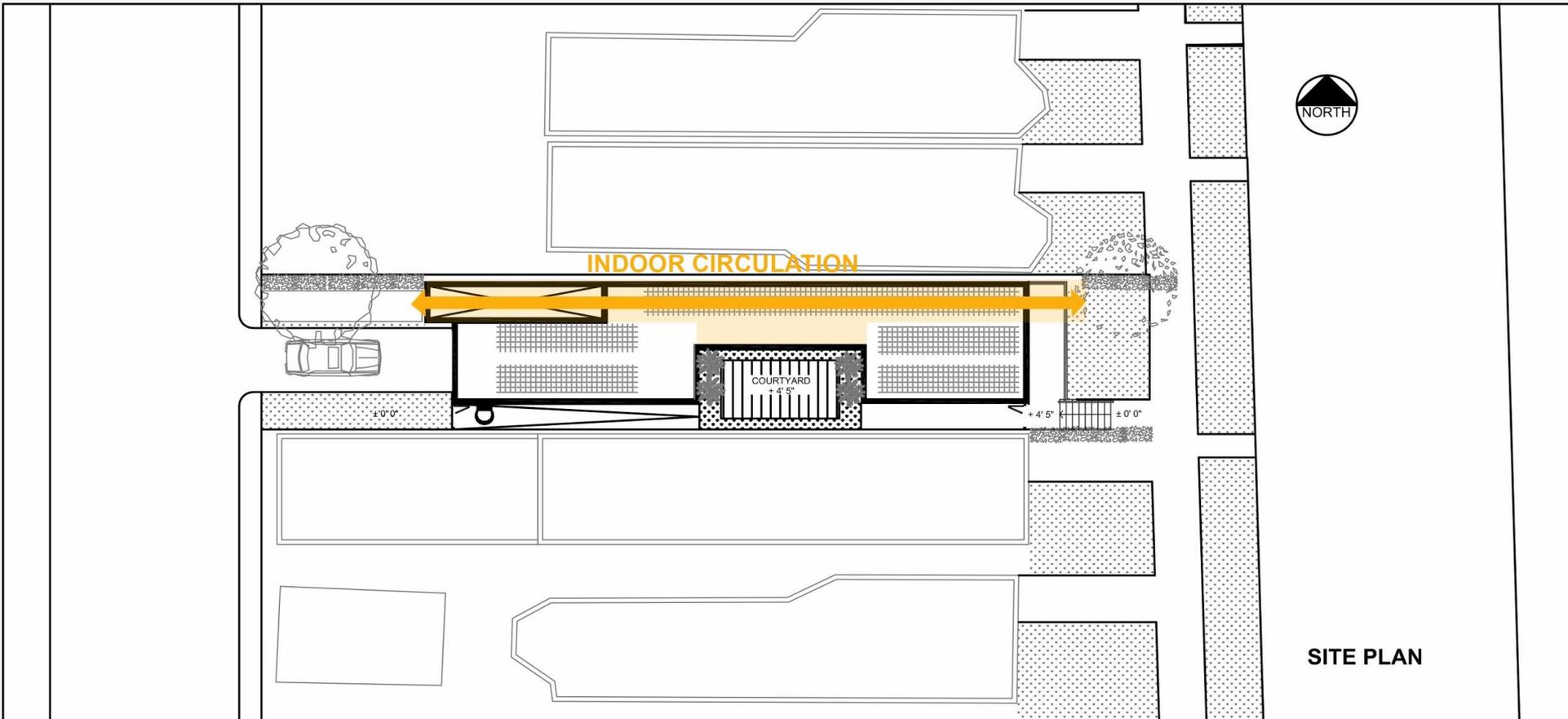


# Site Plan

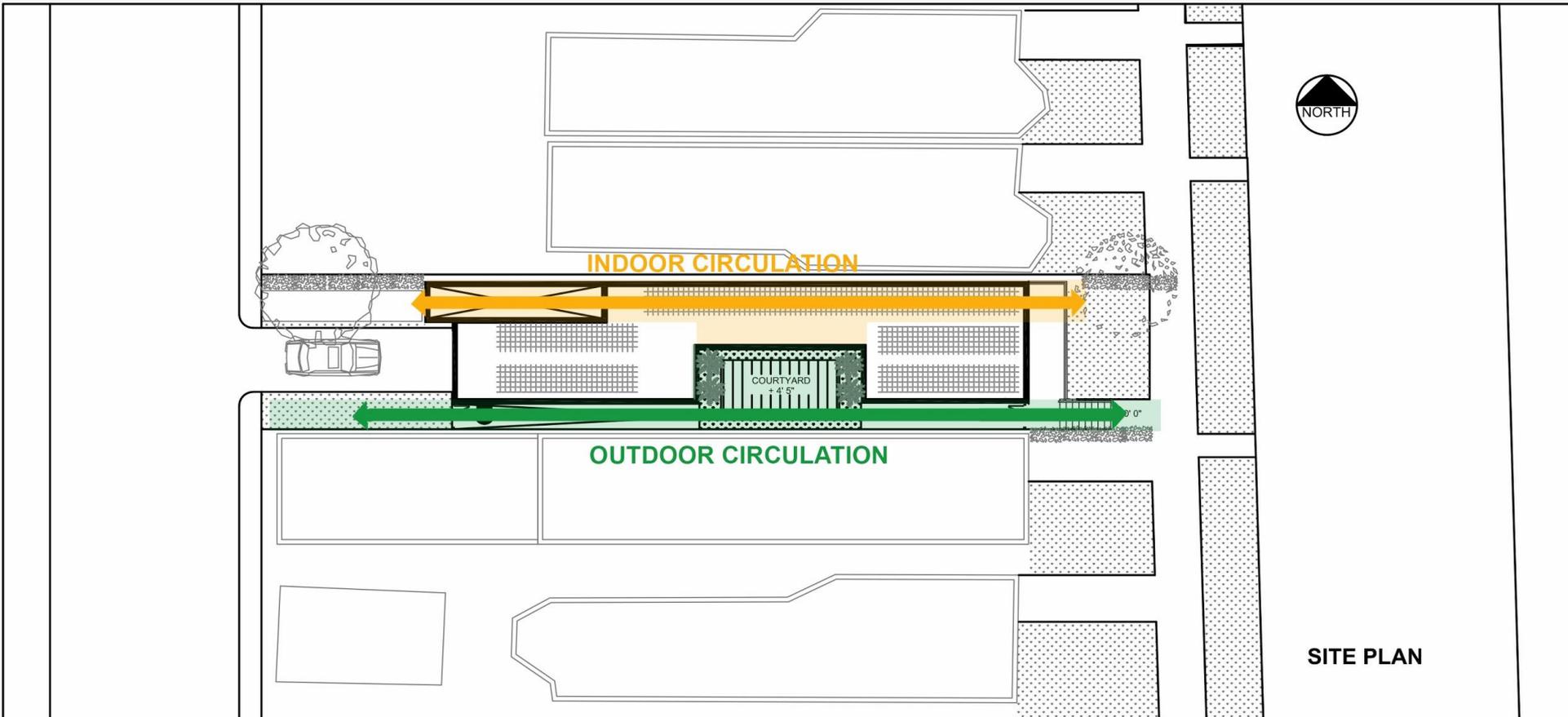


SITE PLAN

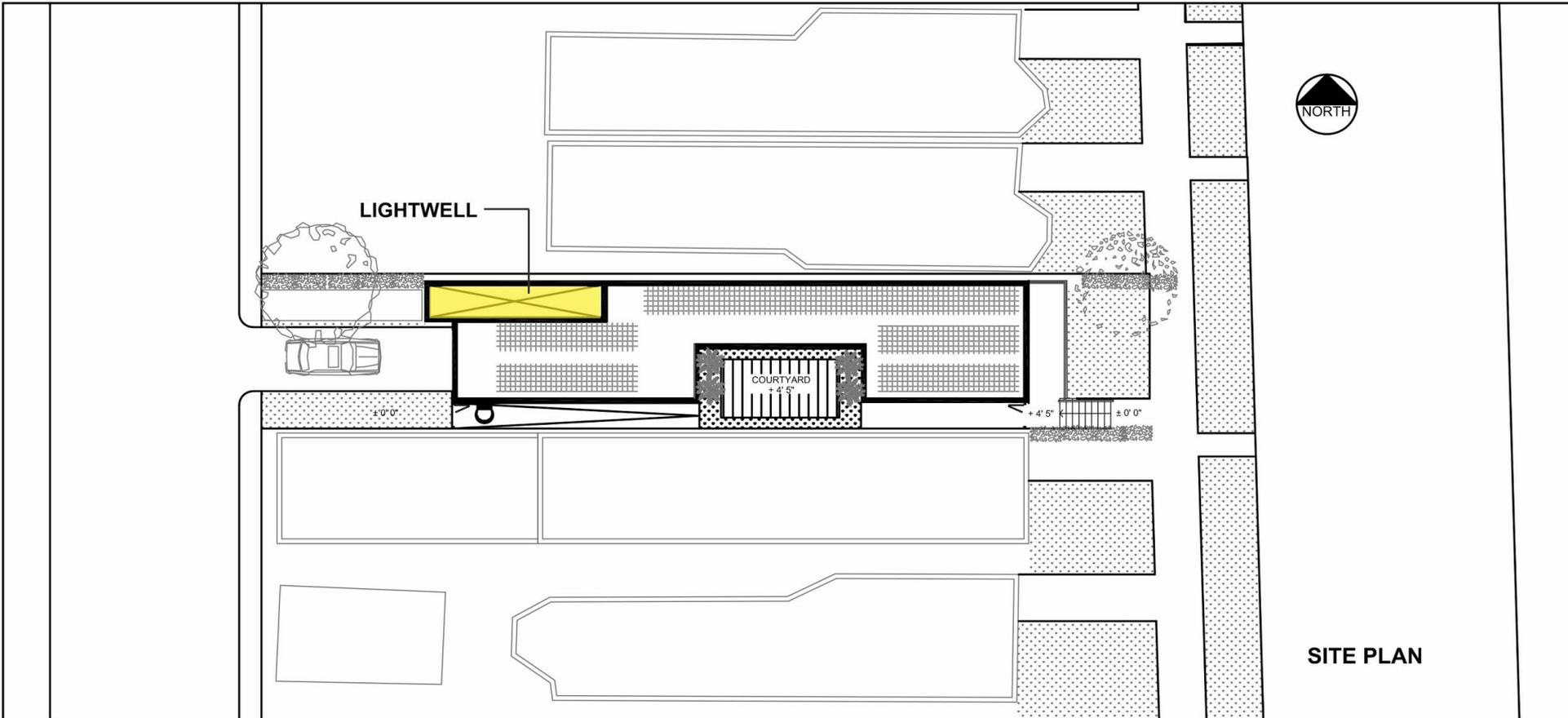
# Circulation Axes



# Circulation Axes

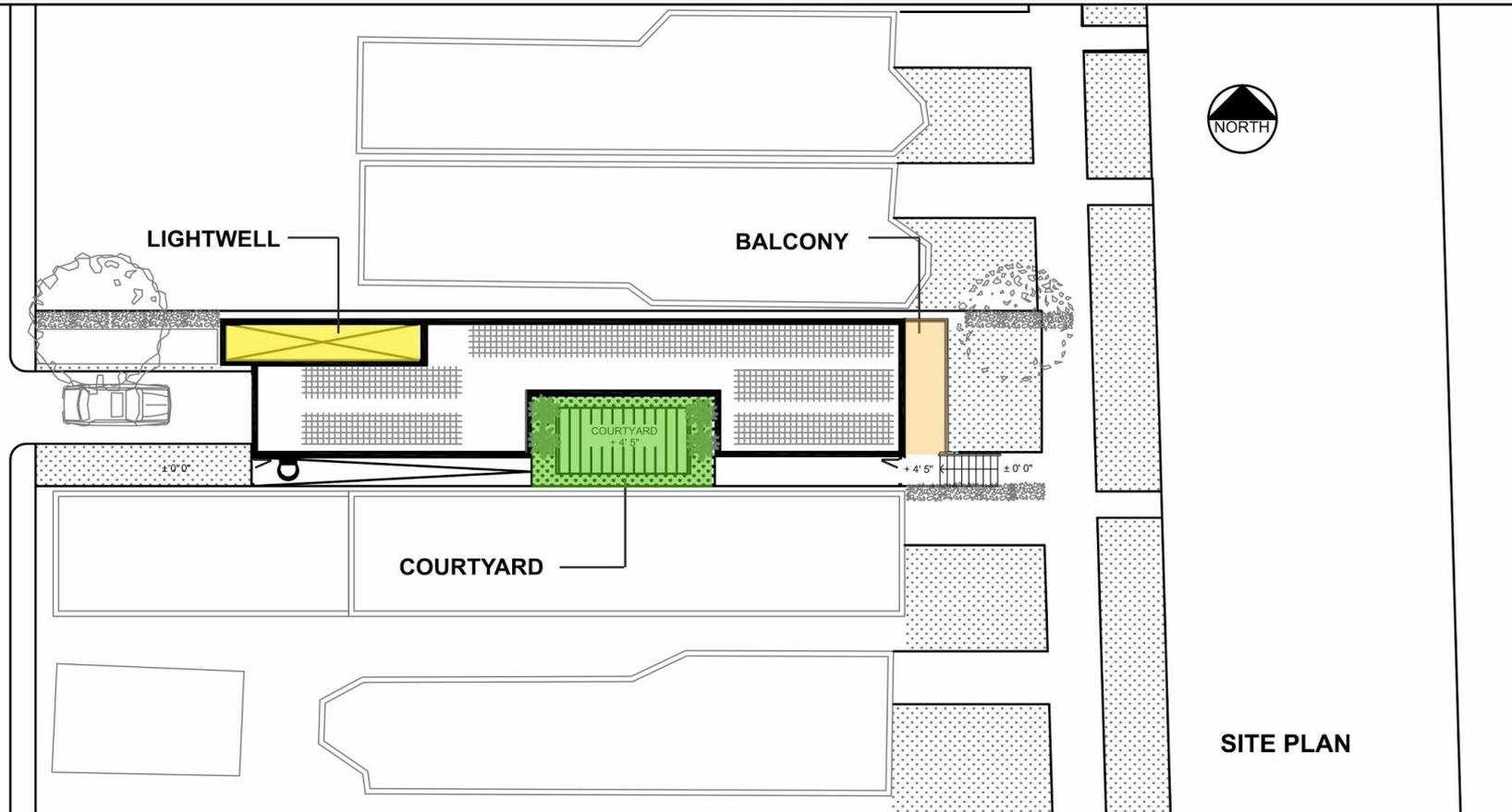


# Concept





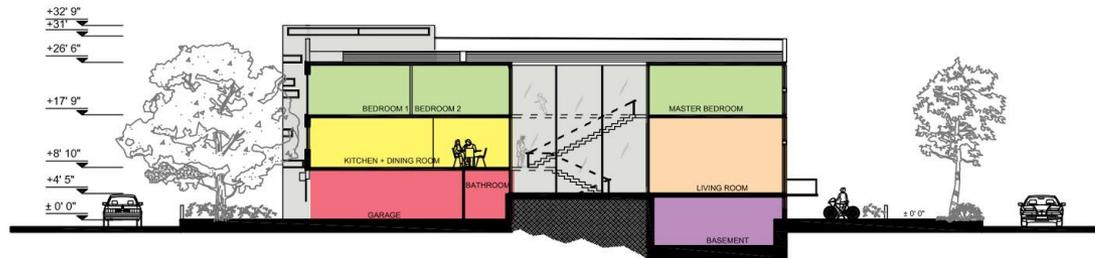
# Concept



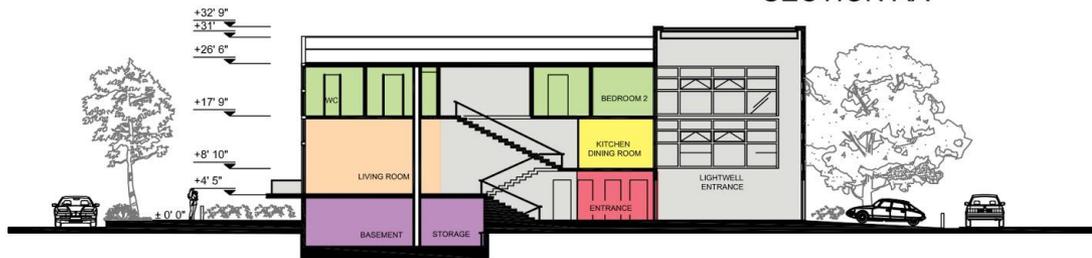




# Sections



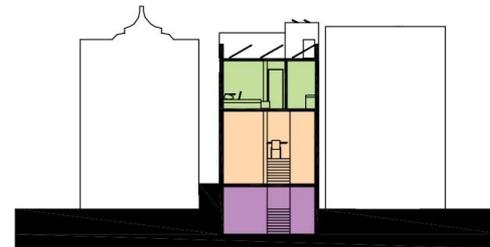
SECTION AA



SECTION BB



SECTION CC

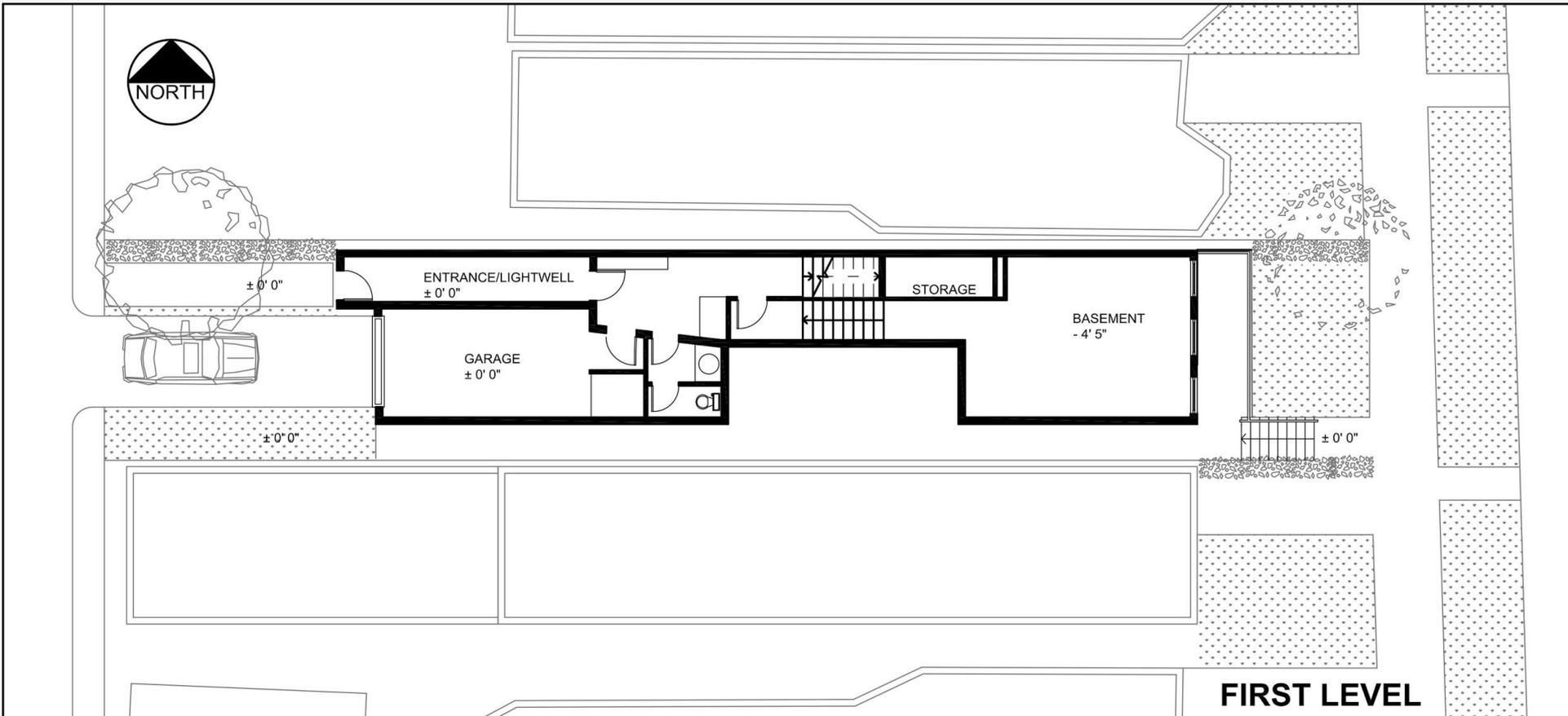


SECTION DD

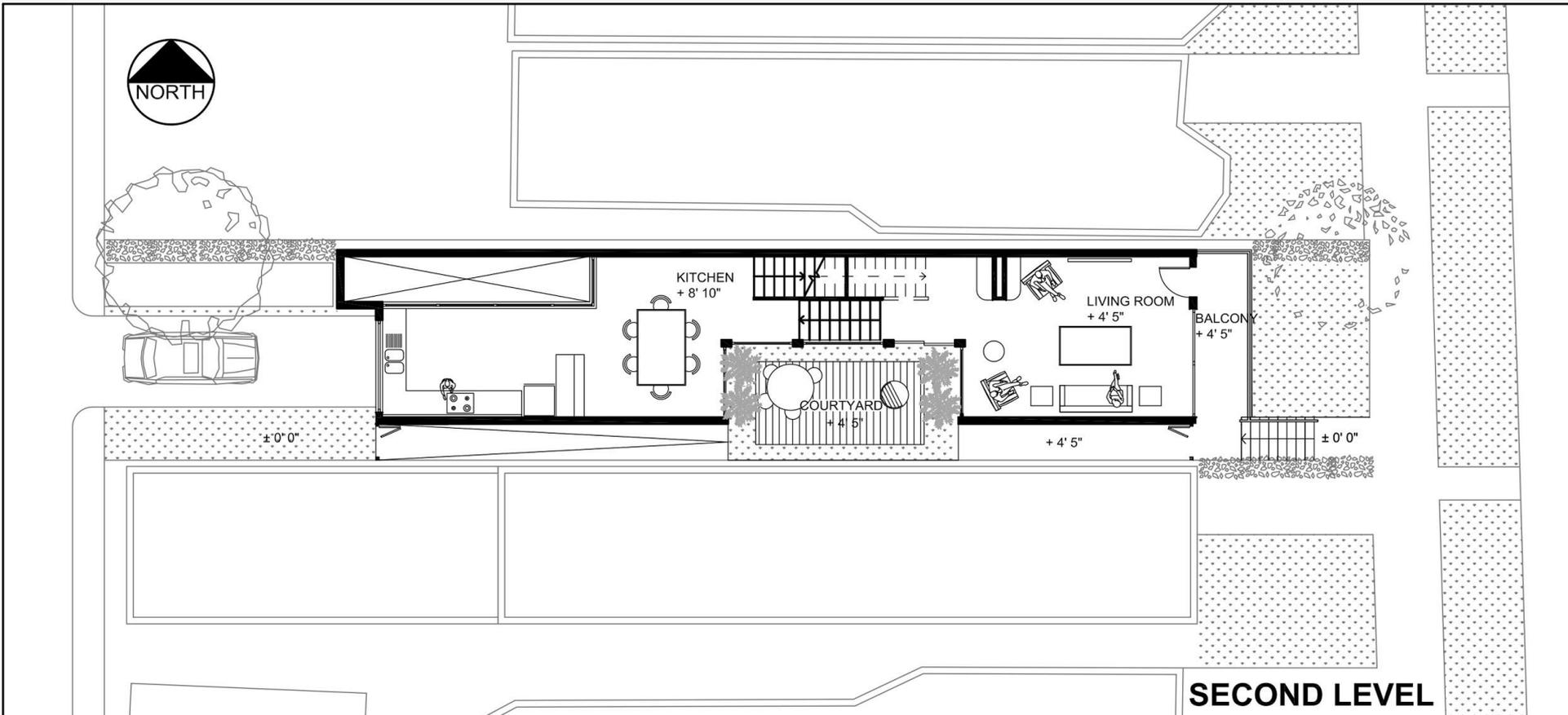
# Renderings



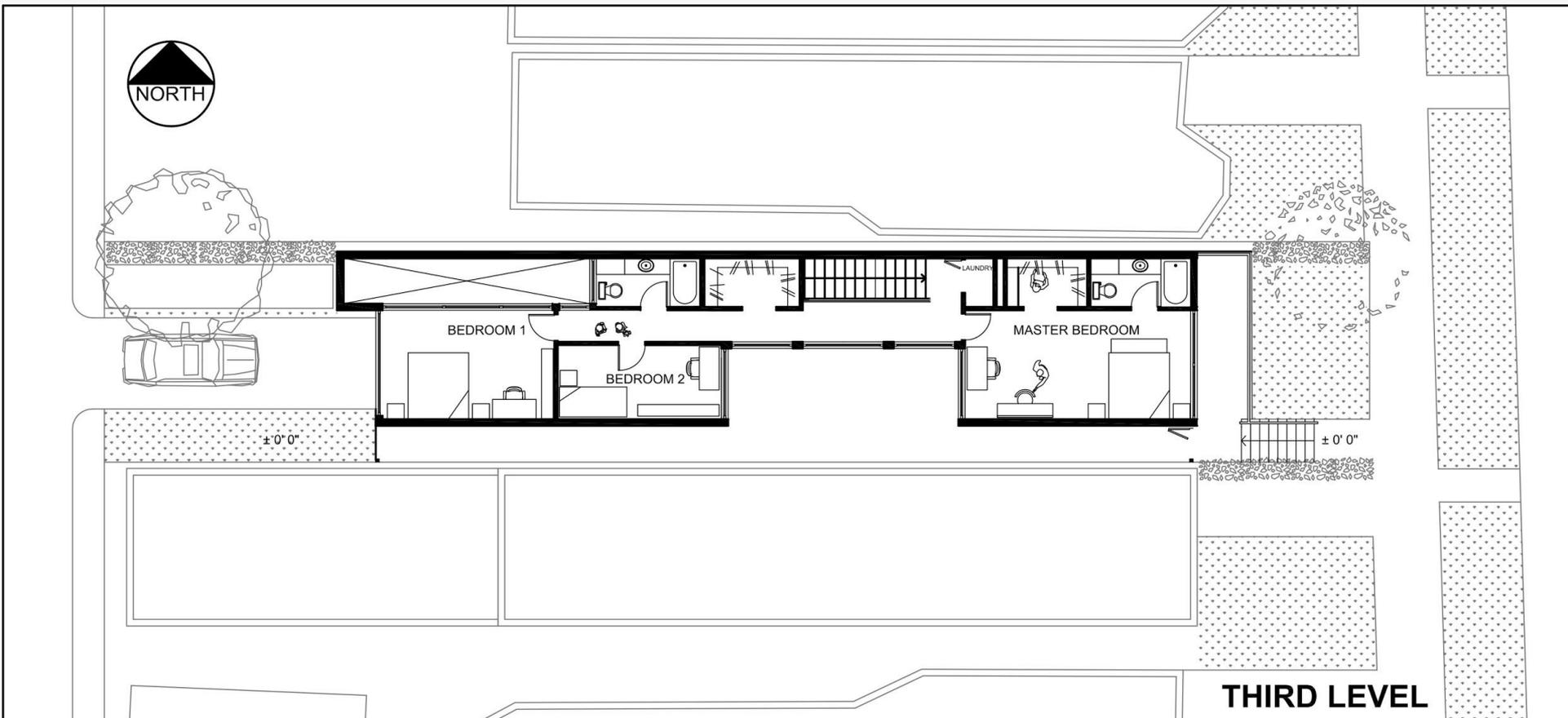
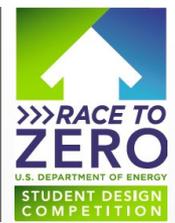
# Floor Plans



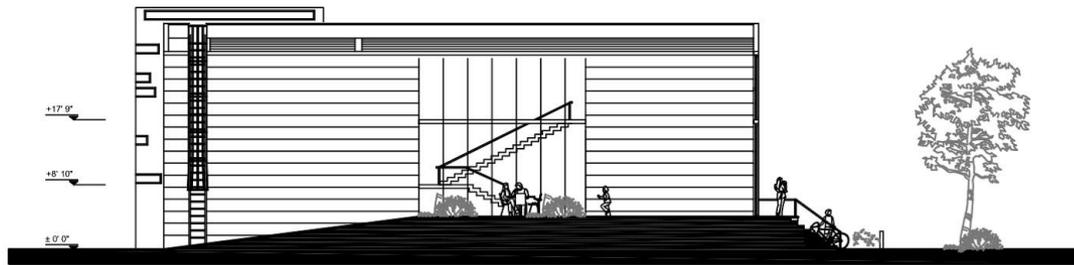
# Floor Plans



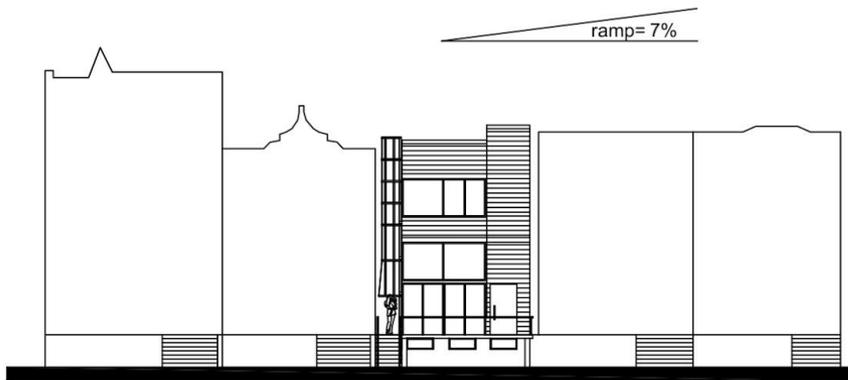
# Floor Plans



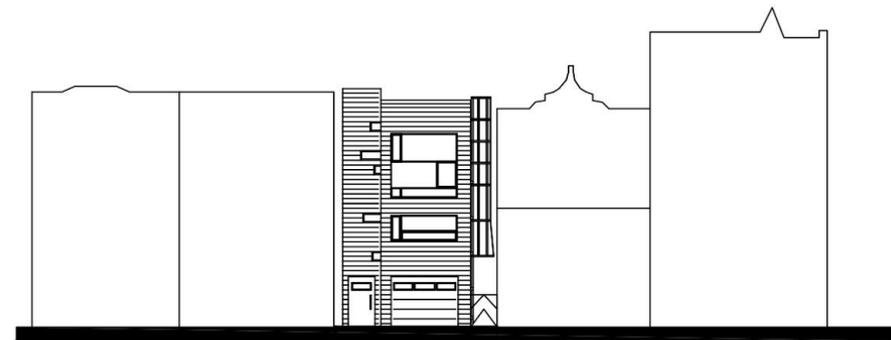
# Elevations



SOUTH ELEVATION

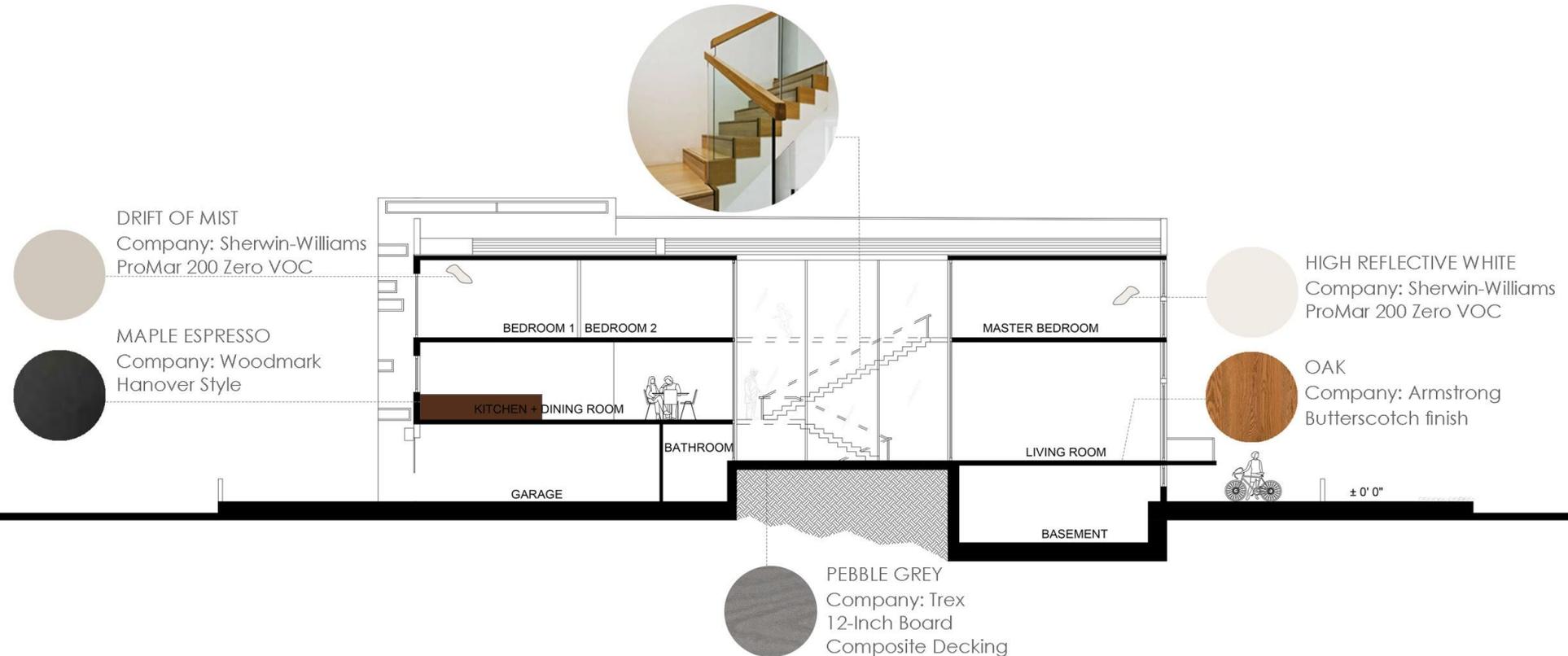


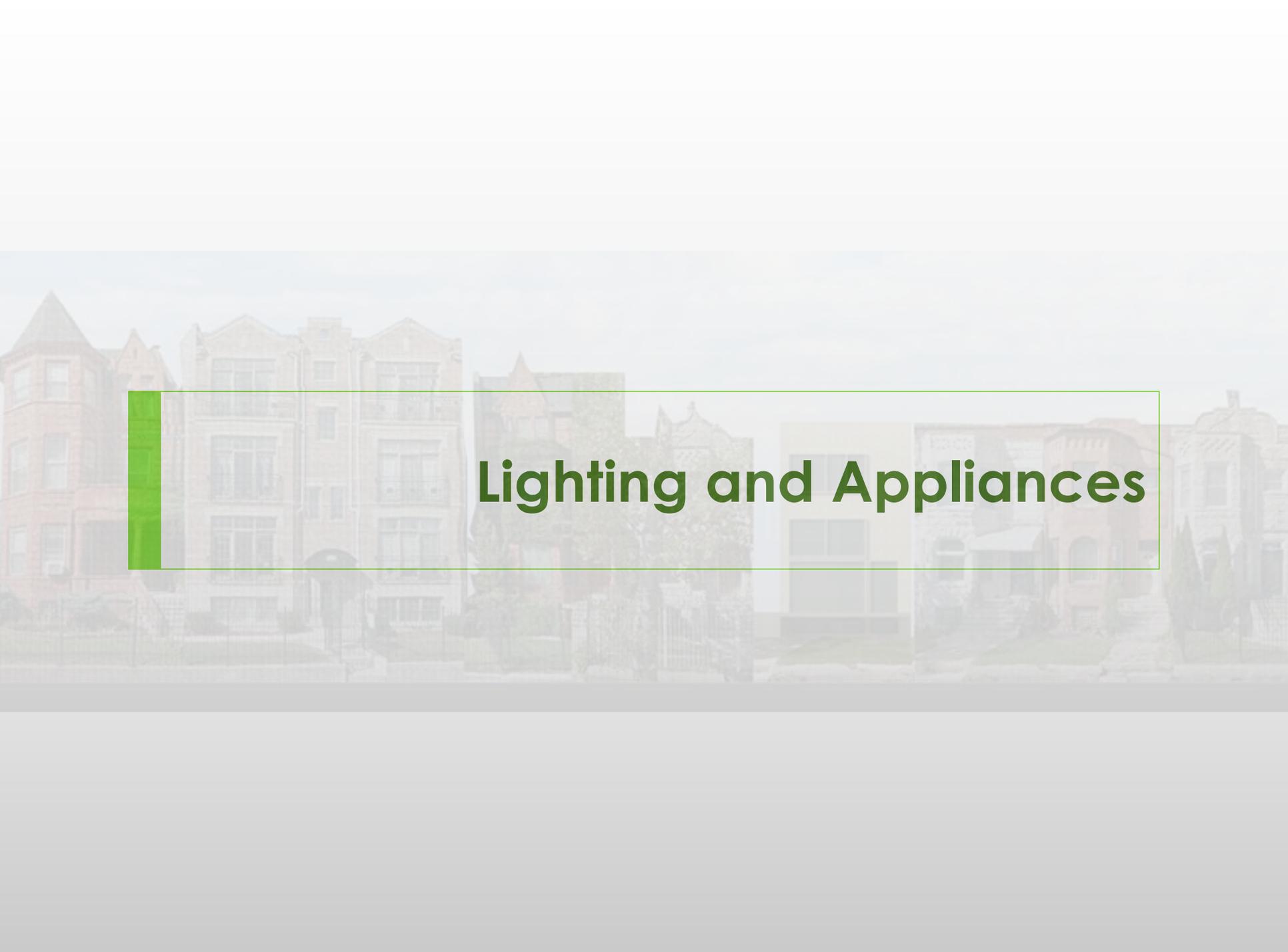
WEST ELEVATION



EAST ELEVATION

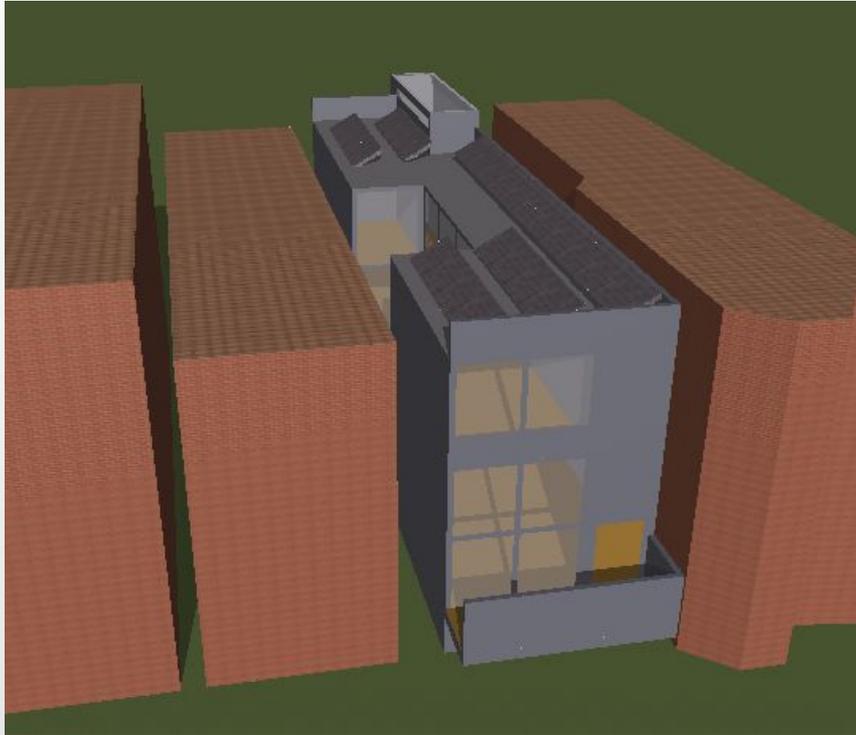
# Interior Design



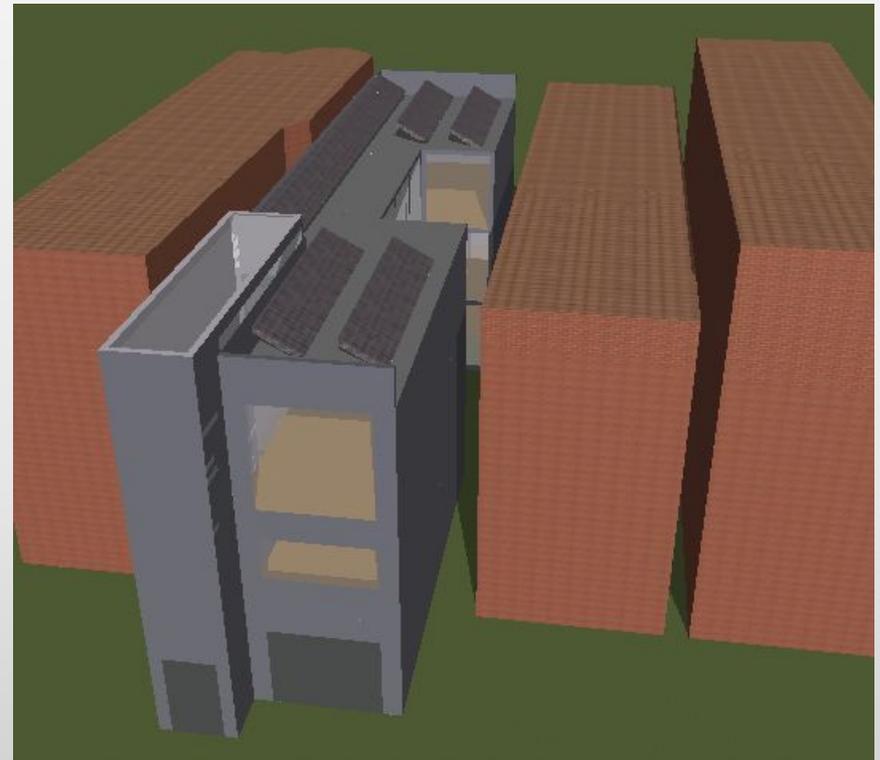


# Lighting and Appliances

# Daylight - April 22<sup>nd</sup>



→ 7.30 a.m.



3.30 p.m. ←

# Artificial Lighting



- ▶ 100% LED - EnergyStar
  - ▶ Philips Hue System
  - ▶ 1500 W approx.



# Appliances

- ▶ DOE Zero Energy Ready Home Requirements
  - ▶ Kitchen



# Appliances

- ▶ DOE Zero Energy Ready Home Requirements
  - ▶ Laundry Room

- ▶ High Efficiency All-In-One System

- ▶ Washer

- ▶ Electric Ventless dryer

- ▶ Good for:

- IAQ
- Internal Heating Loads



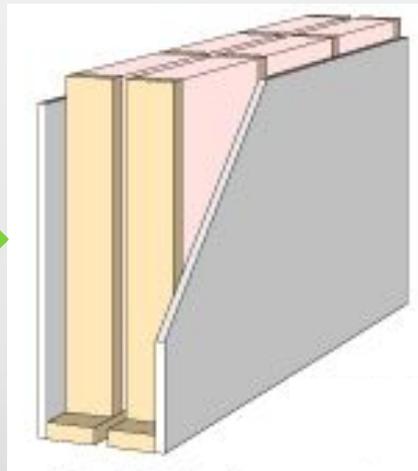


# Energy Analysis

# Energy Analysis

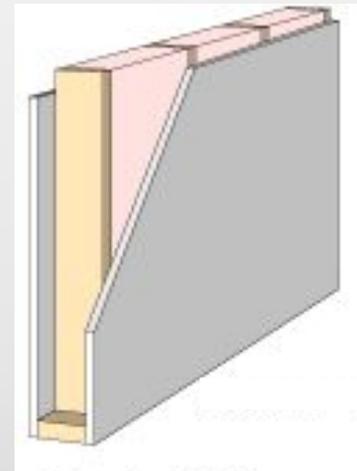
- ▶ Enclosure Design
  - ▶ DOE Zero Energy Ready Home Requirements - IECC 2015

Finalist



Double  
Wood  
Stud

The Winner!

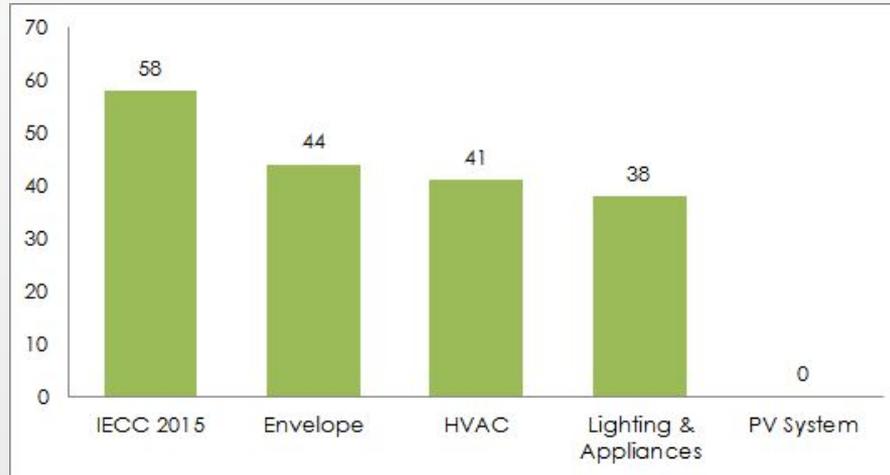


Space Saver

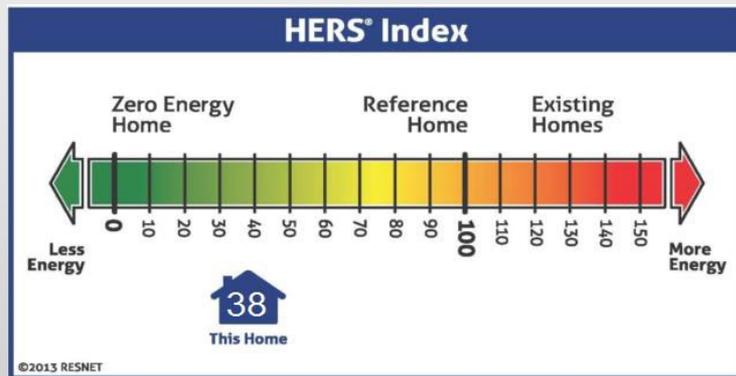
Single  
Wood  
Stud

# Energy Analysis

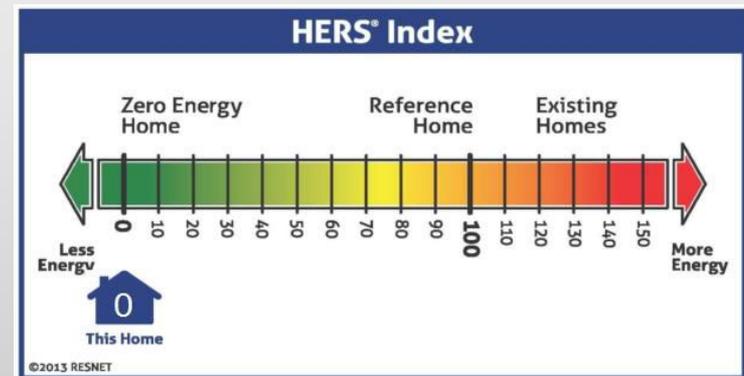
## ► HERS Score



## ► Without PV

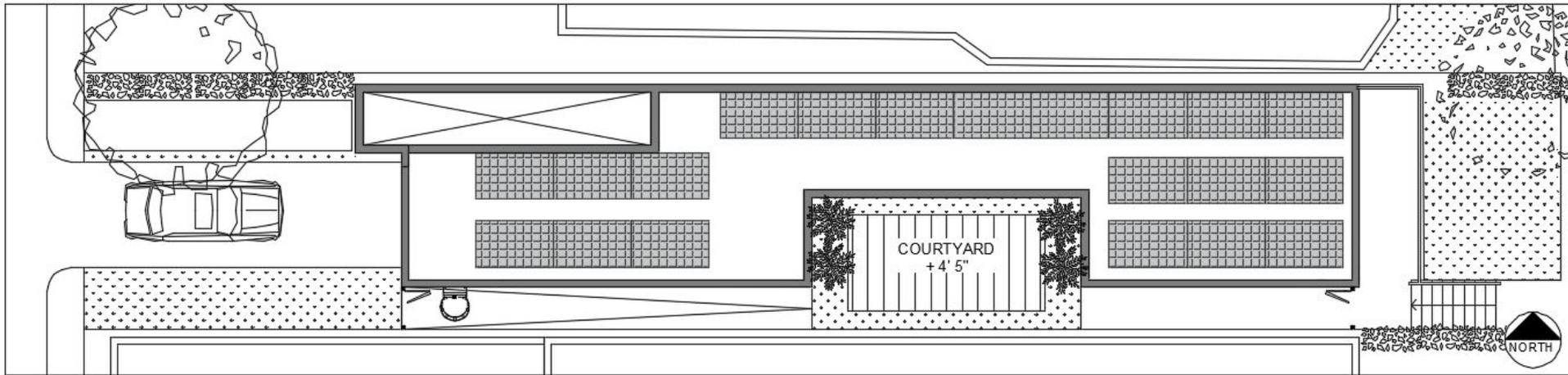


## ► With PV



# PV System

- ▶ Heliene 96<sup>M</sup> - 490 W/Panel (9.8 kW system)



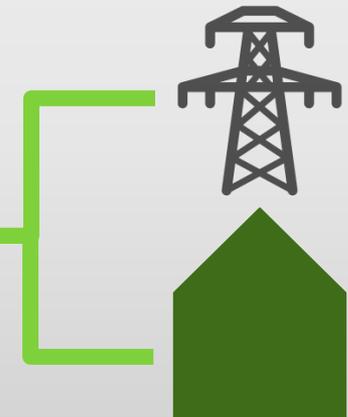
Controller



Battery Pack



Inverter



# PV System

## ► Payback Period

- Database of State Incentives for Renewables & Efficiency (DSIRE)

**RESULTS**

# 12,936 kWh per Year \*

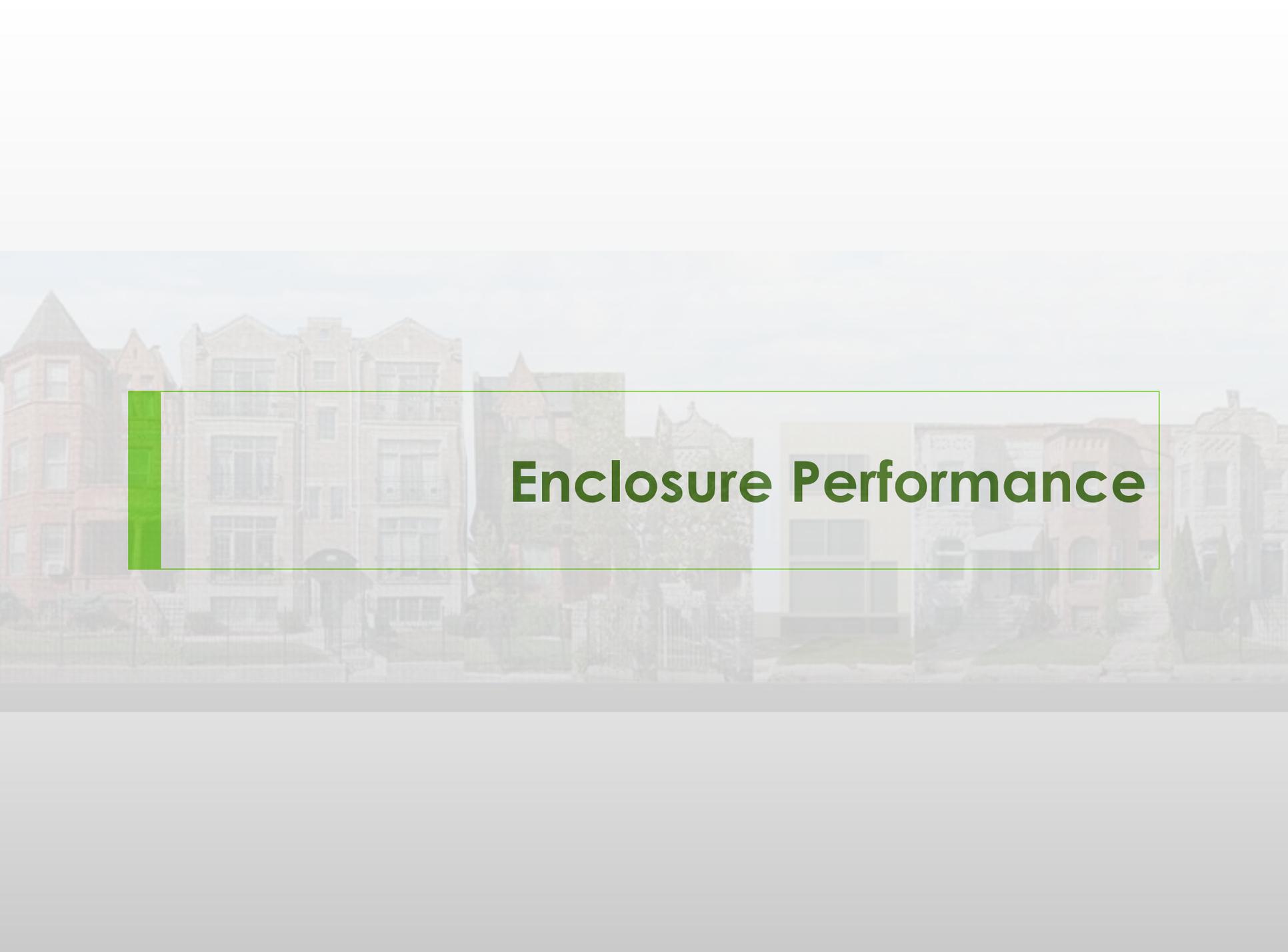
System output may range from 12,384 to 13,478kWh per year near this location.

Month	Solar Radiation ( kWh / m <sup>2</sup> / day )	AC Energy ( kWh )	Energy Value ( \$ )
January	2.76	755	79
February	3.55	858	90
March	4.25	1,123	117
April	5.24	1,275	133
May	6.01	1,434	150
June	6.08	1,386	145
July	6.31	1,449	151
August	5.42	1,267	132
September	4.93	1,131	118
October	4.08	1,018	106
November	2.64	669	70
December	2.09	571	60
<b>Annual</b>	<b>4.45</b>	<b>12,936</b>	<b>\$ 1,351</b>

Initial Cost (\$)	17500
Illinois Rebates - 25% (\$)	4375
Federal Rebates - 30% (\$)	5250
<b>Final Cost (\$)</b>	<b>7875</b>

- Payback just for PV:  
13 Years
- Payback w. rebates:  
**6 Years**

Annual Savings

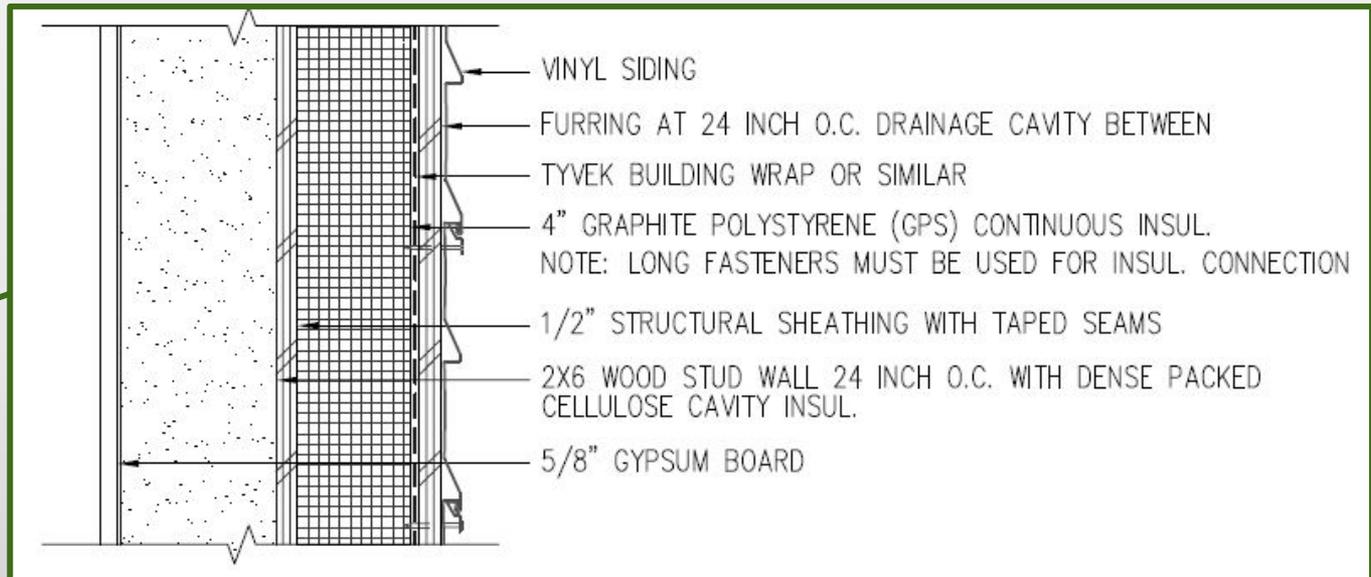
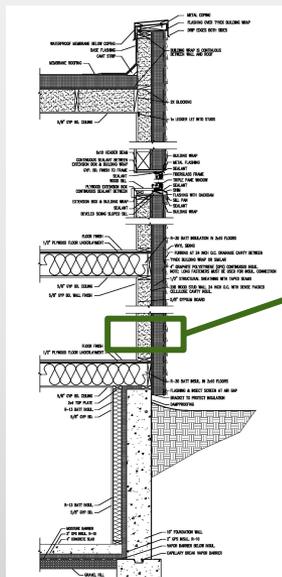


# Enclosure Performance

# Enclosure Performance

## Walls

- ▶ 2x6 Wood Framing: Dense Packed Cellulose Cavity Insulation
- ▶ Continuous Insulation: 4" Graphite Polystyrene Rigid Insulation
- ▶ Rainscreen Facade: Vinyl Siding over Furring Strips

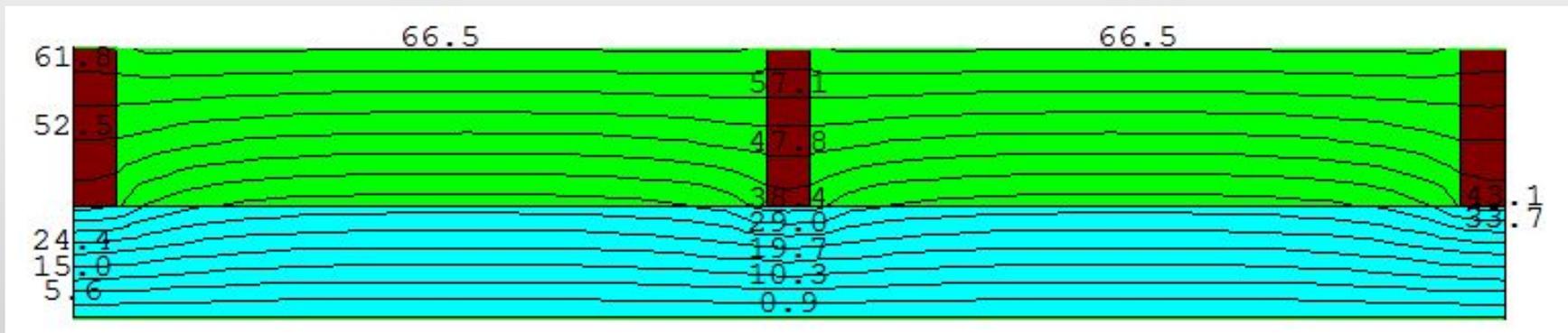


# Enclosure Performance



## Wall Thermal Performance

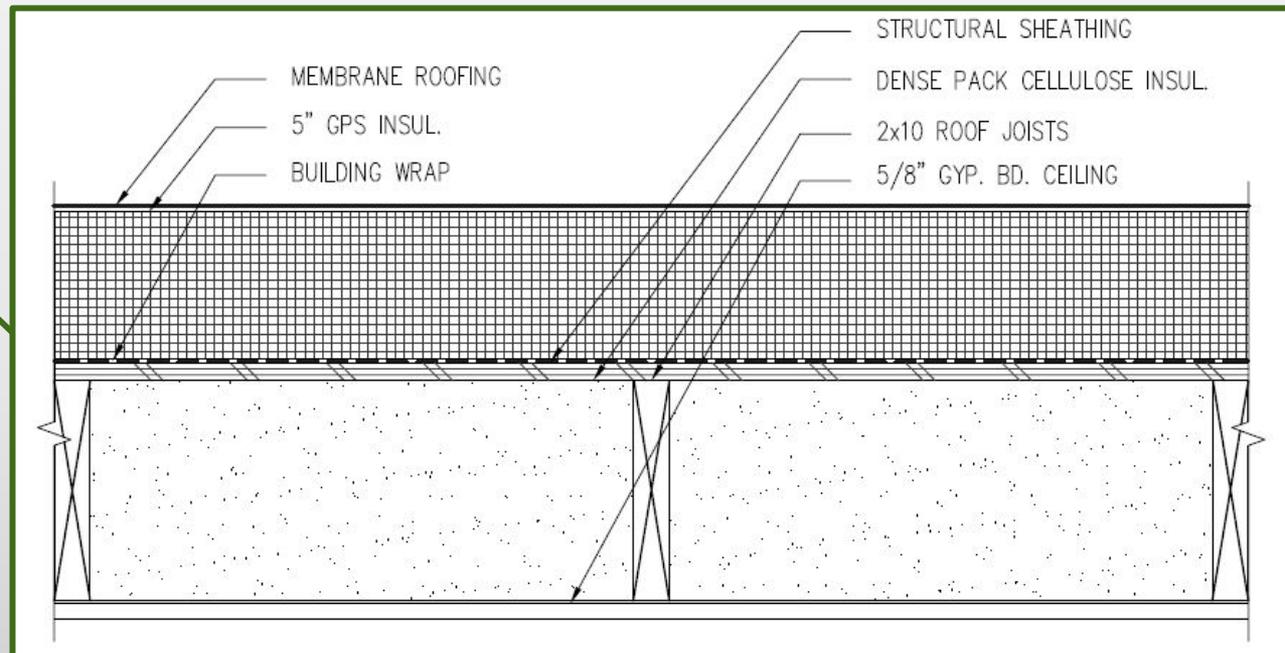
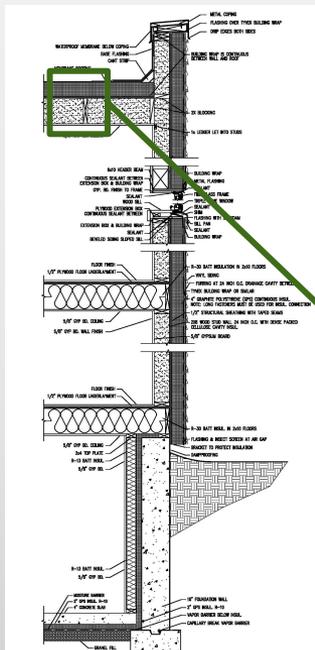
Nominal R-Value	Effective R-Value
<b>R-42</b> R-22 (5.5 inch x R-4/ Inch of Dense Pack Cellulose) R-20 (4 inch x R-5/ Inch of Graphite Polystyrene)	<b>R-37</b> THERM Model Extreme Winter Conditions Interior: 68F, Exterior: 0F



# Enclosure Performance

## Roof

- ▶ 2x10 Roof Joists: Dense Packed Cellulose Cavity Insulation
- ▶ Continuous Insulation: 5" Graphite Polystyrene Rigid Insulation
- ▶ Roof Finish: White Fully Adhered Membrane

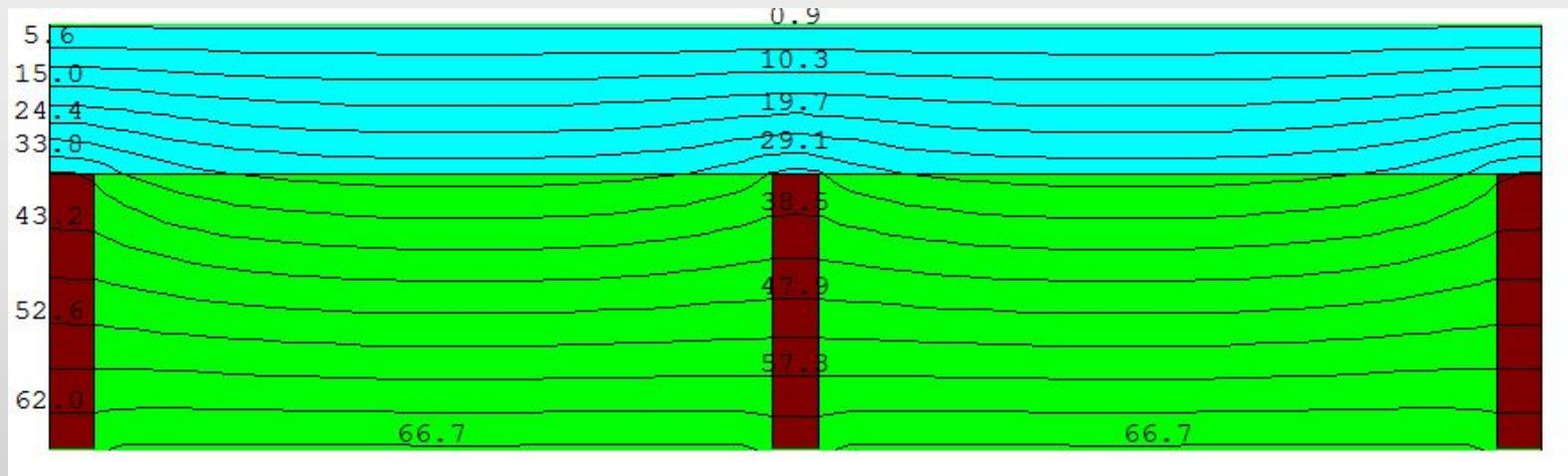


# Enclosure Performance



## Roof Thermal Performance

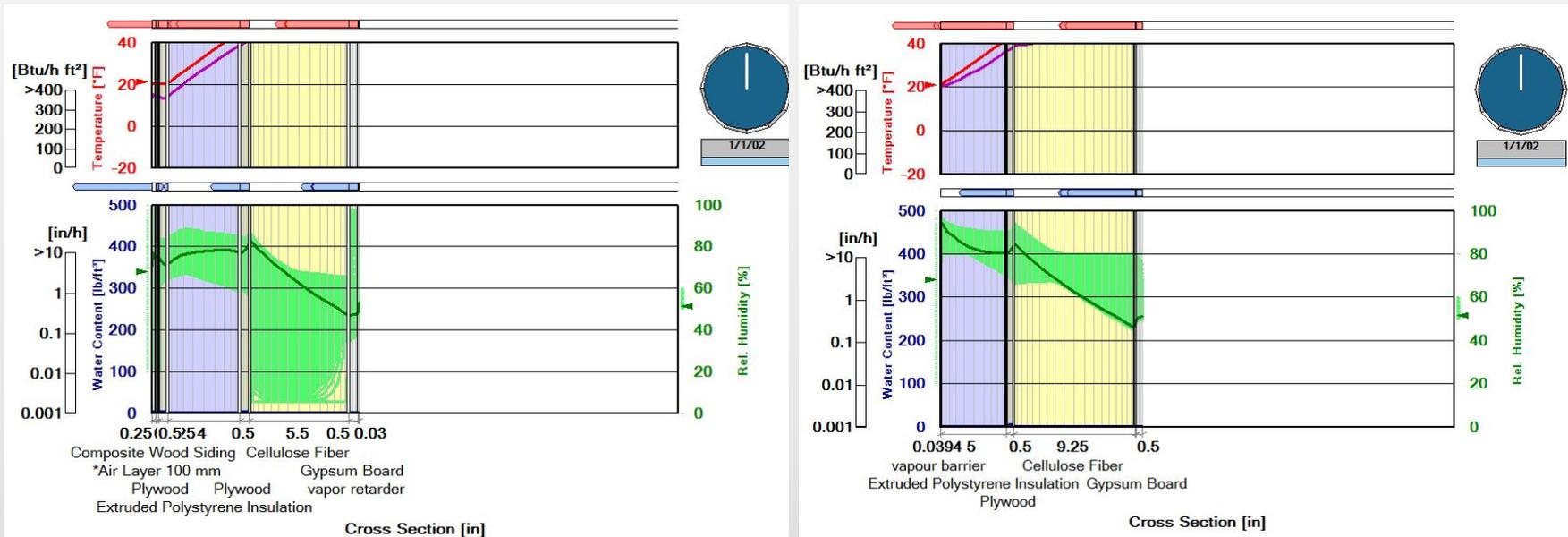
Nominal R-Value	Effective R-Value
<b>R-62</b> R-37 (9.25 inch x R-4/ Inch of Dense Pack Cellulose) R-25 (5 inch x R-5/ Inch of Graphite Polystyrene)	<b>R-53</b> THERM Model Extreme Winter Conditions Interior: 68F, Exterior: 0F



# Enclosure Performance

## Moisture Evaluation - WUFI

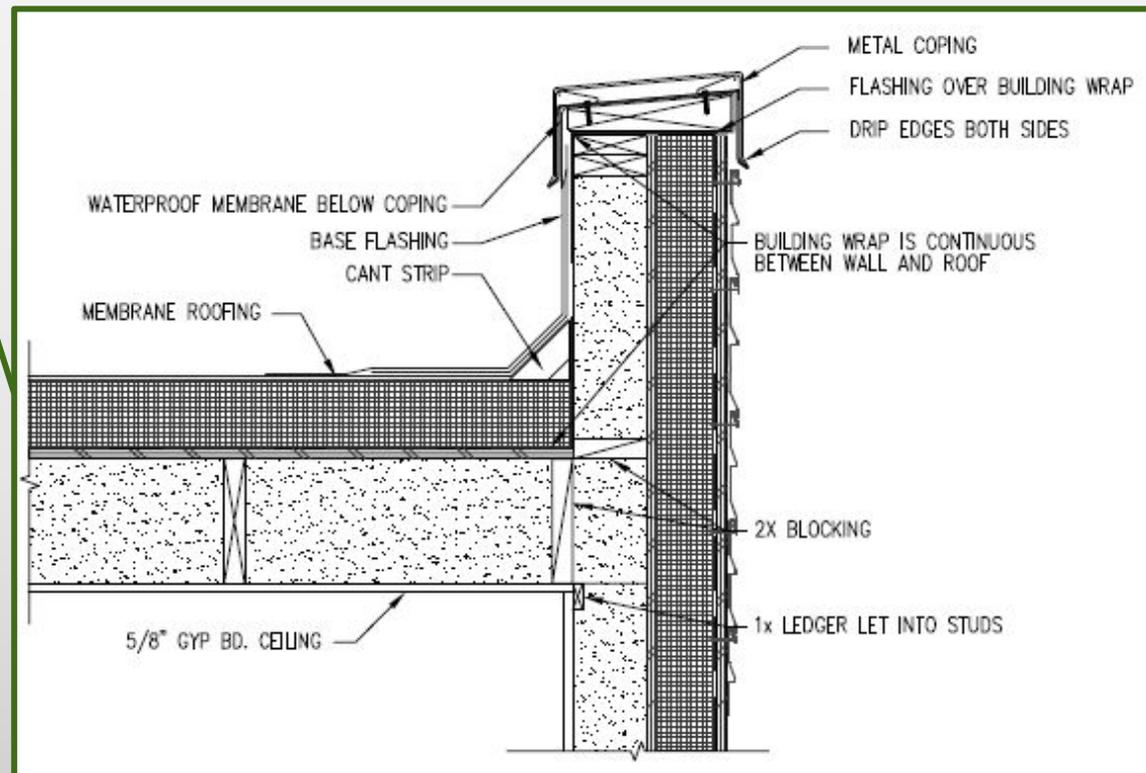
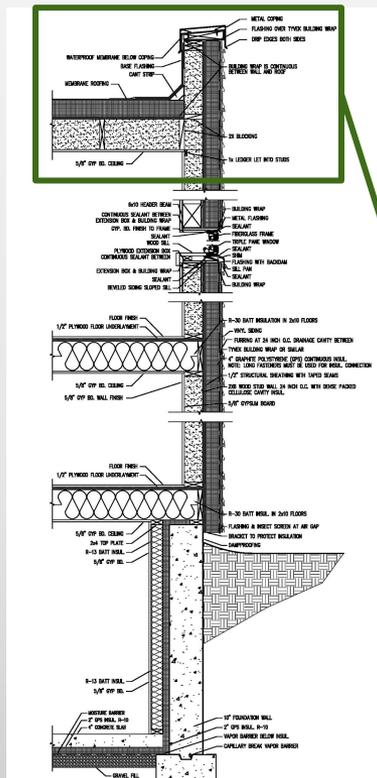
- ▶ Relative Humidity does not reach 100%, wall and roof section both OK.



# Enclosure Performance

## Parapet

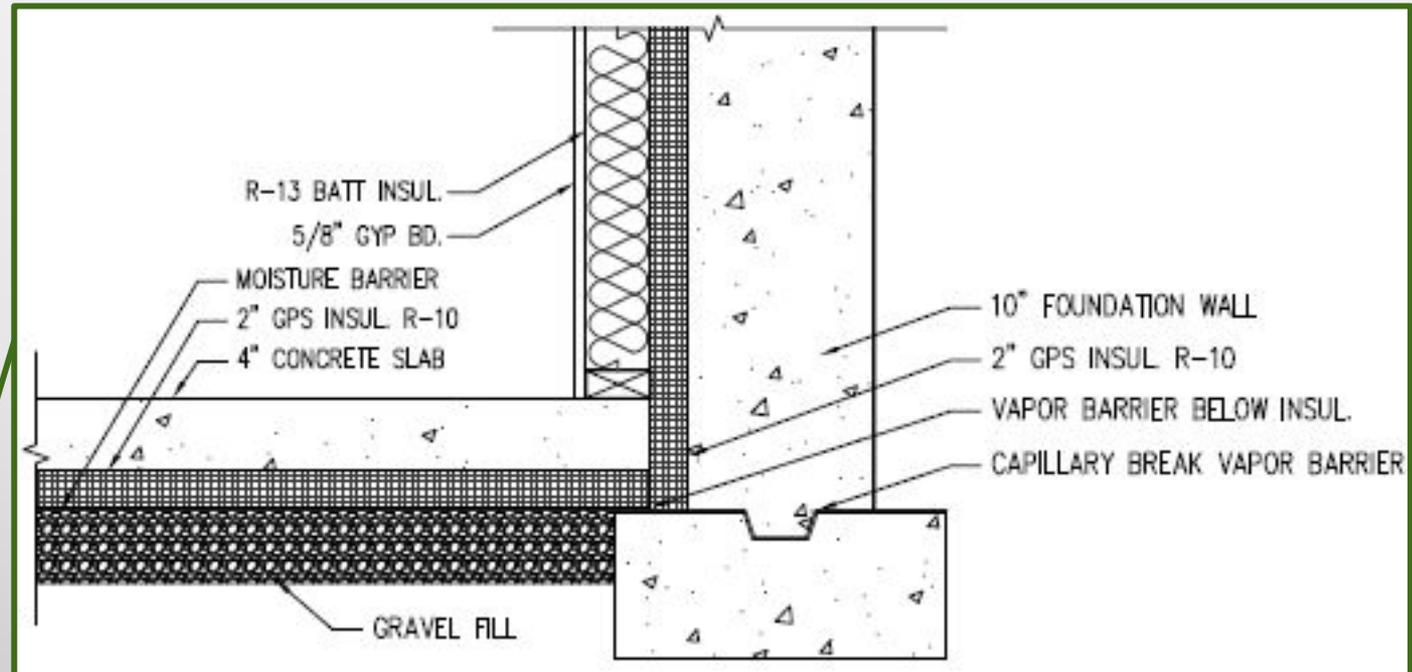
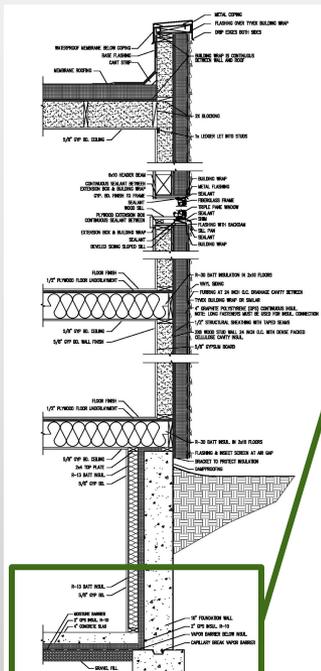
- ▶ Air Barrier is Continuous
- ▶ Waterproof Membrane Below Coping



# Enclosure Performance

## Basement Walls

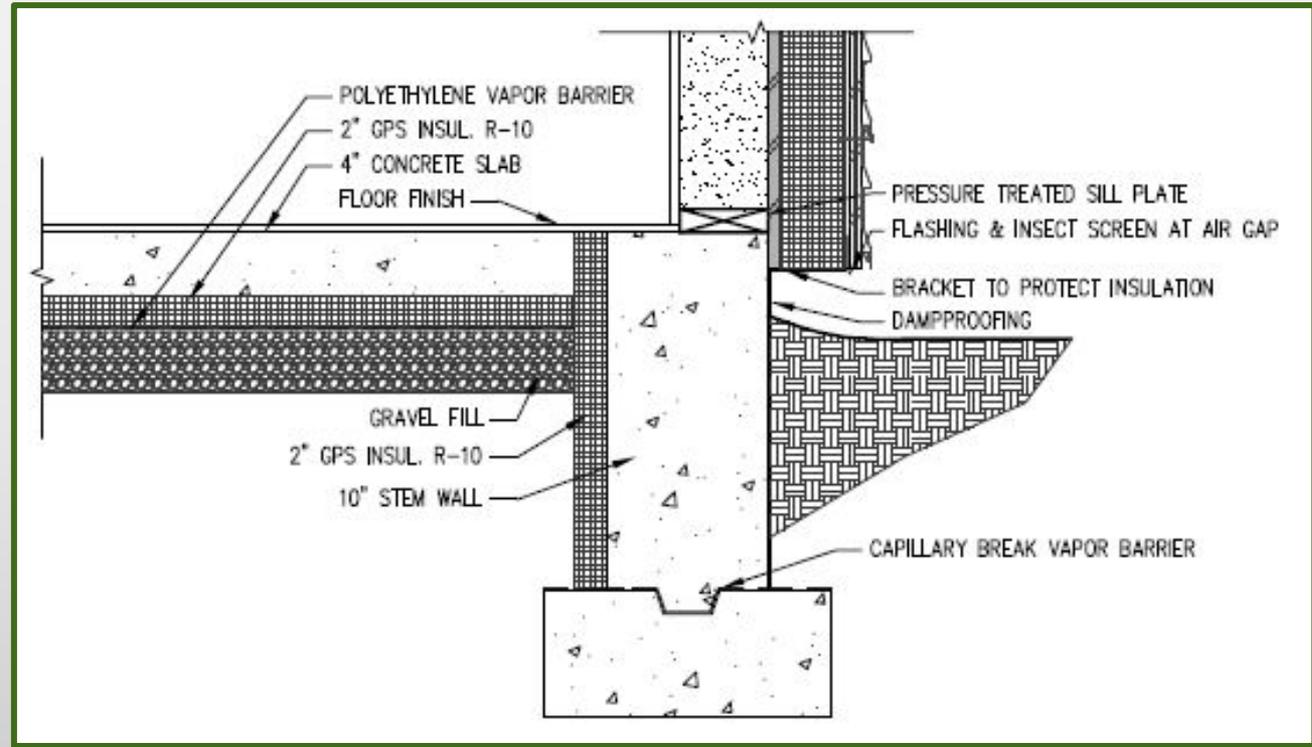
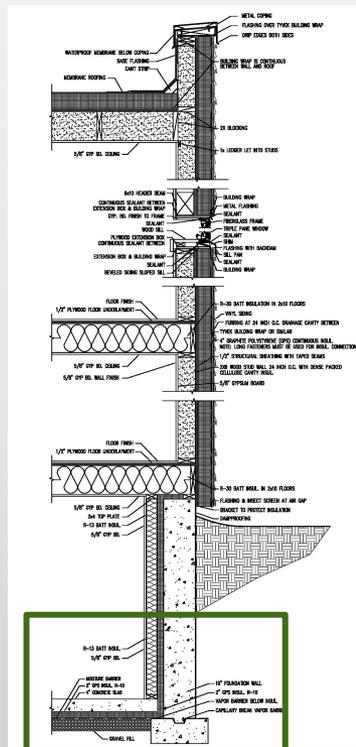
- ▶ R-10 GPS Continuous, Thermal Break Between Foundation and Slab
- ▶ Framed 2x4 Walls with R-13 Batt Insulation
- ▶ Vapor Barrier Below Insulation, Capillary Break at Foundation Base



# Enclosure Performance

## Slab on Grade

- ▶ R-10 GPS Thermal Break Between Foundation and Slab
- ▶ Vapor Barrier Below Insulation, Capillary Break at Foundation Base



# Enclosure Performance

## Window Selection

Triple Pane, Insulated Frame

Alpen High Performance Zenith ZR-6/625 Series Fiberglass Windows



### Three Window Style Types:

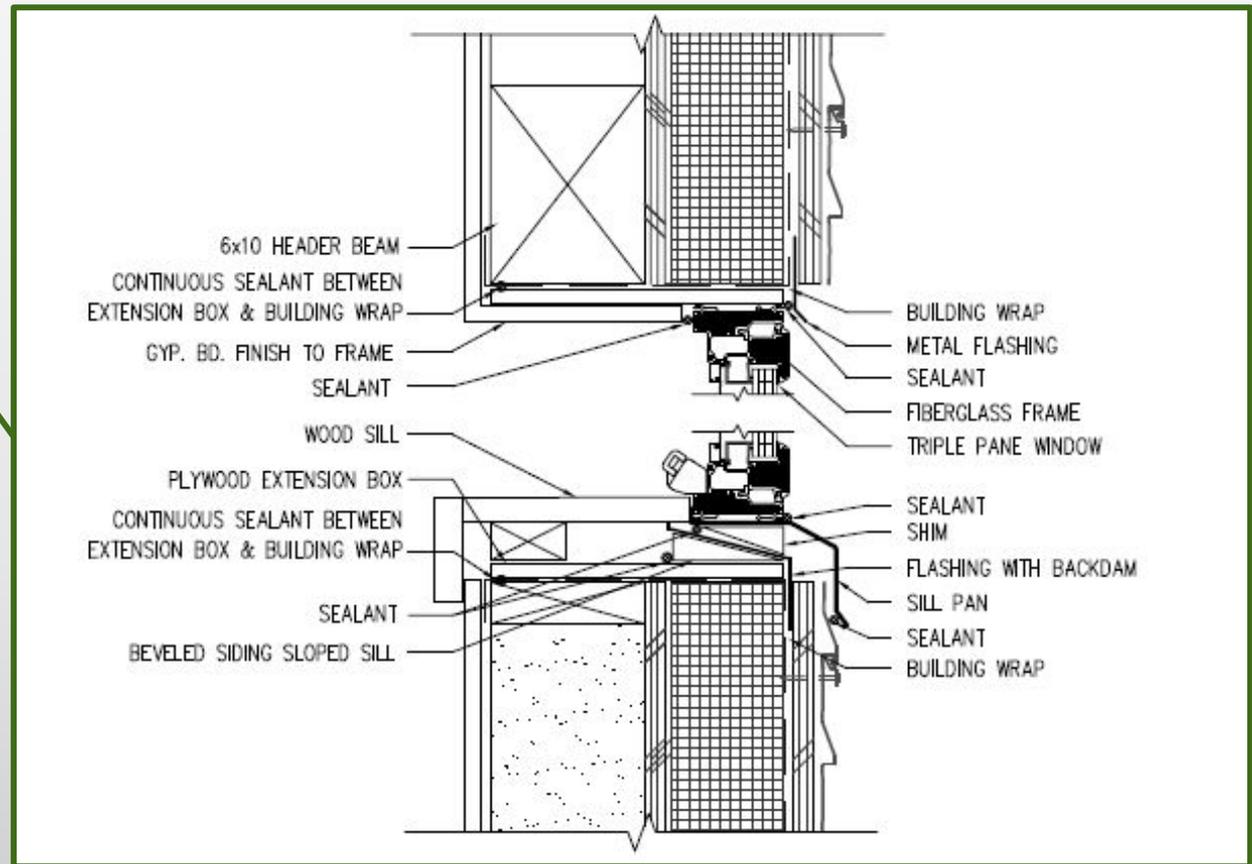
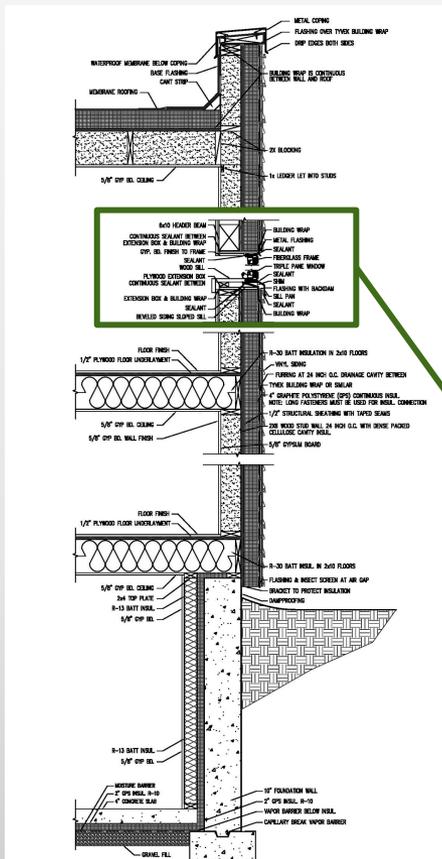
- Fixed High Profile
- Casement: Egress for Bedrooms
- Awning/ Tilt Out

Styles	Alpenglass <i>Balanced-6</i>			
	U-Value	R-Value	SHGC	VT
Fixed Low Profile	0.16	6.3	0.30	0.49
Fixed High Profile	0.16	6.3	0.27	0.44
Casement	0.19	5.3	0.24	0.38
Awning	0.19	5.3	0.24	0.38

# Enclosure Performance

## Window Detail

► Outward Orientation





# MEP Design

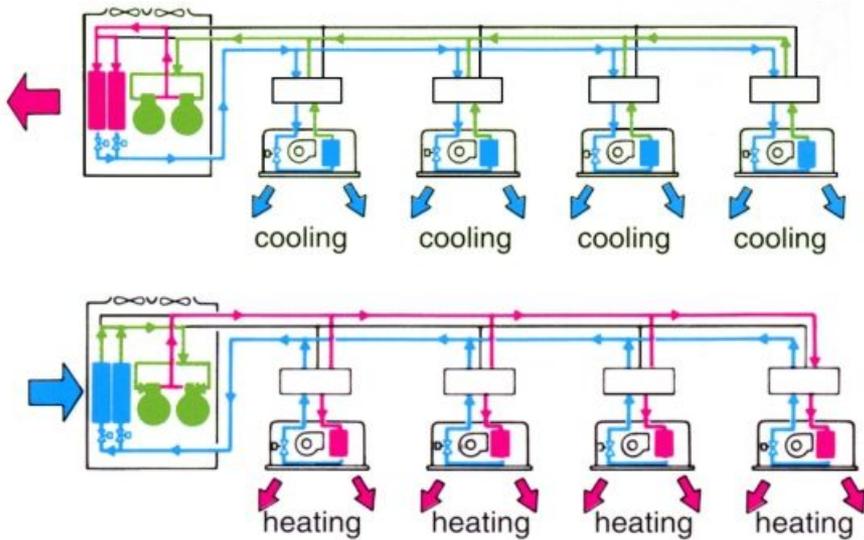
# Mechanical

---

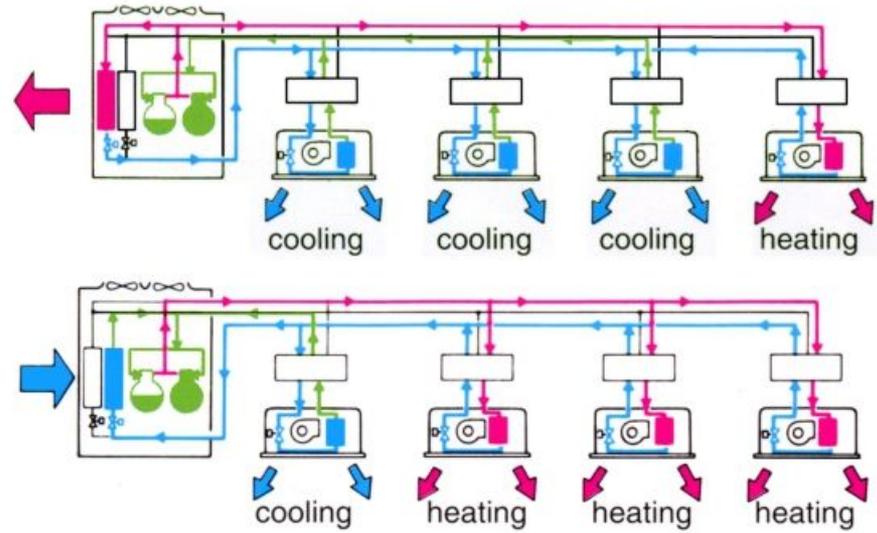


- ▶ Air sourced vs water-sourced heat pump
- ▶ Vertical pipe loop
- ▶ Ductless VRF Mini Split System
  - ▶ Reduces Duct cost and Energy losses
- ▶ Ecobee3 Smart Thermostat- occupancy sensors, local weather data

# Mechanical

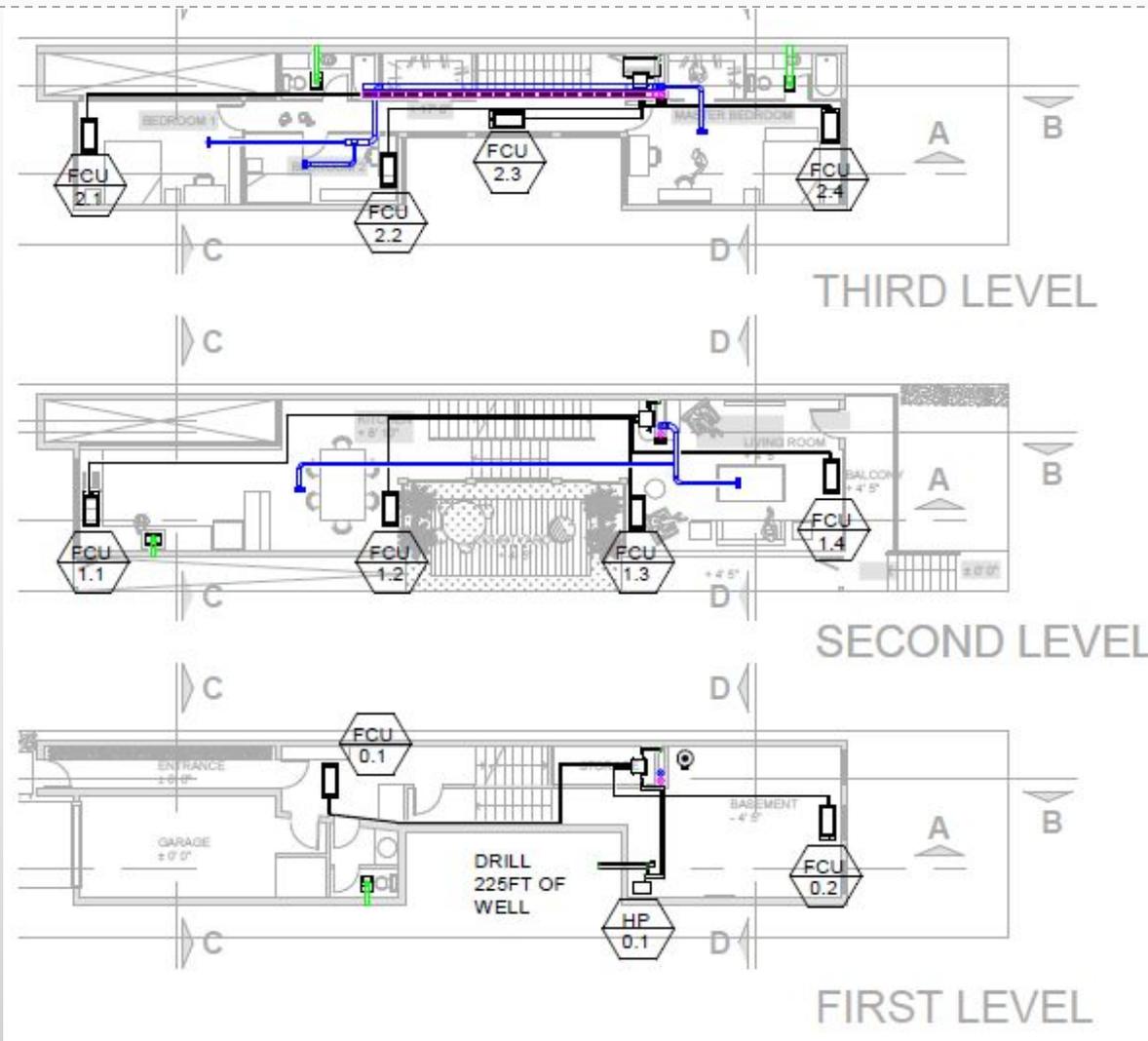


**HEATING OR COOLING**



**HEATING AND COOLING**

# Mechanical



# Plumbing

- ▶ Water heater- GE Geospring
  - ▶ 3.25 Energy Factor
  - ▶ 70% more efficient than a standard electric 50-gallon water heater
  - ▶ Provides the same amount of hot water as a traditional 50-gallon standard electric water heater with 69 gallons first-hour delivery
  - ▶ Electronic controls with 4 operating modes plus a vacation setting
  - ▶ Recirculation loop



# Plumbing

- ▶ All fixtures are low flow, balanced with the architectural design of the house



Plumbing Fixtures			
Type	Model #	Flow Rate (GPM)	Location
Delta Trinsic Pulldown Faucet	9959-DST	1.80	Kitchen Sink
Delta Trinsic Lav Faucet	559LF-TP	1.2	Bathroom Lavs
Delta Prelude Toilet	C41901-WH	1.28 GPF	Bathrooms
Delta Trinsic Tub and Shower Trim	T17T459-H20	2	Bathrooms





# IAQ and Ventilation

# IAQ and Ventilation

- ▶ Ventilation Requirements - ASHRAE 62.2 (2013)



- ▶ Whole-House:  
Zehnder Novus 300  
Up to 177 cfm

- ▶ Bathrooms:  
WhisperCeiling  
FV-05VQ5  
Up to 50 cfm

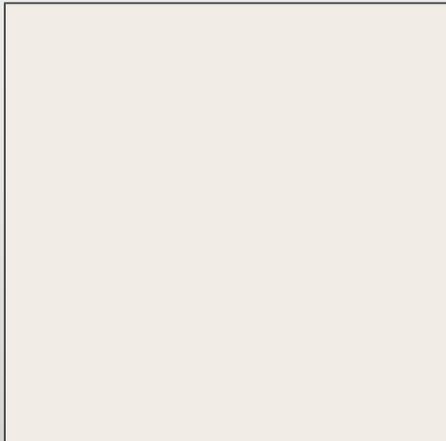


- ▶ Kitchen: 400 cfm, non recirculating
- ▶ Garage:
  - ▶ ENERGY STAR: Air barrier installed at the exterior and interior vertical surface of the wall insulation.
  - ▶ Completely separated from house

# IAQ and Ventilation



## ▶ Interior Design



- ▶ Armstrong - Oak Butterscotch
  - ▶ CARB requirements

- ▶ Sherwin-Williams - ProMar 200 Zero VOC



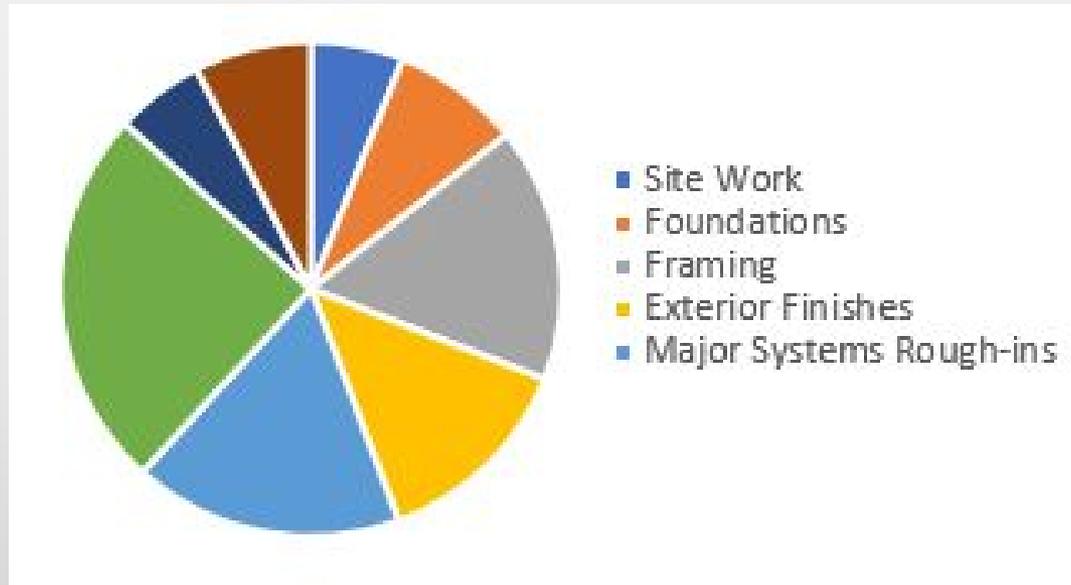
# Financial Analysis

# Financial Analysis

NAHB Financial Spreadsheet

**Construction Cost: \$ 259,730**

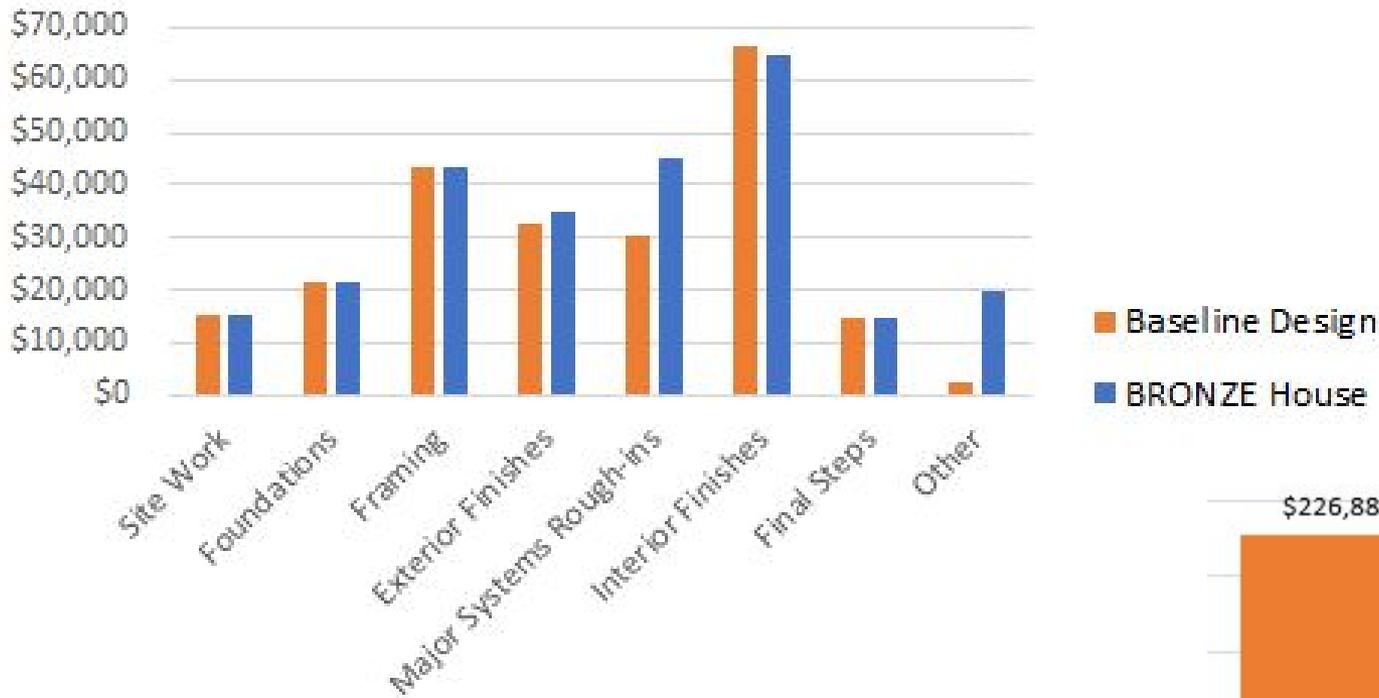
**Sales Price: \$ 400,384**



# Financial Analysis



Comparison to Baseline Design



Estimated Family Income: \$52,250



# Financial Analysis



## ► Rebates

Rebates	State of Illinois	Federal	Final Rebates
PV Solar	\$4,375.00	\$5,250.00	
Geothermal (ComEd)	\$6,500.00		
Smart Thermostat (ComEd)	\$100.00		
Insulation (ComEd)	\$400.00		
Appliances (ComEd)	\$100.00		
Duct Sealing (ComEd)	\$300.00		
<b>Total</b>	<b>\$11,775.00</b>	<b>\$5,250.00</b>	<b>\$17,025.00</b>

- Reduces sales price to **\$383,359** from **\$400,384**

**Sales Price: \$ 383,359**



# Innovation

# Innovation



- ▶ Energy Analysis driven design
- ▶ Narrow Site
  - ▶ Limits usable roof area for PV and exposed faces
- ▶ Architectural Strategies
  - ▶ Courtyard Lighting
  - ▶ Lightwell
  - ▶ Split Levels
- ▶ Combination of Traditional & New Technologies
  - ▶ Standard Wood Framing & Thick Continuous Graphite Polystyrene Insulation
  - ▶ Space conditioning and ventilation are separate systems
  - ▶ Follows the footprint and organization of the Traditional Chicago Home



Thank You

ILLINOIS INSTITUTE  
OF TECHNOLOGY

